MISSOURI RIVER
RECOVERY PROGRAM

FINAL
Missouri River Recovery Management Plan and Environmental Impact Statement

VOLUME 2

August 2018

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Missouri River Recovery Management Plan and Environmental Impact Statement

Volume 2

Contents

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Chapter 3 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 define 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 Alternative 1. Adverse impacts result in a negative change in the condition of the resources when compared to Alternative 1. Impacts are also described in terms of duration. *Temporary* or *short-term* impacts would persist for the duration of the management action and/or occur for a limited time after implementation of the management action. Temporary impacts can be re-occurring such as in the case of flow actions that occur at different intervals over time. *Long-term* impacts would be permanent or continuous over the period of analysis.

Finally, impacts are described in relation to their significance. 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 by 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. Negligible is defined as of such little consequences as to not require additional consideration or mitigation.
- **Small Impact**: The effect to the resource would be perceptible; however, not severe and unlikely to result in an overall change in resource character.
- **Large Impact**: The effect to the resource would be perceptible and may be severe. The effect would likely result in an overall change in resource character.

The rationale for why an impact is considered to fall under one of the preceding intensity 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 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 2.4) 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. The HEC-RAS model geometry and calibration were generally representative of 2012 conditions and revised to reflect the potential extent of early life stage pallid sturgeon habitat for each alternative. It was assumed this revised geometry was in place every year of the POR. HEC-RAS modeling was also conducted for the 15-year implementation timeframe to assess the effect of ongoing sediment transport characteristics on the implementation of alternatives and their associated impacts. The sediment modeling shows that the difference in elevation/stage relative to Alternative 1 (No Action) is nearly the same for any given Alternative whether looking at year 0 or year 15 modeling results (see Figures D-20 to D-30 in Appendix D: Hydrologic Period of Record Analysis of Alternatives).

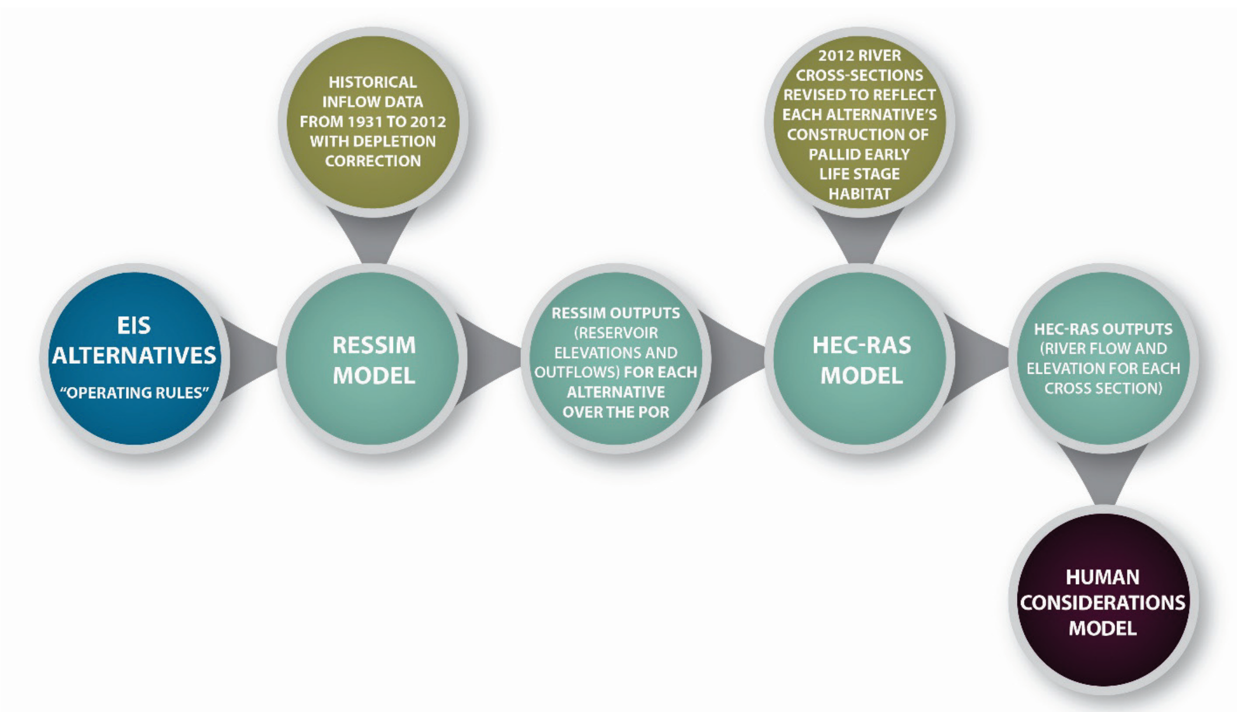


Figure 3-1. Model Outputs for the Missouri River Recovery Plan – Environmental Impact Statement

One might expect the modeling output for Alternative 1 (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 Alternative 1 do not match what actually occurred in the past.

- **Operational Differences**: Alternative 1 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 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 Alternative 1 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 Alternative 1. 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 Alternative 1. 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 Alternative 1. 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 attempt 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 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.

The one-time spawning cue test (Level 2) release, that may be implemented under Alternative 3, was not included in the hydrologic modeling for that alternative because of the uncertainty of the hydrologic conditions that would be present in the year 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.

3.1.2 "Human Considerations" and USACE Planning Accounts

Effects to human considerations (refer to Section 2.4.5) 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). Additional resource topics, other than those categorized as human considerations, were identified and are presented in this chapter.

3.1.3 Cumulative Impacts

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 future 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 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
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	

	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 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
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	
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	
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																	

	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 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
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.

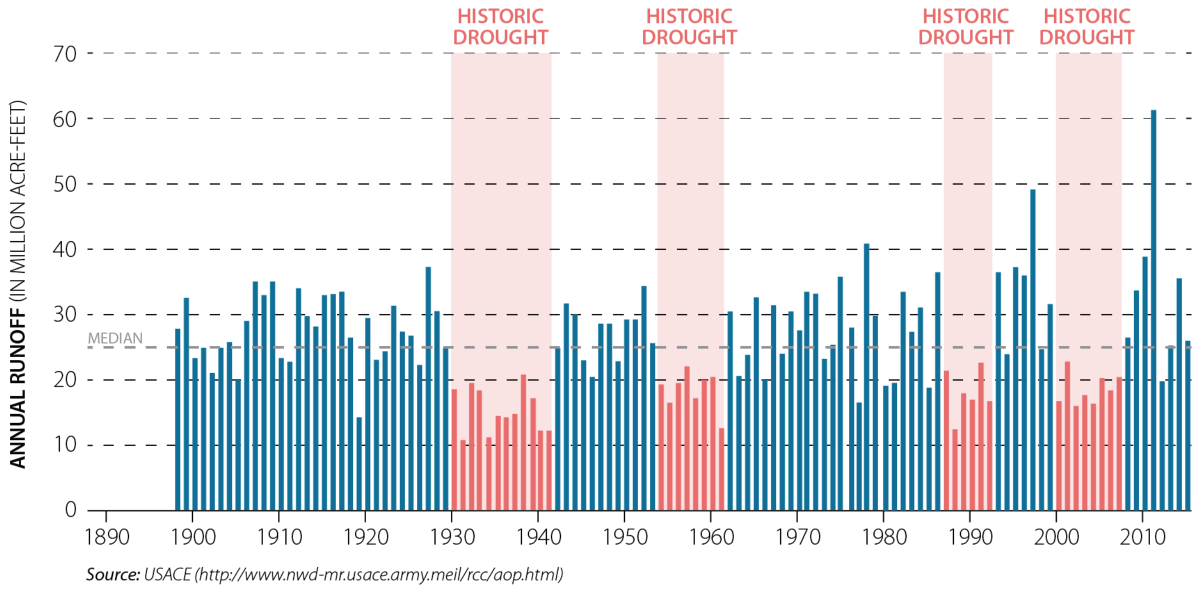
3.2.1.1 Basin Overview

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 1-5). 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. There are no additional dams controlling discharge between Gavins Point Dam and the confluence of the Missouri River with the Mississippi River.



Source: USACE n.d.a

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 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 1-5). 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 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. It is noted that all reservoir elevations listed below are based on the datum NGVD 29.

- **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. 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. 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. Operating pool elevations range from a minimum of 1,540 feet to a maximum of 1,620 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. Operating pool elevations range from a minimum of 1,415 feet to a maximum of 1,423 feet. 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. Operating pool elevations range from a minimum of 1,320 feet to a maximum of 1,375 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. 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.

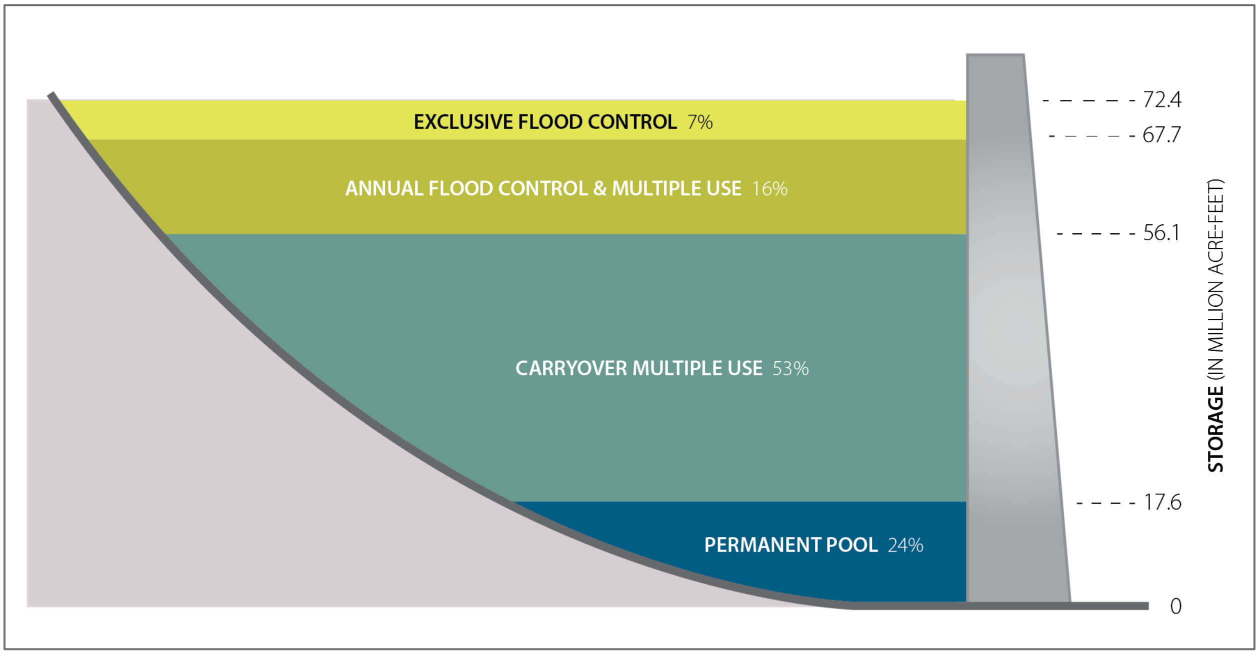
Reservoir Storage

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 Use**: 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**: 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 Control**: 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: USACE 2015a

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 elevations 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.

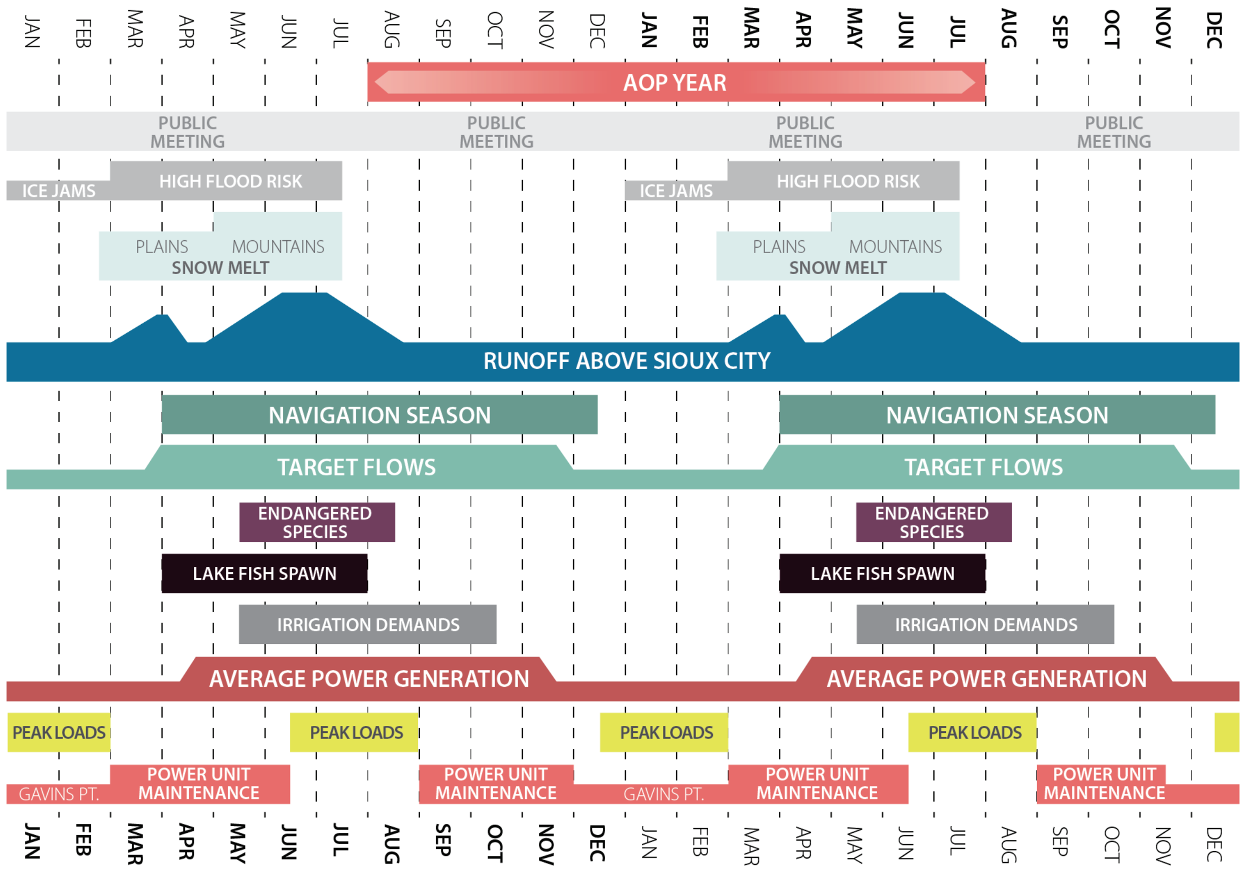


Figure 3-4. Typical System Operation Cycle

The Master Manual describes the water control plan for the System, which consists of the water control criteria for the management of the System for the full spectrum of anticipated runoff conditions that could be expected to occur. Annual water management plans (Annual Operating Plans, or AOPs) are prepared each year, based on the water control criteria contained in the Master Manual, to detail reservoir regulation of the System for the current operating year. Because the System is so large, it can respond to extreme conditions of longer than one-year in duration. The AOP document also provides an outlook for planning purposes in future years (USACE 2006a, Section 1-02.3).

For a portion of some years, deviations may be made from the specific technical criteria stated in the Master Manual to achieve the operational objectives of the current water control plan or to comply with other statutory or regulatory obligations such as the Endangered Species Act (ESA). In such circumstances, the AOP will explain the deviation from the specific technical criteria and the rationale for that deviation related to the operational objectives or applicable statutory and regulatory requirements (USACE 2006a, Section 7-03.5). All significant deviations from the current water control plan will be coordinated and approved by the Northwestern Division Commander. All deviations of significance are modeled and presented to the public through the normal coordination procedures involving public press releases and World Wide Web dissemination. Minor deviations are accomplished by the Missouri River Basin Water Management through coordination directly with the affected parties (USACE 2006a, Section 7-18).

Basin interests can anticipate continued public involvement in the water control management process and any significant water control plan or Master Manual revisions in the future will be processed in accordance with ER 1110-2-240. Changed circumstances or unforeseen conditions may necessitate short-term deviations from the current water control plans. As stated above, such deviations are reviewed and approved by the Commander, Northwestern Division in accordance with ER 1110-2-1400 (USACE 2006a, Section 1-02.5).

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 (e.g., Skalag et al. 2013). 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.

The prevalence of large wood on the Missouri River has been noted in historic references including the Journals of Lewis and Clark (DeVoto 1997). An 1881 report to Congress noted that the “cavings of the banks precipitates into the river countless trees” (Secretary of War 1881). USACE has conducted Missouri River snag removal for navigation purposes starting in the 1800s. Wood structures and river snags provide biological diversity and also contribute to channel habitat diversity by altering depth, velocity, and sediment processes. Refer to the National Large Wood Manual (Bureau of Reclamation and USACE 2016a) for further information regarding the role of wood in fluvial aquatic and riparian ecosystems.

Post-dam construction, the Missouri River is channelized in the lower river downstream of Ponca, Nebraska, 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, North Dakota
Garrison Dam to Bismarck	75	55–60	Bismarck, North Dakota
Downstream of Bismarck to Lake Oahe	18	35–40	–
Oahe Dam to Lake Sharpe	17	(not available) [d]	Pierre, South Dakota
Big Bend Dam to Lake Francis Case (There is no inter-reservoir reach.)	NA	NA	NA
Fort Randall Dam to Lewis and Clark Lake [b]	52	35–40	Springfield, South Dakota
Gavins Point Dam to Rulo, Nebraska [c] (Lower River Reach)	313	80 to 85	Omaha, Nebraska

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, Nebraska. This reach includes the Nebraska City gage which was used in the channel capacity exceedance analysis in Section 3.12.

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

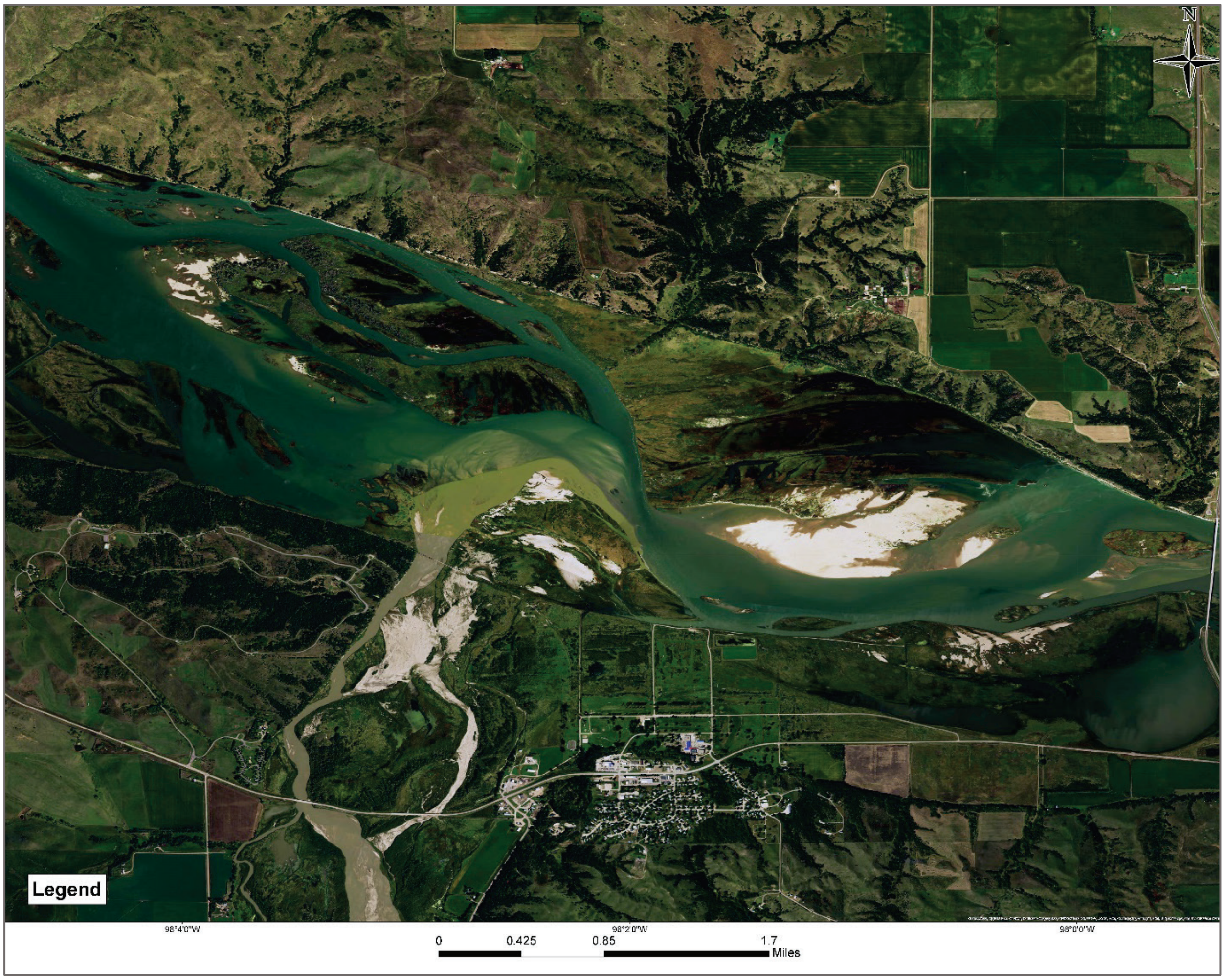


Figure 3-5. Unchannelized Missouri River near the Confluence with the Niobrara River, 17 River Miles Upstream of Lewis and Clark Lake

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, 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. 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 1.7.3, Missouri River Bank Stabilization and Navigation Project, 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).

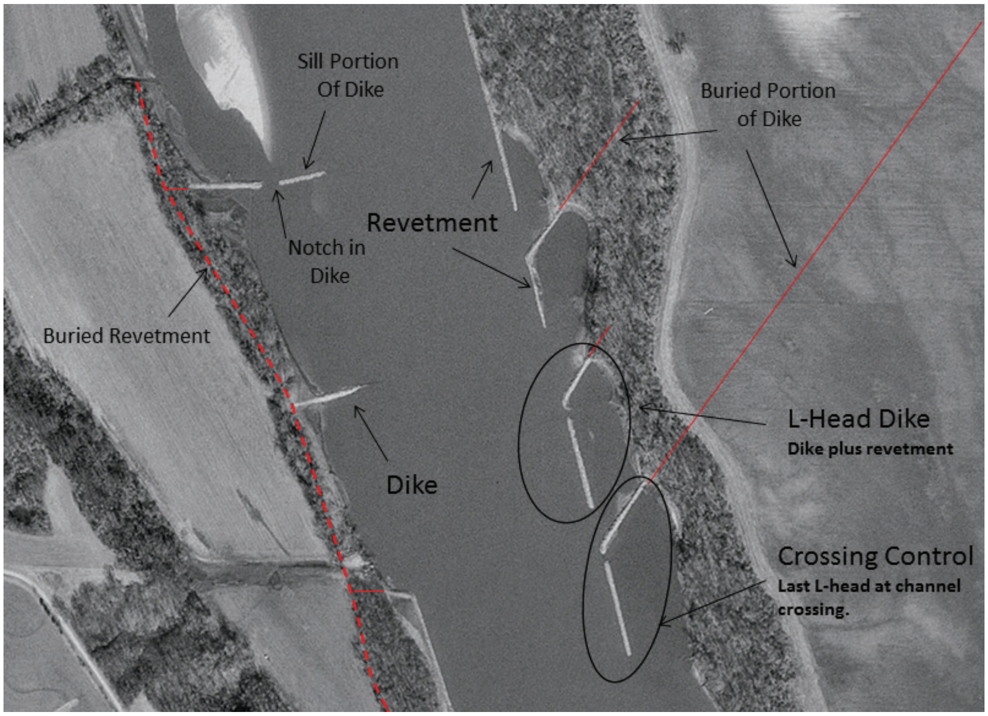


Figure 3-6. Typical Structures of the Bank Stabilization and Navigation Project in the Lower Missouri River

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)

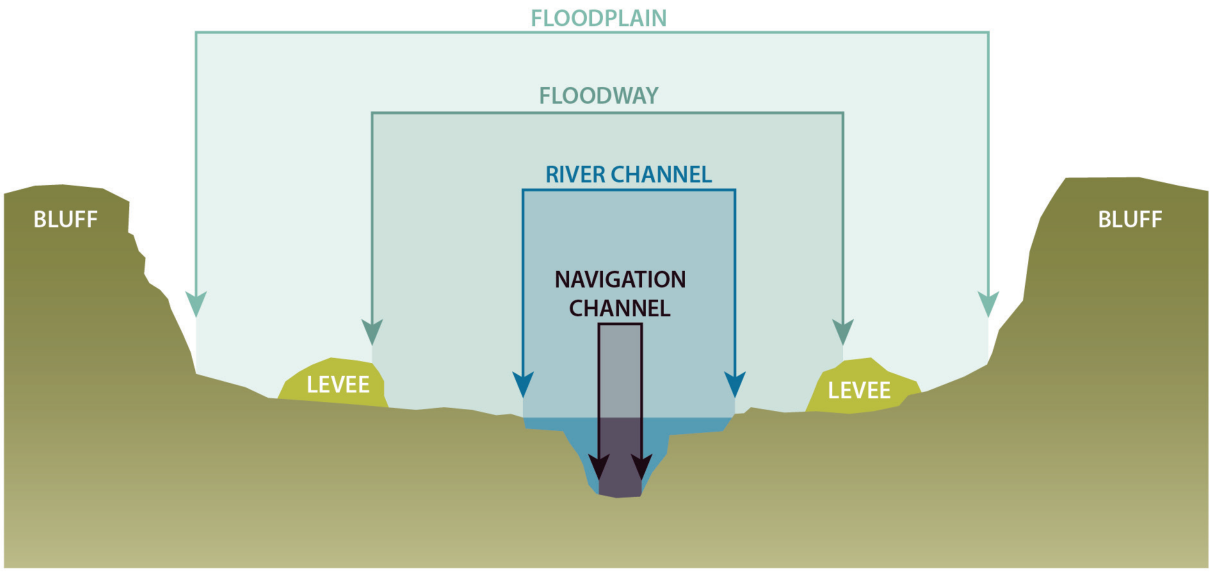


Figure 3-8. Common River Channel Geometry in Channelized River; Floodway Location with Respect to Levee and Channel Varies Significantly

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. Bedforms in the river include sandbars that change over time through flow-driven erosion and deposition processes.

Primary geomorphological processes that are relevant for the proposed management actions consist of degradation and bank erosion, reservoir sediment deposition and aggradation, sandbar erosion and deposition occurring within the river channel and in reservoir deltas, 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 (e.g., USACE 2014e). 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.

Another contributor to geomorphic processes and degradation is sand and aggregate mining in the lower Missouri River between Rulo, Nebraska and the confluence with the Mississippi River in St. Louis. Mining is concentrated in the greater vicinity of urban areas, namely St. Joseph, Kansas City, Jefferson City, and St. Louis (USACE 2017a).

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 2012d). 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 near Omaha, Nebraska. 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. As stated above, sand and aggregate mining contributes to degradation in the approximately 500-mile long reach between Rulo, Nebraska, and St. Louis, Missouri (USACE 2017a). The large volume of material mined within approximately 50-miles around Kansas City resulted in degradation of the riverbed by up to 7 feet between 1990 and 2005 (USACE 2009c). 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 Mainstem Reservoir System by approximately 5 percent. Sedimentation rates have not been uniform between the reservoirs, with the highest rate occurring in Lewis and Clark Lake (formed by Gavins Point Dam), which has lost over 26 percent of storage volume as of 2011. However, the storage volume in Lewis and Clark Lake provides very minor System flood control capacity. The effects of the alternatives on sedimentological and geomorphological processes in reservoir System deltas from flow releases would be small compared to the natural variability in river flows and sediment input; therefore, a detailed evaluation of variation between sediment processes for the various alternatives within the Mainstem Reservoir System deltas, including Lewis and Clark Lake, was not conducted.

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. However, the growing deltas have posed problems at many of the reservoirs. Sediment accumulation within the channel (aggradation) has resulted in elevated surface water and groundwater elevations 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. 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.

Sandbar Erosion and Deposition

The formation of sandbars is common in rivers with high sediment loads such as the Missouri River. Sandbars form within the river channel as well as in the delta of the river flowing into the reservoirs. Sandbars are highly dynamic. Their formation and changes over time are affected by variables such as channel width, streamflow, sediment load in the river, grain size, vegetation, and man-made infrastructure. In the managed system of the Missouri River, sandbars form and change both naturally and as a result of deliberate management actions as discussed in various sections within Chapter 2 (see also Fischenich et al. 2014).

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.

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.

Although ice-induced flooding can occur anywhere along the Missouri River, ice dynamics is of heightened concern for the Bismarck-Mandan area in North Dakota. At the beginning of winter when ice cover is forming, river stage usually rises several feet in a short period of time. During the ice-out period, there is a high risk of ice jams and river stages can fluctuate drastically with little to no warning. Typically, USACE would temporarily reduce releases from Garrison Dam to prevent ice-induced flooding during freeze-in and ice-out periods as conditions permit.

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, Introduction. The impacts of releases under the various action alternatives in the river and reservoirs were analyzed using the statistical 90th, 50th, and 10th percentiles of the 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 Alternative 1):

- 1963: March and May spawning cue releases and low summer flow under Alternative 2.
- 1963: No spawning cue releases under Alternative 3.
- 1963: Spring release simulated under Alternative 4.
- 1966 and 1967: Fall release simulated for 1966 under Alternative 5. Although no release would have occurred under this alternative in 1967, this year was also analyzed to demonstrate the residual impact on the hydrology from the releases that occurred late in 1974.
- 1963: Releases under Alternative 6.

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

[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.

allows for an assessment of impacts to resources and uses, which are driven by water surface elevations.

The assessment of the hydrology described above reflects conditions that are based on the current storage volume in the six reservoirs along the upper Missouri River and the current geometry of the Missouri River riverbed (referred to as “year 0” conditions). Over time, these two variables will continue to change as follows: Continued sediment supply over time will gradually reduce the storage volume in the reservoirs of the upper Missouri River, and continue to cause aggradation in the reservoir headwaters and delta areas. Sediment captured by the reservoirs will not be available to replenish sediment eroded downstream of the dams, resulting in continued degradation of the riverbed in respective downstream reaches. In addition, sand and aggregate mining in the lower Missouri River is expected to further contribute to degradation of the riverbed.

Therefore, HEC-RAS modeling was also conducted for the 15-year implementation timeframe to integrate ongoing sediment transport characteristics into the alternatives analysis (referred to as “year 15” conditions). The primary characteristics considered were sediment accumulation in the reservoirs, aggradation upstream of reservoirs, degradation downstream of dams, the ongoing effects on the BSNP structures, and sand and aggregate mining affecting the riverbed elevations in the lower Missouri River. The understanding of the effect of these characteristics over time was integrated in the analysis of potential management actions for listed species under the six alternatives in the various resource sections.

Geomorphology

The primary geomorphological processes 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 USACE (2014c). 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 Alternative 1 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 Alternative 1. 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.

System Operation during Implementation of Alternatives

Small changes in reservoir levels and reservoir releases are ordinarily insignificant. In addition, the alternatives follow normal reservoir operating guidance as stated in the Missouri River Master Manual (USACE 2006a) when not operating for the special conditions such as an ESH creation release. The normal operating guidance contains measures to reduce impacts while the System is operating within the flood control pool zones or operating for drought conservation. Refer to the HEC-ResSim Modeling Report (available at www.moriverrecovery.org) which describes the development of the model in detail including scripting rules and calibration for additional details.

Datums Employed

All HEC-ResSim models are constructed using the NGVD 29 datum. Use of the 1929 vertical datum was used for consistency with reported reservoir elevations within the Master Manual and operating decisions. All HEC-RAS models are constructed based on the NAVD 88 vertical datum to match current practice along the Missouri River for reporting river flow elevation. Use of two vertical datums within the study area was necessitated for presentation of results in a meaningful manner to the various stakeholder groups. Human consideration evaluations (Sections 3.5 to 3.23) were performed in the appropriate datum for each individual resource. The conversion between NGVD 29 to NAVD 88 varies by geographic location. The variable elevation difference between the two datums is provided in Table 3-3.

Table 3-3. Conversion of Datums for Dams Discussed in EIS

Minimum and Maximum Operating Pool Elevations in Reservoirs		
Location	**NGVD 29**	**Conversion from NGVD 29 to NAVD 88 (ft)**
Fort Peck Lake	2,160 to 2,250	+2.07
Lake Sakakawea	1,775 to 1,854	+1.31
Lake Oahe	1,540 to 1,620	+1.23
Lake Sharpe	1,415 to 1,423	+1.07
Lake Francis Case	1,320 to 1,375	+0.98
Lewis and Clarke Lake	1,204.5 to 1,210	+0.67
USGS Gages along the Missouri River		
Location	**Conversion from NAVD 88 to NGVD 29 (ft)**	**NAVD 88**
Williston, North Dakota	-1.64	1,831.8
Bismarck, North Dakota	-1.34	1,619.6
Sioux City, Iowa	-0.55	1,060.00
Omaha, Nebraska	-0.39	948.97

Nebraska City, Nebraska	-0.35	905.61
Kansas City, Missouri	-0.28	706.68
St. Louis, Missouri	-0.05	379.58

3.2.2.2 Summary of Environmental Consequences

Table 3-4 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 Alternative 1.

However, impacts could be large locally and would be dependent on variables such as the site-specific channel configuration at the time of flow releases and other hydraulic features. Examples of local impacts could be damage of individual riverine infrastructure components, shoreline erosion, or aggradation. Local impacts are not expected to have longer-term or larger-scale residual impacts on the effective implementation of management actions.

Table 3-4. Environmental Consequences for 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	Hydrologic conditions include the wide range of natural flows and System operations by 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) and sand and aggregate mining in the lower river downstream of Rulo, Nebraska. 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. Small increase in average elevations of upper three reservoirs (1–2 feet over 15 years) because of sediment deposition. Changing flows would affect river infrastructure and groundwater levels. Small to negligible impacts to hydrologic conditions from habitat construction because of the localized nature of construction projects.
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 negligible impacts to hydrologic conditions from construction of early life stage habitat for pallid sturgeon because of the localized nature of construction projects. Small to potentially large impacts from ESH construction (upper river).

Alternative	Impacts on River Infrastructure and Hydrologic Processes*
Alternative 3	Negligible to no impacts on the overall hydrology and geomorphology in the river compared to Alternative 1 because absence of the existing spawning cue would have negligible changes to river flow and reservoir elevations. Small to negligible impacts to hydrologic conditions from habitat construction because of the localized nature of construction projects.
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 to hydrologic conditions from habitat construction because of the localized nature of construction projects.
Alternative 5	Same impacts as described under Alternative 4, except that the flow release for ESH creation occurs during the fall instead of the spring. Small to negligible impacts to hydrologic conditions from habitat construction because of the localized nature of construction projects.
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. Small to negligible impacts to hydrologic conditions from habitat construction because of the localized nature of construction projects.

* Impacts listed for action Alternatives 2–6 are compared to Alternative 1.

3.2.2.3 Impacts on Hydrology from the Alternatives

The frequencies of when full and partial releases would occur under the various alternatives based on the POR are listed in Table 3-5 for year 0 and in Table 3-6 for year 15. (It is noted that partial implementation for Alternatives 1, 2, and 6 defined in the following summary are years when a partial cue in March and/or May would occur OR years when a full cue in March or May would occur.)

- **Year 0**: Under Alternative 1, the spawning cue release would be fully implemented (in March and May) in 11 years and partially implemented in 22 years. Under Alternative 2, the spawning cue release would be fully implemented (in March and May) in 3 years and partially implemented in 31 years. Under Alternative 4, the spring release would be fully implemented in 9 years and partially implemented in 7 years. Under Alternative 5, the fall release would be fully implemented in 7 years and partially implemented in 2 years. Under Alternative 6, the spawning cue release would be fully implemented (in March and May) in 6 years and partially implemented in in 29 years.

  Expressed in terms of percentage of occurrence for full releases, spawning cue releases with both full March and May pulses would occur 13 percent, 4 percent, and 7 percent of the time under Alternatives 1, 2, and 6, respectively. Deliberate full spring flow releases under Alternative 4 would occur 11 percent of the time, while deliberate full fall flow releases under Alternative 5 would occur 9 percent of the time. Full flow release levels under Alternatives 4 and 5 would be achieved “naturally” during normal project operations in 7 years (8 percent of the time) during spring and fall, based on the POR.

- **Year 15**: Under Alternative 1, the spawning cue release would be fully implemented (in March and May) in 13 years and partially implemented in 21 years. Under Alternative 2, the spawning cue release would be fully implemented (in March and May) in 4 years and partially implemented in 32 years. Under Alternative 4, the spring release would be fully implemented in 9 years and partially implemented in 8 years. Under Alternative 5, the fall release would be fully implemented in 6 years and partially implemented in 1 year. Under Alternative 6, the spawning cue release would be fully implemented (in March and May) in 5 years and partially implemented in in 31 years.

  Expressed in terms of percentage of occurrence for full releases, spawning cue releases with both full March and May pulses would occur 16 percent, 5 percent, and 6 percent of the time under Alternatives 1, 2, and 6, respectively. Deliberate full spring flow releases under Alternative 4 would occur 11 percent of the time, while deliberate full fall flow releases under Alternative 5 would occur 7 percent of the time. Full flow release levels under Alternatives 4 and 5 would be achieved "naturally" during normal project operations in 6 and 8 years, respectively (7 and 10 percent of the time) during spring and fall, based on the POR.

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, Figures D-12 to D-19. Additional graphics comparing year 0 and year 15 for flows at Gavins Point Dam, elevations at the three main reservoirs, and stages in the Missouri River, and Mississippi River downstream of the confluence, are presented in Figures D-20 to D-30 in Appendix D.

Table 3-5. Summary of Releases Simulated for Six Alternatives over Period of Record, Year 0

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
Alternative 1	March	55	8	19	23
	May	56	10	16	20
	Both months [d]	49	22	**11**	**13**
Alternative 2	March	68	10	4	5
	May	54	7	21	26
	Both months [d]	48	31	**3**	**4**
Alternative 3		Not applicable, no flow management action included			
Alternative 4		66	7	**9** [e]	**11**
Alternative 5		73	2	**7** [e]	**9**
Alternative 6	March	47	16	19	23
	May	69	5	8	10
	Both months [d]	41	29	**6**	**7**

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.

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

d For Alternatives 1, 2, and 6, partial completion for "Both months" may consist of (1) partial completion during one or two months, (2) full completion during one month only, or (3) partial completion during one month and full completion during the other month.

e Shown values for spring (Alternative 4) and fall (Alternative 5) are deliberate releases. These values do not include 7 events for each of these two alternatives when targeted flow release levels would have been achieved "naturally" during normal operations.

Table 3-6. Summary of Releases Simulated for Six Alternatives over Period of Record, Year 15

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
Alternative 1	March	54	8	20	24
	May	54	10	18	22
	Both months [d]	48	21	**13**	**16**
Alternative 2	March	68	9	5	6
	May	52	9	21	26
	Both months [d]	46	32	**4**	**5**
Alternative 3		Not applicable, no flow management action included			
Alternative 4		65	8	**9** [e]	**11**
Alternative 5		75	1	**6** [e]	**7**
Alternative 6	March	46	15	21	26
	May	69	7	6	7
	Both months [d]	46	31	**5**	**6**

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.

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

d For Alternatives 1, 2, and 6, partial completion for "Both months" may consist of (1) partial completion during one or two months, (2) full completion during one month only, or (3) partial completion during one month and full completion during the other month.

e Shown values for spring (Alternative 4) and fall (Alternative 5) are deliberate releases. These values do not include 6 events for Alternative 4 and 8 events for Alternative 5 when targeted flow release levels would have been achieved "naturally" during normal operations.

Hydrology in Reservoirs in Upper River in Year 0: The water surface elevations for the upper four reservoirs for the wet, average, and dry period conditions (90th, 50th, and 10th percentiles) based on the POR are shown in Figures D-2 to 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 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 wet, average, and dry period conditions (90th, 50th, and 10th percentiles) and for individual years. During some of the simulated years, deviations for action alternatives with larger releases (Alternatives 2, 4, 5 and 6) could vary by up to 6 feet from Alternative 1.
- **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 the action alternatives with higher flows (Alternatives 2, 4, 5, and 6) would be up to 3 feet lower throughout the year than Alternative 1. On a year-by-year comparison, elevations under Alternatives 2, 4, and 5 would occasionally be up to 10 feet lower than under Alternative 1. In addition, low summer flows under Alternative 2 could in some years result in reservoir elevations that are up to 10 feet higher than elevations under Alternative 1.

- **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 (10th percentile), elevations under Alternatives 4 and 6 would be up to 4 and 6 feet (respectively) lower than under Alternative 1 throughout the year. On a year-by-year comparison, elevations under Alternatives 2, 4, and 6 would occasionally be up to 10 feet lower than under Alternative 1. Such single-year differences could last several years while the upper reservoirs in the System are refilling. In addition, low summer flows under Alternative 2 could in some years result in reservoir elevations that are up to 6 feet higher than elevations under Alternative 1.
- **Lake Sharpe, Lake Francis Case, Lewis and Clark Lake**: Elevations during wet, average, and dry period conditions (90th, 50th and 10th percentiles) under the action alternatives would vary little in these three reservoirs compared to Alternative 1 (e.g., Lake Francis Lake, see Figure D-5 in Appendix D). 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 in Year 0: 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 (less than 2 feet) in stage would occur, particularly under Alternative 2.
- **Garrison Dam to Lake Oahe**: Alternatives 2, 4, 5, and 6 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 feet higher than during wet period conditions for the other alternatives. In addition, low summer flows under Alternative 2 would result in a 1-foot lower stage in Bismarck under wet period conditions (90th percentile).

  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 170,000 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. The action alternatives 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.

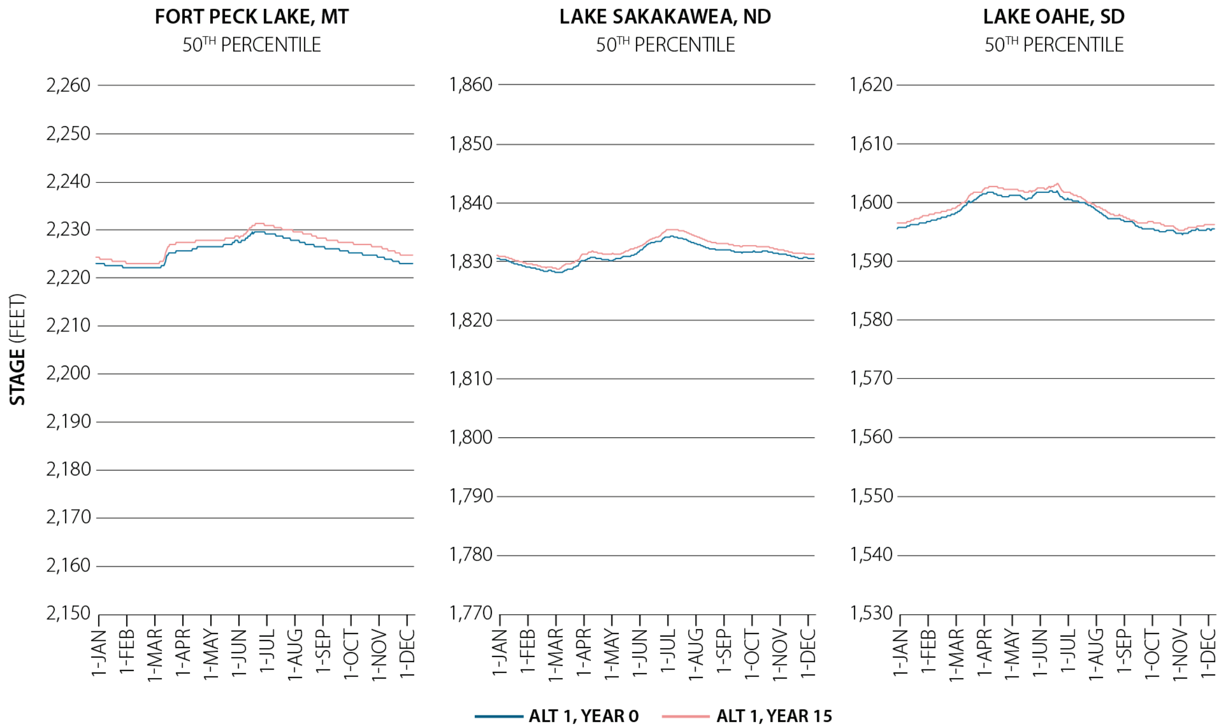
- **Oahe Dam to Lake Sharpe**: The hydrology in this reach would be relatively stable because of the short distance of open water and the fairly stable elevation maintained in Lake Sharpe.
- **Fort Randall Dam to Lewis and Clark Lake**: The action alternatives would have small, long-term impacts on the stage in the Missouri River because of changes in flows at Fort Randall Dam as a result of flow releases for Alternatives 4, 5 and 6. 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 in Year 0: 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 continue broadening 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 and would be consistent with the effects on flow.

Hydrology in the Reservoirs and the Missouri River in Year 15: Reservoir inflows in year 15 would be the same as in year 0 and it is assumed that USACE would continue to operate the System in a manner that meets the requirements specified in the Master Manual. For the HEC-ResSim simulation, storage within each reservoir was reduced to assess storage loss from sediment accumulating over 15 years. The reduction in System storage in year 15 would cause the following changes: If flow releases occurred under action alternatives just prior to drought years, these releases could require reductions in subsequent flow releases at Gavins Point Dam to rebuild the volume of water stored in the reservoirs. For example, this condition would have occurred during the long drought in the 1930s, if flow releases had occurred during the years immediately prior to the drought.

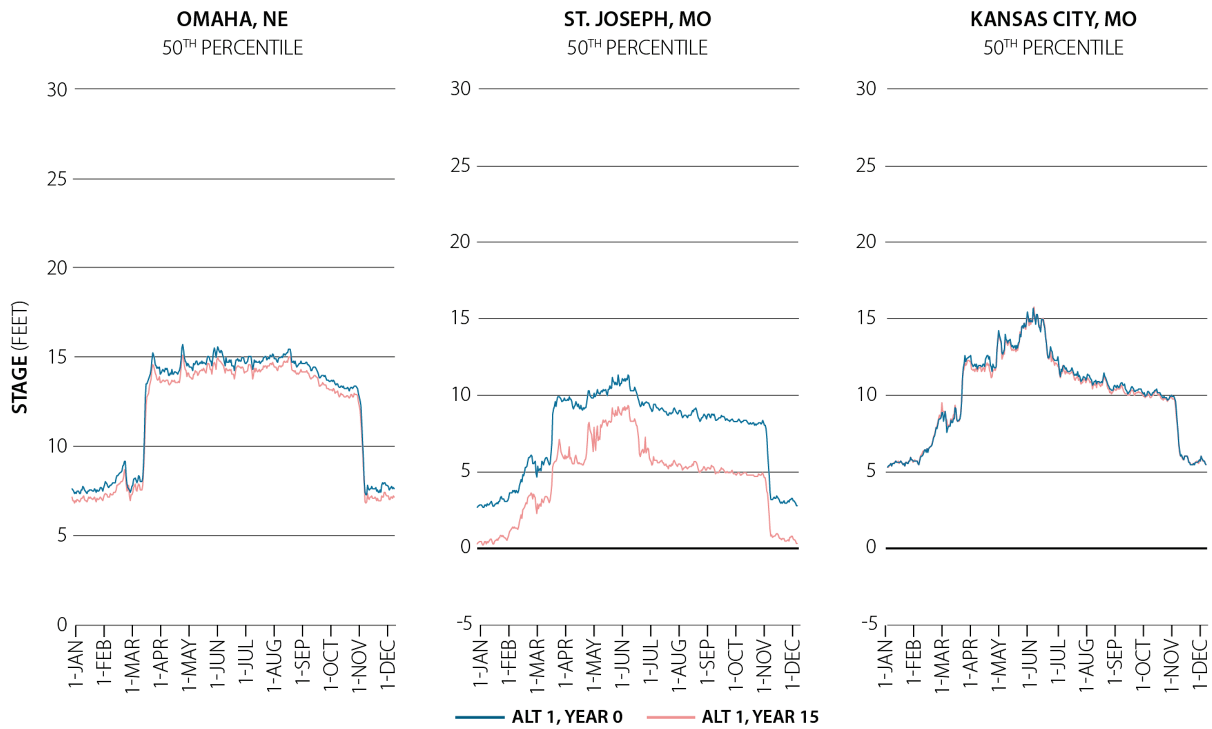
However, while flows would typically remain similar, elevations in the reservoirs and stages in the river would change slightly in year 15 as follows (see Figures D-21 to D-30 in Appendix D):

- Elevations in the upper three reservoirs (Fort Peck Lake, Lake Sakakawea, Lake Oahe) would increase slightly (mean of 1 to 2 feet) in year 15 under all alternatives (Figure 3-9).
- Changes in elevations in the lower three reservoirs (Lake Sharpe, Lake Francis Case, Lewis and Clark Lake) would be negligible.
- The stages in Bismarck, North Dakota, would be slightly lower (mean of approximately 4 inches) under the six alternatives due to minor degradation.
- In the upper portion of the lower Missouri River, continued degradation of the riverbed due to sediment captured by the reservoirs would lower the stages slightly in year 15 compared to year 0, such as in Sioux City, Iowa, and Omaha, Nebraska (Figure 3-10). The mean decrease at these two locations in year 15 as compared to year 0 would be approximately 0.5 foot.
- The residual degradation effect of sediment captured by the reservoirs combines with degradation from sand and aggregate mining in the lower reach of the lower Missouri River (downstream of Rulo, Nebraska). HEC-RAS modeling projected a decrease in the mean stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15 (Figure 3-10). In Kansas City, the projected stage in year 15 would only be slightly lower (less than one inch of the mean stage).
- At Hermann, Missouri, the mean stage in year 15 would be lower by approximately 0.5 foot for the six alternatives.
- There would be no change in the mean stage between year 0 and year 15 for the six alternatives in the Mississippi River downstream of its confluence with the Missouri River. The 5th and 95th percentiles would vary by less than 2 inches in year 15 as compared to year 0 for all six alternatives.



Note: The difference in elevations between years 0 and 15 throughout the year is very similar for the five action alternatives.

Figure 3-9. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternative 1 in Years 0 and 15 for the 50th Percentile over the Period of Record



Note: The difference in stages between years 0 and 15 throughout the year is very similar for the five action alternatives.

Figure 3-10. Stages of Missouri River at Omaha, Nebraska, St. Joseph, Missouri, and Kansas City under Alternative 1 in Years 0 and 15 for the 50th Percentile over the Period of Record

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 13 percent of the time in year 0 (i.e., on average every eighth year; Table 3-5) and 16 percent of the time in year 15 (i.e., on average every sixth year; Table 3-6); 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.

Because of the localized nature of mechanical construction of ESH and early life stage habitat for pallid sturgeon, this alternative would have negligible to no impacts on the overall hydrology in the river. The construction of ESH in the upper river and early life stage habitat for pallid sturgeon projects in the lower river would continue to be conducted in a manner that would maintain hydrologic conditions and minimize or avoid adverse effects to 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 therefore result in negligible impacts on elevations in the reservoirs and stage in flow in the river. Habitat construction could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects. Impacts to hydrology are not anticipated to be significant under Alternative 1. Future aggradation and degradation conditions are projected to cause a slight increase in the spring pulse.

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 flow conditions of the POR, this would occur 4 percent of the time (i.e., on average every 25 years), in year 0 and 5 percent of the time in year 15 (Table 3-5 and Table 3-6). For example, rules for Alternative 2 would allow for these releases to be initiated for hydrologic conditions simulated for 1963 (Figure 3-11); 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 Alternative 1, higher flows may continue later in the fall (as would be the case for 1963 hydrological conditions), and in early winter in some years.

Releases in the spring under Alternative 2 would predominantly be carried out by altering releases from Lake Oahe. As a result, elevations in Lake Oahe would decrease in the spring compared to Alternative 1; for example, for 1963 hydrological conditions, the elevations in spring would decrease by up to 3 feet. The reduction in summer flows would affect the elevation in both Lake Sakakawea and Lake Oahe; for 1963 hydrological conditions, elevations in both reservoirs would rise by up to 3 feet (Figure 3-12). These net effects in the two reservoirs would remain unchanged in year 15, although the base elevations in Lake Sakakawea and Lake Oahe under both Alternative 1 and Alternative 2 would be higher by 1–2 feet on average (Figure 3-9).

Downstream from Gavins Point Dam, the May spawning cue release and summer low flow would remain well-defined in Omaha relative to flows under Alternative 1 (Figure 3-11). In this case, the Gavins Point Dam release is distinct from normal flows and the 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 1963, the May spawning cue release and summer low flow would still be distinct from normal flows in Kansas City. In contrast, the small March spawning cue release for hydrologic conditions in 1963 would no longer be distinguishable in Kansas City.

The reduction in flow during the summer could result in missing flow targets. Based on 1963 conditions, Alternative 2 summer low flow in Omaha would be as low as 19,000 cfs in July, below the flow target of 25,000 cfs for minimum service level. Low flows would persist downstream and are distinct from normal flows downstream of Kansas City.

Habitat construction could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects.

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. Elevations in Lake Oahe and/or Lake Sakakawea would 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 would occur 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. Habitat construction could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects. Impacts could be large locally but overall would be small to negligible.

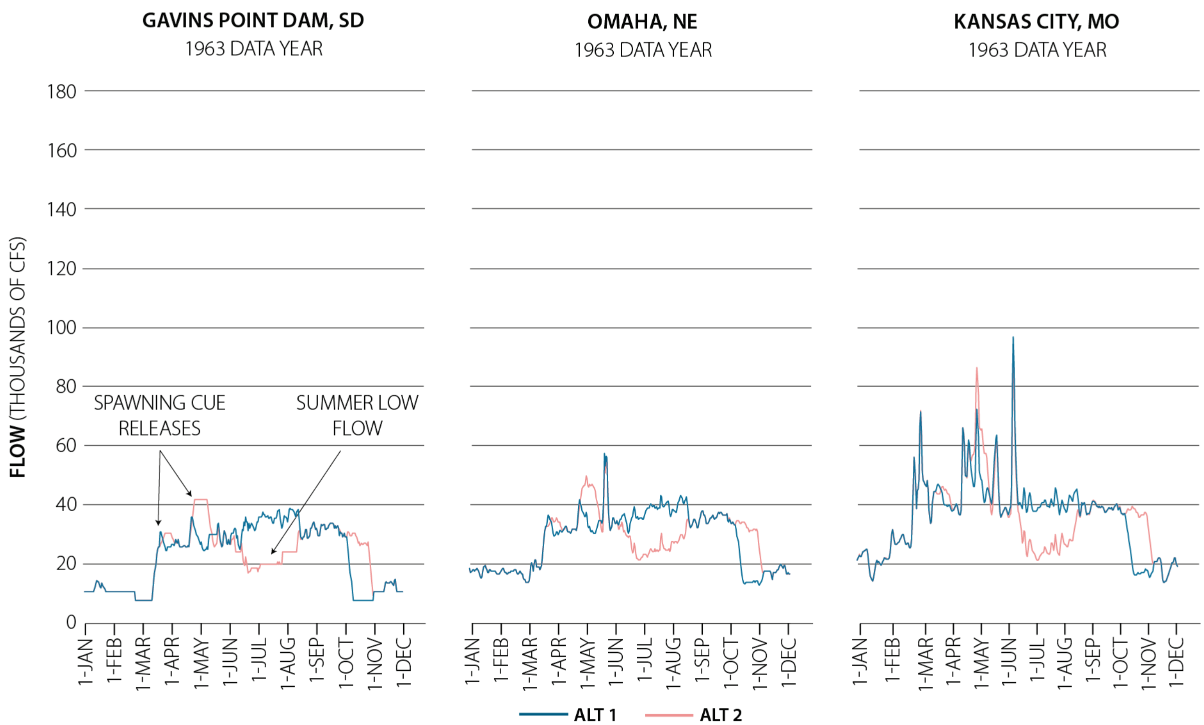


Figure 3-11. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 2 in Year 0, Simulated Based on Hydrologic Conditions in 1963

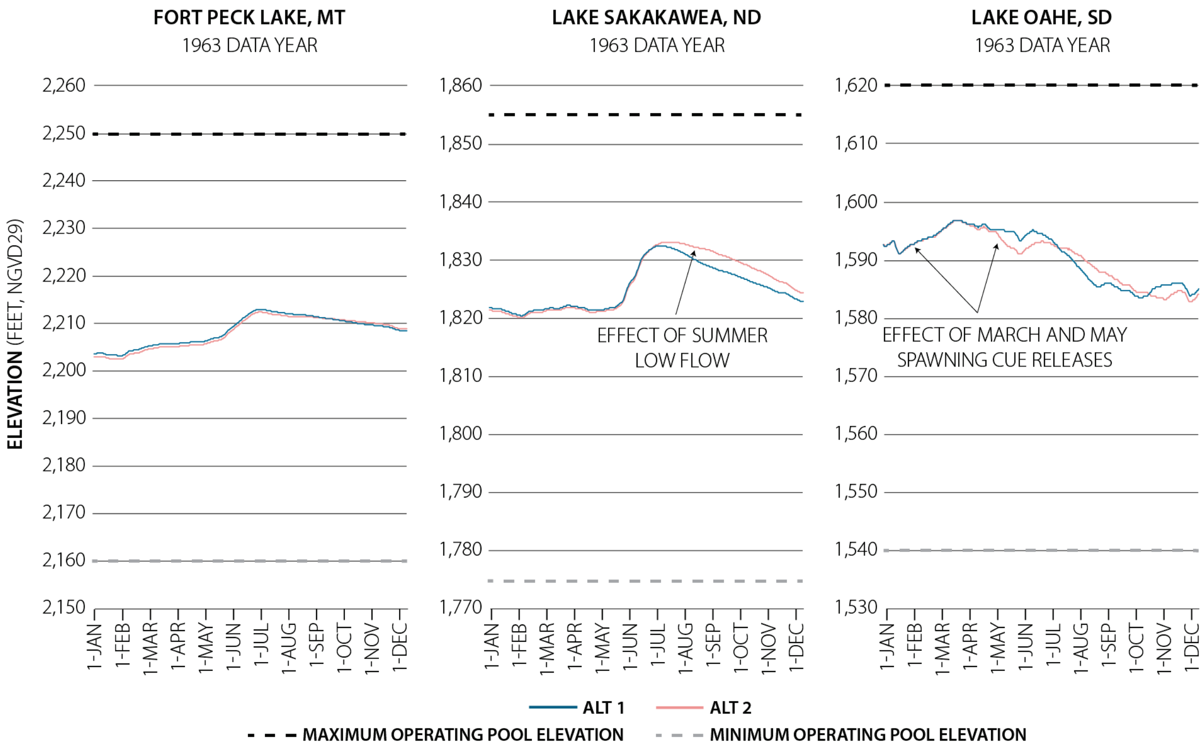


Figure 3-12. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 2 in Year 0, Simulated Based on Hydrologic Conditions in 1963

Alternative 3 – Mechanical Construction Only

Because of the localized nature of mechanical construction of ESH and early life stage habitat for pallid sturgeon, 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 Alternative 1. For example, rules for Alternative 1 would allow for the release of these pulses to be initiated for hydrologic conditions in 1963 (Figure 3-13). As a result, there would typically be no substantial difference in reservoir elevations between Alternatives 1 and 3, but slight differences in May reservoir elevations combined with other reservoir operations could result in minor reservoir elevation changes. On rare occasions, these changes could be up to 3 feet, as shown in Figure 3-14 for hydrological conditions in year 1963. In addition, flows throughout the year would also be similar because the small spawning cue releases under Alternative 1 would be rapidly attenuated downstream of Gavins Point Dam.

Conclusion

Overall, no to negligible long-term 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. Temporary impacts could occur from the one-time spawning cue test release such as localized degradation and aggradation; impacts might be large in some locations but overall would be small to negligible particularly because of its single occurrence. Construction of early life stage habitat for pallid sturgeon could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects.

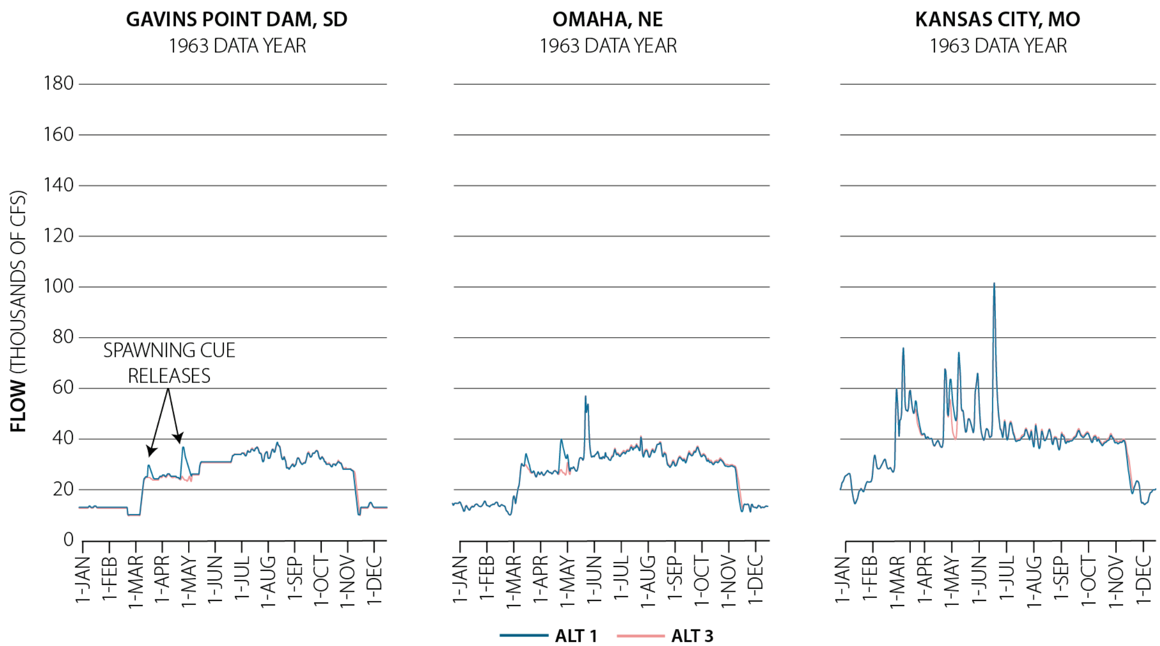


Figure 3-13. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 3 in Year 0, Simulated Based on Hydrologic Conditions in 1963

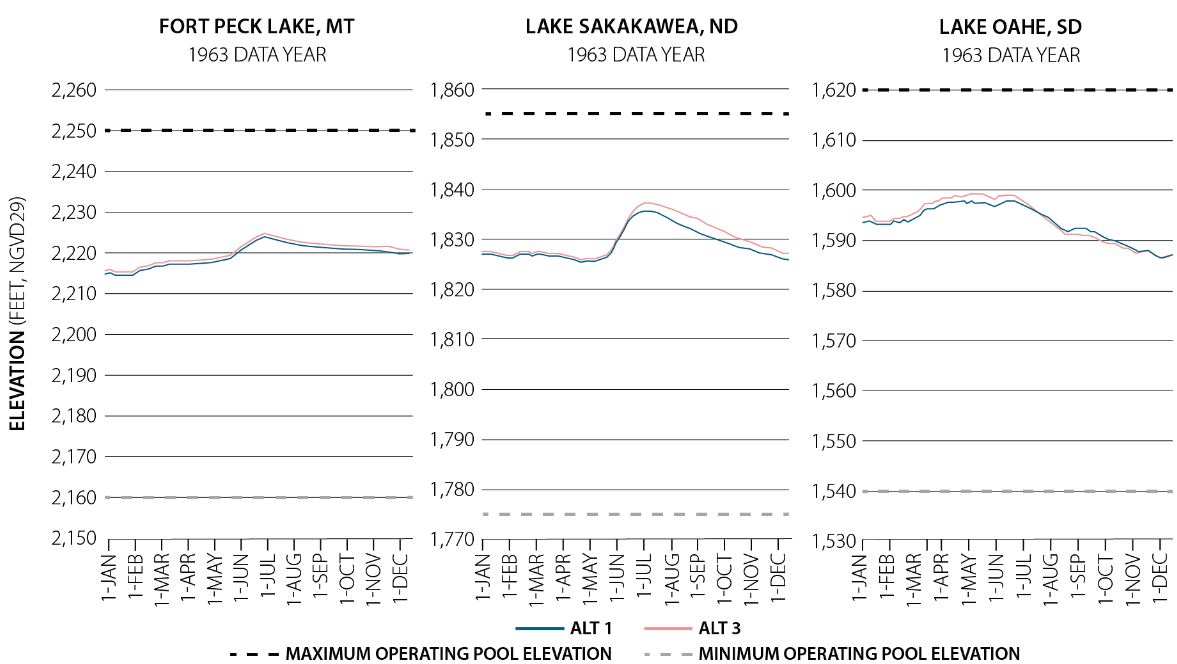


Figure 3-14. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 3 in Year 0, Simulated Based on Hydrologic Conditions in 1963

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. Fall releases (Alternative 5) are further constrained by winter reservoir operations that begin on December 1. Typical Gavins Point Dam releases during winter operations range from 12,000 to 17,000 cfs; starting the fall releases on October 15 provides enough time to complete a 60,000 cfs release for 35 days and have releases reduced to typical winter releases on or near December 1. If a lower magnitude ESH release requiring a longer duration is conducted, Gavins Point Dam releases would still be reduced to typical winter releases on or near December 1 and the ESH release would not reach its full duration. 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. ESH releases would occur at Garrison and Gavins Point Dams. After the ESH release, typical operations would resume. In the EIS simulations, such releases occurred and ran for a full duration 10 times during the spring and 7 times during the fall over the POR.

For Alternative 4, hydrologic conditions in the watershed would be suitable for complete spring releases 11 percent of the time (i.e., on average every ninth year) in both year 0 and year 15 (Table 3-5 and Table 3-6). Rules for Alternative 4 would allow for these releases to be initiated for hydrologic conditions in 1963; 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 service flows ending a week earlier in the fall (November) than under Alternative 1 (Figure 3-15). Flow reductions would have lasted through 1965 before flows again would become similar to flows under Alternative 1. The spring release under Alternative 4 for hydrologic conditions in 1963 would decrease the elevations of Lakes Sakakawea and Oahe by several feet, with a maximum of 10 feet (Figure 3-16), lasting through 1965. The length of the storage recovery in the reservoirs and the extent of flow reductions downstream of Gavins Point Dam following a spring release would vary and would depend on natural hydrologic conditions in the year(s) after the release.

Downstream from Gavins Point Dam, the spring release would remain well-defined during May at Omaha relative to flows under Alternative 1 (Figure 3-15). With increasing distance downstream of Gavins Point Dam, spring releases would be increasingly attenuated. The degree of attenuation would depend on spring runoff flows from tributaries, such as the Platte River (RM 595). For the hydrological conditions in 1963, the spring peak would be still fairly well defined at Kansas City (Figure 3-15) but would become more attenuated by the time it reached Hermann, Missouri.

For Alternative 5, hydrologic conditions in the watershed would be suitable for complete fall releases 9 percent of the time in year 0 (i.e., on average every 11 years; Table 3-5) and 7 percent of the time in year 15 (i.e., on average every 14 years; Table 3-6). Rules for Alternative 5 would, for example, allow for these releases to be initiated for hydrologic conditions in 1966. The fall flow release at Gavins Point Dam under Alternative 5 would have been 60,000 cfs (Figure 3-17). Flow reductions would have lasted through 1967 (Figure 3-18) and part of 1968, before flows would again become similar to flows under Alternative 1.

The fall release for hydrological conditions in 1966 would decrease the elevations of Lake Sakakawea by several feet, with a maximum of 7 feet, lasting through 1967 and part of 1968 (Figure 3-19 and Figure 3-20). As for the spring release (Alternative 4), the length of the storage recovery in the reservoirs and the extent of flow reductions downstream of Gavins Point Dam following a fall release (Alternative 5) would vary for different years.

Downstream from Gavins Point Dam, the fall release would be attenuated less than the spring release because of lower natural flows in the river. The 1966 fall release flow would be well defined both at Omaha, Nebraska, and at Kansas City, Missouri, relative to flows under Alternative 1 (Figure 3-17).

Habitat construction could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects.

Conclusion

Overall, small, temporary, and long-term impacts would occur to the river system as a result of ESH creation releases, including changes in reservoir elevations in the upper three reservoirs compared to Alternative 1. Impacts could be large locally, because of site-specific conditions, 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. Habitat construction could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects.

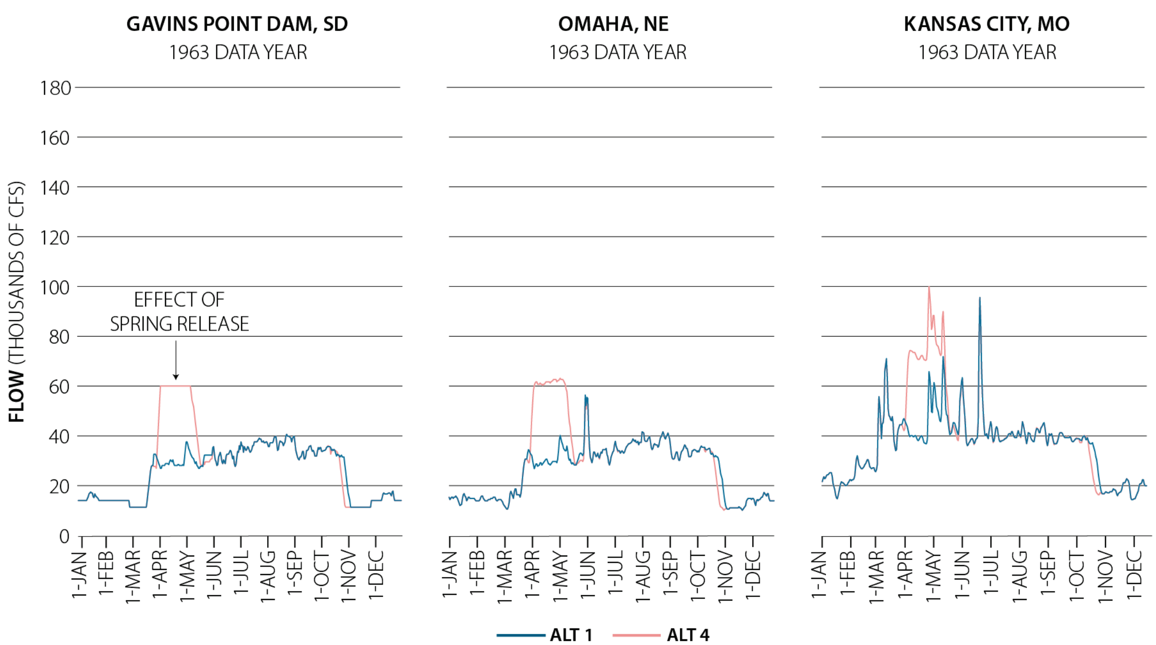


Figure 3-15. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 4 in Year 0, Simulated Based on Hydrologic Conditions in 1963

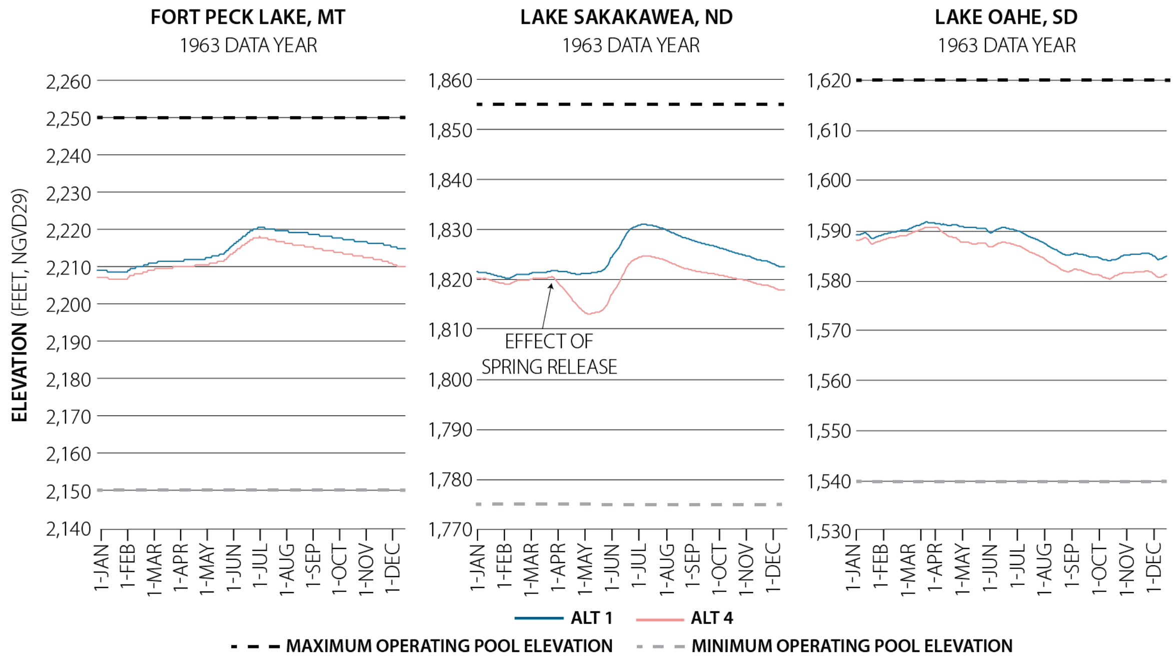


Figure 3-16. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 4 in Year 0, Simulated Based on Hydrologic Conditions in 1963

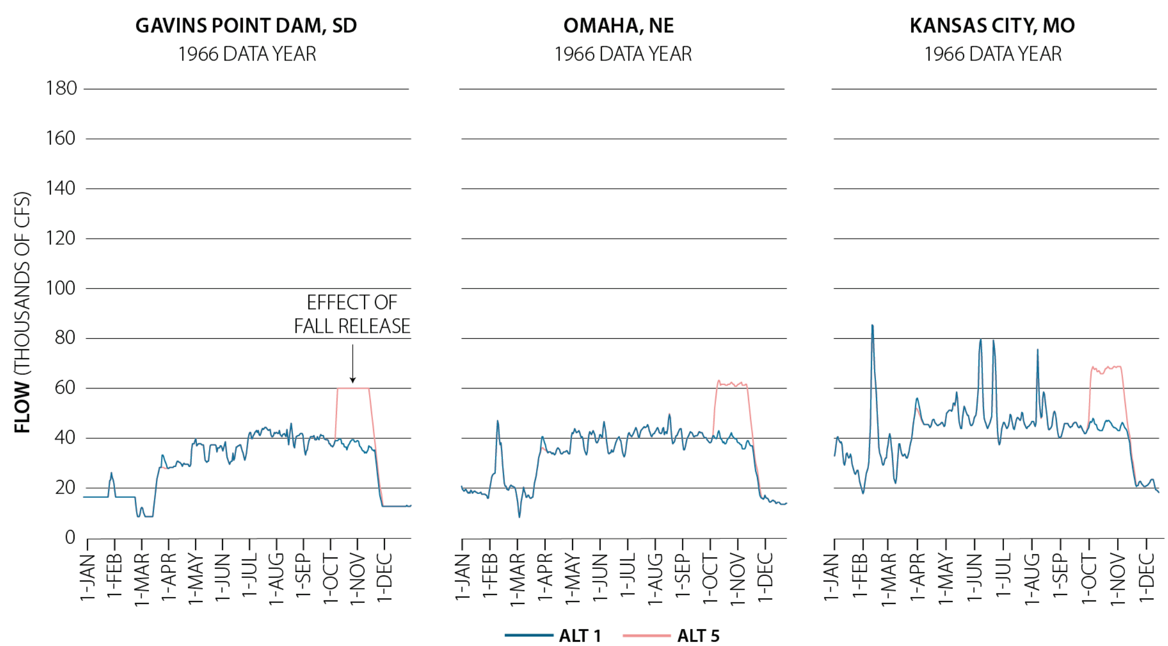


Figure 3-17. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 5 in Year 0, Simulated Based on Hydrologic Conditions in 1966

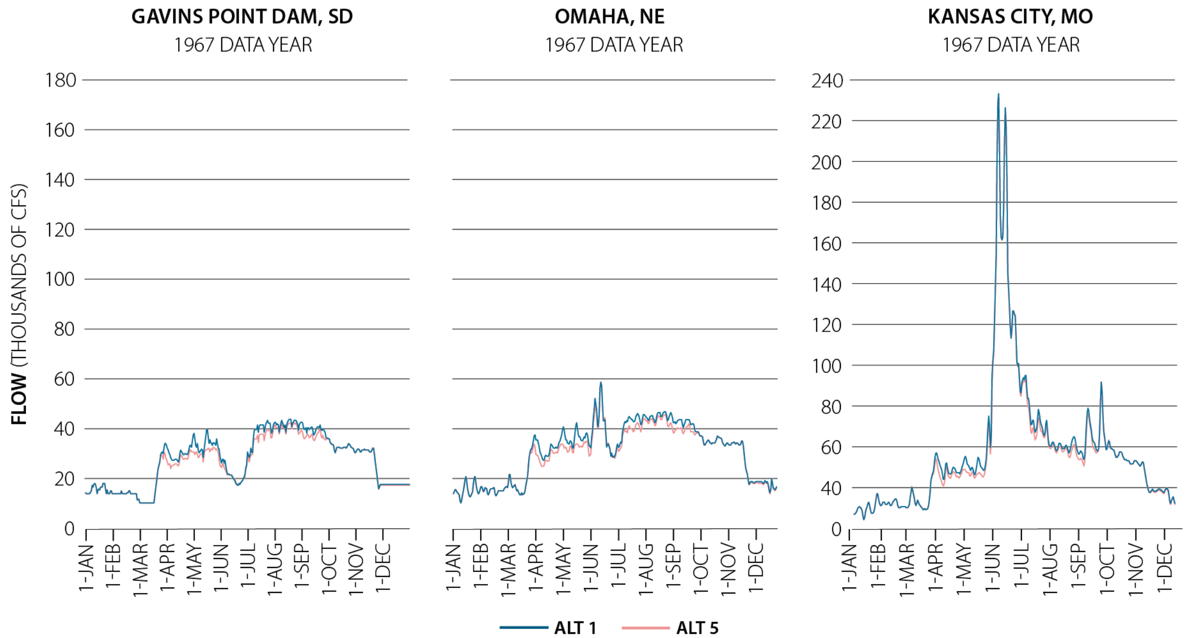


Figure 3-18. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 5 in Year 0, Simulated Based on Hydrologic Conditions in 1967

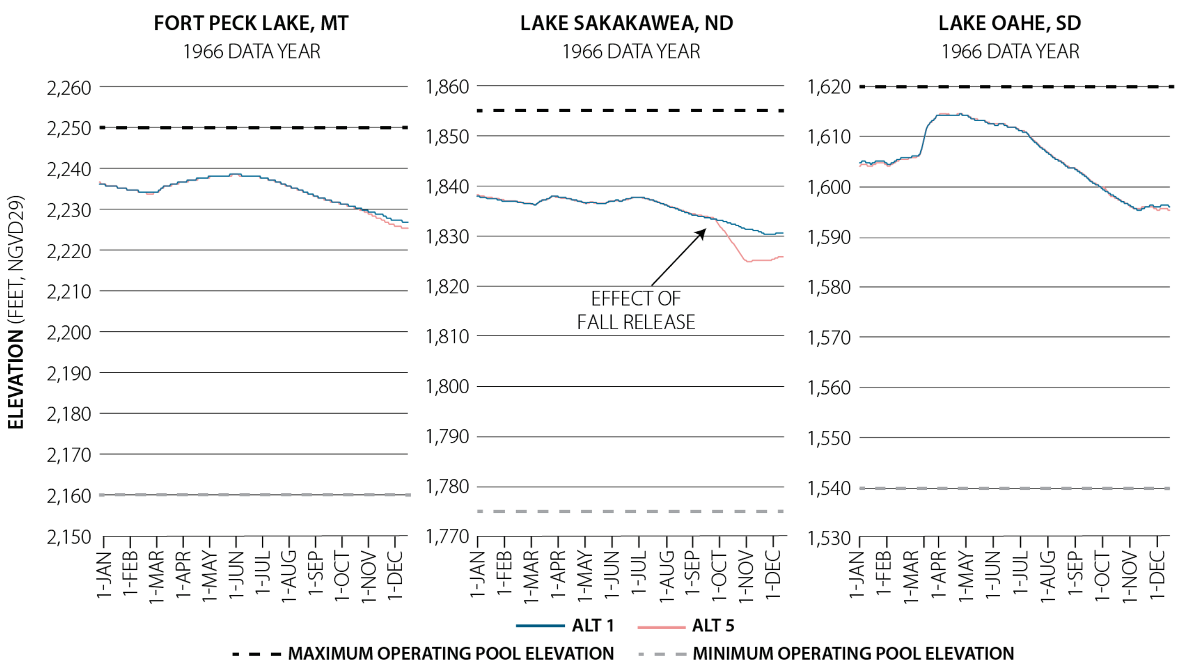


Figure 3-19. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 5 in Year 0, Simulated Based on Hydrologic Conditions in 1966

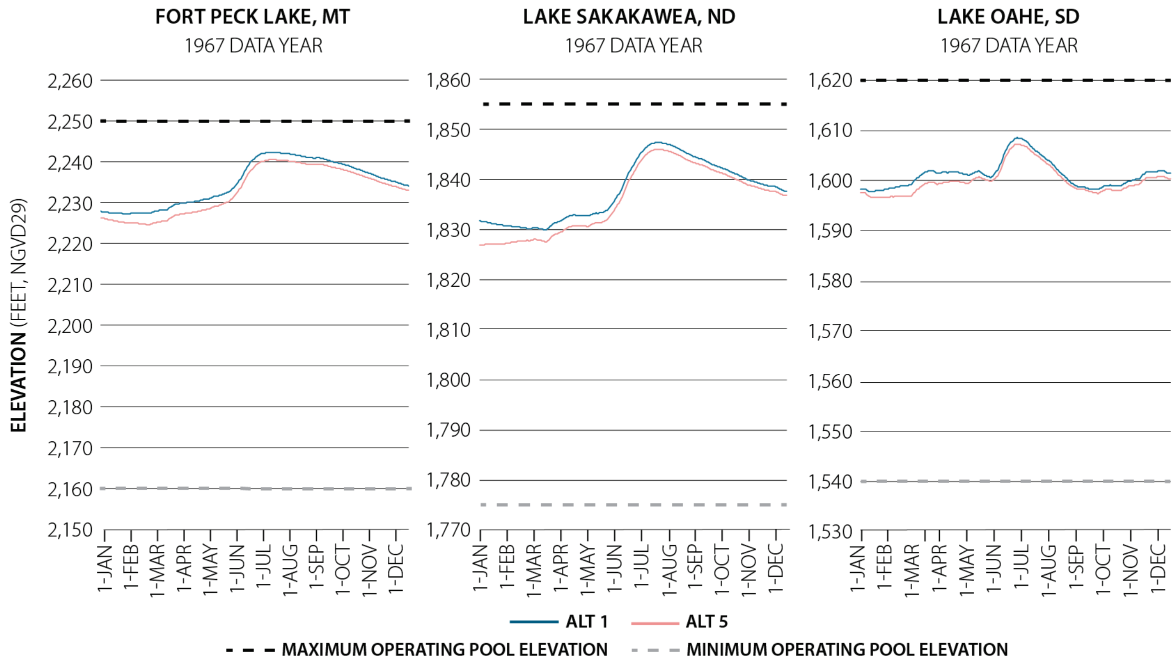


Figure 3-20. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 5 in Year 0, Simulated Based on Hydrologic Conditions in 1967

Alternative 6 – Pallid Sturgeon Spawning Cue

For Alternative 6, hydrologic conditions in the watershed would be suitable for complete spring releases 7 percent of the time (i.e., on average every 14 years) in year 0 (Table 3-5) and 6 percent of the time (i.e., on average every 17 years) in year 15 (Table 3-6). Rules for Alternative 6 would, for example, allow for March and May spawning cue releases to be initiated for hydrologic conditions in 1963; the modeling results for this year are discussed to provide a sense of the effects from these releases. The 2-day peaks would have occurred at Gavins Point Dam at the beginning of April and the beginning of June (Figure 3-21). To compensate for the released water, the flow during the fall of 1963 and the following year 1964 would have been one and two weeks earlier, respectively, from service level flows. Water for the 1963 spawning cue releases would have been drawn from Lake Oahe. Compared to Alternative 1, the elevation of Lake Oahe would have been up to 8 feet lower after the May flow (Figure 3-22). The lake elevation would recover gradually in the remainder of 1963 (Figure 3-22) and in 1964. For hydrologic conditions of other years, recovery of storage after Alternative 6 spawning cue releases could take two years as well.

