APPENDIX F

ENVIRONMENTAL CONSEQUENCES TECHNICAL REPORTS

Fort Peck Dam Test Releases
Environmental Impact Statement

Flood Risk Management
Environmental Consequences Analysis

Technical Report

April 2020

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Acronyms and Abbreviations

BiOp Biological Opinion (amended in 2003)

cfs cubic feet per second

DSS Data Storage System

EQ environmental quality (account)

ER Engineering Regulation

ESA Endangered Species Act

ESH emergent sandbar habitat

FPDTR-EIS Fort Peck Dam Test Releases - Environmental Impact Statement

FRM flood risk management

H&H hydrologic and hydraulic (model)

HC human considerations

HEC Hydrologic Engineering Center

M&I municipal and industrial

MRRP Missouri River Recovery Program

NED national economic development (account)

O&M operations and maintenance

OSE other social effects (account)

P&G 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies

POR period of record

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

1.0 Introduction

The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Fort Peck Dam Test Releases – Environmental Impact Statement (FPDTR – EIS). The purpose of the Environmental Impact Statement (EIS) is to assess the potential impacts of a range of test flow release alternatives from Fort Peck dam designed to benefit reproduction and recruitment of pallid sturgeon to avoid jeopardizing their continued existence in the Missouri River.

The purpose of the Flood Risk Management Technical Report is to provide additional information on the impact analysis and results relevant to flood risk management that was completed for the FPDTR-EIS. Additional details on the National Economic Development (NED) methodology and results are provided in this technical report. The Regional Economic Development (RED) and Other Social Effects (OSE) are presented in the FPDTR-EIS, Chapter 3 Environmental Consequences, Section 3.5 Flood Risk Management. No Environmental Quality (EQ) analysis was undertaken for flood risk management.

1.1 Summary of Alternatives

The FPDTR-EIS evaluates the following alternatives. A detailed description of the alternatives is provided in Chapter 2 of the FPDTR-EIS.

No Action Alternative: The impacts of the No Action Alternative serve as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. When modeling the No Action Alternative, local inflows are adjusted by the difference between the historic (depletions that would have occurred as intakes and other sources of withdrawals were built) and present level depletions (depletions that would have occurred if all sources of current water withdrawals were present throughout the simulation) to ensure the period-of-record (POR) datasets are homogenous and reflect current water use. All modeled flood targets are as outlined in the 2018 Master Manual (USACE,2018) and reservoir storages are based on current reservoir surveys. All four navigation target locations are used when setting navigation releases and the model balances system storage by March 1. To meet navigation service levels, target flows are set at Sioux City, Omaha, Nebraska City, and Kansas City. All four navigation target locations are used when setting navigation releases and the model balances system storage by March 1. It is assumed that other activities and actions for pallid sturgeon in the Upper Basin would be implemented as described in the FPDTR-EIS and 2018 Biological Opinion and the Yellowstone Intake Bypass EIS. These actions include fish bypass construction at Yellowstone Intake, continued propagation and stocking of pallid sturgeon in the Upper Basin, and continued pallid sturgeon science and monitoring activities in the Upper Basin.

Alternative 1: System operations under this alternative are based on those described under the No Action Alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon.

The attraction flow regime begins on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in the given year. For example, the typical early spring release from Fort Peck Dam is approximately 8,000 cubic feet per second (cfs); therefore, the attraction flow regime peak flow would be 16,000 cfs as measured at the Wolf Point gage. The Wolf Point stream gage is located near Wolf Point, MT at river mile 1701.5. Beginning on April 16, spring release flows are increased by 1,700 cfs per day until the peak flow is reached at the Wolf Point gage. The peak flow is held for 3 days and then decreases by 1,300 cfs per day until the retention flow is reached. The retention flow is 1.5 times the Fort Peck Dam early spring release as measured at the Wolf Point gage, 12,000 cfs using the example. The retention flow is held until May 28 when the spawning cue flow regime is initiated.

The spawning cue flow regime under Alternative 1 begins on May 28 and is 3.5 times the Fort Peck Dam spring flow release in the given year. Assuming 8,000 cfs as the typical spring flow, this equates to approximately 28,000 cfs at the peak as measured at the Wolf Point gage. Beginning on May 28, the release is increased by 1,100 cfs per day until the peak flow is reached as measured at the Wolf Point gage. The peak is held for 3 days and then decreases by 1,000 cfs per day for 12 days, then decreases by 3,000 cfs per day until the drifting flow regime of 8,000 cfs is reached. The 8,000 cfs drifting flow regime is held until September 1 when releases to balance storage resume.

Variation 1A: This test flow is a variation of Alternative 1. The parameters for Variation 1A are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The April 9 initiation date is closer to the timing of the initial pulse shown on the unregulated hydrograph. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases. In Alternative 1, the later initiation date of April 16 is designed to enhance the contrast between Missouri River and Yellowstone River discharges by moving the start date approximately two weeks later than the initial pulse shown on the unregulated hydrograph.

Variation 1B: This test flow is another variation of Alternative 1. The parameters for Variation 1B are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 23 and the spawning cue flow regime is initiated on June 4. Similar to the concept described in 1A, the later initiation date is intended to provide contrast and explore any differences in forecasted impacts from a later flow initiation date.

Alternative 2: The parameters for Alternative 2 are the same as described for Alternative 1 except that the attraction flow regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at the Wolf Point gage are held at 14,000 cfs until the spawning cue flow release is initiated. The rationale for keeping the releases high through this period—foregoing the inter-pulse saddle (retention pulse) —is the hypothesis that persistent high flows are needed to hold migrated, reproductive adult pallid sturgeon upstream near the dam.

Variation 2A: This test flow is a variation of Alternative 2. The parameters for Variation 2A are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The difference in timing follows the same reasoning as described for Variation 1A.

Variation 2B: This test flow is another variation of Alternative 2. The parameters for Variation 2B are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 23, rather than April 16, and the spawning cue flow regime is initiated on June 4, rather than May 21. The difference in timing follows the same reasoning as described for Variation 1B.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the FPDTR-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the FPDTR-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR 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 FPDTR-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 NED account displays changes in the economic value of the national output of goods and services expressed in monetary units.

- The RED account registers changes in the distribution of regional economic activity (i.e., jobs and income).

- The EQ account displays non-monetary effect on significant natural and cultural resources.

- The OSE account registers plan effects from perspective 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 to Flood Risk Management of the FPDTR-EIS

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.

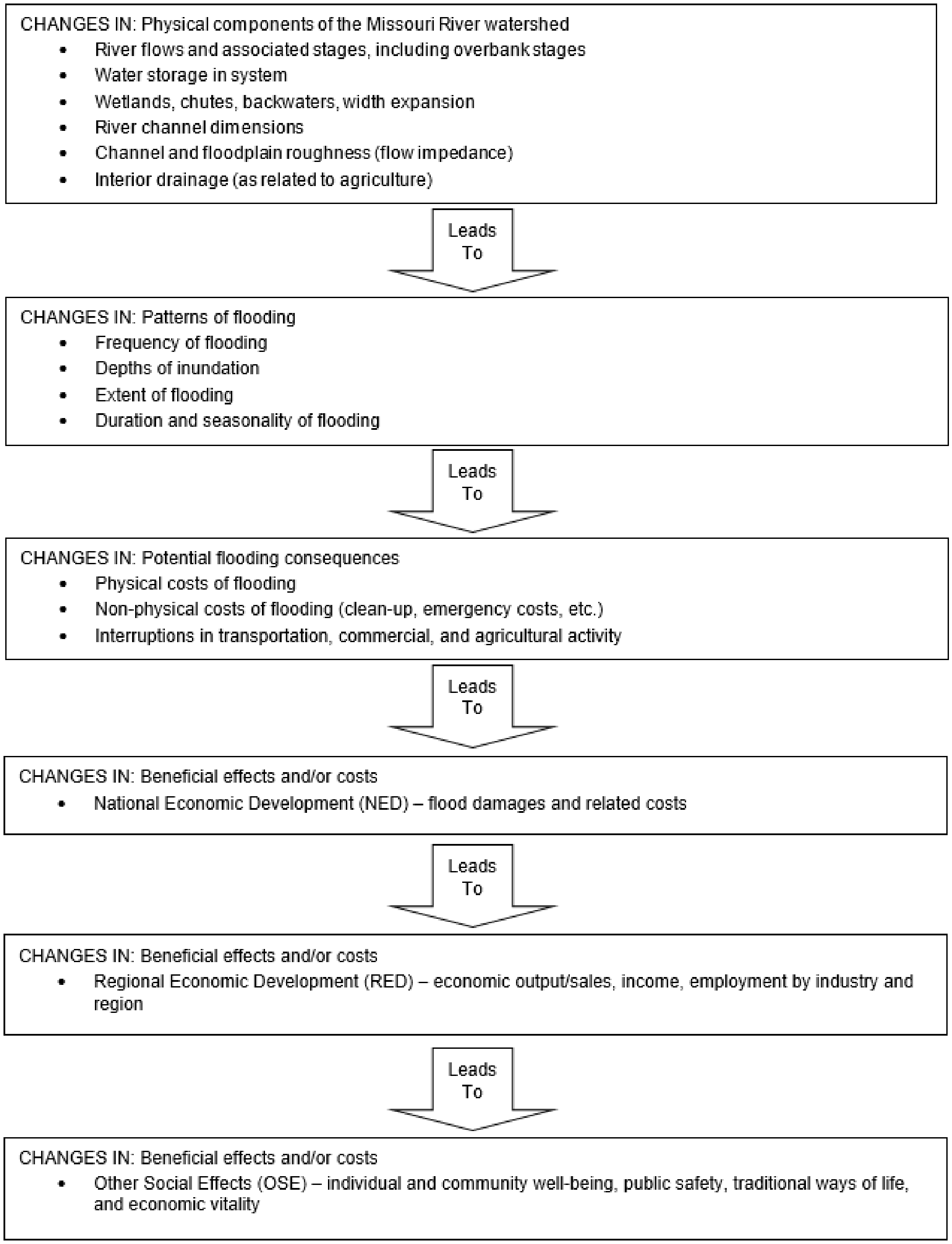

Figure 1. Flow Chart of Inputs Considered in Evaluation of Impacts to Flood Risk Management

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.

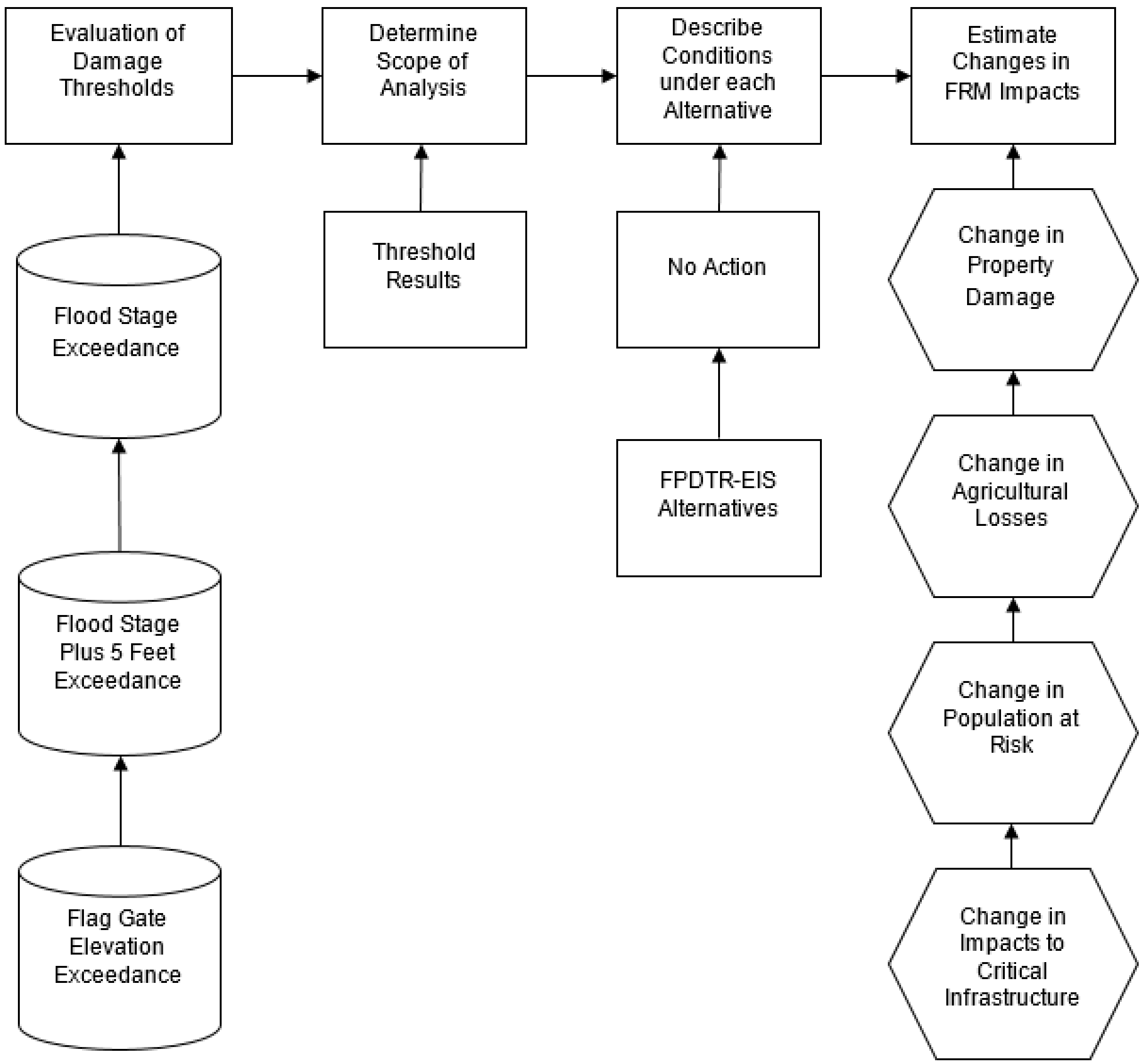

Figure 2. Approach for Evaluating Environmental Consequences to Flood Risk Management

2.0 Assumptions, Limitations, and Risks

2.1 Assumptions and Limitations

In modeling the environmental consequences to flood risk management from the FPDTR -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 FPDTR -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.

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 FPDTR-EIS 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 POR. 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 in the flood risk management model described is this document. The project team has attempted to address risk and uncertainty in the FPDTR-EIS 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 Geographic Areas

Flood risk management impacts are located all along the Missouri River. The impacts evaluated were organized into reaches depending on their location. These reaches include: Fort Peck Dam to Garrison Dam, Garrison Dam to Oahe Dam, and Fort Randall Dam to Gavins Point Dam. The Oahe Dam to Big Bend Dam and Big Bend Dam to Fort Randall Dam were not modeled due to the lack of riverine conditions between these dams. Figure 3 shows a map of the three reaches modeled.

Fort Peck Dam to Garrison Dam: the reach extends from Fort Peck Dam in Montana to Garrison Dam in North Dakota. This reach includes part of the city of Williston, North Dakota.

Garrison Dam to Oahe Dam: the reach extends from Garrison Dam in central North Dakota to Lake Oahe Dam in South Dakota near Pierre. This reach includes part of the metropolitan area of Bismarck, North Dakota.

Fort Randall Dam to Gavins Point Dam: this reach in South Dakota extends from Fort Randall Dam to Gavins Point Dam near Yankton, South Dakota. Locations subject to flooding includes stretches from the mouth of the Niobrara River downstream to the outskirts of Springfield, South Dakota.

Figure 3. Hydraulic Modeling Reaches

2.4 Economic Analysis and Modeling

A model was developed using the Hydrologic Engineering Center Flood Impact Analysis (HEC-FIA) to evaluate the change in NED, RED, and OSE impacts associated with flood risk management as a result of the FPDTR -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 estimates 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. Given the 82-year period of record, HEC-FIA estimated:

- Direct economic damages – 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.

3.0 Methodology

3.1 National Economic Development

NED effects are defined as changes in the net value of the national output of goods and services. In the case of flood risk management, the conceptual basis for the NED impacts analysis is an increase or decrease in risk of physical and non-physical damage from flooding. The measurement of national economic effects was based on the estimated change in flood risk to structures and associated property and agriculture resulting from the FPDTF-EIS alternatives. Risk and uncertainty were not incorporated into HEC-FIA for this study. Uncertainty in any economic variable i snot expected to change the conclusions of the flood risk analysis.

3.1.1 Property Damage Computation

In HEC-FIA, property damages are described by the magnitude of damages to buildings, their contents, and vehicle values resulting from a flood event. Four inputs are required to compute the direct damages at locations throughout the study area: (i) Terrain Model, (ii) Structure Inventory, (iii) Inundation Data, and (iv) Depth-Percent Damage Relationships. All GIS inputs for the model are in NAVD 1988 GCS North American 1983 projection.

A terrain model in HEC-FIA is defined by importing a Digital Elevation Model (DEM) into the program. The DEM represents the ground elevation for the region being studied in a gridded format, which is used to provide elevation data for the structure inventory. The terrain is only used in the HEC-FIA computations when the input hydraulics data is defined using cross sectional data with hydrographs. For the Missouri River HEC-FIA model, a tiled image format (*.tif) terrain created by the HEC-RAS model was used.

Economic losses associated with direct damage to property are based on a structure inventory populated from the National Structure Inventory (NSI2) database. The NSI2 is a data service with a base dataset containing estimated information regarding the locations, building types, population, values, and other relevant information for all residential, commercial, industrial, agricultural, public, and private structures across the nation. The base dataset utilizes parcel data, Census data, Microsoft building footprints, and several other sources that serve as a basis for estimating flood hazard consequences. After the structure points were downloaded to the study areas, they were adjusted to more refined locations as appropriate. Population and structure values are estimated from a variety of sources, but are intended to reflect 2017 population levels and 2020 price levels.

Computing consequences in an HEC-FIA project requires inundation data. Inundation data provides a pattern for HEC-FIA simulations, through defining the source and type of hydraulic information at any point in the study area. For the Missouri River HEC-FIA model, the inundation data was provided as a HEC-DSS (Data Storage System) file that contains stage hydrographs at cross sections and storage areas throughout the study area. The cross sections and storage areas define the geographic locations of the stage hydrographs. Time-series information is exchanged between HEC-DSS and HEC-FIA at each of the georeferenced cross section and storage area locations.

A depth-percent damage relationship (i.e., curve) defines the percent damage caused to a structure, a structure's contents, and any vehicles stored at a structure at incremental depths. As depth increases, percent damage also increases. Depth-percent damage relationships are defined in HEC-FIA within the Structure Occupancy Type. A structure occupancy type describes a class of structures (e.g. single family, no basement, one story). Data entered for a structure occupancy type is applied to all the structures assigned to that structure occupancy type. For this analysis, the default depth-percent damage relationships provided in HEC-FIA and commonly associated with the NSI2 structures were used. While not specific to the region, the relationships are acceptable for use with NIS2 structures, especially for screening level efforts or when analyzing relative changes to consequences based on alternative flow or inundation scenarios. An example structure occupancy for a 1-story, no basement residential is provided in Figure 4.

Depths in the depth-percent damage relationships are relative to the first floor, which is determined by adding the structure foundation height to the ground elevation. For this analysis, default foundation heights for the different occupancy types were utilized and were not sampled, surveyed, or adjusted. This variable is not expected to change the conclusion of the NED analysis.

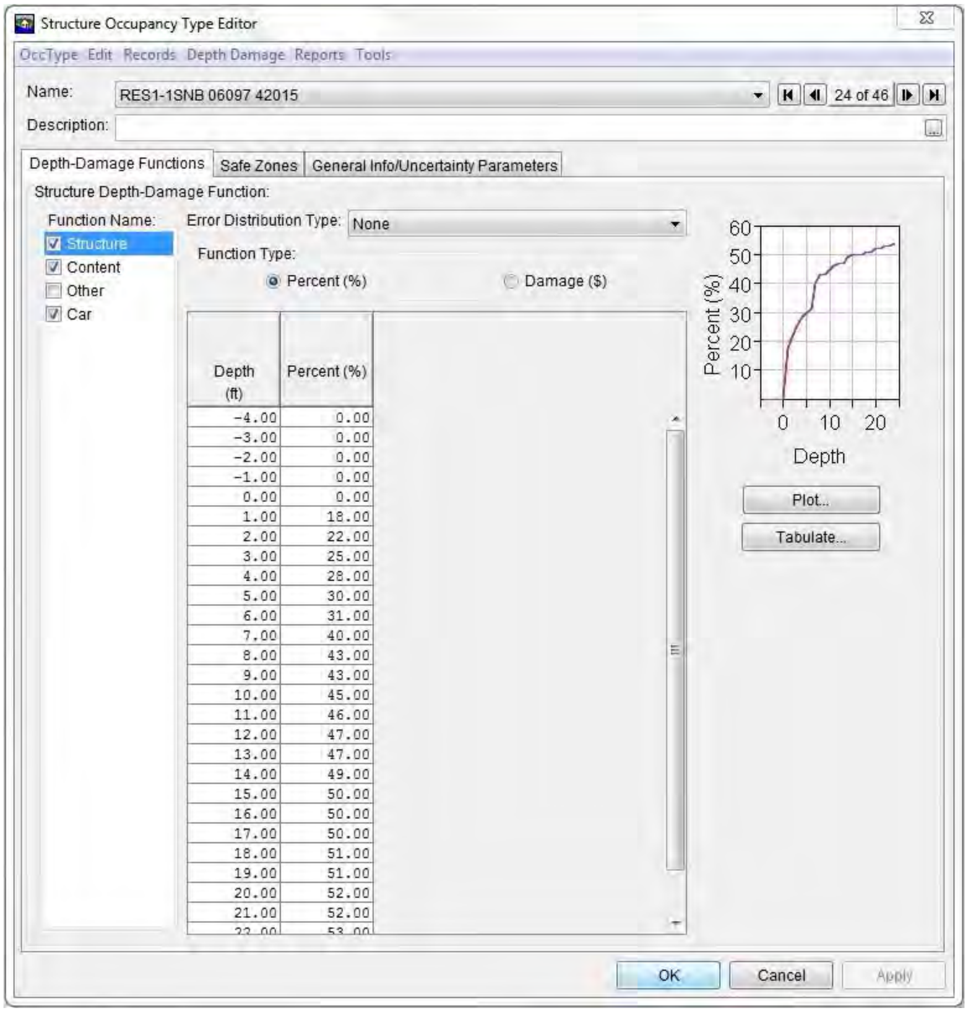

Figure 4. Example of Depth-Damage Function by Structure Occupancy

Direct damages to a building, its contents, and its vehicles are calculated for a single structure as follows: $D_i = d_i * v_i$ where D_i is the direct damage, where the subscript i is used to represent buildings, contents, or vehicles; d_i is damage (in percent) as a function of depth and occupancy type, and v_i is value. To determine the percent direct damage to buildings, contents, and vehicles, both the depth at the structure and occupancy type of the structure need to be known. The occupancy type is specified as part of the structure inventory and is associated with individual depth-percent damage relationships for the building, contents, and vehicles. Therefore, the depth at the structure can be used to determine the percentage that the building, contents, and vehicles are damaged. This percent damage can then be multiplied by the building, contents, and vehicles values (specified in the structure inventory) to determine the total direct damage that occurs at and within a structure.

For the FPDTR-EIS, HEC-FIA was run to compute the property and infrastructure damages associated with the maximum annual 1-day duration stage event for each year in the 82-year period of record. It should be noted, that the date of the highest 1-day stage may very between No Action and the alternatives. The incremental analysis compares the highest 1-day damage total for any day during a given year under No Action and the highest 1-day damage total for each of the alternatives for any day in that same year.

3.1.2 Agricultural Damage Computation

When flooding occurs in agricultural areas, damages can occur to existing crops as well as interruptions to the planting, growing, and harvesting of crops. HEC-FIA can be used to compute the economic impacts of flooding these types of areas. Five inputs are required: (i) Duration of Inundation Data, (ii) National Agricultural Statistics Service Data, (iii) Crop Planting Data, (iv) Crop Harvesting Data, and (v) Duration-Damage Relationships.

HEC-FIA uses the same inundation data mentioned in Section 3.1.1 Property Damage Computation, but in addition to comparing the stage hydrograph at each agricultural point it also looks at the duration of that stage to compute damages.

Agricultural losses were based on data downloaded from USDA's National Agricultural Statistics Service (NASS). The National Agricultural Statistics Service (NASS) Cropland Data Layer is a product that represents the type of crop and the geographic location of crops throughout the entire United States. The Cropland Data Layer is provided in the GeoTiff format, where each cell represents a crop type. HEC-FIA imports this data from the NASS API (Application Programming Interface) to streamline the collection of the type and distribution of crops in the study area.

Once the crops for the study area were identified, several variables in the model's "Crop Loss Editor" were inputted. The planting and harvesting dates for each crop were defined. The planting and harvesting dates were derived from the NASS Agricultural Handbook Number 628: "Field Crops: Usual Planting and Harvesting Dates". Another variable includes the cost to produce the crop. This includes the fixed costs and variable costs associated with planting and harvesting. These costs are defined on a monthly basis in the model. Additionally, the price received for crops and estimated yield information were populated. The crop budget data including the production costs and the estimated yields were obtained from the respective state's agricultural extension service. Further information and links to the each state's crop budget data can be found in the references section of this document (North Dakota data was used for Montana since current crop data was not available for Montana). For data on the prices received for crops, the U.S. Department of Agriculture Economic Research Service (ERS) annually calculates "normalized prices," which smooths out the effects of short run seasonal or cyclical variation for key agricultural inputs and outputs. In accordance with USACE guidance, the state-level normalized prices were calculated by multiplying the national-level normalized prices by the average ratios of the state-level market prices to the national market prices.

A seasonal duration-damage curve from the HEC's AGDAM (Agricultural Flood Damage Analysis) User's Manual was also used to define the percent of crop damage associated with the duration (in days) of inundation.

The computational procedures used by HEC-FIA to calculate agriculture flood damages at a single crop cell uses the inundation durations from the HEC-DSS stage hydrographs. Additionally, the procedures assume that crops are planted at the first available date after flooding and that crops will be planted immediately before an event (meaning that weather forecasting is not taken into account). Once the input data is defined, the model then follows these computational procedures:

1. Determine the crop type in each cell.
2. Determine the arrival of flooding for the crop cell.
3. Determine the duration of flooding for the crop cell.
4. Based on the arrival time and duration, determine if planting dates are impacted or if the crop is damaged before harvest.

5. If damaged during the growing season, determine if the duration is longer than the longest duration damage curve; if so, the model assumes all value placed in the field so far is lost. The loss is equivalent to the marketable value minus harvest costs, prorated by total value input to the field.
6. If the flooding caused planting later than the first day of the season for the primary crop, but the farmer was able to plant the primary crop later in the season, the damages are based on a reduction in full yield due to late planting.
7. After calculating the loss for each crop cell in the inundated area using the process described above, the output is displayed showing the crop type, location, duration, and total damage for each crop cell damaged.

3.2 Regional Economic Development

The RED analysis evaluated the regional economic impacts associated with agricultural damages 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 FPDTR-EIS alternatives. The largest adverse impact to agriculture compared to No Action occurs in the Fort Peck Dam to Garrison Dam reach under the 1983 Alternative 1 simulation. The three most prominent crops in this reach, spring wheat, soybeans, and durum wheat, affect two sectors of farming: oilseeds and grain farming. Applying the full value of the adverse impact, $279,000, to either of these sectors in RECONS results in less than one direct job affected and less than 2 total jobs affected. Therefore, it was determined that a full quantitative RED analysis was not needed.

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

3.3 Other Social Effects

Changes in flood risk have a potential to cause other types of effects on individuals and communities in terms of individual and community 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 FPDTR-EIS alternatives was examined to the extent possible. Inputs necessary for determining population at risk and impacts to potential populations of concern were based on 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 are at risk of inundation.

Flood risk impacts to critical infrastructure were also determined in the HEC-FIA model. The critical infrastructure inventory was imported from the HSIP (Homeland Security Infrastructure Program) 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.

3.4 Environmental Quality

This account was not evaluated for flood risk management.

4.0 National Economic Development Evaluation Results

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

4.1 Summary of National Economic Development Results

Tables 1 and 2 provide an overall summary of the NED analysis for each of the FPDTR-EIS alternatives. Table 1 summarizes the results for all of the average annual flood damages over the modeled 82-year period of record from Fort Peck Dam to Gavins Point Dam. Relative to No Action, both alternatives 1 and 2 and their variations showed a slight increase in flood damages with Alternative 2 exhibiting the largest adverse impact with just over $49,000 in increased average annual flood damages. Note that annual values are not expected annual or based on a statistical range of events, and are calculated by averaging the modeled results from each annual peak over the period of record.

Average Annual Flood Damages from Fort Peck Dam to Gavins Point Dam

	No Action	Alternative 1	Variation 1A	Variation 1B	Alternative 2	Variation 2A	Variation 2B
Property Damages	$1,616,634	$1,620,703	$1,614,166	$1,644,448	$1,650,681	$1,620,759	$1,650,152
Agricultural Losses	$522,489	$538,378	$528,129	$537,745	$537,754	$535,841	$539,639
Total Flood Damages	$2,139,123	$2,159,081	$2,142,295	$2,182,193	$2,188,435	$2,156,599	$2,189,791
Change from No Action		$19,958	$3,172	$43,070	$49,312	$17,476	$50,668
Percentage Change No Action		0.93%	0.15%	2.01%	2.31%	0.82%	2.37%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level.

Table **2**summarizes the NED analysis for each of the reaches relative to No Action. In the Fort Peck to Garrison reach, Variation 2B showed the largest percentage increase in average annual flood damages with an increase of 4 percent, or just under $18,000. Variation 1B exhibited the largest increase in the Garrison to Oahe reach with average annual damages increasing by just under $28,000 or 1.9 percent. All damage increases in the Fort Randall to Gavins Point reach were less than $10,000 annually with the largest being $7,000 under Alternative 2.

Table 2. Estimated Annual NED Flood Damages of FPDTR-EIS Alternatives by Reach

Reach	No Action	Alternative 1	Variation 1A	Variation 1B	Alternative 2	Variation 2A	Variation 2B
Fort Peck to Garrison	**$442,334**	**$459,681**	**$447,860**	**$457,479**	**$458,228**	**$454,429**	**$460,186**
Change from No Action		$17,347	$5,526	$15,145	$15,894	$12,095	$17,852
Percentage Change from No Action		3.92%	1.25%	3.42%	3.59%	2.73%	4.04%
Garrison to Oahe	**$1,444,151**	**$1,443,993**	**$1,443,977**	**$1,471,941**	**$1,470,542**	**$1,445,775**	**$1,470,178**
Change from No Action		-$158	-$174	$27,790	$26,391	$1,624	$26,027
Percentage Change from No Action		-0.01%	-0.01%	1.92%	1.83%	0.11%	1.80%
Fort Randall to Gavins Point	**$252,638**	**$255,407**	**$250,458**	**$252,773**	**$259,665**	**$256,396**	**$259,426**
Change from No Action		$2,769	-$2,180	$135	$7,026	$3,757	$6,788
Percentage Change from No Action		1.10%	-0.86%	0.05%	2.78%	1.49%	2.69%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level. Negative numbers indicate a decrease in damages relative to No Action.

4.2 No Action

Under No Action, operations would be closely based on the 2018 Master Manual criteria. Local inflows are adjusted by the difference between the historic and present level depletions to ensure period-of-record datasets are homogeneous and reflect current water use. Flood targets are as outlined in the 2018 Master Manual.

Modeling results under No Action indicate that the Missouri River floodplain would continue to experience flood damages 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 from actions from the No Action alternative.

The NED analysis for No Action is summarized in Table 3. The estimated flood damages to the Missouri

River floodplain between Fort Peck Dam and Gavins Point Dam are $2.1 million under No Action. Average annual flood damages totaled $442K in the Fort Peck Dam to Garrison Dam reach, $1.4 million in the Garrison Dam to Oahe Dam reach, and $253K in the Fort Randall Dam to Gavins Point Dam reach. In the Fort Peck Dam to Garrison Dam reach, the flood damages are approximately 88 percent agricultural, whereas in the Garrison Dam to Oahe Dam reach, the flood damages are approximately 98 percent urban property. In the Fort Randall Dam to Gavins Point Dam reach, the average annual flood damages are approximately 57 percent urban property and 43 percent agricultural.

Table 3. NED Analysis Summary for No Action by Reach

River Reach	Average Annual Property Damages	Average Annual Agricultural Losses	Average Annual Total Flood Damages
Total	**$1,616,634**	**$522,489**	**$2,139,123**
Fort Peck Dam to Garrison Dam	$53,945	$388,390	$442,334
Garrison Dam to Oahe Dam	$1,418,334	$25,817	$1,444,151
Fort Randall Dam to Gavins Point Dam	$144,356	$108,282	$252,638

Notes: Average annual values at the Fiscal Year (FY) 2020 price level

4.3 Alternative 1

Alternative 1 is based on the No Action but includes a flow regime at Fort Peck for the pallid sturgeon. Actions included under this alternative that may have impacts to flood risk management include:

- Attraction Flow Regime: Initialize on April 16; Wolf Point flows increase by 1,700 cfs per day until peak flow is reached; peak flow is 2 times the spring release from Fort Peck; hold peak for 3 days, Wolf Point flows decrease by 1,300 cfs per day until retention flow is reached.

