Missouri River Recovery Program

DRAFT

Missouri River Recovery Management Plan and Environmental Impact Statement

FLOOD RISK MANAGEMENT ENVIRONMENTAL CONSEQUENCES ANALYSIS TECHNICAL REPORT

December 2016

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Missouri River Recovery Management Plan and Environmental Impact Statement

Flood Risk Management Environmental Consequences Analysis

Technical Report

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Acronyms and Abbreviations

BiOp	Biological Opinion (amended in 2003)
Corps	U.S. Army Corps of Engineers
DSS	Data Storage System
EIS	environmental impact statement
EQ	environmental quality (account)
ER	Engineering Regulation
ESH	Emergent Sandbar Habitat
FIA	Flood Impact Analysis (model)
FRM	Flood Risk Management
H&H	Hydrologic and Hydraulic (model)
HEC	Hydrologic Engineering Center
HSIP	Homeland Security Infrastructure Program
M&I	Municipal and Industrial
MRRIC	Missouri River Recovery Implementation Committee
MRRP	Missouri River Recovery Program
NED	National Economic Development (account)
OMRR&R	Operation, Maintenance, Repair, Replacement, and Rehabilitation
OSE	Other Social Effects (account)
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
RAS	River Analysis System
RED	Regional Economic Development (account)
ResSim	Reservoir System Simulation
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

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1.0 Introduction

The USACE in cooperation with the USFWS are developing a Missouri River Recovery Management Plan and Draft Environmental Impact Statement (MRRMP Draft EIS). The purpose of the MRRMP Draft EIS is to develop a management plan that includes a suite of actions that removes or precludes jeopardy status for the piping plover, the interior least tern, and the pallid sturgeon using USACE authorities.

The purpose of the Flood Risk Management Environmental Consequences Analysis Technical Report is to provide supplemental information on the Flood Risk Management analysis and results in addition to the information presented in the MRRMP-EIS. Additional details on the National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE), methodology and results are provided in this technical report. No Environmental Quality (EQ) analysis was undertaken for Flood Risk Management.

1.1 Summary of Alternatives

The MRRMP Draft EIS evaluates the following Management Plan alternatives. Detailed description of the alternatives is provided in the Draft EIS, Chapter 2.

- **No Action – Current System Operation and Current MRRP Implementation.** This is the no-action alternative, in which the Missouri River Recovery Program (MRRP) would continue to be implemented as it is currently, including a number of management actions associated with the MRRP and BiOp compliance. Management actions under No Action include creation of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring plenary pulse. The construction of habitat will be focused in the Garrison and Gavins reaches for ESH (an average rate of 107 acres per year) and between Ponca to the mouth near St. Louis for early life stage habitat (3,999 additional acres constructed).
- **Alternative 2 – USFWS 2003 Biological Opinion Projected Actions.** This alternative represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp Reasonable and Prudent Alternative (USFWS, 2003). Whereas No Action only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that the USFWS anticipates would ultimately be implemented through adaptive management and as impediments to implementation were removed. Considerably more early life stage habitat (10,758 additional acres constructed) and ESH (an average rate of 3,546 acres per year) would be constructed under Alternative 2 than under No Action. In addition, a spring pallid sturgeon flow release would be implemented every year if specific conditions were met. Alternative 2 would also modify System operations to allow for summer flows that are sufficiently low to provide for early life stage habitat as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon.
- **Alternative 3 – Mechanical Construction.** The USACE would only create ESH through mechanical means at an average rate of 391 acres per year across the entire system. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from system operations. The average annual construction amount includes replacing ESH lost to erosion and vegetative growth, as well as constructing new ESH. An additional 3,380 acres of early life stage habitat for the

pallid sturgeon would be constructed under Alternative 3. There would not be any reoccurring flow releases or pulses implemented under this alternative.

- **Alternative 4 – Spring ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 240 acres per year across the entire system. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of an ESH-creating reservoir release in the spring. Alternative 4 would be similar to No Action (current operations), with the addition of a spring release designed to create ESH for the least tern and piping plover. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 4.
- **Alternative 5 – Fall ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 309 acres per year across the entire system. This alternative is based on No Action (current operations), with the addition of a release in the fall designed to create sandbar habitat for the least tern and piping plover. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 5.
- **Alternative 6 – Pallid Sturgeon Spawning Cue.** The USACE would mechanically construct ESH annually at an average rate of 303 acres per year across the entire system. In addition, the USACE would attempt a spawning cue pulse every three years in March and May. These spawning cue pulses would not be started or would be terminated whenever flood targets are exceeded. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 6.

1.2 USACE Planning Accounts

Alternative means of achieving species objectives will be evaluated including consideration for the effects of each action or alternative on a wide range of human considerations. Human considerations to be evaluated in the MRRMP-EIS alternatives are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to human considerations evaluated in the MRRMP-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR Parts 1500-1508). The 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) also served as the central guiding regulation for the economic and environmental analysis included within the MRRMP-EIS. Further guidance that is specific to the USACE is described in Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, which provides the overall direction by which USACE Civil Works projects are formulated, evaluated, and selected for implementation. These guidance documents describe four accounts that were established to facilitate evaluation and display the effects of alternative plans:

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.
- The regional economic development (RED) account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The environmental quality (EQ) displays non-monetary effects of significant natural and cultural resources.

- The other social effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts. In a general sense, OSE refers to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness are affected by some condition or proposed intervention.

The accounts framework enables consideration of a range of both monetary and non-monetary values and interests that are expressed as important to stakeholders, while ensuring impacts are not double counted. The USACE planning accounts evaluated for flood risk management include NED, RED, and OSE.

1.3 Approach for Evaluating Environmental Consequences of Missouri River Recovery Management Plan

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. Changes 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. Ultimately, one metric for evaluating effects is in terms of monetary net changes (benefits or losses) to the nation's economy.

These changes in flood risk could result in changes in disruptions to transportation, businesses, and agriculture, as well as property damage. Change in regional economic effects such as jobs, income, and sales is also a consideration given changes in business and agriculture revenues from changes in probability of flood risk.

In addition to property and infrastructure damage, and changes in jobs and income, other flood risk-related concerns include public safety and health, and cultural and social effects. For example, exposure to flooding could endanger people (i.e., direct exposure to contaminated flood waters, and mental health concerns such as trauma). Areas with vulnerable populations such as the elderly, the young, low income groups, and the ill are of particular concern during floods, and their exposure may be increased in some locations by changes in flooding patterns. Changes in flooding patterns, such as higher stages and more frequent flooding, could also affect sites considered sacred by Tribes within the Missouri River basin. Similar concerns could adversely affect long-established communities with a strong sense of tradition and cohesion

The conceptual flow chart shown in Figure 1 demonstrates, in a stepwise manner, how changes to the physical conditions of the Missouri River and its floodplain can impact flood risk management. This figure also shows the intermediate factors and criteria that were applied in assessing the NED, RED, and OSE consequences to flood risk management.

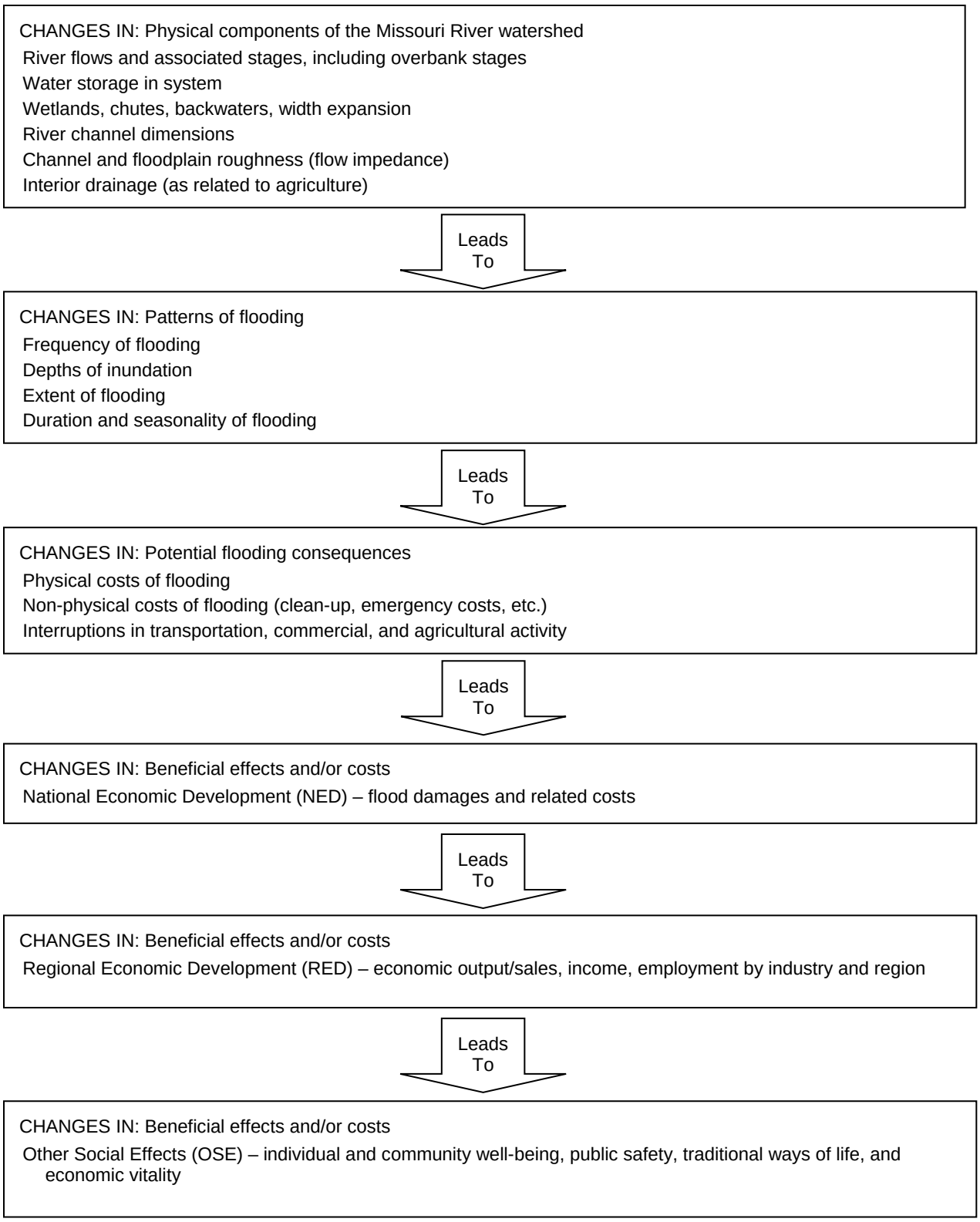

Figure 1. Flow Chart of Inputs Considered in Flood Risk Management Evaluation

The approach for evaluating environmental consequences to flood risk management was initiated with an evaluation of thresholds which were developed to evaluate effects from changes in Missouri River flow and corresponding river stages, for any given event resulting from the alternatives. Effects on the built human environment were evaluated by the frequency and duration that certain damage thresholds were reached during flood or high water events under both without-project and with-project conditions. The results of this analysis were used to verify that a full flood risk management analysis to estimate changes in NED, RED, and OSE impacts was warranted. This second step in the process estimated impacts associated with damage to structures and associated contents, agricultural losses, effects to critical infrastructure, and population at risk. Figure 2 illustrates an overview of the approach for flood risk management.

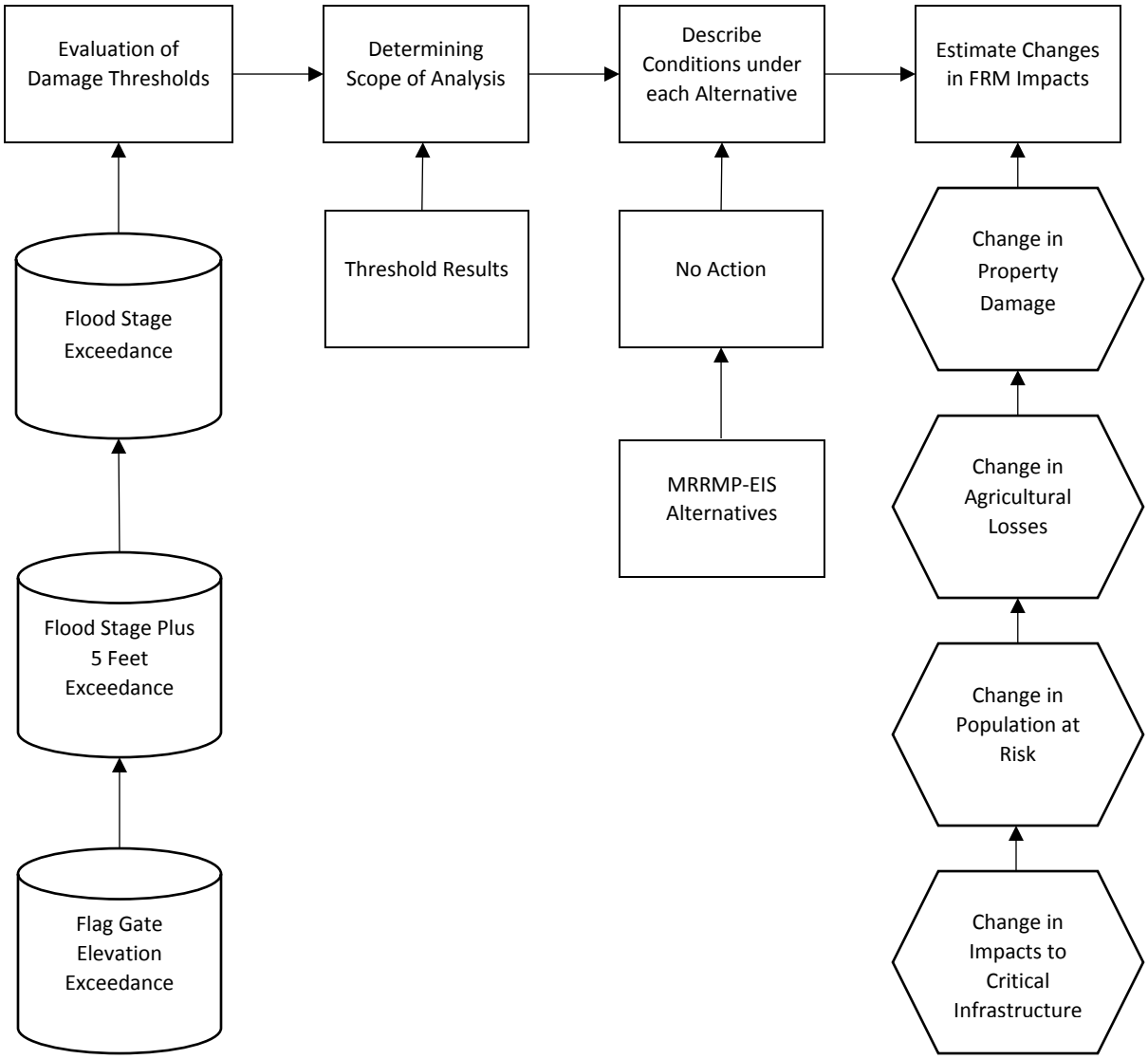

Figure 2. Environmental Consequences Approach for Flood Risk Management

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.

2.0 Methodology and Assumptions

2.1 Assumptions

In modeling the environmental consequences to flood risk management from the MRRMP-EIS alternatives, the project team established a set of assumptions. The important assumptions used in the modeling effort are as follows.

- The economic analysis uses data from the hydrologic and hydraulic (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.
- Aggradation and degradation is assumed to be occurring under all alternatives, including the No Action. This analysis does not attempt to evaluate flood risk management impacts as a result of aggradation and degradation, but focuses on incremental changes that may occur.
- The Missouri River floodplain land use would not change across alternatives or under different flood conditions. (However, a sensitivity analysis that estimates potential changes in land use was conducted.)