As for flow releases under Alternatives 2, 4, and 5, the 1963 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 3-21).

Habitat construction could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects.

Conclusion

Overall, small, temporary, and long-term impacts would occur to the river system as a result of spawning cue releases under Alternative 6, including changes in reservoir elevations in the upper three reservoirs compared to Alternative 1. Habitat construction could have small to negligible impacts to hydrologic conditions because of the localized nature of construction projects.

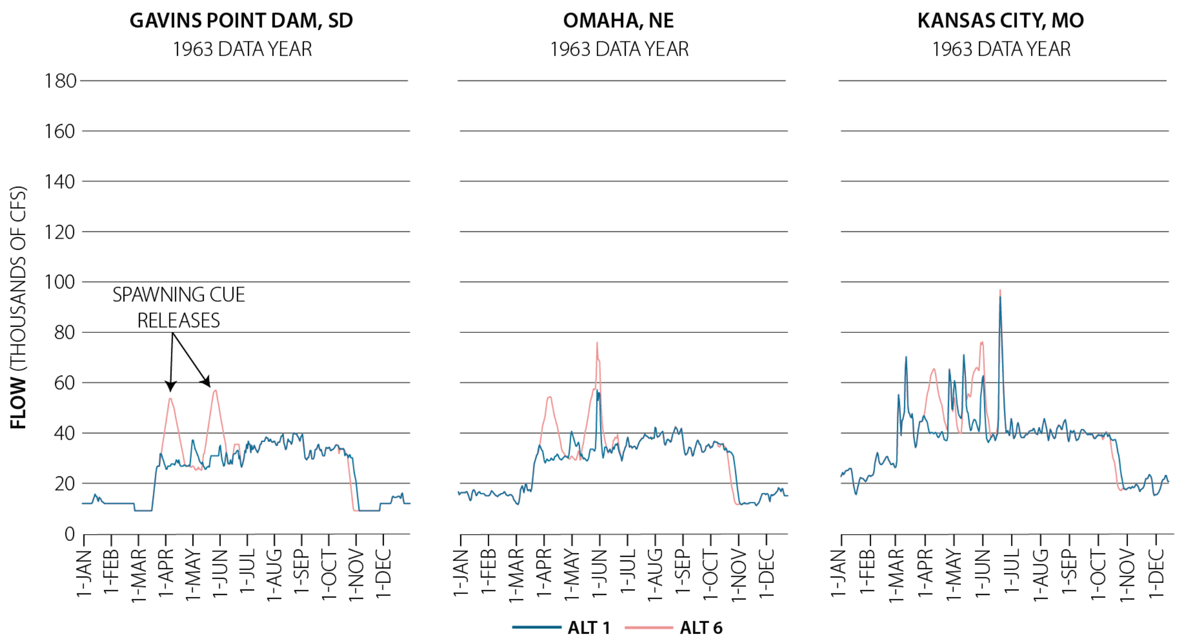


Figure 3-21. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 6 in Year 0, Simulated Based on Hydrologic Conditions in 1963

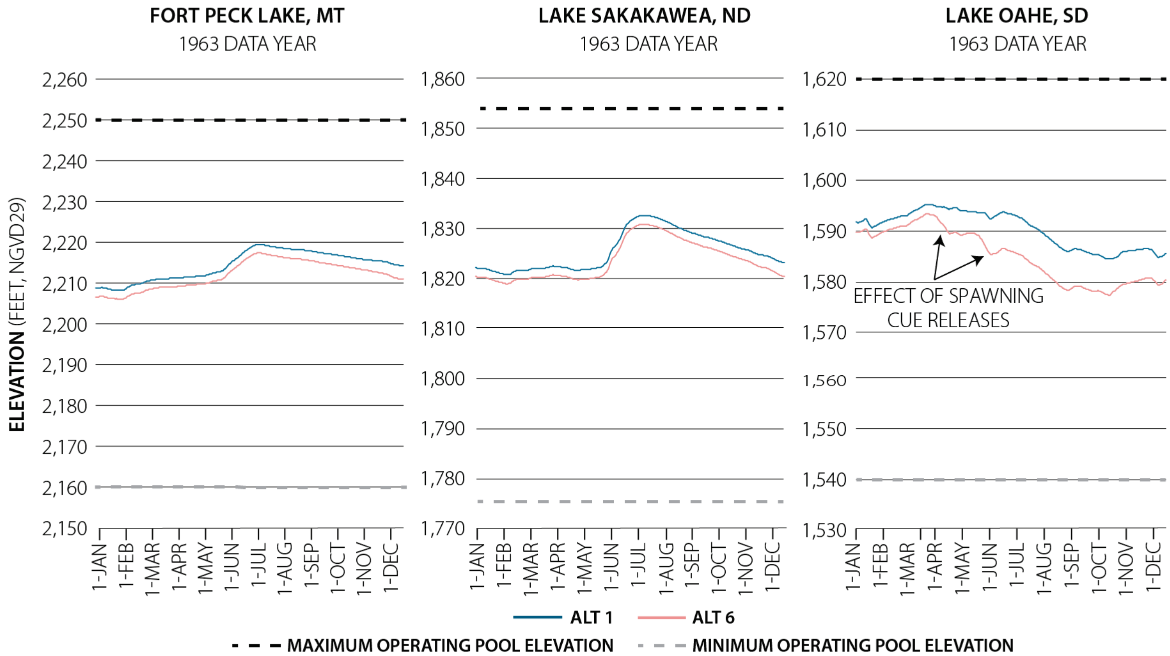


Figure 3-22. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 6 in Year 0, Simulated Based on Hydrologic Conditions in 1963

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 jam formation in the upper river.

Under Alternative 1, existing geomorphological processes and trends would continue, consisting primarily of degradation and bank erosion, reservoir sediment deposition and aggradation, shoreline erosion in reservoirs, and ice dynamics. Continued degradation in the lower Missouri River would be caused by sediment trapped behind dams as well as by continued sand and aggregate mining downstream of Rulo, Nebraska, which lowers the riverbed and the stage of the river over time.

Under Alternative 3, geomorphological processes would be similar to those described under Alternative 1 because 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.

Under all alternatives, ESH construction in the upper river and Gavins Point to Ponca reach would require excavating sediment from the river channel. 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 2011a). A more extensive discussion on ESH construction is presented in Section 3.4, Piping Plover and Least Tern.

Future aggradation and degradation trends have a similar effect on all the alternatives. Modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses (Section 3.2.2.3, Impacts on Hydrology from the Alternatives) and shown in Figure 3-9 and Figure 3-10, the increase in elevation in the reservoirs and the decrease in stage in the river over time relative to Alternative 1 would be nearly the same for all six alternatives. Summary statistics for selected locations along the river for years 0 and 15 are provided in Figures D-20 to D-29 in Appendix D.

Impacts from the primary geomorphological processes are discussed in more detail below. Because flow-related impacts under Alternative 3 are minimal compared to Alternative 1, impacts within individual reaches pertain only to releases under Alternatives 2, 4, 5, and 6.

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 cause temporary and localized degradation and erosion 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 given the comparatively small overall change in hydrological conditions. 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 during the spring and summer of up to 66,500 cfs for 4 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 2012d). 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 on average only every 9 or 11 years, respectively, in year 0 (Table 3-5), and every 9 and 14 years, respectively, in year 15 (Table 3-6), 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 over the long term. Overall, the mean degradation rate at Bismarck, North Dakota, between year 0 and year 15 is projected to be approximately 4 inches for all alternatives.

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. 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 in the vicinity of the constructed ESH.

- **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 adjacent to the river downstream of Fort Randall Dam are less erodible.

  For the recorded high flows in 1996 and 1997 that ranged between approximately 40,000 cfs and 50,000 cfs for 8 months in 1996 and approximately 40,000 cfs and 70,000 cfs for 9 months in 1997 at Fort Randall Dam, 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 2012e). 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. 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 8-month-long (1996) and 9-month-long (1997) high flows in 1996 and 1997, the long-term trend of decreasing river stage at the Yankton gage (RM 806, located 5.3 miles downstream of Gavins Point Dam) was not noticeably affected (USACE 2014d). 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 2014d). 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 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.

  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. 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 2014e). 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.

  Overall, continued degradation from sediment trapped by dams and from sand and aggregate mining would result in lower stages in this reach of the Missouri River under all alternatives (see the year 0 and year 15 analysis in Section 3.2.2.3, Impacts on Hydrology from the Alternatives). Long-term additional 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; elevations would increase over time under all alternatives, as described in the year 0 and year 15 analysis in Section 3.2.2.3, Impacts on Hydrology from the Alternatives. The specific locations for aggradation 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 additional impacts on aggradation in this reach from these action alternatives 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 streambank erosion would occur under Alternatives 2, 6, and particularly 4 and 5, additional aggradation in the downstream stretch of the reach and the delta would be expected. Over the 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, additional erosion in this reach would result in increased aggradation rates and loss of channel capacity in the headwaters of Lewis and Clark Lake. As previously stated, Lewis and Clark Lake has the highest aggradation rate of the six Mainstem dams.

  In addition, different impacts may occur in this reach 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.

  Over the 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. Overall, the elevation in the upper three reservoirs would be expected to increase slightly over time under all alternatives as a result of sediment deposition; the year 15 analysis determined that elevations increase by 1–2 feet from year 0 conditions (see Section 3.2.2.3, Impacts on Hydrology from the Alternatives, including Figure 3-9). 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 Alternative 1. However, the operating ranges of 90 feet (Fort 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 50 feet for Fort Peck Lake and 40 feet for Lake Sakakawea and Lake Oahe (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. While shoreline erosion impacts could be large locally due to factors such as bank material type, prevailing wind direction, and ice dynamics, the action alternatives would not add risk to incur additional impacts above Alternative 1.

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 213 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 Alternative 1. 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 3-4. Continued degradation of the river channel and bank erosion in the reaches below the dams as a result of sand and aggregate mining exceeding the natural rate of recovery would occur under Alternative 1 as well as the five action alternatives. Continued aggradation of the riverbed upstream of reservoirs would occur under all alternatives 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 also continue.

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 and adverse locally.

Small, and temporary impacts would occur from the one-time spawning cue release test 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 and 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.

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 Alternative 1. 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 Alternative 1 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 risk-based 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 Missouri 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 Alternative 1, 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 3-4. 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 Alternative 1, 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 Alternative 1 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 of 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. Over time, they would also be affected by slightly lower stages because of continued degradation from sediment trapped behind dams and from sand and aggregate mining.

Conclusions

Overall, conclusions of impacts to groundwater for each of the alternatives are included in Table 3-4. 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 groundwater would not be significant under any of the alternatives.

3.2.2.7 Climate Change

USACE (2016h) assessed how climate change could potentially change the effects of the alternatives. The "Climate Change Assessment – Missouri River Basin" report is available at www.moriverrecovery.org. Main climate change consequences under the various alternatives are summarized in Table 3-7. 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 jams.
- **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 3.2.2.6, Impacts on Groundwater from the Alternatives; less frequent and shorter flow releases would result in an incremental decrease in impacts.

Table 3-7. Summary of Influence of Climate Change on Alternatives

	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**
Alternative 1	During the summer, water supply operations could have water quality issues with lower Gavins Point releases if water temperatures increase.	May be able to run releases more often because of increased System storage. However, the frequency of a completed release would likely decrease because flood targets would 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.
Alternative 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
Alternative 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 the 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

	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**
Alternative 4	During summer, water supply operations could potentially have water quality issues with lower Gavins Point releases if water temperatures increase.	May be able to run releases more often because of increased System storage. However, the frequency of a completed release would likely decrease because flood targets would 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.
Alternative 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

	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**
Alternative 6	During summer, water supply operations could potentially have water quality issues with lower Gavins Point releases if water temperatures increase. 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. As shown in the analysis for year 0 and year 15 (see Section 3.2.2.3, Impacts on Hydrology from the Alternatives), the mean elevation in the upper three reservoirs would increase by 1–2 feet in this 15-year time span. This increase would be the result of continued sediment deposition in the reservoirs. Future USACE reservoir operations would likely need to be revised to account for storage loss.

Sediment capture in the reservoirs 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. For example, as shown in the analysis for year 0 and year 15 (see Section 3.2.2.3, Impacts on Hydrology from the Alternatives), the river would degrade about 4 inches in Bismarck, and 0.5 foot in both Sioux City, Iowa, and Omaha, Nebraska. Downstream of Rulo, Nebraska, sand and aggregate mining would continue to contribute to degradation in the lower river (e.g., USACE 2017a), with varying rates of degradation depending in part on the mining patterns in this reach.

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 NPS's Missouri River National Recreational River 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 NPS's Missouri River National Recreational River 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 sturgeon 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 with natural variability in hydrologic conditions and actions that contribute to bed degradation and aggradation. The implementation of the spawning cue flows and ESH construction as part of Alternative 1 would 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 could 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 be large and adverse, although the contribution of Alternative 4 would be small to negligible. Locally the contributed impacts could be large, however.

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. Locally the contributed impacts could be large, however.

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. Locally the contributed impacts could be large, however.

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 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 3-23). Pallid sturgeon are similar in appearance to the more common shovelnose sturgeon (*Scaphirhynchus platorynchus*) (Figure 3-23) and the ranges of the two species overlap (USFWS 2014). However, 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 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, 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 3-23. 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; Steffensen et al. 2013). However, the population remains neither self-sustaining nor viable and 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 and South Dakota, Kansas River in Kansas, and Grand and Osage Rivers in Missouri (Figure 3-24).

Since listing in 1990, wild pallid sturgeon have been documented in the following areas (Figure 3-24) (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

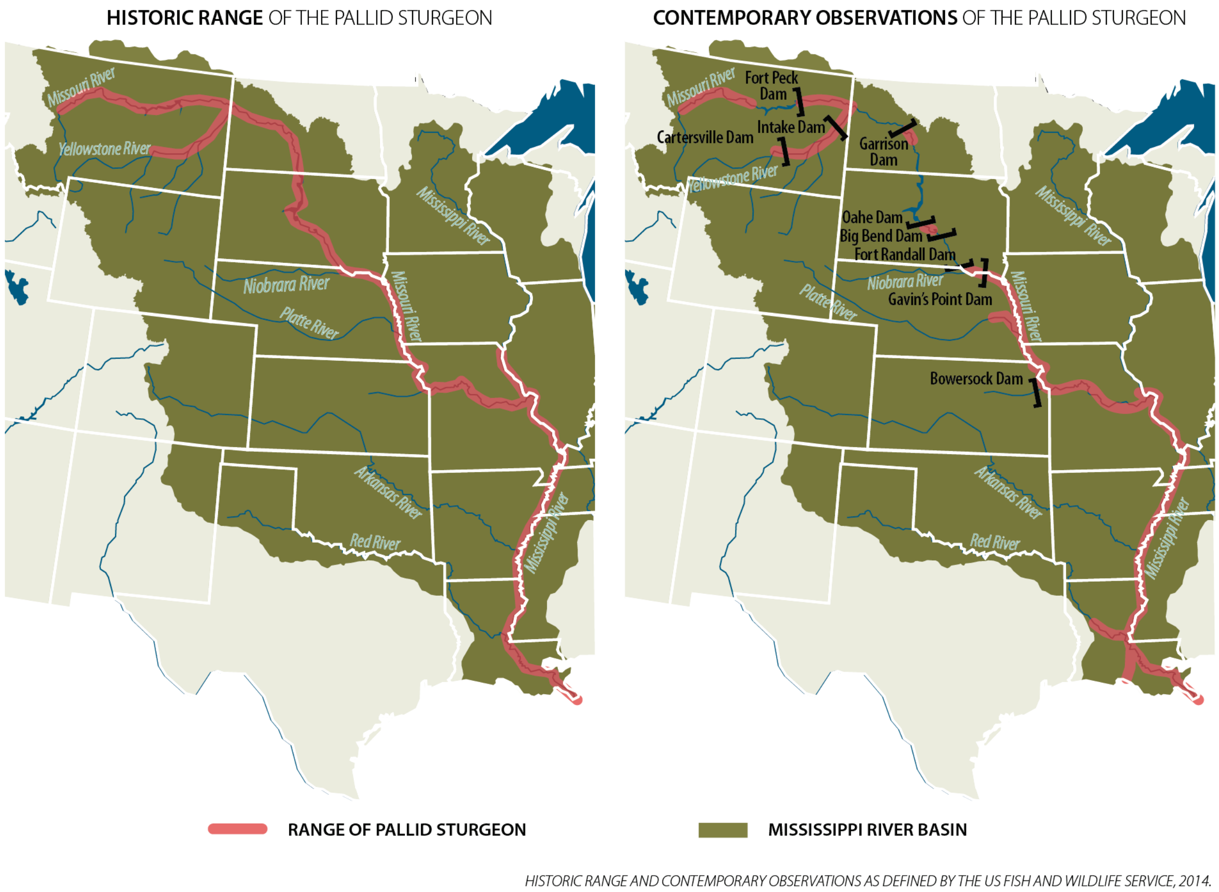


Figure 3-24. Pallid Sturgeon Natural Geographic Distribution (A) and Current Distribution (B)

The following discussion 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, suggesting as few as 6,000 or as many as 12,000 wild pallid sturgeon existed throughout their natural geographic range. 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). 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). 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) developed estimates for a reach below the confluence of the Platte and Missouri rivers, where catch rates of pallid sturgeon were relatively high. The annual population estimates of this reach 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). 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).

USFWS (2014) defines four pallid sturgeon recovery management units, three of which fall all or partly within the geographic scope of the MRRMP-EIS: the Great Plains Management Unit, Central Lowlands Management Unit, and Interior Highlands Management Unit. 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, 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 MRRMP-EIS. All of the Central Lowlands Management Unit (Fort Randall Dam to the confluence with the Grand River) falls within the geographic scope of the MRRMP-EIS. 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 MRRMP-EIS.

USFWS (2014) states that pallid sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery 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. 2015b). Table 3-8 summarizes the seven life stages.

Table 3-8. 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 are long-lived, with females reaching sexual maturity later than males (Keenlyne and Jenkins 1993). However, the age at first reproduction can vary between hatchery-reared and wild fish, depending on local conditions (USFWS 2014). The estimated age at first reproduction of wild fish is about 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).

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. Migration patterns can differ between males and females; where 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 water 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).

On the Yellowstone River, the majority of pallid sturgeon spawning occurs in several locations from RM 6 to 20 (DeLonay et al. 2016; Fuller and Braaten 2012; Bramblett and White 2001; Bramblett 1996). Suitable spawning habitat is also presumed to be available for pallid sturgeon in the upper Missouri River below Fort Peck Dam in areas of coarse substrate. One spawning location was documented in 2011 downstream of the Milk River and one free embryo was collected in the Missouri River (DeLonay et al. 2014). This was the first time pallid sturgeon spawning was documented below Fort Peck Dam and contrasts with most studies indicating the majority of telemetered pallid sturgeon typically move from the Missouri River into the Yellowstone River to spawn. 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). For example, telemetry studies of reproductive pallid sturgeon in the lower Missouri River have documented 29 spawning events (Jacobson et al. 2016b) (Figure 3-25). These studies suggest that pallid sturgeon can spawn in a wide range of environmental conditions; however, they do not answer whether spawning is more or less successful in any particular reach (DeLonay et al. 2016). Spawning habitat is discussed later in this section.

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).

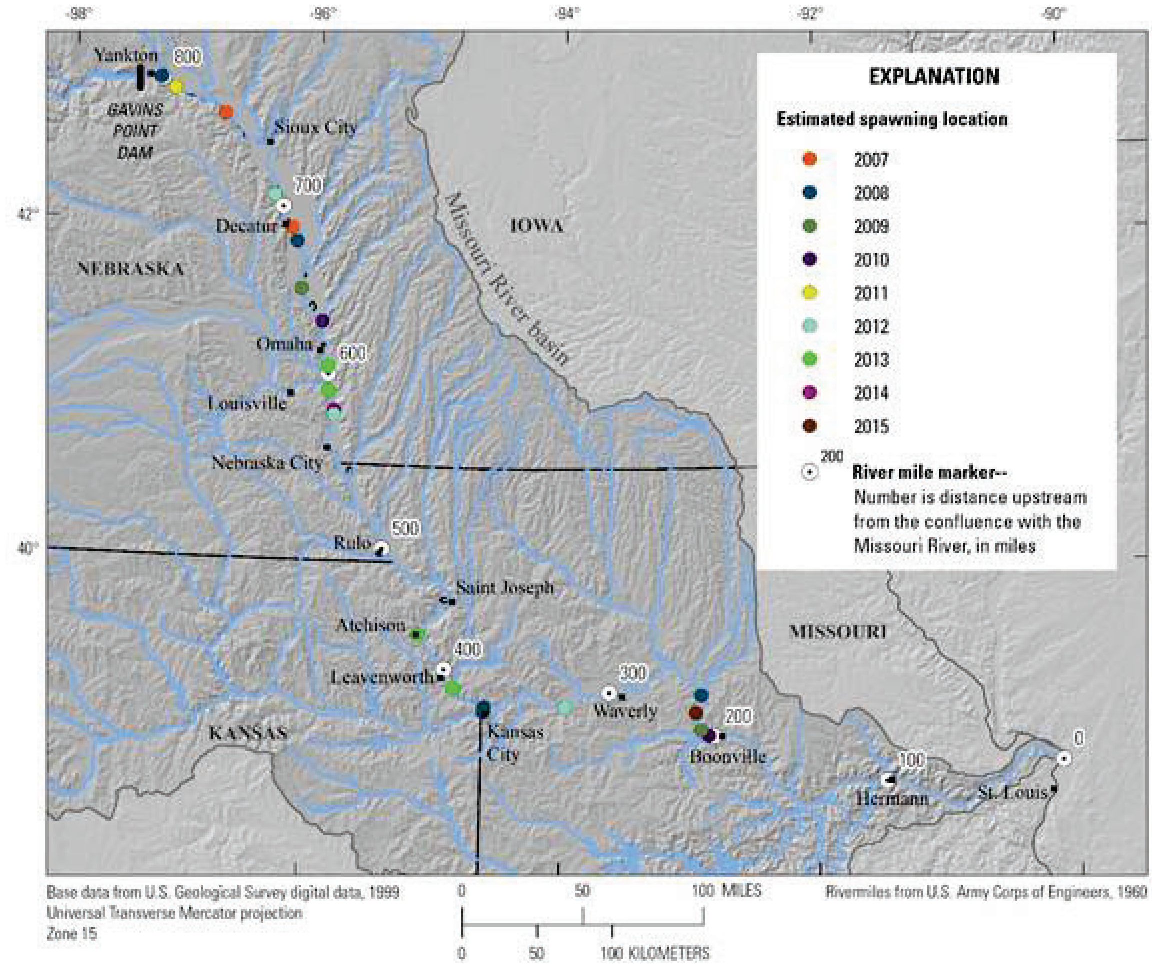


Figure 3-25. Documented Pallid Sturgeon Spawning Sites in the Lower Missouri River (2007–2015)

Embryo Life Stage

An embryo is a developing fish within the egg membrane; this life stage covers the period from fertilization to hatching (lasting 5–8 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 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 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, hypotheses differ regarding whether free embryos initiate drift immediately after hatch or spend one to several days hiding in interstitial spaces in the 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 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 enter their first reproductive cycle. During this period, the juvenile sturgeon shifts their 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 period, 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 adult (Grohs et al. 2009), with chironomids (Order: Diptera) and mayflies (Order: Ephemeroptera) serving as important components of the early juvenile diet (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

Currently there is no known natural recruitment in either the Yellowstone or Missouri Rivers above Lake Sakakawea despite evidence of successful spawning. Pallid sturgeon drifting free embryos have been collected from these areas in 2011–2013: 2011(n=1, collected near Frazer, Montana in the Missouri River), 2012 (N=1, collected near Fairview Montana, from the Yellowstone River) and 2013 (n=4, collected near Fairview, Montana from the Yellowstone River); however, there is no evidence of recruitment to age-1 wild fish. 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 first be conducive 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.

Adhesive eggs are generally associated with spawning that occurs over coarse, hard substrate. However, it is unknown whether fertilized eggs end up in small spaces between 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, may serve to improve the understanding of what occurs with the fertilized eggs. However, 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 an area or water volume, the interception habitat is 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 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. 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." 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 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 3-9).

Table 3-9. 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, 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 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, 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. 2016b). 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 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.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 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 3-10 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 3-10. Environmental Consequences Relative to 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 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. Anticipated 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. Anticipated 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. Anticipated 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. Anticipated 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 vegetation management operations for piping plovers and least terns. However, only 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. Adverse impacts on pallid sturgeon from vegetation management are expected to be negligible because the activity does not occur in the river.

Predation management actions and human restriction measures to benefit piping plover and least tern would have no impact on pallid sturgeon because the activity does not occur in the river and pallid sturgeon life cycles would not be exposed to the effects of the actions.

Propagation and Augmentation

As noted in Chapter 2, USACE supports the PSCAP with annual funding. Decisions on hatchery operations and protocols for propagation and augmentation are within the purview of 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. Continued implementation of the PSCAP is needed to maintain the population over the short term. 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. USFWS and state agencies are responsible for stocking decisions and the program follows a Range-wide Pallid Sturgeon Stocking Plan that is currently being updated and revised. This plan addresses genetic issues that can occur in the hatchery environment. This program is a critical management action to support the recovery of the pallid sturgeon and provides an overall beneficial effect on the pallid sturgeon population. Absent USACE's continued support, the effectiveness of the Propagation and Augmentation program would be significantly impaired. 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 adverse impacts on the population as the few that may be stressed would not affect the species at the population level. 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 (SAMP) 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, although the timing is uncertain. 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 a fish bypass at Intake into the SAMP 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 no adverse impacts on pallid sturgeon because these activities do not occur in the river. 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. Most studies and the life history of pallid sturgeon suggest that larval and early juveniles would be most susceptible to entrainment (Peters and Parham 2008). This is because they have less swimming ability and swimming endurance, and because they drift somewhat passively over long distances as they develop and increase their swimming ability (Hoover et al. 2005). Drifting free embryos are not present during the ESH construction time frame (mid-August until ice flows prevent construction during winter months). Older age-0 pallid sturgeon could be present during the ESH construction window; however, these individuals will have transitioned to a benthic oriented life stage with improved ability to move (i.e., motility). Occurrences of this life stage in the geographical areas in which ESH construction is undertaken is most likely rare. In the lower Missouri River, ESH construction is restricted to areas upstream of Sioux City, Iowa. While pallid sturgeon have spawned within this reach, upon hatching age-0 pallid sturgeon begin drifting and are most likely settling well downstream of areas where ESH is proposed to be constructed. Above Gavins Point dam, ESH construction is restricted to the inter-reservoir reaches. Spawning of pallid sturgeon within these reaches has not been documented and these reaches are generally assumed to not provide supportive habitat to pallid sturgeon (Jacobson et al. 2016b).

In 2015, USACE completed a biological assessment for commercial sand and gravel dredging on the lower Missouri River (USACE 2015). The risk of entrainment to juvenile pallid sturgeon within the lower Missouri River was thoroughly analyzed and USACE concluded "…the proposed action's potential to adversely affect the pallid sturgeon during the larval drift period is improbably low, thus minor and discountable." Concurrence from USFWS was provided in a letter dated November 20, 2015.

Juvenile pallid sturgeon could occupy stretches of the river where ESH construction is proposed. Risks associated with entrainment would be less than those described above for larval sturgeon given their larger size and increased motility.

Evidence suggests a low risk of entrainment (dredge intake) for fish during dredging operations. Although the potential for adverse impacts on pallid sturgeon from entrainment cannot be ruled out entirely, studies indicate the risk is low due to the probability of vulnerable life stages encountering dredging activity and, as a result, adverse impacts 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, adverse impacts would be considered negligible.

A low potential for construction-related adverse impacts on pallid sturgeon associated with the magnitude of ESH construction specified under Alternative 1 is anticipated due to the limited area affected and the duration of construction activities. Avoidance and minimization measures for construction activity impacts on pallid sturgeon 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 for a short period of time (i.e., duration of construction), resulting in negligible adverse 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 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 7 years. System operations have been hypothesized to affect adult pallid sturgeon by altering spawning cues due to reduced high flows and potentially depressed temperatures. While releases from Gavins Point Dam have been shown to track air temperature and be relatively insensitive to discharges during spring–fall (DeLonay et al. 2016), it is not clear if the release temperatures continue to be lower than natural because of the persistent effects of cold releases from Fort Randall Dam. Nonetheless, reproductive migrations of pallid sturgeon on the lower Missouri River have exhibited little evidence of correlation with natural and manipulated flow pulses (Jacobson et al. 2016b). Annual monitoring has shown that pallid sturgeon have spawned every year in the lower Missouri River from 2007 to 2015 (DeLonay et al. 2016) and low levels of recruitment have been documented (Porecca et al. 2015; Love 2016).

Seasonal migration and spawning behavior have been linked to flow pulses and increasing water temperatures in multiple sturgeon species (Anders and Beckman 1993; Chapman and Carr 1995; Kieffer and Kynard 1996; Paragamian and Wakkinen 2002; Goodman et al. 2012). As such, the 2003 Amended BiOp hypothesized that the altered hydrograph below Gavins Point Dam lacked the magnitude and duration of flows necessary to cue spawning and RPA element VII required a bimodal pulse to cue spawning. Since 2003, managed pulses were initiated from Gavins Point Dam in 2006, 2008, and 2009. Annual monitoring has shown that pallid sturgeon have spawned in the lower Missouri River, every year, from 2007 to 2015 (Delonay et al. 2009; DeLonay et al. 2016; DeLonay et al. in review) suggesting that sufficient variability in discharge exists within the lower Missouri River to cue spawning (or that a flow pulse to cue spawning is not necessary) without a managed pulse from Gavins Point Dam (Doyle et al. 2011).

While some fish have exhibited spawning behavior associated with an increase in discharge, this is not necessarily a requirement as other fish have exhibited spawning behavior in the Missouri River without any large increases in discharge before or during spawning activities. Evidence of successful spawning in 2014 was confirmed by the capture of seven pallid sturgeon larvae despite relatively flat hydrographs at both Omaha, Nebraska and Sioux City, Iowa prior to their estimated hatch dates.

It is difficult to pinpoint exactly where these larvae were produced; however, it is highly likely that the three 1- to 3-day old larvae that were captured from the drift by USGS at RM 599.5 originated above Omaha. It cannot be definitively determined where the remaining four larvae originated, but drift models predict that they originated above Omaha, Nebraska in the Missouri River or a tributary. Genetic analyses of these seven individuals showed that two of the individuals were siblings (Ed Heist, SIU, pers. comm.), which indicated that the remaining five individuals were produced from five other pairings. These seven fish are the first genetically-confirmed age-0 pallid sturgeon collected on the Missouri River downstream of Gavins Point Dam. Although these captures represent only one year, sampling for age-0 sturgeon and the genetic tools to differentiate pallid sturgeon are recent developments. Furthermore, it is likely that some free embryos drift into and rear in the Mississippi River (Porreca et al. 2015).

Further evidence of sufficient flow variability within the lower Missouri River to cue spawning may be gleaned from the closely related shovelnose sturgeon (*Scaphirhynchus platorynchus*). Goodman et al. (2012) showed that an increase in discharge and temperature was necessary to cue spawning in shovelnose sturgeon within the lower Marias River, Montana. In contrast, Papoulias et al. (2011) showed that shovelnose sturgeon migrated and spawned within the lower Missouri River, in all years studied, indicating that sufficient cues to spawn were present even without a managed flow pulse. Papoulias et al. (2011) also concluded that "discharge was extremely variable across study sections and years, and sturgeon exhibited no apparent discharge-associated changes in measured physiological indicators of readiness to spawn." Additionally, Richards et al. (2014) concluded that discharge may not cue spawning based on confirmed spawning activity of shovelnose sturgeon in 2 years with drastically different flow regimes. Steffensen et al. (2014) note that shovelnose sturgeon populations in the lower Missouri River appear to be stable, providing more evidence that sufficient spawning cues exist for shovelnose sturgeon in the lower Missouri River.

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. ISAP's 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 (1,331 acres annually vs. 164 acres annually). This level of ESH construction would have a higher potential to impact pallid sturgeon; however, it is anticipated that construction-related adverse 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 adverse impacts.

Channel Reconfiguration for Creation of Early Life Stage Habitat

Under Alternative 2, USACE would create an additional 10,758 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 adverse 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, 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 3 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. 2016b). 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. 2016b).

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, 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 given the short duration and site-specificity of actions 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 (332 acres annually vs. 164 acres annually). This level of ESH construction is anticipated to have a low risk of adverse construction-related impacts on pallid sturgeon; therefore, adverse 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 SAMP 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 and transport free embryos into existing food and foraging habitats as described in Chapter 2. 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 habitat is hypothesized to increase food producing habitats, increase availability and quality of foraging habitat, and improve interception of free embryos (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. However, there are many uncertainties related to IRCs including those related to how those habitats have been defined, which project designs most effectively create the desired habitats, and the importance of those habitats to pallid sturgeon survival.

It is currently unclear that IRCs, especially the interception component, have been defined appropriately. “The lines of evidence to support this hypothesis and provide some insight into the nature of the interception process are relatively weak because the hypothesis has only recently emerged” (Jacobson et al. 2016b). Additional work is needed, therefore to better define the interception process. As such, a careful and stepwise approach is needed to provide habitat creation guidelines and increase confidence that habitat projects will create the desired conditions. It is important to note that any habitat project design at this point is a test of whether the desired interception dynamics can be created and to what extent.

It is also currently unknown whether any component of IRCs is needed to increase survival of age-0 pallid sturgeon. For example, the EA Integrative report (Jacobson et al. 2016b) states “The logic, based on the hydraulic efficiency of the channel, is compelling but there is no empirical information to indicate that interception habitat is limiting to pallid sturgeon populations. We cannot rule out the idea that hydraulic complexity in the channel is sufficient everywhere to promote some exchange of free embryos between the thalweg and channel-marginal habitats." It is also unclear whether a lack of food or nutritional value is currently limiting to survival of age-0 pallid sturgeon (Jacobson et al. 2016b). For example, as noted by Jacobson et al. (2016b), "…the continued growth, recruitment, and survival of shovelnose sturgeon, which are thought to share dietary requirements with pallid sturgeon at this life stage, argue against food as a limiting factor." Despite the many uncertainties, a carefully structured approach to implementation and monitoring of IRCs could reduce these uncertainties and provide useful information for improving pallid sturgeon management actions if caution is taken regarding the pace of implementation as critical information is collected and evaluated.

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 short in duration and 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. Implementation of IRCs under the adaptive management framework included in the SAMP 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 SAMP 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. However, 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). However, the magnitude of the annual ESH construction required under Alternative 4 would be larger than under Alternative 1 (195 acres annually vs. 164 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 indirect beneficial impacts to pallid sturgeon.

Spawning Habitat Construction

Spawning habitat construction would occur as described for Alternative 3. Creation of up to three high-quality spawning sites that would occur under the SAMP 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. Implementation of IRCs under the adaptive management framework included in the SAMP 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 SAMP is anticipated to maximize long-term benefits to the pallid sturgeon population.

Conclusion

Direct, adverse impacts from ESH and IRC construction activities would be adverse and negligible but 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 (253 acres annually vs. 164 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 that would occur under the SAMP 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. Implementation of IRCs under the adaptive management framework included in the SAMP 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 SAMP 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 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 (246 acres annually vs. 164 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, 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 6 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. 2016b). 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. 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 SAMP 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. Implementation of IRCs under the adaptive management framework included in the SAMP 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 SAMP 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 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 USFWS's jeopardy opinion documented in the BiOp (USFWS 2000, 2003). As discussed in Chapter 1 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 (USFWS 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 (USACE 2003b, 2007c, 2008, 2010c). Pallid sturgeon eggs and larval stages are susceptible to predation and it has been hypothesized that decreased turbidity levels relative to historic conditions in inter-reservoir reaches may result in increased predation on early life stages of pallid sturgeon from sight-feeding predators (e.g., walleye or goldeye) (Jacobson et al. 2016b). Experimental data on exogenously feeding larvae and age-0 pallid sturgeon indicate there is little effect from predation (Jacobson et al 2016b). Predation of embryos and free embryos has not been directly evaluated and there still exists a high degree of uncertainty in the hypothesis and ways to evaluate the hypothesis. USFWS (2016a) stated that modeling suggests the numbers and biomass of pallid sturgeon in RPMA 2 (the Missouri River from Ft. Peck Dam to the headwaters of Lake Sakakawea, including the Yellowstone River upstream to the mouth of the Tongue River) is significantly higher than historical estimations due to higher than expected survival of stocked fish and increases in stocking from 2005 through 2009. There is potential that this high biomass in addition to sport fishery stocking and natural presence of other native-species may contribute to an increase in inter-specific competition between piscivorous (fish-eating) species. There is no evidence that increased competition is occurring or having adverse effects on the pallid sturgeon population and therefore the contribution to overall cumulative effects to pallid sturgeon is considered small; however, the actual occurrence or severity of impacts is unknown.

Modifications to the river channel from past, present, and reasonably foreseeable future 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.

Several aquatic nuisance species including zebra mussels have expanded their range into the Missouri River. Zebra mussel colonization has occurred in areas occupied by pallid sturgeon but data on direct effects are limited (USFWS 2014). Likewise, populations of non-native carp species have expanded exponentially in the Missouri and Mississippi Rivers; however, how these populations are affecting pallid sturgeon, if at all, remains an area of uncertainty. The decline of the pallid sturgeon in the Missouri River occurred prior to the introduction of these species. 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. The SAMP has been developed to 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 3-26). 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).

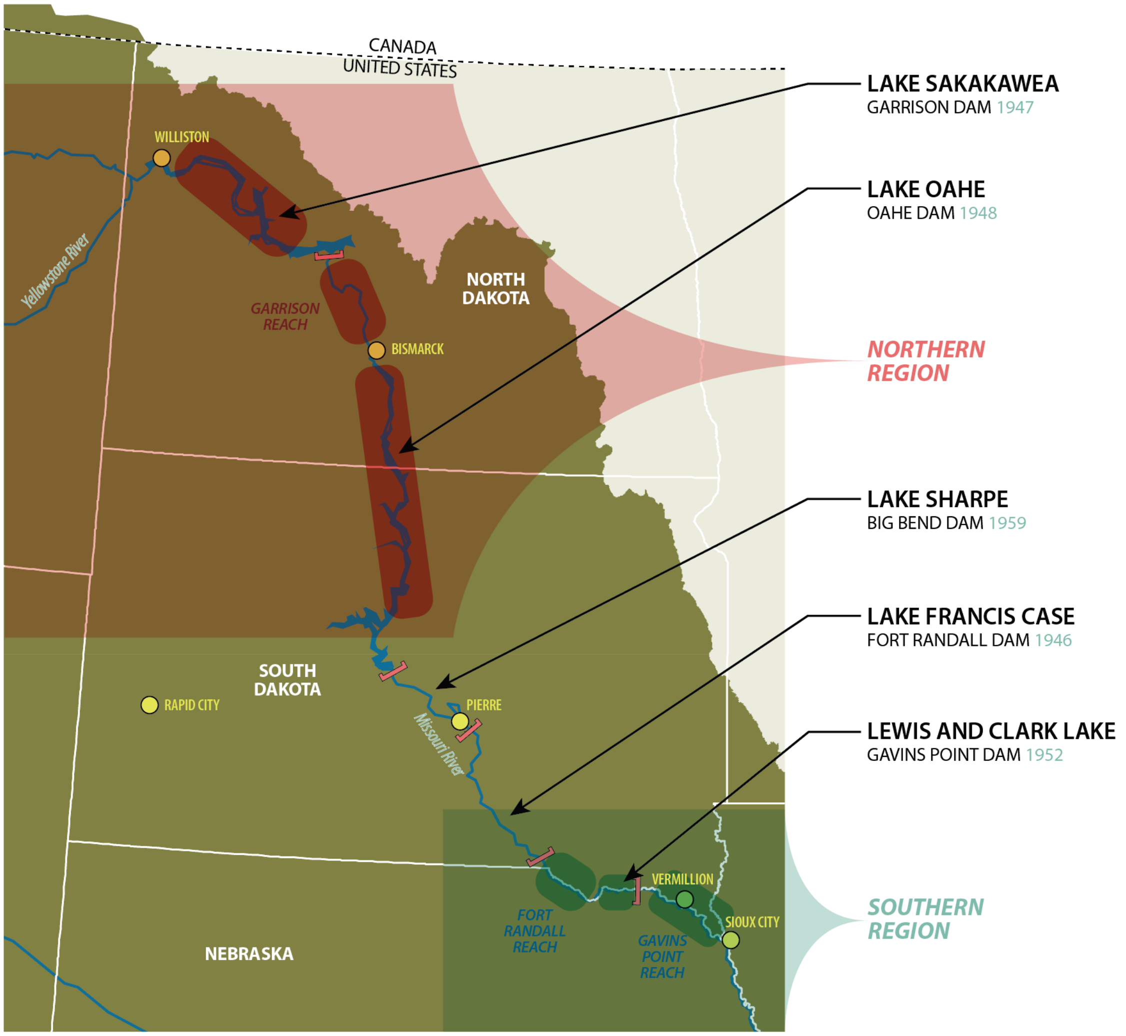
Figure 3-26. Northern Great Plains Piping Plover Adult

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 3-27). Immature birds have darker plumage than adults, a dark bill, and dark eye stripes on white foreheads (USFWS 1990).

Figure 3-27. Interior Least Tern Adults

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 3-28). 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. 2014a

Figure 3-28. 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. 2014a). 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 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 piping plover was listed as threatened outside of the Great Lakes watershed on December 11, 1985, 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 3-29).

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 3-30).

In 2013, a 5-year status review was conducted for the interior least tern. Based on the analysis of best available information, USFWS concluded that the interior least tern is biologically recovered. Prior to initiating a delisting proposal, 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 n.d.

Figure 3-29. Map of Piping Plover Breeding Populations

Map adapted from the Tern and Plover Conservation Partnership n.d.

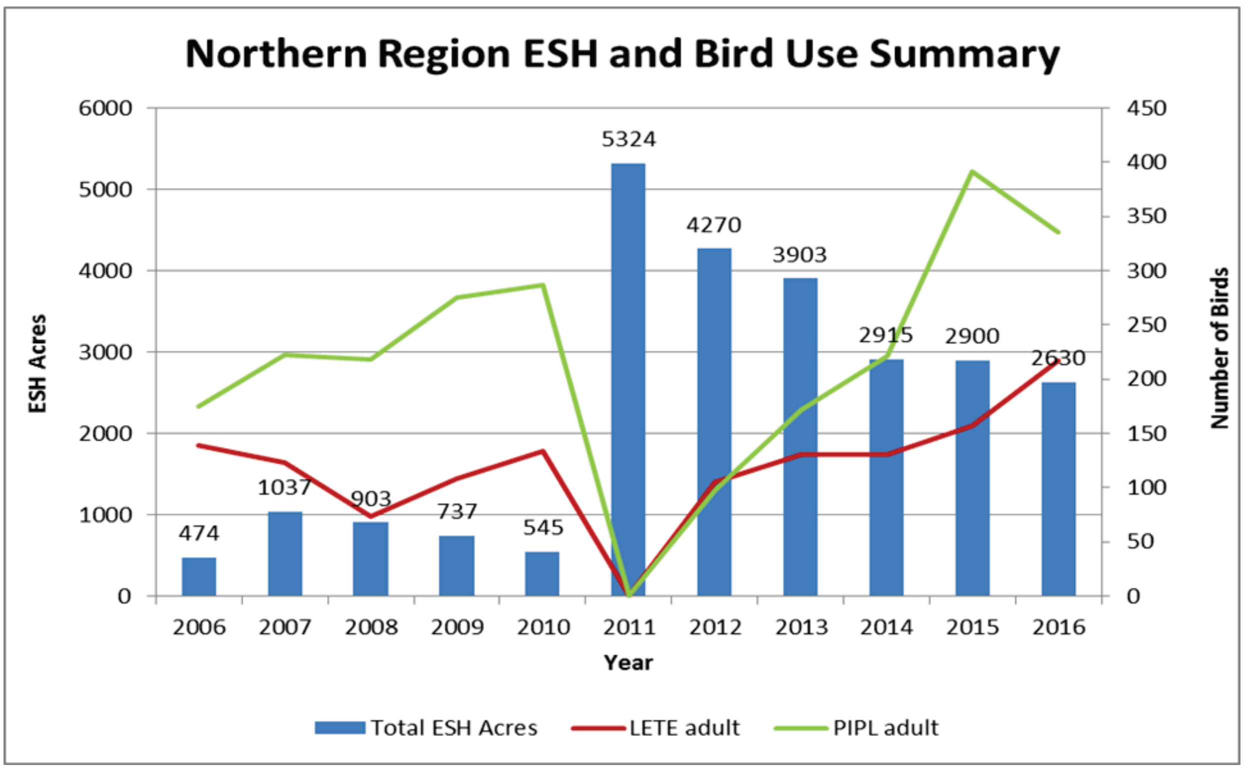
Figure 3-30. Map of Interior Least Tern Breeding Range

3.4.1.2 Life History and Ecology

Breeding Habitat

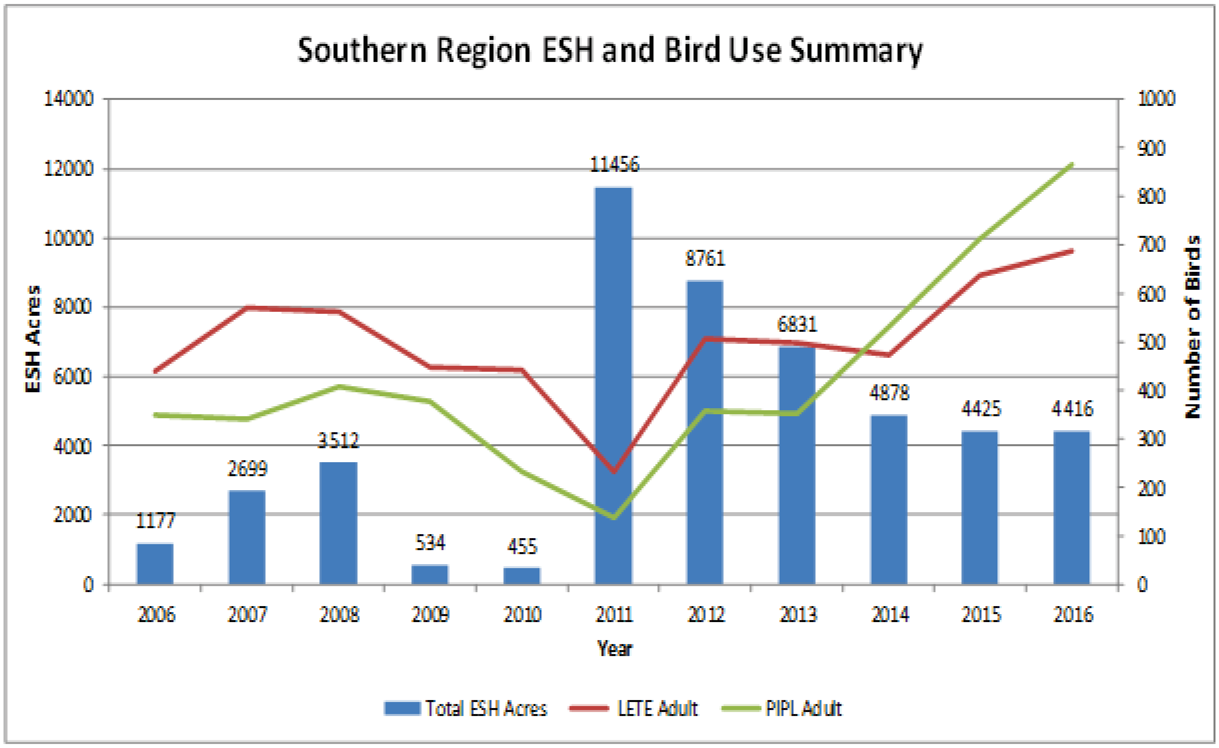
Piping plovers and least terns use sand and gravel substrates with absent or sparse vegetation for nesting and brood-rearing (Prindiville-Gaines and Ryan 1998; Sherfy et al. 2012). Historically, these two species made extensive use of emergent sandbar habitat (ESH) on the Missouri and other large rivers. 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 annually in the Northern and Southern Regions and least tern and piping plover adult use from 2006 to 2016 are presented in Figure 3-31 and Figure 3-32.



Note: Northern Region includes Lake Sakakawea, Lake Oahe, and Garrison reach.

Figure 3-31. Estimated Acreage of Available Emergent Sandbar Habitat and Adult Least Tern and Piping Plover Numbers in the Northern Region (2006-2016)



Note: Southern Region includes Fort Randall reach, Lewis and Clark Lake and Gavins Point reach.

Figure 3-32. Estimated Acreage of Available Emergent Sandbar Habitat and Adult Least Tern and Piping Plover Numbers in the Southern Region (2006-2016)

Reproductive Biology

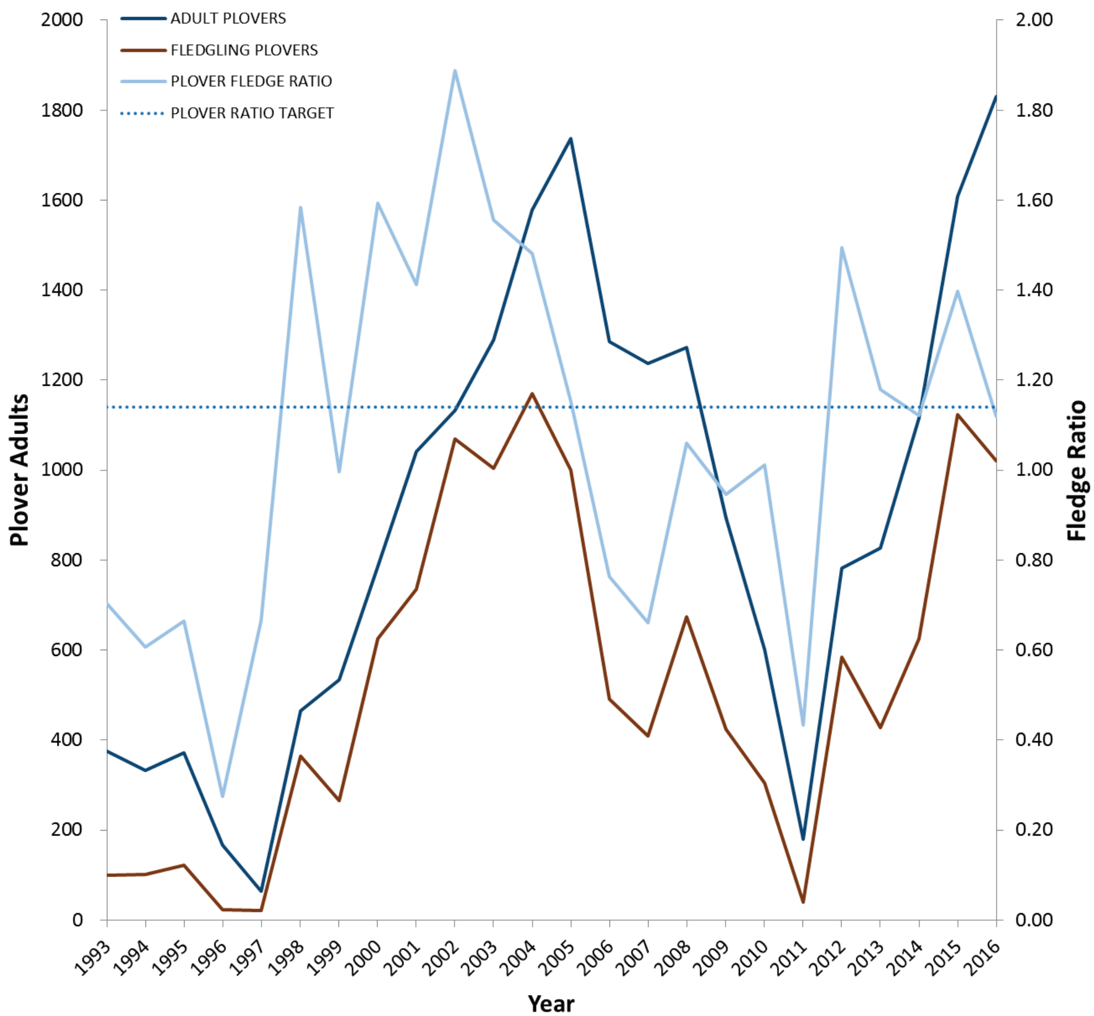
Piping plovers begin to arrive on the breeding grounds in the first half of April, with courtship and nesting beginning in mid-to-late April (Catlin and Fraser 2006; Catlin and Fraser 2007; Felio et al. 2009; Felio et al. 2010a; Felio et al. 2010b; Shaffer et al. 2013). Male plovers create a shallow 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 (Gratto-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 1,832 in 2016. 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, 1,612 adults in 2015 and 1,832 adults in 2016 (Figure 3-33). (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 3-33. Piping Plover Adult Census and Fledge Ratios for Missouri River (1993–2016)

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 1,054 observed in 2016 and a low of 273 in 2011. The largest numbers of fledglings were produced in 2015. 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 1,054 adults in 2016. Figure 3-34 shows the least tern census results from 1993 to 2016.

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

Figure 3-34. Interior Least Tern Adult Census and Fledge Ratios for the Missouri River (1993–2016)

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 were included as part of the RPA in the 2003 BiOp and included (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. In October of 2017, USACE provided a new BA to USFWS. Based on the new BA, USFWS issued a new BiOp in 2018. USFWS found that there would be no jeopardy to the least tern and piping plover from implementation of the USACE proposed action. The major management actions of the proposed action related to terns and plovers on the Missouri River are further described in Chapter 2.

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, 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 term. 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 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 164 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, 1,331 acres would need to be constructed annually.

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 SAMP 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, which serves as a baseline for comparison.

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 3-28). 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

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 3-11 summarizes the environmental consequences related to the piping plover over the 50-year modeled 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 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.

Each action alternative 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.

Table 3-11. Summary of Environmental Consequences Related to Piping Plovers and Least Terns

	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	5.7%	1.4%	4.9%	5.0%	4.9%	4.9%
Piping Plover Sub-Objective 2: South Population Extinction Probability	26.7%	0.68%	5.0%	5.0%	5.1%	5.0%
Piping Plover Sub-Objective 3 (percent of simulated years where median λ ≥ 1)	51%	96%	84%	47%	74%	47%
Piping Plover Sub-Objective 4 (percent of simulated years where median fledge ratio ≥ 1.14)	22%	98%	98%	60%	84%	33%

3.4.2.4 Impacts from Actions Common to All Plan Alternatives

The impacts of vegetation management, predator management, and human restriction measures on piping plovers and least terns are analyzed under this category. 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 or potential 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 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 3-11 shows the piping plover impacts of Alternative 1 relative to achieving the species objectives. An average of 164 acres of ESH would be constructed per year in years where construction is needed. Construction would need to occur in 96 percent 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. Modeling indicates the probability of piping plover extinction would be 3.8 percent for the Missouri River population (i.e., northern and southern populations combined). However, the modeled probability of extinction would be 5.7 percent for the northern region and 26.7 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 164 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 congressionaly authorized 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 a negligible effect on piping plovers and least terns at the regional level.

Conclusion

No significant adverse impacts are anticipated under Alternative 1 because ESH construction, vegetation management, human restriction measures, and predator management are anticipated to result in an overall benefit to piping plovers and least terns through improved habitat conditions and availability, reduced predation, and reduced human disturbance. This alternative would not, however, meet the objective of providing a 95 percent chance of persistence over the 50-year modeled period.

3.4.2.6 Alternative 2 – USFWS 2003 Biological Opinion Project Actions

Emergent Sandbar Habitat Construction: Under Alternative 2, an average of 1,331 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 1.4 percent by the end of the modeled period in the northern region and 0.68 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

No significant adverse impacts are anticipated under Alternative 2 because the management actions of ESH construction, vegetation management, human restriction measures, and predator management are anticipated to result in an overall benefit to piping plovers and least terns through improved habitat conditions and availability, reduced predation, and reduced human disturbance. Significant beneficial effects are anticipated because the objective of providing a 95 percent chance of persistence over the 50-year modeled period would be exceeded under this alternative resulting from implementation of Alternative 2 management actions.

3.4.2.7 Alternative 3 – Mechanical Construction Only

Under Alternative 3, an average of 332 acres of ESH would be constructed per year in years where construction is needed. Construction would need to occur in 61 percent 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 4.9 percent in the northern region, 5.0 percent in the southern region, and 1.3 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

No significant adverse impacts are anticipated under Alternative 3 because the management actions of ESH construction, vegetation management, human restriction measures, and predator management are anticipated to result in an overall benefit to piping plovers and least terns through improved habitat conditions and availability, reduced predation, and reduced human disturbance. Significant beneficial effects are anticipated because the objective of providing a 95 percent chance of persistence over the 50-year modeled period would be met under this alternative resulting from implementation of Alternative 3 management actions.

3.4.2.8 Alternative 4 – Spring Emergent Sandbar Habitat Creating Release

Under Alternative 4, an average of 195 acres of ESH would be constructed per year in years where construction is needed in addition to the Spring ESH creating release. The equivalent of approximately 137 acres per year would be created from periodic flows. Construction would need to occur in 44 percent 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 5.0 percent in the northern and southern regions and 1.2 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. Spring releases would carry an increased risk of nest inundation in years where the releases occur, but these impacts would be outweighed by the re-occurring creation of ESH.

Conclusion

No significant adverse impacts are anticipated under Alternative 4 because the management actions of ESH construction, vegetation management, the ESH creating reservoir release, human restriction measures, and predator management are anticipated to result in an overall benefit to piping plovers and least terns through improved habitat conditions and availability, reduced predation, and reduced human disturbance. Significant beneficial effects are anticipated because the objective of providing a 95 percent chance of persistence over the 50-year modeled period would be met under this alternative resulting from implementation of Alternative 4 management actions.

3.4.2.9 Alternative 5 – Fall Emergent Sandbar Habitat Creating Release

Under Alternative 5, an average of 253 acres of ESH would be constructed per year in years where construction is needed in addition to a fall ESH creating release. The equivalent of approximately 79 acres per year would be created from periodic flows. Construction would need to occur in 51 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 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

No significant adverse impacts are anticipated under Alternative 5 because the management actions of ESH construction, vegetation management, the ESH creating reservoir release, human restriction measures, and predator management are anticipated to result in an overall benefit to piping plovers and least terns through improved habitat conditions and availability, reduced predation, and reduced human disturbance. Significant beneficial effects are anticipated because the objective of providing a 95 percent chance of persistence over the 50-year modeled period would be met under this alternative resulting from implementation of Alternative 5 management actions.

3.4.2.10 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, an average of 245 acres of ESH would be constructed per year in years where construction is needed. The equivalent of approximately 87 acres per year would be created from periodic flows. Construction would need to occur in 56 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 1.4 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

No significant adverse impacts are anticipated under Alternative 6 because the management actions of ESH construction, vegetation management, human restriction measures, and predator management are anticipated to result in an overall benefit to piping plovers and least terns through improved habitat conditions and availability, reduced predation, and reduced human disturbance. Significant beneficial effects are anticipated because the objective of providing a 95 percent chance of persistence over the 50-year modeled period would be met under this alternative resulting from implementation of Alternative 6 management actions.

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. The SAMP 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 USFWS in 2009. The review states that human disturbance is a particular issue in popular river or reservoir reaches where up to about 70 percent of the Northern Great Plains plovers in the United States nest depending on the year. 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 Missouri River National Recreational River 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 Missouri River National Recreational River 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. Missouri River National Recreational River currently coordinates with USACE, USFWS, and other partners to ensure the federally listed species have adequate habitat in compliance with the Endangered Species Act while simultaneously ensuring that Missouri River National Recreational River'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. The SAMP has been developed to 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 3-12).

Table 3-12. Missouri River Study Reaches

Location	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.

A diverse community of coldwater, coolwater, and warmwater fish inhabit the six System reservoirs. The upper three reservoirs have been stocked with coldwater game and forage species to take advantage of the deeper cold waters through the summer and fall. Water levels, inflow, and outflow are important factors in the reservoirs. In the upper three reservoirs, low water levels during droughts limit coldwater fish habitat and shallow spawning and rearing habitat of warmwater and coolwater species. In the lower three reservoirs, high inflow and outflow reduce reservoir productivity and cause young fish to be flushed from the reservoirs.

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 other than inundation, topography, and management practices, drive the transitional states of each habitat class and to what extent they exist across the Missouri River basin. The assessment of fish and wildlife habitat in this EIS assumed inundation regime was the dominant driver of type and extent of habitat types with the floodplain and was the focus of habitat modeling.

While a range of inundation periods could occur within each of the representative vegetation communities within individual habitat classes, the maximum number of days a habitat class could tolerate inundation was assumed for modeling purposes. A habitat class could be inundated no more than its defined number of days to meet its definition. 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, 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 number of acres within the reach that meet each habitat class threshold. It is important to note that the acres represent the amount of different habitat types within the HEC-RAS model cross-sections. The habitat within the cross-sections provides a reasonable comparison of change between the alternatives, but does not represent the total amount of habitat in the floodplain.

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 number of acres within the reach that meet each wetland habitat class thresholds.

3.5.1.5 Depth Classes

Depth diversity in river channels is representative of habitat diversity (e.g., deep, fast waters; shallow slow waters; transitional areas) and availability for fish and other aquatic species over various life stages. Collectively, a wide variety and extent of habitats ensures that the requirements of native taxa (e.g., food, nesting, rearing, foraging) are met. For example, shallow water is beneficial for young and small bodied fishes by providing an area with slower velocities which is critical for survival of many larval fish. During the winter months, many fish species rely on deeper waters with lower velocities to find refuge from the colder temperatures. A channel that can be characterized as having available habitats across a diversity of depths is likely to support native fish species throughout various life stages. 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 aquatic habitat diversity or depth 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 number of acres within the reach.

The HEC-EFM and HEC-RAS models and the Cross Section Viewer software (Shelley and Bailey 2018) were used to estimate 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 river study reaches. Depth class data is presented for the entire lower river and not separated into the previously identified lower river reaches.

The 0–3 feet depth class has the greatest number of acres for all periods in the Fort Peck to Garrison, Garrison to Oahe, and Fort Randall to Gavins Point reaches. The 12–18 feet depth class has the greatest number of acres for all periods in the Gavins Point to Rulo, except the overwintering early period. The greater than 18 feet depth class has the greatest number of acres for the overwintering early period in the Gavins Point to Rulo. The 9–12 feet depth class in the overwintering late period has the greatest number of acres in the Rulo to Mouth reach and the greater than 18 feet depth class in the early spawning, late spawning, and summer rearing and growth periods has the greatest amount in this reach. The 12–18 feet depth class in the overwintering early period has the greatest amount in the Rulo to Mouth reach.

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

During the collaborative development of HC objectives and metrics, some members of MRRIC requested a metric to evaluate flows and potential fish and wildlife impacts in the Fort Randall 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. The total occurrences were divided by the total number of days in the period of record to determine the average 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*). Invasive plants in emergent wetlands 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 are also a main invasive species. 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 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. Buffalo fishes, 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 2 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). Commercial 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 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. This section considers the actions included under each alternative and their impacts to fish and wildlife habitats. This section also 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 sturgeon 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.

As discussed above, a channel that can be characterized as having available habitats across a diversity of depths is likely to support native fish species throughout various life stages. Depth diversity in river channels is representative of habitat diversity (e.g., deep, fast waters; shallow slow waters; transitional areas) and availability for fish and other aquatic species over various life stages. Simpson’s index was used to measure depth class habitat diversity and takes into account the number of depth class habitats present as well as the relative abundance of each depth class habitat. An equal distribution of depth classes would equal 1 with lower index values indicating less diversity and higher index values indicating higher diversity. The Simpson’s index was calculated for diversity across seasonal periods of acres of depth classes.

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, as shown in Table 3-13.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 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 3-13. Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

Flow Occurrences	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Total Number of Flow Occurrences <9,000 cfs	153,138	150,431	152,625	156,252	154,270	155,460
Average Number of Flow Occurrences <9,000 cfs per day	5	5	5	5	5	5

3.5.2.2 Summary of Environmental Consequences

Table 3-14 summarizes the impacts of each alternative to fish and wildlife.

Each alternative consists of management actions designed to benefit piping plovers, least terns, and pallid sturgeon; however, these actions would also provide benefits 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 from acquisition of lands for habitat development and land management. In addition to the analysis described in this MRRMP-EIS, past NEPA documents prepared by 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 3-14. Environmental Consequences Relative to Fish and Wildlife

Alternative	Impacts to Fish and Wildlife
Management Actions Common to All Alternatives	Adverse impacts would be temporary. Negligible to 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 would occur from habitat construction management actions during construction. Long-term large beneficial impacts 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 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. Localized large impacts could occur to reservoir fisheries if criteria for management of water levels, inflow, and outflow for the reservoirs are not met. Compared to Alternative 1, large benefits would occur from habitat construction management actions that would provide habitat for a variety of wildlife species with substantially more habitat created.
Alternative 3	Overall, adverse impacts would be temporary. Negligible to small adverse impacts would occur similar to Alternative 1. Localized large impacts could occur to reservoir fisheries if criteria for management of water levels, inflow, and outflow for the reservoirs are not met from the one-time spawning cue test. Compared to Alternative 1, beneficial impacts would range from negligible to small from habitat construction management actions that would provide habitat for a variety of wildlife species.
Alternatives 4–6	Overall, adverse impacts would be temporary. Negligible to small adverse impacts would occur similar to Alternative 1. Localized large impacts could occur to reservoir fisheries if criteria for management of water levels, inflow, and outflow for the reservoirs are not met. Compared to Alternative 1, beneficial impacts would range from negligible to small from habitat construction management actions that would provide habitat for a variety of wildlife species.

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 3-35 through Figure 3-41. Results are presented as the modeled change in area (acres) of each habitat class 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 for each alternative. EQ account results are presented as percent change in habitat classes 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).