- Retention Flow Regime: Wolf Point flows remain at 1.5 times the spring release from Fort Peck.

- Spawning Cue Flow Regime: Initialize on May 28; Wolf Point flows increase by 1,100 cfs per day until peak flow is reached; peak flow is 3.5 times the spring release from Fort Peck; hold peak for 3 days; Wolf Point flows decrease by 1,000 cfs for 12 days and then decrease by 3,000 cfs until 8,000 cfs is reached.

- Drifting Flow Regime: Wolf Point flows remain at 8,000 cfs until September 1.

The NED analysis for Alternative 1 is summarized in Table 4. The Alternative 1 modeling indicates that flood risk management impacts along the Missouri River between Fort Peck Dam and Gavins Point Dam would average $20K more per year relative to No Action. This represents an overall increase in flood damages of 0.93 percent. The largest adverse impact would occur in the Fort Peck Dam to Garrison Dam reach, which would experience an increase in average annual flood damages of $17,347 or 3.9 percent. Over 93 percent of this increase would be from increased agricultural losses.

Table 4. NED Analysis Summary for Alternative 1 by Reach

River Reach	Average Annual Property Damages	Average Annual Agricultural Losses	Average Annual Total Flood Damages	Average Annual Change from No Action	% Change from No Action
Total	**$1,620,703**	**$538,378**	**$2,159,081**	$19,958	0.93%
Fort Peck Dam to Garrison Dam	$55,242	$404,440	$459,681	$17,347	3.92%

Garrison Dam to Oahe Dam	$1,418,233	$25,760	$1,443,993	-$158	-0.01%
Fort Randall Dam to Gavins Point Dam	$147,228	$108,179	$255,407	$2,769	1.10%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level. Negative numbers indicate a decrease in damages relative to No Action.

When evaluating the impacts of each of the FPDTR-EIS alternatives, it is helpful to examine the annual impacts. Figure 5 shows the change in annual NED flood risk management impacts under Alternative 1 relative to No Action in the upper river. Some notable results include:

- In the 82-year period of record, 31 years showed an increase in flood damages relative to No Action although the impacts in the majority of the years were relatively small. An additional 29 years showed decreases in flood damages with 22 years showing no change.
- The modeled range of impacts compared to No Action varied from a decrease in flood damages of $88,195 in the 1998 simulation to an increase in damages of $290,698 under the 1983 simulated event.
- The majority of changes in annual damages are the result of changes in agricultural losses in the Fort Peck Dam to Garrison Dam reach.
- The overall adverse impacts in the 1983 simulation were primarily driven by the increase in flood damages within the Fort Peck Dam to Garrison Dam reach. The Fort Randall Dam to Gavins Point Dam exhibited an increase of $249,125 in the 2011 simulated event, whereas the maximum adverse impact to the Garrison Dam to Oahe Dam reach was only $248 (1978).

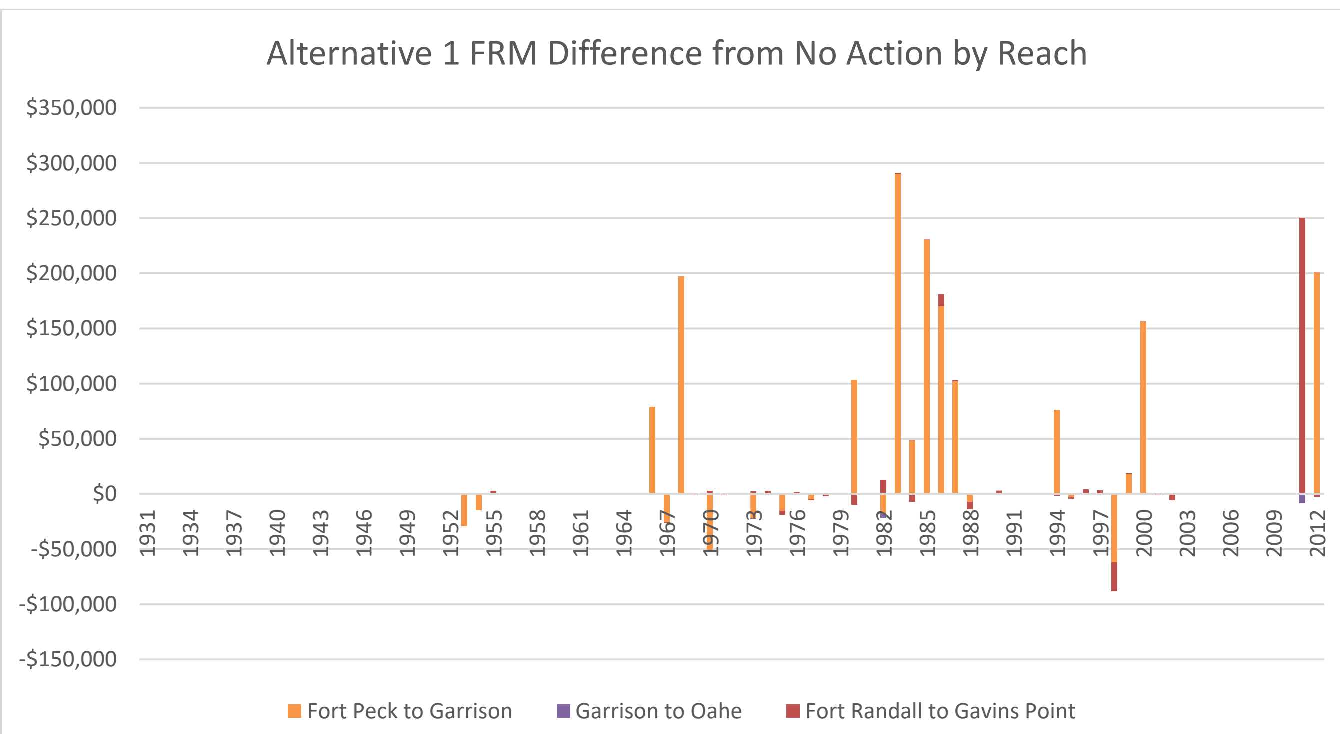

Figure 5. Alternative 1 Annual Flood Damage Difference from No Action by Reach

Additional results highlighting the difference by release type are shown in Figure 6. Here the difference in NED impacts between Alternative 1 and No Action are plotted and color-coded based on the type of modeled release occurring each year. During the period of record, there were 11 full flow years and 11 partial flow years. Some notable results include:

- Seven out of the 11 full flow years exhibited adverse impacts relative to No Action, with the largest being $290,698 under the 1983 simulated flow event.
- Five out of the 11 partial flow years showed adverse impacts relative to No Action, with the greatest increase being $198,343 under the 2012 simulated flow event.
- On average the full and partial flow event years, increased damages relative to No Action, by $80,892 and $46,654, respectively.

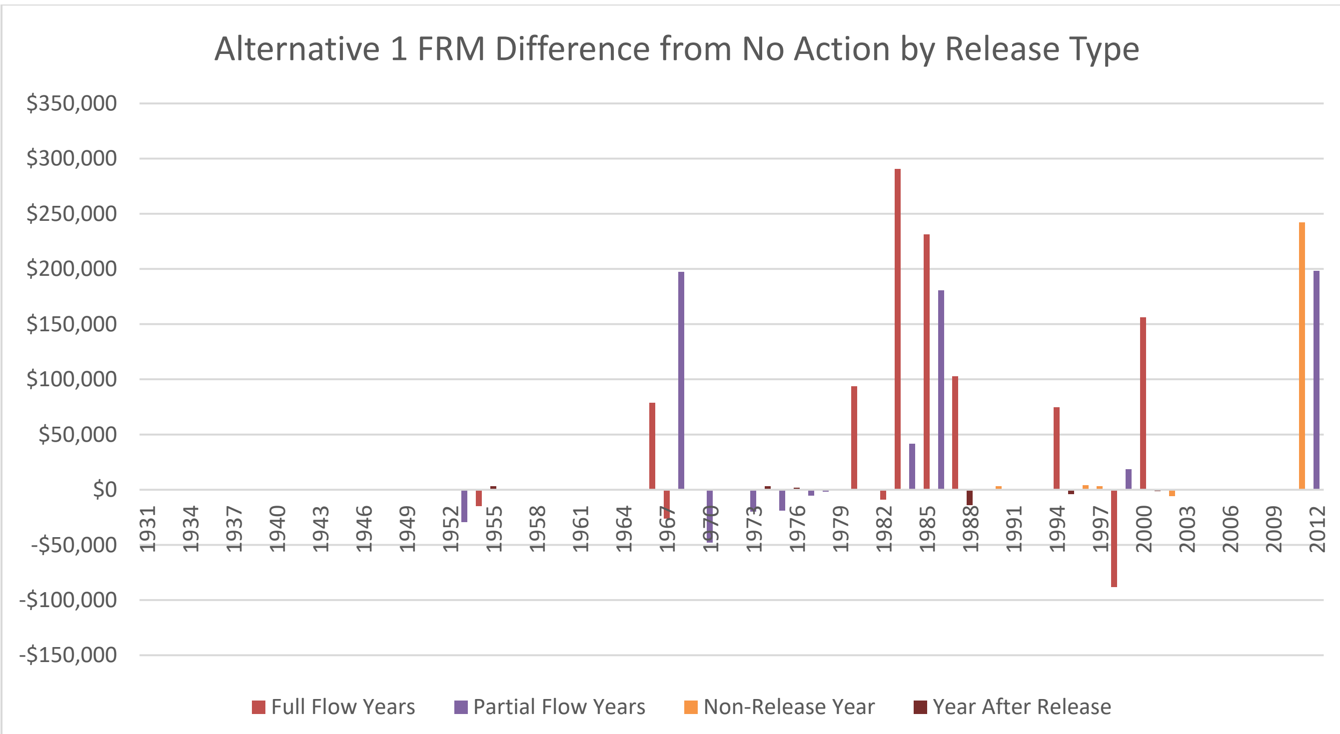

Figure 6. Alternative 1 Annual Flood Damage Difference from No Action by Release Type

4.4 Variation 1A

Variation 1A is based on Alternative 1 but initiating the flow regime one week earlier. Actions included under this variation that may have impacts to flood risk management include:

- Attraction Flow Regime: Initialize on April 9; Wolf Point flows increase by 1,700 cfs per day until peak flow is reached; peak flow is 2 times the spring release from Fort Peck; hold peak for 3 days, Wolf Point flows decrease by 1,300 cfs per day until retention flow is reached.
- Retention Flow Regime: Wolf Point flows remain at 1.5 times the spring release from Fort Peck.
- Spawning Cue Flow Regime: Initialize on May 21; Wolf Point flows increase by 1,100 cfs per day

until peak flow is reached; peak flow is 3.5 times the spring release from Fort Peck; hold peak for 3 days; Wolf Point flows decrease by 1,000 cfs for 12 days and then decrease by 3,000 cfs until 8,000 cfs is reached.

- Drifting Flow Regime: Wolf Point flows remain at 8,000 cfs until September 1.

The NED analysis for Variation 1A is summarized in Table 5. The HEC-FIA modeling indicates that flood risk management damages from Fort Peck Dam to Gavins Point Dam would increase under Variation1A by $3,172 annually relative to No Action. This represents an overall increase in flood damages of 0.15 percent which is the smallest increase among the FPDTR-EIS alternatives.

Table 5. NED Analysis Summary for Variation 1A by Reach

River Reach	Average Annual Property Damages	Average Annual Agricultural Losses	Average Annual Total Flood Damages	Average Annual Change from No Action	% Change from No Action
Total	**$1,614,166**	**$528,129**	**$2,142,295**	**$3,172**	**0.15%**
Fort Peck Dam to Garrison Dam	$53,334	$394,526	$447,860	$5,526	1.25%
Garrison Dam to Oahe Dam	$1,418,182	$25,794	$1,443,977	-$174	-0.01%
Fort Randall Dam to Gavins Point Dam	$142,650	$107,809	$250,458	-$2,180	-0.86%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level. Negative numbers indicate a decrease in damages relative to No Action.

Figure 7 shows the change in annual NED flood risk management impacts under Variation 1A relative to No Action by river reach. Some notable results include:

- In the 82-year period of record, 29 years showed an increase in flood damages relative to No Action although the impacts in the majority of the years were relatively small. An additional 31 years showed decreases in flood damages with 22 years showing no change.

- The modeled range of impacts compared to No Action varied from a decrease in flood damages of $167,321 under the 2011 simulation to an increase in damages of $138,753 in the 1987 simulated event.

- The five years with the greatest adverse impacts (1966, 1985, 1986, 1987, and 2000) were primarily driven by increases in agricultural losses within the Fort Peck Dam to Garrison Dam reach. The Fort Randall Dam to Gavins Point Dam exhibited an increase of $30,164 in the 1986 simulated event, whereas the maximum adverse impact to the Garrison Dam to Oahe Dam reach was only $487 (1994).

- There were two simulated years, 1976 and 2011, that showed a significant reduction in damages with decreases of $148,137 and 167,321 respectively. The reduction in 1976 modeled damages were driven by a decrease in agricultural losses within the Fort Peck Dam to Garrison Dam reach. The reduction in damages under the 2011 event were primarily due to the reduction in property damages within the Fort Randall Dam to Gavins Point Dam reach.

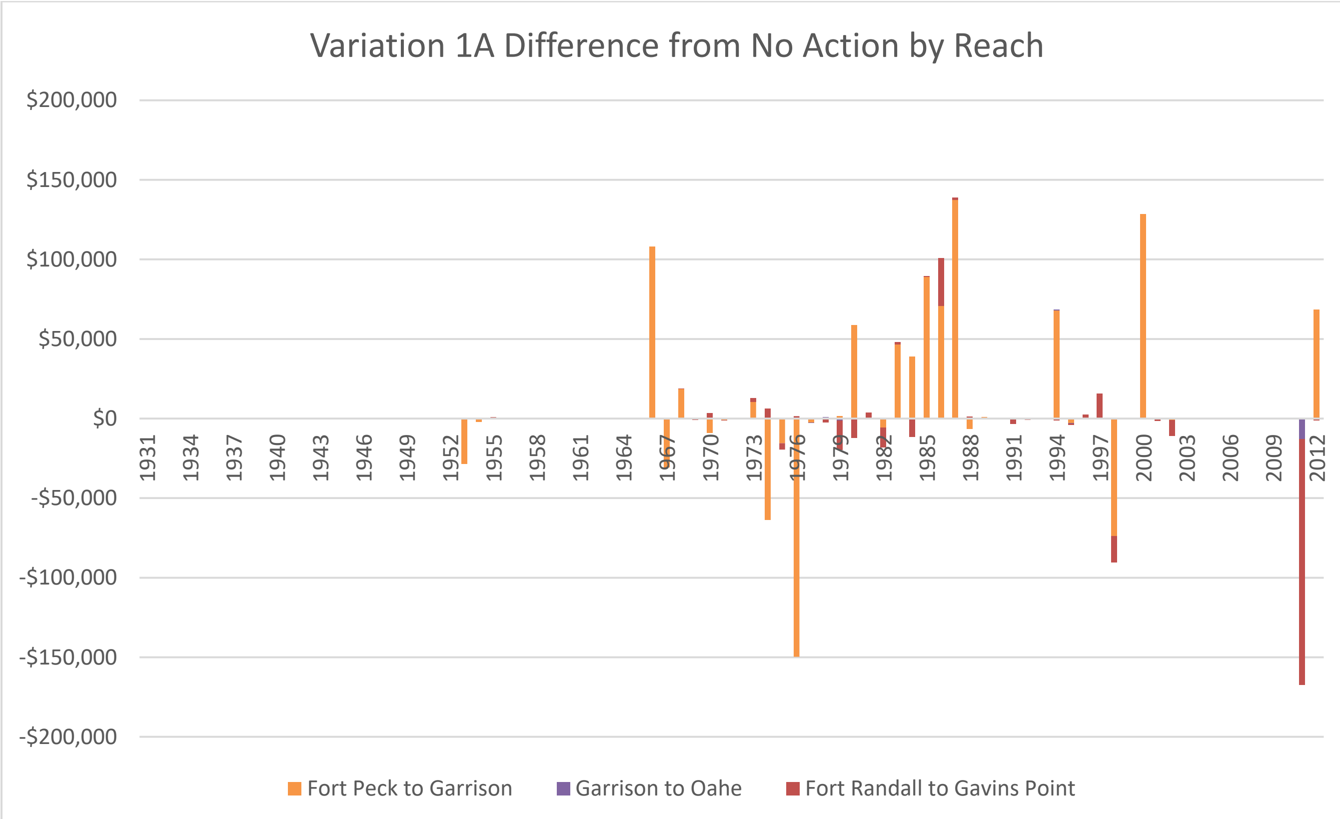

Figure 7. Variation 1A Annual Flood Damage Difference from No Action by Reach

Additional results highlighting the difference by release type are shown in Figure 8. Here the difference in NED impacts between Variation 1A and No Action are plotted and color-coded based on the type of modeled release occurring each year. During the period of record, there were 16 full flow years and 6 partial flow years. Some notable results include:

- Eleven of the 16 full flow years showed an increase in flood damages under Variation 1A relative to No Action. The largest flood damage increase for a full flow year modeled event was $138,753 under the 1987 simulation. The average increase in flood damages under Variation 1A relative to No Action in modeled full flow years was $38,442.

- Only one of the six partial flow years showed an overall increase in flood damages. On average, the annual difference in partial flow years under Variation 1A would be a decrease of flood damages below No Action of $27,457. The single increase occurrence was under the 1973 simulation which showed an increase in flood damages of $12,963 compared to No Action.

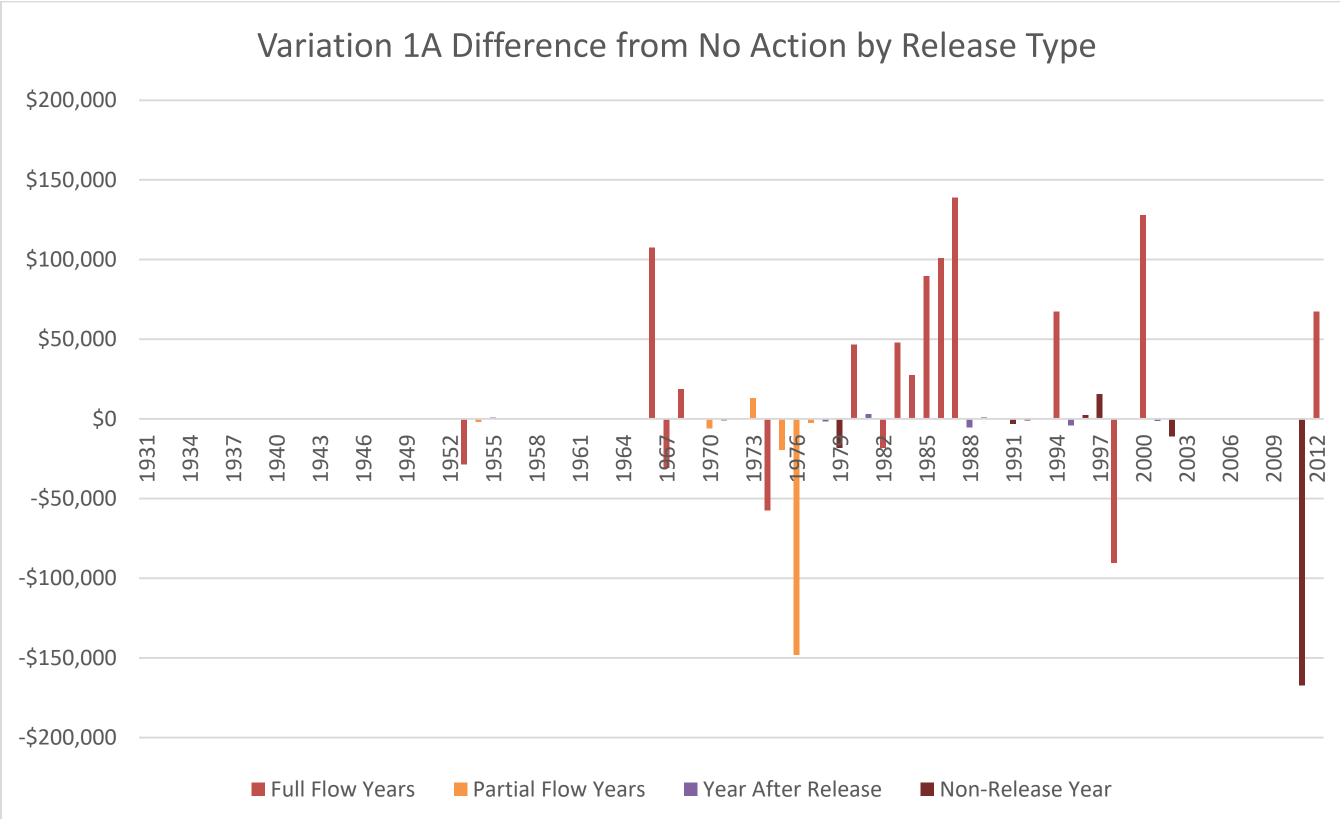

Figure 8. Variation 1A Annual Flood Damage Difference from No Action by Release Type

4.5 Variation 1B

Variation 1B is based on Alternative 1 but initiating the flow regime one week later. Actions included under this alternative that may have impacts to flood risk management include:

- Attraction Flow Regime: Initialize on April 23; Wolf Point flows increase by 1,700 cfs per day until peak flow is reached; peak flow is 2 times the spring release from Fort Peck; hold peak for 3 days, Wolf Point flows decrease by 1,300 cfs per day until retention flow is reached.

- Retention Flow Regime: Wolf Point flows remain at 1.5 times the spring release from Fort Peck.

- Spawning Cue Flow Regime: Initialize on May 21; Wolf Point flows increase by 1,100 cfs per day until peak flow is reached; peak flow is 3.5 times the spring release from Fort Peck; hold peak for 3 days; Wolf Point flows decrease by 1,000 cfs for 12 days and then decrease by 3,000 cfs until 8,000 cfs is reached

- Drifting Flow Regime: Wolf Point flows remain at 8,000 cfs until September 1

The NED analysis for Variation 1B is summarized in Table 6. The Variation 1B modeling indicates that flood risk management impacts from Fort Peck Dam to Gavins Point Dam would increase by $43,070 annually over No Action. This represents an overall increase in flood damages of 2.01 percent which is the largest increase among the Alternative 1 variations.

Table 6. NED Analysis Summary for Variation 1B by Reach

River Reach	Average Annual Property Damages	Average Annual Agricultural Losses	Average Annual Total Flood Damages	Average Annual Change from No Action	% Change from No Action
Total	**$1,644,448**	**$537,745**	**$2,182,193**	**$43,070**	**2.01%**
Fort Peck Dam to Garrison Dam	$54,787	$402,692	$457,479	$15,145	3.42%
Garrison Dam to Oahe Dam	$1,445,665	$26,276	$1,471,941	$27,790	1.92%
Fort Randall Dam to Gavins Point Dam	$143,996	$108,777	$252,773	$135	0.05%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level.

When evaluating the impacts of each of the FPDTR-EIS alternatives, it is helpful to examine the annual impacts. Figure 9 shows the change in annual NED flood risk management impacts under Variation 1B relative to No Action. Some notable results include:

- In the 82-year period of record, 45 years showed an increase in damages relative to No Action although the impacts in the majority of the years were relatively small.

- The modeled range of impacts compared to No Action varied from a decrease in flood damages of $51,613 in the 1998 simulation to an increase in damages of $2,088,346 under the 2011 simulated event.

- The effect of Variation 1B would increase damages by $43,070 on average annually above No Action as a whole, with the majority of that annual increase, $27,790, happening in the Garrison Dam to Oahe Dam reach, due to the 2011 simulated event.

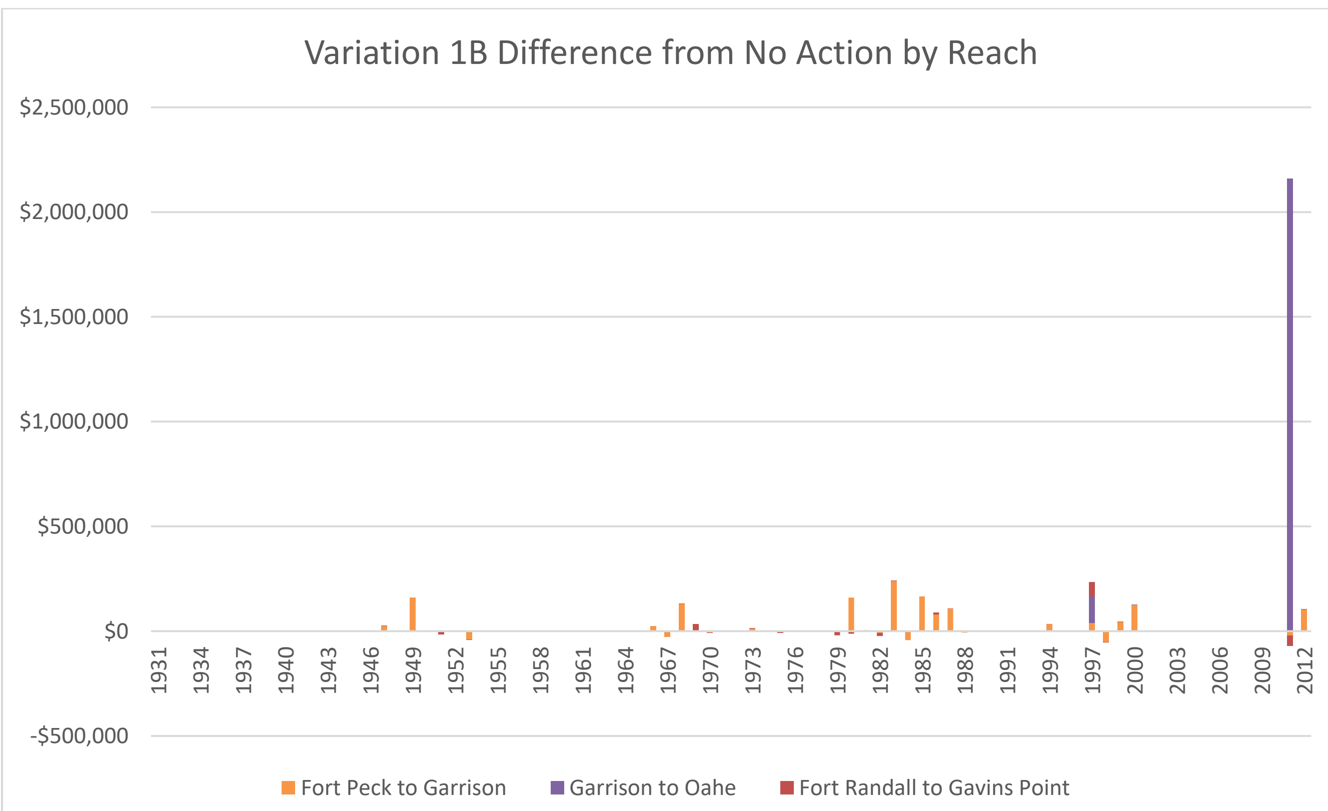

Figure 9. Variation **1B Annual Flood Damage Difference from No Action by Reach**

Additional results are shown in Figure 10. Here the difference in NED impacts between Variation 1B and No Action are plotted and color-coded based on the type of modeled release occurring each year. During the period of record, there were 8 years with a full release and 16 years with partial flow releases. Some notable results include:

- All eight years with full release flow events displayed an increase in flood damages under Variation 1B relative to No Action. The largest flood damage increase for a modeled full release flow event was $165,426 under the 1985 simulation.

- Partial flow release actions also appear to increase damages from Fort Peck Dam to Gavins Point Dam. Seven of the 16 modeled years showed adverse impacts with the largest being a $239,690 increase above No Action under the 1983 simulation.

- On average the full and partial flow event years, increased damages above No Action by $83,594 and $33,931, respectively.

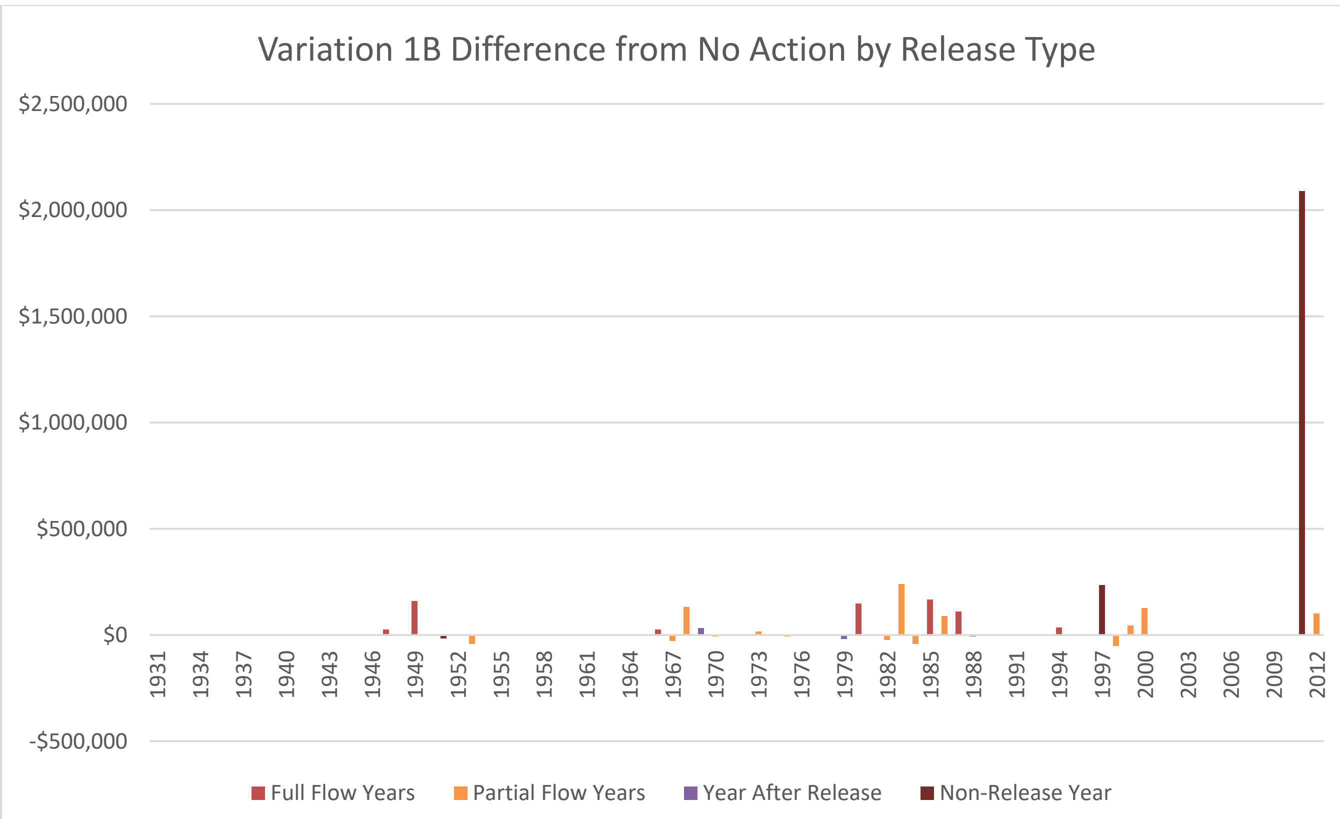

Figure 10. Variation 1B Annual Flood Damage Difference from No Action by Release Type

4.6 Alternative 2

Alternative 2 is based on the No Action but includes a flow regime at Fort Peck for the pallid sturgeon. Actions included under this alternative that may have impacts to flood risk management include:

- Attraction Flow Regime: Initialize on April 16; Wolf Point flows increase by 1,700 cfs per day until peak flow is reached; peak flow is 14,000 cfs (assumed maximum power plant release); hold peak for 3 days.

- Retention Flow Regime: Wolf Point flows remain at 14,000 cfs.

- Spawning Cue Flow Regime: Initialize on May 28; Wolf Point flows increase by 1,100 cfs per day until peak flow is reached; peak flow is 28,000 cfs (2 times the assumed maximum power plant release); hold peak for 3 days; Wolf Point flows decrease by 1,000 cfs for 12 days and then decrease by 3,000 cfs until 8,000 cfs is reached.

- Drifting Flow Regime: Wolf Point flows remain at 8,000 cfs until September 1.

The NED analysis for Alternative 2 is summarized in Table 7. The Alternative 2 modeling indicates that flood damages along the Missouri River from Fort Peck Dam to Gavins Point Dam would increase by $49,312 annually relative to No Action. This represents an overall increase in flood damages of 2.31 percent which is the largest increase among the FPDTR-EIS alternatives.

