Missouri River Recovery Program

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# Missouri River Recovery Management Plan and Environmental Impact Statement

## VOLUME 3

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# Missouri River Recovery Management Plan and Environmental Impact Statement

## Volume 3

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# 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 Missouri River flows from contributing to 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. Operations during the winter require special consideration because ice bridges restrict channel capacity. 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. Most of these levees are inadequate to withstand major floods, but generally protect against floods smaller than a 5 percent annual chance of exceedance event (20-year).

Water surface elevations 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 flapgates) 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 flapgates 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 167,000 people reside along the Missouri River floodplain with the majority of these populations living in the lower river, including the cities of Omaha, St. Joseph, Kansas City, and St. Louis. There are over 56,300 residential and 11,400 nonresidential structures in the floodplain. The total estimated value of these structures $23.1

billion. Table 3-58 presents the estimated population, number of structures and value (in thousands) by river reach that could be affected by Missouri River flooding. The Missouri River from Rulo to the mouth of the Missouri River was divided into four reaches: 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 3-58. Population and Estimated Structure Value of the Floodplain by River Reach**

| | | Residential | | Nonresidential | | Total | |
|---|---|---|---|---|---|---|---|
| **Reach** | **Population at Risk** | **Number** | **Value ($000s)** | **Number** | **Value ($000s)** | **Number** | **Value ($000s)** |
| Fort Peck Dam to Garrison Dam | 10,545 | 3,998 | $691,091 | 498 | $302,648 | 4,496 | $993,739 |
| Garrison Dam to Oahe Dam | 18,978 | 6,278 | $1,148,229 | 684 | $436,237 | 6,962 | $1,584,466 |
| Oahe Dam to Big Bend Dam* | N/A | 271 | $39,451 | 9 | $4,931 | 280 | $44,383 |
| Big Bend Dam to Fort Randall Dam* | N/A | 40 | $6,575 | 13 | $3,288 | 53 | $9,863 |
| Fort Randall Dam to Gavins Point Dam | 758 | 651 | $68,204 | 34 | $12,693 | 685 | $80,898 |
| Gavins Point Dam to Rulo | 57,542 | 20,025 | $3,508,481 | 1,995 | $1,631,206 | 22,020 | $5,139,687 |
| St. Joseph Reach | 20,212 | 7,723 | $1,219,678 | 1,569 | $1,260,130 | 9,292 | $2,479,808 |
| Kansas City Reach | 29,550 | 8,354 | $1,662,433 | 4,064 | $6,506,442 | 12,418 | $8,168,875 |
| Boonville Reach | 9,159 | 2,649 | $479,143 | 456 | $265,876 | 3,105 | $745,019 |
| Hermann Reach | 20,261 | 6,376 | $1,371,996 | 2,108 | $2,490,933 | 8,484 | $3,862,929 |
| **Total** | **167,005** | **56,365** | **$10,195,282** | **11,430** | **$12,914,384** | **67,795** | **$23,109,666** |

All values are at the Fiscal Year (FY) 2016 price level.

Sources: National Structure Inventory; FEMA 2006; *USACE 1998a

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 to the nation while the lower river is a major producer of corn and soybeans. The land use and crop patterns for the Missouri River floodplain are summarized in Section 3.10, Land Use and Ownership.

Critical and public infrastructure in the Missouri River floodplain is displayed in Table 3-59. The flood risk management and interior drainage analysis and discussion of effects are detailed in Section 3.12.2, Environmental Consequences, and the report “Flood Risk Management Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**Table 3-59. Infrastructure in the Missouri River Floodplain**

| Infra-structure 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 Enforcemen t | 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 |
| 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

### Tribal Reservations

The Missouri River floodplain is also home to several Tribal reservations. The population and structures at risk for all of the Tribal reservations in the Missouri River floodplain are listed in Table 3-60.

**Table 3-60. Population and Structure Value at Risk for Tribal Reservations**

| Tribal Reservation | Population at Risk | Residential | | Nonresidential | | Total | |
|---|---|---|---|---|---|---|---|
| | | Number | Value ($000s) | Number | Value ($000s) | Number | Value ($000s) |
| All Tribal Reservations | 623 | 193 | $25,177 | 6 | $2,910 | 199 | $28,028 |

All values are at the FY 2016 price level.

Sources: National Structure Inventory, FEMA 2006

## 3.12.2 Environmental Consequences

The Missouri River floodplain is comprised of approximately 3.6 million acres, including more than 1.7 million in agricultural production, with approximately 167,000 people and 68,000 structures that could be affected by Missouri River flooding. 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. A detailed description of the methodology and results is provided in the report “Flood Risk Management Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

### 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 overall methodology for evaluating impacts to flood risk as well as the approach for each account.

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 the patterns of flooding (beneficially or adversely), such as the frequency of flooding, depths of inundation, and extent and duration of flooding. Alterations in the patterns of flooding 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 analyze flood impacts. 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.

### 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 model (HEC-FIA) was used to compute property damages and agricultural losses for the 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 losses to crops 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 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 costs 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 (sandbagging, for example), 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 emergency costs are equivalent to a maximum of nine percent of physical flood damages. A detailed description of the NED analysis including data sources and assumptions can be found in the report “Flood Risk Management Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

### 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 $250,000 in annual damages in the worst case years compared to No Action. Because there would be negligible change in regional economic conditions in these reaches, no RED evaluation was undertaken. The RED impacts associated with agricultural losses, including employment, labor income and sales, were estimated for six of the eight regions using IMPLAN® Pro, 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 agriculture industry. 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 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. The HEC-FIA model was used to determine impacts to 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 and it includes people permanently residing in the area, as well as workers, customers of area businesses, and people traveling through the area. Flood risk impacts to critical infrastructure, such as public utilities and bridges, were also determined in the HEC-FIA model. The critical infrastructure inventory was imported from the Homeland Security Infrastructure Program Gold database developed by the National Geospatial-Intelligence Agency.

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. Areas identified in the HEC-FIA model showing substantial flood damage or persons at risk, were analyzed for changes in incidences of flooding impacts on disproportionately minority or poor communities.

**Channel Capacity**

In addition to the aforementioned impact assessment methodologies, the frequency of the releases of the alternatives at channel capacity in the inter-reservoir reaches was compared. As described in Section 3.2.1.3 the channel capacity was estimated as a range because the actual capacity varies depending on the amount of aggradation or degradation which occurs due to periods of low or high runoff. 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.

## 3.12.3 Environmental Consequences: Flood Risk Management

### 3.12.3.1 Summary of Environmental Consequences

The environmental consequences relative to flood risk management are summarized in Table 3-61.

**Table 3-61. Environmental Consequences Relative to Flood Risk Management**

| Alternative | NED Impacts | RED Impacts | OSE Impacts | Summary of Impacts |
|---|---|---|---|---|
| Management Actions Common to All Alternatives (human restriction measures, vegetation management, predator management, pallid sturgeon propagation and augmentation) | No NED impacts. | No RED impacts. | No OSE impacts. | No Impacts to flood risk management. |
| No Action | The No Action alternative has expected average annual NED impacts totaling $60,958,002. | Jobs impacted in all locations from agricultural damages range from 2 to 3,444, with an average annual of 281 jobs impacted.<br>Labor income reductions in all locations from agricultural damages ranges from $142 K to $162.8 M, with an average annual of $13.5 M.<br>Large adverse impacts to RED in years with flooding. | Average Annual Population at Risk (PAR): 709<br>Maximum PAR: 12,643 | Baseline. |
| Alternative 2 | Average annual decrease in flood risk management NED impacts of $691,039 relative to No Action.<br>(Range of annual differences $45,290,008 decrease to $21,191,302 increase) | Average annual reduction of 2 jobs and $66 K in labor income.<br>Negligible to small RED impacts from agricultural and structural damages relative to No Action. | Average Annual PAR: 703<br>Maximum PAR: 12,333 | Alternative 2 would have a beneficial flood risk management impacts compared to No Action. |

| Alternative | NED Impacts | RED Impacts | OSE Impacts | Summary of Impacts |
|---|---|---|---|---|
| Alternative 3 | Average annual decrease in flood risk management NED impacts of $483,245 relative to No Action.<br>(Range of annual differences $10,690,694 decrease to $4,289,852 increase) | Average annual reduction of 0 jobs and $8 K in labor income.<br>Negligible RED impacts from agricultural and structural damages relative to No Action. | Average Annual PAR: 700<br>Maximum PAR: 12,674 | Alternative 3 would have a beneficial flood risk management impacts compared to No Action. |
| Alternative 4 | Average annual increase in flood risk management NED impacts of $963,927 relative to No Action.<br>(Range of annual differences $21,100,354 decrease to $48,648,261 increase) | Average annual increase of 0 jobs and $39 K in labor income.<br>Negligible RED impacts from agricultural and structural damages relative to No Action. | Average Annual PAR: 734<br>Maximum PAR: 12,722 | Alternative 4 would have adverse flood risk management impacts compared to No Action. |
| Alternative 5 | Average annual decrease in flood risk management NED impacts of $287,224 relative to No Action.<br>(Range of annual differences $14,529,339 decrease to $15,413,088 increase) | Average annual increase of 0 jobs and $27 K in labor income.<br>Negligible RED impacts from agricultural and structural damages relative to No Action. | Average Annual PAR: 701<br>Maximum PAR: 12,707 | Alternative 5 would have a beneficial flood risk management impacts compared to No Action. |
| Alternative 6 | Average annual increase in flood risk management NED impacts of $505,250 relative to No Action.<br>(Range of annual differences $11,215,725 decrease to $17,562,409 increase) | Average annual increase of 1 jobs and $57 K in labor income.<br>Negligible RED impacts from agricultural and structural damages relative to No Action. | Average Annual PAR: 709<br>Maximum PAR: 12,687 | Alternative 6 would have adverse flood risk management impacts compared to No Action. |

The simulated frequencies of releases which equal or exceed channel capacity are summarized in Table 3-62 for each alternative.

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 and when implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue release over the wide range of hydrologic conditions in the period of record. 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 3-62. Frequency of Releases Simulated to Equal or Exceed Channel Capacity**

| | Fort Peck Dam - Lake Sakakawea (35–40 kcfs) | | Bismarck-Lake Oahe (35–40 kcfs) | | Fort Randall Dam - Lewis and Clark (35–40 kcfs) | | Gavins Point Dam (80–85 kcfs) | |
|---|---|---|---|---|---|---|---|---|
| | # of days in POR exceeding average of the channel capacity range | Difference from No Action | # of days in POR exceeding average of the channel capacity range | Difference from No Action | # of days in POR exceeding average of the channel capacity range | Difference from No Action | # of days in POR exceeding average of the channel capacity range | Difference from No Action |
| No Action | 22 | | 1,095.5 | | 4306 | | 90.5 | |
| Alternative 2 | 22 | 0 | 1,112 | 16.5 | 4997 | 691 | 144 | 53.5 |
| Alternative 3 | 22 | 0 | 1,104 | 8.5 | 4316.5 | 10.5 | 84.5 | −6 |
| Alternative 4 | 22 | 0 | 1,468 | 372.5 | 4538.5 | 232.5 | 87.5 | −3 |
| Alternative 5 | 16.5 | −5.5 | 1,382 | 286.5 | 4434.5 | 128.5 | 84.5 | −6 |
| Alternative 6 | 22 | 0 | 1,096 | 0.5 | 4526 | 220 | 87.5 | −3 |

### 3.12.3.2 Impacts from Management Actions Common to All Alternatives

A number of management actions are common to all alternatives. These include pallid sturgeon propagation and augmentation, predator management, vegetative management, and human restrictions measures. These actions do not affect river stage and would not impact flood risk management.

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

The No Action Alternative represents the continuation of current system operation and implementation of the Missouri River Recovery Program. It is considered the baseline against which the other alternatives are measured. As noted in Section 3.1.1., modeling results of the No Action alternative do not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

The NED value for No Action 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 No Action provides important context, the estimated differences between each of the action alternatives and No Action 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 habitat, No Action was modeled with the assumption of an additional total 3,999 acres distributed from Ponca, Nebraska to the Osage River confluence in Missouri. Generally, these actions involve physical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect river infrastructure, these actions are assessed as not likely to impact flood-risk because each project will be designed to comply with Executive Order 11988, Floodplain Management, as well as not impact other authorized purposes. 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 through technical analysis and coordination with local floodplain management authorities. As with the BSNP, the 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, the USACE works with the affected levee district to develop and implement a corrective plan.

For ESH, an average of 107 acres per year would be constructed distributed 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 No Action is summarized in Table 3-63. The individual reach impacts 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 No Action, the Missouri River floodplain would incur average annual flood damages of $60,958,002. However, the magnitude of these impacts would vary considerably from year to year as a result of the natural hydrologic cycles of precipitation and snow pack. 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 No Action. These impacts would be much greater without operation of the reservoir system. The average annual impacts would be higher in the lower river than in the upper river in large part due to the greater amount of property located below Gavins Point Dam.

**Table 3-63. Summary of Damages for No Action**

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts |
|---|---|---|---|---|
| **Missouri River** | **$41,502,897** | **$3,735,261** | **$15,719,844** | **$60,958,002** |
| **Upper River** | **$6,627,700** | **$596,493** | **$493,092** | **$7,717,285** |
| Fort Peck Dam to Garrison Dam | $1,002,582 | $90,232 | $357,245 | $1,450,059 |
| Garrison Dam to Oahe Dam | $4,836,548 | $435,289 | $17,523 | $5,289,360 |
| Fort Randall Dam to Gavins Point Dam | $788,570 | $70,971 | $118,324 | $977,865 |
| **Lower River** | **$34,875,197** | **$3,138,768** | **$15,226,753** | **$53,240,717** |

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts |
|---|---|---|---|---|
| Gavins Point Dam to Rulo | $13,966,529 | $1,256,988 | $6,357,090 | $21,580,606 |
| St. Joseph Reach | $3,087,416 | $277,867 | $1,199,284 | $4,564,567 |
| Kansas City Reach | $4,096,370 | $368,673 | $3,764,642 | $8,229,686 |
| Boonville Reach | $3,103,382 | $279,304 | $1,268,813 | $4,651,500 |
| Hermann Reach | $10,621,500 | $955,935 | $2,636,924 | $14,214,359 |

Note: All totals are average annual at the FY 2016 price level.

### Land Use Sensitivity Analysis

A change in the land use and management, such as a change in the amount of agricultural land that could be affected by flooding, may have implications for the national economy. An initial step in the evaluation was to obtain the number of acres anticipated to be required to support the target habitat creation under the MRRMP-EIS alternatives over the 15-year implementation period. Based on past pallid sturgeon SWH projects, the USACE estimated that an average of 7.7 acres of land would be required for every 1 acre of pallid sturgeon habitat construction footprint. Because agriculture is a dominant land use in the rural portions of the Missouri River floodplain, many of the private landowners that sell their lands to the USACE are farmers and agricultural producers. A conservative assumption that most lands acquired by the federal government were in agricultural production was used to capture the effect of land acquisition on overall flood risk. For No Action, the estimated land acquisition was 7,046 acres in the lower river. Currently, there are an estimated 1,531,228 acres in agricultural production in the lower river. This means the amount of agricultural land that could be affected by flooding and the estimated flood damages could be up to 0.7 percent less in the lower river than the agricultural flood damages shown in Table 3-63, if the land is taken out of agricultural production.

### 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 3-64 summarizes the economic impacts for each of the regions. Under current system management, agricultural flood losses would result in annual average loss of between 1 and 46 jobs, and between $49,000 and $2.4 million in labor income depending on the region impacted. Three regions tend to experience the largest impacts under No Action: Gavins Point Dam to Rulo, Kansas City Reach, and Hermann Reach. Relatively high water or flooding years, such as those that occurred with conditions similar to 1951, 1984, 1986, 1993, and 2011, would account for the largest economic impacts from agricultural losses. These flooding effects are a result of the natural hydrologic cycles of precipitation and snow pack and not from the management actions under No Action. 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, although adverse impacts from agricultural losses in the Fort Randall to Gavins Point Dam reach would be small to negligible.

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

- Campbell County, South Dakota (Garrison Dam to Oahe Dam)
- Woodbury County, Iowa (Gavins Point Dam to Rulo)
- Cass County, Nebraska (Gavins Point Dam to Rulo)
- Callaway, Osage, St. Charles, St. Louis counties in Missouri (Hermann Reach)
- Holt County, Missouri (Gavins Point Dam to Rulo reach and St. Joseph Reach)
- Jersey and Madison counties in Illinois (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 3-64. RED Effects Associated with Agricultural Damage: No Action, 2016 Dollars**

| | Jobs | | | Labor Income | | | Sales | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Average over 82 years | Agricultural Damage Year | | Annual Average over 82 years | Agricultural Damage Year | | Annual Average over 82 years | Agricultural Damage Year | |
| | | Maximum | Minimum | | Maximum | Minimum | | Maximum | Minimum |
| **Missouri River** | **140** | **1,724** | **1** | **$6,795,000** | **$81,560,000** | **$72,000** | **$28,716,000** | **$343,929,000** | **$313,000** |
| **Upper River** | **1** | **4** | **—** | **$49,000** | **$314,000** | **$2,000** | **$183,000** | **$1,179,000** | **$6,000** |
| Fort Randall Dam to Gavins Point Dam | 1 | 4 | — | $49,000 | $314,000 | $2,000 | $183,000 | $1,179,000 | $6,000 |
| **Lower River** | **139** | **1,720** | **1** | **$6,746,000** | **$81,246,000** | **$70,000** | **$28,533,000** | **$342,750,000** | **$307,000** |
| Gavins Point Dam to Rulo | 38 | 399 | 1 | $2,383,000 | $25,248,000 | $55,000 | $10,521,000 | $111,454,000 | $244,000 |
| St. Joseph Reach | 8 | 68 | — | $495,000 | $4,409,000 | $1,000 | $2,020,000 | $18,010,000 | $3,000 |
| Kansas City Reach | 36 | 568 | — | $1,469,000 | $23,390,000 | $3,000 | $6,077,000 | $96,730,000 | $13,000 |
| Boonville Reach | 12 | 299 | — | $501,000 | $12,320,000 | $1,000 | $2,072,000 | $50,923,000 | $4,000 |
| Hermann Reach | 46 | 386 | — | $1,898,000 | $15,879,000 | $10,000 | $7,843,000 | $65,633,000 | $43,000 |

Note: All totals are average annual at the FY 2016 price level.

### 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 health, safety, and economic vitality. Table 3-65 shows the population at risk totals under No Action. Average annual population at risk is 218 in the upper river and 490 in the lower river. The largest modeled flood events, showed that more than 6,500 people in the lower river and nearly 6,400 people in the upper river could be affected by Missouri River flooding.

**Table 3-65. Population at Risk under No Action**

| River Reach | Maximum PAR | Average Annual PAR |
|---|---|---|
| **Missouri River** | **12,643** | **709** |
| **Upper River** | **6,356** | **218** |
| Fort Peck Dam to Garrison Dam | 350 | 51 |
| Garrison Dam to Oahe Dam | 5,794 | 157 |
| Fort Randall Dam to Gavins Point Dam | 212 | 11 |
| **Lower River** | **6,548** | **490** |
| Gavins Point Dam to Rulo | 5,269 | 217 |
| St. Joseph Reach | 731 | 62 |
| Kansas City Reach | 1,360 | 67 |
| Boonville Reach | 1,197 | 42 |
| Hermann Reach | 1,862 | 103 |

Six hundred census block groups intersect the Missouri River floodplain, of which 186 contain potential environmental justice populations. The largest impacts to populations with potential environmental justice concerns under No Action would occur to a census block group in Woodbury County, IA with a high proportion of minority residents and to census block groups in Jackson and St. Louis counties in Missouri with a high proportion of low-income and minority residents.

In addition to determining impacts to the population, HEC-FIA was used to determine the critical infrastructure that would be impacted during flood events. Table 3-66 lists the type and quantity of critical infrastructure that would be impacted under the largest modeled flood event in the 82-year POR for No Action. While the impacts on average would be less, the table provides an indication of the infrastructure impacted under the worst-case scenario.

**Table 3-66. Critical Infrastructure Impacted under No Action**

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Agricultural Facilities | 6 | 3 |
| Chemical Industries | 13 | 4 |
| Communication Towers | 3 | 0 |
| Educational Schools | 1 | 1 |

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Emergency – EMS | 4 | 0 |
| Emergency – Fire Stations | 6 | 0 |
| Emergency – National Shelters | 2 | 2 |
| Energy – Plants | 6 | 0 |
| Energy – Propane Locations | 8 | 3 |
| Energy – Substations | 14 | 8 |
| Law Enforcement | 3 | 0 |
| Mail – USPS | 11 | 1 |
| Manufacturing Plants | 10 | 1 |
| Public – Campgrounds | 2 | 0 |
| Public – Libraries | 2 | 0 |
| Public – Parks | 29 | 0 |
| Public – Worship | 1 | 1 |
| Transportation – Airports | 19 | 0 |
| Transportation – Bridges | 564 | 18 |
| Transportation – Ports | 122 | 0 |
| Wastewater Treatment Plants | 2 | 0 |

**Conclusion**

The No Action Alternative represents the continuation of current system operation and implementation of the Missouri River Recovery Program. It primarily serves as a reference condition allowing for a comparison of the action alternatives. Under No Action, the Missouri River floodplain would incur average annual flood impacts of $60,958,002. However, the magnitude of these impacts would vary 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 No Action. In the RED analysis three regions tend to experience the largest impacts under No Action: Gavins Point Dam to Rulo, Nebraska; Kansas City Reach, and Hermann Reach. No Action is not anticipated to cause significant impacts to flood risk management because these flooding effects are 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.

Additionally, the simulated frequency of releases equal to or exceeding channel capacity in the inter-reservoir reaches (Table 3-62) are primarily the result of floodwater evacuation to insure flood storage capacity in the reservoirs. Therefore, these releases are not considered significant.

### 3.12.3.4 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 actions that USFWS anticipates would be implemented under adaptive management.

Under Alternative 2, flood risk management would experience relatively small beneficial impacts relative to No Action. These impacts would be due to lower water surface elevations under large flood events relative to No Action, particularly in the lower river. On average these impacts are relatively small in nature but there are some years when the flood impacts are 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 habitat, Alternative 2 was modeled with the assumption of a total 10,758 acres of additional acres distributed from Ponca, Nebraska to the Mississippi River confluence near St. Louis, MO. Despite the higher acreages under Alternative 2 as compared to No Action, no impacts to flood risk management are anticipated because the same impact avoidance measures described under No Action apply.

For ESH, an average of 3,546 acres per year would be constructed 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 unique adverse impacts that are not experienced 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 River 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 3-67. Flood impacts along the Missouri River would be on average $691,039 less annually relative to No Action. This represents an overall decrease in NED impacts in relation to No Action of 1.1 percent. The reduction in NED impacts, specifically structure and content damages, in the lower river is driving the overall total as the upper river would actually experience a slight increase in NED impacts compared to No Action.

**Table 3-67. Summary of National Economic Development Analysis for Alternative 2**

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Average Annual NED Impacts | | % Change from No Action |
|---|---|---|---|---|---|---|
| | | | | Total | Change from No Action | |
| **Missouri River** | **$41,015,909** | **$3,691,432** | **$15,559,622** | **$60,266,963** | **−$691,039** | **−1.1%** |
| **Upper River** | **$6,684,763** | **$601,629** | **$483,857** | **$7,770,249** | **$52,965** | **0.7%** |
| Fort Peck Dam to Garrison Dam | $1,011,195 | $91,008 | $356,737 | $1,458,940 | $8,881 | 0.6% |

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Average Annual NED Impacts | | % Change from No Action |
|---|---|---|---|---|---|---|
| | | | | Total | Change from No Action | |
| Garrison Dam to Oahe Dam | $4,813,769 | $433,239 | $17,688 | $5,264,696 | −$24,664 | −0.5% |
| Fort Randall Dam to Gavins Point Dam | $859,800 | $77,382 | $109,432 | $1,046,613 | $68,748 | 7.0% |
| **Lower River** | **$34,331,146** | **$3,089,803** | **$15,075,765** | **$52,496,714** | **−$744,004** | **−1.4%** |
| Gavins Point Dam to Rulo | $14,114,127 | $1,270,271 | $6,419,053 | $21,803,451 | $222,845 | 1.0% |
| St. Joseph Reach | $2,891,620 | $260,246 | $1,187,452 | $4,339,318 | −$225,249 | −4.9% |
| Kansas City Reach | $3,966,606 | $356,994 | $3,617,012 | $7,940,612 | −$289,073 | −3.5% |
| Boonville Reach | $3,070,153 | $276,314 | $1,262,928 | $4,609,394 | −$42,106 | −0.9% |
| Hermann Reach | $10,288,641 | $925,978 | $2,589,320 | $13,803,939 | −$410,420 | −2.9% |

Note: All totals are average annual in the FY 2016 price level. Negative numbers indicate a decrease in NED impacts relative to No Action.

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 No Action in the lower river varied from a $20,429,493 increase for Alternative 2 to a $45,355,113 decrease. The largest lower river impacts would occur in the Hermann Reach, which would experience an annual reduction in impacts of $410,420 under Alternative 2. The upper river impacts would be more modest with annual range of modeled impacts relative to No Action varying from a $1,117,530 increase to a $1,152,191 decrease for Alternative 2.

Additional results are summarized in Table 3-68. This table 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 10 simulated years with a full flow release plus low summer flow action. In the upper river, Alternative 2 showed NED impacts greater than No Action in 9 out of 10 of these years with the largest increase being $469,786. For the lower river, the modeled results were more mixed with 6 years showing adverse impacts and 4 years with beneficial impacts, relative to No Action. The largest modeled increase relative to No Action in the lower river was $2,078,302, while the largest decrease was $2,317,517. On average, the modeled full flow release plus low summer flow events showed an increase of $496,025 in NED impacts over No Action in the lower river.

In addition to full flow release actions, there were 44 simulated years with partial flow releases. In the upper river, these actions appear to have much less NED impact than the full releases and the average annual difference would be a $21,652 increase in NED impacts over No Action. In the lower river, the average of the partial flow release action impacts were significantly shaped by the 1993 simulated event, which showed a $45,355,113 reduction in NED impacts compared to No Action including a $26,903,478 decrease in the Hermann Reach alone. The partial flow modeled years in the lower river showed an average annual decrease of $999,140.

**Table 3-68. Impacts from Modeled Flow Releases under Alternative 2 Compared to No Action**

| Change in $ from No Action 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 NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| **Missouri River** | **$2,049,094** | **$2,548,089** | **$45,290,008** | **$8,778,280** | **$45,290,008** | **$21,191,302** |
| **Upper River** | **$898,624** | **$469,786** | **$1,152,191** | **$1,117,530** | **$1,152,191** | **$1,117,530** |
| Fort Peck to Garrison | $5,209 | $9,395 | $57,367 | $48,967 | $57,367 | $333,774 |
| Garrison to Oahe | $43,961 | $16,475 | $1,050,436 | $578,144 | $1,050,436 | $578,144 |
| Fort Randall to Gavins Point | $894,074 | $478,813 | $1,096,821 | $1,147,423 | $1,096,821 | $1,147,423 |
| **Lower River** | **$2,317,517** | **$2,078,302** | **$45,355,113** | **$8,489,944** | **$45,355,113** | **$20,429,493** |
| Gavins Point to Rulo | $694,801 | $1,942,429 | $6,782,219 | $5,855,589 | $13,787,222 | $21,086,103 |
| St. Joseph Reach | $812,562 | $153,826 | $3,789,198 | $2,809,402 | $3,789,198 | $2,809,402 |
| Kansas City Reach | $949,495 | $119,692 | $4,171,140 | $413,030 | $4,171,140 | $413,030 |
| Boonville Reach | $128,449 | $110,939 | $5,348,443 | $1,479,722 | $5,348,443 | $1,583,912 |
| Hermann Reach | $1,430,375 | $501,217 | $26,903,478 | $8,074,436 | $26,903,478 | $8,074,436 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 44 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

c The reach totals are from a mixture of years, thus the Missouri River, upper river, and lower river values are not cumulative totals of the individual reaches.

### Land Use Sensitivity Analysis

As mentioned under the No Action analysis, a change in the land use and management, such as a change in the amount of agricultural land that could be affected by flooding, may have implications for the national economy. For Alternative 2, the estimated land acquisition was 45,717 acres in the lower river. Currently, there are an estimated 1,531,228 acres in agricultural production in the lower river. If all of the acquired lands were previously in agricultural production, this means the amount of agricultural land that could be affected by flooding and the estimated agricultural losses in the lower river could be up to 3.0 percent less than the agricultural losses shown in Table 3-68.

### Regional Economic Development

On average, the change in regional economic conditions would be negligible across all regions. Under Alternative 2, agricultural flood losses would result in a change of less than two average annual jobs across all locations, while average labor income would range from an increase of $57,000 in the Kansas City reach to a reduction of $29,000 in the Gavins Point Dam to Rulo reach relative to No Action. Under the eight worst years relative to No Action, three regions tend to experience the largest impacts: Gavins Point Dam to Rulo, Kansas City Reach, and Hermann Reach. In these regions, there would be on average four to eight fewer jobs and $180,000 to $530,000 in less labor income compared to No Action. The impacts during the eight worst years relative to No Action would result in negligible to small adverse impacts to regional economic conditions. Table 3-107 summarizes the differences in economic impacts for each of the flood risk management regions under Alternative 2 relative to No Action.

The counties that would have the largest increase in structural damages under Alternative 2 compared to No Action, with over $10 million increase in total damages over 82 years in each county and between $150,000 and $850,000 increase on average per county, are the following:

- Hughes and Walworth counties in South Dakota (Garrison Dam to Oahe Dam)
- Woodbury County, Iowa (Gavins Point Dam to Rulo)
- Holt County, Missouri (Gavins Point Dam to Rulo and St. Joseph Reach)

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 No Action.

**Table 3-69. RED Impacts Associated with Agricultural Damage under Alternative 2 and Compared to No Action, 2016 Dollars**

| River Reach | Change in Jobs | | | Change in Labor Income | | | Change in Sales | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual Average | 8 worst years relative to No Action (average annual) | Change in 8 best years relative to No Action (average annual) | Annual average (average annual) | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) |
| **Missouri River** | **−2** | **24** | **−20** | **−$64,000** | **$1,251,000** | **−$1,163,000** | **−$257,000** | **$5,286,000** | **−$5,008,000** |
| **Upper River** | **0** | **1** | **−1** | **−$4,000** | **$66,000** | **−$45,000** | **−$14,000** | **$247,000** | **−$168,000** |
| Fort Randall Dam to Gavins Point Dam | 0 | 1 | −1 | −$4,000 | $66,000 | −$45,000 | −$14,000 | $247,000 | −$168,000 |
| **Lower River** | **−2** | **23** | **−19** | **−$60,000** | **$1,185,000** | **−$1,118,000** | **−$243,000** | **$5,039,000** | **−$4,840,000** |
| Gavins Point Dam to Rulo | 0 | 8 | −13 | $29,000 | $533,000 | −$807,000 | −$125,000 | $2,354,000 | −$3,561,000 |
| St. Joseph Reach | 0 | 2 | −2 | −$5,000 | $111,000 | −$115,000 | −$19,000 | $452,000 | −$469,000 |
| Kansas City Reach | −1 | 7 | −2 | −$57,000 | $278,000 | −$62,000 | −$238,000 | $1,149,000 | −$256,000 |
| Boonville Reach | 0 | 2 | −1 | −$8,000 | $79,000 | −$39,000 | −$34,000 | $325,000 | −$163,000 |
| Hermann Reach | −1 | 5 | −2 | −$19,000 | $184,000 | −$95,000 | −$77,000 | $759,000 | −$391,000 |

Note: Positive values indicate decreases in RED impacts (employment and income) compared to No Action, while negative values indicate increase in RED impacts compared to No Action.

### Other Social Effects

For Alternative 2, the greatest changes in PAR relative No Action would range from a 560-person decrease to a 669-person increase for the lower river. In the upper river, the PAR differential relative to No Action would range from a 21-person decrease to a 40-person increase. Table 3-70 shows the PAR under Alternative 2.

**Table 3-70. Population at Risk under Alternative 2**

| River Reach | Maximum PAR | Average Annual PAR | Maximum Increase Relative to No Action | Maximum Decrease Relative to No Action |
|---|---|---|---|---|
| **Missouri River** | **12,333** | **703** | **709** | **560** |
| **Upper River** | **6,389** | **221** | **40** | **21** |
| Fort Peck Dam to Garrison Dam | 383 | 51 | 33 | 4 |
| Garrison Dam to Oahe Dame | 5,794 | 157 | 34 | 12 |
| Fort Randall Dam to Gavins Point Dam | 212 | 12 | 29 | 21 |
| **Lower River** | **5,988** | **483** | **669** | **560** |
| Gavins Point Dam to Rulo | 4,967 | 217 | 674 | 302 |
| St. Joseph Reach | 714 | 62 | 55 | 19 |
| Kansas City Reach | 1,244 | 64 | 78 | 116 |
| Boonville Reach | 1,174 | 41 | 21 | 23 |
| Hermann Reach | 1,540 | 98 | 127 | 322 |

In addition to population at risk, impacts to census block groups with potential environmental justice populations were evaluated for Alternative 2. The census block group 191930036004 in Woodbury County, Iowa, with a high proportion of minority residents was identified as potentially having disproportionate impacts as it accounts for over 150 percent of the modeled NED impact increase under Alternative 2 in the Gavins Point to Rulo reach. The census block group 291892101003 in St. Louis County, Missouri with a high proportion of low-income and minority residents was also identified as experiencing adverse impacts relative to the Hermann Reach under Alternative 2; however these impacts were considered to be small in nature and not disproportional.

Table 3-71 lists the type and quantity of critical infrastructure that would be impacted according to the largest modeled flood event during the POR for both the lower and upper 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.

**Table 3-71. Critical Infrastructure Impacted under Alternative 2**

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Agricultural Facilities | 5 | 3 |
| Chemical Industries | 13 | 4 |
| Communication Towers | 3 | 0 |

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Educational Schools | 1 | 1 |
| Emergency – EMS | 4 | 0 |
| Emergency – Fire Stations | 5 | 0 |
| Emergency – National Shelters | 2 | 2 |
| Energy – Plants | 5 | 0 |
| Energy – Propane Locations | 8 | 3 |
| Energy – Substations | 12 | 8 |
| Law Enforcement | 2 | 0 |
| Mail – USPS | 11 | 1 |
| Manufacturing Plants | 10 | 1 |
| Public – Campgrounds | 2 | 0 |
| Public – Libraries | 2 | 0 |
| Public – Parks | 27 | 0 |
| Public – Worship | 1 | 1 |
| Transportation – Airports | 19 | 0 |
| Transportation – Bridges | 558 | 18 |
| Transportation – Ports | 122 | 0 |
| Wastewater Treatment Plants | 2 | 0 |

### Conclusion

Under Alternative 2, flood risk management would experience relatively small beneficial impacts relative to No Action. These impacts would be due to lower water surface elevations under large flood events relative to No Action, particularly in the lower river. On average these impacts are relatively small in nature but there are some years when the flood impacts would be of greater magnitude, especially in the lower river. There would be an overall decrease in NED impacts in relation to No Action of 1.1 percent. The reduction in NED impacts, specifically structure and content damages in the lower river, is driving the overall total as the upper river would actually experience a slight increase in NED impacts compared to No Action. The Fort Randall Dam to Gavins Point Dam would experience the largest percentage increase in average annual NED impacts over No Action with an increase of 7 percent. On average, the change in regional economic conditions would be negligible across all regions. Overall, given the high risk of impacts to river stage in the Garrison reach from constructing large amounts of ESH in exclusionary zones and the increase in NED impacts in the Fort Randall reach, significant impacts would be anticipated under Alternative 2.

Additionally, the simulated frequency of releases equal to or exceeding channel capacity in the Fort Randall reach increases substantially from No Action due to the spawning cue release (Table 3-62). Therefore, impacts to adjacent property would be substantially increased, which is considered a significant adverse impact.

### 3.12.3.5 Alternative 3 – Mechanical Construction Only

#### Mechanical Habitat Construction

For early life stage pallid habitat, Alternative 3 was modeled with the assumption that up to 3,380 acres of new IRC habitat would be created from channel widening activities distributed from Sioux City, Iowa to the Mississippi River confluence near St. Louis, Missouri. No impacts to flood risk management are anticipated because the same impact avoidance measures described under No Action apply to Alternative 3.

For ESH, an average of 391 acres per year would be 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 No Action 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 3-72. NED impacts, including agricultural losses, along the Missouri River would be on average $483,245 less annually relative to No Action. This represents an overall decrease in NED impacts of 0.8 percent compared to No Action. The reduction in impacts in the lower river, specifically in the Hermann Reach, is the main driver of the overall reduction. However, the upper river also shows beneficial impacts compared to No Action.

**Table 3-72. Summary of National Economic Development Analysis for Alternative 3**

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| **Missouri River** | **$41,060,104** | **$3,695,409** | **$15,719,244** | **$60,474,757** | **−$483,245** | **−0.8%** |
| **Upper River** | **$6,597,821** | **$593,804** | **$490,175** | **$7,681,801** | **−$35,484** | **−0.5%** |
| Fort Peck Dam to Garrison Dam | $1,002,432 | $90,219 | $356,720 | $1,449,371 | −$688 | 0.0% |
| Garrison Dam to Oahe Dam | $4,828,819 | $434,594 | $17,685 | $5,281,098 | −$8,263 | −0.2% |
| Fort Randall Dam to Gavins Point Dam | $766,571 | $68,991 | $115,770 | $951,332 | −$26,533 | −2.7% |
| **Lower River** | **$34,462,283** | **$3,101,605** | **$15,229,068** | **$52,792,956** | **−$447,761** | **−0.8%** |
| Gavins Point Dam to Rulo | $13,906,721 | $1,251,605 | $6,419,895 | $21,578,221 | −$2,385 | 0.0% |
| St. Joseph Reach | $3,154,791 | $283,931 | $1,218,567 | $4,657,289 | $92,722 | 2.0% |
| Kansas City Reach | $4,039,763 | $363,579 | $3,724,009 | $8,127,351 | −$102,335 | −1.2% |
| Boonville Reach | $3,064,549 | $275,809 | $1,290,395 | $4,630,753 | −$20,746 | −0.4% |
| Hermann Reach | $10,296,458 | $926,681 | $2,576,202 | $13,799,341 | −$415,017 | −2.9% |

Note: All totals are average annual in the FY 2016 price level. Negative numbers indicate a decrease in NED impacts relative to No Action.

When evaluating the NED impacts of each alternative, annual impacts as well as those that occur on average over the POR were examined. Over the modeled POR, Alternative 3 showed a reduction in NED impacts relative to No Action of greater than $1 million in 12 years with the largest decrease being $10,485,047. Comparatively, only 1 year showed the impacts exceeding $1 million relative No Action, which was a $4,124,324 increase. The impacts in the upper river would not be quite as large as those experienced in the lower river. The differences relative to No Action in the upper river would range from a $504,520 increase in NED impacts for Alternative 3 to a $632,482 decrease.

**Land Use Sensitivity Analysis**

As mentioned under the No Action analysis, a change in the land use and management, such as a change in the amount of agricultural land that could be affected by flooding, may have implications for the national economy. For Alternative 3, the additional required acreage needed to be acquired would be 1,772 acres in the lower river. Currently, there are an estimated 1,531,228 acres in agricultural production in the lower river. If all of the acquired lands were previously in agricultural production, this means the amount of agricultural land that could be affected by flooding and the estimated agricultural losses could be up to 0.1 percent less than the lower river agricultural losses shown in Table 3-73.

**Regional Economic Development**

Under Alternative 3, agricultural flood damage would result in a change of less than one average annual job across all locations, while average labor income would range from an increase of $27,000 in the Hermann reach, to a reduction of $24,000 in the Gavins Point Dam to Rulo reach relative to No Action. Under the eight worst years relative to No Action, two regions tend to experience the largest impacts: Kansas City Reach and Hermann Reach. In these regions, there would be two to four fewer jobs and $60,000 to $150,000 less in labor income compared to No Action. The impacts during the eight worst years relative to No Action would result in negligible adverse impacts to regional economic conditions. Table 3-73 summarizes the average annual impacts from agricultural damages and the differences in economic impacts for each of the flood risk management regions under Alternative 3 relative to No Action.

The counties that would have the largest increase in structural damages under Alternative 3 compared to No Action, are the following:

- Cass County, Nebraska: $11.5 million increase in total damages; $141,000 change on average (Gavins Point Dam to Rulo)
- Holt County, Missouri: $37.0 million increase in total damages over 82 years; $451,000 change on average (Gavins Point Dam to Rulo and St. Joseph Reach)

Residences, businesses, farming structures, and transportation facilities would be most affected in Cass and Holt counties, with potentially small RED effects occurring during flooding events relative to No Action.

**Table 3-73. RED Impacts Associated with Agricultural Damage under Alternative 3 Compared to No Action, 2016 Dollars**

| River Reach | Change in Jobs | | | Change in Labor Income | | | Change in Sales | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual average (average annual) | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) |
| **Missouri River** | **−1** | **8** | **−4** | **−$7,000** | **$378,000** | **−$261,000** | **−$26,000** | **$1,562,000** | **−$1,112,000** |
| **Upper River** | **0** | **1** | **−1** | **−$1,000** | **$41,000** | **−$38,000** | **−$4,000** | **$155,000** | **−$144,000** |
| Fort Randall Dam to Gavins Point Dam | 0 | 1 | −1 | −$1,000 | $41,000 | −$38,000 | −$4,000 | $155,000 | −$144,000 |
| **Lower River** | **−1** | **7** | **−4** | **−$6,000** | **$337,000** | **−$223,000** | **−$22,000** | **$1,407,000** | **−$968,000** |
| Gavins Point Dam to Rulo | 0 | 1 | −2 | $24,000 | $60,000 | −$150,000 | $104,000 | $266,000 | −$663,000 |
| St. Joseph Reach | 0 | 1 | −1 | $8,000 | $32,000 | −$37,000 | $33,000 | $130,000 | −$152,000 |
| Kansas City Reach | 0 | 2 | 0 | −$15,000 | $82,000 | −$6,000 | −$66,000 | $337,000 | −$26,000 |
| Boonville Reach | 0 | 0 | −1 | $3,000 | $11,000 | −$29,000 | $11,000 | $44,000 | −$121,000 |
| Hermann Reach | −1 | 4 | 0 | −$27,000 | $152,000 | −$1,000 | −$104,000 | $630,000 | −$6,000 |

Note: Positive values indicate decreases in RED impacts (employment and income) compared to No Action, while negative values indicate increases in RED impacts compared to No Action.

### Other Social Effects

For Alternative 3, the greatest changes in PAR relative No Action would range from a 249-person decrease to a 49-person increase for the lower river. In the upper river, the changes in PAR would range from a 44-person decrease to a 12-person increase. Table 3-74 shows the PAR totals under Alternative 3.

**Table 3-74. Population at Risk under Alternative 3**

| River Reach | Maximum PAR | Average Annual PAR | Maximum Increase Relative to No Action | Maximum Decrease Relative to No Action |
|---|---|---|---|---|
| **Missouri River** | **12,674** | **700** | **31** | **254** |
| **Upper River** | **6,338** | **217** | **12** | **44** |
| Fort Peck Dam to Garrison Dam | 341 | 51 | 3 | 9 |
| Garrison Dam to Oahe Dame | 5,785 | 156 | 12 | 44 |
| Fort Randall Dam to Gavins Point Dam | 212 | 10 | 9 | 12 |
| **Lower River** | **6,406** | **483** | **49** | **249** |
| Gavins Point Dam to Rulo | 5,342 | 215 | 73 | 235 |
| St. Joseph Reach | 732 | 64 | 14 | 5 |
| Kansas City Reach | 1,364 | 66 | 4 | 17 |
| Boonville Reach | 1,200 | 41 | 3 | 5 |
| Hermann Reach | 1,700 | 97 | 0 | 162 |

In addition to population at risk, impacts to census block groups with potential environmental justice populations were evaluated for Alternative 3. The census block group 291892101003 in St. Louis County, Missouri with a high proportion of low-income and minority residents was identified as experiencing adverse impacts relative to the Hermann Reach under Alternative 3; however these impacts were considered small in nature and not disproportional.

Table 3-75 lists the type and quantity of critical infrastructure that would be impacted during the largest modeled flood event in the POR for both the lower and upper 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.

**Table 3-75. Critical Infrastructure Impacted under Alternative 3**

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Agricultural Facilities | 6 | 3 |
| Chemical Industries | 13 | 4 |
| Communication Towers | 3 | 0 |
| Educational Schools | 1 | 1 |
| Emergency – EMS | 4 | 0 |
| Emergency – Fire Stations | 6 | 0 |

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Emergency – National Shelters | 2 | 2 |
| Energy – Plants | 5 | 0 |
| Energy – Propane Locations | 8 | 3 |
| Energy – Substations | 13 | 8 |
| Law Enforcement | 3 | 0 |
| Mail – USPS | 11 | 1 |
| Manufacturing Plants | 10 | 1 |
| Public – Campgrounds | 2 | 0 |
| Public – Libraries | 2 | 0 |
| Public – Parks | 29 | 0 |
| Public – Worship | 1 | 1 |
| Transportation – Airports | 19 | 0 |
| Transportation – Bridges | 566 | 18 |
| Transportation – Ports | 122 | 0 |
| Wastewater Treatment Plants | 2 | 0 |

**Conclusion**

Under Alternative 3, the NED impacts, including agricultural losses, along the Missouri River would be on average $483,245 less annually relative to No Action. This represents an overall decrease in NED impacts of 0.8 percent compared to No Action. The reduction in impacts in the lower river, specifically in the Hermann Reach, is the main driver of the overall reduction. However, the upper river also shows beneficial impacts compared to No Action. The RED impacts would be negligible including consideration of the eight worst years relative to No Action. No significant impacts to flood risk management are anticipated under Alternative 3.

Additionally, the simulated frequency of releases equal to or exceeding channel capacity in the inter-reservoir reaches is not substantially different from No Action (Table 3-62) because there are no species flow releases. Therefore, impacts to adjacent property would be minimized and no significant impacts are expected.

### 3.12.3.6 Alternative 4 – Spring ESH Creating Release

**Mechanical Habitat Construction**

No impact would be anticipated from early life stage pallid habitat construction. Alternative 4 was modeled with the same acreages as Alternative 3 with the same distribution and application of the same site-specific impact avoidance measures.

For ESH, an average of 240 acres per year would be constructed 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 No Action are applicable to Alternative 4. All ESH would be sited within available areas of the river.

### National Economic Development

The NED analysis for Alternative 4 is summarized in Table 3-76. Under Alternative 4, the NED impacts along the Missouri River would be greater on average by $963,927 annually relative to No Action. This represents an overall increase in relation to No Action of 1.6 percent. The increase in NED impacts would be driven predominately by greater structure damages in the upper river, but the lower river would also experience a slight increase in impacts compared to No Action. The most notable reach impacted was Garrison Dam to Oahe Dam, which would have a 13.6 percent increase in NED impacts under Alternative 4.

**Table 3-76. Summary of National Economic Development Analysis for Alternative 4**

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| **Missouri River** | **$42,319,467** | **$3,808,752** | **$15,793,710** | **$61,921,929** | **$963,927** | **1.6%** |
| **Upper River** | **$7,351,642** | **$661,648** | **$490,452** | **$8,503,743** | **$786,458** | **10.2%** |
| Fort Peck Dam to Garrison Dam | $1,011,786 | $91,061 | $362,145 | $1,464,993 | $14,933 | 1.0% |
| Garrison Dam to Oahe Dam | $5,498,696 | $494,883 | $17,642 | $6,011,221 | $721,860 | 13.6% |
| Fort Randall Dam to Gavins Point Dam | $841,160 | $75,704 | $110,665 | $1,027,529 | $49,664 | 5.1% |
| **Lower River** | **$34,967,825** | **$3,147,104** | **$15,303,258** | **$53,418,187** | **$177,469** | **0.3%** |
| Gavins Point Dam to Rulo | $14,344,091 | $1,290,968 | $6,522,465 | $22,157,524 | $576,918 | 2.7% |
| St. Joseph Reach | $3,056,098 | $275,049 | $1,205,424 | $4,536,571 | −$27,996 | −0.6% |
| Kansas City Reach | $4,044,454 | $364,001 | $3,700,608 | $8,109,063 | −$120,623 | −1.5% |
| Boonville Reach | $3,056,851 | $275,117 | $1,283,694 | $4,615,661 | −$35,839 | −0.8% |
| Hermann Reach | $10,466,331 | $941,970 | $2,591,067 | $13,999,368 | −$214,991 | −1.5% |

Notes: All totals are at the FY 2016 price level. Negative numbers indicate a decrease in NED impacts relative to No Action.

The annual analysis shows a notable increase in NED impacts in the Garrison Dam to Oahe Dam reach under the 1950 modeled event. This modeled event would result in a $20.2 million increase in NED impacts over No Action in the reach. Additionally, in 9 of the 82 modeled years, NED impacts in the upper river under Alternative 4 would increase by more than $1 million over those experienced under No Action. Comparatively, only 1 year would experience a decrease of more than $1 million relative to No Action. While the net NED impacts would be less in the lower river, the range of impacts would still be sizable relative to No Action. In the 82-year POR, 12 simulated years would show a reduction in NED impacts of over $1 million for Alternative 4, relative to No Action, compared to 18 years that would experience an increase in impacts of over $1 million. Relative to No Action, the modeled range of NED impacts would vary in the upper river from a $41,037,774 increase to a $1,980,127 decrease for Alternative 4. In the lower

river, the range of modeled impacts varied from a $9,023,701 increase to a $20,735,531 decrease for Alternative 4.

Additional results in Table 3-77 show the difference in annual flood damages during years when there is a full or partial flow release action. During the POR, there were 10 modeled years with a full flow release action. In both the upper and lower river, all 10 of these simulated years had adverse impacts relative to No Action. The maximum NED impact increase in the lower river would be $9,023,701 relative to No Action, while the largest NED impact increase in the upper river would be $4,410,093. On average, a full flow release action would have an increase in NED impacts over No Action of $1,520,974 and $3,936,942 in the upper and lower river, respectively.

In addition to full flow release actions, there were five modeled years with partial flow releases. Four of the five partial release years in the upper river and all five in the lower river would experience an increase in NED impacts over No Action. Under Alternative 4, in the upper river, the partial flow release action noticeably impacted the 1950 simulated event, which showed an increase in NED impacts of $41,037,774 compared to No Action. In the lower river, the range of increases in impacts relative to No Action associated with Alternative 4 partial flow releases would vary from $319,657 to $8,929,343.

**Table 3-77. Impacts from Modeled Flow Releases under Alternative 4 Compared to No Action**

| Change in $ from No Action by River Reach[c] | Full Flow Release[a] | | Partial Flow Release[b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| **Missouri River** | **N/A** | **$9,879,535** | **$19,241** | **$48,648,261** | **$21,100,354** | **$48,648,261** |
| **Upper River** | **N/A** | **$4,410,093** | **$338,899** | **$41,037,774** | **$1,980,127** | **$41,037,774** |
| Fort Peck to Garrison | N/A | $3,792,356 | $30,216 | $86,371 | $239,964 | $468,886 |
| Garrison to Oahe | N/A | $3,792,356 | $56,982 | $40,200,291 | $1,899,262 | $40,200,291 |
| Fort Randall to Gavins Point | N/A | $1,009,376 | $251,701 | $779,959 | $886,113 | $1,009,376 |
| **Lower River** | **N/A** | **$9,023,701** | **N/A** | **$8,929,343** | **$20,735,531** | **$9,023,701** |
| Gavins Point to Rulo | N/A | $5,215,909 | $306,730 | $7,887,125 | $9,022,278 | $7,887,125 |
| St. Joseph Reach | $227,100 | $501,817 | $390,631 | $435,846 | $9,755,526 | $2,401,945 |
| Kansas City Reach | $1,175,417 | $263,709 | $264,079 | $886,521 | $1,298,781 | $1,610,636 |
| Boonville Reach | $31,732 | $1,260,898 | $638,176 | $554,821 | $1,560,453 | $1,260,898 |
| Hermann Reach | $535,326 | $4,366,574 | $839,831 | $4,116,959 | $10,653,970 | $4,366,574 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 5 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

c The reach totals are from a mixture of years, thus the Missouri River, upper river, and lower river values are not cumulative totals of the individual reaches.

### Land Use Sensitivity Analysis

As mentioned under the No Action analysis, a change in the land use and management, such as a change in the amount of agricultural land that could be affected by flooding, may have implications for the national economy. For Alternative 4, the additional required acreage that needs to be acquired is 1,772 in the lower river. Currently, there are an estimated 1,531,228 acres in agricultural production in the lower river. If all of the acquired lands were previously in agricultural production, this means the amount of agricultural land that could be affected by flooding and the estimated agricultural losses could be up to 0.1 percent less than the lower river agricultural losses shown in Table 3-79.

### Regional Economic Development

Under Alternative 4, agricultural losses would result in a change of less than one average annual job across all locations, while average labor income would range from an increase of $25,000 in the Kansas City reach to a reduction of $65,000 in the Gavins Point Dam to Rulo reach relative to No Action. Under the eight worst years relative to No Action, two regions tend to experience the largest impacts: Gavins Point Dam to Rulo and Hermann Reach. In these regions during these years, there would be four to five fewer jobs and $150,000 to $320,000 in less labor income compared to No Action. The impacts during the eight worst years relative to No Action would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Table 3-78 summarizes the average annual impacts from agricultural losses and differences in economic impacts for each of the flood risk management regions under Alternative 4 relative to No Action.

The counties that would have the largest increase in structural damages under Alternative 4 compared to No Action, with over $10 million increase in total damages over 82 years in each county and $150,000 to $1.0 million increase on average per county, are the following:

- Woodbury County, Iowa (Gavins Point Dam to Rulo)
- Cass County, Nebraska (Gavins Point Dam to Rulo)
- Holt County, Missouri (Gavins Point Dam to Rulo and St. Joseph Reach)
- Madison County, Illinois (Hermann Reach)
- Campbell County, South Dakota (Garrison Dam to Oahe Dam)

Residences, businesses, farming structures, and transportation facilities would be most affected in the counties listed above, with potentially small RED effects occurring during flooding events relative to No Action.

**Table 3-78. Regional Economic Development Impacts Associated with Agricultural Damage under Alternative 4 Compared to No Action, 2016 Dollars**

| River Reach | Change in Jobs | | | Change in Labor Income | | | Change in Sales | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual average (average annual) | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) |
| **Missouri River** | **0** | **17** | **−17** | **$19,000** | **$880,000** | **−$1,003,000** | **$101,000** | **$3,700,000** | **−$4,341,000** |
| **Upper River** | **0** | **1** | **0** | **−$3,000** | **$52,000** | **−$32,000** | **−$12,000** | **$194,000** | **−$120,000** |
| Fort Randall Dam to Gavins Point Dam | 0 | 1 | 0 | −$3,000 | $52,000 | −$32,000 | −$12,000 | $194,000 | −$120,000 |
| **Lower River** | **0** | **16** | **−17** | **$22,000** | **$828,000** | **−$971,000** | **$113,000** | **$3,506,000** | **−$4,221,000** |
| Gavins Point Dam to Rulo | 1 | 5 | −12 | $65,000 | $320,000 | −$731,000 | $284,000 | $1,413,000 | −$3,229,000 |
| St. Joseph Reach | 0 | 2 | −1 | $2,000 | $139,000 | −$75,000 | $11,000 | $569,000 | −$307,000 |
| Kansas City Reach | −1 | 2 | −1 | −$25,000 | $179,000 | −$40,000 | −$103,000 | $739,000 | −$165,000 |
| Boonville Reach | 0 | 1 | −1 | $0 | $32,000 | −$28,000 | $0 | $131,000 | −$117,000 |
| Hermann Reach | −1 | 4 | −2 | −$20,000 | $158,000 | −$97,000 | −$79,000 | $654,000 | −$403,000 |

Note: Positive values indicate decreases in RED impacts (employment and income) compared to No Action, while negative values indicate increases in RED impacts compared to No Action.

### Other Social Effects

For Alternative 4, the greatest changes in PAR relative to No Action would range from a 312-person decrease to a 168-person increase. In the upper river, the range differential relative to No Action would be a 103-person decrease to a 2,118-person increase. Table 3-79 shows the PAR under Alternative 4.

**Table 3-79. Population at Risk under Alternative 4**

| River Reach | Maximum PAR | Average Annual PAR | Maximum Increase Relative to No Action | Maximum Decrease Relative to No Action |
|---|---|---|---|---|
| **Missouri River** | **12,722** | **734** | **2,286** | **321** |
| **Upper River** | **6,386** | **245** | **2,118** | **103** |
| Fort Peck Dam to Garrison Dam | 380 | 51 | 30 | 7 |
| Garrison Dam to Oahe Dame | 5,794 | 182 | 2,094 | 112 |
| Fort Randall Dam to Gavins Point Dam | 212 | 12 | 23 | 18 |
| **Lower River** | **6,408** | **488** | **168** | **312** |
| Gavins Point Dam to Rulo | 5,342 | 221 | 168 | 80 |
| St. Joseph Reach | 732 | 61 | 14 | 187 |
| Kansas City Reach | 1,364 | 66 | 17 | 24 |
| Boonville Reach | 1,200 | 41 | 4 | 6 |
| Hermann Reach | 1,702 | 99 | 41 | 160 |

In addition to population at risk, impacts to census block groups with potential environmental justice populations were evaluated for Alternative 4. The census block group 191930036004 in Woobury County, Iowa with a high proportion of minority residents was identified as potentially having disproportionate impacts as it accounts for over 50 percent of the NED impact increase under Alternative 4 in the Gavins Point to Rulo reach. The census block group 291892101003 in St. Louis County, Missouri with a high proportion of low-income and minority residents was also identified as experiencing adverse impacts relative to the Hermann Reach; however these impacts were considered small in nature and not disproportional.

Table 3-80 lists the type and quantity of critical infrastructure that would be impacted 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.

**Table 3-80. Critical Infrastructure Impacted under Alternative 4**

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Agricultural Facilities | 6 | 3 |
| Chemical Industries | 13 | 4 |
| Communication Towers | 3 | 0 |
| Educational Schools | 1 | 1 |
| Emergency – EMS | 4 | 0 |
| Emergency – Fire Stations | 6 | 0 |
| Emergency – National Shelters | 2 | 2 |
| Energy – Plants | 5 | 0 |
| Energy – Propane Locations | 8 | 3 |
| Energy – Substations | 13 | 8 |
| Law Enforcement | 3 | 0 |
| Mail – USPS | 11 | 1 |
| Manufacturing Plants | 10 | 1 |
| Public – Campgrounds | 2 | 0 |
| Public – Libraries | 2 | 0 |
| Public – Parks | 29 | 0 |
| Public – Worship | 1 | 1 |
| Transportation – Airports | 19 | 0 |
| Transportation – Bridges | 566 | 18 |
| Transportation – Ports | 122 | 0 |
| Wastewater Treatment Plants | 2 | 0 |

### Conclusion

Under Alternative 4, the NED impacts along the Missouri River would be greater on average by $963,927 annually relative to No Action. This represents an overall increase in relation to No Action of 1.6 percent. The increase in NED impacts would be driven predominately by greater structure damages in the upper river, but the lower river would also experience a slight increase in impacts compared to No Action. The most notable reaches impacted were Garrison Dam to Oahe Dam, which would have a 13.6 percent increase in NED impacts, and Fort Randall Dam to Gavins Point Dam with a 5.1 percent increase. Additionally, the channel capacity in the Fort Randall reach and downstream of Bismarck is between 35 and 40 kcfs. Flow releases for the purpose of creating ESH under Alternative 4 would be in excess of this channel capacity and there would be an increase in the frequency of channel capacity exceedance. RED impacts were forecasted to be negligible. The impacts during the eight worst years relative to No Action would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Given the relatively large increases in NED impacts in the Garrison reach, and 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.

### 3.12.3.7 Alternative 5 – Fall ESH Creating Release

#### Mechanical Habitat Construction

No impact would be anticipated from early life stage pallid habitat construction. Alternative 5 was modeled with the same acreages as Alternative 3 with the same distribution and application of the same site-specific impact avoidance measures.

For ESH, an average of 309 acres per year would be constructed 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 No Action are applicable to Alternative 5. All ESH would be sited within available areas of the river.

#### National Economic Development

The NED analysis for Alternative 5 is summarized in Table 3-81. The NED impacts to the Missouri River floodplain would be on average $287,224 less annually relative to No Action. This would represent an overall decrease in NED impacts in relation to No Action of 0.5 percent. The difference would be driven by a decrease in impacts in the lower river, as the NED impacts in the upper river would increase slightly over No Action.

**Table 3-81. Summary of National Economic Development Analysis for Alternative 5**

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| **Missouri River** | **$41,167,676** | **$3,705,091** | **$15,798,010** | **$60,670,777** | **−$287,224** | **−0.5%** |
| **Upper River** | **$6,668,953** | **$600,206** | **$550,564** | **$7,819,723** | **$102,439** | **1.3%** |
| Fort Peck Dam to Garrison Dam | $1,009,832 | $90,885 | $360,149 | $1,460,866 | $10,807 | 0.7% |
| Garrison Dam to Oahe Dam | $4,811,898 | $433,071 | $18,139 | $5,263,108 | −$26,252 | −0.5% |
| Fort Randall Dam to Gavins Point Dam | $847,223 | $76,250 | $172,276 | $1,095,749 | $117,884 | 12.1% |
| **Lower River** | **$34,498,723** | **$3,104,885** | **$15,247,446** | **$52,851,054** | **−$389,663** | **−0.7%** |
| Gavins Point Dam to Rulo | $13,958,308 | $1,256,248 | $6,482,748 | $21,697,304 | $116,698 | 0.5% |
| St. Joseph Reach | $3,158,521 | $284,267 | $1,209,801 | $4,652,589 | $88,022 | 1.9% |
| Kansas City Reach | $4,039,384 | $363,545 | $3,705,017 | $8,107,945 | −$121,740 | −1.5% |
| Boonville Reach | $3,065,887 | $275,930 | $1,291,838 | $4,633,655 | −$17,844 | −0.4% |
| Hermann Reach | $10,276,624 | $924,896 | $2,558,041 | $13,759,561 | −$454,798 | −3.2% |

Note: All totals are at the FY 2016 price level. Negative numbers indicate a decrease in NED impacts relative to No Action.

The annual flood risk management NED analysis indicates that both the upper and lower river would experience an almost equal numbers of years with increases in NED impacts under Alternative 5 as years with decreases relative to No Action. The net result for Alternative 5 compared to No Action would be a small beneficial NED impact in the lower river and a slight adverse NED impact in the upper river. In the lower river, Alternative 5 NED impacts relative to No Action would range from a decrease of $14.1 million to an increase of $12.2 million. In the upper river, the Alternative 5 NED impacts would range from a $1.5 million decrease to an increase of $3.5 million, relative to No Action.

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 3-82. During the POR for Alternative 5, there were 7 modeled years with a full flow release action. In the lower river, 6 out of 7 of these years would experience an increase in NED impacts relative to No Action with the largest increase being $12,189,654 under the 1994 simulated event. Furthermore, the 1994 simulated event in the Gavins Point Dam to Rulo reach alone showed an increase over No Action by $12,350,769. In the upper river all seven full release action years would exhibit increased NED impacts relative to No Action, with the maximum being a $3,480,433 increase. On average, a full flow release action under Alternative 5 would have increases in annual NED impacts (relative to No Action) of $2,045,806 and $2,732,626 in the upper and lower river, respectively.

In addition to full flow release actions, there were two modeled years with partial flow releases. These actions would also have adverse NED impacts as both of the modeled years with partial releases would experience an increase over No Action in both the upper and lower river.

### Land Use Sensitivity Analysis

As mentioned under the No Action analysis, a change in the land use and management, such as a change in the amount of agricultural land that could be affected by flooding, may have implications for the national economy. For Alternative 5, the additional required acreage that would need to be acquired is 1,772 in the lower river. Currently, there are an estimated 1,531,228 acres in agricultural production in the lower river. If all of the acquired lands were previously in agricultural production, this means the amount of agricultural land that could be affected by flooding and the estimated agricultural losses could be up to 0.1 percent less than the agricultural losses in the lower river shown in Table 3-85.

**Table 3-82. Impacts from Modeled Flow Releases under Alternative 5 Compared to No Action**

| Change in $ from No Action by River Reach c | Full Flow Release a | | Partial Flow Release b | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| **Missouri River** | **N/A** | **$15,413,088** | **N/A** | **$1,777,141** | **$14,529,339** | **$15,413,088** |
| **Upper River** | **N/A** | **$3,480,433** | **N/A** | **$926,149** | **$1,461,037** | **$3,480,433** |
| Fort Peck to Garrison | $449 | $88,499 | N/A | $21,226 | $259,255 | $854,620 |
| Garrison to Oahe | $5,537 | $718,784 | $285 | $4,072 | $1,174,377 | $718,784 |

| Change in $ from No Action by River Reach c | Full Flow Release a | | Partial Flow Release b | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| Fort Randall to Gavins Point | N/A | $3,130,535 | N/A | $905,208 | $878,689 | $3,130,535 |
| **Lower River** | **$774,889** | **$12,189,654** | **N/A** | **$1,355,144** | **$14,038,303** | **$12,189,654** |
| Gavins Point to Rulo | N/A | $12,350,769 | N/A | $2,453,464 | $13,533,392 | $12,350,769 |
| St. Joseph Reach | N/A | $82,125 | N/A | $1,136,695 | $1,374,378 | $2,402,365 |
| Kansas City Reach | $188,189 | N/A | $570,218 | N/A | $1,300,251 | $1,615,836 |
| Boonville Reach | $626,759 | $66,532 | N/A | $1,194,960 | $842,039 | $1,237,167 |
| Hermann Reach | $799,153 | N/A | $1,574,681 | N/A | $10,640,135 | $126,409 |

a Flow action was fully implemented in 7 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 2 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

c The reach totals are from a mixture of years, thus the Missouri River, upper river, and lower river values are not cumulative totals of the individual reaches.

### Regional Economic Development

Under Alternative 5, agricultural losses would result in a change of less than one average annual job across all locations, while average labor income would range from an increase of $26,000 in the Hermann reach to a reduction of $47,000 in the Gavins Point Dam to Rulo reach relative to No Action. Under the eight worst years relative to No Action, three regions tend to experience the largest impacts: Gavins Point Dam to Rulo, Kansas City Reach, and Hermann Reach. In these reaches during years with similar conditions, there would be three to seven fewer jobs and $137,000 to $469,000 less in labor income compared to No Action. The impacts during the eight worst years relative to No Action would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Table 3-83 summarizes the average annual impacts from agricultural losses and differences in economic impacts for each of the flood risk management regions under Alternative 5 relative to No Action.

The counties that would have the largest increase in structural damages under Alternative 5 compared to No Action, are the following:

- Cass County, Nebraska. $11.5 million increase in total damages; $136,000 change on average (Gavins Point Dam to Rulo)
- Holt County, Missouri. $37.0 million increase in total damages over 82 years; $451,000 change on average (Gavins Point Dam to Rulo and St. Joseph Reach)

**Table 3-83. Regional Economic Development Impacts Associated with Agricultural Damage under Alternative 5 Compared to No Action, 2016 Dollars**

| River Reach | Change in Jobs | | | Change in Labor Income | | | Change in Sales | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual average (average annual) | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) |
| **Missouri River** | **0** | **17** | **−16** | **$27,000** | **$911,000** | **−$1,053,000** | **$117,000** | **$3,874,000** | **−$4,466,000** |
| **Upper River** | **0** | **1** | **−3** | **$22,000** | **$53,000** | **−$235,000** | **$83,000** | **$200,000** | **−$883,000** |
| Fort Randall Dam to Gavins Point Dam | 0 | 1 | −3 | $22,000 | $53,000 | −$235,000 | $83,000 | $200,000 | −$883,000 |
| **Lower River** | **0** | **16** | **−14** | **$5,000** | **$858,000** | **−$818,000** | **$34,000** | **$3,674,000** | **−$3,583,000** |
| Gavins Point Dam to Rulo | 1 | 7 | −11 | $47,000 | $469,000 | −$714,000 | $206,000 | $2,068,000 | −$3,153,000 |
| St. Joseph Reach | 0 | 1 | −1 | $4,000 | $82,000 | −$49,000 | $18,000 | $336,000 | −$201,000 |
| Kansas City Reach | −1 | 3 | 0 | −$23,000 | $137,000 | −$6,000 | −$96,000 | $566,000 | −$27,000 |
| Boonville Reach | 0 | 0 | −1 | $3,000 | $16,000 | −$42,000 | $13,000 | $67,000 | −$172,000 |
| Hermann Reach | −1 | 4 | 0 | −$26,000 | $154,000 | −$7,000 | −$107,000 | $637,000 | −$30,000 |

Note: Positive values indicate decreases in RED impacts (employment and income) compared to No Action, while negative values indicate increases in RED impacts compared to No Action.

Residences, businesses, farming structures, and transportation facilities would be most affected in Cass and Holt Counties, with potentially small RED effects occurring during flooding events relative to No Action.

### Other Social Effects

For Alternative 5, the greatest changes in PAR relative No Action would range from a 328-person decrease to a 49-person increase in the lower river. For the upper river, the PAR differential relative to No Action would range from a 44-person decrease to a 50-person increase. Table 3-84 shows the PAR under Alternative 5.

**Table 3-84. Population at Risk under Alternative 5**

| River Reach | Maximum PAR | Average Annual PAR | Maximum Increase Relative to No Action | Maximum Decrease Relative to No Action |
|---|---|---|---|---|
| **Missouri River** | **12,707** | **701** | **64** | **343** |
| **Upper River** | **6,371** | **219** | **50** | **44** |
| Fort Peck Dam to Garrison Dam | 381 | 51 | 31 | 10 |
| Garrison Dam to Oahe Dame | 5,778 | 156 | 2 | 44 |
| Fort Randall Dam to Gavins Point Dam | 212 | 12 | 48 | 16 |
| **Lower River** | **6,408** | **482** | **49** | **328** |
| Gavins Point Dam to Rulo | 5,342 | 214 | 73 | 312 |
| St. Joseph Reach | 732 | 64 | 14 | 5 |
| Kansas City Reach | 1,364 | 66 | 4 | 17 |
| Boonville Reach | 1,200 | 42 | 16 | 5 |
| Hermann Reach | 1,702 | 97 | 0 | 160 |

In addition to population at risk, impacts to census block groups with potential environmental justice populations were evaluated for Alternative 5. The census block group 291892101003 in St. Louis County, Missouri with a high proportion of low-income and minority residents was identified as experiencing adverse impacts relative to the Hermann Reach under Alternative 5; however these impacts were considered small in nature and not disproportional.

Table 3-85 lists the type and quantity of critical infrastructure that would be impacted during the largest flood event during 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.

**Table 3-85. Critical Infrastructure Impacted under Alternative 5**

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Agricultural Facilities | 6 | 3 |
| Chemical Industries | 13 | 4 |
| Communication Towers | 3 | 0 |
| Educational Schools | 1 | 1 |

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Emergency – EMS | 4 | 0 |
| Emergency – Fire Stations | 6 | 0 |
| Emergency – National Shelters | 2 | 2 |
| Energy – Plants | 5 | 0 |
| Energy – Propane Locations | 8 | 3 |
| Energy – Substations | 13 | 8 |
| Law Enforcement | 3 | 0 |
| Mail – USPS | 11 | 1 |
| Manufacturing Plants | 10 | 1 |
| Public – Campgrounds | 2 | 0 |
| Public – Libraries | 2 | 0 |
| Public – Parks | 29 | 0 |
| Public – Worship | 1 | 1 |
| Transportation – Airports | 19 | 0 |
| Transportation – Bridges | 566 | 18 |
| Transportation – Ports | 122 | 0 |
| Wastewater Treatment Plants | 2 | 0 |

**Conclusion**

The net result for Alternative 5 compared to No Action would be a small beneficial NED impact in the lower river and a slight adverse NED impact in the upper river. The most notable impact in terms of NED is a 12.1 percent increase in NED impacts in the Fort Randall Dam to Gavins Point Dam reach. The fall ESH release under Alternative 5 would increase the incidence of channel capacity exceedance in the Fort Randall reach and downstream of Bismarck similar to the spring ESH release in Alternative 4. The impacts during the eight worst years relative to No Action would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Given the relatively large impacts to NED in the Fort Randall reach and unavoidable increased frequency of channel exceedance in the Fort Randall reach and downstream of Bismarck, significant impacts to flood risk management are anticipated under Alternative 5.

### 3.12.3.8 Alternative 6 – Pallid Sturgeon Spawning Cue

**Mechanical Habitat Construction**

No impact would be anticipated from early life stage pallid habitat construction. Alternative 6 was modeled with the same acreages as Alternative 3 with the same distribution and application of the same site-specific impact avoidance measures.

For ESH, an average of 303 acres per year would be constructed 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 No Action are applicable to Alternative 6. All ESH would be sited within available areas of the river.

### National Economic Development

The NED results for Alternative 6 are summarized in Table 3-86. Overall, Alternative 6 has a small adverse NED impact relative to No Action. Over all locations NED impacts increase by $505,250 annually or an increase of 0.8 percent over No Action. In both the upper and lower river, flood risk management NED impacts would increase under Alternative 6. The overwhelming driver of NED impacts would be an $886,211 annual increase over No Action in the Gavins Point Dam to Rulo reach.

**Table 3-86. Summary of National Economic Development Analysis for Alternative 6**

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| **Missouri River** | **$41,795,395** | **$3,761,586** | **$15,906,271** | **$61,463,252** | **$505,250** | **0.8%** |
| **Upper River** | **$6,705,858** | **$603,527** | **$483,150** | **$7,792,536** | **$75,251** | **1.0%** |
| Fort Peck Dam to Garrison Dam | $1,004,054 | $90,365 | $357,655 | $1,452,074 | $2,015 | 0.1% |
| Garrison Dam to Oahe Dam | $4,840,084 | $435,608 | $17,659 | $5,293,351 | $3,990 | 0.1% |
| Fort Randall Dam to Gavins Point Dam | $861,720 | $77,555 | $107,836 | $1,047,111 | $69,246 | 7.1% |
| **Lower River** | **$35,089,536** | **$3,158,058** | **$15,423,121** | **$53,670,716** | **$429,999** | **0.8%** |
| Gavins Point Dam to Rulo | $14,545,663 | $1,309,110 | $6,612,044 | $22,466,817 | $886,211 | 4.1% |
| St. Joseph Reach | $3,144,741 | $283,027 | $1,224,492 | $4,652,260 | $87,693 | 1.9% |
| Kansas City Reach | $4,046,650 | $364,199 | $3,736,259 | $8,147,108 | −$82,578 | −1.0% |
| Boonville Reach | $3,061,149 | $275,503 | $1,284,740 | $4,621,392 | −$30,107 | −0.6% |
| Hermann Reach | $10,291,333 | $926,220 | $2,565,586 | $13,783,139 | −$431,220 | −3.0% |

Note: All totals are at the FY 2016 price level. Negative numbers indicate a decrease in damages relative to No Action.

The annual analysis shows that impacts in the lower river dominate the overall NED flood risk management impacts. In 21 of the 82 modeled years, increases in NED impacts in the lower river would exceed $1 million compared to those experienced under No Action. The upper river would also experience adverse NED impacts, with the differences from No Action ranging from an increase of $1,312,912 to a decrease $908,277.

Additional results are summarized in Table 3-87, which shows the difference in annual flood risk management impacts during years when there is a full or partial release action. Full release actions would have an adverse impact on flood risk management. In the upper river, 10 of the 11 modeled years with full flow release actions showed an increase in NED impacts over No

Action. For the lower river, all 11 years showed adverse impacts. Moreover, the 6 years with the greatest increase in NED impacts over No Action in the entire 82-year modeled POR for Alternative 6 were full flow release action years. On average, the lower river would experience a NED impact increase of $5,597,964 over No Action during full flow release event years.

In addition to full flow release actions, there were 33 modeled years with partial flow releases. In the upper river, these actions would not have much of an NED impact with an average annual increase of $16,723 over No Action. The lower river NED impacts with a partial flow release action would also be relatively small with an average annual decrease of $84,208.

**Table 3-87. Impacts from Modeled Flow Releases under Alternative 6 Compared to No Action**

| Change in $ from No Action by River Reach c | Full Flow Release a | | Partial Flow Release b | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| **Missouri River** | **N/A** | **$17,562,409** | **$11,215,725** | **$4,674,162** | **$11,215,725** | **$17,562,409** |
| **Upper River** | **$232,503** | **$1,312,912** | **$908,277** | **$1,076,986** | **$908,277** | **$1,312,912** |
| Fort Peck to Garrison | $1,808 | $37,944 | $55,115 | $33,935 | $55,115 | $37,944 |
| Garrison to Oahe | N/A | $143,962 | $263,576 | $577,774 | $263,576 | $577,774 |
| Fort Randall to Gavins Point | $374,657 | $1,294,518 | $869,441 | $962,301 | $869,441 | $1,294,518 |
| **Lower River** | **N/A** | **$17,412,154** | **$10,688,980** | **$4,125,098** | **$10,688,980** | **$17,412,154** |
| Gavins Point to Rulo | N/A | $16,021,848 | $3,159,427 | $4,553,488 | $3,159,427 | $16,021,848 |
| St. Joseph Reach | N/A | $764,232 | $1,764,583 | $777,808 | $1,764,583 | $2,393,593 |
| Kansas City Reach | $129,688 | $1,392,484 | $1,281,213 | $269,042 | $1,281,213 | $1,586,709 |
| Boonville Reach | $35,259 | $27,934 | $2,445,467 | $1,833,958 | $2,445,467 | $1,833,958 |
| Hermann Reach | $175,386 | $378,007 | $4,379,392 | $297,936 | $10,922,190 | $378,007 |

a Flow action was fully implemented in 11 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 33 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

c The reach totals are from a mixture of years, thus the Missouri River, upper river, and lower river values are not cumulative totals of the individual reaches.

### Land Use Sensitivity Analysis

As mentioned under the No Action analysis, a change in the land use and management, such as a change in the amount of agricultural land that could be affected by flooding, may have

implications for the national economy. For Alternative 6, the additional required acreage need to be acquired was 1,772 in the lower river. Currently, there are an estimated 1,531,228 acres in agricultural production in the lower river. If all of the acquired lands were previously in agricultural production, this means the amount of agricultural land that could be affected by flooding and the estimated agricultural losses in the lower river could be up to 0.1 percent less than the agricultural losses shown in Table 3-90.

**Regional Economic Development**

Under Alternative 6, agricultural flood losses would result in a change of less than two average annual jobs across all locations, while average labor income would range from an increase of $31,000 in the Hermann reach to a reduction of $94,000 in the Gavins Point Dam to Rulo reach relative to No Action. Under the eight worst years relative to No Action, three reaches tend to experience the largest impacts: Gavins Point Dam to Rulo, Kansas City Reach, and Hermann Reach. In these regions during these years, there would be three to five fewer jobs and $123,000 to $332,000 less in labor income compared to No Action. The impacts during the eight worst years relative to No Action would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Table 3-88 summarizes the average annual impacts from agricultural losses and differences in economic impacts for each of the regions under Alternative 6 relative to No Action.

The counties that would have the largest increase in structural damages under Alternative 6 compared to No Action, with over $10 million increase in total damages over 82 years in each county and $132,000 to $448,000 increase on average per county, are the following:

- Woodbury County, Iowa (Gavins Point Dam to Rulo)
- Cass County, Nebraska (Gavins Point Dam to Rulo)
- Holt County, Missouri (Gavins Point Dam to Rulo and St. Joseph Reach)
- Madison County, Illinois (Hermann Reach)

Residences, businesses, farming structures, and transportation facilities would be most affected in the counties listed above, with potentially small RED effects occurring during flooding events relative to No Action.

**Table 3-88. Regional Economic Development Impacts Associated with Agricultural Damage under Alternative 6 Compared to No Action, 2016 Dollars**

| River Reach | Change in Jobs | | | Change in Labor Income | | | Change in Sales | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual Average | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) | Annual average (average annual) | 8 worst years relative to No Action (average annual) | 8 best years relative to No Action (average annual) |
| **Missouri River** | **1** | **16** | **−20** | **$58,000** | **$819,000** | **−$1,195,000** | **$266,000** | **$3,452,000** | **−$5,187,000** |
| **Upper River** | **0** | **1** | **−1** | **−$5,000** | **$62,000** | **−$37,000** | **−$16,000** | **$233,000** | **−$140,000** |
| Fort Randall Dam to Gavins Point Dam | 0 | 1 | −1 | −$5,000 | $62,000 | −$37,000 | −$16,000 | $233,000 | −$140,000 |
| **Lower River** | **1** | **15** | **−20** | **$63,000** | **$757,000** | **−$1,158,000** | **$282,000** | **$3,219,000** | **−$5,047,000** |
| Gavins Point Dam to Rulo | 2 | 5 | −15 | $94,000 | $332,000 | −$931,000 | $411,000 | $1,466,000 | −$4,110,000 |
| St. Joseph Reach | 0 | 1 | −1 | $10,000 | $48,000 | −$64,000 | $43,000 | $196,000 | −$262,000 |
| Kansas City Reach | 0 | 3 | −3 | −$11,000 | $123,000 | −$108,000 | −$46,000 | $509,000 | −$445,000 |
| Boonville Reach | 0 | 1 | −1 | $1,000 | $42,000 | −$39,000 | $1,000 | $172,000 | −$162,000 |
| Hermann Reach | −1 | 5 | 0 | −$31,000 | $212,000 | −$16,000 | −$127,000 | $876,000 | −$68,000 |

Note: Positive values indicate decreases in RED impacts (employment and income) compared to No Action, while negative values indicate increases in RED impacts compared to No Action.

### Other Social Effects

For Alternative 6, the greatest changes in PAR relative No Action would range from a decrease of 145 people to a 171-person increase in the lower river and an 18-person decrease to 37-person increase in the upper river. Table 3-89 shows the PAR under Alternative 6.

**Table 3-89. Population at Risk under Alternative 6**

| River Reach | Maximum PAR | Average Annual PAR | Greatest Increase Relative to No Action | Greatest Decrease Relative to No Action |
|---|---|---|---|---|
| **Missouri River** | **12,687** | **709** | **182** | **145** |
| **Upper River** | **6,351** | **220** | **37** | **18** |
| Fort Peck Dam to Garrison Dam | 352 | 51 | 6 | 5 |
| Garrison Dam to Oahe Dame | 5,785 | 157 | 31 | 16 |
| Fort Randall Dam to Gavins Point Dam | 214 | 12 | 23 | 18 |
| **Lower River** | **6,403** | **489** | **171** | **145** |
| Gavins Point Dam to Rulo | 5,342 | 221 | 168 | 12 |
| St. Joseph Reach | 732 | 64 | 14 | 8 |
| Kansas City Reach | 1,364 | 66 | 6 | 18 |
| Boonville Reach | 1,197 | 42 | 25 | 6 |
| Hermann Reach | 1,700 | 97 | 2 | 162 |

In addition to population at risk, impacts to census block groups with potential environmental justice populations were evaluated for Alternative 6. The census block group 191930036004 in Woodbury County, Iowa with a high proportion of minority residents was identified as potentially having disproportionate impacts under Alternative 6 as it would account for nearly 50 percent of the NED impact increase in the Gavins Point to Rulo reach. The census block group 291892101003 in St. Louis County, Missouri with a high proportion of low-income and minority residents would also experience adverse impacts relative to the Hermann Reach; however these impacts were considered small in nature and not disproportional.

Table 3-90 lists the type and quantity of critical infrastructure that would be impacted during the largest flood event during 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.

**Table 3-90. Critical Infrastructure Impacted under Alternative 6**

| Critical Infrastructure | Lower River | Upper River |
|---|---|---|
| Agricultural Facilities | 6 | 3 |
| Chemical Industries | 13 | 4 |
| Communication Towers | 3 | 0 |
| Educational Schools | 1 | 1 |
| Emergency – EMS | 4 | 0 |
| Emergency – Fire Stations | 6 | 0 |
| Emergency – National Shelters | 2 | 2 |
| Energy – Plants | 5 | 0 |
| Energy – Propane Locations | 8 | 3 |
| Energy – Substations | 13 | 8 |
| Law Enforcement | 3 | 0 |
| Mail – USPS | 11 | 1 |
| Manufacturing Plants | 10 | 1 |
| Public – Campgrounds | 2 | 0 |
| Public – Libraries | 2 | 0 |
| Public – Parks | 29 | 0 |
| Public – Worship | 1 | 1 |
| Transportation – Airports | 19 | 0 |
| Transportation – Bridges | 566 | 18 |
| Transportation – Ports | 122 | 0 |
| Wastewater Treatment Plants | 2 | 0 |

### Conclusion

Over all locations NED impacts increase by $505,250 annually or an increase of 0.8 percent relative to No Action. The most notable increase in NED impacts is a 7.1 percent increase in the Fort Randall Dam to Gavins Point Dam reach. The spring pulse release under Alternative 6 would increase the incidence of channel capacity exceedance in the Fort Randall reach similar to the spring and fall ESH releases in Alternatives 4 and 5. The impacts during the eight worst years relative to No Action would result in adverse impacts to regional economic conditions that would be negligible even in small rural farming economies. Given the relatively large impacts to NED benefits in the Fort Randall reach and unavoidable increased frequency of channel exceedance in the Fort Randall reach, significant impacts to flood risk management are anticipated under Alternative 6.

### 3.12.3.9 Tribal Resources

All Tribal reservations located within the Missouri River floodplain were evaluated for flood impacts and population at risk. The results for the combined Tribal reservation effects are summarized in Table 3-91.

**Table 3-91. Impacts to Tribal Reservations**

| Alternative | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | Average Annual PAR | Maximum PAR |
|---|---|---|---|---|---|---|---|
| No Action | $17,054 | $1,535 | $105,807 | $124,396 | $0 | 3 | 105 |
| Alternative 2 | $20,039 | $1,803 | $101,214 | $123,056 | −$1,340 | 3 | 127 |
| Alternative 3 | $16,432 | $1,479 | $104,422 | $122,332 | −$2,064 | 2 | 97 |
| Alternative 4 | $20,024 | $1,802 | $102,954 | $124,780 | $384 | 3 | 127 |
| Alternative 5 | $20,115 | $1,810 | $138,615 | $160,541 | $36,145 | 3 | 122 |
| Alternative 6 | $19,219 | $1,730 | $100,865 | $121,813 | −$2,583 | 3 | 105 |

Note: All totals are in the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Under No Action, the average annual NED impacts to Tribal reservations would be $124,396. Compared to No Action, Alternatives 2, 3, and 6 would all experience between a 1 to 2 percent decrease in NED impacts. Alternative 4 would experience a negligible increase compared to No Action, while Alternative 5 would have the largest adverse impact with an average annual increase of $36,145, or 29 percent, in NED impacts. For all alternatives, there is a small average annual population at risk with the maximum PAR totals ranging from 97 under Alternative 3 to 127 under Alternatives 2, 4, and 5.

### 3.12.3.10 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 Draft, 4 May 2016), this section discusses a qualitative assessment of the effects to flood risk management for each alternative.

**No Action and Alternative 2**: As shown in Table 3-92, the following six climate change variables are expected to have an impact on No Action 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 flood and droughts. While all variables will impact the alternatives, increased air temperature was identified as not being a risk to flood risk management. One climatic change variable, decreased peak snow water equivalent, would reduce the risk to flood risk management by lowering reservoir elevations while another variable, earlier snowmelt date 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 impact to flood risk management by exceeding flood targets more frequently or increasing the number of extreme weather events and reducing the overall reliability of the system.

**Table 3-92. Discussion of Risk to Flood Risk Management from Climate Change Variables for No Action and Alternative 2**

| 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. |
| 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 impact to flood risk management by likely 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. | (+) Reduce risk of adverse impact to flood risk management with lower reservoir elevations. |
| 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 impact to flood risk management 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 term by increasing the risk of more frequent extreme events. |

**Alternative 3**: Only two climate change variables were identified as impacting Alternative 3, as shown in Table 3-93. However, neither is likely to have any impact to risk of flood risk management. Increased air temperature was identified as not a risk to flood risk management, while earlier snowmelt date 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 3-93. 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 | 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. |

**Alternatives 4–6**: Alternatives 4, 5, and 6 were identified as being impacted by the same five climate change variables shown in Table 3-94. Increased air temperature was identified as not a risk to flood risk management. One climatic change variable, earlier snowmelt date 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 impact to flood risk management by exceeding flood targets more frequently or increasing the number of extreme weather events and reducing the overall reliability of the system.

**Table 3-94. 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 risk 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 impact to flood risk management by likely 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 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 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 term by increasing the risk of more frequent extreme events. |

### 3.12.3.11 Cumulative Impacts

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 when loss of life and property damage could occur. Regulation efforts will be made to minimize these losses.

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.

Under the No Action alternative, no change in the present operation of the Missouri River system would occur. Therefore, the cumulative impacts of the No Action alternative would be a continuation of the substantial beneficial impacts on flood risk management resulting from the past, present, and reasonable foreseeable future actions. 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.

The incremental impacts of Alternative 2 would result in a relatively small reduction (−1.1 percent) in annual flood damages compared to No Action. 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 small long-term beneficial impacts to flood risk management. 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 2 would contribute adversely to this overall cumulative impact in years with full spring pulse events, especially in the upper river.

The incremental impacts of Alternative 3 would result in a small decrease (0.8 percent) in annual flood damages compared to No Action. 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 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 beneficial contribution to the overall cumulative flood risk management impact.

The incremental impacts of Alternative 4 would result in a small increase (1.6 percent) in annual flood damages compared to No Action. In specific years and locations, management actions under Alternative 4 could result in relatively large adverse impacts, particularly in the upper river during years with full or partial spring ESH creation release. Under Alternative 4, there would be small decreases in annual flood damages in all of the lower river reaches except the Gavins Point Dam to Rulo reach. When these incremental impacts are added to 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 (0.5 percent) in annual flood damages relative to those under No Action. 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 are added to the impacts from past, present, and reasonable 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 reservoirs elevation are lower.

The incremental impacts of Alternative 6 would result in a small increase (0.8 percent) in annual flood damages relative to those under No Action. 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 added to 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.

### 3.12.4 Environmental Consequences: Interior Drainage

An interior drainage analysis was conducted to evaluate water surface elevations within the landward side of federal levee areas along the Missouri River. Elevations within the areas are affected by the ability to drain interior runoff into the Missouri River. Criteria for evaluation of interior areas of levee systems are specified in Engineering Manual (EM) 1110-2-1413 and are applicable to the Missouri River Recovery Management Plan to determine potential economic impacts of various habitat and/or flow alternatives to existing leveed areas. Processes for interior drainage evaluation from EM 1110-2-1413 consist of generating continuous records to a level of detail commensurate with the type of study. In this case, existing interior areas were analyzed against alternative river geometries and/or flow alternatives from the mainstem dams, both of which could influence exterior river stages.

During the Master Manual update process, an interior drainage study was conducted of seven representative sites as documented in *Volume 11: Interior Drainage Study, Master Water Control Manual, Northwest Division, August 1998*. The 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 those sites allowed comparison to previous results.

#### 3.12.4.1 Impacts Assessment Methodology

Three models were assembled to evaluate interior drainage impacts to four sites: HEC-RAS, HEC-HMS, and HEC-FIA. 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 alternative 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.

Primary assumptions and limitations are as follows:

- The economic analysis uses data from the H&H modeling of the river and reservoir system. The analysis assumes that the H&H models reasonably estimate river flows and reservoir levels over the 82-period of record under each of the MRRMP-EIS alternatives as well as the No Action.
- The impacts for the No Action are for the purpose of providing a baseline and allowing for a comparison of the alternatives.
- 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 the seven sites evaluated for the Master Manual were selected to be modeled in detail.
- 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 was not attempted and would require additional evaluation to provide a reasonable methodology and verify 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 located in Chariton County, Missouri and is comprised of approximately 32,000 acres, the majority of which are agricultural. The MRLS 488-L levee is located in Holt County, Missouri and is comprised of approximately 9,500 acres, the majority of which are agricultural. The MRLS 536-L levee is located in Atchison County, Missouri and is comprised of approximately 14,400 acres, the majority of which are agricultural. The MRLS 575-L levee is located in Freemont County, Iowa and is largest interior drainage site modeled, comprising of over 93,000 acres.

**National Economic Development**

For all of the selected sites, and under each alternative scenario, each individual year in the POR was run in HEC-FIA to compute agricultural losses as well as damages to structures and inventory. The losses and damages for each year were aggregated and averaged over the POR

to estimate expected annual impacts for each site across all the alternatives. The HEC-FIA model was also used to compute estimated persons at risk of flooding for each interior drainage site under every year in the POR. 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 costs and disaster relief costs. It was assumed that emergency costs are equivalent to a maximum of nine percent of physical flood damages. A detailed description of the NED analysis including data sources and assumptions can be found in the report "Agriculture and Interior Drainage Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

**Regional Economic Development**

The NED results were further evaluated to determine if regional economic conditions would be affected under the MRRMP-EIS alternatives. For all action alternatives, the differences in damages on average compared to No Action would result in negligible NED effects. However, in some years there are small differences. Alternatives 3, 4, 5, and 6 for the four locations in the NED interior drainage assessment would result in negligible RED impacts when compared to No Action. For these alternatives, the largest adverse difference in agricultural losses and structural damage when compared to No Action was $103,000 (MRLS 488-L), which would result in an impact of less than 1 job. The worst case difference in agricultural and structural damages under Alternative 2 relative to No Action would be $270,000 in MRLS 488-L, which result in a loss of approximately 3 jobs. Because all impacts in any year would result in less than three jobs, a full RED analysis was not undertaken on the interior drainage NED effects.

### 3.12.4.2 Summary of Interior Drainage Environmental Consequences

The environmental consequences relative to interior drainage are summarized in Table 3-95. The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

**Table 3-95. Environmental Consequences Relative to Interior Drainage**

| Alternative | NED Impacts | RED Impacts | OSE Impacts | Summary of Impacts |
|---|---|---|---|---|
| Management Actions Common to All Alternatives | No NED impacts | No RED impacts | No OSE impacts | No impacts were identified. |
| No Action | Average annual impacts at the individual interior drainage sites range from $150 to $468 K | Negligible RED impacts | Minimal PAR | Baseline. |
| Alternative 2 | Average annual impacts at the individual interior drainage sites range from $146 to $468 K | Negligible to small RED impacts | Negligible changes to PAR | Small decrease in the combined average annual NED impacts |

| Alternative | NED Impacts | RED Impacts | OSE Impacts | Summary of Impacts |
|---|---|---|---|---|
| Alternative 3 | Average annual impacts at the individual interior drainage sites range from $151 to $468 K | Negligible RED impacts | Negligible changes to PAR | Small increase in the combined average annual NED impacts |
| Alternative 4 | Average annual impacts at the individual interior drainage sites range from $151 to $467 K | Negligible RED impacts | Negligible changes to PAR | Negligible change in the combined average annual NED impacts |
| Alternative 5 | Average annual impacts at the individual interior drainage sites range from $151 to $468 K | Negligible RED impacts | Negligible changes to PAR | Small increase in the combined average annual NED impacts |
| Alternative 6 | Average annual impacts at the individual interior drainage sites range from $151 to $468 K | Negligible RED impacts | Negligible changes to PAR | Small increase in the combined average annual NED impacts |

#### 3.12.4.3 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. Pallid sturgeon propagation and augmentation, predator management, and vegetative management will not impact interior drainage as these actions do not affect river stage.

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

System operations under No Action would be the same as the current operations. These impacts are discussed in more detail in the report “Agriculture and Interior Drainage Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**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 No Action is summarized in Table 3-96. Under No Action, average annual interior drainage NED impacts would range between $150,208 and $468,101 for the four selected sites. The average annual totals are particularly influenced by three modeled large flood events that would cause large impacts at each of the sites: 1984, 1993, and 2011. Agricultural losses are the primary driver of the NED impacts.

**Table 3-96. Summary of Interior Drainage Impacts under No Action**

| Interior Drainage Site | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts |
|---|---|---|---|---|
| MRLS 246-L | $111,422 | $10,028 | $346,651 | $468,101 |
| MRLS 488-L | $21,207 | $1,909 | $241,491 | $264,607 |
| MRLS 536-L | $52,349 | $4,711 | $93,147 | $150,208 |
| MRLS 575-L | $63,858 | $5,747 | $223,684 | $293,289 |
| **Total** | **$248,836** | **$22,395** | **$904,974** | **$1,176,205** |

Note: All totals are average annual at the FY 2016 price level.

### Regional Economic Development

Because the impacts in any year would be negligible to small, a full RED analysis was not undertaken on the interior drainage NED effects.

### Other Social Effects

Since the interior drainage sites are primarily agricultural, the populations at risk totals are minimal for each of the site. Under the largest modeled flood event, the maximum population at risk would be located at MRLS 246-L with 89 persons that could be affected by flooding. The population at risk for each site is summarized in Table 3-97.

**Table 3-97. No Action PAR at Interior Drainage Sites**

| Interior Drainage Site | Maximum PAR | Average Annual PAR |
|---|---|---|
| MRLS 246-L | 89 | 4 |
| MRLS 488-L | 4 | 1 |
| MRLS 536-L | 11 | 0 |
| MRLS 575-L | 11 | 1 |

### Conclusion

Large impacts to NED were modeled as occurring under No Action; however, the magnitude of these impacts would vary 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 No Action. The No Action alternative is not anticipated to have significant impacts to interior drainage.

### 3.12.4.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Under Alternative 2, the interior drainage sites would experience relatively small beneficial impacts relative to No Action. On average, these impacts are relatively small in nature but some years would experience larger NED impacts. The impacts are discussed in more detail below.

### National Economic Development

The interior drainage NED results for Alternative 2 are summarized in Table 3-98. Overall Alternative 2 has a small, beneficial impact on interior drainage NED impacts relative to No Action. Over all locations average annual impacts decrease by 0.7 percent from No Action. The site with the largest impact is MRLS 488-L, which would experience a decrease of $10,214 in average annual flood impacts.

**Table 3-98. Summary of Interior Drainage National Economic Development Analysis for Alternative 2**

| Interior Drainage Site | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| MRLS 246-L | $111,361 | $10,022 | $346,423 | $467,807 | −$295 | −0.1% |
| MRLS 488-L | $20,320 | $1,829 | $232,243 | $254,393 | −$10,214 | −3.9% |
| MRLS 536-L | $49,124 | $4,421 | $92,653 | $146,198 | −$4,010 | −2.7% |
| MRLS 575-L | $65,286 | $5,876 | $228,044 | $299,205 | $5,917 | 2.0% |
| **Total** | **$246,091** | **$22,148** | **$899,363** | **$1,167,602** | **−$8,603** | **−0.7%** |

Note: All totals are average annual at the FY 2016 price level. Negative values indicate a decrease relative to No Action.

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. These results are summarized in Table 3-99. During the POR, there were 10 years with a modeled full flow release plus low summer flow action. For the two furthest upstream sites, MRLS 536-L and MRLS 575-L, the impacts would be slightly adverse while for the furthest downstream sites, MRLS 488-L and MRLS 246-L, the impacts would be marginally beneficial on average compared to No Action.

In addition to full flow release actions, there were 36 modeled years with partial flow releases. MRLS 246-L, MRLS 488-L, and MRLS 536-L would all exhibit a slight decrease in NED impacts relative to No Action. MRLS 575-L, on the other hand, would have an increase on average in NED impacts over No Action during partial flow release years.

**Table 3-99. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 2**

| Change in $ from No Action by Interior Drainage Site | Full Flow Release [a] | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| MRLS 246-L | $38,074 | $1,861 | $36,552 | $83,161 | $38,074 | $137,443 |
| MRLS 488-L | $77,260 | $3,581 | $98,829 | $271,129 | $98,829 | $271,129 |
| MRLS 536-L | $2,418 | $2,119 | $428,412 | $35,433 | $428,412 | $35,433 |
| MRLS 575-L | $9,826 | $32,981 | $31,559 | $104,853 | $31,559 | $104,853 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 36 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

### Regional Economic Development

Because the impacts in any year would be negligible to small, a full RED analysis was not undertaken on the interior drainage NED effects.

### Other Social Effects

For Alternative 2, there would be minimal changes in population at risk relative to No Action. MRLS 246-L would experience a 3 person maximum decrease, while MRLS 575-L would have a maximum decrease of 4 persons. Table 3-100 shows the PAR under Alternative 2 for each interior drainage site.

**Table 3-100. Alternative 2 PAR at Interior Drainage Sites**

| Interior Drainage Site | Maximum PAR | Average Annual PAR | Maximum Increase Relative to No Action | Maximum Decrease Relative to No Action |
|---|---|---|---|---|
| MRLS 246-L | 89 | 4 | 0 | 4 |
| MRLS 488-L | 4 | 1 | 0 | 0 |
| MRLS 536-L | 11 | 0 | 0 | 0 |
| MRLS 575-L | 11 | 1 | 0 | 3 |

### Conclusion

Under Alternative 2, the interior drainage sites would experience relatively small beneficial impacts relative to No Action. On average these impacts are relatively small in nature but some years would experience larger NED impacts. Significant impacts are not anticipated due to Alternative 2.

### 3.12.4.6 Alternative 3 – Mechanical Construction Only

#### National Economic Development

The interior drainage NED results for Alternative 3 are summarized in Table 3-101. Overall, Alternative 3 would have a relatively negligible adverse impact on interior drainage relative to No Action with a total increase in average annual NED impacts of $1,183 or 0.1 percent. The site with the largest impact is MRLS 536-L, which would experience an increase of $685 in average annual NED impacts under Alternative 3.

**Table 3-101. Summary of Interior Drainage National Economic Development Analysis for Alternative 3**

| Interior Drainage Site | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| MRLS 246-L | $111,564 | $10,041 | $346,704 | $468,309 | $207 | 0.0% |
| MRLS 488-L | $21,371 | $1,923 | $241,983 | $265,277 | $670 | 0.3% |
| MRLS 536-L | $52,740 | $4,747 | $93,406 | $150,892 | $685 | 0.5% |
| MRLS 575-L | $63,806 | $5,743 | $223,360 | $292,909 | −$380 | −0.1% |
| **Total** | **$249,481** | **$22,453** | **$905,453** | **$1,177,388** | **$1,183** | **0.1%** |

Note: All totals are average annual at the FY 2016 price level. Negative values indicate a decrease relative to No Action.

#### Regional Economic Development

Because the impacts in any year would be negligible to small, a full RED analysis was not undertaken on the interior drainage NED effects.

#### Other Social Effects

For Alternative 3, there would be minimal changes in population at risk relative to No Action. The only change would occur in MRLS 488-L, which would experience a maximum 4 person increase. Table 3-102 shows the PAR under Alternative 3 for each interior drainage site.

**Table 3-102. Alternative 3 PAR at Interior Drainage Sites**

| Interior Drainage Site | Maximum PAR | Average Annual PAR | Maximum Increase Relative to No Action | Maximum Decrease Relative to No Action |
|---|---|---|---|---|
| MRLS 246-L | 89 | 4 | 0 | 0 |
| MRLS 488-L | 4 | 1 | 4 | 0 |
| MRLS 536-L | 11 | 0 | 0 | 0 |
| MRLS 575-L | 11 | 1 | 0 | 0 |

### Conclusion

Under Alternative 3, the interior drainage sites would experience relatively small adverse impacts relative to No Action. On average these impacts are relatively small in nature but some years would experience larger NED impacts. Significant impacts are not anticipated due to Alternative 3.

### 3.12.4.7 Alternative 4 – Spring ESH Creating Release

### National Economic Development

The interior drainage NED results for Alternative 4 are summarized in Table 3-103. Overall Alternative 4 would have a relatively negligible adverse impact on interior drainage relative to No Action with a total increase in average annual NED impacts of $389 or less than 0.1 percent. The site with the largest impact would be MRLS 246-L, which would experience a decrease of $1,823 in average annual NED impacts under Alternative 4.

**Table 3-103. Summary of Interior Drainage National Economic Development Analysis for Alternative 4**

| Interior Drainage Site | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| MRLS 246-L | $111,333 | $10,020 | $344,926 | $466,279 | −$1,823 | −0.4% |
| MRLS 488-L | $21,561 | $1,941 | $242,382 | $265,884 | $1,277 | 0.5% |
| MRLS 536-L | $52,828 | $4,755 | $93,352 | $150,934 | $727 | 0.5% |
| MRLS 575-L | $65,263 | $5,874 | $222,359 | $293,496 | $208 | 0.1% |
| **Total** | **$250,985** | **$22,589** | **$903,019** | **$1,176,594** | **$389** | **0.0%** |

Note: All totals are average annual at the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Table 3-104 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 8 simulated years with a full flow release action. MRLS 488-L, MRLS 536-L, and MRLS 575-L would all exhibit an increase in NED impacts relative to No Action with the largest adverse impacts occurring at MRLS 575-L. Meanwhile, the furthest downstream site, MRLS 246-L, showed a decrease in overall NED impacts compared to No Action under all 8 simulated full release action years.

In addition to full flow release actions, there were three modeled years with partial flow releases. At all four interior drainage sites, the partial release years would have an adverse NED impact.

**Table 3-104. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 4**

| Change in $ from No Action by Interior Drainage Site | Full Flow Release [a] | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| MRLS 246-L | $8,315 | N/A | $6,993 | $17,012 | $60,316 | $17,012 |
| MRLS 488-L | $13,762 | $9,910 | N/A | $18,147 | $49,940 | $58,281 |
| MRLS 536-L | $1,427 | $8,808 | N/A | $5,401 | $17,434 | $51,144 |
| MRLS 575-L | $18,925 | $54,203 | $3,921 | $13,619 | $31,559 | $104,853 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 36 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

### Regional Economic Development

Because the impacts in any year would be negligible to small, a full RED analysis was not undertaken on the interior drainage NED effects.

### Other Social Effects

For Alternative 4, there would be minimal changes in population at risk relative to No Action. MRLS 488-L would experience a 4 person maximum increase and a 4 person maximum decrease. MRLS 575-L, meanwhile, would experience a 3 person maximum increase and a 3 person maximum decrease. Table 3-105 shows the PAR under Alternative 4 for each interior drainage site.

**Table 3-105. Alternative 4 PAR at Interior Drainage Sites**

| Interior Drainage Site | Maximum PAR | Average Annual PAR | Greatest Increase Relative to No Action | Greatest Decrease Relative to No Action |
|---|---|---|---|---|
| MRLS 246-L | 89 | 4 | 0 | 0 |
| MRLS 488-L | 4 | 1 | 4 | −4 |
| MRLS 536-L | 11 | 0 | 0 | 0 |
| MRLS 575-L | 11 | 1 | 3 | 3 |

### Conclusion

Alternative 4 has the potential to affect interior drainage flooding. Significant impacts are not anticipated because impacts would be negligible in comparison to No Action.