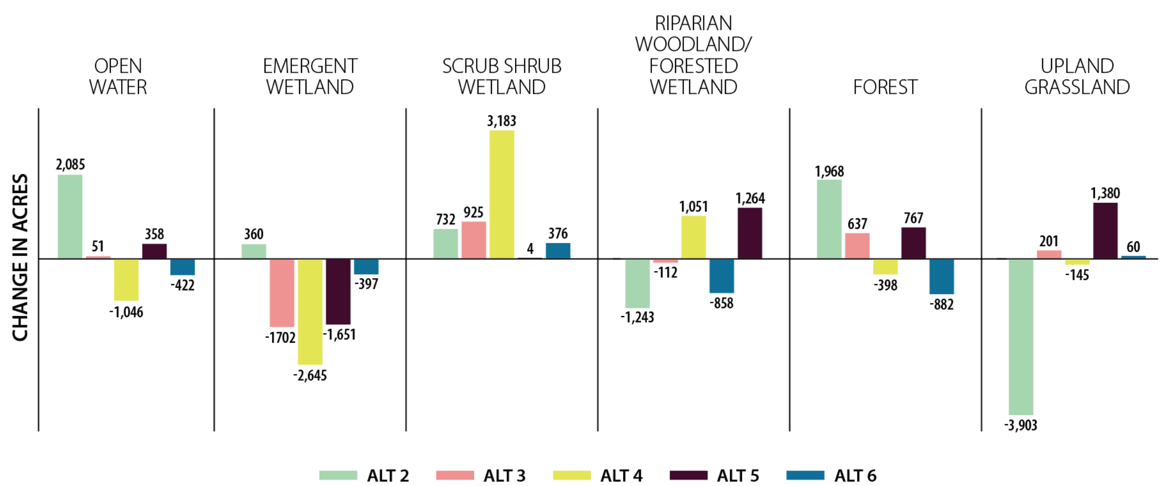


Figure 3-35. Overall Change from Alternative 1 in Fish and Wildlife Habitat Classes

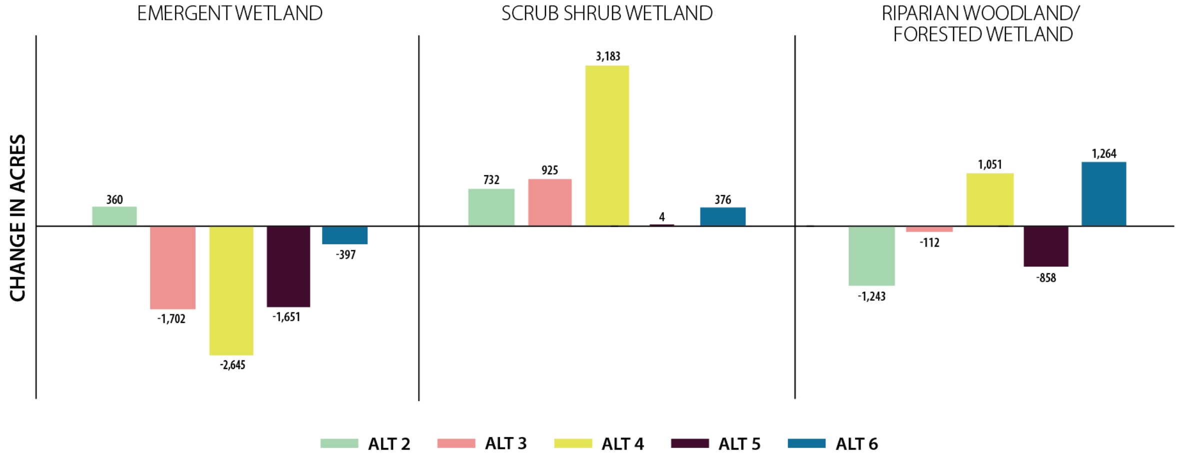


Figure 3-36. Overall Change from Alternative 1 in Wetland Habitat Classes

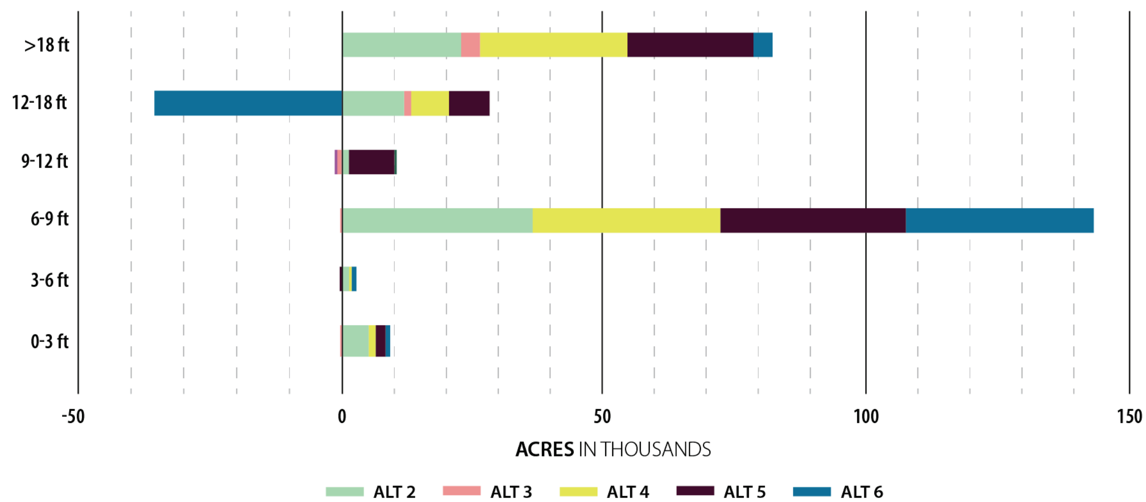


Figure 3-37. Overwintering Late Seasonal Period Overall Change from Alternative 1 in Acres of Depth Classes

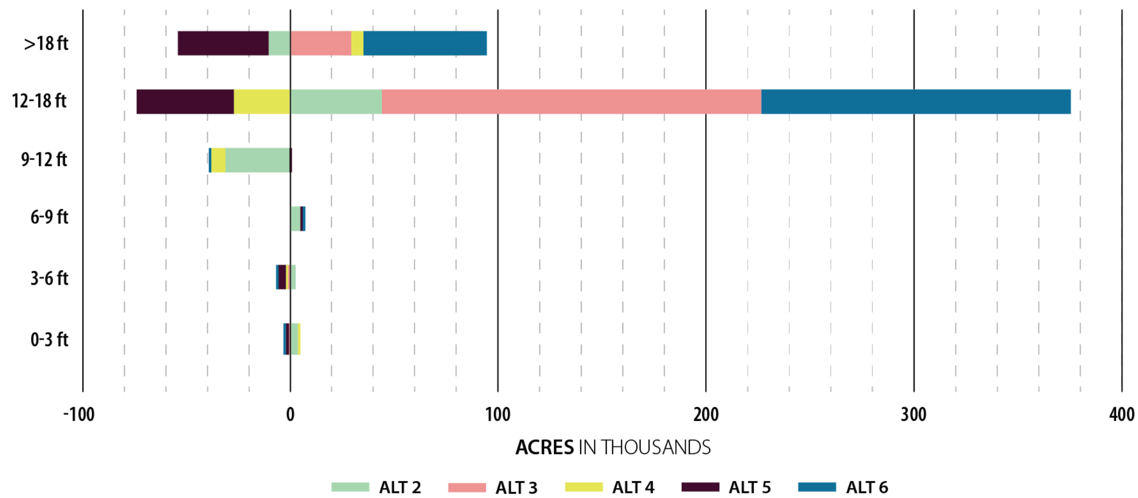


Figure 3-38. Early Spawning Seasonal Period Overall Change from Alternative 1 in Acres of Depth Classes

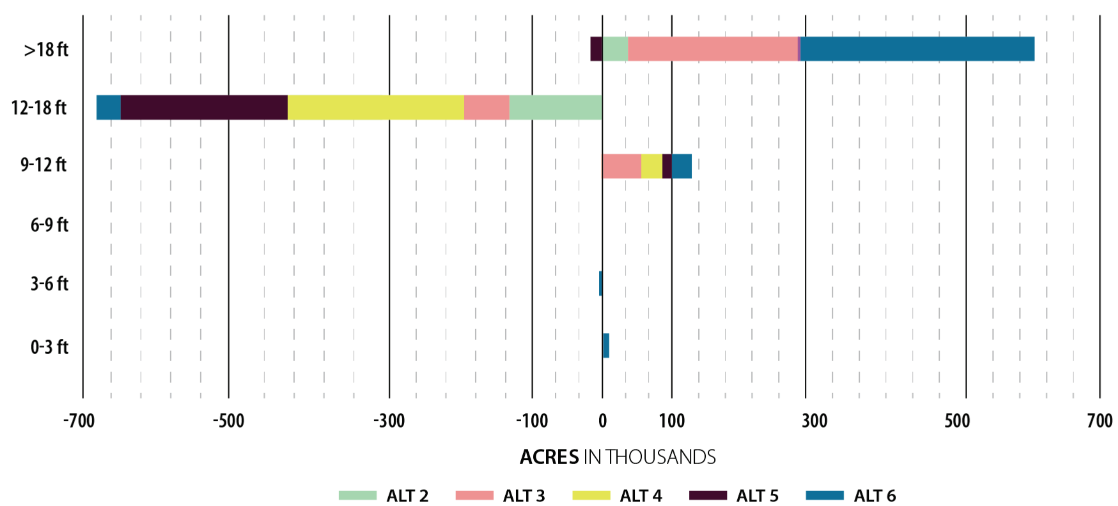


Figure 3-39. Late Spawning Seasonal Period Overall Change from Alternative 1 in Acres of Depth Classes

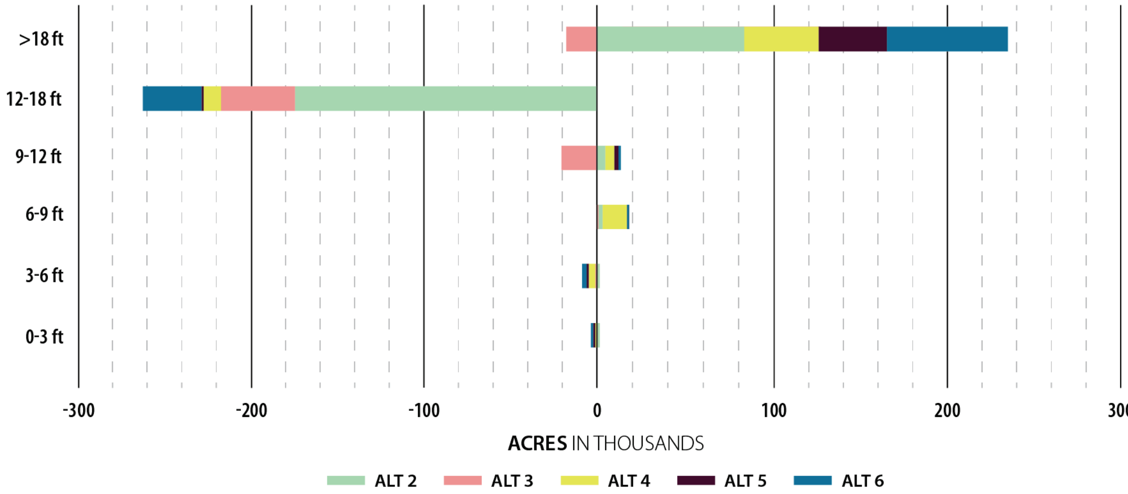


Figure 3-40. Summer Rearing Seasonal Period Overall Change from Alternative 1 in Acres of Depth Classes

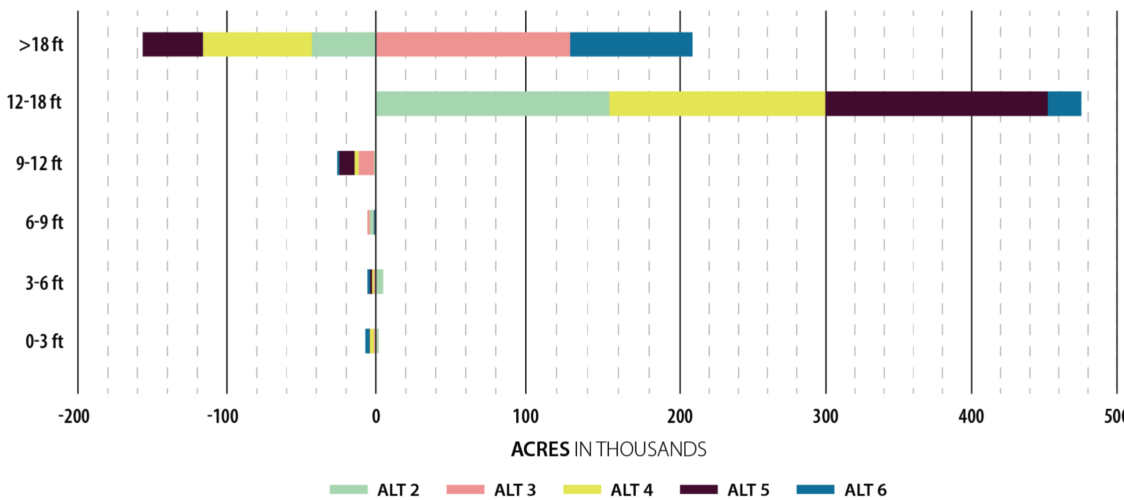


Figure 3-41. Overwintering Seasonal Period Overall Change from Alternative 1 in Acres of Depth Classes

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 2011a). Although herbicides could enter the substrate when vegetation is removed during vegetation management operations, only herbicides approved by EPA for aquatic use would be applied at the recommended rates. 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. Potential indirect impacts to birds, small and large mammals, and invertebrate species from herbicide spraying could occur due to changes in vegetation composition that leads to changes to or loss of habitat. As additional habitat is created for fish and wildlife from mechanical ESH construction, any potential incremental increase to herbicide exposure would result in small temporary impacts to fish and wildlife if individuals are adversely affected by herbicides through contact or from impacts to habitat. 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 2011a).

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 3-15 and Table 3-16.

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 from highest to lowest include open water (218,891 acres), scrub shrub wetland (96,027 acres), upland grassland (53,988 acres), emergent wetland (42,377 acres), forest (24,759), and riparian woodland/forested wetland (25,267 acres). Table 3-15 shows 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 2–6. The acres of each depth class under Alternative 1 are presented in Table 3-16. Diversity across seasonal periods of acres of depth classes for Alternative 1 was calculated as 0.81 indicating a moderately high amount of evenness and diversity of depths across all seasons. This diversity estimate for Alternative 1 is used as a comparison of change for Alternatives 2–6.

Table 3-15. 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	65,156	65,446	9,354	26,462	10,665	12,062	12,917	16,827	**218,891**
Emergent Wetland	7,588	7,365	6,342	8,103	2,771	3,046	3,917	3,246	**42,377**
Scrub Shrub Wetland	55,964	14,985	13,077	3,847	894	1,208	2,162	3,888	**96,027**
Riparian Woodland/Forested Wetland	19,719	1,336	1,551	536	166	339	414	1,206	**25,267**
Forest	16,019	3,096	1,354	330	287	707	1,187	1,779	**24,759**
Upland grassland	14,026	4,509	2,691	1,424	7,445	5,019	9,354	9,519	**53,988**
Total	**178,473**	**96,738**	**34,370**	**40,702**	**22,229**	**22,380**	**29,951**	**36,466**	**461,309**

Table 3-16. 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	112,795	119,716	152,183	120,503	113,277
	3–6 feet	50,841	52,219	93,051	52,901	50,887
	6–9 feet	2,114	39,789	49,941	23,038	6,222
	9–12 feet	11,189	6,758	637	636	10,142
	12–18 feet	16,376	1,707	1,077	2,969	2,170
	>18 feet	30,755	39,013	45,926	54,345	31,479

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	73,392	73,833	74,133	73,927	70,972
	3–6 feet	56,206	58,518	62,537	60,932	51,547
	6–9 feet	29,153	28,856	28,860	29,339	28,669
	9–12 feet	26,068	27,187	16,938	22,642	27,843
	12–18 feet	26,318	47,477	31,866	47,506	4,446
	>18 feet	15,070	23,171	28,893	22,161	6,224
Fort Randall to Gavins Point	0–3 feet	13,633	19,356	23,560	29,907	20,406
	3–6 feet	12,342	12,582	13,162	13,585	13,099
	6–9 feet	9,097	7,458	8,453	7,976	7,762
	9–12 feet	5,538	7,737	7,675	9,125	7,643
	12–18 feet	12,704	9,562	20,522	8,492	19,572
	>18 feet	2,934	12,169	16,851	16,874	15,979
Gavins Point to Rulo	0–3 feet	15,219	20,869	22,630	24,042	22,236
	3–6 feet	16,805	17,046	18,909	19,509	17,005
	6–9 feet	39,642	14,441	14,092	14,418	15,216
	9–12 feet	1,391	31,895	19,166	19,023	26,378
	12–18 feet	68,690	95,209	268,801	230,036	121,211
	>18 feet	9,265	86,805	26,362	142,418	203,614
Rulo to Mouth of the Missouri River	0–3 feet	16,169	14,736	13,035	15,574	16,763
	3–6 feet	18,080	16,056	12,849	16,606	16,170
	6–9 feet	22,483	16,110	15,223	16,477	17,991
	9–12 feet	30,373	18,258	16,989	19,845	21,772
	12–18 feet	2,330	53,168	42,241	57,747	59,822
	>18 feet	4,667	85,069	92,450	57,806	36,002

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 153,138 for the POR and the average number of flow occurrences below 9,000 cfs per day would be 5, as modeled for the POR.

Mechanical ESH Construction

There could be negligible temporary adverse 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 (USACE 2011a). Disturbance of fish and wildlife habitat 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 2011a). Given the acres of ESH construction, these benefits would likely be small at the reach level.

Spawning Cue Releases

As previously discussed, the habitat type acres are presented for the “typical” year in the POR and as such reflect the overall change of implementation of the flow action over time and not the effect within each individual year the action was modeled.

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, River Infrastructure and Hydrologic Processes. 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 Sturgeon Habitat (SWH)

The construction of early life stage pallid sturgeon habitat would occur only in the lower river from Ponca, Nebraska to the mouth of the Missouri River. Construction of early life stage pallid sturgeon 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 sturgeon 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 sturgeon 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 sturgeon 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 sturgeon 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 areas 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 sturgeon 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. 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 from displacement and disruption of fish and wildlife and for species that use terrestrial habitat that is converted to aquatic habitat. Negligible to small adverse impacts from vegetation and predator management activities could occur from changes to or loss of habitat or lethal removal of individual wildlife species. 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 would result in negligible to small temporary adverse impacts from construction disturbance and large long-term benefits from providing habitat for a variety of wildlife species. Alternative 1 would not have significant adverse impacts on fish and wildlife because adverse impacts would be temporary and range from 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 3-42 and Figure 3-43. The change in acres for each habitat class 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.

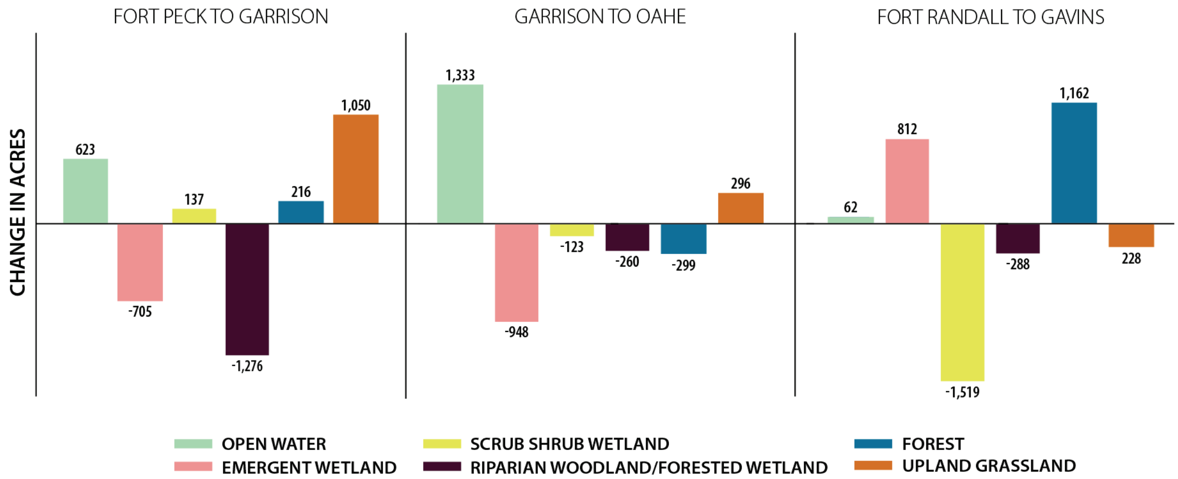


Figure 3-42. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 2 Compared to Alternative 1 – Upper River)

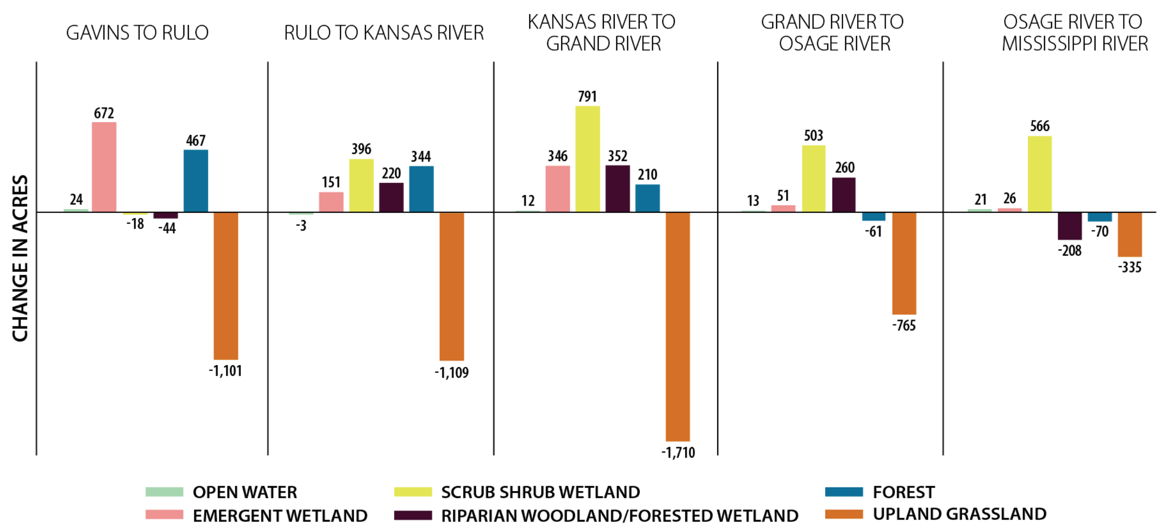


Figure 3-43. Modeled Change in Acres of Fish and Wildlife Habitat Classes Alternative 2 Compared to Alternative 1 – Lower River)

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Compared to Alternative 1, the open water habitat class under Alternative 2 would have the greatest increasing trend. Emergent wetland, scrub shrub wetland, and forest would also have an increasing trend and riparian woodland/forested wetland and upland grassland would have a decreasing trend. Habitat classes as modeled in the Fort Peck to Garrison, Garrison to Oahe, and Fort Randall to Gavins vary in the change among wetter and drier habitat classes compared to Alternative 1 likely due to the changes in reservoir elevations in the upper three reservoirs and the downstream effects and the effects of the low summer flow on the reservoirs and inter-reservoir reaches. There would be an increasing trend as modeled towards wetter habitat classes such as emergent wetland and scrub shrub wetland as modeled under Alternative 2 compared to Alternative 1. This is likely from the increasing stabilization of flows in the lower river with further distance from Gavins Point. Overall river-wide changes in the percent of each habitat class as modeled under Alternative 2 compared to Alternative 1 is small (Figure 3-42 and Figure 3-43), ranging from an 8 percent increase in forest, to a 7 percent decrease in upland grassland.

Depth Classes

For all river reaches combined, all depth classes would have an increasing trend in the overwintering late period. The 0–3, 3–6, 9–12, and 12–18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 3–6, 6–9, 9–12, 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 greater than 18 foot depth classes would have an increasing trend in the summer rearing and growth period. The 0–3, 3–6, 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 3-37 through Figure 3-41).

There was no change in the calculated diversity index for Alternative 2 compared to Alternative 1. Diversity across seasonal periods of acres of depth classes for Alternative 2 was calculated as 0.81 indicating a moderately high amount of evenness and diversity of depths across all seasons. 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 6–9 foot depth class would have the greatest increasing trend (1703 percent) during the overwintering late period and the 9–12 foot depth class would have the greatest decreasing trend (96.2 percent) in the early spawning period.

Garrison to Oahe: The 12–18 foot depth class would have the greatest increasing trend (47.6 percent) during the overwintering early period and the 12–18 foot depth class would have the greatest decreasing trend (75.5 percent) in the overwintering late period.

Fort Randall to Gavins Point: The 12–18 foot depth class would have the greatest increasing trend (105.2 percent) during the early spawning period and the 12–18 foot depth class would have the greatest decreasing trend (65.3 percent) in the summer rearing and growth period.

Lower River

Gavins Point to Rulo: The greater than 18 foot depth class would have the greatest increasing trend (184.3 percent) during the late spawning period and the 12–18 foot depth class would have the greatest decreasing trend (74.3 percent) in the summer rearing and growth period.

Rulo to Mississippi River: The 12–18 foot depth class would have the greatest increasing trend (150.3 percent) during the overwintering late period and the greater than 18 foot depth class would have the greatest decreasing trend (30.5 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 below 9,000 cfs in the Fort Randall reach had a decreasing trend as modeled for the POR; however, the daily average of these occurrences did not change under Alternative 2 compared to Alternative 1. Therefore, beneficial 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 1,331 acres of ESH would be constructed annually, 1,167 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 long-term 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. USACE (2011a) 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 2011a). 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 2011a). 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 Sturgeon Habitat (SWH)

The impacts from channel reconfiguration for construction of early life stage pallid sturgeon 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. 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.

Adverse impacts at the upper three reservoirs under Alternative 2 would occur during the years following a release. These releases would draw down reservoir elevations farther than would occur under Alternative 1. Significant drawdown of the upper three reservoirs could have effects to the fisheries. Timely water level manipulation (i.e., water levels, inflow, and outflow) for fisheries management is important for the overall reproduction of fish in the reservoirs. Maintaining an adequate water level and having a rising pool during the spring spawning and egg incubation period are critical for maintaining the fisheries. If the criteria noted in the Missouri River Fisheries Management Plans for these three reservoirs are not met, large impacts to the fisheries could occur. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 2 would remain relatively stable. However, if significant drawdown were to occur in these two reservoirs the fisheries would experience similar impacts as described for the upper three reservoirs. Adverse impacts could also occur to fish species from fish entrainment in the turbines at the hydropower projects during these releases, however, relatively colder and more oxygenated water could benefit cool and cold-water fish species during these releases.

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. Benefits 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 over the 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, localized, and construction related from displacement and disruption of fish and wildlife and for species that use terrestrial habitat that is converted to aquatic habitat. Overall, the changes in the percent of each habitat class as modeled under Alternative 2 compared to Alternative 1 would be small. Depth class diversity across seasonal periods is moderately high and similar to Alternative 1. Negligible impacts from vegetation, predator management activities, and human restriction measures could occur from changes to or loss of habitat or lethal removal of individual wildlife species. 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. Large temporary construction related impacts would occur to aquatic habitat from disturbance or loss in the upper river due to the large magnitude of acres of ESH construction compared to Alternative 1. Temporary large impacts could occur to fish and wildlife habitat and associated taxa from an increase in suspended silt and sediment during dredging activities. Creation of fish and wildlife habitat from habitat construction and increased hydrology following flow releases would result in long-term benefits by providing a net increase in habitat in localized areas. Benefits from low summer flows on fish and wildlife that utilize backwaters, side channels, and other low-velocity habitat could be large in years when low summer flows could be implemented. Large impacts could occur to the fisheries in the upper three reservoirs from draw down of reservoir elevations if criteria for management of water levels, inflow, and outflow for the reservoirs are not met. These impacts would be limited to fish species in the reservoirs. Habitat construction management actions that would provide habitat for a variety of wildlife species and creation of habitat during low summer flows would have large long-term beneficial impacts with substantially more habitat created under Alternative 2 compared to Alternative 1. Therefore, Alternative 2 would not cause significant adverse impacts to fish and wildlife.

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 3-44 and Figure 3-45. The changes in acres for each metric from management actions under Alternative 3 compared to Alternative 1 are summarized in the following sections.

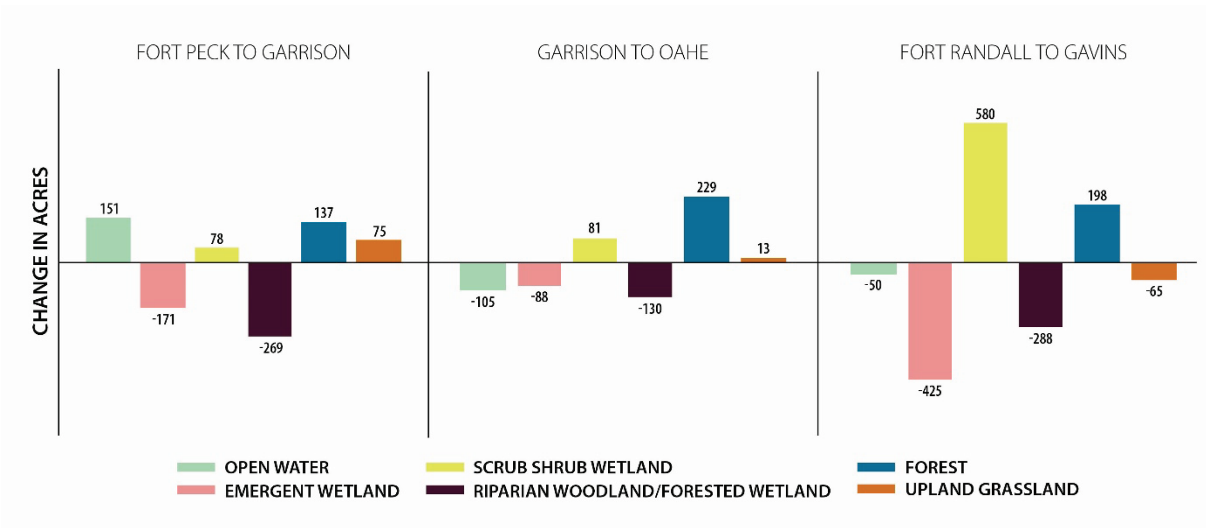


Figure 3-44. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 3 Compared to Alternative 1 – Upper River)

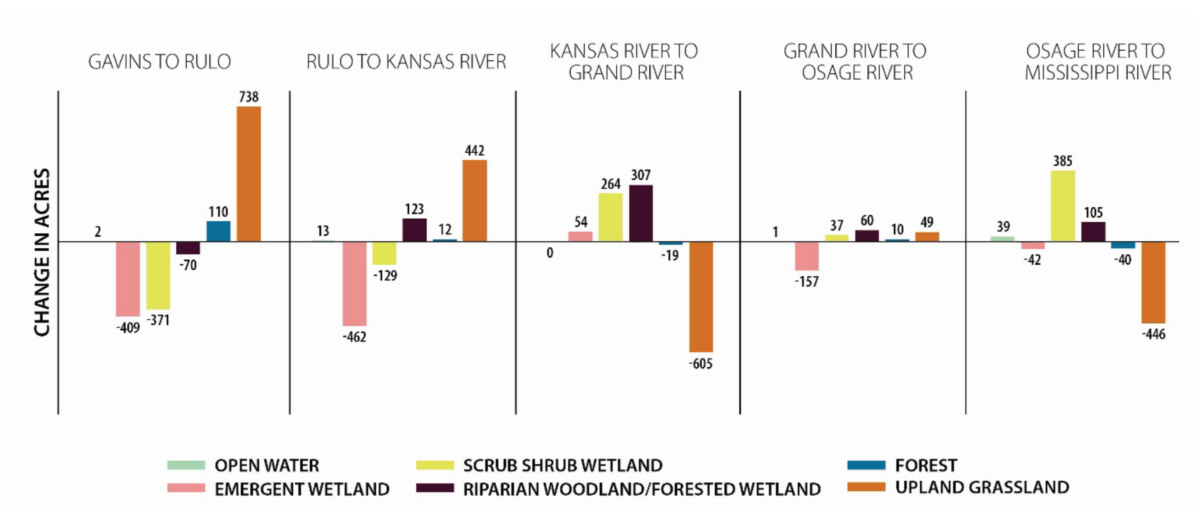


Figure 3-45. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 3 Compared to Alternative 1 – Lower River)

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Overall, comparing Alternative 3 to Alternative 1, the scrub shrub wetland habitat class would have the greatest increasing trend. Open water, forest, and upland grassland would also have an increasing trend and emergent wetland and riparian woodland/forested wetland would have a decreasing trend as modeled. Habitat classes as modeled in all reaches vary in the change among wetter and drier habitat classes likely from the lack of any reoccurring flow releases and negligible impacts on the overall hydrology in the river and reservoir elevations under Alternative 3 compared to Alternative 1. Overall river-wide changes in the percent of each habitat class as modeled under Alternative 3 compared to Alternative 1 is small (Figure 3-44 and Figure 3-45), ranging from a 3 percent increase in forest, and a 4 percent decrease in emergent wetland. The modeling results presented for fish and wildlife habitat and wetland habitat classes in each study reach are for the POR.

Depth Classes

For all river reaches combined, the 12–18 and greater than 18 foot depth classes would have an increasing trend in the overwintering late period. The 6–9, 9–12, 12–18, and greater than 18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 9–12, and greater than 18 foot depth classes would have an increasing trend in the late spawning period. None of the depth classes would have an increasing trend in the summer rearing and growth period. The greater than 18 foot depth class 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 3-37 through Figure 3-41).

There was a slight decrease in the calculated diversity index for Alternative 3 compared to Alternative 1. Diversity across seasonal periods of acres of depth classes for Alternative 3 was calculated as 0.77 still indicating a moderately high amount of evenness and diversity of depths across all seasons. 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 (6671.3 percent) during the early spawning period and the 9–12 foot depth class would have the greatest decreasing trend (95.4 percent) in the overwintering early period.

Garrison to Oahe: The 9–12 foot depth class would have the greatest increasing trend (40.8 percent) during the late spawning period and the 12–18 foot depth class would have the greatest decreasing trend (91.4 percent) in the summer rearing and growth period.

Fort Randall to Gavins Point: The greater than 18 foot depth class would have the greatest increasing trend (127.9 percent) during the overwintering late period and the 12–18 foot depth class would have the greatest decreasing trend (2.5 percent) in the overwintering early period.

Lower River

Gavins Point to Rulo: The greater than 18 foot depth class would have the greatest increasing trend (999.1 percent) during the late spawning period and the 12–18 foot depth class would have the greatest decreasing trend (23.5 percent) in the late spawning period.

Rulo to Mississippi River: The greater than 18 foot depth class would have the greatest increasing trend (27.4 percent) during the overwintering early period and the greater than 18 foot depth class would have the greatest decreasing trend (19.9 percent) in the early spawning period.

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

The total number of flow occurrences below 9,000 cfs in the Fort Randall reach had a decreasing trend as modeled for the POR; however, the daily average of these occurrences did not change under Alternative 3 compared to Alternative 1 as modeled for the POR. Therefore, beneficial 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 332 acres of ESH would be constructed annually in years when construction is needed. Compared to Alternative 1, 168 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 from an increase in habitat for many wildlife species, as described under Alternative 1. 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.

Gavins Point One-Time Spawning Cue Test

Flows equivalent to the one-time spawning cue test were modeled for multiple years in the POR under Alternative 6. While the spawning cue release under Alternative 1 and the one-time spawning cue test under 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 one-time spawning cue test under Alternative 3 would be small compared to existing conditions, similar to those described under Alternative 1. However, long-term benefits to 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.

Adverse impacts at the upper three reservoirs under Alternative 3 could occur following the potential one-time spring pulse flow test. Significant drawdown of the upper three reservoirs could have effects to the fisheries. Timely water level manipulation (i.e., water levels, inflow, and outflow) for fisheries management is important for the overall reproduction of fish in the reservoirs. It can take a number of years for the reservoirs to refill after a release, especially in relatively drier or drought conditions, with prolonged adverse impacts to the fisheries. Maintaining an adequate water level and having a rising pool during the spring spawning and egg incubation period are critical for maintaining the fisheries. If the criteria noted in the Missouri

River Fisheries Management Plans for these three reservoirs are not met, large impacts to the fisheries could occur. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 3 would remain relatively stable. However, if significant drawdown were to occur in these two reservoirs the fisheries would experience similar impacts as described for the upper three reservoirs.

Spawning Habitat Construction

Spawning habitat for pallid sturgeon 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 Sturgeon 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 sturgeon habitat designed following the IRC is anticipated to be primarily accomplished through structure modifications and/or channel widening under Alternative 3. Under Alternative 3, up to 3,380 acres of new early life stage pallid sturgeon habitat following the IRC would be created. Compared to Alternative 1, there would be 619 fewer acres of early life stage pallid sturgeon habitat construction. While slightly less adverse impacts would occur under Alternative 3 compared to Alternative 1, less beneficial impacts to fish and wildlife would occur due to the smaller amount of habitat. 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 from displacement and disruption of fish and wildlife and for species that use terrestrial habitat that is converted to aquatic habitat. Negligible impacts from vegetation, predator management activities, and human restriction measures could occur from changes to or loss of habitat or lethal removal of individual wildlife species. 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. Overall, the changes in the percent of each habitat class as modeled under Alternative 3 compared to Alternative 1 would be small. Depth class diversity across seasonal periods is moderately high but slightly decreased compared to Alternative 1. Creation of fish and wildlife habitat from habitat construction and increased hydrology following the one-time spawning cue test would result in long-term benefits by providing a net increase in habitat in localized areas. Large impacts could occur to the fisheries in the upper three reservoirs from draw down of reservoir elevations if criteria for management of water levels, inflow, and outflow for the reservoirs are not met. These impacts would be limited to fish species in the reservoirs. Alternative 3 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small and localized 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 3-46 and Figure 3-47. 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.

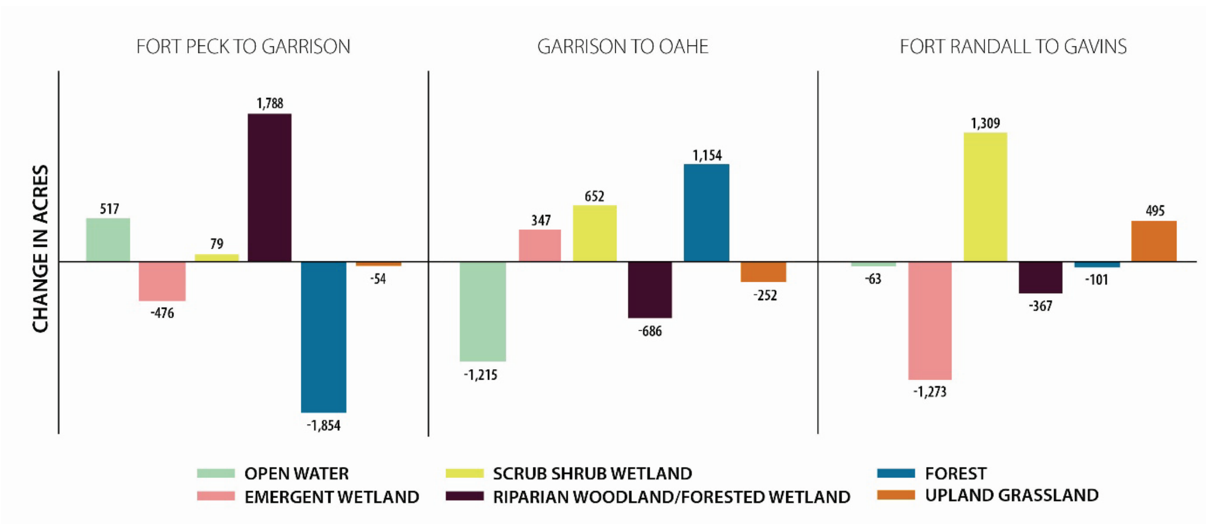


Figure 3-46. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 4 Compared to Alternative 1 – Upper River)

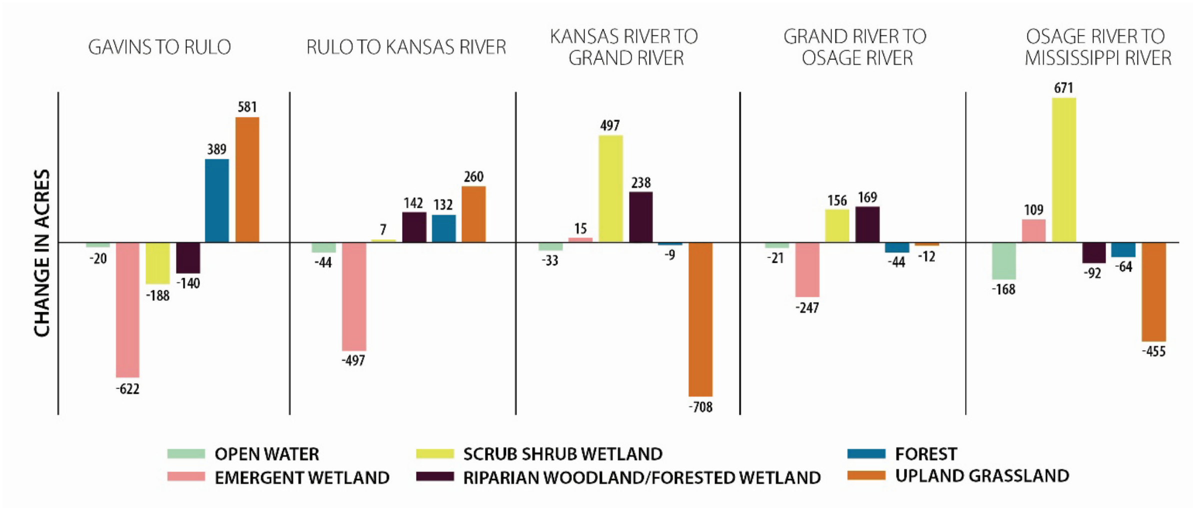


Figure 3-47. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 4 Compared to Alternative 1 – Lower River)

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Overall, under Alternative 4 the scrub shrub wetland habitat class would have the greatest increasing trend compared to Alternative 1. Riparian woodland/forested wetland also would have an increasing trend and open water, emergent wetland, forest, and upland grassland would have a decreasing trend as modeled. Habitat classes as modeled in all reaches vary in the change among wetter and drier habitat classes likely from the changes in reservoir elevations in the upper three reservoirs and the downstream effects. Overall river-wide changes in the percent of each habitat class as modeled under Alternative 4 compared to Alternative 1 is small (Figure 3-46 and Figure 3-47), ranging from a 4 percent increase in riparian woodland/forested wetland, and a 6 percent decrease in emergent wetland. The modeling results presented for fish and wildlife habitat and wetland habitat classes in each study reach are for the POR.

Depth Classes

For all river reaches combined, the 0–3, 3–6, 6–9, 12–18, and greater than 18 foot depth classes would have an increasing trend in the overwintering late period. The 0–3, 6–9, and greater than 18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 9–12, 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 6–9 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 3-37 through Figure 3-41).

There was no change in the calculated diversity index for Alternative 4 compared to Alternative 1. Diversity across seasonal periods of acres of depth classes for Alternative 4 was calculated as 0.81 indicating a moderately high amount of evenness and diversity of depths across all seasons. 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 (4349.8 percent) during the early spawning period and the 12–18 foot depth class would have the greatest decreasing trend (97.4 percent) in the late spawning period.

Garrison to Oahe: The 12–18 foot depth class would have the greatest increasing trend (70.2 percent) during the overwintering late period and the greater than 18 foot depth class would have the greatest decreasing trend (92.5 percent) in the early spawning period.

Fort Randall to Gavins Point: The greater than 18 foot depth class would have the greatest increasing trend (127.8 percent) during the overwintering late period and the 12–18 foot depth class would have the greatest decreasing trend (65.3 percent) in the summer rearing and growth period.

Lower River

Gavins Point to Rulo: The 12–18 foot depth class would have the greatest increasing trend (131.4 percent) during the overwintering early period and the 12–18 foot depth class would have the greatest decreasing trend (77.0 percent) in the late spawning period.

Rulo to Mississippi River: The greater than 18 foot depth class would have the greatest increasing trend (86.9 percent) during the overwintering late period and the greater than 18 foot depth class would have the greatest decreasing trend (34.9 percent) in the early spawning period.

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

The total number of flow occurrences below 9,000 cfs in the Fort Randall reach had an increasing trend as modeled for the POR; however, the daily average of these occurrences did not change under Alternative 4 compared to Alternative 1 as modeled for the POR. 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 195 acres of ESH would be constructed annually in years where construction is needed. Compared to Alternative 1, 31 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 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, and by increasing backwaters and roosting and feeding areas for migrating birds, 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.

Adverse impacts at the upper three reservoirs under Alternative 4 would occur during the years following a release. Significant drawdown of the upper three reservoirs could have effects to the fisheries. Timely water level manipulation (i.e., water levels, inflow, and outflow) for fisheries management is important for the overall reproduction of fish in the reservoirs. It can take a number of years for the reservoirs to refill after a release, especially in relatively drier or drought conditions, with prolonged adverse impacts to the fisheries. Maintaining an adequate water level and having a rising pool during the spring spawning and egg incubation period are critical for maintaining the fisheries. If the criteria noted in the Missouri River Fisheries Management Plans for these three reservoirs are not met, large impacts to the fisheries could occur. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 4 would remain relatively stable. However, if significant drawdown were to occur in these two reservoirs the fisheries would experience similar impacts as described for the upper three reservoirs. Adverse impacts could also occur to fish species from fish entrainment in the turbines at the hydropower projects during these releases, however, relatively colder and more oxygenated water could benefit fish during these releases.

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 Sturgeon Habitat (IRC)

The impacts from channel reconfiguration for creation of early life stage pallid sturgeon 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 from displacement and disruption of fish and wildlife and for species that use terrestrial habitat that is converted to aquatic habitat. Negligible impacts from vegetation, predator management activities, and human restriction measures could occur from changes to or loss of habitat or lethal removal of individual wildlife species. 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. There would be an increasing trend in scrub shrub wetland and riparian woodland/forested wetland and a decreasing trend in emergent wetland, forest, and upland grassland as modeled under Alternative 4 compared to Alternative 1. Overall, changes in the percent of each habitat class as modeled under Alternative 4 compared to Alternative 1 would be small. Depth class diversity across seasonal periods is moderately high and the same compared to Alternative 1. Creation of fish and wildlife habitat from habitat construction and increased hydrology following flow releases would result in long-term benefits by providing a net increase in habitat in localized areas. Large impacts could occur to the fisheries in the upper three reservoirs from draw down of reservoir elevations if criteria for management of water levels, inflow, and outflow for the reservoirs are not met. These impacts would be limited to fish species in the reservoirs. Alternative 4 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small or localized 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 3-48 and Figure 3-49. 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.

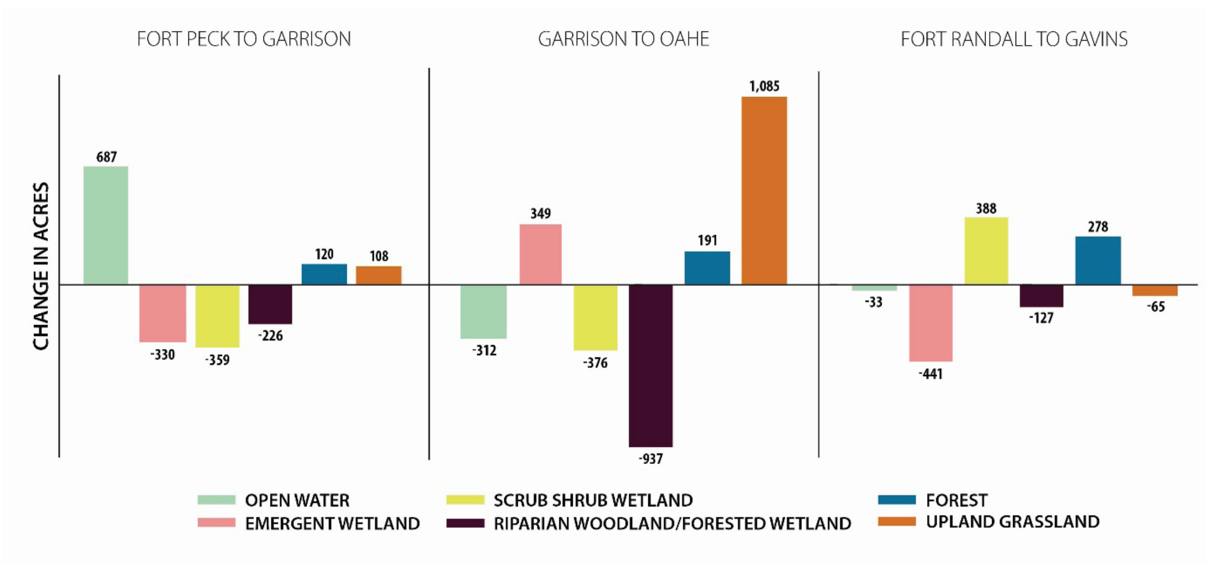


Figure 3-48. Modeled Changes in Acres of Fish and Wildlife Habitat Classes (Alternative 5 Compared to Alternative 1 – Upper River)

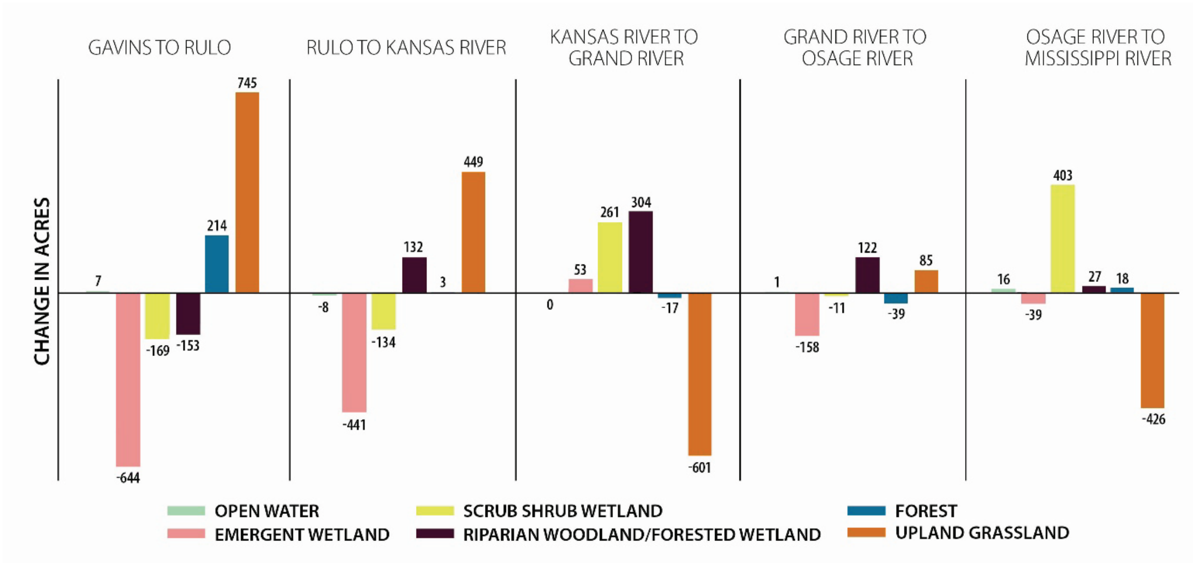


Figure 3-49. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 5 Compared to Alternative 1 – Lower River)

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Overall, under Alternative 5 the upland grassland habitat class would have the greatest increasing trend compared to Alternative 1. Open water, scrub shrub wetland, and forest would also have an increasing trend and emergent wetland and riparian woodland/forested wetland would have a decreasing trend as modeled. Habitat classes as modeled in all reaches vary in the change among wetter and drier habitat classes likely from the changes in reservoir elevations in the upper three reservoirs and the downstream effects. Overall river-wide changes in the percent of each habitat class as modeled under Alternative 5 compared to Alternative 1 is small (Figure 3-48 and Figure 3-49), ranging from a 3 percent increase in forest and upland grassland, and a 4 percent decrease in emergent wetland. The modeling results presented for fish and wildlife habitat and wetland habitat classes in each study reach are for the POR.

Depth Classes

For all river reaches combined, the 0–3, 6–9, 9–12, 12–18, and greater than 18 foot depth classes would have an increasing trend in the overwintering late period. The 6–9 and 9–12 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 6–9, and 9–12 foot depth class would have an increasing trend in the late spawning period. The 6–9 and 9–12 foot depth class would have an increasing trend in the summer rearing and growth period. The 6–9 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 3-37 through Figure 3-41).

There was no change in the calculated diversity index for Alternative 5 compared to Alternative 1. Diversity across seasonal periods of acres of depth classes for Alternative 5 was calculated as 0.81 indicating a moderately high amount of evenness and diversity of depths across all seasons. 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 6–9 foot depth class would have the greatest increasing trend (1699.4 percent) during the overwintering late period and the 9–12 foot depth class would have the greatest decreasing trend (95.3 percent) in the overwintering early period.

Garrison to Oahe: The 12–18 foot depth class would have the greatest increasing trend (362.5 percent) during the overwintering early period and the 12–18 foot depth class would have the greatest decreasing trend (86.4 percent) in the early spawning period.

Fort Randall to Gavins Point: The 12–18 foot depth class would have the greatest increasing trend (139.4 percent) during the summer rearing and growth period and the greater than 18 foot depth class would have the greatest decreasing trend (7.6 percent) in the summer rearing and growth period.

Lower River

Gavins Point to Rulo: The 9–12 foot depth class would have the greatest increasing trend (2267.8 percent) during the overwintering late period and the 12–18 foot depth class would have the greatest decreasing trend (76.9 percent) in the late spawning period.

Rulo to Mississippi River: The greater than 18 foot depth class would have the greatest increasing trend (30.6 percent) during the overwintering early period and the 12–18 foot depth class would have the greatest decreasing trend (46.4 percent) in the early spawning period.

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

The total number of flow occurrences below 9,000 cfs in the Fort Randall reach had an increasing trend as modeled for the POR; however, the daily average of these occurrences did not change under Alternative 5 compared to Alternative 1 as modeled for the POR. 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 253 acres of ESH would be constructed annually in years where construction is needed. Compared to Alternative 1, 89 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, and by increasing backwaters and roosting and feeding areas for migrating birds. 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.

Adverse impacts at the upper three reservoirs under Alternative 5 would occur during the years following a release. Significant drawdown of the upper three reservoirs could have effects to the fisheries. Timely water level manipulation (i.e., water levels, inflow, and outflow) for fisheries management is important for the overall reproduction of fish in the reservoirs. It can take a number of years for the reservoirs to refill after a release, especially in relatively drier or drought conditions, with prolonged adverse impacts to the fisheries. Maintaining an adequate water level and having a rising pool during the spring spawning and egg incubation period are critical for maintaining the fisheries. If the criteria noted in the Missouri River Fisheries Management Plans for these three reservoirs are not met, large impacts to the fisheries could occur. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 5 would remain relatively stable. However, if significant drawdown were to occur in these two reservoirs the fisheries would experience similar impacts as described for the upper three reservoirs. Adverse impacts could also occur to fish species from fish entrainment in the turbines at the hydropower projects during these releases, however, relatively colder and more oxygenated water could benefit fish during these releases.

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 Sturgeon Habitat (IRC)

The impacts from channel reconfiguration for creation of early life stage pallid sturgeon 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 from displacement and disruption of fish and wildlife and for species that use terrestrial habitat that is converted to aquatic habitat. Negligible impacts from vegetation, predator management activities, and human restriction measures could occur from changes to or loss of habitat or lethal removal of individual wildlife species. 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. There would be an increasing trend in scrub shrub wetland, forest and upland grassland and a decreasing trend in emergent wetland and riparian woodland/forested wetland as modeled under Alternative 5 compared to Alternative 1. Overall, changes in the percent of each habitat class as modeled under Alternative 5 compared to Alternative 1 would be small. Depth class diversity across seasonal periods is moderately high and the same compared to Alternative 1. Creation of fish and wildlife habitat from habitat construction and increased hydrology following flow releases would result in long-term benefits by providing a net increase in habitat in localized areas. Large impacts could occur to the fisheries in the upper three reservoirs from draw down of reservoir elevations if criteria for management of water levels, inflow, and outflow for the reservoirs are not met. These impacts would be limited to fish species in the reservoirs. Alternative 5 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small or localized 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 3-50 and Figure 3-51. 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.

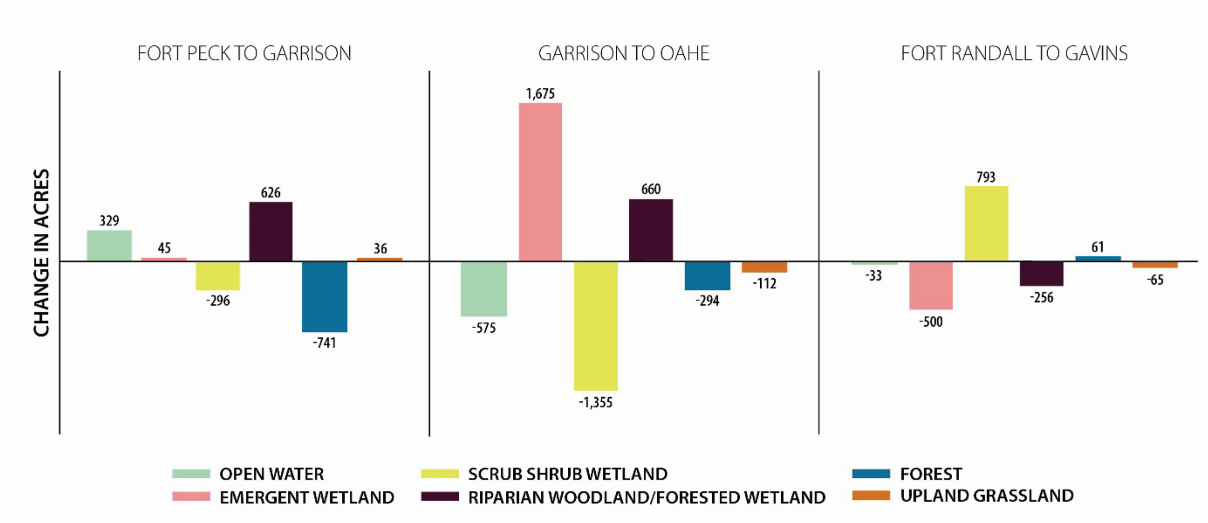


Figure 3-50. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 6 Compared to Alternative 1 – Upper River)

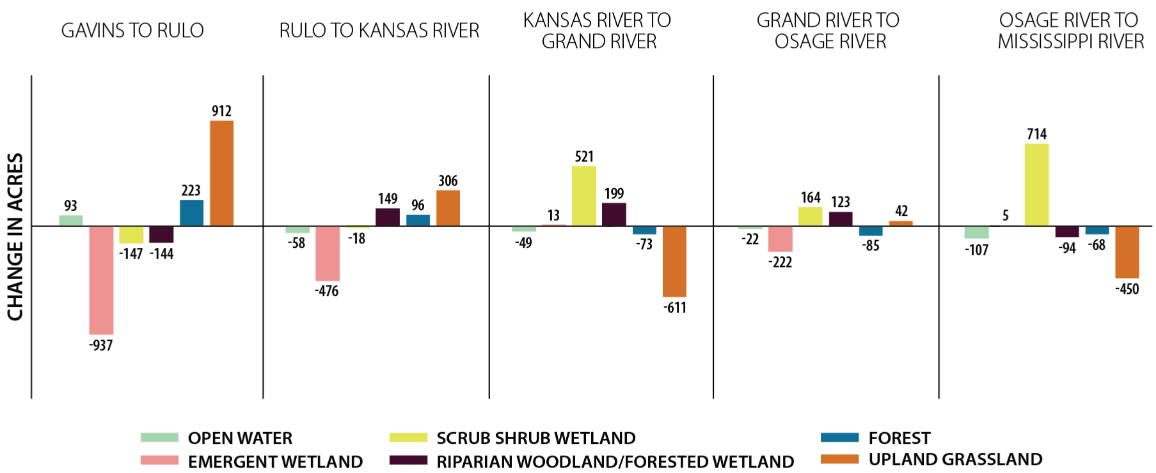


Figure 3-51. Modeled Change in Acres of Fish and Wildlife Habitat Classes (Alternative 6 Compared to Alternative 1 – Lower River)

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. Scrub shrub wetland and upland grassland would also have an increasing trend and open water, emergent wetland, and forest would have a decreasing trend as modeled. Habitat classes as modeled in all reaches vary in the change among wetter and drier habitat classes likely from the changes in reservoir elevations in the upper three reservoirs and the downstream effects. Overall river-wide changes in the percent of each habitat class as modeled under Alternative 6 compared to Alternative 1 is small (Figure 3-50 and Figure 3-51), ranging from a 5 percent increase in riparian woodland/forested wetland, and a 4 percent decrease in forest. The modeling results presented for fish and wildlife habitat and wetland habitat classes in each study reach are for the POR.

Depth Classes

For all river reaches combined, the 0–3, 3–6, 6–9, 9–12, and greater than 18 foot depth classes would have an increasing trend in the overwintering late period. The 6–9, 12–18, and greater than 18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 6–9, 9–12, and greater than 18 foot depth classes would have an increasing trend in the late spawning period. The 6–9, 9–12, and greater than 18 foot depth classes would have an increasing trend in the summer rearing and growth period. The 6–9, 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 3-37 through Figure 3-41).

There was a slight decrease in the calculated diversity index for Alternative 3 compared to Alternative 1. Diversity across seasonal periods of acres of depth classes for Alternative 3 was calculated as 0.76 still indicating a moderately high amount of evenness and diversity of depths across all seasons. 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 (4338.9 percent) during the late spawning period and the 9–12 foot depth class would have the greatest decreasing trend (95.3 percent) in the overwintering early period.

Garrison to Oahe: The 12–18 foot depth class would have the greatest increasing trend (453.6 percent) during the overwintering early period and the 12–18 foot depth class would have the greatest decreasing trend (90.1 percent) in the summer growth and rearing period.

Fort Randall to Gavins Point: The greater than 18 foot depth class would have the greatest increasing trend (123.3 percent) during the overwintering late period and the 0–3 foot depth class would have the greatest decreasing trend (7.7 percent) in the overwintering early period.

Lower River

Gavins Point to Rulo: The greater than 18 foot depth class would have the greatest increasing trend (1157.9 percent) during the late spawning period and the 12–18 foot depth classes would have the greatest decreasing trend (10.6 percent) in the late spawning period.

Rulo to Mississippi River: The greater than 18 foot depth class would have the greatest increasing trend (11.0 percent) during the overwintering late period and the greater than 18 foot depth class would have the greatest decreasing trend (39.9 percent) in the early spawning period.

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

The total number of flow occurrences below 9,000 cfs in the Fort Randall reach had an increasing trend as modeled for the POR; however, the daily average of these occurrences did not change under Alternative 6 compared to Alternative 1 as modeled for the POR. 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 245 acres of ESH would be constructed annually in years where construction is needed. Compared to Alternative 1, 81 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.

Adverse impacts at the upper three reservoirs under Alternative 6 would occur during the years following a release. Significant drawdown of the upper three reservoirs could have effects to the fisheries. Timely water level manipulation (i.e., water levels, inflow, and outflow) for fisheries management is important for the overall reproduction of fish in the reservoirs. It can take a number of years for the reservoirs to refill after a release, especially in relatively drier or drought conditions, with prolonged adverse impacts to the fisheries. Maintaining an adequate water level and having a rising pool during the spring spawning and egg incubation period are critical for maintaining the fisheries. If the criteria noted in the Missouri River Fisheries Management Plans for these three reservoirs are not met, large impacts to the fisheries could occur. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 6 would remain relatively stable. However, if significant drawdown were to occur in these two reservoirs the fisheries would experience similar impacts as described for the upper three reservoirs. Adverse impacts could also occur to fish species from fish entrainment in the turbines at the hydropower projects during these releases, however, relatively colder and more oxygenated water could benefit fish during these releases.

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 Sturgeon Habitat (IRC)

The impacts from channel reconfiguration for creation of early life stage pallid sturgeon 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 and construction related from displacement and disruption of fish and wildlife and for species that use terrestrial habitat that is converted to aquatic habitat. Negligible impacts from vegetation, predator management activities, and human restriction measures could occur from changes to or loss of habitat or lethal removal of individual wildlife species. 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. There would be an increasing trend in scrub shrub wetland, riparian woodland/forested wetland, and upland grassland and a decreasing trend in emergent wetland and forest as modeled under Alternative 6 compared to Alternative 1. Overall, changes in the percent of each habitat class as modeled under Alternative 6 compared to Alternative 1 would be small. Depth class diversity across seasonal periods is moderately high and slightly decreased compared to Alternative 1. Creation of fish and wildlife habitat from habitat construction and increased hydrology following flow releases would result in long-term benefits by providing a net increase in habitat in localized areas. Large impacts could occur to the fisheries in the upper three reservoirs from draw down of reservoir elevations if criteria for management of water levels, inflow, and outflow for the reservoirs are not met. These impacts would be limited to fish species in the reservoirs. Alternative 6 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small or localized, 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 13751, 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 13751 is met. It is not expected that any invasive aquatic wildlife species would spread because of any of the management actions due to site-specific best management practices that would be followed. 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 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.

As a result of sediment deposited in the upper ends of the reservoirs, the river channel downstream of the dams deepen (degrades) as sediment that erodes from the channel floor is not replenished with sediment from upstream sources (USACE 2014e). Sand and aggregate mining in the lower Missouri River between Rulo, Nebraska and the confluence with the Mississippi River in St. Louis also contribute to degradation. 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 has led to increased erosion of streambanks and the riverbed, aquatic habitat degradation, lowering of the groundwater table in the floodplain, potential conversion of some wetland to upland, and reduced fish access up some of the affected tributaries. As described as part of the year 0 and year 15 analyses (Section 3.2.2.3, Impacts on Hydrology from the Alternatives) degradation and the effects on fish and wildlife and habitat would continue because of the sediment trapping behind dams as well as by continued sand and gravel aggregate mining downstream of Rulo, Nebraska, which lowers the riverbed and the stage of the river over time. Future degradation trends have a similar effect on all of the alternatives and modeling indicates that the action alternatives would not substantially contribute to degradation.

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, continued degradation, 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 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 and localized 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 because 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 and drawdown of reservoirs. 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 sturgeon 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 pallid sturgeon, least tern, and piping plover, 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 121 additional species that may occur in the area have been given a special-status designation at the federal or state level. These species include 15 plants, 31 birds, 12 mammals, 17 reptiles and amphibians, 23 fish, 19 mussels and gastropods, and 4 insects (Appendix E: Other Special-Status Species). Thirteen 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 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. In addition to the bald eagle, northern long-eared bat, and Indiana bat, the Draft EIS included whooping crane and western prairie-fringed orchid in this section. However, during ESA Section 7 consultation with USFWS between the Draft EIS and Final EIS (Appendix I), it was determined the proposed action would not affect whooping crane and that western prairie fringed orchid was not present in the project area, therefore, they are no longer included here.

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 2015d).

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 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 southern North Dakota, 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 the ESA. White-nose syndrome continues to spread and USFWS updates the white-nose syndrome zone map the first of every month. Some of the counties adjacent to the Missouri River 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 2015d).

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 2007c). 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 2007c). 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 2016b).

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 2007c). Threats to this species include loss or alteration of cave and forest habitats and human disturbance of hibernating individuals (USFWS 2007c).

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 bald eagle, northern long-eared bat, and Indiana bat, identified by 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 ESH construction in the Fort Peck and Garrison Reaches would be outside the white-nose syndrome zone. Therefore, only individuals occurring in the current white-nose syndrome zone and in reaches where ESH construction would occur are subject to incidental take restrictions under the ESA, in accordance with the 4(d) Rule (81 FR 1901). Avoidance, minimization, and mitigation measures would be developed and implemented at the site-specific level when individual projects are implemented.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 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 3-17 summarizes the environmental impacts to the three species carried forward for detailed analysis by alternative.

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. 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 northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat.

Predator management actions, as described in Chapter 2, 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 northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat.

Table 3-17. Summary of Impacts to Other Special-Status Species

	Bald Eagle	Northern Long-Eared Bat	Indiana Bat
Alternative 1	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 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 7,046 acres of land acquisition and habitat development and land management on MRRP lands.
Alternative 2	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 (−5%) in riparian 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 45,716 acres of land acquisition and habitat development and land management on MRRP lands. Decreasing trend (−2%) in combined riparian 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 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 combined riparian woodland/forested wetland and forest habitats in the lower river basin. *

	Bald Eagle	Northern Long-Eared Bat	Indiana Bat
Alternative 3	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. No change (0%) in riparian 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. No change (−0%) in combined riparian woodland/forested wetland and forest habitats in the upper basin and increasing trend (9%) in the lower 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 (9%) in combined riparian woodland/forested wetland and forest habitats in the lower river basin. *
Alternative 4	Same as Alternative 3 with an increasing trend (4%) in riparian woodland/forested wetland habitat. *	Same as Alternative 3 with no change (0%) in combined riparian woodland/forested wetland and forest habitats in the upper basin and increasing trend (10%) in the lower basin. *	Same as Alternative 3 with an increasing trend (10%) in combined riparian woodland/forested wetland and forest habitats in the lower river basin. *
Alternative 5	Same as Alternative 3 with a decreasing trend (−3%) in riparian woodland/forested wetland habitat. *	Same as Alternative 3 with a decreasing trend (−2%) in combined riparian woodland/forested wetland and forest habitats in the upper basin and increasing trend (9%) in the lower basin. *	Same as Alternative 3 with an increasing trend (9%) in combined riparian woodland/forested wetland and forest habitats in the lower river basin. *
Alternative 6	Same as Alternative 3 with an increasing trend (5%) in riparian woodland/forested wetland habitat. *	Same as Alternative 3 with no change 0%) in combined riparian woodland/forested wetland and forest habitats in the upper basin and increasing trend (5%) in the lower basin. *	Same as Alternative 3 with an increasing trend (5%) in combined riparian woodland/forested wetland and forest habitats in the lower river basin. *

* 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. 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 northern long-eared bats or Indiana bats 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 164 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). 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 Section 3.5.2, Environmental Consequences of the “Fish and Wildlife Habitat” section and described in detail in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Bald Eagle

Construction of ESH and early life stage pallid sturgeon habitat could temporarily displace or disturb bald eagles resulting in direct adverse impacts. Bald eagles could 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. Such impacts would be unlikely to occur because USACE coordinates with state wildlife agencies and USFWS on location of known bald eagle nests and bald eagle activity as part of site-specific coordination. The ESH site selection model incorporates known bald eagle nest locations in order to identify sites where a greater focus may be needed to avoid impacts to bald eagles. USACE would consult with USFWS in compliance with the BGEPA if construction activities for ESH or pallid sturgeon habitat projects had the potential to impact bald eagles. Temporary displacement of prey species could indirectly impact bald eagles. Direct and indirect adverse impacts are anticipated to be temporary and negligible because site-specific coordination would make the potential for impacts unlikely and if disturbance were to occur, the 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.

Under Alternative 1, riparian 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.

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

Direct adverse impacts to northern long-eared bat from ESH or early life stage pallid sturgeon habitat construction would have the potential to occur if tree clearing were required by the project. Timing and location of the tree clearing determines the potential for impacts. USACE would coordinate with USFWS during site-specific project implementation to ensure impacts are avoided or minimized. For projects within the State of Missouri, USACE typically restricts tree clearing to the bat inactive season of November 1 to March 31. Additional restrictions on the amount of tree clearing may be required depending on the proximity of the action to known bat capture sites or hibernaculum. For projects outside of Missouri, but still within the white-nose syndrome zone, USACE would comply with the provisions of the 4(d) rule and avoid tree clearing between June 1 and July 31 and within a 0.25-mile radius of a known roost tree or hibernaculum. The Garrison reach of the Missouri River is outside of the white-nose syndrome zone (based on USFWS mapping dated 2 July 2018) and no impacts would be anticipated in that area. White-nose syndrome continues to spread and USFWS updates the white-nose syndrome zone map regularly. Avoidance, minimization, and mitigation measures would be developed and implemented at the site-specific level when individual projects are implemented. As a result of site-specific coordination and conservation measures, any adverse impacts from ESH or early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur.

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 would 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 developed. Specific impacts would depend on the locations of management actions.

Indiana Bat

Due to the range of this species, only early life stage pallid sturgeon habitat construction within the State of Missouri would have potential to impact the species. ESH construction would not occur within the range of the Indiana bat and therefore, would have no impacts to this species. Direct adverse impacts to Indiana bat from early life stage pallid sturgeon habitat construction would have the potential to occur if tree clearing was required by the project. Timing and location of the tree clearing determines the potential for impacts. USACE would coordinate with USFWS during site-specific project implementation to ensure impacts are avoided or minimized. For projects within the State of Missouri, USACE typically restricts tree clearing to the bat inactive season of November 1 to March 31. Additional restrictions on the amount of tree clearing may be required depending on the proximity of the action to known bat capture sites or hibernaculum. As a result of site-specific coordination and conservation measures, any adverse impacts from early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur.

Under Alternative 1, riparian 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 developed. Specific impacts would depend on the locations of management actions.

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, 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 due to temporary disturbance of habitats resulting in displacement of individuals. Mechanical ESH and early life stage pallid sturgeon habitat construction would result in direct and indirect, temporary, negligible adverse impacts to bald eagles, northern long-eared bats, and Indiana bats because individuals would be temporarily displaced. Vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat, because prey species would be removed or displaced. However, these actions are not anticipated to impact northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat. Long-term, 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 result in significant adverse 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 1,331 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.

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. Such impacts would be unlikely to occur because USACE coordinates with state wildlife agencies and USFWS on location of known bald eagle nests and bald eagle activity as part of site-specific coordination. The ESH site selection model incorporates known bald eagle nest locations in order to identify sites where a greater focus may be needed to avoid impacts to bald eagles. USACE would consult with USFWS in compliance with the BGEPA if construction activities for ESH or pallid sturgeon habitat projects had the potential to impact bald eagles. Specific impacts would depend on the locations of management actions.

Flow actions to be implemented under Alternative 2 would result in a decreasing trend (less than 5 percent) compared to Alternative 1 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 decrease would result in potential for a direct, adverse, long-term, negligible impact for bald eagles compared to Alternative 1. Direct and indirect, adverse impacts are anticipated to be temporary and negligible because site-specific coordination would make the potential for impacts unlikely and if disturbance were to occur, the 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.

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 because habitats suitable for bald eagle foraging would be managed and protected against potential future development. These impacts would be large compared to Alternative 1 because an additional 38,670 acres land would be acquired and managed. 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

Temporary 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. Under Alternative 2 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. As previously noted, USFWS updates the white-nose syndrome zone map regularly. Avoidance, minimization, and mitigation measures would be developed and implemented at the site-specific level when individual projects are implemented. As a result of site-specific coordination and conservation measures, any adverse impacts from ESH or early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as described under Alternative 1.

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 (-2 percent) in combined riparian woodland/forested wetland and forest habitat in the upper river and a positive trend (21 percent) in the lower river compared to Alternative 1 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

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. However, under Alternative 2 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. However, as a result of site-specific coordination and conservation measures, any adverse impacts from early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as described under Alternative 1.

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 compared to Alternative 1 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. Alternative 2 would potentially result in a negligible adverse and a long-term, small beneficial impact for Indiana bats compared to Alternative 1.

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 mechanical construction of ESH, channel reconfiguration for creation of early life stage pallid sturgeon habitat, and flow actions to be implemented under Alternative 2. Direct or indirect adverse impacts would be both temporary and 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. Special-status species that use ESH habitat (birds) could benefit in the long-term because mechanical ESH construction under Alternative 2 would result in a net increase in this habitat type.

Land acquisition and habitat development and land management on MRRP lands would have direct and indirect, long-term, 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, due to temporary disturbance of habitats resulting in displacement of individuals. 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 bald eagles, northern long-eared bats, and Indiana bats because individuals would be temporarily displaced. Vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat, because prey species would be removed or displaced. However, these actions are not anticipated to impact northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat. Riparian woodland/forested wetland habitats would have a decreasing trend in the upper river and an increasing trend in the lower river, while forest habitat would have an increasing trend in both the upper and 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 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 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 332 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.

The site-specific ESA compliance process for Alternative 3, which addresses bald eagle, northern long-eared bat, and Indiana bat, is included in Appendix I.

Bald Eagle

Direct adverse impacts to bald eagles could 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 could be greater under Alternative 3 because ESH construction would occur at a 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. Such impacts would be unlikely to occur because USACE coordinates with state wildlife agencies and USFWS on location of known bald eagle nests and bald eagle activity as part of site-specific coordination. The ESH site selection model incorporates known bald eagle nest locations in order to identify sites where a greater focus may be needed to avoid impacts to bald eagles. USACE would consult with USFWS in compliance with the BGEPA if construction activities for ESH or pallid sturgeon habitat projects had the potential to impact bald eagles. Temporary displacement of prey species could indirectly impact bald eagles.

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.

Direct and indirect adverse impacts are anticipated to be temporary and negligible because site-specific coordination would make the potential for impacts unlikely and if disturbance were to occur, the 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. Specific impacts would depend on the locations of management actions.

Alternative 3 would result in no change (0 percent) in riparian woodland/forested wetland habitat compared to Alternative 1 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). Therefore, there would be no change in bald eagle nesting habitat compared to Alternative 1. 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 developed.

Northern Long-Eared Bat

Alternative 3 could have both potential adverse and beneficial impacts to the northern long-eared bat. Impacts that could 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. Under Alternative 3 ESH construction would occur at a higher rate, compared to Alternative 1. Adverse impacts could occur if mature trees, which may serve as roosting or nesting sites, are removed. As previously noted, USFWS updates the white-nose syndrome zone map regularly. Avoidance, minimization, and mitigation measures would be developed and implemented at the site-specific level when individual projects are implemented. As a result of site-specific coordination and conservation measures, any adverse impacts from ESH or early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as 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 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. There would be no change (0 percent) in combined riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (9 percent) in the lower river compared to Alternative 1, 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. However, as a result of site-specific coordination and conservation measures, any adverse impacts from early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as described under Alternative 1.

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 (9 percent) in riparian woodland/forested wetland and forest habitat in the lower river compared to Alternative 1 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.

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 construction of ESH, channel reconfiguration for creation of early life stage pallid sturgeon habitat, and construction of pallid sturgeon spawning habitat. Adverse impacts would be both temporary and 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.

Land acquisition and habitat development and land management on MRRP lands would have direct and indirect, long-term, 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 compared to Alternative 1 due to temporary disturbance of habitats resulting in displacement of individuals. 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 bald eagles and northern long-eared bats because individuals would be temporarily displaced. Vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat, because prey species would be removed or displaced. However, these actions are not anticipated to impact northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat. Riparian woodland/forested wetland habitats would have a decreasing trend in the upper river. In the lower river, riparian woodland/forested wetland habitat would have an increasing trend. Forest habitat would have an increasing trend in both the upper and lower river under Alternative 3 compared to Alternative 1. These habitat trends would have long-term negligible adverse and beneficial impacts on bald eagles, northern long-eared bats, and Indiana bats. Long-term, beneficial impacts would occur from land acquisition and habitat development and habitat creation. Impacts from management actions are not anticipated 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 195 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.

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.

Direct and indirect, adverse impacts are anticipated to be temporary and negligible because site-specific coordination would make the potential for impacts unlikely and if disturbance were to occur, the 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.

Spring reservoir release under Alternative 4 would result in a slight increasing trend (4 percent) in riparian woodland/forested wetland habitat compared to Alternative 1 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, negligible impact for bald eagles compared to Alternative 1. 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 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. As previously noted, USFWS updates the white-nose syndrome zone map regularly. Avoidance, minimization, and mitigation measures would be developed and implemented at the site-specific level when individual projects are implemented. As a result of site-specific coordination and conservation measures, any adverse impacts from ESH or early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as described under Alternative 1.

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 (0 percent) in combined riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend

(10 percent) in the lower river based compared to Alternative 1 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. As a result of site-specific coordination and conservation measures, any adverse impacts from early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as described under Alternative 1.

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 (10 percent) in riparian woodland/forested wetland and forest habitat in the lower river compared to Alternative 1 based on EQ account modeling results. These changes would result in a long-term, small beneficial impact for Indiana 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.

Other Special-Status Species

Under Alternative 4, direct and indirect adverse impacts to other special-status species would be commensurate with impact changes in habitat type due to mechanical construction of ESH, channel reconfiguration for creation of early life stage pallid sturgeon habitat, and construction of pallid sturgeon spawning habitat. Adverse impacts would be both temporary and 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 4 would result in a net increase in ESH habitat. 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 compared to Alternative 1.

Land acquisition and habitat development and land management on MRRP lands would have direct and indirect, long-term, 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 compared to Alternative 1 due to temporary disturbance of habitats resulting in displacement of individuals. ESH creation would result in direct and indirect, temporary, negligible adverse impacts to bald eagles and northern long-eared bats because individuals would be temporarily displaced during construction activities. Similar to Alternative 1, vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat, because prey species would be removed or displaced. However, these actions are not anticipated to impact northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat. Riparian woodland/forested wetland habitat would have an overall increasing trend throughout the geographic scope of the MRRMP-EIS, 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 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 result in long-term beneficial impacts. Impacts from management actions are not anticipated to result in significant impacts on other special-status species under Alternative 4.

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 253 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.

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 are anticipated to be temporary and negligible because site-specific coordination would make the potential for impacts unlikely and if disturbance were to occur, the 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. Specific impacts would depend on the locations of management actions.