2.2 Risk and Uncertainty

Risk and uncertainty are inherent with any model that is developed and used for water resource planning. Much of the risk and uncertainty with the overall Management Plan is associated with the operation of the Missouri River system and the extent to which flows and reservoir levels will mimic conditions that have occurred over the 82-year period of record. Unforeseen events such as climate change and weather patterns may cause river and reservoir conditions to change in the future and would not be captured by the HEC-RAS models or carried through to the flood risk model described is this document. The project team has attempted to address risk and uncertainty in the Management Plan by defining and evaluating a reasonable range of plan alternatives that include an array of management actions within an adaptive management framework for the Missouri River. All of the alternatives were modeled to estimate impacts to flood risk management.

2.3 Economic Analysis and Modeling

A HEC-FIA model was developed to evaluate the change in NED, RED, and OSE impacts associated with flood risk management as a result of the MRRMP-EIS alternatives. HEC-FIA

evaluates impacts to a study area, with the damageable elements quantified through the addition of user defined agricultural inventories, structural inventories, critical infrastructure, and impact response curves. The HEC-FIA model will be able to estimate impacts associated with historical flood events through a set of geo-referenced hydrographs (stage or flow with accompanying rating curves) which represent a single event. For this specific analysis period, HEC-FIA will estimate:

- Direct economic losses – Losses directly related to damages sustained by structures, contents, vehicles, etc. These losses are essentially all damage to property.
- Agricultural losses – Losses sustained to crops. Damages can be related to a loss of a crop in the ground, the inability to plant a crop due to flooding, or the loss related to planting a crop later in the season due to flooding at planting time. These losses relate to the timing of the flood, duration of flooding, season, and type of crop.
- Population at risk (PAR) – The number and location of people within the potentially inundated area during day and night conditions exposed to the flood hazard. PAR includes people permanently residing in the inundated area, as well as workers, customers of area businesses, and others temporarily in the area.
- Critical infrastructure – Critical infrastructure includes structures, such as public utilities, wastewater treatment plants, and bridges, in the floodplain that are critical to the nation or region, but not part of a traditional structure inventory. The model will not calculate economic losses in terms of dollars, but instead report what critical infrastructure elements were inundated by a flood event.

2.4 National Economic Development Methodology

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 measurement of national economic effects was based on the estimated change in flood risk to structures and associated property and agriculture resulting from the MRRMP-EIS alternatives.

Economic losses associated with direct damage to property are based on a structure inventory populated from the National Structure Inventory (NSI) that was developed by the HEC in coordination with FEMA's HAZUS database. The NSI converts Census block level data to a series of points, each representing a single structure. As part of the quality assurance and quality control process, these points were adjusted to ensure that they are located at their appropriate structure locations. Once the structure inventory was defined, HEC-FIA was run to compute the property and infrastructure damages associated with the maximum annual 1-day duration stage event.

Agricultural losses were based on data downloaded from USDA's National Agricultural Statistics Service (NASS). HEC-FIA has a feature that accesses the NASS database to retrieve all the agricultural categories listed in the NASS website and the associated acreage for the study area. Once the desired crops for the study area were selected, several variables in the model's "Crop Loss Editor" needed to be inputted. Each crop needs planting (first and last) and harvesting dates defined. Another variable is the cost to produce the crop. This is split into fixed costs, variable costs for the first and last planting, and harvesting costs with the fixed and variable costs being defined on a monthly basis. Additionally, price and yield information were

populated. The planting and harvesting dates are taken from the NASS Agricultural Handbook Number 628: “Field Crops: Usual Planting and Harvesting Dates”. The cost and yield variables were all obtained from the respective state’s agricultural extension service and in accordance with Corps of Engineers guidance, the U.S. Department of Agriculture’s normalized agricultural prices were used. A seasonal duration-damage curve from the HEC’s AGDAM (Agricultural flood losses Analysis) User’s Manual was also used to define the percent of crop damage associated with the duration (in days) of inundation. After these inputs were established, HEC-FIA was run to compute agricultural losses related to a loss of a crop in the ground, the inability to plant a crop due to flooding, or the loss related to planting a crop later in the season due to flooding at planting time.

In conjunction with the tangible damages computed in the HEC-FIA model, there are other costs of flooding to the nation that need to be captured. 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.

2.5 Regional Economic Development Methodology

The RED analysis evaluated the regional economic impacts associated with agricultural losses and structural damages, using information from the NED analysis from the period of record 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 agricultural industries.

A state or multi-state study area was identified for each region based on its location. The types of crops affected for each river reach were based on the types of crops damaged, as identified in the HEC-FIA evaluation. Table 1 describes the study areas and the types of crops affected for each of the river reaches.

Table 1. Study Areas and Crops Affected by River Reach

River Reach	State Study Area	Allocation of Crops Affected		
		Soybeans	Corn, Spring Wheat, Barley	Alfalfa, Hay
Fort Randall Dam to Gavins Point Dam	South Dakota and Nebraska	42.2%	48.9%	8.8%
Gavins Point Dam to Rulo	Iowa, Nebraska, and Missouri	46.4%	51.2%	2.4%
St. Joseph Reach	Nebraska, Kansas, and Missouri	51.2%	46.2%	2.6%
Kansas City Reach	Missouri	53.1%	43.9%	3.0%
Boonville Reach	Missouri	53.2%	43.8%	3.0%
Hermann Reach	Missouri	53.2%	43.8%	3.0%

For the purposes of evaluating regional economic impacts, it was 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 damages, 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 reducing harvest costs from the loss of crop value would decrease economic impacts. On balance, the project team felt that agricultural losses were a sufficient proxy for the market value of crops that would be affected from flood damages.

The regional economic impacts can be classified as direct, indirect, or induced sales and are measured through changes in employment, labor income and sales. Direct effects represent the impacts of the production values or industry sales specified as final demand changes. Indirect effects represent the impacts caused by the iteration of industries purchasing goods and services to support the directly affected industries. Induced effects represent the economic impacts from all affected workers spending their income in the study area economy. The labor income and sales economic impact results were inflated to 2016 dollars with the GDP deflator (OMB 2016).

Although the NED analysis included an 82-year period of analysis, there were five scenarios on which the RED analysis was focused for both of the evaluations: the best year (lowest agricultural loss year); the worst year (the highest agricultural loss year); the average annual over the 82-year period of analysis; the average of the eight worst years relative to No Action; and the average of the eight best years relative to No Action. These eight worst and best years relative to No Action allow an understanding of the skewness and magnitude of impacts in the largest difference years.

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.

2.6 Other Social Effects Methodology

Changes in flood risk have a potential to cause other types of effects on individuals and communities in terms of individual and community well-being, as well as traditional ways of life. The HEC-FIA model was used to determine impacts to the other social effects account. Any changes to these areas of concern that would occur under MRRMP-EIS alternatives was examined to the extent possible. Inputs necessary for determining impacts to OSE were Census block level data and the outputs of the RED and NED flood risk management evaluation, which provide a sense of the magnitude of the impacts to the nation or to the regional area.

Beyond determining qualitative impacts to the population, population at risk can be computed quantitatively in HEC-FIA. In order to do this, Census block data is 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 in structures that get inundated.

Flood risk impacts to critical infrastructure were also determined in the HEC-FIA model. The critical infrastructure inventory was imported from the HSIP Gold database developed by the National Geospatial-Intelligence Agency (NGA) in partnership with the Department of Homeland Security (DHS). As it can be difficult to assign a value to these structures or facilities, the model does not calculate economic losses in terms of dollars (except to those structures in the NSI and captured in the NED analysis), but rather reports what critical infrastructure elements were inundated by a flood event.

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.

2.7 Environmental Quality Methodology

This account was not evaluated for flood risk management.

2.8 Geographic Areas

Flood risk management impacts are located all along the Missouri River. The impacts evaluated were organized into two groups depending on their location: “upper river” which includes all locations located from Fort Peck Dam to Gavins Point Dam and “lower river” which includes everything below Gavins Point Dam to the mouth of the Missouri River. Furthermore, the impacts were broken down into eight separate reaches (three in the upper river and five in the lower river).

2.8.1 Upper River

Fort Peck Dam to Garrison Dam: the reach extends from Fort Peck Dam in Montana to Lake Sakakawea in North Dakota. The area most prone to flooding problems is near Williston, North Dakota.

Garrison Dam to Oahe Dam: the reach extends from Garrison Dam to Lake Oahe Dam in South Dakota. The area most prone to flooding is near Bismarck, North Dakota.

Fort Randall Dam to Gavins Point Dam: the reach in South Dakota extends from Fort Randall Dam to Gavins Point Dam. The area most likely to flood stretches from the mouth of the Niobrara River downstream to the outskirts of Springfield.

2.8.2 Lower River

Gavins Point Dam to Rulo: the reach extends from Gavins Point Dam to Rulo, Nebraska. The reach includes the metropolitan areas of Sioux City and Council Bluffs, Iowa and Omaha, Nebraska.

Rulo to Platte River (St. Joseph Reach): the reach extends from approximately River Mile 497 to River Mile 392. The reach includes the metropolitan area of St. Joseph, Missouri.

Platte River to Grand River (Kansas City Reach): the reach extends from approximately River Mile 392 to River Mile 252. The reach includes portions of the metropolitan area of Kansas City, Missouri.

Grand River to Osage River (Boonville Reach): the reach extends from approximately River Mile 252 to River Mile 139. The area most subject to flooding is near Boonville, Missouri.

Osage River to Mouth (Hermann Reach): the reach extends from approximately River Mile 139 to the mouth. The reach includes the northern and western portions of the metropolitan area of St. Louis, Missouri.

3.0 National Economic Development Evaluation Results

The NED analysis for flood risk management focused on the changes in property damages, agricultural losses, and emergency costs as a result of changing conditions in the Missouri River. The impact to flood risk management is an increase or decrease in physical costs of flooding. A summary is provided below.

3.1 Summary of National Economic Development Results

Tables 2, 3, and 4 provide an overall summary of the NED analysis for each of the MRRMP-EIS alternatives. Table 2 summarizes the results for all of the average annual flood impacts in the basin over the 82-year period of record. Relative to No Action, Alternative 4 resulted in the largest increase in impacts, $963,927 or 1.6 percent, on average annually, while Alternative 2 showed a reduction in average annual impacts of $691,039 (1.1 percent).

Table 2. Estimated Annual NED Impacts of MRRMP-EIS Alternatives to Flood Risk Management

All Locations	No Action	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Structure/Content Damages	$41,502,897	$41,015,909	$41,060,104	$42,319,467	$41,167,676	$41,795,395
Emergency Costs	$3,735,261	$3,691,432	$3,695,409	$3,808,752	$3,705,091	$3,761,586
Agricultural Losses	$15,719,844	$15,559,622	$15,719,244	$15,793,710	$15,798,010	$15,906,271
Total Impacts	$60,958,002	$60,266,963	$60,474,757	$61,921,929	$60,670,777	$61,463,252
Change from No Action		-$691,039	-$438,245	$963,927	-$287,224	$505,250
Percentage Change from No Action		-1.1%	-0.8%	1.6%	-0.5%	0.8%

Notes: all totals are average annual at the Fiscal Year (FY) 2016 price level. Negative numbers indicate a decrease in impacts relative to No Action.

Table 3 summarizes the NED analysis for reaches in the upper river. Relative to No Action, Alternative 4 resulted in the greatest increase in impacts, 10.2 percent or $786,458, on average per year. Only Alternative 3 resulted in a beneficial impact to flood risk management in the upper river, lowering impacts relative to No Action by 0.5 percent annually.

Table 3. Estimated Annual NED Impacts in the Upper River

Upper River	No Action	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Fort Peck Dam to Garrison Dam	$1,450,059	$1,458,940	$1,449,371	$1,464,993	$1,460,866	$1,452,074
Garrison Dam to Oahe Dam	$5,289,360	$5,264,696	$5,281,098	$6,011,221	$5,263,108	$5,293,351
Fort Randall Dam to Gavins Point Dam	$977,865	$1,046,613	$951,332	$1,027,529	$1,095,749	$1,047,111
Total Impacts	$7,717,285	$7,770,249	$7,681,801	$8,503,743	$7,819,723	$7,792,536
Change from No Action*		$52,965	-$35,484	$786,458	$102,439	$75,251
Percentage Change from No Action*		0.7%	-0.5%	10.2%	1.3%	1.0%

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

Impacts of the MRRMP-EIS alternatives in the lower river varied from those in the upper river as shown in Table 4. The amount of damageable property that could be affected by flooding is greater in lower river than that in the upper river, resulting in the overall impacts being higher. Relative to No Action, Alternative 6 resulted in the greatest increase in impacts, 0.8 percent or $429,999, on average per year in the lower river. Alternative 2 had the greatest beneficial impact to flood risk management in the lower river, lowering impacts relative to No Action by $744,004 on average per year.

Table 4. Estimated Annual NED Impacts in the Lower River

Lower River	No Action	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Gavins Point Dam to Rulo	$21,580,606	$21,803,451	$21,578,221	$22,157,524	$21,697,304	$22,466,817
St. Joseph Reach	$4,564,567	$4,339,318	$4,657,289	$4,536,571	$4,652,589	$4,652,260
Kansas City Reach	$8,229,686	$7,940,612	$8,127,351	$8,109,063	$8,107,945	$8,147,108
Boonville Reach	$4,651,500	$4,609,394	$4,630,753	$4,615,661	$4,633,655	$4,621,392
Hermann Reach	$14,214,359	$13,803,939	$13,799,341	$13,999,368	$13,759,561	$13,783,139
Total Impacts	$53,240,717	$52,496,714	$52,792,956	$53,418,187	$52,851,054	$53,670,716
Change from No Action*		-$744,004	-$447,761	$177,469	-$389,663	$429,999
Percentage change from No Action*		-1.4%	-0.8%	0.3%	-0.7%	0.8%

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

3.2 No Action – Current System Operation and Current MRRP Implementation

Under the No Action alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. This includes management actions that are in compliance with the BiOp. Management actions that may have impacts to flood risk management include ESH creation and spawning cue flow releases from Gavins Point Dam. The management actions included under No Action are focused on areas below Gavins Point Dam.

Modeling results under No Action indicate that the Missouri River floodplain would continue to experience flood impacts when water surface elevations reach flood stages. The magnitude of these impacts would vary considerably from year to year depending on the natural hydrologic cycles of precipitation and snow pack and not on the management actions under No Action.

The NED analysis for No Action is summarized in Table 5. The Missouri River floodplain would incur average annual damages of approximately $61 million under the No Action. Average annual NED impacts would total $53.2 in the lower river with the largest impacts occurring in the Gavins Point Dam to Rulo reach. In the upper river, average annual NED impacts would total $7.7 million with the Garrison Dam to Oahe Dam reach experiencing the largest flood impacts.

Table 5. Summary of NED Impacts for No Action by Reach

River Reach	Average Annual Property Damage	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***
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

Notes: all totals are average annual at the FY 2016 price level.

3.3 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 philosophy. Actions included under this alternative that may have impacts to flood risk management include:

- Creation of emergent sand bar habitat
- Reservoir unbalancing
- Spring reservoir release
- Low nesting season release
- Spawning cue flows
- Low summer flow

The NED Analysis for Alternative 2 is summarized in Table 6. Flood risk management impacts along the Missouri River would incur on average $691,039 less per year in flood impacts relative to No Action, which represents an overall decrease of 1.1 percent.

Table 6. Summary of National Economic Development Analysis for Alternative 2

River Reach	Average Annual Property Damage	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Total Change from No Action	% 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%
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%

Notes: all totals are average annual at the FY 2016 price level. Negative numbers indicate a decrease relative to No Action.

When evaluating the impacts of each of the MRRMP-EIS alternatives, it is helpful to examine the annual impacts. Figure 3 shows the annual NED flood risk management impacts under Alternative 2 in the upper river. Some notable results include:

- In the 82-year period of record, 52 years showed an increase in impacts relative to No Action.
- The modeled range of impacts compared to No Action varied from a decrease in flood impacts of $1,152,191 in the 1987 simulation to a $1,117,530 increase under the 1983 simulation.
- The effect of Alternative 2 would increase impacts by $52,965 on average annually over No Action in the upper river with a $68,748 increase in the Fort Randall Dam to Gavins Point Dam reach alone.