Table 7. NED Analysis Summary for Alternative 2 by Reach

River Reach	Average Annual Property Damages	Average Annual Agricultural Losses	Average Annual Total Flood Damages	Average Annual Change from No Action	% Change from No Action
Total	**$1,650,681**	**$537,754**	**$2,188,435**	**$49,312**	**2.31%**
Fort Peck Dam to Garrison Dam	$54,886	$403,342	$458,228	$15,894	3.59%
Garrison Dam to Oahe Dam	$1,444,628	$25,914	$1,470,542	$26,391	1.83%
Fort Randall Dam to Gavins Point Dam	$151,166	$108,498	$259,665	$7,026	2.78%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level.

When evaluating the impacts of each of the FPDTR-EIS alternatives, it is helpful to examine the annual impacts. Figure 11 shows the change in annual NED flood risk management impacts under Alternative 2 relative to No Action. Some notable results include:

- In the 82-year period of record, 32 years showed an increase in damages relative to No Action although the impacts in the majority of the years were small.

- The modeled range of impacts compared to No Action varied from a decrease in flood damages of $69,762 in the 1998 simulation to an increase in damages of $2,714,827 under the 2011 simulated event.

- The effect of Alternative 2 would increase damages by $49,312 on average annually above No Action as a whole, with the majority of that annual increase, $27,790, happening in the Garrison Dam to Oahe Dam reach, due to the 2011 simulated event.

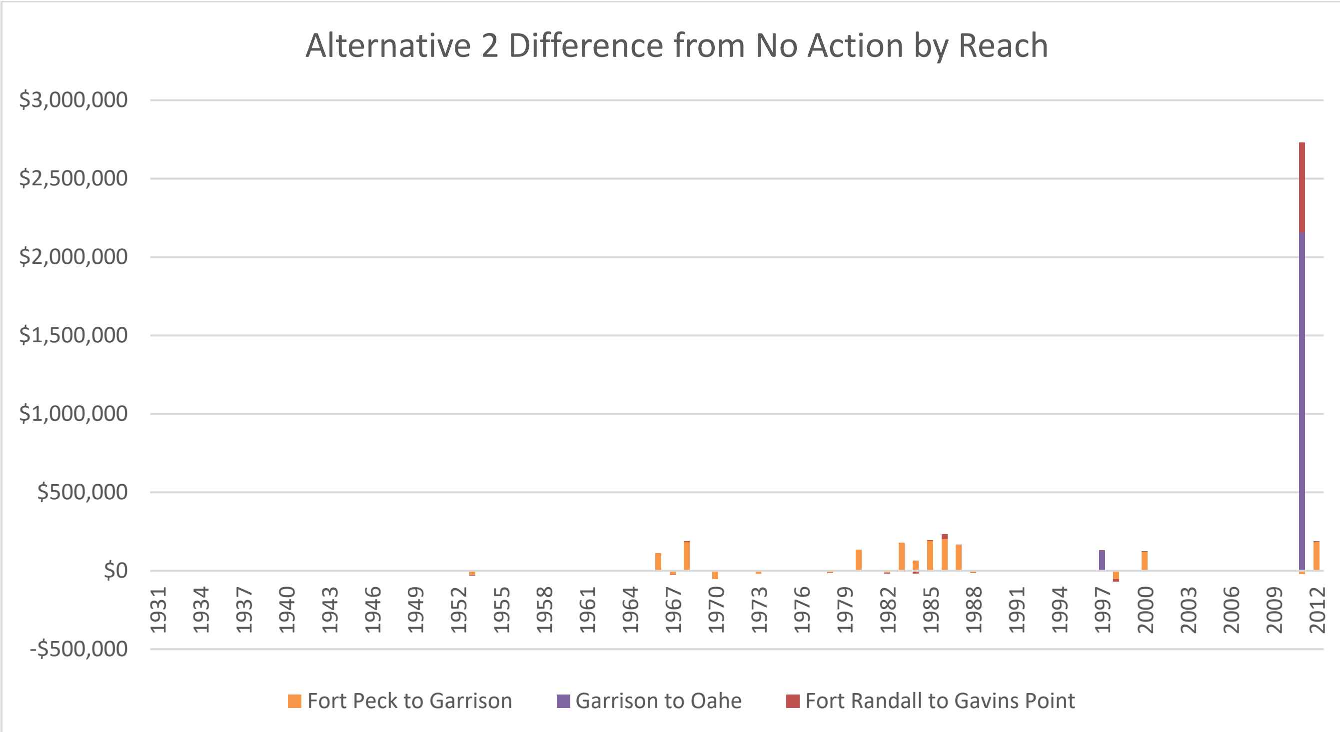

Figure 11. Alternative 2 Annual Flood Damage Difference from No Action by Reach

Additional results are shown in Figure 12. Here the difference in NED impacts between Alternative 2 and No Action are plotted and color-coded based on the type of modeled release occurring each year. During the period of record, there were 10 years with a full flow release and 10 years with partial flow releases. Some notable results include:

- Eight of the 10 years with a full flow release event exhibited an increase in modeled flood damages relative to No Action. The largest flood damage increase for a full flow release modeled event was $194,574 in the 1985 simulation.

- Only 3 of the 10 partial flow event modeled years showed adverse impacts relative to No Action. However, the largest adverse impact was $233,719 under the 1986 simulated event and on average partial flow years would increase damages by $32,835 compared to No Action.

- A non-release year, 2011, had the largest adverse impacts modeled with an increase in damages of $2,714,827 above No Action.

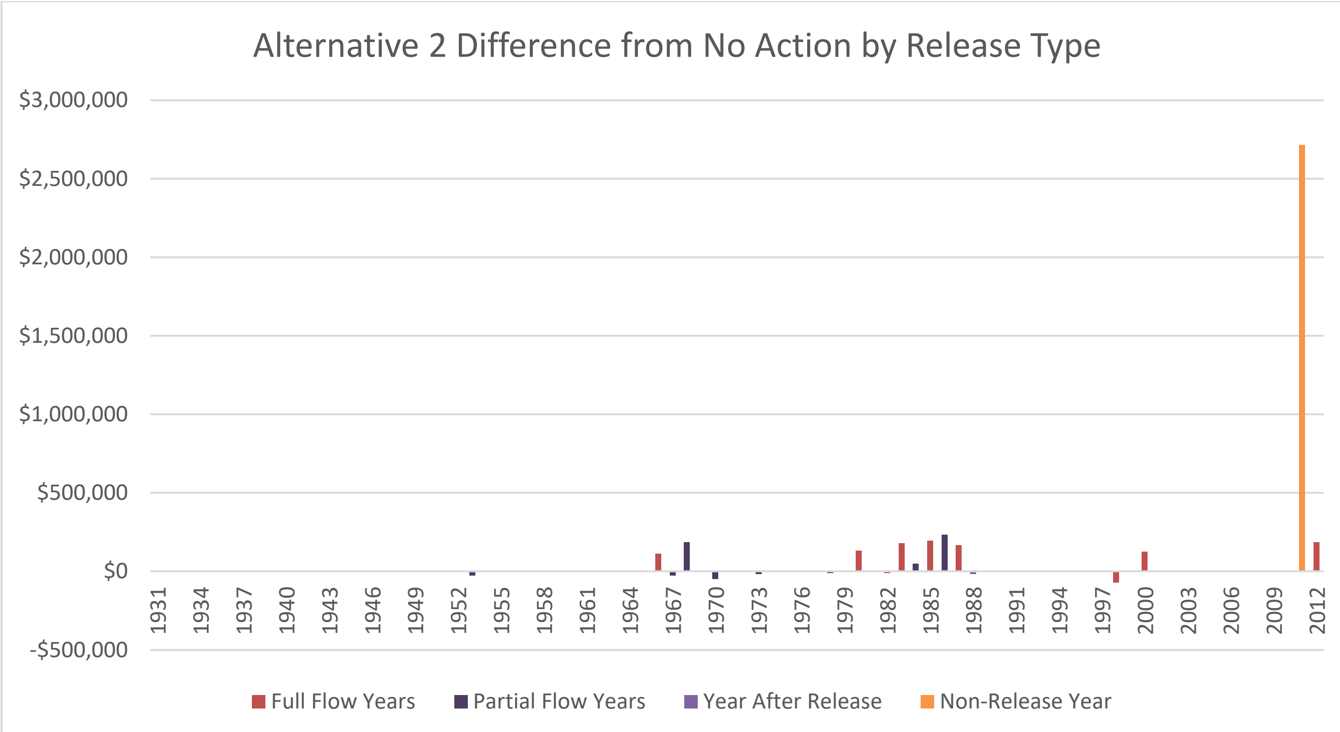

Figure 12. Alternative 2 Annual Flood Damage Difference from No Action by Release Type

4.7 Variation 2A

Variation 2A is based Alternative 2 but initiating the flow regime one week earlier. Actions included under this alternative that may have impacts to flood risk management include:

- Attraction Flow Regime: Initialize on April 9; Wolf Point flows increase by 1,700 cfs per day until peak flow is reached; peak flow is 14,000 cfs (assumed maximum power plant release); hold peak for 3 days.

- Retention Flow Regime: Wolf Point flows remain at 14,000 cfs.

- Spawning Cue Flow Regime: Initialize on May 21; Wolf Point flows increase by 1,100 cfs per day until peak flow is reached; peak flow is 28,000 cfs (2 times the assumed maximum power plant release); hold peak for 3 days; Wolf Point flows decrease by 1,000 cfs for 12 days and then decrease by 3,000 cfs until 8,000 cfs is reached.

- Drifting Flow Regime: Wolf Point flows remain at 8,000 cfs until September 1.

The NED analysis for Variation 2A is summarized in Table 8. The Variation 2A modeling indicates that flood damages along the Missouri River would increase by $17,746 relative to No Action. This represents an overall increase in flood damages of 0.82 percent which is the smallest increase among Alternative 2 variations.

Table 8. NED Analysis Summary for Variation 2A by Reach

River Reach	Average Annual Property Damages	Average Annual Agricultural Losses	Average Annual Total Flood Damages	Average Annual Change from No Action	% Change from No Action
Total	**$1,620,759**	**$535,841**	**$2,156,599**	**$17,476**	**0.82%**
Fort Peck Dam to Garrison Dam	$53,871	$400,558	$454,429	$12,095	2.73%
Garrison Dam to Oahe Dam	$1,419,593	$26,182	$1,445,775	$1,624	0.11%
Fort Randall Dam to Gavins Point Dam	$147,295	$109,100	$256,396	$3,757	1.49%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level.

When evaluating the impacts of each of the FPDTR-EIS alternatives, it is helpful to examine the annual impacts. Figure 13 shows the change in annual NED flood risk management impacts under Variation 2A relative to No Action. Some notable results include:

- In the 82-year period of record, 33 years showed an increase in damages relative to No Action although the impacts in the majority of the years were small and 22 years showed no change at all.
- The modeled range of impacts compared to No Action varied from a decrease in flood damages of $137,518 in the 1976 simulation to an increase in damages of $255,643 under the 2011 simulated event.
- The effect of Variation 2A would increase damages by $17,746 on average annually above No Action, with most of the increase in annual impacts, $12,095, occurring in the Fort Peck Dam to Garrison Dam reach.

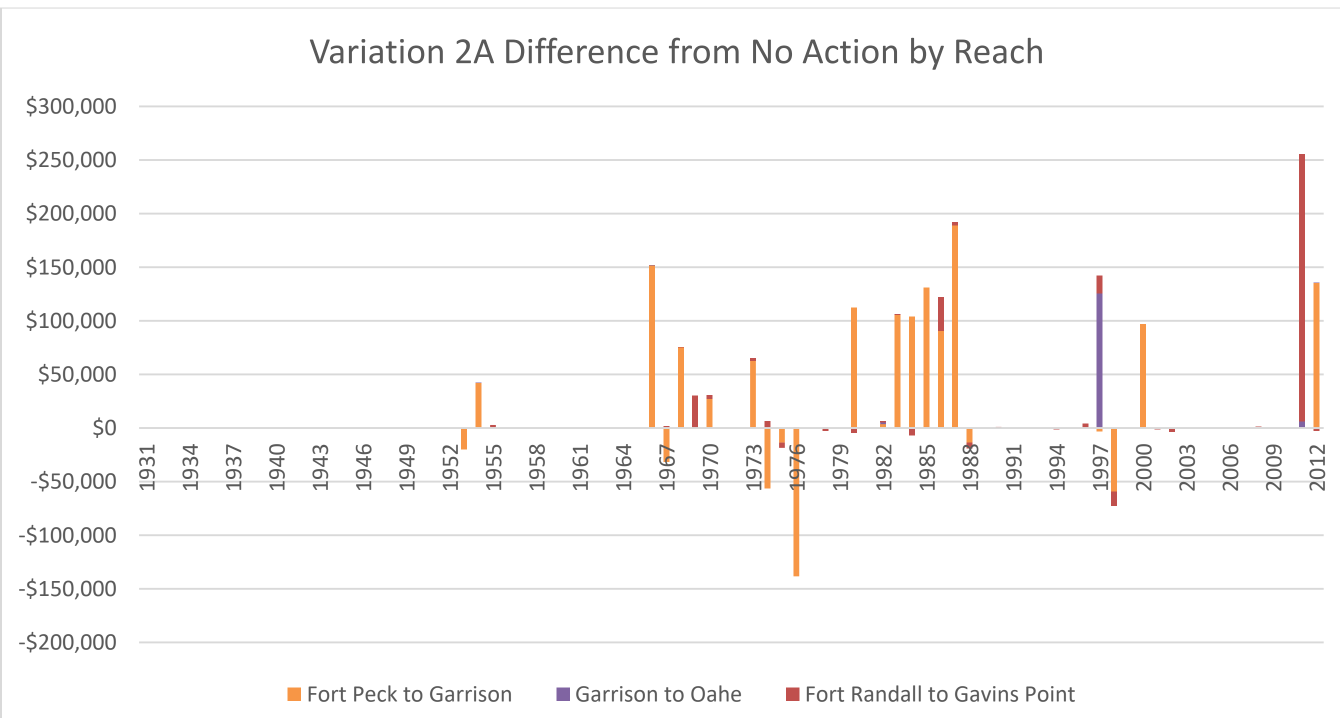

Figure 13. Variation 2A Annual Flood Damage Difference from No Action by Reach

Additional results for the upper river are shown in Figure 14. Here the difference in NED impacts between Variation 2A and No Action are plotted and color-coded based on the type of modeled release occurring each year. During the period of record, there were 15 years with a full release flow and 5 years with partial flow releases. Some notable results include:

- Twelve of the 15 modeled full flow years exhibited an increase in flood damages compared to No Action. The largest flood damage increase for a full flow modeled event was $191,844 in the 1987 simulation.

- Partial flow release actions appear to reduce damages relative to No Action. Three of the 5 modeled years showed beneficial impacts with the greatest decrease being $137,518 under the 1976 modeled event.

- On average, full flow release years increased damages relative to No Action by $75,762 while partial flow release years decreased damages relative to No Action by $21,958.

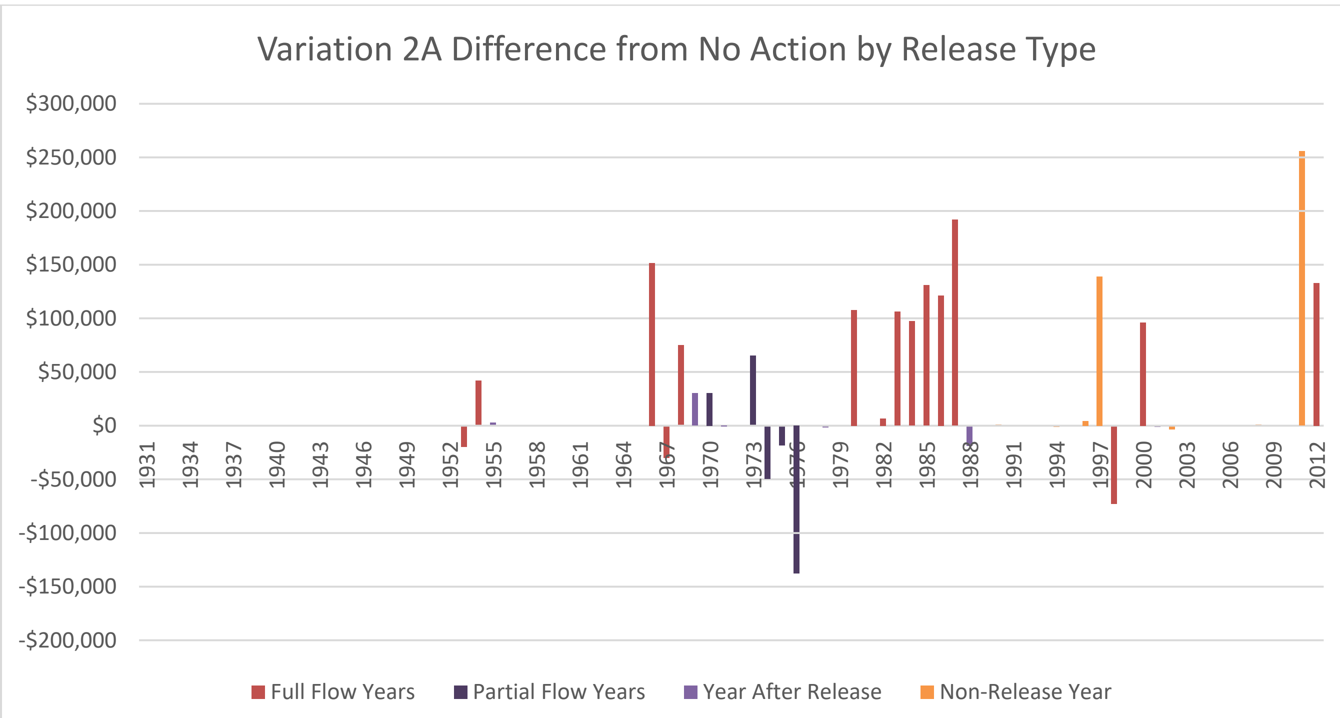

Figure 14. Variation 2A Annual Flood Damage Difference from No Action by Release Type

4.8 Variation 2B

Variation 2B is based Alternative 2 but initiating the flow regime 1 week later. Actions included under this alternative that may have impacts to flood risk management include:

- Attraction Flow Regime: Initialize on April 23; Wolf Point flows increase by 1,700 cfs per day until peak flow is reached; peak flow is 14,000 cfs (assumed maximum power plant release); hold peak for 3 days.

- Retention Flow Regime: Wolf Point flows remain at 14,000 cfs.

- Spawning Cue Flow Regime: Initialize on June 4; Wolf Point flows increase by 1,100 cfs per day until peak flow is reached; peak flow is 28,000 cfs (2 times the assumed maximum power plant release); hold peak for 3 days; Wolf Point flows decrease by 1,000 cfs for 12 days and then decrease by 3,000 cfs until 8,000 cfs is reached.

- Drifting Flow Regime: Wolf Point flows remain at 8,000 cfs until September 1.

The NED analysis for Variation 2B is summarized in Table 9. The Variation 2B modeling indicates that flood risk management impacts along the Missouri River would average $1,705,203 less per year relative to Variation 2B. This represents an overall decrease in flood damages of 5.6 percent which is the largest decrease among the FPDTR-EIS alternatives.

Table 9. NED Analysis Summary for Alternative 2B by Reach

River Reach	Average Annual Property Damages	Average Annual Agricultural Losses	Average Annual Total Flood Damages	Average Annual Change from No Action	% Change from No Action
Total	**$1,650,152**	**$539,639**	**$2,189,791**	**$50,668**	**2.37%**
Fort Peck Dam to Garrison Dam	$54,726	$405,460	$460,186	$17,852	4.04%
Garrison Dam to Oahe Dam	$1,444,277	$25,902	$1,470,178	$26,027	1.80%
Fort Randall Dam to Gavins Point Dam	$151,149	$108,277	$259,426	$6,788	2.69%

Notes: Average annual values at the Fiscal Year (FY) 2020 price level.

When evaluating the impacts of each of the FPDTR-EIS alternatives, it is helpful to examine the annual impacts. Figure 15 shows the change in annual NED flood risk management impacts under Variation 2B relative to No Action. Some notable results include:

- In the 82-year period of record, 45 years showed an increase in damages relative to No Action although the impacts in the majority of the years were relatively small.

- The modeled range of impacts compared to No Action varied from a decrease in flood damages of $71,443 in the 1998 simulation to an increase in damages of $2,696,591 under the 2011 simulated event.

- The effect of Variation 1B would increase damages by $50,668 on average annually above No Action as a whole, with the majority of that annual increase, $26,027, happening in the Garrison Dam to Oahe Dam reach, due to the 2011 simulated event.

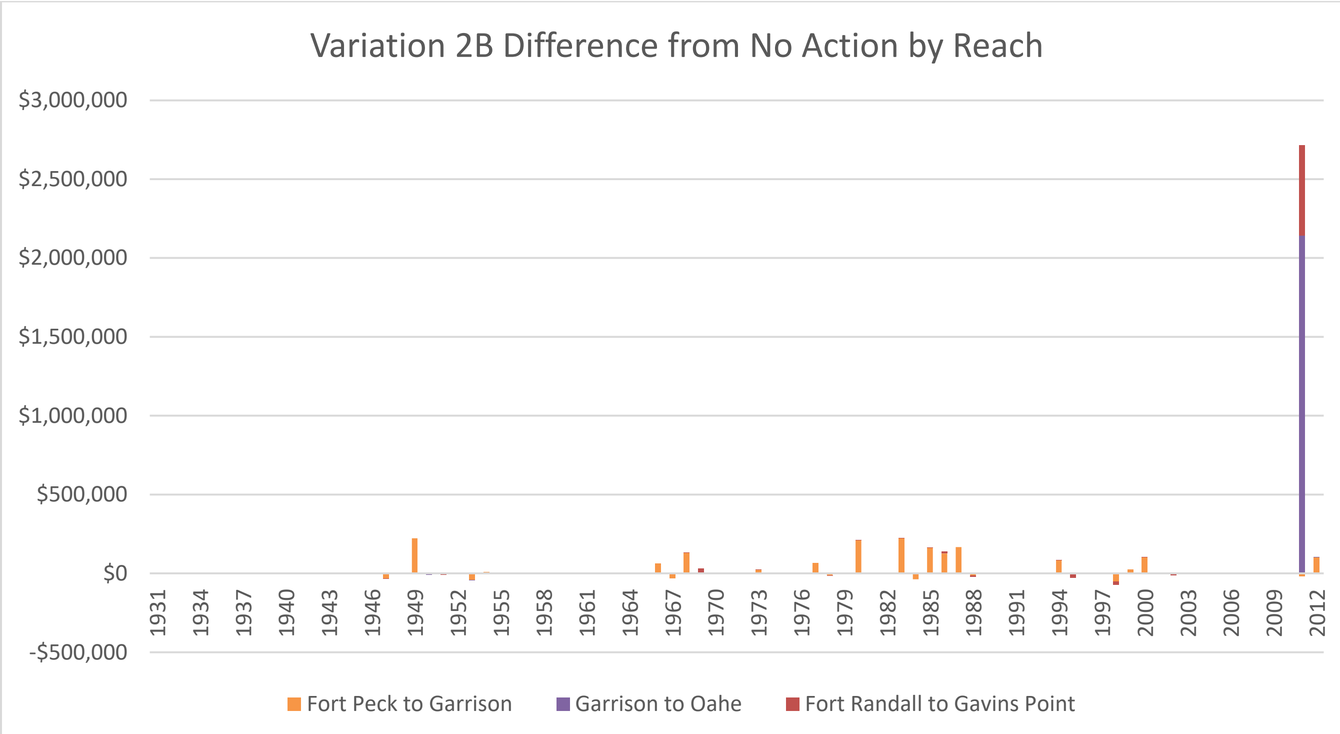

Figure 15. Variation 2B Annual Flood Damage Difference from No Action by Reach

Additional results are shown in Figure 16. Here the difference in NED impacts between Variation 2B and No Action are plotted and color-coded based on the type of modeled release occurring each year. During the period of record, there were 8 years with a full release and 16 years with partial flow releases. Some notable results include:

- Seven of the eight full release flow events displayed an increase in flood damages under Alternative 2B relative to No Action. The largest flood damage increase for a modeled full release flow event was $224,294 under the 1983 simulation.

- Partial flow release actions also appear to increase damages from Fort Peck Dam to Gavins Point Dam. Eight of the 16 modeled years showed adverse impacts with the largest being a $222,325 increase above No Action under the 1949 simulation.

- On average, the full and partial flow event years increased damages above No Action by $103,359 and $41,242, respectively.

- A non-release year, 2011, had the largest adverse impacts modeled with an increase in damages of $2,696,591 above No Action.

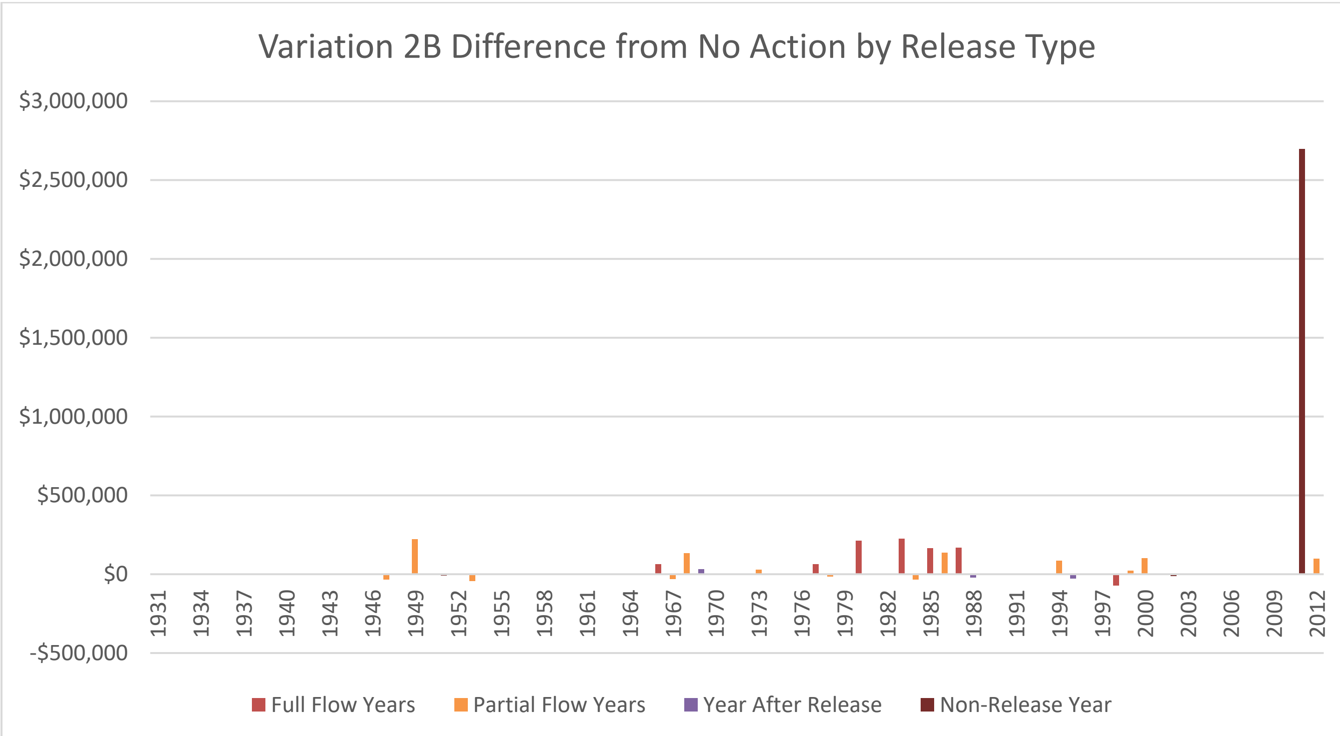

Figure 16. Variation 2B Annual Flood Damage Difference from No Action by Release Type

5.0 Regional Economic Development Evaluation Results

The RED analysis focused on whether changes in NED to flood risk management due to the FPDTR-EIS alternatives would have a measurable impact on local economies. The largest adverse impact to agriculture compared to No Action occurs in the Fort Peck Dam to Garrison Dam reach under the 1983 Alternative 1 simulation. The three most prominent crops in this reach, spring wheat, soybeans, and durum wheat, affect two farming sectors: oilseeds and grain farming. Applying the full value of the adverse impact, $279,000, to either of these sectors in RECONS results in less than one direct job affected and less than 2 total jobs affected. Therefore, it was determined that a full quantitative RED analysis was not needed. A qualitative discussion of the RED impacts on flood risk management is provided in Chapter 3, Section 3.5 of the FPDTR-EIS.

6.0 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. In addition to looking at the population at risk and critical infrastructure facilities that could be inundated, 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 potential flood damage or persons at risk, were analyzed for changes in incidences of flooding impacts on disproportionately minority or poor communities. A qualitative discussion of the OSE impacts on flood risk management is provided in Chapter 3, Section 3.5 of the FPDTR-EIS.

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Acronyms and Abbreviations

BiOp	Biological Opinion (amended in 2003)
DSS	Data Storage System
EQ	environmental quality (account)
ER	Engineering Regulation
ESA	Endangered Species Act
ESH	emergent sandbar habitat
H&H	hydrologic and hydraulic (model)
HC	human considerations
HEC	Hydrologic Engineering Center
M&I	municipal and industrial
FPDTR-EIS	Fort Peck Dam Test Releases - Environmental Impact Statement
MRRP	Missouri River Recovery Program
NED	national economic development (account)
O&M	operations and maintenance
OSE	other social effects (account)
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
POR	period of record
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

1.0 Introduction

The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Fort Peck Dam Test Releases – Environmental Impact Statement (FPDTR – EIS). The purpose of the Environmental Impact Statement (EIS) is to assess the potential impacts of a range of test flow release alternatives from Fort Peck dam designed to benefit reproduction and recruitment of pallid sturgeon to avoid jeopardizing their continued existence in the Missouri River.

The purpose of the Hydropower Technical Report is to provide additional information on the impact analysis and results relevant to hydropower that was completed for the FPDTR-EIS. Additional details on the National Economic Development (NED) methodology and results are provided in this technical report. The Regional Economic Development (RED) and Other Social Effects (OSE) are presented in the FPDTR-EIS, Chapter 3 Environmental Consequences, Section xx Hydropower.

1.1 Summary of Alternatives

The FPDTR-EIS evaluates the following alternatives. A detailed description of the alternatives is provided in Chapter 2 of the FPDTR-EIS.

No Action Alternative: The impacts of the No Action Alternative serve as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. When modeling the No Action Alternative, local inflows are adjusted by the difference between the historic and present level depletions to ensure the period-of-record (POR) datasets are homogenous and reflect current water use. All modeled flood targets are as outlined in the 2018 Master Manual (USACE,2018) and reservoir storages are based on current reservoir surveys. All four navigation target locations are used when setting navigation releases and the model balances system storage by March 1. It is assumed that other activities and actions for pallid sturgeon in the Upper Basin would be implemented as described in the FPDTR-EIS and 2018 Biological Opinion and the Yellowstone Intake Bypass EIS. These actions include fish bypass construction at Yellowstone Intake, continued propagation and stocking of pallid sturgeon in the Upper Basin, and continued pallid sturgeon science and monitoring activities in the Upper Basin.

Alternative 1: System operations under this alternative are based on those described under the No Action Alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon.
The attraction flow regime begins on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in the given year. For example, the typical early spring release from Fort Peck Dam is approximately 8,000 cubic feet per second (cfs); therefore, the attraction flow regime peak flow would be 16,000 cfs as measured at the Wolf Point gage. Beginning on April 16, spring release flows are increased by 1,700 cfs per day until the peak flow is reached at the Wolf Point gage. The peak flow is held for 3 days and then decreases by 1,300 cfs per day until the retention flow is reached. The retention flow is 1.5 times the Fort Peck Dam early spring release as measured at the Wolf Point gage, 12,000 cfs using the example. The retention flow is held until May 28 when the spawning cue flow regime is initiated.
The spawning cue flow regime under Alternative 1 begins on May 28 and is 3.5 times the Fort Peck Dam spring flow release in the given year. Assuming 8,000 cfs as the typical spring flow, this equates to approximately 28,000 cfs at the peak as measured at the Wolf Point gage. Beginning on May 28, the release is increased by 1,100 cfs per day until the peak flow is reached as measured at

the Wolf Point gage. The peak is held for 3 days and then decreases by 1,000 cfs per day for 12 days, then decreases by 3,000 cfs per day until the drifting flow regime of 8,000 cfs is reached. The 8,000 cfs drifting flow regime is held until September 1 when releases to balance storage resume.

Variation 1A: This test flow is a variation of Alternative 1. The parameters for Variation 1A are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The April 9 initiation date is closer to the timing of the initial pulse shown on the unregulated hydrograph. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases. In Alternative 1, the later initiation date of April 16 is designed to enhance the contrast between Missouri River and Yellowstone River discharges by moving the start date approximately two weeks later than the initial pulse shown on the unregulated hydrograph.