Fall reservoir releases for ESH construction under Alternative 5 would result in a slight decreasing trend (-3 percent) in riparian woodland/forested wetland habitat compared to Alternative 1 throughout the geographic scope of the MRRMP-EIS based on EQ account modeling results. This decrease would result in a direct, adverse, long-term, negligible impact for bald eagles 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.

Northern Long-Eared Bat

Direct adverse impacts due to mechanical ESH construction would be the same as those described under Alternative 1, but under Alternative 5 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. As previously noted, USFWS updates the white-nose syndrome zone map regularly. Avoidance, minimization, and mitigation measures would be developed and implemented at the site-specific level when individual projects are implemented. As a result of site-specific coordination and conservation measures, any adverse impacts from ESH or early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as 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 would 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 (-2 percent) in combined riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (9 percent) in the lower river compared to Alternative 1 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. As a result of site-specific coordination and conservation measures, any adverse impacts from early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as described under Alternative 1.

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 compared to Alternative 1 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.

Other Special-Status Species

Under Alternative 5, direct and indirect adverse impacts to other special-status species would be commensurate with impact changes in habitat type due to mechanical construction of ESH, channel reconfiguration for creation of early life stage pallid sturgeon habitat, construction of pallid sturgeon spawning habitat, and flow actions. Adverse impacts would be both temporary and 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 that use ESH habitat (birds) could benefit in the long term because mechanical ESH construction under Alternative 3 would result in a net increase in this habitat type. Overall, impacts under Alternative 5 would be similar to those described under Alternative 4 due to the similarity of changes in various habitat types.

Land acquisition and habitat development and land management on MRRP lands would have direct and indirect, long-term, 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 compared to Alternative 1 due to temporary disturbance of habitats resulting in displacement of individuals. ESH creation would result in direct and indirect, temporary, negligible adverse impacts to bald eagles and northern long-eared bats because individuals would be temporarily displaced during construction activities. Similar to Alternative 1, vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat, because prey species would be removed or displaced. However, these actions are not anticipated to impact northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat. Riparian woodland/forested wetland habitats would have a decreasing trend in the upper river, but an increasing trend in the lower river, and forest habitat would have an increasing trend in both the upper and 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 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 impacts. Impacts from management actions are not anticipated 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 245 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.

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.

Direct and indirect adverse impacts are anticipated to be temporary and negligible because site-specific coordination would make the potential for impacts unlikely and if disturbance were to occur, the 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.

Flow actions to be implemented under Alternative 6 would result in a slight increasing trend (5 percent) in riparian woodland/forested wetland habitat compared to Alternative 1 throughout the geographic scope of the MRRMP-EIS based on EQ account modeling results. This increase would result in a beneficial, long-term, negligible impact for bald eagles 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.

Northern Long-Eared Bat

Direct adverse impacts due to mechanical ESH construction would be the same as those described under Alternative 1, but under Alternative 6 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. As previously noted, USFWS updates the white-nose syndrome zone map regularly. Avoidance, minimization, and mitigation measures would be developed and implemented at the site-specific level when individual projects are implemented. As a result of site-specific coordination and conservation measures, any adverse impacts from ESH or early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as 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.

A March and May spawning cue release attempted every 3 years would result in no change (0 percent) in combined riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (5 percent) in the lower river based compared to Alternative 1 on EQ account modeling results, resulting in a long-term, negligible 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. As a result of site-specific coordination and conservation measures, any adverse impacts from early life stage pallid sturgeon habitat are anticipated to be negligible and unlikely to occur, as described under Alternative 1.

When compared to Alternative 1, Alternative 6 would have a beneficial, long-term, negligible impact to the Indiana bat. A March and May spawning cue release attempted every 3 years would result in a positive increasing trend (5 percent) in combined riparian woodland/forested wetland and forest habitat compared to Alternative 1 in the lower river based on EQ account modeling results. This would result in a long-term, negligible 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.

Other Special-Status Species

Under Alternative 6, direct and indirect adverse or beneficial impacts to other special-status species would be commensurate with impact changes in habitat type due to mechanical construction of ESH, channel reconfiguration for creation of early life stage pallid sturgeon habitat, construction of pallid sturgeon spawning habitat, and flow actions. Adverse impacts would be both temporary and 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 that use ESH habitat (birds) could benefit in the long term because mechanical ESH construction under Alternative 3 would result in a net increase in this habitat type. Overall, impacts under Alternative 6 would be similar to those described for Alternatives 3–5.

Land acquisition and habitat development and land management on MRRP lands would have direct and indirect, long-term, 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 that could be impacted, would depend on the locations of management actions. 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 due to temporary disturbance of habitats resulting in displacement of individuals. ESH creation would result in direct and indirect, temporary, negligible adverse impacts to bald eagles and northern long-eared bats because individuals would be temporarily displaced during construction activities. Similar to Alternative 1, vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat, because prey species would be removed or displaced. However, these actions are not anticipated to impact northern long-eared bats or Indiana bats because these species are not associated with sandbar habitat. Riparian woodland/forested wetland habitat would have an increasing trend in both the upper and lower river, and forest habitat would have a decreasing trend in the upper river and 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 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 impacts. Impacts from management actions are not anticipated 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 special-status species carried forward for detailed analysis, bald eagle was the only species identified as a species of Tribal interest. Impacts to bald eagle 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 (Table 3-1). A summary of cumulative impacts to special-status species is presented below.

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 a decreasing trend (-5 percent) in riparian woodland/forested wetland habitat compared to Alternative 1, resulting in adverse, long-term, negligible 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. There would be no change (0 percent) in riparian woodland/forested wetland habitat under Alternative 3 compared to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, Alternative 3 would result in adverse and beneficial cumulative impacts largely based on 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 (4 percent) in riparian woodland/forested wetland habitat compared to Alternative 1, 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 similar adverse and beneficial cumulative impacts to bald eagles as those described under Alternative 3, but Alternative 5 would result in a decreasing trend (-3 percent) in riparian woodland/forested wetland habitat compared to Alternative 1, resulting in adverse, long-term, negligible impacts. 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 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, 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 a decreasing trend (-2 percent) in combined riparian woodland/forested wetland and forest habitat in the upper and (21 percent) in the lower river compared to Alternative 1, resulting in long-term negligible adverse and 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 no change (0 percent) in combined riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (9 percent) in the lower river compared to Alternative 1, 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 combined riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (10 percent) in the lower river compared to Alternative 1, 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 similar adverse and beneficial cumulative impacts to northern long-eared bats as those described under Alternative 3, resulting in a downward trend (-2 percent) in combined riparian woodland/forested wetland and forest habitat in the upper and a positive increasing trend (9 percent) in the lower river compared to Alternative 1, 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, resulting in no change (0 percent) in combined riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (5 percent) in the lower river compared to Alternative 1, 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 combined riparian woodland/forested wetland and forest habitat in the lower river basin compared to Alternative 1, 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 (9 percent) in combined riparian woodland/forested wetland and forest habitat in the lower river compared to Alternative 1, 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 Indiana bats as those described under Alternative 3, but Alternative 4 would result in an increasing trend (10 percent) in combined riparian woodland/forested wetland and forest habitat in the lower river compared to Alternative 1, 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 combined riparian woodland/forested wetland and forest habitat in the lower river compared to Alternative 1 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 (5 percent) in combined riparian woodland/forested wetland and forest habitat in the lower river compared to Alternative 1, 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.

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 2013b). 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 2013b). 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 2009c).

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 reservoir 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. 2005a; 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 2007a). 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 2007a, 2016a). Water released from the Fort Peck Dam spillway is warmer than the tailwater released directly into the Missouri River (USACE 2007a). Simulations showed that spillway temperatures reach 17°C in late June and stay above 17°C until the end of September (USACE 2007a). Table 3-18 shows mean water temperature for May to September during the period from 2012 to 2014.

Table 3-18. 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, North Dakota	–	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, North Dakota	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, South Dakota	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 2012f). Table 3-19 shows mean dissolved oxygen concentrations for May to September during the period 2012 to 2014.

Table 3-19. 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, North Dakota	–	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, North Dakota	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, South Dakota	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 3-20 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 3-20. 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, North Dakota	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, North Dakota	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, Nebraska	n.d.–89	4	n.d.–0.40	0.06	0.05–1.18	0.46	n.d.–0.11	0.02
Running Water, South Dakota	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: Laboratory tests of sediment samples taken from the Fort Peck Dam to the Yellowstone River reach resulted in impacts to benthic organisms including growth inhibition and death, indicating pollution exposure from the sediments (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 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, 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 3-18 and Table 3-19 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 3-20 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). Laboratory testing of sediments collected from various reaches, particularly Garrison Dam to Bismarck, resulted in impacts to benthic organisms including growth inhibition and death, indicating pollution exposure from the sediments (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 3-18 and Table 3-19 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 3-20 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 3-18 and Table 3-19 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 3-20 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 3-18 and Table 3-19 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 3-20 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 3-21 and Table 3-22 show average monthly temperature and dissolved oxygen values for the Missouri River downstream of Gavins Point Dam.

Table 3-21. 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 3-22. 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, Iowa 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 3-23 shows that turbidity generally increases with distance along the lower river.

Table 3-23. Turbidity in the Lower Missouri River (2012–2014)

Location	Median Turbidity (NTU)		
	2012	2013	2014
Ponca, Nebraska	–	25.0	22.3
Decatur, Nebraska	–	35.9	32.0
Omaha, Nebraska	–	61.7	39.9
Nebraska City, Nebraska	–	61.7	42.2
Rulo, Nebraska	–	63.0	12.7
Atchison, Kansas	46.2	68.6	105.0
Kansas City, Missouri	49.6	90.1	99.5
Waverly, Missouri	70.4	135.4	87.3
Glasgow, Missouri	107.6	111.6	264.9
Marion, Missouri	112.8	99.5	164.2
Hermann, Missouri	97.3	67.7	135.6
Weldon, Missouri	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, South Dakota, 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 3-24 shows nutrient concentrations measured in 2012 through 2014 at sites along the lower reaches of the Missouri River.

Table 3-24. 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, Nebraska	–	0.07	0.06	–	0.05	0.05
Decatur, Nebraska	–	0.55	0.20	–	0.11	0.10
Omaha, Nebraska	–	0.78	0.51	–	0.18	0.11
Nebraska City, Nebraska	–	0.85	0.82	–	0.24	0.23
Rulo, Nebraska	–	0.96	0.22	–	0.24	1.38
Atchison, Kansas	1.01	1.10	1.50	0.23	0.20	0.60
Kansas City, Missouri	0.87	1.40	1.50	0.32	0.23	0.51
Waverly, Missouri	0.94	1.40	1.40	0.29	0.31	0.49
Glasgow, Missouri	1.00	1.40	1.02	0.32	0.32	0.83
Marion, Missouri	0.80	1.55	1.00	0.29	0.29	0.69
Hermann, Missouri	0.74	1.30	1.00	0.28	0.24	0.56
Weldon, Missouri	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 (Missouri Department of Natural Resources 2016a; 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 (Missouri Department of Natural Resources 2016a; 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

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 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. Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 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 3-25 summarizes the impacts of each alternative to water quality.

Table 3-25. 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, 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 to small, beneficial impacts from reduced nutrients and pollutants. Overall, 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. Overall, 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, beneficial impacts from reduced nutrients and pollutants. Overall, 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, beneficial impacts from reduced nutrients and pollutants. Overall, 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 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. Overall, 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. USACE would continue to use an imazapyr-based (e.g., Habitat) and/or a glyphosate-based (e.g., Rodeo) herbicide approved by 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. BMPs such as regularly checking equipment, placing safety measures to minimize the risk of spills, avoiding or minimizing 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 is 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 164 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 the various provisions of the Clean Water Act and by using construction BMPs, 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 the various provisions of the Clean Water Act and by using construction BMPs, 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 decreases in dissolved oxygen. Additionally, construction of early life stage habitat for pallid sturgeon would require the acquisition of land to accommodate the habitat construction and provide a buffer between the project and adjacent lands. Land acquired for habitat construction would be converted from its existing use to a natural land use; therefore, if any land uses (e.g., agriculture) were the source of pollutant or nutrient loading, these sources would be eliminated resulting in negligible long-term, beneficial impacts to water quality.

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 the various provisions of the Clean Water Act and by using construction BMPs, 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. Additionally, habitat development would require the acquisition of land to accommodate the habitat construction and provide a buffer between the project and adjacent lands. Acquired land would be converted from its existing use to a natural land use. If any land uses (e.g., agriculture) were the source of pollutant or nutrient loading, these sources would be eliminated resulting in negligible long-term, beneficial impacts to water quality.

Land management operation and maintenance activities and BMPs 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 2009b). 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 (EPA 2005a). 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 from increased sediment and turbidity, nutrients, pollutants, water temperatures, and lower dissolved oxygen concentrations. In the long term, habitat development actions and construction of early life stage habitat would benefit 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, USACE would mechanically construct ESH at an average rate of 1,331 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 1,167 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 creation by 6,759 acres and land acquisition by 38,670 acres. Although this is a substantial increase in habitat and would result in greater temporary and long-term water quality impacts compared to Alternative 1, overall there would be small 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 BMPs would be used to minimize adverse impacts.

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 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 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 temporary, impacts from the altered water temperature and dissolved oxygen conditions. Warmer water temperature and lower dissolved oxygen conditions may be viewed as beneficial for native Missouri River species, but may be viewed as adverse for other Missouri River interests. 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, 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, impacts to water quality due to warmer temperatures and decreased dissolved oxygen levels. Warmer water temperature and lower dissolved oxygen conditions may be viewed as beneficial for native Missouri River species, but may be viewed as adverse for other Missouri River interests. 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 long-term beneficial and short-term adverse 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 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, the construction of early life stage habitat, 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, USACE would mechanically construct ESH at an average rate of 332 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 to Ponca, Nebraska. 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 and acquire 5,274 fewer acres of land 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 by compliance with a NPDES permit, CWA Section 401 water quality certification, CWA Section 404 authorization, and through the use of construction BMPs, including an emergency response plan and pollution prevention plan. 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. Because spawning habitat is a feature of Alternatives 3–6 and not Alternative 1, the resulting adverse and beneficial impacts to water quality would be greater compared to Alternative 1. However, these impacts would be negligible because of the small amount of spawning habitat projects and the associated localized impacts would be spread over the entire length of the lower Missouri River.

A one-time spawning cue test release from Gavins Point could initiate erosional and depositional processes. The flow and associated impacts would decrease as the flow moves downstream. Sediment could be eroded from the channel resulting in temporary, adverse impacts to water quality from increased sediment and turbidity, nutrients, and other pollutants released from the mobilized sediments; however, these increases would be very small compared to Alternative 1. 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 temporary, adverse impacts to water quality 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.

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, one-time spawning cue test, habitat development, and land management could occur from increased sediment and turbidity, nutrients, pollutants, water temperatures, and lower dissolved oxygen concentrations. Negligible to small long-term adverse impacts from construction of early life stage habitat and habitat development could occur from localized areas of increased water temperatures and lower dissolved oxygen levels. In the long term, early life stage and 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 negligible to small especially when considered in the regional context.

3.7.2.7 Alternative 4 – Spring ESH Creating Release

Under Alternative 4, USACE would mechanically construct ESH at an average rate of 195 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, 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 navigation 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 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 from increased sediment and turbidity, nutrients, pollutants, water temperatures, and lower dissolved oxygen concentrations. There would also be additional small to negligible temporary adverse impacts from the spring ESH creating reservoir release from increased sediment and turbidity, nutrients, pollutants, lower water temperatures, and higher dissolved oxygen concentrations. In the long term, early life stage and 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 negligible to small especially when considered in the regional context.

3.7.2.8 Alternative 5 – Fall ESH Creating Release

Under Alternative 5, USACE would mechanically construct ESH at an average rate of 253 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. Impacts to water quality from mechanical ESH construction are described under Alternative 1 and would generally be temporary and adverse. Compared to Alternative 1, the temporary, adverse impacts to water quality would be small because of the additional ESH acres compared to Alternative 1 and because the associated localized 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 temporary adverse impacts under Alternative 5 would be greater than those under Alternative 1, but this change would be small because of 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 temporary adverse impacts would occur similar to Alternative 1 from increased sediment and turbidity, nutrients, pollutants, water temperatures, and lower dissolved oxygen concentrations with additional temporary adverse impacts from the fall ESH creating reservoir release. In the long term, early life stage and 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 negligible to small especially when considered in a regional context.

3.7.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, USACE would mechanically construct ESH at an average rate of 246 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 impacts to water quality from spawning cue flows would be the same as those described under Alternative 1 and would generally be temporary and adverse. These temporary adverse impacts would be greater than those under Alternative 1 due to the greater peak pulse magnitudes under Alternative 6. Overall, the adverse impacts would be small because of the gradual attenuation of the flows with distance from Gavins Point Dam and 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 temporary adverse impacts from construction of ESH, early life stage habitat, and spawning habitat; spawning cue flows, habitat development, and land management would result from increased sediment, turbidity, nutrients, pollutants, and water temperatures, and lower dissolved oxygen concentrations. In the long term, early life stage and 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 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 heavier, 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 reduced 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 and oil and gas production on the floodplain result in temporary impacts associated with construction including 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. 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. Spills associated with oil and gas production result in small long-term adverse impacts to water quality from increased levels of oil or gas and related production materials and chemicals.

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.

Future aggradation and degradation trends include sediment deposition in reservoirs, aggradation upstream of the reservoir headwaters, and degradation downstream from dams, as shown in the year 0 and year 15 analyses, with natural variability being the main driver of sediment transport. Generally, there would be increases in elevation in the reservoirs and decreases in river stage in the river. Past, present and, future actions that would affect bed degradation and aggradation, such as sand and gravel dredging operations in the lower river could result in impacts to water quality. Negligible to small, temporary, adverse impacts would result during the dredging process from increased levels of sediment and turbidity, nutrients, or other pollutants present and potentially increased temperatures and reduced dissolved oxygen concentrations. In addition to the natural sediment transport, dredging and mining operations would further lower the riverbed in the mining areas over the long term, resulting in negligible impacts on temperature and dissolved oxygen that could be adverse or beneficial depending on the locality.

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 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 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 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 (EPA 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 (EPA 2016a).

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.

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 21 thermal power plants located along or very close to the Missouri River. 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 direct 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.

Assessments of indirect impacts on air quality are included in the sections discussing thermal power, navigation, and hydropower, and related to changes in releases and flows associated with the alternatives. 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 geographic scope of the following analysis is comprised of the airsheds 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.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 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 larger context.

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. Alternative 2 would result in the construction of the most habitat among the alternatives, however, the increases in emissions would not be expected to be high enough to result in any areas entering non-attainment for any NAAQS parameters and would be unlikely to contribute to impacts in a meaningful way 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 limited to construction periods and unlikely to result in adverse impacts to overall air quality. Therefore, management actions would not have significant impacts on air quality.

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, temporary emissions from vehicle and equipment during mechanical ESH construction and channel reconfiguration for creation of early life stage habitat for pallid sturgeon are not expected to result in meaningful impacts such that they would result in a change to the overall character of air quality in areas with Tribal resources.

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 not contribute to overall cumulative impacts as a result of vehicle emissions associated with construction of ESH and early life stage habitat for pallid sturgeon.

3.9 Cultural Resources

3.9.1 Affected Environment

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) (54 USC 306108), its implementing regulations (36 CFR 800), and other pertinent laws, regulations, and policies, as described in Chapter 6.0 of this EIS.

The USACE Planning Guidance Notebook (ER 1105-2-100) and 36 CFR Part 800 define 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.

Data for this cultural resources analysis were obtained from USACE records, State Historic Preservation Offices (SHPOs), from Tribes within the basin. The USACE cultural resources records primarily contain information on federally owned lands within the basin, recorded as a result of the aforementioned federal cultural resources laws. Much of the federal lands in the Mainstem Reservoir System have been surveyed for historic properties, and a program to identify other important cultural resources is ongoing. Although surveys have been conducted, survey efforts in collaboration with Tribes, agencies, and individuals are ongoing, the majority of the Missouri River Recovery Project lands owned by USACE have not been professionally inventoried for cultural resources.

The information for survey and management of the Omaha District Mainstem Projects/Reservoirs was obtained from the Cultural Resource Management Plans (CRMPs): Fort Peck Dam/ Fort Peck Lake; Final Plan November 2004, Garrison Dam/ Lake Sakakawea; Final Plan April 2006, Oahe Dam/ Lake Oahe; Final Plan September 2004, Big Bend Dam/ Lake Sharpe; Final Plan March 2002, Fort Randall Dam/ Lake Francis Case; Final Plan July 2003, Gavins Point Dam/Lewis and Clark Lake; Final Plan 2014. These CRMPs were developed with cultural resource partners and are a management tool that not only identify historic properties and site survey reports but also establish a framework for compliance with the National Historic Preservation Act. The Omaha District has continued to identify historic properties after the CRMPs were finalized. A list of identification and preservation efforts since 2004 can be found in the "Omaha District Cultural Resource Program Final Annual Report for Calendar 2016" located at: http://www.nwo.usace.army.mil/Missions/Civil-Works/Cultural-Resources/Documents/.

The inventory data for cultural resources in the riverine settings of the lower basin and riverine reaches between the Mainstem reservoirs came from the pertinent SHPOs. These inventories of cultural resource sites in riverine settings (developed largely through an accumulation of site-specific compliance with NHPA, recordation by professional and amateur archeologists, and from historic shipwreck maps) are less thorough than the inventories at the reservoirs. Additionally, the vast majority of this land is privately owned and not subject to federal stewardship requirements or protections. Table 3-26 summarizes the number of recorded cultural resource sites that have been identified within the Missouri River Basin. Most of these cultural resources were identified as archaeological sites, burials, historic buildings or structures, and/or shipwrecks. Further 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 3-26. 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
Nebraska Riverine Sections	661
Iowa Riverine Sections	336
Missouri Riverine Sections	2,555
Kansas Riverine Sections	72

Note: This is the total of recorded cultural resources sites within the meander belt of the Missouri River System. Sites without reliable elevation and/or location information were excluded from further hydrologic analysis, as were sites determined ineligible for inclusion in the National Register of Historic Places, except if human remains were associated with the sites. See the “Cultural Resources Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Modeling efforts that aided this analysis utilized archaeological geospatial data along with hydrologic data based on rainfall and flood records, produced using the HEC-RAS modeling of the river and HEC-ResSim modeling of the reservoir System, to estimate impacts to these cultural resources. USACE acknowledges that this inventory is incomplete, and numerous unidentified cultural resources still exist on the landscape. However, this inventory represents a sample of cultural resources used to account for the effects of programmatic impacts to all cultural resources by the actions proposed in the MRRMP-EIS.

The analysis of effects on cultural resources differentiated two categories of cultural resource sites. “Reservoir sites” were sites located on federal fee-titled 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 3-52 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.

These two divisions were further subdivided. Reservoir sites were sub-divided into three classes based on normal pool elevation. These were sites that were above normal pool elevations, sites that were below normal pool elevations and sites that were located within the range of normal pool elevations. Riverine sites were subdivided into two classes. These were sites that were located behind levees and sites that were not located behind levees. Further discussion of the methodology for selection, modeling, and analysis of these cultural resources may be found in the “Cultural Resources Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

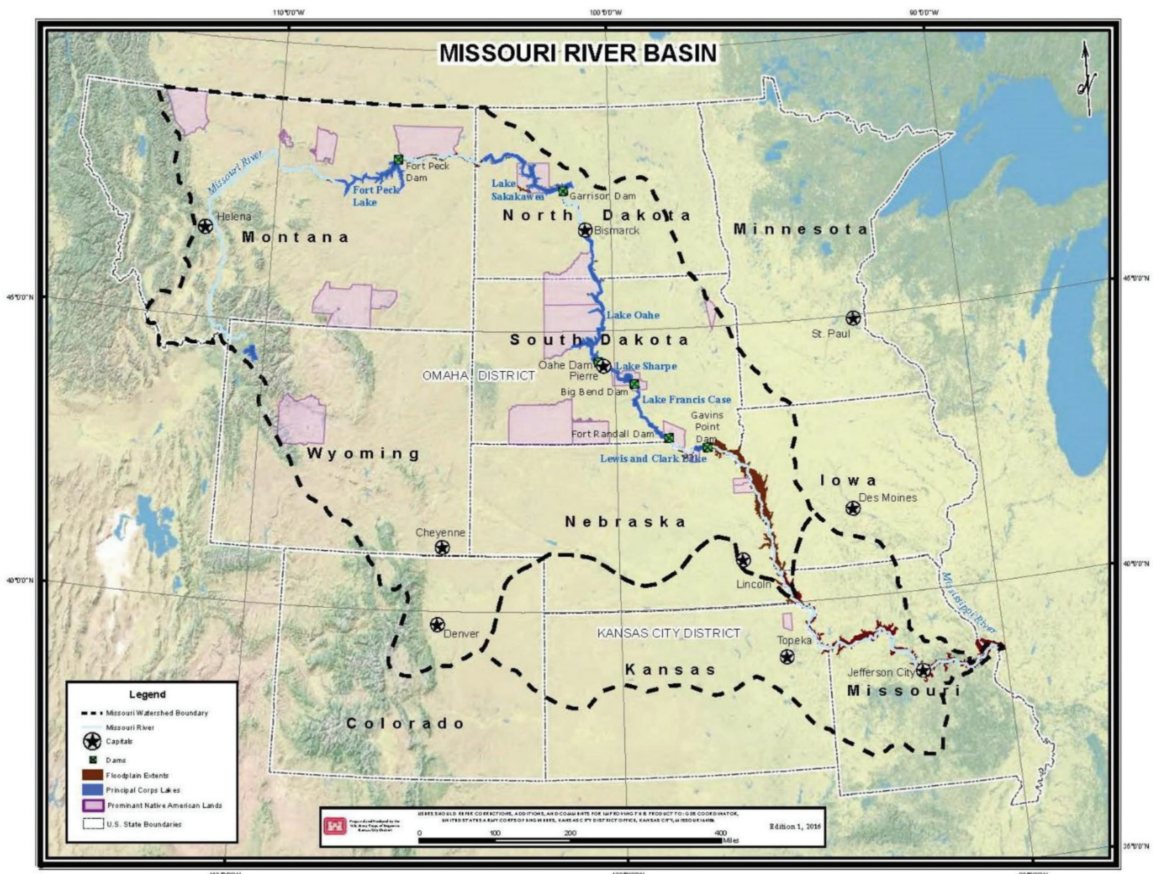


Figure 3-52. Missouri River Watershed

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 elevation fluctuations and wind/wave action. 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) were determined to be at increased risk during periods of low water from droughts or emergency maintenance activities. This risk was the result of direct impacts from wave erosion and vegetation loss as well as greater access via boat that would put these sites at increased risk for looting and vandalism.

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 located above the maximum-normal pool elevation 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 (i.e., 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 eliminate existing vegetation. These sites were determined to be at increased risk when reservoir levels came within three feet of the recorded elevation of the cultural resource site. This risk is the result of direct impacts from wave erosion and vegetation loss as well as greater access via boat that would put these sites at increased risk for looting and vandalism.

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. In other words, these sites are always at high risk, however, local micro-environmental factors may contribute greater or lesser impacts to these cultural resources. Current and ongoing stewardship activities on the Mainstem Reservoirs seek to monitor impacts to all sites, but are particularly focused on this category of historic properties. Ongoing preservation actions can be found online in the "Omaha District Cultural Resource Program Final Annual Report for Calendar Year 2016" located at: http://www.nwo.usace.army.mil/Missions/Civil-Works/Cultural-Resources/Documents/.

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 all located on federal fee owned land, most of the sites in riverine settings are on land that is non-federally owned, and as such are not subjected to the same federal heritage management policies.

The analysis found that in general, cultural resource sites that were located behind levees were less frequently impacted by erosion although they would be impacted during times of high water if the levees/barriers protecting them are overtopped. While these sites would be protected from erosion, they were still susceptible to other impacts, such as vandalism and looting, as well as unintentional impacts associated with maintenance of flood-risk management infrastructure. However, these are continuous risks that would not be increased or decreased due to changes in flow management recommendations that may come from this EIS.

Cultural resource sites located close to river banks and not behind levees 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 can impact 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. However, the construction of the BSNP has resulted in prevention of natural channel migration which in some cases served to preserve cultural resources located in the floodplain from damage due to natural riverine processes.

The majority of the pre-historic cultural resources in riverine settings are located near the bluffs, and are rarely subject to direct flood impacts except during the greatest flood events.

3.9.2 Environmental Consequences

3.9.2.1 Impacts Assessment Methodology

The primary impacts to cultural resource sites located in reservoir settings from the MRRMP-EIS alternatives would be related to modifications of flows and changes in reservoir pool elevations. These changes could result in increased risk of impacts to cultural resource sites through erosion and/or vandalism and looting of the sites. The measures used in this analysis attempt to quantify these increases or decreases in risk to cultural resource sites. These measures included assessing the number of days, the number of sites, and the number of sites times days (this is the basis for the term “site-days” which is further defined below) that cultural or historic resources were inundated or exposed to air based on their relative location to the normal operating elevations of the reservoirs. Normal operations were assumed to be System operations as described in the Master Manual (USACE 2006a). 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 leading to exposure of all or a portion of a site. 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).

Modeled impacts to cultural resource sites that are typically above the normal river/reservoir surface level elevation are subject to increased risk of erosion when river/pool elevations increase covering all or a portion of a site. However, Lenihan et al. (1981) noted that cultural resource sites that are 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 three to five days of high water. More simply, cultural resource sites (whether located on reservoirs or riverine reaches) are sensitive to changes in water-surface elevations. Table 3-27 describes the normal minimum (the top of the carryover multiple use zone) and maximum (top of the annual flood control and multiple use zone) pool elevations as identified in the Master Manual for each of the Mainstem reservoirs.

Table 3-27. Maximum and Minimum Normal Reservoir Pool Elevations

Reservoir	Minimum Normal Pool Elevation (FAMSL)	Maximum Normal Pool Elevation (FAMSL)
Fort Peck Lake	2,234.0	2,246.0
Lake Sakakawea	1,837.5	1,850.0
Lake Oahe	1,607.5	1,617.0
Lake Sharpe	1,420.0	1,422.0
Lake Francis Case	1,350.0	1,365.0
Lewis and Clark Lake	1,204.5	1,208.0

Note: FAMSL is Feet Above Mean Sea Level

The analysis of sites in riverine settings differentiates between sites located behind levees, and sites not located behind levees. Sites located behind levees are assumed to not be at increased risk until flood waters reach a modeled elevation that would overtop the levee. Sites not located behind levees are assumed to be at increased 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, would normally only be impacted during flood events. The same measures used in the reservoir analysis above were used in the riverine analysis. However, the estimate of risk was adjusted (as described in Section 3.9.1.3 and in the paragraphs below) for sites that would not typically be below water surface elevations as once water elevations are within a few feet of the bottom of a riverine cultural resource site (or above the top of a levee protecting a site), then the site is considered to be at increased risk for erosion.

All modeling results in this section are based on calculations from information on known cultural resources site information. USACE recognizes that numerous unidentified cultural resource sites are within proximity to the Missouri River and its Mainstem reservoirs. The inventory of known cultural resource sites used in this analysis is intended to serve as a representative sample, indicating which MRRMP-EIS alternatives have the potential for increased risk to cultural resources in general. The analysis has used the best available information and research to assess reasonably foreseeable impacts to cultural resources. USACE acknowledges that the data used does not represent all cultural resources that could be impacted by the MRRMP-EIS action alternatives; however, additional sites not captured within the available cultural resources data sets are assumed to be affected similarly to the representative sample provided in this analysis. USACE used the most current site data (2016) received from the SHPOs for this analysis. The CEQ NEPA regulations discuss the assessment of impacts when incomplete information exists (40 CFR 1502.22).

Risks to sites were modeled with HEC-RAS hydraulic and HEC-ResSim modeling software to determine the effect of changing river stages and reservoir elevations on these sites by calculating the number of days that a river stage or elevation of a reservoir was within a certain elevation of cultural resource sites. The primary metric used to compare alternatives was "site-days," which were estimated by counting each day that each cultural resource site would have the potential to experience increased risk, then summing these counts across all cultural resource sites for a given area, such as a reservoir or section of the Missouri River within a state. Increased risk is defined as a site experiencing a greater risk for erosion or vandalism than it would when reservoir conditions are within normal pool elevations as defined in Table 3-27 or when riverine levels exceed more than a few feet from the bottom of the site.

Risk levels are assumed to change with changes in water surface elevations. For the purposes of simplifying the terminology in this analysis, the term "site-days" was used to reflect the number of days that each site would have the potential to experience increased risk of erosion or vandalism due to changing water elevations either inundating or exposing a site. 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.

For habitat construction and other non-flow related management actions, assessments were made based on impacts from similar ongoing activities within proximity to the Missouri River and its Mainstem reservoirs. Additionally, due to the size and scope of the programmatic MRRMP-EIS, specific impacts on individual sites were not evaluated. NHPA and its implementing regulation at 36 CFR 800 will be followed as management plan actions are implemented. Consultation requirements under Section 106 will be met for all projects and the Programmatic Agreements will be utilized as appropriate.

The consultation requirements for Section 106 of the NHPA shall be met and where appropriate the Programmatic Agreement for the Operation and Management of the Missouri River Mainstem System for Compliance with the NHPA, as amended, will be followed for recommended actions in the states of Montana, North Dakota, South Dakota, Iowa, and Nebraska (Appendix J). The Programmatic Agreement for Implementation of The Missouri River Recovery Management Plan in The Lower Missouri River from Rulo, Nebraska to the Confluence with The Mississippi River will be followed when completed for recommended actions in the states of Kansas, Missouri, and Nebraska. The lower river PA was pending signature at the time of printing of the Final EIS and is not appended; however, the document will be made available on the MRRP website (www.moriverrecovery.org) concurrent with the signed ROD.

3.9.2.2 Summary of Environmental Consequences

The primary differences between the MRRMP-EIS alternatives were observed changes to the number and duration of sites that would be subject to increased risk, rather than differences in the number of sites affected. Impacts to sites are related to fluctuations in water levels which would result in increased risk, either from erosion or access that correlates to greater likelihood of vandalism or looting. In general, the longer water surface elevations in proximity to sites remain at levels that either inundate normally dry sites or expose normally wet sites, the greater the change in risk to cultural resource sites.

Changes in risk to cultural resource sites focused on changes in the number of site-days for each MRRMP-EIS alternative relative to Alternative 1. Table 3-28 and Table 3-29 summarize the maximum number of sites that could potentially be impacted under each alternative over the period of record. In most cases, each alternative impacts the same sites and the same number of sites with variation occurring only at Lake Sakakawea. Table 3-30 summarizes the difference in average site-days, the primary measure of changes in risk across each alternative. Alternative 3 is the only alternative with a decrease in the average number of site-days for sites at the reservoirs and riverine sites. Alternatives 2 and 5 have result in a decrease in the average number of site-days for riverine sites, while Alternatives 2, 4, 5, and 6 would result in an increase in the average number of site-days for reservoir sites.

Table 3-28. Maximum Number of Affected Reservoir Sites Over the POR (Outside Normal Pool Elevation)

Location	Location Relative to Normal Pool Elevation	Number of Sites Affected					
		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Fort Peck Lake	Above	22	22	22	22	22	22
	Below	6	6	6	6	6	6
Lake Sakakawea	Above	405	382	405	405	405	405
	Below	58	59	58	59	58	59
Lake Oahe	Above	215	215	215	215	215	215
	Below	191	191	191	191	191	191
Lake Sharpe	Above	46	46	46	46	46	46
	Below	16	16	16	16	16	16
Lake Francis Case	Above	122	122	122	122	122	122
	Below	30	30	30	30	30	30
Lewis and Clark Lake	Above	26	26	26	26	26	26
	Below	1	1	1	1	1	1
Total	Above	836	813	836	836	836	836
	Below	302	303	302	303	302	303

Table 3-29. Maximum Number of Affected Riverine Floodplain Sites for POR

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	134	121	61	4	21	196	917
Alternative 2	5	24	134	121	54	4	21	196	916
Alternative 6	5	24	134	121	61	4	21	196	916

Note: All recorded sites in North Dakota and South Dakota are located on the Mainstem reservoirs. Montana has no previously recorded sites located behind levees that would be impacted. Alternative 1, 3, 4, and 5 measured impacts at the same sites for all alternatives. Alternative 2 impacted 7 fewer sites, and Alternative 6 impacted the same number of sites.

Table 3-30. Summary of Average Number of Site-Days

Geography	Average Annual Site-Days Alt 1	Difference Relative to Alternative 1				
		Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Reservoir Sites	55,937	1,614	-237	1,707	879	2,464
Percent Change from Alternative 1	NA	2.9%	-0.4%	3.1%	1.6%	4.4%
Riverine Sites	16,430	-50	-16	38	-68	53
Percent Change from Alternative 1	NA	-0.3%	-0.1%	0.2%	-0.4%	0.3%

3.9.2.3 Impacts from Management Actions Common to all Alternatives

Fish rearing and stocking, predator management, and human restriction have little likelihood of directly or indirectly 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 maintenance of emergent sandbar habitat could impact cultural resource sites in ways similar to mechanical construction. However, the most likely locations for vegetation clearing would be on recently deposited alluvial sandbars, which once provided bird nesting habitat but became overgrown. In general, there is lower risk to cultural resources from this management action, but cultural resource review and consultation will occur based on Section 106 of the NHPA and applicable Programmatic Agreements.

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

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. Management actions under Alternative 1 include construction of early life stage pallid sturgeon habitat and emergent sandbar habitat (ESH), as well as a spawning cue release.

Mechanical Habitat Construction

Alternative 1 includes an average of 164 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, Nebraska 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 vandalism or looting due to access to the site. Risks to cultural resource sites may also increase with erosion caused by a 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 to cultural resources are anticipated to be small. There could be localized long-term adverse impacts to cultural resources, although compliance with NHPA Sections 106 and 110 and Programmatic Agreements will seek to minimize and/or avoid these impacts.

Spring Spawning Cue Flow Release

The amount of risk to cultural resource sites at a particular reservoir is a function of the number of sites and the frequency and duration of fluctuations in reservoir pool elevations. In general, most reservoirs have a greater number of affected sites above normal pool level, but these sites would generally be affected less frequently and for shorter durations than sites below the normal pool level. Of the Mainstem reservoirs, Lake Oahe and Lake Sakakawea have the greatest number of sites that would have the potential to experience risks of vandalism, looting, and erosion as modeled over the POR, with 191 and 58 maximum sites at risk during low water years (sites below the normal pool level) and 215 and 405 maximum sites at risk during high water years, respectively (sites above the normal pool level). However, from year to year, the number of exposed sites varies. Under Alternative 1, cultural resources at Lake Oahe and Lake Sakakawea would experience the greatest number of average annual site-days that would have the potential to experience risks for sites located below the normal pool levels with 7,462 and 32,723 site-days, respectively.

Lake Sakakawea has the largest number of sites located above normal pool elevation that would that would have the potential to experience risks under Alternative 1. During the modeled POR, there would be four years with approximately 200 of Lake Sakakawea sites at risk of erosion during high water periods, seven years with 71 or fewer sites at risk from high water, and 71 years with no sites at risk from water levels above normal pool elevations. However, there would be on average 27 sites impacted during 80 years of the 82-year period of record from low water elevations while only two years would have no impacts to sites. Lake Oahe would have up to 191 sites that would have the potential to experience risks each year during the modeled POR, with an average of 125 sites at risk each year. High water years such as 1952 or 2011 produced the largest risk of impacts to sites at Lake Sakakawea and Lake Oahe with relatively higher reservoir elevations (Table 3-31).

Riverine sites (i.e., sites located in the Missouri River floodplain outside of federally managed lands on the Mainstem Reservoir System) may be at higher risk of impacts during flood events. No known cultural resources sites were impacted during the modeled POR in riverine reaches of North Dakota or South Dakota. Screening efforts indicated that Montana had only five riverine sites that could be affected during the highest flooding or high flow periods. Under Alternative 1, some sites in Iowa, Nebraska, Kansas, and Missouri would be affected by high water in most years, and many sites would be affected for weeks or months during large flood events. The model indicates that Missouri and Nebraska would have more average annual site-days that would have the potential to experience risks, but this is in part due to the greater number of known sites in Missouri and Nebraska (as compared to Iowa and Kansas) (Table 3-32).

Table 3-31. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 1 (Modeled over POR)

Location		Maximum Number of Sites Affected	Average-Annual Site-Days	Number of Years Impacts Would Occur over the POR
Fort Peck Lake	Above	22	15	3
	Below	6	360	70
Lake Sakakawea	Above	405	921	11
	Below	58	7,462	80
Lake Oahe	Above	215	669	12
	Below	191	32,723	82
Lake Sharpe	Above	46	4,367	82
	Below	16	4,054	82
Lake Francis Case	Above	122	79	6
	Below	30	3,704	82
Lewis and Clark Lake	Above	26	1,582	82
	Below	1	2	27

Table 3-32. Change in Risk to Sites within the Riverine Reaches for Alternative 1 (Modeled over POR)

State	Levee Status	Maximum Number of Sites Affected	Average-Annual Site-Days	No, of years impacts would occur over POR
Montana	No Levee	5	2	1
Nebraska	No Levee	134	8,487	82
	Behind Levees	24	69	45
Iowa	No Levee	61	299	76
	Behind Levees	121	464	29
Kansas	No Levee	21	26	17
	Behind Levees	4	21	35
Missouri	No Levee	917	4,664	82
	Behind Levees	196	2,398	70

Conclusion

Alternative 1 primarily serves as a reference condition allowing for a comparison with the action alternatives. This analysis indicates that many cultural resource sites would continue to have the potential to experience risks under Alternative 1 from low and high water conditions due to fluctuations in the hydrologic and climatic cycles and the associated influence on river hydrology and reservoir storage. Actual impacts, which cannot be determined by modeling, would depend on the actual timing and location of a physical change in conditions, the physical damage to the site, and the cultural significance of the site. In addition, continued habitat construction actions could also result in small adverse impacts to cultural resources; however, mitigation actions under NHPA Section 106 and 110 and Programmatic Agreements would seek to minimize and/or avoid these impacts.

3.9.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under an adaptive management framework. Actions under this alternative that may increase risks to cultural resources include a spring pallid sturgeon flow release; low summer flow; and construction of SWH and ESH habitat.

Mechanical Habitat Construction

Alternative 2 includes 1,331 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, Nebraska 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 vandalism or 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 (1,331 acres annually vs. 164 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 higher risk of erosion. Due to the considerably 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 due to erosion. In order to avoid and/or minimize these types of impacts, NHPA Sections 106 and 110 will be followed as management plan actions are implemented.

Spring Spawning Cue Flow Release and Low Summer Flows

As modeled, Alternative 2 flow releases result in greater fluctuations in water levels within three of the Mainstem reservoirs relative to Alternative 1. This fluctuation generally results in increases in number and duration that sites would have the potential to experience risks. The lower three reservoirs, Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake, would experience negligible changes in risk to cultural resource sites because the reservoir elevations would remain relatively stable. There would be varying impacts to the pool levels at the upper three reservoirs (Fort Peck Lake, Lake Sakakawea, and Lake Oahe) from the spawning cue releases and low summer flow events. Spawning cue releases under Alternative 2 would draw down the reservoirs in the year of or years following the flow releases, while reservoir elevations could be relatively higher than under Alternative 1 when releases are lower from Gavins Point Dam to implement the low summer flow events.

Table 3-33 summarizes the change in risk to cultural resources under Alternative 2 as compared to Alternative 1. The sites located above normal pool elevation at Lake Sakakawea and Lake Oahe would experience reduced risks compared to Alternative 1. Over the modeled POR, sites located above the normal pool elevation at Lake Oahe would have three fewer years, and sites located below the normal pool elevation at Fort Peck Lake would have three more years in which risk of impacts to sites increased relative to Alternative 1. Sites located above normal pool elevation would only have one more year of impacts. This would likely occur because spawning cue releases under this alternative would result in lowering reservoir elevations in certain years. At Fort Peck Lake, the change in impacts under Alternative 2 would be negligible with an additional 8 site-days relative to Alternative 1.

In general, an increase in site-days at a reservoir represents an increase in risk to cultural resource sites. The cultural resource sites below the normal pool level at the upper three reservoirs would experience the potential for increased risk from higher frequency of lower reservoir elevations associated with the implementation of the full and partial spawning cue releases. Increased risk of adverse impacts to sites below the normal pool level would occur from relatively lower reservoir elevations under Alternative 2, with sites at Lake Oahe and Lake Sakakawea experiencing an increase of 1,894 and 107 average annual site-days compared to Alternative 1, respectively. Although the percent change in average annual site-days is small (6% and 1%), there is the possibility that impacts to a particular site could be large depending on the site affected and the exposure and/or damage to the site.

As shown in Table 3-34, Missouri would have the largest overall decrease in average annual site-days (4% decrease), and Iowa would have the greatest overall increase in site-days (8% increase) for sites that are located behind levees, as compared to Alternative 1. The change in average annual site-days to sites in Missouri would be partly due to a partial release in March that would occur under Alternative 2 as opposed to a full release in March that would occur in one year under Alternative 1, causing a slight reduction in water levels relative to Alternative 1 and resulting in a reduction in risk of impacts to cultural resource sites in Missouri. Risk of impacts to cultural resource sites in Iowa would increase as a result of a partial release occurring in March in one year instead of an eliminated release that would occur under Alternative 1, slightly increasing the risk of impacts to sites behind levees. Most other locations would have negligible changes from Alternative 1.

Table 3-33. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 2 (Percent Change from Alternative 1)	Alternative 1	Alternative 2
Fort Peck Lake	Above	15	23 (53%)	3	5
	Below	360	368 (2%)	70	73
Lake Sakakawea	Above	921	746 (-19%)	11	11
	Below	7,462	7,569 (1%)	80	81

Location		Average-Annual Site-Days		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 2 (Percent Change from Alternative 1)	Alternative 1	Alternative 2
Lake Oahe	Above	669	457 (-32%)	12	9
	Below	32,723	34,617 (6%)	82	82
Lake Sharpe	Above	4,367	4,349 (0%)	82	82
	Below	4,054	4,062 (0%)	82	82
Lake Francis Case	Above	79	79 (0%)	6	6
	Below	3,704	3,696 (0%)	82	82
Lewis and Clark Lake	Above	1,582	1,583 (0%)	82	82
	Below	2	2 (0%)	27	21

Table 3-34. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 2 (Percent Change from Alternative 1)	Alternative 1	Alternative 2
Montana	No Levee	2	2 (0%)	1	1
Nebraska	No Levee	8,487	8,475 (0%)	82	82
	Behind Levees	69	71 (3%)	45	43
Iowa	No Levee	299	292 (-2%)	76	75
	Behind Levees	464	503 (8%)	29	30
Kansas	No Levee	26	24 (-8%)	17	14
	Behind Levees	21	23 (10%)	35	35
Missouri	No Levee	4,664	4,678 (0%)	82	82
	Behind Levees	2,398	2,312 (-4%)	70	71

Notes: The values in parenthesis indicate percent difference between Alternative 1 and Alternative 2.
All recorded sites in North Dakota and South Dakota are accounted for on the Mainstem reservoirs. Montana has no previously recorded sites located behind levees that would be impacted.

Conclusion

Relatively greater habitat construction actions under Alternative 2 could result in long-term adverse impacts to cultural resources; however, mitigation actions under NHPA Section 106 and 110 and Programmatic Agreements would seek to minimize and/or avoid these impacts. Under Alternative 2 cultural resource sites at the upper three reservoirs located below the normal pool level would experience increases in risk of impacts relative to Alternative 1 from longer duration and greater number of sites due to lower reservoir elevations under Alternative 2. The greatest percentage increase in average annual site-days relative to Alternative 1 would occur at Fort Peck Lake (+2%), Lake Oahe (+6%), and Lake Sakakawea (+1%). In addition, lower average reservoir elevations at Lake Oahe and Lake Sakakawea under Alternative 2 would decrease risks to sites that are located above the normal pool elevation.

There would be negligible changes in risk to cultural resources sites at Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake. Cultural resource sites behind levees in Iowa would experience a small increase in site-days, while sites behind levees in Missouri would experience a small decrease in average annual site-days relative to Alternative 1. There would be negligible change in risks to cultural resources in Montana, Nebraska and Kansas.

In considering the significance of impacts, CEQ states that federal agencies should consider both context and intensity (40 CFR 1508.27). The evaluation of intensity should consider the degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the NRHP or may cause loss or destruction of significant scientific, cultural, or historical resources. Modeling performed for cultural resources impacts assessment cannot determine with certainty that a specific cultural resource site would be adversely impacted; however, it indicates where there is an increase in risk that sites could be impacted. Across the study area, there would be both increases and decreases in risk to cultural resources sites. A relatively small increase in risk would occur for some reservoir and riverine sites under Alternative 2. However, if cultural resource sites were impacted, there is potential that the adverse impact could be large and significant depending on the actual physical impact on the site and the cultural significance of the site.

3.9.2.6 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include those that focus on the construction of ESH and early life stage pallid sturgeon habitat through mechanical means. The spring spawning cue release that occurs under Alternative 1 would not be implemented under Alternative 3. ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and early life stage pallid sturgeon habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Alternative 3 includes fewer acres of early life stage pallid sturgeon habitat compared to the acres constructed under Alternative 1.

Mechanical Habitat Construction

Alternative 3 includes an average of 332 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 early life stage pallid sturgeon habitat construction in the lower river between Ponca, Nebraska 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 vandalism or looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. Compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 3, as ESH construction would also occur in the Fort Randall reach. However, Alternative 3 would result in less early life stage pallid sturgeon habitat construction than under Alternative 1, with fewer potential impacts to cultural resource sites. Impacts would be negligible compared to Alternative 1 because of the very similar amounts of mechanical habitat construction under Alternative 3.

There could be localized long-term adverse impacts to cultural resources if any properties are permanently damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. In order to avoid and/or minimize these types of impacts, NHPA Section 106 and 110 will be followed as management plan actions are implemented.

Elimination of Spawning Cue Release

The elimination of the spawning cue release would result in very little changes in reservoir elevations and river stages along the Missouri River compared to Alternative 1. In some years, the upper three reservoirs would be slightly higher than under Alternative 1 from the elimination of the spring spawning cue release. The greatest increase in average annual site-days would occur for sites located above normal pool elevations at Lake Sakakawea (19 average annual site-days) and Lake Oahe (12 average annual site-days), a 2% increase in site-days compared to Alternative 1 at both reservoirs from higher pool levels from the elimination of the spawning cue release. There would be some very small decreases in site-days for sites below the normal pool elevation at the upper three reservoirs, with sites at Lake Oahe experiencing a decrease of 262 average annual site-days, a decrease of 1 percent. Cultural resources at the lower three reservoirs would experience negligible changes in site-days under Alternative 3 compared to Alternative 1 (Table 3-35). Changes in risk for cultural resources sites in riverine reaches under Alternative 3 would be negligible relative to Alternative 1 (Table 3-36).

Table 3-35. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 3 (Percent Change from Alternative 1)	Alternative 1	Alternative 3
Fort Peck Lake	Above	15	15 (0%)	3	3
	Below	360	356 (-1%)	70	70
Lake Sakakawea	Above	921	940 (2%)	11	12
	Below	7,462	7,456 (0%)	80	80
Lake Oahe	Above	669	681 (2%)	12	13
	Below	32,723	32,461 (-1%)	82	82
Lake Sharpe	Above	4,367	4,368 (0%)	82	82
	Below	4,054	4,053 (0%)	82	82
Lake Francis Case	Above	79	79 (0%)	6	8
	Below	3,704	3,704 (0%)	82	82
Lewis and Clark Lake	Above	1,582	1,584 (0%)	82	82
	Below	2	2 (0%)	27	28

Table 3-36. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 3 (Percent Change from Alternative 1)	Alternative 1	Alternative 3
Montana	No Levee	2	2 (0%)	1	1
Nebraska	No Levee	8,487	8,499 (0%)	82	82
	Behind Levees	69	69 (0%)	45	45
Iowa	No Levee	299	302 (1%)	76	76
	Behind Levees	464	473 (2%)	29	29
Kansas	No Levee	26	26 (0%)	17	17
	Behind Levees	21	21 (0%)	35	35
Missouri	No Levee	4,664	4,670 (0%)	82	82
	Behind Levees	2,398	2,353 (-2%)	70	70

Notes: The values in parenthesis indicate percent difference between Alternative 1 and Alternative 3.

All recorded sites in North Dakota and South Dakota are accounted for on the Mainstem reservoirs. Montana has no previously recorded sites located behind levees that would be impacted.

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release that may be implemented under Alternative 3 was not included in the hydrologic modeling for the alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Flows equivalent to the one-time spawning cue test were modeled for multiple years in the period of record under Alternative 6. In general, under Alternative 6, cultural resource sites at the upper three reservoirs located below the normal pool level would experience increases in annual average site-days relative to Alternative 1 from longer duration and greater frequency of lower reservoir elevations under Alternative 6 in the years of or following the spawning cue release. In addition, higher reservoir elevations in a number of years at Lake Oahe under Alternative 6 would increase risks to sites that are located above the normal pool elevation. There would be negligible to small changes in risks to cultural resources sites at Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake. Cultural resource sites in Nebraska, Iowa, and Missouri would experience an increase in average annual site-days, while sites in other locations in the riverine reaches would experience negligible changes in risk relative to Alternative 1. Because the spawning cue test would be a one-time event, there would be the possibility of increased risks to cultural resources in the year of or following the test, which would likely to occur in Iowa, Nebraska, and Missouri, and at the upper three reservoirs; these impacts would be adverse, localized, and likely temporary, but could be large depending on the site affected and the exposure and/or damage to the site.

Conclusion

Because there are negligible changes in reservoir elevations and river stages from the elimination of the spawning cue release, there would be negligible to small changes in risks to cultural resources sites in most locations under Alternative 3. There would be negligible changes in risks to sites in the lower three reservoirs. The analysis indicates small increases in risk to sites located above the normal pool level at Lake Oahe and Lake Sakakawea and small reductions in risks to cultural resource sites located below the normal pool level at Fort Peck Lake and Lake Oahe. Cultural resources sites located above the normal pool level at Lake Oahe and Lake Sakakawea would experience a small increase in average annual site-days (2%). The spawning cue test under Alternative 3 would be a one-time event, resulting in the possibility of increased risks to cultural resources in the year of or following the test, which could occur to cultural resources in Iowa, Nebraska, and Missouri, and at the upper three reservoirs. Although the change in risk to sites would be small (less than 10%), the potential adverse impacts to the sites would be uncertain, and could be large and significant, depending on type and significance of the site affected and the exposure and/or damage to the site.

Additionally, habitat construction actions would be similar to Alternative 1 and could result in small adverse impacts to cultural resources; adverse impacts could be long-term if any cultural resources are damaged during construction although mitigation actions under NHPA Section 106 and 110 and Programmatic Agreements would seek to minimize and/or avoid these impacts.

3.9.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 includes a spring release in April and part of May to create ESH. In addition, mechanical ESH and early life stage pallid sturgeon habitat would also be constructed.

Mechanical Habitat Construction

Alternative 4 includes an average of 195 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 early life stage pallid sturgeon habitat construction in the lower river between Ponca, Nebraska 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 indirectly in the form of vandalism or looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. Compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 4, as ESH construction would also occur in the Fort Randall reach. However, Alternative 4 would result in less early life stage pallid sturgeon habitat construction than under Alternative 1, with fewer potential impacts to cultural resource sites. Impacts would be negligible compared to Alternative 1 because of the very similar amounts of mechanical habitat construction under Alternative 4. There could be localized long-term adverse impacts to cultural resources if any properties are permanently damaged during construction. The difference in the number 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. In order to avoid and/or minimize these types of impacts, NHPA Section 106 and 110 will be followed as management plan actions are implemented.

Spring Habitat-Forming Flow Release

The spring release under Alternative 4 would result in lower reservoir elevations in the year of or years following the release at Fort Peck Lake, Lake Sakakawea, and Lake Oahe. As a result, Alternative 4 would result in negligible to small changes in risk to cultural resources at risk at the upper three reservoirs. Relative to Alternative 1, sites located below normal pool levels at Fort Peck Lake (6% increase), Lake Sakakawea (5% increase) and Lake Oahe (4%) would experience an increase in the number of average annual site-days from the spring release decreasing reservoir elevation in the year of or following the release. However, because of relatively lower elevations at Lake Sakakawea and Lake Oahe, cultural resources located above the normal pool level would experience reductions in the average annual site-days, a decrease of 8% and 14%, respectively (Table 3-37).

There would be varying risks of impacts on average for the cultural resources sites in the riverine reaches. Sites located in the riverine reaches and not located behind levees in Nebraska, Missouri, and Iowa would have increases in average annual site-days; with up to 143 additional sites in these three states subject to higher risk of impacts under this alternative relative to Alternative 1. Sites at other locations would have either negligible changes or small decreases in risk compared to Alternative 1 (Table 3-38).

Table 3-37. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 4 (Percent Change from Alternative 1)	Alternative 1	Alternative 4
Fort Peck Lake	Above	15	15 (0%)	3	3
	Below	360	382 (6%)	70	70
Lake Sakakawea	Above	921	850 (-8%)	11	10
	Below	7,462	7,854 (5%)	80	80
Lake Oahe	Above	669	574 (-14%)	12	12
	Below	32,723	34,164 (4%)	82	82
Lake Sharpe	Above	4,367	4,383 (0%)	82	82
	Below	4,054	4,046 (0%)	82	82
Lake Francis Case	Above	79	77 (-3%)	6	8
	Below	3,704	3,708 (0%)	82	82
Lewis and Clark Lake	Above	1,582	1,588 (0%)	82	82
	Below	2	3 (50%)	27	34

Table 3-38. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 4 (Percent Change from Alternative 1)	Alternative 1	Alternative 4
Montana	No Levee	2	2 (0%)	1	1
Nebraska	No Levee	8,487	8,501 (0%)	82	82
	Behind Levees	69	68 (-1%)	45	45

State	Levee Status	Average-Annual Site-Days		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 4 (Percent Change from Alternative 1)	Alternative 1	Alternative 4
Iowa	No Levee	299	312 (4%)	76	78
	Behind Levees	464	465 (0%)	29	28
Kansas	No Levee	26	25 (-4%)	17	17
	Behind Levees	21	20 (-5%)	35	35
Missouri	No Levee	4,664	4,700 (1%)	82	82
	Behind Levees	2,398	2,375 (-1%)	70	70

Notes: The values in parenthesis indicate percent difference between Alternative 1 and Alternative 4.
All recorded sites in North Dakota and South Dakota are accounted for on the Mainstem reservoirs. Montana has no previously recorded sites located behind levees that would be impacted.

Conclusion

Under Alternative 4 cultural resource sites at the upper three reservoirs located below the normal pool level would experience increases in average annual site-days relative to Alternative 1 due to lower reservoir elevations under Alternative 4 from the implementation of the spring release. The greatest percentage increase in site days relative to Alternative 1 would occur at Fort Peck Lake (+6%), Lake Sakakawea (+5%), and Lake Oahe (+4%). In addition, lower average reservoir elevations at Lake Oahe and Lake Sakakawea under Alternative 4 would decrease average annual site-days for cultural resource that are located above the normal pool elevation.

There would be negligible changes in risks to cultural resources sites at Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake. Cultural resource sites not behind levees in Nebraska, Iowa, and Missouri would experience an increase in site-days, while sites in other locations in the riverine reaches would experience negligible changes or decreases in risk relative to Alternative 1. There would be both increases and decreases in risks to cultural resources sites at the upper three reservoirs and in the lower river from changes in river stages and reservoir elevations associated with the spring release. These small increases in risks to cultural resources under Alternative 4 could be large, and potentially significant, depending on the actual physical impact on the site and cultural significance of the site.

Similar to Alternative 1, construction of early life stage pallid sturgeon habitat and ESH habitat could result in potential impacts to cultural resources directly through damage to property during construction and indirectly in the form of vandalism or looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover. Impacts from construction activity would be localized but could be long-term and adverse if any properties are permanently damaged during construction although mitigation actions under NHPA Section 106 and 110 and Programmatic Agreements would seek to minimize and/or avoid these impacts.

3.9.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 includes a fall release in October and November to create ESH. Alternative 5 includes fewer acres of constructed early life stage pallid sturgeon habitat compared to the acres constructed under Alternative 1 in the lower river.

Mechanical Habitat Construction

Alternative 5 includes an average of 253 acres annually of mechanical construction of ESH in the Gavins Point, Fort Randall, and Garrison Reaches in years when construction occurs. It also includes up to 3,380 acres of early life stage pallid sturgeon habitat construction in the lower river between Ponca, Nebraska and the confluence with the Mississippi River. The risk to cultural resources from mechanical habitat construction under Alternative 5 is similar to those described under Alternative 1. These risks include potential direct impacts through damage to property during construction and indirect impacts in the form of vandalism or looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. Compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 5, as ESH construction would also occur in the Fort Randall reach. However, Alternative 5 would result in less early life stage pallid sturgeon habitat construction than under Alternative 1, with fewer potential impacts to cultural resource sites. Impacts would be negligible compared to Alternative 1 because of the very similar amounts of mechanical habitat construction under Alternative 5. Risk of impacts would be negligible compared to Alternative 1 because the number of acres of mechanical habitat construction would be similar. There could be localized long-term adverse impacts to cultural resources if any properties are permanently damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. In order to avoid and or minimize these impacts, NHPA Section 106 and 110 will be followed as management plan actions are implemented.

Fall Habitat-Forming Flow Release

The fall release under Alternative 5 would result in slightly lower reservoir elevations in the year of or years following the release at Lake Sakakawea and Lake Oahe. Relative to Alternative 1, sites located below normal pool levels at Lake Sakakawea (2% increase) and Lake Oahe (2% increase) would experience an increase in the number of average annual site-days from the fall release decreasing reservoir elevations. In addition, cultural resource sites located above the normal pool at Lake Oahe would also experience increases in the average annual site-days of 9 percent. This would be due primarily to a release in 1994 that would result in higher water elevations at Lake Oahe in 1995 and a subsequent increase in annual average site-days. Alternative 5 would result in negligible to small changes in risk to cultural resources at the lower three reservoirs. The change in risk of impacts to sites at Lake Francis Case would be primarily due to rebalancing of the reservoirs after a release year in 1994 and an increase in water elevations at Lake Francis Case the following year, 1995, which coincided with a relatively high water year (Table 3-39).

There would be varying impacts on average for the cultural resources sites in the riverine reaches. Sites located in the riverine reaches not behind levees in Nebraska and Iowa would experience increases in average annual site-days. Sites at other locations would have either negligible changes or small decreases in risk compared to Alternative 1 (Table 3-40).

Table 3-39. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 5 (Percent Change from Alternative 1)	Alternative 1	Alternative 5
Fort Peck Lake	Above	15	16 (7%)	3	3
	Below	360	361 (0%)	70	72
Lake Sakakawea	Above	921	830 (-10%)	11	11
	Below	7,462	7,635 (2%)	80	81
Lake Oahe	Above	669	726 (9%)	12	14
	Below	32,723	33,419 (2%)	82	82
Lake Sharpe	Above	4,367	4,381 (0%)	82	82
	Below	4,054	4,047 (0%)	82	82
Lake Francis Case	Above	79	98 (24%)	6	9
	Below	3,704	3,719 (0%)	82	82
Lewis and Clark Lake	Above	1,582	1,582 (0%)	82	82
	Below	2	2 (0%)	27	25

Table 3-40. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 5 (Percent Change from Alternative 1)	Alternative 1	Alternative 5
Montana	No Levee	2	2 (0%)	1	1
Nebraska	No Levee	8,487	8,501 (0%)	82	82
	Behind Levees	69	67 (-3%)	45	44
Iowa	No Levee	299	305 (2%)	76	76
	Behind Levees	464	464 (0%)	29	28
Kansas	No Levee	26	26 (0%)	17	16
	Behind Levees	21	20 (-5%)	35	35
Missouri	No Levee	4,664	4,644 (0%)	82	82
	Behind Levees	2,398	2,332 (-3%)	70	70

Notes: The values in parenthesis indicate percent difference between Alternative 1 and Alternative 5.

All recorded sites in North Dakota and South Dakota are accounted for on the Mainstem reservoirs. Montana has no previously recorded sites located behind levees that would be impacted.

Conclusion

Under Alternative 5, cultural resource sites at Lake Sakakawea and Lake Oahe located below the normal pool level would experience increases in average annual site days relative to

Alternative 1 from longer duration and greater frequency of lower reservoir elevations under Alternative 5. The increase in average annual site-days relative to Alternative 1 would occur at Lake Sakakawea (+2%) and Lake Oahe (+2%). In addition, higher reservoir elevations in a number of years at Fort Peck Lake and Lake Oahe under Alternative 5 would increase risks to sites that are located above the normal pool elevation.

There would be negligible to small changes in risk of impacts to cultural resources sites at Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake. Cultural resource sites in Nebraska and Iowa would experience an increase in site-days, while sites in other locations in the riverine reaches would experience negligible changes or decreases in risk relative to Alternative 1. There would be both increases and decreases in risks to cultural resources sites at the upper three reservoirs and in the lower river from changes in river stages and reservoir elevations associated with the fall release. These small increases in risks to cultural resources under Alternative 5 could be large, and potentially significant, depending on the actual physical impact on the site and cultural significance of the site.

Similar to Alternative 1, construction of early life stage pallid sturgeon habitat and ESH habitat could result in potential impacts to cultural resources directly through damage to property during construction and indirectly in the form of vandalism or looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover. Impacts from construction activity could be adverse if any properties are permanently damaged although mitigation actions under NHPA Section 106 and 110 and Programmatic Agreements would seek to minimize and/or avoid these impacts.

3.9.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes a bi-modal spawning cue release in March and May to benefit the pallid sturgeon. Alternative 6 includes construction of fewer acres of early life stage pallid sturgeon habitat compared to the acres constructed under Alternative 1 in the lower river.

Mechanical Habitat Construction

Alternative 6 includes an average of 245 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 early life stage pallid sturgeon habitat construction in the lower river between Ponca, Nebraska 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 vandalism or looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. Compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 6, as ESH construction would also occur in the Fort Randall reach. However, Alternative 6 would result in less early life stage pallid sturgeon habitat construction than under Alternative 1, with fewer potential impacts to cultural resource sites. Impacts would be negligible compared to Alternative 1 because the mechanical construction amounts would be similar. There could be adverse impacts to cultural resources if any properties are permanently damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. In order to avoid and or minimize these impacts, NHPA Section 106 and 110 will be followed as management plan actions are implemented.

Spring Spawning Cue Flow Release

The spawning cue release under Alternative 6 would result in lower reservoir elevations in the year of or years following the releases at Fort Peck Lake, Lake Sakakawea, and Lake Oahe. Relative to Alternative 1. Sites located below normal pool levels at Fort Peck Lake (6% increase), Lake Sakakawea (3% increase), and Lake Oahe (7% increase) would experience an increase in the number of average annual site-days from the spawning cue release decreasing reservoir elevations. In addition, cultural resource sites located above the normal pool at Lake Oahe would also experience increases in the average annual site-days, an increase of 10 percent. These impacts would occur as a result of a high water year that follows a year with a full release resulting in increased reservoir elevations as reservoirs rebalance in a high water year and likely further reduce flow releases for flood control. Alternative 6 would result in negligible to small changes in cultural resources at risk at the lower three reservoirs (Table 3-41).

There would be varying impacts on average for the cultural resources sites in the riverine reaches. Sites located in the riverine reaches in Nebraska, Iowa, Missouri would experience increases in average annual site-days, with up to 143 additional sites in these three states subject to higher risk of impacts under this alternative relative to Alternative 1. Sites at other locations would have either negligible changes or small decreases in this risk compared to the Alternative 1 (Table 3-42).

Table 3-41. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 6 (Percent Change from Alternative 1)	Alternative 1	Alternative 6
Fort Peck Lake	Above	15	15 (0%)	3	3
	Below	360	381 (6%)	70	71
Lake Sakakawea	Above	921	922 (0%)	11	11
	Below	7,462	7,693 (3%)	80	80
Lake Oahe	Above	669	738 (10%)	12	11
	Below	32,723	34,860 (7%)	82	82
Lake Sharpe	Above	4,367	4,384 (0%)	82	82
	Below	4,054	4,045 (0%)	82	82
Lake Francis Case	Above	79	61 (-23%)	6	5
	Below	3,704	3,708 (0%)	82	82
Lewis and Clark Lake	Above	1,582	1,590 (1%)	82	82
	Below	2	2 (0%)	27	26

Table 3-42. 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		Number of Years impacts would occur over the POR	
		Alternative 1	Alternative 6 (Percent Change from Alternative 1)	Alternative 1	Alternative 6
Montana	No Levee	2	2 (0%)	1	1
Nebraska	No Levee	8,487	8,507 (0%)	82	82
	Behind Levees	69	69 (0%)	45	43
Iowa	No Levee	299	312 (4%)	76	79
	Behind Levees	464	479 (3%)	29	29
Kansas	No Levee	26	25 (-4%)	17	18
	Behind Levees	21	21 (0%)	35	35
Missouri	No Levee	4,664	4,693 (1%)	82	82
	Behind Levees	2,398	2,376 (-1%)	70	70

Notes: The values in parenthesis indicate percent difference between Alternative 1 and Alternative 6.

All recorded sites in North Dakota and South Dakota are accounted for on the Mainstem reservoirs. Montana has no previously recorded sites located behind levees that would be impacted.

Conclusion

Under Alternative 6, cultural resource sites at the upper three reservoirs located below the normal pool level would experience increases in average-annual site-days relative to Alternative 1 from longer duration and greater frequency of lower reservoir elevations under Alternative 6. The greatest percentage increase in site-days relative to Alternative 1 are noted at Fort Peck Lake (+6%), Lake Sakakawea (+3%), and Lake Oahe (+7%). In addition, higher reservoir elevations in a number of years at Lake Oahe under Alternative 6 would increase risks to sites that are located above the normal pool elevation.

There would be negligible to small changes in risks to cultural resources sites at Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake. Cultural resource sites in Nebraska, Iowa, and Missouri would experience an increase in site-days, while sites in other locations in the riverine reaches would experience negligible changes or decreases in risk relative to Alternative 1. There would be both increases and decreases in risks to cultural resources sites at the upper three reservoirs and in the lower river from changes in river stages and reservoir elevations associated with the spring release. Cultural resources at an increased level of risk would occur in Iowa, Nebraska, and Missouri, and at the upper three reservoirs, up to 10 percent increase in average annual site-days; these small increases in risks to cultural resources under Alternative 6 could be large and potentially significant, depending on the actual physical impact on the site and cultural significance of the site.

Similar to Alternative 1, construction of early life stage pallid sturgeon habitat and ESH habitat could result in potential impacts to cultural resources directly through damage to property during construction and indirectly in the form of vandalism or looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover. Impacts from construction activity would be adverse if any properties are permanently damaged during construction although mitigation actions under NHPA Section 106 and 110 and Programmatic Agreements would seek to minimize and/or avoid these impacts.

3.9.2.10 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 (Cook et al. 2015). There is the potential that severe impacts to cultural resources would directly follow from these increases to variability of reservoir water surface elevations, and greater flood related damages in riverine settings. This greater variability would be similar under each alternative, and the increased impacts would be similar for each of the alternatives, therefore the conclusions described for each alternative would not vary substantially under the expected climate change scenario.

3.9.2.11 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 and/or exposure, as well as impacts from changes in existing land 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. Construction can directly impact 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 (Dunn 1996). 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. This is largely because the active management of the reservoir System has drastically changed the landscape, which resulted in significant adverse impacts to cultural resources following the construction of the reservoir System and BSNP (Dunn 1996). The contribution of Alternative 1 to present and future adverse cumulative impacts would result in small increased risks to cultural resources that could be large depending on the actual physical impact on the cultural resource site, and the cultural significance of the site. 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 an increase in risk of 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 the larger projected magnitudes of the 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 adverse. The contribution to adverse impacts from Alternative 2 in context of other past, present, and reasonably foreseeable future actions is anticipated to result in small increased risks to cultural resources that could be large depending on the actual physical impact on the site and the cultural significance of the site.

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 adverse, but the contribution to adverse cumulative impacts from this alternative would negligible. Impacts to individual sites could be large and adverse depending on type and significance of site affected and the exposure and/or damage to the site.

Alternative 4 would result in the potential for fewer adverse impacts to cultural resource sites from construction relative to Alternative 1, but the variation in flows that could adversely impact individual cultural resource sites due to increased frequency and magnitude of reservoir level fluctuations could increase risks. When combined with past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 4 would be adverse. The contribution to adverse impacts from Alternative 4 in context of other past, present, and reasonably foreseeable future actions would be negligible though impacts to individual sites could be large and adverse depending on the actual physical impact on the site and the cultural significance of the site

Alternative 5 releases would occur in the fall rather than the spring. The analysis forecasted an increased chance of risk to cultural resources for some reservoirs, particularly at Lake Oahe. When combined with past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 5 would be adverse. The contribution to adverse impacts from Alternative 5 in context of other past, present, and reasonably foreseeable future actions is anticipated to be negligible though impacts to individual sites could be large and adverse depending on the actual physical impact on the site and the cultural significance of the site.

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 anticipated to be negligible though impacts to individual sites may be large and adverse depending on the actual physical impact on the site, and cultural significance of the site.

3.10 Land Ownership

A change in land ownership under the MRRMP-EIS alternatives may have implications for the economy as well as changes in tax receipts to local governments. This section provides a description of the current land cover, land ownership, and agricultural characteristics in the Missouri river floodplain. This section includes a brief overview of the methodology for evaluating the regional economic development (RED) 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 as well as the RED results. The “Land Ownership Environmental Consequences Analysis Technical Report” provides additional details on the RED methodology and results. This section also includes a discussion of the Other Social Effects considerations and potential impacts associated with changes in land ownership.

It should be noted that the evaluation of flood risk impacts to property, infrastructure, and agriculture are described in Section 3.12, Flood Risk Management and Interior Drainage, with supplemental information in the Flood Risk Management and Interior Drainage Environmental Consequences Analysis Technical Reports. An evaluation of ecosystem services associated with the federal acquisition of lands for habitat is provided in Section 3.23, Ecosystem Services. An evaluation of impacts of the alternatives on irrigation is provided in Section 3.14, Irrigation. An evaluation of the RED benefits (i.e., jobs and income) associated with the construction of habitat is provided in Section 3.25, Regional Economic Effects of Program Expenditures. A description of the land acquisition and the development of early life stage habitat for the pallid sturgeon and ESH is provided in Section 2.5, Management Actions.

3.10.1 Affected Environment

This section describes land cover and land ownership patterns for the floodplain area along the Missouri River, as well as agriculture land use and the prevalence of prime farmlands in the floodplain. A description of current Payments in Lieu of Taxes (PILT) for the counties with MRRP habitat is also provided in this section.

3.10.1.1 Land Cover

Land cover within the floodplain includes developed lands, agricultural lands, open water, and other types of land covers. 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 ownership consists of non-developed areas including croplands, grazing, and ranching lands.

The patterns of land cover and land use in the Missouri River floodplain were interpreted through geospatial analysis based on available land cover data from the National Agricultural Statistics Service (NASS) 2014 Cropland Data Layer. The land cover patterns within the river reaches are summarized in Table 3-43. 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.

Agriculture is a prevalent activity within the floodplain in the lower river, between Gavins Point Dam and the mouth of the Missouri River, accounting between 63 to 72 percent of floodplain land cover along this portion of the river. 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 Garrison Dam to Lake Oahe (48 percent) and from Oahe Dam to Lake Sharpe (36 percent).

Table 3-43. 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%	228,200
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%	295,950
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
Lewis and Clark Lake	81.1%	1.0%	1.3%	16.6%	39,401
Gavins Point Dam to Rulo	5.0%	71.6%	9.1%	14.3%	1,355,293
Rulo to the Mouth of the Missouri River	10.5%	63.2%	8.3%	18.0%	943,007
Total Acres/Percent	**28.5%**	**48.3%**	**6.3%**	**16.9%**	**3,656,402**

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.

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. 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 (see Section 3.10.1.4 for additional details on PILT).

Along the Missouri River, there are lands owned by federal, state, and local governments as well as Tribes and private lands. 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 lands.[2] The PAD-US dataset is administered by the USGS and includes data from counties, cities, federal agencies, states, and national non-profit organizations. The PAD-US data also includes private lands if they have a conservation easement or similar state or federal protection status.

Table 3-44 presents the acreage of these 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 occur throughout the Missouri River floodplain, but are more prevalent 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. In the lower river, the vast majority of lands are privately-owned.

Table 3-44. Federal, State, and Tribal, and Other Private Conservation and Recreation Lands in the Floodplain, 2012

River Reach	Total Floodplain Acres	Privately Owned Lands [a]	Land Ownership				
			Federal	Tribal	State	Local Government	Other Entities [b]
Fort Peck Lake	215,424	23,197	191,878	0	0	0	349
(% of floodplain)	100.0%	10.8%	89.1%	0.0%	0.0%	0.0%	0.2%
Fort Peck Dam to Lake Sakakawea	228,201	113,855	4,023	105,239	4,506	0	578
(% of floodplain)	100.0%	49.9%	1.8%	46.1%	2.0%	0.0%	0.3%
Lake Sakakawea	314,715	45,197	246,087	159	21,508	0	1,764
(% of floodplain)	100.0%	14.4%	78.2%	0.1%	6.8%	0.0%	0.6%
Garrison Dam to Lake Oahe	72,497	65,883	1,597	0	3,248	0	1,769
(% of floodplain)	100.0%	90.9%	2.2%	0.0%	4.5%	0.0%	2.4%
Lake Oahe	295,950	27,523	245,639	5,327	16,869	0	592
(% of floodplain)	100.0%	9.3%	83.0%	1.8%	5.7%	0.0%	0.2%
Oahe Dam to Lake Sharpe	5,645	3,242	1,969	0	434	0	0
(% of floodplain)	100.0%	57.4%	34.9%	0.0%	7.7%	0.0%	0.0%

[2] It should be noted that there are private landowners that manage their lands to support habitat for a wide variety of species. The PAD-US data does not include these private lands unless they have a conservation easement or similar state or federal protection status.