## 3.12.4.8 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. Both actions have the potential to affect

interior drainage flooding. Alternative 5 is expected to have a relatively negligible adverse impact on interior drainage.

### National Economic Development

The interior drainage NED analysis results for Alternative 5 are summarized in Table 3-106. Overall Alternative 5 would have a relatively negligible adverse impact on interior drainage relative to No Action with a total increase in average annual NED impacts of $1,050 or 0.1 percent. The site with the largest impact is MRLS 536-L, which would experience an increase of $724 in average annual NED impacts.

**Table 3-106. Summary of Interior Drainage National Economic Development for Alternative 5**

| Interior Drainage Site | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual NED Impact from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| MRLS 246-L | $111,586 | $10,043 | $346,271 | $467,900 | −$202 | 0.0% |
| MRLS 488-L | $21,353 | $1,922 | $241,985 | $265,260 | $653 | 0.2% |
| MRLS 536-L | $52,754 | $4,748 | $93,430 | $150,932 | $724 | 0.5% |
| MRLS 575-L | $63,811 | $5,743 | $223,609 | $293,163 | −$125 | 0.0% |
| **Total** | **$249,504** | **$22,455** | **$905,295** | **$1,177,255** | **$1,050** | **0.1%** |

Note: All totals are average annual at the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Table 3-107 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 five simulated years with a full flow release action. All four sites would experience an increase on average in NED impacts under the full flow release actions of Alternative 5. At MRLS 575-L, the highest modeled yearly increase in NED impacts relative to No Action was a full release year.

In addition to full flow release actions, there were two years modeled with partial flow releases. The most notable partial release year effect was at MRLS 488-L, which would experience its highest NED Increase, $65,820, under a partial release action event.

**Table 3-107. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 5**

| Change in $ from No Action by Interior Drainage Site | Full Flow Release [a] | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| MRLS 246-L | $118 | $2,224 | $784 | N/A | $24,306 | $15,369 |
| MRLS 488-L | $159 | $5,118 | $10,747 | $65,820 | $104,734 | $65,820 |
| MRLS 536-L | $239 | $523 | $202 | $48 | $7,965 | $52,062 |
| MRLS 575-L | $1,260 | $43,656 | N/A | $11,240 | $55,549 | $43,656 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 36 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

### Regional Economic Development

Because the impacts in any year would be negligible to small, a full RED analysis was not undertaken on the interior drainage NED effects.

### Other Social Effects

For Alternative 5, there would be minimal changes in population at risk relative to No Action. Only MRLS 575-L would experience any changes, which would be an 11 person maximum increase and an 11 person maximum. Table 3-108 shows the PAR under Alternative 5 for each interior drainage site.

**Table 3-108. Alternative 5 PAR at Interior Drainage Sites**

| Interior Drainage Site | Maximum PAR | Average Annual PAR | Greatest Increase Relative to No Action | Greatest Decrease Relative to No Action |
|---|---|---|---|---|
| MRLS 246-L | 89 | 4 | 0 | 0 |
| MRLS 488-L | 4 | 1 | 0 | 0 |
| MRLS 536-L | 11 | 0 | 0 | 0 |
| MRLS 575-L | 11 | 1 | 11 | 11 |

### Conclusion

Alternative 5 has the potential to affect interior drainage flooding. Significant impacts are not anticipated because impacts would be negligible in comparison to No Action.

## 3.12.4.9 Alternative 6 – Pallid Sturgeon Spawning Cue

### National Economic Development

The interior drainage NED analysis results for Alternative 6 are summarized in Table 3-109. Overall Alternative 6 would have a small, adverse impact on interior drainage relative to No

Action with a total increase in average annual NED impacts of $3,568 or 0.3 percent. The site with the largest impact is MRLS 488-L, which would experience an increase of $1,862 in average annual NED impacts.

**Table 3-109. Summary of Interior Drainage National Economic Development Analysis for Alternative 6**

| Interior Drainage Site | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual Economic Impacts | Change in Average Annual Impacts from No Action | % Change from No Action |
|---|---|---|---|---|---|---|
| MRLS 246-L | $111,478 | $10,033 | $345,899 | $467,410 | −$691 | −0.1% |
| MRLS 488-L | $21,548 | $1,939 | $242,981 | $266,469 | $1,862 | 0.7% |
| MRLS 536-L | $52,737 | $4,746 | $93,410 | $150,893 | $685 | 0.0% |
| MRLS 575-L | $64,935 | $5,844 | $224,222 | $295,001 | $1,712 | 0.6% |
| **Total** | **$250,698** | **$22,563** | **$906,512** | **$1,179,773** | **$3,568** | **0.3%** |

Note: All totals are in the FY 2016 price level. Negative values indicate a decrease relative to No Action.

### Regional Economic Development

Because the impacts in any year would be negligible to small, a full RED analysis was not undertaken on the interior drainage NED effects.

### Other Social Effects

For Alternative 6, there would be minimal changes in population at risk relative to No Action. MRLS 488-L would have a 4 person maximum increase and a 4 person maximum decrease. MRLS 575-L would also experience a 3 person maximum increase. Table 3-110 shows the PAR under Alternative 6 for each interior drainage site.

**Table 3-110. Alternative 6 Population at Risk**

| Interior Drainage Site | PAR Max | Average Annual PAR | Maximum Increase Relative to No Action | Maximum Decrease Relative to No Action |
|---|---|---|---|---|
| MRLS 246-L | 89 | 4 | 0 | 0 |
| MRLS 488-L | 4 | 1 | 4 | 4 |
| MRLS 536-L | 11 | 0 | 0 | 0 |
| MRLS 575-L | 11 | 1 | 3 | 0 |

The interior drainage impacts during years when there was a release action modeled are summarized in Table 3-111. During the POR, there were 10 years modeled with a full flow release action. All four sites would experience increases in NED impacts under Alternative 6 full release action years, with the two furthest upstream sites, MRLS 536-L and 575-L, displaying increases in 9 out of the 10 simulated years. MRLS 488-L had its highest modeled NED increase, $103,444, in a simulated full release action event year.

In addition to full flow release actions, there were 26 years modeled with partial flow releases. On average, the results of the partial flow release years would be more modest with all four sites experiencing a slight decrease in average annual NED impacts relative to No Action. The largest decrease was located at MRLS 488-L, which would have a reduction of NED impacts of $67,291 under its worst year relative to No Action.

**Table 3-111. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 6**

| Change in $ from No Action by Interior Drainage Site | Full Flow Release [a] | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase | Highest NED Decrease | Highest NED Increase |
| MRLS 246-L | $8,441 | $10,134 | $42,550 | $5,925 | $60,292 | $16,614 |
| MRLS 488-L | $1,128 | $103,444 | $67,291 | $25,391 | $67,291 | $103,444 |
| MRLS 536-L | $769 | $8,044 | $17,488 | $15,294 | $17,488 | $50,164 |
| MRLS 575-L | $21,996 | $44,184 | $51,540 | $6,821 | $51,540 | $44,184 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

b Flow action was partially implemented in 26 years of the period of analysis. Data represents the largest NED impact increase and decrease in the years the action was implemented relative to No Action.

### Conclusion

Significant impacts to interior drainage under Alternative 6 are not anticipated because adverse impacts to interior drainage would be relatively small in comparison to No Action.

### 3.12.4.10 Tribal Interests

There were no Tribal reservations identified in the sub-sample of modeled interior drainage sites.

### 3.12.4.11 Climate Change

**No Action and Alternative 2**: As shown in Table 3-92, the following six climate change variables are expected to have an impact on No Action 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 flood and droughts. While all variables will impact the alternatives, increased air temperature was identified as not being a risk to interior drainage. One climatic change variable, decreased peak snow water equivalent, would reduce the risk to interior drainage by lowering reservoir elevations while another variable, 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. The remaining three climatic change variables would increase the risk of adverse impact 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 3-112. Discussion of Risk to Interior Drainage from Climate Change Variables for No Action and Alternative 2**

| 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. |
| 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 impact to interior drainage by likely 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. | (+) Reduce risk of adverse impact to interior drainage with lower reservoir elevations. |
| 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 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 risk 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. | (−) Increase risk of adverse impact to interior drainage in the term by increasing the risk of more frequent extreme events. |

**Alternative 3**: Only two climate change variables were identified as impacting Alternative 3, as shown in Table 3-93. However, neither is likely to have any impact to risk of 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 3-113. 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 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 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 3-94. Increased air temperature was identified as not a risk to interior drainage. One climatic change variable, 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. The remaining three climatic change variables would increase the risk of adverse impact 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 3-114. 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. | (−) Increase risk of adverse impact to interior drainage by likely 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 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 risk 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. | (−) Increase risk of adverse impact to interior drainage in the term by increasing the risk of more frequent extreme events. |

#### 3.12.4.12 Cumulative Impacts

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, 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 areas.

Under the No Action alternative, no change in the present operation of the Missouri River system would occur. Therefore, the cumulative impacts of the No Action alternative would be a continuation of the substantial beneficial impacts on interior drainage resulting from the past, present, and reasonable foreseeable future actions. Adverse and beneficial impacts on interior drainage are driven by natural cycles of dry and wet periods (including snowpack and precipitation), and changes in land use management.

The incremental impacts of Alternative 2 would result in a relatively small reduction (−0.7 percent) in the combined annual flood damages at the modeled interior drainage 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 spring pulse events especially at the furthest upstream sites.

The incremental impacts of Alternative 3 would result in a small increase (0.1 percent) in combined annual flood damages at the modeled interior drainage sites compared to No Action. 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 adverse contribution to the overall cumulative interior drainage impact.

On average, the incremental impacts of Alternative 4 would result in a negligible cumulative impact in combined annual flood damages at the modeled interior drainage sites compared to No Action. 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 especially at the furthest upstream sites.

The incremental impacts of Alternative 5 would result in a small increase (0.1 percent) in combined annual flood damages at the modeled interior drainage sites relative to those under No Action. 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 the natural dry cycle. When these incremental impacts are added to the impacts from past, present, and reasonable 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 reservoirs elevation are lower.

The incremental impacts of Alternative 6 would result in a small increase (0.3 percent) in combined annual flood damages at the modeled interior drainage sites relative to those under No Action. Although the relative difference in overall NED impacts 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. Alternative 6 would contribute adversely to this overall cumulative impact at the modeled interior drainage sites in years with full spring spawning cue releases.

# 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 and creating 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 to meet other needs, 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 lost hydropower generation.

### 3.13.1.1 Missouri River Hydropower and Regional Energy Environment

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. In the midst of this effort, the USACE and the Bureau of Reclamation were finalizing the Pick-Sloan Plan as part of the Flood Control Act of 1944. This plan would call 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 3-115 provides a description of the general characteristics of the USACE hydroelectric projects on the mainstem of the Missouri River.

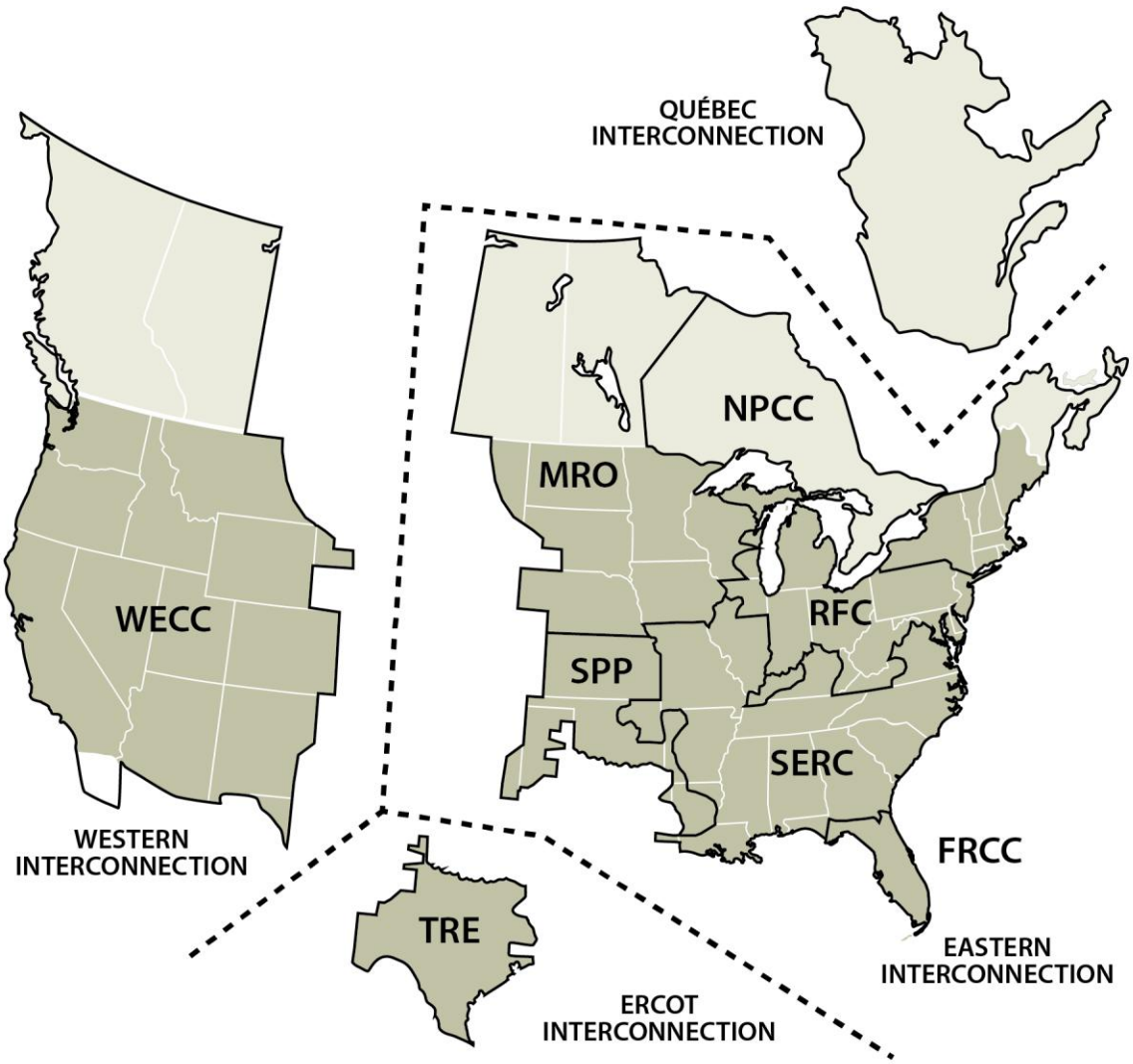
**Table 3-115. Hydropower Plant Characteristics for USACE Projects on the Mainstem of the Missouri River**

| 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 |

### 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 3-52). 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.

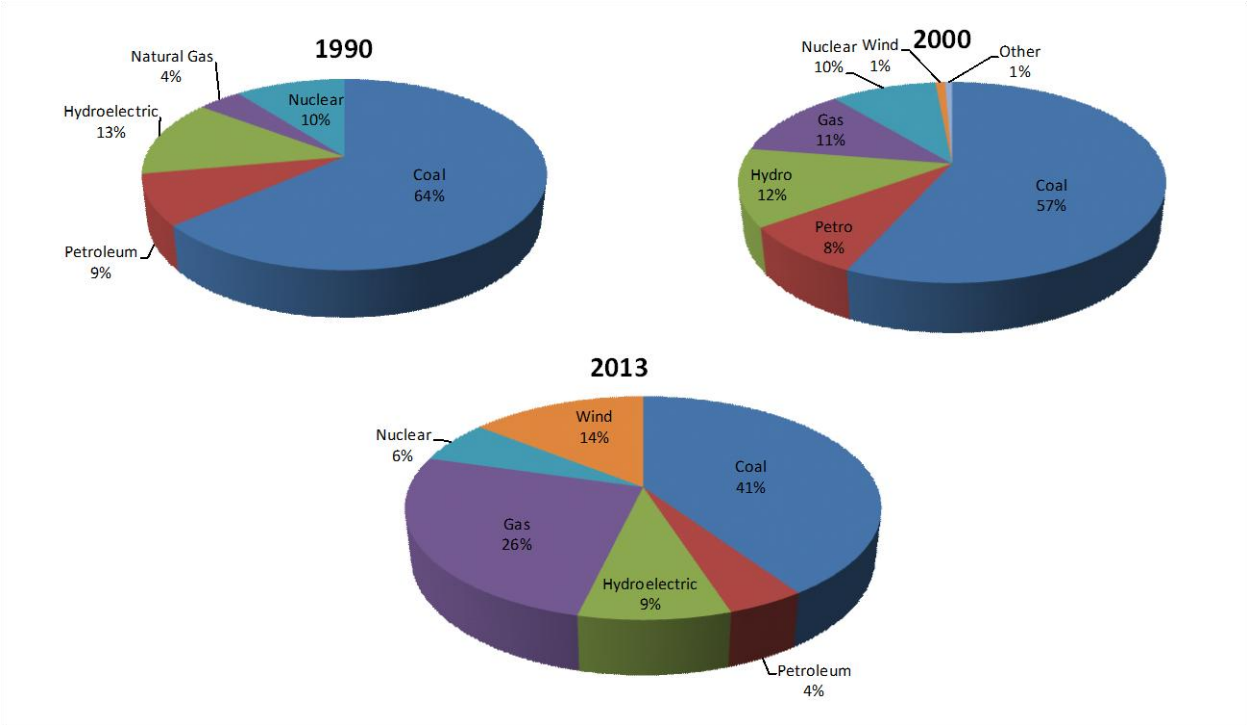



Source: North American Electric Reliability Corporation 2012.
Note: For purposes of this study the United States section of the MRO region is extended to include Montana.

**Figure 3-52. 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 3-53). 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 3-53. 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).

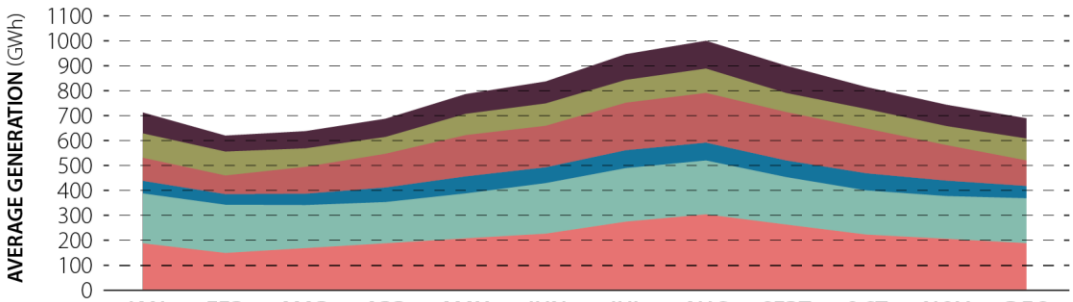
Restrictions on dam releases due to either water availability or other considerations such as minimum flow requirements may reduce both the magnitude and value of the energy produced. Flows outside of the design of the turbines may also reduce the overall efficiency. In addition, when dam releases exceed 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 loss of potential energy as additional 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 like reducing flood risk and maintaining the summer navigation schedule. 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.

### Seasonal and Hourly Generation Patterns

In the Missouri River Basin, peak energy loads (demand) increase in the summer months, when temperatures are highest and farm communities may be pumping water for irrigation or operating grain-drying machinery. These loads are intended to be met by generating the maximum amount of energy during the month of August. Figure 3-54 shows the average monthly generation for the USACE hydropower plants from 1968 to 2014. Over this period, on average, the least amount of energy was generated during February.

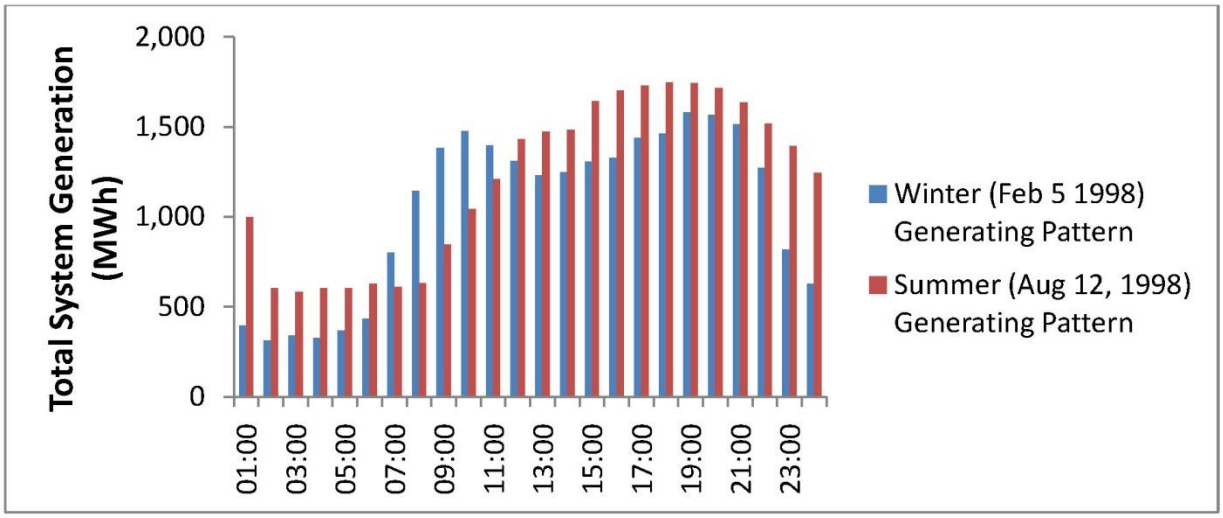



| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEPT | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BIG BEND | 75 | 61 | 67 | 70 | 76 | 83 | 97 | 109 | 99 | 86 | 81 | 76 |
| FORT PECK | 103 | 96 | 77 | 69 | 87 | 89 | 96 | 97 | 83 | 78 | 78 | 92 |
| FORT RANDALL | 91 | 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 3-54. Average Monthly Generation in Gigawatt Hours (GWh) (1968–2014) for USACE Hydropower Facilities on the Missouri River Mainstem**

Figure 3-55 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 constantly, using as much installed capacity as possible. Other plants with storage may turn completely off and then back on again during peak demand periods, while others even have a minimum flow requirement that constantly generates a small amount of electricity with a maximum generation occurring during peak demand periods.




Source: USACE 2012b

**Figure 3-55. 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. In the Missouri River basin, this repayment extends to irrigation facilities, easing water users' financial burden in rural areas.

#### Power Marketing

Western Area Power Administration (WAPA) was formed in 1977 as a subset of the United States Department of Energy along with three other power marketing agencies to market 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 offered some notable constraints on the preferred customer base for the power marketing agencies along with guidelines for the rate structure. The preference customer base includes 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 (Figure 3-56). 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.

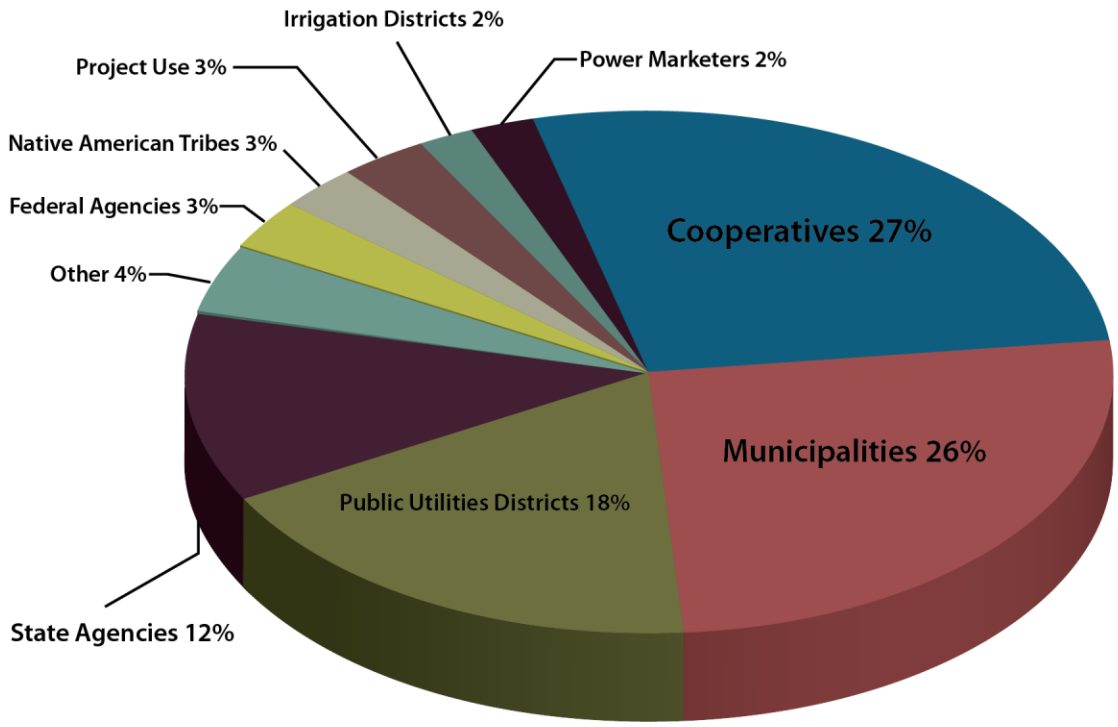



**Figure 3-56. Western Area Power Administration 2015 Firm Sales by Customer**

### Tribal Benefits

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 the WAPA 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 Impacts 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 an 82-year POR, as well as the Missouri River Hydropower Benefits Calculator model to calculate impacts to generation and capacity for each of the six mainstem dams.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources. The following assumptions were used for the impacts analysis for hydropower:

- The analysis assumed that the Missouri River HEC-ResSim model reasonably estimates dam operations over the 82-year POR.
- That the POR is a reasonable estimation of future hydrologic conditions for the purpose of comparing alternatives.

A 2016 estimated U.S. Energy Information Administration energy price 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. A more detailed explanation of the development of the energy and capacity prices can be found in the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**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. Hydropower benefits for the action alternatives (Alternatives 2–6) are assessed and compared to the benefits of the No Action alternative (Alternative 1).

**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 costs, the low cost benefits for preferred customers would decrease and would account for the RED impact. WAPA provided a method for obtaining reasonable estimates of the financial impact to them from each alternative, which would in turn affect rates.

**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 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, the EPA's social cost of carbon (SCC) value was used to approximate a monetary value associated with carbon emissions.

A more detailed description of the methodology for evaluating each of these accounts can be found in the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

### 3.13.2.2 Summary of Consequences

The hydropower consequences are summarized in Table 3-116. The impacts of the No Action alternative 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 as compared to the Alternative 1 scenario would be Alternative 2, with a loss of $5.4 million to hydropower. From there, the alternatives ranging from most impactful to least impactful would be Alternative 4, Alternative 6, and Alternative 5. Alternative 3 would have the smallest impact on hydropower.

The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

**Table 3-116. 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 the No Action alternative, the baseline level of benefit/impact of the system is estimated to be $525,707,000. | Under No Action, the financial impact to WAPA is a surplus of generation valued at $27,832,200. | If the power the Missouri River hydropower system currently produces under the No Action alternative had to be replaced by a thermal power producer, it would produce an additional 17,325,094,839 lbs of carbon dioxide, 463,716 lbs of methane, and 288,456 lbs of nitrous oxide. |

| Alternative | NED Impacts | RED Impacts | OSE Impacts |
|---|---|---|---|
| Alternative 2 | Average annual decrease in generation: 61,680 MWh<br>Average annual decrease in hydropower value: $5,426,000 (−$2,299,000 in generation value and −$3,127,000 in capacity value)<br>Range of annual differences: ($37,781,050 loss to $13,543,647 gain) | Direct financial loss to WAPA: $3,783,700 | Carbon dioxide increase: 121,214,153 lbs<br>Methane increase: 3,244 lbs<br>Nitrous oxide increase: 2,018 lbs<br>SCC increase: $2,089,311 |
| Alternative 3 | Average annual increase in generation: 4,079 MWh<br>Average annual decrease in hydropower value: $256,000 ($6,000 in generation value and -$262,000 in capacity value)<br>Range of annual differences: ($13,188,274 loss to $14,245,979 gain) | Direct financial loss to WAPA: $690,500 | Carbon dioxide decrease: 8,016,092 lbs<br>Methane decrease: 215 lbs<br>Nitrous oxide decrease: 133 lbs<br>SCC decrease: $138,170 |
| Alternative 4 | Average annual decrease in generation: 58,216 MWh<br>Average annual decrease in hydropower value: $4,044,000 (−$1,862,000 in generation value and −$2,182,000 in capacity value)<br>Range of annual differences: ($34,024,351 loss to $35,014,208 gain) | Direct financial loss to WAPA: $837,100 | Carbon dioxide increase: 114,406,665 lbs<br>Methane increase: 3,062 lbs<br>Nitrous oxide increase: 1,905 lbs<br>SCC increase: $1,971,974 |
| Alternative 5 | Average annual decrease in generation: 19,737 MWh<br>Average annual decrease in hydropower value: $1,784,000 (−$1,189,000 in generation value and −$595,000 in capacity value)<br>Range of annual differences: $25,850,202 loss to $31,104,359 gain | Direct financial loss to WAPA: $3,354,200 | Carbon dioxide increase: 38,787,350 lbs<br>Methane increase: 1,038 lbs<br>Nitrous oxide increase: 646 lbs<br>SCC increase: $668,559 |
| Alternative 6 | Average annual decrease in generation: 22,838 MWh<br>Average annual decrease in hydropower value: $2,092,000 (−$714,000 in generation value and −$1,378,601 in capacity value)<br>Range of annual differences: $33,041,450 loss to $17,885,409 gain | Direct financial gain to WAPA: $5,461,000 | Carbon dioxide increase: 44,881,466 lbs<br>Methane increase: 1,201 lbs<br>Nitrous oxide increase: 747 lbs<br>SCC increase: $773,601 |

#### 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 flow through the dams or elevations in the reservoirs.

**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. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering and design phases which further avoid or minimize impacts associated with ESH construction.

#### 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 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 the No Action alternative for hydropower is the value of energy generation and dependable capacity. The NED analysis and baseline level of benefits and impacts for the No Action alternative are summarized in Table 3-117. Average annual generation for the system under this alternative would be estimated at 8,815,900 MWh. The value of this generation would be $264,285,000. The annual values during the POR would range from a low of $126,199,000 to a high of $386,158,000. The calculated dependable capacity for the summer would be 2,127.6 MW and 1,941.4 MW for winter. The value of the summer dependable capacity would be $261,422,000. The value of the winter dependable capacity would be $238,536,000. The total average annual value of hydropower (including generation and summer dependable capacity) would be $525,707,000.

**Table 3-117. Summary of Hydropower National Economic Development Analysis for Alternative 1 (2016 Dollars)**

| | |
|---|---|
| Average Annual System Generation | 8,815,900 MWh |
| Average Annual Generation Value | $264,285,000 |
| Dependable Capacity - Summer | 2,127.6 MW |
| Average Annual Capacity Value - Summer | $261,422,000 |
| Dependable Capacity - Winter | 1,941.4 MW |
| Average Annual Capacity Value - Winter | $238,536,000 |
| Total Average Hydropower Value Generation plus Capacity (Summer) | $525,707,000 |

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.

### 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 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 FY 2016 and compared the generation data from the hydropower benefits model for 2012, identified as a normal generation year. 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.

Under the No Action alternative, the generation for 2012 would provide a surplus of 1,386,600 MWH (valued at $27,832,200) beyond the typical load requirements.

### 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 thermal power generation. If the Missouri River hydropower system generation was actually being produced by thermal power sources, it would increase annual emissions by 17,325,094,839 lbs of carbon dioxide, 463,716 lbs of methane, and 288,456 of nitrous oxide. That the system does not produce these emissions could be considered the baseline level of benefit and impact for the OSE account.

### 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 national and regional economic benefits under Alternative 1. 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

### National Economic Development

The NED analysis for Alternative 2 is summarized in Table 3-118. Average annual system generation under this alternative would be 8,754,220 MWh, a decrease of 0.70 percent from Alternative 1. The average annual value of the generation under this alternative would be $261,986,000, a decrease of 0.87 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 dependable capacity for the critical summer period would be 2,107.7 MW, valued at

$258,967,000. This would be a decrease of 0.94 percent from Alternative 1. The system dependable capacity for the critical winter period would be 1,916.8 MW (a decrease of 1.27 percent from Alternative 1) and valued at $235,514,000. Also included in the table is a maximum average annual capacity loss. However, different plants can be impacted differently in different seasons. The maximum average annual capacity loss is considering the highest impact at each plant, either during the winter or summer period. For Alternative 2, this value would be −$3,127,000. This is also the value used in the total impact value.

The total value of the impact to hydropower from Alternative 2 would be a loss of $5,426,000 in generation and capacity losses. This includes a generation loss of $2,299,000 and a maximum dependable capacity loss of $3,127,000. This is an overall loss of 1.03 percent of the total system value.

When evaluating the impacts of each alternative, year-by-year impacts, as well as annual impacts over the POR, were examined. Additional results are summarized in Table 3-119, 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 full-flow-release-plus-low-summer-flow years of Alternative 2 all would have negative impacts to hydropower, whereas the partial flow years would have a much wider variance, including the year with the greatest negative impact.

In 28 of the 82 years in the POR, Alternative 2 would result in a higher hydropower value than Alternative 1. The average increase in these years is $4,553,000. In 54 of the years, Alternative 2 results in a lower hydropower value than Alternative 1. The average decrease in these years would be $9,646,000. Further annual results can be found in the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**Table 3-118. Summary of National Economic Development Analysis for Alternative 2 (2016 Dollars)**

| | |
|---|---|
| Average Annual System Generation | 8,754,220 MWh |
| System Generation Difference from Alternative 1 | −61,680 MWh |
| Average Annual Generation Value | $261,986,000 |
| Annual Generation Value Difference from Alternative 1 | −$2,299,000 |
| Dependable Capacity - Summer | 2,107.7 MW |
| Difference in Dependable Capacity - Summer from Alternative 1 | −20.0 MW |
| Average Annual Capacity Value - Summer | $258,967,000 |
| Difference in Average Annual Capacity Value - Summer from Alternative 1 | −$2,455,000 |
| Dependable Capacity - Winter | 1,916.8 MW |
| Difference in Dependable Capacity - Winter from Alternative 1 | −24.6 MW |
| Average Annual Capacity Value - Winter | $235,514,000 |
| Difference in Average Annual Capacity Value - Winter from Alternative 1 | −$3,023,000 |
| Maximum Average Annual Capacity Loss Summed by Plant | −$3,127,000 |
| **Total Average Annual Change in Hydropower NED Value from Alternative 1** | **−$5,426,000** |

**Table 3-119. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1 (2016 Dollars)**

| Change in $ from Alternative 1 | | | | | |
|---|---|---|---|---|---|
| Full Flow Release + Low Summer Flow [a] | | Partial Flow Release [b] | | Maximum and Minimum Impact Regardless of Flow Actions | |
| Largest Decrease | Smallest Decrease | Largest Decrease | Largest Increase | Largest Decrease | Largest Increase |
| −$24,214,000 | −$868,000 | −$37,781,000 | $10,309,000 | −$37,781,000 | $13,544,000 |

a Full Flow Release + Low Summer Flow was implemented in 10 years of the period of analysis. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

b Partial Flow Release was implemented in 45 of the years of the period of analysis. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

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.

Generation results for both hydropower and thermal power were compared season-by-season over the 18-year period (1995–2012) when results were available to see when the potential for coupled effects might occur. Under alternative 2, the coupled effects described above could potentially occur during summer months and low summer flow event years, specifically in 2002 and 2003. During that season in those years, both hydropower and thermal power are experiencing reductions in generation during a season when demand is also typically high. All of these factors combined could lead to exacerbated impacts on energy in the region. For more detailed information, refer to the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

### 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 the ability of WAPA to meet the demand for electricity, creating the need to find electricity elsewhere.

The sales of electric power must repay all costs associated with power generation and WAPA must establish power rates sufficient to recover operating, maintenance, and purchase power expenses as well as repay the federal government’s investment in building these generation and transmission facilities within 50 years. Since these costs will not decrease even though the average annual generation will decrease, the rates will need to increase in order to cover these costs. 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.

Under Alternative 2, in 2012, WAPA would incur a financial loss of $3,783,700. The year 2012 was used because it is defined as a normal generation year and, thus, could be representative

of the typical annual impact expected due to the implementation of these alternatives. WAPA provided their hourly preference customer and pumping load in the SPP footprint and their deliveries external to SPP in FY 2016 and compared the generation data from the hydropower benefits model for 2012, identified as a normal generation year. 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 2. An on-peak and off-peak energy price was applied to indicate the financial impact to WAPA of each alternative.

Therefore, Alternative 2 would increase power purchases or reduce surplus sales by almost $3.8 million in a typical generation year. Of the 8,784 hours examined, 52 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 $6,500. The largest single hour purchase over the year was $346,400. Forty-eight percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $5,200. For additional information on these calculations, refer to the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

### Other Social Effects

Reductions in hydropower generation would need to be made up by increasing other sources of power generation, likely to be a reliable fossil fuel source that produces greenhouse gases. As discussed in Section 3.13.2.1, Impacts Assessment Methodology, the EPA eGrid database was used to determine the appropriate region and emissions factors for this study. The emissions factors are 1,965.21 lbs/MWh for carbon dioxide, 0.0526 lbs/MWh for methane, and 0.03272 lbs/MWh for nitrous oxide. The estimated average annual difference in generation between Alternative 1 and Alternative 2 is a reduction of 61,680 MWh. Table 3-120 displays the results of these increased emissions necessary to replace the lost hydropower generation.

**Table 3-120. Summary of Other Social Effects Analysis for Alternative 2**

| | Carbon Dioxide (lbs) | Methane (lbs) | Nitrous Oxide (lbs) |
|---|---|---|---|
| Average Annual Change in Emissions under Alternative 2 | +121,214,152.8 | +3,244.4 | +2,018.2 |

The social cost of carbon discussed in Section 3.13.2.1, Impacts Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The social cost of carbon for 2016 is $38 per metric ton of carbon dioxide (using a 3 percent discount rate). The social cost of increased carbon emissions under Alternative 2 would be $2,089,000.

### Conclusion

Among the alternatives, Alternative 2 has the largest potential NED impact, as compared to Alternative 1. This is likely related to the low summer flows and spring pallid sturgeon flow releases occurring in this alternative. In comparison to Alternative 1, Alternative 2 would have large long-term adverse impacts to hydropower by decreasing NED by an annual average of $5,426,000 with a range of annual differences of a $37,781,050 loss to a $13,543,647 gain. Increased carbon dioxide, methane, and nitrous oxide are also forecasted under Alternative 2 due to reliance on other energy sources resulting from lost hydropower benefits. Overall,

Alternative 2 would have significant adverse impacts on hydropower benefits compared to Alternative 1 due to the potential large adverse impacts on NED and RED within specific years and the large increase in impacts on OSE.

#### 3.13.2.6 Alternative 3 – Mechanical Construction Only

**National Economic Development**

The NED analysis for Alternative 3 is summarized in Table 3-121. Average annual system generation under this alternative would be 8,819,979 MWh, an increase of 4,079 MWh (0.05 percent) over Alternative 1. The value of the generation under this alternative would be $264,291,300, an increase of $6,000. This is a very small increase of 0.0023 percent in generation value. 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. The dependable capacity in the critical summer period under this alternative would be 2,127.5 MW valued at $261,400,000. The dependable capacity in the critical winter period under this alternative would be 1,952.2 MW valued at $239,872,000, an increase of 0.56 percent over Alternative 1. Also included in the table is a maximum average annual capacity loss. The other two capacity values were looking at the capacity loss for the system during summer and winter. However, different plants can be impacted differently in different seasons. The maximum average annual capacity loss is considering the highest impact at each plant, either during the winter or summer period. For Alternative 3, this value would be a loss of $262,000. This is the value used for the total impact value.

The total value of the impact to hydropower from Alternative 3 would be a loss of $256,000, a 0.049 percent decrease from Alternative 1, which includes a small increase in generation and a decrease in dependable capacity. The small increase to generation is valued at $6,000 and the small decrease in dependable capacity is valued at $262,000.

**Table 3-121. Summary of National Economic Development Analysis for Alternative 3 (2016 Dollars)**

| | |
|---|---|
| Average Annual System Generation | 8,819,979 MWh |
| System Generation Difference from Alternative 1 | +4,079 MWh |
| Average Annual Generation Value | $264,291,000 |
| Annual Generation Value Difference from Alternative 1 | +$6,000 |
| Dependable Capacity – Summer | 2,127.5 MW |
| Difference in Dependable Capacity – Summer from Alternative 1 | −0.2 MW |
| Average Annual Capacity Value – Summer | $261,400,000 |
| Difference in Average Annual Capacity Value – Summer from Alternative 1 | −$22,000 |
| Dependable Capacity – Winter | 1952.2 MW |
| Difference in Dependable Capacity – Winter from Alternative 1 | +10.9 MW |
| Average Annual Capacity Value – Winter | $239,872,000 |
| Difference in Average Annual Capacity Value – Winter from Alternative 1 | $1,336,000 |
| Maximum Average Annual Capacity Loss Summed by Plant | −$262,000 |
| **Total Average Annual Change in Hydropower NED Value from Alternative 1** | **−$256,000** |

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 38 of the 82 years in the POR, Alternative 3 would result in a higher hydropower value than Alternative 1. The average increase in these years would be $2,361,800. In 44 of the total years, Alternative 3 would result in a lower hydropower value than Alternative 1. The average decrease in these years would be $2,082,600. Further annual results can be found in the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

If both hydropower and thermal power production are affected during peak and critical periods, there would be 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 3, this potential for coupled effects is not expected to occur as a result of Management Plan actions.

**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 sales of electric power must repay all costs associated with power generation and WAPA must establish power rates sufficient to recover operating, maintenance, and purchase power expenses as well as repay the federal government's investment in building these generation and transmission facilities within 50 years. Since these costs will not decrease even though the average annual generation will decrease, the rates will need to increase in order to cover these costs. 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.

Under Alternative 3, in 2012, WAPA would incur a financial loss of $690,500. 2012 was used because it is defined as a normal generation year and, thus, could be representative of the typical annual impact expected due to the implementation of these alternatives.

WAPA provided their hourly preference customer and pumping load in the SPP footprint and their deliveries external to SPP in FY 2016 and compared the generation data from the hydropower benefits model for 2012, identified as a normal generation year. 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 3. An on-peak and off-peak energy price was applied to indicate the financial impact to WAPA of each alternative.

Therefore, Alternative 3 would increase power purchases or reduce surplus sales by almost $700,000 in this typical generation year. Of the 8,784 hours examined, 49 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 $3,000. The largest single hour purchase over the year was $128,300. Fifty-one percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $2,700. Additional information on these calculations can be found in the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

### Other Social Effects

As discussed in previous sections, reductions in hydropower generation would need to be made up by increasing other sources of power generation, likely to be a reliable fossil fuel source that produces greenhouse gases. Alternative 3 actually shows an increase in generation as compared to Alternative 1, so the comparison actually shows a decrease in greenhouse gases. The difference in average annual generation between Alternative 1 and Alternative 3 would be an increase of 4,079 MWh. Table 3-122 displays the results of these decreased emissions.

**Table 3-122. Summary of Other Social Effects Analysis for Alternative 3**

| | Carbon Dioxide (lbs) | Methane (lbs) | Nitrous Oxide (lbs) |
|---|---|---|---|
| Average Annual Change in Emissions under Alternative 3 | −8,016,091.59 | −214.56 | −133.46 |

The social cost of carbon discussed in Section 3.13.2.1, Impacts Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The social cost of carbon for 2016 is $38 per metric ton of carbon dioxide (using a 3 percent discount rate). The reduced social cost due to decreased carbon emissions under Alternative 3 would be $138,000.

### Conclusion

Alternative 3 has the smallest impact of all of the alternatives on hydropower and results in a small increase in power generation and a small decrease in dependable capacity. This is likely due to this alternative using mechanical ESH construction rather than changing river operations. In comparison to Alternative 1, there would be an average annual decrease in NED of $256,000 with a range of annual differences of a $13,188,274 loss to a $14,245,979 gain. Modeling forecasts a direct financial loss to WAPA of $690,500. Greenhouse gas emissions are forecasted to decrease. Small adverse impacts to NED and RED hydropower benefits occur under Alternative 3; however, these impacts are driven by modeled natural hydrologic variability in the system as this alternative does not include flow release changes for endangered species. Given the small level of impacts associated with Alternative 3, this alternative would not have significant impacts to hydropower.

### 3.13.2.7 Alternative 4 – Spring ESH Creating Release

**National Economic Development**

The NED analysis for Alternative 4 is summarized in Table 3-123. The average annual system generation under this alternative would decrease by 0.66 percent to 8,757,684 MWh. The value of this generation would be $262,424,000, a decrease of 0.66 percent from Alternative 1. The dependable capacity for the summer critical period under this alternative would be 2,112.8 MW. This capacity is valued at $259,601,000, a decrease in 0.70 percent from the critical summer period under Alternative 1. The dependable capacity for the winter critical period would be 1,930.2 MW. The value for this dependable capacity would be $237,159,000, a decrease in 0.58 percent from Alternative 1. Also included in the table is a maximum average annual capacity loss. The other two capacity values were looking at the capacity loss for the system during summer and winter. However, different plants can be impacted differently in different seasons. The maximum average annual capacity loss is considering the highest impact at each plant, either during the winter or summer period. For Alternative 4, this value would be a loss of $2,182,000. This is the value used for the total impact value.

The total value of the impact to hydropower, including a maximum capacity loss of $2,182,000 and a generation loss of $1,862,000, of Alternative 4 would be a loss of $4,044,000. This total value represents a 0.77 percent decrease from Alternative 1.

When evaluating the impacts of each alternative, year-by-year impacts as well as those that occur on average over the POR were examined. Additional results are summarized in Table 3-124, 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 the greatest negative impact to hydropower does not occur in a partial flow year or a full-flow-with-low-summer-releases year, but in 2010, which is neither, under Alternative 4. There would be a wide range of value differences in both partial and full flow years.

In 30 of the 82 years in the POR, Alternative 4 results in a higher hydropower value than Alternative 1. The average increase in these years would be $7,205,000. In 52 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 $9,998,000. Further annual results can be found in the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**Table 3-123. Summary of National Economic Development Analysis for Alternative 4 (2016 Dollars)**

| | |
|---|---|
| Average Annual System Generation | 8,757,684 MWh |
| System Generation Difference from Alternative 1 | −58,216 MWh |
| Average Annual Generation Value | $262,424,000 |
| Annual Generation Value Difference from Alternative 1 | −$1,862,000 |
| Dependable Capacity – Summer | 2,112.8 MW |
| Difference in Dependable Capacity – Summer from Alternative 1 | −14.8 MW |
| Average Annual Capacity Value – Summer | $259,601,000 |
| Difference in Average Annual Capacity Value – Summer from Alternative 1 | −$1,821,000 |

| | |
|---|---|
| Dependable Capacity – Winter | 1,930.2 MW |
| Difference in Dependable Capacity – Winter from Alternative 1 | −11.2 MW |
| Average Annual Capacity Value – Winter | $237,159,000 |
| Difference in Average Annual Capacity Value – Winter from Alternative 1 | −$1,377,000 |
| Maximum Average Annual Capacity Loss Summed by Plant | −$2,182,000 |
| **Total Average Annual Change in Hydropower NED Value from Alternative 1** | **−$4,044,000** |

**Table 3-124. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1 (2016 Dollars)**

| Change in $ from Alternative 1 | | | | | |
|---|---|---|---|---|---|
| **Full Flow Release + Low Summer Flow [a]** | | **Partial Flow Release [b]** | | **Maximum and Minimum Impact Regardless of Flow Actions** | |
| **Largest Decrease** | **Largest Increase** | **Largest Decrease** | **Largest Increase** | **Largest Decrease** | **Largest Increase** |
| −$3,323,000 | $35,014,000 | −$15,862,000 | $9,279,000 | −$34,024,000 | $35,014,000 |

a Full Flow Release + Low Summer Flow was implemented in 10 years of the period of analysis. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

B Partial Flow Release was implemented in 5 of the years of the period of analysis. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

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.

The comparison between the two shows a reduction in generation for both hydropower and thermal power in the fall of 2009. That could potentially lead to coupled effects in conjunction with a high demand for energy. However, since fall is not considered a peak or critical time for energy demand, it is not expected that coupled effects would occur during this alternative.

### 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 sales of electric power must repay all costs associated with power generation and WAPA must establish power rates sufficient to recover operating, maintenance, and purchase power expenses as well as repay the federal government's investment in building these generation and transmission facilities within 50 years. Since these costs will not decrease even though the average annual generation will decrease, the rates will need to increase in order to cover these costs. 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.

Under Alternative 4, in 2012, WAPA would incur a financial loss of $837,100. 2012 was used because it is defined as a normal generation year and, thus, could be representative of the typical annual impact expected due to the implementation of these alternatives. WAPA provided their hourly preference customer and pumping load in the SPP footprint and their deliveries external to SPP in FY 2016 and compared the generation data from the hydropower benefits model for 2012, identified as a normal generation year. 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 power purchases or reduce surplus sales by about $837,100 in this typical generation year. Of the 8,784 hours examined, 51 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 $2,800. The largest single hour purchase over the year was $17,900. Forty-nine percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $2,700. For additional information on these calculations, refer to the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

### Other Social Effects

Reductions in hydropower generation would need to be made up by increasing other sources of power generation, likely to be a reliable fossil fuel source that produces greenhouse gases. As discussed in Section 3.13.2.1, Impacts Assessment Methodology, the EPA eGrid database was used to determine the appropriate region and emissions factors for this study. The emissions factors are 1,965.21 lbs/MWh for carbon dioxide, 0.0526 lbs/MWh for methane, and 0.03272 lbs/MWh for nitrous oxide. The difference in estimated average annual megawatt hours between Alternative 1 and Alternative 4 is a reduction of 58,216 MWh. Table 3-125 displays the results of these increased emissions, necessary to replace the lost hydropower generation.

**Table 3-125. Summary of Other Social Effects Analysis for Alternative 4**

| | Carbon Dioxide (lbs) | Methane (lbs) | Nitrous Oxide (lbs) |
|---|---|---|---|
| Average Annual Change in Emissions under Alternative 4 | +114,406,665.36 | +3,062.16 | +1,904.83 |

The social cost of carbon discussed in Section 3.13.2.1, Impacts Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The social cost of carbon for 2016 is $38 per metric ton of carbon dioxide (using a 3 percent discount rate). The social cost of increased carbon emissions under Alternative 4 would be $1,972,000.

### Conclusion

This alternative is the second most impactful alternative on hydropower. This is likely due to the occurrence of spring flow releases under this alternative. In comparison to Alternative 1, there would be an average annual decrease in hydropower NED benefits of $4,044,000. The range of annual differences is a $34,024,351 loss to a $35,014,208 gain. Modeling forecasts a direct

financial loss to WAPA of $837,100. Greenhouse gas emissions are forecasted to increase. Large adverse impacts to hydropower NED and RED benefits are anticipated under Alternative 4. Overall, Alternative 4 would have significant adverse impacts on hydropower benefits compared to Alternative 1 due to the potential large adverse impacts on NED and RED within specific years and the large increase in impacts on OSE.

#### 3.13.2.8 Alternative 5 – Fall ESH Creating Release

**National Economic Development**

The NED analysis for Alternative 5 is summarized in Table 3-126. The average annual system generation under this alternative would be 8,796,163 MWh, a 0.22 percent decrease from Alternative 1. The value of this generation would be $263,096,000, a decrease of 0.45 percent from Alternative 1. The dependable capacity for the summer critical period under this alternative would be 2,124.5 MW. This capacity would be valued at $261,041,000, a 0.15 percent decrease. The dependable capacity for the winter critical period would be 1,937 MW. The value for this dependable capacity would be $238,003,000, a decrease of 0.23 percent from Alternative 1. Additionally, the maximum average annual capacity loss is in Table 3-126. The other two capacity values were looking at the capacity loss for the system during summer and winter. However, different plants can be impacted differently in different seasons. The maximum average annual capacity loss is considering the highest impact at each plant, either during the winter or summer period. For Alternative 4, this value would be a loss of $595,000. This is the value used for the total impact value.

The total value of the impact to hydropower, including a maximum capacity loss of $595,000 and a generation loss of $1,189,000, of Alternative 5 would be a loss of $1,784,000. This total value represents a 0.34 percent decrease of overall system value from Alternative 1.

When evaluating the impacts of each alternative, year-by-year impacts as well as those that occur on average over the POR were examined. Additional results are summarized in Table 3-127, 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 Alternative 5. Under Alternative 5, these results show that the greatest negative impact to hydropower would not occur in a partial flow year or a full-flow-with-low-summer-releases year, but in a year similar to 1995, which is neither, although it does follow a full release year. There is a wide range of value differences in the full flow release years, from negative to positive. Under Alternative 5, the annual impact has a narrow range of positive changes.

In 25 of the 82 years in the POR, Alternative 5 results in a higher hydropower value than Alternative 1. The average increase in these types of years would be $6,532,000. In 57 of the total years, Alternative 5 would result in a lower hydropower value than Alternative 1. The average decrease in these years would be $5,131,000. Further annual results can be found in the “Hydropower Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**Table 3-126. Impacts from Modeled Flow Releases under Alternative 5 (2016 Dollars)**

| | |
|---|---|
| Average Annual System Generation | 8,796,163 MWh |
| System Generation Difference from Alternative 1 | −19,737 MWh |
| Average Annual Generation Value | $263,096,000 |
| Annual Generation Value Difference from Alternative 1 | −$1,189,000 |
| Dependable Capacity - Summer | 2,124.5 MW |
| Difference in Dependable Capacity - Summer from Alternative 1 | −3.1 MW |
| Average Annual Capacity Value - Summer | $261,041,000 |
| Difference in Average Annual Capacity Value - Summer from Alternative 1 | −$381,000 |
| Dependable Capacity - Winter | 1,937 MW |
| Difference in Dependable Capacity - Winter from Alternative 1 | −4.3 MW |
| Average Annual Capacity Value - Winter | $238,003,000 |
| Difference in Average Annual Capacity Value - Winter from Alternative 1 | −$533,000 |
| Maximum Average Annual Capacity Loss Summed by Plant | −$595,000 |
| **Total Average Annual Change in Hydropower NED Value from Alternative 1** | **−$1,784,000** |

**Table 3-127. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1 (2016 Dollars)**

| Change in $ from Alternative 1 | | | | | |
|---|---|---|---|---|---|
| **Full Flow Release + Low Summer Flow [a]** | | **Partial Flow Release [b]** | | **Maximum and Minimum Impact Regardless of Flow Actions** | |
| **Largest Decrease** | **Largest Increase** | **Smallest Increase** | **Largest Increase** | **Largest Decrease** | **Largest Increase** |
| −$2,426,000 | $31,104,000 | $3,393,000 | $3,849,000 | −$25,850,000 | $31,104,000 |

a. Full Flow Release + Low Summer Flow was implemented in 7 years of the period of analysis. 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 period of analysis. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

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, under Alternative 5, this potential for coupled effects is not expected to occur as a result of Management Plan actions.

### 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 sales of electric power must repay all costs associated with power generation and WAPA must establish power rates sufficient to recover operating, maintenance, and purchase power expenses as well as repay the federal government's investment in building these generation and transmission facilities within 50 years. Since these costs will not decrease even though the average annual generation will decrease, the rates will need to increase in order to cover these costs. 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.

Under Alternative 5, in 2012, WAPA would incur a financial loss of $3,354,200. 2012 was used because it is defined as a normal generation year and thus could be representative of the typical annual impact expected due to the implementation of these alternatives. This result is somewhat unexpected given that the NED impact of Alternative 5 is the second least impactful, whereas in the RED analysis, it is the second largest loss. However, the NED is averaged over the entire POR. For the purposes of this analysis, 2012 in the existing condition was intended to be representative of a normal year. When looking at the individual year NED results for 2012, the RED results are following the same pattern. For a more in-depth discussion of these results, refer to the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

WAPA provided their hourly preference customer and pumping load in the SPP footprint and their deliveries external to SPP in FY 2016 and compared the generation data from the hydropower benefits model for 2012, identified as a normal generation year. 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. 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.

Therefore, Alternative 5 would increase power purchases or reduce surplus sales by about $3,354,200 in this typical generation year. Of the 8,784 hours examined, 51 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 $4,800. The largest single hour purchase over the year was $17,600. Forty-nine percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $3,600. For additional information on these calculations, refer to the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

**Other Social Effects**

Reductions in hydropower generation would need to be made up by increasing other sources of power generation, likely to be a reliable fossil fuel source that produces greenhouse gases. As discussed in Section 3.13.2.1, Impacts Assessment Methodology, the EPA eGrid database was used to determine the appropriate region and emissions factors for this study. The emissions factors are 1,965.21 lbs/MWh for carbon dioxide, 0.0526 lbs/MWh for methane, and 0.03272 lbs/MWh for nitrous oxide. The difference in average annual megawatt hours between Alternative 1 and Alternative 5 is a reduction of 19,737 MWh. Table 3-128 displays the results of these increased emissions, necessary to replace the lost hydropower generation.

**Table 3-128. Summary of Other Social Effects Analysis for Alternative 5**

| | Carbon Dioxide (lbs) | Methane (lbs) | Nitrous Oxide (lbs) |
|---|---|---|---|
| Average Annual Change in Emissions under Alternative 5 | +38,787,349.77 | +1,038.17 | +645.79 |

The social cost of carbon discussed in Section 3.13.2.1, Impacts Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The social cost of carbon for 2016 is $38 per metric ton of carbon dioxide (using a 3 percent discount rate). The social cost of increased carbon emissions under Alternative 5 would be $669,000.

**Conclusion**

In comparison to Alternative 1, there would be an average annual decrease in hydropower NED benefits of $1,784,000. The range of annual differences is a $25,850,202 loss to a $31,104,359 gain. Modeling forecasts a direct financial loss to WAPA of $3,354,200. Greenhouse gas emissions are forecasted to increase. This alternative would have significant impacts to hydropower because of large adverse impacts to hydropower NED and RED benefits. Overall, Alternative 5 would have significant adverse impacts on hydropower benefits compared to Alternative 1 due to the potential large adverse impacts on NED and RED within specific years and the large increase in impacts on OSE.

### 3.13.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

**National Economic Development**

The NED analysis for Alternative 6 is summarized in Table 3-129. The average annual system generation under this alternative would be 8,793,062 MWh. The value of this generation would be $263,572,000, a decrease of 0.2 percent from Alternative 1. The dependable capacity for the summer critical period under this alternative would be 2,117 MW. This capacity would be valued at $260,121,000, a 0.50 percent decrease. The dependable capacity for the winter critical period would be 1,933.5 MW. The value for this dependable capacity would be $237,569,000, a decrease of 0.41 percent from Alternative 1.

Additionally, the maximum average annual capacity loss is in Table 3-129. The other two capacity values were looking at the capacity loss for the system during summer and winter. However, different plants can be impacted differently in different seasons. The maximum average annual capacity loss is considering the highest impact at each plant, either during the winter or summer period. For Alternative 4, this value would be a loss of $1,379,000. This is the value used for the total impact value.

The total value of the impact to hydropower, including a maximum capacity loss of $1,379,000 and a generation loss of $714,000, of Alternative 6 would be a loss of $2,092,000. This total value represents a 0.4 percent decrease of overall system value from Alternative 1.

When evaluating the impacts of each alternative, year-by-year impacts as well as those that occur on average over the POR were examined. 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 where there is a release action or low summer flow, as a result of Alternative 6. Under Alternative 6, these results show that the greatest negative

and the greatest positive impact to hydropower would occur in a partial flow year. There is a wide range of results in partial release years, from a loss of $33,041,000 in 2010 to an increase of $17,885,000 in 1987. In full flow years, under Alternative 6, there is always a positive impact.

In 29 of the 82 years in the POR, Alternative 6 would results in a higher hydropower value than Alternative 1. The average increase in these years is $5,458,000. In 53 of the total years, Alternative 6 results in a lower hydropower value than Alternative 1. The average decrease in these years is $6,141,000. Further annual results can be found in the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

**Table 3-129. Impacts from Modeled Flow Releases under Alternative 6 (2016 Dollars)**

| | |
|---|---|
| Average Annual System Generation | 8,793,062 MWh |
| System Generation Difference from Alternative 1 | −22,838 MWh |
| Average Annual Generation Value | $263,572,000 |
| Annual Generation Value Difference from Alternative 1 | −$714,000 |
| Dependable Capacity – Summer | 2,117 MW |
| Difference in Dependable Capacity – Summer from Alternative 1 | −10.6 MW |
| Average Annual Capacity Value – Summer | $260,121,000 |
| Difference in Average Annual Capacity Value - Summer from Alternative 1 | −$1,301,000 |
| Dependable Capacity – Winter | 1,933.5 MW |
| Difference in Dependable Capacity – Winter from Alternative 1 | −7.9 MW |
| Average Annual Capacity Value – Winter | $237,569,000 |
| Difference in Average Annual Capacity Value – Winter from Alternative 1 | −$967,000 |
| Maximum Average Annual Capacity Loss Summed by Plant | −$1,379,000 |
| **Total Average Annual Change in Hydropower NED Value from Alternative 1** | **−$2,092,000** |

**Table 3-130. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1 (2016 Dollars)**

| **Change in $ from Alternative 1** | | | | | |
|---|---|---|---|---|---|
| **Full Flow Release + Low Summer Flow [a]** | | **Partial Flow Release [b]** | | **Maximum and Minimum Impact Regardless of Flow Actions** | |
| **Smallest Increase** | **Largest Increase** | **Largest Decrease** | **Largest Increase** | **Largest Decrease** | **Largest Increase** |
| $329,000 | $15,722,000 | −$33,041,000 | $17,885,000 | −$33,041,000 | $17,885,000 |

a. Full Flow Release + Low Summer Flow was implemented in 11 years of the period of analysis. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

b. Partial Flow Release was implemented in 33 of the years of the period of analysis. Data represents the maximum and minimum changes from Alternative 1 in the years it was implemented.

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, under Alternative 6, this potential for coupled effects is not expected to occur as a result of Management Plan actions.

**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 sales of electric power must repay all costs associated with power generation and WAPA must establish power rates sufficient to recover operating, maintenance, and purchase power expenses as well as repay the federal government's investment in building these generation and transmission facilities within 50 years. Since these costs will not decrease even though the average annual generation will decrease, the rates will need to increase in order to cover these costs. 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.

Under Alternative 6, in 2012, WAPA would incur a financial gain of $5,461,000. 2012 was used because it is defined as a normal generation year, at least in the existing condition and, thus, could be representative of the typical annual impact expected due to the implementation of these alternatives. This result for Alternative 6 is somewhat unexpected given that the NED impact of Alternative 5 is a loss, whereas in the RED analysis, there is a financial gain. However, the NED result is averaged over the entire POR. For the purposes of this analysis, 2012 in the existing condition was intended to be representative of a normal year. When looking at the individual year NED results for 2012, the RED results are following the same pattern. For a more in-depth discussion of these results, refer to the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

WAPA provided their hourly preference customer and pumping load in the SPP footprint and their deliveries external to SPP in FY 2016 and compared the generation data from the hydropower benefits model for 2012, identified as a normal generation year. 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 6. An on-peak and off-peak energy price was applied to indicate the financial impact to WAPA of each alternative.

Therefore, Alternative 6 would reduce power purchases or increase surplus sales by about $5,461,000 in this typical generation year. Of the 8,784 hours examined, 45 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 $4,600. The largest single hour purchase over the year was $19,100. Fifty-five percent of the hours provided surplus power and, with that, the ability to sell the power on the market at an average of $6,000. For additional information on these calculations, refer to the "Hydropower Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

### Other Social Effects

Reductions in hydropower generation would need to be made up by increasing other sources of power generation, likely to be a reliable fossil fuel source that produces greenhouse gases. As discussed in Section 3.13.2.1, Impacts Assessment Methodology, the EPA eGrid database was used to determine the appropriate region and emissions factors for this study. The emissions factors are 1,965.21 lbs/MWh for carbon dioxide, 0.0526 lbs/MWh for methane, and 0.03272 lbs/MWh for nitrous oxide. The difference in average annual megawatt hours between Alternative 1 and Alternative 6 is a reduction of 22,838 MWh. Table 3-131 displays the results of these increased emissions, necessary to replace the lost hydropower generation.

**Table 3-131. Summary of Other Social Effects Analysis for Alternative 6**

| | Carbon Dioxide (lbs) | Methane (lbs) | Nitrous Oxide (lbs) |
|---|---|---|---|
| Average Annual Change in Emissions under Alternative 6 | +44,881,465.98 | +1,201.28 | +747.26 |

The social cost of carbon discussed in Section 3.13.2.1, Impacts Assessment Methodology, is intended to estimate the social costs of increased and decreased emissions. The social cost of carbon for 2016 is $38 per metric ton of carbon dioxide (using a 3 percent discount rate). The social cost of increased carbon emissions under Alternative 6 would be $774,000.

### 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 $2,092,000. The range of annual differences is a $33,041,450 loss to a $17,885,409 gain. Modeling forecasts a direct financial gain to WAPA of $5,461,000. Greenhouse gas emissions are forecasted to increase. Overall, Alternative 6 would have significant adverse impacts on hydropower benefits compared to Alternative 1 due to the potential large adverse impacts on NED and RED within specific years and the large increase in impacts on OSE.

## 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 the WAPA 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 the way the agreements with the Tribes functions is to provide the Tribes 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 2 has the greatest potential to change the cost of producing power and affect the rate/credit the Tribes receive, followed by Alternative 4, Alternative 6, 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 sporadicalness 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 production 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 production and reliability. Increased sedimentation could potentially result in increased O&M at the dams, which would impact hydropower operations, production, and reliability. Increased sporadicness 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, adverse affected hydropower generation and how power producers have 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

Past, present and reasonable foreseeable future actions that would affect the volume and timing of water in the river upstream of Gavins Point, such as depletions or withdrawals for agriculture, municipal, and industrial uses, have and would continue to have adverse impacts to hydropower generation. In addition, 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.

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 MISO RTO is anticipating that a number of non-hydro power plants would retire or suspend operations as soon as the year 2018, resulting in a reduction of 1.8 GW of generation in southern Illinois, which would reduce capacity below the minimum required reserve margin levels and the ability of the RTO to meet load demands (MISO 2016). This could put pressure on the remaining power producers in the RTO, like hydropower, to maintain power generation even in adverse conditions, especially during peak periods.

Hydropower would continue to provide national and regional economic benefits under Alternative 1. Continued implementation of alternative 1 would not likely cause significant adverse impacts to hydropower. When combined with other actions, significant adverse cumulative impacts of Alternative 1 would be unlikely, although depending on the operations of the river and the energy market impacts could be adverse or beneficial. Alternative 1 contribution to the overall cumulative impacts would be small. Similarly, alternative 3 would likely result in small adverse impacts to NED and RED hydropower benefits; however, these impacts are driven by modeled natural hydrologic variability in the system as this alternative does not include flow release changes for endangered species. Therefore, the cumulative impacts of Alternative 3 would be similar to those under Alternative 1, although the contribution of Alternative 3 would be negligible.

However, Alternatives 2, 4, 5, and 6 would have significant adverse impacts on hydropower benefits compared to Alternative 1 due to large adverse effects on NED and RED benefits. When combined with impacts from other actions, the cumulative impacts of Alternative 2, 4, 5, and 6 would likely be adverse and significant as a result of water releases, with the alternatives providing a substantial contribution to the overall cumulative impact.

# 3.14 Irrigation

## 3.14.1 Affected Environment

Irrigators in 42 counties in Montana, North Dakota, South Dakota, and Nebraska hold permits to use water from the Missouri River for the purpose of agricultural production. This generally includes the area extending from Fort Peck Reservoir to Rulo, Nebraska. No irrigation permits were identified for counties from the states of Iowa, Kansas, or Missouri. The state of Iowa does not require surface water users to file for a permit for withdrawals under 25,000 gallons per day (gpd). No intakes for irrigation are currently permitted in states located on the Missouri River reach from Rulo, Nebraska, to the mouth of the Missouri River. The irrigation intakes permitted on the Missouri River are a mix of semi-permanent (portable) and permanent structures.

Of 12.5 million acres of harvested cropland in the 42 counties along the Missouri, approximately 2,266,000 acres of irrigated cropland were harvested in 2012, or approximately 18.1 percent of all cropland. According to the State Department of Natural Resources and State Water Commission records, 238,766 of these acres are permitted for irrigation using Missouri River water, or approximately 11 percent of all irrigated acres harvested (Table 3-132). Almost all of the permitted acres are located in the upper basin, where lower annual rainfall and a shorter growing season leaves irrigators more dependent on river and reservoir water. For example, McCone County, Montana recorded 17.5 inches of precipitation in 2014.[5] However, the highest recorded precipitation in the 42-county area was in Washington County, Nebraska, which recorded 41.3 inches in 2014. The growing season in the upper basin counties are largely constrained by snowfall and low average temperatures. In the upper reaches of the river, the irrigation season lasts approximately from May through September. In the lower river reaches, in Nebraska, the growing season also begins in May but typically extends through October.

**Table 3-132. Precipitation, Irrigated Crop Acreage, and Intakes for the 42-County Area**

| County | State | County Precipitation (Inches, 2014) | Irrigated Crop Acres Harvested (All Water Sources, 2012) | Acres Permitted (Missouri River Only, 2015) | Actual Acres Irrigated (Missouri River Only, 2015) |
|---|---|---|---|---|---|
| McCone | Montana | 17.5 | 83,141 | 16,209.3 | not reported |
| Valley | Montana | 15.4 | 194,605 | 4,978.4 | not reported |
| Roosevelt | Montana | 13.6 | 74,200 | 21,284.3 | not reported |
| Richland | Montana | 15.9 | 132,818 | 18,156.0 | not reported |
| Williams | North Dakota | 10.2 | 83,007 | 39,965.7 | 12,423.1 |
| McKenzie | North Dakota | 16.4 | 37,635 | 11,029.9 | 735.0 |
| Mountrail | North Dakota | 20.1 | 0 | 1,094.4 | 250.0 |
| McLean | North Dakota | 20.3 | 74,852 | 5,874.5 | 3,162.0 |
| Mercer | North Dakota | n/a | 14,965 | 5,463.1 | 1,739.1 |
| Oliver | North Dakota | n/a | 38,852 | 6,784.0 | 3,518.0 |
| Burleigh | North Dakota | 14.3 | 58,428 | 4,722.8 | 3,640.6 |

[5] County precipitation for 2014 is the average value recorded at varying number of weather stations throughout the county over the course of the calendar year.

| County | State | County Precipitation (Inches, 2014) | Irrigated Crop Acres Harvested (All Water Sources, 2012) | Acres Permitted (Missouri River Only, 2015) | Actual Acres Irrigated (Missouri River Only, 2015) |
|---|---|---|---|---|---|
| Morton | North Dakota | 19.9 | 49,601 | 3,984.9 | 1,848.0 |
| Emmons | North Dakota | 17.9 | 16,310 | 9,507.6 | 6,449.8 |
| Sioux | North Dakota | n/a | 0 | 678.9 | 0.0 |
| Corson | South Dakota | 22.0 | 0 | 1,261.0 | 50.7 |
| Campbell | South Dakota | 16.0 | 14,574 | 2,261.1 | 704.3 |
| Walworth | South Dakota | 19.8 | 23,971 | 2,193.0 | 258.4 |
| Dewey | South Dakota | n/a | 0 | 766.0 | 37.0 |
| Potter | South Dakota | 21.0 | 0 | 929.0 | 356.1 |
| Sully | South Dakota | 17.9 | 67,654 | 22,949.9 | 7,744.0 |
| Stanley | South Dakota | 18.4 | 644 | 1,446.8 | 25.8 |
| Hughes | South Dakota | 16.0 | 21,211 | 20,307.3 | 10,048.2 |
| Buffalo | South Dakota | 15.0 | 12,779 | 5,979.0 | 2,915.3 |
| Hyde | South Dakota | 15.0 | 4,800 | 0.0 | 0.0 |
| Lyman | South Dakota | 15.4 | 21,745 | 2,960.8 | 683.5 |
| Brule | South Dakota | 20.7 | 19,005 | 2,580.0 | 608.2 |
| Charles Mix | South Dakota | 19.2 | 64,649 | 12,492.2 | 4,391.3 |
| Gregory | South Dakota | 20.2 | 2,066 | 534.0 | 162.5 |
| Boyd | Nebraska | 21.0 | 18,425 | 274.0 | not reported |
| Bon Homme | South Dakota | 19.6 | 23,411 | 5,527.6 | 2,826.9 |
| Knox | Nebraska | 25.9 | 137,176 | 454.8 | not reported |
| Cedar | Nebraska | 31.7 | 257,655 | 1,498.0 | not reported |
| Yankton | South Dakota | 27.9 | 49,080 | 685.2 | 353.3 |
| Clay | South Dakota | 28.1 | 62,404 | 246.7 | 21.2 |
| Dixon | Nebraska | 35.4 | 87,943 | 1,340.6 | not reported |
| Union | South Dakota | n/a | 122,751 | 265.0 | 0.0 |
| Thurston | Nebraska | 31.6 | 64,988 | 153.6 | not reported |
| Burt | Nebraska | 32.0 | 130,807 | 839.3 | not reported |
| Washington | Nebraska | 41.3 | 59,355 | 761.5 | not reported |
| Cass | Nebraska | n/a | 33,555 | 37.4 | not reported |
| Otoe | Nebraska | 33.2 | 48,989 | 255.8 | not reported |
| Nemaha | Nebraska | 33.3 | 57,935 | 32.2 | not reported |
| **Total** | | | 2,265,986 | 238,766 | 64,952 |

Sources: National Climatic Data Center 2016; NASS 2016; Montana Department of Natural Resources and Conservation; North Dakota State Water Commission; South Dakota Department of Environment and Natural Resources; Nebraska Department of Natural Resources

Table 3-133 summarizes the irrigation intakes by state. A majority (94 percent) of the 816 intakes are located in Montana, North Dakota, and South Dakota. Montana has the largest number of intakes of the four states, whereas relatively fewer intakes are located in Nebraska.

North Dakota has the greatest number of permitted acres of the four states. In 2015, the state permitted 89,106 acres for irrigation using Missouri River water. South Dakota and Montana also permit a substantial number of acres for irrigation, with 83,385 acres and 60,628 acres, respectively.

The most abundant crop grown in the 42 counties is corn, with 323,000 irrigated acres harvested in 2012. The next most-abundant crop is soybeans, with 162,000 acres irrigated (Table 3-134). However, these crops are not evenly distributed throughout the 42 counties. The 10 counties in Nebraska harvested a higher number of irrigated acres of corn, soybeans, and oats.

**Table 3-133. Irrigation Intakes and Permitted Acres by State**

| State | Number of Counties | Acres Permitted (2015) | Number of Intakes Permitted (2015) |
|---|---|---|---|
| Montana | 4 | 60,628 | 276 |
| North Dakota | 10 | 89,106 | 265 |
| South Dakota | 18 | 83,385 | 224 |
| Nebraska | 10 | 5,647 | 51 |

**Table 3-134. Harvested Acres Irrigated in the 42-County Area, 2012**

| Crop | Acres Irrigated | Percentage of Acreage in Counties in the State | | | |
|---|---|---|---|---|---|
| | | Montana | North Dakota | South Dakota | Nebraska |
| Corn | 322,653 | 3.5% | 5.9% | 26.4% | 64.2% |
| Soybeans | 162,458 | 0.0% | 3.7% | 32.2% | 64.1% |
| Hay | 110,957 | 72.7% | 11.2% | 7.2% | 8.9% |
| Wheat | 90,848 | 70.9% | 23.9% | 4.0% | 1.2% |
| Hay and Haylage | 62,723 | 68.7% | 10.8% | 8.8% | 11.7% |
| Sugarbeets | 25,086 | 70.1% | 29.9% | 0.0% | 0.0% |
| Barley | 21,219 | 63.3% | 36.7% | 0.0% | 0.0% |
| Beans | 10,349 | 89.2% | 10.8% | 0.0% | 0.0% |
| Haylage | 1,257 | 0.0% | 0.0% | 0.0% | 100.0% |
| Peas | 669 | 82.4% | 17.6% | 0.0% | 0.0% |
| Lentils | 300 | 0.0% | 100.0% | 0.0% | 0.0% |
| Canola | 145 | 0.0% | 100.0% | 0.0% | 0.0% |
| Oats | 54 | 0.0% | 0.0% | 0.0% | 100.0% |
| **Total (Acres)** | **808,718** | **240,188** | **82,696** | **154,842** | **330,992** |

Source: Census of Agriculture 2012

Table 3-135 shows the estimated acreage of harvested crops irrigated by the Missouri River for the eight counties that were evaluated, according to the most recent Census of Agriculture and the estimated number of harvested acres irrigated by the Missouri River.

**Table 3-135. Estimated Harvested Crop Acreage Irrigated by Missouri River, 2015**

| | Montana | | | | North Dakota | | | South Dakota |
|---|---|---|---|---|---|---|---|---|
| **Commodity** | **McCone** | **Valley** | **Roosevelt** | **Richland** | **Williams** | **Mercer** | **Emmons** | **Sully** |
| Barley | 0 | 24 | 203 | 820 | 1,576 | 0 | 0 | 0 |
| Corn for grain | 107 | 57 | 46 | 558 | 1,027 | 1,272 | 3,724 | 4,473 |
| Hay, all types | 2,825 | 1,461 | 2,782 | 2,147 | 3,215 | 467 | 0 | 322 |
| Dry beans | 1,979 | 11 | 636 | 0 | 634 | 0 | 0 | 0 |
| Soybeans for beans | 0 | 0 | 0 | 0 | 738 | 0 | 2,726 | 2,949 |
| Sugar beets | 0 | 0 | 256 | 1,191 | 0 | 0 | 0 | 0 |
| Wheat, all types | 1,193 | 322 | 4,092 | 2,120 | 5,233 | 0 | 0 | 0 |
| Total | 6,104 | 1,875 | 8,015 | 6,837 | 12,423 | 1,739 | 6,450 | 7,744 |

Sources: USDA 2012; Montana Department of Natural Resources and Conservation; North Dakota State Water Commission; South Dakota Department of Environment and Natural Resources; Nebraska Department of Natural Resources

#### 3.14.1.1 Irrigation Resources on Tribal Lands

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

### 3.14.2 Environmental Consequences

The environmental consequences analysis for irrigation intakes focuses on changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives. This section summarizes the irrigation impact assessment methodology and presents the results of the assessment. A detailed description of the methodology and results is provided in the report “Irrigation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

#### 3.14.2.1 Impacts Assessment Methodology

The environmental consequences to irrigation intakes were evaluated using three of the four accounts (NED, RED, and OSE). As river flows and reservoir elevations fall below minimum operating requirements, intakes become unavailable to provide water to farm operations (including private farms, Tribes, and commercial operations). This, in turn, can result in changes to net farm income. The analysis used outputs from the HEC-RAS and HEC-ResSim models to simulate river and reservoir conditions for several locations along the river over an 82-year

POR, from 1931 to 2012. No county in the research area relies exclusively on the Missouri River for irrigation. Counties were included in the impact analysis if a significant percentage of irrigated acres in the county used water from the Missouri River and if the alternatives showed noticeable changes in access to water. Counties evaluated included Richland, Roosevelt, McCone, and Valley in Montana; Williams, Mercer, and Emmons in North Dakota; and Sully in South Dakota. Thus, the analysis of irrigation operations in these particular counties represents the likely impacts that would occur under the MRRMP-EIS alternatives. The analysis does not evaluate all agriculture production within each of these counties but only the portion that is irrigated with water from the Missouri River.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

**National Economic Development**

The NED analysis estimated changes in net farm income from irrigated agricultural operations in eight counties expected to experience measurable impacts as a result of changing physical conditions along the Missouri River from the MRRMP-EIS alternatives. The analysis linked changes in access to water to expected yields for crops grown, as reported by relevant state agriculture crop extension budgets. The most recent Census of Agriculture, taken in 2012, was used to estimate harvested acres for each crop. Net farm income was calculated by estimating expected yield per acre for crops irrigated with Missouri River water, taking into account local factors such as amount of rainfall and local water usage for irrigation, and then subtracting the expected cost of production. Cost of production was also drawn from relevant crop extension budgets. The change in yield per acre is driven by the change in access to water—as the number of days an intake would not have access to water increases, the expected yield decreases.

The primary NED metric developed in this section is change in net farm income. Alternative 1 is used as a baseline, and all other alternatives are compared to Alternative 1.

**Regional Economic Development**

The RED analysis used the results from the NED analysis to estimate regional economic effects of MRRMP-EIS alternatives. The RED analysis focused on changes in employment, income, and sales to counties affected by the MRRMP-EIS alternatives. RED impacts were estimated in part with IMPLAN® Pro, an input-output modeling software program. IMPLAN® Pro uses inter-industry relationships to estimate the additional economic activity that can be expected in the study area as a result of generated demand for goods and services associated with the directly affected industry—in this case, agricultural crop production. Value of crop production estimated under the NED analysis was used as the direct input into IMPLAN® Pro to estimate the regional economic benefits of irrigated agriculture.

**Other Social Effects**

Changes in irrigation operations have a potential to cause other types of effects on individuals and communities. These impacts are often evaluated under the OSE account. The OSE

analysis for irrigation relied in part on the results of the NED and RED analysis to determine the scale of impacts that could occur to community well-being, traditional ways of life, and economic vitality. Impacts of the alternatives on OSE are discussed qualitatively.

#### 3.14.2.2 Summary of Environmental Consequences

Table 3-136 summarizes the impacts to irrigation intakes from each of the MRRMP-EIS alternatives. The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

**Table 3-136. Environmental Consequences Relative to Irrigation, 2016 Dollars**

| Alternative | NED Impacts | RED Impacts [a] | 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 irrigation intakes. |
| Alternative 1 | Average annual net farm income: $5,828,474, | Average annual total labor income $10,489,000; Average annual employment of 686.8. | Negligible OSE Impacts | Temporary, relatively small, and adverse impacts and would be limited to intakes near the site of habitat construction. |
| Alternative 2 | Decrease in average annual net farm income of $133,902 or 2.3%; short-term, small, and adverse impacts likely as a result of reservoir rebalancing that would occur in years following bi-modal spawning cue. | Decrease average annual labor income of $224,000 or 2.0%; Decrease in average annual employment of 1 job. | Negligible OSE Impacts | Potential for short-term and long-term, large, and adverse impacts to irrigation intakes located in reaches where the habitat construction would take place. |
| Alternative 3 | Increase in average annual net farm income of $25,049 or 0.4%; small benefit as a result of the elimination of the spring plenary pulse. | Decrease in average annual labor income of $150,000 or 1.4%; Decrease in average annual employment of less than one job. | Negligible OSE Impacts | Temporary, relatively small, and adverse impacts that would be limited to intakes near the site of habitat construction. |

| Alternative | NED Impacts | RED Impacts [a] | OSE Impacts | Other Impacts |
|---|---|---|---|---|
| Alternative 4 | Decrease in average annual net farm Income of $206,380 or 3.5%; short-term, small, and adverse impacts in years following releases during drought periods. | Decrease in average annual labor income of $165,000 or 2.2%; decrease in average annual employment of 2 jobs. | Negligible OSE Impacts | Same as alternative 3 |
| Alternative 5 | Decrease in average annual net farm income of $4,174 or 0.1%; negligible impact. | Decrease in average annual labor income of $244,000 or 1.6%; decrease in average annual employment of less than 1 job. | Negligible OSE Impacts | Same as alternative 3 |
| Alternative 6 | Decrease in average annual net farm income of $132,247 or 2.3%; short-term, small, and adverse impacts in years following spawning cue releases during drought periods. | Decrease in average annual labor income of $224,000 or 2.0%; decrease in average annual employment of 1 job. | Negligible OSE Impacts | Same as alternative 3 |

a NED impacts focus on net farm income, where RED impacts use farm revenue to calculate impacts. Because costs are not factored into revenues, the impacts calculated from net farm revenue may greatly exceed NED impacts.

### 3.14.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include predator management, vegetative management, and human restriction measures. These actions are not expected to have any impacts on irrigation intakes along the Missouri River.

### 3.14.2.4 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 and a spring plenary pulse or a bi-modal spring plenary pulse. These actions will be focused in the Garrison and Gavins Point reaches for ESH habitat construction and between Ponca to the mouth of the Missouri River near St. Louis for SWH. Only irrigation intakes in these reaches would be impacted. Impacts of the spring plenary pulse are evaluated below.

Under current system operations, the Missouri River will remain a viable source of water for irrigation operations, especially in the upper river. Irrigation intakes will need to be managed to adapt to dynamic river and reservoir conditions that are affected by a variety of factors. A consistent supply of water for irrigation purposes requires that intakes be submerged in the water during the growing season and at the same time does not get buried by sediment deposits. Irrigation intakes are thus affected by changes in water surface elevations and

aggradation and degradation processes (refer to Section 3.2 “River Infrastructure and Hydrologic Processes”). The analysis of Alternative 1 focuses on the amount of irrigation that is occurring under current system operations including MRRP implementation.

**Mechanical Habitat Construction**

Management focused on mechanical construction of ESH and SWH have the potential to disrupt irrigation operations and impact irrigation intakes. For instance, constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in aggradation segments of the river. This can result in increased maintenance issues to irrigation intakes in areas of aggradation (USACE 2011).

The extent of these impacts would be dependent on where the MRRMP actions occur relative to any irrigation intakes. The potential impacts of ESH on infrastructure such as irrigation intakes was evaluated in the *Final Programmatic Environmental Impact Statement for Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011). The PEIS noted that in order to mitigate impacts of habitat creation, USACE would identify sensitive resource categories and subsequent restrictive or exclusionary zones associated with these resources. Site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources. Intakes and other infrastructure were one of the categories of sensitive resources.

ESH would be constructed in the Garrison reach from Garrison Dam to Lake Oahe and in the Gavins Point reach from Gavins Point to Ponca Nebraska. The construction of habitat where irrigation intakes are located has the potential to cause temporary, small, and adverse impacts on irrigation intakes, although site specific planning would reduce these adverse effects. Because very few intakes are located below Ponca, Nebraska, there would be negligible impacts to irrigation impacts from SWH construction.

**National Economic Development**

The NED analysis focused on net farm income from irrigated agriculture using water from the Missouri River. Table 3-137 summarizes the NED analysis for Alternative 1. Overall, average annual net farm income for all eight counties evaluated would be over $5.9 million. Under Alternative 1, a negative net farm income does not imply a negative impact as a result of MRRMP-EIS implementation, but rather lower prices for crops grown in the counties under consideration.

Under Alternative 1, the highest variation in net farm income would be in Sully County, which varies from $654,000 in drought years to $2.6 million during years with greater access to water. The least amount of variation in net farm income would be in Valley County, which would vary from $58,000 during drought years to $239,000 during years of greater water access. The natural hydrologic variability of the basin drives these impacts to net farm income under Alternative 1 with lower net farm income during years with drought and relatively drier conditions.

**Table 3-137. National Economic Development Analysis for Alternative 1, 2016 Dollars**

| | Benefit | Total Net Farm Income From Irrigated Acreage (POR) | Average Annual Net Farm Income |
|---|---|---|---|
| **Montana** | McCone | $52,134,000 | $636,00 |
| | Valley | $17,432,000 | $213,000 |
| | Roosevelt | $50,121,000 | $611,000 |
| | Richland | $145,197,000 | $1,771,000 |
| **North Dakota** | Williams | −$8,810,000 | −$107,000 |
| | Mercer | $5,268,000 | $64,000 |
| | Emmons | $53,629,000 | $654,000 |
| **South Dakota** | Sully | $170,531,000 | $2,080,000 |
| | **Total** | $485,502,000 | $5,921,000 |

Note: Based on the prices used for this analysis, some counties, including Williams, show losses in net farm income when crops such as wheat are grown. Although wheat lost money in 2015, it is likely that would not be the case over the entire POR. It is also likely that some low-margin crops, such as hay, are used primarily as a feedstock for livestock and are not sold as a final product at the published prices reported by the USDA.

## Regional Economic Development

The RED analysis for Alternative 1 estimated the employment, labor income, and sales supported from irrigated crop production in the eight counties. The RED analysis calculated the direct, indirect, and induced economic activity resulting from gross sales of irrigated crops. Table 3-138 summarizes the economic contribution for all eight counties evaluated. Under Alternative 1, irrigated agriculture would generate on average 343 jobs, $10 million in labor income, and $43 million in sales.

**Table 3-138. RED Analysis for Average Revenue Year for Irrigated Agriculture Using Missouri River Water - Alternative 1, 2016 Dollars**

| RED Metric | Average Annual Contribution |
|---|---|
| Employment | 343.4 |
| Labor Income | $10,489,000 |
| Total Sales | $43,084,000 |

## Other Social Effects

Agriculture has historically been a critical economic component and way of life for many of the communities within the counties evaluated under this analysis. Relative to all irrigated acreage, the amount of acres irrigated by the Missouri River would be relatively small, with less than eight percent of all irrigated acreage in the eight counties relying on water from the Missouri River. While there is potential for a notable impact to farms that rely on the Missouri River during drought conditions as a source of water for irrigation, it is not likely to lead to wide-spread impacts throughout local communities within the counties evaluated. Even under the most extreme conditions over the POR, the impacts to net farm income and associated regional

economic impacts are not likely to threaten traditional ways of life and economic vitality in the counties being evaluated.

**Conclusion**

Under current system operations, including a number of management actions associated with MRRP implementation, the Missouri River and the reservoirs will remain a viable source of water for irrigation operations with the majority of the irrigation occurring in the upper river. Relative to all irrigated acreage, the amount of acres irrigated by the Missouri River under Alternative 1 would be relatively small, with less than eight percent of all irrigated acreage in the eight counties relying on water from the Missouri River. Considering these conditions, farm operations using water from the Missouri River for irrigation in the eight counties evaluated are expected on average to generate over $5.9 million in NED benefits (net farm income). In addition, this agricultural production is expected to support 343 jobs, $10 million in labor income, and $43 million in sales (RED contribution) under Alternative 1. While there is potential for impacts to farms that rely on the Missouri River during drought conditions as a source of water for irrigation, it is not likely to lead to widespread OSE impacts throughout local communities within the counties evaluated. In addition, the construction of habitat where irrigation intakes are located has the potential to cause temporary, small, and adverse impacts on irrigation intakes, although site specific planning would reduce these adverse effects. As there are very few intakes located below Ponca, Nebraska, there would be negligible impacts to irrigation impacts from SWH construction. Alternative 1 is not expected to have significant impacts on irrigation operations.

### 3.14.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under an adaptive management plan. Actions in this alternative that may have impacts to irrigation intakes include a spawning cue release, low summer flow, and the construction of both ESH and SWH habitat.

Farms using Missouri River water for irrigation would experience temporary, relatively small impacts to net farm income under Alternative 2 relative to Alternative 1, described further below.

**Mechanical Habitat Construction**

Considerably more ESH habitat construction actions would occur in the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches under Alternative 2 than under Alternative 1. Considerably more SWH construction would also occur between Ponca and the mouth of the Missouri River, near St. Louis. In these river reaches, farms do not tend to rely on irrigation from the Missouri River. Due to the large amount of ESH construction, it is likely that irrigation intakes located in the Garrison and Fort Randall reaches would have short-term and potentially long-term, large, and adverse impacts from habitat construction, primarily as a result of sediment buildup and costs associated with relocating these intakes. As with Alternative 1, USACE would minimize impacts to sensitive resources (such as intakes) through site-specific planning.

**National Economic Development**

Under Alternative 2, average annual net farm income would be approximately $5.8 million. Overall, the change in annual average net farm income relative to Alternative 1 would be fairly

minimal, with a decrease in annual average net farm income of $136,000 under Alternative 2. Total net farm income over the POR would be $11 million lower for all eight counties relative to Alternative 1 (Table 3-139). This represents an overall decrease in net farm income of 2.3 percent. The average of the worst eight years modeled would equal a decline of $1.6 million relative to Alternative 1 in the eight counties evaluated.

Additional results are summarized in Table 3-140 which shows the difference in net farm income during years when there would be a release action or low summer flow. The results show that the greatest adverse impacts would occur in years that do not have a full release flow event, likely caused by lower river flows and reservoir elevations as the reservoir re-balance following a spring pulse. Net farm income would increase the most under Alternative 2 during years when there would be a full release followed by a low summer flow.

**Table 3-139. Summary of National Economic Development Analysis for Alternative 2, 2016 Dollars**

| State | County | Total Net Farm Income | Change in Total Net Farm Income | Percent Change | Average Annual Net Farm Income | Change in Average Annual Net Farm Income |
|---|---|---|---|---|---|---|
| **Montana** | McCone | $52,103,000 | −$30,000 | −0.1% | $635,000 | −$400 |
| | Valley | $17,414,000 | −$18,000 | −0.1% | $212,000 | −$200 |
| | Roosevelt | $49,991,000 | −$130,000 | −0.3% | $610,000 | −$2,000 |
| | Richland | $145,106,000 | −$90,000 | −0.1% | $1,770,000 | −$1,000 |
| **North Dakota** | Williams | −$10,160,000 | −$1,350,000 | −15.3% | −$124,000 | −$17,000 |
| | Mercer | $4,858,000 | −$409,000 | −7.8% | $59,000 | −$5,000 |
| | Emmons | $50,188,000 | −$3,441,000 | −6.4% | $612,000 | −$42,000 |
| **South Dakota** | Sully | $164,847,000 | −$5,684,000 | −3.3% | $2,010,000 | −$69,000 |
| | **Total** | $474,348,000 | −$11,154,000 | −2.3% | $5,785,000 | −$136,000 |

Note: ‘Total’ here applies both to absolute figures (e.g., total net income over the POR) and relative figures (e.g., change in total net farm income relative to Alternative 1). For example, ‘percent change relative to Alternative 1’ is calculated by subtracting total net income under Alternative 2 from total net income under Alternative 1 and dividing the difference by the total net income under Alternative 1.

**Table 3-140. Impacts from Modeled Flow Releases to Net Farm Income in the Eight County Area under Alternative 2 Compared to Alternative 1, 2016 Dollars**

| Change in net farm income relative to Alternative 1 | Full Release + Lower Summer Flow[a] | | Partial Flow Release[b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High |
| | −$662,599 | $636,444 | −$2,070,641 | $374,156 | −$2,070,641 | $636,444 |

a Flows similar to those proposed under Alternative 2 occurred in 10 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be implemented. Negative benefits indicate reductions in net farm income relative to Alternative 1.

b Flow action similar to those proposed under Alternative 2 was partially implemented in 44 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be partially implemented. Negative benefits are reductions in net farm income relative to Alternative 1.

### Regional Economic Development

Alternative 2 would have a temporary, small, and adverse impact on employment, labor income, and sales under Alternative 2 (Table 3-141). For the eight counties evaluated, employment would be reduced by an average of 1.1 jobs per year compared to Alternative 1. For the eight years with the smallest net income relative to Alternative 1, there would be 14 fewer jobs on average across all eight counties and labor income would decline by $613,000. Sully County in South Dakota and Emmons County in North Dakota would account for much of the change in sales, employment, and labor income. For instance, of the approximately $224,000 decrease in average annual labor income, Sully County would account for over half of this loss, while Emmons would account for 27 percent of the decline.

**Table 3-141. Economic Benefits of Irrigated Agriculture Production - Alternative 2, 2016 Dollars**

| Economic Impact | Scenario | Total |
|---|---|---|
| **Direct, indirect, and induced jobs** | Average Annual | 342.4 |
| | Change in Average Annual from Alternative 1 | −1.1 |
| | Eight largest net farm income years compared to No Action (average annual) | 7.1 |
| | Eight smallest net farm income years compared to No Action (average annual) | −14.0 |
| **Direct, indirect, and induced labor income** | Average Annual | $10,265,000 |
| | Change in Average Annual from Alternative 1 | −$224,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $193,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$613,000 |
| **Direct, indirect, and induced sales** | Average Annual | $42,243,000 |
| | Change in Average Annual from Alternative 1 | −$841,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $864,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$2,038,000 |

### OSE Analysis

Changes in irrigation operations have the potential to cause other types of effects, such as changes in community well-being, traditional ways of life, and economic vitality. Average annual net farm income under Alternative 2 would decline relative to Alternative 1. Employment, labor income, and sales would also decline relative to Alternative 1. However, while farming and agriculture is an important way of life along much of the Missouri River, changes in access to water—even under the most extreme conditions associated with Alternative 2—would not represent a threat to this traditional way of life in the counties being evaluated. Individual families and farms that rely on the Missouri River could experience large impacts, but these impacts would not be expected to cause more widespread OSE impacts to communities or regions.

### Conclusion

Farms using Missouri River water for irrigation would experience temporary, relatively small impact to net farm income under Alternative 2 relative to Alternative 1. Overall, average annual net farm income is expected to decline by $136,000 (2.3 percent) under Alternative 2. For the eight counties evaluated, employment would be reduced by an average of 1.1 jobs per year and approximately $61,000 loss in average annual labor income. The results show that the greatest adverse impacts would occur in years that do not have a full release flow event, likely caused by lower river flows and reservoir elevations as the reservoir re-balances following a spring pulse. While farming and agriculture is an important way of life along much of the Missouri River, changes in access to water—even under the most extreme conditions associated with Alternative 2—would not represent a threat to this traditional way of life and economic vitality in the counties being evaluated. Considerably more ESH habitat construction actions would occur in the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches under Alternative 2 than under Alternative 1. Due to the large amount of ESH construction, it is likely that irrigation intakes located in the Garrison and Fort Randall reaches would have short-term and potentially long-term, large, and adverse impacts from habitat construction, primarily as a result of sediment buildup and costs associated with relocating these intakes. Alternative 2 is not expected to have significant impacts on irrigation operations.

## 3.14.2.6 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include the construction of ESH and IRC habitat through mechanical means. Overall, farms using Missouri River water for irrigation would experience relatively small, beneficial impacts under Alternative 3 relative to Alternative 1. These impacts are further described in these sections.

### Mechanical Habitat Construction

Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, these adverse impacts are expected to be temporary and small because site specific planning would reduce impacts to sensitive infrastructure. IRC habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches.

### National Economic Development

Under Alternative 3, average annual net farm income would be approximately $6.0 million. Overall, the change in annual average net farm income relative to Alternative 1 would be small, with an increase of $25,000. Total net farm income over the POR would be $2.1 million higher for all eight counties relative to Alternative 1 (Table 3-142), an increase of less than one percent. However, there would be years when net farm income would decline under Alternative 3 relative to Alternative 1, although these losses would be small. In the average of the eight worst years modeled, net farm income would decline by $329,000 overall in the eight counties relative to Alternative 1.

**Table 3-142. Summary of National Economic Development Analysis for Alternative 3, 2016 Dollars**

| | Benefit | Total Net Income (POR) | Change in Total Net Farm Income | Percent Change | Average Annual Net Income | Change in Average Annual Net Farm Income |
|---|---|---|---|---|---|---|
| **Montana** | McCone | $52,053,000 | −$81,000 | −0.2% | $635,000 | −$1,000 |
| | Valley | $17,430,000 | −$2,000 | 0.0% | $213,000 | $0 |
| | Roosevelt | $49,871,000 | −$250,000 | −0.5% | $608,000 | −$3,000 |
| | Richland | $144,853,000 | −$344,000 | −0.2% | $1,767,000 | −$4,000 |
| **North Dakota** | Williams | −$8,458,000 | $353,000 | 4.0% | −$103,000 | $4,000 |
| | Mercer | $5,341,000 | $73,000 | 1.4% | $65,000 | $900 |
| | Emmons | $54,827,000 | $1,197,000 | 2.2% | $669,000 | $15,000 |
| **South Dakota** | Sully | $171,672,000 | $1,141,000 | 0.7% | $2,094,000 | $14,000 |
| | **Total** | **$487,588,000** | **$2,087,000** | **0.4%** | **$5,946,000** | **$25,000** |

Note: 'Total' here applies both to absolute figures (e.g., total net income over the POR) and relative figures (e.g., change in total net farm income relative to Alternative 1). For example, 'percent change relative to Alternative 1' is calculated by subtracting total net income under Alternative 3 from total net income under Alternative 1 and dividing the difference by the total net income under Alternative 1.

The increase in net farm income for the eight-county area would be driven by increases in North Dakota and South Dakota. In Montana, all counties would experience a very small decrease in net farm income, amounting to less than a one percent change in all cases.

Under Alternative 3, the most adverse impact would occur during drought conditions. However, overall, average annual net farm income would improve, relative to Alternative 1 (Table 3-142) under Alternative 3. The longest period of relative improvement would occur during drought conditions that, in other alternatives, coincide with flow events. In years when net farm income would be worse than Alternative 1, the impacts would not be expected to last longer than three years.

### Regional Economic Development

Alternative 3 would have negligible RED impacts relative to Alternative 1. Half of the counties in this analysis would experience relatively small, beneficial impacts in economic activity while the other half would experience relatively small, adverse impacts in economic activity. During the worst eight years modeled, relative to Alternative 1, the average number of jobs would decrease by almost four, and labor income would decline by $70,000 (Table 3-143) for all eight counties. The largest difference would be in Sully County, where average annual labor income would be $7,000 higher than under Alternative 1. The most adversely impacted county would be Richland, where average annual labor income would be $775 lower when compared to Alternative 1. For the other counties there would be a change of less than $3,000 dollars in labor income. None of the counties would experience a change in average annual employment of more than one job.

**Table 3-143. Economic Benefits of Irrigated Agriculture Production - Alternative 3, 2016 Dollars**

| Economic Impact | Scenario | Total |
|---|---|---|
| Direct, indirect, and induced jobs | Average Annual | 343.6 |
| | Change in Average Annual from Alternative 1 | 0.2 |
| | Eight largest net farm income years compared to No Action (average annual) | 4.8 |
| | Eight smallest net farm income years compared to No Action (average annual) | −3.8 |
| Direct, indirect, and induced labor income | Average Annual | $10,339,000 |
| | Change in Average Annual from Alternative 1 | −$150,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $169,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$70,000 |
| Direct, indirect, and induced sales | Average Annual | $42,445,000 |
| | Change in Average Annual from Alternative 1 | −$639,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $640,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$428,000 |

### Other Social Effects

Annual net farm income would vary the least under Alternative 3, relative to Alternative 1. Employment, labor income, and sales would all experience small, beneficial impacts under Alternative 3 relative to Alternative 1. Alternative 3 OSE impacts would be negligible, however, and do not have the potential to impact communities located along the Missouri River.

### Conclusion

Overall, farms using Missouri River water for irrigation would experience relatively small, beneficial impacts under Alternative 3 relative to Alternative 1. This small benefit is likely the result of the elimination of the spring plenary pulse. Overall, the change in annual average net farm income relative to Alternative 1 would be an increase of $25,000 (0.4 percent). Alternative 3 would have negligible RED and OSE impacts relative to Alternative 1. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, these adverse impacts are expected to be temporary and because site specific planning would reduce impacts to sensitive infrastructure. Alternative 3 is not expected to have significant impacts on irrigation operations.

### 3.14.2.7 Alternative 4 – Spring ESH Creating Release

Management actions under Alternative 4 would include the construction of ESH and IRC habitat through mechanical means. Alternative 4 also includes a spring release in April and May to create ESH. On average, Alternative 4 would have temporary, relatively small, and adverse impacts on net farm income relative to Alternative 1. However, in some years, this alternative

would result in temporary, large, and adverse impacts. These impacts are further described in this section.

### Mechanical Habitat Construction

IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would reduce impacts to sensitive infrastructure.

### National Economic Development

Under Alternative 4, average annual net farm income would be approximately $5.7 million. The change in net farm income over the POR would be $17.2 million lower for all eight counties relative to Alternative 1 (Table 3-144). Average annual net farm income would decline by $220,000, or a decrease of less than 4 percent. However, the average decline in the worst eight years modeled relative to Alternative 1 would equal $1.7 million for all eight counties.

All of the counties would experience a decline in total net farm income, relative to Alternative 1. The largest decline would be in Williams County, North Dakota, which would decline by $5 million (54 percent) relative to Alternative 1.

**Table 3-144. Summary of National Economic Development Analysis for Alternative 4, 2016 Dollars**

| | Benefit | Total Net Income (POR) | Change in Total Net Farm Income | Percent Change | Average Annual Net Income | Change in Average Annual Net Farm Income |
|---|---|---|---|---|---|---|
| **Montana** | McCone | $50,950,000 | −$1,184,000 | −2.3% | $621,000 | −$14,400 |
| | Valley | $16,971,000 | −$461,000 | −2.6% | $207,000 | −$6,000 |
| | Roosevelt | $48,867,000 | −$1,254,000 | −2.5% | $596,000 | −$15,000 |
| | Richland | $143,749,000 | −$1,448,000 | −1.0% | $1,753,000 | −$18,000 |
| **North Dakota** | Williams | −$13,555,000 | −$4,745,000 | −53.9% | −$165,000 | −$58,000 |
| | Mercer | $4,440,000 | −$827,000 | −15.7% | $54,000 | −$10,000 |
| | Emmons | $50,907,000 | −$2,722,000 | −5.1% | $621,000 | −$33,000 |
| **South Dakota** | Sully | $165,982,000 | −$4,550,000 | −2.7% | $2,024,000 | −$56,000 |
| | **Total** | $468,311,000 | −$17,191,000 | −3.5% | $5,711,000 | −$210,000 |

Note: ‘Total’ here applies both to absolute figures (e.g., total net income over the POR) and relative figures (e.g., change in total net farm income relative to Alternative 1). For example, ‘percent change relative to Alternative 1’ is calculated by subtracting total net income under Alternative 4 from total net income under Alternative 1 and dividing the difference by the total net income under Alternative 1.

The most adverse impacts on net farm income would occur during conditions similar to release events followed by a prolonged drought. In one case, a spring release event would result in relatively high water elevations in the upper river, followed by low water levels for the remainder of the irrigation season and a correspondingly low net farm income for counties adjacent to reservoirs. However, although the most adverse impacts to net farm income do occur during flow events, flow events tied to ESH creation would not generally result in a consistently adverse effects on irrigation intakes under Alternative 4 relative to Alternative 1 (Table 3-145).