Variation 1B: This test flow is another variation of Alternative 1. The parameters for Variation 1B are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 23 and the spawning cue flow regime is initiated on June 4. Similar to the concept described in 1A, the later initiation date is intended to provide contrast and explore any differences in forecasted impacts from a later flow initiation date.

Alternative 2: The parameters for Alternative 2 are the same as described for Alternative 1 except that the attraction flow regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at the Wolf Point gage are held at 14,000 cfs until the spawning cue flow release is initiated. The rationale for keeping the releases high through this period—foregoing the inter-pulse saddle—is the hypothesis that persistent high flows are needed to hold migrated, reproductive adult pallid sturgeon upstream near the dam.

Variation 2A: This test flow is a variation of Alternative 2. The parameters for Variation 2A are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The difference in timing follows the same reasoning as described for Variation 1A.

Variation 2B: This test flow is another variation of Alternative 2. The parameters for Variation 2B are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 23, rather than April 16, and the spawning cue flow regime is initiated on June 4, rather than May 21. The difference in timing follows the same reasoning as described for Variation 1B.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the FPDTR-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the FPDTR-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR 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 FPDTR-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 NED account displays changes in the economic value of the national output of goods and services expressed in monetary units.
- The RED account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The EQ account displays non-monetary effect on significant natural and cultural resources.
- The OSE account registers plan effects from perspective 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 hydropower include NED, RED, and OSE.

1.3 Approach for Evaluating Environmental Consequences to Hydropower of the FPDTR-EIS

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 lead to changes to the objectives associated with hydropower. This figure also shows the intermediate factors and criteria that were applied in assessing consequences to hydropower.

Hydropower has two important connections with the physical components of the Missouri River watershed: river flows/dam releases and reservoir elevations. The type and amount of dam release directly affects the amount of hydropower generated and can be a function of total water stored in the system. In addition, reservoir elevations can influence the efficiency of turbines and hydropower plants, also impacting the levels of hydropower produced at each facility. Reservoir elevations for all the reservoirs describe the water in system storage, which may affect dam releases. Changes in physical conditions could affect the hydropower system performance, including system hydropower generation, load following capability, plant efficiency, reliability to meet peak demands during critical months, and flexibility to perform ancillary services. (Ancillary services are services that ensure reliability and support the transmission of electricity from generation sites to customer loads. Such activities may include load regulation, spinning reserve, non-spinning reserve, replacement reserve, dark start, and voltage support.)

All of these potential changes in hydropower performance could affect the amount of surplus power generated, the need to purchase additional power to meet contract obligations, and changes in reliance on thermal power energy sources. These changes could affect energy and capacity values, which are described in EM 1110-2-1701 Hydropower Manual. These values are based on the most likely thermal alternative, utilizing updated thermal cost projections. The energy/capacity price is based on the cost of energy from a combination of thermal generation plant types that would replace the lost energy/capacity from the hydropower plant due to operational and/or structural changes. The value of this energy is associated with its ability to meet demand. For example, higher price generating resources may only be utilized to meet peak demand. Energy and capacity have both regional and seasonal values. It is possible during the peak summer months that low flows may reduce both hydropower and replacement thermal generation.

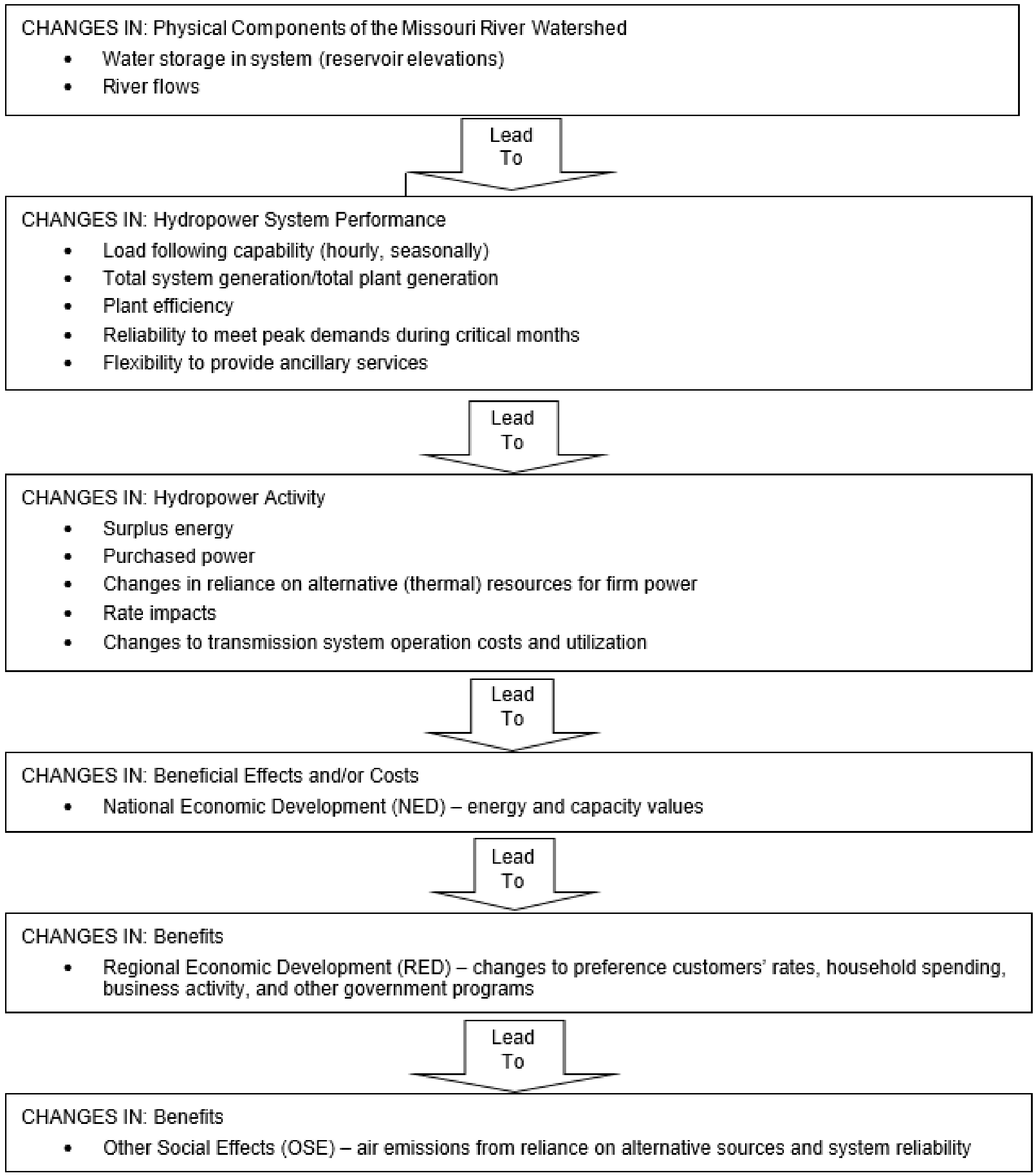

Figure 1. **Flow Chart of Inputs Considered in Evaluation of Impacts to Hydropower**

Evaluation of the environmental consequences of the FPDTR-EIS requires an understanding of how the physical conditions of the river would change under each of the FPDTR-EIS alternatives. This initial first step is critical for evaluating HC impacts and those specified in the three accounts. Figure 2 shows the overall approach used to evaluate the consequences to hydropower from the FPDTR-EIS alternatives.

The following sections provide further details on the methodology.

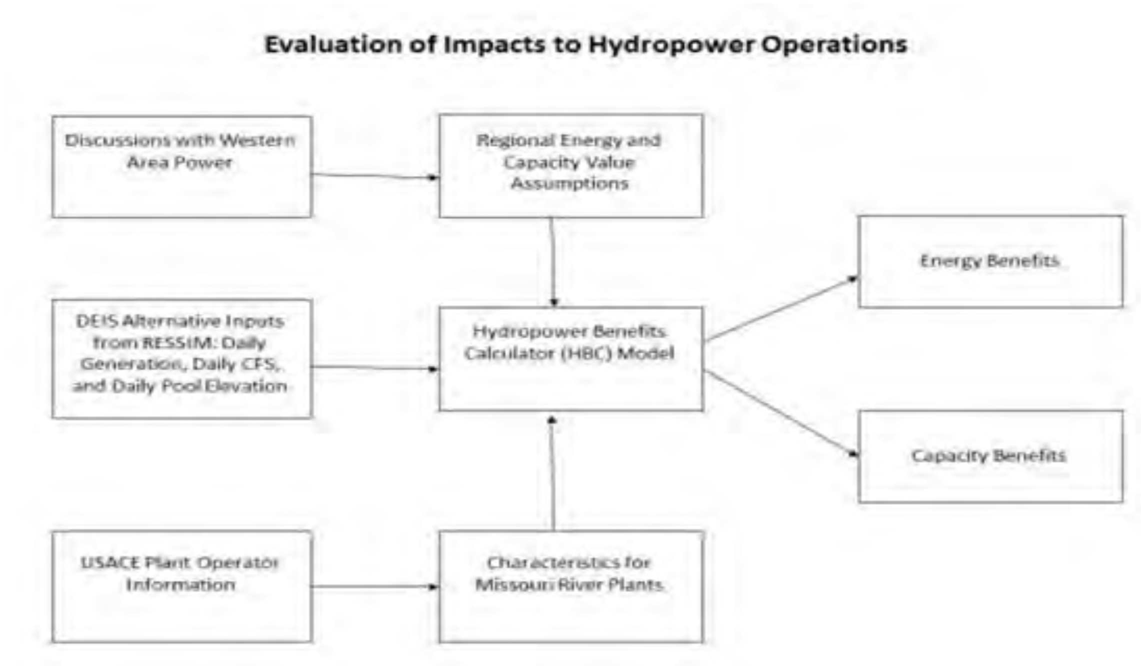

Figure 2. Approach for Evaluating Consequences to Hydropower

The flow chart shows the data necessary to run the Hydropower Benefits Calculator (HBC). This includes discussions with plant operators to get information on plant characteristics and operations and conversations with Western Area Power Administration (WAPA) to determine the appropriate regional energy and capacity value assumptions. This information, along with Hydrologic Engineering Center Reservoir System Simulation (HEC-ResSim) elevation and flow inputs for each of the alternatives, is input into the HBC model. The model then calculates energy benefits and capacity benefits, which can then be compared across alternatives. The outputs from the NED evaluation were used to assess the RED and OSE accounts.

2.0 Assumptions, Limitations, and Risks

2.1 Assumptions and Limitations

In modeling the environmental consequences to hydropower 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 analyses use 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-year period of record (POR) under each of the MRRMP-EIS alternatives as well as the No Action alternative.
- A 2019 estimated Energy Information Administration (EIA) energy price was used in conjunction with the historic pattern of energy prices to determine specific blocks of hourly, daily, and monthly prices. The value was then indexed to 2020. Capacity unit values were determined using a screening curve analysis that plots annual total plant costs for different types of thermal generating plants (fixed capacity cost plus variable operating costs) versus an annual plant factor. The final capacity value is a mix of the least cost alternative sources for each plant factor range. Please see the Energy and Capacity Values section below for more detailed information on the values used in this analysis.
- Some tables presented below were created using spreadsheet software. Arithmetic operations and totals were taken to full decimal accuracy within the spreadsheet. Some tables within this report have been rounded after the mathematical computations were performed; as a consequence, rounded totals may not equal the summation of rounded values.
- The Missouri River HBC model assumes that there is always a market for the power generated. This has the potential to underestimate impacts, in the case where an alternative shifts power production to a time when there isn't a market for the power produced.
- Hill Curves (efficiency) for the existing turbines were assumed based on best engineering judgment.
- The process used to determine power production assumes turbines are dispatched in the most efficient use of the available water.

3.0 Methodology

3.1 National Economic Development Approach

NED effects are defined as changes in the net value of the national output of goods and services. In the case of hydropower, the conceptual basis for the NED impacts analysis is society's willingness to pay for the increase or decrease in the value of goods attributable to hydropower.

The measurement of national economic effects can be based on estimated changes in energy and capacity values of existing hydropower facilities that would result from FPDTR-EIS alternatives. Replacement energy is computed as the product of energy loss in megawatt-hours and the energy unit value price ($/MWh). Replacement capacity is computed as the product of dependable capacity lost in MW and a capacity unit value ($/MW) representing the value of the most likely thermal alternative. The NED benefits for hydropower are based on the accrued cost of the most likely alternative energy source that would replace reduced hydropower generation (energy and capacity).

The HBC model was used for calculating NED benefits for this study. This model was developed by the USACE's Hydropower Analysis Center in early 2014 for use in Missouri River studies and has been approved for use on Missouri River studies.

The Missouri River HBC model is a post-processor of a flow routing model, daily time step, used to calculate NED hydropower benefits. This model is a series of functions written in the Matlab programming language. The functions themselves are not written specifically for the Missouri River System. Instead the functions read a series of input files that define specific Missouri River characteristics. This provides the user transparency to model parameters, easy adjustment, and adaptability to other systems including the addition of new plants.

Version 1.0 of the Missouri River HBC calculates NED hydropower benefits as defined by the ER 1105-2-100 Planning Guidance Notebook (April 22, 2000) for planning-level studies. The model area focuses on the six USACE dams and their associated reservoirs located on the Missouri River mainstem, including Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point.
The model is categorized as a Regional/Local Model as it was conceived to address unique situations and calibrated to specific characteristics for studies related to Missouri River hydropower plants. More details describing a Regional/Local Model can be found in the EC 1105-2-412 entitled, Assuring Quality of Planning Models.

This HBC model acts as a post-processor to the daily time step routing model, HEC-ResSim. Outputs required from the ResSim model include daily flow and reservoir elevations. As the ResSim model simulates MRRMP-EIS alternatives, the HBC model uses this output to compute two NED benefits:

Energy Benefits: the product of energy in megawatt-hours and an energy unit value price ($/MWh). The change in megawatt-hours is estimated based upon the change in water elevation and flow between alternatives, while the value of energy benefits is estimated based on the value of energy from a combination of plants that could provide replacement energy.

Dependable Capacity Benefits: the dependable capacity of a hydropower project is a measure of the amount of capacity that the project can reliably contribute towards meeting system peak power demands. Dependable capacity benefit is computed as the product of the systems dependable capacity (MW) and a composite unit capacity value ($/MW) that reflects the most likely thermal power generation alternative.

3.1.1 Inputs/Outputs for the HBC Model

The HBC model consists of a number of input files. A brief categorization of these files is given below:

Hydrological Inputs – daily flow and reservoir elevations modeled by the HEC-ResSim routing model.

Plant System Files – plant characteristics for each of the six mainstem dams such as turbine efficiency tables, tailwater rating curves, maximum and minimum plant hydraulic capacity including flow limits (USACE 2012).

Calibrated Parameters – parameters such as optimization weights and generator efficiency calibrated to minimize error between observed and simulated results (calculated from USACE 2012, Hourly Plant Generation).

Economic Inputs – regional energy, capacity, and revenue values. Currently these inputs are created outside of the HBC using Excel® spreadsheets from sources such as Southwest Power Pool (SPP) and the EIA.

The HBC model consists of a number of output files. A brief categorization of these files is given below:

Modeled Hydrologic Output: hourly modeled flow, tailwater elevation, and hydraulic head.

Modeled Energy Output: hourly modeled generation, turbine efficiency, critical year dependable capacity values, generation roll up tables

Benefits Data: modeled plant level dependable capacity tables, energy value roll up tables, revenue foregone rollup tables

Calibration Files: performance metrics results for comparing simulated versus observed flow and energy values

Model Verification Files: several result files that look at key modeled values to ensure reliability in the calculations.

The HBC model includes the following Matlab functions:

Hourly Energy Simulation. Takes hydrological inputs from routing model and shapes average daily flows into hourly values. Hourly generation values are then computed using the power equation. The output from this function is hourly flow and generation values for the modeled POR.

Critical Year Hours. This function calculates the number of hours a plant can run at full capability averaged over critical months for a critical year.

Dependable Capacity Calculator. This function takes as input the number of hours a plant can run at full capability calculated in the critical_year_hours.m file and computes the plants average capability operating for defined hours during the critical months over the entire modeled POR. Output of this function is each plant's dependable capacity.

Energy Benefits Calculator. This function takes as input hourly generation data calculated by the Hourly_Energy_Simulation.m file. The function then distinguishes the generation data into six blocks of decreasing generation values, assigning the respective Energy Replacement Values. Output of this function is monthly roll ups of energy replacement value for each plant.

Revenue Foregone Calculator. This function rolls up the hourly data calculated in the Hourly_Energy_Simulation.m file into an annual total generation value. These values are then assigned a constant rate based on the current Power Marketing Administration contracts. The output from this function is the current revenue expected for each modeled year.

3.1.2 Data Collection

The main input to the HBC model consists of daily reservoir elevations and average flows for the six mainstem dams on the Missouri River, which is provided by the HEC-ResSim routing model. The use of this model requires both historic hydrologic and generation data. The hydrologic data required consists of hourly flow distributions and daily reservoir elevations. The required generation data is hourly generation data. The current version of the HBC model uses six representative years of generation and hydrologic data collected from the USACE Omaha District. Six representative years are considered to reflect current hourly operating patterns.

Additional data is needed for the HBC model. Specific plant level hydropower data requirements include turbine efficiency and tailwater rating curves, which have been collected from the USACE Hydropower Center of Expertise, the Hydropower Design Center. Plant level constraints such as minimum and maximum monthly hydraulic capacity values (upper and lower plant level flow limits) are obtained from Missouri River Water Control Manual.

Economic inputs to the HBC model are readily available from the EIA and SPP websites.

3.1.3 Energy Values

The energy benefits calculator function of the HBC computes annual energy benefits for alternatives. In general, energy benefits are calculated as the product of energy generation and an appropriate energy price in terms of $/MWh. The energy prices used are based on the cost of energy from a combination of generation plants that would replace the lost energy from the hydropower plant due to operational and/or structural changes.

Energy prices vary from hour to hour, between weekdays and weekends, and between different months. One difficulty of computing energy benefits associated with replacing hydropower is associating the lost hourly energy generation with the appropriate replacement energy price. One simplifying assumption is that high hourly energy prices are associated with high hourly generation periods. This assumption is reasonable because economical dispatch during periods of peak demand require adding higher cost generating resources required to meet system load. However, power marketing administrations generate power to meet customer loads that may not completely relate to the overall block load. The HBC does make this simplifying assumption and associates high energy price blocks with high generation blocks.

Since energy prices change hourly, daily, and seasonally, quantifying lost hydropower energy benefits requires forecasting when hydropower energy benefits will change and the associated replacement energy pricing variability. The energy values for the Missouri River are best estimated using the Locational Marginal Pricing (LMP) from the Western Area – Upper Great Plains East (WAUE) hub of the SPP. LMP is a computation technique that determines a shadow price for an additional MWh of demand. Historical LMP values for WAUE for 2014 to 2018 were downloaded from the SPP website. Previously, Missouri River studies have used Midcontinent Independent System Operator (MISO) LMP data to estimate energy values for this region. However, in October of 2015, WAPA moved to the SPP market. Unfortunately, this limits the amount of data that includes the Missouri River plants in the estimation of prices. However, given that SPP is the current market, it was deemed as the most appropriate for use in this study. Additionally, values are very similar to those in the MISO market.

Since LMP provides historical pricing it was utilized in combination with information from the EIA to develop an energy price forecast. Each year the EIA publishes an Annual Energy Outlook (AEO) that lists thirty years of forecasted energy costs of different electric market modules. For this study, the 2019 AEO was used to estimate prices. The AEO also lists actual energy prices for three historical years. The energy price forecast is split into three categories; generation, transmission, and distribution. For this study, the EIA generation forecast for the Midwest Reliability Council West was used to forecast future LMP values for this study.

To shape the values the following ratio is assumed:

$$\frac{LMP_{Future}}{LMP_{Past}} = \frac{EIA\_Generation_{Future}}{EIA\_Generation_{Past}}$$

Which can be rewritten as:

$$LMP_{Future} = EIA\_Generation_{Future} * \frac{LMP_{Past}}{EIA\_Generation_{Past}}$$

The future LMP values can then be computed by the product of the EIA generation forecast and a shaping ratio defined as:

$$ShapingRatio = \frac{LMP_{Past}}{EIA\_Generation_{Past}}$$

As explained above, the unique shaping ratio is defined to reflect hourly, weekly, and seasonal variability. Daily LMP values can be sorted from high to low, similar to the sorting of hourly generation. This produces the hourly ranked shaping ratios. Weekly variability is considered by computing shaping ratios for weekends and weekdays. Finally, seasonal variability is taken into account by computing shaping ratios for each month. These shaping ratios are computed as averages with like hourly rankings, month and weekday classification using the equation:

$$ShapingRatio(weekday, month, hourly\_ranking) = Average\left(\frac{LMP_{Past}(weekday, month, hourly\_ranking, year)}{EIA\_Generation_{Past}(year)}\right)$$

The shaping ratios are then averaged for each four-hour block:

$$ShapingRatio_{block=i}(weekday, month) = Average(ShapingRatio(weekday, month, hourly\_ranking))$$

This produces the following equation to compute LMP forecasts for block 1 through 6, weekends, and for each month.

$$LMP_{Future}(block = i, weekday, month) = EIA\_Generation_{Future} * ShapingRatio_{block=i}(weekday, month)$$

It should also be noted that to calculate the average annual energy benefits, the EIA generation 30-year price forecast is annualized to a single number and then applied to the shaping ratios. Table 1 shows the energy prices ($/MWh) used for this analysis.

Table 1: Estimated 2020 Monthly, Weekday and Weekend Energy Values

Weekday Energy Values												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Block 1	$31.53	$29.50	$25.79	$27.03	$27.04	$29.11	$34.68	$30.29	$22.37	$24.83	$27.21	$26.60
Block 2	$27.48	$25.93	$23.72	$23.99	$25.47	$27.96	$33.45	$29.32	$21.52	$23.39	$24.96	$23.50
Block 3	$25.73	$24.39	$22.05	$22.37	$24.46	$26.82	$31.89	$27.75	$20.80	$22.28	$23.29	$22.44
Block 4	$23.86	$23.12	$20.95	$21.63	$23.73	$25.91	$30.58	$26.70	$20.20	$21.56	$22.21	$21.59
Block 5	$22.57	$21.89	$20.04	$20.65	$23.00	$24.91	$29.47	$25.86	$19.60	$21.03	$21.25	$20.64
Block 6	$21.65	$21.04	$19.07	$19.87	$22.18	$23.80	$28.10	$24.62	$19.04	$20.42	$20.40	$19.94
Block 7	$20.85	$20.20	$18.06	$19.18	$21.46	$22.76	$26.79	$23.50	$18.29	$19.85	$19.58	$19.05
Block 8	$20.24	$19.46	$17.33	$18.67	$20.66	$21.70	$25.71	$22.56	$17.62	$19.40	$18.96	$18.50
Block 9	$19.65	$18.99	$16.81	$18.18	$20.11	$20.77	$24.50	$21.50	$17.06	$18.85	$18.33	$18.01
Block 10	$19.10	$18.29	$16.23	$17.68	$19.42	$19.75	$23.16	$20.55	$16.47	$18.42	$17.82	$17.56
Block 11	$18.54	$17.67	$15.70	$17.23	$18.84	$18.91	$21.76	$19.33	$15.81	$17.88	$17.34	$17.12
Block 12	$18.13	$17.10	$15.27	$16.75	$18.18	$17.89	$20.33	$18.29	$15.03	$17.20	$16.93	$16.67

Block 13	$17.62	$16.53	$14.88	$16.36	$17.62	$16.79	$18.77	$17.13	$14.37	$16.52	$16.47	$16.21
Block 14	$17.28	$16.06	$14.49	$15.80	$16.80	$15.70	$17.39	$15.98	$13.68	$15.91	$16.01	$15.82
Block 15	$16.95	$15.49	$14.04	$15.43	$15.74	$14.66	$16.04	$14.94	$12.99	$15.17	$15.38	$15.31
Block 16	$16.50	$15.00	$13.35	$14.67	$14.64	$13.46	$14.65	$13.97	$12.09	$14.15	$14.51	$14.83
Block 17	$16.07	$14.50	$12.52	$13.59	$13.36	$12.35	$13.63	$13.30	$11.15	$12.95	$13.65	$14.31
Block 18	$15.52	$13.96	$11.54	$12.43	$12.24	$11.60	$13.01	$12.72	$10.40	$11.77	$12.84	$13.51
Block 19	$14.80	$13.12	$10.51	$11.28	$11.16	$10.96	$12.52	$12.29	$9.69	$10.60	$11.76	$12.70
Block 20	$14.17	$12.37	$9.83	$10.37	$10.56	$10.46	$12.12	$11.92	$9.20	$9.71	$10.99	$11.72
Block 21	$13.67	$11.63	$9.28	$9.81	$10.01	$10.08	$11.84	$11.61	$8.81	$9.20	$10.25	$11.07
Block 22	$13.18	$11.06	$8.72	$9.33	$9.66	$9.69	$11.59	$11.39	$8.47	$8.71	$9.69	$10.57
Block 23	$12.76	$10.50	$8.12	$8.54	$9.21	$9.35	$11.40	$11.12	$8.14	$8.08	$9.10	$10.05
Block 24	$11.64	$9.58	$7.22	$7.60	$8.59	$9.01	$11.22	$10.88	$7.55	$7.25	$8.29	$9.26
Weekend Energy Values												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Block 1	$27.14	$30.48	$27.55	$26.04	$27.07	$30.14	$32.20	$29.71	$23.88	$24.79	$26.83	$25.07
Block 2	$25.26	$26.47	$25.20	$22.97	$25.26	$28.77	$31.09	$28.78	$22.92	$23.31	$24.82	$22.18
Block 3	$23.27	$25.02	$22.51	$21.46	$24.38	$27.55	$29.83	$27.10	$22.09	$22.35	$23.34	$21.31
Block 4	$22.22	$23.64	$21.42	$20.63	$23.53	$26.52	$28.84	$26.05	$21.52	$21.62	$22.40	$20.55
Block 5	$21.47	$22.55	$20.58	$20.06	$22.91	$25.46	$27.92	$25.26	$20.75	$21.16	$21.48	$19.85
Block 6	$20.59	$21.75	$19.61	$19.41	$21.92	$24.25	$26.64	$24.41	$19.84	$20.44	$20.55	$19.31
Block 7	$19.76	$20.63	$18.86	$18.53	$21.12	$23.23	$25.59	$23.24	$18.96	$19.85	$19.91	$18.57
Block 8	$19.11	$19.96	$18.41	$18.03	$20.24	$22.23	$24.53	$22.20	$18.16	$19.26	$19.18	$17.91
Block 9	$18.61	$19.36	$17.67	$17.57	$19.59	$21.14	$23.50	$21.30	$17.49	$18.73	$18.50	$17.50
Block 10	$18.10	$18.71	$17.20	$17.03	$19.04	$20.18	$22.28	$20.35	$16.64	$18.00	$18.02	$17.06
Block 11	$17.70	$18.29	$16.77	$16.61	$18.39	$18.98	$21.14	$19.08	$15.74	$17.45	$17.65	$16.65
Block 12	$17.35	$17.78	$16.15	$16.19	$17.77	$18.08	$19.98	$17.93	$14.98	$16.80	$17.12	$16.28
Block 13	$16.90	$17.36	$15.73	$15.79	$17.23	$17.05	$18.70	$17.07	$14.07	$16.08	$16.65	$15.88
Block 14	$16.38	$16.87	$15.26	$15.33	$16.50	$16.10	$17.37	$15.91	$13.38	$15.27	$15.91	$15.48
Block 15	$15.80	$16.35	$14.84	$14.89	$15.57	$14.83	$15.98	$14.84	$12.76	$14.38	$15.34	$15.15
Block 16	$15.22	$15.81	$14.09	$14.14	$14.37	$13.63	$14.85	$13.83	$12.09	$13.32	$14.84	$14.72
Block 17	$14.68	$15.27	$13.56	$13.17	$12.71	$12.65	$13.90	$13.25	$11.18	$12.29	$14.11	$14.32
Block 18	$14.01	$14.56	$12.81	$11.81	$11.45	$11.95	$13.35	$12.55	$10.36	$11.25	$13.43	$13.64
Block 19	$13.29	$14.00	$12.00	$10.68	$10.26	$11.20	$12.90	$12.06	$9.76	$10.41	$12.52	$12.85
Block 20	$12.45	$13.05	$11.22	$9.49	$9.32	$10.65	$12.54	$11.64	$9.18	$9.68	$11.45	$12.15
Block 21	$11.89	$12.39	$10.73	$8.87	$8.79	$10.25	$12.21	$11.33	$8.88	$9.22	$10.88	$11.70
Block 22	$11.48	$11.53	$10.19	$8.42	$8.33	$9.97	$12.01	$11.04	$8.56	$8.64	$10.37	$11.17
Block 23	$11.05	$10.91	$9.38	$7.81	$7.87	$9.69	$11.80	$10.79	$8.14	$8.04	$9.85	$10.65
Block 24	$10.06	$9.93	$8.46	$7.06	$7.43	$9.50	$11.51	$10.61	$7.61	$7.23	$8.72	$9.94

3.1.4 Capacity Values

The dependable capacity of a hydropower project is a measure of the amount of capacity that the project can reliably contribute towards meeting system peak power demands. If a hydropower project always maintains approximately the same head, and there is always an adequate supply of stream flow so that there is enough generation for the full capacity to be usable in the system load, the full installed generator capacity can be considered dependable. In some cases, even the overload capacity is dependable.

At storage projects, normal reservoir drawdown can result in a reduction of capacity due to a loss in head. At other times, diminished releases during low flow periods may result in insufficient generation to support the marketable capacity of the load. Dependable capacity accounts for these factors by giving a measure of the amount of capacity that can be provided on average during peak demand periods. The capacity analysis intends to capture the costs of building additional resources to maintain the system capacity on average over the long term.

In order to develop a value for capacity, a screening curve analysis that used and computed capacity unit values for coal-fired steam, gas-fired combined cycle, and gas-fired combustion turbine plants were defined using procedures developed by the Federal Energy Regulatory Commission. A screening curve is a plot of annual total plant costs for a thermal generating plant (fixed [capacity] cost plus variable [operating] cost) versus an annual plant factor (plant utilization factor). When this is applied to multiple types of thermal generation resources, the screening curve provides an algebraic way to show which type of thermal generation is the least cost alternative for each plant factor range. In combination with the Missouri River system generation-duration curve, the screening curve produces a composite unit capacity value. The following is an explanation of the steps required to compute the capacity composite unit values.

The screening curve assumes a linear function defined by the following equation:

$$AC = CV + (EV * 0.0876 * PF)$$

where:

AC = annual thermal generating plant total cost ($/kW-year)

CV = thermal generating plant capacity cost ($/kW-year)
EV = thermal generating plant operating cost ($/MWh)
PF = annual plant factor (percent)

Capacity unit values for coal-fired steam, gas-fired combined cycle and combustion turbine plants were computed using procedures developed by FERC. Table 2 shows the average capacity and energy costs for states that lie in the Midwest Reliability Organization – West (MROW) of EIA's Electricity Market Module (EMM) Region.

Table 2: Average Capacity and Energy Costs for MROW EMM

	Coal-fired Steam (CO)	Combined Cycle (CC)	Combustion Turbine (CT)
Adjusted Capacity Value ($/kW-yr)	$334.73	$139.86	$119.04
Operation Costs ($/MWh)	$19.71	$27.03	$39.36

The plot for each thermal generation type was developed by computing the annual plant cost for various plant factors ranging from zero to 100 percent. As shown in the lower section of Figure 3, combustion turbine had the lowest over all capacity cost up to the breakpoint of 19 percent. After that combined cycle had the lowest cost from the plant factor up from 19 percent. Combustion turbine accounts for

1,129 MW of estimated replacement capacity and combined cycle accounts for 1,371 MW of estimated replacement capacity. In this comparison, coal does not become the least cost alternative for any amount of capacity.
The following algorithm is used to compute the composite unit capacity shown in the Table 3.

1. From the cost screening curve, determine the "breakpoints" (the plant factors at which the least cost plant type changes).

2. Find the points on the generation-duration curve where the percent of time generation is numerically identical to the plant factor breakpoints defined in the preceding step; these intersection points define the portion of the generation capacity (MW) that would be carried by each thermal generation plant type.

3. Calculate percent of total generating capacity for each thermal alternative using the proportions defined in Step 2.

4. Calculated the composite unit capacity value of the system as an average of each thermal alternative's capacity cost weighted by their percent of total generating capacity defined in Step 3.