River Reach	Total Floodplain Acres	Privately Owned Lands [a]	Land Ownership				
			Federal	Tribal	State	Local Government	Other Entities [b]
Lake Sharpe	72,905	17,388	44,040	8,511	2,966	0	0
(% of floodplain)	100.0%	23.9%	60.4%	11.7%	4.1%	0.0%	0.0%
Lake Francis Case	81,084	9,601	70,794	248	441	0	0
(% of floodplain)	100.0%	11.8%	87.3%	0.3%	0.5%	0.0%	0.0%
Fort Randall Dam to Lewis and Clark Lake	32,281	4,119	18,570	8,230	219	0	1,143
(% of floodplain)	100.0%	12.8%	57.5%	25.5%	0.7%	0.0%	3.5%
Lewis and Clark Lake	39,401	4,613	23,299	3	11,456	0	30
(% of floodplain)	100.0%	11.7%	59.1%	0.0%	29.1%	0.0%	0.1%
Gavins Point Dam to Rulo	1,355,293	1,215,393	58,482	14,418	36,156	0	30,843
(% of floodplain)	100.0%	89.7%	4.3%	1.1%	2.7%	0.0%	2.3%
Rulo to the Mouth of the Missouri River	943,007	845,877	17,917	0	40,549	043	37,720
(% of floodplain)	100.0%	89.7%	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 Federal, state, local, tribal, and other lands, which provides an estimate of the existence of privately owned lands.

b Other entities may include non-governmental organizations or private land owners with conservation easements or other agreements that provide for protected land status. The PAD-US definition of a protected area is "Dedicated to the preservation of biological diversity and to other natural, recreation and cultural uses, managed for these purposes through legal or other effective means" (PAD-US 2012)

3.10.1.3 Agriculture

Agriculture is a prevalent activity within the floodplain. Of the nearly 3.6 million acres considered within the Missouri River floodplain, approximately 1.7 million acres, or 48 percent of the floodplain, is currently used for agricultural purposes (Table 3-43). 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 3.14 (Irrigation) and Section 3.12 (Flood Risk Management and Interior Drainage).[3]

When considering the prevalence of agriculture, Missouri has the greatest number of agricultural acres in the Missouri River floodplain, with approximately 676,000 acres (Table 3-45). Corn and soybeans are the most common crops in the lower river states (Iowa, Missouri,

[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/.

Kansas, and Nebraska), while spring wheat and alfalfa are slightly more prevalent in states located in the upper river (North Dakota, South Dakota, Montana).

Table 3-45. Percent of Agriculture Acreage by Crop in the Missouri River Floodplain by State

	Montana	North Dakota	South Dakota	Nebraska	Iowa	Missouri	Kansas
Total Floodplain Acres	440,284	502,995	617,038	372,922	629,279	1,014,994	54,809
Total Agricultural Acres	132,085	60,359	196,218	218,905	460,632	675,986	25,377
Percentage of Floodplain Acres in Agriculture	30.0%	12.0%	31.8%	58.7%	73.2%	66.6%	46.3%
Crop Type, as a Percent of Agricultural Floodplain Acres							
Corn	2.7%	22.5%	47.8%	54.2%	53.6%	43.8%	50.1%
Soybeans	1.7%	17.5%	42.1%	42.6%	45.4%	53.2%	48.4%
Spring Wheat	41.0%	24.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Alfalfa	16.7%	5.0%	5.7%	1.7%	0.4%	0.0%	0.0%
Barley	4.0%	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Other Hay/ Non-Alfalfa	17.0%	6.7%	2.2%	0.3%	0.0%	0.6%	0.4%
Fallow/ Idle Cropland	7.3%	1.7%	0.0%	0.0%	0.0%	0.0%	0.2%
All Other Crops	9.7%	18.3%	2.2%	1.2%	0.7%	2.4%	0.9%

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. The total floodplain acres associated with the state estimates do not match exactly with the river reach estimates because Illinois floodplain acres in the Rulo to the Mouth river reach are not included in the table.

The Missouri River floodplain comprises a considerable amount prime farmland, especially in the lower river below Gavins Point Dam. Prime farmland is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It has the soil quality, growing season, and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management (NRCS 2017).

Prime farmland from Gavins Point Dam to Rulo and Rulo to the confluence with the Mississippi River comprises 53 and 64 percent of the floodplain acres, respectively. In the upper river, prime farmland is most prevalent from Fort Peck Dam to Lake Sakakawea, comprising 36 percent of the floodplain acres. Table 3-46 details the prime farmland acreage in each region and the percentage of prime farmland located within the floodplain.

Table 3-46. Prime Farmland in the Missouri River Floodplain

Region	State	Prime Farmland Acres in the Floodplain	Total Acres in Floodplain	Percent Prime Farmland in the Floodplain
Fort Peck Lake	Montana	**182**	**215,424**	**0.1%**
Fort Peck Dam to Lake Sakakawea	Montana	82,893	224,860	36.9%
	North Dakota	4	3,340	0.1%
	Total	**82,898**	**228,200**	**36.3%**
Lake Sakakawea	North Dakota	162	314,715	0.1%
Garrison Dam to Lake Oahe	North Dakota	5,648	72,497	7.8%
Lake Oahe	North Dakota	686	112,443	0.6%
	South Dakota	2,029	183,507	1.1%
	Total	**2,715**	**295,950**	**0.9%**
Oahe Dam to Lake Sharpe	South Dakota	**434**	**5,645**	**7.7%**
Lake Sharpe	South Dakota	**8,735**	**72,905**	**12.0%**
Lake Francis Case	South Dakota	**1,279**	**81,084**	**1.6%**
Randall Dam to Lewis and Clark Lake	Nebraska	1,951	12,893	15.1%
	South Dakota	2,125	19,389	11.0%
	Total	**4,076**	**32,281**	**12.6%**
Lewis and Clark Lake	Nebraska	8	19,474	0.0%
	South Dakota	165	19,928	0.8%
	Total	**173**	**39,401**	**0.4%**
Gavins Point Dam to Rulo	Iowa	296,765	629,279	47.2%
	Missouri	94,829	153,618	61.7%
	Nebraska	202,359	337,815	59.9%
	South Dakota	118,270	234,581	50.4%
	Total	**712,223**	**1,355,293**	**52.6%**
Rulo to the Mouth	Illinois	5,278	24,082	21.9%
	Kansas	39,130	54,809	71.4%
	Missouri	554,997	861,376	64.4%
	Nebraska	1,804	2,740	65.8%
	Total	**601,209**	**943,007**	**63.8%**

Source: USDA Natural Resources Conservation Service 2017.

3.10.1.4 Payments in Lieu of Taxes

When private lands are purchased by the federal government from willing sellers, property taxes are no longer collected on the federal lands. To compensate local governments for lost property tax revenue, counties with non-taxable federal lands are eligible for PILT to offset losses in property taxes and to help provide funding for local government services and programs. The

Department of the Interior's (DOI) Office of the Secretary has administrative authority over the PILT program. In addition to other responsibilities, DOI calculates payments according to the formulas established by law and distributes the available funds. The formula used to compute the payments is contained in the PILT Act and is based on population, receipt sharing payments, and the amount of Federal land within an affected county (US Department of Interior 2018). There are 34 counties adjacent to the lower Missouri River that include USACE-owned lands that are managed for habitat. The average PILT for these counties was estimated to be $2.47 per acre in Nebraska; $2.69 per acre in Kansas; $2.60 per acre in Iowa; and $2.61 per acre in Missouri in 2018 dollars (U.S. Department of the Interior 2018).

3.10.2 Environmental Consequences

3.10.2.1 Impacts Assessment Methodology

Changes in land 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. Other local, state, and federal taxes could be affected with the federal acquisition of lands from willing sellers, including state and federal corporate taxes; federal and state income taxes; personal and special district property taxes; and local and state sales and use taxes as farmers purchase materials, equipment, and spend their income in the local economy. This evaluation focuses on the most prevalent impact of the federal acquisition of farmlands – the reduction in the tax base and associated property tax receipts.

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 2013c). 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 considered in Section 3.25, Regional Economic Effects of Program Expenditures. This section provides a brief overview of the methodology for evaluating the RED and OSE impacts as a result of the federal acquisition of lands for early life stage habitat for the pallid sturgeon to meet the specified acreages under each of the MRRMP-EIS alternatives.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

Regional Economic Development

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 compares 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. Two models were developed for the RED analysis and were used to evaluate impacts for all alternatives, including Alternative 1 (the No Action alternative). Both models used data based on USACE assumptions for habitat creation under the MRRMP-EIS alternatives over the 15-year implementation period.

The estimated acres for federal acquisition of lands for the pallid sturgeon habitat construction are described in Chapter 2.0 and shown in the third column of Table 3-47Table 3-44. 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 Northwestern Division real estate office. The first model estimated the change in regional economic benefits (e.g., jobs, income, sales) if the lands that were acquired were in full 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. Table 3-47 Table 3-44summarizes the estimates for land acquisition under the MRRMP-EIS alternatives as well as the portion of acquired lands that were estimated to be in agricultural production.

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®, 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® 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 evaluates a change in property taxes as a result of the federal acquisition of agricultural land as well as an estimate of the PILT payments that would partially offset the losses in property taxes. It was assumed that all federally acquired lands under the alternatives would be subject to reduced property taxes and PILT payments. 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. The PILT data was obtained for the counties with USACE MRRP habitat lands from the Department of Interior (US DOI 2018). An average PILT per acre, for payments between 2013 and 2017 adjusted to 2018 dollars, was estimated from the county PILT for each state.

Table 3-47. Acquisition of Lands by Alternative

Alternative	Reach/State	Federally Acquired Lands (acres)	Acquired Lands in Crop Production (acres)
Alternative 1	Ponca to Rulo	1,848	1,109
	Nebraska	924	554
	Iowa	924	554
	Rulo to the Mouth	5,198	4,158
	Kansas	260	208
	Missouri	4,938	3,950
Alternative 2	Ponca to Rulo	15,555	9,333
	Nebraska	7,778	4,667
	Iowa	7,778	4,667
	Rulo to the Mouth	30,162	24,130
	Kansas	1,508	1,206
	Missouri	28,654	22,923
Alternatives 3–6	Ponca to Rulo	0	0
	Nebraska	0	0
	Iowa	0	0
	Rulo to the Mouth	1,772	1,418
	Kansas	89	71
	Missouri	1,683	1,347

Note: 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.

Marginally producing croplands would result in a smaller regional economic impact than estimated under this evaluation because the yields or acres cultivated may be lower than the assumption of extensive and full production of all croplands used in this evaluation. In addition, since willing sellers would be compensated the fair market value for their land, the direct effect as estimated in the economic impact analysis to the farming industry would be lower because the land owners would receive a payment that would theoretically include the future value of crop production. To be conservative, the analysis includes the direct effects, which may result in an overstatement of the regional economic impacts.

The RED results in this section are displayed for all federally acquired lands. The lands would be acquired incrementally over a 15-year implementation period. The RED impacts would be incurred cumulatively over the implementation period as the acreage is acquired by the federal government, resulting in the full impact at the end of the implementation period when all lands are acquired, and then in perpetuity thereafter. For a full discussion of the methodology performed for the RED analysis, please refer to the report “Land Ownership Environmental Consequences Analysis 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 3-48 provides a summary of the environmental consequences of federal acquisition of lands for habitat.

Table 3-48. Environmental Consequences Relative to Land Acquisition, 2018 Dollars

Alternative	RED	OSE
Management Actions Common to All Alternatives	No RED Impacts.	No OSE impacts.
Alternative 1	An estimated 7,046 acres would be targeted for federal acquisition, with 5,267 acres in agricultural production. A loss of 23 jobs and $1.1 million in labor income at the end of the implementation period across all locations. A reduction of $117,000 in net local government revenue at the end of the implementation period.	Negligible to small, adverse impacts to OSE.
Alternative 2	An estimated 45,816 acres would be targeted for federal acquisition, with 33,542 acres in agricultural production. A decrease of 117 jobs and $6.2 million in labor income at the end of the implementation period across all locations relative to Alternative 1. A total decrease of $786,000 in net government revenues 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.
Alternatives 3–6	An estimated 1,772 acres would be targeted for federal acquisition, with 1,418 acres in agricultural production. An increase of 16 jobs and $843,000 in labor income at the end of the implementation period across all locations relative to Alternative 1. A total increase of $106,000 in net government revenues at the end of the implementation period across all locations relative to Alternative 1.	Negligible impacts to OSE.
Alternative 3: Gavins Point One-Time Spawning Cue Test	The one-time spawning cue test would result in no additional changes to RED impacts.	Negligible impacts to OSE.

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 ownership located along the Missouri River because none of these actions will require a change in land ownership.

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

Under Alternative 1, the MRRP would continue to construct early life stage habitat to support recovery of the pallid sturgeon. This includes acquiring private lands from willing sellers when necessary to support the creation of early life stage habitat. Under Alternative 1, it was assumed the USACE would purchase 7,046 acres in the floodplain downstream of Ponca, Nebraska over the 15-year implementation period. Of these acres, it was assumed that 1,109 acres from Ponca to Rulo and 4,158 acres from Rulo to the mouth of the Missouri River were previously in crop production.

Regional Economic Development

Under Alternative 1, a reduction in estimated amount of 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 reduction of 23 jobs, $1.1 million in labor income, and $4.8 million in sales. With the highest number of acres affected, Missouri is expected to experience the most adverse impacts, with a total reduction of approximately 20 jobs, $810,000 in labor income, and sales of approximately $3.5 million (Table 3-49). 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 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. In addition, marginally producing croplands would result in a smaller regional economic impact than estimated under this evaluation because the yields or acres cultivated may be lower than the assumption of extensive and full production of all croplands used in this evaluation. In addition, lands that are federally acquired would no longer be susceptible to flood risk and potential payments for crop damages from flooding.

Table 3-49. Annual Reduction in Regional Economic Activity from Agricultural Land Acquisition under Alternative 1, 2018 Dollars

Impact	State				Total
	Nebraska	Iowa	Kansas	Missouri	
Estimated Federal Acres Acquired in Crop Production over the Implementation Period	554	554	208	3,950	5,267
Reduction in Sales	−$593,904	−$543,247	−$194,352	−$3,503,298	−$4,834,801
Reduction in Employment	−1.6	−1.2	−0.6	−19.5	−22.9
Reduction in Labor Income	−$134,492	−$144,963	−$44,476	−$810,624	−$1,134,555

Note: These annual economic impacts would occur in perpetuity and are presented for all agricultural lands estimated to be federally acquired.

Table 3-50 summarizes the annual 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 an annual loss of up to $135,000 in property tax revenue to local governments from the change in land ownership. There would be an estimated $18,000 in PILT, which would partially offset the reduced property tax revenues to location governments, with an estimated

$117,000 in reduced net government revenue from the federal acquisition of lands under Alternative 1.

The greatest loss in annual property tax receipts for local governments would be in Nebraska because the state of Nebraska assigns a relatively high value to agricultural lands for assessing property taxes compared to the other states. These reductions in property tax receipts would occur as land is purchased over the 15-year implementation period, but would be cumulative in nature and occur annually in perpetuity after the 15-year period. 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 in Nebraska were acquired in one county, the total loss in property tax revenue (after PILT payments) would be $51,000.

In addition, the federal acquisition of productive farmlands from willing sellers can affect not only property tax receipts to local governments, but also other local, state, and federal tax receipts, including state and federal corporate taxes; federal and state income taxes; personal and special district property taxes; and local and state sales and use taxes as farmers purchase materials, equipment, and spend their income in the local economy. The changes in these tax receipts are difficult to estimate and anticipated to be small and adverse as well as small in relation to the estimated changes in property tax receipts. This is due to Federal government payments to landowners for the purchase of the lands, which would be subject to taxes and support spending in the economy, offsetting the reductions in tax receipts.

Table 3-50. Annual Reduction in Property Tax under Alternative 1 from Land Acquisition, 2018 Dollars

Type of Impact	Nebraska	Iowa	Kansas	Missouri	Total
Reduction in Property Tax for All Acquired Lands	−$53,063	−$37,931	−$9,021	−$34,855	−$134,870
PILT	$2,285	$2,404	$699	$12,889	$18,276
Net Reduction in Local Government Revenues	−$50,778	−$35,527	−$8,322	−$21,966	−$116,593

Note: Negative changes indicate decreases in property revenues from the acquisition of lands for habitat construction. These annual fiscal impacts would occur in perpetuity and are presented for all lands anticipated to be federally acquired.

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 are estimated to be 1,848 acres between Ponca and Rulo, Nebraska and 5,198 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 0.2 percent and 0.9 percent of agricultural lands in the floodplain in these reaches, respectively. Although the location of the lands is uncertain, it is likely that some of the lands that would be federally acquired would be identified as prime farmland because of the considerable amount of prime farmland in the floodplain (53% in the floodplain in the Gavins to Rulo reach and 64% in Rulo to the Mouth reach). Even if all of the target acquisition acres were identified as prime farmland (7,046 acres), these acres would represent a very small proportion of prime farmland in the four lower river states (Iowa: 18.4

million acres; Nebraska: 12.1 million acres; Kansas: 23.0 million acres; and Missouri: 12.6 million acres) (USDA NRCS 2015).

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 ownership could have small adverse impacts to individual and community resiliency and economic vitality if acquisition of lands becomes concentrated in a few specific counties. Because land acquisitions would likely involve dozens of separate land purchases, it is unlikely that they would be concentrated in one or two locations. As a result, there are negligible changes anticipated to social effects in affected 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 negligible to small adverse impact on local economies and governments. For all acquired lands across all geographies during the implementation period, annually in perpetuity, employment is expected to reduce by 23 jobs, $1.1 million in labor income, and $4.8 million in sales from the federal acquisition of lands. Missouri is expected to experience the majority of these adverse impacts. Local government revenues would also be reduced under Alternative 1 ($117,000 annually across all locations) from reductions in property taxes. 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 negligible to small; land acquisition would likely be gradual over the implementation period and spread across multiple locations in the lower river; and land owners would be fairly compensated for their lands.

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. Under Alternative 2, the USACE would target to purchase 45,816 acres in the floodplain downstream of Ponca, Nebraska over the 15-year implementation period. Of these acres, it was assumed that 9,333 acres from Ponca to Rulo and 24,130 acres from Rulo to the mouth of the Missouri River were previously in crop production.

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 Rulo to the mouth of the river.

Table 3-51 summarizes the RED impacts associated with the federal land acquisition under Alternative 2. When compared to Alternative 1, Alternative 2 would result in an annual reduction of $6.2 million in labor income and 117 jobs across all locations in perpetuity after all lands have been acquired. In Missouri, land acquisition under Alternative 2, would result in an annual reduction of 94 jobs and $3.9 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.

It should be noted that these results may overestimate RED impacts because they include direct economic impacts; do not account for compensation that land owners would receive for the acquired lands; and full production of all croplands is also assumed. Similar to Alternative 1, lands that would be federally acquired under Alternative 2 would no longer be susceptible to flood risk and potential payments for crop damages from flooding. However, the conversion of private lands to federal lands for habitat is a long-term annual RED impact that eliminates farming economic activity on these lands in perpetuity, although other regional benefits could be realized from public access and recreation activities.

Table 3-51. Change in Annual Regional Economic Activity under Alternative 2 Relative to Alternative 1, 2018 Dollars

Impact	Nebraska	Iowa	Kansas	Missouri	Total
Estimated Federal Acres Acquired in Crop Production	4,667	4,667	1,206	22,923	33,463
Change in Sales Relative to Alternative 1	−$4,405,110	−$4,029,377	−$933,398	−$16,824,995	−$26,192,880
Change in Employment Relative to Alternative 1	−11.7	−8.9	−2.9	−93.8	−117.4
Change in Labor Income Relative to Alternative 1	−$997,552	−$1,075,224	−$213,600	−$3,893,116	−$6,179,492

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. These annual economic impacts would occur in perpetuity and are presented for all agricultural lands anticipated to be federally acquired.

Under Alternative 2, property tax receipts in all four states would be adversely impacted relative to Alternative 1 from land acquisition activities, with an annual reduction of $786,000 in net government revenues compared to Alternative 1. Table 3-52 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 an annual loss of $377,000 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. This is particularly true in Nebraska, where property tax per acre is higher relative to the other states. The PILT would only partially reduce the adverse impacts to these local governments.

The federal acquisition of productive farmlands from willing sellers can also affect state and federal corporate taxes; federal and state income taxes; personal and special district property taxes; and local and state sales and use taxes as farmers purchase materials, equipment, and spend their income in the local economy. Additional associated changes in other local, state, and federal tax receipts are likely to be small and adverse because the government payments to acquire the lands would be subject to taxes and support spending in the economy, offsetting the reductions in tax receipts and local government revenues.

Table 3-52. Change in Annual Property Tax under Alternative 2 Relative to Alternative 1, 2018 Dollars

Type of Impact	Nebraska	Iowa	Kansas	Missouri	Total
Change in Property Tax Relative to Alternative 1	−$393,580	−$281,339	−$43,496	−$168,059	−$886,475
Change in PILT Relative to Alternative 1	$16,950	$17,828	$3,370	$62,144	$100,293
Change in Net Local Government Revenues Relative to Alternative 1	−$376,630	−$263,511	−$40,126	−$105,915	−$786,182

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. These annual fiscal impacts would occur in perpetuity and are presented for all lands anticipated to be federally acquired.

Other Social Effects

Total targeted acres for acquisition of lands are estimated to be 15,555 acres in the Ponca to Rulo reach and 30,261 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 1.6 percent and 5.4 percent of agricultural lands in the floodplain in these reaches, respectively. The transition of the lands to federal ownership would remove its designation as prime farmlands. Even if all of the lands were identified as prime farmland (45,816 acres), these acres would represent a small proportion of prime farmland in the four states (Iowa: 18.4 million acres; Nebraska: 12.1 million acres; Kansas: 23.0 million acres; and Missouri: 12.6 million acres) (USDA NRCS 2015).

After the acquisition of all lands, up to 113 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 140 annual jobs could be affected. 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 become concentrated in only a few counties.

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 small. However, if the concentration of acquired lands over the implementation period is concentrated in a small number of locations in a rural region with limited economic activity, the adverse impacts could be relatively large in relation to that small economy. Alternative 2 would result in an annual reduction of $6.2 million in labor income and 117 fewer jobs across all locations at the end of the implementation period 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 annual reductions in net local government revenue ranging from $40,000 to $377,000 relative to Alternative 1 depending on the state. Due the gradual acquisition of lands over the implementation period, these adverse impacts are likely to be incrementally small, but could be locally large if lands are concentrated and the counties are relatively small and rural with limited funding sources. Alternative 2 would not have significant impacts from land acquisition activities because lands would be acquired from willing sellers, adverse impacts to regional economic and social conditions would be small in a regional context, and impacts associated with property tax reductions would be 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 across these alternatives. Under Alternative 3 through 6, the USACE would target to purchase 1,772 acres in the floodplain downstream of Ponca, Nebraska over the 15-year implementation period. Of these acres, it was assumed that 1,418 acres from Rulo to the mouth of the Missouri River were previously in crop production; no acres are anticipated to be federally acquired between Ponca and Rulo, Nebraska for the purpose of supporting early life stage habitat for pallid sturgeon.

Regional Economic Development

Under Alternatives 3–6, reduced 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 increased RED benefits relative to Alternative 1 (Table 3-53). 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 not 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 and would be negligible even to small rural economies, with an increase in 16 annual jobs associated with the acquisition of all lands relative to Alternative 1.

Table 3-53. Change in Annual Regional Economic Activity under Alternatives 3–6 Relative to Alternative 1, 2018 Dollars

Type of Impact	Nebraska	Iowa	Kansas	Missouri	Total
Estimated Total Federal Acres Acquired in Crop Production	0	0	71	1,347	1,418
Change in Sales Relative to Alternative 1	$593,904	$543,247	$128,097	$2,309,022	$3,574,271
Change in Employment Relative to Alternative 1	1.6	1.2	0.4	12.9	16.1
Change in Labor Income Relative to Alternative 1	$134,492	$144,963	$29,314	$534,282	$843,051

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. These annual economic impacts would occur in perpetuity and are presented for all agricultural lands anticipated to be federally acquired.

Local governments would realize a small increase in RED benefits under Alternatives 3–6 from increases in property tax receipts relative to Alternative 1. At the end of the implementation period, Alternatives 3–6 would result in relatively higher annual net government revenues ranging from $5,500 and $51,000 depending on the state compared to Alternative 1 (Table 3-54). These changes in RED effects relative to Alternative 1 are likely to be negligible to local government budgets.

The federal acquisition of productive farmlands from willing sellers can affect not only property tax receipts to local governments, but also state and federal corporate taxes; federal and state income taxes; personal and special district property taxes; and local and state sales and use taxes as farmers purchase materials, equipment, and spend their income in the local economy. Changes in these tax receipts are anticipated to be small and beneficial relative to Alternative 1.

Table 3-54. Change in Annual Property Tax per Year under Alternatives 3–6 Relative to Alternative 1, 2018 Dollars

Type of Impact	Nebraska	Iowa	Kansas	Missouri	Total
Change in Property Tax Relative to Alternative 1	$53,063	$37,931	$5,946	$22,973	$119,912
Change in PILT Relative to Alternative 1	−$2,285	−$2,404	−$461	−$8,495	−$13,644
Change in Net Local Government Revenues Relative to Alternative 1	$50,778	$35,527	$5,485	$14,478	$106,268

Note: Positive changes compared to Alternative 1 indicate increases in fiscal benefits, while negative changes indicate decreases in regional economic benefits relative to Alternative 1. These annual fiscal impacts would occur in perpetuity and are presented for all lands anticipated to be federally acquired.

Other Social Effects

Total targeted acres for acquisition of lands are estimated to be 1,772 in Rulo to the mouth of the river 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. The transition of the lands to federal ownership would remove its designation as prime farmlands. Even if all of the lands were identified as prime farmland (1,772 acres), these acres would represent a very small proportion of prime farmland in the four states (Iowa: 18.4 million acres; Nebraska: 12.1 million acres; Kansas: 23.0 million acres; and Missouri: 12.6 million acres) (USDA NRCS 2015).

Total change in employment would increase by up to 16 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 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.

Alternative 3: Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release under Alternative 3 would not affect the target number of acres for federal land acquisition to support early life stage habitat for the pallid sturgeon, resulting in no impacts to RED or OSE effects associated with changes in land ownership.

Conclusion

Land acquisition under alternatives 3-6 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. Alternatives 3–6 would result in relatively higher annual net local government revenues ranging from $5,500 and $51,000 depending on the state, compared to Alternative 1. These beneficial impacts are likely to be negligible to local government budgets. 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 Alternative 1. As a result, impacts of federal land purchases under these alternatives would have relative increases in RED benefits to local economies and government revenues due to the relatively larger tax base compared to Alternative 1.

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. 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 ownership within the floodplain. Changes to existing land ownership can occur through cumulative actions or influences on agriculture, urban and infrastructure development, and policies or legislation. Changes in land 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 ownership 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 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 dominant 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 2015c). 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 agricultural lands. 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.

Future aggradation and degradation trends would have similar effects under all of the alternatives. The HEC-RAS modeling indicates that the EIS alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses (Section 3.2, River Infrastructure and Hydrologic Processes), the change in stage in the riverine areas in year 15 in the upper river and the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The degradation effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15. However, in Kansas City, the projected river stage in year 15 would only be slightly lower (less than one inch of the mean stage) than year 0. Past, present and future actions that would affect bed degradation or aggradation of the Missouri River, such as sand and aggregate mining in the lower river, may impact the locations that the USACE targets for land acquisition with a focus on lands that would be most suitable early life history habitat for the pallid sturgeon. However, aggradation and degradation trends would not affect the number of target acres for land acquisition, with negligible impacts to RED and OSE effects associated land ownership.

The actions described previously would result in both adverse and beneficial cumulative impacts to land 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 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 as well as 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 be 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 reductions in property taxes, jobs, labor income, and sales, the contribution to adverse cumulative impacts to land ownership within the floodplain from Alternative 1 and Alternatives 3–6 would be negligible in comparison to the larger agricultural economy in the region. In addition, there would only be small adverse impacts if lands were purchased in a concentrated area. The contribution of Alternative 2 to cumulative impacts would be small and adverse, 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; over the next 20 years, dredging operations grew to produce over 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 2011c). 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 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 estimated 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 3-55 summarizes the production of Missouri River construction sand and gravel from 2010 through 2015 on the Missouri River by river segment. Figure 3-53 depicts the amount dredged in specified segments.

Table 3-55. 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 2015d. 2010-2015

Figure 3-53. Missouri River Average Annual Tonnage Dredged from 2004 to 2015

Every 5 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 ten applications from commercial sand and gravel companies for permits to extract sand and gravel from the lower Missouri River. 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 2007d). In 2007, the USACE St. Louis District authorized two applicants within their jurisdiction. 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 lower Missouri River. All authorized applicants were notified that in order to renew commercial sand and gravel dredging permits an environment impact statement would need to be completed due to areas of degradation. 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, USACE issued a Record of Decision (ROD) that reauthorized the Missouri River commercial dredging permits, and in December 2015, the permits were renewed for January 2016 through December 2020 with a few changes to the tonnage allowed in two segments. The authorized annual permitted extraction amounts by river segment are summarized in Table 3-56.

Table 3-56. Dredging Permits by Ton until 2020 (Tons)

Year	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 2015d

Note: River segments shown are locations of dredging in the Missouri River.

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, while the remaining portion is used in other 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 for construction projects (excluding state transportation projects). According to commercial dredgers and industry research, the primary area served by existing dredging operations is generally 20 to 50 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 and stages, 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 sand and gravel from the river. Benefits and losses can be associated with changes in physical conditions, which can affect dredging 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 river current. Dredgers can typically operate at decreased flows, although there is an increased cost in operations during these conditions. The operator may need to use more fuel and time to transport the materials in the river during low flow conditions. There could also be extra maintenance costs to the dredges in low water conditions.

3.11.1.4 Availability of Materials

The amount 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 material ranging from 0.1 to 4.0 millimeters is typically retained and the unwanted material, typically larger than 4.0 mm, is discharged back to the river.

3.11.2 Environmental Consequences

The commercial sand and gravel dredging impact analysis focuses on determining if changes in river and reservoir conditions associated with the MRRMP-EIS alternatives could impact the sedimentation accumulation rate and if the creation of potential interception rearing complex (IRC) sites with assumed protective measures, could affect access to the material. This section summarizes the methodology and presents the results of the change in the sedimentation accumulation rate assessment. In addition, an evaluation of the potential impacts of protective measures around IRC habitat creation on the commercial sand and gravel dredging industry was conducted. A further discussion of the methodology and results related to the sedimentation accumulation analysis can be found in the “Commercial Sand and Gravel Dredging Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

In addition, as part of the navigation analysis, an evaluation was conducted to consider the impacts of changes in river flows and stages on the ability of commercial sand and gravel dredgers to extract and transport the dredged material. The details of this analysis are presented in Section 3.15, Navigation.

3.11.2.1 Impacts Assessment Methodology

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 commercial sand and gravel dredging as well as the approach for each account. Two analyses were conducted to assess potential impacts to commercial sand and gravel dredging.

The first analysis uses the change in sedimentation rates from seven USGS gages located at different points between St. Joseph and Hermann, Missouri to determine the change in the amount of sediment under each of the alternatives compared to Alternative 1 and the potential for any resulting impacts to commercial sand and gravel dredging. 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. Flow release scenarios were developed with the Management Plan HEC-ResSim model, then routed downstream with 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 second evaluation estimates the potential impacts from future protective measures that could be placed on commercial sand and gravel dredging in the vicinity of IRC projects. The analysis looked at two different scenarios for potential IRC construction. The first scenario provides an estimated overlap between potential sites that were identified in the Management Plan HEC-RAS modeling. Based upon new information developed, a second scenario evaluates the potential construction of twelve IRC sites and twelve control sites. The output is displayed as a potential range of estimated overlap between the areas that are dredged by the industry as well as an estimated range of overlap between the permitted area of commercial sand and gravel dredging.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 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 potential for changes in NED values that may occur due to management actions implemented under the alternatives. As noted above, the evaluation considered the change in the sediment accumulation rate to determine if the change in the amount of sediment could impact availability of sand and gravel material and potentially the net value of goods and services to the Nation. Given the estimated minimal changes in the sediment accumulation rate under each of the MRRMP-EIS alternatives relative to Alternative 1, it was determined that no measurable impacts to NED would result, and thus a detailed cost analysis was not conducted. Additional detail of this 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).

The evaluation also considered potential NED impacts from future protective measures that could be placed on commercial sand and gravel dredging in the vicinity of IRC projects. While there could potentially be small impacts to the commercial sand and gravel dredging industry related to the construction of IRC habitat and control sites, given the uncertainty of protective measures to commercial sand and gravel dredging, no measurable commercial sand and gravel NED impacts were able to be estimated. The protective measure evaluations and results are described under the Mechanical Habitat Construction subsections. In addition, for any future IRC projects, a site-specific environmental assessment will be completed, which will evaluate potential impacts to the sand and gravel dredging industry in detail, as needed.

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 analyses related to the changes in the sedimentation accumulation rate as well as IRC protective measures showed very minimal changes to commercial sand and gravel dredging under each of the MRRMP-EIS alternatives relative to Alternative 1 given best available information at this time. Given this, the potential changes would not be large enough to result in measurable RED impacts and therefore are not discussed further under the alternatives.

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 relies 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 changes in NED and RED among the alternatives, the differences would not be large enough to result in measurable OSE impacts and therefore, are not discussed further under the alternatives.

3.11.2.2 Analysis Assumptions

The following assumptions were used for the sedimentation accumulation rate analysis for commercial sand and gravel dredging:

- This analysis uses 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 from the United States Geological Survey (USGS) in support of sediment modeling for the Missouri River Management Plan. USGS interpolated daily suspended sediment loads and sediment loads less than 0.0625 millimeters at seven USGS gages between St. Joseph, Missouri and Hermann, Missouri 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 the period of record and other simplifications.
- The analysis assumes that the channel geometry does not alter the flow/sediment relationship, either through geomorphic feedbacks or through mechanical habitat creation.

The following assumptions were used for the analysis of impacts from protective measures around shallow water habitat (SWH) or IRC projects for commercial sand and gravel dredging:

- Under Alternatives 1 and 2, it was assumed protective measures associated with new SWH projects would be implemented consistent with existing measures. For example, there are existing protections around the entrance and exits of constructed chutes as well as a 200-foot buffer around all BSNP structures in the river. Forecasted amounts of SWH under Alternatives 1 and 2 did not include new chutes, as channel widening was assumed to be the primary means of constructing future SWH. Channel widening projects would likely involve the placement of new structures that would be subject to the 200-foot protective measures. The analysis for Alternatives 1 and 2 assumed the reach where the channel widening would occur would represent the potential amount of area where new protective measures may apply because site-specific designs are not available. This likely over-estimates the area of impact from SWH project under these alternatives because the protective measures were assumed to apply to the river reach where the channel widening would occur, which would be a greater region than the 200-foot buffer.
- Under Alternatives 3–6, the analysis assumes protective measures would also be associated with IRC projects. As described in Chapter 2, this would include a 200-foot buffer around the area of geomorphic change at an IRC project and a seasonal protection of the entire larval source area at an IRC project. For purposes of this analysis, it was assumed the entire bend of a potential IRC project would be restricted from commercial sand and gravel dredging. The analysis also assumed control sites as part of the IRC experimental staircase design would have protective measures associated with them.
- The analysis assumes that future permitted levels of commercial sand and gravel dredging would be the same as the levels allowed under the existing permits.

- The analysis assumes that commercial sand and gravel dredging operations would occur in currently permitted areas rather than the entire river.

3.11.2.3 Summary of Environmental Consequences

The environmental consequences relative to commercial sand and gravel dredging operations are summarized in Table 3-57. Under all alternatives there would be a negligible overall change from St. Joseph, Missouri to Hermann, Missouri (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.

There could be small impacts to the commercial sand and gravel dredging industry related to the potential construction of IRC habitat and control sites. USACE is coordinating with the commercial sand and gravel dredging industry in the process of selecting potential IRC locations and potential protective measures and it is assumed this avoidance and minimization process would continue under each of the alternatives to the extent practical given the need to comply with the Endangered Species Act.

Table 3-57. Environmental Consequences Relative to Commercial Sand and Gravel Dredging

Alternative	NED Impacts	RED Impacts	OSE Impacts	Summary of Other Impacts
Management Actions Common to All Alternatives	No Impact	No Impact	No Impact	No impact due to vegetation management, predator management and human restrictions.
Alternative 1 Metrics: • Sedimentation accumulation rate • Potential for protective measures due to SWH	Negligible Impacts/Not evaluated	Negligible Impacts/Not evaluated	Negligible Impacts/Not evaluated	Negligible measured change in the average annual sediment accumulation rate from the spring plenary pulse. Small adverse impacts from SWH construction and 56.9 miles of potential protective measures.
Alternative 2 Metrics: • Sedimentation accumulation rate • Potential for protective measures due to SWH	Negligible Impacts/Not evaluated	Negligible Impacts/Not evaluated	Negligible Impacts/Not evaluated	Negligible measured change in the average annual sediment accumulation rate compared to Alternative 1. Small adverse impacts from SWH construction and 115 miles of potential protective measures.
Alternative 3–6 Metrics: • Sedimentation accumulation rate • Potential for protective measures for IRC	Negligible Impacts/Not evaluated	Negligible Impacts/Not evaluated	Negligible Impacts/Not evaluated	Negligible measured change in the average annual sediment accumulation rate compared to Alternative 1. Small adverse impacts from approximately 42 miles of protective measures for IRC habitat.

Note: Refer to the environmental consequences discussion of Section 3.15, Navigation for the NED, RED, and OSE accounts and the change in transportation of materials.

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 operations. These actions include vegetation management, predator management, human restriction measures, and pallid sturgeon propagation and augmentation. Vegetation management, predator management, and human restriction measures do not occur in the same reaches as commercial sand and gravel dredging. Additionally, these actions would have no impact on the sediment accumulation rate in the reaches where they occur. Pallid sturgeon propagation and augmentation would have no impact on the sediment accumulation rate or any other aspect of commercial sand and gravel dredging because it does not affect any physical properties of the river.

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

Alternative 1 would continue current System operations, including the current MRRP management actions. Management actions under Alternative 1 include a spring plenary pulse as well as construction of SWH and emergent sandbar habitat. Alternative 1 is considered the baseline against which the other alternatives are measured. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or historic conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

Mechanical Habitat Construction

Alternative 1 would require approximately 31.1 miles of channel widening in the Rulo to Kansas River reach and 25.8 miles in the Kansas River to Osage River reach to achieve identified amounts of SWH. Channel widening projects would likely involve placement of new structures and potentially removal of existing structures. The details of site-specific design are not available for this programmatic analysis; however, it would be anticipated that a total of 56.9 river miles would be the subject of changes in dredging protective measures due to channel structure modifications (i.e., potential additional protective measures from applying the 200-foot buffer to new structures or elimination of measures where structures might be removed). This represents 15.5 percent of the total river mileage where commercial sand and gravel dredgers are permitted to operate. It is anticipated that this would represent a small adverse impact to commercial sand and gravel dredging because (1) it is possible that additional protective measures would be placed around newly constructed structures; (2) dredgers would be able to mine the same permitted amounts of material from other areas of the river within the permitted reaches; and (3) USACE would coordinate with potentially affected commercial sand and gravel companies during site-selection to avoid or minimize constructing in areas that would have large impacts to commercial sand and gravel dredging.

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 to commercial sand and gravel dredging operations would occur from this action or associated activities.

Sediment Accumulation Rate Summary

The analysis for commercial sand and gravel dredging under Alternative 1 shows a negative sediment accumulation rate, which implies a certain degree of degradation. The spring plenary pulse under Alternative 1 would provide a negligible contribution to the sediment accumulation rate, with negligible impacts to commercial sand and gravel dredging operations. The sediment accumulation rate results are summarized in Table 3-58.

Table 3-58. Sediment Accumulation by Reach: Alternative 1

Reach No.	Reach Name	Sediment Accumulation Rate (tons/year)
Reach 1	St. Joseph to Kansas City	−1,465,910
Reach 2	Kansas City to Hermann	−3,353,668

Conclusion

Alternative 1 would continue commercial sand and gravel dredging operations on the river with a variable amount of sediment. Shallow water habitat and associated protective measures under Alternative 1 could have small and adverse impacts to commercial sand and gravel dredging from protective measures because the USACE would work with the dredging industry to reduce or minimize these impacts and the commercial sand and gravel dredging operators could continue to dredge in other locations. There would be small changes in the sediment accumulation rate under Alternative 1, although the changes associated with the spring plenary pulse would be negligible because of the very small change in river flows from the spring pulse. Impacts to the NED, RED, and OSE accounts evaluated under Alternative 1 would be negligible and not evaluated because of the negligible impacts to dredging operations from the sediment accumulation rate and protective measures around SWH. Impacts under Alternative 1 would not be significant for commercial sand and gravel dredging because current conditions would continue to provide sand and gravel for extraction by the commercial sand and gravel industry and adverse impacts would be negligible to small.

3.11.2.6 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 would include additional iterative actions that USFWS anticipates would be implemented under an adaptive management framework. Management actions under Alternative 2 would include spawning cue releases, low summer flows, and the construction of considerably more early life stage habitat and ESH than under Alternative 1.

Mechanical Habitat Construction

Alternative 2 would require approximately 44.7 miles of channel widening in the Rulo to Kansas River reach, 60.6 miles in the Kansas River to Osage River reach, and 9.7 miles in the Osage River to the mouth reach to achieve identified amounts of SWH. Channel widening projects would likely involve placement of new structures and potentially removal of existing structures. The details of site-specific design are not available for this programmatic analysis; however, it would be anticipated that a total of 115 river miles would be subject to changes in protective measures due to channel structure modifications (i.e., potential protective areas from applying the 200-foot buffer to new structures or elimination of restrictions where structures might be removed). This represents 23.1 percent of the total river mileage where commercial sand and gravel dredgers are permitted to operate. It is anticipated that this would represent a small adverse impact to commercial sand and gravel dredging because (1) it is possible that additional protective measures would be placed around newly constructed structures; (2) dredgers would be able to mine the same permitted amounts of material from other areas of the river within the permitted reaches; and (3) USACE would coordinate with potentially affected commercial sand and gravel companies during site-selection to avoid or minimize constructing in areas that would have large impacts to commercial sand and gravel dredging.

Mechanical construction of emergent sandbar habitat would not occur in the same reaches of the river as commercial sand and gravel dredging; thus, there would be no impacts to commercial sand and gravel dredging operations that would occur from this action or associated activities.

Sediment Accumulation Rate Summary

Impacts to the commercial sand and gravel dredging industry would be negligible due to the measurable but very small percent change in the sediment accumulation rate under Alternative 2 compared to Alternative 1. Alternative 2 would result in a decrease in the sediment accumulation rate of one percent compared to Alternative 1. Given the uncertainty of the input data and limitations of this analysis, these alternatives would result in functionally equivalent sediment accumulation rates. Table 3-59 summarizes the changes in sediment accumulation.

Table 3-59. Sediment Accumulation 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)	−1,465,910	−1,469,743
		Change from Alternative 1 (tons/year)	NA	−3,833
		Percent Change from Alternative 1	NA	−0.3%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,353,668	−3,397,351
		Change from Alternative 1 (tons/year)	NA	−43,684
		Percent Change from Alternative 1	NA	−1.3%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,819,578	−4,867,095
		Change from Alternative 1 (tons/year)	NA	−47,517
		Percent Change from Alternative 1	NA	−1.0%

Conclusion

The additional protective measures that may be placed on the construction of additional SWH structures would reduce the area that commercial sand and gravel dredgers are permitted to dredge; these impacts would be small and adverse because commercial sand and gravel dredging operations would continue to extract permitted amounts from other locations and the USACE would work with the sand and gravel dredging industry to minimize or avoid impacts to dredging operations. Alternative 2 would result in negligible changes in the sediment accumulation rate compared to Alternative 1. Impacts to the NED, RED, and OSE accounts evaluated under Alternative 2 would be negligible because of the negligible to small changes in the sediment accumulation rate and protective measures compared to Alternative 1. Impacts under Alternative 2 would not be significant for commercial sand and gravel dredging because adverse impacts would be negligible to small.

3.11.2.7 Alternative 3 – Mechanical Construction Only

Alternative 3 does not include any spring or fall flow releases to create habitat; all ESH and habitat to support early life stage of the pallid sturgeon would be mechanically constructed. The spring plenary pulse that would occur under Alternative 1 would not occur under Alternative 3.

Mechanical Habitat Construction

When compared to Alternative 1 early life stage pallid sturgeon habitat construction, 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. Given the potential to affect channel structures, these actions could have an impact on the commercial sand and gravel dredging industry.

To evaluate the potential impact of additional protective measures around newly constructed IRC sites, two information sources were used. The first information sources were the potential site locations were developed during the HEC-RAS modeling of this alternative for the Draft EIS. Since release of the Draft EIS, new information has been developed regarding preliminary site locations of the initial 12 IRC sites and associated control sites. Although these sites are not final and are subject to change, this second information source provides additional insight into potential impacts that could result from protective measures. These two information sources are used to present a range of potential impacts to the commercial sand and gravel industry. As information is developed and as sites are being evaluated, site-specific environmental assessments will be conducted. Coordination with potentially affected commercial sand and gravel dredging companies on site-specific locations would continue in order to avoid and minimize impacts.

Impacts were estimated by assessing the overlap of the area of potential IRC site locations with the area where dredging has taken place from 2010 to 2017. As noted above, two sources of information were used for this evaluation to capture a range of potential impacts. For the HEC-RAS modeling source, the IRC sites ranged from river mile 60 to river mile 495. The more recent information source of potential IRC locations includes sites ranging from river mile 3 to river mile 323. These include 12 preliminary IRC sites and 12 preliminary control sites. It is assumed that protective measures on the permitted area for commercial sand and gravel dredging within the area of the site would continue until adaptive management and monitoring determine whether the sites are successful or show that dredging does not affect the performance of IRC projects.

Based on this analysis, it was estimated that the total miles of IRC overlap with commercial sand and gravel dredging could range from 42 to 65 miles, the average annual tonnage extracted in areas that overlap with IRC could range from 16,025 to 93,540 tons, accounting for 0.3 to 1.5 percent of total tonnage affected (Table 3-60). Protective measures on sand and gravel dredging in the vicinity of IRC sites could impact the ability to dredge in the selected locations. Given the very small percentage of affected tonnage and availability of other sites to conduct commercial sand and gravel dredging within the permitted areas, it is anticipated that adverse impacts to commercial sand and gravel dredging would be small.

Table 3-60. Range of Impacts to Commercial Sand and Gravel Industry Based on Potential IRC Construction

	Estimated Total Miles of Potential Alternative 3 IRC Construction	Estimated Total Miles that overlap where dredging occurs	Average annual tonnage extracted from overlap (2010–2017)	Average amount of permitted dredging per permit (in tons) from 2010–2017	Percent of Total permitted tonnage affected by Alternative 3
HEC-RAS Modeled IRC sites (RM 60 to 500)	77	65	16,025	6,282,500	0.3%
Potential location of 12 IRC and 12 Control Sites (RM 0 to 330)	83	42	93,540	6,282,500	1.5%

Note: It is likely that the 12 IRC and 12 control sites would be a more accurate representation of the potential impacts of protective measures to commercial sand and gravel dredging operations.

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 to commercial sand and gravel dredging operations would occur from this action or associated activities.

Sediment Accumulation Rate Summary

There would be no impacts to the commercial sand and gravel dredging industry under Alternative 3 due to the very small percent change in the sediment accumulation rate compared to Alternative 1. The difference in the analysis between Alternative 1 and Alternative 3 is less than one percent. Table 3-61 summarizes the changes in sediment accumulation.

Table 3-61. Sediment Accumulation 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)	−1,465,910	−1,466,725
		Change from Alternative 1 (tons/year)	–	−815
		Percent Change from Alternative 1	–	-0.10%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,353,668	−3,352,887
		Change from Alternative 1 (tons/year)	–	781
		Percent Change from Alternative 1	–	0.0%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,819,578	−4,819,612
		Change from Alternative 1 (tons/year)	–	−34
		Percent Change from Alternative 1	–	0.0%

Conclusion

Given the very small percentage of affected tonnage and availability of other sites to extract commercial sand and gravel within the permitted areas, it is anticipated that adverse impacts from the construction of IRC habitat sites to commercial sand and gravel dredging would be small. Alternative 3 would result in negligible changes in the sediment accumulation rate compared to Alternative 1. Impacts to the NED, RED, and OSE accounts evaluated under Alternative 3 would be negligible because of the negligible to small impacts in the sediment accumulation rate and protective measures for IRC habitat compared to Alternative 1. Impacts under Alternative 3 would not be significant for commercial sand and gravel dredging because adverse impacts would be negligible to small.

3.11.2.8 Alternative 4 – Spring ESH Creating Release

Alternative 4 would include spring releases from Gavins Point Dam and Garrison Dam for emergent sandbar habitat creation. In addition, mechanical construction of ESH and IRC habitat of the pallid sturgeon would occur under Alternative 4 to achieve habitat targets.

Mechanical Habitat Construction

Alternative 4 would result in the same distribution and amounts of IRC habitat as described for Alternative 3. Therefore, the discussion of impacts presented for Alternative 3 in Section 3.11.2.7 is representative of the impacts that could occur under Alternative 4, with small and adverse impacts on sand and gravel from protective measures for dredging in the vicinity of IRC sites.

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 to commercial sand and gravel dredging operations would occur from this action or associated activities.

Sediment Accumulation Rate Summary

Any 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. Alternative 4 would result in less than a one percent (−0.30 percent) reduction in the amount of sediment accumulation compared to Alternative 1. Table 3-62 summarizes the changes in sediment accumulation.

Table 3-62. Sediment Accumulation 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)	−1,465,910	−1,461,634
		Change from Alternative 1 (tons/year)	−	4,276
		Percent Change from Alternative 1	−	0.3%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,353,668	−3,370,365
		Change from Alternative 1 (tons/year)	−	−16,697
		Percent Change from Alternative 1	−	−0.5%

Reach Number	Reach Span	Sediment Impact	Alternative 1	Alternative 4
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,819,578	−4,831,998
		Change from Alternative 1 (tons/year)	–	−12,421
		Percent Change from Alternative 1	–	−0.3%

Conclusion

Given the very small percentage of affected tonnage and availability of other sites to extract commercial sand and gravel within the permitted areas, it is anticipated that adverse impacts from the construction of IRC habitat sites to commercial sand and gravel dredging would be small. Alternative 4 would result in negligible changes in the sediment accumulation rate compared to Alternative 1. Impacts to the NED, RED, and OSE accounts evaluated under Alternative 4 would be negligible because of the negligible to small impacts in the sediment accumulation rate and protective measures for IRC habitat compared to Alternative 1. Impacts under Alternative 4 would not be significant for commercial sand and gravel dredging because adverse impacts would be negligible to small.

3.11.2.9 Alternative 5 – Fall ESH Creating Release

Alternative 5 would include fall releases from Gavins Point Dam and mechanical construction to create ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches. Under Alternative 5, IRC habitat to support early life stage requirements of the pallid sturgeon would be constructed in the lower river below Ponca, Nebraska.

Mechanical Habitat Construction

It is assumed that the same distribution and amounts of IRC habitat would be constructed under Alternative 5 as described for Alternative 3. Therefore, the discussion of impacts presented for Alternative 3 in Section 3.11.2.7 is representative of the impacts that could occur under Alternative 5, with small and adverse impacts on sand and gravel from protective measures for dredging in the vicinity of IRC sites.

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 to commercial sand and gravel dredging operations would occur from this action or associated activities.

Sediment Accumulation Rate Summary

It is anticipated that 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 analysis between Alternative 1 and Alternative 5 is less than one percent (0.50 percent) of an increase in sediment accumulation. The gage analysis for changes in sediment accumulation is summarized in Table 3-63.

Table 3-63. Sediment Accumulation 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)	−1,465,910	−1,458,030
		Change from Alternative 1 (tons/year)	–	7,880
		Percent Change from Alternative 1	–	0.5%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,353,668	−3,336,461
		Change from Alternative 1 (tons/year)	–	33,904
		Percent Change from Alternative 1	–	0.5%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,819,578	−4,794,491
		Change from Alternative 1 (tons/year)	–	37,507
		Percent Change from Alternative 1	–	0.5%

Conclusion

Given the very small percentage of affected tonnage and availability of other sites to extract commercial sand and gravel within the permitted areas, it is anticipated that adverse impacts from the construction of IRC habitat sites to commercial sand and gravel dredging would be small. Alternative 5 would result in negligible changes in the sediment accumulation rate compared to Alternative 1. Impacts to the NED, RED, and OSE accounts evaluated under Alternative 5 would be negligible because of the negligible to small impacts in the sediment accumulation rate and protective measures for IRC habitat compared to Alternative 1. Impacts under Alternative 5 would not be significant for commercial sand and gravel dredging because adverse impacts would be negligible to small.

3.11.2.10 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, the USACE would attempt a spawning cue pulse every three years in March and May. In addition, management actions under Alternative 6 include mechanical construction of ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska reaches; and the construction of IRC habitat in the lower river below Ponca, Nebraska to support the pallid sturgeon.

Mechanical Habitat Construction

It is assumed that the same distribution and amounts of IRC habitat would be constructed under Alternative 6 as described for Alternative 3. Therefore, the discussion of impacts presented for Alternative 3 in Section 3.11.2.7 is representative of the impacts that could occur under Alternative 6, with small and adverse impacts on sand and gravel from protective measures for dredging in the vicinity of IRC sites.

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 to commercial sand and gravel dredging operations would occur from this action or associated activities.

Sediment Accumulation Rate Summary

It is anticipated that 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 analysis between Alternative 1 and Alternative 6 is less than one percent. Table 3-64 summarizes the sediment accumulation rate under Alternative 6.

Table 3-64. Sediment Accumulation 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)	−1,465,910	−1,462,547
		Change from Alternative 1 (tons/year)	–	3,363
		Percent Change from Alternative 1	–	0.2%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,353,668	−3,356,384
		Change from Alternative 1 (tons/year)	–	-2,717
		Percent Change from Alternative 1	–	-0.1%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,819,578	−4,818,931
		Change from Alternative 1 (tons/year)	–	647
		Percent Change from Alternative 1	–	0.0%

Conclusion

Given the very small percentage of affected tonnage and availability of other sites to extract commercial sand and gravel within the permitted areas, it is anticipated that adverse impacts from the construction of IRC habitat sites to commercial sand and gravel dredging would be small. Alternative 6 would result in negligible changes in the sediment accumulation rate compared to Alternative 1. Impacts to the NED, RED, and OSE accounts evaluated under Alternative 6 would be negligible because of the negligible to small impacts in the sediment accumulation rate and protective measures for IRC habitat compared to Alternative 1. Impacts under Alternative 6 would not be significant for commercial sand and gravel dredging because adverse impacts would be negligible to small.

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 would likely 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 minimal.

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.

Existing geomorphological processes and trends would continue, consisting primarily of river degradation and bank erosion, reservoir sediment deposition and aggradation, shoreline erosion in reservoirs, and ice dynamics. Continued degradation in the lower Missouri River would be caused by sediment trapped behind dams as well as by continued sand and aggregate mining downstream of Rulo, Nebraska, which lowers the riverbed and the stage of the river over time.

Impacts of Alternative 1 would be negligible to small and adverse associated with the sedimentation accumulation rate and protective measures associated with SWH. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts to commercial sand and gravel dredging would be small to large and adverse, primarily from the potential for bed degradation to affect the locations and amount of tonnage allowed in the dredging permits in the future. The implementation of the spring spawning cue flows and SWH and ESH construction as part of Alternative 1 would provide a negligible contribution to these cumulative impacts to the commercial sand and gravel industry.

Under Alternative 2, the spawning cue releases and low summer flows would modify reservoir releases and river flows to some extent, but would overall have a negligible impact on the sediment accumulation rate and the commercial sand and gravel industry. The impacts of protective measures around SWH sites would have small and adverse impacts to commercial sand and gravel operations. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 2 would be the same as described under Alternative 1, with small to large and adverse impacts to commercial sand and gravel dredging associated with bed degradation in some areas of the lower river, and the implementation of Alternative 2 would provide a negligible contribution to cumulative impacts.

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 on sediment accumulation rate overall because river flows in the lower river would be slightly higher on average with increased storage in the reservoirs relative to Alternative 1. The impacts of protective measures around IRC sites would have small adverse impacts to commercial sand and gravel operations. 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 to the commercial sand and gravel industry.

Under Alternative 4, the spring release relative to Alternative 1 would have negligible impacts on the sediment accumulation rate. The impacts of protective measures around IRC sites would have small adverse impacts to commercial sand and gravel operations. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 4 would be similar to those under Alternative 1. Implementation of Alternative 4 would provide a negligible contribution to these cumulative impacts.

Under Alternative 5, the sediment accumulation rate would experience a negligible impact relative to Alternative 1. The impacts of protective measures around IRC sites would have small adverse impacts to commercial sand and gravel operations. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 5 would be similar to those of Alternative 1. Implementation of Alternative 5 would have a negligible contribution to these cumulative impacts to the commercial sand and gravel industry.

Alternative 6 is expected to have impacts on the sediment accumulation rate similar to those described under Alternative 4. Overall the impacts are expected to be negligible as a result of the spawning cue flow. The impacts of protective measures around IRC sites would have small adverse impacts to commercial sand and gravel operations. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 would be similar to those of Alternative 1. Implementation of Alternative 6 would provide a negligible contribution to these cumulative impacts to the commercial sand and gravel industry.

3.12 Flood Risk Management and Interior Drainage

3.12.1 Affected Environment

A main objective of the Mainstem Reservoir System is to regulate the reservoirs to reduce the risk of flood damage in the reaches downstream from dams. Regulation of individual reservoirs is coordinated to reduce the risk of damaging releases from a particular reservoir. The usual reservoir operation is to store flood inflows, which generally extend from March through July, and to release them during the remainder of the year. Most of these releases are made before December. Winter releases are restricted due to the formation of ice bridges and the associated higher river stages. The objective is to have reservoir levels lowered to the bottom of the annual flood control and multiple use zone by March 1 of each year. Upstream from Gavins Point, releases from Fort Peck, Garrison, Oahe, and Fort Randall Dams are reduced during periods of ice formation until an ice cover is formed, after which releases can be gradually increased. Minimal ice problems exist directly downstream from Big Bend Dam due to its proximity to Lake Francis Case.

Operation of the reservoirs for flood risk management must take into account highly variable flows from numerous tributaries. During any flood season, the existence of upstream tributary storage reduces Mainstem flood volumes to some extent. Normally, the natural crest flows on the Mainstem reservoirs will also be reduced by the existence of tributary reservoir storage, provided significant runoff contributing to the crest flows originates above the tributary projects.

Levees also play a role in flood risk management along the Missouri River. Federal agricultural levee construction in accordance with the 1941 and 1944 Flood Control Acts began in 1947. Most existing federal levees are in the reach located between Omaha and Kansas City. The levees help to manage flood risk to these localities during the most severe flood events of record. Between Sioux City and the mouth of the Missouri River, local interests have built many miles of levees, consisting of about 500 non-federal levee units through this reach of the river (USACE 2004a). Most of these levees are inadequate to withstand major floods, but generally provide flood risk management for events in the 5 percent to 20 percent annual chance of exceedance event (5-year to 20-year).

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

3.12.1.1 Population and Property at Risk

Population and Property Susceptible to Flood Risk

Land, property (both urban and rural), infrastructure, and people in the floodplain can be affected by Missouri River flooding. Approximately 173,000 people reside along the Missouri River floodplain with the majority of these populations living in the lower river, including the cities of Omaha, Council Bluffs, St. Joseph, Kansas City, and St. Louis. Table 3-65 presents the estimated population, number of structures and property value (in thousands) by river reach that could be affected by Missouri River flooding. There are over 62,000 residential and 11,400 nonresidential structures in the floodplain. The total estimated value of these structures and their contents is $59.5 billion. The Missouri River from Fort Peck Dam to the mouth of the Missouri River was divided into ten reaches: Fort Peck Dam to Garrison Dam, Garrison Dam to Oahe Dam, Oahe Dam to Big Bend Dam, Big Bend Dam to Fort Randall Dam, Fort Randall Dam to Gavins Point Dam, Gavins Point Dam to Rulo, Nebraska, Rulo to Platte River (St. Joseph Reach), Platte River to Grand River (Kansas City Reach), Grand River to Osage River (Boonville Reach), and Osage River to the mouth of the Missouri River (Hermann Reach).

Table 3-65. Population and Estimated Property Value of the Floodplain by River Reach, FY 2018

		Residential		Nonresidential		Total	
Reach	**Population**	**Struc-tures**	**Value ($000s)**	**Struc-tures**	**Value ($000s)**	**Struc-tures**	**Value ($000s)**
Fort Peck Dam to Garrison Dam	12,144	4,109	$2,001,379	649	$897,288	4,496	$2,898,667
Garrison Dam to Oahe Dam	21,346	7,747	$3,304,385	795	$1,248,753	8,542	$4,553,138
Oahe Dam to Big Bend Dam [a]	N/A	271	$37,318	9	$4,665	280	$41,982
Big Bend Dam to Fort Randall Dam [a]	N/A	40	$6,220	13	$3,110	53	$9,329
Fort Randall Dam to Gavins Point Dam	447	620	$193,642	24	$28,095	644	$221,737
Gavins Point Dam to Rulo	69,869	25,343	$7,378,778	2,841	$6,315,815	28,184	$13,694,593
St. Joseph Reach	17,721	7,126	$2,549,803	1,270	$3,111,551	8,396	$5,661,354
Kansas City Reach	29,986	9,211	$4,530,975	3,842	$16,622,533	13,053	$21,153,509
Boonville Reach	5,133	2,366	$961,152	434	$899,008	2,800	$1,860,159
Hermann Reach	15,999	5,186	$2,833,117	1,590	$6,551,394	6,776	$9,384,511
Total	**172,645**	**62,019**	**$23,796,767**	**11,467**	**$35,682,211**	**73,486**	**$59,478,979**

Sources: NSI 2010; USACE 2004a

a The Oahe Dam to Big Bend Dam and Big Ben Dam to Fort Randall Dam reaches were not modeled due to the lack of riverine conditions between these dams. The estimated property value for these reaches was taken from the Description of Existing Environment in the 2004 USACE Master Water Control Manual.

Total land area in the floodplain is approximately 3.6 million acres with more than 1.7 million acres in agricultural production. Agriculture is a dominant land use within the Missouri River floodplain and across the wider Missouri River basin. The upper river is a major source of wheat, alfalfa, barley, and hay while the lower river is a major producer of corn and soybeans. The Missouri River floodplain comprises a considerable amount of prime farmland, especially in the lower river below Gavins Point Dam. Prime farmland can be defined as "Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It has the soil quality, growing season, and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management" (NRCS 2017). The land use, including prime farmland, and crop patterns for the Missouri River floodplain are found in the "Flood Risk Management Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org). Critical infrastructure in the Missouri River floodplain is displayed in Table 3-66. Critical infrastructure includes structures, such as public utilities, wastewater treatment plants, and bridges, in the floodplain that are critical to the Nation or region, but not part of a traditional structure inventory. The critical infrastructure inventory was imported from the Homeland Security Infrastructure Program Gold database developed by the National Geospatial-Intelligence Agency.

Table 3-66. Critical Infrastructure in the Missouri River Floodplain

Infrastructure Type	Fort Peck to Garrison	Garrison to Oahe	Oahe to Big Bend	Big Bend to Fort Randall	Fort Randall to Gavins Point	Gavins Point to Rulo	St. Joseph Reach	Kansas City Reach	Boonville Reach	Hermann Reach	Total
Public Utilities											
Energy Producing Plants	1	1	N/A	N/A	0	12	2	10	0	4	30
Propane Locations and Substations	10	15	N/A	N/A	0	36	6	54	4	13	138
Wastewater Treatment Plants	0	1	N/A	N/A	0	0	4	1	0	2	8
Public Facilities											
Emergency Services	7	7	N/A	N/A	0	63	28	38	16	35	194
Law Enforcement	5	3	N/A	N/A	1	15	9	18	8	7	66
Education	9	6	N/A	N/A	2	26	14	20	6	7	90
Public Venues	4	4	N/A	N/A	1	23	23	35	15	23	128
Transportation Infrastructure											
Interstate Miles	0	15	N/A	N/A	0	314	6	51	5	18	409
Highway Miles	37	48	N/A	N/A	14	198	109	209	66	206	887

Infrastructure Type	Fort Peck to Garrison	Garrison to Oahe	Oahe to Big Bend	Big Bend to Fort Randall	Fort Randall to Gavins Point	Gavins Point to Rulo	St. Joseph Reach	Kansas City Reach	Boonville Reach	Hermann Reach	Total
Local Primary Road Miles	12	24	N/A	N/A	5	51	12	82	13	32	231
Railroad Miles	131	33	N/A	N/A	0	509	175	508	101	160	1,617
Road and Railroad Bridges	10	31	N/A	N/A	9	356	183	510	105	155	1,359
Public Use Airports	0	1	N/A	N/A	0	6	4	9	2	5	27
Ports	0	0	N/A	N/A	0	34	8	26	10	17	95

Sources: Homeland Security Infrastructure Program Gold Database; U.S. Census Bureau, Geography Division 2015 TIGER/Line Shapefiles

The flood risk management and interior drainage analysis and discussion of effects are detailed in Section 3.12.2, Environmental Consequences, and the "Flood Risk Management Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Environmental Justice

An environmental justice assessment requires an analysis of whether minority and low-income populations (i.e., "populations of concern") would be disproportionately adversely affected by a proposed federal action. Of primary concern is whether adverse impacts fall disproportionately on minority and/or low-income members of the community compared to the larger community and, if so, whether they meet the threshold of "disproportionately high and adverse." If disproportionately high and adverse effects are evident, EPA guidance advises that it should initiate consideration of alternatives and mitigation actions in coordination with extensive community outreach efforts (EPA 1998).

U.S. Census block groups containing a portion of land within the floodplain were included in the analysis. Block group data from the U.S. Census Bureau American Community Survey, 5-year averages from 2006 to 2010, were used to identify the percentages of families in poverty and minority populations. While the identification of potential environmental justice populations focused on areas within the floodplain of the Missouri River, there were other minority populations that are dependent on resources from the river but not physically located within the floodplain. These groups, including Tribal populations, were considered in the evaluation of impacts to environmental justice populations. Additional discussion of Tribal Interests is discussed in Section 3.20. The environmental justice analysis and discussion of effects are detailed further in Section 3.12.2, Environmental Consequences, and Section 3.22, Environmental Justice.

Tribal Reservations

The Missouri River floodplain is also home to several Tribal reservations. The combined population and property value for all the Tribal reservations in the Missouri River floodplain is shown in Table 3-67. The Tribal Interests analysis and discussion of effects are detailed further in Section 3.12.2, Environmental Consequences, and Section 3.20, Tribal Interests (Other).

Table 3-67. Population and Property Value of Tribal Reservations in the Missouri River Floodplain

		Residential		Nonresidential		Total	
Tribal Reservation	**Population**	**Number**	**Value ($000s)**	**Number**	**Value ($000s)**	**Number**	**Value ($000s)**
All Tribal Reservations	914	339	$98,415	4	$31,004	343	$129,419

All values are at the FY 2018 price level.
Source: 2010 NSI

3.12.2 Environmental Consequences: Flood Risk Management

The alternatives evaluated include management actions with potential to affect river flows, channel form, and river stage. The flood risk management impacts analysis focuses on determining if changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives could result in an impact to risk of flooding. This section summarizes the flood risk management impacts assessment methodology and presents the results of the assessment.

3.12.2.1 Impacts Assessment Methodology

Alternative means of achieving species objectives were evaluated for their effects on flood risk. The impacts to flood risk management 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, while ensuring impacts are not double counted. The following section provides a brief overview of the methodology for evaluating impacts to flood risk as well as the approach for each account. A detailed description of the methodology and results is provided in the "Flood Risk Management Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Physical characteristics of the Missouri River and its floodplain that are particularly important to flood risk include river flow and associated stages, water storage in System, river channel dimensions, and flow impedance. Changes in these characteristics can result in changes in flood risk management (beneficially or adversely), such as the frequency, extent, and duration of flooding and depths of inundation. These changes can potentially increase or reduce the risks inherent in flooding to land, property (both urban and rural), infrastructure, and people in the floodplain. The output from the HEC-RAS and HEC-ResSim modeling was used to analyze the potential change in flood impacts under each of the MRRMP-EIS alternatives. The analysis focuses on the Missouri River floodplain from Fort Peck Dam in Montana to the mouth of the Missouri River near St. Louis, Missouri.

The Missouri River Reservoir System as currently operated provides substantial flood damage reduction and benefits to the entire basin. Study alternatives include modifying operations of the Missouri River Reservoir System with increased reservoir releases during select periods for species habitat benefits. The current HEC-ResSim and HEC-RAS analysis shows the potential for negative impacts to flood risk management for alternatives that include changes in reservoir flow releases. The current study methodology, which employs an 82-year period of record, is suitable for alternative comparison and providing an indication of change in flood risk. However, the methodology does not simulate a sufficient number of events and possible runoff combinations within the large Missouri River basin to evaluate potential change in downstream flood risk. Prior to implementing any management action that alters reservoir operations, a comprehensive flood risk evaluation will be conducted per USACE requirements. The level of additional hydrologic analysis will be based on USACE guidance and requirements and will identify the change in reservoir pool probability, reservoir release frequency, river stage-frequency, and river stage-duration.

National Economic Development

NED effects are defined as changes in the net value of the national output of goods and services. In the case of flood risk management, the conceptual basis for the NED impacts analysis is an increase or decrease in risk of physical and non-physical damage from flooding. The USACE Hydrologic Engineering Center Flood Impact Analysis (HEC-FIA) model was used to compute property damages and agricultural losses for every year in the modeled POR under each alternative scenario. The model evaluated losses directly related to damages sustained by structures, contents, and vehicles. The model also evaluated crop damages either related to a loss of a crop in the ground, the inability to plant a crop due to flooding, or to planting a crop later in the season due to flooding occurring at planting time. In addition to the tangible damages to businesses, homes, and other physical property items caused by flood inundation or exposure, the costs of flooding include emergency and disaster relief costs. Emergency cost savings can encompass savings related to a wide range of flooding impacts, including emergency personnel costs, flood fighting costs (e.g., sandbagging), avoidance costs (raising or evacuation of property), temporary food and housing, debris cleanup, and damage to infrastructure items not otherwise included in the damage analysis such as sewer lines. Based on an analysis of approved USACE projects, it was assumed that these costs are equivalent to a maximum of nine percent of property damages (USACE 2014f).

Regional Economic Development

The RED analysis evaluated the regional economic impacts associated with agricultural losses and structural damages using information from the NED analysis from the POR under each simulated alternative.

Agricultural Damage: The RED analysis used annual agricultural flood losses from the NED analysis to estimate the changes in regional economic conditions under the MRRMP-EIS alternatives. The NED evaluation included eight floodplain areas or river reach regions. Fort Peck Dam to Lake Sakakawea and Garrison Dam to Oahe Dam had less than $127,000 in annual agricultural damages in the worst-case years compared to Alternative 1. Because there would be negligible change in regional economic conditions in these reaches, no RED evaluation was undertaken. The RED impacts associated with agricultural damages, including employment, labor income and sales, were estimated for six of the eight regions using IMPLAN®, an input-output modeling software program. IMPLAN® Pro uses inter-industry relationships to estimate the direct, indirect, and induced economic activity that can be expected in the study area as a result of generated demand for other goods and services associated with that industry—in this case, sales from agricultural products and employment of workers in agricultural industries. A state or multi-state study area was identified for each region based on its location.

For the purposes of evaluating regional economic impacts, it is assumed that agricultural losses are equal to a change in market value of crop production, which was used as the direct effect (i.e., final demand change) in IMPLAN® Pro. Agricultural losses, as estimated through the HEC-FIA model, include loss of crop value (less harvest costs) and the costs of agriculture inputs (if damage occurs prior to harvest). In HEC-FIA, harvest costs are often removed from the value of crops because the farmer would not incur these costs when crops are damaged. Because IMPLAN® Pro is a revenue-based input-output model, the inclusion of input costs would overstate economic impacts, while the reducing harvest costs from the loss of crop value would decrease economic impacts.

Structural Damage: The RED impacts of structural damages could include loss of business activity due to disruptions from transportation detours and delays and/or offices closures, resulting in loss of labor, income, and economic output. The HEC-FIA results from the NED analysis include structure and content damage, although the NED outputs do not include estimates of the potential loss in industry revenues. It is not appropriate to use property damage as a proxy for loss in industry sales because the estimates represent damages (or possible replacement costs) to structures and not disruptions or loss of industry sales, as needed for an economic impact analysis. As a result, the county-level average annual structural damage estimates from the NED evaluation were used to qualitatively describe the counties that would have the largest potential RED impacts under the MRRMP-EIS alternatives.

Other Social Effects

Changes in flood risk have a potential to cause other types of effects on individuals and communities in terms of individual and community safety, health, and well-being. Results from the HEC-FIA model were used to qualitatively assess other social effects. Any changes to these areas of concern that would occur under MRRMP-EIS alternatives were examined to the extent possible. HEC-FIA estimates the number and location of people within the inundated area exposed to the flood hazard. This estimate is referred to the population at risk (PAR) and it includes people permanently residing in the area, as well as workers, customers of area businesses, and people traveling through the area.

An environmental justice assessment was conducted to determine whether minority and low-income populations (i.e., “populations of concern”) would be affected by a proposed federal action and whether they would experience disproportionate adverse impacts from the proposed action. Six hundred census block groups intersect the Missouri River floodplain, of which 186 contain potential populations of concern. The census blocks with populations of concern identified in the HEC-FIA model as experiencing average annual property damages were analyzed to determine if there were disproportionate flooding impacts on minority or poor communities.

Flood risk impacts to critical infrastructure, such as public utilities and bridges, were also determined in the HEC-FIA model. The model will not calculate economic losses in terms of dollars, but instead report what critical infrastructure elements were inundated by a flood event.

Channel Capacity

In addition to the aforementioned impact assessment methodologies, the frequency of channel capacity exceedance in several reaches were compared. Releases exceeding channel capacity in the Garrison and Fort Randall reaches are of particular concern due to limited channel capacity in those reaches (approximately 35 kcfs). Regardless of downstream tributary flows, a reservoir release equal to or greater than the channel capacity would cause some level of impact to adjacent property. The modeled channel exceedances at the Fort Peck and Nebraska

City gages were also compared. In order to provide a relative comparison between alternatives, the analysis compares the total number of days of flows at or above 35 kcfs for the Fort Peck, Garrison, and Fort Randall gages, and 80 kcfs at the Nebraska City gage that correspond to days in the POR when a simulated flow is running. The analysis may underestimate instances of channel capacity exceedance in some cases where flows may be adjusted later in the year to return to normal operations for authorized purposes; however, it provides for a reasonable comparison between alternatives.

This analysis was completed because reservoir releases for purposes other than floodwater evacuation must be strictly managed to minimize impacts to downstream adjacent property. Regardless of downstream tributary flows, a reservoir release equal to or greater than channel capacity would cause some level of impact to adjacent property.

3.12.2.2 Summary of Environmental Consequences

The environmental consequences relative to flood risk management are summarized in Table 3-68.

Table 3-68. Environmental Consequences Relative to Flood Risk Management

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Management Actions Common to All Alternatives	No NED impacts.	No RED impacts	No OSE impacts.	Management actions common to all alternatives would have no impacts on flood risk management.
Alternative 1	Alternative 1 has expected average annual flood risk management damages totaling $30,482,337. Alternative 1 would have negligible adverse NED impacts from the spring pulse.	Large variations in RED effects, with reductions in jobs and income during flood events; management actions under Alternative 1 would have negligible adverse RED effects from the spring plenary pulse.	Average Annual Population at Risk (PAR): 592 Maximum critical infrastructure impacted: 799 Alternative 1 would have negligible OSE impacts to public health, safety, and economic vitality from the spring pulse.	Impacts from habitat construction actions on flood risk management would be relatively small, beneficial, and limited to areas downstream the site of habitat construction.
Alternative 2	Small beneficial impacts to NED with an average annual decrease in flood risk management damages of $1,705,203 relative to Alternative 1. (Range of annual differences $74,091,598 decrease to $8,714,297 increase)	Average annual increase of 4 jobs and $188,000 in labor income. On average, negligible to small benefits to RED effects from reduced agricultural and structural damages relative to Alternative 1.	Change in Average Annual PAR: -26 Negligible changes in critical infrastructure impacted. Negligible OSE impacts to public health, safety, and economic vitality.	Impacts from habitat construction actions on flood risk management would be relatively small, beneficial, and limited to areas downstream the site of habitat construction.