**Table 3-145. Impacts to Net Farm Income in the Eight County Area from Modeled Flow Releases under Alternative 4 Compared to Alternative 1, 2016 Dollars**

| Change in net income relative to Alternative 1 | Full Release[a] | | Partial Flow Release[b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High |
| | −$194,348 | $87,311 | −$793,756 | $212,138 | −$2,247,450 | $576,148 |

a Flows similar to those proposed under Alternative 4 occurred in 10 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be implemented. Negative benefits indicate reductions in net farm income relative to Alternative 1.

b Flow action similar to those proposed under Alternative 5 was partially implemented in 5 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be partially implemented. Negative benefits are reductions in net farm income relative to Alternative 1.

### Regional Economic Development

The eight counties evaluated would experience temporary, small, and adverse RED impacts under Alternative 4. On average, the change in economic activity would lead to a decline in employment of two jobs and a reduction in labor income of $81,000 across all eight counties (Table 3-146). During the worst eight years modeled, labor income would be $646,000 lower than Alternative 1, and the number of jobs would decline by more than 17. Williams County would experience the largest RED impacts under Alternative 4. Average annual labor income would be $29,000 lower than Alternative 1.

### Other Social Effects

Under Alternative 4, OSE impacts would be similar to those experienced under Alternative 2, and largely negligible. Although the families and farms that rely on the Missouri River have the potential to experience large impacts, those impacts are not expected to be widespread.

**Table 3-146. Economic Benefits of Irrigated Agriculture Production - Alternative 4, 2016 Dollars**

| Economic Impact | Scenario | Total |
|---|---|---|
| Direct, indirect, and induced jobs | Average Annual | 341.3 |
| | Change in Average Annual from Alternative 1 | −2.0 |
| | Eight largest net farm income years compared to No Action (average annual) | 5.2 |
| | Eight smallest net farm income years compared to No Action (average annual) | −17.3 |
| Direct, indirect, and induced labor income | Average Annual | $10,245,000 |
| | Change in Average Annual from Alternative 1 | −$244,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $111,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$646,000 |
| Direct, indirect, and induced sales | Average Annual | $42,139,000 |
| | Change in Average Annual from Alternative 1 | −$945,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $602,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$2,321,000 |

### Conclusion

On average, Alternative 4 would have temporary, relatively small, and adverse impacts on net farm income relative to Alternative 1. However, in some years, this alternative would result in temporary, large, and adverse impacts. Average annual net farm income would decline by more than $209,000 (−4 percent). However, during the worst eight years modeled relative to Alternative 1, net farm income would decline by $1.7 million for all eight counties. On average, the change in economic activity under Alternative 2 would lead to a decline in employment of two jobs and a reduction in labor income of $81,000. The most adverse impacts on net farm income would occur during conditions similar to release events followed by a prolonged drought. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would reduce impacts to sensitive infrastructure. Alternative 4 is not expected to have significant impacts on irrigation operations.

### 3.14.2.8 Alternative 5 – Fall ESH Creating Release

Management actions under Alternative 5 would include the construction of ESH and IRC habitat through mechanical means. Alternative 5 also includes a fall release to create ESH habitat. Overall, farms using Missouri River water for irrigation would experience negligible impacts under Alternative 5 relative to Alternative 1. Some counties would experience adverse impacts relative to Alternative 1, and some small, beneficial impacts. Adverse impacts would be short-term and would not last longer than two years. This section summarizes these impacts.

### Mechanical Habitat Construction

IRC construction habitat would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would reduce impacts to sensitive infrastructure.

### National Economic Development

Under Alternative 5, average annual net farm income would be approximately $5.9 million. Overall, annual average net farm income would decline by $4,000 for all eight counties. Total net farm income would decline by $348,000 for all eight counties relative to Alternative 1, or less than 1 percent (Table 3-147). In the eight worst years modeled net farm income would decline by $600,000 in all eight counties relative to Alternative 1.

Under Alternative 5, most of the counties would experience a decline in total net farm income relative to Alternative 1, with the exception of Emmons and Sully, which would experience a very slight increase in total net farm income relative to Alternative 1. Williams County would experience the largest decrease in total net farm income in terms of both dollar value and percentage, with a decline of $1.1 million and a decrease of 13 percent relative to Alternative 1.

Under Alternative 5, the longest period of decline in net farm income relative to Alternative 1 would last for five years, but the decline for all counties would amount to only about $51,000. On average, annual net farm income would be $4,000 lower than Alternative 1. Flow events would not consistently lead to either positive or negative changes in net farm income under Alternative 5, as summarized in Table 3-148.

**Table 3-147. Summary of National Economic Development Analysis for Alternative 5, 2016 Dollars**

| | Benefit | Total Net Income (POR) | Change in Total Net Farm Income | Percent Change | Average Annual Net Income | Change in Average Annual Net Farm Income |
|---|---|---|---|---|---|---|
| **Montana** | McCone | $52,109,000 | −$25,000 | 0.0% | $635,000 | −$300 |
| | Valley | $17,419,000 | −$13,000 | −0.1% | $212,000 | −$200 |
| | Roosevelt | $49,984,000 | −$137,000 | −0.3% | $610,000 | −$2,000 |
| | Richland | $144,969,000 | −$228,000 | −0.2% | $1,768,000 | −$3,000 |
| **North Dakota** | Williams | −$9,924,000 | −$1,114,000 | −12.6% | −$121,000 | −$14,000 |
| | Mercer | $5,116,000 | −$152,000 | −2.9% | $62,000 | −$2,000 |
| | Emmons | $54,259,000 | $630,000 | 1.2% | $662,000 | $8,000 |
| **South Dakota** | Sully | $171,223,000 | $691,000 | 0.4% | $2,088,000 | $8,000 |
| | **Total** | $485,154,000 | −$348,000 | −0.1% | $5,917,000 | −$4,000 |

Note: ‘Total’ here applies both to absolute figures (e.g., total net income over the POR) and relative figures (e.g., change in total net farm income relative to Alternative 1). For example, ‘percent change relative to Alternative 1’ is calculated by subtracting total net income under Alternative 5 from total net income under Alternative 1 and dividing the difference by the total net income under Alternative 1.

**Table 3-148. Impacts to Net Farm Income in the Eight County Area from Modeled Flow Releases under Alternative 5 Compared to Alternative 1, 2016 Dollars**

| Change in net income relative to Alternative 1 | Full Release[a] | | Partial Flow Release[b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High |
| | −$159,202 | $28,583 | $2,024 | $10,062 | −$672,510 | $1,315,245 |

a Flows similar to those proposed under Alternative 5 occurred in 7 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be implemented. Negative benefits indicate reductions in net farm income relative to Alternative 1.

b Flow action similar to those proposed under Alternative 5 was partially implemented in 2 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be partially implemented. Negative benefits are reductions in net farm income relative to Alternative 1.

## Regional Economic Development

RED impacts under Alternative 5 would be negligible in all eight counties under Alternative 5 (Table 3-149). On average, employment would decline less than one job for all counties. In addition, economic activity in some counties would improve under Alternative 5, although these changes would be small relative to Alternative 1. During the worst eight years modeled relative to Alternative 1, labor income would decline by $172,000 with a loss of nearly seven jobs. Sully County would experience the greatest benefit relative to Alternative 1 with an increase in average annual labor income of $4,000. Williams County would be adversely affected, with average annual labor income declines of $6,800 compared to Alternative 1. In Williams County, the number of jobs generated in an average year would decline by less than one job. No other county would experience a decline of more than $1,000 in labor income, nor a loss of more than one job.

**Table 3-149. Economic Benefits of Irrigated Agriculture Production: Alternative 5, 2016 Dollars**

| Economic Impact | Scenario | Total |
|---|---|---|
| Direct, indirect, and induced jobs | Average Annual | 343.3 |
| | Change in Average Annual from Alternative 1 | −0.1 |
| | Eight largest net farm income years compared to No Action (average annual) | 5.9 |
| | Eight smallest net farm income years compared to No Action (average annual) | −6.8 |
| Direct, indirect, and induced labor income | Average Annual | $10,324,000 |
| | Change in Average Annual from Alternative 1 | −$165,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $166,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$172,000 |
| Direct, indirect, and induced sales | Average Annual | $42,403,000 |
| | Change in Average Annual from Alternative 1 | −$681,000 |
| | Eight largest net farm income years compared to No Action (average annual) | $742,000 |
| | Eight smallest net farm income years compared to No Action (average annual) | −$800,000 |

#### Other Social Effects

OSE impacts under Alternative 5 would be similar to under Alternative 1. OSE impacts would be negligible under this alternative.

#### Conclusion

Overall, farms using Missouri River water for irrigation would experience negligible NED, RED, and OSE impacts under Alternative 5 relative to Alternative 1. Total net farm income would decline by $348,000 for all eight counties relative to Alternative 1, or less than 1 percent. On average, employment would decline less than one job for all counties. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would reduce impacts to sensitive infrastructure. Alternative 5 is not expected to have significant impacts on irrigation operations.

### 3.14.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Management actions under Alternative 6 would include the construction of ESH and IRC habitat through mechanical means. Alternative 6 also includes a spawning cue release to support the pallid sturgeon. Farms using Missouri River water for irrigation would experience temporary, relatively small, and adverse impacts under Alternative 6 relative to Alternative 1. Net farm income would be worse than Alternative 1 for several years modeled, particularly during years when drought conditions follow a release event. However, on average these impacts would be temporary and small. These impacts are further described in this section.

#### Mechanical Habitat Construction

IRC habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would reduce impacts to sensitive infrastructure.

#### National Economic Development

Under Alternative 6, average annual net farm income would be $5.8 million. Annual average net farm income under Alternative 6 would decline by $134,000 relative to Alternative 1. Total net farm income would be $11.0 million lower for all eight counties relative to Alternative 1 (Table 3-150). Most of these impacts would occur in Sully, Emmons, and Williams counties. The change in net farm income in other counties evaluated would not exceed more than three percent relative to Alternative 1. The average of the worst eight years modeled relative to Alternative 1 would equal a decline of $1.3 million in net farm income.

Six of the counties would experience a decline in net farm income relative to Alternative 1. The counties in Montana would experience either negligible impacts, amounting to less than a one percent change relative to Alternative 1, or very small, beneficial impacts. The counties in North Dakota would experience the largest decline relative to Alternative 1, with a total decrease in total net farm income ranging from 7 percent to 25 percent. Sully County in South Dakota would

experience the largest decrease in net farm income, with a decrease of $4.7 million in relative to Alternative 1.

The longest period of decline in net farm income under Alternative 6 would occur when a release occurs prior to a prolonged drought. The worst single year change in net farm income would also occur during this period, when net income for the entire eight counties would be $1.2 million lower than would be expected under Alternative 1.

In general, flow releases and partial flow releases that would occur under Alternative 6 correspond somewhat to the year of greatest change (positive or negative) in net farm income. A year in which a full duration event would be scheduled would also be the year of greatest decline in net farm income relative to Alternative 1 (Table 3-151). However, the year of highest beneficial impact also occurs in a year with a full release.

**Table 3-150. Summary of National Economic Development Analysis for Alternative 6, 2016 Dollars**

| | Benefit | Total Net Income (POR) | Change in Total Net Farm Income | Percent Change | Average Annual Net Income | Change in Average Annual Net Farm Income |
|---|---|---|---|---|---|---|
| **Montana** | McCone | $52,255,000 | $121,000 | 0.2% | $637,000 | $2,000 |
| | Valley | $17,451,000 | $19,000 | 0.1% | $213,000 | $200 |
| | Roosevelt | $50,071,000 | −$49,000 | −0.1% | $611,000 | −$600 |
| | Richland | $145,029,000 | −$168,000 | −0.1% | $1,769,000 | −$2,000 |
| **North Dakota** | Williams | −$11,006,000 | −$2,196,000 | −24.9% | −$134,000 | −$27,000 |
| | Mercer | $4,841,000 | −$426,000 | −8.1% | $59,000 | −$5,000 |
| | Emmons | $49,999,000 | −$3,630,000 | −6.8% | $610,000 | −$44,000 |
| **South Dakota** | Sully | $165,845,000 | −$4,686,000 | −2.7% | $2,023,000 | −$57,000 |
| | **Total** | $474,486,000 | −$11,016,000 | −2.3% | $5,786,000 | −$134,000 |

Note: ‘Total’ here applies both to absolute figures (e.g., total net income over the POR) and relative figures (e.g., change in total net farm income relative to Alternative 1). For example, ‘percent change relative to Alternative 1’ is calculated by subtracting total net income under Alternative 6 from total net income under Alternative 1 and dividing the difference by the total net income under Alternative 1.

**Table 3-151. Impacts to Net Farm Income in the Eight County Area from Modeled Flow Releases under Alternative 6 Compared to Alternative 1**

| Change in net income relative to Alternative 1 | Full Release[a] | | Partial Flow Release[b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High |
| | −$1,460,631 | $372,523 | −$932,449 | $53,478 | −$1,460,631 | $372,523 |

a Flows similar to those proposed under Alternative 6 occurred in 11 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be implemented. Negative benefits indicate reductions in net farm income relative to Alternative 1.

b Flow action similar to those proposed under Alternative 6 was partially implemented in 33 years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be partially implemented. Negative benefits are reductions in net farm income relative to Alternative 1.

### Regional Economic Development

RED impacts under Alternative 6 would be negligible for all counties relative to Alternative 1. On average, employment would be reduced by slightly more than one job for all counties under Alternative 6. During the modeled worst eight years of net farm income relative to Alternative 1, employment would be reduced by 12 jobs across all eight counties, and labor income would decline by $500,000 (Table 3-152). The largest impacts would occur in Sully, Emmons, and Williams counties, which would experience a decline of at least $13,000 in labor income. However, average annual employment would decline by less than one job in these counties. McCone and Valley Counties would experience slight beneficial impacts under this alternative, with average annual labor income increasing by a few hundred dollars relative to Alternative 1.

**Table 3-152. Economic Benefits of Irrigated Agriculture Production - Alternative 6, 2016 Dollars**

| Economic Impact | Scenario | Total |
|---|---|---|
| Direct, indirect, and induced jobs | Average Annual | 342.3 |
| | Change in Average Annual from Alternative 1 | −1.1 |
| | 8 largest net farm income years compared to No Action (average annual) | 4.2 |
| | 8 smallest net farm income years compared to No Action (average annual) | −12.0 |
| Direct, indirect, and induced labor income | Average Annual | $10,265,000 |
| | Change in Average Annual from Alternative 1 | −$224,000 |
| | 8 largest net farm income years compared to No Action (average annual) | $67,000 |
| | 8 smallest net farm income years compared to No Action (average annual) | −$500,000 |
| Direct, indirect, and induced sales | Average Annual | $42,241,000 |
| | Change in Average Annual from Alternative 1 | −$843,000 |
| | 8 largest net farm income years compared to No Action (average annual) | $474,000 |
| | 8 smallest net farm income years compared to No Action (average annual) | −$1,680,000 |

### Other Social Effects

Under Alternative 6, OSE impacts are similar to under Alternative 1. Under Alternative 6, these impacts are negligible.

### Conclusion

Farms using Missouri River water for irrigation would experience temporary, relatively small, and adverse impacts under Alternative 6 relative to Alternative 1. Most impacts would occur in years when drought conditions follow a spawning cue release. NED benefits under Alternative 6 would decline by $134,000 (−2.3 percent) relative to Alternative 1. RED and OSE impacts would be negligible under Alternative 6. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would

reduce impacts to sensitive infrastructure. Alternative 6 is not expected to have significant impacts on irrigation operations.

#### 3.14.2.10 Tribal Effects

Tribal lands are located below Fort Peck Dam in Roosevelt and Valley counties, and the county boundaries that include Tribal land held by sovereign nations represents 73.9 percent and 22.2 percent of all county land, respectively (USGS 2012). It is likely that any Tribal intakes in these areas would experience similar impacts to those described in the NED, RED, and OSE analysis above. Tribal land is also located adjacent to Sully County, Emmons County, and Mercer County. In these areas, Tribal entities involved with irrigation operations may experience similar impacts to those realized in the counties being evaluated. As a result, the change in economic activity and net farm income in Roosevelt, Valley, Sully, Emmons, and Mercer counties could be of importance to Tribes. For impacts specific to Tribes under each alternative, refer to the discussion of these five counties in Sections 3.14.2.4 through 3.14.2.9.

#### 3.14.2.11 Climate Change

In the future, climate change would have an increasing influence on irrigators. With earlier spring snowmelt, lower summer flows would reduce irrigators' access to water. More irregular rainfall would also make irrigators more dependent on the Missouri River and other water sources for irrigation. More frequent and larger spring and fall release events would occur under Alternatives 2, 4, 5, and 6 compared to Alternative 1, which could reduce access to water for irrigators in the years following the releases in the upper three reservoirs especially during relatively drier conditions. Larger, more sporadic rain events could adversely impact irrigation intakes through sediment deposition; these impacts could be exacerbated during spring or fall releases under Alternatives 2, 4, 5, and 6.

With earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses relative to Alternative 1 may result in lower river flows in the fall and winter compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Longer and lower river flows may adversely impact access to water for irrigation. With earlier snowmelt, the fall releases under Alternative 5 may not be able to run as frequently with climate change because mid-summer System storage may be lower, with some benefits to irrigation intakes.

#### 3.14.2.12 Cumulative Impacts

Past, present, and future actions that would affect bed degradation or aggradation of the Missouri River, such as water depletions or withdrawals that would notably affect the volume of water in the river, would continue to have adverse impacts to irrigation intakes. Actions that affect bed degradation can impact river stages, resulting in frequent and prolonged instances when water surface elevations fall below critical operating thresholds. Actions that affect aggradation can impact sediment and/or silting in of intakes. Depending on the frequency and duration of these impacts, irrigation operators may realize an increase in costs associated with moving intakes more frequently, pumping, and/or cleaning screens when intakes become clogged with sediment.

Cumulative actions that impact agricultural operations include federal technical and financial assistance programs such as Environmental Quality Incentives Program, which support the

replacement or upgrade of existing irrigation intakes, or expand the number of acres irrigated as more water becomes available (Nixon 2013; Waas 2015).

State and federal regulations governing water quality have the potential to create adverse impacts and impose additional costs to farm operations including irrigated agriculture. Non-point source agricultural runoff was not included in the 2015 EPA Clean Water Act rulemaking, but as national attention is increasingly focused on the Gulf of Mexico's dead zone and toxic blooms in the country's lakes, it is likely that states would increase restrictions on non-point source agricultural runoff in the future which potentially could lead to fewer irrigated acres using Missouri River water in the future (EPA 2015).

Management actions of Alternative 1 that focus on habitat construction and channel reconfiguration have the potential to impact irrigation. For instance, reconfiguration of the channel in the vicinity of an intake could lead to increased incidents when water surface elevations fall below critical thresholds. In addition, constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in segments of the river experiencing aggradation. This can result in increased maintenance problems at irrigation intakes in areas of aggradation (USACE 2011). However, site selection would occur with the primary focus on avoiding impacts to sensitive resources, such as intakes.

Alternative 1 would have small, temporary adverse impacts on irrigation intakes from lower river flows in the fall and winter and drier conditions in the reservoirs affecting water surface elevations. The variable hydrology and precipitation within the system and its interaction with the past, present foreseeable actions as described in Section 3.1 would result in cumulative impacts associated with Alternative 1 that would be both beneficial and adverse. These impacts would primarily be due to changes occurring in river conditions from natural dry and wet weather cycles, and actions that would contribute to bed degradation and aggradation, market prices, and federal government programs, subsidies, and incentives. The implementation of Alternative 1 would provide a small contribution to these cumulative impacts.

Under Alternative 2, irrigation would experience small short-term, adverse impacts relative to Alternative 1 because of more frequent, short durations (a few days) when water surface elevations fall below critical operating thresholds (shut-down) relative to Alternative 1. On average, these impacts would be small in nature but there are some years when irrigation intakes, especially those near the reservoirs in the upper river, would experience larger adverse impacts.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 2 would be similar to those for Alternative 1. The greatest impacts to irrigation intakes in the upper river would occur in years when there is a spring release followed by a prolonged drought, which results in lower reservoir elevations. Although there are some years when the adverse impacts would be larger, implementation of Alternative 2 would still provide a small contribution to these cumulative impacts because the natural cycles and process of drought and bed degradation and federal government influences on agriculture would have considerable impacts to irrigation operations.

Under Alternative 3, management actions would have a small, beneficial cumulative impact to irrigation intakes using Missouri River water. Management actions included for Alternative 3 would slightly increase the availability of water for the purposes of irrigation, which would have some small benefits to crop yields and net farm income. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3

would continue to have large beneficial and adverse impacts to irrigation operations because of natural dry and wet cycles, bed degradation and aggradation and federal government influences. Implementation of Alternative 3 would have a negligible contribution to these cumulative impacts.

Under Alternative 4, irrigation intakes in the upper river, especially those located near reservoirs, would experience some adverse impacts in the years following a spring release when there are relatively drier conditions. However, when combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 4 would be similar to Alternative 1. These cumulative impacts would be both beneficial and adverse primarily resulting from natural dry and wet cycles, bed degradation and aggradation and federal government influences on agriculture. Implementation of Alternative 4 would provide a small contribution to these cumulative impacts.

Under Alternative 5, irrigation intakes would experience negligible cumulative impacts relative to Alternative 1 due to similar flows and releases from the reservoirs as those of Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 5 would be similar to Alternative 1. Implementation of Alternative 5 would have a negligible contribution to these cumulative impacts.

Alternative 6 is expected to have a small, temporary, adverse impact on irrigation intakes. Irrigation intakes in the upper river would be adversely affected in the years following a spawning cue release when drier conditions are experienced. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 would be similar to Alternative 1. These cumulative impacts would be both beneficial and adverse primarily resulting from natural dry and wet cycles, bed degradation and aggradation, and federal government influences on agriculture. Implementation of Alternative 6 would provide a small contribution to these cumulative impacts.

# 3.15 Navigation

## 3.15.1 Affected Environment

As authorized by The Rivers and Harbors Act of 1945 the navigable portion of the mainstem of the Missouri River stretches 735 miles, from Sioux City, IA at the northern reach to St. Louis, Missouri, in the south (Figure 3-57). This stretch of the river includes a navigation channel measuring nine feet deep and 300 feet wide.

Missouri River navigation refers specifically to the industries that operate barges and freight vessels, transporting various commodities along the river. These commodities include agricultural products, chemicals, petroleum products, manufactured goods, and basic manufacturing materials such as gravel and sand.

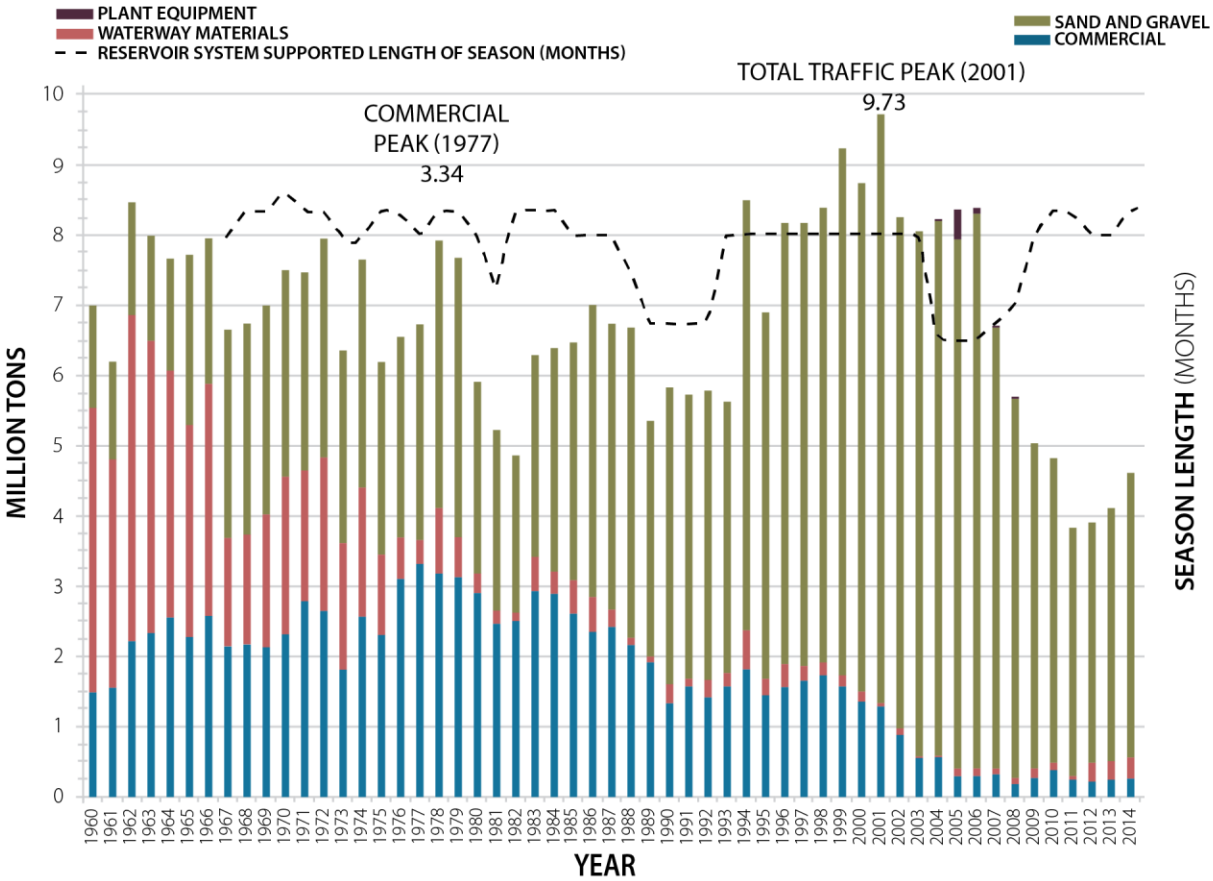
In 2014, the latest year with available data, there were about 48 docks and terminals along the Missouri River. Forty-two docks were located around and downstream of Kansas City, Missouri, while the remaining six were located between Kansas City, Missouri, and Omaha, Nebraska. While the Missouri River between Omaha, Nebraska and Sioux City, Iowa reach does contain docks, only one of these docks was active within the last five years and it was not active in 2014 (USACE 2016).

The period of time when navigation can occur on the Missouri River can be divided into two seasons. The non-flow supported season occurs when the river is ice-free and navigable, however, no releases from Gavins Point Dam to support navigation are made and only the major tributaries supply flow. During the flow supported season, the river is ice-free and navigable and the USACE releases water from Gavins Point Dam, just above Sioux City, IA to support flows from the major tributaries. While the length of the flow supported season varies along the river, a full-length season is considered eight months long from April 1 to December 1 at the mouth of the Missouri River. The decision on length of the navigation supported season is made at two times during the year, March 15th and July 1st. Further discussion of these dates and the criteria for length of the season occurs in the Navigation Service section and Navigation Season Length section within the next few pages.

**Figure 3-57. Map of Navigable Portion of the Missouri River**

### 3.15.1.1 Navigation Operations and Industry

Typically, the types of commodities traveling on the Missouri River are grouped into four broad categories (USACE ND-MRBWMD 2006, Appendix G-1.1): commercial sand and gravel, waterway improvement materials, other commercial cargo, and oversized goods. Figure 3-58 presents tonnage levels for these four commodity groups from 1960 to 2014 along with the system supported navigation season length. While the commercial traffic has been in steady decline since 1977, the total amount of traffic (including sand and gravel) increased until it reached a peak of 9.7 million tons in 2001 (USACE-WCSC 2016). The escalation in total traffic during this time was attributed to an increase in the amount of sand and gravel being transported on the river. Oversized power plant equipment is also moved on the Missouri River. These movements occur infrequently, but range from 10,000 tons to 425,000 tons.




Source: USACE WCSC 2016.

**Figure 3-58. Total Navigation Tonnage and System Supported Length of Season (1960–2014)**

Sand and gravel, and waterway improvement materials are the dominant commodities moving on the Missouri River. In 1982, sand, gravel, and waterway improvement materials accounted for 49 percent of total tonnage, but since 2000, sand and gravel has represented greater than 85 percent of the commodities shipped on the Missouri River. Unlike commercial traffic which is more likely to travel regionally or nationally, 96 percent of sand and gravel tonnage on the Missouri River travels less than 10 miles (WCSC 2016). The reason for the short trips is because much of the sand and gravel is dredged up from the bottom of the river, and then moved to the nearest dock for transit. Often this dredging occurs as close to an available dock as possible. As seen in Table 3-153, 82 percent of sand and gravel tonnage is shipped five miles or less, with over half of sand and gravel tonnage shipped one mile or less.

**Table 3-153. Percentage of Average Sand and Gravel Tonnage (2010 to 2014)**

| 0 to 1 Mile | 2 to 5 Miles | 6 to 9 Miles | 10 Miles or More |
|---|---|---|---|
| 57% | 25% | 14% | 4% |

Source: WCSC 2016.

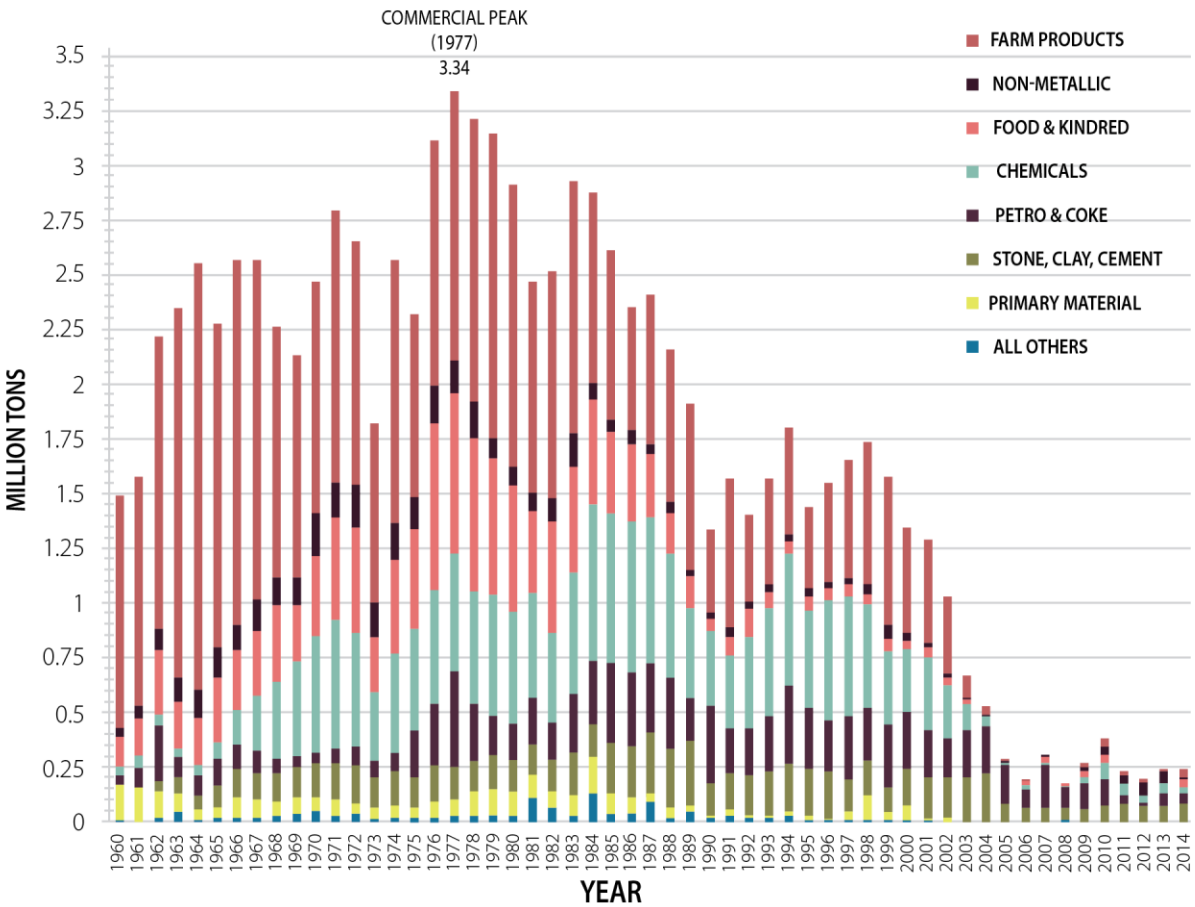
As shown in Figure 3-59, commercial cargo can be broken down into the following eight categories:

- Farm products such as corn, sorghum, wheat, and soybeans.
- Non-metallic products such as clays, salt including sea water, and limestone flux.
- Food and kindred materials such as molasses, bran, sharps, and other cereal residue.
- Chemical products including urea fertilizers, ammonium nitrate fertilizers, and sodium hydroxide.
- Petroleum products and coke including pitch and pitch coke, fuel oils, and asphalt. Coke or petroleum coke describes a high carbon content solid fuel derived from coal or from petroleum, respectively.
- Primary metals such as iron and steel wire, flat rolled iron and steel, and aluminum.
- Stone, clay, and cement types including Portland, aluminous, slag, or super sulfate.
- All others including coal, wood, autos, machinery, and other materials.

As shown in Figure 3-59, farm products were the main commercial commodity moving on the Missouri River from 1960 to 1992, accounting for 71 percent of total commercial tonnage in 1960. By 1992, the percentage had fallen to 29 percent of total commercial tonnage. From 1992 to 1997, slightly more chemical products including fertilizers (an average of 0.51 million tons) were shipped on the Missouri than farm products (an average of 0.46 million tons). However, farm products were the main commodity again from 1997 to 2002. From 2003 to 2010, petroleum products including pitch coke were the leading commodity moving on the Missouri River. From 2011 to 2014, the leading commercial cargo commodity was stone, clay, and cement which accounted for 29% of commercial cargo tonnage in 2014.

Sand and gravel is the major commodity moving on the Missouri River and most of the sand and gravel sites are located south of Kansas City, MO. As a result, the majority of all shipping along the river occurs between Kansas City, MO south and the mouth of the river. As shown in Figure 3-60, Kansas City to the mouth of the Missouri River averaged about 3.8 million tons a year, whereas the Omaha to Kansas City reach averaged approximately 600,000 tons between the years 2010 and 2014. For the Sioux City to Omaha reach, the only cargo being moved on the river was food and kindred products.

Tow configurations on the Missouri River are three to four barges above Kansas City and six to nine loaded barges or twelve empty barges below Kansas City (Petersen 1997). Barges sizes on the Missouri River are similar to other rivers, a width of 35 feet, and a length of 195 feet. Towboats on the Missouri River tend to range from approximately 50 feet to 110 feet in length, 20 feet to 35 feet in breadth, 6 to 9 feet in depth, and generally have engines that range from approximately 800 to 3,000 horsepower. The lower horsepower engines produce less draft which helps prevent sediment resuspension from propeller wash, the backwash from a propeller, and hull dragging.




Source: USACE WCSC 2016.

**Figure 3-59. Commercial Tonnage by Category, 1960–2014**

Source: USACE WCSC 2016

**Figure 3-60. Five-Year Average (2010–2014) Annual Tonnage including Sand and Gravel by River Segment**

### 3.15.1.2 Navigation Service

Navigation service on the lower river between Sioux City and St. Louis is provided by a combination of water from major tributaries, such as the Platte and the Kansas Rivers and the release of water from the mainstem dams necessary to maintain 8 to 9 feet of water depth in the navigation channel. The level of navigation service (full, reduced, or minimum) depends on the quantity of water in System storage. Operating experience has demonstrated that flows for full-service navigation are 31 kcfs (thousands of cubic feet per second) at Sioux City and Omaha, 37 kcfs at Nebraska City, and 41 kcfs at Kansas City. These full-service flows generally provide the authorized 9-foot navigation channel, and they allow the capability to load barges to an 8.5-foot draft. Flows 6 kcfs lower are provided for the designated minimum service. These flows generally provide a minimum 8-foot channel, and barges can be loaded to a 7.5-foot draft. Commercial navigation declines precipitously below the minimum service level of 8 feet. There is generally little traffic when the channel is below 7 feet. Although these flows are generally

adequate to provide the indicated drafts, considerable delays can occur due to bumpings and groundings. During years with lower tributary flows, releases from Gavins Point Dam are increased to meet target flows.

The level of navigation service to be provided is determined according to how much water is available in storage on two constant key dates (March 15 and July 1) of each year. On March 15, if the total System storage is greater than 54.5 MAF, then full-service is provided. If the System storage is between 31.0 and 49.0 MAF, then minimum-service is provided. If the System storage is less than 31.0 MAF, there is no service level computed and there will be no navigation season.

On July 1, if System storage is 57.0 MAF or greater, full service is provided for the remainder of the navigation season. If the System storage is 50.5 MAF or less, minimum service (29 kcfs) is provided for the remainder of the navigation season. Straight-line interpolation defines intermediate service levels between full and minimum service. The criteria for service level, based on System storage, is detailed in Table 3-154.

**Table 3-154. Relation of Service Level to the Volume of Water in System Storage**

| Date | Water in System Storage (MAF) | Service Level Threshold (cfs) |
|---|---|---|
| March 15 | 54.5 or higher | 35,000: full service |
| | 49 to 31 | 29,000: minimum service |
| | Less than 31 | No navigation service that year |
| July 1 | 57 or more | 35,000: full service |
| | 50.5 or less | 29,000: minimum service |

### 3.15.1.3 Navigation Season Length

Navigation on the Missouri River is limited to the normal ice-free season, with a full-length season defined as 8 months. Each year a water-in-storage check for navigation season length is taken on March 15, to determine if a navigation season will occur, and on July 1, to determine the length of the season. If the System water-in-storage is above 31 MAF on March 15, then a navigation season is supported. During the July 1 System water-in-storage check, the length of the season is decided. If System water-in-storage is at or above 51.5 MAF, a full 8-month navigation season would be provided, unless the season is extended to evacuate system flood control storage. However, if System water-in-storage falls below 51.5 MAF on any July 1, a shortened navigation season would be provided to conserve water stored in the system to extend availability of water-in-storage in the case of an extended drought. The specific technical criteria for season length are shown in Table 3-155. Straight-line interpolation between 51.5 and 46.8 MAF of water-in-storage on July 1 provides the closure date for a season length between 8 and 7 months. If System water-in-storage on July 1 is between 46.8 and 41.0 MAF, a 7-month navigation season is provided. A straight-line interpolation is again used between 41.0 and 36.5 MAF, providing season lengths between 7 and 6 months. For System water-in-storage on July 1 below 36.5 MAF, a 6-month season is provided.

**Table 3-155. Relation of System Storage to Season Length**

| Date | System Storage (MAF) | Season Closure Date at Mouth of the Missouri River |
|---|---|---|
| March 15 | 31.0 or less | No season |
| July 1 | 51.5 or more | December 1: 8-month season |
| July 1 | 46.8 through 41.0 | November 1: 7-month season |
| July 1 | 36.5 or less | October 1: 6-month season |

Based on historical records of ice formation on the Missouri River together with experience gained in system regulation to date, the opening and closing dates of a normal 8-month navigation season have been scheduled as shown in Table 3-156.

**Table 3-156. Season Open and Close Dates for Missouri River Sections**

| | Open Date | Close Date |
|---|---|---|
| Sioux City | March 23 | November 22 |
| Omaha | March 25 | November 24 |
| Nebraska City | March 25 | November 24 |
| Kansas City | March 28 | November 27 |
| Mouth of the Missouri River | April 1 | December 1 |

In some years, ice conditions will undoubtedly delay the opening of the season and in others may force an early end to the season. Fall extensions of the season beyond the normal 8-month length will normally be scheduled (ice conditions permitting) in years with above-normal water supply and when such extensions will not result in a drawdown into the Missouri River system carryover multiple use zone. Based on experience to date, these season extensions will normally be limited to 10 days beyond the normal closure date, resulting in a season closing on December 11 at the mouth of the Missouri River.

## 3.15.2 Environmental Consequences

Alternative means of achieving species objectives are evaluated for their effects on navigation. The alternatives evaluated include management actions with potential to affect river flows, channel form, and river stage. The navigation 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 service level and season length and how this could affect changes in navigation. This section summarizes the navigation impacts assessment methodology and presents the results of the assessment. A detailed description of the methodology and results is provided in the “Navigation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

### 3.15.2.1 Impacts Assessment Methodology

The impacts to navigation 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.

Changes to System storage and releases can impact navigation service level flows and season length. Changes in navigation service flows and season length affect the benefit of transporting commodities on the river. This analysis used the output from the HEC-ResSim Missouri River model to simulate the amount of navigation-supported flows released from Gavins Point Dam over an 82-year POR under each of the MRRMP-EIS alternatives. These modeled simulations were then used to determine navigation performance for each month in the POR and how these changing conditions impact navigation. The analysis focuses on the 735-mile-long navigable channel that stretches from Sioux City, Iowa to St. Louis, Missouri.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

A brief overview of the overall methodology that was used to evaluate impacts in the NED, RED, and OSE account is described below.

**National Economic Development**

The net NED for navigation is calculated by subtracting the change in non-routine repair, replacement, and rehabilitation (R, R, & R) costs from the transportation savings. The transportation savings estimates how changes in navigation season length and service levels over the period of record affect the transportation rate savings per ton moved by barge. The evaluation of R, R, & R costs include an evaluation of the changes in non-routine repair, replacement and rehabilitation costs associated with changes in river conditions associated with each of the alternatives. These costs include support for two river field offices, including any funds necessary for rescues, funds for repairs of equipment, funds for staff, and funds for other expenses; repair, replacement, and rehabilitation of thousands of river structures; and emergency dredging that is required for extreme river conditions. The functions to estimate changes in transportation saving and R, R, & R costs were based on *Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998).* Once these two values are known, the change in R, R, & R costs can be subtracted from the transportation savings to estimate the net NED value for each alternative.

**Regional Economic Development**

The RED evaluation for navigation used the results from the NED analysis to evaluate how changes in the amount of commercial products transported on the river under the MRRMP-EIS alternatives may affect local economic conditions, including sales, labor income, and employment. Specifically, this evaluation examined the amount (in tons) of commercial sand and gravel, food, and farm materials that would be anticipated to be affected by navigation on the Missouri River under the MRRMP-EIS alternatives. Two regional economic evaluations were conducted to estimate the RED impacts: (1) impacts to the commercial sand and gravel and associated truck transportation; and (2) impacts to the waterway industries. These evaluations were conducted using IMPLAN® Pro and RECONS (regional economic system), both of which are based on the principles of input-output analysis. IMPLAN® Pro is an industry-standard

input-output data and software system widely used by academics, government, and industry. RECONS is a certified USACE model that customizes IMPLAN® Pro ratios and multipliers to USACE projects and study areas.

**Other Social Effects**

The OSE effects to navigation considers changes in air quality if commodities moving on the waterway could potentially shift to land as a result of any of the MRRMP-EIS alternatives. This navigation impact analysis assesses the OSE impacts by (1) characterizing the current state of air quality within the region; and (2) conducting a preliminary analysis of changes in emissions using estimates for the potential tonnage that could move off the water and published emission factors for inland waterway vessels and trucks. The current state of air quality of the region was determined by consulting the EPA Green Book Nonattainment Areas, which lists all counties that do not meet National Ambient Air Quality Standards (NAAQS) for the six criteria pollutants. The preliminary estimates of changes in air quality parameters were calculated by multiplying the tonnage that could move off the water for each alternative from the NED analysis, by the emission factors for the truck and inland towing published by Texas A & M University, Texas Transportation Institute (2012). After the emissions were estimated, the list of counties potentially affected was compared to the list of counties in nonattainment status.

### 3.15.2.2 Summary of Environmental Consequences

The environmental consequences relative to navigation are summarized in Table 3-157. A discussion of each alternative follows the table. 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 3-157. Environmental Consequences Relative to Navigation**

| Alternative | NED Impacts | RED Impacts | OSE Impacts |
|---|---|---|---|
| Management Actions Common to All Alternatives | No impacts since all measures will be designed to not impact other authorized purposes. | | |
| Alternative 1 | Average Annual NED Benefits: $0.72 million<br>Range of Annual NED Benefits: ($2,300 to $859,800) | Average annual jobs of 284 and labor income of $19.3 million<br>Range in jobs from 0 to 287 and labor income of $0 to $19.5 million | HC: 0.2 thousand g/mile<br>CO: 7 thousand g/mile<br>NOx: 20.6 thousand g/mile<br>PM: 0.5 thousand g/mile |

| Alternative | NED Impacts | RED Impacts | OSE Impacts |
|---|---|---|---|
| Alternative 2 | Average Annual NED Benefits: $0.69 million<br>Range of Annual NED Benefits: ($700 to $775,500).<br>An adverse impact to navigation by reducing NED by $0.028 million annually due to low summer flow reducing navigation season. The impact would be greater, but the shorter season with a greater service level reduces R, R, & R costs in comparison to Alternative 1. | Decrease in average annual jobs of 8 and labor income of $534,000.<br>Relatively large adverse effects to commercial sand dredging in years with low summer flows, but negligible impacts to RED. | HC: 0.4 thousand g/mile<br>CO: 13.7 thousand g/mile<br>NOx: 40.1 thousand g/mile<br>PM: 1 thousand g/mile<br>Relative large impact to NOx, but no area in the region is classified as nonattainment for NOx. |
| Alternative 3 | Average Annual NED Benefits: $0.72 million<br>Range of Annual NED Benefits: ($2,300 to $859,800)<br>Slightly beneficial impact on navigation benefits compared to Alternative 1 because it could improve the annual NED by $0.002 million. The slight increase is due to reduced R, R, & R costs in comparison to Alternative 1. | Increase of $33 K in average annual labor income and no change in jobs. Negligible impacts to RED. | HC: 0.2 thousand g/mile<br>CO: 6.2 thousand g/mile<br>NOx: 18 thousand g/mile<br>PM: 0.4 thousand g/mile<br>As compared to Alternative 1, a slight beneficial impact would occur because less traffic is estimated to move off the water. |
| Alternative 4 | Average Annual NED Benefits: $0.67 million<br>Range of Annual NED Benefits: ($609 to $777,600).<br>An adverse impact on navigation benefits by decreasing the annual NED by $0.045 million. The decrease is due to full releases in spring reducing the service level. | Decrease in average annual jobs of 4 and labor income of $326 K.<br>Relatively large adverse effects to commercial sand dredging from shortened navigation seasons in some years, but negligible impacts to RED. | HC: 0.4 thousand g/mile<br>CO: 13.1 thousand g/mile<br>NOx: 38.2 thousand g/mile<br>PM: 0.9 thousand g/mile<br>Relative large impact to NOx, but no area in the region is classified as nonattainment for NOx. |

| Alternative | NED Impacts | RED Impacts | OSE Impacts |
|---|---|---|---|
| Alternative 5 | Average Annual NED Benefits: $0.71 million<br>Range of Annual NED Benefits: ($2,300 to $777,600)<br>A relatively small adverse impact on navigation benefits compared to Alternative 1 because it could reduce the annual NED by $0.006 million. The reduction is due to higher R, R, & R costs in comparison to Alternative 1. | No change in jobs and increase of $33 K in labor income. Negligible impacts to RED. | HC: 0.2 thousand g/mile<br>CO: 6.2 thousand g/mile<br>NOx: 18 thousand g/mile<br>PM: 0.4 thousand g/mile<br>As compared to Alternative 1, a slight beneficial impact would occur because less traffic is estimated to move off the water |
| Alternative 6 | Average Annual NED Benefits: $0.67 million<br>Range of Annual NED Benefits: ($2,300 to $777,600).<br>An adverse impact by reducing annual NED by $0.042 million due to increase in R, R, & R costs caused by reduction in service level. | Decrease in average annual jobs of 3 and labor income of $219 K.<br>Relatively large adverse effects to commercial sand dredging from shortened navigation seasons in some years, but negligible impacts to RED. | HC: 0.3 thousand g/mile<br>CO: 11.9 thousand g/mile<br>NOx: 34.8 thousand g/mile<br>PM: 0.8 thousand g/mile |

CO = carbon monoxide; HC = hydrocarbon; NOx = nitrogen oxide; PM = particulate matter

### 3.15.2.3 Impacts from Management Actions Common to All Alternatives

A number of actions are common to all alternatives including vegetation management, predator management, and human restriction measures. These actions occur upstream of Gavins Point Dam and would not affect navigation. Pallid sturgeon propagation and augmentation is also common to all alternatives, but would have no impact on navigation.

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

Before discussing the impacts for Alternative 1, it should be noted that the impacts shown are for the purpose of providing a reference condition and allowing for a comparison of the alternatives. As described in Section 3.1, the basis for analysis was simulating the operation of the alternatives over the historic POR resulting in reservoir elevations and releases for each day of the POR. This resulted in time periods when navigation was simulated to not occur or was reduced due to drought conditions. Therefore, Alternative 1 shows commodities moving off the water, regional effects, as well as changes in emissions from modal shift.

#### Mechanical Habitat Construction

For early life stage pallid habitat, Alternative 1 would construct 3,999 acres with 1,021 acres located between Sioux City and Platte; 672 acres located between Platte River and Rulo, NE; 1,129 acres located between Rulo, NE and Kansas River; and 937 acres located between the Kansas River and Osage River. Generally, these actions involve mechanical manipulation of the

riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are not likely to impact navigation because each project will be designed to minimize impacts to other authorized purposes including navigation as described in Section 2.5.3.1. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as shoaling in the navigation channel. If issues are detected then adjustments will be made to restore the authorized 9 foot deep by 300-foot wide navigation channel.

Alternative 1 will construct 107 acres per year on average of ESH which involves mechanical excavation and placement of sand with typical large construction equipment or hydraulic dredge. This activity would not occur in the navigable portion of the river so no impacts to navigation would occur.

### National Economic Development

Under the No Action alternative, the Missouri River Recovery Program would continue its current implementations plans which may have impacts to navigation including spawning cue flow releases from Gavins Point Dam.

As shown in Table 3-158, the annual net NED values for Alternative 1 would range between $0.006 million and $1.45 million with an average of $0.72 million. The reason for the range is due to the POR covering 82 years which covers a multitude of conditions.

**Table 3-158. Transportation Savings, R, R, & R costs, and Net NED for Alternative 1 (2016 $)**

| Costs | Alternative 1 Transportation Savings | Alternative 1 R, R, & R Costs | Alternative 1 Net NED Value |
|---|---|---|---|
| Total That Occurred Over the POR (million $) | $95.36 | $41.00 | $54.36 |
| **Average Annual Value (million $)** | $1.26 | $0.54 | $0.72 |
| Max Annual Over the POR (million $) | $1.46 | $1.22 | $1.45 |
| Min Annual Value Over the POR (million $) | $0.942 | $0 | $0.006 |

*Numbers may not match exactly due to rounding

### Regional Economic Development

Under Alternative 1, RED benefits associated with the value of commercial sand and gravel produced from the Missouri River, transportation benefits, and other shipments on the waterway would support 284 direct and multiplier jobs and $19.3 million in labor income on average over the period of analysis. Over the period of analysis (excluding years when there was no navigation supported by the USACE), during the worst navigation year, there would be no jobs and income supported with no tonnage moved, while in the highest navigation year with the greatest tonnage of commodities shipped, there would be 287 jobs and $19.5 million in labor income. Table 3-159 is a summary of RED benefits under Alternative 1.

The largest RED benefits would be associated with commercial sand and gravel because the vast majority of shipments are commercial sand and gravel. During years when navigation is eliminated or reduced, the reduced ability to produce commercial sand and gravel from the Missouri River would likely be at least partially offset by production from alternative sources. However, sourcing lower quality, more expensive sand and gravel from other rivers or off of the river, and/or relatively higher transportation costs would likely result in higher material costs for

construction projects within Missouri and the region, with potential adverse RED impacts. Overall, there would be adverse impacts to the RED effects associated with the commercial sand dredging industry during years when navigation is reduced or eliminated. In the worst years, these impacts would be negligible in the large economic context in which these activities take place but could be important for the commercial sand dredging industry.

While Alternative 1 would have adverse impacts to the waterway industries when commodities can no longer be shipped via navigation on the Missouri River, these adverse impacts would be at least partially offset by revenue gains and employment growth in other transportation sectors (e.g., truck and rail transport). Since most of these commodities are moved within Missouri, the vast majority of the economic contribution would occur within Missouri, although there may be some very small economic benefits in adjacent states where these commodities would be shipped to or from. Overall, even in the worst years where navigation would be reduced or eliminated, there would be negligible impacts to waterway industries and supporting sectors.

**Table 3-159. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 1 (thousands of 2016$)**

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total RED Benefits |
|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Annual Average RED benefits | 258 | 27 | 284 |
| | Smallest Annual Movement of Commodities on the Missouri River | 0 | 0 | 0 |
| | Largest Annual Movement of Commodities on the Missouri River | 261 | 27 | 287 |
| Direct, Indirect, and Induced Labor Income | Annual Average RED benefits | $17,693 | $1,561 | $19,254 |
| | Smallest Annual Movement of Commodities on the Missouri River | 0 | 0 | 0 |
| | Largest Annual Movement of Commodities on the Missouri River | $17,876 | $1,575 | $19,451 |
| Direct, Indirect, and Induced Sales | Annual Average RED benefits | $54,936 | $4,819 | $59,754 |
| | Smallest Annual Movement of Commodities on the Missouri River | 0 | 0 | 0 |
| | Largest Annual Movement of Commodities on the Missouri River | $55,505 | $4,861 | $60,367 |

### Other Social Effects

Establishing the reference conditions for comparison of alternatives requires also examining how the multitude of conditions within the POR could impact the OSE account. The OSE impacts for Alternative 1 are summarized in Table 3-160. Of the four navigable reaches only two, the Nebraska City reach, which ranges from RM 563 to RM 370 and Kansas City Reach, which ranges from RM 369 to the mouth of the Missouri River, are impacted by Alternative 1. For both reaches, the pollutant most affected by Alternative 1 is nitrogen oxide with the Nebraska City reach seeing an annual average of approximately 1.6 thousand grams per mile of nitrogen oxide and Kansas City reach showing an annual average of 19 thousand grams per mile of nitrogen oxide. A total of 1.54 million grams per mile over 82-year POR is estimated for Missouri River region with approximately 92 percent of these emissions occurring within the Kansas City reach. The impact of Alternative 1 on nitrogen oxide is important to consider since nitrogen oxide reacts in the atmosphere to form low-level ozone and Franklin County, MO; Madison County, IL; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO, are designated as nonattainment status for ozone.

**Table 3-160. Baseline Tonnage off the Water and Total and Annual Change in Emissions for Alternative 1 by Reach**

| Reach | Total Commodities Move Off Water Over POR | Change in HC Over POR | Average Annual Change in HC | Change in CO Over POR | Average Annual Change in CO | Change in NOx Over POR | Average Annual Change in NOx | Change in PM Over POR | Average Annual Change in PM |
|---|---|---|---|---|---|---|---|---|---|
| | (1,000 tons) | (1,000 g/mile) | | | | | | | |
| Sioux City | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Omaha | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nebraska City | 449 | 1.2 | 0.0 | 40.3 | 0.5 | 118.1 | 1.6 | 2.9 | 0.0 |
| Kansas City | 5,433 | 14.3 | 0.2 | 487.8 | 6.5 | 1,428.4 | 19.0 | 34.6 | 0.5 |
| **TOTAL** | **5,882** | **15.5** | **0.2** | **528.1** | **7.0** | **1,546.5** | **20.6** | **37.4** | **0.5** |

CO = carbon monoxide; HC = hydrocarbon; NOx = nitrogen oxide; PM = particulate matter

### Conclusion

Alternative 1 represents the continuation of current system operation and MRRP implementation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. NED and RED results indicate navigation would continue to provide national and regional economic benefits under Alternative 1. Impacts to navigation under Alternative 1 are not anticipated to be significant.

## 3.15.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

### Mechanical Habitat Construction

For early life stage pallid habitat, Alternative 2 will construct 10,758 additional acres with 2,421 acres located between Sioux City and Platte; 1,642 acres located between Platte River and

Rulo, NE; 2,439 acres located between Rulo, NE and Kansas River; 3,307 acres located between Kansas River and Osage River; 529 acres located between Osage River and the mouth of the Missouri River. Generally, these actions involve physical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are assessed as not likely to impact navigation because each project will be designed to not impact other authorized purposes including navigation. Prior to any site-specific construction project, and monitoring will be conducted to detect any issues such as shoaling in the navigation channel. If issues are detected then adjustments will be made to restore the authorized 9 foot deep by 300-foot wide navigation channel. Alternative 2 would include 3,546 acres per year on average of ESH construction. This activity would not occur in the navigable portion of the river so no impacts to navigation would occur.

**National Economic Development**

The NED analysis for Alternative 2 is summarized in Table 3-161. These management actions would result in Alternative 2 having average annual net NED of $0.69 million and an annual net NED range between $0.06 million to a maximum of $1.45 million. This represents an overall decrease in net NED to 5.26 percent compared to Alternative 1.

Simulation of the management actions under Alternative 2 would result in ten split navigation seasons during the POR for conditions similar to the following years: 1955, 1956, 1958, 1966, 1977, 1988, 1989, 1994, 2002, and 2003. Relative to Alternative 1, these split navigation seasons would cause Alternative 2 to have an adverse impact on net NED of $0.028 million which equates to a decrease in net NED of 3.96 percent. By reducing the season length, the low summer flow for Alternative 2 would decrease the transportation savings relative to Alternative 1 by $0.048 million over the POR, but the low summer flow would also likely decrease the R, R, & R costs by $0.019 million over the POR.

**Table 3-161. Transportation Savings, R, R, & R Costs, and Net NED for Alternative 2 (2016 $)**

| Costs | Alternative 2 Transportation Savings | Alternative 2 R, R, & R Costs | Alternative 2 Net NED Value |
|---|---|---|---|
| Total That Occurred Over the POR (million $) | $91.75 | $39.54 | $52.21 |
| **Average Annual Value (million $)** | **$1.21** | **$0.52** | **$0.69** |
| Max Annual Over the POR (million $) | $1.45 | $1.22 | $1.45 |
| Min Annual Value Over the POR (million $) | $0.909 | −$0.104 | $0.006 |
| Change from Alternative 1 (million $) | −$0.048 | −$0.019 | −$0.028 |
| % Change from Alternative 1 | −3.79% | −3.57% | −3.96% |

*Numbers may not match exactly due to rounding

The annual differences in net NED value between Alternative 1 and Alternative 2 are shown in Table 3-162. Some notable trends are the following:

- Alternative 2 contains ten years of full releases plus low summer flows and 44 years with partial release.
- Of the ten full releases, plus low summer flows simulate occurrence, seven cause negative impacts to navigation NED values. However, the greatest beneficial impact of

Alternative 2 in comparison to Alternative 1 occurs under simulated full release low summer flow conditions similar to 1977. Under these conditions, Alternative 2 has a total 6-month supported navigation season with three months in full service and three months in reduce service. Meanwhile, Alternative 1 simulates an eight month supported navigation season with five months at minimum service and three months in reduced service. The shorter season but higher service level for Alternative 2 results in lower transportation savings, but it also reduces R, R, & R costs. The result is conditions similar to those occurring in 1977 having the highest beneficial impact of $0.74 million.

- Of the 44 partial releases simulated over the POR, 14 would have an adverse impact on NED navigation benefits with the greatest impact (−$0.819 million) occurring in conditions similar to 1965. Partial releases under conditions similar to those that occurred in the mid-1940s, the late 1960s, and the early 1980s cause annual adverse impacts that are greater than $0.200 million.

**Table 3-162. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release + Low Summer Flow [a] (Million $) | | Partial Flow Release [b] (Million $) | | Years with Greatest Range in Impacts Regardless of Flow Actions (Million $) | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 |
| Missouri River | −$0.258 | $0.740 | −$0.819 | $0.413 | −$0.819 | $0.7401 |

a Flow action was fully implemented in 9 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action was partially implemented in 22 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

### Regional Economic Development

Low summer flows under Alternative 2 would have a greater adverse RED impact on commercial sand dredging and navigation on the Missouri River when compared to Alternative 1. Under Alternative 2, average annual RED benefits supported by navigation would be 277 jobs and $18.7 million in labor income. When compared to Alternative 1, Alternative 2 would result in 8 fewer jobs and $534,000 in labor income on average over the period of analysis associated with the reduced ability to navigate on the Missouri River. Table 3-163 summarizes the RED impacts under Alternative 2.

Shortened or eliminated navigation seasons under Alternative 2 during low summer flows or when System storage did not meet navigation targets would have an adverse impact on the commercial sand dredging industry, truck transportation, and waterway industries and supporting sectors. Under Alternative 2, the economic impacts in the eight worst years relative to Alternative 1 would result in an average reduction of 44 jobs and $3.0 million in labor income, with most of the impacts associated with commercial sand dredging and truck transportation. Alternative 2 would result in relatively larger adverse RED impacts compared to Alternative 1 for the commercial sand dredging industry. In the years with the largest adverse impacts relative to Alternative 1 (i.e., during the low summer flow events), these impacts would be negligible in the large regional economic context in which these activities take place but could be important to

the commercial sand dredging industry, truck transportation, and supporting sectors. Because the need to source alternative sand would be greater under Alternative 2, there could potentially be relatively higher material costs for construction projects within Missouri and the region. There would be negligible impacts to waterway industries and supporting sectors, even in the years with the largest reductions in shipments compared to Alternative 1.

**Table 3-163. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 2 and Compared to Alternative 1 (Thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total RED Benefits |
|---|---|---|---|---|
| Change in Direct, Indirect, and Induced Jobs | Annual Average RED benefits | 251 | 26 | 277 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | −7 | −1 | −8 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | −39 | −5 | −44 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | 2 | 0 | 2 |
| Direct, Indirect, and Induced Labor Income | Annual Average RED benefits | $17,202 | $1,517 | $18,719 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | −$490 | −$43 | −$534 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | −$2,694 | −$297 | −$2,991 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $119 | $8 | $127 |
| Direct, Indirect, and Induced Sales | Annual Average RED benefits | $53,412 | $4,397 | $57,810 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | −$1,523 | −$421 | −$1,944 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | −$8,365 | −$917 | −$9,282 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $370,321 | $24,188 | $394,509 |

### Other Social Effects

The results of the OSE analysis for Alternative 2 are summarized in Table 3-164. Alternative 2 shows 11.4 million tons moving off water which will result in average annual emissions of 0.4 thousand grams per mile of hydrocarbon, 13.7 thousand grams per mile of carbon monoxide, 40.1 thousand grams per mile of nitrogen oxide; and 1 thousand grams per mile of particulate matter. The pollutant with the greatest increase in emissions is nitrogen oxide, which may react

in the atmosphere to form ozone. Over 86 percent of the emissions will occur within the Kansas City reach (RM 0 to RM 369) which contains Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. These counties are currently designated by the EPA as nonattainment status for ozone. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

**Table 3-164. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 2 by Reach**

| Reach | Total Commodities Move Off Water Over POR | Change in HC Over POR | Average Annual Change in HC | Change in CO Over POR | Average Annual Change in CO | Change in NOx Over POR | Average Annual Change in NOx | Change in PM Over POR | Average Annual Change in PM |
|---|---|---|---|---|---|---|---|---|---|
| | (1,000 tons) | (1,000 g/mile) | | | | | | | |
| Sioux City | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Omaha | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nebraska City | 1,579 | 4.2 | 0.1 | 141.8 | 1.9 | 415.1 | 5.5 | 10.0 | 0.1 |
| Kansas City | 9,861 | 25.9 | 0.3 | 885.4 | 11.8 | 2,592.7 | 34.6 | 62.7 | 0.8 |
| **TOTAL** | **11,440** | **30.1** | **0.4** | **1,027.2** | **13.7** | **3,007.9** | **40.1** | **72.8** | **1.0** |

CO = carbon monoxide; HC = hydrocarbon; NOx = nitrogen oxide; PM = particulate matter

### Conclusion

In comparison to Alternative 1, Alternative 2 would have an adverse impact to navigation by reducing NED by $0.028 million annually, approximately four percent of annual NED benefits, due to the low summer flow reducing navigation season. There would be relatively large adverse effects to commercial sand dredging jobs and income in years with low summer flows, but negligible impacts to regional economic conditions. A relatively large increase in nitrogen oxide emissions would occur, but no area in the region is classified as nonattainment for nitrogen oxide conditions. Although split navigation seasons would adversely affect navigation NED, RED, and OSE under Alternative 2, the impacts would not be significant because the NED decrease in magnitude and percentage change is small; RED impacts would be negligible in the regional context; and air quality impacts for nitrogen oxide would not occur in non-attainment areas.

### 3.15.2.6 Alternative 3 – Mechanical Construction Only

For early life stage pallid habitat, Alternative 3 will construct 3,380 additional acres with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, NE; 670 acres located between Rulo, NE and Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Generally, these actions involve physical manipulation of the river bed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are assessed as not likely to impact navigation because each project will be designed to not impact other authorized purposes including navigation. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as shoaling in the navigation channel. If

issues are detected then adjustments will be made to restore the authorized 9 foot deep by 300-foot wide navigation channel.

In years where construction is needed, Alternative 3 would construct 391 acres per year on average of ESH which involves mechanical excavation and placement of sand with typical large construction equipment or hydraulic dredge. This will not occur in the navigable portion of the river, so no impacts to navigation.

### National Economic Development

Management actions included under Alternative 3 would include those that focus on the construction of ESH through mechanical means. This alternative would have a small, beneficial impact on navigation.

The NED results for Alternative 3 are summarized in Table 3-165. Overall, Alternative 3 has a small, positive impact ($0.002 million) on Missouri River navigation relative to Alternative 1. The result is a 0.34 percent increase in net NED relative to Alternative 1. It should be noted that this analysis focused on the impact to the whole river rather than identifying specific impacts at ESH locations on the river. However, ESH efforts will be designed to not impact authorized purposes, including navigation and monitoring, and will be conducted to detect issues such as shoaling in the navigation channel.

**Table 3-165. Transportation Savings, R, R, & R costs, and Net NED for Alternative 3 (2016 $)**

| Costs | Alternative 3 Transportation Savings | Alternative 3 R, R, & R Costs | Alternative 3 Net NED value |
|---|---|---|---|
| Total That Occurred Over the POR | $95.52 | $40.98 | $54.55 |
| **Average Annual Value** | **$1.26** | **$0.54** | **$0.72** |
| Max Annual Over the POR | $1.46 | $1.22 | $1.45 |
| Min Annual Value Over the POR | $0.942 | $0.000 | $0.006 |
| Change from Alternative 1 | $0.002 | $0.000 | $0.002 |
| % Change from Alternative 1 | 0.17% | 0.06% | 0.34% |

*Numbers may not match exactly due to rounding

As shown by the minimum and maximum annual differences in net NED value in Table 3-166, Alternative 1 and Alternative 3 have similar simulated results. In 1967, Alternative 3 offers an increase of $0.150 million in net NED. While the transportation savings were similar between Alternative 1 and Alternative 3 during this year, the R, R, & R costs for Alternative 1 were 65 percent more expensive due to Alternative 1 having a navigation season with greater amount of time classified as minimal service.

**Table 3-166. Impacts from Modeled Flow Releases under Alternative 3 Compared to Alternative 1**

| Reservoir or River Reach | Years with Greatest Range in Impacts Regardless of Flow Actions (Million $) | |
|---|---|---|
| | Lowest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 |
| Lower River | −$0.009 | −$0.009 |

## Regional Economic Development

Under Alternative 3, average annual RED benefits supported by navigation would be 285 jobs and 19.3 million in labor income. Alternative 3 would result in negligible changes in navigation compared to Alternative 1. Table 3-167 summarizes the RED impacts under Alternative 3. Overall, similar to Alternative 1, there would be adverse impacts to the RED effects associated with the commercial sand dredging industry during years when navigation is reduced or eliminated, although there would be a negligible change in RED impacts compared to Alternative 1. There would be negligible impacts to waterway industries and supporting sectors under Alternative 3.

**Table 3-167. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 3 and Compared to Alternative 1 (Thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total RED Benefits |
|---|---|---|---|---|
| Change in Direct, Indirect, and Induced Jobs | Annual Average RED benefits | 258 | 27 | 285 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | 0 | 0 | 0 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | 0 | 0 | 0 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | 3 | 0 | 3 |
| Direct, Indirect, and Induced Labor Income | Annual Average RED benefits | $17,723 | $1,564 | $19,287 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | $30 | $3 | $33 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | $0 | $0 | $0 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $208 | $14 | $222 |

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total RED Benefits |
|---|---|---|---|---|
| Direct, Indirect, and Induced Sales | Annual Average RED benefits | $55,029 | $4,828 | $59,857 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | $94 | $10 | $103 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | $0 | $0 | $0 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $647 | $43 | $690 |

### Other Social Effects

Similar H&H profiles for Alternative 3 and Alternative 5 means the tonnage estimated to move off the water is the same for both alternatives, so the OSE results summarized in Table 3-168 are the same for both alternatives. Both Alternative 3 and Alternative 5 could cause 5.14 million tons to move off water which will result in average annual emissions of 0.2 thousand grams per mile of hydrocarbon, 6.2 thousand grams per mile of carbon monoxide, 18.0 thousand grams per mile of nitrogen oxide, and 0.4 thousand grams per mile of particulate matter. The pollutant with the greatest increase in emissions is nitrogen oxide which may react in the atmosphere to form ozone. Over 93 percent of the emissions will occur within the Kansas City reach (RM 369 to RM 0) which contains the following counties which are designated as nonattainment areas for ozone: Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

**Table 3-168. Tonnage off the Water and Total and Annual Change in Emissions for Alternative 3 and Alternative 5 By Reach**

| Reach | Total Commodities Move Off Water Over POR | Change in HC Over POR | Average Annual Change in HC | Change in CO Over POR | Average Annual Change in CO | Change in NOx Over POR | Average Annual Change in NOx | Change in PM Over POR | Average Annual Change in PM |
|---|---|---|---|---|---|---|---|---|---|
| | (1,000 tons) | (1,000 g/mile) | | | | | | | |
| Sioux City | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Omaha | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nebraska City | 339 | 0.9 | 0.0 | 30.4 | 0.4 | 89.1 | 1.2 | 2.2 | 0.0 |
| Kansas City | 4,801 | 12.6 | 0.2 | 431.1 | 5.7 | 1,262.4 | 16.8 | 30.5 | 0.4 |
| **TOTAL** | **5,140** | **13.5** | **0.2** | **461.5** | **6.2** | **1,351.4** | **18.0** | **32.7** | **0.4** |

CO = carbon monoxide; HC = hydrocarbon; NOx = nitrogen oxide; PM = particulate matter

### Conclusion

In comparison to Alternative 1, Alternative 3 would have a slightly beneficial impact on navigation compared to Alternative 1 because it could improve the annual NED by $0.002 million and increase average annual jobs of 3 and $33 K in labor income although there would be negligible impacts to regional economic conditions. In comparison to Alternative 1, slightly lower nitrogen oxide emissions would occur because less traffic is estimated to move off the water. Overall, Alternative 3 would not have significant impacts to navigation because the analysis indicates a slight relative benefit would occur in comparison to Alternative 1.

## 3.15.2.7 Alternative 4 – Spring ESH Creating Release

### Mechanical Habitat Construction

For early life stage pallid habitat, Alternative 4 will construct 3,380 additional acres with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, NE; 670 acres located between Rulo, NE and Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Generally, these actions involve physical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are assessed as not likely to impact navigation because each project will be designed to not impact other authorized purposes including navigation.

In years where construction is needed, Alternative 4 would construct 240 acres per year on average of ESH which involves mechanical excavation and placement of sand with typical large construction equipment or hydraulic dredge. This will not occur in the navigable portion of the river, so no impacts to navigation.

### National Economic Development

Alternative 4 develops ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Both actions have the potential to affect navigation. As shown in Table 3-169, relative to Alternative 1, Alternative 4 has an average annual change in net NED value of −$0.045 million which equates to decrease of 6.27 percent on net NED value. While annual net NED value for Alternative 4 would range from a minimum of $0.006 million to a maximum of $1.45 million, the annual difference between Alternative 4 and Alternative 1 would range from −$0.413 million to $0.053 million.

**Table 3-169. Transportation Savings, R, R, & R costs, and Net NED for Alternative 4 (FY 2016 $)**

| Costs | Alternative 4 Transportation Savings | Alternative 4 R, R, & R Costs | Alternative 4 Net NED value |
|---|---|---|---|
| Total That Occurred Over the POR (million $) | $93.69 | $42.74 | $50.96 |
| **Average Annual Value (million $)** | **$1.23** | **$0.56** | **$0.67** |
| Max Annual Over the POR (million $) | $1.46 | $1.22 | $1.45 |
| Min Annual Value Over the POR (million $) | $0.942 | $0 | $0.006 |
| Change from Alternative 1 (million $) | −$0.022 | $0.023 | −$0.045 |
| % Change from Alternative 1 | −1.75% | 4.24% | −6.27% |

*Numbers may not match exactly due to rounding

Table 3-170 presents the maximum and minimum differences in annual net NED value between Alternative 1 and Alternative 4 that occur under various flow scenarios. Some notable trends include the following:

- Under conditions to similar to those modeled for 1966, 1982, and 1994, full releases would likely result in the greatest decrease (>$0.41 million) between Alternative 4 and Alternative 1. While the length of the supported season between Alternative 1 and Alternative 4 would be the same, the full release reduces the service level. This reduction in service level increases the R, R, & R costs along with reducing the transportation savings resulting in an adverse impact to the net NED compared to Alternative 1. Of the ten full releases simulated, five simulation conditions saw adverse changes in navigation benefits, four resulted in no change, and one had a small beneficial impact (<$0.002 million) in navigation benefits.
- While the full releases resulted in the largest difference between Alternative 1 and Alternative 4, some simulated conditions showed partial releases causing adverse impacts. For example, conditions similar to those modeled for 1944, 1945, and 1965 resulted in the partial releases adversely impacting navigation benefits by greater than $0.255 million. Alternative 4 and Alternative 1 have similar transportation savings estimates ($1.3 million) for 1944 and 1945, but the simulated partial spring releases reduce the service level which increases the R, R, & R costs. Of the five partial releases scheduled, four result in adverse impacts and one has a slight beneficial impact (<$0.002 million).
- Of the 82 years simulated for Alternative 4, 26 had an adverse impact compared to Alternative 1 and 45 years showed no difference with Alternative 1.

**Table 3-170. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release [a] (Million $) | | Partial Flow Release [b] (Million $) | | Years with Greatest Range in Impacts Regardless of Flow Actions (Million $) | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 |
| Lower River | −$0.413 | $0.002 | −$0.296 | $0.002 | −$0.413 | $0.526 |

a Flow action was fully implemented in 8 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action was partially implemented in 4 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

## Regional Economic Development

Under Alternative 4, average annual RED benefits supported by navigation would be 280 jobs and $18.9 million in labor income. Spring releases under Alternative 4 would have a greater adverse RED impact on commercial sand dredging and navigation on the Missouri River when compared to Alternative 1. Compared to Alternative 1, Alternative 4 would result in 4 fewer jobs and $326,000 in labor income on average over the period of analysis associated with the

reduced ability to navigate in some years. Table 3-171 summarizes the RED impacts under Alternative 2.

Under Alternative 4, the economic impacts in the eight worst years relative to Alternative 1 would result in an average reduction of 37 jobs and $2.5 million in labor income, with most of the impacts associated with commercial sand dredging and truck transportation. Impacts would be similar to those described under Alternative 2 with negligible impacts to regional economic conditions in the large economic context in which these activities take place but could be important to the commercial sand dredging industry. Because the need to source alternative sand would be greater under Alternative 4, there could potentially be relatively higher material costs for construction projects within Missouri and the region. There would be negligible impacts to waterway industries and supporting sectors, even in the years with the largest reductions in shipments compared to Alternative 1.

**Table 3-171. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 4 and Compared to Alternative 1 (thousands of 2016$)**

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total RED Benefits |
|---|---|---|---|---|
| Change in Direct, Indirect, and Induced Jobs | Annual Average RED benefits | 253 | 26 | 280 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | −4 | 0 | −4 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | −34 | −3 | −37 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | 1 | 0 | 1 |
| Direct, Indirect, and Induced Labor Income | Annual Average RED benefits | $17,385 | $1,542 | $18,928 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | −$308 | −$18 | −$326 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | −$2,328 | −$155 | −$2,482 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $57 | $4 | $61 |
| Direct, Indirect, and Induced Sales | Annual Average RED benefits | $53,981 | $4,762 | $58,742 |
| | Change in Annual Average RED Benefits over 82 years Relative to Alternative 1 | −$955 | −$57 | −$1,012 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | −$7,228 | −$477 | −$7,705 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $177 | $12 | $188 |

### Other Social Effects

The OSE results for Alternative 4 are summarized in Table 3-172. Under Alternative 4, 10.9 million tons are estimated to move off the water which will result in average annual emissions of 0.4 thousand grams per mile of hydrocarbon, 13.1 thousand grams per mile of carbon monoxide, 38.2 thousand grams per mile of nitrogen oxide, and 0.9 thousand grams per mile of particulate matter. Over 85 percent of the emissions will occur within the Kansas City reach (RM 369 to RM 0) which contains the following counties which are designated as nonattainment areas for ozone: Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

**Table 3-172. Tonnage off the Water and Total and Annual Change in Emissions for Alternative 4 by Reach**

| Reach | Total Commodities Move Off Water Over POR | Change in HC Over POR | Average Annual Change in HC | Change in CO Over POR | Average Annual Change in CO | Change in NOx Over POR | Average Annual Change in NOx | Change in PM Over POR | Average Annual Change in PM |
|---|---|---|---|---|---|---|---|---|---|
| | (1,000 tons) | (1,000 g/mile) | | | | | | | |
| Sioux City | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Omaha | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nebraska City | 1,543 | 4.1 | 0.1 | 138.5 | 1.8 | 405.7 | 5.4 | 9.8 | 0.1 |
| Kansas City | 9,358 | 24.6 | 0.3 | 840.3 | 11.2 | 2,460.5 | 32.8 | 59.5 | 0.8 |
| **TOTAL** | **10,901** | **28.7** | **0.4** | **978.8** | **13.1** | **2,866.2** | **38.2** | **69.3** | **0.9** |

CO = carbon monoxide; HC = hydrocarbon; NOx = nitrogen oxide; PM = particulate matter

### Conclusion

In comparison to Alternative 1, Alternative 4 would have an adverse impact on navigation benefits by decreasing the annual NED by $0.045 million, approximately six percent of annual NED benefits. The decrease is due to full releases in spring reducing the service level. Modeling showed a decrease in average annual jobs of 4 and labor income of $326 K. Relatively large adverse effects to commercial sand dredging from shortened navigation seasons would occur in some years, but would result in negligible impacts to regional economic conditions. A relatively large increase in nitrogen oxide emissions would occur, but no area in the region is classified as nonattainment for nitrogen oxide. Although the spring releases would shorten navigation seasons and adversely affect navigation NED, RED and OSE under Alternative 4, the impacts would not be significant because the NED decrease in magnitude and percentage change is small; RED impacts would be negligible in the regional context; and air quality impacts for nitrogen oxide would not occur in non-attainment areas.

### 3.15.2.8 Alternative 5 – Fall ESH Creating Release

#### Mechanical Habitat Construction

For early life stage pallid habitat, Alternative 5 will construct 3,380 additional acres with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, NE; 670 acres located between Rulo, NE and Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Generally, these actions involve physical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are assessed as not likely to impact navigation because each project will be designed to not impact other authorized purposes including navigation.

In years where construction is needed, Alternative 5 would construct 309 acres per year on average of ESH which involves mechanical excavation and placement of sand with typical large construction equipment or hydraulic dredge. This will not occur in the navigable portion of the river, so no impacts to navigation.

#### National Economic Development Account

Alternative 5 develops ESH habitat through both mechanical and reservoir releases that would occur during the fall months. The NED results for Alternative 5 are summarized in Table 3-173. While Alternative 5 has a small, beneficial impact on transportation savings ($0.001 million), the change in R, R, & R costs between Alternative 5 and Alternative 1 ($0.007 million) results in an overall net decline in NED of $0.006 million. This is a minor decrease of 0.86 percent in NED relative to Alternative 1. The annual difference between Alternative 5 and Alternative 1 ranges from −$0.284 million to $0.010 million.

**Table 3-173. Transportation Savings; R, R, & R costs, and Net NED for Alternative 5 (2016 $)**

| Costs | Alternative 5 Transportation Savings | Alternative 5 R, R, & R Costs | Alternative 5 Net NED value |
|---|---|---|---|
| Total That Occurred Over the POR (million $) | $95.46 | $41.57 | $53.89 |
| **Average Annual Value (million $)** | **$1.26** | **$0.55** | **$0.71** |
| Max Annual Over the POR (million $) | $1.46 | $1.22 | $1.45 |
| Min Annual Value Over the POR (million $) | $0.942 | $0.000 | $0.006 |
| Change from Alternative 1 (million $) | $0.001 | $0.007 | −$0.006 |
| % Change from Alternative 1 | 0.1030% | 1.38% | −0.86% |

*Numbers may not match exactly due to rounding

Table 3-174 presents the maximum and minimum differences in annual net NED value between Alternative 1 and Alternative 5 that occur under various flow scenarios. This table shows that for Alternative 5, years with full or partial releases do not have an impact on navigation benefits. This makes sense since the releases would be in the fall when the navigation season is almost complete. This does not imply that fall full release do not have an impact. Two of the three

greatest adverse impacts (−$0.284 million and −$0.109 million) occur in years following a full fall release. However, as shown in Table 3-175, Alternative 5 has seven fall releases occurring throughout the 82-year POR and, under simulated conditions similar to 1944, 1969, 1974, and 1983, the fall releases caused adverse impacts in the years following theses releases. However, the adverse impacts simulated for conditions similar to 1970 and 1984 are less than $0.002 million while the adverse impacts simulated for conditions similar to 1945 and 1975 are −$0.284 million and −$0.109 million, respectively. Since Alternative 5 is simulated to have three months at reduced service levels and Alternative 1 is simulated to have eight months at full service, the R, R, & R costs for Alternative 5 are much higher.

**Table 3-174. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release [a] (Million $) | | Partial Flow Release [b] (Million $) | | Years with Greatest Range in Impacts Regardless of Flow Actions (Million $) | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 |
| Lower River | $0 | $0 | −$0.005 | $0 | −$0.284 | $0.010 |

a Flow action was fully implemented in 8 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action was partially implemented in 4 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

**Table 3-175. Years within Alternative 5 with Fall Release and Impacts in Proceeding Years**

| | |
|---|---|
| 1 | 1944: Negative impact in 1945 |
| 2 | 1948 |
| 3 | 1965 |
| 4 | 1969: Negative impact in 1970 |
| 5 | 1974: Negative impact in 1975 |
| 6 | 1983: Negative impact in 1984 |
| 7 | 1994 |

## Regional Economic Development

Under Alternative 5, average annual RED benefits supported by navigation would be 285 jobs and $19.3 million in labor income. Alternative 5 would result in negligible change in RED impacts compared to Alternative 1. Table 3-176 summarizes the RED impacts under Alternative 5. Overall, there would be a negligible change in RED impacts compared to Alternative 1 for the commercial sand dredging, truck transportation, and waterway industries and supporting sectors under Alternative 5.

**Table 3-176. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 5 and Compared to Alternative 1 (thousands of 2016$)**

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total Economic Loss |
|---|---|---|---|---|
| Change in Direct, Indirect, and Induced Jobs | Annual Average RED benefits | 258 | 27 | 285 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | 0 | 0 | 0 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | 0 | 0 | 0 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | 3 | 0 | 3 |
| Direct, Indirect, and Induced Labor Income | Annual Average RED benefits | $17,723 | $1,564 | $19,287 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | $30 | $3 | $33 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | $0 | $0 | $0 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $208 | $14 | $222 |
| Direct, Indirect, and Induced Sales | Annual Average RED benefits | $55,029 | $4,828 | $59,857 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | $94 | $10 | $103 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | $0 | $0 | $0 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $648 | $43 | $690 |

## Other Social Effects

Similar H&H profiles for Alternative 3 and Alternative 5 means the tonnage estimated to move off the water is the same for both alternatives so the OSE results summarized in Table 3-177 are the same for both alternatives. Both Alternative 3 and Alternative 5 would potentially shift 5.14 million tons off water to land which will result in average annual emissions of 0.2 thousand grams per mile of hydrocarbon, 6.2 thousand grams per mile of carbon monoxide, 18.0 thousand grams per mile of nitrogen oxide, and 0.4 thousand grams per mile of particulate matter. The pollutant with the greatest increase in emissions is nitrogen oxide which may react in the atmosphere to form ozone. Over 93 percent of the emissions will occur within the Kansas

City reach (RM 369 to RM 0) which contains the following counties which are designated as nonattainment areas for ozone: Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

**Table 3-177. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 3 and Alternative 5 by Reach**

| Reach | Total Commodities Move Off Water Over POR | Change in HC Over POR | Average Annual Change in HC | Change in CO Over POR | Average Annual Change in CO | Change in NOx Over POR | Average Annual Change in NOx | Change in PM Over POR | Average Annual Change in PM |
|---|---|---|---|---|---|---|---|---|---|
| | (1,000 tons) | (1,000 g/mile) | | | | | | | |
| Sioux City | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Omaha | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nebraska City | 339 | 0.9 | 0.0 | 30.4 | 0.4 | 89.1 | 1.2 | 2.2 | 0.0 |
| Kansas City | 4,801 | 12.6 | 0.2 | 431.1 | 5.7 | 1,262.4 | 16.8 | 30.5 | 0.4 |
| **TOTAL** | **5,140** | **13.5** | **0.2** | **461.5** | **6.2** | **1,351.4** | **18.0** | **32.7** | **0.4** |

CO = carbon monoxide; HC = hydrocarbon; NOx = nitrogen oxide; PM = particulate matter

### Conclusion

Alternative 5 would have a relatively small adverse impacts on navigation benefits compared to Alternative 1 because it could reduce the annual NED by $0.006 million, approximately 1 percent of annual NED benefits. The reduction in benefits is due to higher R, R, & R costs in comparison to Alternative 1. Modeling predicted no change in jobs and an increase of $33 K in labor income which is a negligible impact to RED. In comparison to Alternative 1, slightly less nitrogen oxide emissions would occur because less traffic is estimated to move off the water. Impacts to navigation under Alternative 5 are not anticipated to be significant because the overall impact is expected to be relatively small.

## 3.15.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

### Mechanical Habitat Construction

For early life stage pallid habitat, Alternative 6 will construct 3,380 additional acres with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, NE; 670 acres located between Rulo, NE and Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Generally, these actions involve physical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are assessed as not likely to impact navigation because each project will be designed to not impact other authorized purposes including navigation.

In years where construction is needed, Alternative 6 would construct 303 acres per year on average of ESH which involves mechanical excavation and placement of sand with typical large

construction equipment or hydraulic dredge. This will not occur in the navigable portion of the river, so no impacts to navigation.

### National Economic Development

Alternative 6 develops ESH habitat through mechanical means and a spawning cue flow that would be mimicked through bi-modal pulses that would occur in March and May. This analysis focuses on the impacts the bi-modal pulses would have on navigation.

The net NED results for Alternative 6 are summarized in Table 3-178. Relative to Alternative 1, Alternative 6 reduces transportation savings by $0.016 million and increases R, R, & R costs by $0.026 million. Over the POR, the difference between Alternative 6 and Alternative 1 in annual net NED varies between $0.12 million and −$0.599 million with an average of −$0.042 million which equates to a decrease of 5.82 percent.

**Table 3-178. Transportation Savings; R, R, & R costs, and Net NED for Alternative 6 (2016 $)**

| Costs | Alternative 6 Transportation Savings | Alternative 6 R, R, & R Costs | Alternative 6 Net NED value |
|---|---|---|---|
| Total That Occurred Over the POR (million $) | $94.15 | $42.95 | $51.2 |
| **Average Annual Value (million $)** | **$1.24** | **$0.57** | **$0.67** |
| Max Annual Over the POR (million $) | $1.46 | $1.22 | $1.45 |
| Min Annual Value Over the POR (million $) | $0.94 | $0 | $0.006 |
| Change from Alternative 1 (million $) | −$0.016 | $0.026 | −$0.042 |
| % Change from Alternative 1 | −1.275% | 4.75% | −5.82% |

*Numbers may not match exactly due to rounding

Table 3-179 presents the maximum and minimum differences in annual net NED value between Alternative 1 and Alternative 5 that occur under various flow scenarios. Some notable trends include the following:

- As noted in Table 3-180, Alternative 6 has 11 years with full releases and 33 years of partial releases.
- Of the eleven full releases implemented in Alternative 6, conditions of four years within the POR cause negative impacts. The worst adverse impacts from full release flow (−$0.599 million) occur under conditions similar to those simulated for 1981. Under the conditions simulated for this year, the full release would likely reduce the service level and shorten the navigation season. Since reducing the service level increases the R, R, & R costs and shortening the season reduces navigation benefits, the difference between Alternative 6 and Alternative 1 increases.
- Of the 33 years with partial release, nine conditions show an adverse difference from Alternative 1 (1950, 1951, 1960, 1969, 1978, 1980, 1994, 2010, and 2012), 22 show no difference from Alternative 1, and two show a slight beneficial difference from Alternative 1. The greatest adverse impacts from partial release (−$0.413 million) occur under conditions simulated for 1980, 1994, and 2012.

**Table 3-179. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release [a] (Million $) | | Partial Flow Release [b] (Million $) | | Years with Greatest Range in Impacts Regardless of Flow Actions (Million $) | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 | Highest Cost Change from Alternative 1 | Lowest Cost Change from Alternative 1 |
| Lower River | −$0.599 | $0.003 | −$0.413 | −$0.599 | $0.003 | −$0.413 |

a Flow action was fully implemented in 9 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action was partially implemented in 34 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

**Table 3-180. Years with Full or Partial Spawning Cue Releases in Alternative 6**

| Years With Full Release = 11 | Years With Partial Release = 33 |
|---|---|
| 1931 | 1943–1952 |
| 1953 | 1959–1961 |
| 1956 | 1969 |
| 1963 | 1973–1974 |
| 1966 | 1978–1980 |
| 1970 | 1984–1987 |
| 1975 | 1994–1999 |
| 1981 | 2009–2012 |
| 1988 | — |
| 2000 | — |
| 2003 | — |

## Regional Economic Development

Under Alternative 6, average annual RED benefits supported by navigation would be 281 jobs and $19.0 million in labor income. Spawning cue pulses under Alternative 6 would have a greater adverse RED impact on commercial sand dredging and navigation on the Missouri River when compared to Alternative 1. Under Alternative 6, the adverse conditions that would affect the ability to navigate and dredge commercial sand and gravel from the Missouri River over the period of analysis would result in an average annual reduction of 3 jobs and $219,000 in labor income associated with reduced ability to navigate. Table 3-181 summarizes the RED impacts under Alternative 6.

Shortened navigation seasons under Alternative 6 associated with reduced System storage as a result of spawning cue pulses would have an adverse impact on the commercial sand dredging industry, truck transportation, and waterway industries and supporting sectors. Under Alternative 6, the economic impacts in the eight worst years relative to Alternative 1 would result in an average reduction of 25 jobs and $1.7 million in labor income, with most of the impact

associated with commercial sand dredging and truck transportation. Impacts would be similar to those described under Alternative 2 with negligible impacts to regional economic conditions in the large economic context in which these activities take place but could be important to these industries. Because the need to source alternative sand would be greater under Alternative 6, there could potentially be relatively higher material costs for construction projects within Missouri and the region. There would be negligible impacts to waterway industries and supporting sectors, even in the years with the largest reductions in shipments compared to Alternative 1.

**Table 3-181. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 6 and Compared to Alternative 1 (thousands of 2016 $)**

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total RED Benefits |
|---|---|---|---|---|
| Change in Direct, Indirect, and Induced Jobs | Annual Average RED benefits | 255 | 26 | 281 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | –3 | 0 | –3 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | –23 | –2 | –25 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | 0 | 0 | 0 |
| Direct, Indirect, and Induced Labor Income | Annual Average RED benefits | $17,486 | $1,549 | $19,035 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | –$207 | –$12 | –$219 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | –$1,564 | –$105 | –$1,670 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $0 | $0 | $0 |

| Economic Impact Parameter | Year | Commercial Sand Dredging and Associated Transportation Impacts | Waterway Industries | Total RED Benefits |
|---|---|---|---|---|
| Direct, Indirect, and Induced Sales | Annual Average RED benefits | $54,294 | $4,782 | $59,075 |
| | Change in Annual Average RED Benefits Relative to Alternative 1 | –$642 | –$37 | –$679 |
| | Average Annual Change in 8 Worst Years Relative to Alternative 1 | –$4,857 | –$325 | –$5,182 |
| | Average Annual Change in 8 Best Years Relative to Alternative 1 | $0 | $0 | $0 |

### Other Social Effects

The OSE results for Alternative 6 are summarized in Table 3-182. Under Alternative 6, 9.9 million tons are estimated to move off the water which will result in average annual emissions of 0.3 thousand grams per mile of hydrocarbon, 11.9 thousand grams per mile of carbon monoxide, 34.8 thousand grams per mile of nitrogen oxide, and 0.8 thousand grams per mile of particulate matter. Over 87 percent of the emissions will occur within the Kansas City reach (RM 0 to RM 369) which contains the following counties which are designated as nonattainment areas for ozone: Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

**Table 3-182. Tonnage off the Water and Total and Annual Change in Emissions for Alternative 6 by Reach**

| Reach | Total Commodities Move Off Water Over POR | Change in HC Over POR | Average Annual Change in HC | Change in CO Over POR | Average Annual Change in CO | Change in NOx Over POR | Average Annual Change in NOx | Change in PM Over POR | Average Annual Change in PM |
|---|---|---|---|---|---|---|---|---|---|
| | (1,000 tons) | (1,000 g/mile) | | | | | | | |
| Sioux City | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Omaha | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nebraska City | 1,253 | 3.3 | 0.0 | 112.5 | 1.5 | 329.3 | 4.4 | 8.0 | 0.1 |
| Kansas City | 8,675 | 22.8 | 0.3 | 778.9 | 10.4 | 2,280.9 | 30.4 | 55.2 | 0.7 |
| **TOTAL** | **9,927** | **26.1** | **0.3** | **891.4** | **11.9** | **2,610.2** | **34.8** | **63.1** | **0.8** |

CO = carbon monoxide; HC = hydrocarbon; NOx = nitrogen oxide; PM = particulate matter

### Conclusion

Modeling indicates a relatively large adverse impact would occur to navigation under Alternative 6 by reducing annual NED by $0.042 million, approximately six percent of annual NED benefits.

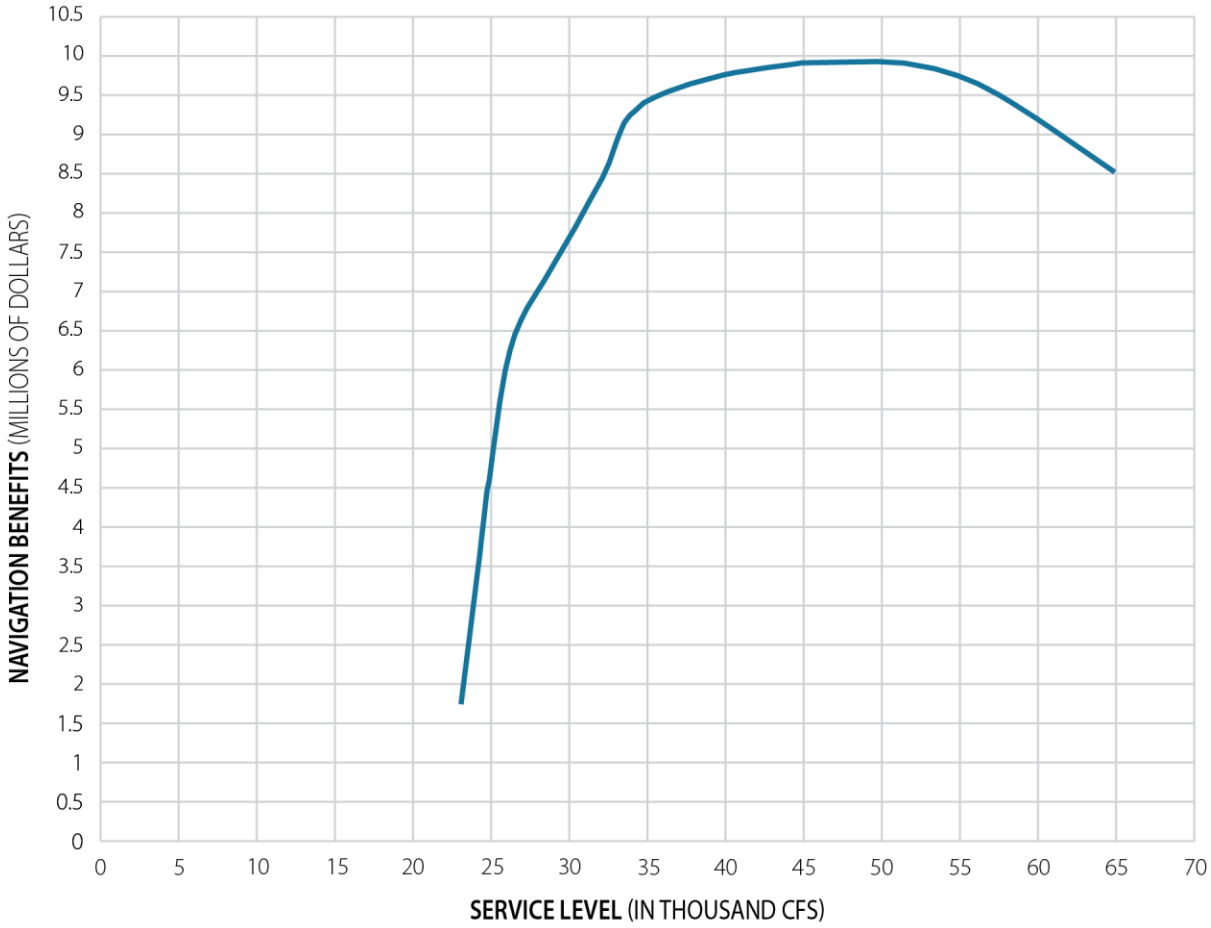
The reduction in benefits is due to higher R, R, & R costs in comparison to Alternative 1. Modeling also forecasted a decrease in average annual jobs of 3 and labor income of $312,000 compared to Alternative 1. Relatively large adverse effects to commercial sand dredging from shortened navigation seasons would occur in some years modeled, but there would be negligible impacts to regional economic conditions. In comparison to Alternative 1, large increases in nitrogen oxide are forecasted to occur, but no area in the region is classified as nonattainment for nitrogen oxide. Although the spawning cue releases would shorten navigation seasons and adversely affect navigation NED, RED and OSE under Alternative 6, the impacts would not be significant because the NED decrease in magnitude and percentage change is small; RED impacts would be negligible in the regional context; and air quality impacts for nitrogen oxide would not occur in non-attainment areas.

#### 3.15.2.10 Climate Change

The Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998) estimated the relationship between service level flows and navigation benefits as an ark. As shown in Figure 3-61, navigation benefits initially increase as the flow increases. However at a certain point, navigation benefits reach a maximum and start to decline. The decrease in benefits is due to higher costs waterway operators incur at higher flows. This relationship is important to keep in mind when considering the potential impacts to navigation benefits from climate change.

USACE climate change guidance and other sources anticipate the Missouri River Basin to have increased temperatures, precipitation, and stream flows. The increase in these climatic variables could lead to shifting of standard service level and movement of navigation benefits along the curve. 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 Draft, 4 May 2016), this section discusses a qualitative assessment of the effects to navigation for each alternative.

As shown in Table 3-183, the following six climate change variables are expected to have an impact on at least one of the alternatives: 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 flood and droughts.




Note: Estimated by the Master Manual Missouri river Review and Update Study in 1998.

**Figure 3-61. Relationship between Navigation Service Level Flows and Navigation Benefits**

**Table 3-183. Discussion of Risk to Navigation from Climate Change Variables for Alternatives 1–6**

| Variable | Alternative Impacted | Consequence from Variable | Impact to Risk for Navigation Benefits |
|---|---|---|---|
| Increased Air Temperature | 1, 2, 3, 4, 5, 6 | 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 navigation benefits. |
| Increased Precipitation and Streamflow | 1, 2, 4, 5, 6 | 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. | (+) Reduce risk of adverse impact to navigation benefits by increasing the supply of water to support navigation. |

| Variable | Alternative Impacted | Consequence from Variable | Impact to Risk for Navigation Benefits |
|---|---|---|---|
| Decreased Peak Snow Water Equivalent | 1, 2 | 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 SWE. Less accurate forecasts may result in an increased risk of overall System impacts (i.e., lower reservoir elevations, lower service level, etc.) due to setting pulse magnitude too high. | (–) Increase risk of adverse impact to navigation benefits by lowering service level. |
| Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration | 1, 2, 3, 4, 5, 6 | 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 2nd 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. | (–) Increase risk of adverse impact to navigation benefits in the short term by increasing the risk of lower service level in 2nd half of navigation season and in the long term by increasing the risk of a less reliable navigation system. |
| Increased Sedimentation | 1, 2, 4, 5, 6 | 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 navigation benefits by decreasing the supply of water available to support navigation. |
| Increased Irregularity of Floods and Droughts | 1, 2, 4, 5, 6 | 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 navigation benefits in the short term by increasing the risk of more frequent extreme events (droughts and floods) which suspend navigation and in long term by increasing the risk of a less reliable navigation system. |

For alternatives 1 and 2, increased air temperature was identified as not a risk to navigation benefits because it affects water quality which is not linked to navigation. One climatic change variable, increase in precipitation and stream flow, would reduce the risk to navigation benefits by increasing the supply of available water and allowing for greater flows. The remaining four climatic change variables would increase the risk of adverse impact to navigation benefits by reducing the System storage and availability of water for navigation flows or increasing the number of extreme weather events that would halt navigation for periods of time and reduce the overall reliability of the system.

#### 3.15.2.11 Cumulative Impacts

Past, present, and reasonably foreseeable future actions that impact navigation on the Missouri River include those listed below and are the same for all Alternatives (1–6), including: changes in the world economic market, such as shifting of grain prices; changes in the industrial profile of the Missouri River basin such as the growth of ethanol industry; changes to sand dredging allocations; changes in rail and highway transportation system within the Missouri River basin, such as increase in the capacity of railways and highways; and federal, state, and local efforts to encourage waterway transportation such as the U.S. Department of Transportation's America's Marine Highway Program and the Port Authority of Kansas City.

Impacts from implementation of Alternative 1 include the increased flow that would occur under the spawning cue pulses. Since the release only occurs over a short period, the benefits to navigation would be temporary and relatively small. Furthermore, benefits would only be experienced if shippers can take advantage of the increase in flow. However the timing of the release could adversely impact navigation if it resulted in a reduction of the service level. When combined with other past, present and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be beneficial in the long term, as navigation would be maintained through operations of the Missouri River. However, the contribution of Alternative 1 would be negligible.

Under Alternative 2, navigation could experience benefits associated with spring pulses, but adverse impacts from summer low flows. Adverse impacts could result in the reduction in navigation season length for years with low summer flow, and the potential reduction in service level provided that could occur in years with spawning cue pulse. When combined with other past, present and reasonably foreseeable future actions, the cumulative impacts on navigation associated with Alternative 2 would result in a relatively large reduction in navigation benefits. The contribution of Alternative 2 would be large and adverse attributed to the low summer flow and the spawning cue pulse. The majority of the relatively large, long-term adverse impacts would be caused by the low summer flow which would shorten the navigation season and prohibit navigation during important months of the year. While shippers may be able to plan around the low summer flow period, the reliability for the Missouri River would be reduced and shippers would begin to transition to other modes of transportation. Over time as more shippers switch to other transportation modes the overall navigation benefits on the Missouri River would be largely reduced.

Adverse impacts to navigation from Alternative 3 would be unlikely, as ESH would not be constructed in the lower river in the same area as the navigation channel (downstream of Ponca, Nebraska). Since Alternative 3 would not result in impacts to navigation, there would be no associated cumulative impacts.

The cumulative impacts on navigation associated with Alternatives 4, 5, and 6 would be similar to those described under Alternative 1. The contribution from Alternatives 4, 5, and 6 to those cumulative impacts described under Alternative 1 would be relatively small. Impacts to navigation from Alternative 4 would be slightly greater than under Alternative 1, as spring releases would only occur approximately every four years depending on System storage criteria. Impacts to navigation from Alternative 5 would likely only occur in years following fall releases where sufficient water is unavailable and the likelihood of this condition is low. Impacts to navigation from Alternative 6 would be relatively small and adverse compared to Alternative 1 as a result of the bimodal spawning cue flows.

# 3.16 Recreation

## 3.16.1 Affected Environment

The Missouri River corridor between Fort Peck Lake and St. Louis, Missouri, supports a wide range of water, land, and wildlife-related activities. Recreational opportunities, settings, and access to public facilities vary considerably along the river. For this analysis, the river was divided into three main geographic locations: mainstem reservoirs; inter-reservoir river reaches; and the lower river below Gavins Point Dam to the confluence with the Mississippi River.

The natural amenities and features of the Missouri River corridor are a popular destination for outdoor enthusiasts, attracting millions of visitors to the corridor each year. Recreational opportunities supported by the Missouri River corridor include a variety of land- and water-based activities. Water-based recreation includes shoreline fishing, boat fishing, power boating, waterskiing, tube towing, jet skiing, tubing, canoeing, kayaking, and swimming. Sport fishing (i.e., fishing for sport or recreation) is a prevalent activity in all locations along the Missouri River and its reservoirs, including cold water and cool water reservoir fishing for salmon and walleye; rainbow trout fishing along the river reaches of Montana; and warm water fishing for bass and catfish. Wetlands, sandbars, and shoreline along the river corridor serve as waterfowl habitat and support opportunities for waterfowl hunting and bird watching. Natural landscapes and viewscapes surrounding the reservoirs and inter-reservoir river reaches of the Missouri River also attract a large number of sightseers.

As visitors travel to and from recreation areas along the Missouri River, they spend money in local communities on food, gas, lodging, and other trip-related expenses. Visitors who live outside the river corridor stimulate economic activity and inject new money into local economies within the corridor, supporting jobs and income of residents.

### 3.16.1.1 Reservoirs

In 2012, the six mainstem reservoirs were estimated to support more than 5.4 million recreation visitor days[6] (Table 3-184). Recreational opportunities at these reservoirs range from primitive to more developed, providing the general public with access to facilities that enhance recreational experiences. Most recreational use of the lakes occurs during the spring, summer, and fall months, with Lakes Sakakawea and Oahe supporting considerably higher annual visitation than the other four reservoirs.

[6] Visits are defined as one person visiting the reservoir for a day or a number of days. Recreation visitor days is an estimate of the total number of person-days for all visits; visits are adjusted to account for certain types of visitors (i.e., campers) that recreate at a reservoir for multiple days to estimate recreational visitor days.