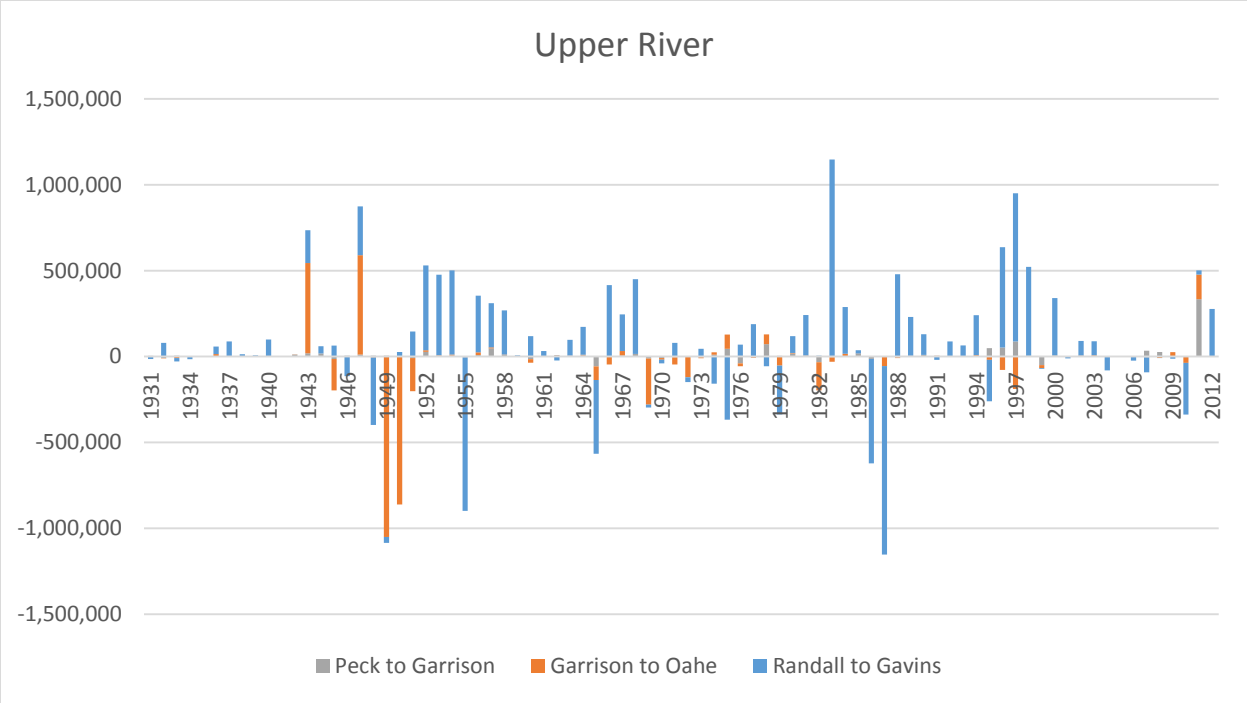

Figure 3. Alternative 2 Difference from No Action for NED Impacts in the Upper River

Figure 4 shows the annual NED flood risk management impacts under Alternative 2 in the lower river. Some notable results include:

- In the 82-year period of record, 53 years showed a decrease in flood impacts relative to No Action.
- Seven modeled years showed a decrease in flood impacts greater than $5 million with the largest decrease being $45,355,113 in the 1993 simulation. The Hermann reach showed a decrease in impacts in the 1993 simulation of $26,903,478.
- Six modeled years meanwhile showed an increase in flood impacts greater than $5 million with the largest increase being $20,429,493 in the 1997 simulation. The Gavins Point Dam to Rulo reach showed an increase in flood impacts of $21,086,103 in the 1997 simulation.
- Four out of the five reaches showed a decrease in impacts on average over the modeled period of record with only the Gavins Point Dam to Rulo reach experiencing adverse flood impacts relative to No Action. The effect of Alternative 2 would decrease impacts by $744,004 on average annually in the lower river relative to No Action.

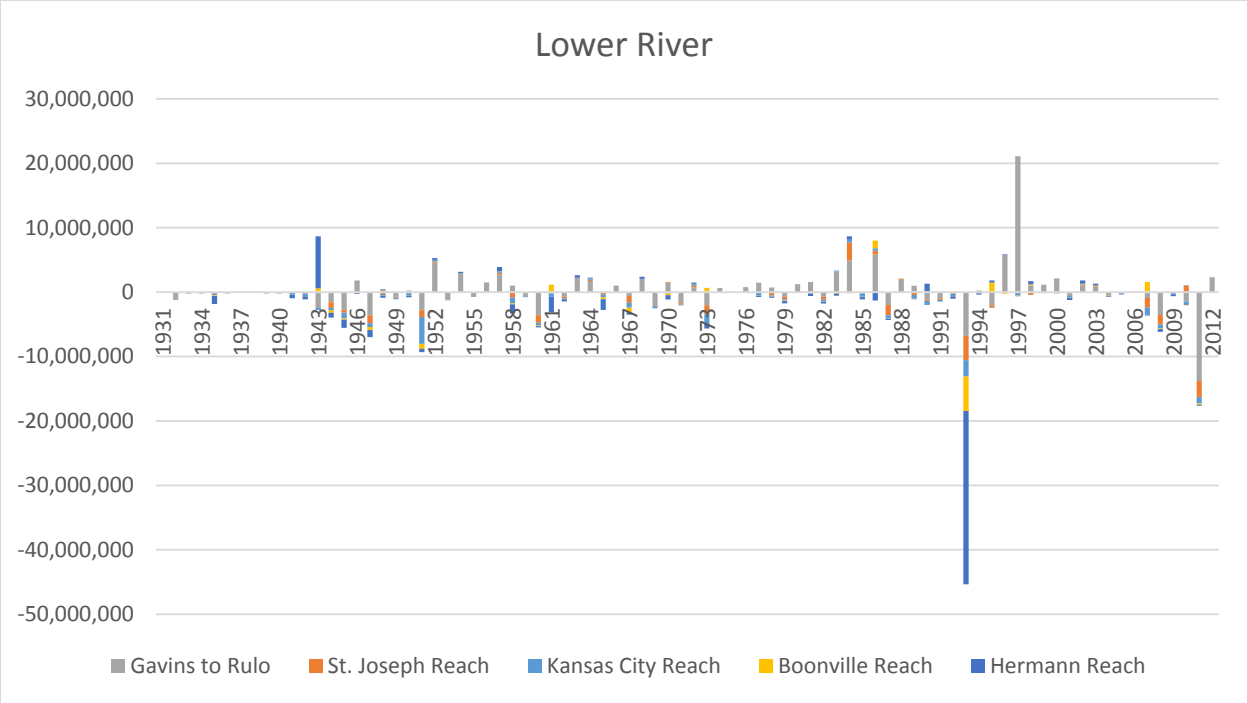

Figure 4. Alternative 2 Difference from No Action for NED Impacts in the Lower River

Additional results for the upper river are shown in Figure 5. Here the difference in NED impacts between No Action and 2 are plotted and color-coded based on the type of release occurring each year. During the period of record, there were 10 years with a full release plus low summer flow action and 44 years with partial flow releases. Some notable results include:

- Nine out of 10 of the years with full release plus low summer flow events had flood impacts increase under Alternative 2 relative to No Action. The largest NED increase was $469,786 in the 1988 simulated event.
- Partial flow release actions appear to have much less NED impact. Twenty-five of the 44 years showed adverse impacts and on average the difference would be a $21,562 increase in impacts over No Action.

Figure 6 shows the same data plot for impacts in the lower river by Alternative 2 release type. Some notable results include:

- Six of the full release years experienced an increase in damages for Alternative 2 relative to No Action. The largest modeled increase relative to No Action was $2,078,302 in the 1988 simulation, while the largest decrease was $2,317,517 in the 1958 simulation. On average, full release plus low summer flow event years experienced an increase of $496,025 relative to No Action.
- The average partial flow release action impacts was significantly shaped by the 1993 simulated event, which showed a $45,355,113 reduction in impacts relative to No Action. Overall, 25 of the 44 years showed beneficial impacts in the lower river under Alternative 2 with an average reduction in flood impacts of $999,140.

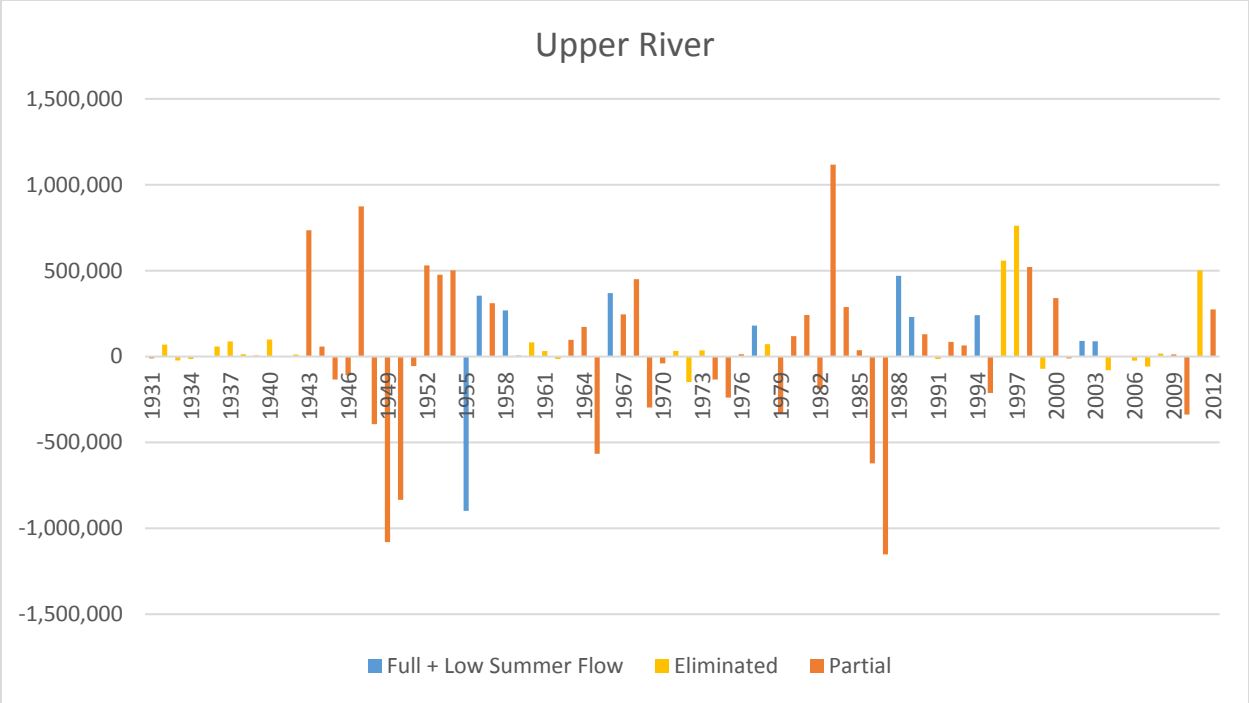

Figure 5. Alternative 2 Difference from No Action in the Upper River by Release Type

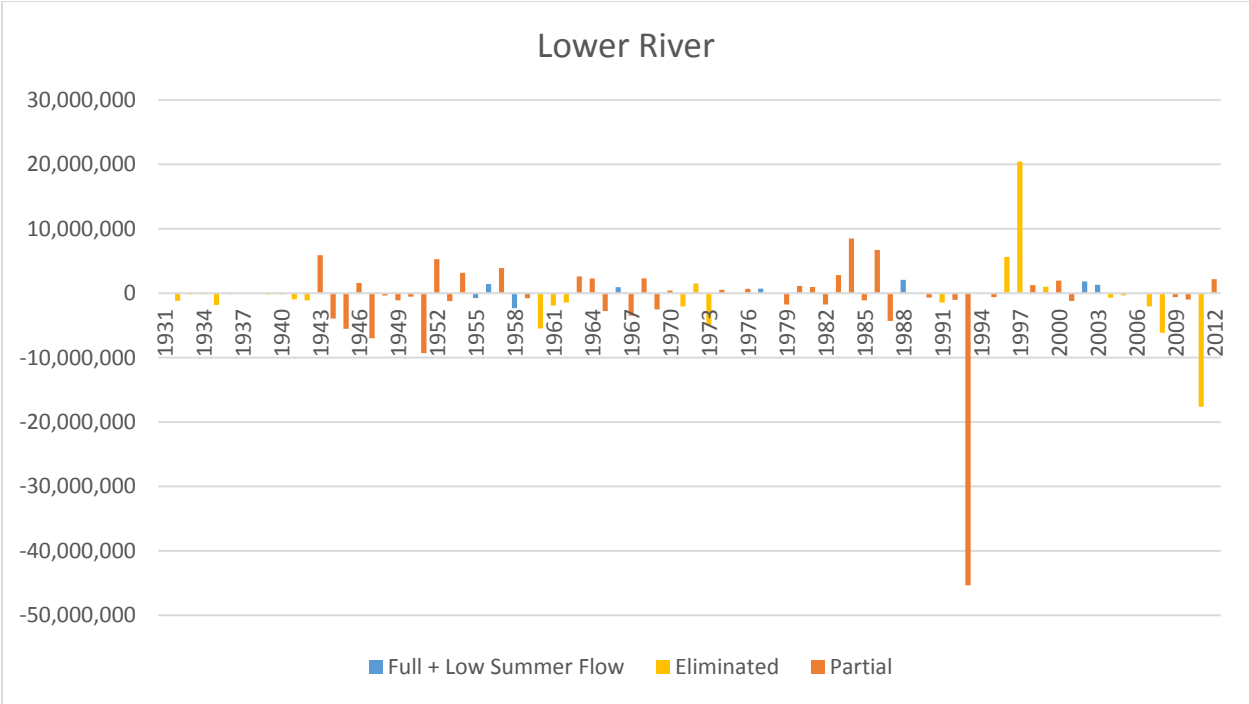

Figure 6. Alternative 2 Difference from No Action in the Lower River by Release Type

3.4 Alternative 3 – Mechanical Construction Only

Management actions included under Alternative 3 would include those that focus on the creation of ESH through mechanical means. This alternative would have a small, beneficial impact on flood risk management. Overall, NED impacts would decrease by $483,245 annually (0.8 percent) over the 82-year period of record relative to No Action. Most of the decrease in flood impacts would be realized in the lower river. The NED results for Alternative 3 are summarized in Table 7.

Table 7. Summary of National Economic Development Analysis for Alternative 3

River Reach	Average Annual Property Damage	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Total Change 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%

Notes: all totals are average annual at the FY 2016 price level. Negative numbers indicate a decrease relative to No Action.

Figure 7 shows the annual NED impacts to flood risk management in the upper river. Some notable results include:

- There were 49 modeled years displaying beneficial impacts in the upper river relative to No Action with the differences ranging from $504,520 in increased impacts for Alternative 3 in the 1956 simulated event to a $632,482 decrease in the 1955 simulated event.
- Overall, the net effects of Alternative 3 in the upper river would be a decrease in impacts of $35,484 relative to No Action.