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Alternative 3	Small beneficial impacts to NED with an average annual decrease in flood risk management damages of $232,725 relative to Alternative 1. (Range of annual differences $6,382,176 decrease to $649,756 increase)	No change in average annual jobs and decrease of $8,000 in labor income. Negligible change in RED effects relative to Alternative 1.	Change in Average Annual PAR: -4 Negligible changes in critical infrastructure impacted. Negligible OSE impacts to public health, safety, and economic vitality.	Impacts from habitat construction actions on flood risk management would be relatively small, beneficial, and limited to areas downstream the site of habitat construction.
Alternative 4	Small beneficial impacts to NED with an average annual decrease in flood risk management damages of $688,044 relative to Alternative 1. (Range of annual differences $23,057,880 decrease to $2,952,176 increase)	Average annual increase of 1 job and $73,000 in labor income. Negligible change in RED effects relative to Alternative 1.	Change in Average Annual PAR: -5 Negligible changes in critical infrastructure impacted. Negligible OSE impacts to public health, safety, and economic vitality.	Impacts from habitat construction actions on flood risk management would be relatively small, beneficial, and limited to areas downstream the site of habitat construction.
Alternative 5	Small beneficial impacts to NED with an average annual decrease in flood risk management damages of $548,536 relative to Alternative 1. (Range of annual differences $28,696,579 decrease to $2,044,636 increase)	Average annual increase of 1 job and decrease of $4,000 in labor income. Negligible change in RED effects relative to Alternative 1.	Change in Average Annual PAR: -14 Negligible changes in critical infrastructure impacted. Negligible OSE impacts to public health, safety, and economic vitality.	Impacts from habitat construction actions on flood risk management would be relatively small, beneficial, and limited to areas downstream the site of habitat construction.
Alternative 6	Small beneficial impacts to NED with an average annual decrease in flood risk management damages of $282,851 relative to Alternative 1. (Range of annual differences $15,617,145 decrease to $7,123,611 increase)	Average annual decrease of 1 job and $65,000 in labor income. Negligible to small and adverse RED effects relative to Alternative 1.	Change in Average Annual PAR: -5 Negligible changes in critical infrastructure impacted. Negligible OSE impacts to public health, safety, and economic vitality.	Impacts from habitat construction actions on flood risk management would be relatively small, beneficial, and limited to areas downstream the site of habitat construction.

The simulated frequencies of releases which equal or exceed channel capacity are summarized in Table 3-69 for each alternative. The analysis may underestimate instances of channel capacity exceedance in some cases where flows may be adjusted later in the year to return to normal operations for authorized purposes; however, it provides for a reasonable comparison between alternatives.

Table 3-69. Number of Days in POR above Channel Capacity Occurring during Simulated Flow Actions

	Alternative 1	Alternative 2	Alternative 3*	Alternative 4	Alternative 5	Alternative 6
Fort Peck (35 kcfs)	0	0	0	0	0	0
Garrison (35 kcfs)	0	0	0	416	265	0
Fort Randall (35 kcfs)	53	480	0	430	283	594
Nebraska City (80 kcfs)	0	1	0	26	4	14
Total	53	481	0	872	552	608

Note: Alternative 3 does not include a reoccurring flow action for the listed species. The potential one-time spring spawning cue pulse associated with Alternative 3 is assumed to be a one-time occurrence of the pulse included under Alternative 6. If the one-time pulse occurs under Alternative 3, a greater risk of channel capacity exceedance would be associated with the single year the pulse runs. All tabulated values are for open water conditions without any ice, debris, or other effects that can significantly affect river stages.

3.12.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include predator management, vegetative management, and human restrictions measures. These actions are not expected to affect river stage and would not impact flood risk management.

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

Alternative 1 represents current System operations including a number of management actions associated with MRRP implementation. Management actions under Alternative 1 include construction of both SWH and ESH habitat as well as a spring plenary pulse. These actions would be focused in the Garrison and Gavins Point reaches for ESH habitat construction and between Ponca to the mouth of the river near St. Louis for SWH. It is considered the baseline against which the other alternatives are measured. As noted in Section 3.1.1., modeling results of Alternative 1 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 NED value for Alternative 1 for flood risk management is calculated in terms of costs from a hypothetical condition where no costs or damages are incurred. Although the absolute value under Alternative 1 provides important context, the estimated differences between each of the MRRMP-EIS alternatives and Alternative 1 are key to understanding the impacts associated with the species management actions included in the alternatives. Please refer to Section 3.1.1 for further description.

Mechanical Habitat Construction

For early life stage pallid sturgeon habitat, Alternative 1 was modeled with the assumption of an additional 3,999 acres distributed from Ponca, Nebraska to the Osage River confluence in Missouri. Generally, designs for pallid sturgeon early life stage habitat will be developed to ensure that the projects do not adversely affect existing flood risk management systems and will comply with Executive Order 11988, Floodplain Management through technical analysis and coordination with local floodplain management authorities. As with the BSNP, USACE routinely monitors the performance of constructed habitat projects to determine if they are contributing to adverse impacts on adjacent flood risk management systems. If issues are identified, USACE works with the affected levee district to develop and implement a corrective plan.

For ESH, an average of 164 acres per year would be constructed between the Garrison and Gavins Point reaches. Similar to pallid sturgeon early life stage habitat construction, ESH projects are designed to comply with Executive Order 11988 and to have no impacts to authorized purposes. Increased river stages are not associated with these projects because the activity involves moving material from one part of the active channel to another. No new material is brought into or leaves the system as part of these projects. Every ESH project includes site-specific NEPA analysis that seeks to avoid impacts to sensitive resources. Significant impacts to environmental/cultural/socioeconomic resources are avoided. All of the ESH acres in this alternative could be constructed in “available” areas that would avoid impacts to sensitive sites such as the active thalweg and narrow channel segments that would have a higher risk of impacting river stage.

National Economic Development

The NED analysis for Alternative 1 is summarized in Table 3-70. The individual reach damages were organized into two groups depending on their location. The upper river includes all locations located above Gavins Point Dam, whereas the lower river includes everything below Gavins Point Dam. Under Alternative 1, the Missouri River floodplain incurred average annual flood damages of $30.5 million in the modeled POR. However, the magnitude of these impacts varied considerably from year to year as a result of the natural variability of the hydrologic cycle. In addition, these impacts result from runoff events that occur downstream of the reservoir System, large upstream runoff events that result in evacuation of flood water from the reservoirs, or the combination of the two, and not from the management actions under Alternative 1. These impacts would be much greater without operation of the reservoir System. Total flood damages for the entire modeled Missouri River floodplain ranged from a low of $390,000 to over $500.2 million.

Table 3-70. Summary of Damages for Alternative 1

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Total Average Annual NED Damages
Missouri River	**$13,478,645**	**$1,213,078**	**$15,790,615**	**$30,482,337**
Upper River	**$1,894,217**	**$170,480**	**$494,249**	**$2,558,946**
Fort Peck Dam to Garrison Dam	$22,185	$1,997	$365,184	$389,366
Garrison Dam to Oahe Dam	$1,675,056	$150,755	$19,340	$1,845,150
Fort Randall Dam to Gavins Point Dam	$196,977	$17,728	$109,725	$324,430
Lower River	**$11,584,427**	**$1,042,598**	**$15,296,366**	**$27,923,391**
Gavins Point Dam to Rulo	$4,919,021	$442,712	$6,977,045	$12,338,778
St. Joseph Reach	$817,600	$73,584	$1,259,503	$2,150,688

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Total Average Annual NED Damages
Kansas City Reach	$2,389,088	$215,018	$3,656,750	$6,260,856
Boonville Reach	$629,536	$56,658	$1,268,069	$1,954,263
Hermann Reach	$2,829,182	$254,626	$2,134,999	$5,218,807

Note: All totals are average annual in the FY 2018 price level. Negative numbers indicate a decrease in damages relative to Alternative 1.

a For Alternative 1, the estimated land acquisition was 7,046 acres in the lower river. If all of the land acquired is currently in agricultural production and subsequently taken out, the agricultural damages in the lower river could be overstated by up to 0.7 percent.

Regional Economic Development

The RED analysis for flood risk management focuses on the locality of flood damages and the types of property being damaged. The changes to the local economy can be measured in terms of economic output, income, and employment. Table 3-71 summarizes the economic impacts for each of the regions resulting from reoccurring flood damages. Under Alternative 1, agricultural damages would result in an annual average reduction of between 1 and 40 jobs, and between $46,000 and $2.6 million in labor income depending on the region impacted. On average, three regions tend to experience the largest impacts under Alternative 1: Gavins Point Dam to Rulo, Kansas City Reach, and Hermann Reach.

Flooding events, such as those that occurred in 1951, 1984, 1986, 1993, and 2011, would account for the largest economic impacts from agricultural damages. These flooding effects are a result of the natural hydrologic cycles and not from the management actions under Alternative 1. In years when flooding would occur, there would be large adverse impacts to regional economic conditions from agricultural damages and loss in the market value of crop production in most of the regions; however, the spring plenary pulse under Alternative 1 would have negligible contribution to these impacts.

Under Alternative 1, the structural damages associated with flooding would have the largest impacts to the following counties with over $1 million in average annual damages:

- Burleigh County, North Dakota (Garrison Dam to Oahe Dam)
- Holt County, Missouri (Gavins Point Dam to Rulo)
- Osage County, Missouri (Hermann Reach)

Residences, businesses, farming structures, and transportation facilities would be most affected in the above-mentioned counties, with large RED effects occurring during flooding events.

Table 3-71. RED Effects Associated with Agricultural Damage – Alternative 1

River Reach	Jobs			Labor Income			Sales		
	Average Annual	Max Ag Damage Year	Min Ag Damage Year	Average Annual	Max Ag Damage Year	Min Ag Damage Year	Average Annual	Max Ag Damage Year	Min Ag Damage Year
Missouri River	−115	−1,585	−1	−$6,035,000	−$79,176,000	−$82,000	−$25,326,000	−$330,732,000	−$351,000
Upper River	−1	−5		−$46,000	−$421,000	−$7,000	−$172,000	−$1,578,000	−$28,000
Fort Randall Dam to Gavins Point Dam	−1	−5		−$46,000	−$421,000	−$7,000	−$172,000	−$1,578,000	−$28,000
Lower River	−114	−1,580	−1	−$5,989,000	−$78,755,000	−$75,000	−$25,154,000	−$329,154,000	−$323,000
Gavins Point Dam to Rulo	−40	−424	−1	−$2,638,000	−$27,917,000	−$67,000	−$11,463,000	−$121,293,000	−$293,000
St. Joseph Reach	−8	−64		−$525,000	−$4,360,000	−$1,000	−$2,130,000	−$17,677,000	−$3,000
Kansas City Reach	−34	−568		−$1,463,000	−$24,201,000	−$3,000	−$5,989,000	−$99,058,000	−$13,000
Boonville Reach	−12	−298		−$508,000	−$12,707,000	−$1,000	−$2,076,000	−$51,978,000	−$4,000
Hermann Reach	−20	−225		−$855,000	−$9,570,000	−$3,000	−$3,496,000	−$39,148,000	−$10,000

Note: Negative values indicate adverse impact to RED effects.

Other Social Effects

Changes in flood risk have a potential to cause other types of effects on individuals and communities in terms health, safety, and economic vitality. Table 3-72 shows the modeled population at risk (PAR) totals under Alternative 1. Average annual PAR was 212 in the upper river and 385 in the lower river. The largest modeled flood events indicated that more than 14,900 people could be affected by Missouri River flooding. For the upper river the largest modeled flood event was 2011, whereas in the lower river the largest modeled flood event was 1993.

Table 3-72. Population at Risk under Alternative 1

River Reach	Largest Flood Event in POR	Average Annual PAR
Missouri River	**14,936**	**592**
Upper River	**9,412**	**212**
Fort Peck Dam to Garrison Dam	81	2
Garrison Dam to Oahe Dam	9,258	207
Fort Randall Dam to Gavins Point Dam	73	3
Lower River	**5,646**	**385**
Gavins Point Dam to Rulo	4,896	217
St. Joseph Reach	958	46
Kansas City Reach	1,746	41
Boonville Reach	825	55
Hermann Reach	940	67

The largest modeled impacts to populations of concern under Alternative 1 occurred to poverty block groups in Carroll and Chariton counties in Missouri and minority race block groups in Platte and Cole counties in Missouri.

HEC-FIA was also used to determine the critical infrastructure that would be impacted during flood events. Table 3-73 lists the type and quantity of critical infrastructure that would be impacted under the largest modeled flood event for Alternative 1 in the POR. As noted above, the largest modeled flood events were 2011 for the upper river and 1993 for the lower river. While the impacts on average would be less, the table provides an indication of the infrastructure impacted under the worst-case scenario.

Table 3-73. Critical Infrastructure Impacted under Alternative 1 based on Largest Modeled Events in Period of Record

Critical Infrastructure	Lower River (1993)	Upper River (2011)
Agricultural Facilities	3	4
Chemical Industries	4	11
Communication Towers	0	4
Educational Schools	2	0
Emergency – EMS	0	4

Critical Infrastructure	Lower River (1993)	Upper River (2011)
Emergency – Fire Stations	0	6
Emergency – National Shelters	2	2
Energy – Plants	0	5
Energy – Propane Locations	4	7
Energy – Substations	8	12
Law Enforcement	2	2
Mail - USPS	2	10
Manufacturing Plants	2	10
Public – Campgrounds	0	2
Public – Libraries	0	2
Public – Parks	0	26
Public – Worship	1	1
Transportation – Airports	0	20
Transportation – Bridges	21	528
Transportation – Ports	0	121
Wastewater Treatment Plants	0	2

Conclusion

Flood risk management is an authorized purpose of the Missouri River System and Alternative 1 represents the continuation of current System operation and implementation of the Missouri River Recovery Program. However, because of the highly variable hydrologic cycle, there was approximately $30.5 million in average annual damages estimated in the modeled POR under Alternative 1. The magnitude of these impacts varied considerably from year to year as a result of the natural hydrologic cycles and not from the spring pulse and mechanical habitat construction management actions in Alternative 1 which showed negligible NED impacts. Similarly, flooding events would result in agricultural and structural damages that would significantly affect regional economic conditions, with the largest RED effects in Gavins Point Dam to Rulo, Nebraska and Kansas City reaches; however, the management actions under Alternative 1 would result in negligible RED impacts from the spring plenary pulse and mechanical habitat development. Modeling results show 53 days of flows at or above channel capacity in the Fort Randall reach that occur during simulated Alternative 1 flow releases (Table 3-69). Alternative 1 management actions would have negligible OSE impacts to public health, safety, and economic vitality. Alternative 1 is not anticipated to cause significant impacts to flood risk management because these flooding effects are mostly a result of the natural hydrologic cycles of precipitation and snow pack and flooding effects would be much greater were it not for the current operation of the reservoir System.

3.12.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp Reasonable and Prudent Alternative (USFWS 2003). Whereas Alternative 1 only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that

USFWS anticipates would ultimately be implemented through adaptive management and as impediments to implementation were removed.

Under Alternative 2, impacts to flood risk management would be relatively small and beneficial relative to Alternative 1. These impacts, particularly in the lower river, would be due to lower peak releases, relative to Alternative 1, from Gavins Point Dam under extreme flood events. On average these impacts are relatively small in nature but there are some years when the flood damages were simulated to be of greater magnitude, especially in the lower river. The impacts are discussed in more detail below.

Mechanical Habitat Construction

For early life stage pallid sturgeon habitat, Alternative 2 was modeled with the assumption of an additional 10,758 acres distributed from Ponca, Nebraska to the Mississippi River confluence near St. Louis, Missouri. Despite the higher acreages under Alternative 2 as compared to Alternative 1, no impacts to flood risk management are anticipated because the same impact avoidance measures described under Alternative 1 apply.

For ESH, an average of 3,546 acres per year would be constructed and distributed between the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches. The extensive amount of ESH construction under Alternative 2 would likely have adverse impacts that are not expected under the other alternatives. It is likely that site-specific impact avoidance measures would not be effective in some cases because of the large amounts of habitat that would need to be constructed. The 2011 ESH Programmatic EIS analyzed a similar amount of habitat construction and indicated that significant impacts were especially possible in the Garrison Reach because construction would need to occur in “exclusionary” areas in order to meet the acreage targets. Large, long-term impacts to flood risk management would be anticipated under this alternative due to the high likelihood of impacts to hydraulics from constructing in exclusionary zones such as the active thalweg and narrow channel segments.

National Economic Development

The NED analysis for Alternative 2 is summarized in Table 3-74. The modeled flood damages along the Missouri River under Alternative 2 were estimated to be on average $1.7 million less annually relative to Alternative 1. This represents an overall decrease in NED damages in relation to Alternative 1 of 5.6 percent. The reduction in impacts, specifically decreased property damages in the lower river, is driving the overall total but the upper river also showed a slight decrease in NED impacts compared to Alternative 1.

When evaluating the impacts of each MRRMP-EIS alternative, annual impacts as well as those that occur on average over the POR were examined. The differences in the modeled annual impacts between Alternative 2 and Alternative 1 in the lower river varied from an $8.8 million increase in damages to a $64.0 million decrease. The largest lower river impacts would occur in the Gavins Point Dam to Rulo reach, which experienced an average annual reduction in modeled damages of $1.1 million under Alternative 2. The yearly variance in upper river impacts was more modest with the annual range of modeled impacts relative to Alternative 1 varying from a $4.9 million increase in damages to a $10 million decrease under Alternative 2.

Table 3-74. Summary of National Economic Development Analysis for Alternative 2

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Average Annual NED Damages		% Change in Damages from Alternative 1
				Total	Change from Alternative 1	
Missouri River	**$12,351,595**	**$1,111,644**	**$15,313,896**	**$28,777,135**	**−$1,705,203**	**−5.6%**
Upper River	**$1,842,530**	**$165,828**	**$479,085**	**$2,487,443**	**−$71,503**	**−2.8%**
Fort Peck Dam to Garrison Dam	$21,277	$1,915	$367,545	$390,737	$1,371	0.4%
Garrison Dam to Oahe Dam	$1,636,972	$147,327	$20,269	$1,804,569	−$40,582	−2.2%
Fort Randall Dam to Gavins Point Dam	$184,281	$16,585	$91,270	$292,137	−$32,293	−10.0%
Lower River	**$10,509,065**	**$945,816**	**$14,834,811**	**$26,289,692**	**−$1,633,700**	**−5.9%**
Gavins Point Dam to Rulo	$4,117,942	$370,615	$6,774,125	$11,262,682	−$1,076,096	−8.7%
St. Joseph Reach	$685,501	$61,695	$1,202,687	$1,949,884	−$200,804	−9.3%
Kansas City Reach	$2,380,026	$214,202	$3,490,202	$6,084,431	−$176,426	−2.8%
Boonville Reach	$549,416	$49,447	$1,260,683	$1,859,547	−$94,716	−4.8%
Hermann Reach	$2,776,179	$249,856	$2,107,113	$5,133,148	−$85,659	−1.6%

Note: All totals are average annual in the FY 2018 price level. Negative numbers indicate a decrease in damages relative to Alternative 1.

a For Alternative 2, the estimated land acquisition was 45,716 acres in the lower river. If all of the land acquired is currently in agricultural production and subsequently taken out, the agricultural damages in the lower river could be overstated by up to 3.7 percent.

Table 3-75 shows the difference in annual flood risk management impacts during years when there was a release action and/or a low summer flow modeled. During the POR, there were three simulated years with a full flow release plus low summer flow action. In the upper river, modeled results for Alternative 2 showed beneficial impacts compared to Alternative 1 in all three of these years with a maximum decrease of $42,819 in damages. In the lower river, two of the three full flow release plus low summer flow action modeled event years showed adverse impacts relative to Alternative 1. The largest modeled increase in damages for these events under Alternative 2 in the lower river was $329,743, while the largest decrease in impacts was $1,023,126. On average, the modeled full flow release plus low summer flow events showed a decrease of $222,507 in damages relative to Alternative 1 in the lower river. In the modeled years following the full flow releases, the damages in the upper river and lower river decreased by $9,254 and $782,161 on average, respectively.

In addition to full flow release actions, there were 31 years in the POR with a simulated partial flow release. In the upper river, 21 of the 31 modeled years exhibited a decrease in damages relative to Alternative 1 with an average annual decrease across these 31 years of $25,750 compared to Alternative 1. In the lower river, 29 of the 31 modeled years with a partial flow release experienced a decrease in damages relative to Alternative 1. However, the Alternative 2 1943 simulated partial release flow event showed an increase in damages over Alternative 1 of $9.2 million in the Hermann Reach alone. Overall, the partial flow modeled years in the lower river showed an average annual decrease of $737,462 compared to Alternative 1.

Table 3-75. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1

Change in Damages from Alternative 1 by River Reach [c]	Full Flow Release + Low Summer Flow [a]		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
Missouri River	**−$1,065,945**	**$314,471**	**−$5,473,129**	**$7,962,948**	**−$74,091,598**	**$8,714,297**
Upper River	−$42,819	$0	−$140,962	$21,925	−$10,025,079	$4,890,121
Fort Peck to Garrison	$0	$16,389	−$26,325	$12,746	−$139,375	$151,209
Garrison to Oahe	−$41	$4	−$4,102	$1,509	−$8,362,051	$4,817,148
Fort Randall to Gavins Point	−$49,739	$0	−$138,345	$23,459	−$1,523,652	$374,270
Lower River	**−$1,023,126**	**$329,743**	**−$5,373,183**	**$8,079,257**	**−$64,066,520**	**$8,821,805**
Gavins Point to Rulo	−$774,562	$50,461	−$4,500,074	$278,034	−$58,034,512	$7,827,580
St. Joseph Reach	−$60,217	$6,408	−$550,884	$22,047	−$3,716,295	$296,109
Kansas City Reach	−$197,449	$105,347	−$725,432	$125,914	−$1,988,346	$4,221,706
Boonville Reach	$0	$62,319	−$727,019	$58,354	−$6,753,534	$2,014,081
Hermann Reach	$0	$105,208	−$890,222	$9,166,078	−$13,604,959	$9,166,078

a Flow action was fully implemented in 3 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 31 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

c The years with the highest increases and decreases may differ between the individual reaches and the combined Missouri River, upper river, and lower river totals. Thus, the combined totals in this table are not meant to be cumulative of the individual reaches.

Regional Economic Development

Under Alternative 2, agricultural flood damages would result in an increase of less than 2 average annual jobs across all locations, while average labor income would range from an increase of $3,000 in the Boonville reach to $76,000 in the Gavins Point Dam to Rulo reach relative to Alternative 1. Under the eight worst years relative to Alternative 1, Gavins Point Dam to Rulo Reach tends to experience the largest impacts, with on average 13 fewer jobs and $839,000 less in labor income compared to Alternative 1. The impacts during the eight worst years relative to Alternative 1 would result in negligible to small adverse impacts to regional economic conditions and would be more than offset with years that would have increases in regional economic benefits from decreased agricultural damages. Table 3-76 summarizes the differences in RED effects for each of the flood risk management regions under Alternative 2 relative to Alternative 1.

The counties that would have the largest increase in structural damages under Alternative 2 compared to Alternative 1, on average per county, are the following:

- Carroll County, Missouri (Kansas City reach) (increase in structural damages of $20,575)
- St. Louis County, Missouri (Hermann reach) (increase in structural damages of $26,592)
- Montgomery County, Missouri (Hermann reach) (increase in structural damages of $5,801)

Residences, businesses, farming structures, and transportation facilities would be most affected in the above-mentioned counties, with potentially small RED effects occurring during flooding events relative to Alternative 1.

The counties that would have the largest decrease in structural damages under Alternative 2 compared to Alternative 1, on average per county, are the following:

- Union County, South Dakota (Gavins Point Dam to Rulo reach) (decrease in structural damages of $197,243)
- Cass County, Nebraska (Gavins Point Dam to Rulo reach) (decrease in structural damages of $141,351)
- Woodbury County, Iowa (Gavins Point Dam to Rulo reach) (decrease in structural damages of $97,941)

Table 3-76. RED Impacts Associated with Agricultural Damage under Alternative 2 Compared to Alternative 1

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**4**	**−22**	**29**	**$188,000**	**−$1,270,000**	**$1,614,000**	**$790,000**	**−$5,404,000**	**$6,805,000**
Upper River	**0**	**0**	**1**	**$8,000**	**−$7,000**	**$58,000**	**$29,000**	**−$26,000**	**$215,000**
Fort Randall Dam to Gavins Point Dam	0	0	1	$8,000	−$7,000	$58,000	$29,000	−$26,000	$215,000
Lower River	**3**	**−22**	**28**	**$180,000**	**−$1,263,000**	**$1,556,000**	**$761,000**	**−$5,378,000**	**$6,590,000**
Gavins Point Dam to Rulo	1	−13	14	$76,000	−$839,000	$895,000	$334,000	−$3,645,000	$3,890,000
St. Joseph Reach	0	−1	2	$23,000	−$37,000	$142,000	$96,000	−$149,000	$576,000
Kansas City Reach	2	−3	7	$66,000	−$115,000	$287,000	$273,000	−$473,000	$1,174,000
Boonville Reach	0	−3	2	$3,000	−$119,000	$88,000	$12,000	−$485,000	$359,000
Hermann Reach	0	−4	3	$12,000	−$153,000	$144,000	$46,000	−$626,000	$591,000

Note: Negative values indicate adverse impact to RED effects compared to Alternative 1, while positive values indicate beneficial impacts to RED effects compared to Alternative 1.

Other Social Effects

For Alternative 2, the average annual PAR is 566 for the Missouri River floodplain. This represents a 26-person decrease on average annually compared to Alternative 1. The greatest one-year changes to PAR in the lower river relative to Alternative 1 in the modeled POR ranged from an 839-person decrease to a 174-person increase. In the upper river, the PAR differential relative to Alternative 1 ranged from a 393-person decrease to a 271-person increase. Table 3-77 shows the PAR under Alternative 2. On average, the impacts to PAR would be small to negligible and beneficial but there could be years in which certain reaches see a small to large adverse impacts to persons at risk under Alternative 2.

Table 3-77. Population at Risk under Alternative 2

River Reach	Largest Flood Event in POR	Average Annual PAR	Largest Increase in POR Relative to Alternative 1	Largest Decrease in POR Relative to Alternative 1
Missouri River	**13,704**	**566**	**185**	**−1,232**
Upper River	**9,019**	**212**	**271**	**−393**
Fort Peck Dam to Garrison Dam	80	2	9	−6
Garrison Dam to Oahe Dame	8,866	207	271	−392
Fort Randall Dam to Gavins Point Dam	73	3	17	−9
Lower River	**5,077**	**355**	**174**	**−839**
Gavins Point Dam to Rulo	4,205	198	146	−753
St. Joseph Reach	948	45	3	−47
Kansas City Reach	1,677	38	28	−131
Boonville Reach	797	52	16	−225
Hermann Reach	787	66	116	−258

In addition to PAR, impacts to census block groups with potential populations of concern were evaluated for Alternative 2. The census block groups 291892114011 (St. Louis County, Missouri) and 291833104002 (St. Charles County, Missouri) with minority race populations and census block 290339603004 (Chariton County, Missouri) with a high poverty population were identified as showing average annual adverse impacts under Alternative 2 compared to Alternative 1. However, while in some years the modeled damages were large in nature, on average the impacts were small and deemed not disproportionate in relation to the general population.

Table 3-78 lists the type and quantity of critical infrastructure that was inundated in the largest modeled flood event during the POR for both the upper river and lower river under Alternative 2. While the impacts on average would be less, the table provides an indication of the potential infrastructure impacted under the worst-case scenario. Under Alternative 2, there would be a negligible change in critical infrastructure impacted compared to Alternative 1.

Table 3-78. Critical Infrastructure Impacted under Alternative 2 based on Largest Modeled Events in Period of Record

Critical Infrastructure	Upper River	Change from Alternative 1	Lower River	Change from Alternative 1
Agricultural Facilities	3	0	4	0
Chemical Industries	4	0	11	0
Communication Towers	0	0	3	1
Educational Schools	2	0	0	0
Emergency – EMS	0	0	3	1
Emergency – Fire Stations	0	0	4	2
Emergency – National Shelters	2	0	2	0
Energy – Plants	0	0	5	0
Energy – Propane Locations	4	0	5	2
Energy – Substations	8	0	11	1
Law Enforcement	2	0	2	0
Mail – USPS	2	0	10	0
Manufacturing Plants	2	0	10	0
Public – Campgrounds	0	0	2	0
Public – Libraries	0	0	2	0
Public – Parks	0	0	26	0
Public – Worship	1	0	1	0
Transportation – Airports	0	0	20	0
Transportation – Bridges	21	0	526	2
Transportation – Ports	0	0	121	0
Wastewater Treatment Plants	0	0	2	0

Conclusion

Under Alternative 2, on average, there would be beneficial NED impacts to flood risk management relative to Alternative 1. These impacts, particularly in the lower river, would be due to lower peak releases, relative to Alternative 1, from Gavins Point Dam under extreme flood events. On average these impacts are relatively small in nature but there are some years when the flood damages would be of greater magnitude, especially in the lower river. There would be an overall decrease in potential NED damages in relation to Alternative 1 of 5.6 percent. The only reach that would experience an increase in damages relative to Alternative 1 is the Garrison Dam to Oahe Dam reach, which exhibited a 0.4 percent increase in average annual damages under Alternative 2.

On average, the change in RED effects would be negligible to small and beneficial across most locations; although there would be years when damages could occur with adverse impacts to RED effects, they would be offset by years with reductions in damages and beneficial impacts to

RED effects compared to Alternative 1. For OSE, there would be a small decrease in average annual PAR but no to negligible impacts to environmental justice and critical infrastructure. Overall, Alternative 2 would have negligible OSE impacts to public health, safety, and economic vitality.

The simulated frequency of releases equal to or exceeding channel capacity in the Fort Randall reach increases by 480 days from Alternative 1 due to the larger spawning cue release under Alternative 2 (Table 3-69). Therefore, impacts to adjacent property would be substantially increased.

Across the study area an over the POR, the NED, RED, and OSE impacts would be negligible to small and beneficial. However, given the high risk of impacts to river stage in the Garrison reach from constructing large amounts of ESH in exclusionary zones and substantial increases in days exceeding channel capacity in the Fort Randall reach, significant impacts would be anticipated in some areas under Alternative 2.

3.12.2.6 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include those that focus on the construction of ESH and IRC through mechanical means. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. No impacts to flood risk management are anticipated because the same impact avoidance measures described under Alternative 1 apply to Alternative 3.

For ESH, an average of 332 acres per year would be constructed and distributed between the Garrison, Fort Randall, and Gavins Point reaches. No impacts to flood risk management are anticipated from this amount of ESH construction. The same site-specific avoidance measures and siting criteria described under Alternative 1 are applicable to Alternative 3. All ESH would be sited within available areas of the river.

National Economic Development

The NED analysis for Alternative 3 is summarized in Table 3-79. Overall, Alternative 3 showed an average annual reduction in damages of $232,725 compared to Alternative 1. This represents an overall decrease of 0.8 percent compared to Alternative 1. The reduction in damages in the lower river, specifically in the Hermann Reach, is the main driver of the overall decrease as the upper river would experience small adverse impacts compared to Alternative 1. The increase in modeled average annual damages in the upper river was $12,902 or 0.5 percent above Alternative 1.

Table 3-79. Summary of National Economic Development Analysis for Alternative 3

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Total Average Annual NED Damages	Change in Average Annual NED Damages from Alternative 1	% Change in Damages from Alternative 1
Missouri River	**$13,241,053**	**$1,191,695**	**$15,816,865**	**$30,249,612**	**−$232,725**	**−0.8%**
Upper River	**$1,904,044**	**$171,364**	**$496,440**	**$2,571,848**	**$12,902**	**0.5%**
Fort Peck Dam to Garrison Dam	$22,380	$2,014	$365,982	$390,376	$1,010	0.3%
Garrison Dam to Oahe Dam	$1,675,006	$150,751	$19,604	$1,845,360	$210	0.0%
Fort Randall Dam to Gavins Point Dam	$206,658	$18,599	$110,854	$336,112	$11,682	3.6%
Lower River	**$11,337,008**	**$1,020,331**	**$15,320,425**	**$27,677,764**	**−$245,628**	**−0.9%**
Gavins Point Dam to Rulo	$4,860,172	$437,415	$7,054,064	$12,351,651	$12,873	0.1%
St. Joseph Reach	$824,299	$74,187	$1,294,292	$2,192,779	$42,091	2.0%
Kansas City Reach	$2,343,123	$210,881	$3,624,704	$6,178,709	−$82,148	−1.3%
Boonville Reach	$611,909	$55,072	$1,270,412	$1,937,393	−$16,870	−0.9%
Hermann Reach	$2,697,505	$242,775	$2,076,952	$5,017,233	−$201,574	−3.9%

Note: All totals are average annual in the FY 2018 price level. Negative numbers indicate a decrease in damages relative to Alternative 1.

a For Alternative 3, the estimated land acquisition was 1,772 acres in the lower river. If all of the land acquired is currently in agricultural production and subsequently taken out, the agricultural damages in the lower river could be overstated by up to 0.1 percent.

Table 3-80 shows the highest damage increases and decreases modeled under Alternative 3 compared to Alternative 1. Over the modeled POR, Alternative 3 showed a reduction in NED damages relative to Alternative 1 of greater than $500,000 in the eight most beneficial years with the largest decrease being $6.4 million. Comparatively, only the two most adverse years showed the damages exceeding $500,000 relative Alternative 1, with the largest being a $649,756 increase. While on average the adverse impacts in the upper river would be relatively small, the magnitude of differences relative to Alternative 1 ranged from an increase in damages of $842,045 to a decrease of $58,346 under Alternative 3.

Table 3-80. Annual Impacts under Alternative 3 Compared to Alternative 1

Change in Damages from Alternative 1 by River Reach [a]	Years with Greatest Range in Impacts	
	Highest Damage Decrease	Highest Damage Increase
Missouri River	**−$6,382,176**	**$649,756**
Upper River	**−$58,346**	**$842,045**
Fort Peck to Garrison	−$27,948	$90,323
Garrison to Oahe	−$12,091	$33,333

Change in Damages from Alternative 1 by River Reach [a]	Years with Greatest Range in Impacts	
	Highest Damage Decrease	Highest Damage Increase
Fort Randall to Gavins Point	−$30,577	$852,053
Lower River	**−$7,224,221**	**$646,383**
Gavins Point to Rulo	−$6,252,827	$621,984
St. Joseph Reach	−$356,574	$394,402
Kansas City Reach	−$2,056,201	$174,621
Boonville Reach	−$1,428,174	$138,974
Hermann Reach	−$4,359,433	$2,144

a The years with the highest increases and decreases may differ between the individual reaches and the combined Missouri River, upper river, and lower river totals. Thus, the combined totals in this table are not meant to be cumulative of the individual reaches.

Regional Economic Development

Under Alternative 3, changes in agricultural damages would result in a change in annual average employment in only one reach (Hermann Reach) by one job. Average annual labor income would range from an increase of $24,000 in the Hermann Reach to a decrease of $29,000 in the Gavins Point Dam to Rulo reach relative to Alternative 1. Under the eight worst years relative to Alternative 1, two regions tend to experience the largest impacts: Gavins Point Dam to Rulo reach and St. Joseph reach. The average of the eight worst years these two reaches, would result in a reduction of $137,000 and $59,000 in labor income, respectively compared to Alternative 1. The impacts during the eight worst years relative to Alternative 1 would result in negligible adverse impacts to regional economic conditions. Table 3-81 summarizes the average annual impacts from agricultural damages and the differences in RED effects for each of the flood risk management regions under Alternative 3 relative to Alternative 1.

Table 3-81. RED Impacts Associated with Agricultural Damage under Alternative 3 Compared to Alternative 1

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
All Regions	**0**	**−4**	**5**	**−$8,000**	**−$236,000**	**$243,000**	**−$43,000**	**−$998,000**	**$1,001,000**
Upper River	**0**	**0**	**0**	**$0**	**−$7,000**	**$5,000**	**−$2,000**	**−$27,000**	**$18,000**
Fort Randall Dam to Gavins Point Dam	0	0	0	$0	−$7,000	$5,000	−$2,000	−$27,000	$18,000
Lower River	**0**	**−4**	**5**	**−$8,000**	**−$229,000**	**$238,000**	**−$41,000**	**−$971,000**	**$983,000**
Gavins Point Dam to Rulo	0	−2	0	−$29,000	−$137,000	$24,000	−$126,000	−$595,000	$105,000
St. Joseph Reach	0	−1	0	−$15,000	−$59,000	$7,000	−$58,000	−$238,000	$29,000
Kansas City Reach	0	0	2	$13,000	−$15,000	$69,000	$52,000	−$62,000	$281,000
Boonville Reach	0	0	0	−$1,000	−$18,000	$12,000	−$4,000	−$76,000	$51,000
Hermann Reach	1	0	3	$24,000	$0	$126,000	$95,000	$0	$517,000

Note: Negative values indicate adverse impact to RED effects compared to Alternative 1, while positive values indicate beneficial impacts to RED effects compared to Alternative 1.

The counties that would have the largest increase in average annual structural damages under Alternative 3 compared to Alternative 1, are the following:

- Knox County, Nebraska (Randall Dam to Gavins reach) (increase in structural damages of $6,833)
- Howard County, Missouri (Boonville reach) (increase in structural damages of $3,081)
- Boyd County, Nebraska (Randall to Gavins reach) (increase in structural damages of $2,659)

Residences, businesses, farming structures, and transportation facilities would be most affected in the above-mentioned counties, with potentially small RED effects occurring during flooding events relative to Alternative 1.

The counties that would have the largest decrease in average annual structural damages under Alternative 3 compared to Alternative 1, are the following:

- Osage County, Missouri (Hermann reach) (decrease in structural damages of $73,117)
- Union County, South Dakota (Gavins Point Dam to Rulo reach) (decrease in structural damages of $26,675)
- Callaway County, Missouri (Boonville reach) (decrease in structural damages of $20,298)

Other Social Effects

For Alternative 3, the average annual PAR is 588 for the Missouri River floodplain. This represents a 4-person decrease on average annually compared to Alternative 1. Under Alternative 3, the greatest one-year changes to PAR in the modeled POR relative to Alternative 1 ranged from a 224-person decrease to a 41-person increase in the lower river. In the upper river, the annual changes in PAR under Alternative 3 ranged from a 3-person decrease to a 20-person increase compared to Alternative 1. Table 3-82 shows the PAR totals under Alternative 3. On average, the impacts to PAR would be small to negligible and beneficial but there could be years in which certain reaches see a small to large adverse impacts to persons at risk under Alternative 3.

Table 3-82. Population at Risk under Alternative 3

River Reach	Largest Flood Event in POR	Average Annual PAR	Largest Increase in POR Relative to Alternative 1	Largest Decrease in POR Relative to Alternative 1
Missouri River	**14,886**	**588**	**41**	**−226**
Upper River	**9,412**	**212**	**20**	**−3**
Fort Peck to Garrison	81	2	6	0
Garrison to Oahe	9,258	207	20	−9
Fort Randall to Gavins Point	73	3	3	−3
Lower River	**5,564**	**377**	**41**	**−224**
Gavins Point to Rulo	4,821	217	46	−75
St. Joseph Reach	958	46	3	−5
Kansas City Reach	1,730	39	1	−43
Boonville Reach	817	49	2	−220
Hermann Reach	895	64	5	−118

In addition to PAR, impacts to census block groups with potential populations of concern were evaluated for Alternative 3. The census block group 291892114011 (St. Louis County, Missouri) was identified as showing adverse average annual adverse impacts under Alternative 3 compared to Alternative 1. However, while in some years the modeled damages were large in nature, on average the impacts were small and deemed not disproportionate in relation to the general population.

Table 3-83 lists the type and quantity of critical infrastructure that was inundated during the largest modeled flood event in the POR for both the upper river and lower river under Alternative 3. While the impacts on average would be less, the table provides an indication of the infrastructure that would be impacted under the worst-case scenario. Under Alternative 3, there would be a negligible change in critical infrastructure impacted compared to Alternative 1.

Table 3-83. Critical Infrastructure Impacted under Alternative 3 based on Largest Modeled Events in Period of Record

Critical Infrastructure	Upper River	Change from Alternative 1	Lower River	Change from Alternative 1
Agricultural Facilities	3	0	4	0
Chemical Industries	4	0	11	0
Communication Towers	0	0	4	0
Educational Schools	2	0	0	0
Emergency – EMS	0	0	4	0
Emergency – Fire Stations	0	0	6	0
Emergency – National Shelters	2	0	2	0
Energy – Plants	0	0	5	0
Energy – Propane Locations	4	0	7	0

Critical Infrastructure	Upper River	Change from Alternative 1	Lower River	Change from Alternative 1
Energy – Substations	8	0	11	0
Law Enforcement	2	0	2	0
Mail - USPS	2	0	9	1
Manufacturing Plants	2	0	10	0
Public – Campgrounds	0	0	2	0
Public – Libraries	0	0	2	0
Public – Parks	0	0	26	0
Public – Worship	1	0	1	0
Transportation – Airports	0	0	20	0
Transportation – Bridges	21	0	530	-2
Transportation – Ports	0	0	121	0
Wastewater Treatment Plants	0	0	2	0

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release that may be implemented under Alternative 3 was not included in the hydrologic modeling for the alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Flows equivalent to the one-time spawning cue test were modeled for multiple years in the period of record under Alternative 6. 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.

NED flood risk management impacts under Alternative 6 were described on average as relatively small and beneficial. On an annual basis, the adverse impacts relative to Alternative 1 tend to be greatest in the lower and upper river in years with a simulated full release. Both RED and OSE impacts were estimated to be negligible under Alternative 6 compared to Alternative 1. Because Alternative 6 modeling results show adverse impacts under full releases, the one-time implementation of the pulse would likely cause temporary adverse impacts in the year the pulse is implemented. Impacts to RED and OSE would likely be negligible because the pulse would only be run once under Alternative 3.

Conclusion

Under Alternative 3, there would be small beneficial impacts to NED with modeled average annual damages $232,725 lower relative to Alternative 1. This represents an overall decrease in damages of 0.8 percent under Alternative 3 compared to Alternative 1. The decrease in modeled damages in the lower river, specifically in the Hermann Reach, under Alternative 3 is the main driver of the overall reduction as the upper river exhibited a 0.5 percent increase in damages above Alternative 1.

The change in RED impacts compared to Alternative 1 would be negligible, even in consideration of the eight worst years relative to Alternative 1. For OSE, there would be a small decrease in average annual PAR but no to negligible impacts to environmental justice and critical infrastructure. Overall, Alternative 3 would have negligible OSE impacts to public health, safety, and economic vitality.

There would be no channel capacity exceedances attributable to flow releases for listed species under Alternative 3 (Table 3-69). For the above reasons, no significant impacts to flood risk management are anticipated under Alternative 3.

3.12.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 focuses on developing ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Alternative 4 would be similar to Alternative 1 (current operations), with the addition of a spring release designed to create ESH for the least tern and piping plover.

Mechanical Habitat Construction

For ESH, an average of 195 acres per year would be constructed between the Garrison, Fort Randall, and Gavins Point reaches. No impacts to flood risk management are anticipated from this amount of ESH construction. An estimated 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 4. Alternative 4 was modeled with the same acreages as Alternative 3 and the same distribution and application of the same site-specific impact avoidance measures. All ESH would be sited within available areas of the river.

National Economic Development

The NED analysis for Alternative 4 is summarized in Table 3-84. Under Alternative 4, the modeled NED damages along the Missouri River were reduced on average by $688,044 annually relative to Alternative 1. This represents an overall decrease in relation to Alternative 1 of 2.3 percent. The most notable reach impacted was Garrison Dam to Oahe Dam, which showed a 9.8 percent decrease in modeled damages under Alternative 4.

Table 3-84. Summary of National Economic Development Analysis for Alternative 4

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Total Average Annual NED Damages	Change in Average Annual NED Damages from Alternative 1	% Change in Damages from Alternative 1
Missouri River	**$13,018,154**	**$1,171,634**	**$15,604,506**	**$29,794,293**	**−$688,044**	**−2.3%**
Upper River	**$1,741,697**	**$156,753**	**$489,694**	**$2,388,144**	**−$170,801**	**−6.7%**
Fort Peck Dam to Garrison Dam	$21,811	$1,963	$366,781	$390,555	$1,190	0.3%
Garrison Dam to Oahe Dam	$1,508,756	$135,788	$19,026	$1,663,570	−$181,580	−9.8%
Fort Randall Dam to Gavins Point Dam	$211,129	$19,002	$103,888	$334,019	$9,589	3.0%

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Total Average Annual NED Damages	Change in Average Annual NED Damages from Alternative 1	% Change in Damages from Alternative 1
Lower River	**$11,276,457**	**$1,014,881**	**$15,114,811**	**$27,406,149**	**−$517,242**	**−1.9%**
Gavins Point Dam to Rulo	$4,797,127	$431,741	$6,881,918	$12,110,786	−$227,992	−1.8%
St. Joseph Reach	$765,527	$68,897	$1,256,385	$2,090,810	−$59,878	−2.8%
Kansas City Reach	$2,324,985	$209,249	$3,616,199	$6,150,432	−$110,424	−1.8%
Boonville Reach	$610,743	$54,967	$1,271,949	$1,937,659	−$16,605	−0.8%
Hermann Reach	$2,778,075	$250,027	$2,088,362	$5,116,463	−$102,344	−2.0%

Note: All totals are average annual in the FY 2018 price level. Negative numbers indicate a decrease in damages relative to Alternative 1.

a For Alternative 4, the estimated land acquisition was 1,772 acres in the lower river. If all of the land acquired is currently in agricultural production and subsequently taken out, the agricultural damages in the lower river could be overstated by up to 0.1 percent.

While the impacts on average would be beneficial compared to Alternative 1, the annual analysis showed a large range of relative damages in the Garrison Dam to Oahe Dam reach. For instance, under the 1950 modeled event, which included a partial ESH release, this reach experienced a $1.3 million increase in damages relative to Alternative 1. Contrarily, in the 2011 simulated event the same reach showed a $16.2 million decrease in damages relative to Alternative 1 as a result of a lower peak release from Garrison Dam in that extreme flood event under Alternative 4. As a whole, the upper river experienced adverse annual impacts relative to Alternative 1 in 40 of the modeled years over the POR.

The range of NED impacts in the lower river would be large relative to Alternative 1. In the POR, the seven best years experienced a reduction in damages of over $1 million for Alternative 4, compared to only the four worst years showing an increase in damages of over $1 million. The modeled range of damages in the lower river varied relative to Alternative 1 from a $23.0 million decrease to a $3.0 million increase for Alternative 4.

Additional results in Table 3-85 show the difference in annual flood damages during years when there was a modeled full or partial flow release action. During the POR, there were nine modeled years with a full flow release action. In the upper river, seven of these simulated years had adverse impacts relative to Alternative 1. The highest damage increase above Alternative 1 in the upper river under a full flow simulated event was $37,109. However, on average a full flow release modeled event decreased damages in the upper river relative to Alternative 1 by $16,268. This average was influenced by a $220,066 reduction shown in the 1982 simulation. Contrarily, while only two of the nine full flow release action years under Alternative 4 showed an increase in damages over Alternative 1 in the lower river, on average these events increased damages by $286,962. This was driven by increases in damages of $2.9 million and $2.8 shown respectively in the 1994 and 2002 modeled years.

In addition to full flow release actions, there were seven modeled years with partial flow releases. Three of the seven partial release years in the upper river and four in the lower river showed an increase in damages over Alternative 1. Under Alternative 4, in the upper river, the partial flow release action in the 1950 simulated event showed an increase in damages of close to $1.4 million compared to Alternative 1. In the lower river, the modeled Alternative 4 partial flow release of 1945 experienced an increase in damages over Alternative 1 of $3.0 million. The Hermann Reach alone showed an increase in damages of $2.9 million under the 1945 simulation. On average, the partial flow release modeled years exhibited an increase in damages over Alternative 1 of $188,725 and $352,259 in the upper river and lower river, respectively.

Table 3-85. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1

Change in Damages from Alternative 1 by River Reach [c]	Full Flow Release [a]		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
Missouri River	**-$1,723,667**	**$2,952,176**	**-$892,026**	**$2,940,311**	**-$23,057,880**	**$2,952,176**
Upper River	**-$220,066**	**$37,109**	**-$83,767**	**$1,357,972**	**-$15,022,990**	**$1,357,972**
Fort Peck to Garrison	-$231	$18,397	-$2,719	$4,797	-$24,670	$90,509
Garrison to Oahe	-$1,335	$783	-$10,509	$1,323,557	-$16,236,902	$1,323,557
Fort Randall to Gavins Point	-$236,043	$36,394	-$93,401	$29,618	-$236,043	$1,213,539
Lower River	**-$1,503,601**	**$2,915,067**	**-$889,847**	**$2,950,212**	**-$23,060,984**	**$2,950,212**
Gavins Point to Rulo	-$1,044,108	$647,603	-$319,830	$478.681	-$13,617,781	$1,096,631
St. Joseph Reach	-$120,410	$26,162	-$75,107	$52,082	-$7,103,332	$322,710
Kansas City Reach	-$377,136	$619,110	-$333,744	$246,056	-$2,096,041	$619,110
Boonville Reach	-$87,309	$277,302	-$55,500	$102,821	-$1,438,331	$277,302
Hermann Reach	-$342,542	$2,234,337	-$872,338	$2,888,657	-$4,397,249	$2,888,657

a Flow action was fully implemented in 9 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 7 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

c The years with the highest increases and decreases may differ between the individual reaches and the combined Missouri River, upper river, and lower river totals. Thus, the combined totals in this table are not meant to be cumulative of the individual reaches.

Regional Economic Development

Under Alternative 4, agricultural damages from flooding would result in a change of one average annual job across the upper and lower river, while average labor income would range from an increase of $36,000 in the Gavins Point Dam to Rulo reach to a decrease of $1,000 in the Boonville reach relative to Alternative 1. Under the eight worst years relative to Alternative 1, Gavins Point Dam to Rulo Reach would experience the largest adverse impacts, with two fewer jobs and a reduction in $148,000 in labor income compared to Alternative 1 on average in these years. The impacts during the eight worst years relative to Alternative 1 would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Table 3-86 summarizes the projected average annual impacts from agricultural damages and differences in RED effects for each of the reaches under Alternative 4 relative to Alternative 1.

The counties that would have the largest increase in structural damages under Alternative 4 compared to Alternative 1, on average per county, are the following:

- Union County, South Dakota (Gavins Point Dam to Rulo reach) (increase in structural damages of $10,540)
- Knox County, Nebraska (Randall Dam to Gavins reach) (increase in structural damages of $10,211)
- Woodbury County, Iowa (Gavins Point Dam to Rulo reach) (increase in structural damages of $5,760)

Residences, businesses, farming structures, and transportation facilities would be most affected in the above-mentioned counties, with potentially small RED effects occurring during flooding events relative to Alternative 1.

The counties that would have the largest decrease in structural damages under Alternative 4 compared to Alternative 1, on average per county, are the following

- Burleigh County, North Dakota (Garrison to Oahe reach) (decrease in structural damages of $130,149)
- Holt County, Missouri (Gavins Point Dam to Rulo and St. Joseph reaches) (decrease in structural damages of $118,052)
- Morton County, North Dakota (Garrison to Oahe reach) (decrease in structural damages of $35,001)

Table 3-86. RED Impacts Associated with Agricultural Damage under Alternative 4 Compared to Alternative 1

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**1**	**-6**	**18**	**$73,000**	**-$346,000**	**$1,041,000**	**$307,000**	**-$1,450,000**	**$4,398,000**
Upper River	**0**	**0**	**0**	**$2,000**	**-$9,000**	**$29,000**	**$9,000**	**-$33,000**	**$110,000**
Fort Randall Dam to Gavins Point Dam	0	0	0	$2,000	-$9,000	$29,000	$9,000	-$33,000	$110,000
Lower River	**1**	**-6**	**18**	**$71,000**	**-$337,000**	**$1,012,000**	**$298,000**	**-$1,417,000**	**$4,288,000**
Gavins Point Dam to Rulo	1	-2	9	$36,000	-$148,000	$596,000	$157,000	-$642,000	$2,591,000
St. Joseph Reach	0	-1	2	$1,000	-$48,000	$136,000	$6,000	-$196,000	$549,000
Kansas City Reach	0	-1	3	$16,000	-$60,000	$120,000	$66,000	-$247,000	$491,000
Boonville Reach	0	-1	1	-$1,000	-$31,000	$21,000	-$7,000	-$128,000	$88,000
Hermann Reach	0	-1	3	$19,000	-$50,000	$139,000	$76,000	-$204,000	$569,000

Note: Negative values indicate adverse impact to RED effects compared to Alternative 1, while positive values indicate beneficial impacts to RED effects compared to Alternative 1.

Other Social Effects

For Alternative 4, the average annual PAR is 587 for the Missouri River floodplain. This represents a 5-person decrease on average annually compared to Alternative 1. The greatest one-year PAR changes in the modeled POR relative to Alternative 1 ranged from a 429-person decrease to a 177-person increase in the lower river. In the upper river, the range differential relative to Alternative 1 was a 919-person decrease to a 754-person increase. Table 3-87 shows the PAR under Alternative 4. On average, the impacts to PAR would be small to negligible and beneficial but there could be years in which certain reaches see a small to large adverse impacts to persons at risk under Alternative 4.

Table 3-87. Population at Risk under Alternative 4

River Reach	Largest Flood Event in POR	Average Annual	Largest Increase in POR Relative to Alternative 1	Largest Decrease in POR Relative to Alternative 1
Missouri River	**14,058**	**587**	**788**	**-878**
Upper River	**8,493**	**212**	**754**	**-919**
Fort Peck Dam to Garrison Dam	81	2	1	0
Garrison Dam to Oahe Dame	8,339	207	754	-919
Fort Randall Dam to Gavins Point Dam	73	4	9	-3
Lower River	**5,679**	**375**	**177**	**-429**
Gavins Point Dam to Rulo	4,934	217	166	-335
St. Joseph Reach	958	45	4	-162
Kansas City Reach	1,730	39	6	-45
Boonville Reach	817	49	7	-221
Hermann Reach	895	66	76	-118

In addition to PAR, impacts to census block groups with potential populations of concern were evaluated for Alternative 4. The census block groups 291892114011 (St. Louis County, Missouri), 291833104002 (St. Charles County, Missouri), and 291892109272 (St. Louis County, Missouri) with minority race populations were identified as showing adverse average annual adverse impacts under Alternative 4 compared to Alternative 1. However, while in some years the modeled damages were large in nature, on average the impacts were small and deemed not disproportionate in relation to the general population.

Table 3-88 lists the type and quantity of critical infrastructure that was inundated under the largest modeled flood event in the POR for Alternative 4. While the impacts on average would be less, the table provides an indication of the potential infrastructure impacted under the worst-case scenario. Compared to Alternative 1, there would be a negligible impact on critical infrastructure under Alternative 4.

Table 3-88. Critical Infrastructure Impacted under Alternative 4 based on Largest Modeled Events in Period of Record

Critical Infrastructure	Upper River	Change from Alternative 1	Lower River	Change from Alternative 1
Agricultural Facilities	3	0	4	0
Chemical Industries	4	0	11	0
Communication Towers	0	0	4	0
Educational Schools	2	0	0	0
Emergency – EMS	0	0	4	0
Emergency – Fire Stations	0	0	6	0
Emergency – National Shelters	2	0	2	0
Energy – Plants	0	0	5	0
Energy – Propane Locations	4	0	7	0
Energy – Substations	8	0	11	1
Law Enforcement	0	2	2	0
Mail – USPS	2	0	9	1
Manufacturing Plants	2	0	10	0
Public – Campgrounds	0	0	2	0
Public – Libraries	0	0	2	0
Public – Parks	0	0	26	0
Public – Worship	1	0	1	0
Transportation – Airports	0	0	20	0
Transportation – Bridges	21	0	530	-2
Transportation – Ports	0	0	121	0
Wastewater Treatment Plants	0	0	2	0

Conclusion

Under Alternative 4, there would be small beneficial impacts to NED with modeled damages along the Missouri River reduced on average by $688,044 annually relative to Alternative 1. This represents an overall reduction of NED impacts in relation to Alternative 1 of 2.3 percent. The decrease in damages was driven by lower structure damages in the lower river, but the upper river also exhibited a slight decrease in damages compared to Alternative 1. The most notable reach impacted was Garrison Dam to Oahe Dam, which showed a 9.8 percent decrease in NED impacts relative to Alternative 1. Although Alternative 4 is showing a decrease in damages on average per year, there are examples, particularly under partial release events, when damages would be much higher in certain years.

RED effects under Alternative 4 would be negligible, even during conditions that reflect the eight worst years in the POR relative to Alternative 1. For OSE, there would be a small decrease in average annual PAR but no to negligible impacts to environmental justice and critical infrastructure. Overall, Alternative 4 would have negligible OSE impacts to public health, safety, and economic vitality.

Flow releases for the purpose of creating ESH under Alternative 4 would increase the incidence of channel capacity exceedance by 416 days in the Garrison Reach and 430 days in the Fort Randall Reach (Table 3-69).

Over the entire study area and over the POR, the NED impacts would be small and beneficial while the RED and OSE impacts would be negligible. However, given the unavoidable increase in incidence of channel capacity exceedance in the Fort Randall reach and downstream of Bismarck, Alternative 4 is anticipated to have significant impacts to flood risk management in some areas.

3.12.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 would focus on developing ESH habitat through both mechanical and reservoir releases that would occur during the fall months. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Overall, Alternative 5 is expected to have a relatively small, beneficial impact on flood risk management.

Mechanical Habitat Construction

An estimated 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 5. No impact to flood risk management would be anticipated from early life stage pallid sturgeon habitat construction. Alternative 5 was modeled with the same acreages as Alternative 3 with the same distribution and application of site-specific impact avoidance measures.

For ESH, an average of 253 acres per year would be constructed between the Garrison, Fort Randall, and Gavins Point reaches. No impacts to flood risk management are anticipated from this amount of ESH construction.

National Economic Development

The NED analysis for Alternative 5 is summarized in Table 3-89. The modeled NED impacts to the Missouri River floodplain showed an average annual reduction in damages of $548,536 relative to Alternative 1. This represents an overall decrease in damages of 1.8 percent compared to Alternative 1. The majority of the decrease in damages would occur in the lower river, but the damages in the upper river were also slightly less than the damages under Alternative 1. However, two reaches under Alternative 5, Fort Randall Dam to Gavins Point Dam and St. Joseph Reach, showed a small increase in average annual damages relative to Alternative 1.

Table 3-89. Summary of National Economic Development Analysis for Alternative 5

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Total Average Annual NED Damages	Change in Average Annual NED Damages from Alternative 1	% Change in Damages from Alternative 1
Missouri River	**$12,969,253**	**$1,167,233**	**$15,797,315**	**$29,933,801**	**-$548,536**	**-1.8%**
Upper River	**$1,783,391**	**$160,505**	**$535,777**	**$2,479,673**	**-$79,272**	**-3.1%**
Fort Peck Dam to Garrison Dam	$21,280	$1,915	$363,545	$386,741	-$2,625	-0.7%
Garrison Dam to Oahe Dam	$1,584,983	$142,648	$20,111	$1,747,742	-$97,408	-5.3%
Fort Randall Dam to Gavins Point Dam	$177,128	$15,942	$152,121	$345,190	$20,761	6.4%
Lower River	**$11,185,862**	**$1,006,728**	**$15,261,538**	**$27,454,128**	**-$469,264**	**-1.7%**
Gavins Point Dam to Rulo	$4,735,114	$426,160	$7,007,077	$12,168,351	-$170,427	-1.4%
St. Joseph Reach	$812,992	$73,169	$1,287,861	$2,174,023	$23,335	1.1%
Kansas City Reach	$2,337,880	$210,409	$3,625,247	$6,173,536	-$87,320	-1.4%
Boonville Reach	$610,690	$54,962	$1,267,622	$1,933,274	-$20,989	-1.1%
Hermann Reach	$2,689,186	$242,027	$2,073,731	$5,004,943	-$213,863	-4.1%

Note: All totals are average annual in the FY 2018 price level. Negative numbers indicate a decrease in damages relative to Alternative 1.

a For Alternative 5, the estimated land acquisition was 1,772 acres in the lower river. If all of the land acquired is currently in agricultural production and subsequently taken out, the agricultural damages in the lower river could be overstated by up to 0.1 percent.

The annual analysis of the modeled impacts under Alternative 5 showed an almost equal number of years with increases in damages relative to Alternative 1 as years with decreases. In the lower river, the modeled Alternative 5 damages relative to Alternative 1 ranged from a decrease of $18.8 million to an increase of $1.7 million. In the upper river, the modeled impacts under Alternative 5 ranged from a $9.9 million decrease in damages to an increase of $0.7 million relative to Alternative 1.

Additional results that show the difference in annual NED impacts during the modeled years that had a full or partial flow release action are summarized in Table 3-90. During the POR for Alternative 5, there were seven years with a modeled full flow release action. In both the upper river and lower river, all seven of these years showed an increase in damages relative to Alternative 1. The largest increases in damages under modeled full flow release events were $664,862 in upper river and $1,679,452 in the lower river. On average, the full flow release action simulations under Alternative 5 increased annual damages, relative to Alternative 1, by $480,095 and $904,108 in the upper river and lower river, respectively. The damage increases under Alternative 5 full release events are more than offset by the beneficial impacts seen in years following the full releases when there is more storage available for flood risk management. In addition, there would be a large decrease in damages exhibited under the modeled natural flood event of 2011 when the peak releases from the Garrison and Gavins Point dams would be lower as System storage is balanced under Alternative 5.

In addition to full flow release actions, there were two modeled years with a partial flow release. This modeled action also showed an adverse NED impact in both the upper river and lower river.

Table 3-90. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1

Change in Damages from Alternative 1 by River Reach [c]	Full Flow Release [a]		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
Missouri River	**$0**	**$2,044,636**	**$0**	**$1,447,593**	**-$28,696,579**	**$2,044,636**
Upper River	$0	$664,862	$0	$170,348	-$9,887,823	$664,862
Fort Peck to Garrison	-$8,385	$6,682	$0	$795	-$119,697	$27,649
Garrison to Oahe	$0	$7,725	-$2,364	$1,010	-$7,986,179	$33,342
Fort Randall to Gavins Point	$0	$665,523	$0	$171,917	-$1,876,468	$665,523
Lower River	**$0**	**$1,679,452**	**$0**	**$1,277,245**	**-$18,808,756**	**$1,717,411**
Gavins Point to Rulo	$0	$1,664,409	$0	$1,317,976	-$16,463,378	$1,664,409
St. Joseph Reach	$0	$65,358	$0	$395,755	-$1,167,051	$525,800
Kansas City Reach	-$72,470	$362,587	-$139,936	$0	-$2,055,054	$362,587
Boonville Reach	-$625	$6,484	$4,817	$14,788	-$1,443,857	$137,861
Hermann Reach	-$747,118	$0	-$97,404	$0	-$4,411,397	$2,144

a Flow action was fully implemented in 7 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 2 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

c The years with the highest increases and decreases may differ between the individual reaches and the combined Missouri River, upper river, and lower river totals. Thus, the combined totals in this table are not meant to be cumulative of the individual reaches.

Regional Economic Development

Under Alternative 5, agricultural damages would result in an increase of one average annual job in the Hermann Reach, the only reach with measurable changes in average annual jobs. Average labor income would range from an increase of $25,000 in the Hermann Reach to a reduction of $18,000 in the Fort Randall Dam to Gavins Point Dam reach relative to Alternative 1. Under the eight worst years relative to Alternative 1, the Gavins Point Dam to Rulo reach would experience the largest adverse impacts, with seven fewer jobs and a reduction of $459,000 in labor income compared to Alternative 1. The impacts during the eight worst years relative to Alternative 1 would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Table 3-91 summarizes the average annual impacts from agricultural damages and differences in RED effects for each of the flood risk management reaches under Alternative 5 relative to Alternative 1.

The counties that would have the largest increase in average annual structural damages under Alternative 5 compared to Alternative 1 are the following:

- St. Louis County, Missouri (Hermann reach) (increase in structural damages of $2,319)
- Howard County, Missouri (Boonville reach) (increase in structural damages of $3,002)
- Atchison County, Missouri (Gavins Point Dam to Rulo reach) (increase in structural damages of $1,217)

Residences, businesses, farming structures, and transportation facilities would be most affected in the above-mentioned counties, with potentially small RED effects occurring during flooding events relative to Alternative 1.

The counties that would have the largest decrease in average annual structural damages under Alternative 5 compared to Alternative 1 are the following

- Union County, South Dakota (Gavins Point Dam to Rulo reach) (decrease in structural damages of $81,534)
- Burleigh County, North Dakota (Garrison to Oahe reach) (decrease in structural damages of $74,670)
- Osage County, Missouri (Hermann reach) (decrease in structural damages of $73,373)

Table 3-91. RED Impacts Associated with Agricultural Damage under Alternative 5 Compared to Alternative 1

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**1**	**-12**	**16**	**-$4,000**	**-$795,000**	**$895,000**	**-$13,000**	**-$3,304,000**	**$3,806,000**
Upper River	**0**	**-2**	**0**	**-$18,000**	**-$181,000**	**$10,000**	**-$67,000**	**-$678,000**	**$38,000**
Fort Randall Dam to Gavins Point Dam	0	-2	0	-$18,000	-$181,000	$10,000	-$67,000	-$678,000	$38,000
Lower River	**1**	**-10**	**16**	**$14,000**	**-$614,000**	**$885,000**	**$54,000**	**-$2,626,000**	**$3,768,000**
Gavins Point Dam to Rulo	0	-7	9	-$12,000	-$459,000	$587,000	-$49,000	-$1,993,000	$2,551,000
St. Joseph Reach	0	-1	1	-$12,000	-$73,000	$43,000	-$48,000	-$297,000	$175,000
Kansas City Reach	0	-1	2	$12,000	-$64,000	$104,000	$51,000	-$260,000	$424,000
Boonville Reach	0	0	0	$1,000	-$13,000	$19,000	$0	-$54,000	$76,000
Hermann Reach	1	0	3	$25,000	-$5,000	$132,000	$100,000	-$22,000	$542,000

Note: Negative values indicate adverse impact to RED effects compared to Alternative 1, while positive values indicate beneficial impacts to RED effects compared to Alternative 1.

Other Social Effects

For Alternative 5, the average annual PAR is 578 for the Missouri River floodplain. This represents a 14-person decrease on average annually compared to Alternative 1. For Alternative 5, the greatest one-year PAR changes in the modeled POR relative Alternative 1 ranged from a 239-person decrease to a 41-person increase in the lower river. For the upper river, the PAR differential relative to Alternative 1 ranged from a 403-person decrease to a 20-person increase. Table 3-92 shows the PAR under Alternative 5. On average, the impacts to PAR would be small to negligible and beneficial but there could be years in which certain reaches see a small to large adverse impacts to persons at risk under Alternative 5.

Table 3-92. Population at Risk under Alternative 5

River Reach	Largest Flood Event in POR	Average Annual	Largest Increase in POR Relative to Alternative 1	Largest Decrease in POR Relative to Alternative 1
Missouri River	**14,321**	**578**	**41**	**-615**
Upper River	**9,009**	**208**	**20**	**-403**
Fort Peck Dam to Garrison Dam	81	2	6	-1
Garrison Dam to Oahe Dame	8,855	202	20	-403
Fort Randall Dam to Gavins Point Dam	73	3	9	-3
Lower River	**5,407**	**373**	**41**	**-239**
Gavins Point Dam to Rulo	4,674	213	46	-222
St. Joseph Reach	958	46	3	-11
Kansas City Reach	1,730	39	0	-45
Boonville Reach	817	49	2	-220
Hermann Reach	895	64	5	-118

In addition to PAR, impacts to census block groups with potential populations of concern were evaluated for Alternative 5. The census block group 291892114011 (St. Louis County, Missouri) was identified as showing adverse average annual impacts under Alternative 5 compared to Alternative 1. However, while in some years the modeled damages were large in nature, on average the impacts were small and deemed not disproportionate in relation to the general population.

Table 3-93 lists the type and quantity of critical infrastructure that were inundated during the largest flood event in the modeled POR for Alternative 5. While the impacts on average would be less, the table provides an indication of the infrastructure that would be impacted under the worst-case scenario. Compared to Alternative 1, there would be a negligible impact on critical infrastructure under Alternative 5.

Table 3-93. Critical Infrastructure Impacted under Alternative 5 based on Largest Modeled Events in Period of Record

Critical Infrastructure	Upper River	Change from Alternative 1	Lower River	Change from Alternative 1
Agricultural Facilities	3	0	4	0
Chemical Industries	4	0	11	0
Communication Towers	0	0	4	0
Educational Schools	2	0	0	0
Emergency – EMS	0	0	4	0
Emergency – Fire Stations	0	0	6	0
Emergency – National Shelters	2	0	2	0
Energy – Plants	0	0	5	0
Energy – Propane Locations	4	0	7	0
Energy – Substations	8	0	11	1
Law Enforcement	2	0	2	0
Mail - USPS	2	0	9	1
Manufacturing Plants	2	0	10	0
Public – Campgrounds	0	0	2	0
Public – Libraries	0	0	2	0
Public – Parks	0	0	26	0
Public – Worship	1	0	1	0
Transportation – Airports	0	0	20	0
Transportation – Bridges	21	0	530	-2
Transportation – Ports	0	0	121	0
Wastewater Treatment Plants	0	0	2	0

Conclusion

Alternative 5 when compared to Alternative 1 would have a small beneficial NED impact with a reduction in annual average damages by 1.8 percent. While the damages increased under every full release simulation, these adverse impacts were more than offset by the beneficial impacts seen in the years following a full release when the System had more flood risk management storage available. Moreover, under the modeled 2011 natural flood event model under Alternative 5, the damages were considerably smaller as the peak flow releases from the Garrison and Gavins Point dams were lower under this alternative.

RED effects under Alternative 5 would be negligible, even during conditions that reflect the eight worst years in the POR relative to Alternative 1. For OSE, there would be a small decrease in average annual PAR but no to negligible impacts to environmental justice and critical infrastructure. Overall, Alternative 5 would have negligible OSE impacts to public health, safety, and economic vitality.

The fall ESH release under Alternative 5 increases the incidence of channel capacity exceedance in the Fort Randall reach by 283 days and the Garrison reach by 265 days (Table 3-69).

For all locations and over the POR, the NED impacts would be small and beneficial while RED and OSE impacts would be negligible. However, given the unavoidable increased frequency of channel exceedance in the Fort Randall and Garrison reaches, significant impacts to flood risk management could occur in some areas under Alternative 5.

3.12.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes actions that would develop ESH habitat through mechanical means and a spawning cue release that would be mimicked through bi-modal pulses that would occur in March and May. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Overall, Alternative 6 would have a small, beneficial impact on flood risk management.

Mechanical Habitat Construction

An estimated 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 6. No impact would be anticipated from early life stage pallid sturgeon habitat construction. Alternative 6 was modeled with the same acreages as Alternative 3 with the same distribution and application of site-specific impact avoidance measures.

For ESH, an average of 245 acres per year would be constructed in years that construction occurs between the Garrison, Fort Randall, and Gavins Point reaches. No impacts to flood risk management are anticipated from this amount of ESH construction. The same site-specific avoidance measures and siting criteria described under Alternative 1 are applicable to Alternative 6. All ESH would be sited within available areas of the river.

National Economic Development

The modeled NED results for Alternative 6 are summarized in Table 3-94. Overall, Alternative 6 showed a small beneficial NED impact relative to Alternative 1. This alternative resulted in a decrease in average annual damages of $282,851 relative to Alternative 1 over the POR. In both the upper and lower river, the average annual damages decreased under Alternative 6. The largest driver of the reduction in damages was the decrease of $168,012 in average annual damages exhibited in the Hermann Reach. However, there was also an increase in damages of 6.0 percent in the Fort Randall Dam to Gavins Point Dam reach under Alternative 6.

Table 3-94. Summary of National Economic Development Analysis for Alternative 6

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses [a]	Total Average Annual NED Damages	Change in Average Annual NED Damages from Alternative 1	% Change in Damages from Alternative 1
Missouri River	**$13,063,132**	**$1,175,682**	**$15,960,672**	**$30,199,487**	**-$282,851**	**-0.9%**
Upper River	**$1,886,653**	**$169,799**	**$492,600**	**$2,549,052**	**-$9,894**	**-0.4%**
Fort Peck Dam to Garrison Dam	$22,256	$2,003	$364,223	$388,483	-$883	-0.2%
Garrison Dam to Oahe Dam	$1,649,125	$148,421	$19,263	$1,816,809	-$28,341	-1.5%
Fort Randall Dam to Gavins Point Dam	$215,272	$19,375	$109,113	$343,760	$19,330	6.0%
Lower River	**$11,176,479**	**$1,005,883**	**$15,468,072**	**$27,650,435**	**-$272,957**	**-1.0%**
Gavins Point Dam to Rulo	$4,721,689	$424,952	$7,191,194	$12,337,835	-$943	0.0%
St. Joseph Reach	$768,439	$69,160	$1,274,571	$2,112,170	-$38,518	-1.8%
Kansas City Reach	$2,347,832	$211,305	$3,633,171	$6,192,308	-$68,548	-1.1%
Boonville Reach	$617,741	$55,597	$1,283,991	$1,957,328	$3,065	0.2%
Hermann Reach	$2,720,779	$244,870	$2,085,145	$5,050,794	-$168,012	-3.2%

Note: All totals are average annual in the FY 2018 price level. Negative numbers indicate a decrease in damages relative to Alternative 1.

a For Alternative 6, the estimated land acquisition was 1,772 acres in the lower river. If all of the land acquired is currently in agricultural production and subsequently taken out, the agricultural damages in the lower river could be overstated by up to 0.1 percent.

The annual breakdown of the modeled flood risk management NED analysis shows that the overall damage reduction is driven by the changes in impacts in the lower river. In the six worst years in the POR, increases in NED damages in the lower river exceeded $1 million compared to those experienced under Alternative 1, while the six best years showed a decrease of $1 million or greater relative to Alternative 1. The damages compared to Alternative 1 ranged from a decrease of $15.7 million to an increase of $7.1 million under Alternative 6 in the lower river. In the upper river, the differences from Alternative 1 in modeled damages ranged from an increase of $143,982 to a decrease of $652,205 under Alternative 6.

Additional results are summarized in Table 3-95, which shows the difference in Alternative 6 damages during years when there was a modeled full or partial release action. There were six years in the modeled POR that had a full flow release. In both the upper and lower river, five of those six years showed adverse impacts relative to Alternative 1. On average, the full flow release increased damages above Alternative 1 by $2.7 million in the lower river and by $32,106 in the upper river.

In addition to full flow release, there were 29 modeled years with partial flow releases. In the upper river, these simulated actions exhibited a small beneficial impact with an average annual decrease in damages of $12,928 compared to Alternative 1. However, in the lower river the modeled partial flow releases produced an adverse impact with average annual damages increasing by $76,731 over Alternative 1.

Table 3-95. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1

Change in Damages from Alternative 1 by River Reach [c]	Full Flow Release [a]		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
Missouri River	**-$89,602**	**$7,123,611**	**-$1,124,625**	**$3,106,313**	**-$15,617,145**	**$7,123,611**
Upper River	-$25,446	$73,567	-$178,735	$143,982	-$652,205	$143,982
Fort Peck to Garrison	-$3,367	$7,303	-$24,556	$7,503	-$24,556	$18,729
Garrison to Oahe	-$305	$1,962	-$8,746	$539	-$2,285,571	$1,962
Fort Randall to Gavins Point	-$25,623	$66,430	-$154,433	$155,543	-$154,433	$1,614,637
Lower River	**-$144,426**	**$7,149,057**	**-$1,123,055**	**$2,962,331**	**-$15,695,759**	**$7,149,057**
Gavins Point to Rulo	$0	$4,080,354	-$735,686	$2,993,872	-$9,202,773	$4,080,354
St. Joseph Reach	$0	$1,380,889	-$32,837	$349,818	-$7,102,841	$1,380,889
Kansas City Reach	-$47,505	$1,903,323	-$272,610	$1,129,930	-$2,095,771	$1,903,323
Boonville Reach	-$49,903	$709,933	-$52,912	$1,021,978	-$1,430,338	$1,021,978
Hermann Reach	-$423,243	$293,089	-$466,979	$703,138	-$4,361,139	$703,138

a Flow action was fully implemented in 6 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 29 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

c The years with the highest increases and decreases may differ between the individual reaches and the combined Missouri River, upper river, and lower river totals. Thus, the combined totals in this table are not meant to be cumulative of the individual reaches.

Regional Economic Development

Under Alternative 6, agricultural damages from flooding would result in a decrease of one average annual job in the lower river, while average labor income ranged from an increase of $20,000 in the Hermann Reach to a decrease of $81,000 in the Gavins Point Dam to Rulo reach relative to Alternative 1. Under the eight worst years relative to Alternative 1, Gavins Point Dam to Rulo reach would experience the largest effects, with 13 fewer jobs and $863,000 less in labor income. However, there would be other years with beneficial impacts to RED effects in this river reach, which would result in negligible adverse impacts on average. The RED effects, even in the eight worst years relative to Alternative 1, would be small. Table 3-96 summarizes the average annual impacts from agricultural damages and differences in RED effects for each of the regions under Alternative 6 relative to Alternative 1.

The counties that would have the largest increase in annual average structural damages under Alternative 6 compared to Alternative 1 are the following:

- Knox County, Nebraska (Randall Dam to Gavins reach) (increase in structural damages of $13,174)
- Boyd County, Nebraska (Randall to Gavins reach) (increase in structural damages of $4,776)
- Howard County, Missouri (Boonville reach) (increase in structural damages of $3,539)

Residences, businesses, farming structures, and transportation facilities would be most affected in the above-mentioned counties, with potentially small RED effects occurring during flooding events relative to Alternative 1.