**Table 3-184. Annual Recreation Visitor Days on the Reservoirs, 2012**

| Reservoir | Winter Recreation Days | Spring, Summer, and Fall Recreation Days | Total Recreation Days |
|---|---|---|---|
| Fort Peck Lake | 58,540 | 539,527 | 598,067 |
| Lake Sakakawea | 83,292 | 1,319,417 | 1,402,709 |
| Lake Oahe | 199,617 | 1,316,289 | 1,515,906 |
| Lake Sharpe | 111,261 | 658,991 | 770,252 |
| Lake Francis Case | 8,076 | 151,891 | 159,967 |
| Lewis and Clark Lake | 105,282 | 894,325 | 999,607 |
| Total | 566,068 | 4,880,440 | 5,446,508 |

Source: USACE OMBIL 2012

Visitation to the reservoirs varies from year to year in response to environmental conditions and water elevations, which can affect fishing opportunities and access to shoreline facilities and boat ramps. Storage volumes and lake elevations in the upper three reservoirs (Fort Peck Lake, Lake Sakakawea, and Oahe Lake) fluctuate more than those of the three downstream reservoirs (Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake). Table 3-185 summarizes the visitation at the lakes during low, middle, and high water years between 2002 and 2012.

**Table 3-185. Average Annual Visitation on the Reservoirs during Low, Middle, and High Water Years**

| Mainstem Reservoir | Low Water Year | Middle Water Years | High Water Years |
|---|---|---|---|
| Fort Peck Dam and Lake | 236,372 | 307,110 | 396,333 |
| Lake Sakakawea | 866,188 | 1,031,992 | 982,612 |
| Lake Oahe | 746,111 | 939,335 | 1,032,676 |
| Lake Sharpe | 572,413 | 651,453 | 591,477 |
| Lake Francis Case | 120,196 | 159,113 | 148,548 |
| Lewis and Clark Lake | 687,532 | 705,894 | 694,589 |

Source: USACE OMBIL 2012

Notes: 2004, 2005, 2006, and 2007 are considered to be low water years (below 40 MAF in System storage); 2002, 2003, 2009, and 2012 are middle water years (between 40 and 60 MAF in System storage); and 2010 and 2011 are high water years (more than 60 MAF in System storage).

The USACE and state, county, and local government agencies manage the recreation facilities at the reservoirs. The quality and quantity of amenities varies across recreation sites and may include: interpretive centers, boat ramps, camp sites, swimming beaches, picnic areas, playgrounds, bathrooms and showers, handicap accessible facilities, electrical hookups and dump stations, grills, fish cleaning stations, and small bait or grocery stores. Public recreation facilities at each of the lakes are summarized in Table 3-186.

**Table 3-186. Recreation Facilities at Mainstem Reservoirs**

| Reservoir | USACE Sites | Ramps, Main (Low-water) | Marinas (Resorts) | Camping Areas (Primitive) | Swim Areas |
|---|---|---|---|---|---|
| Fort Peck Lake | 27 | 20 (8) | 4 (0) | 14 (3) | 5 |
| Lake Sakakawea | 183 | 67 (42) | 7 (1) | 38 (30) | 19 |
| Lake Oahe | 145 | 50 (5) | 3 (2) | 14 (14) | 9 |
| Lake Sharpe | 58 | 20 (0) | 1 (0) | 7 (8) | 6 |
| Lake Francis Case | 59 | 62 (0) | 2 (1) | 7 (0) | 8 |
| Lewis and Clark Lake | 59 | 26 (0) | 3 (0) | 14 (3) | 7 |

Sources For USACE reservoirs: USACE 2003, 2004, 2007, 2008, 2010; USACE Boating and Recreation Guides for each lake; Operation and Maintenance Business Information Link (OMBIL) data, which include USACE-owned areas and many areas for which the USACE transferred title under Title VI. Personal communications: Three Legs 2012; Rousseau 2012; Fletcher 2012; Wells 2012; LaPointe 2012; Little Swallow 2012; Magnan 2009; Persoon 2011; Schuckman 2009a; Shafer 2009

Reservoir visitors participate in a variety of land and water-based activities. Water-based activities that attract a large number of visitors to the reservoirs each year include boating, swimming, and waterskiing. Although most boating is associated with hook-and-line fishing, many visitors partake in pleasure boating and sailing during the warm summer months. Wind surfing, waterskiing, tubing, and jet skiing are also popular water-based activities, as is swimming and sunbathing along the shoreline or in designated swimming areas during the summer months.

Fish and wildlife-associated recreation are some of the most popular uses of the reservoirs. The reservoirs support both cool and cold-water fisheries and provide critical nesting and feeding habitat for upland birds and waterfowl. Several of the lake fisheries are recognized nationally and support competitive fishing events. Chinook salmon, walleye, catfish, bass, northern pike, sauger, crappie, trout, and yellow perch are the primary gamefish. Since wildlife is abundant in areas surrounding the lakes, opportunities exist for wildlife photographers and enthusiasts, birders, and upland game and waterfowl hunters. In addition, the diverse natural landscapes surrounding the six reservoirs attract a large number of sightseers each year.

Camping and picnicking are very popular activities at many of the recreation areas during the warmer months. More developed camping and picnicking facilities are available at many of the public and semi-private recreation sites. These areas are popular destinations for visitors making weekend trips or traveling with families. On summer weekends, especially holiday weekends, these campgrounds are often near capacity.

Recreational opportunities on these reservoirs attract thousands of visitors to local communities surrounding the lakes. Visitors coming from outside of the region stay in local gateway communities and spend their money on food, gas, lodging, and supplies. These expenditures stimulate economic activity and support jobs and income in these communities and counties. The residency of the visitors can affect the economic impact of spending on local economies; Table 3-187 summarizes recent data on the residency of visitors to the six mainstem lakes.

**Table 3-187. Residency of Visitors to the Reservoirs**

| Reservoir | Visitors from Counties Surrounding or Adjacent to Project Area | Non-local Visitors* |
|---|---|---|
| Fort Peck Lake | 8% | 92% |
| Lake Sakakawea | 22% | 78% |
| Lake Oahe | 30% | 70% |
| Lake Sharpe | 45% | 55% |
| Lake Francis Case | 21% | 79% |
| Lewis and Clark Lake | 57% | 43% |

Source: Longhenry pers. comm. 2016; Fryda pers. comm. 2016; USGS 2011; South Dakota Game Fish and Parks 2016.

Note *Non-local visitors include visitors from counties with population centers greater than 50 miles from the reservoir project area.

### 3.16.1.2 Inter-Reservoir River Reaches

The Missouri River System includes four free-flowing river segments between the dam and reservoir projects. Unlike the reservoir projects, the USACE does not administer most of the lands adjacent to the riverine reaches. Instead, the inter-reservoir river reaches pass through a variety of Tribal, state, municipal, and private lands. River access along these reaches is limited and usually restricted to designated access points at recreation sites. Partner agencies and local businesses manage most of the river accesses and recreational facilities within these reaches. Recreation specialists with USACE conducted an extensive effort to reach out to partner agencies, local organizations, and private businesses to collect data on recreational facilities and visitation to non-USACE-administered sites along the inter-reservoir river reaches. Information collected on facilities and annual visitation within the river reaches are summarized in Table 3-188 and Table 3-189.

Recreation opportunities and facilities within these riverine reaches differ from those at the reservoirs. Most recreation sites within the riverine reaches are “low density use” sites, with relatively low visitation and few facilities. However, some “intensive use” recreation sites also exist within the inter-reservoir river reaches. These areas tend to offer more amenities and support higher visitation. Low density and intensive use areas within the riverine reaches include interpretative centers, swimming beaches, boat ramps, and marinas.

Because the most comprehensive estimates for visitation across both USACE and non-USACE-administered sites were for 2009, 2009 annual visitation is presented to provide a more complete picture of river use in the inter-reservoir river reaches. Adjusting for multi-day campers who visit the river recreation areas for an average of 3.8 days per visit, the inter-reservoir river reaches were estimated to support more than 1.2 million recreational visitor days in 2009. Recreation days for each of the inter-reservoir river reaches are summarized in Table 3-190.

**Table 3-188. Recreation Facilities at Inter-Reservoir River Reaches**

| River Reaches | Recreation Sites | Boat Ramps | Marinas or Resorts | Camp Sites | Swim Areas |
|---|---|---|---|---|---|
| Fort Peck Dam to Lake Sakakawea | 19 | 14 | 0 | 121 | 4 |
| Garrison Dam to Lake Oahe | 22 | 20 | 2 | 489 | 2 |
| Oahe Dam to Lake Sharpe | 6 | 6 | 2 | 322 | 4 |
| Fort Randall Dam to Lewis and Clark Lake | 18 | 11 | 0 | 346 | 2 |

Sources: USACE 2003, 2004b, 2007, 2008, 2010; OMBIL data; Hesse et al. 1992, 1993; Sheriff et al. 2011; Missouri Department of Conservation 2012; Iowa Department of Natural Resources 2010a, 2010b, 2010c; North Dakota Game and Fish Department 2009); Nebraska Game and Parks Commission 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2010e; NPS 2003, 2009, 2010a, 2010b; and personal communications by telephone and email with various local, state, private land managers.

**Table 3-189. Average Annual Visits to Inter-Reservoir River Reaches**

| River Reaches | Average Annual Visits | Year(s) from which Visits Were Averaged |
|---|---|---|
| Fort Peck Dam to Lake Sakakawea | 178,000 | FY 1992–2010 |
| Garrison Dam to Lake Oahe | 588,000 | FY 1995–2010 |
| Oahe Dam to Lake Sharpe | 602,000 | FY 2006–2010 |
| Fort Randall Dam to Lewis and Clark Lake | 52,000 | FY 2002–2010 |

Sources: USACE 2003, 2004b, 2007, 2008, 2010; OMBIL data; Hesse et al. 1992, 1993; Iowa Department of Natural Resources 2010a, 2010b, 2010c; North Dakota Game and Fish Department 2009); Nebraska Game and Parks Commission 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2010e; NPS 2003, 2009, 2010a, 2010b; and personal communications by telephone and email between USACE and private, state, and local land managers.

**Table 3-190. Recreation Visitor Days in the Inter-Reservoir River Reaches, 2009**

| River Reaches | Winter Recreation Days | Spring, Summer, and Fall Recreation Days | Total Recreation Days |
|---|---|---|---|
| Fort Peck Dam to Lake Sakakawea | 21,683 | 284,783 | 306,466 |
| Garrison Dam to Lake Oahe | 24,228 | 170,829 | 195,057 |
| Oahe Dam to Lake Sharpe | 13,036 | 285,702 | 298,738 |
| Fort Randall Dam to Lewis and Clark Lake | 26,505 | 414,011 | 440,516 |
| Total Recreation Visitor Days | 85,452 | 1,155,325 | 1,240,777 |

Sources: USACE OMBIL 2012; Hess et al. 1992, 1993; Iowa Department of Natural Resources 2010a, 2010b, 2010c; North Dakota Game and Fish Department 2009); Nebraska Game and Parks Commission 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2010e; NPS 2003, 2009, 2010a, 2010b; and personal communications by telephone and email between USACE and private, state, and local land managers.

The inter-reservoir river reaches are very popular with hunters and anglers. River access points within the inter-reservoir reaches are used for launching boats for fishing, waterfowl hunting, pleasure boating, and other water-based recreational activities. These riverine reaches act as a staging area for migrating geese and ducks in the spring and fall, where they rest and forage before continuing their migration. Waterfowl hunters access these islands and shoreline by boats and from shore (USACE 2011). Northern pike, salmon, bullhead, sauger, bass, walleye, paddlefish, catfish, panfish, and trout are popular species harvested by both shore and boat anglers.

Recreational use of the river increases considerably near the Bismarck-Mandan area in the Garrison Dam to Lake Oahe reach, which has marinas, public boat access sites, and popular intensive use areas like the Kimball Bottoms Recreation Area (also known as the Desert). The overall concentration of marinas, private docks, and boat access in and around Bismarck is the greatest concentration of boating activity in any of the inter-reservoir river reaches. The river reach between Oahe Dam and the headwaters of Lake Sharpe includes the cities of Fort Pierre and Pierre in South Dakota. These relatively large population centers have a number of river developments, including the Fort Pierre and Pierre waterfronts, nature trail and bicycling trails, sand volleyball court, picnic areas, camping facilities, and an amphitheater.

The Fort Randall Dam to Lewis and Clark Lake river reach is un-channelized and relatively undeveloped, with only a small number of low-density recreation areas. The NPS administers a scenic water trail within this reach as part of the Missouri National Recreational River (MNRR).

#### 3.16.1.3 Lower River

The lower Missouri River includes 811 river miles downstream of Gavins Point Dam to the mouth of the Mississippi River just above St. Louis. Like the inter-reservoir river reaches, the lower river and floodplain are characterized by an extensive patchwork of natural landscapes that are a diverse mix of riverine, floodplain, prairie, wetland and forest habitats. Also, similar to the inter-reservoir river reaches, the lower river passes through a variety of Tribal, state, municipal, and private lands. Although USACE manages a few recreation sites and facilities within the lower portion of the river, much of the river access and recreational facilities are managed and maintained by partner agencies and local businesses whose livelihoods are closely tied to recreation on the river.

The lower mainstem can be divided into two distinct segments based on the types of engineering structures within each reach: the upper segment from Gavins Point Dam to Ponca, Nebraska, and the lower segment between Ponca, Nebraska, and the mouth of the Mississippi. The upstream segment between Gavins Point Dam and Ponca, Nebraska, is the only portion of the lower river not channelized or modified by dikes or revetments. This 59-mile portion of the river is designated as a National Recreational River under the Wild and Scenic Rivers Act and has retained a meandering natural channel with many chutes, backwater marshes, sandbars, islands, changing shorelines, and variable current velocities. The lower segment, between Ponca, Nebraska and the mouth of the Mississippi, was channelized under the BSNP and is used for commercial navigation.

Recreational settings and opportunities within the lower river are diverse and located much closer to larger population centers than those in the inter-reservoir river reaches. Approximately 75 percent of visitors to the lower river traveled fewer than 30 miles to get to their recreation destination along the river from their residence, and 95 percent of visitors were within 150 miles of their home (Sheriff et al. 2011).

Outreach to partner agencies and private businesses or organizations was conducted to collect data on recreational facilities and visitation to non-USACE-administered sites along the lower river. Information collected on facilities within the lower river reaches is summarized in Table 3-191.

The Missouri Department of Conservation and the Nebraska Game and Parks Commission, in cooperation with other state and federal partners, estimated public use of the Missouri River between Gavins Point Dam near Yankton, South Dakota, to the mouth of the river near St. Louis, Missouri (Sheriff et al. 2011). The Public Use Assessment collected information on the types and amount of public use, fish and wildlife harvested from the river, socio-demographic characteristics of users, and the economic value of the river to users over a 13-month period. According to their study, the lower river supported nearly 2.2 million visitors between January 2004 and January 2005. This estimate includes visitation to public accesses and recreation areas, private lands not generally accessible by the public, fishing tournaments, and excursion boats (Sheriff et al. 2011). Annual visits supported by each river segment are summarized in Table 3-192.

**Table 3-191. Recreation Facilities in the Lower River**

| River Reaches | Recreation Sites | Boat Ramps | Marinas or Resorts | Camp Sites | Swim Areas |
|---|---|---|---|---|---|
| Gavins Point Dam to Rulo, Nebraska | 71 | 65 | 12 | 1,445 | 12 |
| Rulo to the mouth of the Missouri River | 102 | 70 | 2 | 820 | 2 |

Sources: USACE 2004a; OMBIL data; Missouri Department of Conservation (MDC) 2011, 2012, 2012a; Missouri Department of Natural Resources 2010a, 2010b, 2010c, 2010d, 2010e, 2010f, 2010g, 2010h, 2010i, 2010j, 2010k, 2010l; and personal communications by telephone and email with between the USACE and federal, state, and local managing agencies.

**Table 3-192. Annual Visits to the Lower River, 2004**

| River Reaches | Annual Visits |
|---|---|
| Gavins Point Dam to Rulo, Nebraska* | 1,052,587 |
| Rulo, Nebraska to the mouth of the Missouri River | 1,146,940 |
| Total Lower River Visitation | 2,199,527 |

Source: Sheriff et al. 2011

*Visitation to this river segment was adjusted based on personal communication with Steve Sheriff (January 2016)

Recreation visitor days were estimated by adjusting for the average length of multi-day visits for campers. Most of the other types of visitors were day visitors (Sheriff et al. 2011). The lower river was estimated to support more than 2.4 million recreational days in 2004. Recreation days for the two lower river reaches are summarized in (Table 3-193).

**Table 3-193. Recreation Visitor Days in the Lower River, 2004**

| River Reaches | Winter Recreation Days | Spring, Summer, and Fall Recreation Days | Total Recreation Days |
|---|---|---|---|
| Gavins Point Dam to Rulo, NE | 183,121 | 1,030,415 | 1,213,535 |
| Rulo, Nebraska to the mouth of the Missouri River | 190,866 | 1,038,553 | 1,229,419 |

Source: Calculated with data from Sheriff et al. (2011) and USACE OMBIL databases 2012.

Collectively, the 59 river miles between Gavins Point Dam and Ponca, Nebraska, are designated as a national water trail and administered by the NPS as part of the MNRR. Popular water-based activities within the MNRR include canoeing, kayaking, tubing, and fishing; picnicking, hunting, bird watching, and camping. Outside of the MNRR, the lower river between Gavins Point Dam and Ponca, Nebraska is heavily used for land- and water-based recreation.

Waterfowl hunting is a popular activity in this river reach and typically occurs by boat, where hunters access islands and shorelines. In the fall, flows in the Missouri River below Gavins Point Dam are reduced and sandy islands become exposed, providing access for waterfowl hunters. In addition to providing critical habitat to numerous species, sandbars are popular recreational features in this part of the lower river (USACE 2011).

Fishing is a prevalent activity in the Gavins Point Dam tail waters. Main sport fish species caught in the tailrace are walleye, catfish, and paddlefish. Further downstream from the dam, anglers fish for catfish, walleye, carp, freshwater drum, buffalo, and smallmouth bass and crappie. Approximately 30 percent of angling in this upper part of the lower river is done from shore, while 70 percent is by boat (USACE 2011).

The lower river becomes channelized just below Ponca, Nebraska, through a series of stone wing dams and levees. Recreation in this part of the river tends to be relatively unaffected by drought as long as navigation season flows are maintained (USACE 2011). All or portions of the marina facilities are generally closed during the non-navigation season (generally November 21 through March 20) when river flows are low or iced over. Trail systems along the river have been developed in many municipal areas, including a non-motorized trail bridge between Omaha, Nebraska, and Council Bluffs, Iowa. Many visitors engage in camping, picnicking, sightseeing, observing wildlife, and outdoor photography.

The region surrounding the Missouri River between Rulo, Nebraska, and the mouth of the Mississippi River is heavily populated. The primary activities along this portion of the river are fishing and sightseeing; additional activities include boating, picnicking, hunting, and camping. The Katy Trail State Park is a hiking/bicycling trail that follows the floodplain on the north side of the Missouri River from St. Charles to Franklin, Missouri, before turning south, away from the Missouri River. Many cultural and historical resources are also located along this reach, including Fort Osage Park and five state historic sites. USFWS manages Squaw Creek NWR, which is located near Mound City, Missouri; and Big Muddy NWR, which was established one year after the Great Flood of 1993. State and local government agencies manage boat ramp access areas, which are relatively evenly spaced along the river. Below Rulo, Nebraska, approximately half of anglers fish by boat, while the other half fish from shore (Korman pers. comm. 2015; Niswonger pers. comm. 2016).

#### 3.16.1.4 Recreation Resources on Tribal Lands

There are 13 Native American Tribes, plus the Turtle Mountain Band of Chippewa Indians, who continue to live in rural areas along the mainstem of the Missouri River. While each of these Tribes has a unique history and heritage, Native American cultures can share land-based worldviews rooted in the active recognition of kinship with the natural world. Thus, culture and lifestyles on Tribal reservations do not always create a clear distinction between work, leisure, family, and spirituality. Some Tribal members participate in a number of outdoor activities along the mainstem of the Missouri River, including hunting, fishing, trapping, berry and mushroom picking, camping, hiking, swimming, and collecting medicinal plants. Although these activities at times may include a subsistence component, many Tribal members also view them as recreational experiences that provide personal enjoyment.

In addition to supporting recreational opportunities for Tribal members, many Tribes have begun to manage reservation lands for recreational use and enjoyment by non-Tribal members. Several Tribes along the Missouri River have developed public recreation areas to attract outdoor enthusiasts and visitors interested in learning about the heritage and culture of native Tribes. Many of these reservations are located in rural areas with outstanding opportunities for fishing and hunting. Although it is illegal for non-Tribal members to harvest plants or animals from reservation lands without Tribal consent, many Tribes have begun selling special hunting and fishing permits to non-Tribal members. Non-Tribal visitor spending and revenues from non-Tribal hunting and fishing permits help fund Tribal operations and support economic opportunities for those living on Tribal reservations.

A number of Tribes regularly hold pow-wows and recreation-related events along Lake Sakakawea and Lake Oahe. Some of these Tribal events are held on lands administered by USACE and leased in perpetuity by the Three Affiliated Tribes and South Dakota Game, Fish and Parks. Pow-wows and other Tribal events held along the river promote community empowerment and social cohesion, contribute to the spiritual and social well-being of Tribal members, and attract non-Tribal members interested in learning about Native American cultures and traditions. Many Tribal and non-Tribal visitors who attend these events (on or off USACE lands) often visit other recreational sites and use facilities at nearby USACE recreation areas (USACE 2010).

### 3.16.2 Environmental Consequences

The environmental consequences analysis for recreation focuses on how changes in the prevalence of habitat and river and reservoir conditions under the MRRMP-EIS alternatives could affect visitation, recreational opportunities, and the value of the recreational experiences. This section provides an overview of the recreation impact assessment methodology and presents the result of the assessment. A more detailed description of the methodology and results is provided in the “Recreation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

#### 3.16.2.1 Impact Assessment Methodology

Environmental consequences associated with recreation were evaluated using three of the four Principles and Guidelines accounts (NED, RED, and OSE). These accounts provide a framework for evaluating and displaying effects of management actions to ensure monetary and non-monetary values and interests expressed as important to stakeholders and Tribes are

considered, while ensuring impacts are not double-counted. The following section provides a brief overview of the methodology that was used to evaluate impacts reflected in each account.

River flows and reservoir elevations can fluctuate, causing changes in access to recreational resources and fishing opportunities. Changes in environmental conditions and the quantity and quality of recreational experiences along the Missouri River affect recreation benefits to users and costs associated with maintaining recreation access. The analysis of impacts on recreation used outputs from the HEC-RAS and HEC-ResSim Missouri River models to simulate river and reservoir operations over an 82-year POR under each of the MRRMP-EIS alternatives. These modeled simulations were then used to determine boat ramp operability and reservoir elevations under the alternatives.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

**National Economic Development**

Contributions to the NED account reflect net benefits that accrue in the planning area and the rest of the nation from recreation opportunities along the Missouri River. These benefits are measured using a Unit Day Value (UDV) approach (U.S. Water Resources Council 1983; USACE ER 1105-2-100 Appendix E; USACE Economic Guidance Memorandum (EGM) 06-03) and reflect the maximum amount individuals are willing to pay to engage in recreation activities on the Missouri River, rather than forego them (Walsh 1986). The UDV method of estimating willingness to pay relies on expert and informed opinion to assign relative values to recreation days based on the quality of recreational opportunities supported by individual recreation areas.

In the inter-reservoir and lower river reaches and the lower three reservoirs, boat ramp operability, as estimated from modeled river and reservoir elevations, was used to assess recreational access and visitation at these locations. A statistical process was used to estimate the best variables in predicting visitation at the upper three reservoirs. As a result, mid-August lake elevations and the price of gas were determined to be the greatest influential factors to predict visitation and were used to estimate visitation at each of the upper three reservoirs. The UDV ratings were obtained from the USACE Rec-BEST database and applied to the visitation to estimate recreation NED benefits. The UDV ratings were adjusted to reflect higher values associated with ESH and early life stage habitat for pallid sturgeon.

Potential capital costs to extend and/or replace low-water boat ramps and maintain recreational access at the upper three reservoirs during severe low-water conditions were assessed based on the drought of the 2000s. In addition, operational costs to maintain access to boat ramps were also evaluated when reservoir elevations decrease in subsequent summers. Natural resource managers at the lakes provided information on which the capital and operations and maintenance costs were developed. The recreation NED benefits reflect UDV benefits of visitation (including habitat) less the capital and operating costs and were evaluated based on a POR analysis.

### Regional Economic Development

The RED analysis estimates the direct, indirect, and induced effects to local regions as measured through jobs, labor income, and sales. The recreation RED analysis assesses how changes in visitation under the MRRMP-EIS alternatives, as estimated in the NED analysis, would affect non-local visitor spending and associated impacts on regional economic conditions. Because results from the NED analysis showed that visitation to Lake Sharpe would be unaffected by actions under the MRRMP-EIS alternatives, Lake Sharpe was not evaluated in the RED analysis. The inter-reservoir river reaches and lower river segments were also excluded from the RED analysis because these river reaches primarily wind through private lands where public access is limited, and previous reports indicate that visitation is primarily by residents who live nearby (USACE 2006a; USACE 2011; Sheriff et al. 2011). As a result, the RED analysis assesses economic impacts of non-local visitor spending in regional and state economies surrounding five of the six mainstem reservoirs. These economic impacts were estimated using the USACE-certified RED model, RECONS.

### Other Social Effects

OSE associated with recreation include contributions to individual and community well-being and quality of life; these considerations are evaluated qualitatively based on the results from the recreation NED and RED analyses.

### 3.16.2.2 Summary of Environmental Consequences

Table 3-194 provides a summary of the impacts under the MRRMP-EIS alternatives. The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

**Table 3-194. Summary of Environmental Consequences for Recreation**

| Alternative | NED | RED | OSE | Other Impacts |
|---|---|---|---|---|
| Management Actions Common to All Alternatives | No NED impacts. | No RED impacts. | No OSE impacts. | Short-term, small adverse impacts on recreation from human restriction measures |
| Alternative 1 | Average annual benefits of $38.3 million, with average annual benefits ranging from $22.4 to $48.3 million<br>Large and long-term benefits; variations in the natural hydrological cycles during drought years cause the largest decreases in benefits over the POR | 1,235 jobs and $29.2 million in labor income on average over the POR<br>Jobs would range from 636 to 1,582 and labor income from $13.4 million to $33.4 million over the period of analysis | Continued development of habitat areas would support quality of life and educational amenities for residents<br>Both adverse and beneficial impacts on OSE associated with RED changes, including impacts on well-being, security, standard of income, health and comfort, and the ability to pay for healthcare services at the upper three reservoirs | Small, localized, temporary, adverse impacts from mechanical habitat construction |
| Alternative 2 | Annual average reduction of $163,000 or 0.4 percent compared to Alternative 1<br>Relatively large, adverse impacts in the upper three reservoirs following spawning cue releases during relatively drier periods. Negligible impacts on the lower three reservoirs. Relatively small benefits in the inter-reservoir reaches and lower river from habitat construction and spawning cue releases. | Average annual change in recreation benefits: 14 fewer jobs and $335,000 less in labor income<br>Negligible RED impacts in the regional context but impacts could be large and adverse on tourism businesses in some years in the upper three reservoirs | Relatively higher social benefits to recreation from additional SWH areas<br>There could be relatively small to large, adverse OSE impacts at the upper three reservoirs in years following spawning cue releases during relatively drier conditions from reduced RED benefits during these years | Potentially large, temporary to long-term, adverse impacts from large quantities of ESH construction in the upper river (includes the reservoirs and inter-reservoir river reaches) |
| Alternative 3 | Annual average increase of $23,000 or 0.1 percent compared to Alternative 1<br>The change compared to Alternative 1 would be negligible across all locations | Average annual change in recreation benefits: minimal to no change in employment and $17,000 more in labor income; negligible change in RED benefits in all locations | Similar social benefits to recreation from IRC and ESH areas as Alternative 1; OSE impacts from changes in RED benefits would be the same as those described under Alternative 1 | Similar to Alternative 1, although greater impacts from ESH construction in the Fort Randall reach and relatively smaller construction impacts from fewer acres of IRC habitat in the lower river |

| Alternative | NED | RED | OSE | Other Impacts |
|---|---|---|---|---|
| Alternative 4 | Annual average reduction of $407,000 or 1.1 percent compared to Alternative 1<br>Under some years and conditions, large adverse impacts to recreation benefits in the upper three reservoirs following spring releases during relatively drier periods; negligible impacts to the lower three reservoirs, inter-reservoir reaches, and lower river | Average annual change in recreation benefits: 21 fewer jobs and $514,000 less in labor income<br>Negligible RED impacts in regional context but impacts on tourism businesses could be large and adverse in some years in the upper three reservoirs | Relatively higher social benefits to recreation from IRC and ESH areas<br>Relatively small to large adverse OSE impacts at the upper three reservoirs in years following spring releases during relatively drier conditions from reduced RED benefits during these years | Same as Alternative 3 |
| Alternative 5 | Annual average reduction of $28,000 or 0.1 percent<br>Large, adverse impacts on recreation in the upper three reservoirs following fall releases; negligible impacts on recreation in the lower three reservoirs and inter-reservoir river reaches; small benefits to recreation in the lower river associated with relatively more habitat construction and spawning cue releases | Average annual change in recreation benefits: 3 fewer job and $68,000 less in labor income<br>Small to negligible impacts on recreation RED benefits because of the small change in visitation, even in the years following fall releases | Relatively higher social benefits to recreation from IRC and ESH areas<br>OSE impacts from changes in RED benefits would be the same as those described under Alternative 1 | Same as Alternative 3 |
| Alternative 6 | Annual average reduction of $143,000 or 0.4 percent compared to Alternative 1<br>Large, adverse impacts in some years in the upper three reservoirs following spawning cue releases; negligible impacts on the lower three reservoirs, inter-reservoir river reaches, and lower river | Average annual change in recreation benefits: 15 fewer jobs and $354,000 less in labor income<br>Negligible RED impacts in regional context but could be large and adverse to tourism businesses in some years in the upper three reservoirs | Relatively higher social benefits to recreation from IRC and ESH areas<br>There could be relatively small to large adverse OSE impacts at the upper three reservoirs in years following spring releases during relatively drier conditions from reduced RED benefits during these years | Same as Alternative 3 |

### 3.16.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include vegetation management, predator management, and human restriction measures. These actions have the potential to affect recreation opportunities and experiences along the Missouri River. Human restriction measures during the tern and plover nesting season include restricting public access to sandbars with known nests and posting signs to prevent disturbance by people and pets. Although sandbar use would be prohibited during nesting season, birdwatchers who view wildlife from boats or the shore would still benefit from these areas while access is prohibited. Outside the nesting season, the construction and maintenance of additional sandbars should enhance recreational experiences on the Missouri River because these areas would provide additional opportunities for low-density recreation. Impacts on recreation from human restriction measures would be short term and adverse for some types of visitors; impacts on recreation associated with vegetation management and predator management are anticipated to be negligible.

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

Alternative 1 would include a spring plenary pulse, the construction of ESH habitat in the Garrison and Gavins Point Dam river reaches, and the construction of SWH for the pallid sturgeon in the lower river below Ponca, Nebraska. Management actions under this alternative would provide considerable recreation benefits to visitors and residents who live along the Missouri River. Recreation benefits would vary based on the natural hydrologic cycles, generally with higher river flows and reservoir elevations supporting higher visitation.

#### Mechanical Habitat Construction

The construction of ESH and SWH under Alternative 1 would result in short-term, small to large, adverse impacts from construction-related noise, vibration, and fugitive emissions; temporary localized deterioration in water quality; temporary decreased visual aesthetics; and temporary access limitations during the construction period. Project construction and equipment at habitat sites could impede access to hunting, fishing, and wildlife viewing sites, and the noise and vibrations may deter wildlife and recreationists from using areas near habitat construction sites. These impacts would be temporary, occurring only during the fall construction period in years when construction would occur. These impacts would be highly localized affecting only those visitors or recreation areas adjacent to project sites.

Over the long term, increased prevalence of ESH and SWH would benefit species diversity and abundance along the Missouri River, provide additional primitive areas for recreation outside of nesting season, and enhance the topography and visual aesthetics of the river where projects occur. These enhancements would improve environmental aesthetics, resulting in higher UDVs for recreational experiences in these areas of the river. The increased value of the recreational experience associated with the prevalence of habitat is monetized in the NED evaluation, described below.

#### National Economic Development

Under Alternative 1, average annual recreation NED benefits would be $38.2 million, over half of which would be attributable to the upper three reservoirs (Table 3-195). The upper three reservoirs would have the largest variation in NED benefits, ranging from $9.9 million in a severe low-water year to $24.8 million in higher water years. On annual average, the upper

three reservoirs would support $19.9 million in recreation NED benefits. The lower three reservoirs have relatively stable pool levels, and Alternative 1 would result in average annual NED benefits of nearly $9.5 million from these reservoirs.

Average annual recreation NED benefits supported by the inter-reservoir river reaches would be $1.4 million, and habitat-related benefits would account for less than 1 percent of total NED benefit in the inter-reservoir river reaches. Average annual NED benefits in the lower river would be $7.4 million, ranging between $2.6 and $12.1 million in low and high visitation years based on fluctuations in the natural hydrologic cycles that affect accessibility of boat ramps. The prevalence of ESH and SWH would account for less than 1 percent of recreation NED benefits in the lower river. In addition, some visitors prefer lower river flows, such as those using paddle craft or swimming, because lower flows offer additional shoreline and sandbars amenities and/or perceptions of safer conditions. During the spawning cue releases in March and May, visitors who may prefer lower river flows could experience adverse impacts. Peak summer visitation would not be affected under the spawning cue releases. Changes in NED benefits associated with these types of visitors have not been quantified.

The NED evaluation also assesses costs associated with maintaining accessibility of boat ramps and other recreation facilities when the upper three reservoir elevations experience severe low-water conditions for consecutive years. Results from reservoir simulations show that these Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs associated with extending and/or replacing current ramps, providing infrastructure and road access to low boat ramp locations, and maintaining access to boat ramps when reservoir elevations fall in consecutive summers would be approximately $3.3 million under Alternative 1.

Overall, recreation NED benefits supported by the Missouri River under Alternative 1 would be large and long term, providing local residents and non-local visitors with considerable recreational opportunities. The largest decreases in the recreation NED benefits under Alternative 1 would occur on the upper three reservoirs when access to the lakes and fishing opportunities are directly affected by lower lake elevations during the natural cycles of drought or relatively drier periods.

**Table 3-195. Summary of National Economic Development Analysis for Alternative 1, 1932–2012 (thousands of 2016 dollars)**

| Benefits or Costs | Upper Three Reservoirs | Lower Three Reservoirs | Inter-Reservoir River Reaches | Lower River | All Locations |
|---|---|---|---|---|---|
| Total Visitation* Benefits | $1,616,598 | $766,761 | $115,920 | $599,248 | $3,098,527 |
| Total Habitat Benefits | NA | NA | $157 | $4,527 | $4,684 |
| OMRR&R Costs | $3,259 | NA | NA | NA | $3,259 |
| **Total NED Benefits** | **$1,613,339** | **$766,761** | **$116,076** | **$603,775** | **$3,099,952** |
| Annual Average NED Benefits | $19,918 | $9,466 | $1,433 | $7,454 | $38,271 |
| Maximum Annual NED Benefits | $24,823 | $9,834 | $1,544 | $12,080 | $48,281 |
| Minimum Annual NED Benefits | $9,886 | $9,032 | $1,027 | $2,616 | $22,561 |

* Total Visitation includes lake elevation and non-lake elevation affected visits at the reservoirs and boat accessed and non-boat accessed visits in the river reaches and lower river. For more details, refer to the "Recreation Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

### Regional Economic Development

Reservoir conditions can adversely affect visitation, which in turn can affect the amount of visitor spending in local economies. Non-local visitor spending injects new money into local economies, stimulating sales (i.e., economic output), jobs, and income in local businesses. Table 3-196 summarizes the economic contributions of non-local visitor spending under Alternative 1. On average, spending by these non-local visitors supports 1,235 jobs and $29.2 million under Alternative 1. These contributions vary between 636 and 1,582 jobs and $13.4 and $33.4 million in labor income across all five reservoirs during low and high visitation years. In the highest visitation year, the upper three reservoirs were shown to support approximately 1,280 total jobs and $26.9 million labor income, while in the worst drought conditions in the lowest visitation year, the non-local visitor spending was estimated to support 427 jobs and $8.9 million in labor income.

The economic contributions of non-local visitor spending to communities surrounding these lakes would be large and beneficial in the context of their relatively small rural economies. When lake elevations are lower because of drought conditions, limited boat access and reduced fishing opportunities would considerably reduce economic activity in these local economies as non-local visitation falls. Declines in non-local visitation and recreation-related spending during drought or drier periods would have large, adverse impacts on regional economic conditions in the local economies surrounding the lakes.

**Table 3-196. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 1 (thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Upper Three Reservoirs[a] | Lake Francis Case and Lewis and Clark Lake[a] | Total |
|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Lowest visitation year | 427 | 209 | 636 |
| | Highest visitation year | 1,280 | 302 | 1,582 |
| | Average | 973 | 262 | 1,235 |
| Direct, Indirect, and Induced Labor Income | Lowest visitation year | $8,973 | $4,469 | $13,442 |
| | Highest visitation year | $26,995 | $6,438 | $33,432 |
| | Average | $22,958 | $6,226 | $29,184 |
| Direct, Indirect, and Induced Sales | Lowest visitation year | $28,834 | $14,351 | $43,185 |
| | Highest visitation year | $86,886 | $20,596 | $107,483 |
| | Average | $73,915 | $19,911 | $93,826 |

Note: The lowest visitation year and highest visitation years are not necessarily the same year at each reservoir. The analysis used the annual visitation at each of the upper three reservoirs and the lower two reservoirs to estimate the RED figures.

a As described in Section 3.1, the HEC-ResSim modeling results indicate that lake elevations at Lewis and Clark Lake would fluctuate more than would occur during the real-time management of these reservoirs. Therefore, these impacts, which are based on boat ramp-operability, reflect adverse impacts that would likely not occur.

### Other Social Effects

OSE associated with recreation include factors such as individual and community well-being and quality of life. Management actions under Alternative 1 include the continued construction of ESH and SWH along river reaches in the upper and lower river. Once construction, this habitat would provide some social benefits from viewscapes with more varied landscape topography and benefits from public accessibility and more diverse and abundant wildlife-related recreational opportunities. These attributes may increase social benefits derived from recreation along the river, including promoting a sense of place and quality of life enjoyed by individuals and communities.

Local communities, especially those located near the reservoirs, rely on non-local fishing, boating, camping, and other recreational opportunities that attract tourism spending to support economic opportunities for local residents within these relatively small economies. Changes in non-local visitation would not only affect regional economic conditions in these communities, but could also affect individual and community well-being and quality of life. Conditions that support higher visitation may affect traffic congestion and wait times at restaurants and other local businesses, but may also provide individuals and families with more income to support additional activities, vacations, and a relatively higher standard of living. Reduced income during lower visitation years could have adverse effects on individuals, families, and communities, potentially increasing the level of poverty and reducing the standard of living. With reduced income and higher levels of poverty, adverse social impacts could occur, such as reduced well-being, security, health, and comfort. Because the largest variation in visitation occurs at the upper three reservoirs, impacts to OSE would be both adverse and beneficial impacts from the changes in RED benefits associated with relatively higher water year supporting higher visitation

and drier conditions supporting fewer visitors to these reservoirs associated with the natural hydrological cycles.

**Conclusion**

Under Alternative 1, the Missouri River and its reservoirs would continue to provide a variety of recreational opportunities that would support large NED, RED, and OSE benefits on average, over the long term. Variation in recreation NED, RED, and OSE benefits would occur in some locations from natural variations in the hydrologic cycle. Generally, higher river flows and stages and reservoir elevations (but not flooding) would support greater access and improved fishing opportunities. The lower three reservoirs and inter-reservoir reaches would experience negligible variations in recreation NED, RED, and OSE benefits because of the relatively stable reservoir and river elevations and stages that would maintain access and recreational opportunities under Alternative 1. The lower river would experience variations in recreation NED benefits from natural cycles of drought and flooding that affect boat ramp operability and access to recreational areas, although changes in recreation RED as a result of these natural variations would be negligible over the period of analysis because changes in non-local visitation would be minimal. Small increases in recreation NED and OSE benefits would occur from enhanced recreational experiences through the construction of ESH and SWH. The upper three reservoirs would have the greatest variation in recreation NED, RED, and OSE benefits, with the largest decreases occurring on the upper three reservoirs when access to the lakes and fishing opportunities are adversely affected by lower lake elevations during drought or relatively drier periods. During the worst visitation year attributable to drought conditions, 427 fewer jobs would be supported across these three reservoirs from non-local visitor spending compared to average annual jobs of 973. Although these decreases in recreation NED, RED, and OSE benefits would be small in the regional context of all county economies surrounding the lakes, they would be relatively large in gateway communities whose economies may rely on reservoir tourism and outdoor recreation. Impacts on recreation from habitat construction would be temporary, highly localized, and small to large, depending on the proximity of the habitat site to the recreation activity.

Alternative 1 would not have significant adverse impacts on recreation because the Missouri River and its reservoirs would continue to provide a variety of recreational opportunities that would support NED, RED, and OSE benefits annually, over the long term; higher river flows and stages and reservoir elevations would support greater access and improved fishing opportunities; temporary adverse impacts from habitat construction would be highly localized; and large and long-term benefits would occur.

### 3.16.2.5 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 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 SWH and ESH than under Alternative 1.

Under Alternative 2, recreation NED, RED, and OSE benefits would be reduced in the years when spawning cue releases are followed by relatively drier years, when lake elevations at the upper three reservoirs are lower than those under Alternative 1. Impacts on recreation benefits in the lower three reservoir reaches would be negligible, while impacts on recreation in the inter-reservoir and lower river from increased prevalence of habitat and spring pallid sturgeon flow

releases would be small and beneficial. Habitat construction under Alternative 2 would result in temporary and possibly long-term, small to large, adverse impacts on recreation. Recreation impacts are further described in the following sections.

**Mechanical Habitat Construction**

Compared to Alternative 1, considerably more ESH construction would occur in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches, as well as more SWH construction between Ponca, Nebraska, and the mouth of the river near St. Louis. Mechanical habitat construction would result in localized, adverse impacts and would occur at a greater number of sites within these river reaches compared to Alternative 1. Localized, adverse impacts associated with habitat construction would be temporary and similar to those described under Alternative 1 (i.e., noise, closures, water quality degradation, aesthetics) but would be more prevalent across these reaches because considerably more habitat would be constructed under this alternative. The large amount of habitat constructed under Alternative 2 may also affect river geomorphology over time, which could adversely affect recreational infrastructure and facilities and recreational opportunities in the future. Similar to Alternative 1, increased prevalence of ESH and SWH under Alternative 2 would benefit species diversity and abundance along the Missouri River, provide additional primitive areas for recreation outside of nesting season, and enhance the topography and visual aesthetics of the river; these benefits would be more pronounced with more habitat constructed. The increased value of the recreational experience associated with the prevalence of habitat under Alternative 2 is monetized in the NED evaluation and described below. Habitat construction under Alternative 2 would result in temporary and possibly long-term, small to large, adverse impacts and long-term, small, beneficial impacts on recreation when compared to Alternative 1.

**National Economic Development**

Under Alternative 2, average annual NED benefits would be $38.4 million, a small annual increase of $163,000 on average compared to Alternative 1 (Table 3-197). The upper three reservoirs would experience the largest variation in NED benefits under Alternative 2, and average annual NED benefits would decrease by 1.3 percent or approximately $262,000 relative to Alternative 1. Declines in average annual NED benefits at the upper three reservoirs would be driven by the lower reservoir elevations in the years following the spawning cue releases during periods of low precipitation or relatively drier conditions. Management actions under Alternative 2 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits at the lower three reservoirs under this alternative because these reservoirs are managed as flow-through reservoirs with relatively stable elevations.

Management actions under Alternative 2 would have long-term, small, and beneficial impacts on recreation NED benefits in the inter-reservoir river reaches compared to Alternative 1, leading to an average annual increase in recreation NED benefits of $49,000 (3.4 percent). The majority of impacts on recreation in the inter-reservoir river reaches under Alternative 2 would be attributable to higher value recreational experiences in the Garrison Dam to Lake Oahe and Fort Randall Dam to Lewis and Clark River reaches from the extensive construction of ESH. Under Alternative 2, total habitat-related NED benefits in the inter-reservoir river reaches over the POR would increase to approximately $2.3 million from $157,000.

Compared to Alternative 1, average annual NED benefits in the lower river would increase by $378,000, or 5 percent, as a result of management actions under Alternative 2. The increase in recreation NED benefits would primarily be driven by greater prevalence of ESH and SWH in

the lower river, resulting in relatively small and beneficial impacts on recreation compared to Alternative 1. In addition, visitors who prefer lower river flows in the lower river may experience adverse impacts during spawning cue releases, although this alternative would not affect peak summer visitation. The NED benefits for these types of visitors have not been monetized.

OMRR&R costs associated with the upper three reservoirs would be higher under Alternative 2, increasing by $529,000 compared to OMRR&R costs under Alternative 1 because spawning cue releases under Alternative 2 could reduce lake elevations in the years after release events during periods of relatively low precipitation. As a result, OMRR&R costs associated with low-water recreation infrastructure would increase to maintain reservoir access during these relatively drier periods. OMRR&R costs under Alternative 2 would have small to large, adverse impacts relative to Alternative 1 depending on the timing and location of capital investments.

**Table 3-197. Summary of National Economic Development Analysis for Alternative 2, 1932–2012 (thousands of 2016 dollars)**

| Benefits or Costs | Upper Three Reservoirs | Lower Three Reservoirs | Inter-Reservoir River Reaches | Lower River | All Locations |
|---|---|---|---|---|---|
| Total Visitation Benefits | $1,595,887 | $766,588 | $117,809 | $616,549 | $3,096,833 |
| Total Habitat Benefits | NA | NA | $2,261 | $17,862 | $20,123 |
| OMRR&R Costs | $3,788 | NA | NA | NA | $3,788 |
| **Total NED Benefits** | **$1,592,099** | **$766,588** | **$120,070** | **$634,411** | **$3,113,168** |
| Total Change in NED Benefits from Alternative 1 | −$21,240 | −$173 | $3,993 | $30,636 | $13,216 |
| Percent Change from Alternative 1 | −1.3% | 0.0% | 3.4% | 5.1% | 0.4% |
| Annual Average NED Benefits | $19,656 | $9,464 | $1,482 | $7,832 | $38,434 |
| Change in Annual Average NED Benefits | −$262 | −$2 | $49 | $378 | $163 |

Additional results of flow actions are summarized in Table 3-198. These results show the difference in annual recreation NED benefits during years when there would be a release action or a low summer flow. Results from the simulations show both beneficial and adverse impacts on recreation in the upper river (includes the reservoirs and inter-reservoir river reaches) during full and partial flow releases. In the lower river, relatively more SWH areas and full and partial spawning cues under Alternative 2 would result in increased recreation NED benefits.

Adverse impacts at the upper three reservoirs under Alternative 2 would occur during relatively drier periods in the years following a spawning cue release. Because these releases would draw down reservoir elevations farther than what would occur under Alternative 1, they would exacerbate drought conditions and may have large, adverse impacts on NED benefits in years following a release. The largest, adverse impacts would occur at Lake Oahe, where management actions under Alternative 2 would reduce recreational access and fishing opportunities, resulting in a decrease of up to $1 million (approximately 14 percent) in recreation

NED benefits relative to Alternative 1. As drought conditions are alleviated with typical rainfall and snowpack, System storage would be replenished, and adverse NED impacts at the upper three reservoirs would be reduced.

**Table 3-198. Changes in NED Benefits from Flow Releases under Alternative 2 Compared to Alternative 1 (thousands of 2016 dollars)**

| Location | Full Flow Release + Low Summer Flow [a] | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change |
| Lower River | $37 | $678 | −$1,004 | $953 | −$1,004 | $953 |
| Upper River[c] | −$1,770 | $833 | −$1,644 | $721 | −$2,039 | $833 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represent the lowest and highest dollar impacts in the years the action was implemented. Negative benefits are reductions in benefits from Alternative 1.

b Flow action was partially implemented in 43 years of the period of analysis. Data represent the lowest and highest dollar impacts in the years the action was partially implemented. Negative benefits are reductions in benefits from Alternative 1.

c The upper river includes the reservoirs and the inter-reservoir river reaches.

### Regional Economic Development

Under Alternative 2, non-local visitor spending associated with the reservoirs would support sales in local businesses, 1,221 jobs, and $28.8 million in labor income on annual average. Most of these economic contributions would occur in counties surrounding and adjacent to the upper three reservoirs. Compared to Alternative 1, Alternative 2 would have greater adverse impacts on recreation RED benefits, supported by the upper three reservoirs, and would support 14 fewer jobs and $335,000 less in labor income on annual average (Table 3-199).

Management actions under Alternative 2 would cause visitation to the reservoirs to fall during the relatively drier periods that follow a spawning cue release, when reservoir elevations are lower than under Alternative 1. Reduced non-local visitation would result in adverse impacts on recreation RED benefits at the upper three reservoirs while these conditions persist. Lake Oahe would experience the largest adverse impacts on economic conditions during these relatively drier periods. During the 8 lowest visitation years relative to Alternative 1, average annual RED benefits supported by the upper three reservoirs would be reduced by 79 jobs and $1.9 million in labor income under Alternative 2. Although the decrease in employment represents less than 0.1 percent of regional employment (across all counties surrounding the upper three reservoirs), local employment opportunities associated with non-local visitor spending can be important to the tourism industries that support the recreation activities and visitation at these lakes, resulting in large and adverse impacts for specific industries and small communities that support these recreation activities. As drier conditions are alleviated with typical rainfall and snowpack, System storage would be replenished, and annual average changes in RED benefits would become small to negligible when compared to those under Alternative 1.

Impacts on regional economic conditions surrounding Lake Francis Case and Lewis and Clark Lake would be relatively small because pool elevations would remain relatively stable, providing recreational access and visitation at these lakes even during drier conditions.

**Table 3-199. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 2 Relative to Alternative 1 (Thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Upper Three Reservoirs | Lake Francis Case and Lewis and Clark Lake[a] | Total Economic Impacts[b] |
|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Average annual over 82 years | 959 | 262 | 1,221 |
| | Change in annual average over 82 years relative to Alternative 1 | −14 | 0 | −14 |
| | Annual average during 8 lowest visitation years relative to Alternative 1 | −79 | −24 | −103 |
| | Annual average during 8 highest visitation years relative to Alternative 1 | 27 | 21 | 47 |
| Direct, Indirect, and Induced Labor Income | Annual average over 82 years | $22,623 | $6,226 | $28,850 |
| | Change in annual average over 82 years relative to Alternative 1 | −$335 | $0 | −$335 |
| | Annual average during 8 lowest visitation years relative to Alternative 1 | −$1,935 | −$562 | −$2,497 |
| | Annual average during 8 highest visitation years relative to Alternative 1 | $642 | $500 | $1,142 |
| Direct, Indirect, and Induced Sales | Annual Average over 82 years | $72,830 | $19,914 | $92,744 |
| | Change in average annual average over 82 years relative to Alternative 1 | −$1,085 | $3 | −$1,082 |
| | Annual average during 8 lowest visitation years relative to Alternative 1 | −$6,256 | −$1,800 | −$8,056 |
| | Annual average during 8 highest visitation years relative to Alternative 1 | $2,080 | $1,610 | $3,690 |

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis used the annual visitation from each of the upper three reservoirs and the lower two reservoirs to facilitate the estimates.

a As described in Section 3.1, the HEC-ResSim modeling results indicate that lake elevations at Lewis and Clark Lake would fluctuate more than would occur during the real-time management of these reservoirs. Therefore, these impacts, which are based on boat ramp-operability, reflect adverse impacts that would likely not occur.

b Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

### Other Social Effects

OSE associated with recreation include factors such as individual and community well-being and quality of life. Alternative 2 would include extensive construction of ESH and SWH along many of the river reaches, with target habitat acres at the end of the implementation period substantially higher than under Alternative 1. The greater prevalence of SWH and ESH, and diversity and abundance of wildlife and aquatic life it supports, would have benefits for residents

who live near and recreate on the river, improving the quality of life and providing educational opportunities that connect residents to the natural environment. These beneficial impacts associated with recreation opportunities enjoyed by local residents would be higher under Alternative 2 compared to Alternative 1.

Changes in regional economic conditions as a result of adverse RED impacts under Alternative 2 would also affect individual and community well-being and quality of life. The small to large, adverse RED impacts in the counties surrounding the upper three reservoirs in drier years following a spawning cue release under Alternative 2 would affect social conditions. Impacts would be similar to those described under Alternative 1 but could result in small to large, adverse impacts on OSE depending on the magnitude of the regional effect on local businesses and the size of the gateway communities affected. In general, these adverse impacts relative to Alternative 1 would be temporary and subside as System storage is replenished with normal rainfall and snowmelt conditions, restoring recreation access and opportunities.

**Conclusion**

Under Alternative 2, the increases in recreation NED benefits for all locations would be small compared to Alternative 1 (0.4 percent). Because considerable ESH and SWH would be constructed in the inter-reservoir and lower river reaches, there would be small increases in recreation NED and OSE benefits compared to Alternative 1 (3 to 5 percent), and negligible impacts on recreation RED benefits. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs. The upper three reservoirs would experience small adverse impacts on average (−1.3 percent). However, in specific years under certain conditions, decreases in recreation NED, RED, and OSE benefits under Alternative 2 compared to Alternative 1 would be temporary, large, and adverse. The spawning cue release could exacerbate reductions in reservoir elevations in the years following the release during a relatively drier period. Under these unique conditions, non-local visitation at the upper three reservoirs would support 79 fewer jobs across the region compared to Alternative 1. Although these adverse impacts would be negligible in the context of the larger regional economy, changes in economic activity and opportunities could be large for tourism industries in affected gateway communities. Habitat construction would have temporary, possibly long-term, small to large, adverse impacts on recreation from closures, noise, and other disturbances during construction activities because more habitat would be constructed under Alternative 2.

Alternative 2 would not have significant impacts on recreation because increases in recreation NED would be small on average annually for all locations and changes in RED and OSE benefits would be negligible in the regional context. Large adverse impacts to recreation NED, RED, and OSE benefits in specific years would occur from reductions in visitation and habitat construction, which would be temporary and localized.

### 3.16.2.6 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 spawning cue release that would occur under Alternative 1 would not occur under Alternative 3. Overall, actions under Alternative 3 would result in negligible changes in recreation NED, RED, and OSE benefits in most locations when compared to Alternative 1 because river flows and reservoirs elevations would experience minimal changes.

### Mechanical Habitat Construction

Relative to Alternative 1, more acres of ESH would be mechanically constructed in the Garrison, Fort Randall, and Gavins Point river reaches under Alternative 3. However, fewer acres of habitat to support early life stage requirements would be constructed between Ponca, Nebraska, and the mouth of the river compared to Alternative 1 because habitat construction for the pallid sturgeon under Alternative 3 would focus on functional IRCs. Compared to Alternative 1, localized, adverse construction-related impacts would occur at a greater number of sites in the river reaches where ESH would be constructed, and at fewer sites below Ponca, Nebraska. The localized, adverse impacts would be temporary and small, with impacts similar to those described under Alternative 1 (i.e., noise, closures, water quality degradation, aesthetics). Similar to Alternative 1, early life stage habitat for the pallid sturgeon and ESH for the piping plover and least tern under Alternative 3 would benefit species diversity and abundance and enhance recreational experiences along the Missouri River. The increased value of the recreational experiences associated with the prevalence of habitat under Alternative 3 is monetized in the NED evaluation and described below.

### National Economic Development

Under Alternative 3, average annual NED benefits would be $38.2 million, an annual increase of $23,000 on average compared to Alternative 1 (Table 3-200). The largest impacts on recreation NED benefits would occur in the upper three reservoirs, where recreation benefits would be slightly higher as a result of small increases in reservoir access and visitation in the absence of the spring plenary pulse under Alternative 1. On annual average, changes in recreation NED benefits in the upper three reservoirs would be negligible, increasing by approximately $31,000 relative to Alternative 1. Management actions under Alternative 3 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits at the lower three reservoirs because these reservoirs have relatively stable elevations.

Relative to Alternative 1, average annual recreation NED benefits in inter-reservoir reaches would increase slightly, driven by the greater prevalence of ESH under Alternative 3. Average annual recreation NED benefits in the lower river would be approximately $7.4 million, a negligible change from Alternative 1. Recreation NED benefits over the POR associated with habitat construction in the lower river would be negligible compared to Alternative 1, with fewer acres of early life stage habitat and a greater number of acres of ESH. Alternative 3 would result in $4.0 million in total habitat benefits over the POR, approximately $600,000 less than under Alternative 1. Visitors in the river reaches who prefer lower river flows, such as those using paddle craft or swimming, would have negligible changes under Alternative 3 compared to Alternative 1 because changes in river flows would be negligible.

The OMRR&R costs at the upper three reservoirs would be slightly lower under Alternative 3 ($3.2 million) compared to Alternative 1 ($3.3 million) as a result of relatively higher reservoir elevations during drought conditions because the spring plenary pulse would not occur. Relative to Alternative 1, impacts would be negligible.

**Table 3-200. Summary of National Economic Development Analysis for Alternative 3, 1932–2012 (thousands of 2016 dollars)**

| Benefits or Costs | Upper Three Reservoirs | Lower Three Reservoirs | Inter-Reservoir River Reaches | Lower River | All Locations |
|---|---|---|---|---|---|
| Total Visitation Benefits (Lake-Affected or Boat-Accessed Recreation) | $1,619,101 | $765,630 | $116,149 | $599,885 | $3,100,765 |
| Total Habitat Benefits | NA | NA | $349 | $3,973 | $4,322 |
| OMRR&R Costs | $3,235 | NA | NA | NA | $3,235 |
| **Total NED Benefits** | **$1,615,866** | **$765,630** | **$116,497** | **$603,858** | **$3,101,852** |
| Total Change in NED Benefits from Alternative 1 | $2,527 | −$1,131 | $421 | $83 | $1,901 |
| Percent Change from Alternative 1 | 0.2% | −0.1% | 0.4% | 0.0% | 0.1% |
| Annual Average NED Benefits | $19,949 | $9,452 | $1,438 | $7,455 | $38,294 |
| Change in Annual Average NED Benefits | $31 | −$14 | $5 | $1 | $23 |

## Regional Economic Development

Under Alternative 3, non-local visitor spending associated with recreation on the five reservoirs would support 1,236 jobs and $29.2 million in labor income on annual average. On annual average, recreation at the mainstem reservoirs would support approximately the same number of jobs and labor income regionally as under Alternative 1. Even in the 8 lowest visitation years compared to Alternative 1, impacts on regional economic conditions would be negligible. The recreation RED benefits supported under Alternative 3 and anticipated changes relative to Alternative 1 are summarized in Table 3-201.

**Table 3-201. Economic Benefits of Non-Local Visitor Spending at the Three Reservoirs under Alternative 3 (thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Upper Three Reservoirs | Lake Francis Case and Lewis and Clark Lake[a] | Total Economic Impacts[b] |
|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Average annual over 82 years | 975 | 261 | 1,236 |
| | Change in annual average over 82 years relative to Alternative 1 | 2 | −1 | 1 |
| | Annual average during 8 lowest visitation years relative to Alternative 1 | −5 | −15 | −21 |
| | Annual average during 8 highest visitation years relative to Alternative 1 | 10 | 14 | 25 |

| Economic Impact Parameter | Year | Upper Three Reservoirs | Lake Francis Case and Lewis and Clark Lake[a] | Total Economic Impacts[b] |
|---|---|---|---|---|
| Direct, Indirect, and Induced Labor Income | Annual average over 82 years | $22,996 | $6,205 | $29,201 |
| | Change in annual average over 82 years relative to Alternative 1 | $38 | −$22 | $17 |
| | Annual average during 8 lowest visitation years relative to Alternative 1 | −$128 | −$365 | −$492 |
| | Annual average during 8 highest visitation years relative to Alternative 1 | $243 | $341 | $584 |
| Direct, Indirect, and Induced Sales | Annual average over 82 years | $74,039 | $19,842 | $93,881 |
| | Change in average annual average over 82 years relative to Alternative 1 | $124 | −$70 | $55 |
| | Annual average during 8 lowest visitation years relative to Alternative 1 | −$411 | −$1,174 | −$1,586 |
| | Annual average during 8 highest visitation years relative to Alternative 1 | $782 | $1,100 | $1,882 |

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis used the annual visitation from each of the upper three reservoirs and the lower two reservoirs to facilitate the estimates.

a As described in Section 3.1, the HEC-ResSim modeling results indicate that lake elevations at Lewis and Clark Lake would fluctuate more than would occur during the real-time management of these reservoirs. Therefore, these impacts, which are based on boat ramp-operability, reflect adverse impacts that would likely not occur.

b Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

### Other Social Effects

Recreation OSE associated with the construction of early life stage habitat for the pallid sturgeon and ESH under Alternative 3 would benefit quality of life and individual well-being, and impacts would be similar to those described under Alternative 1. Since RED impacts are negligible under Alternative 3 compared to Alternative 1, recreation RED impacts that support individual and community well-being, quality of life in rural communities, and standard of living would be the same as those described under Alternative 1.

### Conclusion

Alternative 3 would result in negligible changes in NED, RED, and OSE benefits across all locations compared to Alternative 1 (0.1 percent). Although additional acres of ESH would be constructed in the inter-reservoir and lower river reaches, changes in recreation NED, RED, and OSE benefits compared to Alternative 1 would be negligible because of the relatively small change in habitat prevalence and river stages, and flows would not noticeably affect recreational access. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because the fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs. In the upper three reservoirs, recreation NED benefits would be slightly higher as a result of small increases to reservoir access and visitation in the absence of the spring plenary pulse under Alternative 1 (0.2 percent), although the impacts on recreation NED, RED, and OSE benefits would be negligible.

Habitat construction would have temporary and localized, small to large, adverse impacts on recreation from closures, noise, and other disturbances during construction activities.

Alternative 3 would not have significant adverse impacts on recreation because changes in NED, RED, and OSE benefits across all locations would be negligible compared to Alternative 1 and adverse impacts from habitat construction would be temporary and localized.

#### 3.16.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 would include spring releases from Gavins Point Dam and Garrison Dam and mechanical construction of ESH and habitat to support early life stage requirements of the pallid sturgeon to achieve habitat targets. Alternative 4 would result in small, adverse impacts on recreation, driven by decreased visitation at the upper three reservoirs during certain conditions in years following the spring release. Impacts on recreation benefits in the lower three reservoirs, inter-reservoir river reaches, and lower river would be negligible. Recreation impacts are further described in the following sections.

**Mechanical Habitat Construction**

Similar to Alternative 3, management actions under Alternative 4 would include the construction of more ESH in the Garrison, Fort Randall, and Gavins Point river reaches compared to Alternative 1. Efforts to create habitat to support the support early life stage requirements of the pallid sturgeon under Alternative 4 would focus on functional IRC areas and include fewer acres of habitat between Ponca, Nebraska and the mouth of the river near St. Louis. Impacts of habitat construction would be similar to those described under Alternative 1—temporary and localized, small to large, and adverse, depending on the proximity of the construction to the recreational activity. Similar to Alternative 1, early life stage habitat for the pallid sturgeon and ESH for the piping plover and least tern under Alternative 4 would benefit species diversity and abundance and enhance recreational experiences along the Missouri River. The increased value of the recreational experiences associated with the prevalence of habitat under Alternative 4 is monetized in the NED evaluation and described below.

**National Economic Development**

Under Alternative 4, average annual NED benefits would be $37.8 million, a decrease of $407,000 on average compared to Alternative 1 (Table 3-202). The upper three reservoirs would have the largest variation in NED benefits, with average annual NED benefits decreasing by approximately $413,000, approximately 2.1 percent, relative to those under Alternative 1. Decreases in average annual NED benefits supported by the upper three reservoirs would occur in the years following the spring releases when relatively low precipitation or snowmelt conditions occur and the reservoir elevations as simulated under Alternative 4 are lower than those under Alternative 1. Management actions under Alternative 4 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits in the lower three reservoirs because these reservoirs maintain relatively stable elevations, providing consistent recreational access and opportunities.

Relative to Alternative 1, average annual recreational NED benefits in inter-reservoir reaches would increase slightly. This change, however, would be negligible since river stages and boat ramp operability would not noticeably change. Impacts associated with ESH construction under Alternative 4 would increase habitat-related benefits over the POR in the inter-reservoir river

reaches by approximately $96,000, but would still account for less than one percent of recreation NED benefits.

Average annual recreation NED benefits in the lower river would be $7.4 million under Alternative 4, with average NED benefits increasing by $7,000 relative to Alternative 1. Impacts to recreation NED benefits in the lower river would be beneficial and adverse compared to Alternative 1 and would be attributable to changes in boat ramp operability and the construction of ESH and IRC habitat, with negligible changes on average compared to Alternative 1. Habitat-related recreation benefits would account for less than 1 percent of total recreation NED benefits in the lower river and would be slightly lower than those under Alternative 1. In addition, visitors in the lower river that prefer lower river flows, such as those using paddle craft or swimming, would experience some adverse impacts during the spring releases and negligible changes at other times under Alternative 4.

OMRR&R costs at the upper three reservoirs would be approximately $600,000 higher under Alternative 4 than under Alternative 1 because the spring release would draw down reservoir elevations further than under Alternative 1 during relatively drier periods. As a result, there would be additional capital investments and operating costs needed to extend or replace low water boat ramps, with relatively small to large adverse impacts depending on the timing and location of investments.

Additional results of flow actions are summarized in Table 3-203. These results show the difference in annual recreation NED benefits during years when there would be a release action. The results show that adverse impacts would occur in the years following a full spring release when the upper reservoirs would be lower than under Alternative 1. In contrast, recreation benefits in the lower river would be highest during full spring release actions when boat ramp operability would be improved under Alternative 4 relative to Alternative 1 providing additional access for visitors.

There would be both beneficial and adverse impacts to recreation during full and partial flow releases, with reductions in annual benefits outweighing increases in benefits across the period of analysis. The reduction in recreation NED benefits at the upper three reservoirs would occur in a period when under Alternative 1, the visitation and associated recreation NED benefits would already be quite low due to drought or relatively drier conditions. Annual recreation NED benefits at Lake Oahe and Lake Sakakawea would decrease by just over $1 million and $760,000, respectively, during the worst-case year simulated under Alternative 4. As drought conditions are alleviated with typical rainfall and snowpack, System storage would be replenished and adverse NED impacts at the upper three reservoirs would be reduced. As a result, there would be relatively large and temporary adverse impacts during drier conditions following flow releases.

**Table 3-202. Summary of National Economic Development Analysis for Alternative 4, 1932–2012 (thousands of 2016 dollars)**

| Benefits or Costs | Upper Three Reservoirs | Lower Three Reservoirs | Inter-Reservoir River Reaches | Lower River | All Locations |
|---|---|---|---|---|---|
| Total Visitation Benefits (Lake-Affected or Boat-Accessed Recreation) | $1,583,768 | $766,835 | $115,686 | $600,511 | $3,066,801 |
| Total Habitat Benefits | NA | NA | $253 | $3,804 | $4,057 |
| OMRR&R Costs | $3,904 | NA | NA | NA | $3,904 |
| **Total NED Benefits** | **$1,579,864** | **$766,835** | **$115,939** | **$604,315** | **$3,066,953** |
| Total Change in NED Benefits from Alternative 1 | −$33,475 | $74 | −$138 | $540 | −$32,998 |
| Percent Change from Alternative 1 | −2.1% | 0.0% | −0.1% | 0.1% | −1.1% |
| Annual Average NED Benefits | $19,504 | $9,467 | $1,431 | $7,461 | $37,864 |
| Change in Annual Average NED Benefits | −$413 | $1 | −$2 | $7 | −$407 |

**Table 3-203. Changes in NED Benefits from Flow Releases under Alternative 4 Compared to Alternative 1 (thousands of 2016 dollars)**

| | Full Flow Release [a] | | Year After Full Flow Release | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|---|---|
| | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change |
| Lower River | $298 | $1,450 | −$279 | −$72 | −$530 | $185 | −$530 | $1,450 |
| Upper River[c] | −$926 | $145 | −$2,057 | −$108 | −$816 | −$89 | −$2,057 | $361 |

a Flow action was fully implemented in 10 years of the period of analysis. Data represents the lowest and highest change in benefits in the years the action was implemented. Negative benefits represent a decrease in benefits relative to Alternative 1.

b Flow action was partially implemented in 6 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative benefits represent a decrease in benefits relative to Alternative 1.

c The upper river includes the reservoirs and the inter-reservoir river reaches.

### Regional Economic Development

Under Alternative 4, non-local visitor spending associated with recreation on the five reservoirs would support 1,214 jobs and $28.6 million in labor income on annual average. Compared to Alternative 1, Alternative 4 would have greater adverse impacts to recreation RED benefits, supporting 21 fewer jobs and $514,000 less in labor income on average (Table 3-204).

Similar to the NED analysis, the largest changes in recreation RED benefits relative to Alternative 1 would occur in the upper three reservoirs in the years following a spring release. During the 8 worst years relative to Alternative 1, average annual RED benefits in the upper three reservoirs would decrease by 82 jobs and nearly $2.0 million in labor income compared to RED benefits under Alternative 1, with Lake Oahe experiencing the largest adverse impacts. Similar to Alternative 2, adverse recreation RED impacts would be small in context of the broader regional economy, but could be locally large and adverse to the tourism industries and communities most affected by decreases in non-local visitation. As System storage is replenished with typical rainfall and snowpack, reservoir elevations would increase and changes in RED benefits would become small to negligible when compared to those under Alternative 1.

Impacts to regional economic conditions surrounding Lake Francis Case and Lewis and Clark Lake would be negligible to small because pool elevations remain relatively stable, providing recreational access and visitation even during drier conditions.

**Table 3-204. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 4 Relative to Alternative 1 (Thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Upper Three Reservoirs | Lake Francis Case and Lewis and Clark Lake[a] | Total Economic Impacts[b] |
|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Average Annual over 82 Years | 952 | 262 | 1,214 |
| | Change in Annual Average over 82 Years Relative to Alternative 1 | −21 | 0 | −21 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −82 | −16 | −98 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | 8 | 15 | 23 |
| Direct, Indirect, and Induced Labor Income | Annual Average over 82 Years | $22,443 | $6,228 | $28,670 |
| | Change in Annual Average over 82 Years Relative to Alternative 1 | −$515 | $2 | −$514 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −$1,970 | −$381 | −$2,351 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | $190 | $352 | $541 |

| Economic Impact Parameter | Year | Upper Three Reservoirs | Lake Francis Case and Lewis and Clark Lake[a] | Total Economic Impacts[b] |
|---|---|---|---|---|
| Direct, Indirect, and Induced Sales | Annual Average over 82 Years | $72,248 | $19,917 | $92,165 |
| | Change in Average Annual Average over 82 Years Relative to Alternative 1 | −$1,667 | $5 | −$1,661 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −$6,367 | −$1,223 | −$7,590 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | $614 | $1,128 | $1,742 |

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis used the annual visitation from each of the upper three reservoirs and the lower two reservoirs to facilitate the estimates.

a described in Section 3.1, the HEC-ResSim modeling results indicate that lake elevations at Lewis and Clark Lake would fluctuate more than would occur during the real-time management of these reservoirs. Therefore, these impacts, which are based on boat ramp-operability, reflect adverse impacts that would likely not occur.

b Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

### Other Social Effects

Recreation OSE associated with IRC and ESH under Alternative 4 would be very similar to those described under Alternative 3. The small to large adverse RED impacts in the counties surrounding the upper three reservoirs in years following a spring release during relatively drier conditions under Alternative 4 would have adverse impacts on OSE benefits. Impacts would be similar to those described under Alternative 1 but would result in small to large adverse impacts to OSE benefits depending on the magnitude of the local effect and the size of the gateway communities affected. In general, these adverse impacts relative to Alternative 1 would be temporary and subside as System storage is replenished with normal rainfall and snowmelt conditions, restoring recreation access and opportunities.

### Conclusion

Under Alternative 4, there would be small decreases in recreation NED benefits across all locations compared to Alternative 1 (−1.1 percent). Although additional acres of ESH would be constructed in the inter-reservoir and lower river reaches, there would be negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because of the relatively small change in habitat prevalence and river stages and flows would not have a noticeable affect recreational access. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs. Similar to Alternative 2, the upper three reservoirs would experience small adverse impacts on average (−2.1 percent). However, in some years following the spring release under relatively drier climactic conditions, decreases in recreation NED, RED, and OSE benefits under Alternative 4 would be temporary, large and adverse compared to those under Alternative 1 and would persist until precipitation and snowmelt returned to normal conditions. Under these unique

conditions, non-local visitation at the upper three reservoirs would support on average 82 fewer jobs across the region compared to Alternative 1. Although these adverse impacts would be negligible in the context of the larger regional economy, changes in economic activity and opportunities could be large for tourism industries in affected gateway communities. Habitat construction would have temporary and localized, small to large, adverse impacts to recreation from closures, noise, and other disturbances during construction activities.

Alternative 4 would not have significant adverse impacts to recreation because changes in recreation NED, RED, and OSE would be small and adverse to negligible on annual average compared to Alternative 1. Large adverse impacts in specific years in recreation NED, RED, and OSE would occur from reductions in visitation and habitat construction, which would be temporary and localized.

#### 3.16.2.8 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. There would be small temporary adverse impacts to recreation NED benefits in the years following fall releases in the upper three reservoirs and small benefits to recreation benefits in the lower river. There would be negligible impacts to recreation benefits relative to Alternative 1 in the lower three reservoirs and inter-reservoir river reaches. Habitat construction would result in temporary, small to large adverse impacts to recreation. These impacts are further described in this section.

**Mechanical Habitat Construction**

Similar to Alternatives 3 and 4, target acres for habitat construction under Alternative 5 are higher for ESH and lower for habitat to support the early life stage requirements of the pallid sturgeon compared to Alternative 1. Impacts would be very similar to those described under Alternative 3, with temporary, small to large adverse impacts to recreation. The long-term benefits associated with the prevalence of habitat are monetized and described in the following “National Economic Development” section.

**National Economic Development**

Under Alternative 5, average annual recreation NED benefits would be reduced by $28,000, a decrease of approximately 0.1 percent compared to Alternative 1 (Table 3-205). Recreation NED benefits would decrease by nearly $55,000 relative Alternative 1. The upper three reservoirs would be lower than under Alternative 1 in the year following a fall release, with adverse impacts to recreation NED benefits under these conditions. Impacts of fall releases under Alternative 5 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits at the lower three reservoirs because reservoir elevations in these flow-through reservoirs would remain relatively stable.

In the inter-reservoir river reaches, Alternative 5 would result in negligible change in benefits of 0.1 percent. Even in the biggest difference years, changes in recreation NED benefits would be very small. Although the construction of ESH in the Garrison and Fort Randall river reaches would generate nearly twice as many recreation NED benefits as under Alternative 1, the habitat benefits would be a very small part of recreation NED benefits in the inter-reservoir river reaches.

Alternative 5 would result in an increase of $30,000 in average annual recreation NED benefits in the lower river, a 0.5 percent increase relative to Alternative 1, with small increases in recreation NED benefits. Benefits under Alternative 5 would occur from higher amount of ESH and fall releases increase recreational access. In addition, visitors in the lower river that prefer lower river flows, such as those using paddle craft or swimming, would experience some adverse impacts during the fall releases and negligible changes at other times under Alternative 5.

The OMRR&R costs at the upper three reservoirs would be relatively the same as those under Alternative 1. There would be slightly lower reservoir elevations in years following a fall release which would increase OMRR&R costs by an estimated $40,000 relative to those under Alternative 1.

**Table 3-205. Summary of National Economic Development Analysis for Alternative 5, 1932–2012 (thousands of 2016 dollars) Benefits or Costs**

| | Upper Three Reservoirs | Lower Three Reservoirs | Inter-Reservoir River Reaches | Lower River | All Locations |
|---|---|---|---|---|---|
| Total Visitation Benefits (Lake-Affected or Boat-Accessed Recreation) | $1,612,184 | $766,395 | $115,944 | $602,380 | $3,096,902 |
| Total Habitat Benefits | NA | NA | $300 | $3,810 | $4,110 |
| OMRR&R Costs | $3,298 | NA | NA | NA | $3,298 |
| Total NED Benefits | $1,608,885 | $766,395 | $116,244 | $606,190 | $3,097,714 |
| Total Change in NED Benefits from Alternative 1 | −$4,454 | −$366 | $168 | $2,415 | −$2,237 |
| Percent Change from Alternative 1 | −0.3% | −0.0% | 0.1% | 0.4% | −0.1% |
| Annual Average NED Benefits | $19,863 | $9,462 | $1,435 | $7,484 | $38,243 |
| Change in Annual Average NED Benefits | −$55 | −$5 | $2 | $30 | −$28 |

Impacts by flow type for Alternative 5 relative to Alternative 1 are summarized in Table 3-206. These results show the difference in annual benefits during years when there would be full or partial release action or in the years after a full release. Adverse impacts would occur in the year following a full fall release when the lake elevations at the upper three reservoirs would be lower than under Alternative 1. In contrast, recreation NED benefits in the lower river would be highest during full fall release actions when boat ramp operability would be improved under Alternative 5 relative to Alternative 1.

At Lake Sakakawea and Lake Oahe, in the years following a fall release, the reservoirs could be drawn down up to 5 feet lower than conditions under Alternative 1, causing impacts to recreational access and decreased fishing opportunities. There would be small adverse impacts to the upper three reservoirs in these years, although the impacts would be temporary and would typically dissipate within a year.

**Table 3-206. Changes in NED Benefits from Flow Releases under Alternative 5 Compared to Alternative 1 (thousands of 2016 dollars)**

| | Full Flow Release [a] | | Year After Full Flow Release | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|---|---|
| | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change |
| Lower River | $318 | $1,204 | −$874 | $11 | $0 | $287 | −$874 | $1,204 |
| Upper River | −$79 | $219 | −$491 | $171 | $0 | $153 | −$586 | $475 |

a Flow action was fully implemented in 7 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

b Flow action was partially implemented in 2 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

### Regional Economic Development

Under Alternative 5, non-local visitor spending associated with recreation on the reservoirs would support an average of 1,232 jobs and $29.1 million in labor income. Compared to Alternative 1, Alternative 5 would support approximately 3 fewer jobs and $68,000 less in labor income on annual average in communities located near the upper mainstem reservoirs, with negligible impacts to recreation RED benefits (Table 3-207). The largest changes in recreation RED benefits relative to Alternative 1 would occur in the upper three reservoirs in the years following a release event. During the 8 worst years relative to Alternative 1, average annual RED benefits in the upper three reservoirs would decrease by 18 jobs and $409,000 in labor income compared to RED benefits under Alternative 1. Even in the 8 worst years relative to Alternative 1, there would be relatively small and temporary decreases in RED benefits that would be negligible in the regional context.

Impacts to regional economic conditions surrounding Lake Francis Case and Lewis and Clark Lake would be relatively small because pool elevations remain relatively stable, preventing large changes in recreational access and visitation from occurring at these lakes even during drier conditions.

**Table 3-207. Economic Benefits of Non-Local Visitor Spending at the Reservoirs under Alternative 5 (thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Upper Three Reservoirs | Lake Francis Case and Lewis and Clark Lake[a] | Total Economic Impacts[b] |
|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Average Annual over 82 Years | 970 | 262 | 1,232 |
| | Change in Annual Average over 82 Years Relative to Alternative 1 | −2 | 0 | −3 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −18 | −19 | −36 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | 10 | 18 | 28 |
| Direct, Indirect, and Induced Labor Income | Annual Average over 82 Years | $22,902 | $6,215 | $29,116 |
| | Change in Annual Average over 82 Years Relative to Alternative 1 | −$56 | −$12 | −$68 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −$409 | −$433 | −$842 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | $242 | $429 | $671 |
| Direct, Indirect, and Induced Sales | Annual Average over 82 Years | $73,735 | $19,873 | $93,608 |
| | Change in Average Annual Average over 82 Years Relative to Alternative 1 | −$180 | −$38 | −$218 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −$1,311 | −$1,441 | −$2,753 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | $783 | $1,376 | $2,159 |

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis used the annual visitation from each of the upper three reservoirs and the lower two reservoirs to facilitate the estimates.

a described in Section 3.1, the HEC-ResSim modeling results indicate that lake elevations at Lewis and Clark Lake would fluctuate more than would occur during the real-time management of these reservoirs. Therefore, these impacts, which are based on boat ramp-operability, reflect adverse impacts that would likely not occur.

b Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

## Other Social Effects

Recreation OSE benefits associated with IRC and ESH under Alternative 5 would be very similar to those described under Alternative 3. Alternative 5 would result in small adverse RED impacts in some years after the fall release relative to Alternative 1. The changes in RED benefits are not anticipated to adversely affect individual and community well-being, quality of

life in rural communities, and standard of living, with similar impacts as described under Alternative 1.

**Conclusion**

Alternative 5 would result in negligible changes in total NED, RED, and OSE benefits across most locations compared to Alternative 1 (−0.1 percent). Although additional acres of ESH would be constructed in the inter-reservoir, there would be negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because of the relatively small change in habitat prevalence and changes in river stages and flows would not noticeably affect recreational access. Alternative 5 would support small benefits to recreation NED benefits in the lower river from additional ESH and fall releases increasing recreational access. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs. The upper three reservoirs would experience negligible change in recreation NED benefits on average (−0.3 percent). However, in the year following the fall release, there would be temporary and small decreases in recreation NED and RED benefits under Alternative 5 compared to Alternative 1 because reservoir elevations would be reduced from the previous year release, affecting recreational access and fishing opportunities. In these years, non-local visitation at the upper three reservoirs would support 18 fewer jobs than compared to Alternative 1, with negligible impacts to recreation RED and OSE benefits in the context of both the regional economy and local gateway communities. Habitat construction would have temporary and localized, small to large, adverse impacts to recreation from closures, noise, and other disturbances during construction activities.

Alternative 5 would not have significant adverse impacts to recreation because changes in recreation NED, RED, and OSE would be small and adverse to negligible in all locations and years compared to Alternative 1. Small adverse impacts in specific years in recreation NED, RED, and OSE would occur from habitat construction, which would be temporary and localized.

#### 3.16.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, USACE would attempt a spawning cue pulse every 3 years in March and May. In addition, management actions under Alternative 6 include mechanical construction to create ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska; and the construction of IRC habitat in the lower river below Ponca, Nebraska, to support the pallid sturgeon.

Alternative 6 would result in small adverse impacts to recreation NED benefits, driven by adverse impacts in the upper three reservoirs under specific conditions. There would be negligible impacts to recreation benefits in the lower three reservoirs, inter-reservoir and lower river reaches because reservoir elevations and river stages would not be noticeably impacted under Alternative 6. Habitat construction would result in temporary, small to large adverse impacts to recreation. These impacts are further described in this section.

**Mechanical Habitat Construction**

Similar to Alternatives 3, 4, and 5, target acres for habitat construction under Alternative 6 are higher for ESH and lower for habitat to support the early life requirements of the pallid sturgeon compared to Alternative 1. Impacts would be very similar to those described under Alternative 3, with temporary, small to large adverse impacts to recreation. The long-term benefits associated

with the prevalence of habitat are monetized and described in the following “National Economic Development” section.

### National Economic Development

Under Alternative 6, recreation NED benefits would decrease by $21.4 million, a decrease of 0.7 percent compared to Alternative 1. On annual average, recreation NED benefits under Alternative 6 would decrease by $265,000 on average compared to Alternative 1 (Table 3-208). Similar to Alternatives 2 and 4, the adverse impacts under Alternative 6 would be driven by adverse impacts in the upper three reservoirs in the years following a spawning cue release when lake elevations are lower than those under Alternative 1.

Management actions under Alternative 6 would result in small increases in recreation access and associated visitation at the lower three reservoirs, inter-reservoir reaches, and lower river, with negligible changes to boat ramp operability, visitation, and recreation NED benefits at these locations because reservoir elevations and river stages would remain relatively stable. In the lower river, recreational NED benefits would increase on average by $12,000, a change of 0.2 percent compared to Alternative 1. Some visitors that prefer lower river flows, such as those using paddle craft or swimmers, may be adversely impacted during the spawning cue releases, but would have negligible impacts during at other times under Alternative 6.

OMRR&R costs would be higher under Alternatives 6, $3.8 million compared to $3.3 million under Alternative 1. The upper three reservoir elevations would be relatively lower during conditions similar to those simulated in the 2000s drought under Alternative 6, with small to large adverse impacts depending on the timing and location of needed investments.

**Table 3-208. Summary of National Economic Development Analysis for Alternative 6, 1932–2012 (thousands 2016 dollars)**

| Benefits or Costs | Upper Three Reservoirs | Lower Three Reservoirs | Inter-Reservoir River Reaches | Lower River | All Locations |
|---|---|---|---|---|---|
| Total Visitation Benefits (Lake-Affected or Boat-Accessed Recreation) | $1,593,859 | $767,456 | $115,994 | $600,912 | $3,078,222 |
| Total Habitat Benefits | NA | NA | $245 | $3,826 | $4,071 |
| OMRR&R Costs | $3,780 | NA | NA | NA | $3,780 |
| **Total NED Benefits** | **$1,590,079** | **$767,456** | **$116,239** | **$604,738** | **$3,078,513** |
| Total Change in NED Benefits from Alternative 1 | −$23,260 | $695 | $163 | $963 | −$21,439 |
| Percent Change from Alternative 1 | −1.4% | 0.1% | 0.1% | 0.2% | −0.7% |
| Annual Average NED Benefits | $19,631 | $9,475 | $1,435 | $7,466 | $38,006 |
| Change in Annual Average NED Benefits | −$287 | $9 | $2 | $12 | −$265 |

Impacts by flow type for Alternative 6 relative to Alternative 1 are summarized in Table 3-209. These results show the difference in annual recreation benefits during years when there is a release action. Recreation NED benefits under Alternative 6 in the lower river would be highest during full spawning cue release when boat ramp operability would be improved relative to Alternative 1. The largest adverse impacts in the upper river (includes the reservoirs and inter-reservoir river reaches) would occur in the year or so following a full spawning cue release.

Adverse impacts under Alternative 6 would be temporary, occurring primarily in the years following a spawning cue release during relatively drier conditions. The reduction in recreation benefits under Alternative 6 would occur in a period when under Alternative 1, the benefits would already be quite low due to drought or relatively drier conditions. Lake Oahe would experience the biggest reductions in NED benefits during these conditions when the reservoirs could be drawn down up to 7 feet lower than with conditions under Alternative 1, causing impacts to recreational access to the lake and decreased fishing opportunities. Lake Oahe would experience a decrease of up to $890,000 in recreation NED benefits during these conditions. As drought or drier conditions are alleviated with typical rainfall and snowpack, System storage would be replenished and the change in NED benefits would become negligible compared to Alternative 1.

**Table 3-209 Changes in NED Benefits from Flow Releases under Alternative 6 Compared to Alternative 1 Thousands of 2016 dollars)**

| | Full Flow Release [a] | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions. | |
|---|---|---|---|---|---|---|
| | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change | Lowest Benefit Change | Highest Benefit Change |
| Lower River | −$354 | $892 | −$343 | $188 | −$669 | $892 |
| Upper River | −$409 | $89 | −$742 | $194 | −$1,341 | $194 |

a Flow action was fully implemented in 11 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings relative to Alternative 1.

b Flow action was partially implemented in 2 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

### Regional Economic Development

Under Alternative 6, non-local visitor spending associated with recreation on the five reservoirs would support 1,220 jobs and $28.8 million in labor income on annual average. Compared to Alternative 1, Alternative 6 would support 15 fewer jobs and $354,000 less in labor income on average over the period of analysis (Table 3-210). During the 8 worst years relative to Alternative 1, average annual RED benefits in the upper three reservoirs would decrease by 52 jobs and nearly $1.3 million in labor income compared to RED benefits under Alternative 1. Similar to Alternative 2, adverse RED impacts would be small in the regional context but could be locally large and adverse to the tourism industries and communities most affected by decreases in non-local visitation. These impacts would be especially large in low precipitation years following a spawning cue release. As drought conditions are alleviated with typical rainfall and snowpack, System storage would be replenished and changes in RED benefits would become small to negligible when compared to those under Alternative 1.

Impacts on regional economic conditions at Lake Francis Case and Lewis and Clark Lake would be negligible because stable pool elevations would not noticeably affect recreational access and visitation to these lakes.

**Table 3-210. Economic Benefits of Non-Local Visitor Spending at the Reservoirs under Alternative 6 Relative to Alternative 1 (Thousands of 2016 Dollars)**

| Economic Impact Parameter | Year | Upper Three Reservoirs | Lake Francis Case and Lewis and Clark Lake[a] | Total Economic Impacts[b] |
|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Average Annual over 82 Years | 958 | 263 | 1,220 |
| | Change in Annual Average over 82 Years Relative to Alternative 1 | −15 | 1 | −15 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −52 | −14 | −66 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | 4 | 16 | 20 |
| Direct, Indirect, and Induced Labor Income | Annual Average over 82 Years | $22,592 | $6,238 | $28,830 |
| | Change in Annual Average over 82 Years Relative to Alternative 1 | −$366 | $12 | −$354 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −$1,254 | −$344 | −$1,598 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | $99 | $387 | $485 |
| Direct, Indirect, and Induced Sales | Annual Average over 82 Years | $72,729 | $20,401 | $93,130 |
| | Change in Average Annual Average over 82 Years Relative to Alternative 1 | −$1,186 | $490 | −$697 |
| | Annual Average during 8 Lowest Visitation Years Relative to Alternative 1 | −$4,064 | −$1,105 | −$5,170 |
| | Annual Average during 8 Highest Visitation Years Relative to Alternative 1 | $318 | $1,246 | $1,564 |

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis used the annual visitation from each of the upper three reservoirs and the lower two reservoirs to facilitate the estimates.

a described in Section 3.1, the HEC-ResSim modeling results indicate that lake elevations at Lewis and Clark Lake would fluctuate more than would occur during the real-time management of these reservoirs. Therefore, these impacts, which are based on boat ramp-operability, reflect adverse impacts that would likely not occur.

b economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

### Other Social Effects

Recreation OSE associated with IRC and ESH under Alternative 6 would be very similar to those described under Alternative 3. The small to large adverse RED impacts in the counties surrounding the upper three reservoirs in years following a spawning cue release during relatively drier conditions under Alternative 6 would have adverse impacts on OSE benefits. Impacts would be similar to those described under Alternative 1 but would result in small to large adverse impacts to OSE benefits depending on the magnitude of the local effect and the size of the gateway communities affected. In general, these adverse impacts relative to Alternative 1 would be temporary and subside as System storage is replenished with normal rainfall and snowmelt conditions, restoring recreation access and opportunities.

### Conclusion

Under Alternative 6, there would be small decreases in total recreation NED benefits for all locations compared to Alternative 1 (−0.7 percent). Although additional acres of ESH would be constructed in the inter-reservoir and lower river reaches, there would be negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because of the relatively small change in habitat prevalence and river stages and flows and would not have a noticeable affect to recreational access. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs. Similar to Alternative 2, the upper three reservoirs would experience small adverse impacts on average (−1.4 percent). However, in specific years under certain conditions, decreases in recreation NED, RED, and OSE benefits under Alternative 6 compared to Alternative 1 would be temporary, large, and adverse. The spawning cue release could exacerbate reductions in reservoir elevations when releases occur at the beginning of a relatively drier period with lower precipitation. Under these unique conditions, non-local visitation at the upper three reservoirs would support 52 fewer jobs across the region compared to Alternative 1. Although these adverse impacts would be negligible in the context of the larger regional economy, changes in economic activity and opportunities could be large for tourism industries in affected gateway communities. Habitat construction would have temporary and localized, small to large, adverse impacts to recreation from closures, noise, and other disturbances during construction activities.

Alternative 6 would not have significant adverse impacts to recreation because decreases in recreation NED, RED, and OSE would be small to negligible on annual average in all locations. Large adverse impacts in specific years in recreation NED, RED, and OSE would occur from reductions in visitation and habitat construction, which would be temporary and localized.

### 3.16.2.10 Tribal Resources

Impacts on Tribal recreation resources would depend on the location of Tribes and reservations. (Figure 1-2). Changes in recreation NED benefits to reservations and their residents vary depending on hydrologic conditions, but generally include large NED benefits to visitors and residents under all alternatives. RED benefits to Tribes from non-local visitor spending at the reservoirs may be small in the context of the broader regional economy under the MRRMP-EIS alternatives, but could be important to Tribes, especially where opportunities for employment and income are limited. Impacts to Tribal RED benefits in the river reaches would be negligible. The construction of habitat and non-local visitor spending would generate OSE benefits for Tribes and those living on reservations along the Missouri River.

Impacts to Tribal recreation under the alternatives would be similar to those described in Section 3.20, Tribal Interests (Other) and NED, RED, and OSE results described above. In most years, there would be negligible impacts under MRRMP-EIS alternatives relative to Alternative 1. Flow releases under Alternatives 2, 4, 5, and 6 would, however, draw down the upper three reservoir elevations more than under Alternative 1 under some conditions in years following the flow releases, causing temporary, small to large, adverse impacts on recreation. Impacts would range from negligible under Alternative 3 to relatively large under Alternative 4 under certain conditions. Impacts under Alternatives 2, 4, 5, and 6 would be more pronounced during drought or drier conditions in the years following flow releases. Adverse impacts on recreation NED, RED, and OSE benefits during these conditions may also adversely affect Tribal communities and lifestyles.

Recreational opportunities associated with reservations and Tribes near and/or adjacent to the lower three reservoirs would experience negligible impacts to recreational resources under all alternatives because pool elevations at these reservoirs are relatively stable. Impacts to Tribal recreation in the inter-reservoir river reaches and lower river would include temporary adverse impacts from mechanized habitat construction, and long-term benefits from increased diversity and abundance of wildlife following habitat construction under Alternatives 2 through 6. Short-term, adverse impacts from habitat construction to Tribes and Tribal communities would be greatest under Alternatives 2 since target acreages for mechanical construction are substantially higher under these alternatives.

#### 3.16.2.11 Climate Change

All of the climate change variables described in Section 3.2.2.7, could have implications for recreation resources and the associated NED, RED, and OSE effects under the MRRMP-EIS alternatives. Earlier snowmelt may cause spring System storage targets at the upper three reservoirs to be met more frequently, increasing the regularity of spring plenary pulses under Alternative 1, and the potential for adverse impacts associated with the subsequent lower reservoir elevations. Adverse recreational impacts 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 through 6, more sporadic large rain events and flooding could adversely impact access to recreation resources; these impacts could be exacerbated during spring or fall releases. In addition, the risk of releases occurring which may be followed by prolonged drought periods at the upper three reservoirs could reduce reservoir elevations more under alternatives 2, 4, 5, and 6, causing greater adverse impacts to recreation resources and benefits under climate change.

Drought or flood conditions may reduce the frequency of full releases under Alternatives 2, 4, 5, and 6 and the adverse impacts associated with full releases 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 recreation benefits under Alternatives 2, 4, 5, and 6 relative to Alternative 1.

#### 3.16.2.12 Cumulative Impacts

Past, present and future construction projects, including those to maintain the mainstem dams, roads, developed recreational areas, native fish and wildlife habitat areas, and the BSNP, can

cause temporary localized adverse impacts to the quality and quantity of recreational visits as a result of construction-related noise, vibration, fugitive emissions, deterioration in water quality, decreased visual aesthetics, and access limitations. However, many of these actions result in recreational benefits over the long-term by increasing access and providing a range of recreational opportunities available to a variety of users.

Continued management of recreation, wildlife, and natural areas by USFWS, NPS, and agencies that manage these resources at the state and local level generally benefit recreation along the river because they promote conservation and are focused on safeguarding and enhancing wildlife and recreational resources for current and future users. In addition, land easements and agricultural technical and financial programs administered by NRCS support restoring or maintaining natural habitats, with potential benefits to fish and wildlife and associated recreational opportunities.

Actions that would contribute to bed degradation could adversely impact water elevations potentially impacting access to recreational infrastructure, as they notably affect the volume of water in the river. Any resulting changes in aggradation and degradation from actions such as dredging and floodplain development would increase the need for investment in infrastructure repairs and/or upgrades to mitigate these impacts.

Although recreational experiences supported by the river are cumulatively impacted by human actions, visitation is largely influenced by a number of other factors, including the health of the economy and the price of gasoline. Many recreational areas along the river are destination locations that attract hunters, anglers, boaters, and other outdoor enthusiasts from across the country. When gas prices are low and economic conditions are favorable, households have greater disposable income and are more likely to travel for recreational activities. As gas prices rise or households face greater economic uncertainty, recreationists often take trips closer to home. These factors can have mixed effects on visitation to reservoirs, where destination recreation increases during more prosperous periods and visitation by local residents increases during periods of high gas prices or economic downturns.

With the variable hydrology and precipitation within the System and its interaction with the past, present foreseeable actions as described in Section 3.1, cumulative impacts under Alternative 1 would be long-term, large, and beneficial, with recreation resources supporting diverse recreational activities and opportunities to visitors and residents, jobs and income in local economies, and quality of life and social connectedness for surrounding communities. However, over time, the cumulative actions and variability in hydrology can have both adverse or beneficial impacts on recreation; adverse and beneficial impacts to recreation are influenced by natural cycles of dry and wet periods (including snowpack and precipitation), and lesser so, by the price of gas, the state of the national and regional economy, trends in outdoor recreation use, and other public land management, programs, and activities. Alternative 1 would provide a small contribution to these cumulative impacts.

Alternatives 2, 4, and 6 would exacerbate adverse impacts to recreation in the years following releases during the drought or drier years because the releases would reduce reservoir elevations and the lower precipitation and/or snowpack would not be able to replenish the water storage at the upper three reservoirs, having a large contribution to cumulative adverse effects in these types of conditions, especially at Lake Oahe. In the lower three reservoirs, and inter-reservoir and lower river reaches, implementation of Alternatives 2, 4, and 6 would have a negligible contribution to cumulative impacts because of the small change in river stages and reservoir elevations impacting recreational access in these areas.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3 would be similar to those described for Alternative 1. Implementation of Alternative 3 would have a negligible contribution to these cumulative impacts.

When combined with other past, present, and reasonable foreseeable actions, cumulative impacts of Alternative 5 would be long-term large and beneficial. Implementation of Alternative 5 would contribute temporary small adverse impacts to cumulative impacts in the upper three reservoirs, mostly occurring in Lake Sakakawea and Lake Oahe that would dissipate within two years following the fall release. Cumulative impacts under Alternative 5 would also be beneficial in the lower river, inter-reservoir river reaches, and lower three reservoirs, although the overall contributions of Alternative 5 to cumulative impacts would be negligible because of the small change in river stages and reservoir elevations impacting recreational access in these areas.

# 3.17 Thermal Power

## 3.17.1 Affected Environment

There are 22 thermal power plants (3 nuclear and 19 coal-fired power plants) located along the mainstem of the Missouri River or its reservoirs. One power plant is located on Lake Sakakawea in North Dakota; six are located on the river below Garrison Dam in North Dakota; and the remaining power plants are located on the river downstream of Sioux City, Iowa.

Coal combustion at these plants produces heat energy which is used to boil water into steam. The steam turns the turbines which spin the generators to produce electricity. Like coal-fired plants, nuclear power plants produce electricity by boiling water into steam. However, nuclear power plants do not burn any fuel. Instead, they obtain the heat needed to produce steam through a physical process called fission which involves the splitting of uranium atoms in a nuclear reactor. The power plants operate generating units and one or more intakes for withdrawing water for once through cooling or for use in recirculating cooling systems. Of the 22 power plants, 9 have units with recirculating cooling systems or cooling ponds, while 13 plants withdraw water for once-through cooling.

These plants are mainly base load plants used to meet customers' continuous minimum demand for electricity. Base load plants typically run at all times of the year except during repairs or scheduled maintenance. The nuclear plants generally run at close to peak output continuously (except for maintenance). Although coal-fired plants may be cycled over a 24-hour period to meet fluctuations in demand, it is most economical if they are operated at constant production levels.

Thermal power plants access water for once through cooling or recirculating through their cooling systems through intakes. River flows and the associated water surface elevations can affect the amount, timing, frequency, and duration of access to water through the intakes. Intake elevation data was initially collected from the Master Manual and survey data conducted by the Missouri River Basin Water Management Division in 2012; power plant representatives have updated or confirmed the intake elevations during outreach with plants in 2015.

All of the power plants discharge wastewater into the river and have NPDES permits that guide the effluent and temperature requirements based on state water quality standards. Low river flows and high river water temperatures can affect plant operational efficiency as well as the ability of the plants to meet their NPDES effluent and temperature requirements.

The NPDES permit of a thermal power facility includes temperature limits for maximum river water temperature and maximum change in river water temperature within the mixing zone (the volume and flow of the receiving water below the outfall). A number of factors are part of the estimation of these temperature requirements, including the flow of the receiving river, temperature of the receiving water, and the volume and temperature of effluent (i.e., the discharge water). Critical low flow conditions are used to define mixing zones and the effluent requirements. Maximum temperature requirements, as described in state regulations, range

from 90°F for plants along the Missouri River in Missouri, Nebraska, Kansas, and Iowa to 85°F for plants in northern Nebraska and North Dakota.[7]

#### 3.17.1.1 Gross Capacity of Power Plants along the Missouri River

The thermal plants along the Missouri River have a nameplate capacity of 16,964 MW (EIA 2015). Nameplate capacity is the maximum rated output of a generator or power production equipment under specific conditions designated by the manufacturer (EIA 2016a). The 19 coal-fired plants have a combined gross megawatt capacity of 14,425 MW. The three nuclear plants have a combined gross generating capacity of 2,539 MW. Table 3-211 summarizes the location and gross megawatt capacity of the power plants.

**Table 3-211. Gross Capacity of Missouri River Power Plants**

| Name | River Mile | County | State | 2014 Nameplate Capacity (MW) |
|---|---|---|---|---|
| **Lake Sakakawea** | | | | |
| Basin Electric – Antelope Valley* | 1415.5 | Mercer | ND | 870 |
| **Garrison Dam to Lake Oahe** | | | | |
| Montana Coyote Utilities – Coyote* | 1372.4 | Mercer | ND | 450 |
| Great River Energy – Stanton | 1372 | Mercer | ND | 191 |
| Basin Electric – Leland Olds Station | 1371.6 | Mercer | ND | 656 |
| Minnkota Power Coop – Missouri River Pump for Milton R. Young* | 1364.4 | Oliver | ND | 734 |
| Great River Energy – Coal Creek* | 1362.4 | McLean | ND | 1,210 |
| Montana Dakota Utilities – Heskett | 1319.5 | Morton | ND | 115 |
| **Gavins Point Dam to Rulo** | | | | |
| MidAmerican – Neal North | 718.3 | Woodbury | IA | 1,280 |
| **Rulo to the Mouth of the Missouri River** | | | | |
| OPPD – Fort Calhoun Nuclear | 645.9 | Washington | NE | 502 |
| OPPD – North Omaha Power | 625.3 | Douglas | NE | 655 |
| MidAmerican – Walter Scott Energy Center* | 606 | Pottawattamie | IA | 1,648 |
| OPPD – Nebraska City* | 556.3 | Otoe | NE | 1,390 |
| NPPD – Cooper Nuclear | 532.6 | Nemaha | NE | 801 |
| KCPL – St. Joseph – Lake Road | 446 | Buchanan | MO | 90 |
| KCPL – Iatan Power Station* | 411 | Platte | MO | 1,640 |
| KCBPU – Nearman Creek* | 378.7 | Wyandotte | KS | 355 |
| KCBPU Quindaro | 373.5 | Jackson | MO | 66 |
| Veolia Energy – Kansas City | 367.7 | Jackson | MO | 5 |

[7] For the Missouri River in Nebraska, from the South-Dakota-Nebraska state line near Ft. Randall Dam to Sioux City, Iowa, the maximum river water temperature limit is 85 degrees. For warmer water below Sioux City in Nebraska, the maximum limit is 90 degrees Fahrenheit (Nebraska Administrative Code Title 117, Chapter 4 2016).

| Name | River Mile | County | State | 2014 Nameplate Capacity (MW) |
|---|---|---|---|---|
| KCPL Hawthorne | 358.3 | Jackson | MO | 740 |
| KCPL – Sibley | 336.4 | Jackson | MO | 524 |
| Ameren – Callaway Nuclear* | 115.5 | Callaway | MO | 1,236 |
| Ameren – Labadie | 57.9 | Franklin | MO | 2,390 |

Source: EIA 2015, Report EIA-860.

* Indicates that the power plant has a recirculating cooling system or pond for at least one unit.

### 3.17.1.2 Energy Generation for Power Plants along the Missouri River

Monthly energy generation is provided to the U.S. Energy Information Administration by the power plants. Table 3-212 summarizes the available average daily seasonal net generation for the Missouri River power plants based on monthly generation reported to the U.S. Energy Information Administration between 2012 and 2015. Power generation and market energy prices vary by season, with higher energy generation and market prices in the peak seasons of summer (July and August) and winter (January and February). For all of the units, average daily generation is highest during the summer months, when peak demands for energy are highest.