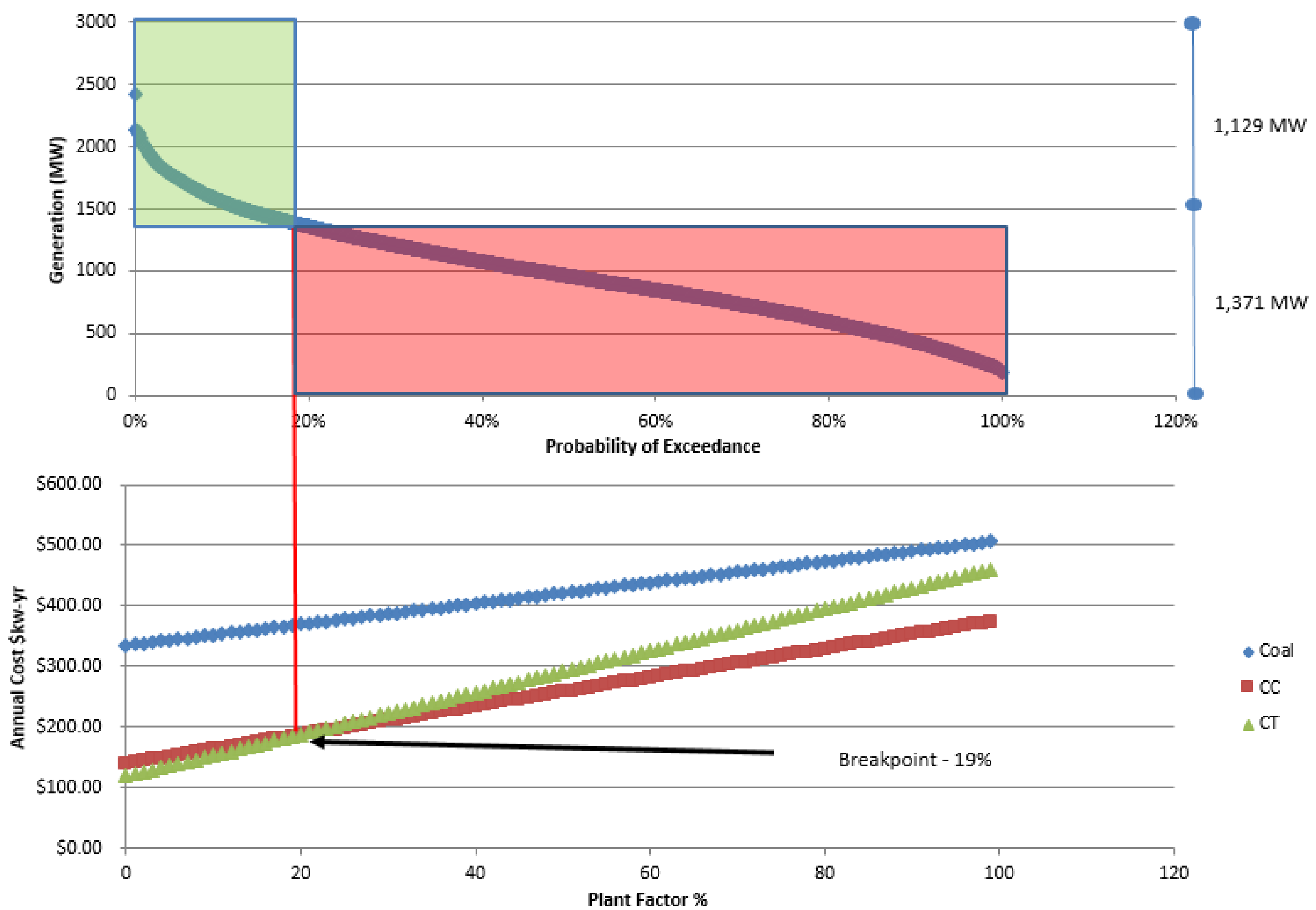

Figure 3: Total System Duration Curve and Regional Screening Curve

Table 3: Composite Capacity Value of Thermal Generation Plants

	Estimated Replacement Capacity (MW)	Percentage of Total Generating Capacity	Capacity Cost ($/KW-yr)	Weighted Value ($)
Combustion Turbine	1129	45.16%	$119.04	$53.76
Combined Cycle	1371	54.84%	$139.86	$76.70
Coal-fired Steam	0	0.00 %	$0.00	$0.00
weighted average ($/kW-yr)	–	–	–	$130.46

3.1.5 Calculating Dependable Capacity

Dependable capacity can be computed in several ways. The method that is most appropriate for evaluating the dependable capacity of a hydropower plant in a predominantly thermal-based power system like the Missouri River Basin is the average availability method. This method is described in Section 6-7g of EM 1110-2-1701, Hydropower Engineering and Design, dated 31 December 1985. The occasional unavailability of a portion of a hydropower project's generating capacity due to hydrologic variations can be treated in the same manner as the occasional unavailability of all or part of a thermal plant's generating capacity due to forced outages.

There are two components in calculating dependable capacity using the average availability method. The first component is the number of hours in a day a plant can run at full capability during a critical water year. This number represents the lower bound estimate of a plant’s daily contribution in meeting the peak energy demand. The second component is the plant’s actual capability over the hours calculated. The plant’s capability over the defined hours can be less than the rated capacity if there are restrictions in flow less than the plant’s full hydraulic capacity, or if storage in the system has been depleted, reducing reservoir elevations and consequently hydraulic head.

3.1.6 Estimating Hours at Full Capability for Critical Water Year

As explained above, the first component of calculating dependable capacity is estimating the number of hours in a day a plant can run at full capability in a critical water year (critical hours at full capability). This is done for periods of the year when customer demands are high and water availability may be restricted. Conversations with WAPA suggested two critical periods: a summer period from July through August and a winter period from December through January.

For power marketing purposes, WAPA defines the critical water year for the Missouri River plants as 1961. Historically this represents one of the worst adverse water inflow years on record excluding the years 1934–1942. Alternatives for this study include a much longer POR spanning from 1931 to 2012. For the purposes of this study, new critical water years consistent with the POR modeling were developed for this analysis.

The new critical water years were developed by creating a probability of exceedance curve for the total generation for the critical months defined above. These were identified as 1993 for the winter critical period and 1942 for the summer critical period in the No-Action Alternative. Critical years are defined as the year that corresponds to the 95 percent exceedance probability of the total generation.

3.1.7 Equations Used in Computing Critical Hours at Full Capability

The HBC model calculates the daily hours at full capacity (Hours_At_Cap) number for all weekdays in the critical year and critical months. This is done using the following calculations:

$$1)\ \text{Volume\_total (Daily)} = \text{Average\_Flow (Daily)} * 24 * 60 * 60$$

$$2)\ \text{Volume\_Required(Daily)} = \text{Min\_Flow (Hourly)} * 24 * 60 * 60$$

$$3)\ \text{Volume\_Flex} = \min(0,\ \text{Volume\_total (Daily)} - \text{Volume\_Required(Daily)})$$

$$4)\ \text{Volume\_To\_Cap (Hourly)} = (\text{Max\_Flow(Hourly)} - \text{Min\_Flow(Hourly)}) * 60 * 60$$

$$5)\ \text{Hours\_At\_Cap(Daily)} = \text{Volume\_Flex}/\text{Volume\_To\_Cap}$$

$$6)\ \text{Hours\_At\_Cap} = \text{average(Hours\_At\_Cap(daily)) over the critical year and months}$$

To ensure the critical_year_hours.m function is working as intended the model outputs two files that can be used to check calculations:

Plant_name_peak_hours_mat_CY.txt: plant level hours on peak calculation matrix.

Critical marketable_capacity.txt: annual average capability and hours on peak for all plants for the critical year using a baseline alternative.

Once the critical hours at full capability are determined using a baseline alternative, the HBC model can then calculate a plant's dependable capacity for all alternatives.
The HBC model calculates a daily dependable capacity for all weekdays in the critical months over the entire POR. This is done using the following calculations:

$$1)\ \text{Volume\_total (Daily)} = \text{Average\_Flow (Daily)} * 24 * 60 * 60$$

$$2)\ \text{Volume\_Required(Daily)} = \text{Min\_Flow (Hourly)} * 24 * 60 * 60$$

$$3)\ \text{Volume\_Flex(Daily)} = \min(0,\ \text{Volume\_total (Daily)} - \text{Volume\_Required(Daily)})$$

$$4)\ \text{Volume\_Flex(Hourly)} = \text{Volume\_Flex(Daily)}/\text{Hours At Cap}$$

$$5)\ \text{Flow\_Flex(Hourly)} = \text{Volume\_Flex(Hourly)}/(60 * 60)$$

$$6)\ \text{If Flow\_Flex(Hourly)} + \text{Min\_Flow (Hourly)} > \text{Max\_Flow (Hourly)}$$

$$\text{Peak\_FLow} = \text{Max\_Flow (Hourly)}$$

$$\text{Else}$$

$$\text{Peak\_FLow} = \text{Min\_Flow (Hourly)} + \text{Flow\_Flex(Hourly)}$$

$$7)\ \text{Capability (daily)} = \text{Head(daily)} * \text{Peak\_Flow} * \text{efficiency (daily)}/11\ 800$$

A plant's dependable capacity is the average of the capability (daily) during the critical months over the period of record.

3.1.8 Limitations of Modeling and Assumptions

Reductions in renewable hydropower generation would be costly for power cooperatives and rural customers. Typically, when WAPA cannot generate enough hydropower to fulfill its contractually obligated agreements, they must go on the open market and purchase electricity, typically at higher costs. The NED modeling is attempting to estimate the national economic impact of these potential alternatives. However, the impacts illustrated in the results are likely underestimating the total impact of these alternatives. In addition, there could be impacts to ancillary services, reliability, and grid stability, which could be affected under the alternatives. Additional evaluation may result in more adverse impacts under some of the alternatives; however, it should not change the relative ranking of the alternatives compared to No Action. Given the considerable additional analysis required for analyzing these impacts and the likelihood that the modeling would not impact the selection of the preferred alternative, additional evaluation on energy prices, ancillary services, and electricity reliability was not undertaken. Some preliminary analysis on the impact to the units that transmit power to the west from Ft. Peck is included at the end of this report.

3.2 Regional Economic Development Methodology

The RED evaluation uses the output of the NED evaluation to estimate the changes in electricity supplied and/or wholesale electricity rates for preference customers as a result of changes in hydropower production. If there are changes in the hydropower energy generated or capacity due to FPDTR-EIS alternatives, it could lead to changes in electricity supplied or electricity rates, which could affect customer's household spending or business activity. The generation provided by the HBC model is used in the RED evaluation. The RED evaluation uses the hourly load (demand) experienced by WAPA in an attempt to estimate the direct financial impact to WAPA.

The RED benefits for hydropower are based on the results of the NED analysis. WAPA markets its firm power from the hydropower plant to various preferred customers who meet federally mandated criteria. In general, power is marketed to meet the customer's hourly needs. Changes to overall system operations may affect the ability for WAPA to meet these firm demands. Sales of electric power must repay all costs associated with power generation. Under the Reclamation Project Act of 1939, WAPA must establish power rates sufficient to recover operating, maintenance and purchase power expenses and repay the federal government's investment within 50 years for building these generation and transmission facilities. Rates must also be set to cover certain non-power costs Congress has assigned to power users to repay, such as irrigation costs in excess of water users' ability to repay, interest expenses on the unpaid balance of power-related principal and replacement of power facilities within the expected service life of the replacement (Western 2011). WAPA conducts annual power repayment studies to ensure power rates for each project are adequate. Data in the study include historic expenses and investments already repaid from power revenues as well as projections for future years. Also listed is estimated annual repayment of generation and transmission investment costs throughout the repayment period of the project. More specifically, the studies detail year-by-year revenues and expenses, estimated amounts of investment and interest to be paid each year and the total amount of investment remaining to be repaid. Historical data is gathered primarily from accounting records through the last fiscal year. In addition to WAPA marketing and billing records, generation, hydrology and project data, historical and projected figures are provided by the Bureau of Reclamation, the USACE and the International Boundary and Water Commission. Since the amount of energy generated is based on the current hydrology of the system, accurate annual water supply forecasting is important in establishing the proper rate value.

As cooperatives, municipalities, and other preference customers receive their allocation from WAPA, the cooperative and other customers benefit from the relatively low-cost source of hydropower energy, providing rates lower than other for profit electric utilities. If the rates for repayment that WAPA charges its preferred customers need to be increased to cover an increase in costs, these low-cost benefits for preferred customers would decrease and would account for the RED impact. The intent was to obtain reasonable estimates of the financial impact of each alternative, which would in turn affect rates.

The pricing used in this estimate was based on actual 2018 average SPP LMP pricing at USACE generators in the SPP footprint for on- and off-peak periods.

3.3 Other Social Effects Methodology

An environmental benefit associated with hydropower generation is avoided air emissions. In general, electricity generated from a hydropower resource is considered a low emission-producing resource when compared to thermal alternatives because no fuels are actually burned. Without the generation of electricity from hydropower sources, power would likely come from a fossil fuel source, such as a coal-fired or natural gas power plant. Therefore, a reduction in hydropower generation could result in an increase in air emissions due to a greater reliance on fossil fuel power generation in meeting system demand. Since different regions have different electricity-generating resource mixes, the avoided emissions factor is dependent on the region and available alternative sources of electric generation. This factor may also be seasonally or even hourly dependent as different mixes of electricity-generating resources are required to meet demand.

The primary inputs for this analysis are from the HBC model, described in detail in the NED hydropower evaluation. This model will produce monthly and annual average energy generation for each alternative. Electricity generation under the NED hydropower evaluation will be multiplied by a regional emission rate to compute the change in air emissions.

The change in benefits of a particular alternative is based on the difference in electricity generation when compared to existing conditions. For example, a positive difference from existing conditions implies an increase in annual generation, while a negative difference implies a decrease in average annual electricity generation. The decreases in hydropower generation are assumed to be met with alternative sources of energy within the region and are multiplied by the average rate of emissions provided by replacement sources of energy.

The factors used to calculate the increased or decreased emissions depend on what mix of resources would replace the hydropower production. Since different regions have different generating resource mixes, this factor is regionally dependent. The Environmental Protection Agency's (EPA's) eGRID is a comprehensive database of environmental attributes of electric power systems, incorporating data from several federal agencies. One field of data stored in the eGRID database is emission rates for 26 eGRID subregions. These regions are contained within a single North American Electric Reliability Corporation (NERC) region with similar emissions and generating resource mixes. Emission rates from the eGRID database are defined as pounds per MWh for greenhouse gases: CO2, methane, NO, and CO2 equivalent. These can be further divided into baseload and non-baseload generating resources. Since hydropower is used to replace the generating resources on the margin in this region, this study uses the non-baseload emission rates. The appropriate subregion for this study is the MROW, where the most recent database (2016) emissions factors are 1,822 lbs/MWh for carbon dioxide, 0.154 lbs/MWh or methane, 0.029 lbs/MWh for nitrous oxide, and 1,834 for carbon dioxide equivalent.

4.0 National Economic Development Evaluation Results

The table below provides an overall summary of the NED analysis for each of the FPDTR-EIS alternatives. Table 4 summarizes the results for all of the hydropower plants in the Missouri River system. Average annual system NED value ranges from $409.6 million under Alterative 1 to $408.9 million under Alternative 2. Average system impacts over this time period range from a positive impact of $385,000 under Alternative 1 to a negative impact of $290,000 under Alternative 2. Relative to No Action, Alternative 1 has a positive impact and Alternative 2 has the largest negative impact.

Table 4: National Economic Development Analysis of FPDTR-EIS Alternatives to Hydopower Access (2020 Dollars, $000s)

Missouri River Hydropower System	No Action	Alternative 1	Variation 1A	Variation 1B	Alternative 2	Variation 2A	Variation 2B
Average Annual Generation (MWh)	7,155,949	7,154,036	7,150,328	7,154,597	7,150,951	7,151,717	7,156,445
Average Annual Generation Value	$135,255	$135,227	$135,146	$135,221	$135,161	$135,181	$135,266
Average Annual Dependable Capacity – Summer Value	$273,979	$274,392	$273,966	$273,802	$273,783	$273,822	$273,833
Average Annual Dependable Capacity – Winter Value	$260,054	$260,230	$259,999	$260,039	$260,202	$260,170	$260,263
Total Average Annual System Value (NED)	$409,234	$409,620	$409,112	$409,024	$408,944	$409,003	$409,098
Total Average Annual System Value Change from No Action		$385	($122)	($211)	($290)	($231)	($136)
Total Average Annual System Value Percent Change from No Action		0.09%	-0.03%	-0.05%	-0.07%	-0.06%	-0.03%

4.1 No Action (Current System Operation)

The No Action Alternative serves as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow.

The NED analysis for No Action is summarized in Table 5. The information for both the system as a whole and the individual plants are detailed. Average annual generation NED value is estimated to be $135 million for the system and $15 million for Fort Peck. Average annual summer capacity value is $274 million for the system and $24 million for Ft. Peck. Total average annual estimated NED value for the system is $409 million for the system and almost $40 million for Fort Peck.

Table 5. Summary of National Economic Development Analysis for No Action (2020 Dollars, $000s)

Measure	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavin's Point	System
Period of Record							
Average Annual Generation Value	$15,091	$39,344	$45,626	$18,641	$4,469	$12,084	$135,255
Average Annual Capacity Value - Summer	$24,431	$57,662	$74,216	$58,824	$43,911	$14,935	$273,979
Average Annual Capacity Value - Winter	$24,864	$54,896	$70,005	$55,897	$39,576	$14,788	$260,054
Total Average Annual Generation and (Summer) Capacity NED Value	$39,523	$97,006	$119,842	$77,465	$48,380	$27,018	$409,234

4.2 Alternative 1 including Variations 1A and 1B

4.2.1 Alternative 1

The NED Analysis for Alternative 1 is summarized by plant in the table below. This table details the estimated impacts averaged over the full period of record as well as the estimated impact specifically in full flow years, partial flow years, non-flow years, and years after flow years. When looking at the full period of record, the estimated average annual NED impact is actually a positive $385,000 for the system as a whole, but Ft. Peck specifically averages $349,000 in average annual negative NED impact relative to No Action. Changes being made under this alternative at Ft. Peck which reduced the total average annual value, are actually increasing the total average annual value for many of the downstream dams, which is why the system as a whole is showing positive impacts. For the system, Alternative 1 increases the value by about 0.1% for the system and decreases the value at Ft. Peck by about 0.9%.

The estimated average annual NED impact of Alternative 1 in full flow years is positive $3 million for the system as a whole, but with negative impacts at Ft. Peck of nearly $1.3 million during full flow years. This is a 2.85% decrease from No Action.

Table 6. Summary of National Economic Development Analysis for Alternative 1 (2020 Dollars, $000s)

Measure	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavin's Point	Missouri River System
Period of Record							
Average Annual Generation Value	$14,943	$39,441	$45,652	$18,640	$4,467	$12,083	$135,227
Average Annual Capacity Value - Summer	$24,231	$58,270	$74,221	$58,819	$43,915	$14,936	$274,392
Total Average Annual Generation and Capacity NED Value	$39,174	$97,712	$119,873	$77,460	$48,383	$27,019	$409,620
Difference in NED Value from No Action	-$349	$706	$31	-$5	$3	$0	$385
% Difference from No Action	-0.88%	0.73%	0.03%	-0.01%	0.01%	0.00%	0.09%
Full Flow Years							
Average Annual Generation Value	$17,381	$42,742	$51,671	$19,652	$4,643	$13,372	$149,460
Average Annual Capacity Value - Summer	$26,029	$62,014	$79,944	$59,218	$43,950	$14,951	$286,106
Total Average Annual Generation and Capacity NED Value	$43,410	$104,756	$131,614	$78,870	$48,593	$28,323	$435,566
Difference in NED Value from No Action	-$1,271	$4,163	$145	$28	-$1	-$4	$3,060
% Difference from No Action	-2.85%	3.71%	0.12%	0.03%	-0.07%	-0.01%	0.71%
Partial Flow Years							
Average Annual Generation Value	$18,695	$48,238	$55,886	$21,868	$4,837	$13,399	$162,922
Average Annual Capacity Value - Summer	$26,301	$62,636	$82,396	$61,150	$44,534	$15,099	$292,116

Total Average Annual Generation and Capacity NED Value	$44,995	$110,874	$138,281	$83,018	$49,371	$28,498	$455,038
Difference in NED Value from No Action	-$959	$941	-$51	-$22	$3	-$7	-$96
% Difference from No Action	-2.09%	0.79%	-0.04%	-0.04%	-0.01%	-0.03%	-0.02%
Non-Flow Years							
Average Annual Generation Value	$12,848	$35,569	$40,659	$17,322	$4,303	$11,344	$122,044
Average Annual Capacity Value - Summer	$22,989	$56,759	$69,869	$57,860	$43,649	$14,865	$265,991
Total Average Annual Generation and Capacity NED Value	$35,837	$92,328	$110,528	$75,183	$47,951	$26,209	$388,036
Difference in NED Value from No Action	-$2	$36	$19	-$22	$3	-$7	$48
% Difference from No Action	-0.01%	0.05%	0.02%	0.00%	0.00%	0.01%	0.01%
Years After Flow Years							
Average Annual Generation Value	$18,612	$45,497	$52,743	$20,569	$4,692	$12,912	$155,024
Average Annual Capacity Value - Summer	$26,186	$56,908	$80,688	$60,612	$44,530	$15,091	$284,015
Total Average Annual Generation and Capacity NED Value	$44,797	$102,405	$133,431	$81,181	$49,222	$28,003	$439,039
Difference in NED Value from No Action	-$395	-$6	$55	-$12	$16	$2	-$340
% Difference from No Action	-0.88%	-0.01%	0.04%	-0.02%	0.03%	0.01%	-0.08%

The estimated average annual NED impact of Alternative 1 in partial flow years is adverse impacts of $96,000 for the system as a whole and $960,000 at Fort Peck. This is a 2.13% decrease from No Action. In non-flow years, as would be expected, there is minimal change to the average annual value. In the years after flow years, there is a decrease in value for both the system and Ft. Peck specifically.

4.2.2 Alternative 1 - Variation 1A

The NED Analysis for Alternative 1 – Variation 1A is summarized in the table below. This table details the estimated impacts averaged over the full period of record as well as the estimated impact specifically in full flow years, partial flow years, non-flow years, and years after flow years. When looking at the full period of record, the estimated average annual NED impact is $122,000 for the system as a whole, but Ft. Peck specifically averages $276,000 in average annual impact as compared to No Action. This surprising contradiction between the system and Ft. Peck impacts is primarily due to positive benefits at Garrison. Alternative 1A decrease the value by about 0.03% for the system and decreases the value at Ft. Peck by about 0.7%.

The estimated average annual NED impact of Alternative 1A in full flow years is adverse impacts of $738,000 for the system as a whole and $993,000 at Fort Peck. This is a 2.24% decrease from No Action.

Table 7. Summary of National Economic Development Analysis for Alternative 1A (2020 Dollars, $000s)

Measure	Ft. Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavin's Point	Missouri River System
Period of Record							
Average Annual Generation Value	$14,944	$39,369	$45,632	$18,644	$4,470	$12,086	$135,146
Average Annual Capacity Value - Summer	$24,303	$57,801	$74,195	$58,813	$43,922	$14,934	$273,966
Total Average Annual Generation and Capacity NED Value	$39,247	$97,170	$119,827	$77,457	$48,391	$27,020	$409,112
Difference in NED Value from No Action	-$276	$164	-$15	-$8	$11	$2	-$122
% Difference from No Action	-0.70%	0.17%	-0.01%	-0.01%	0.02%	0.01%	-0.03%
Full Flow Years							
Average Annual Generation Value	$17,984	$44,152	$52,792	$20,159	$4,707	$13,358	$153,151
Average Annual Capacity Value - Summer	$26,264	$59,183	$81,040	$59,918	$44,169	$14,995	$285,569
Total Average Annual Generation and Capacity NED Value	$44,248	$103,335	$133,833	$80,077	$48,875	$28,353	$438,721
Difference in NED Value from No Action	-$993	$284	-$45	$17	-$2	$1	-$738
% Difference from No Action	-2.19%	0.28%	-0.03%	0.04%	-0.03%	0.00%	-0.17%
Partial Flow Years							
Average Annual Generation Value	$19,180	$49,414	$57,039	$22,695	$4,895	$13,601	$166,825
Average Annual Capacity Value - Summer	$27,406	$62,295	$80,565	$61,037	$44,597	$15,117	$291,017
Total Average Annual Generation and Capacity NED Value	$46,586	$111,709	$137,605	$83,732	$49,492	$28,718	$457,841
Difference in NED Value from No Action	-$735	-$153	-$57	-$9	$1	-$1	-$953
% Difference from No Action	-1.58%	-0.13%	-0.05%	-0.03%	0.04%	-0.01%	-0.21%
Non-Flow Years							
Average Annual Generation Value	$13,063	$35,912	$41,052	$17,446	$4,317	$11,390	$123,180
Average Annual Capacity Value - Summer	$23,086	$56,866	$70,140	$57,922	$43,684	$14,866	$266,564
Total Average Annual Generation and Capacity NED Value	$36,149	$92,778	$111,192	$75,368	$48,001	$26,257	$389,744
Difference in NED Value from No Action	-$27	$19	-$5	-$16	$15	$4	$18
% Difference from No Action	-0.08%	0.03%	0.00%	-0.01%	0.03%	0.02%	0.00%
Years After Flow Years							
Average Annual Generation Value	$17,378	$43,761	$51,253	$20,037	$4,631	$12,763	$149,824

Average Annual Capacity Value - Summer	$25,640	$57,649	$80,756	$60,413	$44,377	$15,082	$283,918
Total Average Annual Generation and Capacity NED Value	$43,019	$101,410	$132,009	$80,450	$49,009	$27,845	$433,742
Difference in NED Value from No Action	-$261	$984	$8	-$9	$19	-$7	$734
% Difference from No Action	0.60%	0.84%	0.01%	0.01%	0.04%	-0.02%	0.17%

The estimated average annual NED impact of Alternative 1A in partial flow years is $953,000 for the system as a whole and impacts at Ft. Peck of $735,000. This is a 1.6% decrease from No Action at Ft. Peck. In non-flow years, as would be expected, there is minimal change to the average annual value. In the years after flow years, there is a decrease in value for Ft. Peck specifically, but an increase in system value overall.

4.2.3 Alternative 1 - Variation 1B

The NED Analysis for Alternative 1 – Variation 1B is summarized in the table below. This table details the estimated impacts averaged over the full period of record as well as the estimated impact specifically in full flow years, partial flow years, non-flow years, and years after flow years. When looking at the full period of record, the estimated average annual NED impact is adverse impacts of $211,000 for the system as a whole, but Ft. Peck specifically averages $364,205 in adverse average annual impacts relative to No Action. This indicates that most of the decreases in value are occurring at Ft. Peck. Changes downstream, primarily at Garrison, are mitigating some of the impact for the system as a whole. Variation 1B decreased the value by about 0.05% for the system and decreases the value at Ft. Peck by about 0.9%.

The estimated average annual impact of Variation 1B in full flow years is positive for the system as a whole, but with negative impacts at Ft. Peck of $691,000. This is a 1.6% decrease from No Action.

Table 8. Summary of National Economic Development Analysis for Alternative 1B (2020 Dollars, $000s)

Measure	Ft. Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavin's Point	Missouri River System
Period of Record							
Average Annual Generation Value	$14,993	$39,389	$45,639	$18,644	$4,470	$12,086	$135,221
Average Annual Capacity Value - Summer	$24,166	$57,781	$74,185	$58,805	$43,927	$14,939	$273,802
Total Average Annual Generation and Capacity NED Value	$39,159	$97,170	$119,824	$77,449	$48,397	$27,025	$409,024
Difference in NED Value from No Action	-$364	$164	-$18	-$16	$17	$6	-$211
% Difference from No Action	-0.92%	0.17%	-0.02%	-0.02%	0.04%	0.02%	-0.05%
Full Flow Years							
Average Annual Generation Value	$16,700	$42,017	$51,969	$20,014	$4,625	$13,461	$148,787
Average Annual Capacity Value - Summer	$26,465	$61,796	$80,992	$60,480	$44,454	$15,093	$289,279

Total Average Annual Generation and Capacity NED Value	$43,165	$103,813	$132,961	$80,494	$49,079	$28,554	$438,066
Difference in NED Value from No Action	-$691	$734	$33	-$26	-$5	$0	$46
% Difference from No Action	-1.58%	0.72%	0.05%	-0.04%	-0.09%	0.00%	0.01%
Partial Flow Years							
Average Annual Generation Value	$18,703	$47,236	$54,458	$21,123	$4,792	$13,316	$159,629
Average Annual Capacity Value - Summer	$25,750	$60,106	$81,046	$60,019	$44,167	$15,002	$286,091
Total Average Annual Generation and Capacity NED Value	$44,453	$107,342	$135,504	$81,142	$48,960	$28,318	$445,720
Difference in NED Value from No Action	-$1,265	$541	-$93	-$7	$4	-$3	-$824
% Difference from No Action	-2.77%	0.47%	-0.07%	0.01%	0.01%	-0.01%	-0.18%
Non-Flow Years							
Average Annual Generation Value	$12,521	$34,576	$39,471	$16,955	$4,265	$11,157	$118,945
Average Annual Capacity Value - Summer	$22,607	$56,243	$68,843	$57,538	$43,575	$14,841	$263,647
Total Average Annual Generation and Capacity NED Value	$35,129	$90,819	$108,314	$74,493	$47,840	$25,997	$382,591
Difference in NED Value from No Action	-$14	-$3	-$13	-$17	$30	$7	-$11
% Difference from No Action	-0.04%	0.01%	0.03%	-0.01%	0.08%	0.08%	0.00%
Years After Flow Years							
Average Annual Generation Value	$17,929	$44,777	$52,242	$20,595	$4,687	$12,945	$153,176
Average Annual Capacity Value - Summer	$26,198	$57,771	$80,041	$60,668	$44,527	$15,104	$284,308
Total Average Annual Generation and Capacity NED Value	$44,127	$102,548	$132,283	$81,263	$49,214	$28,049	$437,484
Difference in NED Value from No Action	-$266	-$71	$25	-$15	$2	$21	-$305
% Difference from No Action	-0.60%	-0.08%	0.03%	-0.01%	0.08%	0.08%	-0.07%

The estimated average annual impact of Variation 1B in partial flow years is $824,000 for the system as a whole and impacts at Ft. Peck of $1.3 million. This is a 2.85% decrease from No Action at Ft. Peck. In non-flow years, as would be expected, there is minimal change to the average annual value. In the years after flow years, there is a decrease in value for both the system and Ft. Peck specifically.

4.3 Annual Impacts for Alternative 1 including Variations 1A and 1B

4.3.1 Alternative 1

When evaluating the impacts for each of the FPDTR-EIS alternatives, it is helpful to also examine the annual impacts. The figures below shows the annual NED impacts to hydropower for Alternative 1 relative to No Action for both the Missouri River system and Fort Peck specifically. The differences in annual NED costs between No Action and Alternative 1 are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences from No Action for the system range from an increase of $31.5 million in 1983 (a full flow year) to a decrease of $2.2 million in 1995 (the year after a full release). Full flow years under this alternative seem to have a mostly positive impact on the system under this alternative. Impacts to the system in other types of flow years are more varied.

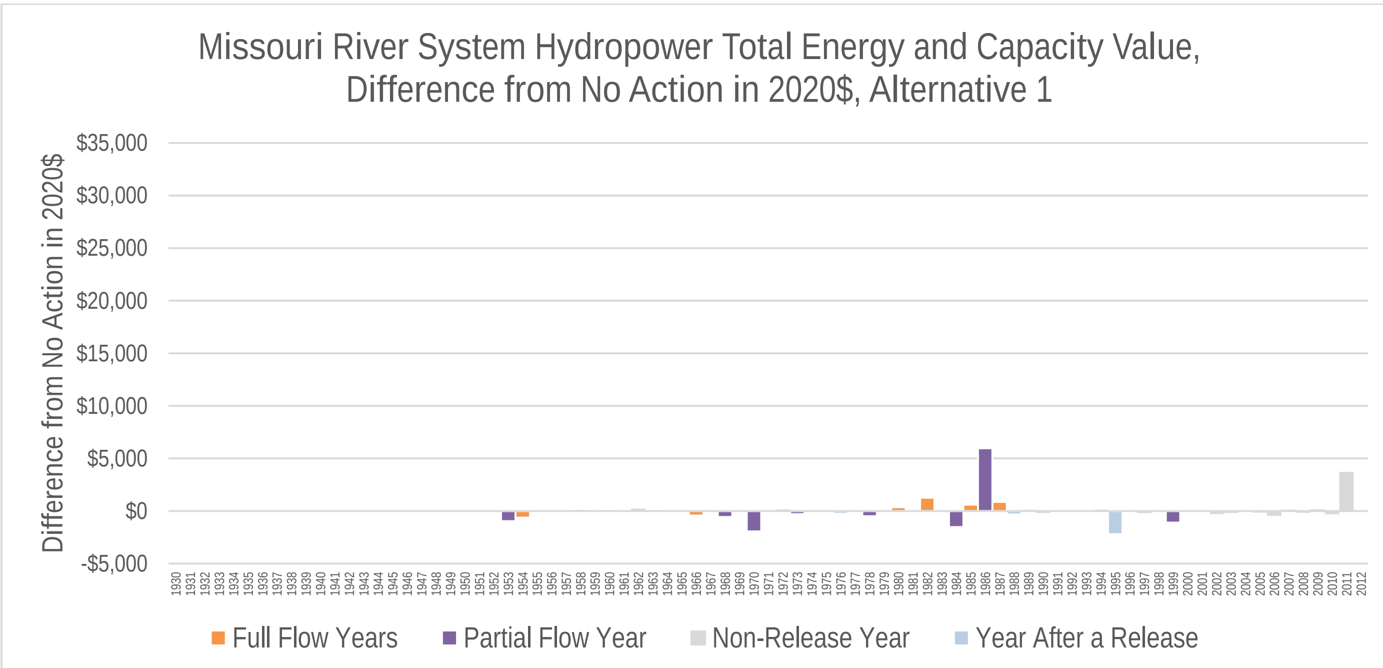

Figure 4. System Difference in Generation and Summer Capacity Hydropower Value under Alternative 1 from No Action (2020 Dollars, $000s)

At Ft. Peck, differences from No Action under Alternative 1 range from a decrease of $7.2 million in 1983 to an increase of $74,000 in 1975. Both full flow and partial flow years seem to have a negative impact at Ft. Peck, as well as a few years that are occurring after a release.