The counties that would have the largest decrease in annual average structural damages under Alternative 6 compared to Alternative 1 are the following

- Holt County, Missouri (Gavins Point Dam to Rulo and St. Joseph reaches) (decrease in structural damages of $113,429)
- Osage County, Missouri (Hermann reach) (decrease in structural damages of $58,234)
- Union County, South Dakota (Gavins Point Dam to Rulo reach) (decrease in structural damages of $40,932)

Table 3-96. RED Impacts Associated with Agricultural Damage under Alternative 6 Compared to Alternative 1

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**-1**	**-20**	**10**	**-$65,000**	**-$1,193,000**	**$555,000**	**-$282,000**	**-$5,091,000**	**$2,299,000**
Upper River	**0**	**0**	**0**	**$0**	**-$23,000**	**$31,000**	**$1,000**	**-$88,000**	**$114,000**
Fort Randall Dam to Gavins Point Dam	0	0	0	$0	-$23,000	$31,000	$1,000	-$88,000	$114,000
Lower River	**-1**	**-20**	**10**	**-$65,000**	**-$1,170,000**	**$524,000**	**-$283,000**	**-$5,003,000**	**$2,185,000**
Gavins Point Dam to Rulo	-1	-13	3	-$81,000	-$863,000	$181,000	-$352,000	-$3,748,000	$787,000
St. Joseph Reach	0	-1	2	-$7,000	-$84,000	$104,000	-$25,000	-$339,000	$420,000
Kansas City Reach	0	-3	2	$9,000	-$122,000	$103,000	$38,000	-$501,000	$420,000
Boonville Reach	0	-2	0	-$6,000	-$78,000	$16,000	-$26,000	-$319,000	$66,000
Hermann Reach	0	-1	3	$20,000	-$23,000	$120,000	$82,000	-$96,000	$492,000

Note: Negative values indicate adverse impact to RED effects compared to Alternative 1, while positive values indicate beneficial impacts to RED effects compared to Alternative 1.

Other Social Effects

For Alternative 6, the average annual PAR is 587 for the Missouri River floodplain. This represents a 5-person decrease on average annual employment compared to Alternative 1. Under Alternative 6, the greatest one-year changes to PAR relative to Alternative 1 in the modeled POR ranged from a 123-person decrease to a 13-person increase in the upper river and a 230-person decrease to 244-person increase in the lower river. Table 3-97 shows the PAR under Alternative 6. On average, the impacts to PAR would be small to negligible and beneficial but there could be years in which certain reaches see a small to large adverse impacts to persons at risk under Alternative 6.

Table 3-97. Population at Risk under Alternative 6

River Reach	Largest Flood Event in POR	Average Annual	Largest Increase in POR Relative to Alternative 1	Largest Decrease in POR Relative to Alternative 1
Missouri River	**14,726**	**587**	**249**	**-230**
Upper River	**9,289**	**211**	**13**	**-123**
Fort Peck Dam to Garrison Dam	81	2	0	0
Garrison Dam to Oahe Dame	9,135	205	3	-123
Fort Randall Dam to Gavins Point Dam	73	4	13	-4
Lower River	**5,527**	**382**	**244**	**-230**
Gavins Point Dam to Rulo	4,787	218	166	-109
St. Joseph Reach	958	48	240	-162
Kansas City Reach	1,730	39	4	-45
Boonville Reach	817	52	19	-220
Hermann Reach	895	64	9	-118

In addition to PAR, impacts to census block groups with potential populations of concern were evaluated for Alternative 6. The census block groups 291892114011 (St. Louis County, Missouri) and 291892109272 (St. Louis County, Missouri) with minority race populations were identified as showing adverse average annual impacts under Alternative 6 compared to Alternative 1. However, while in some years the modeled damages were large in nature, on average the impacts were small and deemed not disproportionate in relation to the general population.

Table 3-98 lists the type and quantity of critical infrastructure that were inundated during the largest modeled flood event in the POR for Alternative 6. While the impacts on average would be less, the table provides an indication of the potential infrastructure impacted under the worst-case scenario. Compared to Alternative 1, there would be a negligible impact on critical infrastructure under Alternative 6.

Table 3-98. Critical Infrastructure Impacted under Alternative 6 based on Largest Modeled Events in Period of Record

Critical Infrastructure	Upper River	Change from Alternative 1	Lower River	Change from Alternative 1
Agricultural Facilities	3	0	4	0
Chemical Industries	4	0	11	0
Communication Towers	0	0	4	0
Educational Schools	2	0	0	0
Emergency – EMS	0	0	4	0
Emergency – Fire Stations	0	0	6	0
Emergency – National Shelters	2	0	2	0
Energy – Plants	0	0	5	0
Energy – Propane Locations	4	0	7	0
Energy – Substations	8	0	11	1
Law Enforcement	2	0	2	0
Mail - USPS	2	0	9	1
Manufacturing Plants	2	0	10	0
Public – Campgrounds	0	0	2	0
Public – Libraries	0	0	2	0
Public – Parks	0	0	26	0
Public – Worship	1	0	1	0
Transportation – Airports	0	0	20	0
Transportation – Bridges	21	0	530	-2
Transportation – Ports	0	0	121	0
Wastewater Treatment Plants	0	0	2	0

Conclusion

The modeled Missouri River NED damages decreased on average by $282,851 annually or 0.9 percent under Alternative 6 relative to Alternative 1. While the average NED impacts would be small and beneficial there would be years, particularly when there is a full release, when there is a potential for large, adverse impacts.

Alternative 6 would result in negligible RED effects on average in most years and most locations. However, in the Gavins Point Dam to Rulo reach, there would be temporary, small, and adverse RED effects in some years from the spawning cue increasing agricultural damages relative to Alternative 1. For OSE, there would be a small decrease in average annual PAR but no to negligible impacts to environmental justice and critical infrastructure. Overall, Alternative 6 would have negligible OSE impacts to public health, safety, and economic vitality.

The spring pulse release under Alternative 6 would increase the incidence of channel capacity exceedance in the Fort Randall reach by 594 days over Alternative 1 (Table 3-69).

For the study area and over the POR, NED impacts under Alternative 6 would be small and beneficial, and there would be negligible to small adverse impacts to RED and OSE. However, given the impacts to NED damages and unavoidable increased frequency of channel exceedance in the Fort Randall reach, significant impacts to flood risk management could occur in some areas under Alternative 6.

3.12.2.10 Tribal Resources

All Tribal reservations located within the Missouri River floodplain were evaluated for flood damages and population at risk (PAR). The results for the combined Tribal reservation effects are summarized in Table 3-99.

Under Alternative 1, the average annual NED damages to Tribal reservations in the modeled POR was $115,120. Compared to Alternative 1, Alternatives 3, 5, and 6 all showed negligible to small increases in modeled average annual damages with Alternative 5 showing the largest increase ($26,069 or 22.6 percent). Conversely, Alternatives 2 and 4 exhibited a negligible to small decrease in average annual damages compared to Alternative 1, while Alternative 2 showed the largest reduction (-$13,306 or 11.6 percent). For each of the alternatives including Alternative 1, there is a small average annual PAR shown in the modeled POR with the maximum PAR being 66 in the largest modeled flood event under every alternative.

Table 3-99. Impacts to Tribal Reservations

	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses	Total Average Annual NED Damages	Change in Total Average Annual NED Damages from Alternative 1	% Change Relative to Alternative 1	Average Annual PAR	PAR in Largest Modeled Flood Event in POR
Alt 1	$11,848	$1,066	$102,206	$115,120	$0	0.0%	3	66
Alt 2	$11,263	$1,014	$89,537	$101,814	-$13,306	-11.6%	3	66
Alt 3	$12,105	$1,089	$104,416	$117,610	$2,490	2.2%	3	66
Alt 4	$11,841	$1,066	$99,897	$112,803	-$2,317	-2.0%	4	66
Alt 5	$11,070	$996	$129,123	$141,189	$26,069	22.6%	4	66
Alt 6	$12,192	$1,097	$103,148	$116,438	$1,318	1.1%	4	66

Note: All totals are in the FY 2018 price level. Negative values indicate a decrease relative to Alternative 1.

3.12.2.11 Climate Change

In accordance with *Engineering and Construction Bulletin: Guidance for Climate Change Adaptation Engineering Inputs to Inland Hydrology for Civil Works Studies, Designs, and Projects* (USACE 2016d), this section provides a qualitative assessment of the climate change effects to flood risk management for each alternative.

Alternative 1 and Alternative 2: As shown in Table 3-100, the following six climate change variables are expected to have an impact on Alternative 1 and Alternative 2: increased air temperature; increased precipitation and stream flow; decreased peak snow water equivalent; earlier snowmelt date and decreased snow accumulation season duration; increased sedimentation; and increased irregularity of floods and droughts. While all variables will impact the alternatives, increased air temperature was identified as not being a risk to flood risk management. Two climatic change variables, decreased peak snow water equivalent and earlier snowmelt date and decreased snow accumulation season duration, could have either an adverse or beneficial impact depending on accurate forecasting and the location and season of snowmelt. The remaining three climatic change variables would increase the risk of adverse impact of floods by potentially exceeding flood targets more frequently or increasing the number of extreme weather events and reducing the overall reliability of the System.

Table 3-100. Discussion of Risk to Flood Risk Management from Climate Change Variables for Alternative 1 and Alternative 2

Variable	Consequence from Variable	Risk for Flood Risk Management Impacts
Increased Air Temperature	During summer water supply operations, could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	No identified impact to flood risk.
Increased Precipitation and Streamflow	May be able to run spring pulses more often due to increased System storage. However, the frequency of a completed pulse would likely decrease due to exceeding flood targets more frequently.	(−) Increase risk of adverse impacts from floods by potentially exceeding flood targets more frequently.
Decreased Peak Snow Water Equivalent	Forecasting calendar year runoff has the potential to become less accurate, since 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 due to setting pulse magnitude too high.	Lower reservoir elevations from the decreased snow water would reduce the risk of adverse impacts to flood risk management. Less accurate forecasts could potentially increase the risk to flood risk management if the magnitude of the pulses was set too high.
Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration	May be able to run spring pulses more frequently due to System storage rising earlier in the year. Could potentially lower the service level for second half of navigation season if current year's runoff falls as rain in late winter while System storage is being evacuated back to 56.1 MAF.	The decrease in available flood storage during early spring would increase flood risk downstream of Gavins Point Dam in a large rain event. During the summer months, reservoir levels would drop providing more flood storage and decreasing the risk to flood risk management.
Increased Sedimentation	Decreased System storage may lead to decreased frequency of all pulses (assuming pulse requirements remain the same and sedimentation is not addressed).	(−) Increase risk of adverse impacts from floods with increased aggradation of sediment.
Increased Irregularity of Floods and Droughts	Accuracy of downstream forecasting may decrease, resulting in more frequent flood impacts caused by pulses. Have a greater potential to impact System storage with pulses if more droughts occur.	(−) Increase risk of adverse impact to flood risk management in the long term with an increased risk of more frequent extreme events.

Alternative 3: Only two climate change variables were identified as impacting Alternative 3, as shown in Table 3-101. Increased air temperature was identified as not a risk to flood risk management, while earlier snowmelt dates and decreased snow accumulation season duration, could have either an adverse or beneficial impact on flood risk management depending on the location and season.

Table 3-101. Discussion of Risk to Flood Risk Management from Climate Change Variables for Alternative 3

Variable	Consequence from Variable	Impact to Risk for Flood Risk Management
Increased Air Temperature	During summer water supply operations, could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	No identified impact to risk of flood risk management.
Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration	Could potentially lower the service level for second half of navigation season if current year's runoff falls as rain in late winter while System storage is being evacuated back to 56.1 MAF.	The decrease in available flood storage during early spring would increase flood risk downstream of Gavins Point Dam in a large rain event. During the summer months, reservoir levels would drop providing more flood storage and decreasing the risk to flood risk management.

Alternatives 4–6: Alternatives 4, 5, and 6 were identified as being impacted by the five climate change variables shown in Table 3-102. Increased air temperature was identified as not a risk to flood risk management. One climate change variable, earlier snowmelt dates and decreased snow accumulation season duration, could have either an adverse or beneficial impact on flood risk management depending on the location and season. The remaining three climatic change variables would increase the risk of adverse impacts from floods by potentially exceeding flood targets more frequently or increasing the number of extreme weather events and reducing the overall reliability of the System.

Table 3-102. Discussion of Risk to Flood Risk Management from Climate Change Variables for Alternative 4, Alternative 5, and Alternative 6

Variable	Consequence from Variable	Impact to Risk for Flood Risk Management
Increased Air Temperature	During summer water supply operations, could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	No identified impact to flood risk management.
Increased Precipitation and Streamflow	May be able to run spring pulses more often due to increased System storage. However, the frequency of a completed pulse would likely decrease due to exceeding flood targets more frequently.	(−) Increase risk of adverse impacts from floods by potentially exceeding flood targets more frequently.
Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration	May be able to run spring pulses more frequently due to System storage rising earlier in the year. Could potentially lower the service level for second half of navigation season if current year's runoff falls as rain in late winter while System storage is being evacuated back to 56.1 MAF.	The decrease in available flood storage during early spring would increase flood risk downstream of Gavins Point Dam in a large rain event. During the summer months, reservoir levels would drop providing more flood storage and decreasing the risk to flood damages.
Increased Sedimentation	Decreased System storage may lead to decreased frequency of all pulses (assuming pulse requirements remain the same and sedimentation is not addressed).	(−) Increase risk of adverse impact to flood risk management with increased aggradation of sediment.

Variable	Consequence from Variable	Impact to Risk for Flood Risk Management
Increased Irregularity of Floods and Droughts	Accuracy of downstream forecasting may decrease, resulting in more frequent flood impacts caused by pulses. Have a greater potential to impact System storage with pulses if more droughts occur.	(−) Increase risk of adverse impact to flood risk management in the long term by increasing the risk of more frequent extreme events.

3.12.2.12 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, including flood risk management. 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. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impact to flood risk management in addition to any changes in land use management.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the MRRMP-EIS alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses (Section 3.2.2.3, Impacts on Hydrology from the Alternatives), the elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in year 15 under all alternatives compared to year 0. The change in stage in the riverine areas in year 15 in the upper river and the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The degradation effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15. However, in Kansas City, the projected river stage in year 15 would only be slightly lower (less than one inch of the mean stage) than year 0.

Past, present, and future construction projects, including those of the Mainstem dams, levees, native fish and wildlife habitat areas, and the Bank Stabilization and Navigation Project (BSNP), have in the past and will continue to have cumulative impacts on flood risk management. The construction and operation of the Missouri River Mainstem Reservoir System and the BSNP significantly altered the Missouri River by creating a system of six dams and channelizing the Missouri River from Sioux City, Iowa to St. Louis, Missouri. These alterations resulted in significant flow changes within the Missouri River and have substantially reduced flood risk over the long term by regulating the flows and river stages on the Missouri River. The flood control purpose of the Missouri River System is given the highest priority during periods of significant runoff. Regulation efforts will continue to minimize flood-related losses.

Under Alternative 1, existing geomorphological processes and trends would continue, consisting primarily of river degradation and bank erosion, reservoir sediment deposition and aggradation, shoreline erosion in reservoirs, and ice dynamics. Continued degradation in the lower Missouri River would be caused by sediment trapped behind dams as well as by continued sand and aggregate mining downstream of Rulo, Nebraska, which lowers the riverbed and the stage of the river over time.

Impacts of Alternative 1 would be a continuation of the substantial beneficial impacts on flood risk management resulting from the past, present, and reasonably foreseeable future actions. The implementation of the spawning cue flows and ESH construction as part of Alternative 1 would provide a negligible contribution to these cumulative impacts to flood risk management. Adverse and beneficial impacts to flood risk management are driven by natural cycles of dry and wet periods (including snowpack and precipitation), and changes in land use management. In general, flood impacts in the Missouri River floodplain vary considerably depending on the year and location and can range from near zero to relatively large impacts. The primary driver affecting flood risk is the hydrologic conditions in the basin including natural cycles of dry and wet periods (including snowpack and precipitation). The largest impacts generally occur in the lower river, below Gavins Point Dam, where there is considerably more property that could be affected by flooding and more uncontrolled drainage area.

The incremental impacts of Alternative 2 would result in a small reduction (-5.6 percent) in average annual flood damages compared to Alternative 1. In specific years and locations, however, management actions under Alternative 2 could result in relatively large adverse impacts. In the lower river, under Alternative 2, there would be long-term beneficial impacts to flood risk management. When these incremental impacts are combined with the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impact would continue to be substantially beneficial.

The incremental impacts of Alternative 3 would result in a small reduction (-0.8 percent) in average annual flood damages compared to Alternative 1. The small decrease in impacts under Alternative 3 is largely attributable to annual impacts being reduced in the lower river, particularly in the Hermann Reach of the river. When these incremental impacts are combined with the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impact would continue to be substantially beneficial. Alternative 3 would have a negligible beneficial contribution to the overall cumulative flood risk management impact.

The incremental impacts of Alternative 4 would result in a small reduction (-2.3 percent) in average annual flood damages compared to Alternative 1. In specific years and locations, management actions under Alternative 4 could result in relatively large adverse impacts, particularly in the lower river during years with full or partial spring ESH creation release. Under Alternative 4, there would be small decreases in average annual flood damages in all of the reaches except the Fort Randall Dam to Gavins Point Dam reach. When these incremental impacts combined with the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impacts in both the upper and lower river would continue to be substantially beneficial. Alternative 4 would contribute adversely to this overall cumulative impact in years with full or partial ESH creation releases.

The incremental impacts of Alternative 5 would result in a small reduction (-1.8 percent) in average annual flood damages relative to those under Alternative 1. In specific years and locations, however, management actions under Alternative 5 could result in relatively large adverse impacts particularly during years with a full fall ESH creation release. Elevations at the upper three reservoirs would be drawn down more in the year following a fall release which could lessen flood conditions when releases occur at the beginning of a natural dry cycle. When these incremental impacts combined with the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impacts would continue to be substantially beneficial. Alternative 5 would contribute adversely to this overall cumulative impact in years with full fall ESH creation releases and contribute beneficially in years following these releases when reservoir elevations are lower.

The incremental impacts of Alternative 6 would result in a small reduction (-0.9 percent) in average annual flood damages relative to those under Alternative 1. Although the relative difference in overall annual flood risk management impacts would be small, these actions could result in relatively large adverse impacts during years with a full spring spawning cue release. When these incremental impacts are combined with the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impacts would continue to be substantially beneficial. Alternative 6 would contribute adversely to this overall cumulative impact in both the upper and lower river in years with full spring spawning cue releases.

3.12.3 Environmental Consequences: Interior Drainage

Crop damage as a result of levee overtopping was accounted for in the flood risk management environmental consequences assessment but damage to crops behind levees can be caused by other mechanisms. Typical Missouri River levee systems have culverts to allow local drainage to exit the interior of the levee and drain to the river. Each culvert typically would include one or more closures, such as a flap gate or sluice gate, to prevent river water from backing up into the leveed area. When river levels are higher than the culvert outlets and this coincides with heavy local rainfall, ponding water can cause flooding on the interior of the levee. Additionally, when river levels are above the interior ground level, seepage through the ground under the levee can also cause flooding on the interior.

To simulate these types of flooding, and measure differences between the MRRMP-EIS alternatives and Alternative 1, a sub-set of the seven sites evaluated for the Master Manual (USACE 1998a) were modeled in detail. Four sites were selected, MRLS 575-I and MRLS 536-L in the Omaha district and MRLS 488-L and MRLS 246-L in the Kansas City District. The Master Manual analysis was performed with the Interior Flood Hydrology model (HEC-IFH), which is no longer supported and is not compatible with current computer operating systems. It was not possible to update the former model or extrapolate model results to current conditions. However, the sites were selected during the Master Manual as representative, some calibration parameters determined were useful, and repeating evaluation at four of those sites allowed for comparison to previous results

In addition to the modeling of the four sites, an analysis was conducted to determine the number of days per year that river stages exceed flap gate outlet elevations for a sample of the surveyed drainage areas. The analysis compared the changes in the average number of days per year that outlet elevations on flap gates at selected locations were reached or exceeded for the MRRMP-EIS alternatives with Alternative 1 as an indicator of potential impact to interior drainage. Further details are provided in Section 3.12.3.2, Proxy Analysis.

3.12.3.1 Impacts Assessment Methodology

Detailed modeling included a HEC-HMS model to simulate runoff, a HEC-RAS model to simulate the water surface profile of the river and water elevation on the levee interior, and a HEC-FIA model to calculate damages. The HEC-HMS model was used to model rainfall for the POR and determine runoff entering the levee interior area. Hydrologic parameters used in the previous HEC-IFH analysis were used where applicable in order to expedite modeling. The HEC-RAS model was based on the current model in use for MRRMP-EIS alternatives analysis. The model used the runoff entering the levee cell, stage-storage for the area, Missouri River water levels, estimated seepage, and the hydraulic parameters of the drainage structures to perform computations of the drainage structures that convey runoff from the interior drainage area into the Missouri River. Model results determined daily ponding levels for the entire POR.

Stage and flow hydrographs for the interior drainage areas were input into HEC-FIA models for evaluation of impacts to agriculture and associated structures.

Primary assumptions and limitations for the assessment are as follows:

- The economic analysis uses data from the H&H modeling of runoff and the river and reservoir system. The analysis assumes that the H&H models reasonably estimates rainfall inflow, river flows, and reservoir levels for the POR under each of the MRRMP-EIS alternatives as well as Alternative 1.
- Because the models are quite complex and time consuming to develop, it was not feasible to model every levee on the Missouri River. Therefore, a sub-set of four sites (from the seven sites evaluated for the Master Manual) were selected to be modeled in detail. These sites provide a reasonable representation of the magnitude of impacts to interior drainage that may occur under the MRRMP-EIS alternatives.
- Extrapolation from the four sites to other levee areas was not feasible since the hydraulics, hydrology, and drainage varies between sites. Translation of damage-duration relationships between sites would require additional evaluation to provide a reasonable methodology and verification of results.

Selected Sites

The four sites modeled for NED analysis were the Missouri River Levee System (MRLS) 246-L, MRLS 488-L, MRLS 536-L, and MRLS 575-L. Each site is a separable drainage area as defined by the upstream and downstream tiebacks and the Mainstem levee.

The MRLS 246-L levee is in Chariton County, Missouri and is comprised of approximately 32,000 acres, the majority of which are agricultural. The MRLS 488-L levee is in Holt County, Missouri and is comprised of approximately 9,500 acres, the majority of which are agricultural. The MRLS 536-L levee is in Atchison County, Missouri and is comprised of approximately 14,400 acres, the majority of which are agricultural. The MRLS 575-L levee is in Fremont County, Iowa and is the largest interior drainage site modeled, comprising over 93,000 acres, the majority of which are agricultural.

National Economic Development

For each of the selected sites, and under each alternative scenario, every individual year in the POR was run in HEC-FIA to compute agricultural losses as well as damages to related structures and inventory from the inability to drain interior runoff into the Missouri River. The losses and damages for each year were aggregated and averaged over the POR to estimate average annual impacts for each site across all the alternatives. A detailed description of the NED analysis including data sources and assumptions can be found in the “Interior Drainage Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Regional Economic Development

For all action alternatives, the differences in damages on average compared to Alternative 1 would result in negligible NED impacts. The largest adverse difference in agricultural damages would occur under Alternative 2 with an increase in damages of $175,000 (Missouri River Levee System (MRLS)-488L), which would result in a loss of approximately 1 average annual job.

Because all agricultural losses in any year would result in less than 1 job, a full RED analysis was not undertaken on the interior drainage impacts.

Other Social Effects

Since the interior drainage sites are primarily agricultural, the PAR totals are minimal for each of the sites. Under the largest modeled flood event (1993), the maximum PAR would be 27 persons located at MRLS 246-L, 19 at MRLS 575-L, 7 at MRLS 536-L, and 0 at MRLS 488-L that could be affected by interior drainage impacts. Because the OSE impacts would be minimal in any year and there would be no changes to PAR, environmental justice, or critical infrastructure it was determined that impacts to public health, safety, and economic vitality would be negligible.

3.12.3.2 Proxy Analysis

In addition to the modeling of the four selected interior drainage sites, the interior drainage analysis considered the effects of MRRMP-EIS alternatives on additional leveed floodplain areas. The analysis considered a larger number of drainage sites and compared the flap gate outlet elevations at each of the drainage sites with the river stages from the HEC-RAS modeled POR to determine how often stages exceed the outlet elevations for each alternative. While the underlying hydrologic processes can be complex and dependent on multiple factors, this analysis provides an indicator of the potential risk for impacts at these interior drainage site locations.

Property and infrastructure can be adversely affected by high flows even within the river banks due to blocked interior drainage and potential for elevated groundwater levels. Blockage of interior drainage can occur whenever outfalls from levee drainage structures, often consisting of a flap gate on gravity drainage pipe, become inundated. Interior drainage water can often continue to drain as long as the interior water surface remains above the river elevation. However, ponding in drainage channels is likely to begin to occur above these levels and present some risk of reduced outflow capacity. When river elevation exceeds the top of drainage pipes, minor amounts of localized runoff from rainfall can cause more widespread interior ponding.

Additionally, many drainage districts report problems with wet soils or generally high ground water table at similar river levels, especially when the high but within bank river stages are exceeded for several days. In serious cases, crops may be destroyed or damaged by inundation. In other cases, ponding areas may not directly harm any property, but the high water table can complicate planting schedules for farmers, sometimes delaying planting long enough that lost revenues cannot be recouped.

Interior drainage is a complex hydrologic process that includes the ever-changing dynamics of river water surface elevation, ground water interactions between the river, floodplain and adjacent highlands, localized rainfall and runoff, wetting and drying of soils, evaporation and infiltration, and design and operation of interior drainage channels and structures. While not a direct measure of impacts due to the complexities involved, interior drainage-related effects are determined partially by whether the river reaches the flap gate elevation on the levee and by the length of time the river is elevated. Based on the experience of MRRIC members, these impacts typically begin to occur at between two and seven feet below flood stage depending on the location along the river. Additionally, spot checks of operation and maintenance manuals by USACE show inundation of levee outfall structure flap gates within this range of river levels.

This analysis evaluated potential for impacts to interior drainage using a proxy of the number of days per year that river stages meet or exceed outlet elevations of selected gates on selected levees during the growing season. USACE has survey data on approximately 1,400 flap gate structures. Approximately 100 flap gates located along the entire length of the leveed portion of the river, had usable estimated outlet elevations as well as river mile stationing to include in the analysis. The proxy model analyzed Missouri River daily stage and flow data over the available POR to determine the number of days that these selected flap gate elevations were reached or exceeded. The analysis was limited to dates within the growing season (April 1 to November 30), defined broadly to accommodate farmers across several hundred miles of the river.

Calculations

HEC-RAS modeling was used to produce daily flow data defining high flow conditions under each alternative along with associated stages at each location of interest along the Missouri River. The HEC-RAS results were then loaded into an Excel-based model along with elevation and river stationing data for the flap gate thresholds described above.

For each alternative, the model calculated the number of days per growing season that the damage thresholds (individual flap gate outlet elevations) were reached/exceeded. The changes in the average number of days per growing season that outlet elevations were reached or exceeded were compared with Alternative 1.

Results

Table 3-103 shows the combined results of the proxy alternatives analysis in terms of days of flap gate exceedance relative to Alternative 1. In terms of total days of threshold exceedance over the POR, the number of flap gate exceedances changed minimally under each of the alternatives compared to Alternative 1. The average annual differences compared to Alternative 1 ranged from a decrease of 37 days under Alternative 2 to an increase of 82 days under Alternative 4.

Table 3-103. Relative Difference (days of flap gate exceedance) of Alternatives to Alternative 1 over the Period of Record

	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
POR Total	-3,055	372	6,732	2,671	5,283
Average Annual	-37.26	4.54	82.10	32.57	64.43
% Change	-1.04%	0.13%	2.30%	0.91%	1.81%

Figures 3-1 to 3-3 show the analysis of flap gate exceedance at the individual sites for each of the alternatives. Locations upstream of Fort Leavenworth (approximately river mile 400) saw as much as 300+ days of additional exceedance over the modeled POR as a result of Alternatives 4, 5, and 6. This averages to 4 or 7 additional days per year at certain individual gate locations. Alternative 2 exhibited mostly negligible to small decreases in flap gate exceedances upstream of Fort Leavenworth over the modeled POR. Under Alternative 3 there would have negligible to small increases above Alternative 1 in flap gate exceedances on average annually over the POR upstream of Fort Leavenworth.

	Location	RM	Alt 1 (total)	Alt 2 (total)	Alt 3 (total)	Alt 4 (total)	Alt 5 (total)	Alt 6 (total)	Alt 1 (change)	Alt 2 (change)	Alt 3 (change)	Alt 4 (change)	Alt 5 (change)	Alt 6 (change)
1	L-627 MO Riv LB & Indian Creek RB	609.09	2,517	2,469	2,648	2,966	2,730	2,905		-48	131	449	213	388
2	R-616 - Missouri River RB Segment	598.44	3,446	3,608	3,459	3,764	3,536	3,746		162	14	318	91	300
3	R-613 - Platte LB & Papillion RB & M	595.23	9,831	9,775	9,777	9,694	9,821	9,826		-56	-54	-138	-10	-5
4	L-594 - Missouri River LB - Pleasant	576.08	2,646	2,523	2,683	2,977	2,813	2,879		-124	37	331	166	233
5	L-575 - MO River LB & Plum Creek LI	558.75	4,608	4,824	4,676	4,941	4,761	5,005		217	69	333	153	397
6	Hamburg - Main Ditch 6 LB	552.64	17,239	17,066	17,260	17,100	17,232	17,118		-173	21	-139	-7	-121
7	L-550 - Missouri River LB & Rock Cre	525.55	2,710	2,650	2,803	3,080	2,960	2,964		-60	93	371	250	254
8	R-520 - Missouri River RB	500.94	2,951	2,984	2,958	3,255	3,134	3,148		33	7	304	183	197
9	MRLS 512-513-R N	495.79	5,937	5,949	6,121	6,319	6,206	6,389		12	184	382	269	452
10	Holt County #10	492.50	3,415	3,338	3,649	3,957	3,750	3,883		-78	233	542	334	468
11	Canon	490.33	1,329	1,324	1,370	1,372	1,344	1,366		-5	41	44	15	37
12	Holt County #9	486.32	4,035	4,123	4,253	4,563	4,377	4,516		88	218	528	342	481
13	Kimsey Holly	482.60	3,213	3,079	3,354	3,655	3,474	3,528		-134	142	442	261	315
14	MRLS 497-L(2)	476.98	2,079	2,045	2,125	2,251	2,165	2,177		-34	46	172	86	98
15	MRLS 488-L	465.60	2,577	2,501	2,647	2,848	2,806	2,743		-76	70	270	229	166
16	MRLS 482-R	458.17	3,052	3,071	3,070	3,260	3,217	3,166		19	18	208	165	114
17	MRLS 476-L	453.96	3,781	3,706	3,801	4,094	3,914	3,971		-75	20	314	133	190
18	MRLS 455-L	445.88	615	520	645	635	624	650		-95	30	20	9	35
19	MRLS 448-443-L	444.36	3,136	3,062	3,220	3,445	3,378	3,342		-74	84	309	242	206
20	MRLS 471-460-R	441.91	2,165	2,113	2,296	2,404	2,354	2,340		-51	132	239	190	175
21	MRLS 440-R	424.66	1,687	1,738	1,708	1,714	1,679	1,698		51	21	27	-7	12
22	Rushville-Sugar Lake	418.44	1,822	1,843	1,856	1,898	1,834	1,867		22	34	77	12	45
23	Platte County sec 1	417.09	552	594	573	551	551	578		42	21	-1	-1	26
24	Henry Pohl	411.39	1,232	1,256	1,317	1,304	1,276	1,304		24	85	73	45	72
25	Grape-Bollin-Schwartz	406.25	2,818	2,888	2,847	3,022	2,986	2,959		69	29	204	167	140
26	Ft. Leavenworth	398.86	138	136	136	132	144	131		-2	-2	-6	6	-7
27	MRLS 408-L	391.08	1,296	1,346	1,311	1,313	1,288	1,308		50	15	17	-8	12
28	Kansas Department of Corrections	388.52	532	575	535	520	520	540		43	3	-12	-12	8
29	Wolcott sec 1	385.66	160	160	160	159	165	160				-1	5	
30	MRLS 400-L	385.66	1,039	1,116	1,040	1,045	1,021	1,050		77	1	6	-18	11
31	Wolcott sec 2	382.89	1,342	1,426	1,342	1,355	1,318	1,345		84		13	-24	3
32	Fairfax-Jersey Creek	373.45	2,688	2,705	2,674	2,747	2,666	2,686		17	-14	59	-22	-2
33	MRLS 385-L Quindaro Bend	372.86	315	324	314	291	303	313		9	-1	-24	-12	-2
34	MRLS 385-L Riverside	371.47	81	74	80	84	78	81		-7	-1	3	-3	
35	North Kansas City Airport	369.39	11	11	11	11	11	11						

Figure 3-54. Individual Flap Gate Exceedances (days/year), Total in POR (1 of 3)

Downstream of Kansas City (approximately river mile 366), several gate locations showed increases of 100 to 200 total days (about 1 to 2 days per year per location), under Alternatives 4, 5, and 6. Under Alternative 2, several sites just downstream of Kansas City showed a significant reduction in days exceeded (up to 300+) relative to Alternative 1. Alternative 3 exhibited more marginal effects in the area downstream of Kansas City to Glasgow (approximately river mile 220), and many gates did not show sizable increases in total days of exceedance over the period in any of the alternatives.

	Location	RM	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
36	Lower Fairfax	367.58	20	21	20	20	20	20		1				
37	CID, Missouri	366.19	23	24	23	23	23	23		1				
38	North Kansas City Lower	364.78	462	488	458	454	450	456		26	-4	-8	-12	-6
39	East Bottoms	358.26	1,682	1,679	1,663	1,674	1,644	1,670		-3	-19	-8	-38	-12
40	Birmingham	353.44	630	651	595	601	589	604		21	-35	-29	-41	-26
41	Lake City AAP	349.19	15	11	12	12	12	12		-4	-3	-3	-3	-3
42	MRLS 351-R sec 2	348.24	4,779	4,516	4,708	4,801	4,733	4,751		-264	-71	22	-47	-29
43	MRLS 351-R sec 1	340.32	8,822	8,662	8,865	8,977	9,013	9,043		-160	43	155	191	221
44	Tri-County of Ray, Clay, Jackson, MO	337.96	7,995	7,722	7,933	8,068	8,084	8,105		-273	-62	73	89	110
45	Egypt	334.24	961	934	926	940	910	939		-27	-35	-21	-51	-22
46	MO Valley D&L Dist of Ray Co. MO se	326.66	976	983	938	945	917	948		8	-38	-31	-59	-28
47	MO Valley D&L Dist of Ray Co. MO se	325.95	8,026	7,840	7,950	8,104	8,108	8,137		-186	-76	78	82	111
48	MO Valley D&L Dist of Ray Co. MO se	325.95	2,435	2,373	2,369	2,402	2,345	2,363		-62	-66	-33	-90	-72
49	Ray-Lafayette	317.21	2,792	2,651	2,786	2,844	2,744	2,785		-142	-6	52	-48	-8
50	Henrietta-Crooked sec 1	314.23	2,038	1,858	2,023	2,033	2,003	2,017		-179	-15	-5	-35	-21
51	Baltimore Group	311.91	1,806	1,768	1,768	1,777	1,754	1,765		-38	-38	-29	-52	-41
52	Sugartree Bottom	299.62	444	438	434	432	434	433		-6	-10	-12	-10	-11
53	Saline-Lafayette	279.14	1,359	1,370	1,398	1,415	1,389	1,416		11	39	56	30	57
54	Coles Lake Levee	278.60	283	267	288	274	280	286		-16	5	-9	-3	3
55	Malta Bend	273.88	11,290	11,210	11,322	11,301	11,405	11,356		-80	32	11	115	66
56	Wakenda	267.50	1,972	1,956	1,946	1,957	1,926	1,944		-16	-26	-15	-47	-28
57	Teteseau Bend	266.15	8,381	8,322	8,355	8,510	8,528	8,546		-60	-26	129	147	165
58	DeWitt sec 1	257.14	2,234	2,231	2,221	2,245	2,206	2,219		-3	-13	11	-28	-15
59	Mi-De	257.14	5,746	5,716	5,768	5,920	5,831	5,894		-30	22	174	85	147
60	Big Bend	255.79	1,486	1,530	1,512	1,528	1,500	1,531		44	26	42	14	45
61	Dewitt sec 2	254.96	5,222	5,175	5,228	5,324	5,220	5,299		-47	6	101	-2	76
62	Miami	252.02	1,750	1,700	1,757	1,771	1,742	1,766		-50	7	21	-8	16
63	Brunswick	250.27	6,522	6,381	6,537	6,685	6,619	6,659		-141	16	163	97	137
64	MRLS 246-L 2	248.41	4,412	4,057	4,440	4,489	4,436	4,478		-355	27	76	23	66
65	Saline County	247.83	2,885	2,698	2,895	2,922	2,873	2,878		-187	10	37	-12	-7
66	MRLS 246-L 1	241.63	1,668	1,663	1,683	1,705	1,672	1,695		-5	15	36	4	27
67	Cambridge	231.72	1,575	1,572	1,516	1,541	1,499	1,533		-3	-59	-34	-76	-41
68	West Glasgow 2	231.08	1,998	2,040	2,011	2,022	1,998	2,029		42	14	25	1	31
69	Lower Chariton River	227.77	8,474	8,474	8,462	8,580	8,598	8,621			-11	106	125	147
70	West Glasgow 1	220.79	2,321	2,348	2,318	2,348	2,307	2,325		26	-4	27	-15	3

Figure 3-55. Individual Flap Gate Exceedances (days/year), Total in POR (2 of 3)

The total effect at most downstream locations (below river mile 220) is relatively small over the POR. In the stretch from Mokane (river mile 120.56) to Steedman (river mile 116.95), there were reductions in total flap gate exceedances over 100 to 300 days under every MRRMP-EIS alternative compared to Alternative 1.

	Location	RM	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
71	Howard County L.D. #6	220.03	138	136	140	141	138	145		-2	2	3		7
72	Howard County L.D. #7 sec 4	205.31	882	920	892	905	899	897		38	10	24	17	15
73	Linneman-Weekly	204.51	520	522	531	521	523	524		2	11	1	3	4
74	Howard County L.D. #2	197.96	5,640	5,647	5,743	5,820	5,738	5,810		7	103	180	98	170
75	Howard County #4	194.33	8,417	8,409	8,470	8,591	8,589	8,607		-7	54	174	172	191
76	Bonne Femme	189.78	203	208	196	198	194	197		5	-7	-5	-9	-6
77	Cooper County #1	177.91	2,965	3,004	3,043	3,080	3,037	3,048		38	78	115	71	82
78	McBaine	175.86	1,664	1,706	1,662	1,688	1,650	1,681		42	-2	25	-14	17
79	Plowboy Bend	166.55	4,379	4,341	4,406	4,429	4,393	4,409		-38	27	50	13	30
80	Hartsburg sec 1	154.40	109	112	108	102	102	110		3	-1	-7	-7	1
81	Hartsburg sec 2	153.45	1,136	1,188	1,129	1,154	1,125	1,150		52	-7	18	-11	14
82	Prison Farm	151.74	4,511	4,474	4,499	4,518	4,484	4,509		-38	-13	7	-27	-3
83	Hartsburg sec 3	150.69	1,946	2,005	1,937	1,965	1,922	1,962		59	-9	19	-24	16
84	Cole Junction	146.12	3,254	3,275	3,240	3,282	3,237	3,235		21	-14	28	-17	-19
85	Renz	144.60	1,294	1,345	1,281	1,296	1,264	1,299		51	-14	1	-31	5
86	Capital View	139.84	1,537	1,564	1,506	1,529	1,493	1,528		27	-31	-9	-44	-10
87	Rievaux	136.61	4,357	4,269	4,293	4,312	4,267	4,294		-88	-65	-45	-90	-63
88	Wainwright	134.25	3,354	3,303	3,291	3,319	3,279	3,283		-52	-63	-35	-75	-71
89	Jacobs	130.37	3,039	3,026	3,014	3,046	3,018	3,032		-13	-25	7	-21	-7
90	Tebbetts East	125.12	1,581	1,504	1,502	1,521	1,496	1,528		-77	-78	-60	-85	-53
91	Mokane	120.56	2,781	2,508	2,588	2,613	2,578	2,599		-273	-193	-168	-204	-182
92	Chamois sec 1	120.56	1,268	1,101	1,130	1,136	1,120	1,130		-166	-138	-132	-148	-138
93	Chamois sec 2	118.59	1,732	1,531	1,570	1,584	1,563	1,584		-201	-163	-148	-169	-149
94	Steedman	116.95	3,163	2,945	3,012	3,047	3,006	3,028		-218	-151	-116	-157	-136
95	Morrison Lower	109.29	2,355	2,381	2,281	2,312	2,277	2,292		26	-74	-43	-78	-63
96	A-1	108.48	2,920	2,943	2,835	2,871	2,840	2,849		23	-85	-49	-80	-71
97	Tri-County L.D. sec 1	98.54	1,634	1,671	1,626	1,654	1,625	1,651		37	-8	20	-10	16
98	Tri-County L.D. sec 2	91.81	4,094	4,039	4,048	4,072	4,042	4,061		-55	-46	-22	-52	-32
99	Berger	86.11	998	949	942	952	937	942		-49	-56	-46	-61	-56
100	MO Valley L.D. #1	72.64	3,524	3,512	3,512	3,537	3,500	3,537		-12	-12	13	-24	13
101	Tuque Creek	71.96	2,584	2,578	2,563	2,596	2,560	2,578		-6	-21	12	-24	-6
102	MO Valley L.D. #2 (Charrette Bottoms	71.96	930	914	916	920	909	914		-17	-14	-11	-21	-16
103	Labadie Bottoms #4	57.85	3,003	3,060	3,011	3,044	3,015	3,027		58	8	41	12	24
	Total		292,387	289,331	292,759	299,119	295,058	297,670		-3,055	372	6,732	2,671	5,283

Figure 3-56. Individual Flap Gate Exceedances (days/year), Total in POR (3 of 3)

Overall, Alternatives 4, 5, and 6 exhibited small adverse impacts in terms of number of additional days of flap gate exceedances relative to Alternative 1 over the POR. Alternative 3 showed a negligible increase of 0.1 percent in combined total days exceeded over Alternative 1, while Alternative 2 showed an overall reduction in total days exceeded over the POR compared to Alternative 1.

3.12.3.3 Summary of Interior Drainage Environmental Consequences

The environmental consequences relative to flood risk management are summarized in Table 3-104.

Table 3-104. Environmental Consequences Relative to Interior Drainage

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Management Actions Common to All Alternatives	No NED impacts	No RED impacts	No OSE impacts	Management actions common to all alternatives would have no impacts on interior drainage.
Alternative 1	Alternative 1 management actions would have no to negligible NED impact. Average annual damages at the individual interior drainage sites range from $120K to $399K	Negligible to small adverse RED effects from agricultural damages.	No OSE impacts	There would be no to negligible impacts from habitat construction actions on interior drainage.
Alternative 2	Negligible to small changes in NED impacts. Average annual damages at the individual interior drainage sites range from $114K to $387K	Negligible change in RED effects.	No OSE impacts	There would be no to negligible impacts from habitat construction actions on interior drainage.
Alternative 3	Negligible to small changes in NED impacts. Average annual damages at the individual interior drainage sites range from $123K to $399K	Negligible change in RED effects.	No OSE impacts	There would be no to negligible impacts from habitat construction actions on interior drainage.
Alternative 4	Negligible to small changes in NED impacts. Average annual damages at the individual interior drainage sites range from $123K to $399K	Negligible change in RED effects.	No OSE impacts	There would be no to negligible impacts from habitat construction actions on interior drainage.
Alternative 5	Negligible to small changes in NED impacts. Average annual damages at the individual interior drainage sites range from $124K to $398K	Negligible change in RED effects.	No OSE impacts	There would be no to negligible impacts from habitat construction actions on interior drainage.
Alternative 6	Negligible to small changes in NED impacts. Average annual damages at the individual interior drainage sites range from $124K to $397K	Negligible change in RED effects.	No OSE impacts	There would be no to negligible impacts from habitat construction actions on interior drainage.

3.12.3.4 Impacts from Management Actions Common to All Alternatives

A number of management actions were common to all alternatives. These include pallid sturgeon propagation and augmentation, predator management, vegetative management, and human restrictions measures. None of these actions would impact interior drainage.

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

Alternative 1 represents current System operations including a number of management actions associated with MRRP implementation. Management actions under Alternative 1 include construction of both SWH and ESH habitat and a spring plenary pulse or a bi-modal spring plenary pulse.

The NED value for Alternative 1 for interior drainage is calculated in terms of costs from a hypothetical condition where no costs or damages are incurred. Although the absolute value under Alternative 1 provides important context, the estimated differences between each of the MRRMP-EIS alternatives and Alternative 1 are key to understanding the impacts associated with the species management actions included in the alternatives. Please refer to Section 3.1.1 for further description.

Mechanical Habitat Construction

No impact to interior drainage is anticipated from ESH construction under any of the alternatives as this activity does not occur in the same river reaches as the federal levee system. No impact to interior drainage is anticipated in association with pallid sturgeon early life stage habitat construction under any of the alternatives. The same site-specific impact avoidance and minimization measures described previously in this chapter would apply to all alternatives.

National Economic Development

The impacts analysis for interior drainage under Alternative 1 is summarized in Table 3-105. Under Alternative 1, the modeled average annual interior drainage damages ranged from $119,495 (MRLS 536-L) to $402,548 (MRLS 246-L) for the four selected sites. Agricultural losses are the primary driver of the NED impacts.

Table 3-105. Summary of Interior Drainage NED Impacts under Alternative 1

Interior Drainage Site	Average Annual Spring Agricultural Losses	Average Annual Summer-Fall Agricultural Losses	Average Annual Property Damages	Total Average Annual NED Damages	$ Damage per Acre
MRLS 575-L	$16,995	$211,987	$55	$229,037	$2.46
MRLS 536-L	$4,803	$77,930	$33,726	$116,459	$8.32
MRLS 488-L	$10,305	$224,055	$6	$234,366	$24.56
MRLS 246-L	$7,017	$347,256	$44,289	$398,562	$12.49

Note: All totals are average annual values at the FY 2018 price level.

Conclusion

While some large NED impacts were modeled as occurring under Alternative 1, the magnitude of these impacts varied considerably from year to year as a result of the natural hydrologic cycles of precipitation and snow pack and not from the management actions that are part of Alternative 1. Alternative 1 is not anticipated to have significant impacts to interior drainage.

3.12.3.6 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Under Alternative 2, all of the modeled interior drainage sites experienced relatively small beneficial NED impacts relative to Alternative 1. On average, the reduction in damages were small in nature but some years exhibited relatively larger impacts. The impacts are discussed in more detail below.

National Economic Development

The results of the interior drainage NED analysis for Alternative 2 are summarized in Table 3-106. Across each of the interior drainage sites, the Alternative 2 modeling showed a small beneficial NED impact relative to Alternative 1. The decrease in average annual damages ranged from 1.4 percent at MRLS 575-L to 4.7 percent at MRLS 488-L. The modeled site with the largest dollar impact was MRLS 246-L, which exhibited a decrease of $11,436 in average annual interior drainage damages under Alternative 2.

Table 3-106. Summary of Interior Drainage NED Analysis for Alternative 2

Interior Drainage Site	Average Annual Spring Agricultural Losses	Average Annual Summer-Fall Agricultural Losses	Average Annual Property Damages	Total Average Annual NED Damages	Change in Total Average Annual NED Damages from Alternative 1	% Change from Alternative 1	$ Damage per Acre
MRLS 575-L	$17,175	$208,595	$54	$225,824	-$3,213	-1.4%	$2.42
MRLS 536-L	$4,685	$77,125	$31,696	$113,506	-$2,953	-2.5%	$8.11
MRLS 488-L	$9,651	$213,732	$0	$223,383	-$10,983	-4.7%	$23.41
MRLS 246-L	$7,731	$339,465	$39,931	$387,127	-$11,436	-2.9%	$12.13

Note: All totals are average annual values at the FY 2018 price level. Negative values indicate a decrease in damages relative to Alternative 1.

In addition to the overall NED impacts, the interior drainage sites were analyzed to examine the difference in impacts during years when there is a release action and/or a low summer flow modeled. These results are summarized in Table 3-107. During the POR, there were three years with a modeled full flow release plus low summer flow action. For three of the sites (MRLS 575-L, MRLS 536-L, and MRLS 246-L), the impacts from the modeled full flow releases were small and adverse relative to Alternative 1, whereas at MRLS 488-L the impacts were negligible. The largest adverse dollar impact from a modeled full flow release action occurred at MRLS 575-L, which experienced an $8,936 increase in damages under the 2002 simulated event.

In addition to full flow release actions, there were 25 modeled years with partial flow releases. All four modeled interior drainage sites exhibited a small decrease in NED damages on average relative to Alternative 1 under partial flow simulated events.

Over the total POR, the greatest one-year decreases in damages were −$109K (MRLS 575-L), −$245K (MRLS 536-L), −$152K (MRLS 488-L), and −$339K (MRLS 246-L). Across the same POR, the greatest one-year increases in damages were $86K (MRLS 575-L), $42K (MRLS 536-L), $156K (MRLS 488-L), and $127K (MRLS 246-L).

Table 3-107. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 2

Change in Damages from Alternative 1 by Interior Drainage Site	Full Flow Release + Low Summer Flow [a]		Partial Flow Release [b]		Years with Greatest Range in Damages Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
MRLS 575-L	-$3,951	$8,936	-$17,116	$12,244	-$108,575	$85,697
MRLS 536-L	-$962	$1,434	-$12,349	$9,300	-$245,056	$42,351
MRLS 488-L	-$888	$182	-$51,385	$4,233	-$151,538	$156,357
MRLS 246-L	-$225	$2,306	-$33,880	$13,864	-$339,138	$127,414

a Flow action was fully implemented in 3 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 25 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

Conclusion

Under Alternative 2, all four interior drainage sites that were modeled experienced relatively small beneficial impacts relative to Alternative 1 with reductions in average annual damages ranging from 1.4 to 4.7 percent. Although on average, these impacts are small in nature, some years would experience relatively larger damages. Significant impacts are not anticipated to interior drainage under Alternative 2.

3.12.3.7 Alternative 3 – Mechanical Construction Only

National Economic Development

The results of interior drainage NED analysis for Alternative 3 are summarized in Table 3-108. Across each of the four modeled interior drainage sites, Alternative 3 would have a negligible to small adverse impact on interior drainage relative to Alternative 1. Interior drainage site MRLS 536-L showed the largest adverse impact under Alternative 3, with an estimated increase of $6,922, or 5.9 percent, in average annual damages over Alternative 1.

Table 3-108. Summary of Interior Drainage NED Analysis for Alternative 3

Interior Drainage Site	Average Annual Spring Agricultural Losses	Average Annual Summer-Fall Agricultural Losses	Average Annual Property Damages	Total Average Annual NED Damages	Change in Total Average Annual NED Damages from Alternative 1	% Change from Alternative 1	$ Damage per Acre
MRLS 575-L	$16,930	$212,701	$55	$229,687	$650	0.3%	$2.46
MRLS 536-L	$5,192	$80,774	$37,415	$123,382	$6,922	5.9%	$8.82
MRLS 488-L	$10,632	$226,519	$5	$237,156	$2,791	1.2%	$24.86
MRLS 246-L	$7,021	$346,834	$44,686	$398,542	-$20	0.0%	$12.48

Note: All totals are average annual values at the FY 2018 price level. Negative values indicate a decrease in damages relative to Alternative 1.

Over the total POR, the greatest one-year decreases in damages were −$36K (MRLS 575-L), −$25K (MRLS 536-L), −$19K (MRLS 488-L), and −$6K (MRLS 246-L). Across the same POR, the greatest one-year increases in damages were $34K (MRLS 575-L), $75K (MRLS 536-L), $407K (MRLS 488-L), and $21K (MRLS 246-L). Refer to Table 3-109.

Table 3-109. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 3

Change in Damages from Alternative 1 by Interior Drainage Site	Years with Greatest Range in Damages	
	Highest Damage Decrease	Highest Damage Increase
MRLS 575-L	-$35,519	$33,582
MRLS 536-L	-$24,641	$74,913
MRLS 488-L	-$19,450	$407,051
MRLS 246-L	-$6,220	$20,757

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release that may be implemented under Alternative 3 was not included in the hydrologic modeling for the alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Flows equivalent to the one-time spawning cue test were modeled for multiple years in the period of record under Alternative 6. 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. These impacts are described below in Section 3.12.4.10.

NED impacts to interior drainage under Alternative 6 were described on average as relatively small and adverse. During the POR, there were five years modeled with a full flow release action. During these years, all four sites would experience increases in average annual damages under Alternative 6. MRLS 488-L had its highest modeled one-year increase in damages over Alternative 1, $175,966, in a simulated full release action event year. Because Alternative 6 modeling results show adverse impacts under full releases, the one-time implementation of the pulse would likely cause temporary adverse impacts in the year the pulse is implemented to interior drainage.

Conclusion

Under Alternative 3, each of the four interior drainage sites would experience a negligible to small adverse impacts relative to Alternative 1. Although on average these impacts are relatively small in nature, some years would experience larger damages. The one-time implementation of the pulse would likely cause temporary adverse impacts in the year the pulse is implemented to interior drainage. Significant adverse impacts to interior drainage are not anticipated due to Alternative 3.

3.12.3.8 Alternative 4 – Spring ESH Creating Release

National Economic Development

The results of the interior drainage NED analysis for Alternative 4 are summarized in Table 3-110. The modeled site with the largest adverse impact was MRLS 536-L which showed an average annual increase in damages of $6,330, or 5.4 percent. MRLS 488-L exhibited a decrease in modeled damages of $2,819, or 1.2 percent, relative to Alternative 1. The other two modeled sites, MRLS 575-L and MRLS 246-L, showed negligible changes under Alternative 4 modeling with percent changes of -0.3 percent and less than 0.1 percent relative to Alternative 1, respectively.

Table 3-110. Summary of Interior Drainage NED Analysis for Alternative 4

Interior Drainage Site	Average Annual Spring Agricultural Losses	Average Annual Summer-Fall Agricultural Losses	Average Annual Property Damages	Total Average Annual NED Damages	Change in Total Average Annual NED Damages from Alternative 1	% Change from Alternative 1	$ Damage per Acre
MRLS 575-L	$16,988	$211,310	$55	$228,353	-$684	-0.3%	$2.45
MRLS 536-L	$5,301	$80,073	$37,415	$122,789	$6,330	5.4%	$8.78
MRLS 488-L	$10,398	$221,140	$8	$231,546	-$2,819	-1.2%	$24.27
MRLS 246-L	$7,586	$346,301	$44,679	$398,566	$4	0.0%	$12.49

Note: All totals are average annual values at the FY 2018 price level. Negative values indicate a decrease in damages relative to Alternative 1.

Table 3-111 shows the difference in annual NED impacts during years when there was a full or partial flow release action modeled. Under Alternative 4, there were eight simulated years with a full flow release action. MRLS 575-L, MRLS 536-L, and MRLS 246-L would all exhibit a small increase in damages on average over Alternative 1 with the largest adverse impacts occurring at MRLS 246-L under full release action simulations. Meanwhile, MRLS 488-L, showed a decrease in overall NED impacts on average compared to Alternative 1 under the simulated full release action years. Each interior drainage site saw beneficial impacts in the years following a full release.

In addition to full flow release actions, there were five modeled years with partial flow releases. MRLS 575-L and MRLS 488-L showed beneficial impacts on average under Alternative 4 partial flow simulations, while MRLS 536-L and MRLS 246-L experienced adverse impacts under the same conditions.

Over the total POR, the greatest one-year decreases in damages were −$111K (MRLS 575-L), −$37K (MRLS 536-L), −$162K (MRLS 488-L), and −$107K (MRLS 246-L). Across the same

POR, the greatest one-year increases in damages were $37K (MRLS 575-L), $407K (MRLS 536-L), $22K (MRLS 488-L), and $58K (MRLS 246-L).

Table 3-111. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 4

Change in Damages from Alternative 1 by Interior Drainage Site	Full Flow Release [a]		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
MRLS 575-L	-$37,458	$30,051	-$5,675	$1,132	-$111,369	$36,897
MRLS 536-L	-$9,719	$4,213	-$375	$12,122	-$36,712	$407,085
MRLS 488-L	-$10,794	$9,209	-$12,976	$4,436	-$161,715	$21,592
MRLS 246-L	-$1,473	$56,800	-$1,261	$29,224	-$106,828	$57,686

a Flow action was fully implemented in 8 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 5 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

Conclusion

Alternative 4 has the potential to cause impacts to interior drainage. Two modeled interior drainage sites, MRLS 536-L and MRLS 246-L, showed negligible to small increases in average annual damages relative to Alternative 1, while MRLS 575-L and MRLS 488-L showed negligible to small decreases under Alternative 4. Significant impacts are not anticipated due to Alternative 4.

3.12.3.9 Alternative 5 – Fall ESH Creating Release

Alternative 5 would focus on developing ESH habitat through both mechanical and reservoir releases that would occur during the fall months. Both actions have the potential to affect interior drainage flooding. Alternative 5 is expected to have a small adverse impact on interior drainage relative to Alternative 1.

National Economic Development

The results of the interior drainage analysis for Alternative 5 are summarized in Table 3-112. Alternative 5 had a small adverse impact relative to Alternative 1 at three of the modeled interior drainage sites: MRLS 575-L, MRLS 536-L, and MRLS 488-L. At MRLS 246-L, the modeled results showed a negligible decrease in average annual damages compared to Alternative 1. The site with the largest impact was MRLS 536-L, which experienced an increase of 6.1 percent in average annual damages over Alternative 1.

Table 3-112. Summary of Interior Drainage NED Analysis for Alternative 5

Interior Drainage Site	Average Annual Spring Agricultural Losses	Average Annual Summer-Fall Agricultural Losses	Average Annual Property Damages	Total Average Annual NED Damages	Change in Total Average Annual NED Damages from Alternative 1	% Change from Alternative 1	$ Damage per Acre
MRLS 575-L	$16,821	$214,979	$55	$231,855	$2,819	1.2%	$2.49
MRLS 536-L	$5,149	$81,014	$37,413	$123,576	$7,116	6.1%	$8.83
MRLS 488-L	$10,246	$224,745	$5	$234,997	$631	0.3%	$24.63
MRLS 246-L	$6,957	$345,956	$44,677	$397,591	-$972	-0.2%	$12.46

Note: All totals are average annual values at the FY 2018 price level. Negative values indicate a decrease in damages relative to Alternative 1.

Table 3-113 shows the difference in annual NED impacts during years when there was a modeled full or partial flow release action. Under Alternative 5, there were six simulated years with a full flow release action. Three of the four sites experienced an increase average annual damages under the full flow release actions of Alternative 5 with only the furthest downstream site, MRLS 246-L, showing beneficial impacts compared to Alternative 1. At MRLS 575-L, the year with the highest modeled increase in damages relative to Alternative 1 was a simulated full release event year.

In addition to full flow release actions, there was two modeled years with a partial flow release. The two furthest upstream sites, MRLS 575-L and MRLS 536-L, showed a small increase in damages over Alternative 1 under the partial flow simulated events while the two furthest downstream sites, MRLS 488-L and MRLS 246-L, exhibited small beneficial impacts under that same Alternative 5 modeled condition.

Over the total POR, the greatest one-year decreases in damages were −$63K (MRLS 575-L), −$36K (MRLS 536-L), −$162K (MRLS 488-L), and −$73K (MRLS 246-L). Across the same POR, the greatest one-year increases in damages were $119K (MRLS 575-L), $407K (MRLS 536-L), $79K (MRLS 488-L), and $33K (MRLS 246-L).

Table 3-113. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 5

Change in Damages from Alternative 1 by Interior Drainage Site	Full Flow Release [a]		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
MRLS 575-L	$0	$118,618	-$3,173	$5,069	-$63,456	$118,618
MRLS 536-L	$0	$6,294	$0	$4,625	-$36,203	$406,934
MRLS 488-L	-$5,011	$14,852	-$24,644	$0	-$161,739	$78,576
MRLS 246-L	-$6,680	$1,883	-$7,260	$0	-$73,028	$32,781

a Flow action was fully implemented in 6 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 2 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

Conclusion

Under Alternative 5, the three modeled interior drainage sites, MRLS 575-L, MRLS 536-L, and MRLS 488-L, showed negligible to small increases in average annual damages relative to Alternative 1. MRLS 246-L showed negligible average annual impacts under Alternative 5. Significant impacts are not anticipated due to Alternative 5.

3.12.3.10 Alternative 6 – Pallid Sturgeon Spawning Cue

National Economic Development

The results of the interior drainage NED analysis for Alternative 6 are summarized in Table 3-114. Alternative 6 would have a small, adverse impact on interior drainage relative to Alternative 1 at the three modeled sites furthest upstream: MRLS 575-L, MRLS 536-L, and MRLS 488-L. The site with the largest adverse impact is MRLS 536-L, which exhibited an increase of $7,468, or 6.4 percent, in average annual damages over Alternative 1. The furthest downstream site, MRLS 246-L, experienced a small decrease in average annual damages of $1,228 or -0.3 percent.

Table 3-114. Summary of Interior Drainage NED Analysis for Alternative 6

Interior Drainage Site	Average Annual Spring Agricultural Losses	Average Annual Summer-Fall Agricultural Losses	Average Annual Property Damages	Total Average Annual NED Damages	Change in Total Average Annual NED Damages from Alternative 1	% Change from Alternative 1	$ Damage per Acre
MRLS 575-L	$16,778	$213,414	$55	$230,247	$1,210	0.5%	$2.47
MRLS 536-L	$5,160	$81,360	$37,408	$123,927	$7,468	6.4%	$8.86
MRLS 488-L	$10,706	$225,781	$6	$236,493	$2,127	0.9%	$24.79
MRLS 246-L	$7,080	$345,572	$44,683	$397,334	-$1,228	-0.3%	$12.45

Note: All totals are average annual values at the FY 2018 price level. Negative values indicate a decrease in damages relative to Alternative 1.

The interior drainage impacts during years when there was a release action modeled are summarized in Table 3-115. During the POR, there were five years modeled with a full flow release action. All four sites would experience increases in average annual damages under Alternative 6 full release action years, with the two furthest upstream sites, MRLS 575-L and 536-L, displaying increases in all five of the simulated years. MRLS 488-L had its highest modeled one-year increase in damages over Alternative 1, $175,966, in a simulated full release action event year.

In addition to full flow release actions, there were 23 years modeled with partial flow releases. On average, the results of the partial flow release years were more modest with two sites, MRLS 575-L and MRLS 246-L, showing a small decrease in average annual damages relative to Alternative 1, while the other two modeled sites, MRLS 536-L and MRLS 488-L, experienced small average annual increases in damages.

Over the total POR, the greatest one-year decreases in damages were −$112 (MRLS 575-L), −$19K (MRLS 536-L), −$132K (MRLS 488-L), and −$95K (MRLS 246-L). Across the same

POR, the greatest one-year increases in damages were $75K (MRLS 575-L), $406K (MRLS 536-L), $176K (MRLS 488-L), and $33K (MRLS 246-L).

Table 3-115. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 6

Change in Damages from Alternative 1 by Interior Drainage Site	Full Flow Release [a]		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase	Highest Damage Decrease	Highest Damage Increase
MRLS 575-L	$0	$74,902	-$16,957	$28,215	-$111,585	$74,902
MRLS 536-L	$0	$12,560	-$11,410	$38,105	-$19,346	$406,441
MRLS 488-L	-$527	$175,966	-$8,115	$15,141	-$132,341	$175,966
MRLS 246-L	-$6,010	$27,823	-$5,565	$1,618	-$95,438	$33,052

a Flow action was fully implemented in 5 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

b Flow action was partially implemented in 23 years of the POR. Data represents the largest NED damage increase and decrease in the years the action was implemented relative to Alternative 1.

Conclusion

Under Alternative 6 the three modeled interior drainage sites, MRLS 575-L, MRLS 536-L, and MRLS 488-L, showed negligible to small increases in average annual damages relative to Alternative 1, while MRLS 246-L showed negligible impacts under Alternative 6. Significant impacts to interior drainage are not anticipated due to Alternative 6.

3.12.3.11 Tribal Interests

There were no Tribal reservations identified in the sample of modeled interior drainage sites. However, there are Tribal reservations located in interior areas where flap gates are present on the river and would be susceptible to the risks of interior drainage flooding.

3.12.3.12 Climate Change

Alternative 1 and Alternative 2: As shown in Table 3-116, the following six climate change variables are expected to have an impact on Alternative 1 and Alternative 2: increased air temperature; increased precipitation and stream flow; decreased peak snow water equivalent; earlier snowmelt dates and decreased snow accumulation season duration; increased sedimentation; and increased irregularity of flood and droughts. While all variables will impact the alternatives, increased air temperature was identified as not being a risk to interior drainage. Two climatic change variables, decreased peak snow water equivalent and earlier snowmelt dates and decreased snow accumulation season duration, could have either an adverse or beneficial impact depending on accurate forecasting and the location and season of snowmelt. The remaining three climatic change variables would increase the risk of adverse impacts to interior drainage by exceeding flood targets more frequently or increasing the number of extreme weather events and reducing the overall reliability of the System.

Table 3-116. Discussion of Risk to Interior Drainage from Climate Change Variables for Alternative 1 and Alternative 2

Variable	Consequence from Variable	Risk Impact to Interior Drainage
Increased Air Temperature	During summer water supply operations, could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	No identified impact to risk of interior drainage.
Increased Precipitation and Streamflow	May be able to run spring pulses more often due to increased System storage. However, the frequency of a completed pulse would likely decrease due to exceeding flood targets more frequently.	(−) Increase likelihood adverse impacts to interior drainage from more extreme weather events.
Decreased Peak Snow Water Equivalent	Forecasting calendar year runoff has the potential to become less accurate, since 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 due to setting pulse magnitude too high.	Lower reservoir elevations from the decreased snow melt would reduce the risk of adverse impacts to interior drainage. Less accurate forecasts could potentially increase the risk to interior drainage if the magnitude of the pulses was set too high.
Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration	May be able to run spring pulses more frequently due to System storage rising earlier in the year. Could potentially lower the service level for second half of navigation season if current year's runoff falls as rain in late winter while System storage is being evacuated back to 56.1 MAF.	The decrease in available flood storage during early spring would increase the likelihood of impacts to interior drainage downstream of Gavins Point Dam in a large rain event. During the summer months, reservoir levels would drop providing more flood storage and decreasing the risk to interior drainage.
Increased Sedimentation	Decreased System storage may lead to decreased frequency of all pulses (assuming pulse requirements remain the same and sedimentation is not addressed).	(−) Increase likelihood of adverse impact to interior drainage with increased aggradation of sediment.
Increased Irregularity of Floods and Droughts	Accuracy of downstream forecasting may decrease, resulting in more frequent flood impacts caused by pulses. Have a greater potential to impact System storage with pulses if more droughts occur.	(−) Increased likelihood of adverse impact to interior drainage with more frequent extreme events.

Alternative 3: Only two climate change variables were identified as impacting Alternative 3, as shown in Table 3-117. However, neither is likely to have any impact on interior drainage. Increased air temperature was identified as not a risk to interior drainage, while earlier snowmelt date and decreased snow accumulation season duration, could have either an adverse or beneficial impact on interior drainage depending on the location and season.

Table 3-117. Discussion of Risk to Interior Drainage from Climate Change Variables for Alternative 3

Variable	Consequence from Variable	Impact to Risk for Interior Drainage
Increased Air Temperature	During summer water supply operations, could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	No identified impact to risk of interior drainage.
Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration	May be able to run spring pulses more frequently due to System storage rising earlier in the year. Could potentially lower the service level for second half of navigation season if current year's runoff falls as rain in late winter while System storage is being evacuated back to 56.1 MAF.	The decrease in available flood storage during early spring would increase the likelihood of impacts to interior drainage downstream of Gavins Point Dam in a large rain event. During the summer months, reservoir levels would drop providing more flood storage and decreasing the risk to interior drainage.

Alternatives 4–6: Alternatives 4, 5, and 6 were identified as being impacted by the same five climate change variables shown in Table 3-118. Increased air temperature was identified as not a risk to interior drainage. One climatic change variable, earlier snowmelt dates and decreased snow accumulation season duration, could have either an adverse or beneficial impact on interior drainage depending on the location and season. The remaining three climatic change variables would increase the risk of adverse impact to interior drainage with increasing the number of extreme weather events.

Table 3-118. Discussion of Risk to Interior Drainage from Climate Change Variables for Alternative 4, Alternative 5, and Alternative 6

Variable	Consequence from Variable	Impact to Risk for Interior Drainage
Increased Air Temperature	During summer water supply operations, could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	No identified impact to risk to interior drainage.
Increased Precipitation and Streamflow	May be able to run spring pulses more often due to increased System storage. However, the frequency of a completed pulse would likely decrease due to exceeding flood targets more frequently.	(−) Increased likelihood of adverse impacts to interior drainage due to an increase in extreme weather events.
Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration	May be able to run spring pulses more frequently due to System storage rising earlier in the year. Could potentially lower the service level for second half of navigation season if current year's runoff falls as rain in late winter while System storage is being evacuated back to 56.1 MAF.	The decrease in available flood storage during early spring would increase the likelihood of impacts to interior drainage downstream of Gavins Point Dam in a large rain event. During the summer months, reservoir levels would drop providing more flood storage and decreasing the risk to interior drainage.
Increased Sedimentation	Decreased System storage may lead to decreased frequency of all pulses (assuming pulse requirements remain the same and sedimentation is not addressed).	(−) Increased likelihood of adverse impact to interior drainage with increased aggradation of sediment.

Variable	Consequence from Variable	Impact to Risk for Interior Drainage
Increased Irregularity of Floods and Droughts	Accuracy of downstream forecasting may decrease, resulting in more frequent flood impacts caused by pulses. Have a greater potential to impact System storage with pulses if more droughts occur.	(−) Increased likelihood of adverse impact to interior drainage with more frequent extreme events.

3.12.3.13 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. 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. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impact to interior drainage.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the MRRMP-EIS alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses Section 3.2.2.3, Impacts on Hydrology from the Alternatives), the elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in year 15 under all alternatives compared to year 0. The change in stage in the riverine areas in year 15 in the upper river and the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The degradation effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15. However, in Kansas City, the projected river stage in year 15 would only be slightly lower (less than one inch of the mean stage) than year 0. It is not expected that future degradation will have any impacts to interior drainage.

Past, present, and future construction projects, including those of the Mainstem dams, levees, native fish and wildlife habitat areas, and the Bank Stabilization and Navigation Project (BSNP), have in the past and will continue to have cumulative impacts on interior drainage. The construction and operation of the Missouri River Mainstem Reservoir System and the BSNP significantly altered the Missouri River by creating a system of six dams and channelizing the Missouri River from Sioux City, Iowa to St. Louis, Missouri. These alterations resulted in significant flow changes within the Missouri River and have substantially reduced flood risk over the long term by regulating the flows and river stages on the Missouri River. The flood control purpose of the Missouri River System is given the highest priority during periods of significant runoff when loss of life and property damage could occur. Regulation efforts will be made to minimize these losses.

In general, interior drainage impacts in the Missouri River floodplain vary considerably depending on the year and location and can range from near zero to relatively large impacts. The primary driver for interior drainage impacts is the hydrologic conditions in the basin including natural cycles of dry and wet periods (including snowpack and precipitation).

Under Alternative 1, no change in the present operation of the Missouri River System would occur. Therefore, the cumulative impacts of Alternative 1 would be a continuation of the substantial beneficial impacts on interior drainage resulting from the past, present, and reasonably foreseeable future actions. Adverse and beneficial impacts on interior drainage are driven by natural cycles of dry and wet periods (including snowpack and precipitation).

The incremental impacts of Alternative 2 would result in a relatively small reduction in average annual interior drainage damages at each of the four modeled sites. In specific years and locations, however, management actions under Alternative 2 could result in relatively large adverse impacts. When these incremental impacts are added to the impacts from past, present, and reasonably foreseeable future actions, the overall cumulative impact would continue to be substantially beneficial. Alternative 2 would contribute adversely to this overall cumulative impact in years with full releases.

The incremental impacts of Alternative 3 would result in a small increase in average annual interior drainage damages at each of the four modeled sites compared to Alternative 1. When these incremental impacts are added to the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impact would continue to be substantially beneficial. Alternative 3 would have a negligible contribution to the overall cumulative interior drainage impact.

The incremental impacts of Alternative 4 would result in a negligible impact in average annual interior drainage damages at the modeled sites compared to Alternative 1. When these incremental impacts are considered with the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impacts would continue to be substantially beneficial. Alternative 4 would contribute adversely to this overall cumulative impact in years with full or partial ESH creation releases.

The incremental impacts of Alternative 5 would result in a negligible impact in average annual interior drainage damages at the modeled sites compared to Alternative 1. In specific years and locations, however, management actions under Alternative 5 could result in relatively large adverse impacts particularly during years with a full fall ESH creation release. When these incremental impacts are added to the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impacts would continue to be substantially beneficial.

The incremental impacts of Alternative 6 would result in a negligible impact in average annual interior drainage damages at the modeled sites compared to Alternative 1. Although the relative difference in average annual damages would be small, these actions could result in relatively large adverse impacts in specific years and locations particularly during years with a full spring spawning cue release. When these incremental impacts are added to the impacts from past, present, and reasonably foreseeable actions, the overall cumulative impacts would continue to be substantially beneficial.

3.13 Hydropower

3.13.1 Affected Environment

Mainstem dams hold water in the river reservoir system; passing water through the hydropower plants electricity-generating turbines creates a source of low cost, renewable energy. Hydropower generation is dependent on three primary features of the Missouri River system: river flows (dam releases), water elevations, and reservoir System storage. Changes in available water, including daily and hourly river flows and System storage, can impact both the magnitude of normal seasonal generating patterns and reduce the flexibility to meet hourly peaking demands. The value associated with hydropower is based on the accrued cost of the most likely energy source that would replace reductions in hydropower generation.

3.13.1.1 History of Missouri River Hydropower

In 1933, as part of the New Deal, the construction of Fort Peck Dam began and with it, the interest in hydropower on the Mainstem of the Missouri River. Initially designed for the multi-purposes of flood control, water quality, and hydropower, Fort Peck began generating hydropower in 1943. During this effort, USACE and the Bureau of Reclamation were finalizing the Pick-Sloan Plan as part of the Flood Control Act of 1944. This plan called for the construction of a number of multi-purpose projects in the Missouri River Basin including five more major hydropower plants on the Mainstem of the river.

3.13.1.2 Missouri River Hydropower System Description

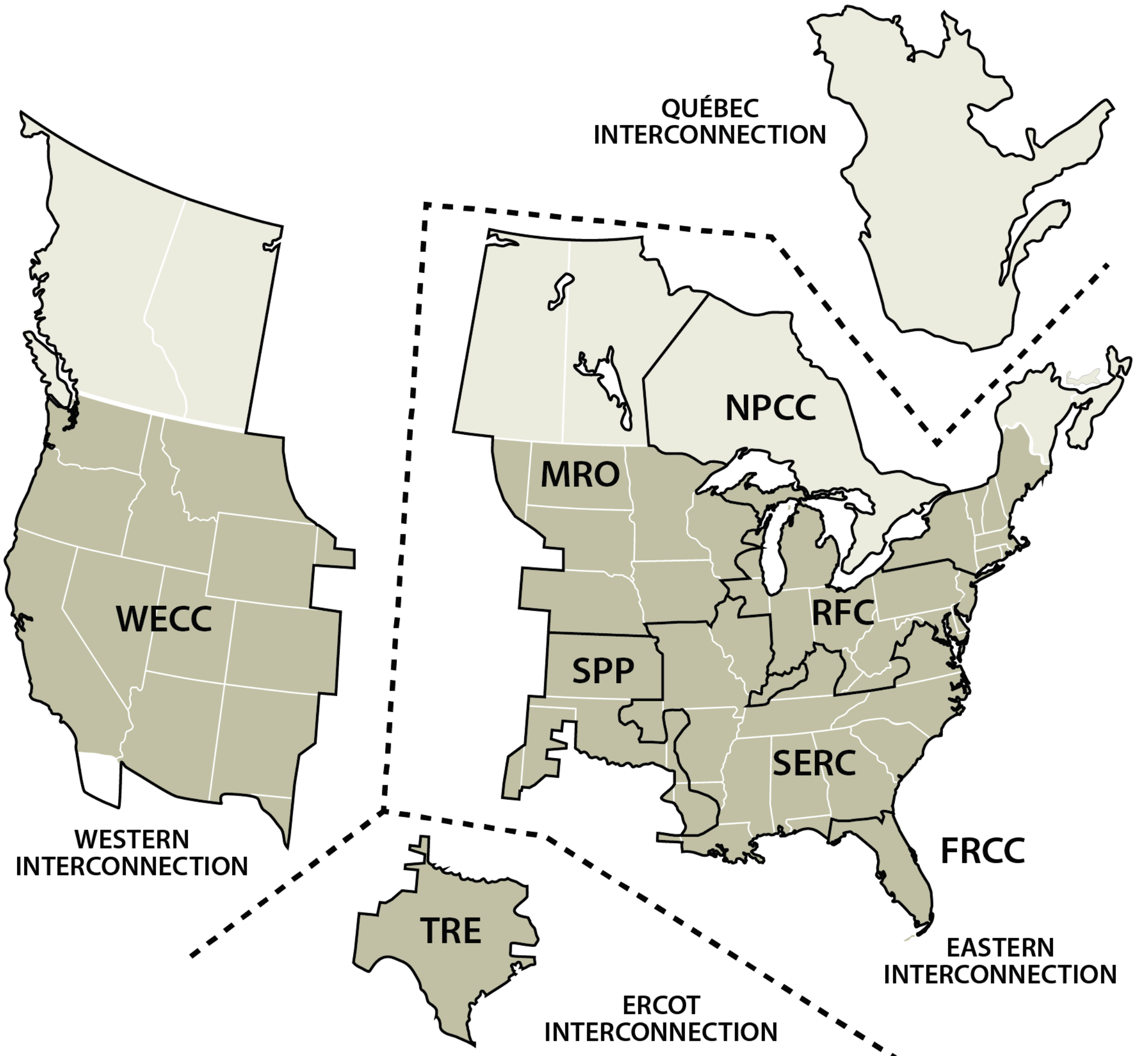
The Missouri River hydropower system contains six USACE facilities with a combined nameplate capacity of 2,500 MW. Table 3-119 provides a description of the general characteristics of USACE hydroelectric projects on the Mainstem of the Missouri River.