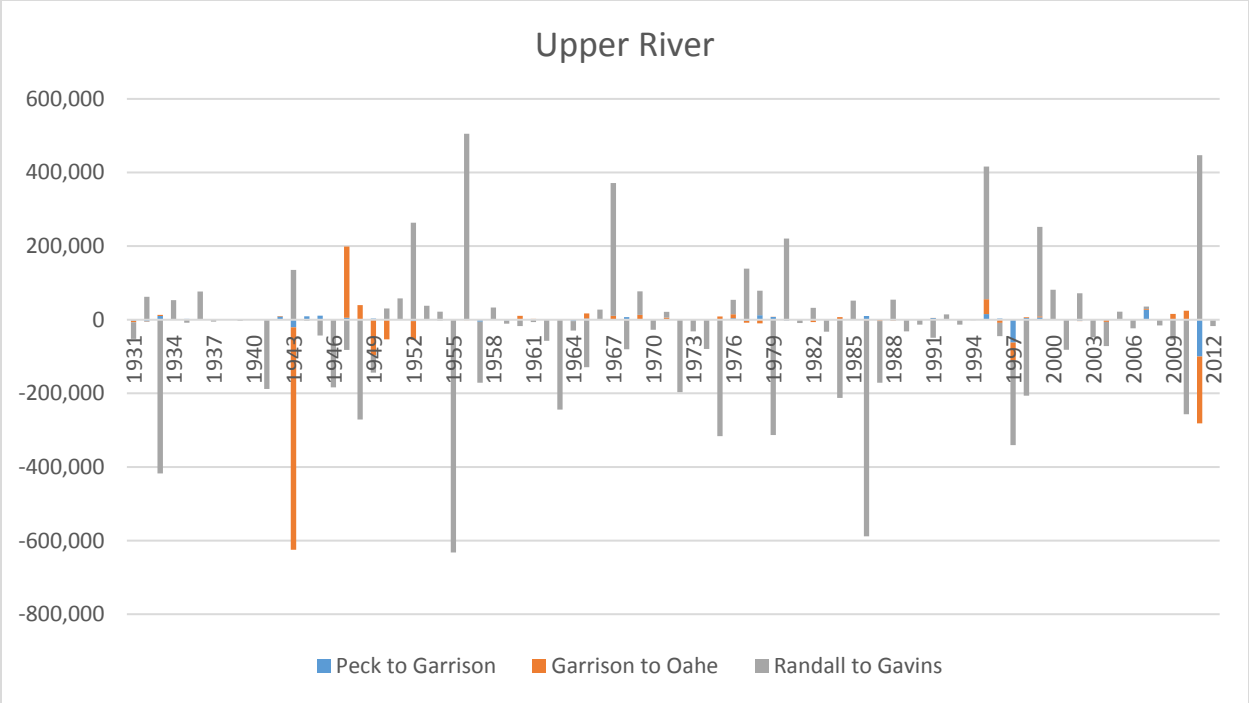

Figure 7. Alternative 3 Difference from No Action for NED Impacts in the Upper River

Figure 8 shows the annual NED impacts to flood risk management in the lower river. Some notable results include:

- In 42 of the 82 modeled years, flood risk impacts experienced an increase over No Action; however in only 1 year of those years did impacts exceed $1 million relative to No Action. The same period of record showed a reduction in flood impacts relative to No Action of greater than $1 million in 12 years.
- The furthest upstream lower river reach (Gavins Point Dam to Rulo) experienced an increase in impacts over No Action in 73 years out of the 82-year period of record, while the furthest downstream lower river reach (Hermann Reach) only experienced adverse impacts in 35 years.
- The impacts relative to No Action in the lower river ranged from an increase of $4,124,324 in 2011 simulated event to a decrease of $10,485,047 in the 1984 simulation. Overall in the lower river, Alternative 3 would decrease impacts on average by $447,761 annually compared to No Action.

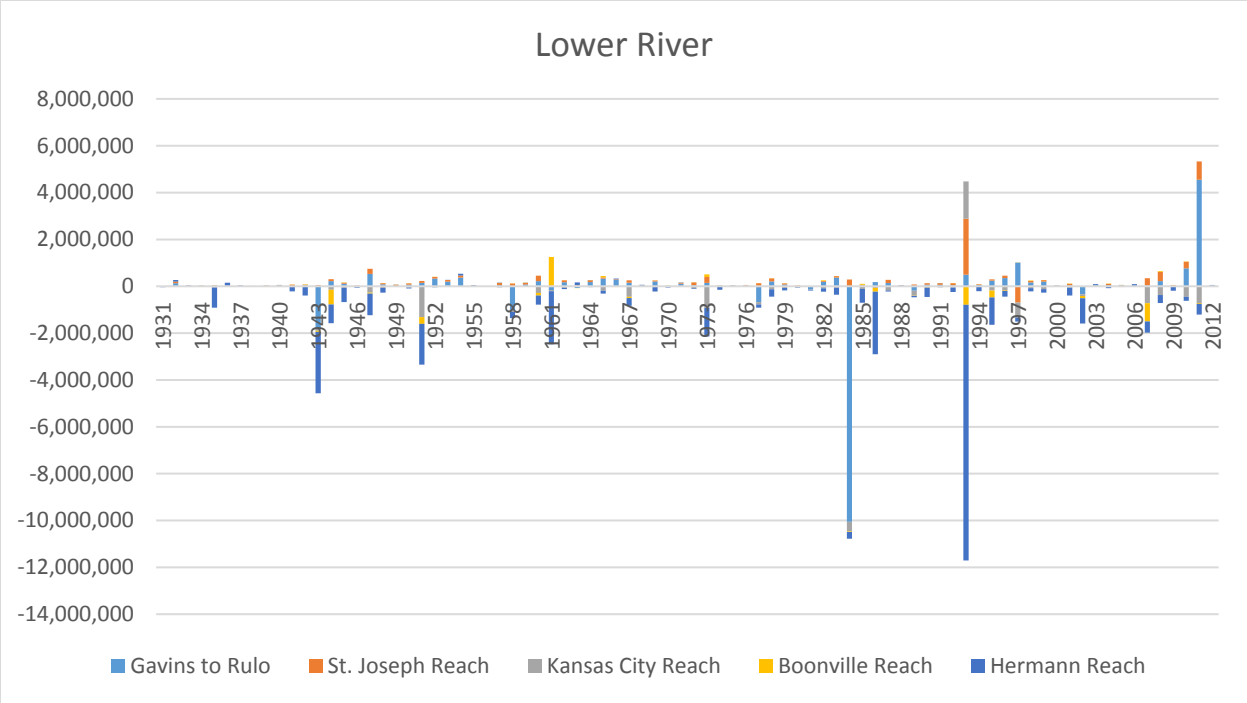

Figure 8. Alternative 3 Difference from No Action for NED Impacts in the Lower River

3.5 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. Both actions have the potential to affect flood risk management. Alternative 4 would have largest adverse impact on flood risk management relative to No Action of any of the MRRMP-EIS alternatives. Over all locations flood impacts would increase by $963,927 annually, or 1.5 percent, over No Action. The most noticeable impact would occur in the Garrison Dam to Oahe Dam reach which would experience an average annual increase in flood impacts of $721,860 relative to No Action. The NED results for Alternative 4 are summarized in Table 8.

Figure 9 shows the annual NED impacts to flood risk management in the upper river. Some noticeable impacts include:

- The increase in impacts is driven in large part by the 1950 simulated event which resulted in a $41,037,774 increase in impacts over No Action in the upper river. Approximately 98 percent of this increase is attributable to the Garrison Dam to Oahe Dam reach alone.
- Additionally, 9 of the 82 modeled years in the upper river showed an impacts increase relative to No Action of greater than $1 million. On average, the flood impacts would increase by $786,458 annually over No Action.

Table 8. Summary of National Economic Development Analysis for Alternative 4

River Reach	Average Annual Property Damage	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Total Change 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 average annual at the FY 2016 price level. Negative numbers indicate a decrease relative to No Action.

While the NED impacts were less in the lower river, flood risk impacts would also increase on average over No Action. Figure 10 shows the annual NED impacts in the lower river. Some notable results include:

- Eighteen years in the modeled period of record showed an increase in impacts greater than $1 million. Differences compared to No Action ranged from a reduction in impacts of $20,735,531 in the 2010 simulation to an increase of $9,023,701 in the 1961 simulation.

- On average, the flood impacts would increase by $177,469 annually over No Action.

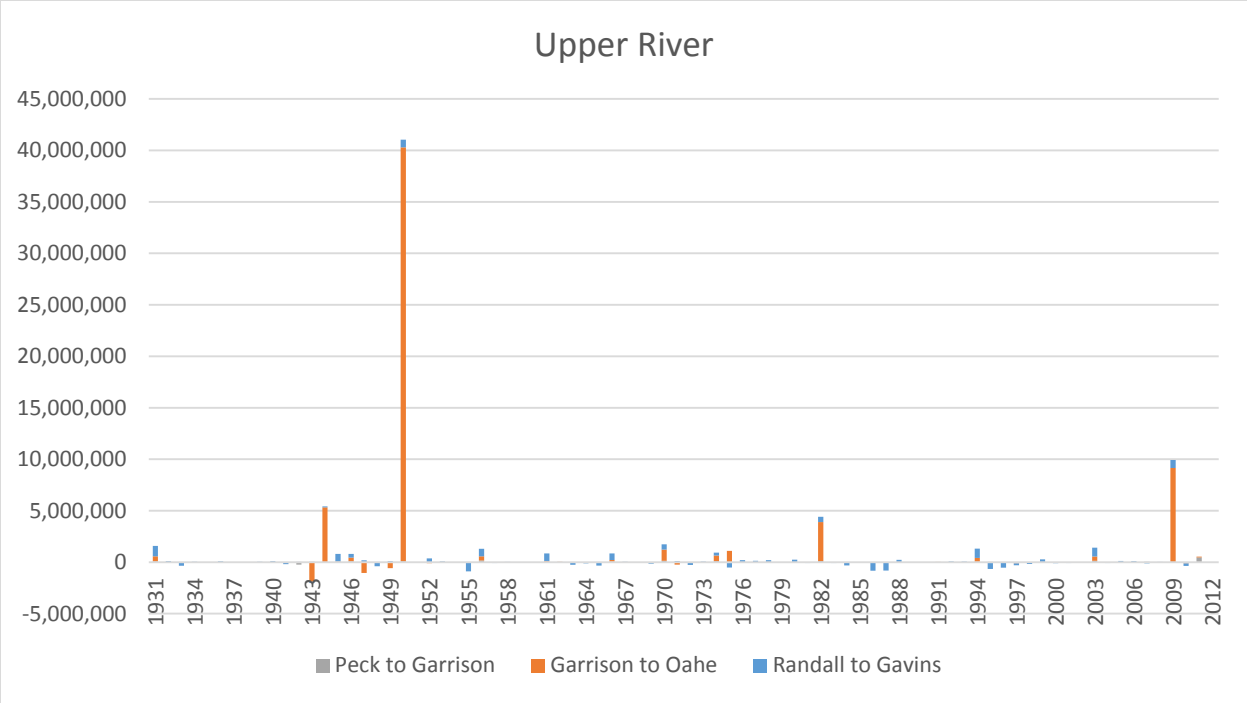

Figure 9. Alternative 4 Difference from No Action for NED Impacts in the Upper River

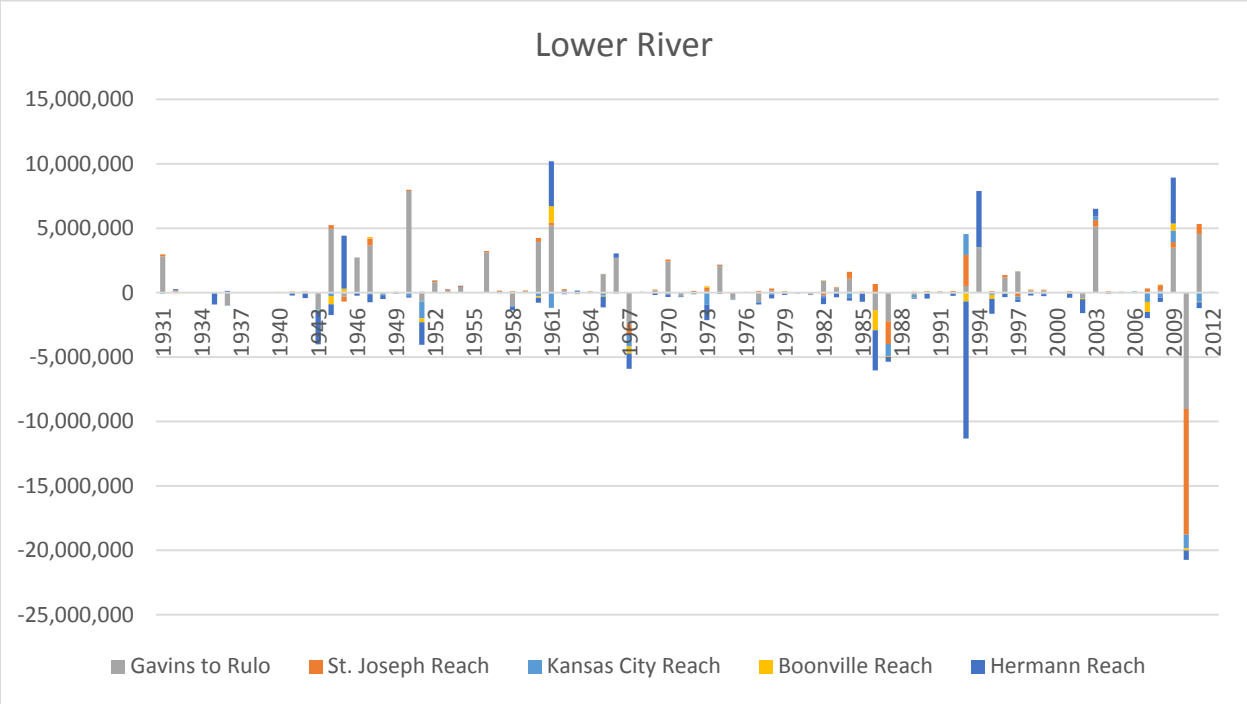

Figure 10. Alternative 4 Difference from No Action for NED Impacts in the Lower River

Figure 11 shows the difference in NED impacts between No Action and 4 for the type of release occurring each year for the upper river. Some notable results include:

- Alternative 4 modeled release actions had a noticeable effect relative to No Action. All 10 full release and 4 out of the 5 partial release years showed an increase in impacts relative to No Action in the upper river.
- The modeled full release actions years under Alternative 4 showed increases over No Action ranging from $801,403 to $4,410,093 in the upper river. The partial flow release action particularly impacted the 1950 simulated event, which showed an increase in impacts of $41,037,774 compared to No Action in the upper river.

Figure 12 shows the same data plot for flood impacts by release type in the lower river for Alternative 4. Some notable results include:

- The modeled release actions also had a noticeable effect in the lower river. Nine out of 10 modeled full release action years resulted in an increase in impacts relative to No Action. Furthermore, all five years in which there was a modeled partial release exhibited an increase over No Action.
- On average, full release action years experienced an increase of $3,936,942 annually while partial release years showed an annual increase of $4,818,160 relative to No Action.