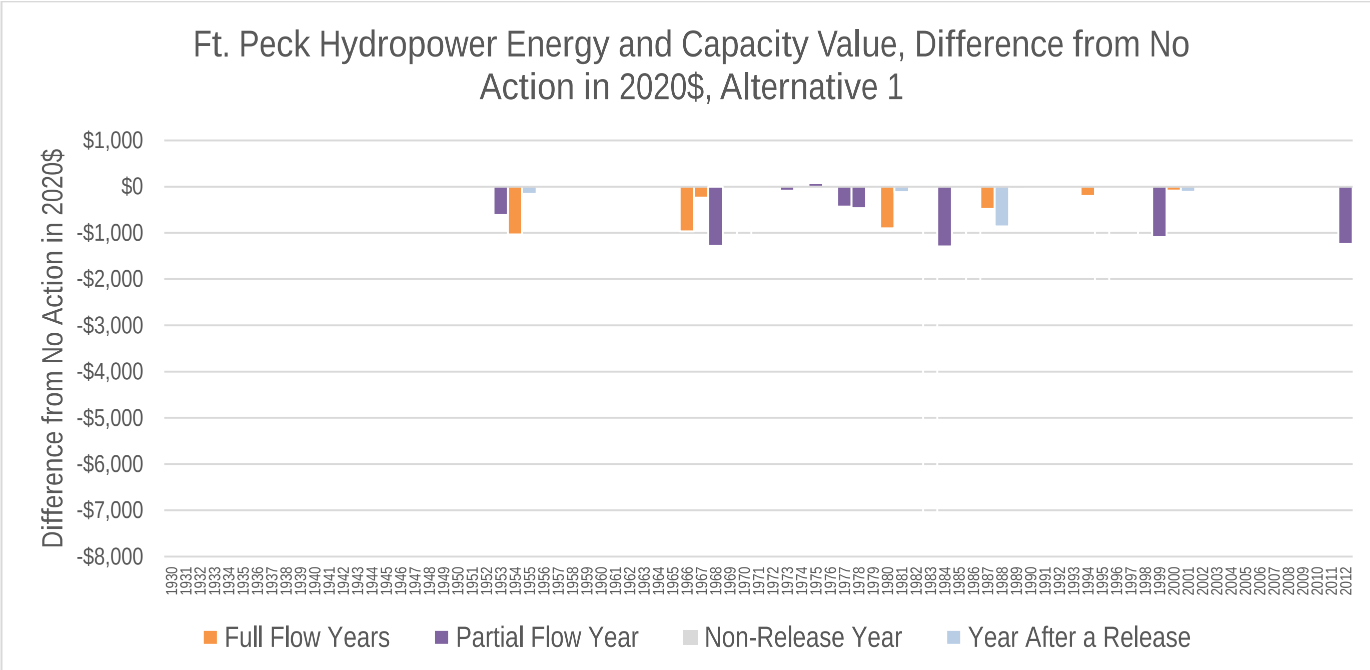

Figure 5. Ft Peck Difference in Generation and Summer Capacity Hydropower Value under Alternative 1 from No Action (2020 Dollars, $000s)

4.3.2 Alternative 1 – Variation 1A

The figures below shows the annual NED impacts to hydropower for Alternative 1A relative to No Action for both the Missouri River system and Ft. Peck specifically. The differences in annual NED costs between No Action and Alternative 1 are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences from No Action for the system range from an increase of $8.9 million in 1995 (which is the year after a release) to a decrease of $6.6 million in 1986. Full and partial flow years under this variation seem to have a mostly negative impact on the system under this alternative. Impacts to the system in other types of flow years are more varied.

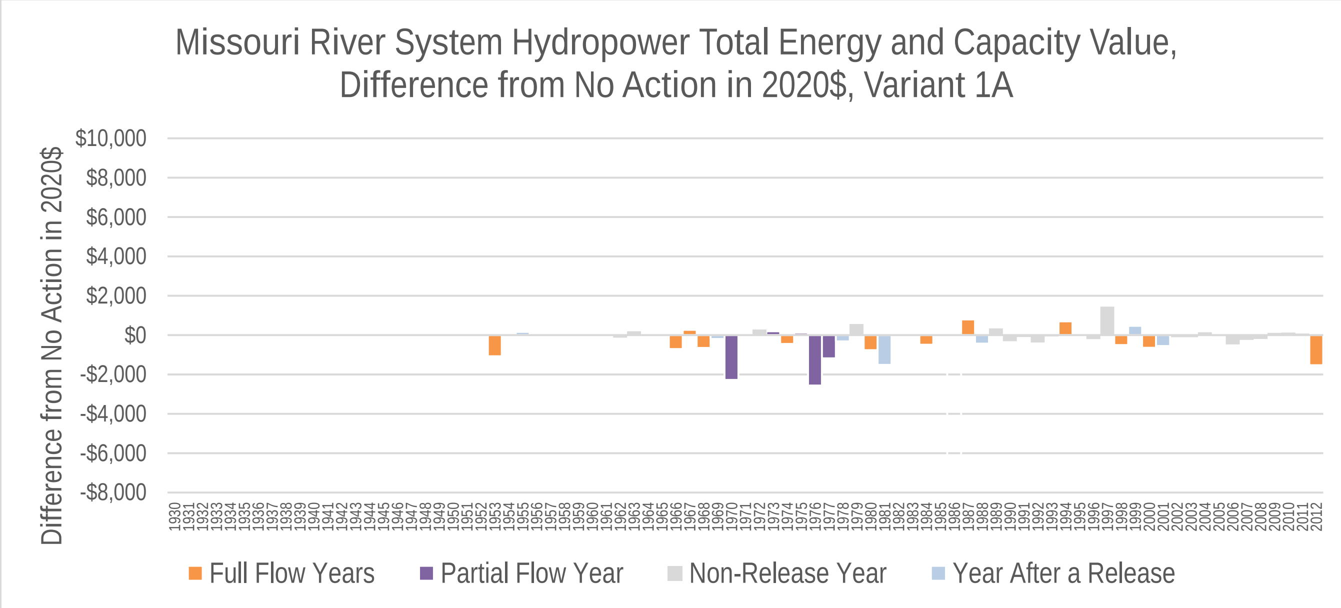

Figure 6. System Difference in Generation and Summer Capacity Hydropower Value under Alternative 1A from No Action (2020 Dollars, $000s)

At Ft. Peck, differences from No Action under Alternative 1A range from a decrease of $3.9 million in 1986 to an increase of $275,000 in 1975. Both full flow and partial flow years seem to have a negative impact at Ft. Peck for the most part, as well as a few years that are occurring after a release.

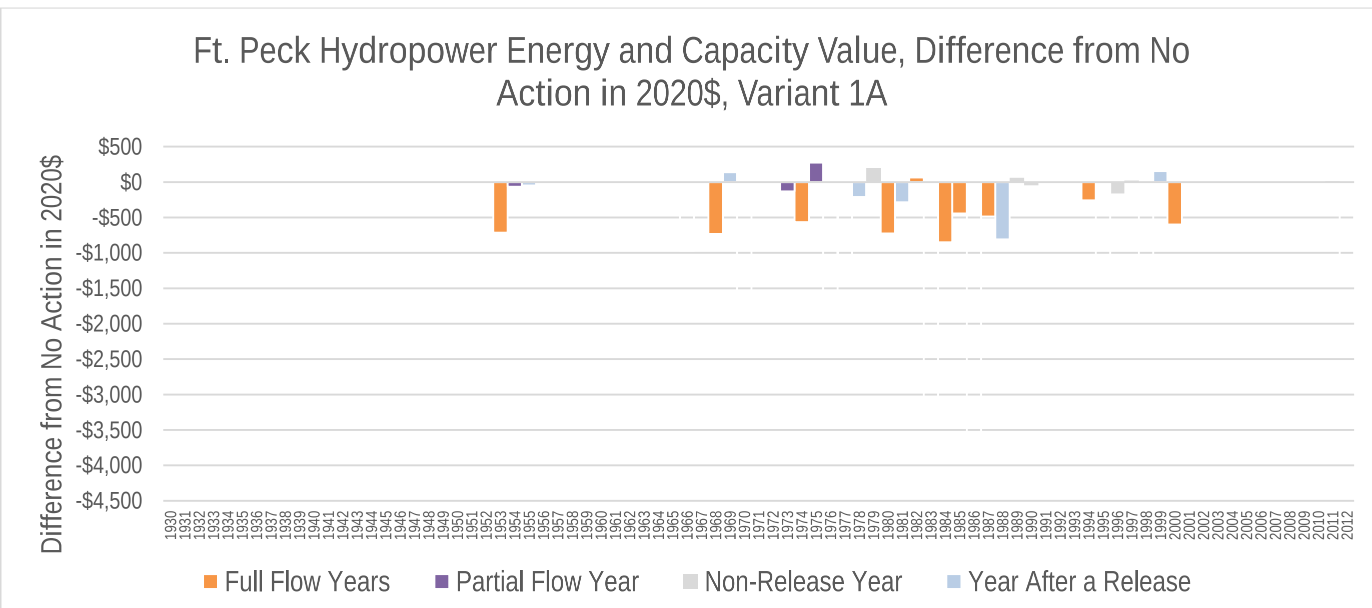

Figure 7. Ft Peck Difference in Generation and Summer Capacity Hydropower Value under Alternative 1A from No Action (2020 Dollars, $000s)

4.3.2 Alternative 1 – Variation 1B

The figures below shows the annual NED impacts to hydropower for Alternative 1B relative to No Action for both the Missouri River system and Ft. Peck specifically. The differences in annual NED value between No Action and Alternative 1B are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences from No Action for the system range from an increase of $4.8 million in 1983 to a decrease of $6.2 million in 1986. Both of these years are partial flow years, indicating there are varied impacts for the system for these types of years under this alternative.

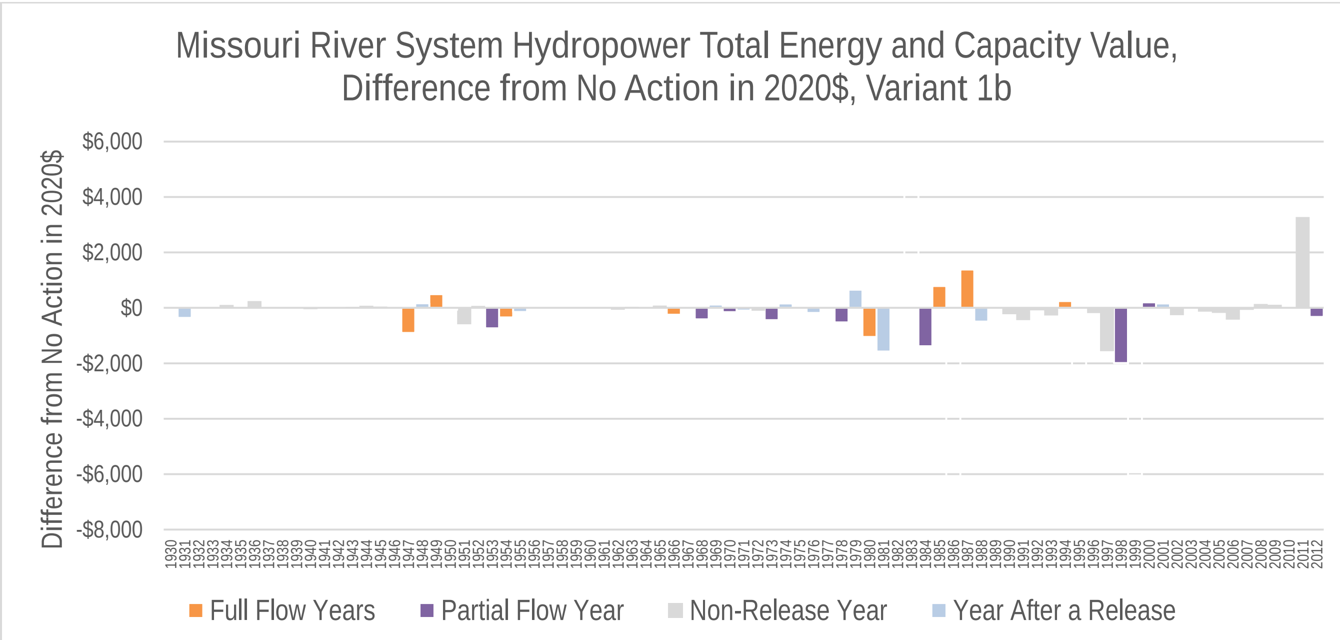

Figure 8. System Difference in Generation and Summer Capacity Hydropower Value under Alternative 1B from No Action (2020 Dollars, $000s)

At Fort Peck, differences from No Action under Alternative 1B range from a decrease of $6.2 million in 1983 to an increase of $291,000 in 1982. Both full flow and partial flow years seem to have a negative impact at Ft. Peck for the most part, as well as a few years that are occurring after a release.

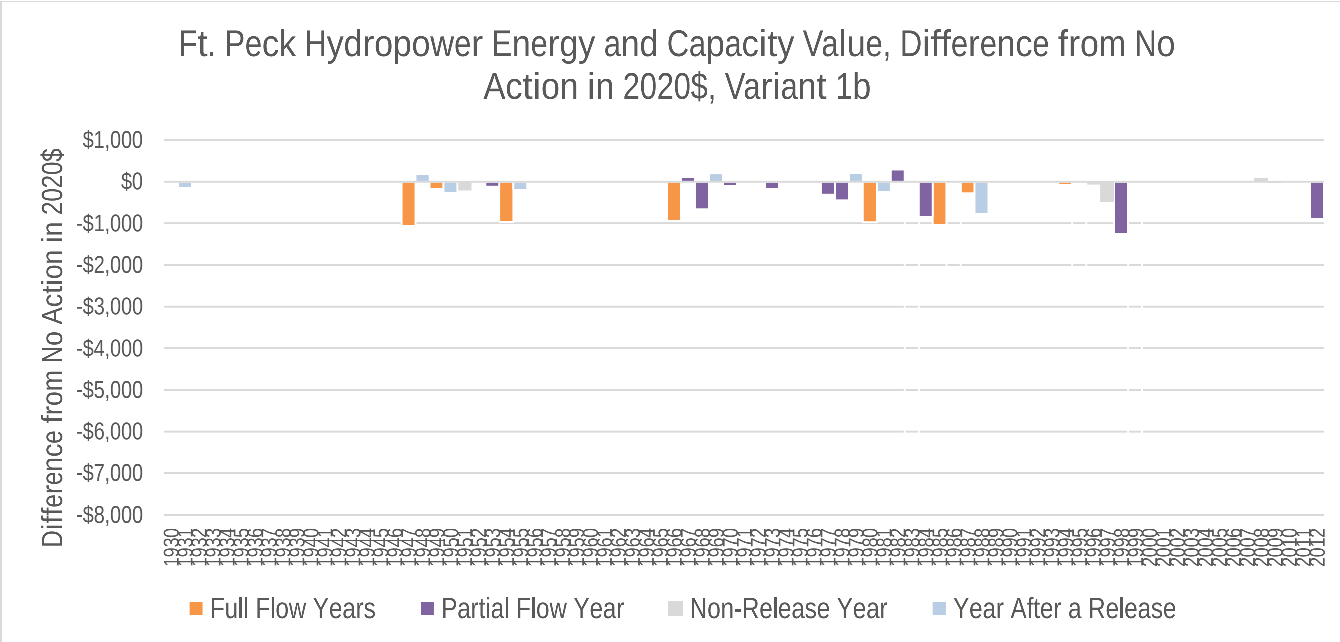

Figure 9. Ft Peck Difference in Generation and Summer Capacity Hydropower Value under Alternative 1B from No Action (2020 Dollars, $000s)

4.3.3 Summary of Annual Impacts for Alternative 1 including Variations 1A and 1B

In comparing the annual impacts over the period of record across all variations of Alternative 1, the differences in value relative to No Action is very dependent on the variation as well as the scale at which the impacts are being examined. In many of the years, decreases at Ft. Peck are actually showing increases in value for the system as a whole. This indicates that changes made at Ft. Peck under those alternatives are being mitigated by changes downstream. Additionally, the tables below show the annual impacts for Alternative 1 and its variations at both Fort Peck and for the system as a whole.

Table 9. Annual Missouri River System NED Impacts (2020 Dollars, $000s)

Missouri River System Impacts							
Year	No Action	Alternative 1	Alt1 Diff from No Action	Alternative 1 - Variation A	Alt1A Diff from No Action	Alternative 1 - Variation B	Alt1B Diff from No Action
1931	$406,234.3	$406,234.3	$0.0	$406,234.3	$0.0	$405,872.5	-$361.8
1932	$386,859.1	$386,859.1	$0.0	$386,859.1	$0.0	$386,838.8	-$20.4
1933	$378,813.0	$378,813.0	$0.0	$378,813.9	$0.9	$378,801.0	-$12.0
1934	$350,596.1	$350,596.1	$0.0	$350,596.2	$0.1	$350,704.1	$108.0
1935	$299,122.3	$299,122.3	$0.0	$299,122.3	$0.0	$299,119.5	-$2.8
1936	$299,235.6	$299,235.6	$0.0	$299,235.6	$0.0	$299,483.6	$248.0
1937	$301,940.9	$301,940.9	$0.0	$301,940.9	$0.0	$301,912.4	-$28.5
1938	$307,630.2	$307,630.2	$0.0	$307,630.6	$0.3	$307,635.5	$5.2
1939	$324,456.9	$324,456.9	$0.0	$324,456.9	$0.0	$324,439.0	-$18.0
1940	$319,016.7	$319,016.7	$0.0	$319,016.7	$0.0	$318,966.6	-$50.1
1941	$315,599.4	$315,599.4	$0.0	$315,599.4	$0.0	$315,583.5	-$16.0
1942	$333,572.1	$333,572.1	$0.0	$333,572.1	$0.0	$333,564.2	-$7.9

1943	$429,537.1	$429,537.1	$0.0	$429,537.8	$0.8	$429,567.9	$30.8
1944	$408,220.9	$408,220.9	$0.0	$408,221.3	$0.4	$408,301.2	$80.3
1945	$439,201.8	$439,201.8	$0.0	$439,201.6	-$0.1	$439,252.8	$51.0
1946	$430,067.0	$430,067.0	$0.0	$430,066.9	-$0.1	$430,060.6	-$6.4
1947	$443,113.5	$443,113.5	$0.0	$443,113.7	$0.3	$442,209.4	-$904.0
1948	$455,605.6	$455,605.6	$0.0	$455,605.6	$0.0	$455,767.4	$161.9
1949	$441,703.1	$441,703.1	$0.0	$441,703.1	$0.0	$442,197.6	$494.5
1950	$435,621.5	$435,621.5	$0.0	$435,621.7	$0.1	$435,547.4	-$74.2
1951	$418,491.0	$418,491.0	$0.0	$418,491.5	$0.5	$417,897.4	-$593.6
1952	$479,908.2	$479,908.2	$0.0	$479,905.9	-$2.3	$479,977.3	$69.1
1953	$462,355.8	$461,388.0	-$967.8	$461,282.0	-$1,073.9	$461,616.8	-$739.0
1954	$437,219.5	$436,594.5	-$625.0	$437,217.1	-$2.5	$436,873.3	-$346.2
1955	$425,609.3	$425,518.0	-$91.3	$425,768.5	$159.1	$425,462.0	-$147.4
1956	$418,373.4	$418,321.4	-$51.9	$418,361.1	-$12.2	$418,361.0	-$12.4
1957	$402,293.8	$402,271.0	-$22.7	$402,323.9	$30.2	$402,301.7	$7.9
1958	$399,295.0	$399,397.1	$102.1	$399,282.2	-$12.7	$399,308.0	$13.0
1959	$400,308.9	$400,221.6	-$87.3	$400,317.9	$9.0	$400,327.2	$18.2
1960	$383,963.8	$384,029.2	$65.4	$383,962.8	-$1.0	$383,978.3	$14.5
1961	$376,706.7	$376,684.4	-$22.3	$376,698.1	-$8.6	$376,715.3	$8.6
1962	$288,922.0	$289,148.7	$226.7	$288,789.3	-$132.7	$288,858.1	-$63.9
1963	$406,127.9	$406,202.5	$74.6	$406,322.6	$194.7	$406,163.7	$35.8
1964	$416,943.9	$416,928.2	-$15.7	$416,950.8	$7.0	$416,953.7	$9.9
1965	$442,180.5	$442,094.3	-$86.3	$442,189.0	$8.5	$442,263.7	$83.2
1966	$452,695.1	$452,271.3	-$423.8	$451,987.8	-$707.3	$452,447.8	-$247.2
1967	$454,073.6	$453,914.1	-$159.5	$454,343.9	$270.3	$454,139.0	$65.4
1968	$464,088.5	$463,514.8	-$573.7	$463,439.7	-$648.8	$463,678.1	-$410.5
1969	$454,721.5	$454,782.3	$60.8	$454,525.5	-$196.0	$454,839.8	$118.3
1970	$470,124.0	$468,180.3	-$1,943.7	$467,844.9	-$2,279.1	$469,971.1	-$152.9
1971	$483,077.2	$482,956.5	-$120.7	$483,093.0	$15.7	$482,984.4	-$92.8
1972	$478,480.2	$478,626.5	$146.3	$478,758.2	$278.0	$478,385.8	-$94.4
1973	$440,924.7	$440,634.8	-$290.0	$441,115.3	$190.6	$440,481.3	-$443.5
1974	$460,107.5	$460,229.9	$122.3	$459,656.6	-$450.9	$460,265.2	$157.7
1975	$495,637.2	$495,461.9	-$175.4	$495,757.8	$120.6	$495,639.9	$2.6
1976	$490,737.3	$490,473.2	-$264.2	$488,171.1	-$2,566.2	$490,557.0	-$180.4
1977	$418,126.0	$418,127.3	$1.3	$416,942.8	-$1,183.2	$418,126.3	$0.4
1978	$463,547.3	$463,052.6	-$494.7	$463,232.9	-$314.4	$463,021.3	-$525.9
1979	$476,640.7	$476,461.0	-$179.7	$477,196.8	$556.2	$477,298.8	$658.1
1980	$444,824.1	$445,182.6	$358.5	$444,054.6	-$769.5	$443,778.1	-$1,046.0
1981	$430,116.0	$429,903.9	-$212.1	$428,603.6	-$1,512.5	$428,539.2	-$1,576.9
1982	$445,361.2	$446,615.4	$1,254.2	$445,287.6	-$73.6	$445,362.0	$0.8
1983	$356,320.1	$387,840.8	$31,520.7	$356,221.8	-$98.3	$361,119.8	$4,799.7
1984	$451,486.2	$449,964.8	-$1,521.4	$450,999.0	-$487.2	$450,103.5	-$1,382.8
1985	$433,861.1	$434,472.1	$611.0	$433,929.6	$68.5	$434,649.4	$788.3

1986	$422,390.9	$428,352.6	$5,961.7	$415,737.7	-$6,653.2	$416,158.3	-$6,232.7
1987	$436,726.5	$437,593.9	$867.4	$437,523.3	$796.8	$438,107.4	$1,380.9
1988	$420,096.8	$419,769.9	-$326.8	$419,660.6	-$436.2	$419,601.7	-$495.0
1989	$403,312.8	$403,433.0	$120.2	$403,652.8	$340.0	$403,283.9	-$28.9
1990	$386,067.8	$385,888.0	-$179.8	$385,760.9	-$306.9	$385,837.5	-$230.3
1991	$386,551.9	$386,553.1	$1.2	$386,450.2	-$101.7	$386,111.3	-$440.5
1992	$351,539.2	$351,603.0	$63.8	$351,161.6	-$377.5	$351,449.1	-$90.0
1993	$206,762.7	$206,718.7	-$44.0	$206,694.9	-$67.8	$206,490.6	-$272.1
1994	$414,019.5	$414,232.6	$213.1	$414,713.8	$694.3	$414,264.6	$245.0
1995	$381,006.5	$378,807.9	-$2,198.6	$389,978.9	$8,972.4	$378,722.6	-$2,283.9
1996	$497,920.0	$497,842.6	-$77.5	$497,715.2	-$204.8	$497,732.8	-$187.2
1997	$521,304.1	$521,098.2	-$205.9	$522,746.7	$1,442.7	$519,739.9	-$1,564.2
1998	$439,016.6	$439,135.1	$118.5	$438,507.6	-$509.0	$437,025.3	-$1,991.4
1999	$467,218.2	$466,116.0	-$1,102.2	$467,687.3	$469.1	$461,174.1	-$6,044.1
2000	$443,449.1	$443,372.4	-$76.7	$442,807.1	-$642.0	$443,649.3	$200.2
2001	$371,675.7	$371,490.6	-$185.1	$371,124.3	-$551.4	$371,833.2	$157.5
2002	$391,082.5	$390,794.8	-$287.7	$390,973.2	-$109.3	$390,821.3	-$261.2
2003	$388,405.4	$388,224.8	-$180.6	$388,300.7	-$104.7	$388,411.7	$6.2
2004	$368,193.9	$368,145.5	-$48.4	$368,342.1	$148.2	$368,057.3	-$136.6
2005	$359,366.8	$359,210.0	-$156.8	$359,317.4	-$49.3	$359,186.1	-$180.6
2006	$368,246.6	$367,779.1	-$467.5	$367,774.4	-$472.2	$367,824.5	-$422.1
2007	$349,318.6	$349,445.3	$126.7	$349,074.0	-$244.6	$349,247.9	-$70.7
2008	$345,914.4	$345,738.8	-$175.6	$345,718.3	-$196.1	$346,054.7	$140.3
2009	$369,728.9	$369,887.1	$158.2	$369,840.5	$111.6	$369,839.4	$110.5
2010	$374,496.3	$374,188.2	-$308.1	$374,625.0	$128.7	$374,490.4	-$5.8
2011	$513,036.2	$516,757.0	$3,720.8	$513,116.1	$79.8	$516,316.1	$3,279.9
2012	$450,571.9	$450,621.6	$49.7	$449,043.6	-$1,528.3	$450,246.7	-$325.1

The table below details the annual energy and capacity impacts at Fort Peck for Alternative 1 and each variation. On average, the variation with the greatest impact is Alternative 1 – Variation B. There are a number of years under all of the alternatives that have a large decrease in NED value relative to No Action.

Table 10. Annual NED Impacts at Fort Peck (2020 Dollars, $000s)

Ft. Peck NED Impacts							
Year	No Action	Alternative 1	Alt1 Diff from No Action	Alternative 1 - Variation A	Alt1A Diff from No Action	Alternative 1 - Variation B	Alt1B Diff from No Action
1931	$38,124.7	$38,124.7	$0.0	$38,124.7	$0.0	$37,978.0	-$146.7
1932	$34,638.0	$34,638.0	$0.0	$34,638.0	$0.0	$34,635.0	-$3.0
1933	$33,974.1	$33,974.1	$0.0	$33,974.1	$0.0	$33,978.2	$4.1
1934	$32,895.2	$32,895.2	$0.0	$32,895.2	$0.0	$32,888.9	-$6.3
1935	$23,031.5	$23,031.5	$0.0	$23,031.5	$0.0	$23,025.3	-$6.2
1936	$22,723.7	$22,723.7	$0.0	$22,723.7	$0.0	$22,734.6	$11.0
1937	$19,069.0	$19,069.0	$0.0	$19,069.0	$0.0	$19,083.2	$14.2

1938	$19,542.3	$19,542.3	$0.0	$19,542.3	$0.0	$19,551.8	$9.5
1939	$23,572.9	$23,572.9	$0.0	$23,572.9	$0.0	$23,579.6	$6.7
1940	$25,907.6	$25,907.6	$0.0	$25,907.6	$0.0	$25,914.6	$7.0
1941	$25,681.4	$25,681.4	$0.0	$25,681.4	$0.0	$25,689.2	$7.8
1942	$29,223.4	$29,223.4	$0.0	$29,223.4	$0.0	$29,228.6	$5.2
1943	$35,320.2	$35,320.2	$0.0	$35,320.2	$0.0	$35,327.7	$7.4
1944	$36,995.6	$36,995.6	$0.0	$36,995.6	$0.0	$36,984.0	-$11.5
1945	$38,251.1	$38,251.1	$0.0	$38,251.1	$0.0	$38,273.6	$22.5
1946	$39,871.8	$39,871.8	$0.0	$39,871.8	$0.0	$39,873.3	$1.5
1947	$43,448.4	$43,448.4	$0.0	$43,448.4	$0.0	$42,383.8	-$1,064.6
1948	$47,858.1	$47,858.1	$0.0	$47,858.1	$0.0	$48,042.5	$184.5
1949	$41,890.0	$41,890.0	$0.0	$41,890.0	$0.0	$41,715.6	-$174.3
1950	$39,198.4	$39,198.4	$0.0	$39,198.4	$0.0	$38,932.4	-$266.0
1951	$45,961.9	$45,961.9	$0.0	$45,961.9	$0.0	$45,752.6	-$209.3
1952	$43,307.4	$43,307.4	$0.0	$43,308.0	$0.6	$43,297.6	-$9.8
1953	$49,568.3	$48,955.3	-$613.0	$48,854.5	-$713.8	$49,449.8	-$118.6
1954	$42,618.4	$41,584.5	-$1,033.9	$42,551.2	-$67.1	$41,650.6	-$967.8
1955	$41,147.7	$40,989.3	-$158.4	$41,099.5	-$48.2	$40,953.0	-$194.7
1956	$40,204.6	$40,202.4	-$2.2	$40,199.0	-$5.6	$40,206.8	$2.3
1957	$38,452.8	$38,450.3	-$2.4	$38,458.0	$5.2	$38,455.4	$2.6
1958	$39,284.1	$39,281.6	-$2.5	$39,284.1	$0.0	$39,286.6	$2.6
1959	$40,420.3	$40,417.7	-$2.6	$40,420.3	$0.0	$40,423.0	$2.7
1960	$39,013.1	$39,010.7	-$2.4	$39,013.1	$0.1	$39,015.6	$2.5
1961	$36,074.4	$36,072.6	-$1.8	$36,074.4	$0.0	$36,076.3	$1.9
1962	$28,569.0	$28,567.4	-$1.7	$28,569.0	$0.0	$28,570.9	$1.8
1963	$33,727.4	$33,725.8	-$1.6	$33,727.4	$0.0	$33,728.7	$1.4
1964	$43,984.4	$43,982.3	-$2.1	$43,984.4	$0.0	$43,986.4	$2.0
1965	$47,741.5	$47,739.8	-$1.6	$47,741.5	$0.0	$47,743.4	$1.9
1966	$47,010.8	$46,043.0	-$967.8	$46,039.7	-$971.1	$46,066.5	-$944.3
1967	$46,976.0	$46,738.0	-$238.0	$46,952.9	-$23.1	$47,083.0	$107.0
1968	$49,120.2	$47,839.6	-$1,280.6	$48,387.6	-$732.6	$48,457.5	-$662.7
1969	$48,748.9	$48,786.4	$37.5	$48,887.5	$138.6	$48,948.1	$199.2
1970	$50,799.6	$49,237.7	-$1,561.8	$49,097.2	-$1,702.4	$50,693.3	-$106.2
1971	$49,476.6	$49,467.8	-$8.8	$49,463.8	-$12.8	$49,488.3	$11.7
1972	$41,898.6	$41,912.9	$14.3	$41,898.3	-$0.3	$41,897.7	-$0.9
1973	$43,029.5	$42,941.6	-$87.9	$42,896.8	-$132.8	$42,852.5	-$177.0
1974	$45,468.3	$45,483.3	$15.0	$44,902.0	-$566.3	$45,488.6	$20.3
1975	$52,421.6	$52,495.4	$73.7	$52,696.2	$274.6	$52,444.8	$23.2
1976	$52,854.3	$52,851.3	-$3.0	$51,185.5	-$1,668.8	$52,849.8	-$4.5
1977	$42,201.7	$41,771.4	-$430.3	$41,089.8	-$1,111.9	$41,893.2	-$308.5
1978	$42,974.7	$42,510.7	-$463.9	$42,764.2	-$210.5	$42,524.4	-$450.3
1979	$51,623.4	$51,572.4	-$51.0	$51,816.2	$192.8	$51,832.1	$208.7
1980	$47,376.0	$46,473.0	-$903.0	$46,649.8	-$726.2	$46,402.7	-$973.2
1981	$48,283.4	$48,164.9	-$118.5	$47,996.8	-$286.6	$48,029.4	-$254.0
1982	$47,531.1	$47,509.0	-$22.2	$47,596.5	$65.4	$47,822.5	$291.4

1983	$42,729.6	$35,550.9	-$7,178.7	$39,385.4	-$3,344.1	$36,524.8	-$6,204.8
1984	$48,104.2	$46,813.0	-$1,291.2	$47,254.8	-$849.4	$47,261.0	-$843.2
1985	$44,476.2	$43,051.2	-$1,424.9	$44,032.4	-$443.8	$43,438.1	-$1,038.1
1986	$37,748.4	$35,183.1	-$2,565.3	$33,817.8	-$3,930.6	$34,827.3	-$2,921.1
1987	$43,470.8	$42,987.2	-$483.7	$42,983.8	-$487.1	$43,189.6	-$281.3
1988	$41,151.5	$40,291.7	-$859.8	$40,341.4	-$810.1	$40,371.9	-$779.6
1989	$40,060.5	$40,035.4	-$25.1	$40,121.2	$60.7	$40,062.1	$1.6
1990	$37,976.0	$37,966.5	-$9.5	$37,930.4	-$45.5	$37,979.2	$3.3
1991	$37,801.8	$37,792.7	-$9.1	$37,794.7	-$7.0	$37,799.4	-$2.4
1992	$34,425.7	$34,416.9	-$8.8	$34,427.4	$1.6	$34,423.3	-$2.4
1993	$29,031.5	$29,025.5	-$6.0	$29,032.5	$1.0	$29,030.2	-$1.3
1994	$40,556.1	$40,354.8	-$201.2	$40,298.0	-$258.0	$40,473.9	-$82.1
1995	$40,706.3	$38,014.5	-$2,691.8	$39,465.2	-$1,241.1	$38,297.9	-$2,408.4
1996	$51,307.2	$51,298.3	-$8.8	$51,145.1	-$162.0	$51,240.3	-$66.8
1997	$50,220.2	$50,219.5	-$0.8	$50,242.1	$21.9	$49,734.8	-$485.4
1998	$46,974.7	$45,526.6	-$1,448.0	$45,746.3	-$1,228.4	$45,722.2	-$1,252.5
1999	$44,566.6	$43,473.6	-$1,093.0	$44,721.7	$155.1	$37,816.7	-$6,749.9
2000	$41,772.2	$41,688.5	-$83.6	$41,173.2	-$599.0	$41,803.4	$31.2
2001	$32,464.0	$32,352.4	-$111.6	$32,428.4	-$35.6	$32,434.5	-$29.4
2002	$31,994.0	$31,991.6	-$2.3	$31,992.2	-$1.7	$31,990.7	-$3.3
2003	$37,425.6	$37,422.8	-$2.8	$37,412.4	-$13.2	$37,421.6	-$4.0
2004	$34,979.8	$34,976.5	-$3.3	$34,976.9	-$2.9	$34,975.2	-$4.7
2005	$32,416.0	$32,412.9	-$3.1	$32,413.3	-$2.7	$32,411.7	-$4.3
2006	$35,643.3	$35,639.2	-$4.1	$35,639.9	-$3.4	$35,631.9	-$11.5
2007	$32,226.0	$32,223.1	-$2.9	$32,223.6	-$2.4	$32,226.2	$0.2
2008	$29,451.1	$29,448.9	-$2.1	$29,449.3	-$1.8	$29,541.2	$90.1
2009	$31,783.6	$31,781.9	-$1.7	$31,782.1	-$1.5	$31,754.0	-$29.6
2010	$28,686.0	$28,680.9	-$5.1	$28,681.2	-$4.7	$28,689.0	$3.0
2011	$46,666.8	$46,661.2	-$5.6	$46,679.0	$12.2	$46,670.3	$3.5
2012	$44,969.1	$43,728.2	-$1,240.9	$43,895.6	-$1,073.5	$44,073.4	-$895.7

4.4 Alternative 2 including Variations 2A and 2B

This section contains average annual and annual information for Alternative 2 and all of the variations of Alternative 2 being analyzed.