Table 3-119. Hydropower Plant Characteristics for USACE Projects on the Mainstem of the Missouri River

Project	Online Date	Number of Units	Generator Capacity Rated (MW)
Fort Peck	1943	5	185
Garrison	1956	5	583
Oahe	1962	7	786
Big Bend	1964	8	494
Fort Randall	1954	8	320
Gavins Point	1956	3	132
Total	-	36	2,500

3.13.1.3 Regional Energy Environment

The Missouri River hydropower system is mostly contained in the North American Electric Reliability Corporation (NERC) Midwest Reliability Organization (MRO) (Figure 3-57). Note: For purposes of this study, the United States section of the MRO region is extended to include Montana. The MRO is one of eight regions in North America tasked with ensuring the reliability and security of the bulk power system. An understanding of the value of the hydropower begins with a look into the current available generating capacity of the region.

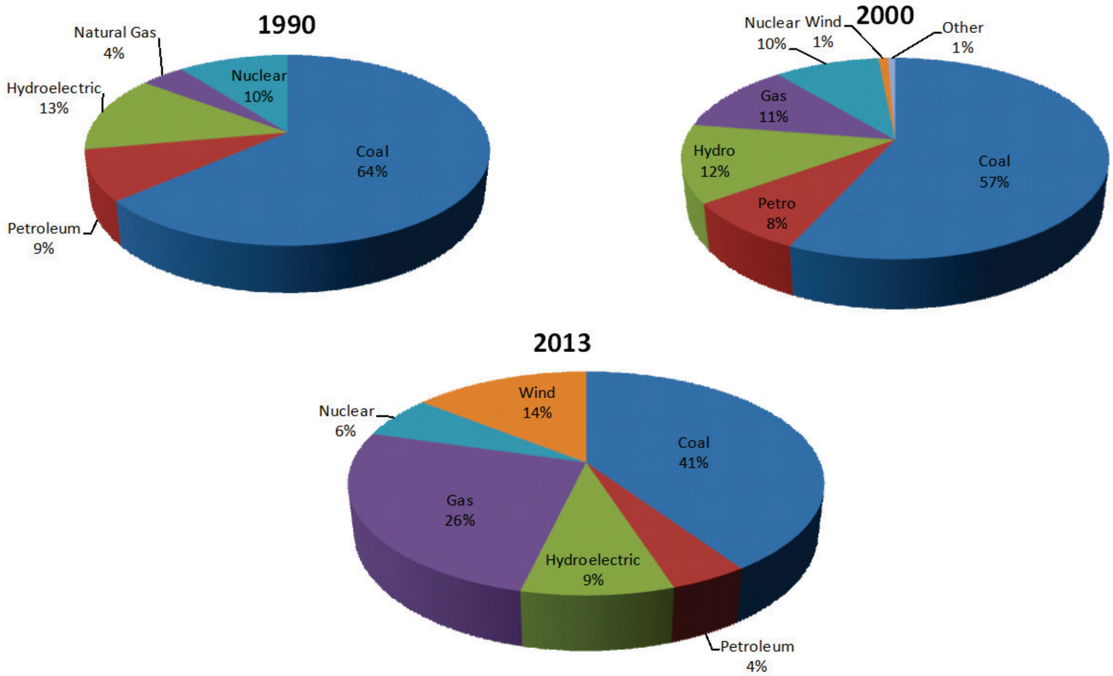


Source: North American Electric Reliability Corporation 2012.

Note: For purposes of this study the United States section of the MRO region is extended to include Montana.

Figure 3-57. North American Reliability Corporations Interconnections

Between 1990 and 2013, there was a dramatic change in the sources of generating capacity in the MRO-US. In 1990, coal represented almost 64 percent of the entire region's capacity with a nameplate capacity of 52,000 MW. During this time, natural gas only supplied 3,400 MW of capacity and wind power had zero. By 2013, however, natural gas development was supplying 26 percent of the region's capacity with 34,000 MW of the region's nameplate capacity. The contribution of wind has also increased steadily, supplying almost 19,000 MW and 14 percent of the region's nameplate capacity (Figure 3-58). The capacity contributions for coal, nuclear, petroleum, and hydropower have stayed fairly stable in terms of the actual megawatts being contributed to the system, but the influx of natural gas and wind has decreased their percent contribution to the system.



Source: Energy Information Agency 2014

Figure 3-58. Percent of Nameplate Capacity to Total Capacity by Generating Source for Extended Midwest Reliability Organization Region (1990–2013)

3.13.1.4 USACE Hydropower Operations

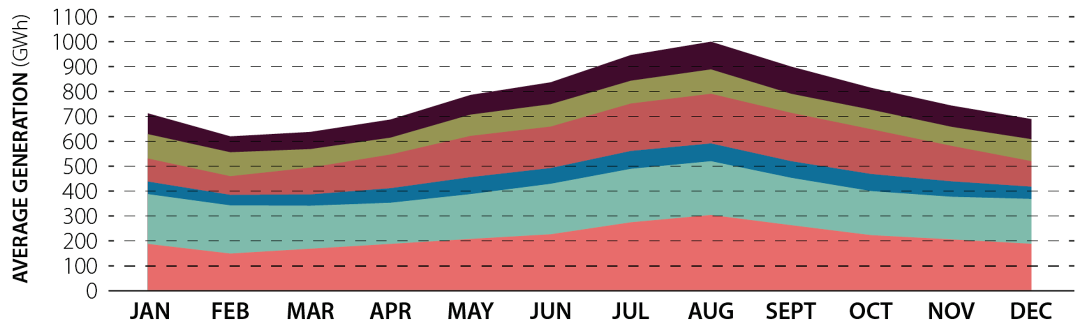
The amount of power produced from a hydropower facility is directly proportional to three variables; the efficiency of the hydropower plant turbines, the amount of flow going through the turbines, and the head (the height of the water in the reservoir relative to its height after discharge).

Restrictions on dam releases due to either water availability or other considerations such as minimum flow requirements may reduce both the magnitude and value of the energy produced. Flows outside of the design of the turbines may also reduce the overall efficiency. In addition, when dam releases exceed the hydraulic capacity of the plant, potential energy is lost as water is released through the spillway. This can have a cascading effect in the reduction of potential energy as downstream dams pass the same volume of water through the spillway rather than using it to generate power.

Like dam releases, power generated is directly related to the water elevation in the reservoir. Also like dam releases, reservoir elevations outside of the turbine design can lead to a reduction in overall generating efficiency. Since the reservoirs on the Mainstem of the Missouri River are so large, dramatic changes in reservoir elevations are generally a result of system responses to extreme hydrologic events such as an extended drought or a flood.

System storage, represented by the volume of water stored in the six USACE hydropower reservoirs, can affect the magnitude and timing of dam releases at individual plants associated with hydropower generation in an attempt to meet other project purposes, such as reducing flood risk and providing navigation support. Hydropower generation for the federal plants is scheduled to best meet the needs of customers under the constraints of the other projects purposes such as navigation and flood control. Generation patterns can be viewed on time scales of seasonally (monthly), daily, and hourly. These patterns should be viewed both as a system and individually as different plants may have different operating constraints.

In the Missouri River Basin, peak energy loads (demand) increase in the summer months, when temperatures are highest. These loads are intended to be met by generating the maximum amount of energy during the month of August. Figure 3-59 shows the average monthly generation for USACE hydropower plants from 1968 to 2014. Over this period, on average, the least amount of energy was generated during February.

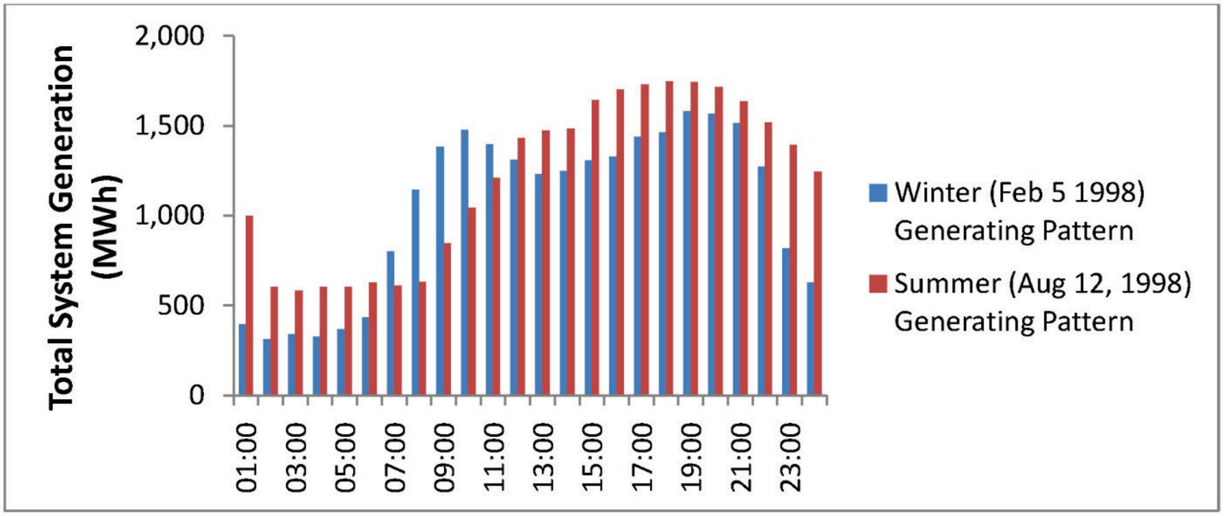


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
BIG BEND	75	61	67	70	76	83	97	109	99	86	81	76
FORT PECK	103	96	77	69	87	89	96	97	83	78	78	92
FORT RANDALL	91	77	104	135	161	166	190	200	191	176	139	97
GAVINS POINT	46	42	49	57	64	65	70	73	73	73	63	49
GARRISON	202	191	171	164	190	202	215	216	184	175	176	181
OAHE	192	154	171	192	207	231	278	306	268	226	205	193

Figure 3-59. Average Monthly Generation in Gigawatt Hours (GWh) (1968–2014) for USACE Hydropower Facilities on the Missouri River Mainstem

Figure 3-60 illustrates the seasonal differences in hourly generation patterns for USACE hydro-facilities using hourly generation data for a select winter and summer day. The winter heating demand consists of two peaks; early morning and evening with a slight dip in the afternoon. The summer cooling demand consists of a much broader peak time from mid-afternoon until late evening reaching a maximum around 6:00 p.m.

The hydropower operations of the individual power plants within a system can vary significantly. For example, run of river plants are operated (Missouri River plants are not run of river) constantly, using as much installed capacity as possible. Other plants with storage may turn completely off and then increase during peak demand periods, while others even have a minimum flow requirement with a constant generation of a small amount of electricity and with a maximum generation occurring during peak demand periods.



Source: USACE 2012g

Figure 3-60. Example Hourly Summer and Winter Generation Schedule for USACE Hydropower Facilities on the Missouri River Mainstem

3.13.1.5 Characteristics of the Missouri River Hydropower System

Missouri River hydropower benefits the country in several ways. Water acts as a low cost, renewable energy source, reducing the overall price of electricity. In addition to the lower cost of power, hydropower plant operations are not a major contributor to atmospheric emissions like other fuel sources such as coal and natural gas. Hydropower plants have extremely flexible operating capabilities with the ability to almost immediately match peak load energy demands and emergencies on the power grid, increasing the reliability of the power system. Finally, the revenue generated from the hydropower plants goes toward repayment of the federal investment in the facilities.

Power Marketing

Western Area Power Administration (WAPA) was formed in 1977 as one of four regional power marketing agencies within the United State Department of Energy focused on marketing federal power in the Missouri River basin. Prior to that, the Bureau of Reclamation took responsibility for marketing the federal power in the Missouri River basin.

The Reclamation Project Act of 1939 provided some notable constraints on the preferred customer base for the power marketing agencies along with guidelines for the rate structure. The preference customers include a number of non-profit organizations including municipalities, state and federal agencies, irrigation districts, public utility districts, and rural electric cooperatives. WAPA has extended this base to include Native American Tribes. The preference customer base are the only power users allowed to establish long-term firm power contracts, power that is guaranteed to be available 24 hours a day and receive preference rates (Figure 3-61). The customer service area is generally meant to lie within the watershed due to the desire to maximize local benefits and efficiency in electricity transmission.

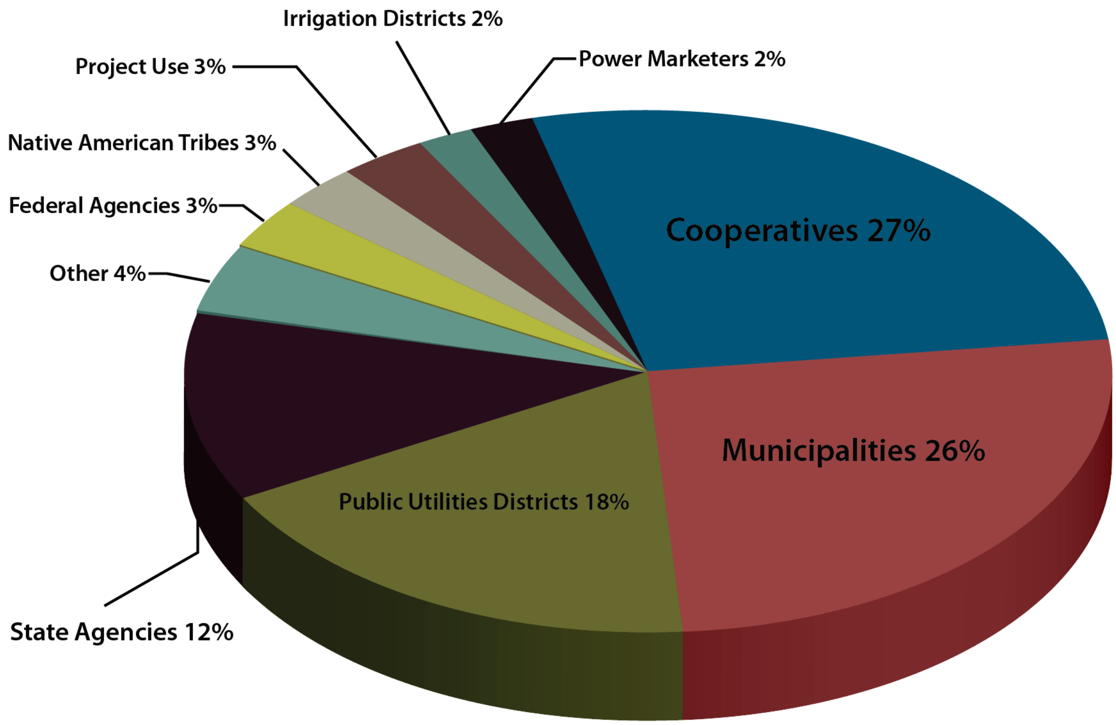


Figure 3-61. Western Area Power Administration 2015 Firm Sales by Customer

Tribal Benefits

WAPA allocates low-cost power to Tribal irrigation districts, which is mainly used for pumping water out of the Missouri to Tribal agricultural and ranching productions. In 2001, WAPA also contracted with 25 Tribes in the Upper Great Plains region to provide Tribal allocations of power. Generally, these power allocations provide 50 percent of Tribal power needs (Sundsted 2011). As part of WAPA's Energy Planning and Management Program, one of the purposes was to extend long-term firm power allocations to those who meet the federally mandated criteria. Since these Tribes are not utilities, WAPA contracts with the rural cooperatives to provide power to Tribes at the cost that WAPA charges the cooperatives. The financial benefit for these Tribes is the difference between what the cooperative would have charged and the rate that WAPA charges the cooperative. The Tribal Council decides who within the reservation will receive the benefit (e.g., school, library, all households, etc.). WAPA works closely with the Tribes to manage and audit these contracts to ensure that these Tribal financial benefits are realized.

3.13.2 Environmental Consequences

This section summarizes the hydropower impacts assessment methodology and presents the results of the assessment. A detailed description of the methodology and results is provided in the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

3.13.2.1 Impact Assessment Methodology

The accounts framework (NED, RED, and OSE) enables consideration of a range of both monetary and non-monetary values and interests that are expressed as important to stakeholders and Tribes. The following section provides a brief overview of the methodology for evaluating impacts to hydropower as well as the approach for each account.

Hydropower generation on the Missouri River depends primarily on river flows and dam releases, reservoir elevations, and System storage. Changes in available water can impact both the magnitude of normal seasonal generating patterns and reduce the flexibility to meet hourly peaking demands. This analysis used the HEC-ResSim Missouri River model that simulates reservoir operations over the POR, as well as the Missouri River Hydropower Benefits Calculator model to calculate impacts to generation and capacity for each of the six Mainstem dams.

Alternative 1 is considered the baseline increase against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 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 NED benefits for hydropower are based on the accrued cost of the most likely alternative energy source that would replace reduced hydropower generation. This benefit is separated into two categories; an energy value (replacement energy) and a capacity value (dependable capacity). The energy value represents the fuel cost or variable cost of an alternative thermal generation resource that replaces the lost hydropower generation.

The capacity value represents the capital cost and fixed operation and maintenance cost of the alternative energy resource.

A 2016 estimated U.S. Energy Information Administration energy price (obtained from the 2017 EIA Annual Outlook Report and indexed to 2018 for this report) was used in conjunction with the historic pattern of energy prices to determine specific blocks of hourly, daily, and monthly prices. Capacity unit values were determined using a screening curve analysis that plots annual total plant costs for different types of thermal generating plants (fixed capacity cost plus variable operating costs) versus an annual plant factor. The final value is a mix of the least cost alternative sources for each plant factor range.

Regional Economic Development

The RED benefits for hydropower are based on the results of the NED analysis. WAPA markets its firm power from the hydropower plant to various preferred customers. Sales of electric power must repay all costs associated with power generation. If the rates for repayment that WAPA charges its preferred customers need to be increased to cover an increase in power costs, the low-cost benefits for preferred customers would decrease. WAPA provided a method for obtaining reasonable estimates of the financial impact from each alternative, which would in turn could affect rates. The RED impact includes an assessment of the direct financial impacts to WAPA, the potential of the alternative to affect the rates for preferred customers, and indirect effects on regional economic conditions.

The sales of electric power must repay all costs associated with power generation. WAPA provided their hourly preference customer and pumping load in the Southwest Power Pool (SPP) footprint and their deliveries external to SPP in 2016. This was compared to the average generation data from the hydropower benefits model. Then they obtained net hourly generation for every day of that year by subtracting the load or demand from the generation to see when the generation fell short, when they would have to purchase energy to meet the demand, and when there was extra generation that could be sold onto the market. The prices used in these comparisons are different than those used for the NED analysis and were based on actual October 2015 to June 2016 average SPP locational marginal pricing at USACE generators in the SPP footprint for on/off peak periods.

Other Social Effects

The OSE analysis for hydropower relied on the results of the NED analysis to determine the impacts on the OSE account. For hydropower, the OSE impacts would occur when a decrease in hydropower generation leads to an increase in thermal power generation to meet the demand, which increases carbon dioxide, methane, and nitrous oxide emissions. Additionally, EPA's social cost of carbon (SCC) value was used to approximate a monetary value associated with carbon emissions.

3.13.2.2 Summary of Consequences

The hydropower consequences are summarized in Table 3-120. The impacts of Alternative 1 are described as the value of energy generation and dependable capacity. The impacts of the other alternatives are described as the results of the alternative compared to Alternative 1. The alternative that would have the largest impact to hydropower compared to Alternative 1 would be Alternative 4, with a reduction in NED value of $3.8 million. From there, the alternatives ranging from the most impact to the least impact would be Alternative 6, Alternative 2, and Alternative 5. Alternative 3 would result in a slightly beneficial impact compared to Alternative 1.

Table 3-120. Consequences Relative to Hydropower

Alternative	NED Impacts	RED Impacts	OSE Impacts
Management Actions Common to All Alternatives	No impact.	No impact.	No impact.
Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)	Under Alternative 1, the baseline level of benefit/impact of the system is estimated to be $491,099,000. NED value would range from $268,904,000 during drought conditions to a high of $656,458,000 under relatively higher water conditions; management actions under Alternative 1 would have negligible impacts on NED value.	Under Alternative 1, there would be a financial cost to WAPA of $1,761,000 to meet preference customer obligations. Management actions under Alternative 1 would have a small contribution to this financial cost, with negligible impacts to customer rates and regional economic conditions.	If the power the Missouri River hydropower system currently produces under Alternative 1 had to be replaced by a thermal power producer, it would produce 15,889,805,078 lbs of carbon dioxide, 1,343,046 lbs of methane, and 252,911 lbs of nitrous oxide. The social cost of carbon associated with these avoided emissions would be $348,239,000.

Alternative	NED Impacts	RED Impacts	OSE Impacts
Alternative 2	Average annual decrease in generation: 5,409 MWh (-0.6%) Average annual decrease in hydropower value: $3,099,000 (−$203,000 in generation value and −$2,896,000 in capacity value) Range of annual differences: ($37,781,050 reduction to $13,543,647 increase)	Increase in financial cost of $30,000 to WAPA to meet preferred customer obligations compared to Alternative 1. Under Alternative 2, any impacts on customer rates are anticipated to be small to negligible, with negligible impacts to regional economic conditions.	Carbon dioxide increase: 9,855,094 lbs Methane increase: 833 lbs Nitrous oxide increase: 157 lbs SCC increase: $216,000
Alternative 3	Average annual increase in generation: 6,037 MWh (0.04%) Average annual increase in hydropower value: $203,000 ($110,000 in generation value and $93,000 in capacity value) Range of annual differences: ($13,188,274 reduction to $14,245,979 increase)	Decrease in financial cost to WAPA of $102,000 compared to Alternative 1. Under Alternative 3, any impacts on customer rates and regional economic conditions are anticipated to be negligible.	Carbon dioxide decrease: 10,999,306 lbs Methane decrease: 930 lbs Nitrous oxide decrease: 175 lbs SCC decrease: $241,000
Alternative 4	Average annual decrease in generation: 60,246 MWh (-0.8%) Average annual decrease in hydropower value: $3,771,000 (−$1,799,000 in generation value and −$1,972,000 in capacity value) Range of annual differences: ($34,024,351 reduction to $35,014,208 increase)	Increase in financial costs to WAPA of $1,156,000 compared to Alternative 1. Under Alternative 4, any impacts on customer rates could potentially be large, with the potential for adverse impacts to regional economic conditions.	Carbon dioxide increase: 109,769,010 lbs Methane increase: 9,278 lbs Nitrous oxide increase: 1,747 lbs SCC increase: $2,406,000
Alternative 5	Average annual decrease in generation: 19,130 MWh (-0.2%) Average annual decrease in hydropower value: $1,031,000 (−$678,000 in generation value and −$353,000 in capacity value) Range of annual differences: $25,850,202 reduction to $31,104,359 increase	Increase in financial costs to WAPA of $356,073 compared to Alternative 1. Under Alternative 5, any impacts on customer rates are anticipated to be moderate, with the potential for adverse impacts to regional economic conditions.	Carbon dioxide increase: 34,854,585 lbs Methane increase: 2,946 lbs Nitrous oxide increase: 555 lbs SCC increase: $764,000

Alternative	NED Impacts	RED Impacts	OSE Impacts
Alternative 6	Average annual decrease in generation: 41,724 MWh (-0.7%) Average annual decrease in hydropower value: $3,209,000 (−$1,260,000 in generation value and −$1,949,000 in capacity value) Range of annual differences: $33,041,450 reduction to $17,885,409 increase	Increase in financial costs to WAPA of $792,000 compared to Alternative 1. Under Alternative 6, any impacts on customer rates could potentially be large, with the potential for adverse impacts to regional economic conditions.	Carbon dioxide increase: 76,021,175 lbs Methane increase: 6,425 lbs Nitrous oxide increase: 1,210 lbs SCC increase: $1,666,000

3.13.2.3 Impacts from Management Actions Common to All Alternatives

A number of actions are common to all alternatives including vegetation management, predator management, human restriction measures, and pallid sturgeon propagation and augmentation. These actions would have no impact to hydropower because they do not affect System storage, reservoir elevations, or dam releases.

Mechanical Habitat Construction

Construction of early life stage habitat for pallid sturgeon occurs downstream of Gavins Point Dam and, therefore, would not impact hydropower. Mechanical construction of ESH is not anticipated to impact hydropower under any of the alternatives. Actions that do not affect the flow through the dams or the elevations at the reservoirs are unlikely to have an impact on hydropower.

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

Under Alternative 1, System operations would be the same as current operations, with no change to how the dams are currently operated. This alternative is considered the baseline increase against which the other alternatives are measured. These results are discussed in more detail in the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

National Economic Development

Under Alternative 1, no changes to the current hydropower operations would occur. The basis of impact description for Alternative 1 for hydropower is the value of energy generation and dependable capacity. The NED analysis and baseline level of benefits and impacts of Alternative 1 are summarized in Table 3-121. Average annual generation for the system under this alternative would be estimated at 8,721,079 MWh. The value of this generation would be $229,057,000. The annual values during the POR would range from a low of $112,332,000 to a high of $369,952,000. The calculated dependable capacity for the summer would be 2,115.8 MW and 1,859.9 MW for winter. The value of the summer dependable capacity would be $262,042,000. The value of the winter dependable capacity would be $230,347,000. The total average annual value of hydropower (including generation and summer dependable capacity) would be $491,099,000. The management actions under Alternative 1 (spring plenary pulse) would have a negligible effect on NED values because of the small amount of water affected during pulses.

Table 3-121. Summary of Hydropower National Economic Development Analysis for Alternative 1 (2018 Dollars)

Average Annual System Generation	8,721,079 MWh
Average Annual Generation Value	$229,057,000
Dependable Capacity – Summer	2,115.8 MW
Average Annual Capacity Value – Summer	$262,042,000
Dependable Capacity – Winter	1,859.9 MW
Average Annual Capacity Value – Winter	$230,347,000
Total Average Hydropower Value Generation plus Capacity (Summer)	$491,099,000

Regional Economic Development

RED impacts are based on the results of the NED analysis. WAPA markets its firm power from hydropower to various preferred customers that meet federally mandated criteria. Changes to the operations of the System will impact WAPA's ability to meet the demand for electricity, creating the need to find electricity elsewhere. These values are intended to capture the financial cost to WAPA of the MRRMP-EIS alternatives.

Under Alternative 1, the average generation over the period of record would result in a deficit of 195,594 MWH (valued at $1,761,000) beyond the typical load requirements, resulting in financial costs ($1.8 million) to WAPA to meet its preferred customer obligations. The spring pulse under Alternative 1 would have a small contribution to these costs; the preferred customer rates would not be anticipated to change with the management actions under Alternative 1. There would be negligible impacts to regional economic conditions due to the negligible change in rates.

Other Social Effects

Changes in hydropower operations have the potential to cause other types of effects than simply impacting generation and capacity associated values. An environmental benefit associated with hydropower would be a reduction in greenhouse gases as compared to replacement thermal power generation. If the Missouri River hydropower system generation was replaced by thermal power sources, there would be an increase in annual emissions by 15,889,805,078 lbs of carbon dioxide, 1,343,046 lbs of methane, and 252,911 of nitrous oxide. Hydropower emissions are considered negligible, and therefore this benefit provides the baseline for the Other Social Effects account.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

If both hydropower and thermal power production are affected during peak and critical periods, there is a potential for coupled effects of the two and amplified impacts from Management Plan actions. Generally, energy providers have to balance how much energy each type of producer generates with the demand for energy at any given time. If both kinds of energy producers experience decreased generation during the same peak or critical period, it could lead to lower overall energy production in the region, the need to buy additional power on the grid to meet the demand, and possibly increased energy prices. However, this potential for coupled effects is not expected to occur as a result of any Management Plan actions under this alternative.

Seasonal power generation under Alternative 1 from both hydropower and thermal power plants along the Missouri River generally accounts for between 12 and 14 percent of seasonal power generation in the MISO and SPP RTOs. During drought conditions, power generation under Alternative 1 would be a relatively lower percentage, especially in the summer season, from lower power generation from both hydropower and thermal power plants. During drought conditions, power generation from Missouri River power plants accounts for 11.7 percent of the RTO generation (summer of 1980), a drop of 3.2 percent from a high of 14.9 percent (summer of 1975). In 1975, power generation from hydropower as modeled is estimated to be 3.2 million MWh and thermal power would be 18.7 million MWh, and in 1980, power generation from hydropower and thermal power plants would reduce to 2.2 million MWh and 14.9 million MWh, respectively.

The simultaneous reductions in power generation from both hydropower and thermal power plants during drought and relatively drier conditions would put further upward pressure on wholesale electricity prices. However, replacement power would be available from alternate sources (pers. comm. SPP 2018) and additional impacts from coupled effects to electricity rates and electricity reliability would be negligible to small. The management actions under Alternative 1 of the spring plenary pulse and habitat development would not have a noticeable contribution to these coupled effects.

Conclusion

Alternative 1 represents the continuation of current System operation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. NED and RED results indicate hydropower would continue to provide NED, RED, and OSE benefits under Alternative 1. Relatively drier and drought conditions would reduce these benefits, but management actions under Alternative 1 would have a negligible adverse contribution to changes in NED, RED, and OSE. Continuation of current System operation and MRRP implementation actions would not be anticipated to have significant impacts to hydropower under Alternative 1.

3.13.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 includes a spring pallid sturgeon flow release and low summer flows, as well as considerably more early life stage habitat and ESH construction than would occur under Alternative 1.

National Economic Development

The NED analysis for Alternative 2 is summarized in Table 3-122. Average annual system generation under this alternative would be 8,715,670 MWh, a decrease of 0.06 percent from Alternative 1. The average annual value of the generation under this alternative would be $228,855,000, a decrease of 0.09 percent. The change in generation and the change in generation value would be proportionally different because the decreases in generation are occurring at times when the value of generation is higher than the average. The system average annual dependable capacity for the critical summer period would be 2,111.3 MW, valued at $261,483,000, an average annual decrease of 0.21 percent from Alternative 1. The system average annual dependable capacity for the critical winter period would be 1,840.4 MW (a decrease of 1.05 percent from Alternative 1) and valued at $227,928,000. Also included in the table is a maximum average annual capacity reduction. Different plants can be impacted differently in different seasons. The maximum average annual capacity reduction is considering the highest impact at each plant, either during the winter or summer period. For Alternative 2, maximum average annual capacity reduction would be −$2,896,000, which is included in the NED value.

Table 3-122. Summary of National Economic Development Analysis for Alternative 2 (2018 Dollars)

Average Annual System Generation	8,715,670 MWh
System Generation Difference from Alternative 1	−5,409 MWh
Average Annual Generation Value	$228,854,000
Annual Generation Value Difference from Alternative 1	−$203,000
Dependable Capacity - Summer	2,111.3 MW
Difference in Dependable Capacity - Summer from Alternative 1	−4.5 MW
Average Annual Capacity Value - Summer	$261,483,000
Difference in Average Annual Capacity Value - Summer from Alternative 1	−$559,000
Dependable Capacity - Winter	1,840.4 MW
Difference in Dependable Capacity - Winter from Alternative 1	−19.5 MW
Average Annual Capacity Value - Winter	$227,928,000
Difference in Average Annual Capacity Value - Winter from Alternative 1	−$2,419,000
Maximum Average Annual Capacity Reduction Summed by Plant	−$2,896,000
Total Average Annual Change in Hydropower NED Value from Alternative 1	**−$3,099,000**
Percent Change in Average Annual Hydropower NED Value from Alternative 1	-0.63%

The total value of the impact to hydropower from Alternative 2 would be a reduction of $3,099,000 in generation and capacity reductions. This includes a generation reduction of $203,000 and a maximum dependable capacity reduction of $2,896,000. This is an overall reduction of 0.63 percent of the total system value.

When evaluating the impacts of each alternative, annual impacts over the POR were examined. Additional results are summarized in Table 3-123, which shows the difference in annual impacts to system hydropower (including both capacity and generation) during the years where there is a release action or low summer flow, as a result of the alternative. These results show that the years with a full spawning cue release and low summer flow would result in the largest adverse impacts to hydropower, whereas the partial flow years would have small adverse and beneficial effects. On average and in most years over the period of record, there would be small adverse impacts to hydropower NED under Alternative 2 when compared to Alternative 1 from the spawning cue releases reducing System storage and reservoir elevations affecting hydropower generation. In addition, low summer flows would reduce the ability to generate hydropower during peak summer demand seasons. The year with the largest negative impact on hydropower value, 1988, results in a 13 percent reduction in overall value, mostly due to the impact on capacity. The year with the greatest positive impact on overall value, 1983, shows an increase of 21 percent. However, those years are two large impacts relative to the rest of the years. Removing those two years, the range of impacts is between an increase of 6 percent and a reduction of 5 percent.

In 32 years of the POR, Alternative 2 would result in a higher hydropower value than Alternative 1. The average increase in these years is $8,707,000. In 50 of the years, Alternative 2 results in a lower hydropower value than Alternative 1. The average decrease in these years would be $6,806,000.

Table 3-123. Impacts from Modeled Flow Releases under Alternative 2; Change in NED Value from Alternative 1 (2018 Dollars)

Full Flow Release [a]		Years after Full Release		Partial Flow Release [b]		Maximum and Minimum Impact Regardless of Flow Actions	
Largest Decrease	Smallest Decrease	Largest Decrease	Smallest Decrease	Largest Decrease	Largest Increase	Largest Decrease	Largest Increase
-$66,786,000	-$31,000	-$14,957,000	-$10,836,000	-$9,757,000	$10,325,000	-$66,786,000	$101,807,000

a Full Flow Release + Low Summer Flow (the spawning cue release) was fully implemented in 3 years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

b Partial Flow Release was implemented in 31 of the years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented. Partial implementation years are defined as years when a partial cue in March and/or May would occur or years when a full cue in March or May would occur.

Regional Economic Development

Alternative 2 would increase power purchases or reduce surplus sales and financial costs to WAPA by approximately $30,000 in an average generation year, a 1.7 percent increase compared to Alternative 1. Of the 8,784 hours examined, 57 percent of the hours resulted in an inability to meet the load, meaning power would need to be purchased. The average cost of the purchase would be $514. The largest single hour purchase over the year was $2,069. Forty-three percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $671. Under Alternative 2, any impacts on customer rates are anticipated to be small to negligible, with negligible impacts on regional economic conditions.

Other Social Effects

Reductions in hydropower generation would need replaced with other sources of power generation, likely a reliable fossil fuel source that produces greenhouse gases. The estimated average annual difference in generation between Alternative 1 and Alternative 2 is a reduction in power generation of 5,409 MWh, leading to small increases in air emissions. Overall, emissions would increase by 0.062 percent as compared to the baseline assumption of avoided emissions Table 3-124 displays the results of these increased emissions necessary to replace the lost hydropower generation.

Table 3-124. Summary of Other Social Effects Analysis for Alternative 2

	Carbon Dioxide	Methane	Nitrous Oxide
Average Annual Change in Emissions compared to Alternative 1	+9,855,094 lbs	+833 lbs	+157 lbs

The social cost of carbon discussed in Section 3.13.2.1, Impact Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The average social cost of carbon updated to a 2018 price level is $48 per metric ton of carbon dioxide (using a 3 percent discount rate). The social cost of increased carbon emissions under Alternative 2 would be $216,000 relative to Alternative 1. Additional estimates for social cost of carbon values are referenced in the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Under Alternative 2, simultaneous reductions in hydropower and thermal power could potentially occur during summer months when low summer flow events would be implemented. During the low summer flow events, as simulated during the POR in 1988, 1989, 2002, and 2003, both hydropower and thermal power generation would be reduced during a season when demand for electricity is also typically high. These reductions in power generation in the summer would come during relatively drier conditions when power generation is already being affected, especially as simulated in 1988, 2002, and 2003. Reductions in power generation compared to Alternative 1, as simulated, would be greatest in a modeled year like 1988 with a reduction of 5.9 million MWH, the bulk of which (88 percent) would be from reductions in thermal power generation. In the summer of 1988, the change in power generation from both hydropower and thermal power plants accounts for 4.0 percent of SPP and MISO power generation (Table 3-125).

Table 3-125. Seasonal Changes in Power Generation under Alternative 2 Compared to Alternative 1

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	-30,522	130,015	-93,426	-2,690
	Thermal Power (MWh)	689	11,874	-284,880	27,313
MISO and SPP	Worst-Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	-403,744	-300,495	-5,907,389	-573,247
	Worst-Case Change from Alternative 1 (% of RTO generation)	-0.3%	-0.1%	-4.0%	-0.2%
	Worst-Case Change from Alternative 1: Year	1987	2000	1988	1983
	Average Annual Change from Alternative 1 (% of RTO generation)	-0.0%	0.1%	-0.3%	0.0%
MISO	Worst-Case Change from Alternative 1 (% of RTO generation)	0.0%	-0.0%	-3.7%	-0.2%
	Worst-Case Change from Alternative 1: Year	1988	1988	1988	2007
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	-0.2%	0.0%
SPP	Worst-Case Change from Alternative 1 (% of RTO generation)	-1.0%	-0.4%	-4.7%	-0.8%
	Worst-Case Change from Alternative 1: Year	1987	2000	1988	1983
	Average Annual Change from Alternative 1 (% of RTO generation)	-0.1%	0.2%	-0.5%	0.0%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

These coupled effects in the summer season during the low summer flow events would exacerbate impacts to wholesale power prices. Although replacement capacity within the markets is likely to be available during these conditions, it is possible that simultaneous reductions in power generation especially during a condensed period of time could adversely impact voltage pressure, power availability, and local grid stability (SPP pers. comm. 2018).

Conclusion

Among the alternatives, Alternative 2 has the third largest adverse impact to NED value, as compared to Alternative 1, the low summer flows and spawning cue release occurring in this alternative. In comparison to Alternative 1, Alternative 2 would have adverse impacts to hydropower by decreasing average annual NED value by $3,099,000 with a range of annual differences of a $66,786,000 reduction to a $101,807,000 increase. On average, Alternative 2 could result in an increase in financial costs to WAPA of $30,000. Under Alternative 2, any impacts on customer rates are anticipated to be small to negligible, with negligible impacts to regional economic conditions. Increased carbon dioxide, methane, and nitrous oxide would also occur under Alternative 2 due to reliance on other energy sources resulting from reduced average annual hydropower generation. Overall, Alternative 2 would have small impacts on NED, RED, and OSE hydropower benefits compared to Alternative 1. However, there is a potential for large impacts in years when the full implementation of the spawning cue release and low summer flows occur or in years following these releases. Impacts could be significant in years with large reductions in hydropower benefits.

3.13.2.6 Alternative 3 – Mechanical Construction Only

Alternative 3 includes mechanical habitat for construction of ESH and IRC habitat. Alternative 3 includes fewer acres of IRC habitat compared to the acres of early life stage habitat constructed under Alternative 1. In addition, the spring plenary pulse under Alternative 1 would not be implemented under Alternative 3.

National Economic Development

The NED analysis for Alternative 3 is summarized in Table 3-126. Average annual system generation under this alternative would be 8,727,115 MWh, an increase of 6,037 MWh (0.07 percent) compared Alternative 1. The value of the generation under this alternative would be $229,167,000, an increase of $110,000 or 0.05 percent compared to Alternative 1. There are slight differences in flows between Alternative 1 and Alternative 3, primarily occurring during spring that would lead to this slight increase in generation from the elimination of the plenary pulse under Alternative 3. The dependable capacity in the critical summer period under this alternative would be 2,116.9 MW valued at $262,177,000. The dependable capacity in the critical winter period under this alternative would be 1,862.0 MW valued at $230,606,000, an increase of 0.11 percent over Alternative 1. The maximum average annual capacity impact, considering the highest impact at each plant either during the winter or summer period, is an average annual increase of $93,000 compared to Alternative 1. These differences between Alternative 3 and Alternative 1 can be attributed to the lack of bi-modal spring pulse under Alternative 3.

Alternative 3 would result in an average annual increase in NED value of $203,000, a 0.041 percent increase from Alternative 1, which includes a small increase in generation and in dependable capacity.

Table 3-126. Summary of National Economic Development Analysis for Alternative 3 (2018 Dollars)

Average Annual System Generation	8,727,115 MWh
System Generation Difference from Alternative 1	+6,037 MWh
Average Annual Generation Value	$229,167,000
Annual Generation Value Difference from Alternative 1	+$110,000
Dependable Capacity – Summer	2,116.9 MW
Difference in Dependable Capacity – Summer from Alternative 1	+01.08 MW
Average Annual Capacity Value – Summer	$262,177,000
Difference in Average Annual Capacity Value – Summer from Alternative 1	+$135,000
Dependable Capacity – Winter	1,862.0 MW
Difference in Dependable Capacity – Winter from Alternative 1	+2.1 MW
Average Annual Capacity Value – Winter	$230,606,000
Difference in Average Annual Capacity Value – Winter from Alternative 1	$259,000
Maximum Average Annual Capacity Increase Summed by Plant	+$93,000
Total Average Annual Change in Hydropower NED Value from Alternative 1	**+$203,000**
Percent Change in Average Annual Hydropower NED Value from Alternative 1	**+0.04%**

When evaluating the impacts of each alternative, year-by-year impacts as well as those that occur on average over the POR were examined. Since under Alternative 3 there would be no changes in terms of partial or full-flow-plus-low-summer-flow releases from Alternative 1, there is not a table of results showing the difference between those. However, the following paragraph explains some of the changes that occur under this alternative in annual terms.

In 50 years of the POR, Alternative 3 would result in a higher hydropower value than Alternative 1. The average increase in these years would be $776,000. In 32 of the total years, Alternative 3 would result in a lower hydropower value than Alternative 1. The average decrease in these years would be $585,313.

Regional Economic Development

Under Alternative 3, there would be a decrease in financial costs to WAPA of $102,400 on average over the period of record; Alternative 3 would decrease power purchases or increase surplus sales by about $100,000 on average over the period of record compared to Alternative 1, a change of 5.6 percent. Of the 8,784 hours examined, 46 percent of the hours resulted in an inability to meet the load, meaning power would need to be purchased. The average cost of the purchase would be $153. The largest single hour purchase over the year was $1,205. Fifty-four percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $154.

Other Social Effects

As discussed in previous sections, reductions in hydropower generation would be replaced by other sources of power generation, likely a reliable fossil fuel source that produces greenhouse gases. Alternative 3 would result in an increase in generation as compared to Alternative 1, with an associated decrease in greenhouse gases. Alternative 3 would result in a small increase of 6,036 MWh compared to Alternative 1. Overall, emissions would increase by 0.069 percent as compared to the baseline assumption of avoided emissions. Table 3-127 displays the results of these decreased emissions.

Table 3-127. Summary of Other Social Effects Analysis for Alternative 3

	Carbon Dioxide	Methane	Nitrous Oxide
Average Annual Change in Emissions compared to Alternative 1	−10,999,306 lbs	−930 lbs	−175 lbs

The social cost of carbon discussed in Section 3.13.2.1, Impact Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The average social cost of carbon updated to a 2018 price level is $48 per metric ton of carbon dioxide (using a 3 percent discount rate). The average annual social cost of carbon would decrease by $241,000 due to lower carbon emissions under Alternative 3 compared to Alternative 1. Additional estimates for social cost of carbon values are referenced in the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Under Alternative 3, there would be negligible impacts from simultaneous reductions in hydropower and thermal power generation. The fall of the modeled year 2005 shows the greatest impact, with a reduction of 259,022 MWh, 0.10 percent of both MISO and SPP generation (see Table 3-128).

Table 3-128. Seasonal Changes in Power Generation under Alternative 3 Compared to Alternative 1

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	2,963	-9,464	3,322	8,936
	Thermal Power (MWh)	-	-736	17,860	-4,404
MISO and SPP	Worst-Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	-7,341	-63,206	-37,566	-264,886
	Worst-Case Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.1%
	Worst-Case Change from Alternative 1: Year	1996	1977	1998	2005
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
MISO	Worst-Case Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	-0.1%
	Worst-Case Change from Alternative 1: Year	1975	2005	2010	2005
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
SPP	Worst-Case Change from Alternative 1 (% of RTO generation)	0.0%	-0.1%	0.0%	0.0%
	Worst-Case Change from Alternative 1: Year	1996	1977	1998	1997
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release that might be implemented under Alternative 3 was not included in the hydrologic modeling for this alternative 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.

The one-time implementation of the spawning pulse would cause temporary, small, adverse impacts to power plants in the year the pulse is implemented or the 1 to 2 years following the pulse when releases from Garrison and Gavins Point Dams are lower than under Alternative 1. In some years and conditions, there is the potential for adverse impacts to hydropower generation and capacity.

Conclusion

Alternative 3 would result in a small increase in power generation and dependable capacity from the elimination of the spring plenary pulse under Alternative 3. In comparison to Alternative 1, there would be an average annual increase in NED of $203,000 with a range of annual differences of a $3,199,000 reduction to a $6,585,000 increase. On average, there would be a decrease in financial costs to WAPA of $102,000 under Alternative 3 compared to Alternative 1, with negligible impacts to preferred customer rates and regional economic conditions. Alternative 3 would result in small decreases in greenhouse gas emissions and social cost of carbon compared to Alternative 1. Small beneficial impacts would occur to NED, RED, and OSE under Alternative 3 compared to Alternative 1; as a result, this alternative would not have significant impacts to hydropower.

3.13.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 includes a spring release in April and part of May to create ESH. In addition, mechanical ESH and early life stage habitat would also be constructed.

National Economic Development

The NED analysis for Alternative 4 is summarized in Table 3-129. The average annual system generation under this alternative would decrease by 8,660,832 MWh or 0.69 percent. The value of this generation would be $227,258,000, a decrease of 0.79 percent from Alternative 1. The dependable capacity for the summer critical period under this alternative would be 2,106.9 MW. This capacity is valued at $260,933,000, a decrease in 0.42 percent from the critical summer period under Alternative 1. The dependable capacity for the winter critical period would be 1,847.2 MW. The value for this dependable capacity would be $228,760,000, a decrease in 0.69 percent from Alternative 1. The maximum average annual capacity considers the highest impact at each plant, either during the winter or summer period; Alternative 4 would result in an average annual decrease of $1,972,000.

The average annual change in NED value under Alternative 4 for hydropower, including a maximum capacity reduction of $1,972,000 and a generation reduction of $1,799,000, would be a reduction of $3,771,000 (-0.8 percent) compared to Alternative 1.

Additional results are summarized in Table 3-130, which shows the difference in annual impacts to system hydropower (including both capacity and generation) during the years when there is a release action or low summer flow, as a result of Alternative 4. These results show that some of the greatest adverse impacts to hydropower occur in the year following a full release, when reservoir elevations are relatively lower, reducing power generation. The largest decrease in hydropower NED values would occur in 2010, the year after a partial release. Under Alternative 4, the largest increase (as compared to Alternative 1) occurs during a full release year.

On average over the period of record, there would be small adverse impacts to hydropower NED value under Alternative 2 when compared to Alternative 1 from the spring releases reducing System storage and reservoir elevations affecting hydropower generation. In the years following the spring release, there could be large impacts to NED, up to $18 million decrease in NED value compared to Alternative 1.

In 21 years of the POR, Alternative 4 results in a higher hydropower value than Alternative 1. The average increase in these years would be $4,895,000. In 61 of the total years, Alternative 4 would result in a lower hydropower value than Alternative 1. The average decrease in these types of years would be $5,588.

Table 3-129. Summary of National Economic Development Analysis for Alternative 4 (2018 Dollars)

Average Annual System Generation	8,660,832 MWh
System Generation Difference from Alternative 1	−60,246 MWh
Average Annual Generation Value	$227,258,000
Annual Generation Value Difference from Alternative 1	−$1,799,000
Dependable Capacity – Summer	2,106.9 MW
Difference in Dependable Capacity – Summer from Alternative 1	−8.9 MW
Average Annual Capacity Value – Summer	$260,933,000
Difference in Average Annual Capacity Value – Summer from Alternative 1	−$1,109,000
Dependable Capacity – Winter	1,847.1 MW
Difference in Dependable Capacity – Winter from Alternative 1	−12.8 MW
Average Annual Capacity Value – Winter	$228,760,000
Difference in Average Annual Capacity Value – Winter from Alternative 1	−$1,587,000
Maximum Average Annual Capacity Reduction Summed by Plant	−$1,972,000
Total Average Annual Change in Hydropower NED Value from Alternative 1	**−$3,771,000**
Percent Change in Average Annual Hydropower NED Value from Alternative 1	-0.77%

Table 3-130. Impacts from Modeled Flow Releases under Alternative 4; Change in NED Value from Alternative 1 (2018 Dollars)

Full Flow Release [a]		Year After a Full Release		Partial Flow Release [b]		Maximum and Minimum Impact Regardless of Flow Actions	
Largest Decrease	**Largest Increase**	**Largest Decrease**	**Largest Increase**	**Largest Decrease**	**Largest Increase**	**Largest Decrease**	**Largest Increase**
-$1,673,000	$25,963,000	-$18,130,000	$6,137,000	-$1,749,000	$4,448,000	-$24,909,000	$25,963,000

a Full Flow Release was implemented in 9 years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

b Partial Flow Release was implemented in 7 of the years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

Regional Economic Development

RED impacts are based on the results of the NED analysis. WAPA markets its firm power from hydropower to various preferred customers that meet federally mandated criteria. Changes to the operations of the System will impact WAPA's ability to meet the demand for electricity, creating the need to find electricity elsewhere.

Under Alternative 4, there would be an increase in financial costs to WAPA of $1,156,000 to meet preferred customer obligations as compared to Alternative 1. WAPA provided their hourly preference customer and pumping load in the SPP footprint and their deliveries external to SPP in 2016 and compared the generation data from the hydropower benefits model. Then they obtained net hourly generation for every day of that year by subtracting the load or demand from the generation to see where the generation fell short, when they would have to purchase energy to meet the demand, and where there was extra generation that could be sold onto the market. The values and numbers discussed represent the difference between the net generation under Alternative 1 and Alternative 4. An on-peak and off-peak energy price was applied to indicate the financial impact to WAPA of each alternative. Therefore, Alternative 4 would increase average annual power purchases or reduce surplus sales by about $1,156,000. This is a 65 percent increase over Alternative 1. Of the 8,784 hours examined, 78 percent of the hours would result in an inability to meet the load, meaning power would need to be purchased. The average cost of the purchase would be $402. The largest single hour purchase over the year was $1,729. Twenty-two percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $848. Given this increase on average over the period of record, it is possible that large impacts to customer rate could occur, with the potential for adverse impacts to regional economic conditions.

Other Social Effects

Reductions in hydropower generation would need to be replaced by other sources of power generation, likely a reliable fossil fuel source that produces greenhouse gases. Alternative 4 would result in a reduction of 60,246 MWh compared to Alternative 1. Table 3-131 displays the results of estimated increases in air emissions. Overall, emissions would increase by 0.69 percent as compared to the baseline assumption of avoided emissions.

Table 3-131. Summary of Other Social Effects Analysis for Alternative 4

	Carbon Dioxide	Methane	Nitrous Oxide
Average Annual Change in Emissions compared to Alternative 1	+109,769,010 lbs	+9,278 lbs	+1,747 lbs

The social cost of carbon discussed in Section 3.13.2.1, Impact Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The average social cost of carbon updated to a 2018 price level is $48 per metric ton of carbon dioxide (using a 3 percent discount rate). The increase in the social cost of carbon emissions under Alternative 4 compared to Alternative 1 would be $2,406,000.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Alternative 4 could result in adverse impacts to coupled power generation from hydropower and thermal power, occurring primarily in the fall as relatively lower flows in the late summer and fall cause adverse impacts to power generation as a result of river stages falling below shut down intake elevations. For example, in the modeled year 1994, a full spring release is simulated to occur, which would result in the largest power reduction of 2.6 million MWh compared to Alternative 1, 2.4 million (93 percent) of which would be from reductions in thermal power generation. These reductions would be up to 1 percent of MISO and SPP generation in (see Table 3-132). Because the reductions in power generation from hydropower and thermal power would occur in the fall and demand for electricity is relatively lower during the fall season, there would be replacement capacity, with minimal impacts to wholesale power prices, power supply, electricity rates, grid stability, and regional economic conditions.

Table 3-132. Seasonal Changes in Power Generation under Alternative 4 Compared to Alternative 1

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	-11,515	83,397	-24,308	-88,031
	Thermal Power (MWh)	-387	-9,493	11,632	-97,000
MISO and SPP	Worst-Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	-119,731	-791,421	-378,766	-2,623,569
	Worst-Case Change from Alternative 1 (% of RTO generation)	-0.1%	-0.3%	-0.3%	-1.0%
	Worst-Case Change from Alternative 1: Year	1983	2010	2010	1994
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	-0.1%
MISO	Worst-Case Change from Alternative 1 (% of RTO generation)	0.0%	0.2%	-0.2%	-1.3%
	Worst-Case Change from Alternative 1: Year	1993	2010	2010	1994
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	-0.1%
SPP	Worst-Case Change from Alternative 1 (% of RTO generation)	-0.3%	-0.8%	-0.4%	-1.0%
	Worst-Case Change from Alternative 1: Year	1983	1995	1982	1982
	Average Annual Change from Alternative 1 (% of RTO generation)	-.0%	0.12%	0.0%	-0.1%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Conclusion

This alternative has the largest adverse impact on hydropower due to the full spring releases reducing System storage and reservoir elevations in the years following the releases, reducing average annual generation and capacity when compared to Alternative 1. As simulated, full release years would lead to an increase in hydropower generation during the release year, but would reduce generation in the years following. In comparison to Alternative 1, there would be an average annual decrease in hydropower NED benefits of $3,771,000 (-0.8 percent). There would be an increase in financial costs to WAPA of $1,156,000. Given this increase on average over the period of record, it is possible that large impacts to customer rate could occur, with the potential for adverse impacts to regional economic conditions. However, individual years will have very different impacts. Greenhouse gas emissions and social cost of carbon would increase. Large adverse impacts to hydropower NED, RED, and OSE benefits could occur under Alternative 4 especially in specific years following flow releases due to reduced System storage which directly impact generation and capacity. Impacts could be significant in years with large reductions in hydropower benefits.

3.13.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 includes a fall release in October and November to create ESH. Alternative 5 includes fewer acres of IRC habitat compared to the acres of early life stage habitat constructed under Alternative 1 in the lower river.

National Economic Development

The NED analysis for Alternative 5 is summarized in Table 3-133. The average annual system generation under this alternative would be 8,701,949 MWh, a 0.2 percent decrease from Alternative 1. The value of this generation would be $228,379,000, a decrease of 0.3 percent from Alternative 1. The dependable capacity for the summer critical period under this alternative would be 2,114.2 MW. This capacity would be valued at $261,848,000, a 0.07 percent decrease compared to Alternative 1. The dependable capacity for the winter critical period would be 1,858.5 MW. The value for this dependable capacity would be $230,174,000, a decrease of 0.08 percent from Alternative 1. The maximum average annual capacity reduction is considering the highest impact at each plant, either during the winter or summer period; Alternative 4 would result in a reduction of $353,000.

The average annual reduction in hydropower NED value under Alternative 5 compared to Alternative 1, including a maximum capacity reduction of $353,000 and a generation reduction of $678,000, is $1,031,000, a 0.21 percent decrease of average annual NED value from Alternative 1.

Additional results are summarized in Table 3-134, which shows the difference in annual impacts to system hydropower (including both capacity and generation) during the years where there is a release action, as a result of Alternative 5. Under Alternative 5, these results show that the greatest adverse impacts to hydropower would occur in the year following a full release; as simulated in 1984, there would be a decrease in NED value of $50.4 million compared to Alternative 1. The full release years generally result in small beneficial impacts to hydropower NED value due to higher dam releases in these years. Overall, there would be negligible to small changes on average, although the specific years following the full release would have the potential to result in large adverse effects to hydropower generation and NED value from lower System storage and reservoir elevations.

In 41 years of the POR, Alternative 5 results in a higher hydropower value than Alternative 1. The average increase in these types of years would be $3,197,000. In 41 of the total years, Alternative 5 would result in a lower hydropower value than Alternative 1. The average decrease in these years would be $4,931,000.

Table 3-133. Impacts from Modeled Flow Releases under Alternative 5 (2018 Dollars)

Average Annual System Generation	8,701,949 MWh
System Generation Difference from Alternative 1	−19,130 MWh
Average Annual Generation Value	$228,379,000
Annual Generation Value Difference from Alternative 1	−$678,000
Dependable Capacity – Summer	2,114.2 MW
Difference in Dependable Capacity – Summer from Alternative 1	−1.6 MW
Average Annual Capacity Value – Summer	$261,848
Difference in Average Annual Capacity Value – Summer from Alternative 1	−$194,000
Dependable Capacity – Winter	1,858.5 MW
Difference in Dependable Capacity – Winter from Alternative 1	−1.4 MW
Average Annual Capacity Value – Winter	$230,174,000
Difference in Average Annual Capacity Value – Winter from Alternative 1	−$173,000
Maximum Average Annual Capacity Reduction Summed by Plant	−$353,000
Total Average Annual Change in Hydropower NED Value from Alternative 1	**−$1,031,000**
Percent Change in Average Annual Hydropower NED Value from Alternative 1	-0.21%

Table 3-134. Impacts from Modeled Flow Releases under Alternative 5; Change in NED Value from Alternative 1 (2018 Dollars)

Full Flow Release [a]		Year After a Full Release		Partial Flow Release [b]		Maximum and Minimum Impact Regardless of Flow Actions	
Smallest Increase	Largest Increase	Largest Decrease	Smallest Decrease	Smallest Increase	Largest Increase	Largest Decrease	Largest Increase
$4,821,000	$18,223,000	$50,426,000	$12,171,000	$7,418,000	$7,418,000	−$50,426,000	$18,223,000

a Full Flow Release was implemented in 7 years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

b Partial Flow Release was implemented in 2 of the years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

Regional Economic Development

RED impacts are based on the results of the NED analysis. WAPA markets its firm power from hydropower to various preferred customers that meet federally mandated criteria. Changes to the operations of the System will impact WAPA's ability to meet the demand for electricity, creating the need to find electricity elsewhere.

These values and numbers discussed represent the difference between the net generation under Alternative 1 and Alternative 5. An on-peak and off-peak energy price was applied to indicate the financial impact to WAPA of each alternative.

Alternative 5 would result in an increase in financial costs (i.e., increase power purchases or reduce surplus sales) to WAPA of approximately $356,000 on an average basis, a 20.2 percent change from Alternative 1. Of the 8,784 hours examined, 64 percent of the hours would result in an inability to meet the load, meaning power would need to be purchased. The average cost of the purchase would be $290. The largest single hour purchase over the year was $1,960.36

percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $394. Given this relative increase on average over the period of record, it is possible that moderate impacts to customer rates could occur, with the potential for adverse impacts to regional economic conditions.

Other Social Effects

Reductions in hydropower generation would need to be replaced by other sources of power generation, likely a fossil fuel source that produces greenhouse gases. Alternative 5 would result in an average annual reduction of 19,129 MWh compared to Alternative 1. Table 3-135 displays the results of these increased emissions, necessary to replace the reduction in hydropower generation from Alternative 1. Overall, emissions would increase by 0.22 percent as compared to the baseline assumption of avoided emissions.

Table 3-135. Summary of Other Social Effects Analysis for Alternative 5

	Carbon Dioxide	Methane	Nitrous Oxide
Average Annual Change in Emissions compared to Alternative 1	+34,854,585 lbs	+2,946 lbs	+555 lbs

The increase in the social cost of carbon emissions under Alternative 5 compared to Alternative 1 would be $764,000.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Alternative 5 could result in adverse impacts to coupled power generation from hydropower and thermal power, and these conditions would primarily occur in the spring months. The year 1984, the year after a full fall release, as simulated, would result in the largest power reduction of 709,000 MWH compared to Alternative 1, 654,000 MWH of which would be from hydropower plants. These reductions would be driven by lower river flows in the spring and summer following a fall full release in 1983. These power reductions, as simulated, would be up to 0.3 percent of MISO and SPP generation in the spring (see Table 3-136). Because of the relatively small amount of power generation affected and because the reductions in power generation from hydropower and thermal power would occur in the spring non-peak power demand season, there would likely be replacement capacity, with minimal impacts to wholesale power prices, electricity rates, grid stability, and regional economic conditions.

If both hydropower and thermal power generation are affected during peak and critical periods, there is a potential for coupled effects of the two and amplified impacts from Management Plan actions. Generally, energy providers have to balance how much energy each type of producer generates with the demand for energy at any given time. If both kinds of energy producers experience decreased generation during the same peak or critical period, it could lead to lower overall energy production in the region, the need to buy additional power on the grid to meet the demand, and possibly increased energy prices. However, under Alternative 5, this potential for coupled effects is not expected to occur as a result of Management Plan actions. Please see section 3.13.2.13 for further discussion on coupled effects under the other Management Plan alternatives.

Table 3-136. Seasonal Changes in Power Generation under Alternative 5 Compared to Alternative 1

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	-8,736	-77,202	-8,233	46,914
	Thermal Power (MWh)	-464	-2,881	12,321	-15,551
MISO and SPP	Worst-Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	-117,725	-708,680	-269,864	-354,383
	Worst-Case Change from Alternative 1 (% of RTO generation)	-0.1%	-0.3%	-0.3%	-0.1%
	Worst-Case Change from Alternative 1: Year	1996	1984	1984	1975
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
MISO	Worst-Case Change from Alternative 1 (% of RTO generation)	(% of	0.0%	-0.2%	-0.2%
	Worst-Case Change from Alternative 1: Year	1993	2005	1984	2005
	Average Annual Change from Alternative 1 (% of RTO generation)	0.00%	0.00%	0.00%	-0.01%
SPP	Worst-Case Change from Alternative 1 (% of RTO generation)	-0.3%	-1.0%	-0.2%	-0.5%
	Worst-Case Change from Alternative 1: Year	1996	1984	1995	1975
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	-0.1%	0.0%	0.1%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Conclusion

In comparison to Alternative 1, there would be an average annual decrease in hydropower NED value of $1,031,000 due to the fall releases reducing System storage and reservoir elevations in the years following the releases, reducing average annual generation and capacity when compared to Alternative 1. There would be a small average annual increase in financial costs to WAPA of $356,000 compared to Alternative 1. Given this relative increase on average over the period of record, it is possible that moderate impacts to customer rates could occur. However, individual years will have very different impacts. Greenhouse gas emissions and social cost of carbon would increase. There is the potential for large adverse impacts to NED, RED, OSE in the years following the flow releases from reduced System storage and lake elevations affecting power generation and dependable capacity. Alternative 5 would not result in significant impacts because generation reductions even in the worst difference years represent a small percentage change from Alternative 1.

3.13.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

National Economic Development

The NED analysis for Alternative 6 is summarized in Table 3-137. The average annual system generation under this alternative would be 8,679,355 MWh, an average annual decrease of 41,724 MWh. The value of this generation would be $227,797,000, a decrease of 0.55 percent from Alternative 1. The dependable capacity for the summer critical period under this alternative would be 2,103.2 MW. This capacity would be valued at $260,480,000, a 0.6 percent decrease. The dependable capacity for the winter critical period would be 1,848.4 MW. The value for this dependable capacity would be $228,921,000, a decrease of 0.62 percent from Alternative 1.

The maximum average annual capacity reduction considers the highest impact at each plant, either during the winter or summer period; for Alternative 6, there would be a maximum average annual reduction of $1,949,000 compared to Alternative 1. The reduction in average annual hydropower NED value, including a maximum capacity reduction of $1,949,000 and a generation reduction of $1,260,000, of Alternative 6 would be $3,209,000, a 0.65 percent decrease of average annual system value from Alternative 1.

Additional results are summarized in Table 3-138, which shows the difference in annual impacts to system hydropower (including both capacity and generation) during the years where there is a release action, as a result of Alternative 6. Under Alternative 6, these results show that the greatest adverse impact to hydropower occurs in the year or years following a full or partial release. For example, the largest difference year was in 2004, a decrease of $18.8 million compared to Alternative 1; a full spawning cue release would be simulated to occur in 2002, drawing down the reservoirs in subsequent years during relatively drier conditions, with adverse impacts to hydropower generation and dependable capacity. The greatest beneficial impacts to hydropower would occur in during full release years; in 2002, hydropower NED value would be $14.6 million higher than Alternative 1. There is a wide range of results in partial release years, from a reduction of $10,177,000 in 1949 to an increase of $4,460,000 in 1977. In full flow years, under Alternative 6, there is also a narrower range of impacts from a reduction of $2,293,000 in 1970 to an increase of $14,576,000 in 2002.

In 25 years of the POR, Alternative 6 would results in a higher hydropower value than Alternative 1. The average increase in these years is $2,915. In 57 of the total years, Alternative 6 results in a lower hydropower value than Alternative 1. The average decrease in these years is $5,359,000.

Table 3-137. Impacts from Modeled Flow Releases under Alternative 6 (2018 Dollars)

Average Annual System Generation	8,679,355 MWh
System Generation Difference from Alternative 1	−41,724 MWh
Average Annual Generation Value	$227,797,000
Annual Generation Value Difference from Alternative 1	−$1,260,000
Dependable Capacity – Summer	2,103.2 MW
Difference in Dependable Capacity – Summer from Alternative 1	−12.6 MW
Average Annual Capacity Value – Summer	$260,480
Difference in Average Annual Capacity Value - Summer from Alternative 1	−$1,562,000
Dependable Capacity – Winter	1,848.4 MW
Difference in Dependable Capacity – Winter from Alternative 1	−11.5 MW
Average Annual Capacity Value – Winter	$228,921,000
Difference in Average Annual Capacity Value – Winter from Alternative 1	−$1,426,000
Maximum Average Annual Capacity Reduction Summed by Plant	−$1,949,000
Total Average Annual Change in Hydropower NED Value from Alternative 1	**−$3,209,000**
Percent Change in Average Annual Hydropower NED Value from Alternative 1	-0.65%

Table 3-138. Impacts from Modeled Flow Releases under Alternative 6; Change in NED Value from Alternative 1 (2018 Dollars)

Full Flow Release [a]		Year after a Full Release		Partial Flow Release [b]		Maximum and Minimum Impact Regardless of Flow Actions	
Largest Decrease	Largest Increase	Largest Decrease	Smallest Decrease	Largest Decrease	Largest Increase	Largest Decrease	Largest Increase
-$2,293,000	$14,576,000	-$14,653,000	-$4,827,000	−$10,177,000	$4,460,000	−$18,838,000	$14,576,000

a. Full Flow Release was implemented in 6 years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

b. Partial Flow Release was implemented in 29 of the years of the POR. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

Regional Economic Development

RED impacts are based on the results of the NED analysis. WAPA markets its firm power from hydropower to various preferred customers that meet federally mandated criteria. Changes to the operations of the system will impact WAPA's ability to meet the demand for electricity, creating the need to find electricity elsewhere.

The values and numbers discussed represent the difference between the net generation under Alternative 1 and Alternative 6. An on-peak and off-peak energy price was applied to indicate the financial impact to WAPA of each alternative.

Under Alternative 6, on average, there would be an increase in financial costs to WAPA of $792,000. Alternative 6 would increase power purchases or decrease surplus sales by about $792,000 on average over the period of record, a change of 44 percent. Of the 8,784 hours examined, 72 percent of the hours would result in an inability to meet the load, meaning power would need to be purchased. The average cost of the purchase would be $320. The largest single hour purchase over the year was $1,604. Twenty-eight percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $512. Given this large relative increase on average over the period of record, it is possible that large impacts to customer rates could occur, with the potential for adverse impacts to regional economic conditions. Impacts could be significant in years with large reductions in hydropower benefits.

Other Social Effects

Reductions in hydropower generation would need to be replaced by other sources of power generation, likely a fossil fuel source that produces greenhouse gases. Alternative 5 would result in an average annual reduction of 41,724 MWh compared to Alternative 1. Table 3-139 displays the results of these increased emissions, necessary to replace the lost hydropower generation.

Table 3-139. Summary of Other Social Effects Analysis for Alternative 6

	Carbon Dioxide	Methane	Nitrous Oxide
Average Annual Change in Emissions under Alternative 6	+76,021,175 lbs	+6,425 lbs	+1,210 lbs

The social cost of carbon discussed in Section 3.13.2.1, Impact Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The social cost of carbon for 2018 is $48 per metric ton of carbon dioxide (using a 3 percent discount rate). The social cost of increased carbon emissions under Alternative 6 would be $1,666,000.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Under Alternative 6, coupled effects associated with simultaneous reductions in thermal power and hydropower generation would affect up to 0.4 percent of SPP and MISO generation during a worst-case season. The spring of the modeled year 2010 shows the greatest impact of a reduction of 1.0 million MWh of generation, with thermal power generation representing two-thirds of power reduction (see Table 3-140). Because of the relatively small amount of power generation affected and because the reductions in power generation from hydropower and thermal power would occur in the spring non-peak power demand season, there would likely be replacement capacity, with minimal impacts to wholesale power prices, electricity rates, grid stability, and regional economic conditions.

Table 3-140. Seasonal Changes in Power Generation under Alternative 6 Compared to Alternative 1

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	-8,693	42,657	-11,353	-42,479
	Thermal Power (MWh)	-387	-17,200	3,110	-12,404
MISO and SPP	Worst-Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	-72,339	-1,017,689	-523,023	-694,821
	Worst-Case Change from Alternative 1 (% of RTO generation)	-0.1%	-0.4%	-0.4%	-0.3%
	Worst-Case Change from Alternative 1: Year	1983	2010	2010	2007
	Average Annual Change from Alternative 1 (% of RTO generation)	-0.01%	0.01%	-0.01%	-0.02%
MISO	Worst-Case Change from Alternative 1 (% of RTO generation)	0.0%	-0.4%	-0.4%	-0.3%
	Worst-Case Change from Alternative 1: Year	1993	2010	2010	2007
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
SPP	Worst-Case Change from Alternative 1 (% of RTO generation)	-0.2%	-0.5%	-0.2%	-0.4%
	Worst-Case Change from Alternative 1: Year	1983	2010	2004	1978
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.1%	0.0%	-0.1%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Conclusion

Alternative 6 is the third most impactful alternative on hydropower. This is likely due to the spawning cue release under this alternative. In comparison to Alternative 1, there would be an average annual decrease in hydropower NED benefits of $3,209,000. The range of annual differences is a $18,838,000 reduction to a $14,576,000 increase. Alternative 6 would result in an increase in financial costs to WAPA of $792,000 on average, with potentially large adverse impacts to customer rates. Greenhouse gas emissions are forecasted to increase. Overall, Alternative 6 would have adverse impacts on hydropower benefits compared to Alternative 1. This is due to large adverse impacts to hydropower NED, RED, and OSE benefits that could occur under Alternative 6 especially in specific years following the spawning cue release due to reduced System storage which directly impact generation and capacity.

3.13.2.10 Tribal Impacts

Tribes benefit from the low-cost power in two ways. WAPA allocates low-cost power to Tribal irrigation districts, which is mainly used for pumping water out of the Missouri to Tribal agricultural and ranching productions. In 2001, WAPA also contracted with 25 Tribes in the Upper Great Plains region to provide Tribal allocations of power. Generally, these power allocations provide 50 percent of Tribal power needs (Sundsted 2011). As part of WAPA's Energy Planning and Management Program, one of the purposes was to extend long-term firm power allocations to those who meet the federally mandated criteria. Since these Tribes are not utilities, WAPA contracts with the rural cooperatives to provide power to Tribes at the cost that WAPA charges the cooperatives. The financial benefit for these Tribes is the difference between what the cooperative would have charged and the rate that WAPA charges the cooperative. The Tribal Council decides who within the reservation will receive the benefit (e.g., schools, libraries, all households, etc.). WAPA works closely with the Tribes to manage and audit these contracts to ensure that these Tribal financial benefits are realized.

The potential for adverse impacts to the Tribes would follow the same pattern as the NED results. That is, the more adverse the impact on hydropower generation and capacity, the larger potential to negatively affect the rate/credit that the Tribes receive. Since agreements with the Tribes provide them with at-cost power, if the cost of producing the same amount of power goes up, due to changes in river and reservoir operations, this could potentially impact the credit the Tribes receive on their bill. Alternative 4 has the greatest potential to change the cost of producing power and affect the rate/credit the Tribes receive, followed by Alternative 6, Alternative 2, and then Alternative 5. Alternative 3 has the least potential to impact power production and affect the rate/credit the Tribes receive.

3.13.2.11 Climate Change

Many of the climate change variables described in Section 3.2.2.7, could have implications for hydropower and the associated NED, RED, and OSE effects under all of the MRRMP-EIS alternatives. Expected climate change variables include increased air temperature, increased precipitation and streamflow, decreased peak snow water equivalent, earlier snowmelt date and decreased snow accumulation season duration, increased sedimentation, and increased sporadic nature of floods and droughts. Any of these expected climate change variables would impact hydropower in the same way under each of the alternatives. Increased precipitation and streamflow has the potential to increase hydropower generation across all alternatives. Decreased peak snow could potential decrease hydropower production and reliability, especially during peak seasons. This may lead to difficulty to meet demand during high demand times. Decreased snow accumulation would lead to decreased hydropower generation and reliability. Increased sedimentation could potentially result in increased O&M at the dams, which would impact hydropower operations, generation, and reliability. Increased sporadic nature of droughts could potentially lead to less reliable and less overall hydropower production during drought years.

Under Alternative 1, earlier snowmelt may cause spring System storage targets at the reservoirs to be met more frequently, increasing the regularity of spring plenary pulses, and the potential for adverse hydropower impacts associated with the subsequent lower reservoir elevations in the summer and winter peak power demand seasons. Adverse impacts to hydropower generation associated with more frequent spring plenary pulses may be offset in part by higher levels of precipitation limiting the implementation of the full release because flood targets may be exceeded more frequently.

Under Alternatives 2, 4, 5, and 6, the risk of full and partial releases occurring and then followed by prolonged drought periods at the upper three reservoirs could reduce reservoir elevations more under these alternatives, causing greater adverse impacts to hydropower benefits under climate change than under Alternative 1. Earlier snowmelt could result in spring System storage targets at the reservoirs to be met more frequently, increasing the regularity of spring releases under Alternatives 2, 4, and 6. This situation may increase hydropower benefits in the spring when power demand is not as high, and potentially decrease the benefits during the summer and winter when demand for power is much higher, adversely affecting hydropower generation and the ability to balance demand between different producers.

Prolonged and/or more extreme drought or flood conditions could also reduce the frequency of full releases under Alternatives 2, 4, 5, and 6 and reduce the associated adverse hydropower impacts associated with full releases reducing reservoir elevations at the upper three reservoirs. Adverse impacts associated with partial releases may, however, increase as the frequency in which release events are started and then prematurely stopped increases. With these factors, the impact of climate change would both increase and decrease hydropower benefits under Alternatives 2, 4, 5, and 6 relative to Alternative 1.

3.13.2.12 Cumulative Impacts

Consumption of electricity has steadily increased, with sales of electricity increasing by 1.4 percent per year nationwide on average since 1990. Electricity sales in the Missouri River basin states have increased at a slightly higher rate of 2.0 percent on average over the same period. Continued increasing demand for electricity would benefit hydropower, with market pressure to maintain generation and increase capacity.

The Missouri River Mainstem Reservoir System operations and management for other project purposes could reduce the amount of generation during specific periods as water is passed over the spillways. The reduced generation could require the purchase of replacement power to fulfill existing power contracts. In addition, 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. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impacts to hydropower. However, other actions, such as water depletions or withdrawals for agriculture, municipal, and industrial uses have and would continue to have adverse impacts to hydropower, as they would affect the reservoir elevations.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses (Section 3.2), the elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in year 15 under all alternatives compared to year 0.

In addition, any resulting changes in aggradation, degradation, and sediment deposition in the reservoirs could increase the need for investment in hydropower infrastructure repairs and/or upgrades to mitigate these impacts.

Hydropower would continue to provide national and regional economic benefits under Alternative 1. The past, present, and foreseeable future actions would result in both beneficial and adverse impacts to hydropower with the natural hydrologic variability most likely to affect hydropower. The management actions under Alternative 1 would provide a negligible contribution to these impacts because of the small amount of System storage affected under the plenary pulse. Similarly, Alternative 3 would likely result in beneficial impacts to hydropower NED and RED compared to Alternative 1 and would have a negligible impact to cumulative effects because the plenary pulse is eliminated under Alternative 3.

However, Alternatives 2, 4, 5, and 6 would have adverse impacts on hydropower benefits compared to Alternative 1 due to adverse effects on NED and RED benefits. When combined with impacts from other cumulative actions, the cumulative impacts of Alternative 2, 4, 5, and 6 would likely be small to large and adverse, with the alternatives providing a small to large adverse contribution to the overall cumulative impact because of the potential of the flow releases to reduce System storage and reservoir elevations in subsequent years affecting hydropower generation and capacity.