**Table 3-212. Average Daily Net Generation for Missouri River Thermal Power Plants by Season**

| | Winter | Spring | Summer | Fall |
|---|---|---|---|---|
| | (January and February) | (March through June) | (July and August) | (September through December) |
| Basin Electric – Antelope Valley[a] | 19,107 | 10,983 | 26,843 | 17,311 |
| Montana Coyote Utilities – Coyote[a] | 6,556 | 4,876 | 11,023 | 6,048 |
| Great River Energy – Stanton | 3,888 | 2,474 | 5,361 | 2,539 |
| Basin Electric – Leland Olds Units 1 and 2 | 11,714 | 7,120 | 15,515 | 9,123 |
| Minnkota Power – Missouri River Pump Unit 2[a] | 9,156 | 6,408 | 11,881 | 7,435 |
| Great River Energy – Coal Creek[a] | 26,246 | 16,116 | 37,901 | 25,249 |
| Montana Dakota Utilities – Heskett[b] | 1,491 | 863 | 1,988 | 1,419 |
| MidAmerican – Neal North Unit 3 | 23,275 | 7,726 | 36,896 | 15,661 |
| MidAmerican – Neal South Unit 4 | 12,522 | 8,179 | 18,804 | 8,947 |
| OPPD – Fort Calhoun | 5,782 | 3,144 | 7,587 | 6,094 |
| OPPD – North Omaha | 3,651 | 3,326 | 7,742 | 4,436 |
| MidAmerican – Walter Scott Energy Units 3 and 4[a] | 29,541 | 18,860 | 46,053 | 27,195 |
| OPPD – Nebraska City Units 1 and 2[a] | 24,149 | 16,552 | 41,074 | 26,183 |
| NPPD – Cooper Nuclear | 18,967 | 13,910 | 26,512 | 15,369 |
| KCPL – St. Joseph – Lake Road | 5,499 | 2,514 | 7,421 | 1,993 |

| | Winter | Spring | Summer | Fall |
|---|---|---|---|---|
| | (January and February) | (March through June) | (July and August) | (September through December) |
| KCPL – Iatan Power Station[a] | 28,442 | 18,595 | 45,596 | 28,537 |
| KCBPU – Nearman Creek[a] | 3,820 | 1,777 | 5,468 | 3,461 |
| KCBPU Quindaro | 2,713 | 1,468 | 3,212 | 1,941 |
| Veolia Energy – Kansas City[b] | — | — | — | 283 |
| KCPL Hawthorne | 11,214 | 5,613 | 16,707 | 10,095 |
| KCPL – Sibley | 6,853 | 3,524 | 11,313 | 4,398 |
| Ameren – Callaway[a] | 29,499 | 18,843 | 39,086 | 26,540 |
| Ameren – Labadie | 48,170 | 28,830 | 70,102 | 43,133 |

Source: EIA 2016c. Report EIA-923

Note: Data from the U.S. Energy Information Administration between 2012 and 2015 were used unless otherwise noted. All relevant units are included in the energy generation estimates; based on input from the power plants, energy generation from units that have been or are planning on being decommissioned in 2016 were not included in the energy generation estimates.

a Indicates that the power plant has a recirculating cooling system or pond for at least one unit.

b U.S. Energy Information Administration data was only available for December 2013 and 2014.

#### 3.17.1.3 Tribal Resources and Perspectives on Thermal Power

There are no power plants located on Tribal lands. Additional Tribal perspectives on thermal power are provided in the Tribal report.

### 3.17.2 Environmental Consequences

The environmental consequences analysis for thermal power plants focuses on changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives. The sections that follow provide a summary of the analysis and a description of environmental consequences related to thermal power plants. Additional details on the methodology and results are provided in the “Thermal Power Environmental Consequences Analysis Technical Report” (available online at www.moriverrecovery.org).

#### 3.17.2.1 Impact Assessment Methodology

This section describes the methodology for the NED, RED, and OSE analyses. The analysis focuses on the costs (replacement costs of reduced power generation, capital costs for lost capacity, and variable costs) to power plants and utilities to adapt to changing river and reservoir conditions. The costs reflect reductions in power generation associated with specific river conditions (river stages and river temperatures) relative to conditions which would not have adverse impacts on power generation. The costs estimated for each of the MRRMP-EIS action alternatives are compared to the costs incurred under Alternative 1. As river flows and reservoir elevations fall below intake operational requirements or river temperatures increase above operational or regulatory thresholds, access to water, power plant operational efficiencies, and regulatory constraints could affect power generation and variable costs. Reductions in power generation can in turn drive costs to replace power generation and lost capacity. The following

section provides a brief overview of the of the overall methodology for evaluating impacts to thermal power plants as well as the approach for each planning account evaluated.

In addition to the NED, RED, and OSE analyses, there would be potential associated with habitat construction and channel reconfiguration for early life stage for the pallid sturgeon due to the possible disruption of water supply to thermal power intakes. The analysis used previous reports (USACE 2011a) and information provided by the USACE to qualitatively describe these impacts in the NED section.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

**National Economic Development**

The environmental consequences for the NED analysis evaluated the potential effects from changes in river stage, river flow, or temperatures at specified locations along the river in close proximity to power plants. H&H data on river stages and flows were used to assess when and how often intake access to water was affected. In addition, the Engineering Research and Development Center (ERDC) developed a HEC-Nutrient Simulation Modules (NSM) temperature model to estimate daily temperatures for a 15-year period between 1995 and 2012 (excluding 2007, 2010, and 2011). An extensive data collection effort was undertaken to reach out to power plants and utilities to obtain information on how river conditions affect power generation, operations, and variable costs. An important step in the process was to obtain the average daily power generation for the affected power plants for years when no adverse conditions occurred. Monthly generation was obtained from the U.S. Energy Information Administration for monthly net generation for each power plant and confirmed with the plant representatives. Power generation was evaluated seasonally because replacement costs of power vary by season, with peak demand for electricity forcing replacement prices higher in the winter and summer months. The estimates of reductions in power generation were used to estimate replacement power costs (losses in energy values) and capital costs to replace lost capacity (losses in capacity values). A 15-year period of analysis was used to include issues associated with both access to water and river temperatures.

The resulting power generation loss was reviewed with representatives from Southwest Power Pool (SPP) and Midcontinent Independent System Operator (MISO) to better understand the context and importance of these reductions in power generation on the power markets and electricity prices. In addition, the impacts to hydropower facilities were considered to assess any coupled impacts on power generation to the SPP.

**RED Analysis**

The RED analysis used power generation information from the SPP and MISO Regional Transmission Organizations (RTOs) and consultation with RTO experts to describe the potential impacts of the reductions in power generation on wholesale electricity prices and how changes to those prices could impact consumer electricity rates that are set by retail electricity providers. Any changes in retail electricity rates could impact household and business spending, with implications for jobs and income in regional economies. If consumers must spend more of their

income on higher electricity rates, they would have less disposable income to spend on other goods and services, which could adversely impact jobs and income in affected industries.

Consumer electricity rates are typically regulated by the state utility commissions. Retail electricity providers must petition the state utility commission to change the rates. Input was also obtained from experts to better understand the magnitude of power reductions during peak seasons which could affect wholesale electricity prices such that retail electricity providers would have justification to petition for electricity rate changes (SPP pers. comm. 2016; WAPA pers. comm. 2016).

If multiple power plants must reduce power generation simultaneously during peak summer seasons or if Missouri River thermal power plants must reduce power generation for a long period or on a re-occurring basis during peak periods, this could create an average increase in the wholesale cost of electricity to retail electrical providers. The providers may then have sufficient rationale to petition state utility commissions for an increase in consumer electricity rates. The RED analysis considered the worst-case peak seasonal reduction in power generation as a percent of total seasonal generation for the RTOs, the timing of the reductions in power generation within the peak season, and input from SPP to qualitative assess the potential impacts to electricity rates and RED effects.

**Other Social Effects**

The thermal power OSE analysis used the results of the NED and RED thermal power analysis to determine the scale of impacts to the OSE account. The OSE impacts are described qualitatively based on the potential impacts associated with changes in thermal power operations under the MRRMP-EIS alternatives. Issues that are addressed include access to reliable power, impacts to low-income populations associated with anticipated changes in electricity rates, and impacts to air quality as a result of replacement sources of electricity generation that may replace the reduced power generation from Missouri River thermal plants. Access to reliable power was qualitatively evaluated with the estimates of the reductions in power generation and expert opinion (SPP pers. comm. 2016). The analysis on air emissions uses the impacted power generation from Missouri River power plants and the installed capacity by fuel type for the SPP and MISO RTOs to qualitatively evaluate the potential impacts to air quality.

#### 3.17.2.2 Summary of Environmental Consequences

Table 3-213 is a summary of the environmental consequences relative to thermal power. 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 3-213. Environmental Consequences Relative to Thermal Power**

| Alternative | NED Impacts | RED Impacts | OSE Impacts | Other Impacts |
|---|---|---|---|---|
| Management Actions Common to All Alternatives | No NED Impacts. | No RED Impacts. | No OSE Impacts. | No impacts anticipated. |
| Alternative 1 | Reductions in average annual energy values and variable costs of $52.9 million from drought conditions affecting operational efficiencies and regulatory constraints, resulting in reductions in power generation. | Potential increase in retail electricity rates over time compared to current rates, with the potential for long-term adverse impacts to RED effects. | The potential for temporary adverse impacts to electricity reliability.<br>Uncertain impacts on air quality. | Negligible to small, temporary adverse impacts associated with SWH and ESH construction. |
| Alternative 2 | Reduction in average annual energy values of $6.1 million (11.5%) from Alternative 1.<br>Loss of energy and capacity values and increased variable costs of $28.2 million on average.<br>Relatively small to large adverse impacts to power generation in the lower river from low summer flows and relatively higher amounts of SWH. | Relatively small to large long-term adverse impacts to electricity rates and RED effects. | Potentially large, temporary adverse impacts to electricity reliability, with a higher risk of occurrence.<br>Potentially more adverse impacts to air quality from reduced nuclear power generation. | Small to large, temporary adverse impacts could result from actions associated with SWH and ESH construction. |
| Alternative 3 | Increase in average annual energy values of $1.7 million (−3.2%).<br>Increase of energy and capacity values and decreased variable costs of $1.4 million on average.<br>Relatively small benefits to power plants from higher river flows and lower river temperatures from the elimination of the spring plenary pulse. | Negligible change from Alternative 1. | Negligible change from Alternative 1. | Negligible change from Alternative 1. |
| Alternative 4 | Reduction in average annual energy values of $105,000 (0.2%).<br>Reduction of energy and capacity values and increased costs of $422,000 on average.<br>Relatively small to large temporary adverse impacts to power plants in upper river from reductions in river flows as reservoirs rebalance after a spring release; relatively small benefits to power plants in lower river. | Negligible change from Alternative 1. | Negligible change from Alternative 1. | Negligible change from Alternative 1. |

| Alternative | NED Impacts | RED Impacts | OSE Impacts | Other Impacts |
|---|---|---|---|---|
| Alternative 5 | Increase in average annual energy values of $1.4 million (−2.6%).<br>Increase of energy and capacity values and decreased variable costs of $1.1 million on average.<br>Relatively small benefits to power plants from the fall release and lower river temperatures from IRC habitat. | Negligible change from Alternative 1. | Negligible change from Alternative 1. | Negligible change from Alternative 1. |
| Alternative 6 | Increase in average annual energy values of $2.4 million (−4.4%).<br>Increase of energy and capacity values and decreased variable costs of $1.3 million on average.<br>Small benefits to power plants from higher river flows and lower river temperatures from IRC habitat and spawning cue releases. | Negligible change from Alternative 1. | Negligible change from Alternative 1. | Negligible change from Alternative 1. |

#### 3.17.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include pallid sturgeon propagation and augmentation, predator management, vegetative management, and human restrictions measures. These actions are not expected to have any impacts on thermal power intakes or power generation for power plants located along the Missouri River.

#### 3.17.2.4 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 early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring plenary pulse.

Overall, the impacts to thermal power energy values under No Action would be temporary and adverse, with the bulk of the effect occurring to the lower river power plants in the summer peak power period during drought conditions. These adverse impacts would occur due to the variability of hydrological conditions in the basin during the natural cycles of drought with lower river flows and higher air and river temperatures affecting power plant operations and power generation. Impacts from habitat construction would be negligible to small. The impacts of No Action are further described in this section.

**Mechanical Habitat Construction**

The construction of habitat would be focused in the Garrison and Gavins Point reaches for ESH construction and between Ponca to the mouth of the river near St. Louis for SWH, and power plant intakes in these reaches could be impacted. Constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in aggregation segments of the river. This can result in increased maintenance issues to thermal power intakes in areas of aggradation (USACE 2011a). The extent of these impacts would be dependent on the location of the management action relative to thermal power intakes. The

construction of habitat below Gavins Point Dam could affect 15 power plants in the lower river. However, most of the power plants are located in urban areas where habitat would likely not be constructed. There are six power plants in the Garrison Dam to Lake Oahe reach that could be affected by the construction of ESH, although these power plants have been working with the USACE to place acceptable buffers around their infrastructure.

Potential impacts of ESH on infrastructure such as thermal power intakes were evaluated in the Final *Programmatic Environmental Impact Statement for Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (PEIS) (USACE 2011a). Each habitat site would continue to be designed to avoid impacts to environmental, cultural, and socioeconomic resources. In addition, USACE has identified sensitive resource categories and subsequent restrictive or exclusionary zones associated with many of these resources. A more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering and design phases which further mitigate impacts associated with these actions on thermal power plants. With the site-specific planning and sensitive resource restrictions in place, the impacts of the habitat construction management actions on thermal power plant intakes would be negligible to small, temporary, and adverse.

**National Economic Development**

Management of the Missouri River system under No Action would result in annual average decrease of $52.9 million[8] in energy values (i.e., replacement costs of reduced power generation) over the 15-year period of analysis when compared to ideal conditions when power generation would not be affected under adverse river conditions. Most (78 percent) of this impact would be to power plants in the lower river. The vast majority of these adverse impacts would be due to high river temperatures in the summer months during the drought conditions simulated under No Action in the 2000s, which resulted in lower river flows in the summer and/or higher ambient air temperatures, causing river temperatures to increase above certain critical operating and regulatory thresholds for power plants. During these conditions, twelve power plants in the lower river would be impacted during these relatively drier conditions. Because power generation would be affected in peak summer seasons, it is possible that electricity prices for replacement power would be higher than estimated with locational marginal pricing, resulting in larger adverse effects to energy values than reported here. These reductions in power generation would account for 1.6 percent of total Missouri River power plant generation with no adverse impacts. Total annual power generation for all impacted power plants without adverse conditions is 93.4 million MWh.

The No Action alternative would result in an average annual reduction of $11.6 million in energy values in the upper river when compared to ideal conditions when power generation would not be affected under adverse river conditions. The reduction in power generation under Alternative 1 would account for 1.9 percent of power generation with no adverse conditions in the upper river. Most of the impacts in the upper river would occur with reduced river flows in relatively drier conditions in September through November affecting access to water through intakes.

Lost capacity occurs if power generation is impacted during peak summer and winter seasons. Capacity values for Alternatives 2–6 are based on the loss in dependable capacity relative to Alternative 1 and are defined as the amount of capacity that a power plant can reliably contribute to meeting peak season needs (USACE EM 1110-2-1701). Under Alternative 1,

[8] In this analysis, positive values represent costs for power plants, including costs to replace lost power generation, lost capacity, or variable costs.

dependable capacity would be higher in the winter (11,524 MW) compared to the summer (9,563 MW) for all power plants in the lower river due to temperatures affecting power generation during the peak summer season. Capacity values, because they are calculated relative to Alternative 1, are not estimated for Alternative 1. Impacts to variable costs would be small under Alternative 1, with an average annual cost of $31,869. The NED analysis for Alternative 1 is summarized in Table 3-214.

**Table 3-214. Summary of National Economic Development Analysis for Alternative 1**

| Costs | Upper River[a] | Lower River | All Locations |
|---|---|---|---|
| Effect of Adverse Conditions on Energy Values (Total over 15 years)[b] | $174,320,910 | $619,191,372 | $793,512,282 |
| Effect of Adverse Conditions on Energy Values (Average Annual) | $11,621,394 | $41,279,425 | $52,900,819 |
| Maximum Loss in Annual Energy Values Costs | $74,052,467 | $146,695,066 | $147,882,573 |
| Minimum Loss in Annual Energy Values Costs | $0 | $908,836 | $908,836 |
| Average Annual Reduction in Missouri River Power Generation from Adverse Conditions under Alternative 1 (MWh) | 449,284 | 1,033,200 | 1,482,484 |
| Percent of Power Generation relative to Generation with No Adverse Conditions (MWh) (93 million MWh total) | 1.9% | 1.5% | 1.6% |
| Total Variable Costs[c] | $478,030 | NA | $478,030 |
| **Average Annual Variable Costs** | **$31,869** | **NA** | **$31,869** |
| Summer Dependable Capacity[d] (MW) | 2,917.7 | 6,645.3 | 9,563.0 |
| Winter Dependable Capacity[d] (MW) | 2,953.5 | 8,570.3 | 11,523.8 |
| Effect of Adverse Conditions on Energy Values and Variable Costs (Total) | $174,798,941 | $619,181,372 | $793,990,313 |
| Effect of Adverse Conditions on Energy Values and Variable Costs (Annual Average) | $11,653,263 | $41,279,425 | $52,932,688 |

Note: Higher positive values represent higher costs associated with adverse river conditions.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach and one power plant on Lake Sakakawea.

b Energy values represent replacement costs for power generation that is reduced under adverse conditions.

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected.

d Dependable Capacity is estimated as the 15th percentile of the annual peak season capacity for each power plant, which represents the amount of capacity that a power plant can reliably contribute to meeting peak season needs (USACE EM 1110-2-1701).

### Regional Economic Development

Under Alternative 1, reductions in power generation under adverse conditions under Alternative 1 could lead to increases in electricity rates and adverse impacts to regional jobs and income. In the worst-case summer for power plants in the SPP RTO, there would be a reduction in 724,361 MWh, which represents a loss of 1.6 percent of SPP's total generation during a summer season with no adverse conditions. Within the MISO RTO, power generation from all power plants during the worst-case summer season would be reduced by 2,757,688 MWh, or 2.7 percent of

total generation of the MISO RTO. There would be up to 0.5 percent of SPP total generation affected during the worst-case winter season and no power generation affected in the MISO market. Table 3-215 presents the worst-case season reductions in power generation from Missouri River power plants under Alternative 1 along with the relative percentage these losses represent compared to total generation for each RTO by season with no adverse conditions.

Although there would be reduced power generation in non-peak seasons when compared to seasons with no adverse conditions, replacement generation would likely cost considerably less than during peak seasons and would not affect the wholesale electricity prices for retail electricity providers. Therefore, reductions in power during these off-peak seasons would not likely contribute to higher consumer electricity rates.

The reduction in Missouri River power generation in the worst-case summer season under Alternative 1 as a percent of RTO summer generation with no adverse conditions is a relatively small percent (1.6–2.7 percent). However, the reductions in power generation, as simulated under Alternative 1, occur during higher river temperatures during one period of time (peak summer river temperatures) during peak power demand seasons, when replacement power from MISO, SPP, or other markets may be scarce. In addition, these impacts are estimated to occur over multiple years during the simulated period of analysis during drought conditions. These factors could support the rationale for retail electricity providers to increase consumer electricity rates compared to current rates because of the higher prices to purchase the wholesale electricity. As a result, the large, but temporary, estimated reductions in power generation could increase the price that retail electricity providers pay for wholesale electricity, which could result in higher consumer electricity rates. The impacts to consumer electricity rates are likely to be long-term and adverse, although the exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. Increases in electricity rates may cause households to have less disposable income to spend on other goods and services in the community or region, causing adverse effects on local and regional economies. Similarly, businesses may have lower profits with less money to spend on other business expenses or labor in the region.

**Table 3-215. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 1**

| Season | SPP | MISO |
|---|---|---|
| Reduction in Power Generation under the MRRMP-EIS Alternative (MWh) | | |
| Winter | 210,013 | 2,982 |
| Spring | 92,612 | 12,184 |
| Summer | 724,361 | 2,757,688 |
| Fall | 212,655 | 2,799,889 |
| Percent of Power Generation Reduction as a Percent of the RTO's Generation | | |
| Winter | 0.5% | 0.0% |
| Spring | 0.1% | 0.0% |
| Summer | 1.6% | 2.7% |
| Fall | 0.3% | 1.5% |

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

### Other Social Effects

Under Alternative 1, electricity reliability could be adversely affected as a result of reductions in power generation when compared to power generation under no adverse river conditions; these impacts would depend on the timing of the reductions, the location of power plants affected, the power generation affected, transmission line capacity, and the electricity demand. Some of the Missouri River baseload power plants are important for electricity reliability. When multiple plants in one location (i.e., Kansas City or Omaha) are affected, there could be impacts to electricity reliability. Under some extreme adverse conditions when multiple plants in the same location must reduce power generation simultaneously during peak seasons, there may not be any available electricity generation from other plants or markets. While unlikely, under certain extreme circumstances, brown outs (a reduction in voltage on the power grid) or potentially rolling black outs (a complete loss of power on the power grid) could occur.

Under Alternative 1, extreme conditions could occur in the summers during drought or relatively drier conditions as simulated in the 2000s due to the natural cycles of drought that occur when power plants along the Missouri River would have to reduce power generation, which could potentially lead to brownouts or rolling blackouts (SPP pers. comm. 2016). If these conditions occur, there would be relatively large temporary adverse impacts to the communities and locations affected. If power generation is not reliable, there can be consequences to health and safety from lost cooling or heating abilities, which could result in impacts to children and the elderly who are the most susceptible to high heat conditions. Additionally, as described in the RED analysis above, the retail electricity rates that consumers pay may be increased relative to current rates under Alternative 1, which could adversely affect lower-income populations because a higher portion of their income would need to be spent on electricity.

Power generation from coal-fired and nuclear Missouri River power plants would be affected under Alternative 1, which could have implications for air emissions and air quality. Because the bulk of the MISO and SPP installed capacity is from coal and natural gas sources, when energy from the three Missouri River nuclear plants needs to be replaced with alternate fossil fuel sources, there would be adverse impacts to air emissions. When energy from the coal-fired Missouri River nuclear plants needs to be replaced with alternate sources, there would be benefits to air emissions if the power generation were replaced with natural gas, hydropower, nuclear, or renewable sources of energy. However, because the RTO capacity includes a considerable amount of coal-installed capacity, it is difficult to conclude that there would be benefits to air quality from reductions in power generation from Missouri River coal-fired plants. The actual impact of the change in air emissions would be dependent on the Missouri River power plant that must reduce power generation and the fuel types of the replacement source of energy. Two of the nuclear power plants could be affected under Alternative 1, resulting in potential adverse impacts to air emissions with replacement energy likely to be from fossil fuel sources. A number of coal-fired Missouri River plants would be affected under Alternative 1, although the fuel type of the replacement energy is not known, with uncertain impacts to air emissions and air quality.

### Conclusion

There would be small adverse impacts to thermal power energy values under Alternative 1 on annual averages across the locations and seasons, but could result in temporary, large, and adverse impacts under some conditions in some seasons. The impacts would occur from power generation reductions during the summer peak power period during drought conditions experienced with the natural variability of hydrological conditions in the basin. Adverse effects

would also occur to intake access for power plants in the upper river in the fall season. Impacts to variable costs would be small under Alternative 1, with negligible variation in impacts over the period of analysis. Capacity values, because they are calculated relative to Alternative 1, are not estimated for Alternative 1.

It is possible for power reductions to occur simultaneously during peak power demand seasons when replacement power from MISO, SPP, or other markets may be scarce, potentially leading to higher prices that retail electricity providers pay for wholesale electricity, higher consumer electricity rates, and adverse impacts to regional economic conditions. The RED impacts to businesses and households are likely to be long-term and adverse relative to current conditions, although the exact impact on electricity prices (wholesale prices), consumer electricity rates, and regional economic conditions is uncertain. Electricity reliability could be adversely affected depending on the timing of the reductions, the location of power plants affected, the power generation affected, transmission line capacity, and the electricity demand. While unlikely, under certain extreme circumstances, OSE effects such as brown outs (a reduction in voltage on the power grid) or potentially rolling black outs (a complete loss of power on the power grid) could occur under Alternative 1 if multiple plants would be affected simultaneously. Alternative 1 would result in uncertain OSE effects on air quality because many of the affected plants are coal-fired plants and the fuel types for the replacement source include fossil fuels.

The construction of ESH and SWH in the Garrison reach and the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants. In addition, most of the power plants in the lower river are in urban areas where habitat would likely not be constructed.

Alternative 1 would not have significant impacts on thermal power because the Missouri River and its reservoirs would continue to provide water supply for thermal power plants over the long term; temporary adverse impacts from habitat construction would be highly localized; and adverse impacts to power generation from drought conditions are not associated with management actions under Alternative 1.

#### 3.17.2.5 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 SWH and ESH construction than would occur under Alternative 1. Impacts to thermal power NED, RED, and OSE effects would be relatively small to large and adverse from reductions in power generation in the lower river from low summer flow events and a higher prevalence of SWH. Impacts from habitat construction would be temporary, small to large and adverse from sediment affecting intakes. These impacts are further discussed in this section.

**Mechanical Habitat Construction**

A targeted 10,758 additional acres of SWH habitat would be constructed for the pallid sturgeon habitat between Ponca, Nebraska and the mouth of the river near St. Louis; an average of 3,546 acres per year of ESH would be constructed in years when construction occurs in the Garrison Dam to Lake Oahe river reach; Fort Randall Dam to Lewis and Clark Lake river reach; Gavins Point Dam to Ponca, Nebraska river reach; and Lewis and Clark Lake. The mechanical construction of significantly more SWH and ESH would have the potential to lead to more issues associated with sediment erosion and deposition affecting thermal power intakes than under No

Action. Similar to No Action, sensitive resource restrictions and buffers would minimize and attempt to avoid adverse impacts to power plants. However, because considerably more sediment would be moved under Alternative 2, the potential for adverse effects associated with silt and sediment obstructing intakes and the need to dredge around intakes would be higher under this alternative. Impacts of the habitat construction on thermal power plant intakes could range from small to large, temporary, and adverse compared to Alternative 1, depending on the proximity of the habitat sites to thermal power plants.

**National Economic Development**

Alternative 2 would result in $6.0 million in reduced energy values (i.e., replacement costs of reduced power generation) on average annually over the 15-year period of analysis when compared to No Action, a change of 11.5 percent. Most of this impact (81 percent) would occur at power plants in the lower river, where the loss in energy values over the 15-year period would increase by 16 percent. The average annual reduction in power generation is 174,000 Mwh although in some years when low summer flow events occur, there would be considerably larger reductions in power generation when compared to Alternative 1. River temperatures during the low summer flow events during the peak summer river temperatures would range from 1 to 3 degrees Fahrenheit higher than under No Action. In addition, higher river temperatures would also adversely impact energy values during non-low summer flow years compared to No Action. The higher amount of SWH and associated shallow water under Alternative 2 relative to No Action would increase river temperatures under Alternative 2. Overall, adverse impacts to thermal power plants in the lower river would be relatively large and adverse for the summers when low summer flow events would occur, causing reductions in energy values from 17 to 40 percent higher than those expected under No Action.

On average, energy values under Alternative 2 would increase in the Garrison reach relative to No Action associated with small benefits to power generation for power plants in this location. Changes in variable costs under Alternative 2 would be negligible when compared to No Action.

As evaluated, adverse impacts to plant capacity would occur if power generation were impacted during peak summer and winter seasons. Dependable capacity for power plants in the lower river would decrease by an estimated 158 MW relative to No Action. Although the lost capacity represents only 1.3 percent of nameplate capacity for all power plants in the lower river, losses in capacity values, relative to Alternative 1, would be long-term, large, and adverse with $22.0 million in recurring annual cost over the period of analysis. There would be negligible impacts to capacity values to power plants in the Garrison reach.

Modeling results indicate that reductions in power generation would typically occur during peak summer high-temperature periods when multiple plants with simultaneous power generation losses would be affected; these conditions would adversely affect the availability of replacement power, electricity prices (i.e., increase unit energy values), and costs to replace lost capacity, possibly resulting in more adverse impacts than reported here. The NED analysis for Alternative 2 is summarized in Table 3-216.

**Table 3-216. Summary of National Economic Development Analysis for Alternative 2**

| Costs | Upper River[a] | Lower River | All Locations |
|---|---|---|---|
| Effect of Adverse Conditions on Energy Values (Total over 15 years)[b] | $164,901,298 | $719,813,684 | $884,714,982 |
| Change in Energy Values from Alternative 1 (Total) | −$9,419,612 | $100,622,311 | $91,202,699 |
| Percent Change in Energy Values from Alternative 1 | −5.4% | 16.3% | 11.5% |
| Effect of Adverse Conditions on Energy Values (Average Annual) | $10,993,420 | $47,987,579 | $58,980,999 |
| Change in Energy Values from Alternative 1 (Average Annual) | −$627,974 | $6,708,154 | $6,080,180 |
| **Average Annual Variable Costs[c]** | **$32,948** | **NA** | **$32,948** |
| **Change in Annual Variable Costs from Alternative 1** | **$1,079** | **NA** | **$1,079** |
| Average Annual Reduction in Power Generation (MWh) | 424,763 | 1,207,505 | 1,632,268 |
| Percent of Reduction in Power Generation relative to Power Generation with No Adverse Conditions (MWh) (93 million MWh total) | 1.8% | 1.7% | 1.7% |
| Annual Average Change in Power Generation Reduction Compared to Alternative 1 (MWh) | −24,521 | 174,305 | 149,783 |
| **Loss in Capacity Values (Relative to Alternative 1)[d]** | **$86,338** | **$21,995,472** | **NA** |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Total) | −$8,108,347 | $430,554,385 | $422,446,038 |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Average Annual) | −$540,556 | $28,703,626 | $28,163,069 |

Note: Higher positive values represent higher costs associated with adverse river conditions, while negative values represent lower costs or higher values when compared to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach and one power plant on Lake Sakakawea.

b Energy values represent replacement costs for power generation that is reduced under adverse conditions.

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected.

d Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $136,657/MW-year (Hydropower Analysis Center 2015).

Additional results are summarized in Table 3-217 and show the difference in annual impacts to thermal power plants during years when there would be a release action or a low summer flow. The results show that the greatest adverse impacts to thermal power plants in the lower river would occur in years when there is full release and low summer flow. These impacts would occur during the summer months when relatively lower summer flows increase river temperatures. Alternatively, years that have a full release and a low summer flow result in the greatest beneficial impacts to power plants in the upper river relative to Alternative 1 because of relatively higher fall river flows.

**Table 3-217. Impacts from Flow Releases under Alternative 2 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release + Low Summer Flow a | | Partial Flow Release b | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Change in $ From Alternative 1 | | | | | |
| | Change in Losses (Best Year) | Change in Losses (Worst Year) | Change in Losses (Best Year) | Change in Losses (Worst Year) | Change in Losses (Best Year) | Change in Losses (Worst Year) |
| Lower River | $45,127,462 | $81,098,487 | $21,928,937 | $30,859,547 | $21,881,029 | $81,098,487 |
| Upper River | −$3,102,131 | −$865,977 | $86,338 | $115,031 | −$3,102,131 | $14,713,383 |

Note: Impacts include energy values, capacity values, and variable costs. Higher values represent higher costs or lost benefits for power plants; negative values indicated benefits or reduced costs relative to Alternative 1.

a Flow action and low summer flow was fully implemented in 2 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a reduction in loss or benefit compared to Alternative 1.

b Flow action was partially implemented in 22 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a reduction in loss or benefit from Alternative 1.

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. Power generation estimates for both hydropower and thermal power were compared season by season over the 15-year period (1995–2012 not including 2007, 2010, and 2011) to evaluate the potential for coupled effects to wholesale electricity prices. Under Alternative 2, the coupled effects could potentially occur during summer months and low summer flow events, which were simulated to occur under Alternative 2 in 2002 and 2003. During the low summer flow events, both hydropower and thermal power are experiencing reductions in generation during a season when demand for electricity is also typically high, which could lead to higher energy and capacity values than reported above with more adverse impacts to thermal power plants when compared to Alternative 1.

### Regional Economic Development

Alternative 2 would result in an average annual reduction in 150,000 MWH compared to Alternative 1. However, during the low summer event under Alternative 2, power generation for power plants in the SPP RTO would be reduced during the summer by up to a total of 1,754,007 MWh under the worst-case summer period, which is a 1,029,646 MWh higher reduction than under Alternative 1. This reduction in power generation under Alternative 2 represents a loss of up to 3.8 percent total generation in SPP during this summer period, 2.2 percent higher than under Alternative 1. Within the MISO RTO, power generation of all power plants during the summer months would be reduced by 3,401,385 MWh during the worst-case summer, accounting for 3.4 percent of total generation of the MISO RTO and 0.7 percent higher than Alternative 1. Table 3-218 presents the worst-case year losses in power generation along with the relative percentage these losses represent compared to total generation for each RTO by season.

The reduction in Missouri River power generation under Alternative 2, when compared to power generation under no adverse conditions, as a percent of total generation in the summer is relatively small, 3-4 percent. This reduction in generation is approximately 1 to 2 percent higher than under No Action. However, these reductions would likely occur simultaneously during high river temperatures and peak power demand season, when replacement power from MISO, SPP or other markets may be scarce (SPP pers. comm. 2016). As a result, the relatively large, but temporary, reductions in power generation would increase the price that retail electricity provider's pay for wholesale electricity, especially during low summer flow events, which could provide rationale for state regulating agencies to increase consumer electricity rates higher than under Alternative 1. The impacts to electricity rates under Alternative 2 could be long-term, relatively small to large, and adverse and would be more adverse under Alternative 2 compared to Alternative 1, although the exact impact on energy prices (wholesale prices) and consumer electricity rates is uncertain. An increase in retail electricity rates may cause households to have less disposable income to spend on other goods and services, with adverse effects on regional economic conditions. Similarly, businesses may have lower profits with less money to spend on other business expenses or labor in the region.

**Table 3-218. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 2**

| Season | SPP | MISO |
|---|---|---|
| Reduction in Power Generation under the MRRMP-EIS Alternative (MWh) | | |
| Winter | 210,013 | 5,964 |
| Spring | 88,044 | 5,538 |
| Summer | 1,754,007 | 3,401,385 |
| Fall | 219,476 | 2,801,308 |
| Percent of Power Generation Reduction as a Percent of the RTO's Generation | | |
| Winter | 0.5% | 0.0% |
| Spring | 0.1% | 0.0% |
| Summer | 3.8% | 3.4% |
| Fall | 0.3% | 1.5% |

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Coupled reductions in power generation from hydropower and thermal power plants during low summer flow events could lead to more adverse impacts to electricity rates because of simultaneous reductions in electricity generation during peak seasons. The re-occurrence of these conditions during low summer flow events would likely lead to higher wholesale electricity prices and retail electricity rates.

### Other Social Effects

There would be a greater reduction in power generation under the worst-case years under Alternative 2 within each RTO relative to No Action. In addition, electricity rates could increase more under Alternative 2 than under No Action as described in the RED analysis. The OSE impacts described under No Action would also occur under this alternative, but would likely be more adverse under Alternative 2 compared to No Action with the potential for relatively large, short-term, adverse impacts to electricity reliability. Brown outs and black outs could have health

and safety impacts from lost cooling or heating abilities, which could result in adverse impacts to children and the elderly. Additionally, the potential increase in retail electricity rates that consumers pay under Alternative 2 could adversely affect lower-income populations because a higher portion of their income would need to be spent on electricity. These impacts would be greater than experienced under No Action, and the coupled effects of thermal power and hydropower reductions could exacerbate these adverse impacts.

Under Alternative 2, both nuclear and coal-fired plants would need to reduce power generation under adverse conditions. The actual impact of the change in air emissions would be dependent on the Missouri River power plant that must reduce power generation and the fuel type of the replacement source of energy. Three of the nuclear power plants would be affected under Alternative 2, resulting in potential adverse impacts to air emissions with replacement energy likely to be from fossil-fuel sources, with more adverse impacts to air emissions than those experienced under No Action. More coal-fired Missouri River plants and power generation would be affected under Alternative 2 relative to No Action. However, because the fuel type of the replacement energy is not known, there are uncertain impacts to air emissions and air quality.

**Conclusion**

Under Alternative 2, reductions in energy values would be greater in the lower river and smaller in the upper river than under No Action. The adverse impacts in the lower river would be small in most years but would be relatively large in the summer when low summer flow events occur and higher river temperatures impact power plant operating efficiencies. This in turn will degrade the ability of power plants to discharge cooling water to meet regulatory requirements, resulting in decreased power generation. In addition, capacity would be adversely impacted by reduced power generation. Although the reduced capacity represents a small amount of nameplate capacity in the lower river, the costs to replace the lost capacity would be large, $22 million per year. There would be negligible impacts to variable costs compared to No Action.

The RED impacts to regional household and business spending as a result of changes in consumer electricity rates are likely to be long-term and adverse compared to No Action, although the exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. The potential for extreme circumstances to cause brown outs (a reduction in voltage on the power grid) or potentially rolling black outs could occur under Alternative 2 because multiple plants would likely be affected simultaneously during the low summer flow events. Although Alternative 2 would result in uncertain OSE effects on air quality, there would be more adverse impacts to air quality under Alternative 2 than under No Action because nuclear power plant generation would be impacted under Alternative 2.

The considerable amount of ESH construction in the upper river reaches and SWH in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. Although buffers around sensitive infrastructure and site-specific planning would reduce these impacts, construction activities could cause large temporary impacts to intakes located nearby where these actions are occurring because of the considerable amount of sediment being moved under Alternative 2.

Alternative 2 has the potential to significantly affect capacity values; energy values; and electricity reliability during low summer flow events.

### 3.17.2.6 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 SWH constructed under Alternative 1 (3,380 acres under Alternative 3 and 3,999 acres under Alternative 1). The spring plenary pulse under Alternative 1 does not occur under Alternative 3, resulting in slightly higher river flows than Alternative 1 in the fall in some years. Alternative 3 would result in slight benefits to power generation and energy values, with negligible changes in capacity values, variables costs, and RED and OSE impacts relative to Alternative 1. Impacts from habitat construction would be negligible to small. The impacts are further described in this section.

#### Mechanical Habitat Construction

ESH construction would include an average of 391 aces per year in years when construction occurs. Alternative 3 would result in fewer acres of IRC habitat compared to the acres of SWH under Alternative 1 (3,380 acres under Alternative 3 and 3,999 acres under No Action). Construction of IRC habitat and ESH could have some adverse impacts to thermal power plants in the Garrison reach and lower river, but similar to No Action, impacts would be negligible to small, temporary and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

#### National Economic Development

Alternative 3 would result in slight benefits compared to No Action, with an average annual increase in energy values of $1.7 million (a decrease in the loss) compared to No Action. Table 3-219 summarizes the NED analysis for Alternative 3. The bulk of the increased benefit would come from power generation increases relative to No Action in the lower river. The power plants in the lower river would experience slightly lower river temperatures under Alternative 3 compared to No Action in the summer months because of fewer acres of early life stage habitat for the pallid sturgeon, which would result in small benefits to power generation.

There would also be benefits to power generation compared to No Action in the upper river due to slightly higher river flows, with on average $366,000 higher (decreased loss in) energy values than would be experienced under No Action. Variable costs for power plants in the upper river would be slightly less than the costs incurred under No Action. Dependable capacity in the peak season in the summer would be higher for plants in the lower river and unchanged for plants in the upper river compared to Alternative 1 with negligible impacts to capacity values. Overall, there would be relatively small benefits to NED values under Alternative 3 because of small increases in river flows in the fall and slight reductions in river temperatures compared to No Action.

**Table 3-219. Summary of National Economic Development Analysis for Alternative 3**

| Costs | Upper River[a] | Lower River | All Locations |
|---|---|---|---|
| Effect of Adverse Conditions on Energy Values (Total over 15 years)[b] | $168,827,502 | $599,523,434 | $768,350,935 |
| Change in Energy Values from Alternative 1 (Total) | −$5,493,408 | −$19,667,938 | −$25,161,347 |
| Percent Change in Energy Values from Alternative 1 | −3.2% | −3.2% | −3.2% |
| Effect of Adverse Conditions on Energy Values (Average Annual)) | $11,255,167 | $39,968,229 | $51,223,396 |

| Costs | Upper River[a] | Lower River | All Locations |
|---|---|---|---|
| Change in Energy Values from Alternative 1 (Average Annual) | −$366,227 | −$1,311,196 | −$1,677,423 |
| **Average Annual Variable Costs[c]** | **$28,508** | **NA** | **$28,508** |
| **Change in Annual Variable Costs from Alternative 1** | **−$3,361** | **NA** | **−$3,361** |
| Average Annual Reduction in Power Generation (MWh) | 434,994 | 997,564 | 1,432,559 |
| Percent of Power Generation relative to Generation with No Adverse Conditions (MWh) (93 million MWh total) | 1.8% | 1.4% | 1.5% |
| Change in Average Annual Power Reduction Compared to Alternative 1 (MWh) | −14,290 | −35,636 | −49,926 |
| **Loss in Capacity Values (Relative to Alternative 1)[d]** | **$38,884** | **$275,181** | **$314,065** |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Total) | −$4,960,571 | −$15,540,218 | −$20,500,788 |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Average Annual) | −$330,705 | −$1,036,015 | −$1,366,719 |

Notes: Higher positive values represent higher costs associated with adverse river conditions, while negative values represent lower costs or higher values when compared to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach and one plant on Lake Sakakawea.

b Energy values represent replacement costs for power generation that is reduced under adverse conditions.

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected.

d Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $136,657/MW-year (Hydropower Analysis Center 2015).

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. However, the potential for coupled effects is not expected to occur as a result of any Management Plan actions under this alternative because there are generally benefits to power generation under Alternative 3 for thermal power.

### Regional Economic Development

Under Alternative 3, reductions in power generation under adverse conditions during the peak summer seasons would be slightly lower than under No Action in both RTOs (Table 3-220). Therefore, there would be a negligible change in the impacts to retail electricity rates, household and business spending and associated regional economic conditions compared to No Action.

**Table 3-220. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 3**

| Season | SPP | MISO |
|---|---|---|
| Reduction in Power Generation under the MRRMP-EIS Alternative (MWh) | | |
| Winter | 210,013 | 5,964 |
| Spring | 81,174 | 11,076 |
| Summer | 658,386 | 2,664,205 |
| Fall | 208,800 | 2,799,888 |
| Percent of Power Generation Reduction as a Percent of the RTO's Generation | | |
| Winter | 0.5% | 0.0% |
| Spring | 0.1% | 0.0% |
| Summer | 1.4% | 2.6% |
| Fall | 0.3% | 1.5% |

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

### Other Social Effects

OSE impacts would be the same as those described No Action. Impacts to air emissions would be similar to those described under No Action. Although there are some small decreases in power generation reductions under Alternative 3 relative to No Action, the impacts would be about the same as those described under No Action with uncertain impacts on air quality.

### Conclusion

Under Alternative 3, energy values would be higher in the lower and upper river than under No Action, with small benefits to power plants. The benefits would occur from slightly lower summer river temperatures in the lower river from the construction of fewer acres of early life stage habitat for the pallid sturgeon in the lower river and slightly higher river flows in the fall in the upper river. There would be negligible impacts to variable costs and capacity values compared to No Action. RED impacts to regional household and business spending and associated regional economic conditions as a result of changes to consumer electricity rates would be the same as those described under No Action, with the potential for long-term and adverse impacts relative to current rates, although the exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. OSE impacts would be the same as described under No Action. Alternative 3 would result in uncertain effects on air quality because many of the affected plants are coal-fired plants and the fuel types for the replacement source include fossil fuels.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 3 would not have significant impacts on thermal power because changes in NED, RED, and OSE impacts across all locations would be small and beneficial compared to Alternative 1 and adverse impacts from habitat construction would be temporary and localized.

### 3.17.2.7 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 SWH would also be constructed. Compared to No Action, Alternative 4 includes fewer acres of early life stage habitat for pallid sturgeon in the river below Ponca, Nebraska. Impacts to thermal power NED, RED, and OSE effects would be negligible for all plants across the Missouri River, but could be relatively small to large for a number of plants in the upper river under certain conditions. The impacts are further described in this section.

**Mechanical Habitat Construction**

ESH construction would include an average of 240 acres per year in years when construction occurs. Construction of ESH would occur in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches. Construction of IRC habitat and ESH could have some adverse impacts to thermal power impacts, but similar to No Action, there would be negligible to small, temporary and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

**National Economic Development**

Alternative 4 would result in benefits in the lower river and adverse impacts in the upper river from changes in power generation, with an average annual decrease in all locations from No Action of $105,000. The power plants in the lower river would benefit from an increase in average annual energy value of $1.6 million (a decrease in losses). In specific years and conditions, the relatively higher river flows in the summer in the lower river would reduce river temperatures in July when they are at their highest point, resulting in fewer impacts to power generation under Alternative 4 compared to No Action.

Alternative 4 would result in adverse impacts to power generation compared to No Action in the upper river, with an average annual reduction of 67,500 MWh although most of the impacts would occur in one release year when river flows fall below shut down thresholds. There would be an average annual reduction of $1.6 million or 15 percent change compared to No Action. The losses would occur in the fall after a release year as the reservoir system rebalances its storage levels. Overall, adverse impacts to power generation and energy values would be short-term and relatively small to large for the plants in the upper river. Because these reductions in power generation would likely occur during off-peak months of September, October, and November, dependable capacity would not be affected and impacts to capacity values would be negligible under Alternative 4. Variable costs for power plants in the upper river would be slightly higher than the costs incurred under No Action with a negligible average annual change of $2,654. Table 3-221 summarizes the NED impacts under Alternative 4.

**Table 3-221. Summary of National Economic Development Analysis for Alternative 4**

| Costs | Upper River[a] | Lower River | All Locations |
|---|---|---|---|
| Effect of Adverse Conditions on Energy Values (Total over 15 years)[b] | $200,499,564 | $594,590,588 | $795,090,152 |
| Change in Energy Values from Alternative 1 (Total) | $26,178,654 | −$24,600,784 | $1,577,870 |
| Percent Change in Energy Values from Alternative 1 | 15.0% | −4.0% | 0.2% |
| Effect of Adverse Conditions on Energy Values (Average Annual) | $13,366,638 | $39,639,373 | $53,006,010 |
| Change in Energy Values from Alternative 1 (Average Annual) | $1,745,244 | −$1,640,052 | $105,191 |
| **Average Annual Variable Costs[c]** | **$34,523** | **NA** | **$34,523** |
| **Change in Annual Variable Costs from Alternative 1** | **$2,654** | **NA** | **$2,654** |
| Average Annual Reduction in Power Generation (MWh) | 516,747 | 990,558 | 1,507,305 |
| Percent of Power Generation relative to Generation with No Adverse Conditions (MWh) (93 million MWh total) | 2.2% | 1.4% | 1.6% |
| Change in Average Annual Power Reduction Compared to Alternative 1 (MWh) | 67,462 | −42,642 | 24,821 |
| **Loss in Capacity Values (Relative to Alternative 1)[d]** | **$38,884** | **$275,181** | **$314,065** |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Total) | $26,801,724 | −$20,473,063 | $6,328,661 |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Average Annual) | $1,786,782 | −$1,364,871 | $421,911 |

Note: Higher positive values represent higher costs associated with adverse river conditions, while negative values represent lower costs or higher values when compared to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach and one plant on Lake Sakakawea.

b Energy values represent replacement costs for power generation that is reduced under adverse conditions.

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected.

d Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $136,657/MW-year (Hydropower Analysis Center 2015).

Additional results are summarized in Table 3-222, which shows the difference in annual impacts to thermal power plants during years when there would be a release action. The results show that the greatest adverse impact to power plants would occur in the upper river when there is a partial release due to lower fall flows in the Garrison Dam to Lake Oahe river reach. Alternatively, years that have a full spring release would have beneficial impacts to thermal power plants in the lower river relative to No Action due to relatively higher river flows during the summer months, reducing peak river temperatures.

**Table 3-222. Impacts from Flow Releases under Alternative 4 Compared to No Action**

| Reservoir or River Reach | Full or Partial Flow Release [a b] | | Year After a Full Release[c] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Change in $ From Alternative 1 | | | | | |
| | Change in Losses (Best Year) | Change in Losses (Worst Year) | Change in Losses (Best Year) | Change in Losses (Worst Year) | Change in Losses (Best Year) | Change in Losses (Worst Year) |
| Lower River | −$18,936,042 | $228,417 | −$275,181 | −$35,451 | −$18,936,042 | $2,397,952 |
| Upper River | −$2,841,893 | $26,928,110 | −$38,884 | −$38,884 | −$2,841,893 | $26,928,110 |

Note: Impacts include energy values, capacity values, and variable costs. Higher values represent higher costs or lost benefits for power plants; negative values indicated benefits or reduced costs relative to Alternative 1. Because there is only one year for the full flow and partial flow release in the period of analysis, a range was not provided for these scenarios.

a Flow action and low summer flow was fully implemented in 1 year of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a reduction in loss or benefit compared to Alternative 1.

b Flow action was partially implemented in 1 year over the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a reduction in loss or benefit from Alternative 1.

c 2 years that followed a full release year over the period of analysis.

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. Power generation estimates for both hydropower and thermal power were compared season by season over the 15-year period (1995–2012 not including 2007, 2010, and 2011) to evaluate the potential for coupled effects to wholesale electricity prices. Under alternative 4, the coupled effects could potentially occur during the fall months under conditions simulated under Alternative 4. Because the reductions in power generation from hydropower and thermal power would occur in the fall and demand for electricity is typically low during that period, there are not anticipated to be coupled effects.

### Regional Economic Development

There would be slight benefits to power generation under Alternative 4 in the lower river and increased power reductions for plants in the upper river compared to No Action. Over all locations, Alternative 4 would result in very slight benefits to power generation for plants. Within the SPP RTO, power generation reductions would be slightly less in the summer (0.2 percent) and slightly more that those described in the fall than would be experienced under No Action under the worst case season. Impacts to power generation in the fall under Alternative 4 within the MISO RTO would be small relative to the total MISO power generation and would occur during non-peak periods (Table 3-223). There would be no change in the impacts to power generation during the winter season. Because peak season summer power generation would have slight benefits under Alternative 4 and reductions in power generation in the off-peak fall period would be small in the RTOs, there would not be noticeable changes in wholesale electricity prices compared to No Action. Similar to No Action, the potential impacts to consumer electricity rates associated with higher wholesale electricity prices would be relatively long-term

and adverse relative to current rates, although the exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. There would be a negligible change in the impacts to consumer electricity rates and household and business spending and associated regional economic conditions when compared to No Action.

**Table 3-223. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 4**

| Season | SPP | MISO |
|---|---|---|
| Reduction in Power Generation under the MRRMP-EIS Alternative (MWh) | | |
| Winter | 206,225 | 4,473 |
| Spring | 81,174 | 6,646 |
| Summer | 664,610 | 2,688,962 |
| Fall | 238,270 | 2,799,888 |
| Percent of Power Generation Reduction as a Percent of the RTO's Generation | | |
| Winter | 0.5% | 0.0% |
| Spring | 0.1% | 0.0% |
| Summer | 1.4% | 2.7% |
| Fall | 0.3% | 1.5% |

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

### Other Social Effects

OSE impacts would be the same as those described under No Action. Impacts to air emissions would be negligible depending on the type of fuel in the affected plant. Impacts to air emissions would be negligible depending on the type of fuel in the affected plant. Although there would be some small decreases in nuclear power generation reductions, coal-fired plants would also be affected under Alternative 4 relative to No Action, and the impacts to air quality would be uncertain.

### Conclusion

Alternative 4 would result in benefits to power generation and energy values in the lower river and adverse impacts to power generation and energy values in the upper river when compared to No Action, with negligible changes on average across all locations. The benefits in the lower river would occur from slightly lower summer river temperatures from the construction of fewer acres of early life stage habitat for the pallid sturgeon. Adverse impacts to power generation and energy values in the upper river would be temporary and range from small to large, stemming from relatively lower river flows in the fall while reservoirs rebalance following a spring release. There would be negligible impacts to variable costs and capacity values compared to No Action. RED impacts to household and business spending and associated regional economic conditions as a result of changes to consumer electricity rates would be the same as those described under No Action because reductions in power generation under Alternative 4 in the upper river would not occur during peak periods. The OSE impacts would be the same as described under No Action. Alternative 4 would result in uncertain effects on air quality because many of the affected plants are coal-fired plants and the fuel types for the replacement source include fossil fuels.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 4 is not anticipated to have potential significant impacts on thermal power because adverse impacts to power generation to power plants in the upper river would occur during off-peak seasons and there would be beneficial impacts to power plants in the lower river.

#### 3.17.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 includes a fall release in October and November to create ESH; the fall release (full and partial) does not occur in the 15-year period of analysis, making the estimation of impacts to power plants during and following the flow releases difficult in this short period of analysis. Alternative 5 includes fewer acres of IRC habitat compared to the acres of SWH constructed under No Action in the lower river (3,380 acres under Alternative 5 and 3,999 acres under No Action). ESH construction would include an average of 309 aces per year, while No Action would result in an average of 107 acres per year in years when construction occurs. Overall, Alternative 5 would result in small benefits to power plants from slightly higher power generation and energy values and temporary negligible to small adverse impacts from habitat construction. These impacts are further described in this section.

**Mechanical Habitat Construction**

Construction of ESH would occur in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches. Construction of IRC habitat and ESH could have some adverse impacts to thermal power impacts in the Garrison and lower river reaches, but similar to No Action, the impacts would be negligible to small, temporary and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

**National Economic Development**

Alternative 5 results in beneficial impacts to NED impacts compared to No Action, with an average annual increase in power generation and energy values (decreased loss) of $1.4 million. Table 3-224 summarizes the NED analysis for thermal power plants. The Missouri River power plants in the lower river would experience an increase of $1.0 million in energy values per year when compared to energy values under No Action. The beneficial effects would be from slight reductions in peak summer river temperatures from fewer acres of early life stage habitat for the pallid sturgeon (IRC) constructed under Alternative 5. In the upper river, Alternative 5 would result in an average annual increase of $350,000 compared to No Action. Higher fall river flows would account for the small benefits in power generation and energy values relative to No Action.

Variable costs for power plants in the upper river would be slightly lower than the costs incurred under No Action with negligible change in costs compared to No Action. Alternative 5 would result in negligible impacts to capacity values.

**Table 3-224. Summary of National Economic Development Analysis for Alternative 5**

| Costs | Upper River[a] | Lower River | All Locations |
|---|---|---|---|
| Effect of Adverse Conditions on Energy Values (Total over 15 years)[b] | $169,105,674 | $603,786,958 | $772,892,632 |
| Change in Energy Values from Alternative 1 (Total) | −$5,215,236 | −$15,404,414 | −$20,619,650 |
| Percent Change in Energy Values from Alternative 1 | −3.0% | −2.5% | −2.6% |
| Effect of Adverse Conditions on Energy Values (Average Annual)) | $11,273,712 | $40,252,464 | $51,526,175 |
| Change in Energy Values from Alternative 1 (Average Annual) | −$347,682 | −$1,026,961 | −$1,374,643 |
| **Average Annual Variable Costs[c]** | **$29,336** | **NA** | **$29,336** |
| **Change in Annual Variable Costs from Alternative 1** | **−$2,532** | **NA** | **−$2,532** |
| Average Annual Reduction in Power Generation (MWh) | 435,801 | 1,004,819 | 1,440,620 |
| Percent of Power Generation relative to Generation with No Adverse Conditions (MWh) (93 million MWh total) | 1.8% | 1.4% | 1.5% |
| Change in Average Annual Power Reduction Compared to Alternative 1 (MWh) | −13,483 | −28,381 | −41,864 |
| **Loss in Capacity Values (Relative to Alternative 1)[d]** | **$38,884** | **$275,181** | **$314,065** |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Total) | −$4,669,966 | −$11,276,693 | −$15,946,659 |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Average Annual) | −$311,311 | −$751,780 | −$1,063,111 |

Note: Higher positive values represent higher costs associated with adverse river conditions, while negative values represent lower costs or higher values when compared to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach and one plant on Lake Sakakawea.

b Energy values represent replacement costs for power generation that is reduced under adverse conditions.

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected.

d Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $136,657/MW-year (Hydropower Analysis Center 2015).

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. However, the potential for coupled effects is not expected to occur as a result of any Management Plan actions under this alternative because there are generally benefits to power generation under Alternative 5 for thermal power.

### Regional Economic Development

As described above, there would be small benefits to power generation under Alternative 5 compared to No Action. Impacts to power generation within the SPP and MISO RTOs would be

very similar to those described under No Action (Table 3-225). Similar to No Action, the potential impacts to consumer electricity rates associated with higher wholesale electricity prices would be relatively long-term and adverse relative to current rates, although the exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. There would be a negligible change in the impacts to consumer electricity rates and associated regional economic conditions compared to No Action.

**Table 3-225. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 5**

| Season | SPP | MISO |
|---|---|---|
| Reduction in Power Generation under the MRRMP-EIS Alternative (MWh) | | |
| Winter | 210,013 | 2,982 |
| Spring | 81,174 | 11,076 |
| Summer | 664,610 | 2,688,962 |
| Fall | 208,800 | 2,799,888 |
| Percent of Power Generation Reduction as a Percent of the RTO's Generation | | |
| Winter | 0.5% | 0.0% |
| Spring | 0.1% | 0.0% |
| Summer | 1.4% | 2.7% |
| Fall | 0.3% | 1.5% |

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

### Other Social Effects

OSE impacts would be the same as those described under No Action. Impacts to air emissions would be negligible depending on the type of fuel in the affected plant. Although there would be some small decreases in nuclear power generation reductions, coal-fired plants would also be affected under Alternative 5 relative to No Action, and the impacts to air quality would be uncertain.

### Conclusion

Under Alternative 5, power generation would increase and energy values would be higher in the lower and upper river than under No Action, with small benefits to power plants. The benefits would occur from slightly lower summer river temperatures in the lower river from the construction of fewer acres of early life stage habitat for the pallid sturgeon and slightly higher river flows in the fall in the upper river from the fall releases. There would be negligible impacts to variable costs and capacity values compared to No Action. Impacts to consumer electricity rates and associated regional economic conditions would be the same as those described under No Action, with the potential for long-term and adverse relative to current rates, although the exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. The OSE impacts would be the same as described under No Action. Alternative 5 would result in uncertain effects on air quality because many of the affected plants are coal-fired plants and the fuel types for the replacement source include fossil fuels.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 5 is not anticipated to have potential significant impacts on thermal power because impacts to power generation would be beneficial impacts in all locations.

#### 3.17.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes a bi-modal spawning cue in March and May to benefit the pallid sturgeon. Alternative 6 includes fewer acres of IRC habitat compared to the acres of SWH constructed under No Action in the lower river (3,380 acres under Alternative 6 and 3,999 acres under No Action). However, ESH construction would include an average of 303 aces per year, while No Action would result in an average of 107 acres per year in years when construction occurs. Overall, Alternative 6 would result in some benefits to power generation and energy values and temporary negligible to small adverse impacts from habitat construction. The impacts are further described in this section.

**Mechanical Habitat Construction**

Construction of ESH would occur in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches, while IRC habitat would be constructed in the lower river below Ponca, Nebraska. Construction of IRC habitat and ESH could have some adverse impacts to thermal power plant intakes in the Garrison and lower river reaches, but similar to No Action, the impacts would be negligible to small, temporary and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

**National Economic Development**

Alternative 6 results in beneficial impacts to NED impacts compared to No Action, with an average annual increase of energy values (decrease loss) of $2.4 million compared to No Action (Table 3-226). Most of the benefit would occur in the lower river, with an annual average increase of $2.2 million, the bulk of which would occur during a simulated full release year. Alternative 6 would result in very small beneficial impacts on average to power generation at power plants in the upper river when compared with No Action, with an annual average increase in energy values of $144,000 compared to No Action. Overall, there would be relatively small benefits to power plant generation and energy values under Alternative 6 due to small increases in river flows in the fall and winter that benefit access for intake cooling water and provide lower river temperatures and increase power generation relative to No Action.

Variable costs for power plants in the upper river would be lower than the costs incurred under No Action, with negligible change in costs compared to No Action. Capacity values under Alternative 6 would be adversely affected under Alternative 6, resulting in $1.0 million in lost capacity values, with most of the impact occurring in the lower river. The adverse impacts to capacity values would occur at two plants in relatively drier years when the reservoir system is rebalancing in the year or two following a spawning cue release. Impacts to capacity values would be relatively long-term, small and adverse.

**Table 3-226. Summary of National Economic Development Analysis for Alternative 6**

| Costs | Upper River[a] | Lower River | All Locations |
|---|---|---|---|
| Effect of Adverse Conditions on Energy Values (Total over 15 years)[b] | $172,158,508 | $586,084,116 | $758,242,623 |
| Change in Energy Values from Alternative 1 (Total) | −$2,162,403 | −$33,107,257 | −$35,269,659 |
| Percent Change in Energy Values from Alternative 1 | −1.2% | −5.3% | −4.4% |
| Effect of Adverse Conditions on Energy Values (Average Annual)) | $11,477,234 | $39,072,274 | $50,549,508 |
| Change in Energy Values from Alternative 1 (Average Annual) | −$144,160 | −$2,207,150 | −$2,351,311 |
| **Average Annual Variable Costs[c]** | **$28,050** | **NA** | **$28,050** |
| **Change in Annual Variable Costs from Alternative 1** | **−$3,818** | **NA** | **−$3,818** |
| Average Annual Reduction in Power Generation (MWh) | 443,479 | 977,056 | 1,420,535 |
| Percent of Power Generation relative to Generation with No Adverse Conditions (MWh) (93 million MWh total) | 1.9% | 1.4% | 1.5% |
| Change in Average Annual Power Reduction Compared to Alternative 1 (MWh) | −5,805 | −56,144 | −61,950 |
| **Loss in Capacity Values (Relative to Alternative 1)[d]** | **$138,183** | **$915,719** | **$1,053,903** |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Total) | −$146,929 | −$19,371,465 | −$19,518,394 |
| Change in Energy Values, Capacity Values, and Variable Costs from Alternative 1 (Average Annual) | −$9,795 | −$1,291,431 | −$1,301,226 |

Note: Higher positive values represent higher costs associated with adverse river conditions, while negative values represent lower costs or higher values when compared to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach and one plant on Lake Sakakawea.

b Energy values represent replacement costs for power generation that is reduced under adverse conditions.

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected.

d Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $136,657/MW-year (Hydropower Analysis Center 2015).

Table 3-227 summarizes the difference in annual impacts to thermal power plants during years when there is a full or partial spawning cue release. The results show that the greatest benefits to thermal power plants in the upper and lower river would occur in years when there is a full release. Adverse impacts to thermal power plants would not occur in years when there is a full or partial spawning cue release but would occur in the year or two following the release.

**Table 3-227. Impacts from Flow Releases under Alternative 6 Compared to No Action**

| Reservoir or River Reach | Full Spawning Cue Release[a] (Change in $ from Alternative 1) | | Partial Spawning Cue Flow Release[b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Change in Losses (Best Year) | Change in Losses (Best Year) | Change in Losses (Best Year) | Change in Losses (Best Year) | Change in Losses (Best Year) | Change in Losses (Best Year) |
| | Change in $ from Alternative 1 | | | | | |
| Lower River | −$25,961,316 | $705,076 | $176,169 | $915,719 | −$25,961,316 | $3,038,490 |
| Upper River | −$3,542,325 | $138,183 | −$1,729,823 | $138,183 | −$3,542,325 | $5,583,161 |

Note: Impacts include energy values, capacity values, and variable costs. Higher values represent higher costs or lost benefits for power plants; negative values indicated benefits or reduced costs relative to Alternative 1.

a Full spawning cue release was fully implemented in 2 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a reduction in loss or benefit compared to Alternative 1.

b The spawning cue release was partially implemented in 7 year of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a reduction in loss or benefit from Alternative 1.

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. However, the potential for coupled effects is not expected to occur as a result of any Management Plan actions under this alternative because there are generally benefits to power generation under Alternative 6 for thermal power.

### Regional Economic Development

There would be relatively small benefits to power generation under Alternative 6 compared to No Action. Reductions in power generation under the worst-case summer would be slightly less than under No Action in both RTOs. (Table 3-228). Similar to No Action, the potential impacts to consumer electricity rates associated with higher wholesale electricity prices would be relatively long-term and adverse relative to current rates, although the exact impact on electricity prices and consumer electricity rates are uncertain. There would be a negligible change in the impacts to consumer electricity rates and business and household spending and associated regional economic conditions compared to No Action.

**Table 3-228. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 6**

| Season | SPP | MISO |
|---|---|---|
| Reduction in Power Generation under the MRRMP-EIS Alternative (MWh) | | |
| Winter | 210,013 | 5,964 |
| Spring | 81,174 | 6,646 |
| Summer | 663,170 | 2,688,962 |
| Fall | 234,415 | 2,801,308 |
| Percent of Power Generation Reduction as a Percent of the RTO's Generation | | |
| Winter | 0.5% | 0.0% |
| Spring | 0.1% | 0.0% |
| Summer | 1.4% | 2.7% |
| Fall | 0.3% | 1.5% |

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

### Other Social Effects

OSE impacts would be the same as those described under No Action. Impacts to air emissions would be negligible depending on the type of fuel in the affected plant. Although there would be some small decreases in nuclear power generation reductions, coal-fired plants would also be affected under Alternative 6 relative to No Action, and the impacts to air quality would be uncertain.

### Conclusion

Under Alternative 6, power generation would increase and energy values would be higher in the lower and upper river than under Alternative 1, with small benefits to power plants. The benefits would be small and long-term and occur from slightly lower summer river temperatures in the lower river from the full release and from the construction of fewer acres of early life stage habitat for the pallid sturgeon. There would be negligible impacts to variable costs compared to No Action, and there would be the potential for small adverse impacts to capacity values for power plants in the lower river. RED impacts to regional household and business spending as a result of changes to consumer electricity rates would be the same as those described under No Action, with the potential for long-term and adverse relative to current rates, although the exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. The OSE impacts would be the same as described under No Action. Alternative 6 would result in uncertain OSE effects on air quality because many of the affected plants are coal-fired plants and the fuel types for the replacement source include fossil fuels.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 6 is not anticipated to have significant impacts on thermal power because there would be beneficial impacts to power plants in all locations over the period of analysis and adverse impacts to capacity values would be small.

#### 3.17.2.10 Tribal Resources

There are no power plants located on Tribal lands; all Tribal members would be affected by the RED and OSE effects as described in the previous sections.

#### 3.17.2.11 Climate Change

Relatively higher river temperatures, especially during lower river flows caused by prolonged drought conditions with climate change, would adversely affect all power plants that do not have cooling towers because the relatively warmer water is not as efficient in cooling plant condensers and may result in decreases in power generation. With higher river temperatures, all power plants would have more difficulty in meeting the 90°F NPDES permit requirement. Prolonged drought conditions may also cause lower river flows to cause river stages to fall below critical intake elevations with adverse impacts to power generation and energy values. Earlier snowmelt may cause spring System storage targets to be met more frequently, increasing the regularity of spring plenary pulses under No Action, and the potential for adverse impacts associated with the subsequent lower rivers flows as the system rebalances. Adverse impacts associated with more frequent spring plenary pulses may be offset in part by higher levels of precipitation limiting the implementation of the pulse because flood targets may be exceeded more frequently. Management actions under Alternative 1 would not be substantially affected by climate change.

Impacts to power generation under Alternatives 2, 3, 4, 5, and 6 with climate change would be similar to Alternative 1. However, the influence of climate change with the low summer flow events and construction of SWH under Alternative 2 in the lower river during the summer periods would increase the adverse impacts to power plants with relatively higher river temperatures during these peak power periods, which would cause decreased power generation compared to Alternative 1. Large more sporadic rain events could adversely impact intakes and outfalls of thermal power plants affected by flooding river flows, possibly shutting plants down; climate change could exacerbate the possibility of flooding during spring or fall releases under Alternatives 2, 4, 5, and 6.

With earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses relative to Alternative 1 may result in lower river flows in the fall and winter compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Longer and lower river flows would adversely impact access to water of cooling, especially in the fall and winter months when flows are at their lowest levels.

#### 3.17.2.12 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 power generators, with market pressure to maintain generation with capital investments to maintain and increase capacity. In addition, fuel costs for power plants, including the price of coal and natural gas, would have both

adverse and beneficial impacts on utilities and power plants, which would affect operating costs, RTO wholesale electricity prices, and potentially retail electricity rates. Costs to maintain operations and power generation, and for replacement power would result in temporary and long-term adverse impacts to utilities, power plants, and potentially consumers of electricity.

The EPA has proposed five recent rules that would affect Missouri River thermal power plants, including: the Clean Power Plan; Mercury and Air Toxics Standards (MATS); the Cross-State Air Pollution Rule (CSAPR); the Coal Ash Rule; and the Cooling Water Intake Structures Rule. The first three rules pertain to limiting air pollutants from coal-fired power plants including carbon dioxide, sulfur dioxide, nitrous oxide, mercury, hydrogen fluoride, and hydrogen chloride. Implementation of these rules could require additional pollution control equipment to reduce power plant emissions from coal-fired power plants. The Coal Ash Rule would require coal-fired power plants to close surface ash impoundments and dispose of ash in regulated landfills. The Cooling Water Intake Structures Rule would require plants with once through cooling technologies to use best technologies available for their cooling systems, which may force power plants to construct cooling towers to or construct intake structures to limit potential impacts to fish and other aquatic organisms from entering cooling water intakes. Utilities may choose to retire power plants rather than comply with the rules because it may not be cost effective to undertake costly investments.

The MISO RTO is anticipating that a number of power plants would retire or suspend operations as soon as the year 2018, resulting in a reduction of 1.8 GW of generation in southern Illinois, which would reduce capacity below the minimum required reserve margin levels and the ability of the RTO to meet load demands (MISO 2016). This could put pressure on the remaining power plants in the RTO to maintain power generation even in adverse conditions, especially during peak periods.

Past, present, and future actions that would affect bed degradation or aggradation of the Missouri River, such as water depletions or withdrawals for agriculture, municipal, and industrial uses, have had and would continue to have adverse impacts to thermal power plants as they could affect the volume of water in the river. Actions that affect bed degradation, such as dredging in the lower river, could impact the stability of the intake and outfall infrastructure of the power plant and reduce the ability of the plant to access water for cooling. Actions that affect aggradation, such as floodplain development and habitat construction, could impact sediment and/or silting in intakes or outfalls. These types of actions would result in long-term, adverse impacts to power plants and may require power plants to incur operating and maintenance costs or undertake capital investments to modify intakes and/or dredge sediment. It could also cause plants to curtail or shut down generation if they would no longer have access to water from the Missouri River.

In general, impacts to thermal power generation under No Action would be adverse under some conditions, primarily in the lower river, when power plants are susceptible to higher river temperatures in the summer and early fall during relatively drier conditions. These conditions can cause reductions in power generation due to reduced power plant operating efficiencies and water quality regulations. Because peak season power generation would be affected under No Action, there could be adverse impacts to consumer electricity prices over time, regional economic conditions, and the potential for large temporary adverse impacts to electricity reliability.

When combined with other past, present and reasonably foreseeable future actions, the cumulative impacts associated with No Action would be both beneficial and adverse although in

the long-term would likely be adverse. Although power plants would continue to provide essential electricity to MISO and SPP RTOs, they would be adversely impacted by climate, air quality, water quality, and other environmental regulations, natural cycles of drought, higher fuel costs, and actions that affect bed degradation and aggradation. Natural wet hydrologic periods along with actions such as bank stabilization activities and levee construction and maintenance activities would provide some benefits to power plants but these activities are small in comparison with the potentially large adverse impacts of pending and current environmental regulations, fuel costs, and natural drought periods. The continued implementation of No Action would provide a negligible contribution to these cumulative impacts.

Alternative 2 would result in large adverse impacts to power plants and power generation, including impacts to energy and capacity values, retail electricity rates and associated regional economic conditions, and electricity reliability. The largest adverse impacts, compared to No Action, would occur in the lower river, associated with higher temperatures during low summer flow events and from the construction of more SWH. When combined with other past, present and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 2 would be long-term, large and adverse. Management actions under Alternative 2 would contribute large adverse impacts to the cumulative impacts to thermal power plants, especially to power plants in the lower river where low summer flow events and SWH would be created.

The impacts of Alternative 3 would result in relatively small beneficial impacts to energy and capacity values because of small increases in river flows in the fall and very slight reductions in river temperatures compared to Alternative 1. Alternative 3 would result in negligible changes in RED and OSE relative to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3 would be similar to those described for Alternative 1. Power plants would continue to be adversely impacted by climate, air quality, water quality, and other environmental regulations, potentially higher fuel prices, natural cycles of drought, and actions that affect bed degradation and aggradation. Management actions of Alternative 3 would provide a negligible contribution to cumulative impacts to thermal power plants.

There would be small to large and temporary adverse impacts to power plants under Alternative 4, compared to No Action, in the upper river because of reductions in river flows in the fall following a spring release as the reservoir system rebalances. Power plants in the lower river would experience some benefits to power generation under Alternative 4 if Gavins Point releases continue in the summer months, reducing peak summer temperatures. Overall, impacts of Alternative 4 would result in negligible changes to energy and capacity values, retail electricity rates and associated regional economic conditions, and electricity reliability compared to No Action. When combined with other past, present, and reasonably foreseeable future actions, the impacts of Alternative 4 would be similar to those of No Action. Alternative 4 would provide a negligible contribution to these cumulative impacts.

Under Alternative 5, there could be small long-term beneficial impacts to energy and capacity values relative to No Action because of higher river flows in the fall in the Garrison Dam to Lake Sakakawea reach and lower peak summer river temperatures in the lower river. However, a fall release during the period of analysis did not occur, making the estimates of the effects uncertain. Alternative 5 would result in negligible changes in RED and OSE relative to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 5 would be similar to those described for No Action. Alternative 5 would provide a negligible contribution to these cumulative impacts.

Under Alternative 6 there would be small benefits to power plant generation and energy values because of small increases in river flows in the fall and winter that benefit access for intake cooling water and provide lower river temperatures, compared to No Action. Capacity values would experience small adverse impacts to plants in the lower river with approximately $1 million per year compared to Alternative 1. Alternative 6 would result in negligible changes to RED and OSE relative to No Action. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 would be similar to those described for No Action. Power plants would continue to be adversely impacted by climate, air quality, water quality, and other environmental regulations, natural cycles of drought and associated management actions, potentially higher fuel prices, and actions that affect bed degradation and aggradation. Alternative 6 would provide a negligible contribution to these cumulative impacts.

# 3.18 Water Supply

## 3.18.1 Affected Environment

Water is withdrawn from the Missouri River and its mainstem lakes for multiple purposes including municipal, industrial, and commercial water supply as well as domestic and public uses. Municipal water supply includes Tribal and public supply of water to reservations, residents of cities and towns, and customers of rural water districts and associations. The larger municipal water supply intakes are located in the river segments below Gavins Point Dam and serve major urban areas including Omaha, Kansas City, and St. Louis. Most of the smaller municipal water supply intakes and rural water districts are located on the lakes and the river reaches above Gavins Point Dam. The large municipal and industrial intakes are permanent/fixed structures associated with large facilities that also treat the raw water. The large intakes typically operate full-time whereas some of the small intakes operate part-time especially during the winter months. Treated water is provided for drinking water and other household uses, as well as, for businesses and industries. Water is withdrawn from the river and reservoirs and sent to water treatment facilities. Following treatment, the supply is sent to the various water systems for distribution to users. Most municipalities located on the river or reservoirs have limited or no alternative sources of water other than the Missouri River. Some have existing wells that serve only as backup systems whereas others can store a limited volume of water for use.

Commercial and industrial use includes self-supplied water for commercial, manufacturing, and other processing uses other than thermal power use. The Missouri River and reservoirs also supply water to domestic and public users. Most domestic intakes are portable and provide water to one household and are sometimes used for drinking water but more often for other domestic uses such as small lawn or garden irrigation, stock watering, or washing cars, with many only used seasonally. Public water supply intakes typically provide water for fish and wildlife uses and recreation such as parks and golf courses. Municipal, commercial, and industrial intakes are the focus of the water supply analysis as these intakes tend to be larger and at a fixed location and are unable to adjust to changing river conditions and are more likely to be impacted by MRRMP-EIS alternatives. Table 3-229 presents the distribution of water supply intakes by location along the Missouri River.

**Table 3-229. Number of Water Supply Intakes by River/Reservoir Location**

| River/Reservoir Reach | Intakes | | | |
|---|---|---|---|---|
| | Municipal | Commercial/ Industrial | Domestic | Public |
| Fort Peck Lake | 1 | 0 | 101 | 2 |
| Fort Peck Dam to Lake Sakakawea | 4 | 0 | 162 | 1 |
| Lake Sakakawea | 9 | 1 | 228 | 11 |
| Garrison Dam to Lake Oahe | 1 | 1 | 28 | 3 |
| Lake Oahe | 8 | | 21 | 8 |
| Oahe Dam to Lake Sharpe | 1 | 0 | 0 | 0 |
| Lake Sharpe | 3 | 0 | 19 | 2 |
| Lake Francis Case | 5 | 0 | 4 | 3 |

| River/Reservoir Reach | Intakes | | | |
|---|---|---|---|---|
| | Municipal | Commercial/ Industrial | Domestic | Public |
| Fort Randall Dam to Lewis and Clark Lake | 0 | 0 | 0 | 0 |
| Lewis and Clark Lake | 2 | 0 | 6 | 2 |
| Gavins Point Dam to Rulo, Nebraska | 4 | 1 | 10 | 8 |
| Rulo, Nebraska to the Mouth of the Missouri River | 14 | 0 | 0 | 4 |
| **Total** | **52** | **3** | **579** | **44** |

Sources: USACE 2015c, 2006a; USACE and USFWS 2012; Personal communication with water supply intake managers and operators

There are an estimated 52 municipal intakes and three commercial/industrial water supply intakes on the reservoirs and river reaches of the Missouri River mainstem. Approximately 3.2 million people are served by Missouri River municipal water supply intakes and associated facilities. Several Tribes are served by water supply intakes along the Missouri River including the Assiniboine and Sioux, Three Affiliated, Standing Rock Sioux, Cheyenne River Sioux, and lower Brule Sioux. The Mni Wiconi Pipeline project supplies water to several reservations that are not located on the Missouri River including the Oglala Sioux Tribe and Rosebud Sioux Tribe.

There are an estimated three commercial/industrial water supply intakes operating along the Missouri River, two in North Dakota and one in Iowa (USACE 2015c; USACE 2006a; USACE 2012; Personal communication with water supply intake managers and operators, November 2015 through March 2016). The North Dakota intakes are the Great Plains Synfuels and Blue Flint Ethanol Refinery. Terra International (CF Industries) is located in Iowa.

**Interaction of River Conditions and Water Supply Intakes**

Water supply for municipal and industrial/commercial uses along the Missouri River can be affected by conditions such as river flows and stages, reservoir water surface elevations, river water chemistry including sediment, and channel locations. Changes to these physical components, in turn, lead to changes in the interrelated water supply conditions of access to water, operation and maintenance, and water treatment requirements. Although sediment is not a focus of the impact analysis, the effects of sediment on water supply intakes and operation was mentioned by several water supply intake managers; therefore, discussion was included to provide a complete description of the intakes.

### 3.18.1.1 Access to Water

Access to water is vital to the operations of water supply intakes. The ability of the water supply intakes to access water is typically affected by the river flow or river/reservoir elevation, the amount of sediment in the water and around the intake and, less frequently, by the presence of ice. Each water supply intake typically has a minimum elevation necessary for normal operation as well as a critical shutdown elevation. River or reservoir conditions above the minimum flow/elevation allow for the unimpeded pumping of water or free-flow of water through the intake. However, when the conditions are below the minimum flow/elevation, the ability for free-flow or pumping becomes more difficult requiring additional measures as discussed in the “Operations, Maintenance, and Modifications” section. An intake cannot access water when the

elevation falls below the intake screen. Suspended sediment can clog intake screens and impede the withdrawal of water through the intake. Depending on the position of the screen, ice can build up or be pulled through the intake. If sediment and ice issues do occur, it is usually during periods of low flow/elevation or during conditions specific to a site (e.g., wind). Permanent water supply intakes have been built at specific elevations and locations to access river and reservoir water. If access to river water is decreased or interrupted, permanent intakes would require more effort (i.e., labor, cost, infrastructure modification, etc.) to ensure continued water withdrawal compared to portable intakes.

Table 3-230 contains the estimated range of flows and elevations associated with operating and shutdown conditions for municipal and commercial/industrial water supply intakes on the Missouri River. There is a wide range of threshold values due to the specific river channel geometry at each intake location, the location and elevation of each intake within the river channel, and the differences in intake infrastructure used during operation.

**Table 3-230. Range of Flow and Elevations Associated with Municipal and Commercial/Industrial Water Supply Intakes**

| | Water Surface Elevation (feet NAVD88) | |
|---|---|---|
| | **Operating** | **Shutdown** |
| Above Gavins Point Dam | 2160–1194 | 2160–1192 |
| Below Gavins Point Dam | 1055–411 | 1049–407 |

Sources: USACE 2015c; USACE 2006a; USACE 2012; Personal communication with water supply intake managers and operators, November 2015 through March 2016.

### 3.18.1.2 Water Quality and Water Treatment

Water quality is important to municipal and commercial/industrial water supplies because it can affect the level of treatment required to provide potable water for various needs. Various treatment requirements, processes, and associated costs are necessary to protect public health by limiting the levels of contaminants, pollutants, and other undesirable characteristics in drinking water. The Safe Drinking Water Act of 1974 established the basic framework for protecting drinking water used by public water systems in the United States. The EPA sets the national standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. The amount and type of treatment applied to drinking water can vary greatly depending on the quality of the source. Water suppliers use one or a combination of treatment processes to remove contaminants from drinking water including flocculation and sedimentation, filtration, ion exchange, absorption, and disinfection (USEPA 2004). Monitoring ensures that treated water complies with federal and state or Tribal standards. Changes in the level of river sediment concentration and in the size of suspended sediment particles can affect the level of treatment, operations, and maintenance activities required for water supply needs.

### 3.18.1.3 Operations, Maintenance, and Modifications

Physical and chemical river conditions described above influence operational and maintenance activities and associated operational, maintenance, and capital costs. Low flows or low pool elevations can affect the efficiency of intake pumping operations and can require operational shutdown if water levels are too low. Inadequate access to water requires intake operators to

alter operations and/or modify their intake structures. Intakes can be extended or pumping operations modified. Other modifications include installation of new pumps or a new intake or screen, modification of the intake screen position, enhanced connections to other water providers for emergency supplies, temporary modifications of intakes, or drilling of a well for an alternative water source. Ice deflectors can be installed to prevent water access issues from ice jams. Changes or extreme fluctuations to river stages would require pumps to be reset. Frequent disruptions in water supply due to access issues may cause the intakes to modify the intake structures and/or invest in substitute water sources.

Transport of sediment during high flows and sedimentation during low flows can affect operations and maintenance in various ways. Increased suspended sediment or bed load material can clog screens and settle around the intakes reducing their pumping efficiency and cause instability to the intake structure. This situation would require increased maintenance efforts such as cleaning and restabilization to allow for reliable access to water and efficient pumping. The deposition of sediment around an intake structure can be beneficial by providing support and stability whereas too little sediment could adversely affect the structural integrity of the intake. Algal blooms and sedimentation could lead to increased water treatment costs. Extreme situations require the replacement of equipment or the shutdown of an intake or associated water treatment facility.

Flow or elevation requirements for water supply intakes are based partially on the changes to operations, maintenance, or modifications that would be necessary if the requirements are not met. If the elevation falls below the operating elevation, the intake begins to require more than “normal” measures in order to operate, in the form of increased pumping or operations, maintenance, and water treatment. The shutdown elevation is the point at which the intake is no longer operable or can no longer function without damaging the infrastructure.

## 3.18.2 Environmental Consequences

Alternative means of achieving species objectives are evaluated for their effects on access to water supply. The alternatives evaluated include management actions with potential to affect river flows, channel form, and river stage. The water supply 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 water supply access and costs. This section summarizes the water supply impacts assessment methodology and presents the results of the assessment.

### 3.18.2.1 Impact Assessment Methodology

The impacts to water supply access and costs are evaluated using three of the four accounts (NED, RED, and OSE). The analysis focuses on the costs to water supply operations to adapt to changing river and reservoir conditions. The costs estimated for each management plan alternative are compared to the costs incurred under Alternative 1 (No Action).

As river flows and reservoir elevations fall below minimum operating requirements, intakes are unable to access water for municipalities, Tribes, commercial operations, and others. This in turn can drive changes in costs to operate water supply intakes. The analysis used outputs from the HEC-RAS and HEC-ResSim Missouri River models to simulate river and reservoir operations over an 82-year POR. The impact analysis first determined the operating and shut-down thresholds for each water intake. Model simulations were used to determine how many days each intake would be below each threshold annually under the respective alternative. The

analysis focuses on 55 municipal and commercial intakes used for water supply along the river from Montana to Missouri that were determined to be operable during the MRRMP-EIS study period (2017 to 2067). These fixed intakes are likely to realize any impacts that may occur from the MRRMP-EIS alternatives and are representative of the impacts that may occur to other intakes.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

**National Economic Development**

The NED analysis calculated the change in costs from changes in access to water from the Missouri River. An Excel®-based model was developed that estimated the costs to access water under each alternative. The NED analysis for water supply access focuses on the change in variable and fixed costs to municipal and commercial water facilities. A detailed description of the NED analysis including data sources and assumptions can be found in the “Water Supply Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**Regional Economic Development**

The RED analysis for water supply was based on the results of the NED analysis. The NED analysis showed small changes in costs to access water from the Missouri River under each of the MRRMP-EIS alternatives relative to Alternative 1. Although there are measureable differences in costs between alternatives, these differences are not large enough to result in measurable RED impacts through rate changes. Therefore, any RED affects are discussed qualitatively.

**Other Social Effects**

Changes in water supply access have a potential to cause other types of effects on individuals and communities which are analyzed under the OSE account. The OSE analysis for water supply relied on the results of the NED and RED analysis to determine the scale of impacts that could occur to individual and community well-being, access to safe water sources, and economic vitality. Although there are measureable differences in costs between alternatives, these differences are not large enough to result in measurable OSE impacts. Impacts of the alternatives on OSE are discussed qualitatively.

#### 3.18.2.2 Summary of Environmental Consequences

The environmental consequences relative to water supply are summarized in Table 3-231. The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the

potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

**Table 3-231. Environmental Consequences Relative to Water Supply**

| 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 water supply intakes. |
| Alternative 1 | Average Annual Costs: $376,000.<br>Range of Annual Costs: ($46,700 to $1.5 million).<br>Long-term adverse impacts would occur mainly from the variability in hydrology and change in hydrologic conditions over the period of analysis. | Intake improvements may result in increases in water utility rates to customers. | Negligible OSE impacts. | Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction. |
| Alternative 2 | Change in Average Annual Costs: $4,671 or 1.2%.<br>Small short-term, adverse impacts would occur in the late fall and winter months in certain years. | Negligible change in RED impacts. | Negligible OSE impacts. | Potential for large, short-term, and adverse impacts to water supply intakes located in reaches where the habitat construction would take place. |
| Alternative 3 | Change in Average Annual Costs: −$4,000.<br>Small, beneficial impact with an elimination of the spring pulse. | Negligible change in RED impacts. | Negligible OSE impacts. | Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction. |
| Alternative 4 | Change in Average Annual Costs: $12,800.<br>Small, adverse impact on water supply intakes which occur in the late fall and winter months in certain years. | Negligible change in RED impacts. | Negligible OSE impacts. | Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction. |
| Alternative 5 | Change in Average Annual Costs: −$1,400.<br>Small, beneficial impact on water supply intakes. Some years show adverse impacts likely due to system rebalancing. | Negligible change in RED impacts. | Negligible OSE impacts. | Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction. |

| Alternative | NED Impacts | RED Impacts | OSE Impacts | Other Impacts |
|---|---|---|---|---|
| Alternative 6 | Change in Average Annual Costs: $7,800.<br>Small, temporary, and adverse impact on water supply intakes, which are likely indirect impacts of the pulses when the system is rebalancing. | Negligible change in RED impacts. | Negligible OSE impacts. | Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction. |

### 3.18.2.3 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 have any impacts on water supply intakes along the Missouri River.

### 3.18.2.4 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 and a spring plenary pulse or a bi-modal spring plenary pulse. These actions will 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. Only intakes in these reaches would be impacted. Impacts of the spring plenary pulse are evaluated below.

Consistent water supply for communities requires intakes to be submerged in the water at all times and at the same time does not get buried by sediment deposits. Water supply intakes are thus affected from the variability in hydrology and change in hydrologic conditions over the period of analysis as well as aggradation and degradation processes (see Section 3.2 “River Infrastructure and Hydrologic Processes”). The POR is characterized by substantial variability in hydrologic conditions which includes periods of drought (i.e., 1930s) and high runoff. This variation results in substantial variability in impacts to water supply intakes in the basin which can be adverse or beneficial depending on the conditions at the site of the intake.

Modeling results for Alternative 1 indicate that water supply intakes, if they were to remain at existing elevations, would experience long-term, adverse impacts under continuation of current system operations. These impacts would be due to frequent instances when water surface elevations fall below critical operating thresholds (operating and shut-down). The modeling results show that 33 of the 55 intakes would experience on average 57.1 days when water surface elevations would fall below operating thresholds. In addition, 21 of the 55 intakes would experience on average 14.7 days when water surface elevations are below shut-down elevations under Alternative 1. These impacts are occurring in both the upper and lower river and along riverine areas as well as reservoirs, although the drivers of these impacts varies by location. For intakes in the upper river located on the reservoirs, impacts appear to occur most often during extended drought periods like those of the 1930s when reservoir storage levels fall to a point where releases have been reduced to non-navigation support. Intakes in the lower river located in riverine stretches appear to be affected most directly from bed degradation issues.

System operations under Alternative 1 would be the same as the current operations. However, as described in Section 3.1, Introduction, the impacts modeled do not account for the ability of water management to adapt to changing conditions on the system to serve authorized purposes, such as water supply. It also does not account for what activities may be implemented in the future relative to bed degradation which may be influencing model results. This is because the 2012 river geometry used in HEC-RAS modeling reflects a level of bed degradation that was not present in prior years included in the POR analysis. These impacts are discussed in more detail in Section 3.2 “River Infrastructure and Hydrologic Processes.” Given the frequency and duration of these periods where water surface elevations fall below critical operational thresholds, it is likely that water supply operators would need to make intake improvements, modifications, or relocation to adapt to changing conditions along the river.

Management actions associated with habitat construction have the potential to impact access to water supply. In particular, management actions focused on mechanical construction of ESH and SWH, have the potential to disrupt water supply operations. For instance, constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in aggregation segments of the river. This can result in increased maintenance issues to water supply intakes in areas of aggradation (USACE 2011).

While the construction of habitat using similar means is common across all alternatives, the location and magnitude of these actions varies by alternative. The extent of these impacts would be dependent on where the MRRMP-EIS actions would occur relative to any water supply intakes. The potential impacts of ESH on infrastructure such as water supply intakes was evaluated in the *Final Programmatic Environmental Impact Statement for Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011). The PEIS noted that in order to mitigate impacts of habitat creation, USACE would identify sensitive resource categories and subsequent restrictive or exclusionary zones associated with these resources. These practices would continue to occur. Site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources. Intakes and other infrastructure were one of the categories of sensitive resources. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases which would identify approaches to mitigate impacts associated with these actions on water supply intakes. With these restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, localized, temporary, and adverse and limited to intakes near the site of habitat construction.

**National Economic Development**

Under Alternative 1, several of the water supply intakes would experience long-term, adverse impacts. The project team did not attempt to evaluate the cost of intake modifications that may occur due to bed degradation or prolonged drought conditions. Instead the NED analysis focused on actions that water supply operators can take to adapt to small, less frequent changes in river flows and reservoir elevations under the MRRMP-EIS alternatives such as using different-sized portable submersible pumps. In order to compare the MRRMP-EIS alternatives to Alternative 1, this same approach of using submersible pumps to adapt to periods of low water surface elevations was used in the NED analysis for Alternative 1. The NED analysis looks at the costs of using portable, submersible pumps under Alternative 1 to adapt to more frequent periods when water surface elevations are below critical water supply intake thresholds.

The NED analysis for Alternative 1 is summarized in Table 3-232. Water supply intake operators along the Missouri River would incur on average annual costs of over $376,000 to adapt to changing conditions of the river. Average costs would be higher in the lower river than in the upper river in part due to the size of the intakes which require larger pumps to move the required amount of water to the intake than for intakes in the upper river. In addition, more intakes in the lower river would be impacted (days below critical thresholds) than in the upper river under this alternative. Total annual costs for all intakes would range from a low of just under $46,000 to over $1.5 million.

**Table 3-232. Summary of National Economic Development Analysis for Alternative 1**

| Costs | Upper River | Lower River | All Locations |
|---|---|---|---|
| Total Variable Costs (82-year POR) [a] | $6,896,6587 | $20,048,888 | $26,945,546 |
| Total Fixed Costs (82-year POR) [b] | $1,377,150 | $2,514,089 | $3,891,239 |
| Total Costs (82-year POR) | $8,273,808 | $22,562,977 | $30,836,785 |
| Annual Average Total Costs | $100,900 | $275,158 | $376,058 |
| Annual Average Total Costs per Intake | $2,803 | $14,482 | $6,837 |
| Maximum Annual Costs | $241,931 | $1,336,463 | $1,535,664 |
| Minimum Annual Costs | $36,748 | $0 | $45,729 |

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

### Regional Economic Development

The RED analysis for water supply intakes focuses on the potential for local customers to realize an increase in rates due to changes in operations. Under Alternative 1, some water supply operations would consider making capital investments for intake modifications to adapt to changing river conditions. The NED analysis showed that on average water supply operations would incur just over $6,800 per year to adapt to changing conditions along the river and reservoirs using submersible pumps. For intakes in the lower river, costs would increase to $14,500 per year per intake. For many of the larger facilities these average annual cost increases would be a small percentage of annual operating budgets that can exceed $100 million. However, smaller facilities may realize costs increases associated with use of submersible pumps that may result in an increase in rates to account for increases in operating costs.

### Other Social Effects

Changes in access to water supply have the potential to cause other types of effects on individuals and communities such as community well-being, access to safe water sources, and economic vitality. While water supply intakes are expected to experience long-term, adverse impacts under Alternative 1, OSE would be negligible. Adverse impacts under Alternative 1 can be described as increased frequency and duration of periods of inaccessibility to water. However, there are not instances with individual intakes where access is completely eliminated. These impacts are likely to result in increased costs and possible subsequent rate increases;

however, OSE including community well-being, economic vitality and public health and safety are not expected under Alternative 1.

**Conclusion**

Consistent water supply for communities requires that intakes be submerged in the water at all times and at the same time does not get buried by sediment deposits. Water supply intakes are thus affected from the variability in hydrology and change in hydrologic conditions over the period of analysis and aggradation and degradation processes. Modeling results for Alternative 1 indicate that water supply intakes, if they were to remain at existing elevations, would experience long-term, adverse impacts under continuation of current operations. These impacts would be due to frequent instances when water surface elevations fall below critical operating thresholds (operating and shut-down). It was estimated that water supply intake operators along the Missouri River would incur on average annual costs of over $376,000 to adapt to changing conditions of the river. Total annual costs for all intakes would range from a low of just under $45,700 to over $1.5 million. Under Alternative 1, some water supply facilities would likely consider making capital investments associated with intake modifications to adapt to changing conditions. These cost increases have the potential to lead to an increase in rates although the magnitude of the rate increases is unknown; however, OSE including community well-being, economic vitality, and public health and safety are not expected under Alternative 1.

Management actions focused on mechanical construction of ESH and SWH have the potential to disrupt water supply operations. Constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in aggregation segments of the river. With site selections restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, localized, temporary, and adverse and limited to intakes near the site of habitat construction and thus management actions implemented under Alternative 1 would not have significant impact to water supply access.

#### 3.18.2.5 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 have impacts to water supply intakes include a spring pallid sturgeon flow release; low summer flow; and construction of SWH and ESH habitat.

Under Alternative 2, impacts to water supply access would be relatively small, short-term, and adverse relative to Alternative 1. These impacts would be due to more frequent, short durations (a few days) when water surface elevations fall below critical operating thresholds (operating and shut-down) for water supply intakes relative to Alternative 1. The modeling results show that 33 of the 55 intakes would experience a slight increase in the average number of days (58.7) when water surface elevations would fall below operating thresholds under Alternative 2. In addition, 22 of the 55 intakes would experience on average 14.4 days when water surface elevations are below shut-down elevations under Alternative 2. While on average these impacts would be small in nature, there would be some years when access to water supply, especially in the lower river, would experience larger impacts. The impacts are discussed in more detail below.

### Mechanical Habitat Construction

Habitat construction actions would be focused in the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for SWH. Because of the substantial amount of habitat that would be constructed under this alternative, there would be the potential for large, short-term, and adverse impacts to water supply intakes. These impacts would be limited to those that are located in the reaches where the habitat construction would take place.

### NED Analysis

The NED Analysis for Alternative 2 is summarized in Table 3-233. Water supply operations along the Missouri River would incur on average $3800,000 per year to adapt to changing conditions of the river. Total annual costs range from $51,000 to $1.5 million. This represents an overall increase in costs to water supply intakes of 1.2 percent over Alternative 1.

**Table 3-233. Summary of National Economic Development Analysis for Alternative 2**

| Costs | Upper River | Lower River | All Locations |
|---|---|---|---|
| Total Variable Costs (82-year POR) [a] | $7,013,257 | $20,225,598 | $27,238,856 |
| Total Fixed Costs (82-year POR) [b] | $1,405,416 | $2,575,540 | $3,980,956 |
| Total Costs (82-year POR) | $8,418,673 | $22,801,138 | $31,219,811 |
| Difference in Total Costs from Alternative 1 | $144,865 | $238,161 | $383,026 |
| Percentage Difference from Alternative 1 | 1.8% | 1.1% | 1.2% |
| Annual Average Total Costs | $102,667 | $278,063 | $380,729 |
| Difference in Annual Average Costs from Alternative 1 | $1,767 | $2,904 | $4,671 |
| Difference in Annual Costs per Intake | $49 | $153 | $85 |
| Maximum Annual Costs | $244,829 | $1,337,273 | $1,537,929 |
| Minimum Annual Costs | $36,976 | $7,459 | $51,100 |

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

When evaluating the impacts of each MRRMP-EIS alternative, annual impacts as well as those that would occur on average were examined. The annual analysis shows that access to water supply in the lower river dominate the overall NED impacts. In three of the 82 years in the POR, modeling results show that water supply intakes in the lower river would experience costs greater than $100,000 above those experienced under Alternative 1. However, these same locations would experience a decrease in costs to access water relative to Alternative 1 of greater than $100,000 in five years of the 82-year POR. Water supply access in the upper river, including Tribal intakes, would experience smaller impacts under Alternative 2 than in the lower river. The difference in costs from Alternative 1 for intakes in the upper river ranged from −$17,000 to $23,000.

Additional modeling results are summarized in Table 3-234, which shows the difference in annual costs to water supply during years when there is a release action or a low summer flow.

The results show that the greatest impacts to intakes in the lower river would occur in years when a release was eliminated or a natural release occurs. These impacts would occur during the winter or fall months when flows tend to be at their lowest levels in the lower river. Alternatively, years that have a full release and a low summer flow would result in some of the greatest beneficial impacts to water supply access in the lower river relative to Alternative 1.

Table 3-234 also summarizes the impacts by flow type for intakes in the upper river for Alternative 2 relative to Alternative 1. There are less conclusive results of impacts to water supply access in the upper river, with all types of releases showing impacts. However, the impacts would be much smaller than for intakes in the lower river. The increase in costs to access water in the upper river would be relatively small with the largest increase in costs of approximately $23,000 for all 36 intakes located in the upper river.

**Table 3-234. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release + Low Summer Flow [a] (Change in $ from Alternative 1) | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change |
| Lower River | −$207,000 | $90,000 | −$57,000 | $141,000 | −$207,000 | $141,000 |
| Upper River | −$736 | $7,700 | −$17,000 | $23,000 | −$17,000 | $23,000 |

a Flow action would be fully implemented in 10 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action would be partially implemented in 45 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

### Regional Economic Development

It is anticipated that Alternative 2 would have negligible RED impacts. Under Alternative 2, a number of water supply facilities would likely realize an increase in costs associated with changing river conditions, especially on the lower river. While these cost increases have the potential to result in an increase in rates it is anticipated that these rate increases would be small. Rate increases for water supply intakes in the upper river are not expected due to the small increases in costs predicted under Alternative 2.

### Other Social Effects

On average water supply intakes are expected to experience short-term, relatively small, and adverse impacts under Alternative 2 and it is not expected that OSE will occur. Adverse impacts under Alternative 2 can be described as increased frequency and duration of periods of inaccessibility to water relative to Alternative 1. These impacts are likely to result in increased costs; however, OSE including community well-being, economic vitality, and public health and safety are not expected under Alternative 2.

### Conclusion

Under Alternative 2, water supply intakes would experience relatively small, short-term, and adverse impacts relative to Alternative 1. These impacts would be due to more frequent, short durations (a few days) when water surface elevations fall below critical operating thresholds (operating and shut-down) for water supply intakes relative to Alternative 1. On average, water supply intakes along the Missouri River would incur an additional $4,700 (1.2%) per year to adapt to changing conditions of the river under Alternative 2. While on average these impacts are small in nature there are some years when water supply intakes, especially in the lower river, would experience larger impacts. The greatest impacts to water supply in the lower river would occur in years when there is a full release. These impacts would occur during the winter or fall months when flows tend to be at their lowest levels in the lower river. It is anticipated that Alternative 2 would have negligible RED and OSE impacts.

Habitat construction actions would be focused in the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for SWH. Because of the substantial amount of habitat that would be constructed under this alternative, there would be the potential for large, short-term, and adverse impacts to water supply intakes. These impacts would be limited to those that are located in the reaches where the habitat construction would take place. Alternative 2 is not expected to have significant impacts on water supply access.

### 3.18.2.6 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. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Overall, this alternative would have a relatively small, beneficial impact on water supply access. Most of the benefits would be realized in the lower river.

### National Economic Development

The NED effects associated with Alternative 3 are summarized in Table 3-235. Overall, Alternative 3 would have a relatively small, beneficial impact on water supply access relative to Alternative 1. The modeling results show that 33 of the 55 intakes would experience a slight decrease in the average number of days (57.0) when water surface elevations would fall below operating thresholds under Alternative 3. In addition, 22 of the 55 intakes would experience on average 14.0 days when water surface elevations are below shut-down elevations under Alternative 3. Total costs for all water supply intakes would decrease by nearly $333,000 over the 82-year POR or a decrease of 1.1 percent from Alternative 1. Most of these cost decreases would occur in the lower river with costs to water supply operations in the upper river showing a slight increase.

**Table 3-235. Summary of National Economic Development Analysis for Alternative 3**

| Costs | Upper River | Lower River | All Locations |
|---|---|---|---|
| Total Variable Costs (82-year POR) [a] | $6,917,315 | $19,728,714 | $26,646,029 |
| Total Fixed Costs (82-year POR) [b] | $1,380,925 | $2,477,017 | $3,857,941 |
| Total Costs (82-year POR) | $8,298,239 | $22,205,731 | $30,503,970 |
| Difference in Total Costs from Alternative 1 | $24,432 | −$357,246 | −$332,815 |
| Percentage Difference from Alternative 1 | 0.3% | −1.6% | −1.1% |
| Annual Average Total Costs | $101,198 | $270,802 | $372,000 |
| Difference in Annual Average Costs from Alternative 1 | $298 | −$4,357 | −$4,059 |
| Difference in Annual Costs per Intake | $8 | −$229 | −$74 |
| Maximum Annual Costs | $253,182 | $1,335,357 | $1,557,985 |
| Minimum Annual Costs | $36,770 | $0 | $46,460 |

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Evaluation of annual NED impacts to water supply access in the upper and lower river shows that intakes in the lower river again dominate the overall NED effects for water supply and most years show a reduction in costs relative to Alternative 1. In ten years of the 82-year POR, costs for water supply access would increase in the lower river, however, in only two years do these costs exceed $10,000 for all 19 intakes in this region. These same locations would also realize a reduction in costs relative to Alternative 1 of greater than $20,000 in six of the 82-year POR.

Water supply access in the upper river, including Tribal intakes, would experience more impacts under Alternative 3 than locations in the lower river. In particular, under conditions similar to those of the 1930s costs would increase to access water in the upper river with the greatest increase in costs exceeding $22,000. Intakes in the upper river would also experience several years when costs decreased under Alternative 3 relative to Alternative 1. Difference in costs to access water in the upper river would range from a low of −$6,100 to $22,000.

### Regional Economic Development

It is anticipated that Alternative 3 will have negligible RED impacts. Under Alternative 3, a number of water supply facilities would likely realize a small decrease in costs associated with changing river conditions, especially along the lower river. The cost decreases predicted under Alternative 3 are not expected to lead to a change in water rates.

### Other Social Effects

Access to water supply from the Missouri River is expected to experience relatively small beneficial impacts under Alternative 3; however, these beneficial impacts are not expected to result in changes in OSE. Beneficial impacts predicted under Alternative 3 can be described as a decrease in the frequency and duration of periods of inaccessibility to water relative to Alternative 1. These impacts are likely to result in a relatively small decrease in costs; however,

OSE including community well-being, economic vitality, and public health and safety are not expected to occur under Alternative 3.

**Conclusion**

Overall, Alternative 3 would have a relatively small, beneficial impact on water supply access relative to Alternative 1. Over all locations, costs would decrease by nearly $332,000 (-1.1%) over the 82-year POR from Alternative 1. Most of these cost decreases would occur in the lower river and are likely the result of the elimination of the spring pulse release under this alternative. Alternative 3 is expected to have negligible RED and OSE impacts. Additional ESH habitat would be construction 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. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Alternative 3 is not expected to have significant impacts on water supply access.

### 3.18.2.7 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. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Overall, Alternative 4 is expected to have a relatively small, adverse impact on water supply intakes.

**National Economic Development**

The NED effects of Alternative 4 are summarized in Table 3-236. On average, Alternative 4 has a relatively small, adverse impact to water supply access relative to Alternative 1. The modeling results show that one additional intake (34) would experience a slight increase in the average number of days (57.6) when water surface elevations would fall below operating thresholds under Alternative 4. In addition, 24 of the 55 intakes would experience on average 14.2 days when water surface elevations are below shut-down elevations under Alternative 2. Over all locations, costs would increase by slightly more than $1.0 million or 3.4 percent from Alternative 1. Alternative 4 has the largest impact to water supply access relative to Alternative 1 of any of the MRRMP-EIS alternatives and these impacts would occur across both the lower and upper river. Annual costs range from $46,500 to $1.6 million.