4.4.1 Impacts of Alternative 2 including Variations 2A and 2B

The NED Analysis for Alternative 2 is summarized in the table below. This table details the estimated impacts averaged over the full period of record as well as the estimated impact specifically in full flow years, partial flow years, non-flow years, and years after flow years. When looking at the full period of record, the estimated average annual NED impact relative to No Action is a decrease of $290,000 for the system as a whole, and Ft. Peck specifically averages $283,000 in average annual impact showing most of the adverse system impact occurring at Ft. Peck. Alternative 2 decreases the value by about 0.07% for the system and decreases the value at Ft. Peck by about 0.7% relative to No Action.

The estimated average annual NED impact of Alternative 2 in full flow years relative to No Action is negative $1.5 million for the system as a whole, and negative impacts at Fort Peck of $617,000 during full flow years. This is a 1.4% decrease from No Action at Fort Peck and a 0.36% change for the overall system. The bulk of the impact for this alternatives is occurring at Garrison.

Table 11. Summary of National Economic Development Analysis for Alternative 2 (2020 Dollars, $000s)

Measure	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavin's Point	Missouri River System
Period of Record							
Average Annual Generation Value	$14,940	$39,391	$45,642	$18,636	$4,468	$12,083	$135,161
Average Annual Capacity Value - Summer	$24,300	$57,531	$74,255	$58,840	$43,922	$14,935	$273,783
Total Average Annual Generation and Capacity NED Value	$39,240	$96,923	$119,897	$77,475	$48,391	$27,018	$408,944
Difference in NED Value from No Action	-$283	-$83	$55	$11	$10	$0	-$290
% Difference from No Action	-0.71%	-0.09%	0.05%	0.01%	0.02%	0.00%	-0.07%
Full Flow Years							
Average Annual Generation Value	$17,634	$43,290	$52,655	$19,885	$4,688	$13,499	$151,651
Average Annual Capacity Value - Summer	$26,642	$55,787	$79,983	$59,464	$43,970	$14,963	$280,809
Total Average Annual Generation and Capacity NED Value	$44,276	$99,076	$132,637	$79,349	$48,658	$28,462	$432,460
Difference in NED Value from No Action	-$617	-$1,589	$428	$204	$22	$7	-$1,545
% Difference from No Action	-1.39%	-1.26%	0.31%	0.19%	0.04%	0.02%	-0.36%
Partial Flow Years							
Average Annual Generation Value	$19,150	$49,718	$56,579	$22,325	$4,868	$13,369	$166,009
Average Annual Capacity Value - Summer	$25,993	$63,240	$82,658	$61,229	$44,530	$15,094	$292,743
Total Average Annual Generation and Capacity NED Value	$45,143	$112,958	$139,237	$83,554	$49,398	$28,463	$458,752
Difference in NED Value from No Action	-$1,388	$1,034	-$84	$9	$5	-$9	-$433
% Difference from No Action	-3.08%	0.85%	-0.07%	0.00%	-0.02%	-0.03%	-0.09%
Non-Flow Years							
Average Annual Generation Value	$12,920	$35,444	$40,887	$17,326	$4,305	$11,389	$122,272
Average Annual Capacity Value - Summer	$23,100	$56,056	$70,391	$57,937	$43,687	$14,868	$266,039

Total Average Annual Generation and Capacity NED Value	$36,021	$91,499	$111,277	$75,264	$47,993	$26,258	$388,311
Difference in NED Value from No Action	-$3	-$22	-$7	-$22	$11	$0	-$43
% Difference from No Action	-0.01%	-0.03%	-0.01%	-0.04%	0.01%	0.00%	-0.01%
Years After Flow Years							
Average Annual Generation Value	$18,542	$45,694	$52,424	$20,507	$4,694	$12,991	$154,851
Average Annual Capacity Value - Summer	$26,502	$61,242	$80,216	$60,519	$44,490	$15,094	$288,063
Total Average Annual Generation and Capacity NED Value	$45,044	$106,936	$132,640	$81,025	$49,185	$28,084	$442,915
Difference in NED Value from No Action	-$298	-$14	$141	-$9	$2	$2	-$176
% Difference from No Action	-0.66%	-0.02%	0.11%	-0.01%	-0.02%	0.01%	-0.04%

The estimated average annual NED impact of Alternative 2 in partial flow years is $433,000 for the system as a whole and impacts at Ft. Peck of $1.3 million. This is a 3.08% decrease from No Action at Ft. Peck. This also indicates that the rest of the system is actually realizing benefits under this alternative. In non-flow years, as would be expected, there is minimal change to the average annual value. In the years after flow years, there is a decrease in value for both the system and Ft. Peck specifically.

4.4.2 Alternative 2 - Variation 2A

The NED Analysis for Alternative 2A is summarized in the table below. This table details the estimated impacts averaged over the full period of record as well as the estimated impact specifically in full flow years, partial flow years, non-flow years, and years after flow years. When looking at the full period of record, the estimated average annual impact is decrease of $231,000 for the system as a whole, but Ft. Peck specifically averages $437,000 in adverse average annual NED impact. Since there are actually benefits at many of the other downstream plants, the total impact to the system is smaller than the impact at Ft. Peck. Alternative 2A decreases the value by about 0.06% for the system and decreases the value at Ft. Peck by about 1.1%.

The estimated average annual NED impact of Alternative 2 in full flow years relative to No Action is negative $957,000 for the system as a whole, and negative impacts at Ft. Peck of $1.8 million during full flow years. This is a 3.99% decrease from No Action at Fort Peck.

Table 12. Summary of National Economic Development Analysis for Alternative 2A (2020 Dollars, $000s)

Measure	Ft. Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavin's Point	Missouri River System
Period of Record							
Average Annual Generation Value	$14,886	$39,445	$45,656	$18,644	$4,467	$12,084	$135,181

Average Annual Capacity Value - Summer	$24,200	$57,721	$74,219	$58,818	$43,927	$14,936	$273,822
Total Average Annual Generation and Capacity NED Value	$39,086	$97,166	$119,875	$77,462	$48,395	$27,020	$409,003
Difference in NED Value from No Action	-$437	$160	$32	-$3	$15	$1	-$231
% Difference from No Action	-1.12%	0.16%	0.03%	0.00%	0.03%	0.01%	-0.06%
Full Flow Years							
Average Annual Generation Value	$17,949	$44,841	$52,998	$20,299	$4,716	$13,394	$154,197
Average Annual Capacity Value - Summer	$25,605	$59,118	$80,658	$59,911	$44,180	$15,002	$284,475
Total Average Annual Generation and Capacity NED Value	$43,554	$103,959	$133,656	$80,210	$48,896	$28,397	$438,672
Difference in NED Value from No Action	-$1,809	$803	$28	$20	-$1	$2	-$957
% Difference from No Action	-3.99%	0.81%	0.03%	0.04%	-0.03%	0.01%	-0.22%
Partial Flow Years							
Average Annual Generation Value	$20,238	$53,419	$60,439	$23,840	$5,026	$13,716	$176,678
Average Annual Capacity Value - Summer	$27,692	$63,365	$81,799	$61,455	$44,624	$15,105	$294,039
Total Average Annual Generation and Capacity NED Value	$47,930	$116,784	$142,238	$85,295	$49,650	$28,820	$470,717
Difference in NED Value from No Action	-$984	$233	$23	-$59	$4	-$6	-$789
% Difference from No Action	-2.01%	0.22%	0.01%	-0.13%	0.03%	-0.02%	-0.17%
Non-Flow Years							
Average Annual Generation Value	$13,121	$35,828	$41,298	$17,458	$4,316	$11,428	$123,448
Average Annual Capacity Value - Summer	$23,192	$56,174	$70,658	$58,005	$43,721	$14,876	$266,625
Total Average Annual Generation and Capacity NED Value	$36,313	$92,001	$111,955	$75,463	$48,037	$26,304	$390,073
Difference in NED Value from No Action	-$5	$17	$25	-$8	$22	$2	$53
% Difference from No Action	-0.01%	0.03%	0.03%	0.00%	0.01%	0.01%	0.01%
Years After Flow Years							
Average Annual Generation Value	$17,197	$43,991	$50,872	$19,982	$4,634	$12,856	$149,532
Average Annual Capacity Value - Summer	$25,857	$61,369	$80,244	$60,323	$44,335	$15,087	$287,214
Total Average Annual Generation and Capacity NED Value	$43,054	$105,360	$131,116	$80,304	$48,969	$27,943	$436,745
Difference in NED Value from No Action	-$392	-$110	$89	$21	$4	$1	-$387
% Difference from No Action	-0.91%	-0.13%	0.06%	0.06%	-0.01%	0.01%	-0.09%

The estimated average annual impact of Alternative 2A in partial flow years is a decrease of $789,000 for the system as a whole and $984,000 at Fort Peck relative to No Action. This is a 2.05% decrease from No Action at Ft. Peck. This also indicates that the rest of the system is actually realizing benefits under this alternative relative to No Action but Ft. Peck is experiencing large impacts, relative to the system. In non-flow years, as would be expected, there is minimal change to the average annual value. In the years after flow years, there is a decrease in value for both the system and Ft. Peck specifically.

4.4.3 Alternative 2 - Variation 2B

The NED Analysis for Alternative 2B is summarized in the table below. This table details the estimated impacts averaged over the full period of record as well as the estimated impact specifically in full flow years, partial flow years, non-flow years, and years after flow years. When looking at the full period of record, the estimated average annual impact is a decrease in NED value $136,000 for the system as a whole, but Ft. Peck specifically averages $371,000 in adverse average annual impact. Since there are actually benefits at many of the other downstream plants, the total impact to the system is smaller than the impact at Ft. Peck. showing there are actually benefits to the system at the plants outside Ft. Peck. Alternative 2B decreases the value by about 0.03% for the system and decreases the value at Ft. Peck by about 0.95%.

The estimated average annual NED impact of Alternative 2B in full flow years relative to No Action is negative $944,000 for the system as a whole, and negative impacts at Ft. Peck of $1.5 million during full flow years. This is a 3.43% decrease from No Action at Fort Peck.

Table 13. Summary of National Economic Development Analysis for Alternative 2B (2020 Dollars, $000s)

Measure	Ft. Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavin's Point	Missouri River System
Period of Record							
Average Annual Generation Value	$14,967	$39,445	$45,658	$18,642	$4,469	$12,084	$135,266
Average Annual Capacity Value - Summer	$24,185	$57,984	$74,094	$58,717	$43,918	$14,935	$273,833
Total Average Annual Generation and Capacity NED Value	$39,152	$97,429	$119,752	$77,359	$48,387	$27,019	$409,098
Difference in NED Value from No Action	-$371	$423	-$90	-$105	$7	$1	-$136
% Difference from No Action	-0.95%	0.44%	-0.08%	-0.14%	0.01%	0.00%	-0.03%
Full Flow Years							
Average Annual Generation Value	$17,585	$42,160	$51,007	$19,611	$4,630	$13,449	$148,442
Average Annual Capacity Value - Summer	$25,542	$58,381	$78,498	$58,724	$43,775	$14,931	$279,850
Total Average Annual Generation and Capacity NED Value	$43,127	$100,541	$129,504	$78,335	$48,405	$28,380	$428,292
Difference in NED Value from No Action	-$1,480	$2,338	$82	$3	-$1	$3	$944
% Difference from No Action	-3.43%	2.21%	0.10%	0.07%	-0.02%	0.01%	0.22%
Partial Flow Years							
Average Annual Generation Value	$18,326	$47,416	$54,965	$21,361	$4,792	$13,325	$160,185
Average Annual Capacity Value - Summer	$26,344	$62,756	$82,393	$60,888	$44,502	$15,081	$291,963
Total Average Annual Generation and Capacity NED Value	$44,670	$110,172	$137,359	$82,249	$49,294	$28,405	$452,148
Difference in NED Value from No Action	-$673	$933	$9	$6	-$1	-$5	$269
% Difference from No Action	-1.51%	0.81%	-0.01%	0.03%	0.01%	-0.02%	0.06%

Non-Flow Years							
Average Annual Generation Value	$12,522	$34,582	$39,490	$16,942	$4,264	$11,156	$118,957
Average Annual Capacity Value - Summer	$22,604	$56,272	$68,859	$57,556	$43,555	$14,836	$263,682
Total Average Annual Generation and Capacity NED Value	$35,126	90,854	$108,349	$74,499	$47,819	$25,991	$382,638
Difference in NED Value from No Action	-$17	$32	$22	-$11	$9	$1	$36
% Difference from No Action	-0.05%	0.05%	0.03%	-0.03%	0.01%	0.00%	0.01%
Years After Flow Years							
Average Annual Generation Value	$17,688	$44,796	$52,264	$20,582	$4,684	$12,929	$152,943
Average Annual Capacity Value - Summer	$26,161	$57,793	$79,290	$60,062	$44,543	$15,104	$282,953
Total Average Annual Generation and Capacity NED Value	$43,849	$102,589	$131,554	$80,644	$49,227	$28,033	$435,896
Difference in NED Value from No Action	-$544	-$30	-$704	-$635	$15	$5	-$1,893
% Difference from No Action	-1.24%	-0.04%	-0.42%	-0.55%	0.07%	0.02%	-0.43%

The estimated average annual impact of Alternative 2B in partial flow years is an increase of $269,000 for the system as a whole and decreases at Ft. Peck of $673,000. This is a 1.51% decrease from No Action at Ft. Peck. This also indicates that the rest of the system is actually realizing benefits under this alternative but Ft. Peck is experiencing large impacts, relative to the system. In non-flow years, as would be expected, there is minimal change to the average annual value. In the years after flow years, there is a decrease in value for both the system and Ft. Peck specifically.

4.4.4 Alternative 2 Summary Results

In comparing the annual impacts over the period of record across all variations of Alternative 2, the differences in value relative to No Action is very dependent on the variation as well as the scale at which the impacts are being examined. In many of the years, decreases at Ft. Peck are actually showing increases in value for the system as a whole. This indicates that changes made at Ft. Peck under those alternatives are being mitigated by changes downstream.

4.5 Annual Impacts for Alternative 2 including Variations 2A and 2B

When evaluating the impacts for each of the FPDTR-EIS alternatives, it is helpful to also examine the annual impacts. The figures below shows the annual NED impacts to hydropower for Alternative 2 relative to No Action for both the Missouri River system and Ft. Peck specifically. The differences in annual NED costs between No Action and Alternative 2 are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences from No Action for the system range from an increase of $9.4 million in 1983 (a full flow year) to a decrease of $23.3 million in 1987 (also a full flow year). Full flow years under this alternative seem to have varied impacts.

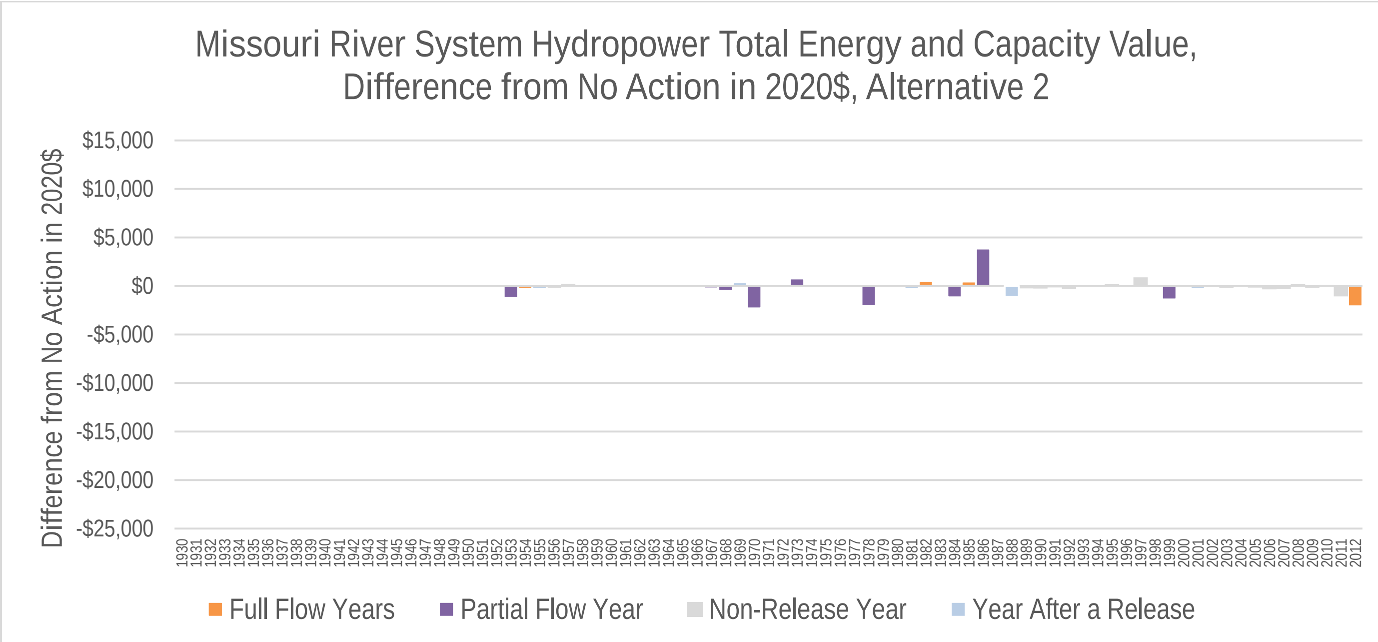

Figure 10. System Difference in Generation and Summer Capacity Hydropower Value under Alternative 2 from No Action (2020 Dollars, $000s)

At Ft. Peck, differences from No Action under Alternative 2 range from a decrease of $4.9 million in 1986 to an increase of $2.1 million in 1983. Both full flow and partial flow years seem to have a negative impact at Ft. Peck for the most part, as well as a few years that are occurring after a release. There is one full flow year that is experiencing an increase.

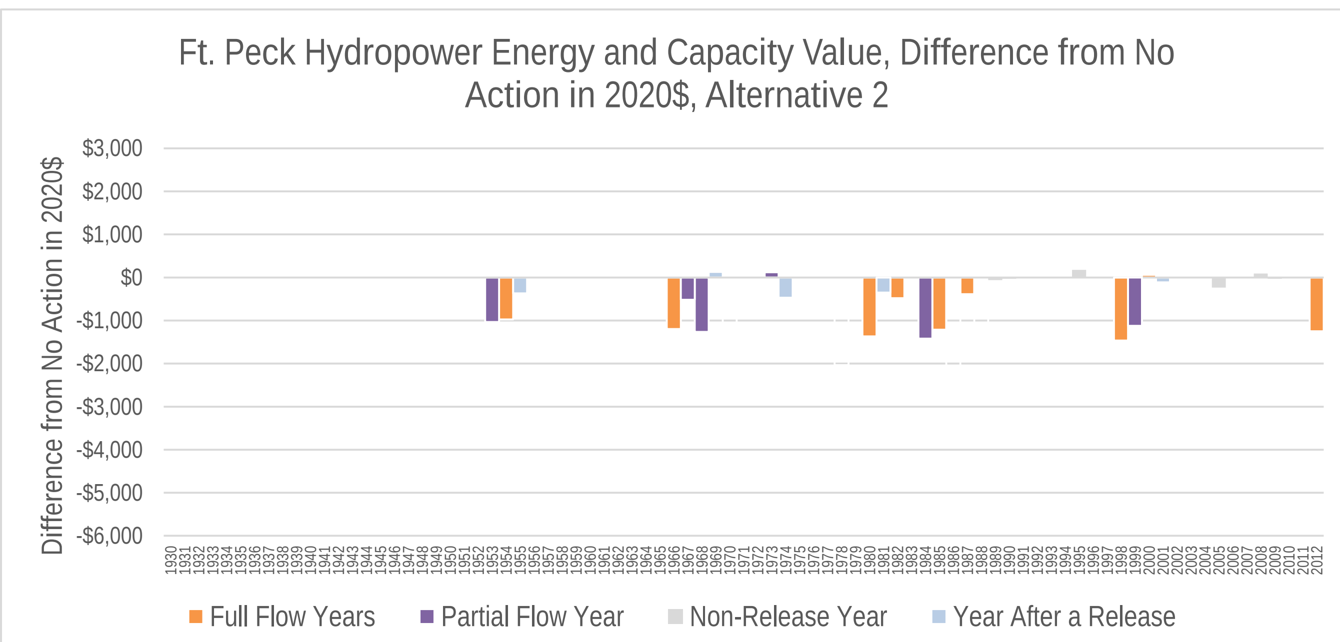

Figure 11. Ft Peck Difference in Generation and Summer Capacity Hydropower Value under Alternative 2 from No Action (2020 Dollars, $000s)

4.5.1 Alternative 2 – Variation 2A

When evaluating the impacts for each of the FPDTR-EIS alternatives, it is helpful to also examine the annual impacts. The figures below shows the annual NED impacts to hydropower for Alternative 2A relative to No Action for both the Missouri River system and Ft. Peck specifically. The differences in annual NED costs between No Action and Alternative 2A are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences from No Action for the system range from an increase of $7.9 million in 1986 (a full flow year) to a decrease of $23.5 million in 1987 (also a full flow year). Full flow years under this alternative seem to have varied impacts. However, besides those two years of both increasing and decreasing value, many of the years are showing little difference from No Action.

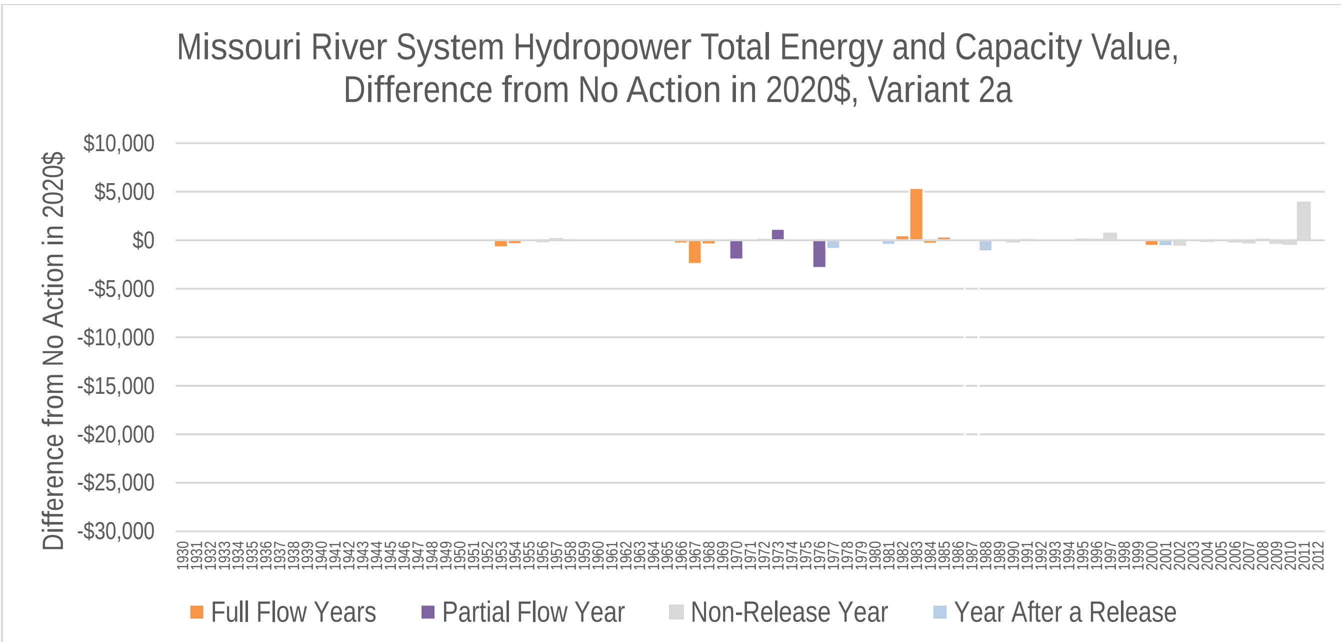

Figure 12. System Difference in Generation and Summer Capacity Hydropower Value under Alternative 2A from No Action (2020 Dollars, $000s)

At Ft. Peck, differences from No Action under Alternative 2A range from a decrease of $5.6 million in 1986 to an increase of $178,000 million in 1995. Both full flow and partial flow years seem to have a negative impact at Ft. Peck for the most part, as well as a few years that are occurring after a release.

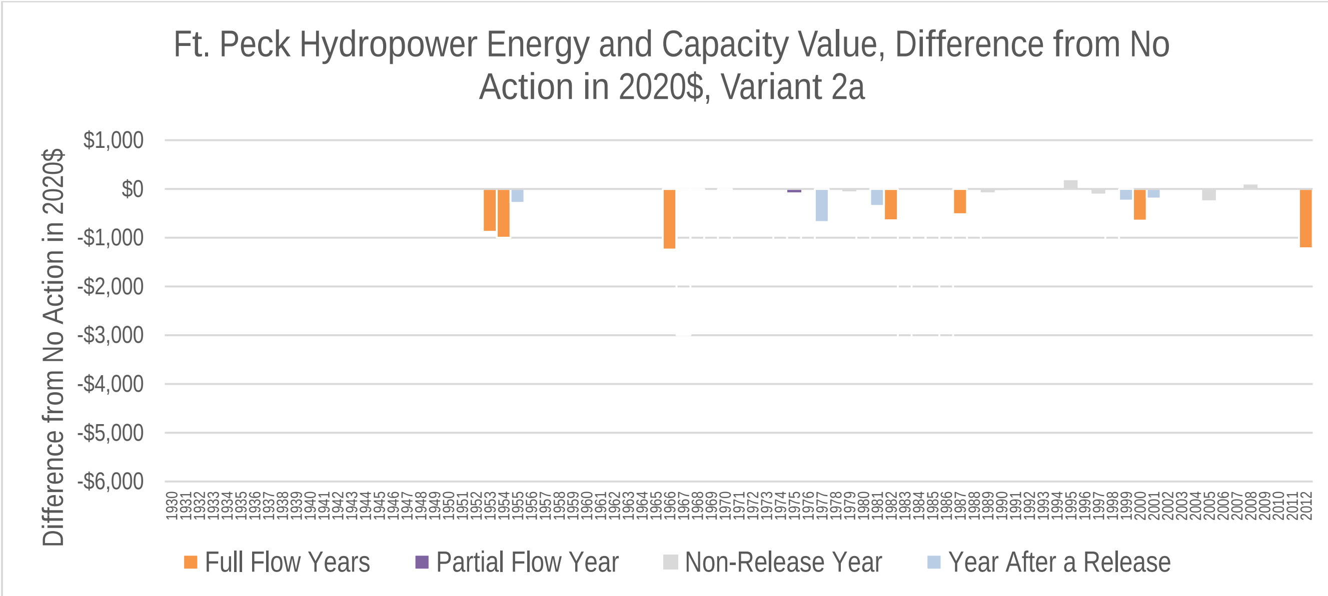

Figure 13. Ft Peck Difference in Generation and Summer Capacity Hydropower Value under Alternative 2A from No Action (2020 Dollars, $000s)

4.5.2 Alternative 2 – Variation 2B

When evaluating the impacts for each of the FPDTR-EIS alternatives, it is helpful to also examine the annual impacts. The figures below shows the annual NED impacts to hydropower for Alternative 2B relative to No Action for both the Missouri River system and Ft. Peck specifically. The differences in annual NED costs between No Action and Alternative 2B are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences from No Action for the system range from an increase of $6.5 million in 1986 (a partial flow year) to a decrease of $22.6 million in 1995. Full and partial flow years under this alternative seem to have varied impacts for the system. The largest impact is occurring in the year after a partial release.