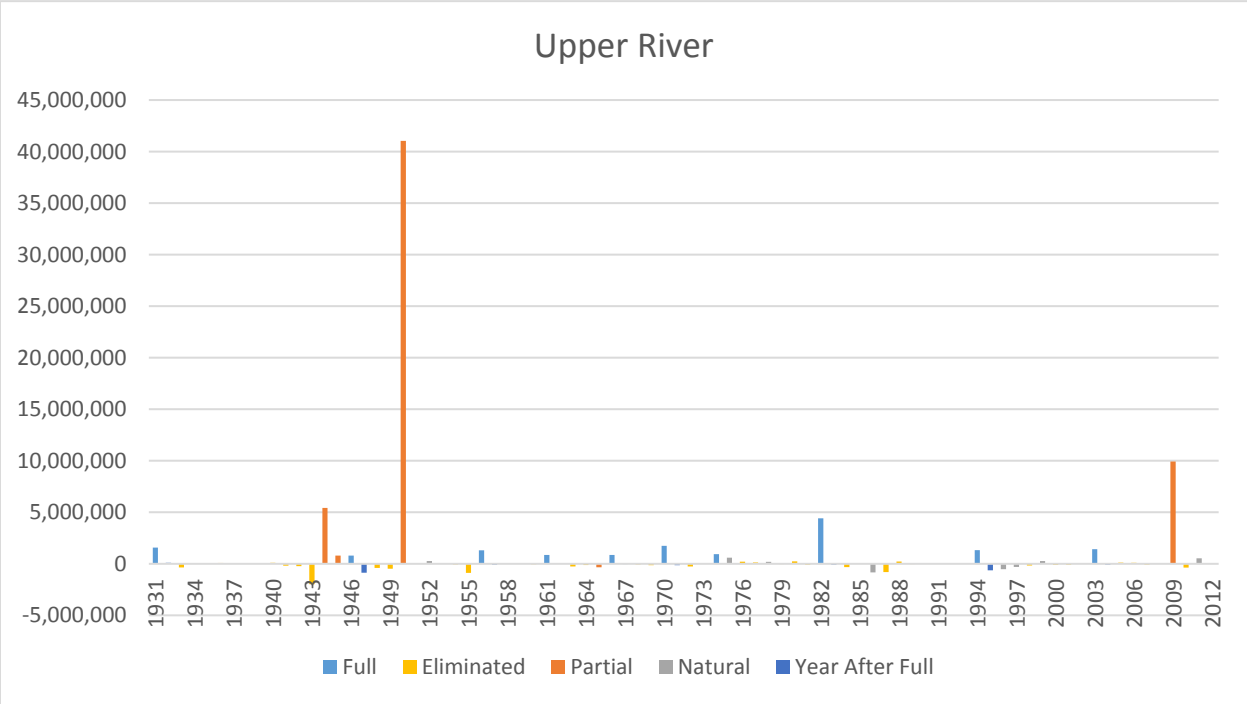

Figure 11. Alternative 4 Difference from No Action in the Upper River by Release Type

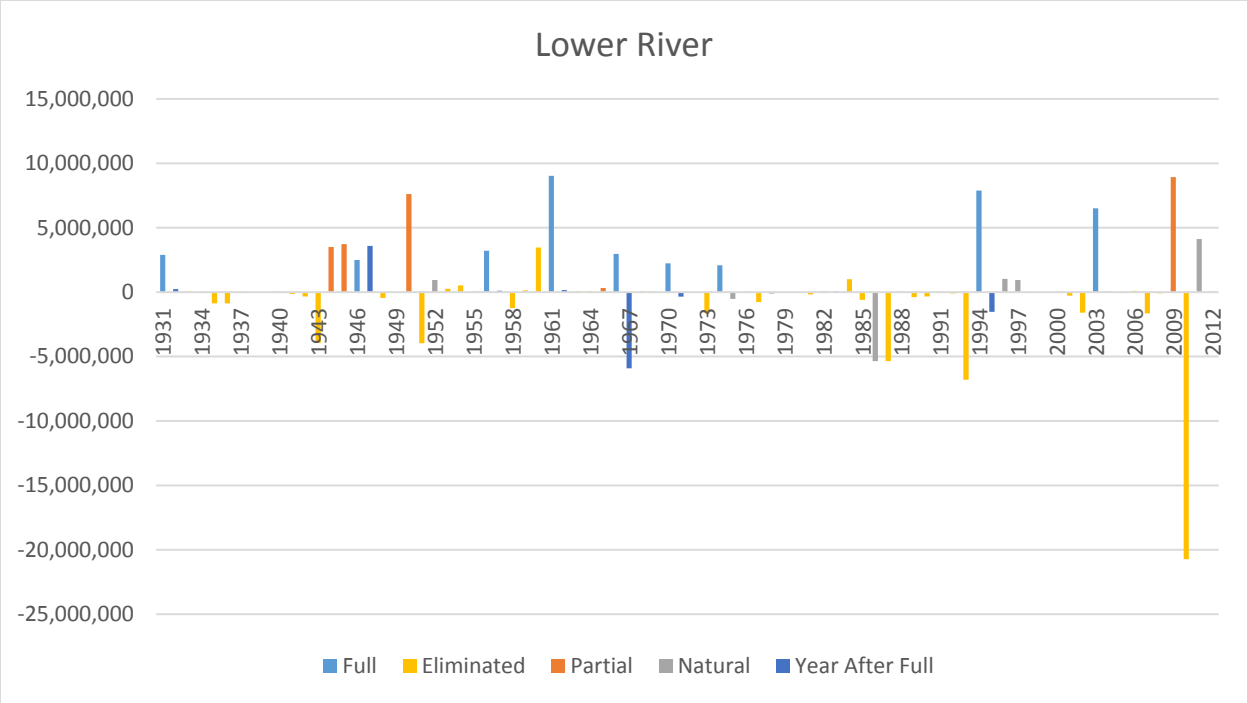

Figure 12. Alternative 4 Difference from No Action in the Lower River by Release Type

3.6 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 flood risk management. Alternative 5 is expected to have a small, beneficial impact on flood risk management impacts. Over all locations damages decrease by $287,224 annually or a decrease of 0.5 percent relative to No Action. While Alternative 5 is having an overall small beneficial impact, flood impacts in the upper river would actually experience a small increase under Alternative 5. The NED results for Alternative 5 are summarized in Table 9.

Table 9. Summary of National Economic Development Analysis for Alternative 5

River Reach	Average Annual Property Damage	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Total Change 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%

River Reach	Average Annual Property Damage	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Total Change from No Action	% Change from No Action
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%

Notes: all totals are average annual at the FY 2016 price level. Negative numbers indicate a decrease relative to No Action.

Figure 13 shows the annual NED impacts to flood risk management in the upper river. Some notable results include:

- There were 6 modeled years where the increase in impacts over No Action exceeded $1 million in the upper river. The majority of the impacts in these years were driven by the increases occurring in the Fort Randall Dam to Gavins Point Dam reach.

- On average, flood impacts would increase over No Action by $117,884 annually in the Fort Randall Dam to Gavins Point Dam reach. The upper river reaches combined would experience an average annual increase of $102,439.

Figure 14 shows the annual NED impacts to flood risk management in the lower river. Some notable results include:

- The Alternative 5 modeled impacts relative to No Action in the lower river ranged from a decrease of $14,038,303 in the 1984 simulation to an increase of $12,189,654 in the 1994 simulation. The lower river impacts in both of these modeled events were driven by the impacts occurring in the Gavins Point Dam to Rulo reach.

- The two furthest upstream lower river reaches, Gavins Point Dam to Rulo and St. Joseph Reach, showed adverse impacts relative to No Action while the furthest downstream lower river reach, Hermann Reach, had the largest NED impact overall with an average annual decrease of $454,798 expected under Alternative 5.

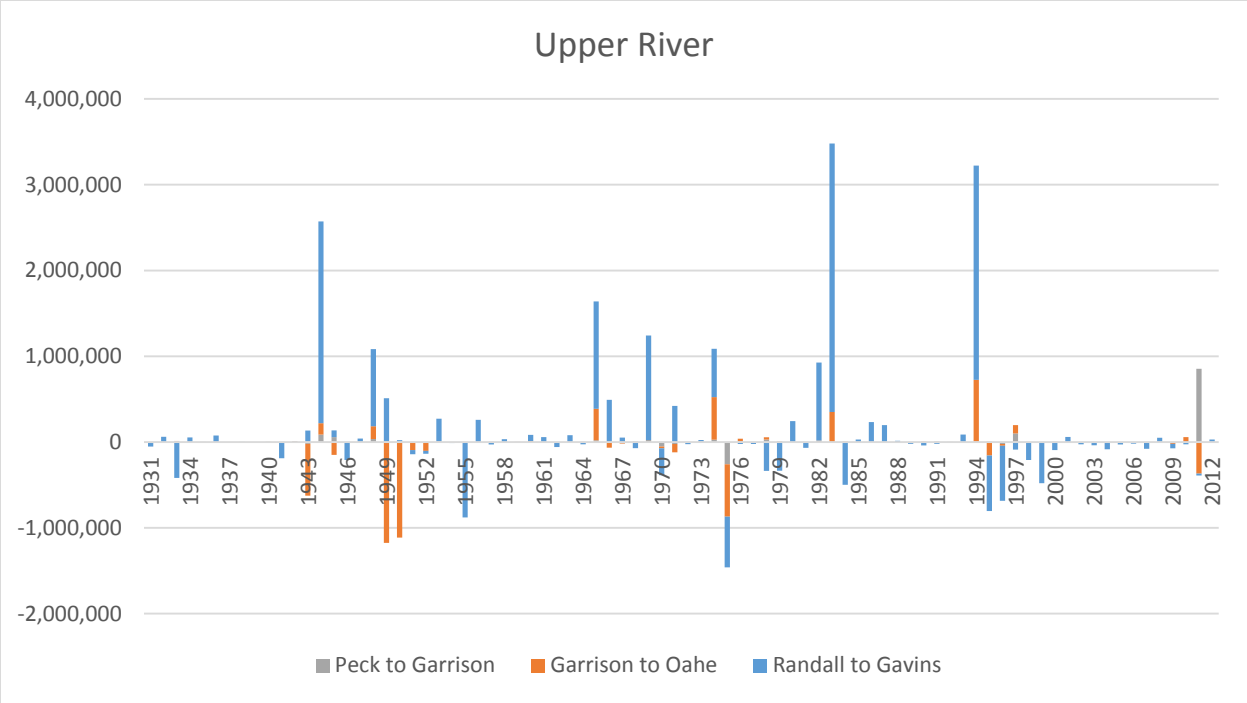

Figure 13. Alternative 5 Difference from No Action for NED Impacts in the Upper River

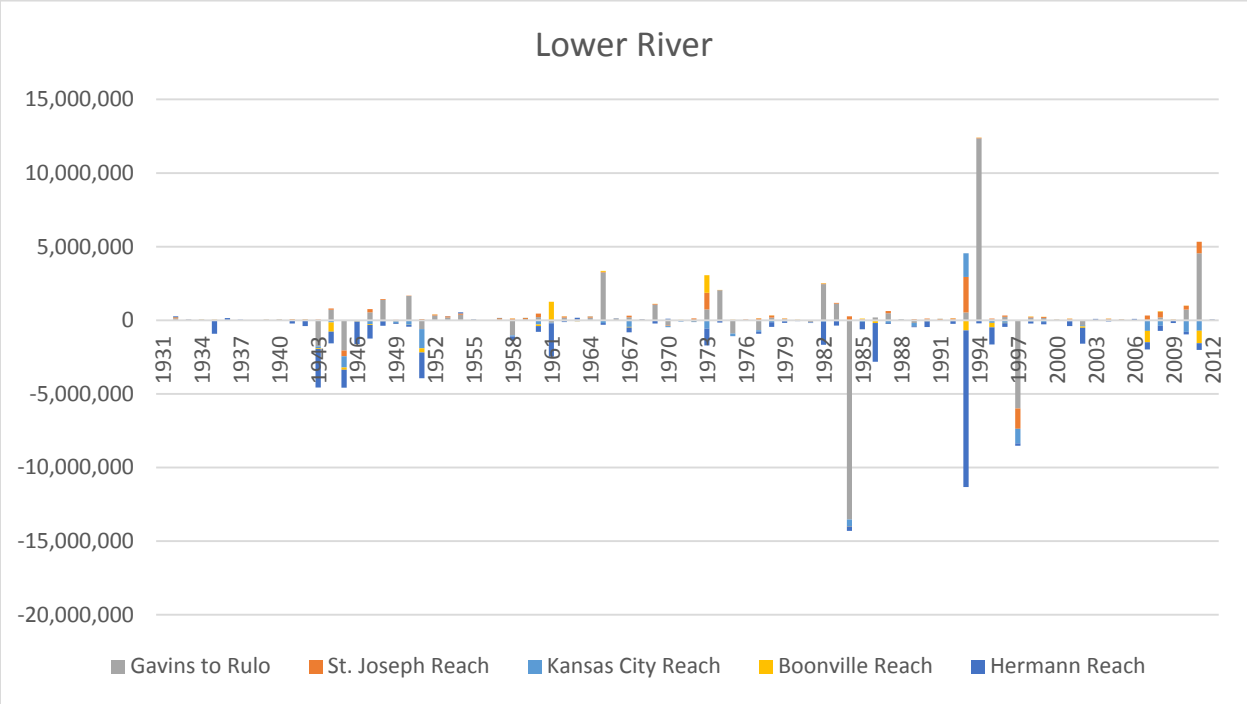

Figure 14. Alternative 5 Difference from No Action for NED Impacts in the Lower River

Figure 15 shows the difference in NED impacts between No Action and Alternative 5 for the type of release occurring each year in the upper river. Some notable results include:

- All seven modeled years with full release action events exhibited increased impacts relative to No Action in the upper river. On average, a full flow release action under Alternative 5 had an increase in impacts relative to No Action in the upper river of $2,045,806 with the largest increase being $3,480,433 in the 1983 simulation.
- A modeled year (1975) that followed a full release action year experienced the largest beneficial impacts relative to No Action, with a $1,461,037 reduction in impacts in the upper river.

Figure 16 shows the same data plot for flood impacts by release type in the lower river for Alternative 5.

- In the lower river, six out of the seven modeled years with full action release events showed an increase in impacts over No Action. Differences in modeled annual flood impacts in the lower river under a full release event ranged from a reduction of $774,889 in the 1944 simulation to an increase in impacts of $12,189,654 in the 1994 simulation.
- Again, a modeled year that followed a full release event, this time 1984, experienced the largest beneficial impacts relative to No Action, with a $14,038,303 reduction in flood impacts in the lower river.

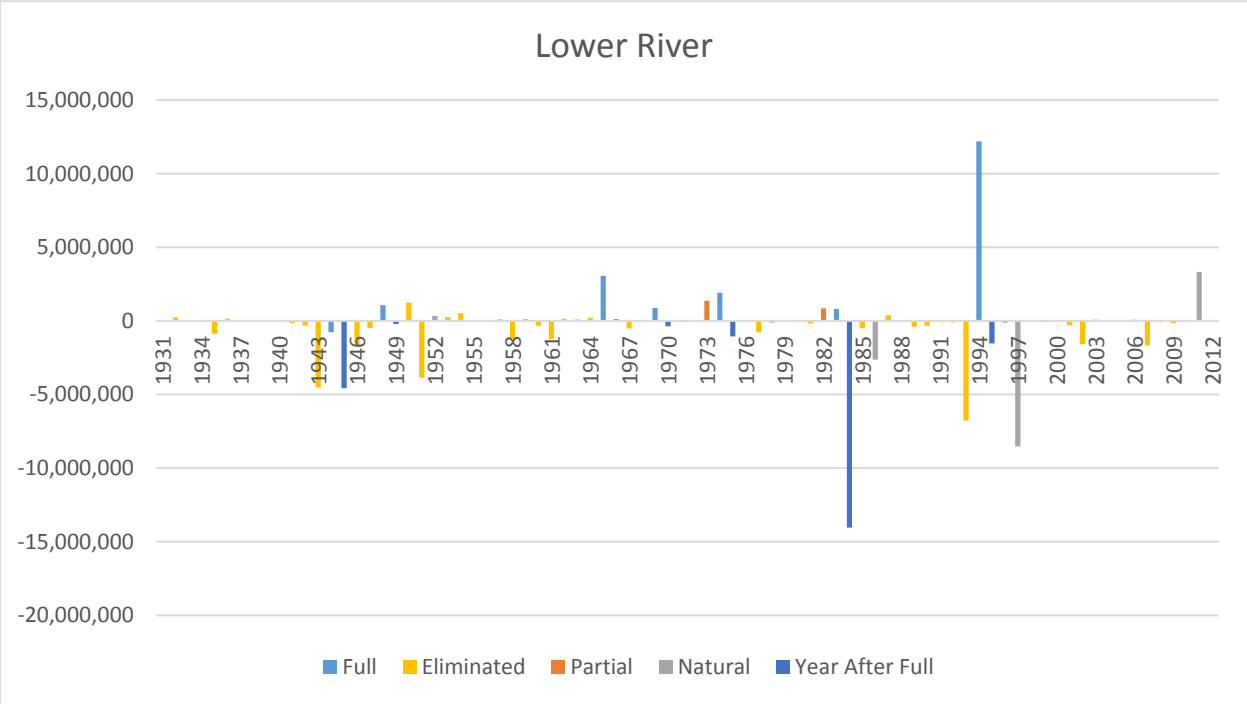

Figure 15. Alternative 5 Differences from No Action in the Upper River by Release Type