**Table 3-236. Summary of National Economic Development Analysis for Alternative 4**

| Costs | Upper River | Lower River | All Locations |
|---|---|---|---|
| Total Variable Costs (82-year POR) [a] | $7,133,135 | $20,723,315 | $27,856,450 |
| Total Fixed Costs (82-year POR) [b] | $1,438,022 | $2,599,074 | $4,037,096 |
| Total Costs (82-year POR) | $8,571,156 | $23,322,389 | $31,893,546 |
| Difference in Total Costs from Alternative 1 | $297,348 | $759,412 | $1,056,761 |
| Percentage Difference from Alternative 1 | 3.6% | 3.4% | 3.4% |
| Annual Average Total Costs | $104,526 | $284,419 | $388,946 |

| Costs | Upper River | Lower River | All Locations |
|---|---|---|---|
| Difference in Annual Average Costs from Alternative 1 | $3,626 | $9,261 | $12,887 |
| Difference in Annual Costs per Intake | $101 | $487 | $234 |
| Maximum Annual Costs | $253,182 | $1,335,357 | $1,557,985 |
| Minimum Annual Costs | $36,770 | $0 | $46,460 |

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

While the changes in average annual costs to access water from the Missouri river relative to Alternative 1 would be relatively small under Alternative 4, facilities would experience an increase in costs much more frequently under Alternative 4 than other MRRMP-EIS alternatives. In over half the years of the 82-year POR, costs for water supply access in the upper river would increase under Alternative 4. These costs are relatively small (less than $20,000 in all but three years). Five of the years with the largest increase in costs would occur in years with drought conditions similar to those that occurred during the 1930s and are not necessarily associated with a flow event. Drought conditions similar to those in the mid-2000s would also cause cost increases for water supply access in the upper river. Differences in costs for water supply access in the upper river over the period of analysis would range from a low of −$13,800 to a high of $42,600.

Water supply access s in the lower river would also experience an increase in costs relative to Alternative 1. Five of these years show an increase in costs greater than $60,000. Differences in costs to access water in the lower river over the period of analysis would range from −$29,000 to $142,000.

Table 3-237 shows the difference in NED costs between Alternative 1 and 4 for the type of releases occurring each year for the lower and upper river. The results show that full and partial releases would result in both increases and decreases in costs to access water in the lower river relative to Alternative 1. However, the largest adverse impacts would occur in years after an eliminated release. Years with the largest adverse impacts would occur during the winter or fall months when flows tend to be at their lowest levels in the lower river.

Water supply access in the upper river would be affected most often under Alternative 4 during drought conditions similar to those of the 1930s, early 1960s, and mid-2000s. Drought conditions and its effects on reservoirs appear to be exacerbated when a full release occurs prior to drought years. Modeling results show that when drought conditions similar to those that occurred in the late 1950s and early 1960s are combined with full and partial release would result in an increase in costs for water supply access in the upper river. Similar results occur when drought conditions in the mid-2000s coincide with a full release event causing adverse impacts to water supply access in the upper river. However, the adverse impacts would be relatively small with the largest impact resulting in an increase in costs of approximately $42,600 for all 36 intakes located in the upper river.

**Table 3-237. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release [a] (Change in $ from Alternative 1) | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change |
| Lower River | −$20,500 | $68,000 | $646 | $43,000 | −$29,000 | $142,000 |
| Upper River | −$13,900 | $13,400 | −$4,100 | $12,000 | −$13,900 | $42,600 |

a Flow action would be fully implemented in 10 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action would be partially implemented in six years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

### Regional Economic Development

In is anticipated that Alternative 4 would have negligible RED impacts. Under Alternative 4, a number of water supply facilities would likely realize a relatively small increase in costs on average associated with changing river conditions, especially for intakes in the upper river. While these cost increases have the potential to result in an increase in rates it is anticipated that these rate increases would be relatively small.

### Other Social Effects

While water supply intakes are expected to experience small, short-term, and adverse impacts under Alternative 4, it is not expected that OSE will occur. Adverse impacts under Alternative 4 can be described as increased frequency and duration of periods of inaccessibility to water relative to Alternative 1. These impacts are likely to result in increased costs; however, OSE including community well-being, economic vitality, and public health and safety are not expected under Alternative 4.

### Conclusion

Overall, Alternative 4 is expected to have a relatively small, adverse impact on water supply accessibility. Over all locations, annual average costs would increase by $12,900 (3.4%) from Alternative 1. Alternative 4 has the largest impact on water supply access relative to Alternative 1 of any of the MRRMP-EIS alternatives and these impacts would occur across both the lower and upper river. Annual costs range from nearly $47,800 to $1.6 million. For water supply facilities in the lower river, full and partial releases would result in both increases and decreases in costs relative to Alternative 1. However, the largest adverse impacts would occur in years after a full release. For years with the largest adverse impacts, these impacts would occur during the winter or fall months when flows tend to be at their lowest levels in the lower river. Water supply access in the upper river would be affected most often under Alternative 4 during drought conditions similar to those of the 1930s, early 1960s, and mid-2000s. Drought conditions and its effects on reservoirs appear to be exacerbated when a full release occurs prior to drought years under Alternative 4. RED and OSE impacts would be negligible under Alternative 4.

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. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Alternative 4 is not expected to have significant impacts on water supply access.

#### 3.18.2.8 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. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Overall, Alternative 5 is expected to have a relatively small, beneficial impact on water supply intakes.

**National Economic Development**

The NED effects of Alternative 5 are summarized in Table 3-238. Overall, Alternative 5 would have a relatively small, beneficial impact on water supply access relative to Alternative 1. The modeling results show that 33 of the 55 intakes would experience a small increase in the average number of days (57.2) when water surface elevations would fall below operating thresholds under Alternative 5. In addition, 22 of the 55 intakes would experience on average 14.1 days when water surface elevations are below shut-down elevations under Alternative 2. Over all locations costs would decrease by $117,000 over the 82-year POR or a decrease of 0.4 percent from Alternative 1. While Alternative 5 would have an overall small beneficial impact, intakes in the upper river would experience a relatively small, adverse impact under Alternative 5. Annual costs to access water along the river would range from over $48,000 to $1.6 million.

**Table 3-238. Summary of National Economic Development Analysis for Alternative 5**

| Costs | Upper River | Lower River | All Locations |
|---|---|---|---|
| Total Variable Costs (82-year POR) [a] | $6,921,972 | $19,914,031 | $26,836,002 |
| Total Fixed Costs (82-year POR) [b] | $1,383,792 | $2,499,363 | $3,883,154 |
| Total Costs (82-year POR) | $8,305,764 | $22,413,393 | $30,719,157 |
| Difference in Total Costs from Alternative 1 | $31,956 | −$149,584 | −$117,628 |
| Percentage Difference from Alternative 1 | 0.4% | −0.7% | −0.4% |
| Annual Average Total Costs | $101,290 | $273,334 | $374,624 |
| Difference in Annual Average Costs from Alternative 1 | $390 | −$1,824 | −$1,434 |
| Difference in Annual Costs per Intake | $11 | −$96 | −$26 |
| Maximum Annual Costs | $247,699 | $1,335,357 | $1,557,985 |
| Minimum Annual Costs | $36,932 | $0 | $47,627 |

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Evaluation of annual NED effects to water supply access in the upper and lower river shows that both regions would experience more years of cost reductions under Alternative 5 relative to Alternative 1. This results in a relatively small beneficial impact to water supply access in the lower river and a slight increase in costs in the upper river. However, four years in the POR show cost increases greater than $40,000 with the highest costs of nearly $122,000. Costs would be higher in years when flows are lower in winter months relative to Alternative 1.

Table 3-239 shows the difference in NED costs between Alternative 1 and 5 for the type of release occurring each year. For intakes in the lower river the results show that full and partial releases would have a direct adverse impact on water supply access in the lower river. In most years when a full or partial release would occur, access to water in the lower river would realize a cost reduction relative to Alternative 1. However, in years when the largest adverse impacts would occur, these impacts would likely result from system rebalancing. Differences in annual costs for intakes in the lower river range from −$32,300 to $122,000.

**Table 3-239. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release [a] (Change in $ from Alternative 1) | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change |
| Lower River | −$8,400 | $13,600 | $0 | $0 | −$32,300 | $122,000 |
| Upper River | −$14,500 | -$5,3 | −$6,700 | $2 | −$14,500 | $22,300 |

a Flow action would be fully implemented in seven years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action would be partially implemented in two years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

Table 3-239 also reports the impacts of flow releases on access to water in the upper river for Alternative 5. Water access in the upper river would experience more adverse effects under Alternative 5 than facilities in the lower river. Years with the greatest increase in costs are those with drought conditions similar to those of the 1930s. Some adverse impacts would occur in years following a release event (full or partial) and may be the result of system rebalancing and changing reservoir elevations. In many years when pulse events would occur, the costs to access water would be lower in the upper river under Alternative 5. Adverse impacts would be relatively small with the largest impact resulting in an increase in costs of approximately $22,300 for all 36 intakes located in the upper river. Differences in annual costs would range from a cost savings of nearly $14,500 to a cost increase of $22,300.

### Regional Economic Development

In is anticipated that Alternative 5 would have negligible RED impacts. Under Alternative 5, water supply costs in the lower basin are expected to realize on average a relatively small decrease associated with changing river conditions. Costs are expected to increase slightly to access water in the upper river. While these cost changes have the potential to result in changes in rates it is anticipated that these rate changes would be negligible.

### Other Social Effects

OSE under Alternative 5 water supply access are expected to be negligible. Annual adverse impacts that may occur under Alternative 5 can be described as increased frequency and duration of periods of inaccessibility to water relative to Alternative 1. These periods are expected to be short and not lead to changes in community well-being, economic vitality and public health and safety under Alternative 5.

### Conclusion

Alternative 5 is expected to have a relatively small, beneficial impact on water supply access. Over all locations, costs would decrease by $117,600 (−0.4%) over the 82-year POR. While Alternative 5 would have an overall small beneficial impact, water supply access in the upper river would experience a relatively small adverse impact under this alternative. Years when access to water in the upper river would experience the greatest increase in costs are those with drought conditions similar to those of the 1930s. Some adverse impacts would occur in years following a release event (full or partial) and may be the result of system rebalancing and changing reservoir elevations. RED and OSE impacts would be negligible under Alternative 5.

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. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Alternative 5 is not expected to have significant impacts on water supply access.

## 3.18.2.9 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. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Overall, Alternative 6 would have a small, adverse impact on water supply intakes.

### National Economic Development

The NED effects of Alternative 6 are summarized in Table 3-240. On average, Alternative 6 would have a relatively small, adverse impact on water supply access relative to Alternative 1. The modeling results show that 33 of the 55 intakes would experience a small increase in the average number of days (58.7) when water surface elevations would fall below operating thresholds under Alternative 6. In addition, 22 of the 55 intakes would experience on average 14.7 days when water surface elevations are below shut-down elevations under Alternative 6. Over all locations costs would increase by $638,500 over the 82-year POR or an increase of nearly 2.1 percent from Alternative 1. Impacts would occur to water supply access in both the upper and lower river under Alternative 6. Annual costs range from just over $46,000 to $1.6 million.

**Table 3-240. Summary of National Economic Development Analysis for Alternative 6**

| Costs | Upper River | Lower River | All Locations |
|---|---|---|---|
| Total Variable Costs (82-year POR) [a] | $7,030,889 | $20,461,581 | $27,492,469 |
| Total Fixed Costs (82-year POR) [b] | $1,417,644 | $2,565,198 | $3,982,842 |
| Total Costs (82-year POR) | $8,448,532 | $23,026,779 | $31,475,311 |
| Difference in Total Costs from Alternative 1 | $174,725 | $463,802 | $638,526 |
| Percentage Difference from Alternative 1 | 2.1% | 2.1% | 2.1% |
| Annual Average Total Costs | $103,031 | $280,814 | $383,845 |
| Difference in Annual Average Costs from Alternative 1 | $2,131 | $5,656 | $7,787 |
| Difference in Annual Costs per Intake | $59 | $298 | $142 |
| Maximum Annual Costs | $247,699 | $1,335,357 | $1,552,778 |
| Minimum Annual Costs | $36,932 | $0 | $46,000 |

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Evaluation of annual NED impacts shows that water supply access in both the upper and lower river would experience changes in costs (either positive or negative) nearly every year of the POR under Alternative 6 relative to Alternative 1. The results overall show a relatively small adverse impact to water supply access. Total annual costs range from a cost savings of nearly $22,000 to an increase in costs of $72,000.

Table 3-241 shows the difference in NED costs between Alternative 1 and 6 for the type of release occurring each year. In the lower river, the results show that in about half the years when a full or partial release would occur, access to water supply in the lower river would realize an increase in costs, but decrease in costs in the other years of these releases. Two years with the largest adverse impacts would occur when there is a full release, although the increase in costs is relatively small. The largest decrease in annual costs relative to Alternative 1 would occur in a year when a release was eliminated. Differences in annual costs for water supply access in the lower river range from a low of −$21,000 to a high of $72,000.

Access to water supply in the upper river appears to be more adversely affected under Alternative 6 than in the lower river and many of these impacts would occur during drought conditions. Years with the greatest increase in costs would occur during drought conditions similar to those of the 1930s, but also conditions similar to those in the late 1950s, early 1960s, and the mid-2000s. In many years when pulse events would occur, costs would be lower to access water in the upper river under Alternative 6. Adverse impacts would be relatively small with the largest impact resulting in an increase in costs of less than $32,000 for all 36 intakes located in the upper river. Differences in annual costs relative to Alternative 1 over the period of analysis would range from a low of −$14,500 to a high of $32,000.

**Table 3-241. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1**

| Reservoir or River Reach | Full Flow Release [a] (Change in $ from Alternative 1) | | Partial Flow Release [b] | | Years with Greatest Range in Impacts Regardless of Flow Actions | |
|---|---|---|---|---|---|---|
| | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change | Lowest Cost Change | Highest Cost Change |
| Lower River | −$15,700 | $72,000 | −$11,100 | $43,000 | −$21,000 | $72,000 |
| Upper River | −$14,500 | $10,100 | -$1,200 | $5,000 | −$14,500 | $32,000 |

a Flow action was fully implemented in 11 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action was partially implemented in 33 years of the period of analysis. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

### Regional Economic Development

It is anticipated that Alternative 6 will have negligible RED impacts. Under Alternative 6, access to water supply in the upper and lower river is expected to realize a relatively small increase in costs associated with changing river conditions. While these cost changes have the potential to result in changes in rates, it is anticipated that these rate changes would be negligible.

### Other Social Effects

Access to water supply is expected to experience negligible OSE under Alternative 6. Annual adverse impacts that may occur under Alternative 6 can be described as increased frequency and duration of periods of inaccessibility to water relative to Alternative 1. These periods are expected to be short and not lead to changes in community well-being, economic vitality, and public health and safety under Alternative 6.

### Conclusion

On average Alternative 6 would have a relatively small, adverse impact on water supply access relative to Alternative 1. Over all locations, annual average costs would increase by $7,800 (2.1%). Evaluation of annual NED impacts shows that water supply access in both the upper and lower river would experience changes in costs (either positive or negative) nearly every year of the POR under Alternative 6 relative to Alternative 1. Total annual costs range from a cost savings of nearly $22,000 to an increase in costs of $72,000. In the lower river, the results show that in about half the years when a full or partial release would occur, costs of water supply access would increase, but decrease in costs in the other years of these releases. Water supply access in the upper river appears to have more adverse effects under Alternative 6 than in the lower river and many of these impacts would occur during drought conditions. RED and OSE impacts would be negligible under Alternative 6.

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. Only water supply intakes in these reaches would be affected

in a manner similar to the impacts discussed under Alternative 1. Alternative 6 is not expected to have significant impacts on water supply access.

#### 3.18.2.10 Tribal Intakes

All the intakes serving Tribal communities are located along the reservoirs and riverine stretches along the Missouri River in the upper river. Similar to other intakes in the upper river, Tribal intakes are likely to experience small, short-term, and adverse impacts under Alternative 1. Total annual average costs under this alternative to access water in the upper river is expected to be just over $103,000 per year which equates to approximately $2,100 per intake. It is expected that intakes in the upper river, including Tribal Intakes, would not realize as many impacts under Alternative 1 as those in the lower river due to the number of improvements and modifications that were made in the late 2000s in response to drought conditions. Several intakes have been extended to avoid low reservoir levels that can occur during extended drought periods. These improvements have made many of the intakes less vulnerable to water surface elevation changes like those modeled under Alternative 1. Similar to other intakes in the upper river, Tribal intakes would experience relatively small, short-term, adverse impacts under Alternatives 2, 3, 4, 5, and 6 compared to Alternative 1.

#### 3.18.2.11 Climate Change

Higher spring runoff would result in higher spring System storage and the ability to run spring plenary pulses more frequently under Alternative 1. However, relatively lower late summer and fall river flows may have adverse impacts to water supply access with increase periods when water surface elevations fall below critical thresholds. The sporadic drought periods along with decreased peak snow water equivalent would result in difficulties forecasting runoff and System storage. If spring plenary pulses are run in a given year and are followed by longer, drier periods, water supply access would be affected with an increase in the number of days water surface elevations fall below critical thresholds for intakes.

Impacts of climate change under Alternatives 2 through 6 would be similar to those described under Alternative 1. However, with earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses relative to Alternative 1 may result in lower river flows in the fall and winter compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Longer and lower river flows would adversely impact water supply access, especially in the fall and winter months when flows are at their lowest levels.

Impacts of climate change under Alternative 5 would be similar to those described under Alternative 1 although with earlier snowmelt, the fall release may not be able to run as frequently if the navigation service level is lower for the second half of the navigation season. Less frequent releases may increase river flows in the fall and winter compared to Alternative 1 which would benefit water supply access.

#### 3.18.2.12 Cumulative Impacts

Past, present and future actions that would affect bed degradation or aggradation of the Missouri River, such as water depletions or withdrawals for agriculture, municipal, and industrial uses have and would continue to have adverse impacts to water supply access, as they would notably affect the volume of water in the river. Cumulative actions that affect bed degradation,

such as dredging in the lower river can impact the stability of the intakes and result in frequent and prolonged instances when water surface elevations fall below critical operating thresholds. Cumulative actions that affect aggradation such as floodplain development including agricultural operations affecting runoff can impact sediment and/or silting in intakes. In addition, much of the water supply infrastructure is nearing the end of its useful life and will require large investments to modernize these systems. Utilities would likely be forced to fund these improvements through increased water utility bills which could be notable to customers served by these utilities. Delaying the investment can result in degrading water service, increasing water service disruptions, and increasing expenditures for emergency repairs (AWRA n.d.).

Impacts of Alternative 1 would be adverse and long-term if water supply intakes remain at their existing elevations, but these impacts are due to bed degradation that is not caused by any of the actions under this Alternative. When combined with other past, present and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would continue to be long-term, and adverse primarily due to changes occurring in river conditions from natural dry and wet weather cycles and actions that would contribute to bed degradation and aggradation. The continued implementation of Alternative 1 would provide a relatively small contribution to these cumulative impacts.

Under Alternative 2 the cumulative impacts from other past, present, and reasonably foreseeable actions would be the same as described for Alternative 1. Under Alternative 2, access to water supply would have relatively small short-term, adverse impacts relative to Alternative 1. These impacts would be due to more frequent, short durations (a few days) when water surface elevations fall below critical operating thresholds (operating and shut-down) relative to Alternative 1. On average these impacts are small in nature but there are some years when water supply access, especially in the lower river, would experience larger impacts. The greatest impacts to water supply access in the lower river would occur during the winter or fall months when flows tend to be at their lowest levels in the lower river. Although there are some years when the adverse impacts would be larger in the lower river, implementation of Alternative 2 would provide a relatively small contribution to these cumulative impacts because of the considerable impacts of cumulative actions.

Under Alternative 3, water supply access overall would experience a relatively small, beneficial cumulative impact relative to Alternative 1 because river flows in the lower river would be higher on average with increased storage in the reservoirs relative to Alternative 1. Water supply access in the upper river would experience a small adverse impact under Alternative 3. 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.

Alternative 4 would have the largest cumulative impact on water supply access relative to Alternative 1 of any of the MRRMP-EIS alternatives. These impacts would occur across the lower and upper river. Years with the largest adverse impacts to water supply access in the lower river would occur during the winter or fall months when flows tend to be at their lowest levels. Water supply access in the upper river would be most affected in the reservoirs in the years when a spring release is followed by prolonged drought conditions under Alternative 4. Overall, Alternative 4 would have a relatively small, adverse impact on water supply access. 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 relatively small contribution to these cumulative impacts.

Under Alternative 5, water supply access would experience a relatively small, beneficial cumulative impact relative to Alternative 1. Water supply access in the lower river would experience more years of cost reductions while costs to access water in the upper river would increase slightly. 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.

Alternative 6 is expected to have a relatively small, adverse impact on water supply access based on ESH construction and a spawning cue flow. In the lower river, water supply access would experience adverse impacts in about half the years when a full or partial release occurs, but beneficial impacts in the other years of these releases. Water supply access in the upper river would have more adverse effects under Alternative 6 than in the lower river with many of these impacts occurring in the years following a spawning cue release during drought or drier conditions. 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 relatively small contribution to these cumulative impacts.

# 3.19 Wastewater Facilities

## 3.19.1 Affected Environment

Several facilities discharge treated wastewater to the Missouri River and its reservoirs. River flows, stages, and channel geometry can affect these facilities. The facilities include publicly owned treatment works (POTWs) or sewerage facilities and other types of industrial discharges from fertilizer and agricultural chemical companies and meat processing facilities. Most of the discharging facilities are located in the lower river below Gavins Point Dam. Thermal power plants are discussed in Section 3.17.

The EPA Enforcement and Compliance History Online (ECHO) database was used to identify the major wastewater facilities that discharge to the Missouri River. The list of facilities was confirmed with the EPA specialist overseeing state wastewater discharge regulations and compliance (Dunn, pers. comm., 2016). Major facilities include all facilities with design flows of greater than 1 million gallons per day and facilities with approved industrial pretreatment programs. Major facilities are determined based on specific ratings criteria developed by EPA and/or the state. Table 3-242 summarizes the 37 major wastewater facilities discharging to the Missouri River.

**Table 3-242. Missouri River Major Wastewater Facilities**

| Name | River Mile | County | State |
|---|---|---|---|
| **Fort Peck Dam to Lake Sakakawea** | | | |
| City of Willison | 1546.8 | Williams | North Dakota |
| **Garrison Dam to Lake Oahe** | | | |
| City of Bismarck POTW | 1313.6 | Burleigh | North Dakota |
| Roughrider Estates | 1313.2 | Morton | North Dakota |
| **Lake Oahe** | | | |
| City of Mobridge Wastewater Treatment Plant | 1192.8 | Walworth | South Dakota |
| **Oahe Dam to Lake Sharpe** | | | |
| Pierre Wastewater Treatment Plant | 1062.8 | Hughes | South Dakota |
| City of Chamberlain | 966.5 | Brule | South Dakota |
| **Gavins Point Dam to Rulo** | | | |
| City of Yankton | 804.1 | Yankton | South Dakota |
| City of Vermillion | 772.0 | Clay | South Dakota |
| City of Sioux City | 729.1 | Woodbury | Iowa |
| Tyson Fresh Meats | 726.5 | Dakota | Nebraska |
| CF Industries (Port Neal Corporation) | 718.6 | Woodbury | Iowa |
| Gelita North America | 718.0 | Woodbury | Iowa |
| Blair Wastewater Treatment | 648.3 | Washington | Nebraska |
| City of Omaha – Missouri River Wastewater Treatment Facility | 611.9 | Douglas | Nebraska |
| City of Council Bluffs | 605.5 | Pottawattamie | Iowa |

| Name | River Mile | County | State |
|---|---|---|---|
| Bellevue Wastewater Treatment Plant | 601.3 | Sarpy | Nebraska |
| Omaha Papillion Creek Wastewater Treatment Plant | 597.0 | Sarpy | Nebraska |
| Plattsmouth Wastewater Treatment Plant | 591.3 | Cass | Nebraska |
| GMU Wastewater Treatment Facility | 591.2 | Mills | Iowa |
| Nebraska City Wastewater Treatment | 562.3 | Otoe | Nebraska |
| **Rulo to the Mouth of the Missouri River** | | | |
| Exide Tech-Canon Hollow | 490.9 | Holt | Missouri |
| St. Joseph Wastewater Treatment Plant | 446.0 | Buchanan | Missouri |
| City of Atchison | 422.7 | Atchison | Kansas |
| Leavenworth Wastewater Treatment | 395.6 | Leavenworth | Missouri |
| City of Lansing | 389.3 | Leavenworth | Missouri |
| #1 Kansas City Wastewater Treatment Plant | 367.4 | Wyandotte | Missouri |
| Kansas City, Westside Wastewater Treatment Plant | 367.0 | Jackson | Missouri |
| Blue River Treatment Plant | 359.2 | Jackson | Missouri |
| Conservation Chemical Company | 358.2 | Jackson | Missouri |
| Bayer Corporation Agriculture Division | 358.2 | Jackson | Missouri |
| Birmingham Sewage Treatment Plant | 356.8 | Clay | Missouri |
| Atherton Plant | 349.0 | Jackson | Missouri |
| Booneville Wastewater Plant | 195.2 | Cooper | Missouri |
| Jefferson City | 143.5 | Cole | Missouri |
| MSD, Missouri River Wastewater Treatment Plant | 62.1 | St. Louis | Missouri |
| St. Charles Missouri River Wastewater Treatment Facility | 26.9 | St. Charles | Missouri |
| Coldwater Creek Wastewater Treatment Plant | 6.8 | St. Louis | Missouri |

Source: EPA ECHO database; state websites to verify current NPDES permits.

To discharge wastewater, wastewater facilities must have a NPDES permit, which specifies the effluent requirements for the relevant parameters for the facilities. The effluent limits include both technology-based effluent limits and water quality-based effluent limits in the NPDES permits. Technology-based effluent limits are usually used for municipal sewage treatment plants (i.e., POTWs) to regulate limits for biochemical oxygen demand, total suspended solids, oil and grease, *Escherichia coli*, and pH acid/base balance (Dunn, pers. comm., 2016; Wieberg pers. comm. 2015). The technology-based effluent limits are end of the pipe conditions that do not consider low flows in the receiving river to estimate the effluent limit.

Water quality-based effluent limits are often based on the assimilative capacity of the receiving river and use critical low-flow criteria to estimate the effluent limits that are specified in water quality permits. The parameters typically regulated by water quality-based effluent limits include ammonia, total residual chlorine, whole effluent toxicity tests, and acute toxicity. Critical low

flows are measured as the average low flow that occurs over a certain number of days (e.g., 7 days) and has a reoccurrence interval over a certain number of years (e.g., 10 years). For the Missouri River, critical low flows are defined most often as follows:

- 7-consecutive-day, average low flow; reoccurrence 1 in 10 years (7Q10)
- 30-consecutive-day, average low flow; reoccurrence 1 in 10 years (30Q10)
- 1-day, average low flow; reoccurrence 1 in 10 years (1Q10)
- 30-consecutive-day, average low flow; reoccurrence 1 in 5 years (30Q5)

Permits are renewed or reissued every 5 years, and low-flow criteria are re-estimated with updated data at that time. The states along the Missouri River have the following low-flow criteria that can be used to estimate effluent limits for wastewater facilities (Table 3-243).

**Table 3-243. Critical Low-Flow Conditions Used to Determine Discharge Limits for National Pollutant Discharge Elimination System Permits**

| State | Critical Low-Flow Criteria for NPDES Permits |
|---|---|
| Missouri<br><br>(Missouri Code of State Regulations, 10 CSR 20-7.031) | 7Q10: all criteria, except ammonia nitrogen<br>30Q10: chronic criterion[b] for ammonia nitrogen<br>1Q10: acute[c] criterion for ammonia nitrogen |
| Kansas<br><br>(Kansas Administrative Rules 28-16-28b through 28-16-28g) | 7Q10: all criteria<br>30Q10: ammonia<br>"Alternative low-flow" based on seasonal, hydrological or biological conditions |
| Iowa<br><br>(Iowa Administrative Code, 567, Chapter 61) | 1Q10: acute criteria (toxics and ammonia)<br>7Q10: chronic (toxics)<br>30Q10: chronic (ammonia)<br>30Q5: non-carcinogenic<br>Harmonic mean[d]: carcinogenic |
| Nebraska<br><br>(Nebraska Administrative Code, Title 117, Chapter 4) | 7Q10 (average dry weather or seasonal flow): all chronic criteria except ammonia<br>30Q5: ammonia criteria<br>1Q10: acute criteria for various pollutants |
| South Dakota (South Dakota Administrative Code 74:51:01:31) | 7Q5: warm water<br><br>7Q25: cold water |
| North Dakota<br><br>(North Dakota Administrative Code Chapter 33-16-02.1) | 4-day, 3-year flow: aquatic chronic<br>1-day, 3-year flow: aquatic acute<br>Harmonic mean flow: carcinogens<br>4-day, 3-year flow: non-carcinogens<br>1-day, 3-year flow: non-carcinogens |
| Montana (Administrative Rules of Montana, Chapter 30, Subchapter 6) | 7Q10: all criteria |

**Tribal Use of Wastewater Facilities**

Several Tribes discharge treated wastewater into the Missouri River and its tributaries after using wastewater plants or lagoons to treat the water.

## 3.19.2 Environmental Consequences

Wastewater discharge facility operations can be sensitive to changes in river flows. For facilities with water quality-based effluent limits, low river flows can have a direct relationship with the effluent limits and resulting wastewater treatment requirements.

### 3.19.2.1 Impact Assessment Methodology

This section describes the process used to evaluate the impacts to wastewater discharge facilities under the MRRMP-EIS alternatives. The critical low-flow criteria were obtained for all of the major wastewater facilities either from NPDES permits or state regulators. Most of the low-flow criteria statistics are calculated for an annual season with daily river flow data, providing year-round statistics on the re-occurrence of low-flow conditions. Some of the NPDES permits, primarily in Missouri and Nebraska, specify seasonal criteria (i.e., spring, summer, and winter) and use river flows in specified date ranges to estimate effluent limits for these seasons.

A low-flow criteria analysis was conducted on modeled rivers flows under the MRRMP-EIS alternatives for locations close to the wastewater discharge facilities. The low-flow criteria were estimated under the MRRMP-EIS alternatives with the log-Pearson Type III probability distribution commonly used by the USGS and state water quality regulators to estimate effluent limits in NPDES permits (U.S. Interagency Advisory Committee on Water Data 1982). The period of analysis for the calculations was from 1960 to 2012 to be consistent across all facilities and to be reflective of periods for the criteria in the NPDES permits (Dunn pers. comm. 2015a, 2016). With information on the low-flow criteria, EPA water quality specialists, state regulators, and plant representatives provided input on the potential effect of the change of low-flow conditions on effluent limits and treatment requirements.

The scope of analysis included facilities in Iowa, Nebraska, Kansas, and Missouri. Facilities in North Dakota and South Dakota were eliminated from further analysis because state water quality regulators indicated that low-flow conditions in the Missouri River do not drive effluent limits for facilities in these states (Haroldson pers. comm. 2015; Spangler pers. comm. 2015). Twenty-nine major wastewater facilities that discharge to the Missouri River were identified in these four lower river states. An EPA Region 7 NPDES specialist was consulted who has a comprehensive understanding of the wastewater facilities, effluent limits, violations, monitoring reports, and other issues related to these facilities, their NPDES permits, and compliance with permits (Dunn pers. comm. 2015b, 2016). The facilities identified could potentially be affected by a change in the low-flow criteria affecting specific pollutant effluent limits. It was determined that wastewater facilities were not affected by potential changes in river flows and the low-flow criteria if:

- the wastewater facilities only had technology-based effluent limits in their NPDES permits;
- the wastewater facilities were not a direct Missouri River discharger;
- the dilution in the river was more than sufficient to meet effluent limits in the NPDES permits (lots of headroom); or

- if facilities were using a relatively new technology called biological nutrient removal[9] or enhanced nutrient removal to treat for ammonia (Dunn pers. comm. 2015b, 2016).

Each of these facilities was evaluated, and facilities were removed from further analysis if they met any of the criteria listed above. However, facilities were not removed if there was any uncertainty about the facility, its effluent and compliance status, or pending upgrades to the facilities. The result was five facilities (two in Iowa and three in Missouri) that could potentially be affected under MRRMP-EIS alternatives and were evaluated through further consultation with the facilities and state regulators.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

#### 3.19.2.2 Summary of Environmental Consequences

Table 3-244 summarizes the environmental consequences for wastewater discharge facilities. The one-time spawning cue test (Level 2) release that may be implemented under alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

**Table 3-244. Environmental Consequences for Wastewater Facilities**

| Alternative | Impacts |
|---|---|
| Management Actions Common to All Alternatives | Impacts to wastewater facilities are not anticipated. |
| Alternative 1 | Current system operations are anticipated to continue to provide stable low-flow criteria in the future, and minimal changes to effluent limits based on low-flow conditions and negligible impacts on wastewater facilities are anticipated in the future.<br>Negligible to small, temporary, adverse impacts to wastewater facility infrastructure are anticipated from habitat construction. |
| Alternative 2 | Possible short-term, large, adverse impacts to wastewater facilities are anticipated, although anticipated future investments in treatment technology would reduce impacts to small, adverse impacts compared to Alternative 1.<br>Negligible to large, long-term, adverse impacts to wastewater facilities are anticipated from considerably more SWH and ESH constructed compared to Alternative 1. |
| Alternatives 3–6 | Negligible to small impacts to wastewater facilities are anticipated compared to Alternative 1. |

[9] Biological nutrient removal is a process used for treating nitrogen, including ammonia-nitrogen, and phosphorus in wastewater. With the new stringent ammonia standards being implemented by the EPA and states, more wastewater facilities are upgrading their treatment systems to use biological nutrient removal or enhanced nutrient removal; with these types of technologies, changes in low flows are not likely to affect water quality (Dunn, pers. comm. 2016).

#### 3.19.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives, such as predator management and human restrictions measures, would not affect wastewater facilities.

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

Alternative 1 would continue current system operations, including the current MRRP management actions. In general, current system operations and guidelines to meet navigation and water supply targets would continue to provide sufficient river flows to assimilate effluent to meet water quality limits. Although lower river flows in the late fall and winter typically would occur and drought periods could exacerbate lower river flows at any time of the year, current flow management under the Master Manual and Alternative 1 is anticipated to provide stable low-flow criteria in the future, and minimal changes to effluent limits from low-flow conditions are anticipated. Although wastewater facilities would continue to incur capital and operating costs to treat and remove pollutants associated with water quality standards, current management under Alternative 1 would not have noticeable changes to those impacts in the future.

**Mechanical Habitat Construction**

Alternative 1 includes the continued construction of early life stage habitat for the pallid sturgeon from Ponca, Nebraska, to the mouth of the river near St. Louis, Missouri, with a target of 3,999 acres at the end of the 15-year implementation period. Construction of ESH would also continue to occur in the Garrison Dam to Lake Oahe and Gavins Point Dam to Ponca, Nebraska, river reaches, with on average 107 acres constructed per year in years when construction occurs. Construction of ESH in the Garrison and Gavins Point reaches and SWH construction in lower river reaches in the vicinity of a wastewater facility outfall could lead to issues associated with sediment erosion and deposition and potential impacts to the structural stability of the outfall. The extent of these impacts would depend on the proximity of the location where the habitat site would be constructed relative to any wastewater facility outfall. Each habitat site is designed to avoid significant impacts to environmental, cultural, and socioeconomic resources. In addition, USACE has identified sensitive resource categories and subsequent restrictive or exclusionary zones associated with many of these resources. A more detailed hydraulic/geomorphic assessment would also be completed during site-specific planning, engineering and design phases to further mitigate impacts associated with these actions on wastewater facilities. With the site-specific planning and sensitive resource restrictions in place, the impacts of the habitat construction management actions on wastewater facility outfalls would be temporary and negligible to small.

**Conclusion**

Alternative 1 would result in negligible impacts to wastewater facilities from MRRMP actions because current management of the system would continue to provide relatively stable low-flow criteria in the future. Alternative 1 would result in negligible to small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with SWH and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize the impacts to facilities. Therefore, Alternative 1 would not have significant impacts to wastewater facilities.

### 3.19.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

**Mechanical Habitat Construction**

A targeted 10,758 additional acres of SWH habitat would be constructed for the pallid sturgeon between Ponca, Nebraska, and the mouth of the river near St. Louis, Missouri; an average of 3,546 acres per year of ESH would be constructed in years when construction occurs in the Garrison Dam to Lake Oahe river reach; Fort Randall Dam to Lewis and Clark Lake river reach; Gavins Point Dam to Ponca, Nebraska, river reach; and Lewis and Clark Lake. The mechanical construction of substantially more SWH and ESH would have the potential to lead to more issues associated with local and regional flow patterns and sediment erosion and deposition affecting wastewater facility outfalls relative to Alternative 1. Similar to Alternative 1, sensitive resource restrictions and buffers would minimize and attempt to avoid adverse impacts to wastewater facilities. However, the potential for more adverse impacts to wastewater facility outfalls could occur under Alternative 2. Impacts of the habitat construction management actions on wastewater facility outfalls could range from negligible to large, long-term, and adverse on wastewater facilities compared to Alternative 1, depending on the proximity of the constructed habitat site to wastewater facilities.

**Spring Habitat-Forming Flow Release**

Alternative 2 includes a bi-modal spawning cue release followed by a low summer flow. The estimated low-flow criteria under simulated Alternative 2 river flows were compared to the low-flow criteria estimated for river flows simulated under Alternative 1. The low-flow criteria for two facilities in Iowa under Alternative 2 were estimated to be slightly higher than under Alternative 1, with negligible impacts to the Iowa wastewater facilities. In Missouri, three wastewater facilities could be affected by low-flow conditions. One Missouri facility uses annual low-flow criteria, and the analysis showed that the low-flow criteria under Alternative 2 could decrease by 2 percent compared to Alternative 1. This small change is expected to have negligible impacts to effluent limits for this facility.

According to the calculated low-flow criteria under Alternative 2, the two remaining Missouri facilities would experience decreases in low-flow criteria compared to Alternative 1, with the largest decreases under the summer low-flow criteria. Decreases in low-flow criteria under Alternative 2 compared to Alternative 1 indicate more restrictive effluent limits for these facilities under Alternative 2, which could lead to increased operational or capital costs for treatment requirements. Under the low-flow criteria calculated on the modeled river flows for Alternatives 1 and 2, the Alternative 2 summer low-flow criteria for the 1Q10 and 30Q10 for both facilities could decrease from between 10 and 16 percent compared to Alternative 1. The low summer flow events under Alternative 2 would likely cause these decreases in low-flow criteria under Alternative 2, compared to Alternative 1.

While the analysis shows that low summer flows under Alternative 2 have the potential to affect effluent limits for two facilities in Missouri, further discussions with plant operators indicated that these plants either are currently making a capital investment or are developing a master plan that would likely address the options to comply with pending and more stringent ammonia limits in anticipation of the new ammonia standard in Missouri (O'Kelley pers. comm. 2016; Coles pers. comm. 2016). The master plan would likely not be implemented for 5 to 10 years. Investments in new technologies would allow these wastewater facilities to comply with more stringent ammonia effluent limits. If one of these facilities does not make the investments or delays making the investment, the facility would likely experience permit violations and

exceedances of effluent limits under Alternative 2, resulting in short-term, large, adverse impacts compared to Alternative 1, especially during low summer flow events. Because the wastewater facilities are currently undergoing or planning to undergo capital investments involving new treatment technologies, the adverse impacts to these facilities under Alternative 2, relative to Alternative 1, are anticipated to be long-term, small, and adverse. However, there is uncertainty because of the state of Missouri's pending ammonia standards, effects of low flows under Alternative 2 on the actual effluent limits, and the ability of the new technologies to meet these standards and limits.

**Conclusion**

Alternative 2 would result in negligible impacts to wastewater facilities in most locations because of sensitive resource restrictions and buffers. However, two facilities in Missouri would likely experience adverse impacts associated with summer low-flow criteria for ammonia. Because pending and more stringent water quality standards are driving near-term capital investments for these facilities, the adverse impacts would be temporary and large (prior to investment) and would occur during low summer flow events, but in the long term, these impacts would be small and adverse because new treatment technology would likely be able to treat effluent to meet the limits under reduced assimilative capacity with low summer flows. Although site-specific planning and infrastructure buffers would attempt to minimize impacts to wastewater facilities, Alternative 2 would have the potential for negligible to large, long-term, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with SWH and ESH construction. Alternative 2 would not have significant impacts on wastewater facilities because adverse impacts would be negligible in most locations and any site-specific adverse impacts in the long-term would be small.

### 3.19.2.6 Alternative 3 – Mechanical Construction Only

Alternative 3 includes construction of up to 3,380 acres of new IRC area for the pallid sturgeon, slightly fewer acres than under Alternative 1. Alternative 3 includes an average of 391 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Alternative 3 does not include the spring plenary pulse for the pallid sturgeon that would occur under Alternative 1. According to the low-flow criteria analysis estimated with the Alternative 1 and Alternative 3 modeled river flows, five facilities under Alternative 3 would experience less than a 1 percent decrease in low-flow criteria compared to Alternative 1. This small decrease in low-flow conditions is expected to have negligible impacts on effluent limits and treatment requirements for these facilities compared to Alternative 1. Construction of IRC habitat and ESH could have some adverse impacts to wastewater facilities, but these impacts would be negligible to small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

**Conclusion**

Alternative 3 would result in negligible impacts to wastewater facilities in all locations. Simulated river flows under Alternative 3 near wastewater facility locations in Iowa and Missouri would not have noticeable changes from river flows under Alternative 1, resulting in negligible changes in low-flow criteria. Alternative 3 would result in negligible to small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with SWH and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize impacts to those facilities. Alternative 3 would not have significant impacts to

wastewater facilities because adverse impacts would be negligible at all locations and temporary adverse impacts to wastewater facility outfalls would be negligible to small.

#### 3.19.2.7 Alternative 4 – Spring ESH Creating Release

**Mechanical Habitat Construction**

Alternative 4 includes construction of up to 3,380 acres of new IRC area for the pallid sturgeon (same as Alternative 3) and an average of 240 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Alternative 4 would result in negligible to small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with IRC and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize the impacts to facilities.

**Spring Habitat-Forming Flow Release**

Alternative 4 includes a spring release in April and part of May to create ESH. The estimated low-flow criteria with river flows simulated under Alternatives 1 and 4 indicates that the criteria under Alternative 4 would decrease by approximately 2 percent for the summer criteria, and would increase or decrease by less than 1 percent compared to Alternative 1 for the winter and annual criteria. The slight decreases in low-flow conditions for these facilities in the summer is expected to have negligible impacts on effluent limits and treatment requirements for these facilities because of the small decrease in low-flow criteria and the investments currently being made or anticipated to be made in the near future for new treatment technologies.

**Conclusion**

Similar to Alternative 3, Alternative 4 would result in negligible impacts to wastewater facilities in all locations. Simulated river flows under Alternative 4 would result in slight changes in low-flow criteria with negligible changes to wastewater facilities under Alternative 1. Alternative 4 would not have significant impacts to wastewater facilities because adverse impacts would be negligible to small at all locations, with only slight changes in low-flow criteria and temporary adverse impacts to wastewater facility outfalls.

#### 3.19.2.8 Alternative 5 – Fall ESH Creating Release

**Mechanical Habitat Construction**

Alternative 5 includes construction of up to 3,380 acres of new IRC area for the pallid sturgeon (same as Alternative 3) and an average of 309 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Similar to Alternative 3, Alternative 5 would result in negligible to small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with IRC and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize the impacts to facilities.

**Spring Habitat-Forming Flow Release**

Alternative 5 includes a fall release in October and November to create ESH. The estimated low-flow criteria under river flows simulated under Alternatives 1 and 5 indicate that the criteria

under Alternative 5 would decrease by less than 2 percent for the summer criteria, and increase for the remaining low-flow criteria compared to Alternative 1. The small change in low-flow conditions for the summer criteria is expected to have negligible impacts on effluent limits and treatment requirements for these facilities compared to Alternative 1 resulting from the small decrease in low-flow criteria and the investments currently being made or anticipated to be made in the near future for new treatment technologies. Similar to Alternative 3, construction of IRC habitat and ESH could have some adverse impacts to wastewater facilities, but these impacts would be negligible to small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

**Conclusion**

Similar to Alternative 3, Alternative 5 would result in negligible impacts to wastewater facilities in all locations. Simulated river flows under Alternative 5 would result in slight changes in low-flow criteria with negligible changes to wastewater facilities under Alternative 1. Alternative 5 would not have significant impacts to wastewater facilities because adverse impacts would be negligible to small at all locations, with only slight changes in low-flow criteria and temporary adverse impacts to wastewater facility outfalls.

#### 3.19.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

**Mechanical Habitat Construction**

Alternative 6 includes construction of up to 3,380 acres of new IRC area for the pallid sturgeon (same as Alternative 3) and an average of 303 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Similar to Alternative 3, Alternative 6 would result in negligible to small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with IRC and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize the impacts to facilities.

**Spring Habitat-Forming Flow Release**

In addition, Alternative 6 includes a bi-modal spawning cue in March and May to benefit the pallid sturgeon. The estimated low-flow criteria with simulated river flows under Alternatives 1 and 6 indicate that the criteria under Alternative 6 would decrease by less than 3 percent for the summer criteria, and change (increase or decrease) by less than 1 percent compared to Alternative 1 for the remaining criteria. This small change in low-flow conditions is expected to have negligible impacts on effluent limits and treatment requirements for these facilities because of the small change in low-flow criteria and the investments currently being made or anticipated to be made in the near future for new treatment technologies. Similar to Alternative 3, under Alternative 6, construction of IRC habitat and ESH could have some adverse impacts to wastewater facilities, but these impacts would be negligible to small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

**Conclusion**

Similar to Alternative 3, Alternative 6 would result in negligible impacts to wastewater facilities in all locations. Simulated river flows under Alternative 6 would result in slight changes in low-flow criteria with negligible changes to wastewater facilities under Alternative 1. Alternative 6 would

not have significant impacts to wastewater facilities because adverse impacts would be negligible to small at all locations, with only slight changes in low-flow criteria and temporary adverse impacts to wastewater facility outfalls.

#### 3.19.2.10 Tribal Resources

There are no affected wastewater facilities associated with Tribal resources.

#### 3.19.2.11 Climate Change

Earlier snowmelt may result in both lower river flows in the fall and winter and the possibility of the spring plenary pulse under Alternative 1 running more frequently with higher System storage in the spring. The drought conditions and more frequent implementation of the pulse would likely result in lower river flows, especially in the fall and winter, for longer periods, and would have the potential to reduce the low-flow criteria used in the effluent limit calculations.

Impacts of climate change under Alternatives 2 through 6 would be similar to those described for Alternative 1. However, with earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses may result in lower river flows in the fall and winter compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Longer and lower river flows would reduce low-flow criteria, and the effluent limits on which they are based would become more stringent, resulting in adverse impacts to wastewater facilities.

Large, more sporadic rain events could adversely affect the ability of facilities affected by flooding river flows to discharge wastewater, possibly shutting down facilities; climate change could exacerbate the possibility of flooding during spring or fall releases under Alternatives 2, 4, 5, and 6.

Impacts of climate change under Alternative 5 would be similar to those described for Alternative 1, although with earlier snowmelt, the fall release may not be able to run as frequently if the navigation service level is lower for the second half of the navigation season. Less frequent releases may benefit river flows in the fall and winter compared to Alternative 1. These changes may benefit wastewater facilities because effluent limits for pollutants specified by low-flow criteria may not become more stringent in the future.

#### 3.19.2.12 Cumulative Impacts

Past, present and reasonably foreseeable future construction projects, including projects to maintain the levees, roads, floodplain development, and habitat creation, can cause temporary adverse impacts as a result of localized deterioration in water quality. Any habitat construction or channel reconfiguration by state or other federal agencies could have adverse impacts to the stability of the outfalls at the wastewater facilities, although buffers around sensitive resources would reduce these adverse impacts. Continued or future water withdrawals for irrigation, municipal, and industrial uses would adversely affect river flows, with potential adverse impacts to the assimilative capacity of the river, possibly affecting effluent limits and wastewater treatment operations and the need for investment in infrastructure upgrades to mitigate these impacts. Any additional agricultural, municipal, industrial and floodplain development in the service areas of wastewater facilities can put new demands on the operations of wastewater

facilities, and may require capital investments to improve and expand the capacity of the facilities.

Changes in federal and state water quality regulations that specify both technology-based effluent limits and low-flow standards for relevant water quality parameters can impact wastewater facilities. Recent revisions in the water quality standards by EPA in 2013 include new recommended ammonia criteria, bacteria criteria, nutrient criteria development for streams, regional dissolved oxygen criteria, and others. The states of Iowa, Nebraska, Kansas, and Missouri are in various stages of implementing new water quality regulations to meet the new EPA standards. Any resulting changes in effluent limits may require that wastewater facilities upgrade their treatment systems to comply with regulations, possibly requiring changes in operating and capital investments.

The variable hydrology and precipitation within the system and its interaction with the past, present foreseeable actions as described in Section 3.1 would result in cumulative impacts that would be long-term and adverse, small to large, with wastewater facilities affected primarily by drought and drier conditions and water quality regulations. Under Alternative 2, two wastewater facilities in Missouri would experience small and adverse impacts from low summer flow events in the long-term due to more stringent water quality effluent limits. However, over time, the cumulative actions can have both adverse and beneficial impacts on wastewater operations. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 through 6 would be long-term adverse small to large with potentially beneficial impacts. Implementation under Alternative 2 would provide a small adverse contribution to cumulative impacts. Alternatives 1, 3, 4, 5, and 6 would provide a negligible contribution to cumulative impacts because of the small change in low flow criteria and because facilities are already making or planning investments to upgrade facilities to meet more stringent water quality standards.

# 3.20 Tribal Interests (Other)

## 3.20.1 Affected Environment

### 3.20.1.1 Native American Tribes

The Tribes of the Missouri River basin are diverse in their histories and their perspectives regarding the Missouri River. There are a total of 29 Tribes located within or having expressed significant interest in their historical connection to the Missouri River Basin (Figure 3-62). Listed below are each of those 29 Tribes and the location of their Tribal headquarters.

- Apsaalooke (Crow) Tribe—Crow Agency, MT
- Assiniboine and Sioux Tribes of Fort Peck—Poplar, MT
- Blackfeet Tribe—Browning, MT
- Cheyenne River Sioux Tribe—Eagle Butte, SD
- Chippewa Cree Tribe of Rocky Boy's Reservation—Box Elder, MT
- Crow Creek Sioux Tribe—Fort Thompson, SD
- Eastern Shoshone Tribe—Fort Washakie, WY
- Flandreau Santee Sioux Tribe—Flandreau, SD
- Gros Ventre and Assiniboine Tribes of Fort Belknap—Harlem, MT
- Iowa Tribe of Kansas and Nebraska—White Cloud, KS
- Kickapoo Tribe in Kansas—Horton, KS
- Lower Brule Sioux Tribe—Lower Brule, SD
- Northern Arapaho Tribe—Fort Washakie, WY
- Northern Cheyenne Tribe—Lame Deer, MT
- Oglala Sioux Tribe—Pine Ridge, SD
- Omaha Tribe of Nebraska—Macy, NE
- Osage Nation—Pawhuska, OK
- Ponca Tribe of Nebraska—Niobrara, NE
- Prairie Band of Potawatomi Nation—Mayetta, KS
- Rosebud Sioux Tribe—Rosebud, SD
- Sac and Fox Nation of Missouri in Kansas and Nebraska—Reserve, KS
- Santee Sioux Tribe of Nebraska—Santee, NE
- Sisseton-Wahpeton Oyate—Agency Village, SD
- Spirit Lake Sioux Tribe—Fort Totten, ND
- Standing Rock Sioux Tribe—Fort Yates, ND
- Three Affiliated Tribes—New Town, ND

- Turtle Mountain Band of Chippewa—Belcourt, ND
- Winnebago Tribe of Nebraska—Winnebago, NE
- Yankton Sioux Tribe—Marty, SD

These Tribes maintain current and ancestral ties to the Missouri River and possess cultural, economic, and social interests in the river. Federal agencies planning and implementing recovery and mitigation actions on the river have a trust responsibility to work with Tribes on a government-to-government basis in recognition of Tribal sovereignty. Additional Tribes with ancestral ties to the basin are being contacted to determine their consulting interest.

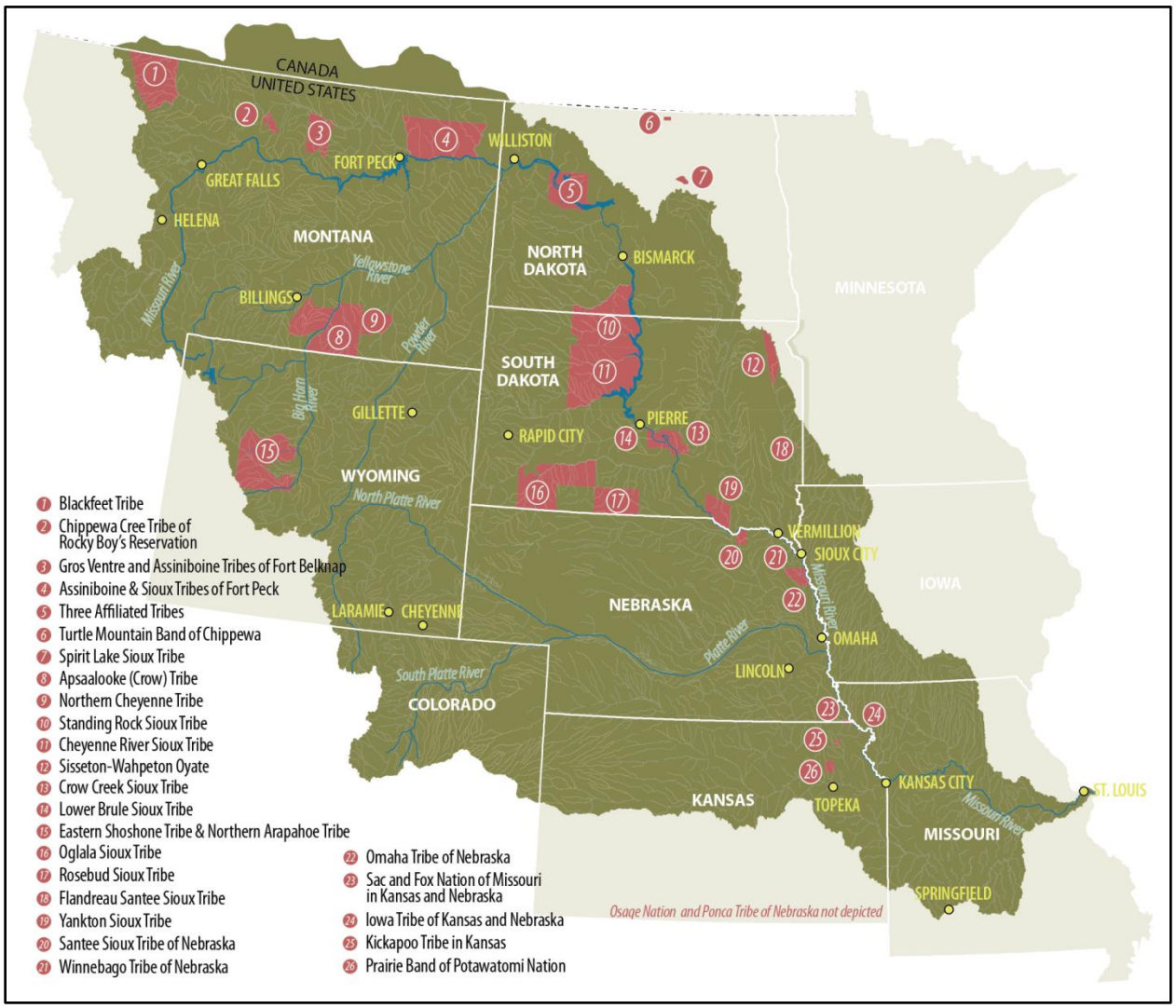



**Figure 3-62. Map of Reservations Located Within or Around the Missouri River Basin**

### 3.20.1.2 Tribal Lands

According to the U.S. Department of the Interior "a federal Indian reservation is an area of land reserved for a Tribe or Tribes under treaty or other agreement with the United States, executive order, or federal statute or administrative action as permanent Tribal homelands, and where the federal government holds title to the land in trust on behalf of the Tribe" (U.S. Department of the

Interior 2012). Instead of a reservation, the Ponca Tribe of Nebraska has service areas in 15 counties located in Nebraska, South Dakota, and Iowa. (Ponca Tribe of Nebraska 2012) A service area is a location at which the Tribe offers services such as education, healthcare, and social services.

Thirteen of the Tribal reservations (as well as a portion of the Ponca trust land) are adjacent to the river and/or partially within the floodplain (Table 3-245). These reservations vary in size, with Fort Peck having the most land within the floodplain, and also in resources present within the floodplain. Natural vegetation regimes (herbaceous grasslands, wetlands, and forest) are the most prevalent land cover feature among Tribal areas in the floodplain; although in general, there are more grasslands present than other natural vegetation. Croplands represent the next largest proportion of land cover type.

**Table 3-245. Tribal Reservation Land within the Missouri River Floodplain**

| Tribal Reservation | Natural Vegetation (Grassland, wetland, and forest) | Croplands | Open Water | Developed/ Low Intensity/ Open Space | Other | Total Reservation Land in the Floodplain |
|---|---|---|---|---|---|---|
| Fort Peck Reservation | 1,198,493 | 793,655 | 11,811 | 68,939 | 17,800 | **2,117,699** |
| Fort Berthold (Three Affiliated) | 567,366 | 291,925 | 151,200 | 25,283 | 12,675 | **1,048,449** |
| Standing Rock Reservation | 1,747,778 | 429,742 | 9,222 | 29,277 | 3,846 | **2,219,865** |
| Cheyenne River Reservation | 2,284,414 | 383,555 | 12,523 | 20,604 | 5,263 | **2,706,359** |
| Lower Brule Reservation | 171,212 | 41,949 | 8,868 | 3,200 | 248 | **225,475** |
| Crow Creek Reservation | 202,413 | 68,971 | 47,305 | 5,300 | 554 | **324,541** |
| Yankton Reservation | 112,008 | 285,793 | 6,061 | 16,479 | 1,378 | **421,719** |
| Santee Sioux Reservation | 81,423 | 23,558 | 1,722 | 3,300 | 105 | **110,106** |
| Winnebago Reservation | 29,961 | 79,701 | 749 | 4,947 | 86 | **115,443** |
| Ponca Tribe of Nebraska | NA | NA | NA | NA | NA | **NA** |
| Omaha Tribe of Nebraska Reservation | 34,809 | 87,633 | 1,087 | 6,259 | 67 | **129,854** |
| Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation | 1,185 | 11,600 | 44 | 469 | 510 | **13,808** |

| Tribal Reservation | Natural Vegetation (Grassland, wetland, and forest) | Croplands | Open Water | Developed/ Low Intensity/ Open Space | Other | Total Reservation Land in the Floodplain |
|---|---|---|---|---|---|---|
| Iowa Tribes of Kansas and Nebraska Reservation | 2,780 | 5,078 | 12 | 308 | 989 | **9,167** |
| **Total for Reservations Along the Missouri River Floodplain** | **6,433,842** | **2,503,160** | **250,604** | **184,365** | **43,521** | **9,422,485** |

Source: USDA NASS Agriculture Census 2011 Cropland Data Layer

### 3.20.1.3 Tribal Interests

Tribes of the Missouri River Basin have an interest in many of the resources that are described in the other sections of this chapter. These resources include agriculture, irrigation, water supply, thermal power, recreation, flood risk management, and fish and wildlife. Each section describing one of these resources also describes the connection to Tribes. However, this section describes additional connections to the Missouri River that are unique to Tribal members.

#### Subsistence Hunting, Fishing, and Gathering

Opportunities for fishing, hunting, and trapping can be essential for Tribal members. Through hunting, fishing, and gathering, some Tribal members use the fish, wildlife, and vegetation of the Missouri River and its floodplain to account for a significant portion of their food supply. Fishing could include native and nonnative species, depending on the Tribe and location. Subsistence gathering typically consists of native fruits, berries, and vegetables. Many Tribal members also gather native plants for medicinal and ceremonial uses. The availability of resources that allow for subsistence and/or traditional cultural practices contributes to the cultural identity of many Tribal members.

Native American Tribal reservations are located in rural areas where opportunities for fishing, hunting, and trapping are greater than in urban areas. For environmental justice purposes, a distinction is made between fishing, hunting, and trapping for recreational purposes versus for subsistence. In 1997, the CEQ defined subsistence consumption of fish and wildlife by minority populations, low income populations, and/or Indian Tribes two ways: (1) dependence on indigenous fish, vegetation, and/or wildlife as the principal portion of their diet; and (2) differences in rates and/or patterns of subsistence consumption by minority populations, low-income populations, and Indian Tribes as compared to rates and patterns of consumption of the general population. The average number of days spent fishing and hunting by residents (Tribal and non-Tribal) at least 16 years old (adults) in each state along the Missouri River in 2001 is shown in Table 3-246.

**Table 3-246. Average Hunting and Fishing Days in 2001 by Adult Residents of Missouri River States**

| State | Adult Residents (1,000s), 2001 | Adult Resident Hunting Days (1,000s) | Average Hunting Days per Adult Resident | Adult Resident Fishing Days (1,000s) | Average Fishing Days per Adult Resident |
|---|---|---|---|---|---|
| Montana | 699 | 2,112 | 3.02 | 3,656 | 5.23 |
| North Dakota | 483 | 1,417 | 2.93 | 2,584 | 5.35 |
| South Dakota | 559 | 1,347 | 2.41 | 2,414 | 4.32 |
| Nebraska | 1,266 | 1,963 | 1.55 | 3,378 | 2.67 |
| Iowa | 2,201 | 4,086 | 1.86 | 8,534 | 3.88 |
| Kansas | 2,017 | 3,424 | 1.70 | 6,426 | 3.19 |
| Missouri | 4,206 | 6,715 | 1.60 | 12,396 | 2.95 |
| All seven states | 11,431 | 21,064 | 1.84 | 39,388 | 3.45 |

Source: USFWS / U.S. Census Bureau 2002. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. The 2006 survey was not used because results were affected by drought conditions.

In general, residents of states with high concentrations of Tribal members (Montana, North Dakota, and South Dakota) spend more time hunting and fishing than other states in the Missouri River Basin. Additional information was obtained from knowledgeable members and/or employees of each of the Tribes located along the Missouri River or with service areas along the river. No specific percentages of adult Tribal members who hunt and/or fish were provided, but the average percentages of Tribal members' diets that consist of harvested game, fish, and shellfish that were estimated suggest that the average adult Tribal member spends many more days hunting and/or fishing than the highest state average of 3 days per year hunting and 5 days per year fishing (Table 3-246). Even for Tribes with a relatively small overall percentage of harvested game and fish in their diets, some members may have a much higher percentage and could be considered subsistence hunters and/or anglers on an individual or family basis.

### 3.20.1.4 Traditional Cultural Practices and Educational Opportunities

Many Tribal members use the Missouri River and its floodplain for traditional cultural practices, including traditional Tribal ways of daily life (which may include seeing and interacting with the river throughout the day) and sacred/spiritual values through ceremonies, sundances, vision quests, and sweat lodges. Protection of cultural resources (described in Section 3.9, Cultural Resources) and preservation of cultural practices are paramount for many Tribal members. These values and ways of life are affected by the physical components of the Missouri River and its floodplain, including its effect on physical resources such as plants, berries, trees, and water. For example, the availability of cottonwood trees, which have important cultural uses for many Tribes, is dependent on "forested wetland/riparian woodland" habitat, as described in Section 3.5, Fish and Wildlife Habitat. Also, access to sites used for traditional cultural practices and educational opportunities are affected by frequency/severity of flooding. Natural aquatic and floodplain habitats resemble the conditions under which traditional cultural practices were developed. Similarly, the educational opportunities are improved by natural aquatic and floodplain habitats on current and historic Tribal land.

## 3.20.2 Environmental Consequences

Each of the human considerations sections in this chapter has documented the potential effects of MRRMP-EIS alternatives on Tribal interests, to the extent applicable. This section documents other potential effects on Tribal interests that have not been addressed in the other sections. These specific Tribal interests include subsistence hunting, fishing, and gathering, as well as traditional cultural practices and educational opportunities.

### 3.20.2.1 Impacts Assessment Methodology

Alternative means of achieving species objectives are evaluated for their effects on these Tribal interests. Some effects are specific to reservations, while some effects occur on other parts of the Missouri River but are relevant to Tribes nonetheless. The impacts to these specific Tribal interests are evaluated using the OSE account. 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 methodology for evaluating impacts to Tribal interests.

**Other Social Effects**

Changes in the physical conditions of the Missouri River and its floodplain have a potential to affect Tribal communities and/or individual Tribal members by affecting the ability of Tribal members to use the floodplain for subsistence hunting and gathering, to access the river and mainstem reservoirs for subsistence fishing, to access the river and its environment for traditional cultural practices, and to access the river for educational opportunities. These effects are analyzed under the OSE account. All of these potential effects are assessed qualitatively.

The assessment of subsistence hunting and fishing draws upon the analysis that can be found in the Environmental Consequences discussion in Section 3.16, Recreation, particularly the “Tribal Resources” subsection. When Tribal members have better opportunities to hunt or fish for the purpose of recreation, they will also have better opportunities to hunt or fish for the purpose of subsistence.

The assessment of subsistence gathering draws upon the analysis that can be found in the Environmental Consequences discussion in Section 3.5, Fish and Wildlife Habitat. The ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants is subject to the quantity of habitat where plant species collected for subsistence gathering typically occur, including scrub shrub wetland, riparian woodland/forested wetland, forest, and upland grassland.

The assessments of traditional cultural practices and educational opportunities also draw upon the analysis found in the Environmental Consequences discussion in Section 3.5, Fish and Wildlife Habitat. Opportunities for both traditional cultural practices and education are benefited when the river and its floodplain more closely resemble habitat classes that occurred under the conditions that traditional cultural practices developed: primarily open water, emergent wetland, scrub shrub wetland, and riparian woodland / forested wetland. Given the importance of cottonwood trees in Tribal culture, the riparian woodland /forested wetland habitat class is of particular importance in assessing opportunities for traditional cultural practices.

### Analysis Assumptions

The following assumptions were used for the impacts analysis for Tribal interests:

- Effects on subsistence hunting and fishing on or near reservations will generally be proportional with effects on recreational value for the applicable reach, identified in the recreation analysis.
- Effects on subsistence gathering on or near reservations will generally be proportional with effects on trends in upland grassland habitat in the applicable reach, identified in the fish and wildlife analysis.
- Effects on traditional cultural practices and educational opportunities will generally be proportional with effects on trends in open water, emergent wetland, scrub shrub wetland, and (particularly) riparian woodland/forested wetland.

Importantly, the fish and wildlife habitat analysis does not provide absolute change in habitat classes. Because of modeling constraints, specific day inundation regimes were used to facilitate comparison of alternatives. For example, in the Garrison to Oahe Reach, modeling assumed upland grassland is represented by areas with one day of inundation; forest is represented by areas with 16 days of inundation; riparian woodland/forested wetland is represented by 36 days of inundation; scrub shrub wetland is represented by 52 days of inundation; emergent wetland is represented by 159 days of inundation; and open water is represented by 365 days of inundation. The modeling produces the change in the acreage of upland grassland inundated at one day, for instance, rather than the change in acreage of the upland grassland category as a whole. The analysis is useful for comparing trends between alternatives (e.g., trending toward wetter or drier habitats), but should not be used as an indicator of absolute changes or shifts in habitat classes. The impacts analysis assumes that changes in specific day inundation regimes are representative of the trends that would occur under each alternative.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

### 3.20.2.2 Summary of Consequences

The consequences on Tribal interests (other) are summarized in Table 3-247. 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 3-247. Consequences Relative to Tribal Interests**

| Alternative | OSE Impacts – Subsistence Hunting and Fishing | OSE Impacts – Subsistence Gathering | OSE Impacts – Traditional Cultural Practices and Educational Opportunities |
|---|---|---|---|
| Alternative 1 – No Action (Current System Operation and Current MRRP Implementation) | Alternative 1 represents the No Action alternative / baseline of comparison for the other alternatives | Alternative 1 represents the No Action alternative / baseline of comparison for the other alternatives | Alternative 1 represents the No Action alternative / baseline of comparison for the other alternatives |
| Alternative 2 | Slight decrease in subsistence hunting and fishing opportunities in the upper three reservoirs.<br>Slight increase in subsistence hunting and fishing opportunities in the lower river. | Decreases in habitat, suitable for subsistence gathering, in Garrison to Oahe and Rulo to Kansas River reaches.<br>Increase in habitat suitable for gathering in Gavins Point to Rulo reach. | Increase in historic habitat classes, more suitable for traditional cultural practices and educational opportunities, in the upper river.<br>Increase in historic habitat classes in the lower river.<br>Increase in habitat suitable for cottonwood trees. |
| Alternative 3 | No significant change in subsistence hunting and fishing opportunities. | Decrease in habitat suitable for subsistence gathering in Garrison to Oahe reach.<br>Increase in habitat suitable for subsistence gathering in Rulo to Kansas reach. | Increase in historic habitat classes, more suitable for traditional cultural practices and educational opportunities, in the upper river.<br>No significant change in historic habitat classes in the lower river.<br>Increase in habitat suitable for cottonwood trees. |
| Alternative 4 | Slight decrease in subsistence hunting and fishing opportunities in the upper three reservoirs. | Increases in habitat suitable for subsistence gathering in Garrison to Oahe, Gavins Point to Rulo, and Rulo to Kansas reaches. | No significant change in historic habitat classes, more suitable for traditional cultural practices and educational opportunities, in the upper river or lower river.<br>Increase in habitat suitable for cottonwood trees. |
| Alternative 5 | No significant change in subsistence hunting and fishing opportunities. | Decrease in habitat suitable for subsistence gathering in Garrison to Oahe River reach.<br>Slight decreases in habitat suitable for subsistence gathering in Gavins Point to Rulo and Rulo to Kansas reaches. | Increase in historic habitat classes, more suitable for traditional cultural practices and educational opportunities, in the upper river.<br>No significant change in historic habitat classes in the lower river.<br>Increase in habitat suitable for cottonwood trees. |
| Alternative 6 | Slight decrease in subsistence hunting and fishing opportunities in the upper three reservoirs. | Decrease in habitat suitable for subsistence gathering in Garrison to Oahe River reach.<br>Increases in suitable for subsistence gathering in Gavins Point to Rulo and Rulo to Kansas River reaches. | Increase in historic habitat classes, more suitable for traditional cultural practices and educational opportunities, in the upper river.<br>No significant change in historic habitat classes in the lower river.<br>Increase in habitat suitable for cottonwood trees. |

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

Under Alternative 1, system operations would be the same as current operations. This alternative is considered the baseline against which the other alternatives are measured.

**Other Social Effects**

Opportunities for traditional cultural practices under Alternative 1 are affected by the trends in habitat types (open water, emergent wetland, scrub shrub wetland, and riparian woodland/forested wetland).The acres of these habitat types under Alternative 1 modeled under typical hydrologic conditions for the POR (82 years) includes approximately 264,749 acres in the upper river and 114,015 acres in the lower river. Alternative 1 would have 21,123 acres of riparian woodland/forested wetland habitat (i.e., the habitat class most suitable for cottonwood trees) in the upper river and 2,767 acres of riparian woodland/forested wetland habitat in the lower river as modeled under typical hydrologic conditions for the POR (82 years). While a variety of physical conditions are required for recruitment and establishment of cottonwoods, the presence of habitat could be beneficial to the abundance of species important for traditional cultural practices, including cottonwoods.

The ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants under Alternative 1 is affected by the quantity of scrub shrub wetland, riparian woodland/forested wetland, forest, and upland grassland habitat, particularly in areas on or near reservations. The acres of these habitat types modeled under typical hydrologic conditions under Alternative 1 for the POR include 159,920 combined acres of habitat suitable for subsistence gathering across all upper river reaches, as well as 5,446 acres in the Gavins to Rulo reach and 8,270 acres in the Rulo to Kansas River reach. Further details on the acres of habitat types are located in Section 3.5, Fish and Wildlife.

The ability of Tribal members to use the river and reservoirs for subsistence fishing and to use the floodplain for subsistence hunting are highly correlated with the ability to access similar areas for recreation. This is particularly true for recreation areas on or near reservations. Therefore, the relevant reaches from the recreation analysis include the upper three reservoirs, the lower three reservoirs, the inter-reservoir river reaches, and the lower river.

**Conclusion**

Alternative 1 represents the continuation of current system operation including MRRP implementation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. Alternative 1 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities. The management actions that comprise Alternative 1 would continue to provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species.

### 3.20.2.4 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

**Other Social Effects**

Opportunities for traditional cultural practices and education in the upper river are modeled to be somewhat better under Alternative 2, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 2 has an increasing trend.

Open water, emergent wetland, and scrub shrub wetland would also have an increasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the upper river in riparian woodland/forested wetland habitat would occur in the Garrison to Oahe reach, which could mean much better conditions for species important for traditional cultural practices including cottonwoods in that area.

Opportunities for traditional cultural practices and education in the lower river are modeled to be somewhat better under Alternative 2, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 2 has an increasing trend. Emergent wetland and scrub shrub wetland would also have an increasing trend and open water would have a decreasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the lower river in riparian woodland/forested wetland habitat would occur in the Rulo to Kansas River reach, which could mean much better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants is modeled to be less under Alternative 2 than under Alternative 1 with a general decreasing trend in upland grassland in the upper river. Most of the decrease would occur in the Garrison to Oahe reach. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in the Gavins Point to Rulo reach and a decreasing trend in habitat suitable for subsistence gathering in the Rulo to Kansas River reach.

The ability of Tribal members to use the upper three reservoirs for subsistence fishing and hunting are modeled to be slightly less under Alternative 2 than under Alternative 1, given that the recreation analysis shows a 1.3 percent decrease in recreation value at the upper three reservoirs under Alternative 2. However, the ability to use the lower river for subsistence fishing and hunting are modeled to be slightly better under Alternative 2 than under Alternative 1, given that the recreation analysis shows a 1.9 percent increase in recreation value on the lower river under Alternative 2. There would likely be little to no effect on subsistence fishing and hunting on the lower three reservoirs or in the inter-reservoir reaches, given that the recreation analysis indicates that Alternative 2 would have little to no effect on those areas.

**Conclusion**

Alternative 2 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities. As assessed, Alternative 2 would have a small increase in benefits to OSE as compared to Alternative 1. The management actions that comprise Alternative 2 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species.

### 3.20.2.5 Alternative 3 – Mechanical Construction Only

**Other Social Effects**

Opportunities for traditional cultural practices and education in the upper river are modeled to be somewhat better under Alternative 3, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 3 has an increasing trend. Open water and emergent wetland would also have an increasing trend and scrub shrub wetland would have a decreasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the upper river in

riparian woodland/forested wetland habitat would occur in the Fort Peck to Garrison reach, which could mean better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

Opportunities for traditional cultural practices and education in the lower river would be very similar under Alternative 3, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 3 would have an increasing trend. Open water, emergent wetland, and scrub shrub wetland would have a decreasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the lower river in riparian woodland/forested wetland habitat would occur in the Kansas River to Grand River reach, which could mean better conditions for species important to cultural practices, including cottonwoods, in that area.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants is modeled to be less under Alternative 3 than under Alternative 1, with a decreasing trend in upland grassland. Most of the decrease would occur in the Garrison to Oahe reach. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in the Rulo to Kansas River reach and no significant change (relative to Alternative 1) in habitat suitable for subsistence gathering in the Gavins Point to Rulo reach.

Alternative 3 would likely have little impact on the ability of Tribal members to use the river, reservoirs, or floodplain for subsistence fishing and hunting in any reach, given that the recreation analysis indicates that (relative to Alternative 1) Alternative 3 would not increase or decrease recreation value by more than 0.2 percent in any reach.

**Conclusion**

Alternative 3 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities. As assessed, Alternative 3 would have a small increase in benefits in OSE as compared to Alternative 1. The management actions that comprise Alternative 3 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species.

### 3.20.2.6 Alternative 4 – Spring ESH Creating Release

**Other Social Effects**

Opportunities for traditional cultural practices and education in the upper river under Alternative 4 are modeled to be very similar to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 4 would have an increasing trend. Scrub shrub wetland would also have an increasing trend and open water and emergent wetland would have a decreasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the upper river in riparian woodland/forested wetland habitat would occur in the Garrison to Oahe reach, which could mean much better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

Opportunities for traditional cultural practices and education in the lower river are modeled to be very similar under Alternative 4, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 4 would have an increasing trend. Open water, emergent wetland, and scrub shrub wetland would have a decreasing trend

as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the lower river in riparian woodland/forested wetland habitat would occur in the Kansas River to Grand River reach, which could mean better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants are modeled to be slightly more under Alternative 4 than under Alternative 1, with an increasing trend in upland grassland in the upper river. Most of the increase would occur in the Garrison to Oahe reach. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in the Gavins Point to Rulo reach as well as the Rulo to Kansas River reach.

The ability of Tribal members to use the upper three reservoirs for subsistence fishing and hunting would likely be slightly less under Alternative 4 than under Alternative 1, given that the recreation analysis shows a 2.1 percent decrease in recreation value at the upper three reservoirs under Alternative 4. Alternative 4 would likely have little impact on subsistence fishing and hunting in the other reaches, given that the recreation analysis indicates that (relative to Alternative 1) Alternative 3 would not increase or decrease recreation value by more than 0.2 percent at the lower three reservoirs, the inter-reservoir river reaches, or the lower river.

#### Conclusion

Alternative 4 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities. As assessed, Alternative 4 would provide similar benefits to OSE as compared to Alternative 1. The management actions that comprise Alternative 4 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species.

### 3.20.2.7 Alternative 5 – Fall ESH Creating Release

#### Other Social Effects

Opportunities for traditional cultural practices and education in the upper river are modeled to be slightly better under Alternative 5, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 5 would have an increasing trend. Open water and emergent wetland would also have an increasing trend, and scrub shrub wetland would have a decreasing trend, as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the upper river in riparian woodland/forested wetland habitat would occur in the Fort Peck to Garrison reach, which could mean better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

Opportunities for traditional cultural practices and education in the lower river would likely be very similar under Alternative 5, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 5 would have an increasing trend. Open water, emergent wetland, and scrub shrub wetland would have a decreasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the lower river in riparian woodland/forested wetland habitat would occur in the Kansas River to Grand River reach, which could mean better conditions for species important for traditional cultural practice, including cottonwoods, in that area.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants could be less in the upper river under Alternative 5, due to a decreasing trend as modeled in upland grassland. Most of the decrease would occur in the Garrison to Oahe river reach. In the lower river, there would be a slight decreasing trend in habitat suitable for subsistence gathering in the Gavins Point to Rulo reach as well as the Rulo to Kansas River reach.

Alternative 5 would likely have little effect (relative to Alternative 1) on subsistence fishing and hunting. The recreation analysis showed only a 0.3 percent decrease in recreation value at the upper three reservoirs, a 0.5 percent decrease in recreation value in the lower river, and no change in recreation value on the lower three reservoirs or in the inter-reservoir river reaches.

**Conclusion**

Alternative 5 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities. As assessed, Alternative 5 would have a small increase in benefits to OSE as compared to Alternative 1. The management actions that comprise Alternative 5 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species.

### 3.20.2.8 Alternative 6 – Pallid Sturgeon Spawning Cue

**Other Social Effects**

Opportunities for traditional cultural practices and education in the upper river would likely be somewhat better under Alternative 6, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 6 would have an increasing trend. Open water, emergent wetland, and scrub shrub wetland would also have an increasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the upper river in riparian woodland/forested wetland habitat would occur in the Fort Peck to Garrison river reach, which could mean much better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

Opportunities for traditional cultural practices and education in the lower river would likely be very similar under Alternative 6, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 6 would have an increasing trend. Open water, emergent wetland, and scrub shrub wetland would have a decreasing trend as modeled under typical hydrologic conditions for the POR (82 years). The largest increasing trend (relative to Alternative 1) in the lower river in riparian woodland/forested wetland habitat would occur in the Kansas River to Grand River reach, which could mean much better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants are modeled to be less in the upper river under Alternative 6, due to a decreasing trend in upland grassland in the upper river reaches. Most of the decrease would occur in the Garrison to Oahe reach. In the lower river reaches where current Tribal lands occur, there would be an overall increasing trend in habitat suitable for subsistence gathering. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in the Gavins Point to Rulo reach as well as the Rulo to Kansas River reach.

The ability of Tribal members to use the upper three reservoirs for subsistence fishing and hunting would likely be slightly less under Alternative 6 than under Alternative 1, given that the recreation analysis shows a 1.4 percent decrease in recreation value at the upper three reservoirs under Alternative 6. There would likely be little effect on subsistence fishing and hunting in the other reaches, given that the recreation analysis shows increases in recreation benefits of 0.3 percent or less for the lower three reservoirs, the inter-reservoir reaches, and the lower river.

**Conclusion**

Alternative 6 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities. As assessed, Alternative 6 would have a small increase in benefits to OSE as compared to Alternative 1. The management actions that comprise Alternative 6 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species.

#### 3.20.2.9 Climate Change

As described in Section 3.5, Fish and Wildlife, climate change could have a beneficial or an adverse effect on, wetter habitat classes (i.e., open water, emergent wetland, scrub shrub wetland, and riparian habitat) that are more suitable for traditional cultural practices, depending on whether climate change has a greater effect on drought conditions or the frequency of spring flood events. Climate change could also have some effect on the ability of Tribal members to use the floodplain for subsistence gathering; however, habitats most suitable for subsistence gathering are a mixture of wetter (i.e., scrub shrub wetland and riparian) and drier (i.e., forest and upland grassland) habitat classes, so the overall effect on subsistence gathering is less clear.

The effects of climate change on subsistence hunting and fishing would parallel the effects of climate change described in Section 3.16, Recreation. Earlier snowmelt could lead to more frequent spring pulses under Alternative 1, followed by more frequent low reservoir elevations, decreasing access to the reservoirs for subsistence fishing. Climate change could also negatively affect access for subsistence fishing under Alternatives 2 through 6, due to increased frequency of prolonged drought periods, which also decrease reservoir elevations. These impacts could be exacerbated by spring or fall releases under Alternatives 2, 4, 5, and 6. Climate change may also increase the number of partial-release events under Alternatives 2, 4, 5, and 6, which would have a mixed effect on subsistence hunting and fishing.

#### 3.20.2.10 Cumulative Impacts

Tribes in the Missouri River basin have experienced direct impacts as a result of changes made in the river from past Missouri River mainstem dam system construction and operation and the Bank Stabilization and Navigation Project past construction and operation. Subsistence hunting, fishing and gathering, along with Traditional Cultural Practices were largely affected for all Tribes along the river, as well as those Tribal members that have historical ties to the river. For Tribes in the reservoir reaches, large areas of land were covered by reservoirs, while in the lower reaches, the river channelization changed the floodplain environment. Along with the changing landscape, access to remaining traditional sites became limited in certain areas. The decrease, or in some cases loss, of the many berries, flowers, medicinal, and sacred plants disrupted the traditional cultural activities that are intrinsic to the identity of the Tribes. Consequently, these losses created a decrease in opportunities to educate future Tribal

members about these traditional cultural activities. Eroding embankments due to changes in flows threaten areas that may be used in ceremony or contain cottonwood trees that are important to many of the Tribes. Access continues to be an issue as it is often in competition with the different Authorized Purposes, such as recreation. Subsistence hunting and fishing was changed, impacting the culture and the economy. Similarly, the flooding of land from the reservoirs impacted many of the Tribes that historically used these lands for farming.

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 and would be anticipated to have a positive impact on Tribal interests. These actions include USACE Continuing Authority Programs with the purpose of ecosystem restoration, 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 Tribal interests related to fish and wildlife and their habitat.

Reasonably foreseeable future actions which may adversely impact fish and wildlife and their habitat include future transportation and utility corridor development, oil and gas development, conversion of habitat for agriculture and other land uses, and water table depletion due to withdrawals from the Missouri River and are the same for all of the Alternatives (1–6). These 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 and would therefore also impact Tribal interests.

The management actions that comprise Alternative 1 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts that have occurred combined with adverse actions that may occur in the future. The incremental impact of Alternative 1 when added to other past, present and reasonably foreseeable actions would be negligible. Large impacts to subsistence hunting, fishing, gathering and opportunities for traditional cultural practices and educational opportunities have occurred and continue to occur.

Under Alternative 2, modeled conditions would be somewhat better overall for traditional and cultural practices in both the upper and lower basin under Alternative 2. Traditional and educational opportunities would be somewhat better in the lower river under Alternative 2, than Alternative 1. Based upon the recreation analysis, which shows little change between Alternative 2 and 1, subsistence hunting and fishing appears to have little change between Alternative 1 and Alternative 2. When combined with past, present, and reasonably foreseeable future actions, large impacts to subsistence hunting, fishing, gathering and opportunities for traditional cultural practices and educational opportunities would continue to occur. Although Alternative 2 would provide additional benefit in comparison to Alternative 1, the incremental impact of Alternative 2 would be negligible.

Under Alternative 3 modeled conditions and associated impacts would be somewhat better for traditional cultural practices and education in the upper river under Alternative 3, as compared to Alternative 1, although some small adverse impacts to subsistence gathering could occur. Although Alternative 3 would provide additional benefit in comparison to Alternative 1, when added to other past, present and reasonably foreseeable future actions the cumulative impacts

of Alternative 3 would be large and adverse to subsistence hunting, fishing, gathering and opportunities for traditional cultural practices and educational opportunities. The management actions that comprise Alternative 3 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts.

Under Alternative 4, in both the upper and lower rivers, the opportunities for traditional cultural practices and education would be very similar to Alternative 1. Recreation opportunities would be slightly less under Alternative 4, than Alternative 1, by approximately 2.1 percent in the upper three reservoirs, so it may be assumed that this will be similar for subsistence hunting and fishing. The lower three reservoirs and lower river reaches show little change between the two alternatives. When combined with other past, present, and reasonably foreseeable future action, the cumulative impacts of Alternative 4 would be large and adverse; however, the contribution of Alternative 4 would be negligible.

Under Alternative 5, the slight increase of habitat types associated with traditional and cultural practices could provide a slightly better opportunity for the ability to either continue or bring back traditional cultural activities and provide educational opportunities as compared to Alternative 1. The largest increase may occur in both the Fort Randall to Gavins Point and Rulo to Kansas River riverine reach. Alternative 5 would provide a similar benefit in comparison to Alternative 1. When combined with other past, present, and reasonably foreseeable future action, the cumulative impacts of Alternative 5 would be large and adverse; however, the contribution of alternative 5 would be negligible. The management actions that comprise Alternative 5 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts that have occurred combined with adverse actions that may occur in the future.

While Alternative 6 would likely result in a slightly better opportunity for traditional cultural practices and educational opportunities compared to Alternative 1 in both the upper and lower river reaches, the acreage inundated at 1 day (upland grassland) was notably less in the upper river. Alternative 6 would provide a similar benefit in comparison to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 would be large and adverse; however, the contribution of alternative 6 would be negligible. The management actions that comprise Alternative 6 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts that have occurred combined with adverse actions that may occur in the future.

# 3.21 Human Health and Safety

## 3.21.1 Affected Environment

The alternatives analyzed in this EIS may have the potential to affect the health and safety of USACE employees and contractors as well as residents of communities along the Missouri River. More traditional human health and safety issues associated with the use of construction equipment and other occupational hazards involved in ESH creation and SWH construction are discussed in previous USACE NEPA documents (USACE 2009 and 2012). This section focuses on the potential for increased risk of mosquito-borne diseases as a consequence of implementing any of the MRRMP-EIS alternatives.

Mosquitoes are serious nuisance pests due to their persistent biting behavior and are responsible for affecting the health and well-being of humans, companion animals, livestock, and wildlife (Rolston and Johnson 2012). Accordingly, human health and safety could be affected by the implementation of the alternatives analyzed in this EIS if they result in changes in the availability of mosquito breeding habitat along the mainstem Missouri River that lead to the potential for increased risk of transmission of disease.

### 3.21.1.1 Arboviral Diseases of Concern in Mainstem Missouri River States

In the United States, mosquitoes transmit a variety of arboviruses (arthropod-borne viruses). The most common arboviral disease within the Missouri River Basin, and in the United States as a whole, is West Nile Virus. Other arboviral diseases known to occur within the mainstem Missouri River states include St. Louis encephalitis, western equine encephalitis, and LaCrosse encephalitis. The Zika virus, while not yet known to be transmitted within the Missouri River Basin, represents an emerging threat to human health and safety in states along the mainstem Missouri River and throughout the country.

**West Nile Virus**

West Nile virus was first reported in the U.S. in 1999 and is presently the most common mosquito-borne disease in the seven mainstem Missouri River states as well as in the U.S. (KDOH 2016; Rolston and Johnson 2012; MDHSS 2016). West Nile virus has been detected in a number of mosquito species; however, *Culex* mosquito species act as the primary vector for West Nile virus in the United States (Zurek and Broce 2002; IDPH 2015; KDOH 2016; Rolston and Johnson 2012). Certain birds, particularly crows, jays, robins, and other passerine birds, play an important role in the amplification of the West Nile virus in the environment. These amplifying hosts develop high concentrations of virus in their bodies, making them a source of disease for feeding mosquitoes, which then transmit the disease to humans.

**St. Louis Encephalitis**

Encephalitis refers to inflammation of the brain. St. Louis encephalitis virus, like West Nile virus, is a member of the genus *Flavivirus*, and similar to West Nile virus, mosquitoes (primarily *Culex* species) become infected with St. Louis encephalitis virus by feeding on birds infected with the virus (CDC 2016a). Infected mosquitoes then transmit the virus to humans and animals during the feeding process. St. Louis encephalitis virus grows in both infected birds and mosquitoes, but does not make either one sick. In the United States, the majority of St. Louis encephalitis virus cases have occurred in eastern and central states, where episodic urban-centered outbreaks have recurred since the 1930s.

### Western Equine Encephalitis

Western equine encephalitis has been recognized for nearly 50 years as a disease not only of horses but also of humans in the central and western United States. (Andre 1981). Western equine encephalitis is normally maintained between *Culex* mosquito species and birds. People and horses are bitten by *Culex* mosquitoes that have previously fed on infected birds during the late summer months (mid-July through early September). Horses and humans are often referred to as "dead-end" hosts for Western equine encephalitis, as the virus does not build to high enough levels in horse or human blood to infect other mosquitoes (MNDH 2016).

### LaCrosse Encephalitis

La Crosse encephalitis is a rare disease typically transmitted to humans by the treehole mosquito (*Aedes triseriatus*). La Crosse encephalitis is not transmitted directly from person to person. Many people infected with La Crosse encephalitis have no apparent symptoms, and similar to other types of mosquito-borne encephalitis, most cases of La Crosse encephalitis likely go unreported. Historically, most cases of La Crosse encephalitis neuroinvasive disease were reported from the upper Midwestern states (Minnesota, Wisconsin, Iowa, Illinois, Indiana, and Ohio). Recently, more cases have been reported from mid-Atlantic and southeastern states (West Virginia, Virginia, Kentucky, North Carolina, and Tennessee). La Crosse encephalitis is relatively rare in the mainstem Missouri River states. Between 2004 and 2013, one case of La Crosse encephalitis was reported in Missouri and four cases were reported in Iowa. No cases of La Crosse encephalitis were reported in the other mainstem Missouri River states during this period (CDC 2016c).

### Zika Virus

Zika virus disease is caused by the Zika virus, which is spread to people primarily through the bite of an infected *Aedes* species mosquito. *Aedes aegypti* and *Aedes albopictus* are the principal vectors of Zika virus. These species are native to Africa and Asia, respectively, but have been transported globally throughout the tropical, subtropical, and temperate world through shipping activities. Of the two species, *Aedes aegypti* mosquitoes are more likely to spread Zika virus (CDC 2016d).

### Prevalence of Mosquito-Borne Diseases in Mainstem Missouri River States

All of the states along the mainstem Missouri River maintain surveillance programs that track the incidence of mosquito-borne diseases. This information is then shared with the Centers for Disease Control (CDC). As shown in Table 3-248, West Nile virus is by far the most prevalent mosquito-transmitted disease in the seven states along the mainstem Missouri River. During the 5-year period from 2010 to 2014, a total of 1,767 cases of West Nile virus were reported within the seven states, and 46 fatalities were documented (CDC 2016f). In contrast, only two cases of St. Louis encephalitis have been documented over same the 5-year period, both in Missouri (CDC 2016h; USGS 2016). No human cases of Western equine encephalitis or La Crosse encephalitis have been documented in the seven mainstem Missouri River states since at least 2003 (USGS 2016).

The number of confirmed Zika infections in the United States has been growing at a rapid rate, considering that the virus has only recently been documented in the western hemisphere. As shown in Table 3-248, a total of 16 laboratory-confirmed cases of Zika have been documented within the seven mainstem Missouri River states as of June 8, 2016.

**Table 3-248. Incidence of West Nile Virus, St. Louis Encephalitis Virus, and Zika Virus in Mainstem Missouri River States**

| | | West Nile Virus [a] | | | | | | St. Louis Encephalitis Virus | | | | | | Zika Virus[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | 2012 | 2013 | 2014 | Total | 2010 | 2011 | 2012 | 2013 | 2014 | Total | 2015–2016 |
| Montana | Reported Cases | 0 | 1 | 6 | 38 | 5 | **50** | 0 | 0 | 0 | 0 | 0 | **0** | **1** |
| | Fatalities | 0 | 0 | 1 | 2 | 0 | **3** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| North Dakota | Reported Cases | 9 | 4 | 89 | 125 | 23 | **250** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| | Fatalities | 0 | 0 | 1 | 2 | 2 | **5** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| South Dakota | Reported Cases | 20 | 2 | 203 | 149 | 57 | **431** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| | Fatalities | 0 | 0 | 3 | 3 | 0 | **6** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| Iowa | Reported Cases | 9 | 9 | 31 | 44 | 15 | **108** | 0 | 0 | 0 | 0 | 0 | **0** | **7** |
| | Fatalities | 2 | 0 | 0 | 0 | 0 | **2** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| Nebraska | Reported Cases | 39 | 29 | 193 | 226 | 142 | **629** | 0 | 0 | 0 | 0 | 0 | **0** | **2** |
| | Fatalities | 2 | 0 | 4 | 5 | 1 | **12** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| Kansas | Reported Cases | 19 | 4 | 56 | 91 | 54 | **224** | 0 | 0 | 0 | 0 | 0 | **0** | **2** |
| | Fatalities | 0 | 1 | 3 | 7 | 0 | **11** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |
| Missouri | Reported Cases | 3 | 10 | 20 | 29 | 13 | **75** | 1 | 1 | 0 | 0 | 0 | **2** | **4** |
| | Fatalities | 0 | 0 | 3 | 2 | 2 | **7** | 0 | 0 | 0 | 0 | 0 | **0** | **0** |

Source: CDC 2016f, CDC 2016g, CDC 2016h, USGS 2016.

Notes: No cases of Western equine encephalitis have been reported in the mainstem Missouri River states since at least 2003. No cases of La Crosse encephalitis virus have been reported since prior to 2010.

a CDC information on reported cases of West Nile virus and St. Louis encephalitis virus only available through 2014.

b Travel-related Zika cases acquired outside of US

A total of 691 cases have been confirmed within the United States as a whole. Most of the documented cases of Zika virus in the United States have been travel-related, wherein the patient acquired the disease outside of the United States in an area experiencing an outbreak of Zika virus (CDC 2016h); however, local transmission of Zika virus by *Aedes aegypti* mosquitoes was documented in south Florida in July, 2016 (CDC 2016i). There has been no documentation to date of local transmission among people via mosquito vectors within the mainstem Missouri River states, although cases of person-to-person transmission via sexual contact have been confirmed (CDC 2016h). It is expected that Zika virus transmission will increase throughout the western hemisphere and, therefore, it is possible that infected travelers visiting or returning to parts of the United States with established populations of *Aedes aegypti* or *Aedes albopictus* mosquitoes, including several of the mainstem Missouri River states, could increase the potential for local transmission (CDC 2016d; CDC 2016e).

#### 3.21.1.2 Vector Mosquito Species in Mainstem Missouri River States and their Breeding Habitat Requirements

There are between 35 and nearly 60 mosquito species known to be present within each state along the mainstem Missouri River. In general, the number of species present increases as one moves from northwest to southeast along the length of the river (McCauley et al. 2000; Waddington and Hayes 1976; NDDOH 2016; SDSU Extension 2016; Rolston and Johnson 2012). Each mosquito species has its own unique ecology and life history, but all share a few biological similarities. All mosquito species require water for three of the four stages of their lifecycle. Only female mosquitoes bite. Male mosquitoes feed on plant nectars and sugars and are not equipped with a proboscis or stinger. Female mosquitoes of most species, but not all, require protein from blood in order to lay viable eggs. Some prefer mammalian hosts, some avian ones, some reptilian, and some have no preference, but are opportunistic biters of any available host. Some mosquito species are potential disease vectors and some are not. (McCauley et al. 2000).

The most common nuisance mosquitoes in all of the mainstem Missouri River states include *Aedes vexans* and several different species within the *Culex* genus. As discussed above, *Culex* species are the most common vector species for transmission of West Nile virus, St. Louis encephalitis virus, and Western equine encephalitis from infected birds to humans (NDDOH 2016; Zurek and Broce 2002; Marcelli 2012; CDC 2016a; KDOH 2016; MDH 2016; Andre 1981). *Aedes vexans* prefers to feed on large animals such as cattle, deer, horses, and rarely feeds on birds; therefore, while it is a considerable nuisance to humans, there is uncertainty regarding the extent of its potential role in West Nile virus transmission (Larsen et al. 2010) and it is generally not considered to be a significant vector for the mosquito-borne diseases discussed above (Rolston and Johnson 2012). Other vector species known or believed to be present in portions of the mainstem Missouri River states include *Aedes triseriatus*, or eastern treehole mosquito, which is the main vector for La Crosse encephalitis (CDC 2016c) and *Aedes aegypti* and *Aedes albopictus,* which would be the most likely potential vector species for local transmission of Zika virus in the United States (CDC 2016d). The range inhabited by *Aedes triseriatus* includes Iowa, Kansas, Missouri, and Nebraska, but does not include Montana, North Dakota, or South Dakota (Farajollahi and Price 2013). The estimated range of *Aedes albopictus* in the United States includes Iowa, Kansas, Missouri, and Nebraska, while the estimated range of *Aedes aegypti*, which has higher vectorial capacity than *Aedes albopictus*, includes southwestern Missouri and southeastern Kansas (CDC 2016f).

Among the mosquito species that are known to act as vectors for the arboviral diseases described above, the majority lay their eggs on the surface of standing and often stagnant water

with poor circulation, high temperatures, and high organic content. These species use both natural and man-made breeding habitats that include tree holes, standing pools in agricultural fields, roadside ditches, cans, buckets, birdbaths, discarded tires, and clogged gutters (Cofrancesco 1990; Dom et al. 2013; Farajollahi and Price 2013; Houseman 2011). *Aedes aegypti* in particular has been shown to thrive in human-made breeding habitats in urban areas, including water storage containers, discarded tires, tin cans, flower pots, and roof gutters (Dom et al. 2013; Philbert and Ijumba 2013). *Aedes vexans*, on the other hand, is known as a floodwater mosquito. It typically lays its eggs on moist soil in vegetated areas just above the waterline in floodplains and pothole depressions. *Aedes vexans* eggs can withstand drought, cold, and rain for up to four years. It is only when eggs are inundated by flooding that they hatch into larvae (Houseman 2011; McCauley et al. 2000; Cofrancesco 1990).

## 3.21.2 Environmental Consequences

For the analysis of impacts to human health and safety, this section considers the potential for actions included in each alternative to affect the availability of mosquito breeding habitat, which could in turn affect the transmission of the mosquito-borne arboviruses discussed above in the Affected Environment section.

### 3.21.2.1 Impacts Assessment Methodology

Analysis of the potential impacts to human health and safety is based on review of available scientific literature discussing the breeding habitat requirements for mosquito species that commonly act as vectors for disease, and assessment of the potential for actions included in each of the alternatives to create conditions that meet these breeding habitat requirements. For comparison, this analysis also discusses the potential for the creation of additional breeding habitat for *Aedes vexans*, which is one of the most common nuisance mosquito species in the mainstem Missouri River states, but rarely acts as a vector for human diseases.

For the analysis of impacts to human health and safety, it is assumed that the vector species of greatest concern for transmission of mosquito-borne disease discussed in the Affected Environment section would remain the same under all of the alternatives and would not be supplanted by other species with substantially different life histories. It is also assumed that, as opposed to rural areas, there is generally less floodplain habitat in more heavily populated urban areas along the Missouri River that could potentially be inundated as a result of actions associated with the alternatives. Additionally, it is assumed that actions associated with the alternatives would be more likely to take place in areas that are not close to urban areas.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

### 3.21.2.2 Summary of Environmental Consequences

The management actions common to all of the alternatives considered in this MRRMP-EIS, as well as the actions that would be specific to each of the individual alternatives considered, are anticipated to have negligible to no adverse impacts on human health and safety with respect to

their potential to contribute to the spread of mosquito-borne diseases. Table 3-249 summarizes the impacts of each alternative to human health and safety.

The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

**Table 3-249. Environmental Consequences Relative to Human Health and Safety**

| Alternative | Impacts to Human Health and Safety |
|---|---|
| Management Actions Common to All Alternatives | Vegetation management, predator management, human restriction measures, and pallid sturgeon propagation and augmentation would have no impacts on human health and safety, because none of these actions would be expected to result in the creation of mosquito breeding habitat. Channel reconfiguration for pallid sturgeon spawning habitat and habitat development and land management on Missouri River Recovery Program (MRRP) lands would each have some potential to create breeding habitat for *Aedes vexans* mosquitoes, which are not common vectors for human disease, but would have no potential to create habitat for common vector mosquito species. As a result, these actions would be expected to have no to negligible adverse impacts on human health and safety. |
| Alternatives 1–6 | Although each alternative has the potential to create breeding habitat for *Aedes vexans* mosquitoes, they would have no potential to create habitat for common vector mosquito species. As a result, these alternatives would be expected to have no to negligible adverse impacts on human health and safety. |

### 3.21.2.3 Impacts from Management Actions Common to All Alternatives

Vegetation management would maintain bare sand conditions in ESH habitat, which as described above, would not be expected to provide mosquito-breeding habitat. Predator management and human restriction measures would not result in any manipulation of physical habitat and, therefore, would not create mosquito-breeding habitat. As a result, these actions would not contribute to the increased spread of mosquito-borne diseases and, therefore, would have no impact on human health and safety.

Pallid sturgeon propagation and augmentation efforts involve supplementing the pallid sturgeon population with additional live pallid sturgeon and do not involve any manipulation of physical habitat. As a result, this action would not create mosquito-breeding habitat, would not contribute to the increased spread of mosquito-borne diseases, and, therefore, would have no impact on human health and safety.

The establishment of native vegetation, creation of wetlands, and restoration of riparian buffer habitat on MRRP lands along the Missouri River floodplain would not be expected to lead to the creation of areas where the stagnant conditions preferred by common vector species would have an opportunity to develop. These actions could have the potential to enhance habitat types that provide breeding opportunities for *Aedes vexans* in floodplains along the Missouri River; however, the restoration of natural components of floodplain ecosystems would also create habitat for mosquito predators. For example, mosquitoes in wetlands provide a food source for many invertebrates, birds, bats, amphibians, and fish species. These natural predators make

wetlands less than ideal mosquito breeding sites (NRCS 2008). In addition, wetlands having good connectivity with the mainstem river allow additional mosquito predators to enter the wetlands during high flows (Cofrancesco 1990). Although the magnitude of implementation of this action varies under each alternative, none of the potential scenarios would be expected to create sufficient breeding habitat for *Aedes vexans* to substantially increase the abundance of these mosquitoes. As a result, actions associated habitat development and land management on MRRP lands are not expected to measurably affect the spread of mosquito-borne diseases and would likely result in no to negligible adverse impacts on human health and safety.

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

In addition to the management actions common to all alternatives described above, the No Action alternative would involve the mechanical construction of approximately 107 acres per year of emergent sandbar habitat (ESH), on average. Since this action would involve the construction of in-river bird habitat consisting of bare sand substrate, it would not be expected to create any opportunities for standing, stagnant pools of water to develop, and, therefore, would not create breeding habitat for the mosquito species that would be expected to act as disease vectors in the mainstem Missouri River states. The No Action alternative would furthermore involve the construction of approximately 3,999 acres of shallow-water early life stage habitat for pallid sturgeon. This action would create side channels, chutes, and widened river sections, increasing the abundance of areas of shallow, slower-moving, relatively warmer water throughout the mainstem Missouri River. While the typical river flow velocity in some of these areas may be near zero, they would nonetheless be unlikely to provide the stagnant conditions that common vector species prefer as breeding habitat because these areas would retain connectivity with the river. Additionally, mosquito larvae that may hatch in these areas would be subject to predation by fish and other predators. It is possible that channel reconfiguration and shallow water habitat creation could lead to the longer-term development of additional riparian wetland areas where the adjacent upland soil and vegetation may provide attractive sites for *Aedes vexans* to lay its eggs. Larvae in these areas would be subject to predation by fish and other predators, making these areas less effective as breeding habitat. It is unlikely that this scenario would result in a meaningful level of increase in *Aedes vexans* breeding habitat beyond the amount that currently exists within proximity to the Missouri River. Further, as noted above, *Aedes vexans* is not a common vector for human disease. The No Action alternative would also include the continuation of a spring plenary pulse, which would include downstream flow limits. Inundation of floodplain areas could result during years when this pulse is implemented, which would not be expected to create opportunities for stagnant pools and associated breeding habitat for common vector mosquitoes to develop; however, it may help to maintain breeding habitat for *Aedes vexans*. For reasons similar to those described under the discussion of habitat development and land management on MRRP lands, the inundation of floodplain areas resulting from the spring pulse would not be expected to add a substantial amount of mosquito breeding habitat or related opportunities for the spread of mosquito-borne disease. Overall, based on the above, the No Action alternative would be expected to result in negligible to no adverse impacts to human health and safety

**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. Alternative 1 would not have the potential to create habitat for common vector mosquito species, thus continuation of

current system operation and MRRP implementation actions are not anticipated to cause significant impacts to human health and safety.