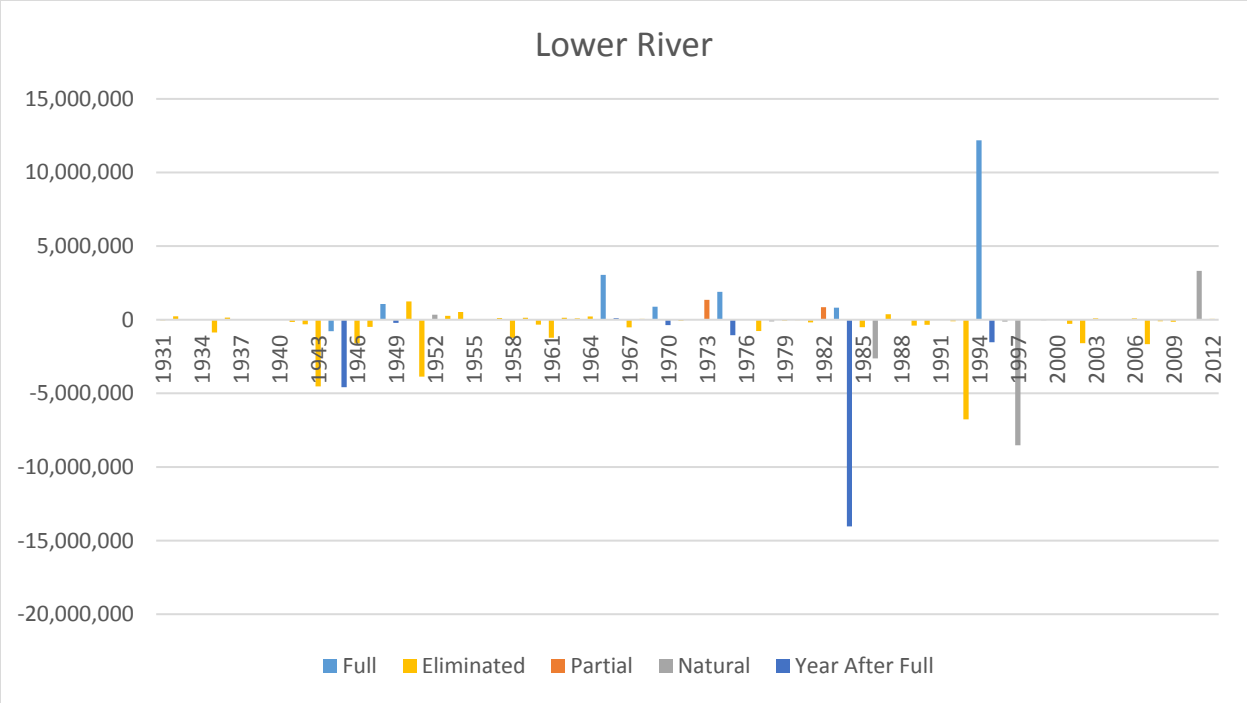

Figure 16. Alternative 5 Differences from No Action in the Lower River by Release Type

3.7 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. Both of these management actions have the potential to impact flood risk management. Alternative 6 would have a small, adverse impact on flood risk management. Overall, NED impacts would increase by $478,930 annually or an increase of 0.8 percent over No Action. Both the upper and lower river would experience increases in flood impacts under Alternative 6. The NED results for Alternative 6 are summarized in Table 10.

Table 10. Summary of National Economic Development Analysis for Alternative 6

River Reach	Average Annual Property Damage	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Total Change 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%

River Reach	Average Annual Property Damage	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Total Change from No Action	% Change from No Action
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%

Notes: all totals are average annual at the FY16 price level. Negative numbers indicate a decrease relative to No Action.

Figure 17 shows the annual NED impacts to flood risk management in the upper river. Some notable results include:

- There were 5 modeled years where flood impacts increased by over $1 million compared to No Action in the upper river, whereas there were no years with modeled impacts that decreased by $1 million.
- The range of simulated upper river impacts varied from a $908,277 decrease relative to No Action in the 1987 event to a $1,312,912 increase in the 2000 event. On average, annual impacts would increase over No Action by $75,251 in the upper river.

Figure 18 shows the annual NED impacts to flood risk management in the lower river. Some notable results include:

- Over the combined lower river, there were 52 modeled years in the 82-year period of record that showed an increase in flood impacts over No Action. However, within the reaches themselves, Gavins Point Dam to Rulo had 68 modeled increase years compared to only 27 such years in the Hermann Reach.
- The modeled range of annual lower river impacts compared to No Action varied from a $10,688,980 decrease in the 1986 simulated event to a $17,412,154 increase in the 1953 simulated event. On average, the lower river would experience an annual increase in impacts of $429,999 over No Action.
- The relative to No Action impacts among the reaches varied from an average annual increase of $886,211 in the Gavins Point Dam to Rulo reach to a $431,220 decrease in the Hermann Reach.

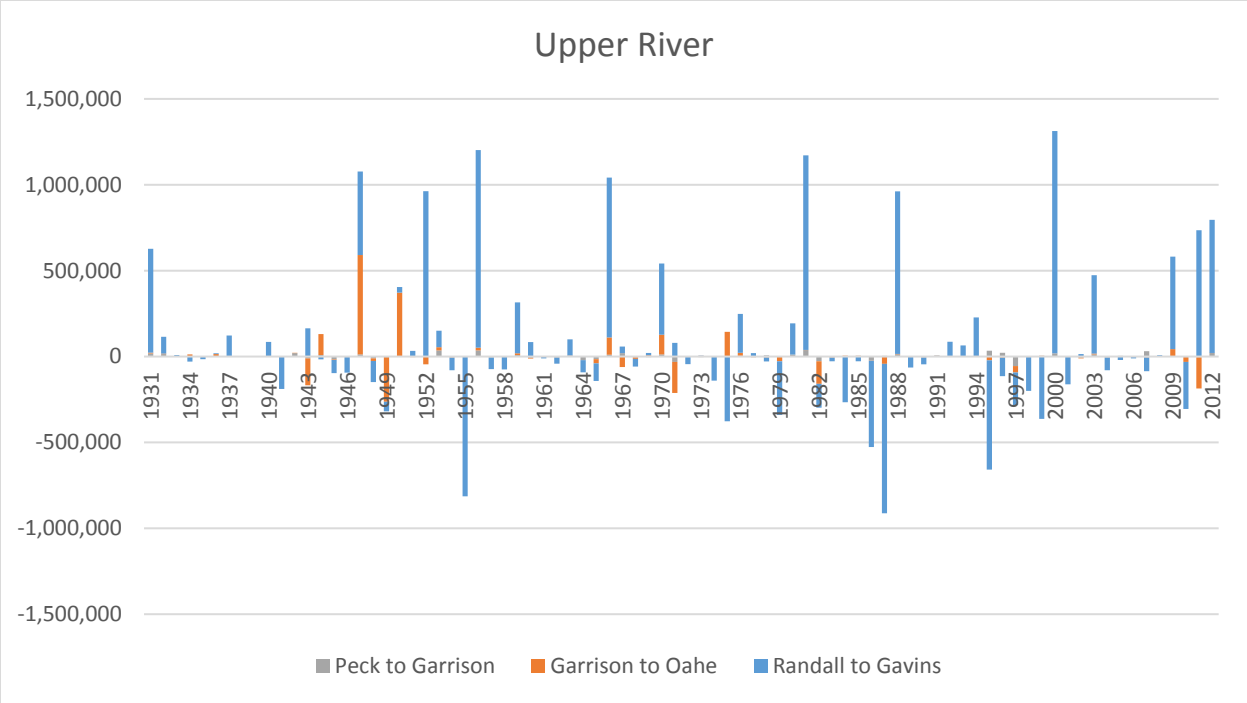

Figure 17. Alternative 6 Difference from No Action for NED Impacts in the Upper River

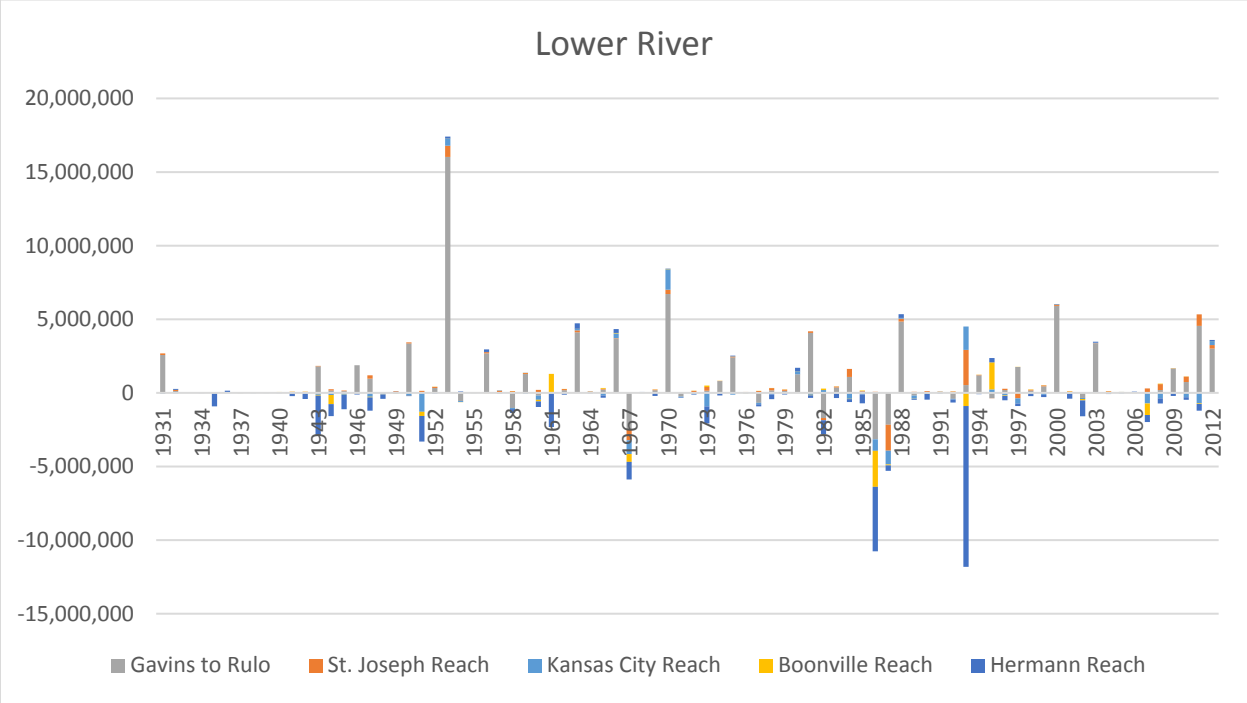

Figure 18. Alternative 6 Difference from No Action for NED Impacts in the Lower River

Figure 19 shows the difference in NED costs between No Action and Alternative 6 for the type of release occurring each year in the upper river. Some notable results include:

- All but one full modeled release year had increasing damages relative to No Action in upper river, but over half of the partial event years showed a decrease in damages.
- The ten modeled years with the largest upper river adverse impacts compared to No Action are occurring in years when there was either a full or partial release; however the largest decrease in annual impacts from No Action occurred in a modeled year when there was a partial release.
- Differences in annual upper river impacts relative to No Action ranged from a reduction of $908,277 million in the 1987 simulation to an increase of $1,312,912 in the 2000 simulation.

Figure 20 shows that the Alternative 6 full and partial event years also have adverse impacts compared to No Action. Some notable results include:

- All 11 years when a full release was simulated and in over half of the 33 years with a partial release event, impacts in the lower river are increased relative to No Action.
- The six years with the largest adverse impacts over No Action in the lower river occurred in years when there was a full release action event modeled. These impacts ranged from a $2,407,032 increase in the 1975 simulated event to a $17,412,154 increase in the 1953 simulation.

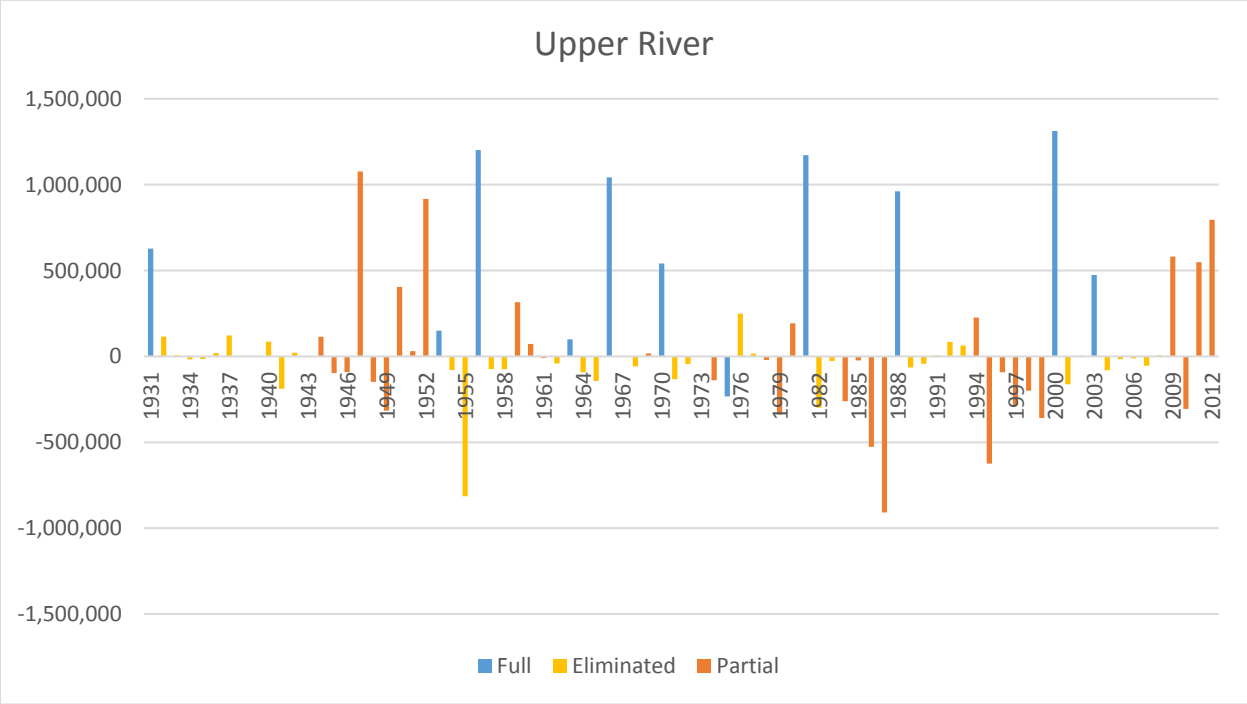

Figure 19. Alternative 6 Differences from No Action in the Upper River by Release Type

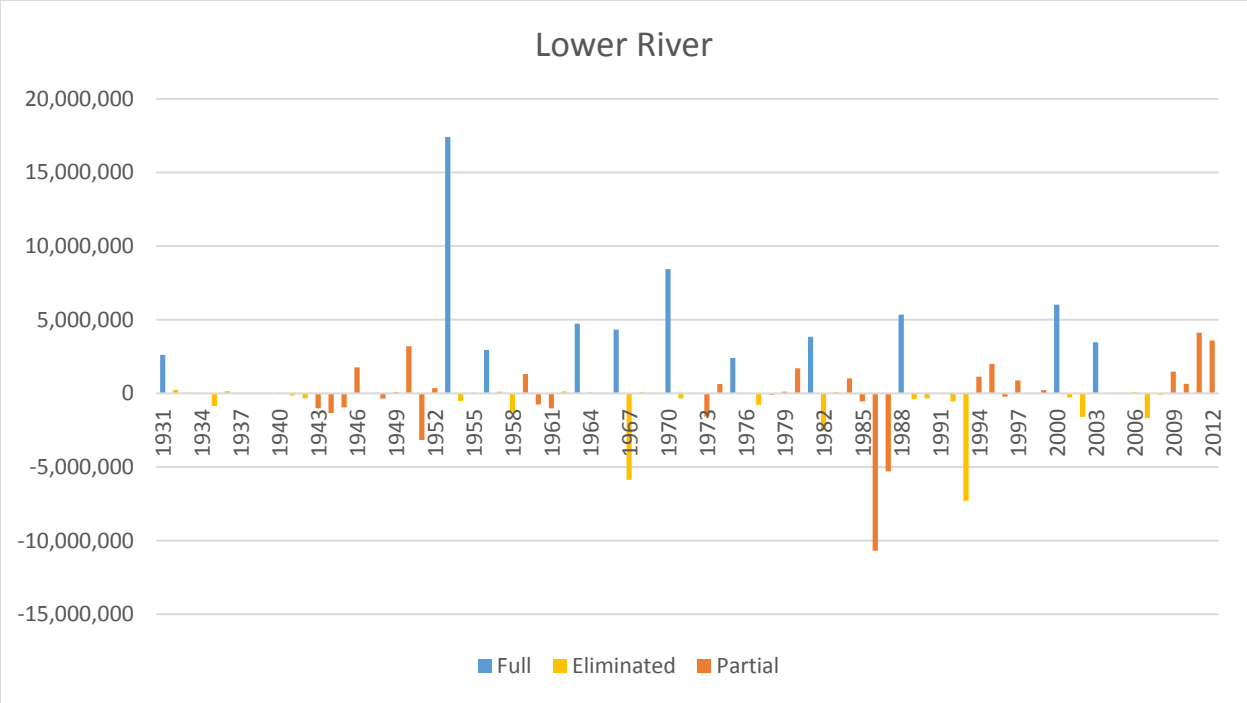

Figure 20. Alternative 6 Differences from No Action in the Lower River by Release Type

4.0 Regional Economic Development Evaluation Results

The RED analysis focused on whether changes in flood risk management impacts due to the MRRMP-EIS alternatives would have a measurable impact on local economies. The results are summarized below.

4.1 Summary of Regional Economic Development Results

A summary of the RED impacts for each alternative is provided in Tables 11, 12, and 13 for employment, labor income, and sales, respectively. The Fort Randall Dam to Gavins Point Dam, St. Joseph, and Booneville reaches have very little change in RED impacts from agricultural flooding losses relative to No Action, even in the worst years compared to No Action. The Gavins Point Dam reach on average experiences slight adverse increases in RED impacts under all action alternatives compared to No Action. Under Alternatives 2, 3, 4, 5, and 6, the Kansas City and Hermann reaches experience small decreases in average annual RED impacts compared to No Action. For all action alternatives, on average in the 8 worst years relative to No Action, there would be from two (Alternative 3 in the Kansas City reach) to eight (Alternative 2 in the Gavins Point reach) fewer jobs associated with agriculture flood losses in these reaches when compared to No Action.

Table 11. Employment RED Effects Associated with Agricultural Damage for All MRRMP-EIS Alternatives

River Reach	Alternatives					
	No Action	2	3	4	5	6
Average Annual Direct, Indirect, and Induced Jobs						
Fort Randall Dam to Gavins Point Dam	0.6	0.6	0.6	0.6	0.9	0.6
Gavins Point Dam to Rulo	37.6	38.1	38	38.6	38.4	39.1
St. Joseph Reach	7.6	7.5	7.7	7.6	7.7	7.8
Kansas City Reach	35.7	34.3	35.3	35.1	35.1	35.4
Boonville Reach	12.2	12	12.2	12.2	12.2	12.2
Hermann Reach	46.1	45.6	45.5	45.6	45.4	45.3
Change in Average Annual Direct, Indirect, and Induced Jobs						
Fort Randall Dam to Gavins Point Dam	0.0	0.0	0.0	0.0	0.3	-0.1
Gavins Point Dam to Rulo	0.0	0.4	0.4	1.0	0.7	1.5
St. Joseph Reach	0.0	-0.1	0.1	0.0	0.1	0.2
Kansas City Reach	0.0	-1.4	-0.4	-0.6	-0.6	-0.3
Boonville Reach	0.0	-0.2	0.1	0.0	0.1	0.0
Hermann Reach	0.0	-0.5	-0.6	-0.5	-0.6	-0.7
Average of 8 Worst Years Relative to No Action -- Direct, Indirect, and Induced Jobs						
Fort Randall Dam to Gavins Point Dam	0	0.8	0.5	0.6	0.7	0.8
Gavins Point Dam to Rulo	0	8.4	0.9	5.1	7.4	5.2
St. Joseph Reach	0	1.7	0.5	2.1	1.3	0.7
Kansas City Reach	0	6.7	2.0	4.3	3.3	3.0
Boonville Reach	0	1.9	0.3	0.8	0.4	1.0
Hermann Reach	0	4.5	3.7	3.8	3.7	5.1
Average of 8 Best Years Relative to No Action -- Direct, Indirect, and Induced Jobs						
Fort Randall Dam to Gavins Point Dam	0	-0.6	-0.5	-0.4	-2.9	-0.5
Gavins Point Dam to Rulo	0	-12.7	-2.4	-11.5	-11.3	-14.7
St. Joseph Reach	0	-1.8	-0.6	-1.2	-0.8	-1,0
Kansas City Reach	0	-1.5	-0.2	-1.0	-0.2	-2.6
Boonville Reach	0	-1.0	-0.7	-0.7	-1.0	-0.9
Hermann Reach	0	-2.3	0.0	-2.4	-0.2	-0.4

Note: Positive values indicate adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared to No Action.

Table 12. Labor Income RED Effects Associated with Agricultural Damage for All MRRMP-EIS Alternatives

River Reach	Alternatives					
	No Action	2	3	4	5	6
Average Annual Direct, Indirect, and Induced Labor Income						
Fort Randall Dam to Gavins Point Dam	$48,684	$45,025	$47,633	$45,533	$70,883	$44,369
Gavins Point Dam to Rulo	$2,383,428	$2,411,611	$2,406,859	$2,447,641	$2,430,118	$2,476,601
St. Joseph Reach	$494,622	$489,742	$502,575	$497,155	$498,963	$505,019
Kansas City Reach	$1,469,473	$1,411,848	$1,453,613	$1,444,479	$1,446,200	$1,458,395
Boonville Reach	$501,271	$493,126	$503,851	$501,234	$504,414	$501,643
Hermann Reach	$1,897,570	$1,878,928	$1,872,240	$1,878,451	$1,871,621	$1,866,754
Change in Average Annual Direct, Indirect, and Induced Labor Income						
Fort Randall Dam to Gavins Point Dam	$0	-$3,659	-$1,051	-$3,151	$22,199	-$4,315
Gavins Point Dam to Rulo	$0	$28,183	$23,431	$64,212	$46,690	$93,173
St. Joseph Reach	$0	-$4,880	$7,953	$2,532	$4,341	$10,397
Kansas City Reach	$0	-$57,625	-$15,861	-$24,995	-$23,274	-$11,079
Boonville Reach	$0	-$8,145	$2,580	-$36	$3,144	$372
Hermann Reach	$0	-$18,641	-$25,329	-$19,118	-$25,948	-$30,815
Average of 8 Worst Years Relative to No Action -- Direct, Indirect, and Induced Labor Income						
Fort Randall Dam to Gavins Point Dam	$0	$65,624	$41,327	$51,518	$53,313	$61,971
Gavins Point Dam to Rulo	$0	$533,365	$60,155	$320,205	$468,558	$332,185
St. Joseph Reach	$0	$110,579	$31,816	$139,326	$82,252	$48,049
Kansas City Reach	$0	$277,878	$81,510	$178,701	$136,823	$123,186
Boonville Reach	$0	$78,648	$10,758	$31,573	$16,135	$41,578
Hermann Reach	$0	$183,555	$152,367	$158,300	$154,157	$212,051
Average of 8 Best Years Relative to No Action -- Direct, Indirect, and Induced Labor Income						
Fort Randall Dam to Gavins Point Dam	$0	-$44,677	-$38,376	-$31,820	-$234,946	-$37,157
Gavins Point Dam to Rulo	$0	-$806,693	-$150,254	-$731,401	-$714,189	-$931,061
St. Joseph Reach	$0	-$114,837	-$37,174	-$75,234	-$49,253	-$64,071
Kansas City Reach	$0	-$61,809	-$6,397	-$39,996	-$6,428	-$107,642
Boonville Reach	$0	-$39,430	-$29,298	-$28,282	-$41,641	-$39,078
Hermann Reach	$0	-$94,541	-$1,394	-$97,465	-$7,148	-$16,431

Note: Positive values indicate adverse RED impacts, while negative values indicate reductions in adverse effects or increases in RED impacts compared to No Action.

Table 13. Sales RED Effects Associated with Agricultural Damage for All MRRMP-EIS Alternatives

River Reach	Alternatives					
	No Action	2	3	4	5	6
Average Annual Direct, Indirect, and Induced Sales						
Fort Randall Dam to Gavins Point Dam	$182,929	$169,182	$178,981	$171,088	$266,339	$166,714
Gavins Point Dam to Rulo	$10,521,142	$10,645,550	$10,624,571	$10,804,594	$10,727,245	$10,932,435
St. Joseph Reach	$2,020,452	$2,000,519	$2,052,939	$2,030,796	$2,038,184	$2,062,920
Kansas City Reach	$6,077,033	$5,838,723	$6,011,442	$5,973,667	$5,980,785	$6,031,216
Boonville Reach	$2,071,927	$2,038,261	$2,082,591	$2,071,776	$2,084,921	$2,073,464
Hermann Reach	$7,843,316	$7,766,265	$7,738,622	$7,764,294	$7,736,063	$7,715,946
Change in Average Annual Direct, Indirect, and Induced Sales						
Fort Randall Dam to Gavins Point Dam	$0	-$13,747	-$3,948	-$11,841	$83,410	-$16,215
Gavins Point Dam to Rulo	$0	$124,408	$103,429	$283,452	$206,103	$411,293
St. Joseph Reach	$0	-$19,933	$32,487	$10,344	$17,732	$42,469
Kansas City Reach	$0	-$238,310	-$65,592	-$103,366	-$96,249	-$45,817
Boonville Reach	$0	-$33,666	$10,664	-$151	$12,993	$1,537
Hermann Reach	$0	-$77,051	-$104,695	-$79,023	-$107,254	-$127,370
Average of 8 Worst Years Relative to No Action -- Direct, Indirect, and Induced Sales						
Fort Randall Dam to Gavins Point Dam	$0	$13,747	$3,948	$11,841	-$83,410	$16,215
Gavins Point Dam to Rulo	$0	$2,354,426	$265,543	$1,413,475	$2,068,349	$1,466,363
St. Joseph Reach	$0	$451,698	$129,964	$569,124	$335,985	$196,272
Kansas City Reach	$0	$1,149,170	$337,087	$739,023	$565,834	$509,437
Boonville Reach	$0	$325,080	$44,465	$130,501	$66,691	$171,855
Hermann Reach	$0	$758,697	$629,787	$654,309	$637,183	$876,480
Average of 8 Best Years Relative to No Action -- Direct, Indirect, and Induced Sales						
Fort Randall Dam to Gavins Point Dam	$0	-$167,874	-$144,195	-$119,563	-$882,802	-$139,616
Gavins Point Dam to Rulo	$0	-$3,560,978	-$663,267	-$3,228,615	-$3,152,638	-$4,109,973
St. Joseph Reach	$0	-$469,093	-$151,851	-$307,320	-$201,189	-$261,720
Kansas City Reach	$0	-$255,611	-$26,455	-$165,406	-$26,583	-$445,157
Boonville Reach	$0	-$162,979	-$121,098	-$116,899	-$172,116	-$161,522
Hermann Reach	$0	-$390,772	-$5,760	-$402,857	-$29,545	-$67,914

Note: Positive values indicate adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared to No Action.

Table 14 summarizes the change in average annual structural damages by county for the action alternatives compared to No Action.

Table 14. Change in Average Annual Structural Damages Relative to Alternative 1 by County

County	State	Alternative				
		2	3	4	5	6
Fremont	IA	$1,088	$831	$684	$828	$745
Harrison	IA	$30,942	-$9,390	$23,185	-$11,416	$21,350
Mills	IA	$4,891	$5,343	$5,325	$5,218	$6,035
Monona	IA	-$2,799	-$2,206	$2,693	-$3,547	$2,586
Pottawattamie	IA	$54,489	$28,088	$83,769	$26,843	$81,605
Woodbury	IA	$151,824	-$876	$150,082	$25,943	$193,373
Calhoun	IL	-$3,238	$42	-$12,121	$17	-$10,198
Jersey	IL	-$63,224	-$1,251	-$132,976	-$1,960	-$130,983
Madison	IL	$94,545	-$434	$187,937	-$4,811	$132,623
Atchison	KS	$7,269	$1,734	$9,739	$929	$9,624
Brown	KS	$147	$390	$721	$497	$434
Doniphan	KS	-$1,962	$7,706	$7,646	$7,763	$7,746
Leavenworth	KS	-$942	$5,355	$4,128	$5,156	$4,631
Wyandotte	KS	-$67	-$849	-$1,015	-$659	-$874
Andrew	MO	-$30,495	$1,019	-$3,113	$899	-$713
Atchison	MO	$2,422	$3,496	$3,357	$3,433	$3,513
Boone	MO	-$4,856	-$4,679	-$5,750	-$4,006	-$6,270
Buchanan	MO	-$134,502	$37,254	-$30,466	$41,025	$22,316
Callaway	MO	-$5,063	-$60,873	-$53,195	-$55,072	-$61,841
Carroll	MO	-$17,731	-$5,451	-$14,735	-$5,334	-$8,322
Chariton	MO	-$22,682	$384	$1,450	$484	$619
Clay	MO	-$9,250	-$4,205	$2,871	-$4,175	-$4,189
Cole	MO	-$20,688	-$17,713	-$12,167	-$19,081	-$15,548
Cooper	MO	-$8,062	$599	$2,857	$651	$1,364
Franklin	MO	-$51,420	-$40,186	-$25,265	-$40,609	-$40,319
Gasconade	MO	-$322	-$29,532	-$4,206	-$34,556	-$34,153
Holt	MO	$442,173	$450,528	$356,145	$450,414	$447,210
Howard	MO	-$10,042	$4,319	$6,083	$4,496	$4,729
Jackson	MO	-$25,614	-$31,991	-$29,837	-$32,543	-$27,457
Lafayette	MO	-$19,637	-$11,210	-$8,721	-$11,543	-$11,072
Lincoln	MO	$304	$233	$326	$210	$255
Moniteau	MO	-$5,331	-$926	-$395	-$844	-$1,226

County	State	Alternative				
		2	3	4	5	6
Montgomery	MO	-$548	-$4,271	-$4,724	-$4,293	-$5,545
Osage	MO	-$68,740	-$60,665	-$111,011	-$61,969	-$112,873
Platte	MO	$21,064	$11,283	-$209	$12,000	$12,463
Ray	MO	-$14,234	-$1,398	-$1,334	-$1,355	-$1,383
Saint Charles	MO	-$90,067	-$62,796	-$9,874	-$73,617	-$60,963
Saint Louis	MO	-$12,907	$8,230	$71,379	$6,186	$51,404
Saline	MO	-$6,615	-$1,408	-$99	-$1,513	-$364
Warren	MO	-$31,309	-$25,075	-$22,552	-$24,734	-$25,522
McCone	MT	$411	$44	$433	$194	$108
Richland	MT	$419	-$463	-$292	-$495	-$452
Roosevelt	MT	-$12,990	-$14,810	-$5,172	-$3,724	$11,713
Valley	MT	$16,481	$15,335	$726	-$9,743	-$10,558
Burleigh	ND	$318	$0	$0	$0	$0
Dunn	ND	-$12	$6	$657	$1,292	-$8
Emmons	ND	$0	$0	$0	$0	$0
McKenzie	ND	$592	-$33	$11,486	$16,779	$371
McLean	ND	$282	$4	-$603	-$1,635	-$50
Mercer	ND	$0	$0	$0	$0	$0
Morton	ND	$0	$0	$0	$0	$0
Mountrail	ND	$25	-$157	-$214	$280	-$127
Oliver	ND	$0	$0	$0	$0	$0
Sioux	ND	$0	$0	$0	$0	$0
Williams	ND	$1,416	-$37	$185	$2,636	$141
Boyd	NE	$11,097	-$36,186	$17,725	$63,401	$22,584
Burt	NE	$10,934	$1,403	$12,985	$1,414	$13,648
Cass	NE	-$81,355	$140,628	$155,176	$135,846	$163,655
Cedar	NE	$4,485	-$680	$3,711	$909	$4,088
Dakota	NE	$926	-$111	$7,596	$760	$7,824
Dixon	NE	$941	$419	$1,422	$553	$1,357
Douglas	NE	-$635	-$304	-$21	-$303	-$21
Nemaha	NE	$1,941	$4,350	$9,714	$4,199	$9,785
Otoe	NE	$7,216	$7,129	$6,423	$6,870	$7,722
Richardson	NE	$2,597	$4,864	$4,637	$4,916	$4,818
Sarpy	NE	$9,310	$5,466	$7,739	$5,429	$9,110
Thurston	NE	-$24	-$17	$2	-$20	-$1
Washington	NE	$13,111	$7,152	$44,022	$9,153	$40,818