### 3.21.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

In addition to the management actions common to all alternatives described above, Alternative 2 would include approximately 3,546 acres per year of ESH construction. As discussed under the No Action alternative, this action would not create breeding habitat for mosquito species that would be expected to act as disease vectors in the mainstem Missouri River states. Alternative 2 would also involve the construction of 10,758 acres of pallid sturgeon early life stage habitat. While this is substantially more than the amount that would be created under the No Action alternative, it is not expected to result in the creation of breeding habitat for vector mosquito species, for reasons discussed for Alternative 1. It is also not expected to result in a meaningful increase in breeding habitat for *Aedes vexans* relative to that which currently exists throughout the mainstem Missouri River states. Finally, Alternative 2 would implement a spring pulse combined with a summer low flow that would create conditions of periodic inundation of floodplain areas, thereby creating conditions that may be favorable to the *Aedes vexans* life cycle by helping to maintain breeding opportunities in floodplain habitats. As a result, the impacts of the spring pulse and summer low flow would likely be similar to those described for the spring plenary pulse under the No Action alternative. Any adverse impacts to human health and safety resulting from this action are expected to be negligible. Alternative 2 would also incorporate reservoir unbalancing, which would not create breeding habitat for vector species but could have the potential to create some habitat for *Aedes vexans* if vegetated and/or wetland areas exist adjacent to the reservoirs that could be inundated in some years and not in others. The exposed sand and gravel habitat below the high water level that is exposed in dry years would not be expected to provide breeding habitat for *Aedes vexans*. It is generally expected that reservoir unbalancing would contribute a relatively small amount of mosquito breeding habitat compared to currently existing mosquito habitat in the states where reservoirs are located. Overall, Alternative 2 is not expected to contribute measurably to the availability of mosquito breeding habitat and, therefore, this alternative would likely result in no to negligible adverse impacts to human health and safety.

#### Conclusion

Alternative 2 has the potential to result in some floodplain inundation due to habitat creating flow releases, but would be temporary and would not have the potential to create habitat for common vector mosquito species, thus it is not anticipated to cause significant impacts to human health and safety.

### 3.21.2.6 Alternative 3 – Mechanical Construction Only

Under Alternative 3, the use of mechanical construction for implementing restoration actions would result in impacts similar to those described for each of the management actions common to all alternatives. Since the construction of ESH would not provide any opportunities for stagnant pools to develop, and the IRC habitat concept is limited to creation of flowing aquatic habitat rather than areas of standing water, Alternative 3 would not be expected to create any additional mosquito-breeding habitat. Therefore, Alternative 3 would have no to negligible adverse impacts on human health and safety.

**Conclusion**

Alternative 3 would have no potential to create mosquito-breeding habitat, thus it is not anticipated to cause significant impacts to human health and safety.

#### 3.21.2.7 Alternatives 4, 5, and 6 – Spring ESH Creating Release, Fall ESH Creating Release, and Pallid Sturgeon Spawning Cue – Mechanical Construction Only

In addition to the impacts associated with the management actions common to all alternatives described above, alternatives 4, 5, and 6 would involve the construction of slightly fewer acres of pallid sturgeon early life stage habitat and a slightly greater acreage of ESH than the No Action alternative, with resulting impacts similar to those described for the No Action alternative. Alternatives 4, 5, and 6 would each have the potential to result in some level of floodplain inundation that would have impacts similar to those described under Alternatives 1 and 2, because periodic floodplain inundation under each of these alternatives could create breeding opportunities for *Aedes vexans*. Alternatives 4, 5, and 6 would not be expected to contribute to the development of breeding habitat for common vector mosquito species, nor would they be expected to contribute measurably to breeding habitat for *Aedes vexans* relative to the amount of habitat that currently exists in the mainstem Missouri River states. Therefore, Alternatives 4, 5, and 6 would each be expected to have no to negligible adverse impacts on human health and safety.

**Conclusion**

Alternatives 4, 5, and 6 have the potential to result in some floodplain inundation due to habitat creating flow releases, but would be temporary and would have no potential to create habitat for common vector mosquito species, thus it is not anticipated to cause significant impacts to human health and safety.

#### 3.21.2.8 Tribal Resources

Under all of the alternatives, the impacts to human health and safety would be identical whether management actions take place on Tribal or non-Tribal lands. Since all of the alternatives would have no to negligible adverse impacts related to the creation of breeding habitat for vector mosquito species, Tribes would not be disproportionately impacted under any of the alternatives.

#### 3.21.2.9 Climate Change

While climate change by itself could affect the spread of mosquito-borne diseases, Alternatives 1–6 would not create breeding habitat for mosquitoes that are common vectors for human disease. Therefore, even when considering changes in climate, Alternatives 1–6 would not be expected to contribute to impacts on human health and safety.

#### 3.21.2.10 Cumulative Impacts

All past, present and future management actions that result in the enhancement of wetland habitat, including construction and management of native fish and wildlife habitat areas, NRCS easement and technical/financial assistance programs, Tribal programs, and NPS Missouri National Recreation River Management Actions could contribute beneficial impacts. Wetland

restoration can decrease mosquito populations in two ways: by providing proper habitat for mosquito predators, and by reducing flood risk in areas that are not normally wet and thus may support mosquitoes but not their predators (NRCS 2008). The acreage of wetlands that would be restored along the mainstem Missouri River is expected to be relatively small compared to the total acreage of wetland habitat existing throughout the mainstem Missouri River states. Therefore, the beneficial impacts that these wetlands provide as habitat for mosquito predators are not anticipated to be measurable, and actions that enhance wetland habitat along the mainstem Missouri River likely contribute negligible beneficial impacts to human health and safety.

Conversion of floodplain land to urban uses or agricultural uses such as crop production and livestock grazing could potentially contribute adverse impacts on human health and safety, since these uses can provide opportunities for standing pools of water to develop. The larvae of the *Culex* mosquito species that are the primary vectors for human disease within the Missouri River Basin prefer to live in stagnant, still, often polluted pools of water, which may collect in places such as rain barrels, discarded tires, clogged gutters, ditches, ruts from automobile and tractor tires, low-lying areas of agricultural fields, and similar places where standing water may collect (McCauley et al. 2000; Cofrancesco 1990; Dom et al. 2013; Farajollahi and Price 2013; Houseman 2011). Similarly, *Aedes aegypti*, which is the most common vector species for the Zika virus, has been shown to thrive in human-made breeding habitats in urban areas, including water storage containers, discarded tires, tin cans, flower pots, and roof gutters (Dom et al. 2013; Philbert and Ijumba 2013). The contribution to vector mosquito breeding habitat by converted floodplain lands that are now in urban and agricultural uses is likely minimal relative to the aggregate amount of land within the mainstem Missouri River states that has been converted to these uses. As a result, while conversion of floodplain land to urban and agricultural uses may contribute to conditions that have adverse impacts on human health and safety, it is likely that the overall contribution to adverse impacts is negligible.

Overall cumulative impacts of Alternatives 1–6 are expected to be negligible on human health and safety. As detailed in the analysis of environmental consequences of the alternatives, each of the six alternatives would be expected to contribute negligible impacts to human health and safety.

## 3.22 Environmental Justice

### 3.22.1 Affected Environment

Executive Order 12898, issued in 1994, directs federal agencies to incorporate environmental justice (EJ) as part of their mission by identifying and addressing the effects of programs, policies, and activities on minority and low-income populations. The fundamental principles of Executive Order 12898 are as follows:

- Ensure full and fair participation by potentially affected communities in the decision making process.
- Prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority or low-income populations.
- Avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.
- Encourage meaningful community representation in the NEPA process through the use of effective public participation strategies and special efforts to reach out to minority and low-income populations.
- Identify mitigation measures that address the needs of the affected low-income and minority populations.

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, then the EPA guidance advises that it should initiate consideration of alternatives and mitigation actions in coordination with extensive community outreach efforts (USEPA 1998).

The EPA defines a community with potential environmental justice populations as one that has a greater percentage of minority and/or low-income populations than does an identified reference area. Areas with high proportions of minority residents are defined as those populations having (1) 50 percent or more of their population identifying themselves as being of a minority; or (2) a significantly greater minority population than the reference area (USEPA 1998). Individuals are considered to be of a minority if they are identified as a race other than Non-Hispanic White Alone. Low-income populations are defined as those families living below the poverty line, as defined by the U.S. Census Bureau.

The EPA has not specified any percentage of the population characterized as “significant” in order to identify the presence of minority populations in an area. For purposes of this study, a conservative approach was used to identify areas having high concentrations of minority and/or low-income residents. It is assumed that if the affected area has a minority population more than ten percentage points higher than the reference area, then a potential minority environmental justice population exists. For this analysis, the state and/or county in which the block group is located were used as the reference area. Therefore, census block groups whose minority population is ten percentage points higher than the state or county average in which it is located

are identified as environmental justice populations. According to the U.S. Census Bureau, guidelines for a poverty area consist of 20 percent of the population living below the poverty level (U.S. Census Bureau 2016). Thus, block groups with more than 20 percent of their families living below the poverty level were identified as a potential environmental justice poverty area.

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, five-year averages from 2006 to 2010, were used to identify the percentages of families in poverty and minority populations. This section describes the locations of potential environmental justice populations within the floodplain of each state along the mainstem of the Missouri River.

Table 3-250 summarizes the racial and ethnic composition for each state along the Missouri River. Block groups that exceed the state or county minority percent by more than 10.0 percentage points are identified as having a high concentration of minority residents.

Table 3-251 summarizes the poverty levels for the states located along the Missouri River. Environmental justice block groups are summarized by state.

**Table 3-250. Missouri River Basin States Racial Composition and Minority Presence, 2006–2010 5-year Estimates**

| Race and Ethnicity | State | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Iowa** | **Kansas** | **Missouri** | **Montana** | **Nebraska** | **North Dakota** | **South Dakota** |
| Non-Hispanic, White Alone | 89.4% | 79% | 81.3% | 88% | 83% | 89.4% | 85.4% |
| Black or African American Alone | 2.7% | 5.6% | 11.3% | 0.4% | 4.2% | 1.0% | 1.0% |
| American Indian and Alaskan Native Alone | 0.3% | 0.7% | 0.3% | 6.0% | 0.7% | 5.2% | 8.3% |
| Asian Alone | 1.6% | 2.3% | 1.5% | 0.6% | 1.6% | 0.9% | 0.9% |
| Native Hawaiian and Other Pacific Islander Alone | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.0% |
| Two or More Races Alone | 1.3% | 2.2% | 1.8% | 2.0% | 1.7% | 1.4% | 1.7% |
| Some Other Race | 0.2% | 0.4% | 0.4% | 0.2% | 0.3% | 0.1% | 0.2% |
| **Total** | 3,016,267 | 2,809,329 | 5,922,314 | 973,739 | 1,799,125 | 659,858 | 799,462 |
| Minority[a] | 10.6% | 21.0% | 18.7% | 12.0% | 17.0% | 10.6% | 14.6% |
| Hispanic Origin[b] | 4.5% | 9.8% | 3.3% | 2.7% | 8.4% | 1.9% | 2.5% |

Source: U.S. Census Bureau 2012.

Notes:

a "Minority" population includes all individuals who identify as being of a race other than "Non-Hispanic, White Alone" in addition to those of Hispanic origin.

b "Hispanic Origin" includes all individuals who identify as being of Hispanic or Latino decent and is thus not considered an exclusive race category.

**Table 3-251. Missouri River Basin States Poverty Levels, 2006–2010 5-year Estimates**

| Geography | State Population | Total Families | Percent of Families Below the Poverty Line |
|---|---|---|---|
| Iowa | 3,016,267 | 793,842 | 7.4% |
| Kansas | 2,809,329 | 730,945 | 8.4% |
| Missouri | 5,922,314 | 1,546,509 | 10.0% |
| Montana | 973,739 | 256,130 | 9.7% |
| Nebraska | 1,799,125 | 467,250 | 7.9% |
| North Dakota | 659,858 | 170,477 | 7.2% |
| South Dakota | 799,462 | 205,879 | 8.7% |

Source: U.S. Census Bureau 2012.

Note: This information is available from the 2006–2010 American Community Survey 5-Year Estimates.

Six hundred census block groups intersect the Missouri River floodplain, of which 186 contain potential environmental justice populations. Table 3-252 summarizes total populations and environmental justice populations for the block groups that intersect the floodplain for all of the states. The vast majority of the environmental justice populations are located in the block groups within the states of Nebraska and Missouri, with approximately 150,084 affected residents located in identified environmental justice communities in both states. The following section provides further detail regarding environmental justice populations and their locations within each of the states.

**Table 3-252. Missouri River Populations and Environmental Justice Populations, 2006–2010 5-year Estimates**

| State | Total Populations of All Block Groups that Intersect the Floodplain | Total Population of All Environmental Justice Block Groups that Intersect the Floodplain | Percent Environmental Justice Populations |
|---|---|---|---|
| Iowa | 98,432 | 3375 | 3.4% |
| Montana | 56,124 | 18,358 | 32.7% |
| North Dakota | 24,451 | 10,359 | 42.4% |
| South Dakota | 124,190 | 30,658 | 24.7% |
| Nebraska | 242,264 | 92,953 | 38.4% |
| Kansas | 36,462 | 12,829 | 35.2% |
| Missouri | 255,021 | 57,131 | 22.4% |
| **Total** | **751,444** | **223,643** | **29.8%** |

Source: U.S. Census Bureau 2012.

## Montana

Twenty-nine census block groups in the Montana portion of the study area demonstrate high concentrations of minority and/or low-income populations, with a majority located within the Fort

Peck Reservation. Poverty is the main driver for environmental justice status in Montana, because most block groups identified as having high proportions of environmental justice populations also exhibit high concentrations of low-income populations. Environmental justice populations for the block groups that intersect the Missouri River floodplain in Montana are described in Table 3-253.

**Table 3-253. Environmental Justice Populations Located in Missouri River Floodplain in Montana, 2006–2010 5-year Estimates**

| Type of Population | Number of Block Groups | Population |
|---|---|---|
| All Block Groups in Montana | 75 | 80,575 |
| Minority Block Groups | 11 | 12,035 |
| Poverty Block Groups | 10 | 9,243 |
| Both Minority and Poverty Block Groups | 8 | 7,439 |
| **All Environmental Justice Block Groups** | **29** | **28,717** |

Source: U.S. Census Bureau 2012.

### North Dakota

Twelve census block groups that intersect the Missouri River floodplain in North Dakota comprise potential environmental justice populations. These block groups are all located in the Bismarck, North Dakota, metropolitan area and exhibit high concentrations of minority populations. Eight block groups have high concentrations of people that identify as both minority and low-income populations. The percentage of families living below the poverty line in these block groups ranges from 22 percent to 44 percent, and the percent minority population ranges from 80 percent to 96 percent of total population. Environmental justice populations located in the Missouri River floodplain in North Dakota are described in Table 3-254.

**Table 3-254. Environmental Justice Populations Located in Missouri River Floodplain in North Dakota, 2006–2010 5-year Estimates**

| Type of Population | Number of Block Groups | Population |
|---|---|---|
| All Block Groups in the North Dakota | 60 | 44,022 |
| Minority Block Groups | 1 | 1,047 |
| Poverty Block Groups | 3 | 4,335 |
| Both Minority and Poverty Block Groups | 8 | 9,051 |
| **All Environmental Justice Block Groups** | 12 | 14,433 |

Source: U.S. Census Bureau 2012.

### South Dakota

Twenty-three block groups that intersect the Missouri River floodplain in South Dakota are identified as containing potential environmental justice populations. Twenty are located in rural counties. Nine block groups are located within the city boundaries of Pierre and Fort Pierre, South Dakota. Ten block groups have minority and low-income environmental justice populations. All of the 13 block groups on Tribal lands have high concentrations of people that identify as both low-income and high-minority populations. Of the block groups located off Tribal

lands, 5 are identified as minority, low-income populations. Environmental justice populations for this study area are described in Table 3-255.

**Table 3-255. Environmental Justice Populations Located in Missouri River Floodplain in South Dakota, 2006–2010 5-year Estimates**

| Type of Population | Number of Block Groups | Population |
|---|---|---|
| All Block Groups in South Dakota | 42 | 44,022 |
| Poverty Block Groups | 4 | 2,716 |
| Minority Block Groups | 9 | 11,468 |
| Both Poverty and Minority Block Groups | 10 | 9,665 |
| **All Environmental Justice Block Groups** | 23 | 23,841 |

Source: U.S. Census Bureau 2012.

### Iowa

Twenty-six census block groups located in the Missouri River floodplain in Iowa are identified as having potential environmental justice populations. Of these, four have high concentrations of people that identify as both low-income and minority populations. All but one of the environmental justice block groups in Iowa are located within the Sioux City or Omaha-Council Bluffs metropolitan areas. Environmental justice populations in the Missouri River floodplain in Iowa are described in Table 3-256.

**Table 3-256. Environmental Justice Populations Located in Missouri River Floodplain in Iowa, 2006–2010 5-year Estimates**

| Type of Population | Number of Block Groups | Population |
|---|---|---|
| All Block Groups in Iowa | 101 | 95,385 |
| Poverty Block Groups | 10 | 9,755 |
| Minority Block Groups | 12 | 11,410 |
| Both Poverty and Minority Block Groups | 4 | 3,375 |
| **All Environmental Justice Block Groups** | **26** | **24,540** |

Source: U.S. Census Bureau 2012.

### Nebraska

Fifty-seven census block groups located in the Missouri River floodplain in Nebraska are identified as having potential environmental justice populations. These are located either in rural counties on Tribal lands associated with the Winnebago, Santee Sioux, or Omaha Tribes or within the Omaha-Council Bluffs metropolitan area. Of the ten highest-poverty Nebraska block groups, eight are located within the Omaha-Council Bluffs metropolitan area. These eight block groups have minority populations ranging from 68 percent to 100 percent of their total populations. Environmental justice populations located in the Missouri River floodplain in Nebraska are described in Table 3-257.

**Table 3-257. Environmental Justice Populations Located in Missouri River Floodplain in Nebraska, 2006–2010 5-year Estimates**

| Type of Population | Number of Block Groups | Population |
|---|---|---|
| All Block Groups in Nebraska | 109 | 120,286 |
| Poverty Block Groups | 5 | 4,973 |
| Minority Block Groups | 21 | 25,125 |
| Both Poverty and Minority Block Groups | 31 | 32,064 |
| **All Environmental Justice Block Groups** | **57** | **62,162** |

Source: U.S. Census Bureau 2012.

### Kansas

Eleven census block groups located in the Missouri River floodplain in Kansas are identified as having potential environmental justice populations, most of which are in urban areas of Kansas City and Atchison, Kansas. Two block groups are associated with rural counties. Of the six block groups that are located in Kansas City, all have high concentrations of people that identify as both minority and low-income populations. The majority of potential environmental justice block groups in the Atchison area are low-income populations. Environmental justice populations are described in Table 3-258.

**Table 3-258. Environmental Justice Populations Located in Missouri River Floodplain in Kansas, 2006–2010 5-year Estimates**

| Type of Population | Number of Block Groups | Population |
|---|---|---|
| All Block Groups in Kansas | 34 | 36,462 |
| Poverty Block Groups | 1 | 1,337 |
| Minority Block Groups | 4 | 7,421 |
| Both Poverty and Minority Block Groups | 6 | 4,064 |
| **All Environmental Justice Block Groups** | **11** | **12,829** |

Source: U.S. Census Bureau 2012.

### Missouri

Thirty-nine census block groups located in the Missouri River floodplain in Missouri are identified as having potential environmental justice populations. Twenty-eight of these are located in the urban areas of Kansas City, St. Louis, St. Joseph, and Jefferson City, Missouri, while 11 block groups are associated with rural counties. Of the 18 that are located in Kansas City, 10 block groups have high concentrations of people that identify as both minority and low-income populations. The majority of potential environmental justice block groups in the St. Joseph, and Jefferson City areas are low-income populations, while the majority of environmental justice block groups in the St. Louis metropolitan area have high concentrations of minority populations. Environmental justice populations are described in Table 3-259.

**Table 3-259. Environmental Justice Populations Located in Missouri River Floodplain in Missouri, 2006–2010 5-year Estimates**

| Type of Population | Number of Block Groups | Population |
|---|---|---|
| All Block Groups in Missouri | 197 | 255,021 |
| Poverty Block Groups | 11 | 10,004 |
| Minority Block Groups | 17 | 33,054 |
| Both Poverty and Minority Block Groups | 11 | 14,073 |
| **All Environmental Justice Block Groups** | **39** | **57,131** |

Source: U.S. Census Bureau 2012.

## 3.22.2 Environmental Consequences

Alternative means of achieving species objectives are evaluated for their effects on environmental justice. The alternatives evaluated include management actions with potential to affect river flows, channel form, river stage, land cover, and land ownership. The impact analysis focuses on determining if any of the management actions described under the alternatives would have disproportionate impacts on environmental justice populations, and if so, what level of impact would be expected. This section presents the results of the assessment.

### 3.22.2.1 Impacts Assessment Methodology

An environmental justice assessment requires an analysis of whether minority and low-income populations (i.e., “populations of concern”) would be disproportionately affected by a proposed federal action and if so the severity of the adverse impacts from the proposed action. The environmental justice assessment for the MRRMP-EIS first evaluated the nature and extent of impacts evaluated under the other resource areas addressed in the EIS (including flood risk management, water supply, thermal power, hydropower, land acquisition, irrigation, recreation, navigation, water quality, and others) and then qualitatively evaluated whether these impacts would fall disproportionately on potential environmental justice populations that live within the floodplain. Additional information on impacts to low income and minority populations are provided in Section 3.12, Flood Risk Management and Interior Drainage, and Section 3.13, Hydropower.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

### 3.22.2.2 Summary of Environmental Consequences

Table 3-260 summarizes the environmental consequences relative to EJ populations.

**Table 3-260. Environmental Consequences to Environmental Justice Populations**

| Alternative | Impacts to Environmental Justice Populations |
|---|---|
| Management Actions Common to All Alternatives | Not expected to cause impacts to EJ populations. |
| Alternatives 1–6 | Not expected to have disproportionate adverse impacts on any potential EJ populations. |

### 3.22.2.3 Impacts from Management Actions Common to All Alternatives

The MRRMP-EIS considers a number of management actions that are common to all alternatives, including pallid sturgeon propagation and augmentation, predator management, vegetative management, and human restrictions measures. These actions are expected to cause negligible to small, temporary adverse impacts to the other resource areas being evaluated; however, none of these impacts are expected to fall disproportionately on EJ populations. Therefore, management actions common to all alternatives would not result in impacts to environmental justice.

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

Under Alternative 1, the MRRP would continue to be implemented as it is currently. Management actions that could affect EJ populations under Alternative 1 include creation of both SWH and ESH habitat and a spring plenary pulse or a bi-modal spring plenary pulse. These actions would be focused in the Garrison and Gavins Point reaches for ESH habitat creation and between Ponca to the mouth of the river near St. Louis for SWH.

Construction activities under Alternative 1 could have adverse impacts on EJ populations although these impacts would be negligible to small and not disproportionate. In the lower river, most of the identified EJ populations are located within or near urban areas. It is expected that the management actions, especially related to habitat creation under Alternative 1, would be in rural areas away from urban corridors and thus would not be located near potential EJ populations.

#### Conclusion

Impacts under Alternative 1 are expected to be small, short-term, adverse impacts to other resources such as water supply, irrigation, and recreation; although in some years there may be somewhat higher adverse impacts. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Alternative 1 is not expected to have significant disproportionate impacts on potential EJ populations; therefore, environmental justice issues are unlikely.

### 3.22.2.5 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 adaptive management. Actions included under this

alternative that may have impacts to EJ populations include a spawning cue release; low summer flow; and mechanical construction of SWH and ESH habitat.

Relative to Alternative 1, Alternative 2 would cause relatively small, short-term, adverse impacts to other resources such as water supply, irrigation, and recreation; although in some years there may be somewhat higher adverse impacts. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Many of the thermal power plants would experience relatively large adverse impacts under Alternative 2. For example, the adverse impacts to thermal power plants in the lower river would be relatively large and adverse for the summers when low summer flow events occur, causing energy values to increase from 17 to 40 percent during these periods. This would lead to considerably greater reduction in power generation on average and under the worst-case years. The potential for relatively large short-term, adverse impacts to grid stability and power reliability could increase under Alternative 2, leading to an increased potential for brownouts and black-outs and an increase in electricity rates. These impacts have implications for EJ and non-EJ populations in the region and are not expected to fall disproportionately on potential EJ populations.

**Conclusion**

Relative to Alternative 1, Alternative 2 would cause relatively small, short-term, adverse impacts to other resources such as water supply, irrigation, and recreation; although in some years there may be somewhat higher adverse impacts. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Alternative 2 is not expected to have significant disproportionate impacts on potential EJ populations and therefore is not expected to result in environmental justice issues.

#### 3.22.2.6 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include those that focus on the creation of ESH and IRC habitat through mechanical means. Additional ESH habitat would be created in the Garrison, Fort Randall, and Gavins Point reaches and IRC creation would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. This alternative would result in relatively small, beneficial impacts on several of the resources evaluated (e.g., water supply, irrigation, thermal power, recreation). This alternative would not be expected to have any impacts to potential EJ populations.

**Conclusion**

Alternative 3 is not expected to have any impacts on potential EJ populations, therefore would not result in environmental justice issues.

#### 3.22.2.7 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 created in the Garrison, Fort Randall, and Gavins Point reaches and IRC creation would be focused in the

riverine areas between Ponca and the mouth of the river near St. Louis. Alternative 4 would have a relatively small, adverse impact on several of the resources evaluated (e.g., water supply, irrigation, recreation).

In the upper basin, relatively large and temporary adverse impacts to thermal power plants would be expected under Alternative 4 relative to Alternative 1. In the lower river there could be some benefits to power generation under Alternative 4. Impacts to power generation would be expected to impact all populations (minority and non-minority; low-income and non-low income) and not cause a disproportionate impact to potential EJ populations.

**Conclusion**

Relative to Alternative 1, Alternative 4 would have a relatively small, adverse impact on several of the resources evaluated (e.g., water supply, irrigation, recreation). While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Alternative 4 is not expected to have significant disproportionate impacts on potential EJ populations, and therefore would not result in environmental justice issues.

#### 3.22.2.8 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 created in the Garrison, Fort Randall, and Gavins Point reaches and IRC creation would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Alternative 5 would have a relatively small, beneficial impact on water supply intakes and thermal power plants and relatively small or negligible, adverse impacts to recreational resources and irrigation intakes. These impacts would not be expected to fall disproportionately on potential EJ populations.

**Conclusion**

Alternative 5 would have a relatively small, beneficial impact on water supply intakes and thermal power plants and relatively small or negligible, adverse impacts to recreational resources and irrigation intakes. These impacts would not be expected to fall disproportionately on potential EJ populations.

Alternative 5 is not expected to have significant disproportionate impacts on potential EJ populations and therefore would not result in any environmental justice issues.

#### 3.22.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes actions that would develop ESH habitat through mechanical means and a spawning cue flow that would be mimicked through bi-modal pulses that would occur in March and May. Alternative 6 would have relatively small, temporary adverse impacts on water supply and irrigation intakes and recreational resources. Overall, there would be relatively small benefits to power plant generation and energy values under Alternative 6. These impacts would not fall disproportionately on potential EJ populations.

**Conclusion**

Alternative 6 would have relatively small, temporary adverse impacts on water supply and irrigation intakes and recreational resources. Overall, there would be relatively small benefits to power plant generation and energy values under Alternative 6. These impacts would not fall disproportionately on potential EJ populations.

Alternative 6 is not expected to have significant disproportionate impacts on potential EJ populations and therefore would not result in any environmental justice issues.

#### 3.22.2.10 Climate Change

Natural climatic conditions that result in flooding or droughts can have direct and indirect adverse impacts on environmental justice populations, especially when weather events are extreme. For example, the POR is characterized by substantial variability in hydrologic conditions which includes periods of drought (i.e., 1930s) and high runoff (i.e., 1997, 2011). This variation results in substantial variability in impacts to EJ and non-EJ populations. These impacts would not represent a disproportional impact. For a detailed discussion of projected climate change see section 3.2. The forecasted effects of climate change are not expected to change the effects to environmental justice populations described previously for Alternatives 1–6 and are not expected to lead to more disproportionate impacts on environmental justice populations.

#### 3.22.2.11 Cumulative Impacts

Since none of the alternatives would result in environmental justice issues as described above, there would be no contribution to cumulative impacts from implementation of any of the alternatives.

# 3.23 Ecosystem Services

## 3.23.1 Affected Environment

The Missouri River and related terrestrial areas create a complex and biologically productive aquatic ecosystem. Although areas of the Missouri River have been modified, the Missouri River ecosystem continues to provide a steady flow of environmental benefits that sustain life and bestow values for humans. These benefits include tangible goods and intangible services that are often collectively referred to as ecosystem services. Ecosystem services are defined as *socially valued aspects or outputs of ecosystems that depend on self-regulating or managed ecosystem structures and processes* (Murray et al. 2013).

Ecosystem services provided by the Missouri River, and its related terrestrial lands, support economic activity and contribute to regional quality of life. These environmental goods and services contribute to human well-being in ways that may or may not be considered in market transactions or economic activity. Some of the notable ecosystem services provided by the Missouri River include[10]:

- **Natural Resource Goods**: The provision of food (e.g., fish, mushrooms, venison), fiber (e.g., firewood, lumber), and commercial products (e.g., sand).
- **Water Supply**: Filtering, retention, and storage of fresh water.
- **Water Quality, Waste Assimilation, and Nutrient Regulation**: Role of biota, vegetation, and ecological processes in recycling nutrients and removal of nutrients, pollutants, and compounds.
- **Water Regulation and Flood Attenuation**: Role of floodplain connectivity and land cover in regulating runoff and river discharge; wetlands can provide flood attenuation during peak flows.
- **Climate Regulation and Carbon Sequestration**: Influence of land cover and biological mediated processes on climate resources, which affect the ability to store and absorb carbon.
- **Recreation**: The Missouri River ecosystem provides habitat supporting hunting, fishing, bird-watching, and other recreational opportunities; river and floodplain landscapes also provide recreational amenities.
- **Other Cultural Services**: May include aesthetic, cultural, artistic, spiritual, historic, and science and educational functions.

Benefits can be derived from these ecosystem services through their direct and indirect uses or through their intrinsic values (not tied to uses). For example, cold-water fisheries along the Missouri River provide direct use benefits to anglers who visit the area, and indirect benefits to people who may enjoy watching fishing programs or competitions at home. Other values for ecosystem services provided by the Missouri River and its related terrestrial lands stem from people's desire to preserve and/or improve the river, floodplain, species, and/or habitat as a social or public good, and are unrelated to the *use* of the ecosystem.

[10] The term "ecosystem services" refers to human benefits from ecological conditions and natural processes and does not include benefits from human-engineered infrastructure (i.e., flood protection benefits associated with dams and levees).

This section describes notable ecosystem services provided by the Missouri River, and the benefits people derive from these services. Many of these ecosystem services are further described in other sections of the document, including recreation, water supply, wastewater, flood risk management, cultural resources, and Tribal Resources.

#### 3.23.1.1 Natural Resource Goods

The Missouri River and its floodplain produce a variety of natural products that can be harvested for subsistence and commercial uses, including food, fiber and fuel, and construction materials. Fisheries, waterfowl, native wild game, mushrooms, and commercial sand are some of the goods provided by the Missouri River ecosystem. The river and its floodplain are fertile lands that grow crops, edible plants and fungi, and serve as feeding and spawning grounds for fish, birds, and wild game. Hunting, fishing, and bird-watching are recreational activities that attract visitors, stimulate economic activity in rural economies, and contribute to the maintenance of subsistence lifestyles along the river. Commercial fishing along the river is primarily for buffalo fish, catfish (flathead, blue, and channel), common carp, and Asian carp. In addition to food products, the Missouri River serves as a source of high-quality sand for use in the construction market. Permitted operators dredge sand from the main channel of the river and sell it regionally for use in construction projects. These natural resource goods and products support local employment opportunities for residents and businesses.

#### 3.23.1.2 Water Supply

Missouri River water is used by many residences, businesses, and facilities along the river. Municipal water facilities use Missouri River water and provide potable water to residences, businesses, industrial establishments, Tribal reservations, cities and towns, and water districts or associations.[11] Numerous private and public entities withdraw water from the Missouri River for irrigation purposes. In addition to private irrigators, six Bureau of Reclamation units withdraw water from the Missouri River for irrigation purposes. Twenty-two thermal power plants withdraw water for cooling purposes or to recirculate in cooling systems. The Missouri River water supply provides benefits for residents and business by supporting municipal water supplies, electric power generation, agricultural production, and other business operations.

#### 3.23.1.3 Water Quality, Waste Assimilation and Nutrient Regulation

Wetlands are an integral component of inland aquatic ecosystems, filtering nutrients, organic compounds, metals, and components of organic matter as water passes through them. They have a high capacity to absorb and process excess nutrients as well as to destroy bacteria, reducing levels of nitrogen, phosphorus, bacteria such as fecal coliform, and other pollutants. Water that flows through wetland areas is considerably cleaner once filtered through wetlands, improving water quality for drinking, recreation, and agricultural and industrial purposes (Millennium Ecosystem Assessment 2003). In addition, floodplain connectivity and shallow water habitat features facilitate the filtering of water, providing benefits for water quality and regulating nutrients.

There are 37 major wastewater facilities and 22 thermal power plants that discharge wastewater to the Missouri River between Fort Peck Dam and the confluence with the Mississippi River. Each of these facilities or plants has a National Pollutant Discharge Elimination System permit that specifies effluent limits to meet water quality standards. In addition, there are 55 municipal

[11]. There are additional water supplies for domestic, public, fish and wildlife, and agricultural uses.

and industrial water supply intakes across the Missouri River and its reservoirs. The natural filtering of nutrients and other pollutants and improved water quality can reduce water treatment requirements for wastewater dischargers and water supply facilities.

#### 3.23.1.4 Water Regulation and Flood Attenuation

Although the operations and infrastructure (i.e., dams, levees, bank stabilization, and engineered channel) of the Missouri River system reduces flood risks to urban and rural areas, the ecological structure and processes of the river and its floodplain can also mitigate downstream flooding and lessen damage from floods. One acre of wetland adjacent to a river typically stores about three acre-feet of water or one million gallons (NRCS n.d.), and trees and other wetland vegetation can slow the flow of floodwaters. Wetland features, channel widening, backwaters, chutes, and other river-floodplain connectivity can increase storage capacity for flood waters, attenuating flood risks for people and property downstream (Jacobson et al. 2015; Galat et al. 1998; Hey et al. 2004; Opperman and Buss 2008).

#### 3.23.1.5 Climate Regulation and Carbon Sequestration

Carbon dioxide is naturally present in the atmosphere as part of the earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals) and is also one of the greenhouse gasses emitted through human activities. In 2014, carbon dioxide accounted for about 81 percent of all U.S. greenhouse gas emissions from human activities according to the Environmental Protection Agency (USEPA 2015). Although the main human activity attributed with emitting carbon dioxide is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, many industrial processes and land-use changes can affect the carbon cycle and the ability of soils and plants to sequester carbon. Carbon sequestration refers to the ability of vegetation to convert carbon dioxide into sugar, cellulose, and other carbon-containing carbohydrates through photosynthesis, and store it for long periods in their woody tissues, the soil, or both.

Herbaceous wetlands store large amounts of carbon in the soil while forested wetlands store it in both soil and woody tissue. Wetlands are eutrophic systems that are able to process large quantities of nitrogen and phosphorous and rapidly sequester carbon. Ecosystems regulate the earth's climate by adding and removing greenhouse gases such as carbon dioxide from the atmosphere. In fact, forests, grasslands, peat swamps, and other terrestrial ecosystems collectively store carbon. By storing this carbon in wood, other biomass, and soil, ecosystems keep carbon dioxide out of the atmosphere, potentially mitigating the effects of climate change.

Changes in land use, vegetation, the quality of wetlands, and geomorphic processes impact the amount of carbon sequestered from the atmosphere. Shifting land from cultivated uses to a more natural state often results in replenishment of carbon stocks and the capture and storage of carbon. A number of studies have analyzed changes in land use, restoring wetlands, and conversion of croplands and the associated change in carbon sequestration rates. Some studies have noted the following:

- Conversion of croplands to restored grasslands results in a range of 0.22 to 0.45 tons of carbon sequestered per acre per year (NRCS 2012; Follett et al. 2001).
- Every acre of replanted floodplain forests will sequester 2.5 tons of carbon each year (NRCS n.d.; Birdsey 1996).

- Restored wetlands have been shown to recover lost carbon at up to 5 metric tons per hectare per year (2.02 tons/acre/year) (Gleason et al. 2009; University of North Dakota Energy and Environment Research Center 2008).

#### 3.23.1.6 Recreation

Many outdoor recreational activities, like fishing, hunting, wildlife watching, and boating are attributed to the natural processes, vegetation, and natural features of the Missouri River and its associated terrestrial areas. These recreational activities, in addition to others, such as site seeing, picnicking, camping, and hiking benefit from varied landscapes and viewscapes. Changes in natural features within the river, such as floodplain connectivity, shallow water habitat, and ESH, can contribute to variations in viewscapes and benefit visual resources for recreators. These opportunities can provide a sense of place and quality of life for residents and visitors, increase the value of recreational opportunities, and support visitor spending in local economies.

#### 3.23.1.7 Other Cultural Services

Natural landscapes along the Missouri River can provide aesthetic enjoyment, educational opportunities, artistic and spiritual inspiration, and emotional comfort. Natural landscapes offer a refuge from the modern world, a place where people can reconnect with nature and escape the stresses of everyday life (de Groot et al. 2005).

#### 3.23.1.8 Non-Use Values

Many natural ecosystems, endangered species, environmental components, and natural amenities are often appreciated by people but may not be directly or indirectly used by humans. Non-use values, also referred to as “passive use” values, are values that are not associated with actual use, nor are they directly valued in the market. Non-use values stem from a desire to preserve or improve a resource (e.g., natural landscape, restored ecosystem, endangered species) as a social or public good (existence value), for future use (option value), or for enjoyment by future generations (bequest value) (Sanders et al. 1990; Brown et al. 2007). Since these values or benefits are not associated with behavior or use, their valuation must rely on people stating their preferences for these preferences, goods, and/or services.

The preservation of endangered species has clear value to people and to society in general. The value of threatened and endangered species includes benefits from recreational uses (e.g., wildlife viewing, ecotourism, photography) but also include non-use values. Although threatened and endangered species are not commodities that can be bought and sold in traditional markets, they are widely regarded as valuable for biological, educational, scientific, recreational, historical, and cultural purposes. The existence of the ESA, WRDA, and many other environmental protection and enhancement laws and regulations show strong support for these passive-use societal values. Non-use values for threatened and endangered species reflect the personal satisfaction people obtain from knowing that the species exists, sustaining biological systems, maintaining genetic information of species that may be useful for medicinal and genetic engineering applications, or from knowing that preservation today will allow future generations to enjoy these species (Loomis and White, 1996). Providing and maintaining habitat along the Missouri River for threatened and endangered species benefit their populations and the values that society holds for their preservation.

## 3.23.2 Environmental Consequences

This section provides a description and analysis of how management actions under the MRRMP-EIS alternatives could affect socially valued aspects of ecosystems provided by the Missouri River ecosystem structures and processes. Since impacts to many key ecosystem services are discussed in other sections of the MRRMP-EIS, this section focuses on impacts to climate regulation and carbon sequestration, other cultural services, and non-use values.

### 3.23.2.1 Impacts Assessment Methodology

Many of the ecosystem services are analyzed and evaluated in other sections:

- Impacts to the provision of natural resource goods are evaluated in Section 3.5, Fish and Wildlife Habitat; Section 3.16, Recreation; and Section 3.11, Commercial Sand and Gravel Dredging.
- Impacts to water supply are evaluated in Section 3.18, Water Supply.
- Impacts to water quality, waste assimilation, and nutrient regulation are evaluated in Section 3.7, Water Quality.
- Impacts to recreation are evaluated in Section 3.16, Recreation.
- Impacts to water regulation and flood attenuation are evaluated in Section 3.12, Flood Risk Management and Interior Drainage.

The analysis of potential impacts to climate regulation and carbon sequestration, other cultural services, and non-use values examines how changes in the structure and function of this ecoregion may affect future provisions of these goods and services. Relevant studies, reports, and information were reviewed to qualitatively evaluate how management actions under the MRRMP-EIS alternatives could affect pertinent ecosystem services.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

### 3.23.2.2 Summary of Environmental Consequences

Table 3-261 summarizes the impacts of alternatives on ecosystem services with respect to climate regulation and carbon sequestration, other cultural services, and non-use values.

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 3-261. Environmental Consequences for Ecosystem Services**

| Resource | Alternative | Impacts to Ecosystem Services |
|---|---|---|
| Ecosystem Services | Management Actions Common to All Alternatives | Negligible benefits to other cultural resources; small benefits to non-use values and carbon sequestration from actions to support the species and the establishment of natural vegetation. |
| Carbon Sequestration and Climate Regulation | Alternative 1 | Beneficial impact on carbon sequestration capacities from restoration of acquired lands. Small temporary adverse impacts to carbon sequestration during construction of habitat. These impacts are anticipated to be negligible compared to overall carbon stocks and carbon sequestration capacity across the floodplain and the regional distribution of these benefits. |
| | Alternative 2 | Relatively higher long-term benefits to carbon sequestration capacities compared to Alternative 1. Small to large temporary adverse impacts to carbon sequestration from habitat construction. All changes would be negligible due to the extensive size of the river basin and relatively small habitat class changes. |
| | Alternatives 3–6 | Negligible change from Alternative 1. |
| Other Cultural Services | Alternative 1 | SWH and ESH would provide beneficial impacts for public access and cultural experiences on the river and its related terrestrial lands. |
| | Alternative 2 | Relatively small benefits to other cultural services from substantially more SWH and ESH compared to Alternative 1. |
| | Alternatives 3–6 | Similar beneficial impacts as those described under Alternative 1. |
| Non-Use Values | Alternative 1 | Alternative 1 may have a reduced likelihood of meeting the species' objectives compared to the action alternatives, with potential adverse impacts to non-use values. |
| | Alternative 2 | Relatively higher non-use values compared to other alternatives from substantially more ESH and IRC habitat creation, indirectly improving habitat quality for other species and enhancing ecological functions. |
| | Alternatives 3–6 | Management actions to meet the species' objectives, including IRC and ESH creation, would result in relatively higher non-use values compared to Alternative 1. |

### 3.23.2.3 Impacts from Management Actions Common to All Alternatives

The Missouri River and its terrestrial lands are a dynamic aquatic ecosystem with global biogeochemical cycles that can impact the oceans, atmosphere, and climate. Aspects of the MRRMP-EIS alternatives, including vegetation and predator management, population propagation and augmentation, and human restrictions measures would provide beneficial impacts to the pallid sturgeon, piping plover, and least tern. As a result, there would be beneficial impacts to non-use values under all alternatives. There would be negligible impacts to other cultural resources associated with these management actions because of the relatively small area impacted by the localized nature of the management actions common to all alternatives when compared to the extensive size of the river basin.

### 3.23.2.4 Carbon Sequestration and Climate Regulation

In order to enhance and create ESH and habitat to support the early life stage requirements of the pallid sturgeon, the USACE would transition some terrestrial areas of the floodplain into aquatic habitats and acquire additional lands to develop and restore functional habitats for the

pallid sturgeon. The reestablishment of natural vegetation covers and soils on federally acquired lands purchased for habitat would likely result in long-term benefits to carbon sequestration and climate regulation. Alternative 2 would result in substantially more construction of ESH and SWH, and larger long-term benefits from the establishment stable soils and natural vegetation on federally acquired lands compared to Alternative 1. All changes to carbon sequestration from the construction of habitat under the management plan alternatives would be negligible in the regional context because of the large land area in which these impacts would occur.

As discussed in Section 3.10, Land Use and Ownership, lands that would be federally acquired when needed to support early life stage requirements for the pallid sturgeon are likely to have been previously farmed. The transition of farmlands, especially croplands previously tilled, to a more natural state would enrich soil life and restore soil organic matter, increasing localized terrestrial carbon pools. Increasing organic matter in soils, reducing soil disturbances, and increasing vegetation cover and densities of previously cultivated lands would have a beneficial impact on carbon stocks and sequestration within the floodplain, and contribute to regional climate regulation and the mitigation of climate change.

As shown in Table 3-262, the trends in different habitat types would vary between alternatives. In addition to providing additional habitat, management actions would improve floodplain connectivity, reduce soil disturbances and increase soil organic matter, and improve ecological functions of surrounding areas over time.

**Table 3-262. Changes in Aquatic/Floodplain Habitat Classes**

| Habitat Types | Change in Acres and % Change Relative to Alternative 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Alternative 2 | | Alternative 3 | | Alternative 4 | | Alternative 5 | | Alternative 6 | |
| Open Water | 197 | 0% | 1,071 | 1% | −127 | 0% | 317 | 0% | 665 | 0% |
| Wetlands | 9,325 | 6% | 1,489 | 1% | 1,297 | 1% | 1,855 | 1% | 3,624 | 2% |
| Forest | −692 | −3% | −3,457 | −13% | −319 | −1% | −3,314 | −13% | −4,332 | −17% |
| Prairie | −7,199 | −11% | −5,095 | −8% | −232 | 0% | −4,300 | −7% | −3,115 | −5% |

Without site-specific studies and data, it is difficult to determine whether management actions that impact aquatic and terrestrial habitat classes under Alternatives 2 through 6 would have a net impact on the ability of the river basin to act as a natural carbon sink relative to the capabilities under Alternative 1. Temporary adverse and long-term beneficial impacts to carbon sequestration capacities and carbon stocks would be greatest under Alternative 2, since considerably more cultivated lands would be acquired and transitioned to a more natural state and more wetland habitat classes would emerge relative to the other alternatives. Relative to Alternative 1, impacts under Alternatives 3 through 6 would be smaller since fewer acres would be federally acquired to create habitat to support the early life stage requirements of the pallid sturgeon, but the changes relative to Alternative 1 would be negligible.

Due to the extensive size of the river basin, the relatively small amount of acreage to be federally acquired, relatively small changes in habitat classes, and the likelihood that sequestration losses by some habitat classes would be offset by gains in sequestration in other habitat classes, management actions under all MRRMP-EIS alternatives are anticipated to have both adverse and beneficial impacts that result in negligible long-term net impacts on carbon stocks and sequestration capacity across the floodplain.

#### 3.23.2.5 Other Cultural Services

Under Alternative 1, the continued acquisition of lands and creation and restoration of early life stage habitat for the pallid sturgeon as well as the creation of ESH would enhance visual aesthetics and potentially increase public access along the river, with potential benefits to other cultural services, including benefits to emotional well-being; a sense of belonging, commitment, and identity within communities; the cultivation of stronger emotional bonds with the natural environment; and educational and leisure opportunities. Because there would be considerably more acres acquired and restored for early life stage habitat for the pallid sturgeon and ESH created under Alternative 2 compared to target acreages under Alternative 1, habitat areas would provide relatively small local benefits for other cultural services relative to those under Alternative 1. Because there would be a similar number of lands acquired for pallid sturgeon early life stage habitat under Alternatives 3 through 6 compared to Alternative 1, beneficial impacts to other cultural services under Alternatives 3–6 would be similar to those under Alternative 1.

#### 3.23.2.6 Non-Use Values

All MRRMP-EIS alternatives include management actions that would improve ecological function of the Missouri River floodplain and benefit the least tern, piping plover, and pallid sturgeon and would continue to support non-use benefits associated with these populations and improved ecosystem functioning. It is anticipated that management actions under Alternatives 2 through 6 have a higher likelihood of meeting the species' objectives. In doing so, these alternatives would provide beneficial impacts to societal non-use values associated with threatened and endangered species and improved ecological function.

#### 3.23.2.7 Conclusion

No significant adverse impacts to ecosystem services are anticipated under any of the alternatives. All alternatives would have negligible long-term net impacts on carbon stocks and sequestration capacity across the floodplain because of the extensive size of the river basin, the relatively small amount of acreage to be federally acquired, relatively small changes in habitat classes, and the likelihood that sequestration losses by some habitat classes would be offset by gains in sequestration in other habitat classes.

The creation of additional early life stage habitat for the pallid sturgeon and ESH under alternatives 1, 3, 4, 5, and 6 would provide beneficial impacts to public access and other cultural services, such as visual aesthetics, the cultivation of stronger emotional bonds with the natural environment, and educational and leisure opportunities. Because there would be considerably more and ESH created and more acres acquired and restored for early life stage habitat for the pallid sturgeon under Alternative 2, there would be relatively more beneficial impacts to other cultural services under Alternative 2.

Impacts to non-use values associated with endangered species preservation and improved ecological functioning under alternatives 2 through 6 would provide beneficial impacts compared to Alternative 1 because of the higher likelihood of meeting the species' objectives. With considerably more pallid sturgeon early life stage habitat and ESH created under Alternative 2, beneficial impacts to non-use values would be relatively greater than under the other alternatives.

#### 3.23.2.8 Tribal Resources

Tribal resources would be affected by the changes to ecosystem services as described in the above-noted sections.

#### 3.23.2.9 Climate Change

Climate change could influence the ability and functioning of the ecosystem to provide ecosystem services under Alternative 1. More frequent drought periods could impact the effectiveness of the pallid sturgeon early life stage habitat with relatively lower river stages during these periods constraining pallid access to these habitat areas. More intense flooding could also deposit sediment and possibly silt in early life stage habitat for the pallid sturgeon, with adverse impacts to these populations. Climate change could result in both adverse and beneficial impacts to non-use values associated with the pallid sturgeon, piping plover, and least tern and improved ecosystem functioning under Alternative 1.

Impacts associated with climate change under Alternatives 2 through 6 would be similar to those described for Alternative 1. With climate change, pulses and releases under Alternatives 2, 4, 5, and 6 could possibly contribute to the effects of flooding, with possibly greater adverse impacts to plant succession and pallid sturgeon early life stage habitat, and greater benefits through natural ESH creation. Any changes in river flows and stages associated with prolonged droughts, flooding events, earlier snowmelt, and the resulting changes in frequency of pulses from climate change would have adverse and beneficial impacts to carbon sequestration, other cultural services, and non-use values associated with the alternatives.

#### 3.23.2.10 Cumulative Impacts

**Carbon Sequestration and Climate Regulation**

Past, present and reasonably foreseeable future actions have both temporary and long-term impacts on carbon sequestration. Temporary adverse impacts would result from construction activities, including levee construction, oil and natural gas development, and floodplain development actions; these activities would result in adverse impacts from the loss of stored carbon due to soil disturbance and vegetation removal.

Surface water and groundwater withdrawals can indirectly impact carbon sequestration. Surface water withdrawals for agricultural, municipal, and industrial uses and groundwater withdrawals for oil and natural gas production and municipal water supplies could lower water flows or elevations in the river. Groundwater withdrawals and the actions that exacerbate bed degradation and aggradation can also reduce groundwater levels. Low surface water and groundwater levels adversely impact the persistence, quality, abundance, and distribution of habitats such as shallow water riverine habitats and wetlands. Vegetation and soils in these degraded habitats would have a decreased capacity to capture and store carbon resulting in adverse impacts to carbon sequestration in localized areas.

Oil and gas production would have direct, long-term, adverse impacts from the removal of stored carbon and the direct emission of that sequestered carbon dioxide during fracking and other production related activities (USEPA 2015). Urban, residential, transportation, utility, commercial, and industrial development on the floodplain result in relatively small long-term adverse impacts to carbon sequestration from the removal of natural habitats and associated

vegetation, soils, and biogeochemical processes. Additionally, development tends to result in the emission of greenhouse gases including previously captured and stored carbon dioxide.

Past, present and/or reasonably foreseeable future actions from floodplain animal pasturing would have long-term beneficial impacts. Grazing land has high root density and associated root exudates (i.e., secreted compounds that regulate soil microbes and hinder herbivores), and soil carbon is more permanent. Typically, pasturing results in limited soil disturbance which allows for the continued protection of below ground organic matter and associated carbon from exposure and oxidation. These impacts would be perceptible over localized areas resulting in relatively large benefits. However, the exact nature of the impacts of floodplain grazing would depend on the land use and land cover prior to conversion to grazing, physical soil and climatic factors, grazing intensity, and pasture management practices.

Past, present and/or reasonably foreseeable future actions from land uses changes for crop production result in large long-term adverse impacts from decreased carbon sequestration on a localized scale. The conversion of land from native habitat to crop production has and would result in the loss of soil organic carbon from reduced input of organic matter associated with crop harvesting and an increase in decomposition associated with more above ground organic matter and the effects of tillage (i.e., the exposure of previously inaccessible organic material). Conversely, land use changes that include the conversion of farmlands to conservation lands or wildlife or wetland easements would provide beneficial impacts for carbon sequestration

The past, present and/or reasonably foreseeable future actions of the USACE Continuing Authority Programs, and Management of USACE Project Properties as well as the actions and programs of other federal agencies (i.e., USFWS, NRCS, NPS, and EPA) that focus on land and river conservation and management and restoration of natural habitats would result in long-term beneficial impacts for carbon sequestration. Protection, improvement, and restoration of natural habitat including vegetation and soils would allow for more photosynthesis by terrestrial vegetation, increased below ground biomass, and decreased disturbance which increase the capture and storage of carbon in the soil and vegetation. In addition, these actions would reduce or eliminate deforestation or other forms of vegetation removal and potentially limit soil erosion thereby stabilizing or increasing the carbon sequestration capability of the habitat. The restoration of wetland habitats, in particular, would allow for more carbon storage due to decreased decomposition in hydrophytic environments.

All alternatives would result in negligible impacts to ecosystem services. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts of all alternatives would be long-term, and adverse or beneficial on carbon sequestration. The contribution from all alternatives would be negligible compared to widespread adverse and beneficial impacts associated with cumulative actions throughout the basin. The relatively larger amount of land acquired and habitat created under Alternative 2 would have temporary adverse and long-term beneficial impacts to carbon sequestration resulting from the initial loss of stored carbon from habitat, vegetation, and soil disturbance followed by increased carbon storage as the created and restored habitats become established. Although the impacts under Alternative 2 would be greater than those under Alternative 1 due to the amount of acreage involved, the beneficial impacts under Alternative 2 would provide a negligible contribution to the more widespread impacts associated with the cumulative actions.

### Other Cultural Services

In general, the visual quality of natural landscape features and viewscapes along the river has diminished as natural lands within the floodplain have been developed and fragmented as a result of past, present and reasonably foreseeable future actions. Cumulative actions, such as agricultural and energy production, continued rural, urban, and utility development, and the construction and continued operation of the reservoir system, levees, BSNP, and other river structures to provide flood control and navigation have collectively had a large adverse impact on the visual aesthetics of the Missouri River and its floodplain, and contributed to long-term declines in the provision of other cultural services.

Other cumulative actions include the USACE Continuing Authority Programs, and the USACE continued management of water and related land resources, as well as, the actions and programs of other federal agencies (i.e., USFWS, NRCS, NPS, and EPA) who are stewards of the environment. These actions contribute to long-term beneficial impacts to other cultural services by protecting, restoring, and enhancing natural habitats that improve viewscapes and the natural features of the river and its floodplain.

All alternatives would provide some beneficial impacts by providing public access and cultural experiences on the river and its related terrestrial lands. Alternative 2 would provide greater beneficial impacts to cultural services than under Alternative 1 because of a greater amount of ESH created and habitat to support early life stage requirements for the pallid sturgeon. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts from all alternatives would be both beneficial and adverse to cultural services, and the contributions to cumulative impacts in the provision of cultural services under all alternatives would be beneficial, but negligible compared to adverse cumulative impacts of agricultural and energy production; continued rural, urban, and utility development; to other cumulative actions occurring within the floodplain; and the relatively small proportion of the channel and floodplain in which habitat would be created or managed.

### Non-Use Values

As discussed in the piping plover, least tern, and pallid sturgeon cumulative impacts sections, numerous past, present and/or reasonably foreseeable future actions have had adverse and beneficial impacts on the productivity and distribution of these species within the Missouri River and its floodplain. Alternative 1 may have a reduced likelihood of meeting the species' objectives compared to the action alternatives, with potential adverse impacts to non-use values. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts from Alternative 1 would be long term and adverse and beneficial; however, Alternative 1 is expected to provide a negligible contribution to cumulative impacts.

Management actions under Alternatives 2–6 would have beneficial impacts to ecological conditions that would increase native habitats compared to Alternative 1. When combined with past, present, and reasonably foreseeable actions, cumulative impacts under Alternatives 2–6 would provide beneficial impacts to societal non-use values associated with populations of endangered species and improved natural ecosystem functioning, and Alternatives 2–6 would have a relatively larger contribution to beneficial impacts than under Alternative 1.

# 3.24 Mississippi River Impacts

## 3.24.1 Affected Environment

This section describes resources in the middle Mississippi River that could be potentially affected by the alternatives. The middle Mississippi River is the portion of the Mississippi River that lies between the confluence with the Missouri River and the confluence with the Ohio River. Counting of river miles on the middle Mississippi River begins at mile 0 at the Ohio River confluence near Cairo, IL and ends at mile 195 at the Missouri River confluence north of St. Louis, MO.

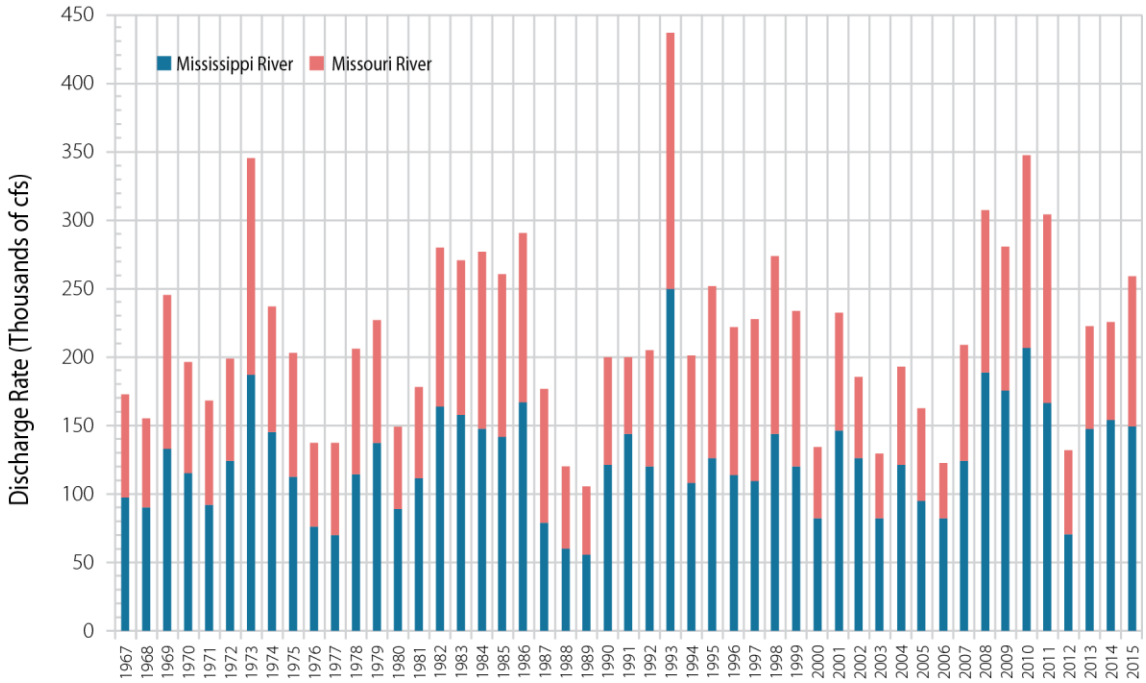
The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

The 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.

## 3.24.2 Riverine Infrastructure and Hydrologic Processes

### 3.24.2.1 Affected Environment

The Missouri River contributes almost half of the flow in the middle Mississippi River. Between 1967 through 2015, the mean annual discharge rate of the Missouri River at Hermann, Missouri, was 91,800 cfs, whereas the rate for the Mississippi River below the confluence in St. Louis was 217,300 cfs (USGS 2016). The mean annual discharge contribution of the Missouri River to the Mississippi River between 1967 and 2015 was 42 percent, ranging between 30 and 55 percent (Figure 3-63). On a monthly basis, discharge contributions by the Missouri River between 1967 and 2015 ranged from a low of 20 percent (May 2014) to a high of 73 percent (September 1996). The Missouri River contributes approximately 75 to 95 percent of the suspended sediment load in the Mississippi River (Davinroy 2006).




Note: The combined total represents the flow in the Mississippi River at the St. Louis stage.

**Figure 3-63. Mean Annual Discharge Rates for the Missouri River and Mississippi River at their Confluence in St Louis, Missouri**

Other tributaries to the middle Mississippi River include the Meramec River at RM 160, the Kaskaskia River at RM 117, and the Big Muddy River at RM 75. These tributaries are small compared to the Missouri River; they contribute mean flows of approximately 3,200 cfs, 3,800 cfs, and 1,900 cfs, respectively (WEST 2000).

The highest flows and stages on the middle Mississippi River typically occur in April and May and the lowest flows and stages tend to be in December and January (Figure 3-64). The mean stage and corresponding flow for flood stage, approximate elevation of the top of river training structures and the Annual Exceedance Probability for the Mississippi River at St. Louis, MO are listed in Table 3-263.

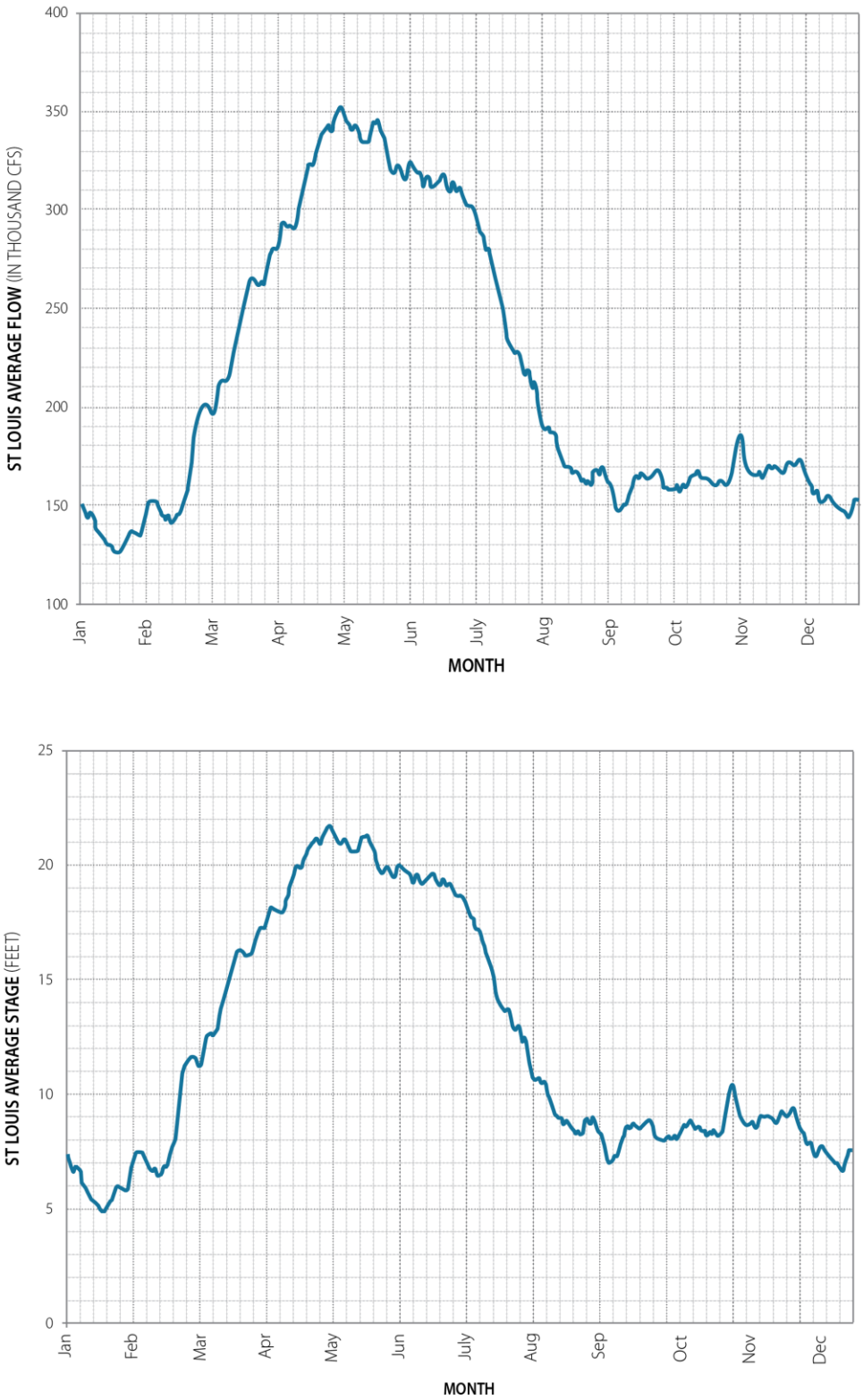



**Figure 3-64. Daily Average Middle Mississippi River Flows and Stages at St. Louis over the Period 1967 to 2015**

**Table 3-263. Annual Exceedance Probability: Mississippi River at St. Louis, Missouri**

| Annual Exceedance Probability: Mississippi River at St. Louis, Missouri | Stage (ft) | Flow (cfs) |
|---|---|---|
| Structure Top Elevation | 15.00 | 247,000 |
| 0.50 (2 – year) | 29.96 | 450,000 |
| Flood Stage | 30.00 | 510,000 |
| 0.20 (5 – year) | 35.76 | 590,000 |
| 0.10 (10 – year) | 38.46 | 670,000 |
| 0.04 (25 – year) | 41.96 | 780,000 |
| 0.02 (50 – year) | 44.06 | 850,000 |
| 0.01 (100 – year) | 46.06 | 910,000 |
| 0.005 (200 – year) | 47.86 | 1,000,000 |
| 0.002 (500 – year) | 50.56 | 1,120,000 |

An analysis of changes in river planform[12] in the middle Mississippi River was recently conducted by the St Louis District (Brauer et al. 2005; Brauer et al. 2013). The analysis demonstrates that the middle Mississippi River went through a period of planform widening in the mid-nineteenth century followed by a period of planform narrowing from the end of the nineteenth century through the mid-twentieth century (Figure 3-65). These trends were observed throughout the middle Mississippi River. The period of narrowing corresponded to the widespread use of river training structures and bank protection for navigation improvements. The increase in planform and channel width in 1881 found between RM 110.3 and RM 120.0 is the result of the channel cutoff that occurred on the Mississippi River when it captured the Kaskaskia River.

The first training structures were mainly permeable wooden structures, which focused the river's energy into the main channel by reducing the velocities between the structures, causing sediment to deposit in channel border areas. This deposited sediment narrowed the channel. Since 1968, however, the channel width appears to have reached dynamic equilibrium with very little change. In the 1960s, USACE began constructing impermeable dikes primarily out of stone. The use of impermeable dikes reduced the rate of deposition between the structures when compared to the previously used permeable structures. Another change was the reduction of the design elevation of dike fields. Unlike in the past, the area between the structures did not fill with sediment, but instead have been growing vegetation and have been becoming part of the floodplain. In the 43 years between 1968 and 2011, the average planform width remained relatively steady with a net reduction in average planform width of 167 feet. This was the result of the changes in structure material, structure elevation, and bank protection.

[12] The planform is the view of river from above. For example, meandering channels are sinuous single channels with a series of point bars, deep pools and eroding meander bends.

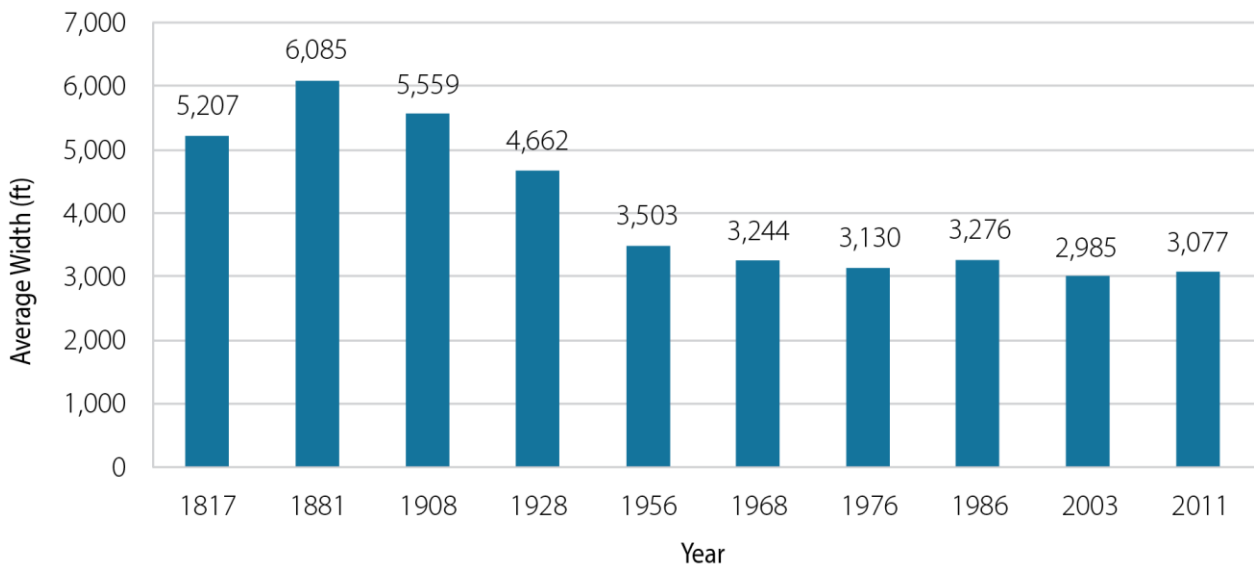



**Figure 3-65. Average Planform Width of the Middle Mississippi River from 1817 to 2011**

### 3.24.2.2 Environmental Consequences

**Impact Assessment Methodology**

The methodology for the analysis of the impacts on the hydrology in the middle Mississippi River from the alternatives was similar to the methodology used for analyzing the impacts for the Missouri River. Specifically, the analysis of the flow alterations under the six alternatives was largely based on HEC-ResSim and HEC-RAS modeling for the 82-year POR (1931 to 2012), as described in Section 3.1. General hydrologic conditions in the river were analyzed using the statistical 90th percentile (wet period conditions), 50th percentile (average conditions), and 10th percentile (dry period conditions) of the POR.

In addition, flow alterations were assessed for individual years throughout the POR to assess potential impacts on the middle Mississippi River for specific action alternatives. Examples of individual years shown graphically include the same as the individual years analyzed for the Missouri River (see Section 3.2.2) to show the effect of these altered flows as they travel through the Missouri River into the Mississippi River. These example years were compared to Alternative 1 (No Action):

- 1966: Representing March and May spawning cue release and low summer flow under Alternative 2 (2003 BiOp Projected Actions)
- 1974: Representing spring and fall habitat-forming flow releases under Alternatives 4 and 5, respectively.
- 1975: Representing pallid sturgeon spawning cue releases under Alternative 6.

These years were selected because they are considered fairly typical in their responses to flow alterations under the various alternatives. Ultimately, there would be considerable variability from year to year in response to individual flow alterations, driven by the specific meteorological conditions in the large Missouri River watershed in that year and years prior.

The impact analysis considered both flow (measured in cubic feet per second [cfs]) and stage (measured in feet). Flow is relevant as it affects erosion and deposition rates in the river. Stage affects flooding and navigation (refer to Table 3-264).

**Table 3-264. Stages with Action Levels for Navigation at St. Louis, Missouri**

| Trigger Reading | Description | Details |
|---|---|---|
| 15 feet | Normal Operations | |
| 5 feet | Normal Operations with Advisory | |
| 0 foot | Low Water | Channel narrows in various sections |
| −3 feet | Extreme Low Water | Channel continues to narrow and channel depth decreases |
| −5 feet | Minimum Navigation | In many areas of the zone, channel is at best 300-feet wide by 9-feet deep |
| −6 feet | Below Minimum Navigation | |
| −7 feet | Historic Low Water | |

Source: USCG 2012

## Summary of Environmental Consequences

The environmental consequences relative to river infrastructure and hydrologic processes are summarized in Table 3-265.

**Table 3-265. Environmental Consequences Relative to River Infrastructure and Hydrologic Processes**

| Alternative | Impacts on River Infrastructure and Hydrologic Processes |
|---|---|
| Management Actions Common to All Alternatives | • The flow in the middle Mississippi River at St. Louis would be nearly identical for all alternatives throughout the year for the 90th, 50th, and 10th percentile conditions, as well as for maximum high and low flow conditions.<br>• As modeled the volume of sediment supplied by the Missouri River to the middle Mississippi River would change very little. Combined with the impacts on flow alterations the impacts on geomorphology and river infrastructure would be negligible.<br>• Impacts on groundwater elevations in the middle Mississippi River would be temporary, adverse, and negligible to small from adverse negligible to small impacts on hydrology in the middle Mississippi River. |
| Alternative 1 | • Existing hydrologic conditions in the middle Mississippi River would continue and the spawning cue release pulses would be mostly attenuated by the time they reach the middle Mississippi River and would not cause impacts. |
| Alternative 2 | • The spawning cue releases and summer low flows may affect the stage by lowering it for up to one to two feet for short periods in the middle Mississippi River in July and August. |
| Alternative 3 | • No impacts would occur to flows or stage of the middle Mississippi River. |
| Alternative 4 | • Flows would mostly be attenuated before they reach the middle Mississippi River but releases would increase the stage by 1 to 2 feet and the flow in the middle Mississippi River and long-term adverse impacts would be small. |
| Alternative 5 | • Flows would mostly be attenuated before they reach the middle Mississippi River but releases would increase the stage by 1 to 3 feet and the flow in the middle Mississippi River. These impacts on stage and flow would be negligible. |

| Alternative | Impacts on River Infrastructure and Hydrologic Processes |
|---|---|
| Alternative 6 | • The spawning cue release would be largely attenuated by the time it reaches the middle Mississippi River but releases would increase the stage by 1 to 3 feet and flow in the middle Mississippi River. These impacts on stage and flow would be negligible to small. |

### Hydrology

**Impacts from Management Actions Common to All Plan Alternatives**: The flow in the middle Mississippi River at St. Louis simulated for the POR would be nearly identical for each of the six alternatives throughout the year for 90th, 50th and 10th percentile conditions, as well as for maximum high and low flow conditions.

**Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)**: Existing hydrologic conditions in the Mississippi River would continue. The spawning cue release pulses in March and May would be almost entirely attenuated in the Missouri River by the time they reach the Mississippi River (Figure 3-66) and thus would not impact the hydrology in the middle Mississippi River.

**Alternative 2 – USFWS 2003 Biological Opinion Projected Actions**: The spring pallid sturgeon flow releases and summer low flows under Alternative 2 may for short periods affect the stage in the Mississippi River by up to one or two feet, based on the hydrology simulated for individual years of the POR. For example, for hydrologic condition of year 1966, the spawning cue release would be attenuated considerably by the time it reached Hermann, MO; the summer low flow would still be recognizable (Figure 3-66). Both flows would be further attenuated at St. Louis, although the summer low flow would result in a lower stage of approximately 2 feet in July and August.

There would be a few years, as simulated over the POR, with the stage decreasing at St. Louis to below 0 foot due to Alternative 2. These occasions would reflect the hydrologic conditions from two weeks in November 1963 when the stage of +1 foot decreased to −1 foot under, two weeks in December 1999 when the stage of −2 feet decreased to −3 feet, a few days in August 2003 when the stage of −3 feet decreased to −4 feet, and a few days in October 2006 when the stage of −1 foot decreased to −2 feet. On the other hand, Alternative 2 would result in increased stages at other times compared to No Action alternative. This would occur under hydrologic conditions represented by a few weeks in November 1955 and 1956 when the stage as low as −2 increased to 0, two weeks in November 1958 when the stage of −1 foot decreased to +1 foot, November 2002 when the stage of between −4 and 0 feet increased to between −3 feet and +1 foot, and a few days in November 2003 when the stage of −3 feet increased to 0 foot. As illustrated by these modeled years, overall, long-term adverse impacts to stage and flows in the Mississippi River under Alternative 2 would be negligible to small.

**Alternative 3 – Mechanical Construction Only**: There would be no impacts to the flows or stages of the middle Mississippi River under Alternative 3 as the absence of the Alternative 1 spawning cue release would not have a noticeable effect.

**Alternative 4 – Spring ESH Creating Release**: Although the flow releases under Alternative 4 would be partially attenuated by the time they reach Hermann, MO, the releases still would increase the stage (on the order of 1 to 2 feet) and flow in the Mississippi River at St. Louis compared to the No Action alternative, as shown, for example, by hydrologic conditions

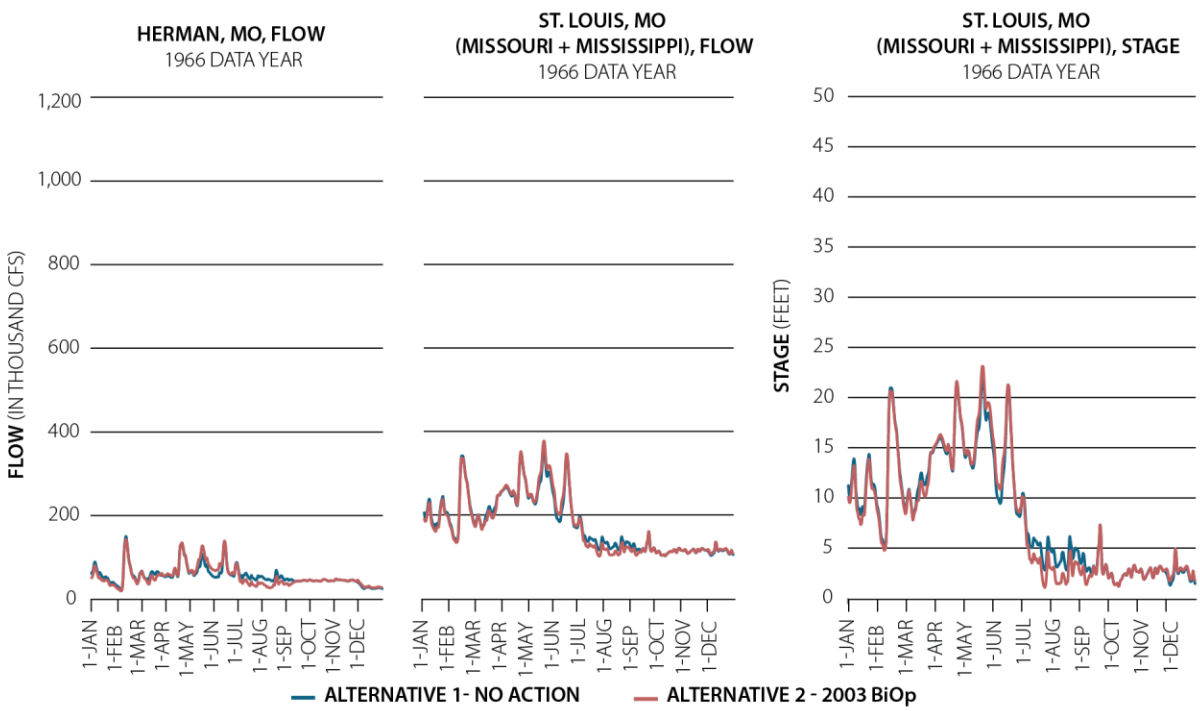



**Figure 3-66. Flows of Missouri River at Hermann, MO, and flows and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 2, simulated based on hydrologic conditions in year 1966.**

simulated for year 1974 (Figure 3-67). In some of the simulated POR years with flow releases, flows in the middle Mississippi River decreased slightly in late fall. A decrease below the stage of 0 at St. Louis would have occurred for about two weeks in October 1933 when the stage of −2.5 feet decreased to between −4 and −6 feet under Alterative 4, November 1963 when the stage of on average +1.5 feet decreased to on average −1 foot, two weeks in November 1964 when the stage of +1 foot decreased to –1 foot, and October 2006 when the stage of −1 foot decreased to −2.5 feet. Considering the POR, these occurrences are comparatively infrequent, thus overall the long-term adverse impacts on stage and flow in the middle Mississippi River would be small.

**Alternative 5 – Fall ESH Creating Release**: Similar to flow releases under Alternative 4, flow releases under Alternative 5 would be partially attenuated by the time they reach Hermann, MO. However, the releases would still increase the stage (on the order of 1 to 3 feet) and flow in the Mississippi River at St. Louis compared to the No Action alternative, as shown for example by hydrologic conditions simulated for year 1974 (Figure 3-68). None of the flow releases would lower the stage in St. Louis to below Stage 0 compared to the No Action alternative. Therefore, overall impacts on stage and flow in the middle Mississippi River would be negligible.

**Alternative 6 – Pallid Sturgeon Spawning Cue**: The spawning cue release simulated over the POR under Alternative 6 would often be largely attenuated by the time it reaches Hermann, MO, but some of the spawning cue releases would still increase the stage (by up to 3 feet) and flow in the middle Mississippi River at St. Louis compared to the No Action alternative, as shown for example for hydrologic conditions in year 1975 (Figure 3-69).

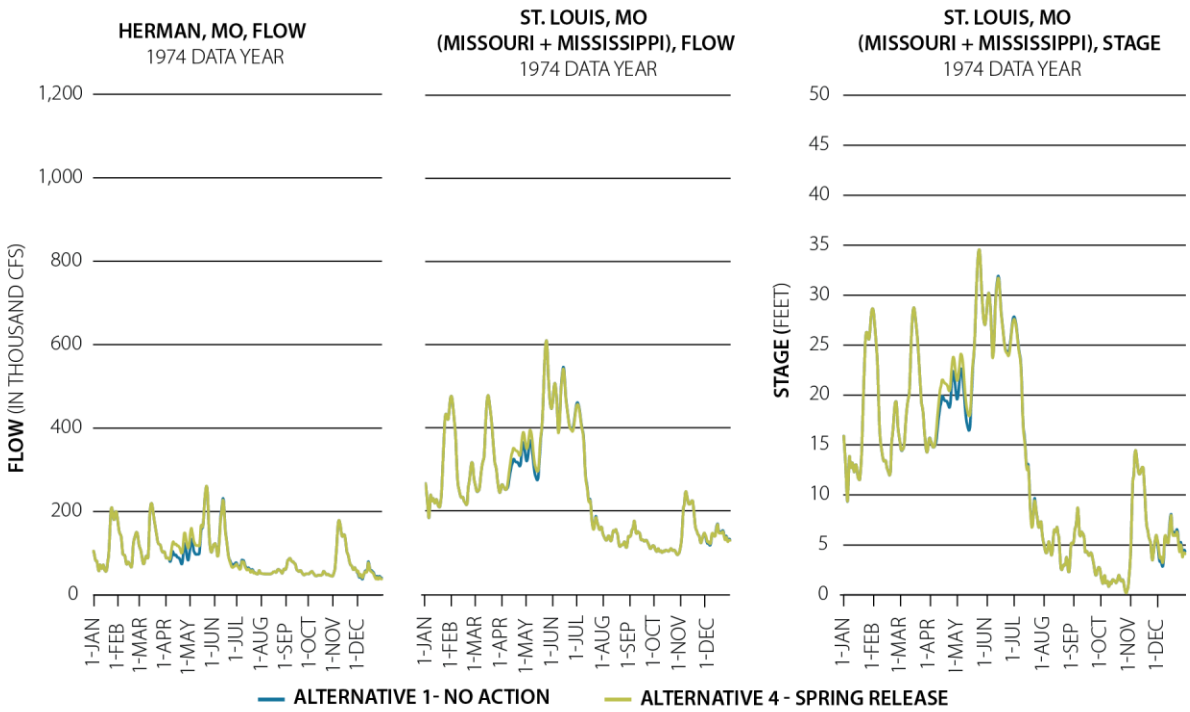



**Figure 3-67. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 4, simulated based on hydrologic conditions in year 1974.**

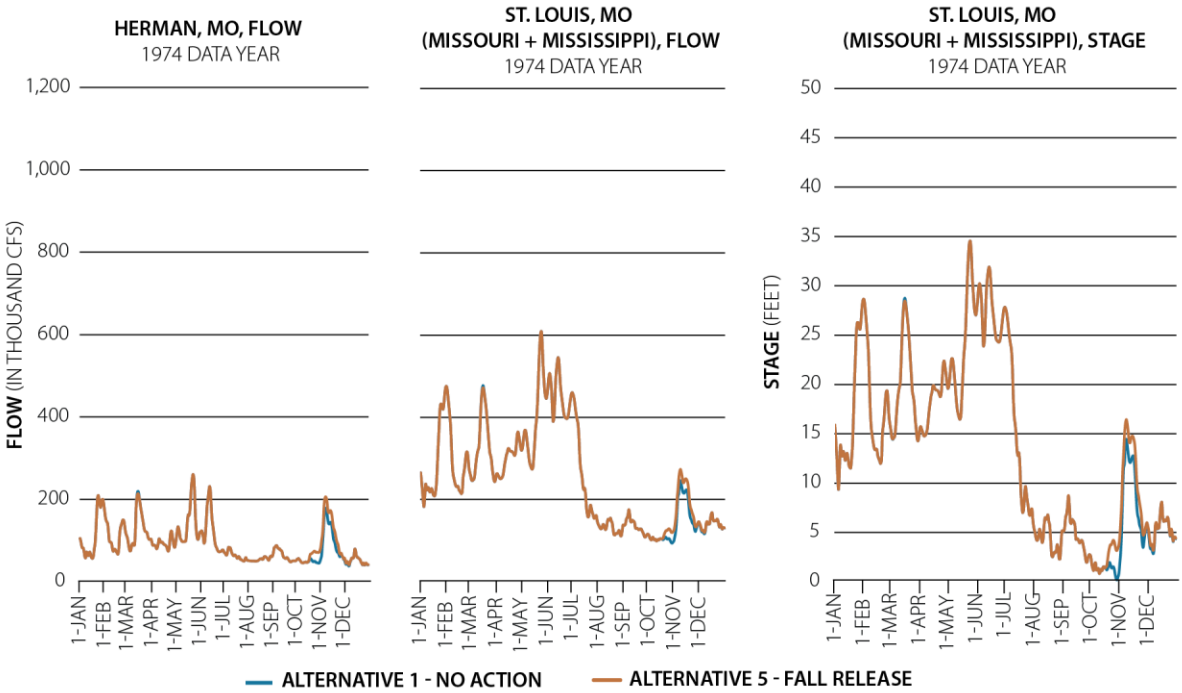



**Figure 3-68. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 5, simulated based on hydrologic conditions in year 1974.**

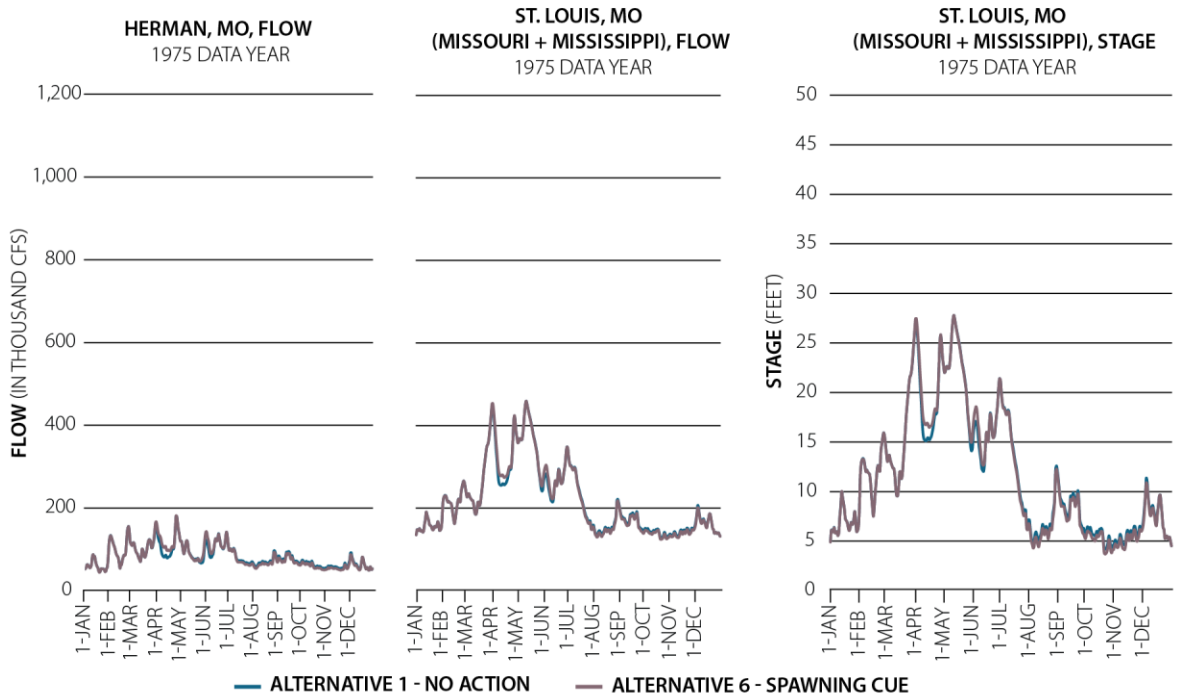



**Figure 3-69. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 6, simulated based on hydrologic conditions in year 1975.**

In some of the POR years with spawning cue releases, flows at St. Louis decreased slightly in late fall. A decrease below the stage of 0 at St. Louis occurred for a few days in November 1932 and October 1933 when the low stages later in the fall of approximately −5 feet at St. Louis occurred about a week earlier, a few days in October 2004 when the stage of on average +1 foot decreased up to −1 foot, and October 2006 when the stage of −1 foot decreased to −2.5 feet. Considering the long POR, these occurrences would be comparatively infrequent, thus overall impacts on stage and flow in the middle Mississippi River would be negligible to small.

### Geomorphology and Riverine Infrastructures (all Alternatives)

Modeling has shown that sediment transport in the Kansas City reach of the Missouri River would change very little under the action alternatives compared to the No Action alternative, indicating that the volume of sediment supplied by the Missouri River to the middle Mississippi River by the action alternatives would also change very little. Therefore, combined with relatively small to negligible flow alterations under the action alternatives, there would be negligible impacts on the geomorphology in the middle Mississippi River from the action alternatives. Similarly, there would be negligible impacts on riverine infrastructure in the middle Mississippi River.

### Groundwater (all Alternatives)

Considering that any changes from flow alterations under the action alternatives on the stage in the middle Mississippi River would be at most comparatively small and also of short duration, there would be negligible to small adverse impacts to groundwater elevations along the middle Mississippi River.

**Conclusion**

Given the negligible to small change in hydrology, geomorphology, groundwater, and river infrastructure, no significant impacts are anticipated from any of the alternatives.

## 3.24.3 Biological Resources

### 3.24.3.1 Affected Environment

Biological resources associated with the middle Mississippi River have been shaped over time by a variety of actions, including urbanization, agriculture, levee construction, dam construction, and river training structure placement. Many of the changes in the middle Mississippi River which have led to its current condition are due to improvements made for navigation including river training structure placement and resulting sedimentation patterns.

A variety of habitat types are found in the middle Mississippi River, including main channel, main-channel border unstructured, main-channel border wing-dike, and side-channel. Unstructured main-channel border areas provide preferred habitat for fish species that require flowing water throughout all or most of their life cycle and generally consist of moderate depths of flowing water over a sandy substrate. Main channel border wing dike areas produce pockets of still, freshwater habitat in the form of flow refugia and plunge pools, providing habitat often used by macrohabitat generalists, adaptable fish species which live in highly diverse habitat types. The side channel areas provide arguably the most important habitat type in the middle Mississippi River, as it creates lateral connectivity and is likely used as a surrogate for floodplain and backwater habitat by many species. Side channel habitats are known to support a greater abundance of macrohabitat generalists compared to other macrohabitat types (Simmons 2015), presumably due to shallow, low-velocity habitat they provide at certain river stages.

Side channels typically provide a well-defined gradient between flowing to non-flowing water depending on their level of connectivity to the main channel. The level of connectivity affects substrates, water quality conditions (Crites et al. 2012), bottom dwelling macroinvertebrate communities, and fish communities (Barko and Herzog 2003; Barko et al. 2004a). Flowing side channels, those connected to the main channel, generally have course bottom substrates (i.e., sand and gravel) and support large-river aquatic species (suckers, minnows, and darters) tolerant of current and/or turbidity. This diversity of habitat provides important feeding, spawning, nursery, and overwintering habitat for fish, and habitat for other environmentally sensitive macroinvertebrates, fish, and wildlife (Barko and Herzog 2003). As such, side channels are important to the health of the river ecosystem as a whole, and are even more important in the middle Mississippi River because of the loss of hydraulic connectivity to the floodplain.

The middle Mississippi River side channel habitat can be characterized or represented by three side channels; Mosenthein, Moro, and Boston which cover the upper, middle, and lower reaches of the middle Mississippi River, respectively. The connectivity of these side channels in relation to the main channel is dependent on the stage of the river. Decreases and increases in river stage can alter this relationship and cause changes in side channel connectivity. The river stage at which a side channel becomes disconnected from the main channel is called the choke point elevation. For the purposes of this EIS, the choke point elevation identified for Mosenthein, Moro, and Boston side channels is the one that is the most limiting among the upstream and downstream choke points for each of the side channels. It is assumed that side channel habitat

conditions and benefits are maximized or fully functional when both the upstream and downstream connection points with the main channel are flowing.

Table 3-266 describes the median monthly stage at Mosenthein, Moro, and Boston side channels during 2014, choke point stage, and connectivity status (i.e., connected to main channel or disconnected from main channel) (USACE: Unpublished data from St. Louis District).

**Table 3-266. Median Monthly Stage (feet) in 2014 and Chokepoint Elevations for Each of the Three Side Channels**

| Side Channel | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Chokepoint Elevation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mosenthein | 7.6 | 9.9 | 15.5 | 19.9 | 21.1 | 19.2 | 15.6 | 10.8 | 9.7 | 9.5 | 10.0 | 8.7 | 9.8 |
| Moro | 8.7 | 10.8 | 16.3 | 20.7 | 21.9 | 20.0 | 16.4 | 11.7 | 10.5 | 10.4 | 10.8 | 9.7 | 9.2 |
| Boston | 15.9 | 19.7 | 25.4 | 26.4 | 23.7 | 19.3 | 14.3 | 9.5 | 8.2 | 8.2 | 10.0 | 13.4 | 16.5 |

Source: USACE Unpublished data, St. Louis District)

Note: *Cells highlighted in red note that the side channel was disconnected from the main channel at that stage.

### 3.24.3.2 Environmental Consequences

#### Impact Assessment Methodology

The anticipated impacts to biological resources in the middle Mississippi River as a result of the alternatives are described below. Impacts were qualitatively analyzed based on stage and flow simulated for each alternative by modeling the alternative operation over the POR. (USACE H&H Tech Report 2016). Side channel habitat has been identified as the most diverse and representative habitat in the middle Mississippi River that supports the highest abundance of aquatic species. Impacts to the three representative side channels; Mosenthein, Moro, and Boston are quantitatively discussed in terms of how changes in stage may potentially alter or impact side channel habitat through altering connectivity with the main channel. It is assumed that changes in stage can alter or impact the condition and accessibility of side channel habitat. It is assumed that the changes in stage modeled under each alternative at the St. Louis gage is representative of the middle Mississippi River and each of the representative side channels.

Known limiting choke point elevations based on 2014 data at the Mosenthein, Moro, and Boston side channels were used to assess the impact from each of the alternatives on the connectivity of each of the representative side channels. Average monthly 10th, 50th, and 90th percentile stages at the St. Louis gage for each of the modeled alternatives were compared to those modeled under Alternative 1. Connectivity status was evaluated for each of the side channels under each of the alternatives in order to report potential impacts.

#### Summary of Environmental Consequences

The environmental consequences relative to biological resources are summarized in Table 3-267.

**Table 3-267. Environmental Consequences Relative to Biological Resources**

| Alternative | Impacts on Biological Resources |
|---|---|
| Alternative 1 | • The periods of connection and disconnection of the side channels would be a result of natural cycles experienced with the natural variability of hydrologic conditions in the basin and impacts rather than caused by management actions. |
| Alternatives 2 and 4 | • No changes would occur in connectivity or flow status of the three evaluated side channels in the middle Mississippi River compared to Alternative 1. |
| Alternative 3 | • No impacts would occur to side channel habitat condition or accessibility because flow and stage would not be impacted in the middle Mississippi River. |
| Alternatives 5 and 6 | • No change or a small beneficial change in connectivity and flow status would occur in the middle Mississippi River compared to Alternative 1. |

### Impacts from Management Actions Common to All Alternatives

It is anticipated that there will be no impacts to biological resources in the middle Mississippi River from management actions common to all alternatives. The listed activities would occur on the Missouri River and would not impact the stage or flow on the middle Mississippi River.

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

Alternative 1 would result in periods of connection and disconnection to the main channel river for the Mosenthein, Moro, and Boston side channels (Table 3-268). The 10th percentile modeled stages resulted in disconnection of all three side channels from the main river for the entire year. The 50th percentile modeled stages resulted in Mosenthein and Moro flowing or connected in the spring and summer months while disconnected in the fall and winter months and with Boston disconnected the entire year except for May. Modeled average monthly stages in the 90th percentile resulted in the Monenthein and Moro side channels flowing all year round and Boston only flowing during late spring and summer. Given that the spawning cue releases from Gavins Point Dam under Alternative 1 would be largely attenuated by the time they reach the Mississippi River, the periods of connection and disconnection would be attributed to natural hydrologic cycles observed over the POR rather than the spawning cue release.

It is anticipated that there would be no adverse impacts to biological resources in the middle Mississippi River from mechanical ESH construction, channel reconfiguration for construction of pallid sturgeon early life stage habitat, or habitat development and land management on MRRP lands. These activities would occur on the Missouri River and would not adversely impact the stage or flow on the middle Mississippi River and would therefore not impact, disturb, or alter biological resources in the middle Mississippi River.

### Conclusion

Given the spawning cue release from Gavins Point Dam would be largely attenuated by the time it reaches the Mississippi River, the periods of connection and disconnection of the side channels that were analyzed would be a result of natural cycles experienced with the natural variability of hydrologic conditions in the basin rather than caused by management actions associated with Alternative 1. None of the potential impacts from Alternative 1 would be significant for biological resources in the middle Mississippi River.

**Table 3-268. Alternative 1 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels**

| No Action Alternative | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side Channel** | **Percentile** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Mosenthein** (choke point 9.8 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.7 | 6.8 | 7.0 | 4.1 | 1.0 | 0.4 | -0.2 | -0.1 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.0 | 16.6 | 14.7 | 12.0 | 6.4 | 5.9 | 5.2 | 5.5 | 4.3 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |
| **Moro** (choke point 9.2 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.7 | 6.8 | 7.0 | 4.1 | 1.0 | 0.4 | -0.2 | -0.1 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.1 | 16.6 | 14.7 | 12.0 | 6.4 | 5.8 | 5.2 | 5.6 | 4.3 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.1 | 11.3 |
| **Boston** (choke point 16.5 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.9 | 7.4 | 7.0 | 3.4 | 0.9 | 0.4 | -0.3 | -0.1 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.2 | 16.8 | 14.7 | 12.0 | 6.4 | 5.8 | 5.2 | 5.6 | 4.3 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.1 | 12.0 | 13.3 | 16.1 | 11.2 |

Note: *Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

## Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 would result in no change in impacts to the biological resources in the middle Mississippi River (Table 3-269) compared to Alternative 1. There would be no change in connectivity for Mosenthein, Moro, or Boston side channels under Alternative 2 when compared to Alternative 1, thus there would be no additional adverse impacts to biological resources in middle Mississippi River from this alternative.

**Table 3-269. Alternative 2 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels**

| Alternative 2 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side Channel** | **Percentile** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Mosenthein** (choke point 9.8 ft) | 10th | -1.1 | -0.5 | 3.3 | 7.9 | 7.5 | 7.6 | 3.3 | 0.9 | 0.4 | -0.4 | 0.0 | -0.9 |
| | 50th | 4.1 | 6.5 | 12.3 | 16.2 | 16.9 | 14.9 | 12.1 | 6.2 | 6.0 | 5.3 | 5.6 | 4.2 |
| | 90th | 13.1 | 13.2 | 20.9 | 26.5 | 27.5 | 27.5 | 20.8 | 13.1 | 12.0 | 13.4 | 16.0 | 11.2 |
| **Moro** (choke point 9.2 ft) | 10th | -1.1 | -0.5 | 3.3 | 7.9 | 7.5 | 7.6 | 3.3 | 0.9 | 0.4 | -0.4 | 0.0 | -0.9 |
| | 50th | 4.1 | 6.5 | 12.3 | 16.2 | 16.9 | 14.9 | 12.1 | 6.2 | 6.0 | 5.3 | 5.6 | 4.2 |
| | 90th | 13.1 | 13.2 | 20.9 | 26.5 | 27.5 | 27.5 | 20.8 | 13.1 | 12.0 | 13.4 | 16.0 | 11.2 |
| **Boston** (choke point 16.5 ft) | 10th | -1.1 | -0.5 | 3.3 | 7.6 | 6.7 | 7.6 | 3.4 | 1.0 | 0.4 | -0.3 | 0.0 | -0.9 |
| | 50th | 4.1 | 6.5 | 12.3 | 16.0 | 16.6 | 14.9 | 12.1 | 6.4 | 6.0 | 5.3 | 5.6 | 4.2 |
| | 90th | 13.1 | 13.2 | 20.9 | 26.5 | 27.5 | 27.5 | 20.8 | 13.3 | 11.8 | 13.3 | 16.0 | 11.3 |

Note: *Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 2. Connectivity analysis based on the choke points as described in the Affected Environment section.

Impacts from mechanical ESH construction, channel reconfiguration for construction of early life stage habitat, and habitat development and land management on MRRP lands would be the same as what is discussed under Alternative 1.

### Conclusion

There would be no changes in connectivity or flow status of the three evaluated side channels from Alternative 1. Impacts from management actions under Alternative 2 are not determined to be significant for biological resources in the middle Mississippi River.

### Alternative 3 – Mechanical Construction Only

There would be no change in connectivity for Mosenthein and Moro side channels under Alternative 3 when compared to Alternative 1 (Table 3-270). There would be a temporary, relatively small benefit to the Boston side channel under Alternative 3 when compared to Alternative 1. In the 50th percentile, the Boston side channel would be flowing or connected under Alternative 3 and would be disconnected under Alternative 1 in the month of April, representing an improvement in condition.

There would be no changes in connectivity or flow status for Mosenthein and Moro side channels, and a relatively small increase in time the Boston side channel is flowing. There would be no impact to biological resources in the middle Mississippi River from mechanical habitat construction. These activities will occur on the Missouri River and will not impact the stage or flow on the middle Mississippi River.

**Table 3-270. Alternative 3 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels**

| Alternative 3 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side Channel** | **Percentile** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Mosenthein** (choke point 9.8 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.6 | 6.6 | 7.0 | 4.1 | 1.0 | 0.4 | -0.2 | 0.0 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.4 | 16.6 | 14.7 | 12.0 | 6.4 | 5.9 | 5.2 | 5.6 | 4.4 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |
| **Moro** (choke point 9.2 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.6 | 6.6 | 7.0 | 4.1 | 1.0 | 0.4 | -0.2 | 0.0 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.4 | 16.6 | 14.7 | 12.0 | 6.4 | 5.9 | 5.2 | 5.6 | 4.4 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |
| **Boston** (choke point 16.5 ft) | 10th | -1.1 | -0.4 | 3.3 | 8.0 | 7.1 | 7.0 | 4.1 | 1.0 | 0.4 | -0.3 | -0.1 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.9 | 16.8 | 14.7 | 12.0 | 6.4 | 5.9 | 5.2 | 5.6 | 4.4 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |

Note: *Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 3. Cells highlighted in green note a shift in connectivity status from non-flowing to flowing when compared to Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

### Conclusion

There would be no significant impacts to biological resources in the middle Mississippi River under Alternative 3. Alternative 3 would not impact flow or stage in the middle Mississippi River, thus resulting in no impacts to side channel habitat condition or accessibility.

### Alternative 4- Spring ESH Creating Release

Alternative 4 would have no impact to the biological resources in the middle Mississippi River. There would be no change in connectivity for Mosenthein, Moro, or Boston side channels under Alternative 4 when compared to Alternative 1 (Table 3-271), thus there would be no impacts to biological resources in middle Mississippi River from this alternative.

There would be no impact to biological resources in the middle Mississippi River from mechanical habitat construction. These activities will occur on the Missouri River and would not impact the stage or flow on the middle Mississippi River.

### Conclusion

Impacts from Alternative 4 would not be significant for biological resources in the middle Mississippi River. There would be no changes in connectivity or flow status of the three evaluated side channels from Alternative 1, indicating there would be no significant impacts to biological resources under Alternative 4.

**Table 3-271. Alternative 4 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels**

| Alternative 4 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side Channel** | **Percentile** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Mosenthein** (choke point 9.8 ft) | 10th | -1.1 | -0.4 | 3.3 | 8.0 | 7.1 | 7.0 | 4.1 | 1.0 | 0.4 | -0.4 | -0.1 | -0.9 |
| | 50th | 4.4 | 6.5 | 12.3 | 16.7 | 16.8 | 14.7 | 12.0 | 6.4 | 5.9 | 5.1 | 5.5 | 4.3 |
| | 90th | 13.3 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |
| **Moro** (choke point 9.2 ft) | 10th | -1.1 | -0.4 | 3.3 | 8.0 | 7.1 | 7.0 | 4.1 | 1.0 | 0.4 | -0.4 | -0.1 | -0.9 |
| | 50th | 4.4 | 6.5 | 12.3 | 16.7 | 16.8 | 14.7 | 12.0 | 6.4 | 5.9 | 5.1 | 5.5 | 4.3 |
| | 90th | 13.3 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |
| **Boston** (choke point 16.5 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.6 | 6.6 | 7.0 | 4.1 | 1.0 | 0.4 | -0.3 | 0.0 | -0.9 |
| | 50th | 4.4 | 6.5 | 12.3 | 16.0 | 16.6 | 14.7 | 12.0 | 6.4 | 5.9 | 5.1 | 5.5 | 4.3 |
| | 90th | 13.3 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |

Note: *Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 4. Connectivity analysis based on the choke points as described in the Affected Environment.

### Alternative 5 – Fall ESH Creating Release

Alternative 5 would have no impacts to small beneficial impacts to the biological resources in the middle Mississippi River. There would be no change in connectivity for Mosenthein and Moro side channels under Alternative 5 when compared to Alternative 1 (Table 3-272). There would be a temporary relatively small benefit to the Boston side channel under Alternative 5 when compared to Alternative 1. In the 50th percentile, Boston side channel would be flowing under Alternative 5 and would be disconnected under Alternative 1 in the month of April representing an improvement in condition.

There would be no changes in connectivity or flow status for Mosenthein and Moro side channels, and a relatively small increase in time the Boston side channel is flowing.

### Conclusion

There would be no significant impacts to biological resources in the middle Mississippi River under Alternative 5. There would be either no change or a small beneficial change in connectivity and flow status compared to Alternative 1.