County	State	Alternative				
		2	3	4	5	6
Bon Homme	SD	$36,122	$20,469	$21,983	-$22,542	$27,562
Campbell	SD	-$1,019,021	-$4,557	$458,968	-$14,822	$3,436
Charles Mix	SD	$1,383	$755	$1,025	-$901	$1,260
Clay	SD	$123	-$26	$29	-$22	$10
Corson	SD	-$2,468	$1,033	$4,392	-$777	$1,800
Dewey	SD	$589	$193	-$1,097	$3	$639
Gregory	SD	-$415	-$4,545	$1,989	$6,631	$1,858
Hughes	SD	$829,163	-$2,616	$51,589	-$2,626	-$2,409
Potter	SD	-$334	-$1	$136	-$2	$0
Stanley	SD	$325	$0	$0	$0	$0
Sully	SD	$62	$0	$0	$0	$0
Union	SD	$50,309	-$10,685	$43,575	-$22,544	$41,088
Walworth	SD	$174,556	$0	$0	$0	$0
Yankton	SD	$64,622	$1,439	$59,599	$24,717	$67,402
Fremont	IA	$1,041	-$33	$1,061	-$92	$698
Atchison	MO	$51	-$5	$90	-$6	$44
Chariton	MO	-$36	$84	-$53	$97	$33
Holt	MO	-$3,006	$397	$578	$398	$500
Nemaha	NE	$6	-$1	$1	-$2	$0
Fremont	IA	$2,129	$798	$1,744	$736	$1,443
Harrison	IA	$30,942	-$9,390	$23,185	-$11,416	$21,350
Mills	IA	$4,891	$5,343	$5,325	$5,218	$6,035
Monona	IA	-$2,799	-$2,206	$2,693	-$3,547	$2,586
Pottawattamie	IA	$54,489	$28,088	$83,769	$26,843	$81,605
Woodbury	IA	$151,824	-$876	$150,082	$25,943	$193,373
Calhoun	IL	-$3,238	$42	-$12,121	$17	-$10,198
Jersey	IL	-$63,224	-$1,251	-$132,976	-$1,960	-$130,983
Madison	IL	$94,545	-$434	$187,937	-$4,811	$132,623
Atchison	KS	$7,269	$1,734	$9,739	$929	$9,624
Brown	KS	$147	$390	$721	$497	$434
Doniphan	KS	-$1,962	$7,706	$7,646	$7,763	$7,746
Leavenworth	KS	-$942	$5,355	$4,128	$5,156	$4,631
Wyandotte	KS	-$67	-$849	-$1,015	-$659	-$874
Andrew	MO	-$30,495	$1,019	-$3,113	$899	-$713
Atchison	MO	$2,473	$3,490	$3,447	$3,428	$3,557
Boone	MO	-$4,856	-$4,679	-$5,750	-$4,006	-$6,270

County	State	Alternative				
		2	3	4	5	6
Buchanan	MO	-$134,502	$37,254	-$30,466	$41,025	$22,316
Callaway	MO	-$5,063	-$60,873	-$53,195	-$55,072	-$61,841
Carroll	MO	-$17,731	-$5,451	-$14,735	-$5,334	-$8,322
Chariton	MO	-$22,719	$468	$1,398	$581	$652
Clay	MO	-$9,250	-$4,205	$2,871	-$4,175	-$4,189
Cole	MO	-$20,688	-$17,713	-$12,167	-$19,081	-$15,548
Cooper	MO	-$8,062	$599	$2,857	$651	$1,364
Franklin	MO	-$51,420	-$40,186	-$25,265	-$40,609	-$40,319
Gasconade	MO	-$322	-$29,532	-$4,206	-$34,556	-$34,153
Holt	MO	$439,167	$450,925	$356,723	$450,812	$447,711
Howard	MO	-$10,042	$4,319	$6,083	$4,496	$4,729
Jackson	MO	-$25,614	-$31,991	-$29,837	-$32,543	-$27,457
Lafayette	MO	-$19,637	-$11,210	-$8,721	-$11,543	-$11,072
Lincoln	MO	$304	$233	$326	$210	$255
Moniteau	MO	-$5,331	-$926	-$395	-$844	-$1,226
Montgomery	MO	-$548	-$4,271	-$4,724	-$4,293	-$5,545
Osage	MO	-$68,740	-$60,665	-$111,011	-$61,969	-$112,873
Platte	MO	$21,064	$11,283	-$209	$12,000	$12,463
Ray	MO	-$14,234	-$1,398	-$1,334	-$1,355	-$1,383
Saint Charles	MO	-$90,067	-$62,796	-$9,874	-$73,617	-$60,963
Saint Louis	MO	-$12,907	$8,230	$71,379	$6,186	$51,404
Saline	MO	-$6,615	-$1,408	-$99	-$1,513	-$364
Warren	MO	-$31,309	-$25,075	-$22,552	-$24,734	-$25,522
McCone	MT	$411	$44	$433	$194	$108
Richland	MT	$419	-$463	-$292	-$495	-$452
Roosevelt	MT	-$12,990	-$14,810	-$5,172	-$3,724	$11,713
Valley	MT	$16,481	$15,335	$726	-$9,743	-$10,558
Burleigh	ND	$318	$0	$0	$0	$0
Dunn	ND	-$12	$6	$657	$1,292	-$8
Emmons	ND	$0	$0	$0	$0	$0
McKenzie	ND	$592	-$33	$11,486	$16,779	$371
McLean	ND	$282	$4	-$603	-$1,635	-$50
Mercer	ND	$0	$0	$0	$0	$0
Morton	ND	$0	$0	$0	$0	$0
Mountrail	ND	$25	-$157	-$214	$280	-$127
Oliver	ND	$0	$0	$0	$0	$0

County	State	Alternative				
		2	3	4	5	6
Sioux	ND	$0	$0	$0	$0	$0
Williams	ND	$1,416	-$37	$185	$2,636	$141
Boyd	NE	$11,097	-$36,186	$17,725	$63,401	$22,584
Burt	NE	$10,934	$1,403	$12,985	$1,414	$13,648
Cass	NE	-$81,355	$140,628	$155,176	$135,846	$163,655
Cedar	NE	$4,485	-$680	$3,711	$909	$4,088
Dakota	NE	$926	-$111	$7,596	$760	$7,824
Dixon	NE	$941	$419	$1,422	$553	$1,357
Douglas	NE	-$635	-$304	-$21	-$303	-$21
Nemaha	NE	$1,946	$4,349	$9,715	$4,197	$9,785
Otoe	NE	$7,216	$7,129	$6,423	$6,870	$7,722
Richardson	NE	$2,597	$4,864	$4,637	$4,916	$4,818
Sarpy	NE	$9,310	$5,466	$7,739	$5,429	$9,110
Thurston	NE	-$24	-$17	$2	-$20	-$1
Washington	NE	$13,111	$7,152	$44,022	$9,153	$40,818
Bon Homme	SD	$36,122	$20,469	$21,983	-$22,542	$27,562
Campbell	SD	-$1,019,021	-$4,557	$458,968	-$14,822	$3,436
Charles Mix	SD	$1,383	$755	$1,025	-$901	$1,260
Clay	SD	$123	-$26	$29	-$22	$10
Corson	SD	-$2,468	$1,033	$4,392	-$777	$1,800
Dewey	SD	$589	$193	-$1,097	$3	$639
Gregory	SD	-$415	-$4,545	$1,989	$6,631	$1,858
Hughes	SD	$829,163	-$2,616	$51,589	-$2,626	-$2,409
Potter	SD	-$334	-$1	$136	-$2	$0
Stanley	SD	$325	$0	$0	$0	$0
Sully	SD	$62	$0	$0	$0	$0
Union	SD	$50,309	-$10,685	$43,575	-$22,544	$41,088
Walworth	SD	$174,556	$0	$0	$0	$0
Yankton	SD	$64,622	$1,439	$59,599	$24,717	$67,402

Note: Positive values indicate more structural damages on average compared to No Action, while negative values indicate fewer structural damages on average compared to No Action.

4.2 No Action – Current System Operation and Current MRRP Implementation

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 15 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 Dam to Gavins Point Dam reach would be small to negligible.

Under No Action, 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 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.

4.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

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 one average annual jobs across all locations, while average labor income would range from an increase of $29,000 in Gavins Point Dam to Rulo (adverse effect) to a reduction of $57,000 in Kansas City Reach (beneficial effect) 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 five to eight fewer jobs and $184,000 to $533,000 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 16 summarizes the differences in economic impacts for each of the flood risk management regions under Alternative 2 relative to No Action.

Table 15. RED Effects Associated with Agricultural Damage – No Action

River Reach	Jobs			Labor Income			Sales		
	Average Annual	Max Ag Damage Year	Min Ag Damage Year	Average Annual	Max Ag Damage Year	Min Ag Damage Year	Average Annual	Max Ag Damage Year	Min Ag Damage Year
Missouri River	**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: Positive values indicate adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared to No Action.

Table 16. RED Impacts Associated with Agricultural Damage under Alternative 2 Compared to No Action

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**-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 adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared 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 to $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.

4.4 Alternative 3 – Mechanical Construction Only

Under Alternative 3, agricultural flood 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 $24,000 in Gavins Point Dam to Rulo reach (adverse effect) to a reduction of $27,000 in the Hermann Reach (beneficial effect) 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 17 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 the above-mentioned counties, with potentially small RED effects occurring during flooding events relative to No Action.

Table 17. RED Impacts Associated with Agricultural Damage under Alternative 3 and Compared to No Action

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**−1**	**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 adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared to No Action.

4.5 Alternative 4 – Spring ESH Creating Release

Under Alternative 4, agricultural flood 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 $65,000 in Gavins Point Dam to Rulo, Nebraska (adverse effect) to a reduction of $25,000 in the Kansas City reach (beneficial effect) 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 $158,000 to $320,000 in less labor income compared to No Action on average in these years. 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 18 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 above-mentioned counties, with potentially small RED effects occurring during flooding events relative to No Action.

4.6 Alternative 5 – Fall ESH Creating Release

Under Alternative 5, agricultural flood 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 $47,000 in the Gavins Point Dam to Rulo reach (adverse effect) to a reduction of $26,000 in the Herman Reach (beneficial effect) 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 (annual average) 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 19 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.

Table 18. RED Impacts Associated with Agricultural Damage under Alternative 4 and Compared to No Action

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**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 adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared to No Action.

Table 19. RED Impacts Associated with Agricultural Damage under Alternative 5 and Compared to No Action

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**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 adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared 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)

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.

4.7 Alternative 6 – Pallid Sturgeon Spawning Cue

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 $94,000 (adverse effect) in the Gavins Point Dam to Rulo reach to a reduction of $31,000 (beneficial effect) in the Hermann Reach relative to No Action. Under the eight worst years relative to No Action, two reaches tend to experience the largest impacts: Gavins Point Dam to Rulo, Nebraska; 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 20 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 and $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 above-mentioned counties, with potentially small RED effects occurring during flooding events relative to No Action.

Table 20. RED Impacts Associated with Agricultural Damage under Alternative 6 and Compared to No Action

River Reach	Change in Jobs			Change in Labor Income			Change in Sales		
	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years	Average Annual	8 Worst Years	8 Best Years
Missouri River	**1**	**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 adverse RED impacts, while negative values indicate reductions in adverse effects to RED compared to No Action.

5.0 Other Social Effects Results

The OSE analysis for flood risk management relied on the results of the FIA modeling to determine the scale of impacts that could occur to individual and community well-being, economic vitality, and critical infrastructure.

5.1 Summary of Other Social Effects Impacts

A summary of the OSE impacts for each alternative are summarized in Table 21.

Table 21. Environmental Consequences Relative to Flood Risk Management: Other Social Effects

Alternative	RED Impacts
No Action	Average Annual PAR: 709, Maximum PAR: 12,643. Critical facilities at risk: 869.
Alternative 2	Average Annual PAR: 703, Maximum PAR: 12,333. No change in critical infrastructure. 1 potential EJ census block group.
Alternative 3	Average Annual PAR: 700, Maximum PAR: 12,674. No change in critical infrastructure. No potential EJ.
Alternative 4	Average Annual PAR: 734, Maximum PAR: 12,722. No change in critical infrastructure. 1 potential EJ census block group.
Alternative 5	Average Annual PAR: 701, Maximum PAR: 12,707. No change in critical infrastructure. No potential EJ.
Alternative 6	Average Annual PAR: 709, Maximum PAR: 12,687. No change in critical infrastructure. No potential EJ.

5.2 No Action – Current System Operation and Current MRRP Implementation

Beyond determining qualitative impacts to the population, population at risk can be computed quantitatively in HEC-FIA. Table 22 shows the population at risk totals under No Action. The largest modeled flood events indicated 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 22. Population at Risk (PAR) 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 potential environmental justice populations under No Action would occur to a minority race block group in Woodbury County, IA and minority race and poverty block groups in Jackson and St. Louis counties in Missouri.

Another aspect of OSE is potential impacts to critical infrastructure under large flood events. HSIP (Homeland Security Infrastructure Program) Gold is a database of critical facilities that was imported into the HEC-FIA model. HEC-FIA then reports what facilities are impacted during individual events. The largest lower and upper river events were selected for comparison across MRRMP-EIS alternatives. The quantity and type of facilities impacted for No Action is shown for the lower and upper river in Table 23.

Table 23. 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
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

5.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

For Alternative 2, the greatest changes in PAR relative to 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 24 shows the PAR under Alternative 2.

Table 24. PAR 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 minority race population 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 minority race and poverty block group 291892101003 in St. Louis County, Missouri 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 25 lists the type and quantity of critical infrastructure that would be impacted according to the largest modeled flood event during the period of record 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 25. Critical Infrastructure Impacted under Alternative 2

Critical Infrastructure	Lower River	Upper River
Agricultural Facilities	5	3
Chemical Industries	13	4
Communication Towers	3	0
Educational Schools	1	1
Emergency – EMS	4	0
Emergency – Fire Stations	5	0
Emergency – National Shelters	2	2

Critical Infrastructure	Lower River	Upper River
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

5.4 Alternative 3 – Mechanical Construction Only

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 26 shows the PAR totals under Alternative 3.

Table 26. PAR 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 Missouri block group 291892101003 in St. Louis County, Missouri with a minority race and poverty population 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 27 lists the type and quantity of critical infrastructure that would be impacted during the largest modeled flood event in the period of record 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 27. 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
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

5.5 Alternative 4 – Spring ESH Creating Release

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 28 shows the PAR under Alternative 4.

Table 28. PAR 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 minority race census block group 191930036004 in Woobury County, Iowa 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 minority race and poverty census block group 291892101003 in St. Louis County, Missouri was also identified as experiencing adverse impacts relative to the Hermann Reach; however these impacts were considered small in nature and not disproportional.

Table 29 lists the type and quantity of critical infrastructure that would be impacted under the largest modeled flood event in the period of record 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 29. 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

Critical Infrastructure	Lower River	Upper River
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

5.6 Alternative 5 – Fall ESH Creating Release

For Alternative 5, the greatest changes in PAR relative to 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 30 shows the PAR under Alternative 5.

Table 30. PAR 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 Missouri block group 291892101003 with a minority race and poverty population in St. Louis County 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 31 lists the type and quantity of critical infrastructure that would be impacted during the largest flood event during the modeled period of record 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 31. Alternative 5 Critical Infrastructure at Risk

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

5.7 Alternative 6 – Pallid Sturgeon Spawning Cue

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 32 shows the PAR under Alternative 6.

Table 32. Alternative 6 Population at Risk

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 minority race census block group 191930036004 in Woodbury County, Iowa 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 Missouri block group 291892101003 with a minority race and poverty population in St. Louis County, would also experience adverse impacts relative to the Hermann Reach; however these impacts were considered small in nature and not disproportional.

Table 33 lists the type and quantity of critical infrastructure that would be impacted during the largest flood event during the period of record 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 33. Alternative 6 Critical Infrastructure at Risk

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

Critical Infrastructure	Lower River	Upper River
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

6.0 Environmental Quality Results

This account was not evaluated for flood risk management.

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