**Table 3-272. Alternative 5 Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels**

| Alternative 5 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side Channel** | **Percentile** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Mosenthein** (choke point 9.8 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.6 | 6.6 | 7.0 | 4.1 | 1.0 | 0.4 | -0.2 | 0.0 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.0 | 16.6 | 14.7 | 12.0 | 6.4 | 5.9 | 5.4 | 5.3 | 4.3 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |
| **Moro** (choke point 9.2 ft) | 10th | -1.1 | -0.4 | 3.3 | 7.6 | 6.6 | 7.0 | 4.1 | 1.0 | 0.4 | -0.2 | 0.0 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.3 | 16.0 | 16.6 | 14.7 | 12.0 | 6.4 | 5.9 | 5.4 | 5.3 | 4.3 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |
| **Boston** (choke point 16.5 ft) | 10th | -1.1 | -0.4 | 3.3 | 8.0 | 6.7 | 7.0 | 4.1 | 1.0 | 0.4 | -0.3 | 0.0 | -0.9 |
| | 50th | 4.3 | 6.5 | 12.4 | 16.8 | 16.6 | 14.7 | 12.0 | 6.4 | 5.9 | 5.4 | 5.3 | 4.3 |
| | 90th | 13.4 | 13.2 | 20.9 | 26.5 | 27.5 | 27.4 | 20.7 | 13.3 | 11.7 | 13.3 | 16.0 | 11.3 |

Note: *Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 5. Cells highlighted in green note a shift in connectivity status from non-flowing to flowing when compared to Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

### Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 would have no impacts to small beneficial impacts to the biological resources in the middle Mississippi River. There would be no change in connectivity for Mosenthein and Moro side channels under Alternative 6 when compared to Alternative 1 (Table 3-273). There would be a temporary, relatively small benefit to the Boston side channel under Alternative 6 when compared to Alternative 1. In the 50th percentile, Boston side channel would be flowing under Alternative 6 and would be disconnected under Alternative 1 in the months of April and June, representing an increase in connectivity. There would be no changes in connectivity or

flow status for Mosenthein and Moro side channels, and a relatively small increase in time the Boston side channel is flowing.

**Table 3-273. Alternative 6 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels**

| Alternative 6 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side Channel** | **Percentile** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Mosenthein** (choke point 9.8 ft) | 10th | -0.5 | 0.5 | 3.6 | 8.5 | 7.0 | 7.5 | 4.7 | 3.1 | 2.0 | 1.3 | 1.0 | -0.6 |
| | 50th | 6.0 | 7.6 | 12.4 | 17.9 | 20.2 | 15.7 | 12.4 | 6.3 | 5.7 | 5.3 | 5.6 | 4.9 |
| | 90th | 13.4 | 13.7 | 21.2 | 26.6 | 28.2 | 27.4 | 20.7 | 13.5 | 12.3 | 14.8 | 16.2 | 11.7 |
| **Moro** (choke point 9.2 ft) | 10th | -0.5 | 0.5 | 3.6 | 8.5 | 7.0 | 7.5 | 4.7 | 3.1 | 2.0 | 1.3 | 1.0 | -0.6 |
| | 50th | 6.0 | 7.6 | 12.4 | 17.9 | 20.2 | 15.7 | 12.4 | 6.3 | 5.7 | 5.3 | 5.6 | 4.9 |
| | 90th | 13.4 | 13.7 | 21.2 | 26.6 | 28.2 | 27.4 | 20.7 | 13.5 | 12.3 | 14.8 | 16.2 | 11.7 |
| **Boston** (choke point 16.5 ft) | 10th | 1.1 | 2.4 | 5.8 | 10.6 | 6.9 | 7.5 | 4.5 | 3.0 | 1.9 | 1.1 | 0.6 | 0.9 |
| | 50th | 6.9 | 9.1 | 15.2 | 20.0 | 22.4 | 17.2 | 13.5 | 6.7 | 6.9 | 5.4 | 7.1 | 6.7 |
| | 90th | 14.5 | 14.4 | 22.6 | 29.1 | 28.6 | 28.7 | 24.2 | 13.6 | 11.7 | 16.4 | 16.2 | 13.4 |

Note: *Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 5. Cells highlighted in green note a shift in connectivity status from non-flowing to flowing when compared to Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

### Conclusion

None of the potential and anticipated impacts from Alternative 6 would be significant for biological resources in the middle Mississippi River. There would be no change or a small beneficial change in connectivity and flow status compared to Alternative 1. None of the other proposed management actions under Alternative 6 would impact flow or stage in the middle Mississippi River.

## 3.24.4 Flood Risk Management

### 3.24.4.1 Affected Environment

### Upstream of St. Louis

Approximately 17,994 people reside in the middle Mississippi River reach upstream of St. Louis. Residential and nonresidential structures located in areas along the Mississippi River are subject to flood risk. There are 6,501 residential and 686 nonresidential structures identified in the floodplain. Total estimated value of these structures is $2.0 billion. Table 3-274 presents the estimated population, number of structures and value (in thousands) susceptible to flooding.

In addition to the structures, the total land area subject to flooding in the middle Mississippi River upstream of St. Louis is approximately 131,259 acres with 58,135 acres in agricultural production, predominately corn and soybeans. Table 3-275 summarizes the crop acreage and patterns. Critical and public infrastructure in the middle Mississippi River floodplain upstream of St. Louis is displayed in Table 3-276. The flood risk management discussion of effects is detailed in the Environmental Consequences section and “Flood Risk Management

Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

**Table 3-274. Population and Estimated Structure Value of the Middle Mississippi River Floodplain**

| Reach | Population at Risk | Residential | | Nonresidential | | Total | |
|---|---|---|---|---|---|---|---|
| | | Number | Value ($000s) | Number | Value ($000s) | Number | Value ($000s) |
| Mississippi River (upstream of St. Louis) | 17,994 | 6,501 | $1,387,130 | 686 | $642,306 | 7,187 | $2,029,436 |

Sources: National Structure Inventory (NSI), HAZUS 2006, U.S. Census Bureau 2000
Note: All values are in the FY 2016 price level

**Table 3-275. Percent of Agriculture Acreage by Crop in the Middle Mississippi River**

| Reach | Total Floodplain Acres | Agricultural Acres | Crop Type, as Percent of Total Agricultural Acres | | |
|---|---|---|---|---|---|
| | | | Corn | Soybeans | All Other Crops |
| Mississippi River (upstream of St. Louis) | 131,259 | 58,135 | 48.7% | 50.3% | 0.9% |

Source: USDA NASS Cropland Data Layer, 2014

**Table 3-276. Critical Infrastructure at Risk in the Middle Mississippi River**

| | |
|---|---|
| **Public Utilities** | |
| Energy Producing Plants | 5 |
| Propane Locations and Substations | 14 |
| Wastewater Treatment Plants | 2 |
| **Public Facilities** | |
| Emergency Services | 9 |
| Law Enforcement | 7 |
| Education | 7 |
| Public Venues | 9 |
| **Transportation Infrastructure** | |
| Interstate Miles | 4 |
| Highway Miles | 118 |
| Local Primary Road Miles | 60 |
| Railroad Miles | 123 |
| Road and Railroad Bridges | 71 |
| Public Use Airports | 5 |
| Ports | 44 |

Source: Homeland Security Infrastructure (HSIP) Gold Database 2012, U.S. Census Bureau, Geography Division 2015 TIGER/Line Shapefiles

**Downstream of St. Louis**

Within the middle Mississippi River floodplain between St. Louis and Thebes, IL, a majority of the area is leveed. A total of 13 levee systems comprised of 20 levee districts protect over 310,000 acres of floodplain. Nineteen of these levees were federally constructed. Additional flood risk reduction is realized through flood storage in the many reservoirs in the Missouri, Upper Mississippi, and Kaskaskia River basins. This series of levee systems is very robust. Since they were completed, only four of the federal systems have been overtopped and breached, which occurred during the record-breaking flood of 1993.

### 3.24.4.2 Environmental Consequences – Upstream of St. Louis

**Impact Assessment Methodology**

The impact analysis focuses on determining if changes in river conditions associated with each of the MRRMP-EIS alternatives could result in an impact to flood risk management along the middle Mississippi River. Given the more-detailed hydrology and hydraulics modeling from the confluence of the Missouri River to St. Louis, the assessment of impacts upstream of St. Louis follows the impacts assessment for the Missouri River more closely than downstream of St. Louis where detailed channel cross-sections were not available. Downstream of St. Louis the analysis was conducted through comparison of change in flood flow frequency curves at St. Louis.

The impacts to flood risk management were evaluated using two of the four accounts (NED and OSE). The following section provides a brief overview of the overall methodology for evaluating impacts to flood risk as well as the approach for each account.

Physical characteristics of the Mississippi River and its floodplain that are particularly important to flood risk include river flow and associated stages, water storage in the System, river channel dimensions, and flow impedance. Changes in these characteristics can result in changes in the patterns of flooding (beneficially or adversely), such as the frequency of flooding, depths of inundation, and extent and duration of flooding. Alterations in the patterns of flooding potentially increase or reduce the risks inherent in flooding to people in the floodplain, land, property (both urban and rural), and infrastructure. The analysis used outputs from the HEC-RAS and HEC-ResSim models to simulate river operations over an 82-year POR.

**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 model (HEC-FIA) was used to compute property damages and impacts to critical infrastructure for every year in the POR under each alternative scenario. The model evaluated losses directly related to damages sustained by structures, contents, and vehicles. The model also evaluated losses to crops 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 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 costs 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 (sandbagging, for example), 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 emergency costs are equivalent to a maximum of 9 percent of physical flood damages. A detailed description of the NED analysis including data sources and assumptions can be found in the “Flood Risk Management Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

**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. The HEC-FIA model was used to determine impacts to other social effects (OSE). Any changes to these areas of concern that would occur under MRRMP-EIS alternatives were examined to the extent possible. Inputs necessary for determining impacts to OSE were census block level data and the outputs of the NED flood risk management evaluation, which provide a sense of the magnitude of the impacts to the nation or to the regional area.

One aspect of other social effects related to flood risk is safety. A measure used to assess the safety of the population in the floodplain is population at risk. This measure is computed quantitatively in HEC-FIA. Census block data was imported into the model with populations evenly distributed to structures based on their occupancy type. The total population at risk is computed by determining the number of people associated with those structures that get inundated.

### Summary of Environmental Consequences

The environmental consequences relative to flood risk management are summarized in Table 3-277 Table 3-278 summarizes the NED analysis from each of the alternatives relative to flood risk management upstream of St. Louis. Table 3-279 summarizes the population at risks totals from each of the alternatives relative to flood risk management upstream of St. Louis as the largest increase and decrease relative to Alternative 1.

**Table 3-277. Environmental Consequences Relative to Flood Risk Management**

| Alternative | NED Impacts | OSE Impacts |
|---|---|---|
| Management Actions Common to All Alternatives | No Impacts | No Impacts |
| Alternative 1 | Expected average annual impacts of $31,471,159 | Estimated maximum population at risk of 2,238 |
| Alternatives 2 and 4 | Relatively small, beneficial impacts compared to Alternative 1 | No to negligible changes in OSE compared to Alternative 1 |
| Alternatives 3, 5 and 6 | Relatively small, beneficial impacts compared to Alternative 1 | No to negligible changes in OSE compared to Alternative 1 |

**Table 3-278. Summary of National Economic Development Analysis**

| River Reach | Average Annual Structure / Content Damages | Average Annual Emergency Costs | Average Annual Agricultural Losses | Total Average Annual NED Impacts | Change in Average Annual Damage from Alternative 1 | % Change from Alternative 1 | Maximum Annual NED Impacts |
|---|---|---|---|---|---|---|---|
| Alternative 1 | $31,471,159 | $2,832,404 | $167,246 | $36,526,439 | NA | NA | $289,348,001 |
| Alternative 2 | $31,447,496 | $2,830,275 | $2,222,738 | $36,500,508 | -$25,931 | −0.1% | $273,808,235 |
| Alternative 3 | $31,451,850 | $2,830,666 | $2,218,728 | $36,501,244 | -$25,194 | −0.1% | $285,073,868 |
| Alternative 4 | $31,508,080 | $2,835,727 | $2,219,770 | $36,563,577 | $37,138 | 0.1% | $285,299,347 |
| Alternative 5 | $31,436,727 | $2,829,305 | $2,224,391 | $36,490,424 | -$36,015 | −0.1% | $285,314,679 |
| Alternative 6 | $31,430,689 | $2,828,762 | $2,215,293 | $36,474,745 | -$51,694 | −0.1% | $285,079,848 |

Note: All damage totals are average annual at the FY 2016 price level.

**Table 3-279. Summary of Population at Risk**

| River Reach | Maximum PAR | Average Annual PAR | Highest Increase Relative to Alternative 1 | Highest Decrease Relative to Alternative 1 |
|---|---|---|---|---|
| Alternative 1 | 2,238 | 265 | NA | NA |
| Alternative 2 | 2,251 | 265 | 77 | 38 |
| Alternative 3 | 2,306 | 265 | 22 | 15 |
| Alternative 4 | 2,306 | 265 | 24 | 15 |
| Alternative 5 | 2,306 | 265 | 22 | 15 |
| Alternative 6 | 2,306 | 265 | 30 | 15 |

### Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives would not have any impacts on flood risk management along the Mississippi River. The management actions common to all alternatives would occur in the Missouri River and would not impact flow or stage in the middle Mississippi River.

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

**NED Analysis**: Under Alternative 1, the middle Mississippi River floodplain upstream of St. Louis would experience measurable flood impacts during large flood events. The magnitude of these impacts would vary considerably from year to year depending on the river stages associated with the year. Under Alternative 1, the floodplain would incur average annual flood risk management NED impacts of $31,471,159, with annual impacts ranging as high as $289.3 million.

**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 health, safety, and economic vitality. 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 and it includes

people permanently residing the area, as well as temporary residents. Under the largest flood events, over 2,200 people in the floodplain would be susceptible to the risks of flooding.

**Conclusion**

Alternative 1 represents the continuation of current system operation on the Missouri River. It primarily serves as a reference condition allowing for a comparison of the action alternatives. NED and OSE results indicate Flood Risk Management in the middle Mississippi River would have the potential to be impacted under Alternative 1 during those modeled years when the largest flood events occur. The magnitude of these impacts would vary considerably from year to year depending on the river stages associated with the year but would not be anticipated to be significant.

**Alternative 2 – USFWS 2003 Biological Opinion Projected Actions**

**NED Analysis**: When evaluating the impacts of each MRRMP-EIS alternative, annual impacts as well as those that occur on average over the POR were examined. NED impacts, including agricultural losses, along the Mississippi River floodplain upstream of St. Louis would incur on average $25,931 less in annual impacts relative to Alternative 1. This represents an overall decrease in NED impacts in relation to Alternative 1 of 0.1 percent. For Alternative 2, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1943, respectively. The modeled results in 1993 under Alternative 2 displayed a decrease in impacts of $15,539,766, while the modeled 1943 event saw the adverse impacts increase by $5,451,336.

**Other Social Effects**: Under the largest flood event, approximately 2,251 people in the floodplain are susceptible to the risk of flooding. For Alternative 2, there would be no change in the average annual PAR, but a small decrease in the PAR under the largest flood event. The highest flood event increase in PAR would be 77, while the highest flood event decrease would be 38.

**Conclusion**

Under Alternative 2, NED and OSE results indicate Flood Risk Management in the middle Mississippi River would have the potential to be beneficially impacted when compared to Alternative 1. The percent change in average annual damage would be less than 1% (−0.1%), thus impacts to flood risk management in the middle Mississippi River would not be significant under Alternative 2.

**Alternatives 3–6**

**NED Analysis**: NED impacts under alternatives 3 through 6, including agricultural losses, along the Mississippi River floodplain upstream of St. Louis would incur on average $25,194 to $37,138 less in annual flood damages relative to Alternative 1. This represents an overall decrease in NED impacts in relation to Alternative 1 of 0.1 percent for alternatives 3 through 6.

When evaluating the impacts of each MRRMP-EIS alternative, annual impacts as well as those that occur on average over the POR were examined. For Alternative 3, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1973, respectively. The 1993 event under Alternative 3 displayed a decrease in impacts of $4,274,132, while the 1973 event saw the impacts rise by $771,639. For Alternative 4, the

modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1994, respectively. The 1993 event under Alternative 4 displayed a decrease in impacts of $4,048,653, while the 1994 event saw the impacts rise by $3,380,643. For Alternative 5, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1973, respectively. The 1993 event under Alternative 5 displayed a decrease in impacts of $4,033,322, while the 1973 event saw the impacts rise by $772,039. For Alternative 6, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1995, respectively. The 1993 event under Alternative 6 displayed a decrease in impacts of $4,268,153, while the 1995 event saw the impacts rise by $1,085,694.

**Other Social Effects**: Under the largest flood event, approximately 2,306 people in the floodplain would be susceptible to the risk of flooding under Alternatives 3–5 and approximately 2,251 people in the floodplain would be susceptible to the risk of flooding under Alternative 6. For Alternative 3, there would be no change in the average annual PAR, but a small decrease in the PAR under the largest flood event. The highest flood event increase in PAR would be 22, while the highest flood event decrease would be 15. For Alternative 4, there would be no change in the average annual PAR, but a small decrease in the PAR under the largest flood event. The highest flood event increase in PAR would be 24, while the highest flood event decrease is 15. For Alternative 5, there would be no change in the average annual PAR, but a small decrease in the PAR under the largest flood event. The highest flood event increase in PAR would be 22, while the highest flood event decrease would be 15. For Alternative 6, there would be no change in the average annual PAR, but a small decrease in the PAR under the largest flood event. The highest flood event increase in PAR would be 77, while the highest flood event decrease would be 38.

**Conclusion**

Under alternatives 3, 5, and 6, NED and OSE results indicate Flood Risk Management in the middle Mississippi River would have the potential to be beneficially impacted when compared to Alternative 1. Alternative 4 would result in a small increase in average annual NED damages of $37,000 compared to Alternative 1. The percent change in average annual damage would be less than 1% (0.1 to 0.1%), thus impacts to flood risk management in the middle Mississippi River are not anticipated to be significant under alternatives 3 through 6.

#### 3.24.4.3 Environmental Consequences – Downstream of St. Louis

Analysis of the potential for flood risk management impacts along the middle Mississippi River downstream of St. Louis was conducted through a comparison of change in flood flow frequency curves at St. Louis. Data for this analysis were taken from hydraulic modeling conducted as part of this study. Flow frequency curves were calculated with a procedure matching that used in the Upper Mississippi River Flow Frequency Study (USACE, 2004). Peak annual discharges from the 82 years of simulated record for each alternative were converted from regulated to unregulated flows using the curve found in Appendix D of the Upper Mississippi River Flow Frequency Study. Frequency curves were then computed using the unregulated discharges. The resulting curves were then converted back to regulated discharges using the same regulated to unregulated relationship. A comparison of the action alternative curves was conducted against the Alternative 1 curve.

Results from this analysis are summarized in Table 3-280. All values for the action alternatives were within 2 percent of the Alternative 1 values. For all curves, a reduction was seen for floods

rarer than the 1/10 annual chance exceedance event. Alternatives 3 and 5 saw negligible reductions for all frequencies. Minor reductions in rare floods and increases in frequent floods were seen with Alternatives 2, 4, and 6.

**Table 3-280. St. Louis Flow Frequency Alternatives Comparison**

| Percent Change in Flow Frequency Discharge from Alternative 1 | | | | | |
|---|---|---|---|---|---|
| Annual Chance Exceedance | Alternative | | | | |
| | 2 | 3 | 4 | 5 | 6 |
| 1/500 | −0.58 | −0.07 | −1.84 | −0.14 | −0.46 |
| 1/200 | −0.48 | −0.07 | −1.65 | −0.14 | −0.42 |
| 1/100 | −0.40 | −0.07 | −1.48 | −0.14 | −0.39 |
| 1/50 | −0.28 | −0.07 | −1.15 | −0.14 | −0.32 |
| 1/20 | −0.08 | −0.04 | −0.51 | −0.08 | −0.15 |
| 1/10 | 0.01 | −0.05 | −0.38 | −0.10 | −0.14 |
| 1/5 | 0.14 | −0.05 | −0.07 | −0.09 | −0.07 |
| 1/2 | 0.42 | −0.05 | 0.54 | −0.09 | 0.05 |
| 1/1.25 | 0.59 | −0.04 | 0.99 | −0.07 | 0.16 |
| 1/1.11 | 0.70 | −0.04 | 1.26 | −0.07 | 0.21 |
| 1/1.05 | 0.79 | −0.04 | 1.48 | −0.06 | 0.26 |
| 1/1.01 | 0.92 | −0.03 | 1.80 | −0.05 | 0.33 |

#### Conclusion

No significant impacts to flood risk management in the middle Mississippi River are anticipated under Alternatives 1–6. Alternative 1 represents the continuation of current system operation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. Impacts under Alternatives 2–6 would be negligible when compared to Alternative 1 (within 2 percent of the Alternative 1 values) thus it is anticipated that none of the Alternatives would result in significant impacts in the middle Mississippi River downstream of St. Louis.

## 3.24.5 Navigation

### 3.24.5.1 Affected Environment

This section presents the navigation resources present in the middle Mississippi River that could potentially be affected by the alternatives. This section discusses the characteristics of the vessels moving traffic on the waterway, the amount and type of commodities moving on the waterway, and the main origins and destinations for the movements on the middle Mississippi River.

#### Vessels Traveling on the Middle Mississippi River

While the size, horsepower, and barge configurations of waterborne commerce vessels vary for any given movement, some generalizations of traffic can be made. The towboats on the upper

Mississippi River are usually 160-foot towboats with 3,000 to 5,000 horsepower. Towboats on the lower Mississippi River can reach 180 ft in length and have an engine with 8,000 to 10,000 horsepower. The barge sizes are fairly typical in comparison to other rivers, measuring 35 feet wide by 195 feet long. Additionally, the average tow configuration on the lower Mississippi River may consist of 30 to 35 barges. The middle Mississippi River can accommodate these larger arrangements for much of its 195 miles, but typically averages around 25 barges per tow.

**Amount and Type of Commodities Moving on Middle Mississippi River**

As shown in Figure 3-70 over the last 15 years the total tons traveling on the middle Mississippi River ranged between 89.6 million tons (2013) to 121.6 million tons (2000) with a 15-year average of 107.3 million tons. These fluctuations are a notable because they demonstrate a 16 percent difference and 13 percent difference from the 15-year average, respectively. The 2014 traffic levels represent an overall decrease of 10 percent. Part of the reason for the decline in tonnage was the economic recession in 2008 and 2009. Before 2008, the average tonnage was 111.7 million tons, but the average between 2008 and 2014 decreased to 102.3 million tons.

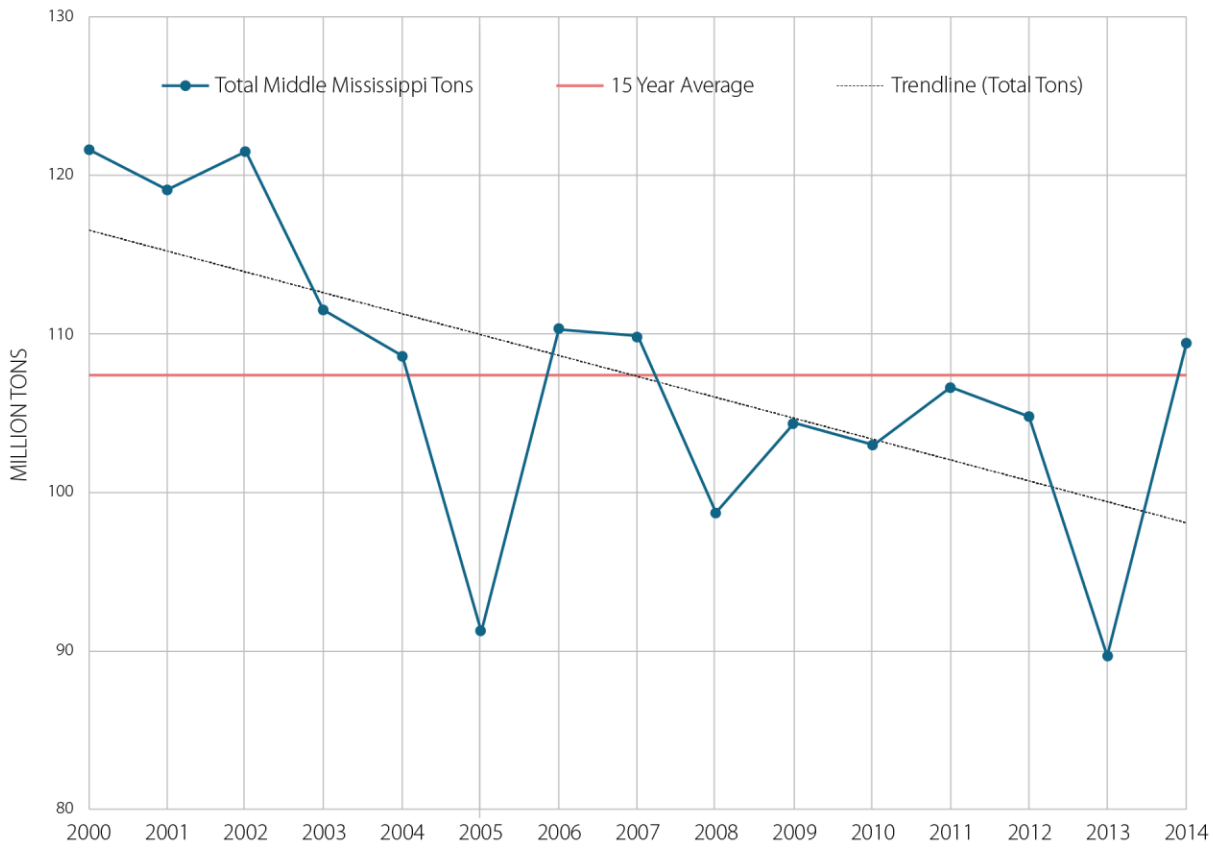



**Figure 3-70. Total Annual Tons Travel and 15-Year Average on Middle Mississippi**

The data for the middle Mississippi analysis was obtained from the Waterborne Commerce Statistics Center database. The database tracks at least 190 commodity categories, but the data presented in this analysis will be broken down into nine parent categories. Table 3-281

presents the annual tons for each of the nine categories as well as the total tonnage for any movements touching the middle Mississippi River. The following noticeable trends have occurred among the 9 parent commodity categories.

- Crude petroleum had the largest gain among the commodity groups. Crude shipments have increased from 15 thousand tons in 2003, to 4.7 million tons in 2014.
- For most years, the amount of grain and grain products traveling on the middle Mississippi River ranged between the upper 30 and the lower 40 million tons. However, in 2012 and 2013, grain and grain products decreased to 33.8 million tons and 23.1 million tons, respectively. This corresponds to drought conditions in 2012 and flooding conditions in 2013.
- Chemicals have seen a 54 percent increase (4.3 million tons) and aggregates have seen a 65 percent increase (4.5 million tons) since 2005.
- The amount of coal traveling on the middle Mississippi River started at 15.4 million tons, increased to 27.1 million tons in 2009, and decreased to 15.5 million tons in 2014. This trend is related to the changes in U.S. coal export market over the last 10 years.

**Table 3-281. Middle Mississippi River Waterborne Tonnage by Commodity and Year (in thousands of tons)**

| Commodity | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | Last 10 Years (avg) | Last 5 Years (avg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coal | 15,416 | 26,340 | 26,428 | 26,228 | 27,127 | 22,264 | 25,589 | 22,408 | 17,348 | 15,539 | 22,469 | 20,629 |
| Petroleum products | 7,256 | 8,284 | 8,493 | 7,197 | 7,339 | 6,990 | 7,069 | 7,785 | 8,233 | 9,353 | 7,800 | 7,886 |
| Crude petroleum | 15 | 103 | 375 | 725 | 677 | 891 | 3,229 | 4,827 | 5,751 | 4,796 | 2,139 | 3,899 |
| Aggregates | 6,959 | 10,338 | 9,738 | 8,701 | 8,428 | 8,340 | 7,952 | 9,785 | 10,900 | 11,486 | 9,263 | 9,693 |
| Grains and grain products | 37,570 | 40,567 | 41,676 | 32,527 | 40,010 | 41,522 | 36,264 | 33,822 | 23,113 | 38,040 | 36,511 | 34,552 |
| Chemicals | 8,032 | 7,417 | 9,205 | 8,638 | 8,575 | 10,369 | 11,591 | 11,156 | 10,378 | 12,389 | 9,775 | 11,177 |
| Non-metallic ores and minerals | 3,497 | 3,577 | 3,130 | 4,874 | 4,797 | 2,811 | 3,581 | 2,564 | 2,665 | 4,880 | 3,638 | 3,300 |
| Iron ore, iron and steel products | 6,640 | 6,687 | 5,037 | 4,927 | 3,205 | 3,310 | 3,987 | 4,241 | 3,429 | 4,547 | 4,601 | 3,903 |
| Others | 5,877 | 6,956 | 5,752 | 4,848 | 4,157 | 6,471 | 7,368 | 8,183 | 7,849 | 8,345 | 6,581 | 7,643 |
| Total | 91,261 | 110,268 | 109,833 | 98,665 | 104,315 | 102,968 | 106,630 | 104,772 | 89,666 | 109,375 | 102,775 | 102,682 |

Source: Waterborne Commerce Statistics Center (USACE 2016)

### Origin and Destination of Commodities Moving on Middle Mississippi River

Along with examining the amount and type of commodity on the waterway, it is useful to examine the origin and destination of the commodity movements. Figure 3-71 shows the states that shipped or received commodities that touched the middle Mississippi River. Between 2005 and 2014, the top three receiving states are 1) Louisiana (53.9 million tons), 2) Illinois (15.3 million tons), and 3) Pennsylvania (6.2 million tons) and the top shipping states were 1) Illinois (49.7 million tons), 2) Missouri (20.6 million tons), and 3) Louisiana (15.3 million tons).

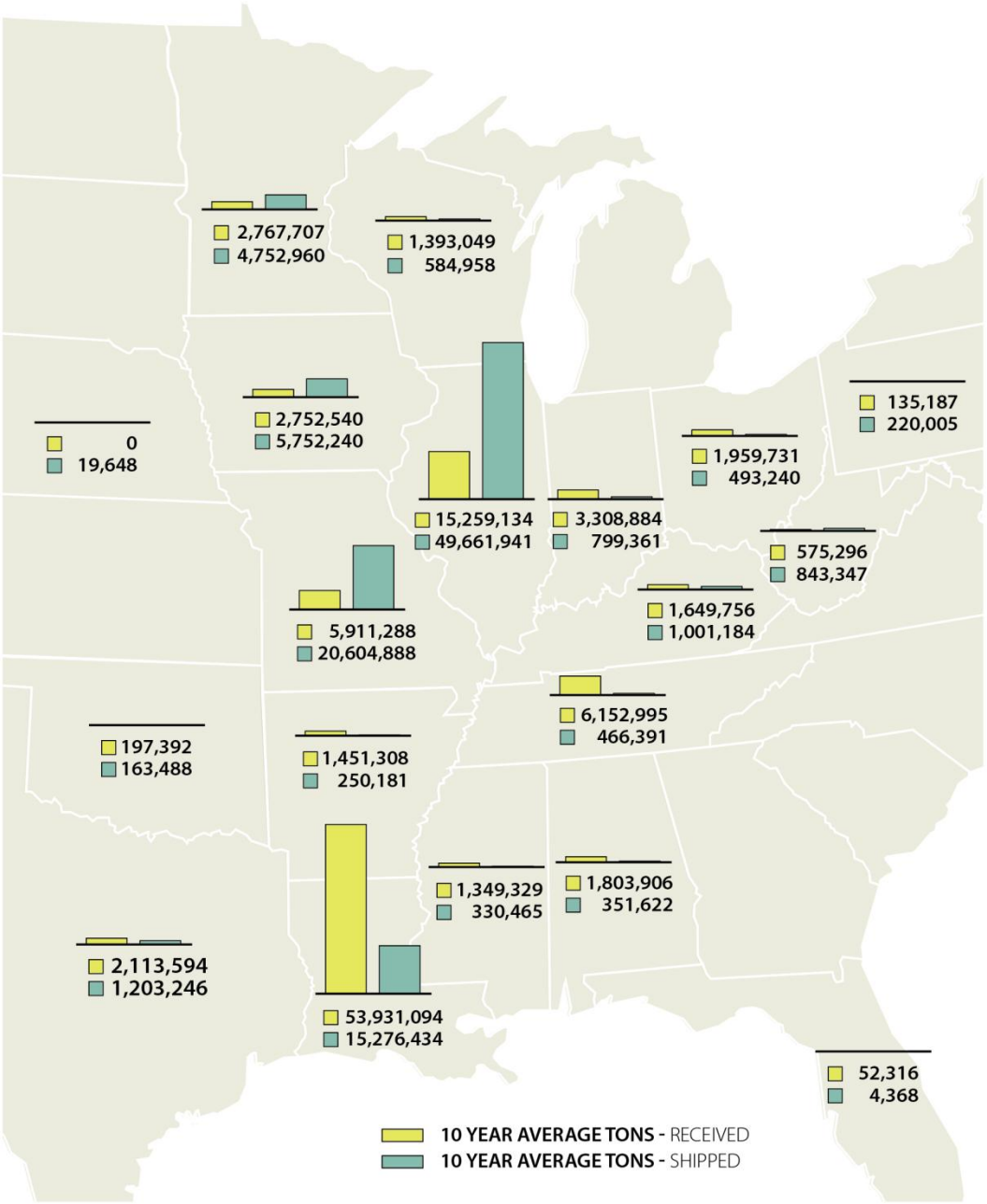



**Figure 3-71. Ten-Year (2005 to 2014) Average Tons Received and Shipped by State for Commodities Traveling on Middle Mississippi River**

Over the last ten years, 41 percent of the middle Mississippi River traffic has been traveling between Illinois and Louisiana. A majority (32 percent over last 10 years) is shipped from Illinois to Louisiana. As shown in Table 3-282, the top five commodities making this journey are maize, coal, soy beans, petroleum, and flours and meals of oil seeds or oleaginous fruits. The second most popular origin and destination pair (10 percent) over the last ten years is Missouri and Louisiana. The Port of Metropolitan St. Louis plays a key role in the bulk transportation for the Midwest and was the third largest inland port in the U.S. by tonnage in 2014 (USACE NDC 2016).

**Table 3-282. Top Three Origin and Destination Pairs for Commodities Traveling on the Middle Mississippi**

| Shipping State | Receiving State | Top Commodities Moving Between States | 5 Year Average (2010 to 2014) | 10 Year Average (2005 to 2014) |
|---|---|---|---|---|
| Illinois | Louisiana | 1) Maize, 2) Coal, 3) Soy Beans, 4) Petroleum, and 5) Flour | 32.6 million tons | 33.4 million tons |
| Missouri | Louisiana | 1) Coal, 2) Maize, 3) Crushed Stone, 4) Soya Beans | 14.4 million tons | 10.6 million tons |
| Louisiana | Illinois | 1) Sodium Chloride, 2) Pig Iron | 8.3 million tons | 9.0 million tons |
| | | **Total for Middle Mississippi River** | 102.68 million tons | 102.78 million tons |

Source: Waterborne Commerce Statistics Center

Since changes in flow releases on the Missouri River have the potential to impact the flow and stage of the middle Mississippi River, an examination of typical draft for barges is useful. Draft depth is driven by the demand for waterborne shipping and river conditions. Table 3-283 shows the 10-year average tons distribution of commodities shipped by draft depth. The vast majority (80 percent) of tonnage is shipped on barges with a draft of 8–9 feet. During favorable river conditions, barges can be loaded in excess of a 9-foot draft, resulting in fewer trips and a lower shipping cost. Between 2005 and 2014, 15 percent of total tonnage was loaded in barges with greater than a 9-foot draft. If there is low demand or unfavorable river conditions, the carrier may be forced to partially load a barge, resulting in draft depths of less than 9 feet.

**Table 3-283. Middle Mississippi River Commodity Tonnages by Draft Depth (in thousands of tons)**

| Draft (ft) | Coal | Petroleum Products and Crude Petroleum | Aggregates | Grains and Grain Products | Chemicals | Non-Metallic Ores and Minerals | Iron Ore, Iron, and Steel Products | Others | Total |
|---|---|---|---|---|---|---|---|---|---|
| < 5 | 72 | 92 | 8 | 47 | 525 | 165 | 54 | 121 | 1,083 |
| 6 | 85 | 104 | 12 | 532 | 213 | 79 | 17 | 81 | 1,122 |
| 7 | 412 | 450 | 22 | 686 | 693 | 373 | 92 | 339 | 3,067 |
| 8 | 4,549 | 1,260 | 218 | 2,623 | 13,852 | 4,760 | 1,837 | 2,101 | 31,202 |
| 9 | 15,518 | 3,785 | 1,068 | 4,019 | 14,852 | 3,340 | 1,024 | 1,684 | 45,289 |
| 10 | 802 | 1,565 | 501 | 818 | 1,871 | 565 | 210 | 120 | 6,452 |
| ≥11 | 1,031 | 544 | 310 | 539 | 4,505 | 494 | 403 | 155 | 7,980 |
| All drafts | 22,469 | 7,800 | 2,139 | 9,263 | 36,511 | 9,775 | 3,638 | 4,601 | 96,195 |

Source: Waterborne Commerce Statistics Center

### 3.24.5.2 Environmental Consequences

The navigation impact analysis focuses on determining if changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives could affect commodities traveling on the middle Mississippi River. This section summarizes the middle Mississippi River navigation impact assessment methods and presents the results of the assessment.

**Impacts Assessment Methodology**

The anticipated impacts to middle Mississippi River navigation as a result of the alternatives are described below. Impacts were qualitatively analyzed using commodity movement data from the Waterborne Commerce Statistics Center and daily stage level data for the St. Louis gage from the HEC-RAS model for the entire POR for each alternative. The analysis used the following steps:

1. Estimate the 5-year average tons traveling on middle Mississippi River for each month.
2. Estimate the percentage of days the St. Louis gage falls to −3 or less within each month for each year within the POR.
3. Multiply the percentage of days within each month for each year in the POR by the five-year average tons for each month.
4. Estimate average tons affected for each month for each year by dividing total tons affected for a month by 82 years (1931 to 2012). For example, divide the total affected tons for all Januarys by 82 years.

In modeling the consequences to middle Mississippi River navigation from the alternatives, the following assumptions were employed:

- An affected day was defined as a day when the daily average for the St. Louis gage was equal to or less than −3 feet. This criterion was chosen because the USACE St. Louis District identified this as the level when channel restrictions begin.
- The impacts shown for Alternative 1 are for the purpose of providing a baseline and allowing for a comparison of the alternatives. The HEC-RAS model output for Alternative 1 is based on historical record and displays periods when St. Louis gage falls below −3. This means Alternative 1 will show affected tonnage.
- Affected tons represents tons that would experience increase costs. Since channel restrictions occur at −3 on the St. Louis gage, operators would have to light load, re-configure the tow package, or take other steps that reduce the efficiency and increase costs.

**Summary of Environmental Consequences**

The environmental consequences relative to middle Mississippi River navigation are summarized in Table 3-284. This table shows the five year (2010 to 2014) average tonnage for each month, the total annual tonnage affected over the 82-year POR for Alternative 1, and the difference in affected tons between Alternative 1 and the other alternatives. The average monthly affected tons for Alternative 1 ranges from 0 in April and May to 0.59 million tons in December. This is because the highest flows and stages on the middle Mississippi River typically occur in April and May and the lowest tend to be in December and January. The

difference in affected tons between alternatives ranges from a decrease in affected tons of 0.029 million tons for Alternative 3 to an increase in affected tons of 0.110 million tons for Alternative 4. When compared to the monthly tonnage levels for the middle Mississippi River which range from 7 million tons to 9.35 million tons, it is clear the alternatives show relatively small impacts to the middle Mississippi River traffic.

**Table 3-284. Difference in Average Tonnage Affected by Periods Below −3 on St. Louis Gage Between Alternative 1 and Other Alternatives**

| Month | 5 Year Average Tons (By Receiving Date) (million tons) | Alt 1 Average Tons Affected Over 82 Years (million tons) | Alt 2 Difference From Alt 1 (million tons) | Alt 3 Difference From Alt 1 (million tons) | Alt 4 Difference From Alt 1 (million tons) | Alt 5 Difference From Alt 1 (million tons) | Alt 6 Difference From Alt 1 (million tons) |
|---|---|---|---|---|---|---|---|
| January | 7.37 | 0.481 | 0.000 | 0.000 | −0.003 | 0.000 | 0.000 |
| February | 7.01 | 0.306 | 0.000 | 0.000 | −0.003 | 0.000 | 0.000 |
| March | 8.41 | 0.150 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| April | 8.31 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| May | 8.90 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| June | 8.74 | 0.011 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| July | 9.36 | 0.120 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| August | 9.30 | 0.148 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 |
| September | 8.03 | 0.155 | −0.003 | −0.003 | −0.003 | 0.000 | 0.000 |
| October | 8.91 | 0.315 | 0.003 | −0.007 | 0.111 | −0.007 | 0.038 |
| November | 9.31 | 0.479 | −0.015 | −0.015 | 0.004 | −0.015 | 0.000 |
| December | 9.03 | 0.590 | 0.014 | −0.004 | −0.004 | −0.004 | −0.004 |
| **Total** | **102.68** | **2.755** | **0.017** | **−0.029** | **0.102** | **−0.025** | **0.035** |

### Impacts from Management Actions Common to All Plan Alternatives

In the MRRMP-EIS, a number of actions are common to all alternatives that have the potential to impact navigation. These actions would have no impact on middle Mississippi River navigation because they would have no impact on the middle Mississippi River flows. Similarly, although the locations and amounts of mechanical habitat construction and associated land acquisition and management differ between alternatives it would all be located on the Missouri River and would have no impact on middle Mississippi River navigation because there would be no impact on middle Mississippi River flows from these actions.

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

For Alternative 1, Table 3-285 shows the five year (2010 to 2014) average tonnage for each month, the total annual tonnage affected over the 82-year POR, the number of years where the St. Louis gage drops below −3, the average tons affected by low flow periods, the percent of affected tons, the maximum annual tons affected and the minimum non zero amount of tons

affected that occurred over the 82-year period. Some notable trends within Table 3-285 are the following:

- January and December, the low flow months, show the greatest amount of affected tons (0.48 million tons and 0.59 million tons respectively) and the highest number of years when affected tons occur (15 and 12 respectively).
- April and May show no tons affected by low water situations.
- In some extreme low water months (January 1931, November 1933, etc.) all tons are labeled as affected because the stage level stays below −3 for the entire month.
- The percent of tons potentially affected by increased costs ranged from 0 percent to 6.5 percent.

Mechanical habitat construction under Alternative 1 would have no impact on middle Mississippi River navigation because they would have negligible impacts on the middle Mississippi River flows.

**Table 3-285. Alternative 1 Affected Tons Statistics by Month**

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|
| Jan | 7.37 | 39.95 | 15 | 0.48 | 6.5% | 7.37 | 0.24 |
| Feb | 7.01 | 25.48 | 9 | 0.31 | 4.4% | 6.76 | 0.25 |
| Mar | 8.41 | 12.47 | 3 | 0.15 | 1.8% | 6.24 | 0.54 |
| Apr | 8.31 | 0 | 0 | 0 | 0.0% | 0 | 0 |
| May | 8.90 | 0 | 0 | 0 | 0.0% | 0 | 0 |
| Jun | 8.74 | 0.87 | 1 | 0.01 | 0.1% | 0.87 | 0.87 |
| Jul | 9.36 | 9.96 | 2 | 0.12 | 1.3% | 9.36 | 0.60 |
| Aug | 9.30 | 12.30 | 3 | 0.15 | 1.6% | 9.30 | 1.50 |
| Sep | 8.03 | 12.85 | 4 | 0.15 | 1.9% | 8.03 | 0.80 |
| Oct | 8.91 | 26.15 | 7 | 0.32 | 3.5% | 8.91 | 0.86 |
| Nov | 9.31 | 39.74 | 7 | 0.48 | 5.1% | 9.31 | 1.24 |
| Dec | 9.03 | 48.96 | 12 | 0.59 | 6.5% | 9.03 | 0.58 |
| **Total** | **102.68** | **228.64** | | **2.75** | | | |

### Conclusion

Alternative 1 represents the continuation of current system operation on the Missouri River. It primarily serves as a reference condition allowing for a comparison of the action alternatives. Impacts evaluation results indicate Navigation in the middle Mississippi River would have the potential to be impacted under Alternative 1 during those modeled years when the St. Louis gage drops below −3. The magnitude of these impacts would vary considerably from year to year depending on the river stages associated with the year and would not be significant.

### Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

For Alternative 2, Table 3-286 shows the 5-year (2010 to 2014) average tonnage for each month, the total annual tonnage affected over the 82-year POR, the number of years where the St. Louis gage drops below −3, the average tons affected by low flow periods, the difference with Alternative 1 in tons affected, the percent of affected tons, the maximum annual tons affected and the minimum non zero amount of tons affected that occurred over the 82 year period. Some notable trends within Table 3-286 are the following:

- Alternative 2 would have relatively small adverse effect on affected tons compared to Alternative 1.
- As with Alternative 1, December (0.59 million tons) and January (0.48 million tons) show the greatest amount of affected tons and the highest number of years when affected tons occur (15 and 12 respectively).
- April and May show no tons affected by low water situations. This is why the max annual amount of tons affected matches the monthly totals.
- August would experience the greatest change in relation to Alternative 1. It shows an additional year with affected tons and an increase in affected tons of 18 thousand tons.
- In some extreme low water months (January 1931, November 1933, etc.) all tons are labeled as affected because the stage level stays below −3 for the entire month.
- The percent of tons potentially affected by increased costs ranged from 0 percent (April, May) to 6.7 percent (Dec).

**Table 3-286. Alternative 2 Affected Tons Statistics by Month**

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Alt 2 Difference in Affected Tons From Alt 1 (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|---|
| Jan | 7.37 | 39.95 | 15 | 0.48 | 0.000 | 6.5% | 7.37 | 0.24 |
| Feb | 7.01 | 25.38 | 9 | 0.31 | 0.000 | 4.4% | 6.76 | 0.25 |
| Mar | 8.41 | 12.47 | 3 | 0.15 | 0.000 | 1.8% | 6.24 | 0.54 |
| Apr | 8.31 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| May | 8.90 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| Jun | 8.74 | 0.87 | 1 | 0.01 | 0.000 | 0.1% | 0.87 | 0.87 |
| Jul | 9.36 | 9.96 | 2 | 0.12 | 0.000 | 1.3% | 9.36 | 0.60 |
| Aug | 9.30 | 13.80 | 4 | 0.17 | 0.018 | 1.8% | 9.30 | 1.50 |
| Sep | 8.03 | 12.58 | 4 | 0.15 | −0.003 | 1.9% | 8.03 | 0.80 |
| Oct | 8.91 | 26.15 | 7 | 0.32 | 0.003 | 3.6% | 8.91 | 0.86 |
| Nov | 9.31 | 39.74 | 7 | 0.48 | −0.015 | 5.0% | 9.31 | 1.24 |
| Dec | 9.03 | 48.96 | 12 | 0.59 | 0.014 | 6.7% | 9.03 | 0.58 |
| **Total** | **102.68** | 230.08 | | **2.75** | **0.017** | | | |

### Conclusion

Alternative 2 would have negligible impacts to Navigation in the middle Mississippi River when compared to Alternative 1. The percent change in affected tons from Alternative 1 is less than 1 % (0.017%), thus impacts to Navigation in the middle Mississippi River would not be significant under Alternative 2.

### Alternative 3 – Mechanical Construction Only

For Alternative 3, Table 3-287 shows the five year (2010 to 2014) average tonnage for each month, the total annual tonnage affected over the 82 year POR, the number of years where the St. Louis gage drops below −3, the average tons affected by low flow periods, the difference with Alternative 1 in tons affected, the percent of affected tons, the maximum annual tons affected and the minimum non zero amount of tons affected that occurred over the 82 year period. Some notable trends within Table 3-287 are the following:

- Alternative 3 would have a relatively small beneficial effect on affected tons compared to Alternative 1. It would reduce the amount of affected tonnage by 29 thousand tons.
- Under Alternative 3, September to December would experience a reduction in the amount of affected tons in comparison to Alternative 1.
- December (0.59 million tons) and January (0.48 million tons) show the greatest amount of affected tons.
- April and May show no tons affected by low water situations. This is why the max annual amount of tons affected matches the monthly totals.
- In some extreme low water months (January 1931, November 1933, etc.) all tons are labeled as affected because the stage level stays below −3 for the entire month.
- The percent of tons potentially affected by increased costs ranged from 0 percent (April, May) to 6.5 percent (Jan, Dec).

**Table 3-287. Alternative 3 Affected Tons Statistics By Month**

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Alt 3 Difference in Affected Tons From Alt 1 (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|---|
| Jan | 7.37 | 39.95 | 15 | 0.48 | 0.000 | 6.5% | 7.37 | 0.24 |
| Feb | 7.01 | 25.38 | 9 | 0.31 | 0.000 | 4.4% | 6.76 | 0.25 |
| Mar | 8.41 | 12.47 | 3 | 0.15 | 0.000 | 1.8% | 6.24 | 0.54 |
| Apr | 8.31 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| May | 8.90 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| Jun | 8.74 | 0.87 | 1 | 0.01 | 0.000 | 0.1% | 0.87 | 0.87 |
| Jul | 9.36 | 9.96 | 2 | 0.12 | 0.000 | 1.3% | 9.36 | 0.60 |
| Aug | 9.30 | 12.30 | 4 | 0.15 | 0.000 | 1.6% | 9.30 | 1.50 |

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Alt 3 Difference in Affected Tons From Alt 1 (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|---|
| Sep | 8.03 | 12.58 | 4 | 0.15 | −0.003 | 1.9% | 8.03 | 0.80 |
| Oct | 8.91 | 25.58 | 7 | 0.31 | −0.007 | 3.5% | 8.91 | 0.86 |
| Nov | 9.31 | 38.50 | 7 | 0.46 | −0.015 | 5.0% | 9.31 | 1.24 |
| Dec | 9.03 | 48.67 | 13 | 0.59 | −0.004 | 6.5% | 9.03 | 0.58 |
| **Total** | **102.68** | **226.26** | | **2.73** | **−0.029** | | | |

### Conclusion

Alternative 3 would have negligible impacts to Navigation in the middle Mississippi River when compared to Alternative 1. The percent change in affected tons from Alternative 1 would be less than 1 % (−0.029%), thus impacts to Navigation in the middle Mississippi River would not be significant under Alternative 3.

### Alternative 4 – Spring ESH Creating Release

For Alternative 4, Table 3-288 shows the five year (2010 to 2014) average tonnage for each month, the total annual tonnage affected over the 82 year POR, the number of years where the St. Louis gage drops below −3, the average tons affected by low flow periods, the difference with Alternative 1 in tons affected, the percent of affected tons, the maximum annual tons affected and the minimum non zero amount of tons affected that occurred over the 82 year period. Some notable trends within Table 3-288 are the following:

- Alternative 4 would have a relatively small adverse effect on affected tons compared to Alternative 1. It would increase the amount of affected tonnage by 102 thousand tons.
- October would have the greatest difference in affected tonnage to Alternative 1. The difference stems from two years (1932 and 1933) when under Alternative 1 the middle Mississippi River is never below −3 stage in October, but under Alternative 4 the middle Mississippi River is below −3 stage for the majority of the month.
- Alternative 4 shows April and May would have no tons affected by low water situations and no difference with Alternative 1 in affected tons for most of summer months.
- In some extreme low water months (January 1931, November 1933, etc.) all tons are labeled as affected because the stage level stays below −3 for the entire month.
- The percent of tons potentially affected by increased costs ranged from 0 percent (April, May) to 6.5 percent (January, December).

**Table 3-288. Alternative 4 Affected Tons Statistics by Month**

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Alt 4 Difference in Affected Tons From Alt 1 (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|---|
| Jan | 7.37 | 39.71 | 15 | 0.48 | −0.003 | 6.5% | 7.37 | 0.48 |
| Feb | 7.01 | 25.13 | 9 | 0.30 | −0.003 | 4.3% | 6.76 | 0.25 |
| Mar | 8.41 | 12.47 | 3 | 0.15 | 0.000 | 1.8% | 6.24 | 0.54 |
| Apr | 8.31 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| May | 8.90 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| Jun | 8.74 | 0.87 | 1 | 0.01 | 0.000 | 0.1% | 0.87 | 0.87 |
| Jul | 9.36 | 9.96 | 2 | 0.12 | 0.000 | 1.3% | 9.36 | 0.60 |
| Aug | 9.30 | 12.30 | 4 | 0.15 | 0.000 | 1.6% | 9.30 | 1.50 |
| Sep | 8.03 | 12.58 | 4 | 0.15 | −0.003 | 1.9% | 8.03 | 0.80 |
| Oct | 8.91 | 35.35 | 7 | 0.43 | 0.111 | 4.8% | 8.91 | 0.86 |
| Nov | 9.31 | 40.05 | 7 | 0.48 | 0.004 | 5.2% | 9.31 | 1.24 |
| Dec | 9.03 | 48.67 | 13 | 0.59 | −0.004 | 6.5% | 9.03 | 0.58 |
| **Total** | **102.68** | **237.10** | | **2.86** | **0.102** | | | |

### Conclusion

Alternative 4 would have negligible impacts to Navigation in the middle Mississippi River when compared to Alternative 1. The percent change in affected tons from Alternative 1 would be less than 1 % (0.102%), thus impacts to Navigation in the middle Mississippi River would not be significant under Alternative 4.

### Alternative 5 – Fall ESH Creating Release

For Alternative 5, Table 3-289 shows the five year (2010 to 2014) average tonnage for each month, the total annual tonnage affected over the 82 year POR, the number of years where the St. Louis gage drops below −3, the average tons affected by low flow periods, the difference with Alternative 1 in tons affected, the percent of affected tons, the maximum annual tons affected and the minimum non zero amount of tons affected that occurred over the 82 year period. Some notable trends within Table 3-289 are the following:

- Alternative 5 would have a relatively small beneficial effect on affected tons compared to Alternative 1. It would decrease the amount of affected tonnage by 25 thousand tons.

- Alternative 5 shows no difference from Alternative 1 in affected tons for January through September. However, October to December would have slight decreases in affected tons because the middle Mississippi River under Alternative 5 spends less time below stage −3 than under Alternative 1.
- April and May would have no tons affected by low water situations. This is why the max annual amount of tons affected matches the monthly totals.
- In some extreme low water months (January 1931, November 1933, etc.) all tons are labeled as affected because the stage level stays below −3 for the entire month.
- The percent of tons potentially affected by increased costs ranged from 0 percent (April, May) to 6.5 percent (Jan, Dec).

**Table 3-289. Alternative 5 Affected Tons Statistics by Month**

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Alt 5 Change in Affected Tons From Alt 1 (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|---|
| Jan | 7.37 | 39.95 | 15 | 0.48 | 0.000 | 6.5% | 7.37 | 0.24 |
| Feb | 7.01 | 25.38 | 9 | 0.31 | 0.000 | 4.4% | 6.76 | 0.25 |
| Mar | 8.41 | 12.47 | 3 | 0.15 | 0.000 | 1.8% | 6.24 | 0.54 |
| Apr | 8.31 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| May | 8.90 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| Jun | 8.74 | 0.87 | 1 | 0.01 | 0.000 | 0.1% | 0.87 | 0.87 |
| Jul | 9.36 | 9.96 | 2 | 0.12 | 0.000 | 1.3% | 9.36 | 0.60 |
| Aug | 9.30 | 12.30 | 4 | 0.15 | 0.000 | 1.6% | 9.30 | 1.50 |
| Sep | 8.03 | 12.85 | 4 | 0.15 | 0.000 | 1.9% | 8.03 | 0.80 |
| Oct | 8.91 | 25.58 | 7 | 0.31 | −0.007 | 3.5% | 8.91 | 0.86 |
| Nov | 9.31 | 38.50 | 7 | 0.46 | −0.015 | 5.0% | 9.31 | 1.24 |
| Dec | 9.03 | 48.67 | 13 | 0.59 | −0.004 | 6.5% | 9.03 | 0.58 |
| **Total** | **102.68** | **226.53** | | **2.73** | **−0.025** | | | |

### Conclusion

Alternative 5 would have negligible impacts to Navigation in the middle Mississippi River when compared to Alternative 1. The percent change in affected tons from Alternative 1 is less than 1 % (−0.025%), thus impacts to Navigation in the middle Mississippi River would not be significant under Alternative 5.

### Alternative 6 – Pallid Sturgeon Spawning Cue

For Alternative 6, Table 3-290 shows the five year (2010 to 2014) average tonnage for each month, the total annual tonnage affected over the 82 year POR, the number of years where the St. Louis gage drops below −3, the average tons affected by low flow periods, the difference with Alternative 1 in tons affected, the percent of affected tons, the maximum annual tons affected and the minimum non zero amount of tons affected that occurred over the 82 year period. Some notable trends within Table 3-290 are the following:

- Alternative 6 would have a relatively small adverse effect on affected tons compared to Alternative 1. It would increase the amount of affected tonnage by 35 thousand tons.
- Alternative 6 would show no difference compared to Alternative 1 in affected tons for January through September and November. However, October would have an increase in affected tons because the middle Mississippi River under Alternative 6 spends slightly greater amount of time below stage −3 than under Alternative 1.
- April and May would have no tons affected by low water situations. This is why the max annual amount of tons affected matches the monthly totals.
- In some extreme low water months (January 1931, November 1933, etc.) all tons are labeled as affected because the stage level stays below −3 for the entire month.
- The percent of tons potentially affected by increased costs ranged from 0 percent (April, May) to 6.5 percent (Jan, Dec).

**Table 3-290. Alternative 6 Affected Tons Statistics by Month**

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Alt 6 Difference in Affected Tons From Alt 1 (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|---|
| Jan | 7.37 | 39.95 | 15 | 0.48 | 0.000 | 6.5% | 7.37 | 0.24 |
| Feb | 7.01 | 25.38 | 9 | 0.31 | 0.000 | 4.4% | 6.76 | 0.25 |
| Mar | 8.41 | 12.47 | 3 | 0.15 | 0.000 | 1.8% | 6.24 | 0.54 |
| Apr | 8.31 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| May | 8.90 | 0.00 | 0 | 0.00 | 0.000 | 0.0% | 0.00 | 0.00 |
| Jun | 8.74 | 0.87 | 1 | 0.01 | 0.000 | 0.1% | 0.87 | 0.87 |
| Jul | 9.36 | 9.96 | 2 | 0.12 | 0.000 | 1.3% | 9.36 | 0.60 |
| Aug | 9.30 | 12.30 | 4 | 0.15 | 0.000 | 1.6% | 9.30 | 1.50 |
| Sep | 8.03 | 12.85 | 4 | 0.15 | 0.000 | 1.9% | 8.03 | 0.80 |

| Month | 5 Year Average Tonnage (By Receiving Date) (million tons) | Total Tons Affected Over 82 Years (million tons) | Number of Years With Affected Tons Over 82 Years | Average Tons Affected Over 82 Years (million tons) | Alt 6 Difference in Affected Tons From Alt 1 (million tons) | Percent Affected | Max Annual Amount of Tons Affected (million tons) | Min Annual Amount of Tons Affected (million tons) |
|---|---|---|---|---|---|---|---|---|
| Oct | 8.91 | 29.31 | 7 | 0.35 | 0.038 | 4.0% | 8.91 | 0.29 |
| Nov | 9.31 | 39.74 | 7 | 0.48 | 0.000 | 5.1% | 9.31 | 1.24 |
| Dec | 9.03 | 48.67 | 13 | 0.59 | −0.004 | 6.5% | 9.03 | 0.58 |
| **Total** | **102.68** | **231.51** | | **2.79** | **0.035** | | | |

**Conclusion**

Alternative 6 would have negligible impacts to Navigation in the middle Mississippi River when compared to Alternative 1. The percent change in affected tons from Alternative 1 is less than 1% (0.035%), thus impacts to Navigation in the middle Mississippi River would not be significant under Alternative 6.

## 3.24.6 Water Intakes

The impact analysis focuses on determining if changes in river conditions associated with each of the MRRMP-EIS alternatives could result in an impact to water supply intakes and thermal power plants along the middle Mississippi River. This section summarizes the impact assessment methodology and presents the results of the assessment.

### 3.24.6.1 Affected Environment

Water is withdrawn from the Mississippi River for multiple purposes including municipal, industrial, and commercial water supply as well as for cooling purposes for power plants. There are four thermal power plants or generating stations and three permanent/fixed water supply intakes located along middle Mississippi River between St. Louis to Cairo.

There is one power plant, one power-generating unit as part of an industrial facility, and one municipal water supply facility located in St. Louis. The Ameren Rush Island power plant is located south of St. Louis in Festus, Illinois. About 30 miles downstream of Festus, the City of Chester Municipal intake and water treatment plant is located in Illinois. The Grand Tower Energy Center is located in Wittenberg, Illinois about 20 miles downstream of Chester, Illinois. The southern-most facility is the City of Cape Girardeau water plant, although the primarily sources for water supply for this facility are groundwater wells located near the Mississippi River. The City does maintain an intake on the Mississippi River for emergency purposes only.

Two of these power plants use conventional steam coal; one plant uses a mixture of coal, petroleum liquids, and natural gas-fired combustion; and the fourth plant is a natural gas fired combined cycle plant. Three of the thermal power plants in this river reach access Mississippi River water for once-through cooling. It is uncertain if the Anheuser Busch power-generating unit uses Mississippi River water for cooling purposes. All of the power plants discharge wastewater into the river and have National Pollutant Discharge Elimination System (NPDES)

permits that guide the effluent and temperature requirements based on state water quality standards. The thermal plants along the middle Mississippi River have a nameplate capacity of 2,303 megawatts (MW).[13]

The water supply intakes using Mississippi River water as the primary source of water supply service a population of 164,382 (IL EPA 2016; Missouri DNR 2016). Most municipalities located on the river have limited or no alternative sources of water other than the Mississippi River. The exception is the City of Cape Girardeau, which uses groundwater as the primarily source of water. Table 3-291 summarizes the location, capacities and population served for the power plants and water supply intakes located along the middle Mississippi River.

**Table 3-291. Thermal Plants and Water Supply Intakes along the Middle Mississippi River**

| Name | River Mile | County | State | 2014 Nameplate Capacity (MW)[1] | Cooling System[1] | Critical Threshold and Gage Referenced[4] |
|---|---|---|---|---|---|---|
| **Middle Mississippi (St. Louis to Cairo): Thermal Power Facilities** | | | | | | |
| Anheuser Busch Inc. | 177 | St. Louis | MO | 26 | NA | NA |
| Ameren - Meramec | 161 | St. Louis | MO | 1041 | ON | −3 St. Louis |
| Ameren - Rush Island | 140.5 | Festus | IL | 621 | ON | −4.6 St. Louis |
| Mainline Generation LLC - Grand Tower Energy Center | 81.9 | Jackson | IL | 641 | ON | −6 Chester |
| **Middle Mississippi (St. Louis to Cairo): Water Supply Facilities** | | | | | | |
| | **River Mile** | **County** | **State** | **Intake Type** | **Population Served[2,3]** | |
| Illinois American Water | 180.8 | St. Clair | IL | Municipal | 155,382 | −5 St. Louis |
| City of Chester Water Plant | 110 | Randolph | IL | Municipal | 8,702 | −10; −8 Chester |
| City of Cape Girardeau Water Plant* | 54 | Cape Girardeau | MO | Municipal | 38,800 | −1 Cape Girardeau |

Source: [1]Report EIA-860 (2016), USACE Navigation Charts Upper Mississippi River, [2]Illinois EPA Public Drinking Water (2016), [3]Missouri DNR Public Water Supply (2016), [4]USACE Master Manual Volume 13 Mississippi River Studies (1998).

Notes: ON -- Once through cooling (without cooling system or pond(s)); *The source of the City of Girardeau water is from groundwater wells. The City does maintain an intake on the Mississippi, which is for emergency purposes only.

[13] Nameplate capacity is the maximum rated output of a generator or power production equipment under specific conditions designated by the manufacturer (EIA, 2016a).

### 3.24.6.2 Environmental Consequences

#### Impact Assessment Methodology

As river flows or stages fall below minimum operating requirements, water can no longer be accessed through intakes, with adverse impacts to municipalities, commercial operations, and power plants. This in turn can drive changes in costs to operate intakes and replace power, and possibly affect capital costs to address water access issues. In addition, relatively lower river flows in the summer can affect operational efficiencies of power plants that use once through cooling and affect the ability of the plants to meet (NPDES requirements.

The analysis used two approaches to describe the potential impacts to water supply facilities and power plants along the middle Mississippi River. To assess the impacts of the facilities or plants when river stages fall below critical operating elevations, river stage thresholds, shown in the right-hand column of Table 1, were used from the USACE Master Manual Mississippi River Studies Volume 13 (USACE 1998, Appendix C). The analysis used these critical stages along with the outputs from the HEC-RAS Missouri River models of simulated river flows at the confluence of the Missouri and Mississippi Rivers in St. Louis at river mile 180. Because only one location on the Mississippi River was available from the HEC RAS model, input from the USACE St. Louis district was used to estimate how the critical stages at Chester could be evaluated with stages at the St. Louis gage (Duncan pers. comm. 2016). The City of Cape Girardeau was not evaluated because it uses ground water as its primary source of water.

Based on expert input from the St. Louis District, a Low Water Reference Plane method was used to estimate the lowest stage levels that would occur at the Chester gages of −6 (critical threshold at Grand Tower Energy Center). The Low Water Reference Plane method uses the low water stages at St. Louis and compares them with the Chester gage to estimate the river flow and stage that would translate to the critical threshold at the Chester gage.

Since these stage levels are so low, an alternative method using rating curves was employed to verify the stages. A stage value of −6 on the Chester gage equates to a flow of 38 kcfs, which is associated with a river stage at St. Louis −7.15. Output from the HEC-RAS model at St. Louis was used to estimate impacts on intakes located in St. Louis and Chester. The project team used these stages to estimate the number of days when water surface levels in the middle Mississippi River would fall below critical intake operating thresholds under each of the alternatives. This analysis was the basis for the impact analysis provided below.

In addition, power plants can also be affected by river temperature with higher temperatures during the peak summer months causing reduced operating efficiencies and difficulties in meeting NPDES permit requirements. As a result, power plants may need to reduce their power generation. Because a river temperature model is not available for the Mississippi River, the evaluation uses the river flow data in the summer at St. Louis under the MRRMP-EIS alternatives, the river temperature differences under the MRRMP-EIS alternatives in the lower Missouri River, and the temperature impacts to plants on the lower Missouri River to qualitative evaluate the potential impacts to the middle Mississippi plants associated with possibly higher river temperatures under the MRRMP-EIS alternatives.

#### Summary of Environmental Consequences

The environmental consequences relative to water supply and thermal power are summarized in Table 3-292.

**Table 3-292. Environmental Consequences Relative to Water Supply and Thermal Power**

| Alternative | Impacts to Water Supply Intakes | Impacts Thermal Power Facilities |
|---|---|---|
| Management Actions Common to All Alternatives | No Impacts | No Impacts |
| Alternative 1 | Small, temporary adverse impacts | Small, temporary adverse impacts |
| Alternatives 2, 4 and 6 | Relatively small, temporary adverse impacts compared to Alternative 1 | Potential large, temporary adverse impacts to power generation during the low summer flows events relative to Alternative 1. Potentially large impacts to wholesale power prices, grid stability, and electricity reliability. |
| Alternatives 3 and 5 | Relatively small, temporary beneficial impacts compared to Alternative 1 | Relatively small, temporary beneficial impacts compared to Alternative 1. No anticipated impacts to power plants associated with river temperatures. |

### Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include pallid sturgeon propagation and augmentation, predator management, vegetative management, human restrictions measures. These actions occur on the Missouri River and do not impact stage and are not expected to have any impacts on water intakes along the Mississippi River.

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

Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently.

Impacts of Alternative 1 to the critical thresholds to water supply and thermal power plants are summarized in Table 3-293. Based on the 82-year POR, these facilities would realize between 300 and 800 days when water surface elevations are below critical operating thresholds. This represents a relatively small percentage of time (1 to 3 percent) when intakes would be impacted under Alternative 1. Lowest river flows and stages usually occur in the fall and winter seasons, with small temporary adverse impacts to water supply intakes and thermal power generation.

**Table 3-293. Impacts of Alternative 1 on Water Supply and Thermal Power Intakes**

| Facility | Total Number of Days Below Threshold over Period of Record | Percentage of Days Below Thresholds |
|---|---|---|
| Facility 1 (St. Louis) | 318 | 1.1% |
| Power Plant 1 (St. Louis) | 414 | 1.4% |
| Power Plant 2 (St. Louis) | 819 | 2.7% |
| Power Plant (Chester) | 1 | 0.0% |

The Thermal Power NED evaluation for the Missouri River power plants indicates that power generation would be reduced under Alternative 1 for the lower Missouri River plants with the bulk of the effect occurring to the plants in the summer peak power period during drought conditions. On average, the river flows in the Mississippi are two to three times higher than in the lower Missouri River. Under Alternative 1, the impacts to Missouri River water intakes could be temporary, large and adverse. It is possible that there would be small temporary adverse impacts to Mississippi River plants associated with reduced power generation from higher temperatures under Alternative 1, which are likely to occur during drought conditions when there are relatively lower river flows and higher ambient air temperatures.

### Conclusion

Alternative 1 represents the continuation of current system operation on the Missouri River. It primarily serves as a reference condition allowing for a comparison of the action alternatives. Impacts evaluation results indicate water intakes in the middle Mississippi River has the potential to be impacted under Alternative 1 during those modeled years when water elevations drop below the critical threshold. The results indicate these impacts would occur a relatively small percentage of time (1 to 3 percent) and would be temporary. These impacts are considered to be a result of natural hydrologic variability in the system rather than from the spawning cue release that is part of Alternative 1 as the spawning cure pulse is almost entirely attenuated by the St. Louis gage. Thus it is anticipated that impacts to water intakes in the middle Mississippi River are not significant under Alternative 1.

### Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

The management actions under Alternative 2 results in relatively small and temporary adverse impacts, with up to 5 more days below the critical threshold compared to Alternative 1 (Table 3-294). These low flows as simulated under Alternative 2 in the POR would occur in the 1930s drought years when river stages in St. Louis and Chester would be affected in the fall season. Alternative 2 shows adverse impacts but these impacts are relatively small and temporary.

**Table 3-294. Impacts of Alternative 2 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in St. Louis**

| Facility | Difference in number of days below critical thresholds under Alternative 2 Relative to Alternative 1 (Percentage Change from Alternative 1) |
|---|---|
| Facility 1 (St. Louis) | 3 (1%) |
| Power Plant 1 (St. Louis) | 1 (0%) |
| Power Plant 2 (St. Louis) | 5 (1%) |
| Power Plant (Chester) | 4 (300%) |

Under Alternative 2, the low summer flow as simulated in the ERDC temperature model in 2002 and 2003 in the lower Missouri River (river mile 57) could result in river temperatures up to 2 degrees Fahrenheit higher than under Alternative 1 during peak summer river temperatures. The thermal power evaluation for the Missouri River power plants under Alternative 2 shows that power generation would be reduced for the lower Missouri River plants during the low summer flow events due to relatively higher river temperatures, resulting in relatively large adverse impacts to energy values, capacity values, wholesale electricity prices, retail electricity

rates, and grid stability and electricity reliability compared to Alternative 1. Although the Mississippi River has considerably more water volume than the Missouri River, the relatively lower flows during the higher temperature summer periods in the Missouri River may have some adverse impacts to Mississippi River temperatures, resulting in reduced operational efficiencies and power generation for the plants along the Mississippi River. If Mississippi power plants were impacted at the same time as the Missouri River plants were impacted, which is likely the case during the low summer flow events, there could be relatively large impacts not only to power generation, but also to wholesale electricity prices, retail electricity rates, capital costs to replace lost capacity, and grid stability and power reliability.

### Conclusion

Alternative 2 has the potential to have small impacts to Water Intakes in the middle Mississippi River when compared to Alternative 1. The number of days below critical thresholds from Alternative 2 is very small (1–5 days) over the POR for all of the evaluated facilities, thus impacts to Water Intakes in the middle Mississippi River are not anticipated to be significant under Alternative 2.

### Alternatives 3–6

Similar to the analysis conducted under Alternative 1 on the critical operating thresholds, the analysis was also conducted for each of the MRRMP-EIS Alternatives 3 through 6 (Table 3-295). The management actions under the various alternatives have both beneficial and adverse impacts on water supply and thermal power intakes in the middle Mississippi. However, all of these impacts are relatively small and temporary. Adverse impacts occur under Alternatives 4 and 6 with Alternative 4 showing the largest adverse impacts of any of the alternatives. Under Alternative 4, intakes could experience between 20 and 29 additional days based on the POR when water surface elevations fall below critical thresholds relative to Alternative 1. Similar low flows occurred during the 1930s drought years during the fall season. Alternative 6 also would result in adverse impacts relative to Alternative 1 but these impacts would be smaller than those for Alternative 4. Small beneficial impacts to intakes would likely occur under Alternative 3 and 5. No impacts would occur to the power plant that reads the Chester gage under alternatives 3 through 6.

**Table 3-295. Impacts of Alternative 3–6 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in St. Louis**

| Facility | Difference in number of days below critical thresholds from Alternative 1 (Percentage Change from Alternative 1) | | | |
|---|---|---|---|---|
| | Alternative 3 | Alternative 4 | Alternative 5 | Alternative 6 |
| Facility 1 (St. Louis) | −5 (−2%) | 20 (6%) | −4 (−1%) | 2 (1%) |
| Power Plant 1 (St. Louis) | −6 (−1%) | 28 (7%) | −4 (−1%) | 11(3%) |
| Power Plant 2 (St. Louis) | −8 (−1%) | 29 (4%) | −7 (−1%) | 10 (1%) |
| Power Plant (Chester) | 1 (0.0%) | 1 (0.0%) | 1 (0.0%) | 1 (0.0%) |

Alternatives 3 through 6 would result in small benefits to power generation in the lower part of the Missouri River from river temperatures associated with fewer numbers of acres of early life stage habitat, but these impacts would be negligible. Because there would be negligible

changes in river temperatures under Alternative 3, 4, 5, and 6 relative to Alternative 1, there would not be impacts to power plants located along the Mississippi River associated with river temperatures.

**Conclusion**

Alternatives 3 through 6 have the potential to have impacts to Water Intakes in the middle Mississippi River when compared to Alternative 1. Temporary adverse impacts occur under Alternatives 4 and 6 while small beneficial impacts to intakes would likely occur under Alternatives 3 and 5. The percent changes in number of days below critical thresholds from Alternative 1 is small (−2 to 7%) for all of the evaluated facilities, thus impacts to Water Intakes in the middle Mississippi River are not anticipated to be significant under Alternatives 3 through 6.

### 3.24.7 Climate Change

A discussion on the influence of climate change to alternatives' operations is included in Section 3.2 River Infrastructure under Climate Change. The northern plains are expected to experience changes similar to the Missouri River Basin with more rainfall and less snowpack accumulating during winter months resulting in earlier peaks in seasonal plains runoff patterns. As a result, the influence of climate change on the hydrology of the Mississippi River is expected to be similar to the impacts of the management actions described for the Missouri River. Annual rainfall amounts will increase during the summer months, but rainfall events will become sporadic. Large rain events will be more frequent and interspersed by longer relatively dry periods. Extremes in climate will likely magnify periods of wet or dry weather, resulting in longer, more severe droughts, and larger more extensive flooding. Increased air temperatures could also have impacts on water temperatures and water quality, which could exacerbate impacts of alternatives to the middle Mississippi River.

Higher natural annual flows and a higher number of peak flow events would result in higher sediment erosion rates, an increase in adverse impacts (i.e., erosion, wear and tear from frequent overtopping, burial) on river infrastructure, and greater variability in groundwater elevations throughout the year in the floodplain and land adjacent to the middle Mississippi River. More frequent and longer flow releases would result in an incremental increase in geomorphological adverse impacts and less frequent and shorter flow releases would result in an incremental decrease in geomorphological adverse impacts. Higher air temperatures and higher sporadic flood flows would also adversely affect ice dynamics, resulting in altered flooding patterns from ice dams.

It is anticipated that climate change could influence operation of both the Missouri River and Mississippi River in the future and potentially the timing and duration of side channel connectivity. During periods of low water, similar to those conditions modeled in the average monthly 10th percentile stages, side channels could remain disconnected from the main channel for the entire year or longer. If more intense storms cause high water or flooding, similar to those conditions modeled in the average monthly 90th percentile stage, side channels could become connected to the main channel and could be flowing much longer throughout the year. Both dry and wet periods could impact biological resources on the middle Mississippi River by causing transitions from one habitat type to another. These impacts are dynamic and related to up-river operations and activities on the Mississippi River that are not accounted for in this modeling effort. Given the nature of side channels and that they are maximizing benefits when flowing, impacts could be exacerbated in the future if dry periods increase and stages dropped

below the choke point and the side channel was not flowing. However, these impacts would result from changing patterns of climate rather than actions from the alternatives.

It is anticipated that climate change could influence the flows on the middle Mississippi River by increasing the severity, length, and frequency of extreme flow events. Changes in these variables would impact the stage and frequency of water elevations potentially affecting navigation and dropping below the critical water intake thresholds. Drought conditions from would result in greater impacts to water intakes in times of very low water.

Overall, the influence of climate change is not expected to change conditions to the point that it would change impacts from the alternatives considered.

### 3.24.8 Cumulative Impacts Associated with all Alternatives

Past construction and operation of the Missouri River mainstem system has affected the hydrology in the middle Mississippi River because the Missouri River contributes almost half of the flow to the middle Mississippi River. Additionally, the Missouri River contributes approximately 75 to 95 percent of the suspended sediment load to the middle Mississippi River (Davinroy 2006). Reduced suspended sediment in the Missouri River from construction of the Missouri River mainstem dams has affected the sediment load to the middle Mississippi River. In addition to past, present, and continuing effects on hydrology, the Mississippi River basin has been shaped over time by a variety of actions, including urbanization, agriculture, levee construction, and dam construction. Many of the changes in the middle Mississippi River which have led to its current condition are due to improvements made for navigation including river training structure placement and associated changes sedimentation patterns. Navigation improvements to the middle Mississippi River were achieved and maintained through the continuing Regulating Works Project. These alterations in hydrology, structure and condition have large past, present, and continuing effects on middle Mississippi River resources and functions, such as flood-risk management, navigation, biological resources, and water supply intakes.

All six alternatives would have long term, negligible to small adverse impacts to the middle Mississippi River from releases. When combined, the cumulative impacts of the 6 alternatives on the middle Mississippi River would be large and adverse; however the contribution by any of the alternatives would be small to negligible and not significant.

## 3.25 Regional Economic Effect of Program Expenditures

Program expenditures were used to evaluate the regional economic benefits of the MRRMP-EIS alternatives. Many types of actions and activities were included in the list of costs, including habitat construction; program management, integration, and coordination; MRRIC; among many others. Detailed costs categories can be found in Appendix F: Missouri River Recovery Management Plan, EIS Alternatives – Cost Estimates. This section describes the methodology and provides the results of the RED analysis of program expenditures for the MRRMP-EIS alternatives.

#### 3.25.1.1 Regional Economic Development Impact Methodology

The analysis used the IMPLAN® Pro data and modeling system to estimate the change in regional economic activity (jobs, income, and sales) as a result of USACE spending on program expenditures. Program costs were grouped based on the time-period in which they are anticipated to be incurred. Two periods were associated with the timing of the activities and associated costs: short-term program activities, incurred in years 1 to year 15; and long-term program activities, incurred in years 1 to year 50. The annual costs for each year over 50 years were obtained for each cost category, and annualized using the Fiscal Year 2016 federal interest rate of 3.125 percent. The cost categories were assigned to appropriate industry sectors in IMPLAN® Pro with information from Appendix F: Missouri River Recovery Management Plan-EIS Alternatives – Cost Estimates, *USACE Resource Guide for Work Activities and Spending Profiles for the Regional ECONomic System for Federal Spending Appendix* (USACE 2016), and the Census Bureau North American Industry Classification System descriptions. USACE staff familiar with implementation of projects under MRRP identified two regions where spending was likely to occur: the upper river, including the states of Montana, North Dakota, and South Dakota; and the lower river, including Iowa, Missouri, Kansas, and Nebraska. To present the economic impacts of the program expenditures, the jobs and income supported in the short-term (years 1 to 15) are shown separately from the jobs and income supported in the long-term (years 16 to 50). The regional economic benefits of the MRRMP-EIS alternatives are described below.

#### 3.25.1.2 Summary of Environmental Consequences

Table 3-296 provides a summary of the RED environmental consequences for MRRP program expenditures and the MRRMP-Draft EIS alternatives.

**Table 3-296. RED Environmental Consequences for Program Expenditures**

| Alternative | RED Impacts |
|---|---|
| Alternative 1 | Large beneficial impacts to regional economic conditions, supporting 1,278 annual jobs and $66.6 million in labor income on average for the first 15 years and 450 annual jobs and $23.6 million in the long-term (years 16 to 50); vast majority of the regional benefits would be experienced in the lower river. |
| Alternative 2 | An increase of 4,029 annual jobs and $197.3 million in labor income in the short-term (years 1 to 15) and an increase of 2,689 annual jobs and $128.6 million in labor income in the long-term (years 16 to 50); regional benefits would increase in the lower river and upper river relative to Alternative 1. |

| Alternative | RED Impacts |
|---|---|
| Alternative 3 | A decrease of 129 annual jobs and $7.3 million in labor income in the short-term (years 1 to 15) and an increase of 98 annual jobs and $4.5 million in labor income in the long-term (years 16 to 50); regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1. |
| Alternative 4 | A decrease of 255 annual jobs and $13.3 million in labor income in the short-term (years 1 to 15) and a decrease of 27 annual jobs and $1.5 million in labor income in the long-term (years 16 to 50); regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1. |
| Alternative 5 | A decrease of 200 annual jobs and $10.6 million in labor income in the short-term (years 1 to 15) and an increase of 28 annual jobs and $1.1 million in labor income in the long-term *years 16 to 50); regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1. |
| Alternative 6 | A decrease of 184 annual jobs and $9.9 million in labor income in the short-term (years 1 to 15) and an increase of 43 annual jobs and $1.8 million in labor income in the long-term (years 16 to 50); regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1. |

### 3.25.1.3 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 early life stage habitat for the pallid sturgeon and ESH. Total program expenditures under this alternative would equal approximately $3.3 billion. Program expenditures for MRRP along with management actions under Alternative 1 would support 1,278 annual jobs during the first 15 years and 450 jobs in the long-term (year 16-50). The bulk of the jobs created under Alternative 1 would be supported by this spending in the lower river and are associated with activities that would occur in the first fifteen years, including SWH construction (Table 3-297). The main types of jobs supported by these program expenditures include habitat construction and maintenance, vegetation management, environmental research and scientific activities and consulting, and federal government jobs. During the first 15 years, annual labor income would be approximately $66.6 million; and during years 16 through 50, annual labor income would be nearly $24 million. Alternative 1 would result in large, long-term, beneficial impacts to regional economic conditions.

**Table 3-297. Annual Economic Benefits of Program Expenditures – Alternative 1**

| Impact Type | Expenditure Period | Upper River | Lower River | Total |
|---|---|---|---|---|
| Direct, Indirect and Induced Jobs | Short-term (1–15 years) | 111 | 1,167 | 1,278 |
| | Long-term (16–50 years) | 81 | 369 | 450 |
| Direct, Indirect, and Induced Labor Income | Short-term (1–15 years) | $6,233,000 | $60,319,000 | $66,552,000 |
| | Long-term (16–50 years) | $4,543,000 | $19,055,000 | $23,598,000 |
| Direct, Indirect, and Induced Sales | Short-term (1–15 years) | $12,638,000 | $141,891,000 | $154,529,000 |
| | Long-term (16–50 years) | $9,504,000 | $43,987,000 | $53,491,000 |

### 3.25.1.4 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under an adaptive management plan. Actions in this alternative include a spawning cue release, low summer flow, and the construction of considerably more ESH and SWH habitat than under Alternative 1.

Under Alternative 2, the largest increases in total program expenditures over the 50 years (relative to Alternative 1) include channel-widening projects for early life stage habitat and mechanical ESH construction, which would increase by $3.4 billion and $8.6 billion, respectively. Total program expenditures under this alternative would equal approximately $15.8 billion, an increase of approximately 378 percent compared to Alternative 1. Program expenditures under Alternative 2 would support 5,307 jobs annually during the first 15 years, and 3,139 jobs in the long-term (years 16-50), with most of the jobs supported in the lower river (Table 3-298). Under Alternative 2, the total number of jobs supported annually in the short-term (years 1 to 15) would increase by 4,029, relative to Alternative 1, while the number of jobs supported in the long-term (years 16 to 50) would increase by 2,689 annually relative to Alternative 1. Additional jobs under Alternative 2 would be primarily habitat construction and maintenance jobs as Alternative 2 would result in more funding on ESH and SWH construction relative to Alternative 1. Labor income and sales would also experience considerable increases compared to Alternative 1.

**Table 3-298. Annual Economic Benefits of Program Expenditures – Alternative 2**

| Impact Type | Period | Impact | Upper River | Lower River | Total |
|---|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Short-term (1–15 years) | Annual Impact | 1,484 | 3,823 | 5,307 |
| | | Change in annual impact relative to Alternative 1 | 1,373 | 2,656 | 4,029 |
| | Long-term (16–50 years) | Annual Impact | 1,454 | 1,685 | 3,139 |
| | | Change in annual impact relative to Alternative 1 | 1,373 | 1,316 | 2,689 |
| Direct, Indirect, and Induced Labor Income | Short-term (1–15 years) | Annual Impact | $71,501,000 | $192,554,000 | $264,055,000 |
| | | Change in annual impact relative to Alternative 1 | $65,268,000 | $132,235,000 | $197,503,000 |
| | Long-term (16–50 years) | Annual Impact | $69,811,000 | $82,430,000 | $152,241,000 |
| | | Change in annual impact relative to Alternative 1 | $65,268,000 | $63,375,000 | $128,643,000 |
| Direct, Indirect, and Induced Sales | Short-term (1–15 years) | Annual Impact | $180,928,000 | $470,608,000 | $651,536,000 |
| | | Change in annual impact relative to Alternative 1 | $168,290,000 | $328,717,000 | $497,007,000 |
| | Long-term (16–50 years) | Annual Impact | $177,794,000 | $205,347,000 | $383,141,000 |
| | | Change in annual impact relative to Alternative 1 | $168,290,000 | $161,360,000 | $329,650,000 |

### 3.25.1.5 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include the construction of ESH and IRC habitat through mechanical means. Additional acres of ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches compared to Alternative 1. IRC habitat would be constructed in the riverine areas between Ponca, Nebraska, and the mouth of the river near St. Louis.

The largest change in total program expenditures (over 50 years), relative to Alternative 1, would be reductions in costs for channel-widening projects for early life stage habitat for the pallid sturgeon, and over $500 million in additional expenditures for mechanical ESH construction. Total expenditures under this alternative would equal approximately $3.2 billion, a decrease of approximately 4 percent relative to Alternative 1. Under Alternative 3, the number of annual jobs supported in the first 15 years would decrease by 129 relative to Alternative 1. In the long-term (years 16 to 50), the number of jobs supported annually would increase by 98 relative to Alternative 1 (Table 3-299). Labor income and sales follow the same pattern, with decreases in the short-term and increases in the long-term relative to Alternative 1. The types of jobs supported under Alternative 3 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.

**Table 3-299. Annual Economic Benefits of Program Expenditures – Alternative 3**

| Impact Type | Period | Scenario | Upper River | Lower River | Total |
|---|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Short-term (1–15 years) | Annual Impact | 188 | 961 | 1,149 |
| | | Change in annual impact relative to Alternative 1 | 77 | −206 | −129 |
| | Long-term (16–50 years) | Annual Impact | 160 | 388 | 548 |
| | | Change in annual impact relative to Alternative 1 | 79 | 19 | 98 |
| Direct, Indirect, and Induced Labor Income | Short-term (1–15 years) | Annual Impact | $9,837,000 | $49,428,000 | $59,265,000 |
| | | Change in annual impact relative to Alternative 1 | $3,604,000 | −$10,891,000 | −$7,287,000 |
| | Long-term (16–50 years) | Annual Impact | $8,263,000 | $19,802,000 | $28,065,000 |
| | | Change in annual impact relative to Alternative 1 | $3,720,000 | $747,000 | $4,467,000 |
| Direct, Indirect, and Induced Sales | Short-term (1–15 years) | Annual Impact | $22,139,000 | $116,501,000 | $138,640,000 |
| | | Change in annual impact relative to Alternative 1 | $9,501,000 | −$25,390,000 | −$15,889,000 |
| | Long-term (16–50 years) | Annual Impact | $19,214,000 | $46,536,000 | $65,750,000 |
| | | Change in annual impact relative to Alternative 1 | $9,710,000 | $2,549,000 | $12,259,000 |

### 3.25.1.6 Alternative 4 – Spring ESH Creating Release

Management actions under Alternative 4 would include the construction of ESH and IRC habitat. IRC habitat would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. In addition, a spring release would be implemented to create ESH habitat.

The largest change in total program expenditures (over 50 years), relative to Alternative 1, would be reductions in costs for channel-widening projects for early life stage habitat for the pallid sturgeon, and more than $70 million for mechanical ESH construction. Total spending under this alternative would equal approximately $2.7 billion, a decrease of approximately 18 percent relative to Alternative 1. Relative to alternative 1, Alternative 4 would result in 255 fewer annual jobs in the first 15 years, while in the long-term (years 16 to 50), there would be 27 fewer annual jobs (Table 3-300). Annual labor income and sales would also be lower in the short- and long-term, relative to Alternative 1. The types of jobs supported under Alternative 3 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.

**Table 3-300. Annual Economic Benefits of Program Expenditures – Alternative 4**

| Impact Type | Period | Scenario | Upper River | Lower River | Total |
|---|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Short-term (1–15 years) | Annual Impact | 117 | 906 | 1,023 |
| | | Change in annual impact relative to Alternative 1 | 6 | −261 | −255 |
| | Long-term (16–50 years) | Annual Impact | 89 | 333 | 422 |
| | | Change in annual impact relative to Alternative 1 | 8 | −36 | −27 |
| Direct, Indirect, and Induced Labor Income | Short-term (1–15 years) | Annual Impact | $6,486,000 | $46,808,000 | $53,294,000 |
| | | Change in annual impact relative to Alternative 1 | $253,000 | −$13,511,000 | −$13,258,000 |
| | Long-term (16–50 years) | Annual Impact | $4,912,000 | $17,182,000 | $22,094,000 |
| | | Change in annual impact relative to Alternative 1 | $369,000 | −$1,873,000 | −$1,504,000 |
| Direct, Indirect, and Induced Sales | Short-term (1–15 years) | Annual Impact | $13,497,000 | $109,737,000 | $123,234,000 |
| | | Change in annual impact relative to Alternative 1 | $859,000 | −$32,154,000 | −$31,295,000 |
| | Long-term (16–50 years) | Annual Impact | $10,572,000 | $39,772,000 | $50,344,000 |
| | | Change in annual impact relative to Alternative 1 | $1,068,000 | −$4,215,000 | −$3,147,000 |

### 3.25.1.7 Alternative 5 – Fall ESH Creating Release

Management actions under Alternative 5 would include the construction of ESH and IRC habitat. IRC habitat would be constructed in the riverine areas between Ponca and the mouth of the river near St. Louis, and ESH habitat would be created in the Garrison, Fort Randall, and Gavins Point reaches. Alternative 5 would also include a fall release to create ESH.

The largest change in project expenditures (over 50 years), relative to Alternative 1, would be reductions in costs for channel-widening projects for early life stage habitat for the pallid sturgeon, and $265 million in additional spending for mechanical ESH construction. Total expenditures over 50 years under this alternative would equal approximately $2.9 billion, a decrease of approximately 12 percent relative to Alternative 1. Under Alternative 5, annual jobs supported during the first 15 years would decrease by 200, relative to Alternative 1, while the number of jobs supported in the long-term (years 16 to 50) would increase by 28 annually relative to Alternative 1 (Table 3-301). Annual labor income and sales would also decrease relative to Alternative 1 in the short-term, and increase in the long-term. The types of jobs supported under Alternative 3 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.

**Table 3-301. Annual Economic Benefits of Program Expenditures – Alternative 5**

| Impact Type | Period | Scenario | Upper River | Lower River | Total |
|---|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Short-term (1–15 years) | Annual Impact | 148 | 930 | 1,078 |
| | | Change in annual impact relative to Alternative 1 | 37 | −237 | −200 |
| | Long-term (16–50 years) | Annual Impact | 120 | 357 | 477 |
| | | Change in annual impact relative to Alternative 1 | 39 | −12 | 28 |
| Direct, Indirect, and Induced Labor Income | Short-term (1–15 years) | Annual Impact | $7,953,000 | $47,955,000 | $55,908,000 |
| | | Change in annual impact relative to Alternative 1 | $1,720,000 | −$12,364,000 | −$10,644,000 |
| | Long-term (16–50 years) | Annual Impact | $6,379,000 | $18,329,000 | $24,708,000 |
| | | Change in annual impact relative to Alternative 1 | $1,836,000 | −$726,000 | $1,110,000 |
| Direct, Indirect, and Induced Sales | Short-term (1–15 years) | Annual Impact | $17,280,000 | $112,698,000 | $129,978,000 |
| | | Change in annual impact relative to Alternative 1 | $4,642,000 | −$29,193,000 | −$24,551,000 |
| | Long-term (16–50 years) | Annual Impact | $14,355,000 | $42,733,000 | $57,088,000 |
| | | Change in annual impact relative to Alternative 1 | $4,851,000 | −$1,254,000 | $3,597,000 |

### 3.25.1.8 Alternative 6 – Pallid Sturgeon Spawning Cue

Management actions under Alternative 6 would include the construction of ESH and IRC habitat through mechanical means. IRC habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. A bi-modal spawning cue release would also occur in the spring for the pallid sturgeon.

The largest change in total project expenditures, relative to Alternative 1, would be reductions in costs for channel-widening projects for early life stage habitat for the pallid sturgeon, and approximately $319 million more total spending for mechanical ESH construction. Total expenditures over 50 years under this alternative would equal approximately $3.0 billion, a decrease of approximately 10 percent relative to Alternative 1. Under Alternative 6, the number of jobs supported annually during the firth 15 years would decrease by 184, relative to Alternative 1, while the number of jobs supported in the long-term (years 16 to 50) would increase by 43 annually relative to Alternative 1 (Table 3-302). Annual labor income and sales would also experience a decrease in the short-term, relative to Alternative 1, and an increase in the long-term. The types of jobs supported under Alternative 6 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.

**Table 3-302. Annual Economic Benefits of Program Expenditures – Alternative 6**

| Impact Type | Period | Scenario | Upper River | Lower River | Total |
|---|---|---|---|---|---|
| Direct, Indirect, and Induced Jobs | Short-term (1–15 years) | Annual Impact | 157 | 937 | 1,094 |
| | | Change in annual impact relative to Alternative 1 | 46 | -230 | -184 |
| | Long-term (16–50 years) | Annual Impact | 129 | 364 | 493 |
| | | Change in annual impact relative to Alternative 1 | 48 | -5 | 43 |
| Direct, Indirect, and Induced Labor Income | Short-term (1–15 years) | Annual Impact | $8,365,000 | $48,277,000 | $56,642,000 |
| | | Change in annual impact relative to Alternative 1 | $2,132,000 | -$12,042,000 | -$9,910,000 |
| | Long-term (16–50 years) | Annual Impact | $6,791,000 | $18,651,000 | $25,442,000 |
| | | Change in annual impact relative to Alternative 1 | $2,248,000 | -$404,000 | $1,844,000 |
| Direct, Indirect, and Induced Sales | Short-term (1–15 years) | Annual Impact | $18,343,000 | $113,530,000 | $131,873,000 |
| | | Change in annual impact relative to Alternative 1 | $5,705,000 | -$28,361,000 | -$22,656,000 |
| | Long-term (16–50 years) | Annual Impact | $15,418,000 | $43,565,000 | $58,983,000 |
| | | Change in annual impact relative to Alternative 1 | $5,914,000 | -$422,000 | $5,492,000 |

## 3.26 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those impacts that cannot be avoided or mitigated should the alternatives be implemented. Full descriptions of impacts are provided under each resource topic previously in this chapter. Although many adverse impacts could be avoided, minimized, or mitigated by the measures described under each resource topic, Table 3-303 describes those types of impacts which may not be fully avoided, as required by CEQ regulations (40 CFR 1502.16). Location and intensity of unavoidable impacts would vary by alternative.

**Table 3-303. Unavoidable Adverse Impacts to Resources**

| Resource | Unavoidable Adverse Impacts |
|---|---|
| River Infrastructure and Hydrologic Processes | • Channel reconfiguration could result in alteration of geomorphological processes (degradation and bank erosion and ice dynamics) at various localized river locations, depending on the selected alternative.<br>• Alternatives 2, 4, 5 and 6 would cause changes in reservoir levels, shoreline erosion and degradation and aggradation in inter-reservoir reaches from ESH creating releases or spawning cue flows. |
| Pallid Sturgeon | • Habitat construction would result in temporary displacement of, or disturbance to, pallid sturgeon that would be common to all alternatives, with higher impacts for those alternatives that construct the most habitat. |
| Piping Plover and Least Tern | • Alternatives that included a spring flow release could impact nesting plovers and terns below the reservoirs although these impacts would be minimized through coordination between the USACE and USFWS and use of steady-release, flow-to-target. |
| Fish and Wildlife Habitat | • Altered abundance of terrestrial and aquatic habitat classes could have short-or long-term adverse effects on native fish and wildlife. Alternative 2 would result in the largest adverse impacts during habitat construction due to the amount of habitat that would be constructed—especially aquatic habitat given the amount of ESH created. However, long-term benefits would occur to fish and wildlife from the continued addition of lost aquatic and terrestrial habitat to the Missouri River under all alternatives.<br>• Management actions associated with mechanical ESH construction and construction of early life stage habitat for pallid sturgeon may temporarily disturb or displace wildlife during construction. |
| Other Special Status Species | • Altered abundance of terrestrial and aquatic habitat classes could have short- or long-term adverse effects on special status species.<br>• Management actions associated with ESH construction and construction of early life stage habitat for pallid sturgeon may temporarily disturb or displace some special status species during construction. However, most alternatives would result in benefits from the continued addition of lost aquatic and terrestrial habitat to the Missouri River under all alternatives. |
| Water Quality | • ESH construction and construction of early life stage habitat for pallid sturgeon would result in temporary increases in turbidity and mobilization of nutrients and pollutants for all alternatives with Alternative 2 having the most localized impacts given the amount of ESH created.<br>• Changes in river flow, channel form, or river stage under Alternatives 2, 4, 5, and 6 could result in adverse impacts to water quality including increases in turbidity, mobilization of nutrients and pollutants, changes in dissolved oxygen concentration, or changes in water temperature. |

| Resource | Unavoidable Adverse Impacts |
|---|---|
| Air Quality | • Emissions from vehicles and equipment would result in localized adverse impacts on air quality during mechanical ESH construction and channel reconfiguration. Alternative 2 would likely have the highest impacts as it would construct the most habitat. |
| Cultural Resources | • Cultural resources located along reservoirs and river banks would be at risk of impacts due to erosion or looting, depending on water levels from all the alternatives. |
| Land Use and Ownership | • Federal land acquisitions could result in loss of jobs and property tax revenue. Alternative 2 would have the largest decrease in annual jobs (9) and property taxes. |
| Commercial Sand and Gravel Dredging | • Changes in flow regime and sediment conditions, due to management actions, would result in negligible adverse impacts to commercial sand and gravel dredging. However, there is no perceived difference among alternatives. |
| Flood Risk Management and Interior Drainage | • Changes in river flow or river stage could result in increased flood risk especially for Alternatives 4 and 6, which would have increase in annual costs for flood risk management.<br>• Changes in flow regime could result in potential reduction of jobs, especially for Alternative 2, where the average annual employment reduction would be 2 jobs. |
| Hydropower | • Changes in river flows, water elevations, and reservoir System storage under the alternatives 2, 4, 5 and 6 could result in reductions of hydropower production and reduced revenue generation. Alternative 2 would have the highest decrease in revenue.<br>• Replacement of hydropower with thermal power would result in increased greenhouse gas emissions, with the highest contributions from Alternative 2. |
| Irrigation | • Changes in river flows and reservoir elevations as a result of the alternatives may result in adverse impacts to irrigation if intakes become inoperable if they are not submerged or buried in sediment. Decreased in average annual net income would be largest for Alternative 4.<br>• Loss of irrigation water supply would result in loss of jobs and income in the agricultural sector with the largest decrease for Alternative 5. |
| Navigation | • Changes in river flows and river stage under the alternatives could adversely affect navigation service level and season length.<br>• Reduced navigation opportunities would result in loss of jobs and income, especially Alternative 2, which would result in the largest decrease in jobs (8) and average annual labor income ($534,000). |
| Recreation | • Mechanical construction of ESH habitat would result in temporary loss of recreational opportunities with Alternative 2 resulting in the largest impacts given the amount of ESH that would be created.<br>• Changes in river flows and reservoir elevations and associated changes in abundance of habitat classes could result in changes in quantity and quality of recreational experiences. There could be adverse effect in the upper three reservoirs due to releases under Alternatives 2, 4 and 6.<br>• Changes in visitation could result in reduced jobs and revenue in recreation and tourism industries, especially for Alternative 4 which could see a reduction of 21 jobs and $514,000 in labor income. |

| Resource | Unavoidable Adverse Impacts |
|---|---|
| Thermal Power | • Mechanical ESH construction and construction of early life stage habitat for pallid sturgeon could result in temporary disruption of water supply to thermal power intakes depending on where habitat is constructed.<br>• Changes in river flows, reservoir conditions (including temperature) and river stages under the alternatives could result in reduced power generation, grid stability, and electrical reliability, which could result in increased retail electricity rates, especially in Alternative 2 which would result in the highest increases in costs and reductions in value. |
| Water Supply | • Changes in river flows, reservoir conditions, and river stages under the alternatives could result in changes to water supply conditions including access to water, operation and maintenance, and water treatment requirements for municipal and industrial/commercial uses. Given the amount of constructed ESH, Alternative 2 would result in the largest impacts.<br>• Changes in water supply conditions could result in increased operation costs and water utility rates. These changes in costs would be small across all alternatives, with Alternative 4 having the highest change in costs ($12,800). |
| Wastewater Facilities | • Changes in river flows and stages under the alternatives could result in reductions in wastewater discharge associated with water quality-based effluent limits at five facilities (two in Iowa and three in Missouri). Alternative 2 could have the largest impact compared to the other action alternatives. |
| Tribal Resources | • Altered abundance of terrestrial and aquatic habitat classes could result in decreased subsistence hunting, fishing, or gathering opportunities, especially for Alternative 2, though there would be some level of unavoidable adverse effects from Alternatives 4 and 6. |
| Human Health and Safety | • Management actions associated with each alternative would not create additional habitat for common vector mosquito species; thus no unavoidable impacts would occur to human health and safety. |
| Environmental Justice | • None of the alternatives are expected to result in unavoidable adverse impacts to environmental justice. |
| Ecosystem Services | • Unavoidable adverse impacts to ecosystem services would only occur if the jeopardy avoidance objective is not met, resulting in reduced non-use values. |
| Mississippi River Impacts | • None of the alternatives are expected to result in unavoidable adverse impacts to the Mississippi River as any releases would be largely attenuated before they reached the Mississippi River. |
| Regional Economic Effect of Program Expenditures | • The alternatives could result in a decrease in jobs and labor income, especially Alternatives 3–6 that could result in a decrease of 27 annual jobs. And associated labor income of up to $1.8 million for Alternative 6. |

## 3.27 Relationship between Short-Term Uses and Long-Term Productivity

To facilitate comparison of the alternatives, NEPA requires that an EIS consider the proposed short-term uses of environmental resources compared with the long-term productivity of the environment. This section discusses whether the short-term uses of environmental resources proposed by the alternatives would impact, either adversely or beneficially, the long-term productivity of the environment.

Short-term uses of environmental resources necessary to carry out the action alternatives would include any actions associated with the construction of pallid sturgeon, least tern, or piping plover habitat either through flow actions or mechanical habitat construction. Impacts of these short-term uses are generally the same as the short-term impacts described for each resource in this EIS. These impacts would include disturbance or alteration of aquatic and terrestrial habitats, water quality impacts associated with increased turbidity, air quality impacts associated with emissions from construction equipment, disruptions to hydropower or thermal power operations, disruptions to water supplies and wastewater treatment facilities, temporary loss of recreational opportunities, and all associated economic impacts.

Productivity can be broadly grouped into three categories: ecosystem (biological) productivity, hydrologic productivity (water resources), and land use productivity. Overall, short-term uses of environmental resources necessary to carry out the action alternatives would benefit long-term productivity. Creation of habitat for pallid sturgeon, least terns, and piping plover would increase populations of these species. The acquisition of lands and management of habitats associated with the alternatives would benefit ecosystem productivity throughout the geographic scope of the EIS. Protection of acquired lands from future development or other land use practices would also benefit hydrologic productivity by preventing loss of wetlands and expansion of impervious cover. Water supply intakes could be impacted both adversely and beneficially over the long-term due to hydrologic changes associated with flow actions and channel reconfiguration under the alternatives. Agriculture is the dominant land use type within the Missouri River basin. Land acquisition associated with the alternatives may reduce agricultural production over the long term due to the development and management of wildlife habitat on lands that would otherwise be used for agriculture. Although there could be short-term decreases in hydrologic and land use productivity associated with human considerations, environmental productively would be enhanced under all action alternatives.

## 3.28 Irreversible and Irretrievable Commitment of Resources

An irreversible or irretrievable commitment of resources refers to impacts on or losses to resources that cannot be recovered or reversed. Irreversible and irretrievable resource commitments associated with the alternatives would include the loss of funds, labor, energy (including by not limited to the burning of fossil fuels), and materials required to plan, conduct, and monitor various components of the proposed action. The acquisition of land would not represent an irreversible or irretrievable commitment of resources because the land could be returned to its previous use in the future. Similarly, alteration or conversion of habitat types resulting from flow actions or habitat construction would not represent an irreversible or irretrievable commitment of resources because these changes could potentially be reversed, allowing habitats to revert to their previous conditions. The use of water resources associated with flow actions under the alternatives would not represent an irreversible or irretrievable commitment of resources because water resources would be restored during the winter months as part of the annual precipitation cycle.