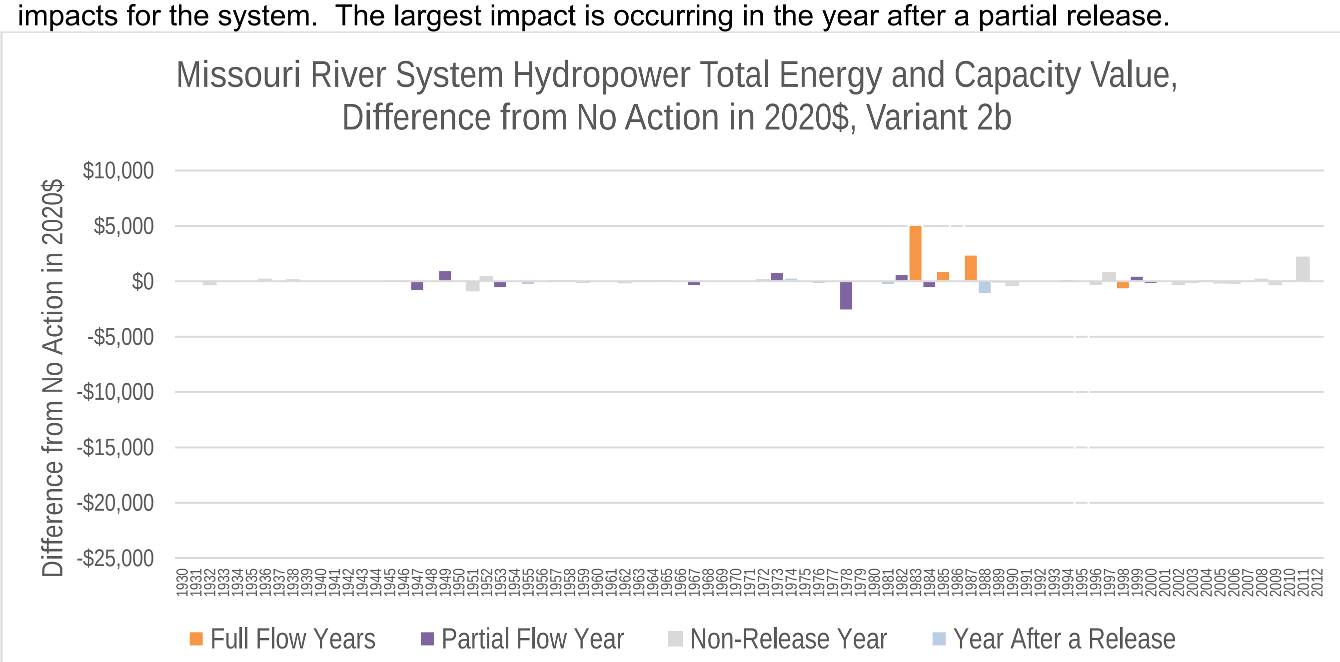

Figure 14. System Difference in Generation and Summer Capacity Hydropower Value under

Alternative 2B from No Action (2020 Dollars, $000s)

At Ft. Peck, differences from No Action under Alternative 2B range from a decrease of $5.6 million in 1983 to an increase of $201,000 million in 1969. Both full flow and partial flow years seem to have a negative impact at Ft. Peck for the most part, as well as a few years that are occurring after a release.

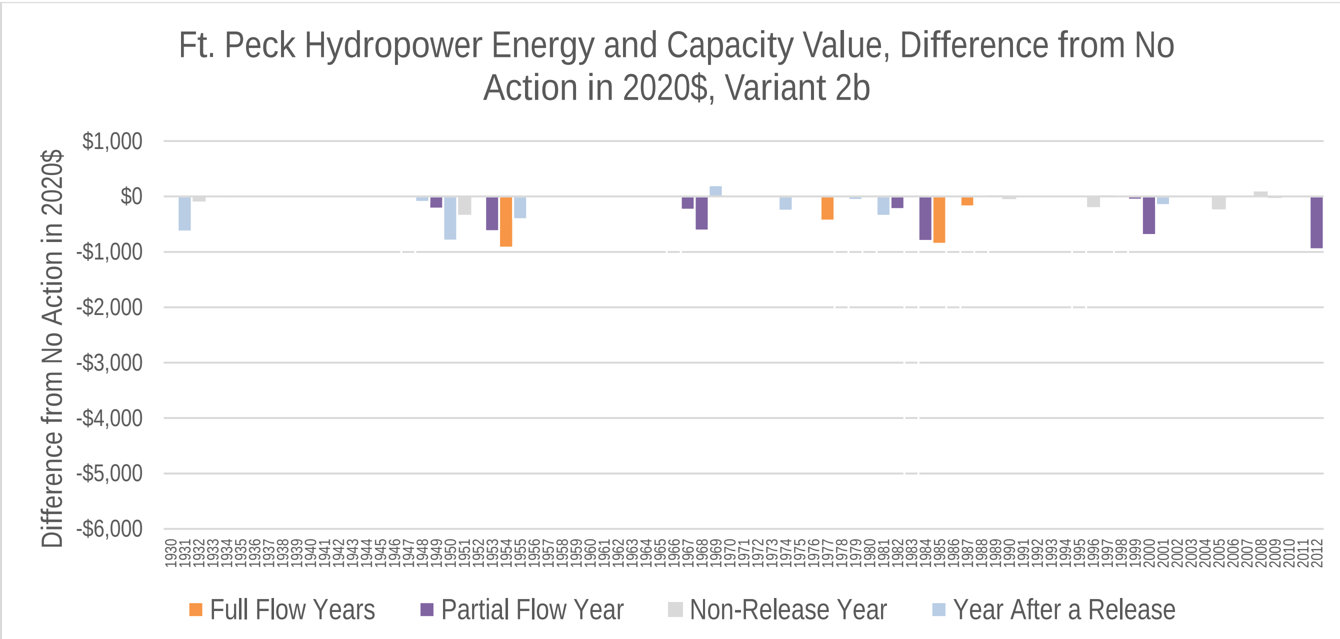

Figure 15. Ft Peck Difference in Generation and Summer Capacity Hydropower Value under Alternative 2B from No Action (2020 Dollars, $000s)

4.5.3 Summary of Annual Impacts for Alternative 2 including Variations 2A and 2B

In comparing the annual impacts over the period of record across all variations of Alternative 2, the differences in value relative to No Action are similar for the system and Ft. Peck. Generally, the system as a whole is experiencing minimal impacts in most years, but Ft. Peck specifically is experiencing impacts in many of the flow years, including the full, partial, and year after flow years. The tables below have further details on the annual NED impacts for the Missouri River system and Fort Peck.

Table 14. Missouri River System Total Energy and Capacity NED Impacts for Alternative 2 (2020 Dollars, $000s)

Missouri River System Impacts							
Year	No Action	Alternative 2	Alt2 Diff from No Action	Alternative 2 - Variation A	Alt2A Diff from No Action	Alternative 2 - Variation B	Alt2B Diff from No Action
1931	$406,234.3	$406,234.3	$0.0	$406,234.3	$0.0	$406,229.4	-$4.9
1932	$386,859.1	$386,858.7	-$0.4	$386,859.1	$0.0	$386,495.8	-$363.3
1933	$378,813.0	$378,813.9	$0.9	$378,813.9	$0.9	$378,872.0	$59.0
1934	$350,596.1	$350,597.4	$1.3	$350,596.2	$0.1	$350,658.0	$61.9
1935	$299,122.3	$299,121.7	-$0.6	$299,122.3	$0.0	$299,085.7	-$36.6

1936	$299,235.6	$299,235.8	$0.2	$299,235.6	$0.0	$299,476.6	$241.0
1937	$301,940.9	$301,940.9	$0.0	$301,940.9	$0.0	$301,944.4	$3.5
1938	$307,630.2	$307,630.9	$0.6	$307,630.6	$0.3	$307,824.5	$194.2
1939	$324,456.9	$324,457.2	$0.3	$324,456.9	$0.0	$324,437.8	-$19.2
1940	$319,016.7	$319,016.3	-$0.4	$319,016.7	$0.0	$318,995.9	-$20.9
1941	$315,599.4	$315,598.8	-$0.7	$315,599.4	$0.0	$315,581.5	-$17.9
1942	$333,572.1	$333,572.2	$0.1	$333,572.1	$0.0	$333,563.7	-$8.4
1943	$429,537.1	$429,539.0	$1.9	$429,537.8	$0.8	$429,539.2	$2.2
1944	$408,220.9	$408,220.8	-$0.1	$408,221.3	$0.4	$408,268.3	$47.4
1945	$439,201.8	$439,201.7	$0.0	$439,201.6	-$0.1	$439,275.4	$73.6
1946	$430,067.0	$430,066.7	-$0.3	$430,066.9	-$0.1	$430,135.4	$68.4
1947	$443,113.5	$443,113.6	$0.1	$443,113.7	$0.3	$442,231.0	-$882.4
1948	$455,605.6	$455,604.4	-$1.2	$455,605.6	$0.0	$455,612.7	$7.2
1949	$441,703.1	$441,704.0	$0.9	$441,703.1	$0.0	$442,694.5	$991.4
1950	$435,621.5	$435,622.2	$0.7	$435,621.7	$0.1	$435,537.7	-$83.9
1951	$418,491.0	$418,492.3	$1.3	$418,491.5	$0.5	$417,578.3	-$912.7
1952	$479,908.2	$479,905.6	-$2.6	$479,905.9	-$2.3	$480,406.0	$497.8
1953	$462,355.8	$461,134.4	-$1,221.5	$461,637.4	-$718.4	$461,770.3	-$585.6
1954	$437,219.5	$436,923.7	-$295.9	$436,831.2	-$388.3	$437,034.9	-$184.6
1955	$425,609.3	$425,310.3	-$299.0	$425,391.6	-$217.7	$425,292.5	-$316.8
1956	$418,373.4	$418,167.5	-$205.9	$418,155.0	-$218.3	$418,320.7	-$52.6
1957	$402,293.8	$402,518.0	$224.3	$402,529.0	$235.2	$402,407.4	$113.6
1958	$399,295.0	$399,331.6	$36.6	$399,382.2	$87.2	$399,405.6	$110.6
1959	$400,308.9	$400,219.2	-$89.7	$400,229.5	-$79.4	$400,171.3	-$137.6
1960	$383,963.8	$383,960.9	-$2.9	$383,960.6	-$3.2	$384,000.4	$36.6
1961	$376,706.7	$376,678.6	-$28.1	$376,679.0	-$27.7	$376,692.5	-$14.2
1962	$288,922.0	$288,839.6	-$82.4	$288,839.5	-$82.5	$288,732.4	-$189.7
1963	$406,127.9	$406,144.7	$16.9	$406,144.2	$16.4	$406,224.2	$96.4
1964	$416,943.9	$416,929.0	-$14.9	$416,929.0	-$14.9	$417,047.9	$104.1
1965	$442,180.5	$442,093.5	-$87.0	$442,093.1	-$87.5	$442,301.4	$120.9
1966	$452,695.1	$452,591.0	-$104.1	$452,370.1	-$325.0	$452,586.3	-$108.8
1967	$454,073.6	$453,820.2	-$253.5	$451,636.7	-$2,436.9	$453,668.6	-$405.0
1968	$464,088.5	$463,591.1	-$497.4	$463,662.7	-$425.8	$464,071.4	-$17.1
1969	$454,721.5	$455,092.5	$371.1	$454,685.2	-$36.2	$454,728.9	$7.4
1970	$470,124.0	$467,804.9	-$2,319.1	$468,137.9	-$1,986.0	$469,933.0	-$191.0
1971	$483,077.2	$483,104.6	$27.4	$483,001.8	-$75.5	$483,061.7	-$15.5
1972	$478,480.2	$478,552.9	$72.7	$478,629.6	$149.5	$478,653.8	$173.7
1973	$440,924.7	$441,692.7	$767.9	$442,099.8	$1,175.1	$441,752.4	$827.7
1974	$460,107.5	$460,113.1	$5.6	$459,953.4	-$154.1	$460,442.2	$334.7
1975	$495,637.2	$495,624.2	-$13.1	$495,518.1	-$119.1	$495,625.5	-$11.7
1976	$490,737.3	$490,803.5	$66.1	$487,875.5	-$2,861.8	$490,504.0	-$233.3
1977	$418,126.0	$418,149.0	$23.0	$417,243.4	-$882.5	$418,283.1	$157.1
1978	$463,547.3	$461,458.3	-$2,089.0	$463,492.0	-$55.3	$460,917.9	-$2,629.4
1979	$476,640.7	$476,428.9	-$211.8	$476,563.1	-$77.6	$476,568.1	-$72.5
1980	$444,824.1	$444,622.1	-$202.0	$444,855.7	$31.7	$444,787.0	-$37.1

1981	$430,116.0	$429,785.2	-$330.8	$429,638.4	-$477.7	$429,786.0	-$330.0
1982	$445,361.2	$445,869.9	$508.7	$445,876.7	$515.6	$446,022.8	$661.6
1983	$356,320.1	$365,797.0	$9,477.0	$361,703.8	$5,383.7	$361,429.0	$5,108.9
1984	$451,486.2	$450,314.9	-$1,171.3	$451,141.8	-$344.4	$450,908.5	-$577.8
1985	$433,861.1	$434,323.3	$462.2	$434,248.8	$387.6	$434,786.1	$925.0
1986	$422,390.9	$426,243.0	$3,852.0	$430,364.9	$7,973.9	$428,935.7	$6,544.7
1987	$436,726.5	$413,396.2	-$23,330.2	$413,214.7	-$23,511.8	$439,135.2	$2,408.8
1988	$420,096.8	$418,981.7	-$1,115.1	$418,952.4	-$1,144.4	$418,939.1	-$1,157.7
1989	$403,312.8	$403,067.7	-$245.1	$403,221.3	-$91.5	$403,199.6	-$113.2
1990	$386,067.8	$385,805.9	-$261.9	$385,814.2	-$253.6	$385,660.5	-$407.3
1991	$386,551.9	$386,409.4	-$142.5	$386,685.8	$133.9	$386,541.9	-$10.0
1992	$351,539.2	$351,206.8	-$332.4	$351,548.8	$9.7	$351,562.1	$23.0
1993	$206,762.7	$206,690.3	-$72.4	$206,818.9	$56.2	$206,728.6	-$34.0
1994	$414,019.5	$413,999.3	-$20.3	$414,056.0	$36.4	$414,229.9	$210.3
1995	$381,006.5	$381,209.4	$202.9	$381,190.8	$184.2	$358,380.7	-$22,625.9
1996	$497,920.0	$497,865.6	-$54.4	$498,078.5	$158.4	$497,588.1	-$332.0
1997	$521,304.1	$522,196.8	$892.7	$522,095.6	$791.5	$522,150.8	$846.7
1998	$439,016.6	$439,021.2	$4.6	$439,181.6	$165.0	$438,297.2	-$719.4
1999	$467,218.2	$465,833.2	-$1,385.0	$467,243.9	$25.7	$467,723.6	$505.4
2000	$443,449.1	$443,581.2	$132.1	$442,876.8	-$572.3	$443,215.6	-$233.5
2001	$371,675.7	$371,378.9	-$296.7	$371,060.0	-$615.6	$371,561.2	-$114.4
2002	$391,082.5	$390,978.0	-$104.5	$390,527.8	-$554.7	$390,768.5	-$314.0
2003	$388,405.4	$388,214.2	-$191.2	$388,392.0	-$13.4	$388,231.0	-$174.5
2004	$368,193.9	$368,265.6	$71.7	$368,007.0	-$186.9	$368,280.3	$86.4
2005	$359,366.8	$359,194.2	-$172.5	$359,280.1	-$86.7	$359,165.8	-$200.9
2006	$368,246.6	$367,890.8	-$355.7	$368,016.8	-$229.8	$368,032.9	-$213.6
2007	$349,318.6	$348,990.4	-$328.2	$348,988.0	-$330.5	$349,331.6	$13.0
2008	$345,914.4	$346,107.6	$193.2	$346,088.7	$174.3	$346,153.9	$239.5
2009	$369,728.9	$369,522.3	-$206.6	$369,346.7	-$382.2	$369,367.9	-$360.9
2010	$374,496.3	$374,614.2	$118.0	$374,020.8	-$475.5	$374,587.8	$91.5
2011	$513,036.2	$511,963.1	-$1,073.1	$517,011.1	$3,974.9	$515,276.9	$2,240.7
2012	$450,571.9	$448,471.5	-$2,100.3	$450,478.1	-$93.8	$450,663.3	$91.4

The table below details the annual energy and capacity impacts at Fort Peck for Alternative 2 and each variation. On average, the variation with the greatest impact is Alternative 2 – Variation A. This Alternative variation also has the largest impact of any alternative. There are a number of years under all of the alternatives that have a large decrease in NED value relative to No Action.

Table 15. Fort Peck Total Energy and Capacity NED Impacts for Alternative 2 (2020 Dollars, $000s)

Fort Peck NED Impacts							
Year	No Action	Alternative 2	Alt2 Diff from No Action	Alternative 2 - Variation A	Alt2A Diff from No Action	Alternative 2 - Variation B	Alt2B Diff from No Action
1931	$38,124.7	$38,124.7	$0.0	$38,124.7	$0.0	$37,493.2	-$631.5

1932	$34,638.0	$34,638.1	$0.1	$34,638.0	$0.0	$34,547.6	-$90.3
1933	$33,974.1	$33,974.2	$0.1	$33,974.1	$0.0	$33,976.0	$1.9
1934	$32,895.2	$32,895.3	$0.1	$32,895.2	$0.0	$32,885.4	-$9.8
1935	$23,031.5	$23,031.4	-$0.1	$23,031.5	$0.0	$23,022.7	-$8.8
1936	$22,723.7	$22,723.6	-$0.1	$22,723.7	$0.0	$22,731.7	$8.0
1937	$19,069.0	$19,068.9	$0.0	$19,069.0	$0.0	$19,079.5	$10.5
1938	$19,542.3	$19,542.4	$0.1	$19,542.3	$0.0	$19,549.3	$7.0
1939	$23,572.9	$23,572.8	$0.0	$23,572.9	$0.0	$23,577.9	$5.0
1940	$25,907.6	$25,907.5	-$0.1	$25,907.6	$0.0	$25,912.8	$5.2
1941	$25,681.4	$25,681.3	$0.0	$25,681.4	$0.0	$25,687.2	$5.8
1942	$29,223.4	$29,223.4	$0.0	$29,223.4	$0.0	$29,227.3	$3.9
1943	$35,320.2	$35,320.3	$0.1	$35,320.2	$0.0	$35,326.1	$5.9
1944	$36,995.6	$36,995.5	$0.0	$36,995.6	$0.0	$36,995.2	-$0.3
1945	$38,251.1	$38,251.1	$0.1	$38,251.1	$0.0	$38,250.8	-$0.3
1946	$39,871.8	$39,872.0	$0.1	$39,871.8	$0.0	$39,871.6	-$0.3
1947	$43,448.4	$43,448.7	$0.3	$43,448.4	$0.0	$42,256.0	-$1,192.5
1948	$47,858.1	$47,858.2	$0.1	$47,858.1	$0.0	$47,759.5	-$98.6
1949	$41,890.0	$41,890.1	$0.1	$41,890.0	$0.0	$41,670.0	-$220.0
1950	$39,198.4	$39,198.6	$0.2	$39,198.4	$0.0	$38,401.8	-$796.6
1951	$45,961.9	$45,962.0	$0.0	$45,961.9	$0.0	$45,630.9	-$331.0
1952	$43,307.4	$43,308.0	$0.6	$43,308.0	$0.6	$43,300.0	-$7.4
1953	$49,568.3	$48,535.8	-$1,032.5	$48,688.2	-$880.1	$48,941.2	-$627.1
1954	$42,618.4	$41,645.0	-$973.3	$41,616.4	-$1,001.9	$41,695.9	-$922.5
1955	$41,147.7	$40,778.1	-$369.6	$40,860.7	-$287.1	$40,739.8	-$408.0
1956	$40,204.6	$40,203.5	-$1.1	$40,196.1	-$8.4	$40,209.1	$4.5
1957	$38,452.8	$38,455.7	$2.9	$38,454.5	$1.7	$38,462.0	$9.3
1958	$39,284.1	$39,279.0	-$5.1	$39,280.9	-$3.2	$39,285.3	$1.3
1959	$40,420.3	$40,417.9	-$2.4	$40,416.8	-$3.5	$40,425.0	$4.7
1960	$39,013.1	$39,011.1	-$2.0	$39,009.9	-$3.1	$39,031.3	$18.3
1961	$36,074.4	$36,072.9	-$1.5	$36,072.1	-$2.3	$36,074.2	-$0.2
1962	$28,569.0	$28,567.5	-$1.5	$28,566.7	-$2.3	$28,568.7	-$0.3
1963	$33,727.4	$33,725.9	-$1.5	$33,725.3	-$2.1	$33,721.3	-$6.1
1964	$43,984.4	$43,982.7	-$1.7	$43,981.6	-$2.8	$43,987.5	$3.1
1965	$47,741.5	$47,740.0	-$1.4	$47,739.1	-$2.4	$47,744.2	$2.8
1966	$47,010.8	$45,811.9	-$1,198.9	$45,766.4	-$1,244.4	$45,855.5	-$1,155.3
1967	$46,976.0	$46,456.8	-$519.2	$43,979.6	-$2,996.4	$46,736.7	-$239.3
1968	$49,120.2	$47,857.7	-$1,262.5	$47,708.0	-$1,412.1	$48,504.7	-$615.5
1969	$48,748.9	$48,879.0	$130.1	$48,701.6	-$47.3	$48,950.4	$201.6
1970	$50,799.6	$49,160.4	-$1,639.2	$49,117.5	-$1,682.1	$50,832.7	$33.1
1971	$49,476.6	$49,464.9	-$11.8	$49,470.1	-$6.5	$49,483.6	$6.9
1972	$41,898.6	$41,900.0	$1.4	$41,913.0	$14.4	$41,898.3	-$0.3
1973	$43,029.5	$43,152.3	$122.7	$43,069.8	$40.2	$43,038.1	$8.5
1974	$45,468.3	$44,997.1	-$471.2	$44,029.9	-$1,438.4	$45,211.7	-$256.6
1975	$52,421.6	$52,443.3	$21.6	$52,360.6	-$61.0	$52,403.1	-$18.6
1976	$52,854.3	$52,885.1	$30.8	$51,073.2	-$1,781.1	$52,850.9	-$3.4

1977	$42,201.7	$42,195.0	-$6.8	$41,521.5	-$680.3	$41,765.2	-$436.6
1978	$42,974.7	$40,940.0	-$2,034.7	$42,984.5	$9.8	$40,197.1	-$2,777.5
1979	$51,623.4	$51,566.5	-$56.9	$51,573.7	-$49.7	$51,560.6	-$62.8
1980	$47,376.0	$46,008.7	-$1,367.2	$45,983.1	-$1,392.8	$46,056.2	-$1,319.7
1981	$48,283.4	$47,933.1	-$350.3	$47,934.2	-$349.3	$47,934.5	-$348.9
1982	$47,531.1	$47,049.6	-$481.6	$46,888.6	-$642.6	$47,304.2	-$226.9
1983	$42,729.6	$44,833.8	$2,104.2	$37,414.3	-$5,315.3	$37,126.9	-$5,602.7
1984	$48,104.2	$46,683.3	-$1,420.9	$46,754.6	-$1,349.6	$47,303.5	-$800.7
1985	$44,476.2	$43,264.1	-$1,212.1	$43,059.8	-$1,416.4	$43,622.8	-$853.3
1986	$37,748.4	$32,753.0	-$4,995.4	$32,168.7	-$5,579.7	$35,385.2	-$2,363.2
1987	$43,470.8	$43,083.5	-$387.3	$42,951.7	-$519.1	$43,291.8	-$179.0
1988	$41,151.5	$39,389.9	-$1,761.5	$39,416.6	-$1,734.9	$39,409.5	-$1,741.9
1989	$40,060.5	$39,998.2	-$62.3	$39,992.9	-$67.6	$40,082.6	$22.1
1990	$37,976.0	$37,944.2	-$31.8	$37,951.2	-$24.8	$37,927.5	-$48.5
1991	$37,801.8	$37,786.1	-$15.7	$37,792.7	-$9.1	$37,791.9	-$9.8
1992	$34,425.7	$34,418.8	-$6.9	$34,425.3	-$0.4	$34,424.3	-$1.4
1993	$29,031.5	$29,026.7	-$4.8	$29,031.3	-$0.2	$29,030.8	-$0.7
1994	$40,556.1	$40,551.8	-$4.3	$40,555.7	-$0.4	$40,538.3	-$17.7
1995	$40,706.3	$40,882.2	$175.9	$40,885.0	$178.7	$37,928.4	-$2,777.9
1996	$51,307.2	$51,306.6	-$0.5	$51,311.3	$4.1	$51,115.3	-$191.8
1997	$50,220.2	$50,208.8	-$11.4	$50,124.8	-$95.4	$50,240.6	$20.4
1998	$46,974.7	$45,509.2	-$1,465.5	$45,457.2	-$1,517.4	$45,601.6	-$1,373.1
1999	$44,566.6	$43,444.8	-$1,121.8	$44,327.9	-$238.7	$44,508.5	-$58.1
2000	$41,772.2	$41,832.9	$60.7	$41,122.2	-$650.0	$41,078.3	-$693.9
2001	$32,464.0	$32,352.7	-$111.3	$32,266.7	-$197.2	$32,309.0	-$155.0
2002	$31,994.0	$31,992.0	-$2.0	$31,992.8	-$1.2	$31,982.3	-$11.7
2003	$37,425.6	$37,430.8	$5.2	$37,431.8	$6.2	$37,421.1	-$4.6
2004	$34,979.8	$34,973.1	-$6.7	$34,974.4	-$5.4	$34,974.6	-$5.2
2005	$32,416.0	$32,180.5	-$235.4	$32,181.4	-$234.6	$32,181.6	-$234.3
2006	$35,643.3	$35,649.4	$6.0	$35,650.6	$7.2	$35,651.0	$7.7
2007	$32,226.0	$32,226.2	$0.2	$32,227.1	$1.1	$32,227.3	$1.3
2008	$29,451.1	$29,541.1	$90.0	$29,542.8	$91.7	$29,542.0	$90.9
2009	$31,783.6	$31,754.1	-$29.5	$31,777.2	-$6.3	$31,754.7	-$28.9
2010	$28,686.0	$28,688.6	$2.6	$28,668.6	-$17.4	$28,694.5	$8.5
2011	$46,666.8	$46,671.4	$4.5	$46,661.2	-$5.6	$46,666.8	-$0.1
2012	$44,969.1	$43,720.3	-$1,248.8	$43,753.1	-$1,216.0	$44,017.6	-$951.5

5.0 Regional Economic Development Evaluation Results

Regional Economic Development impacts are based on the results of the NED analysis. WAPA markets its firm power from hydropower to various preferred customers that meet federally mandated criteria. Changes to the operations of the system will impact WAPA's ability to meet the demand for electricity, possibly leading to the need to purchase power. The need to purchase power may lead to increases in electricity rates. If rates were to be impacted, there would be indirect RED effects such as impacts on disposable income for households or discretionary spending for businesses. These have the potential to affect jobs and income regionally.

Sales of electric power must repay all costs associated with power generation. WAPA provided the hourly preference customer and pumping load in the SPP footprint and the deliveries external to SPP, and they were compared to the generation data from the HBC model. Then net hourly generation for every day of the year was obtained by subtracting the load or demand from the generation. The price used in these comparisons are different than those used for the NED analysis and were based on actual 2018 SPP LMP pricing at USACE generators was $22.58.

A summary of the total average monthly generation change from No Action is shown in the table below for the system as a whole. The average annual impact of Alternative 1 is a decrease of $43,022 for the total over the course of the year relative to No Action. Generation is reduced by 1,905 MWh over the average year from the average assumed generation. However, as can be seen in the table, the changes implemented under Alternative 1 are pushing the system to increase generation availability in the spring and decreasing generation availability in the summer. This means that WAPA would likely need to make additional power purchases in the summer.

The average annual impact of Variation 1A is a decrease of $126,756 for the total over the course of the year. Generation is reduced by 5,613 MWh over the year from the average generation. As with Alternative 1, the changes implemented seem to shift the purchasing that would need to be done to the summer time.

The average annual impact of Variation 1B is a decrease of $30,057 for the total over the course of the year. Generation is reduced by 1,331 MWh over the average year from the average generation. As with the earlier alternative variations, the changes implemented seem to shift the purchasing that would need to be done to the summer time.

The average annual impact of Alternative 2 is a decrease of $112,604 for the total over the course of the year. Generation is reduced by 4,986 MWh over the average year from the average generation assumed. As with the earlier alternative variations, the changes implemented seem to shift the purchasing that would need to be done to the summer time.

The average annual impact of Variation 2A is a decrease of $95,453 for the total over the course of the year. Generation is reduced by 4,227 MWh over the average year from the average generation. As with the earlier alternative variations, the changes implemented seem to shift the purchasing that would need to be done to the summer time.

The average annual impact of Variation 2B is an increase of $11,357 for the total over the course of the year. Generation is increased by 503 MWh over the average year from the average generation. As with the earlier alternative variations, the changes implemented seem to shift the purchasing that would need to be done to the summer time. However, in this case the overall impact over the course of the year is positive.

Table 16. Total Average Monthly Generation Change from No Action (MWH)

Total Average Monthly Generation Change From No Action						
	Alternative 1	Alternative 1A	Alternative 1B	Alternative 2	Alternative 2A	Alternative 2B
Jan	(176.1)	(480.5)	(343.0)	(670.4)	(584.5)	(541.5)
Feb	79.9	(236.2)	(13.5)	(496.2)	(168.6)	(206.7)

Mar	(45.3)	2,613.6	2,593.0	(26.1)	(47.0)	2.9
Apr	4,894.5	3,948.0	4,059.5	5,389.4	7,302.5	4,259.3
May	5,225.2	4,902.7	4,193.8	8,829.4	9,166.6	10,874.4
Jun	822.6	(2,718.9)	2,264.7	1,343.2	(2,607.2)	3,167.1
Jul	(4,156.7)	(5,851.6)	(5,652.5)	(5,628.7)	(6,773.9)	(6,663.1)
Aug	(4,018.3)	(4,765.5)	(6,492.3)	(4,370.5)	(5,565.5)	(5,793.0)
Sep	(4,482.4)	(2,566.6)	(3,497.8)	(4,163.8)	(5,864.4)	(4,158.4)
Oct	424.7	(349.7)	1,287.3	(2,424.3)	1,072.8	(577.5)
Nov	(366.1)	(613.6)	(373.7)	(2,202.9)	(75.7)	12.0
Dec	(107.3)	504.7	643.4	(565.9)	(82.3)	127.5
Total	(1,905.3)	(5,613.6)	(1,331.1)	(4,986.8)	(4,227.3)	503.0

Table 17. Total Monthly Generation Value Impact Change from No Action (Averaged over the period of record)

	Alternative 1	Alternative 1A	Alternative 1B	Alternative 2	Alternative 2A	Alternative 2B
Jan	($3,976)	($10,849)	($7,745)	($15,137)	($13,198)	($12,228)
Feb	$1,803	($5,334)	($304)	($11,203)	($3,808)	($4,668)
Mar	($1,022)	$59,015	$58,549	($590)	($1,062)	$66
Apr	$110,519	$89,147	$91,663	$121,694	$164,890	$96,174
May	$117,984	$110,703	$94,696	$199,368	$206,982	$245,544
Jun	$18,573	($61,393)	$51,136	$30,329	($58,870)	$71,513
Jul	($93,858)	($132,130)	($127,633)	($127,095)	($152,954)	($150,453)
Aug	($90,734)	($107,605)	($146,596)	($98,686)	($125,670)	($130,806)
Sep	($101,213)	($57,955)	($78,980)	($94,018)	($132,419)	($93,897)
Oct	$9,590	($7,896)	$29,066	($54,742)	$24,224	($13,039)

Nov	($8,267)	($13,856)	($8,437)	($49,742)	($1,710)	$272
Dec	($2,422)	$11,397	$14,528	($12,778)	($1,859)	$2,879
Total	($43,022)	($126,756)	($30,057)	($112,601)	($95,453)	$11,357

As most of the alternatives seem to shift the need to purchase power in the summer as well as increase the availability of generation in the spring, this many have some additional impacts on the system, as power is generally less expensive and more available in the spring and more expensive and less available in the summer. All of the alternatives result in a need to purchase power on average over the year except for Alternative 2 – Variation B.

6.0 Other Social Effects Results

The OSE analysis for hydropower relied on the results of the NED analysis to determine the impact to generation and the subsequent potential impact to emissions due to each of the alternatives. Reductions in hydropower generation would need to be made up by increasing other sources of power generation. Given the make-up of the power system in this region, this source would likely be a fossil fuel source that produces greenhouse gases. As discussed in the methodology section, the EPA eGrid database was used to determine the appropriate region and emissions factors for this study.

Table 18. Impact on Emissions

Change in Emissions	Change in Average Annual Generation (MWh)	Carbon Dioxide (lbs)	Methane (lbs)	Nitrous Oxide (lbs)
Average Annual Change in Emissions under Alternative 1	-1,913	3,485,357	295	55
Average Annual Change in Emissions under Variation 1A	-5,620	10,239,876	865	163
Average Annual Change in Emissions under Variation 1B	-1,351	2,461,609	208	39
Average Annual Change in Emissions under Alternative 2	-4,998	9,106,382	770	145
Average Annual Change in Emissions under Variation 2A	-4,231	7,709,011	652	123
Average Annual Change in Emissions under Variation 2B	496	-904,012	-76	-14

The largest change in average annual generation is occurring under Variation 1A which shows a loss of 5,620 MWh on average. This would increase carbon dioxide emissions by 10.2 million, methane by 865 lbs, and nitrous oxide by 163 lbs. The alternative with the least increase in emissions actually decreases emissions due to increased hydropower generation under Variation 2B. This alternative could potentially decrease carbon dioxide emissions by 904,000 lbs, methane by 76 lbs, and nitrous oxide by 14 lbs on an annual basis.

7.0 References

Institute for Water Resources, Hydrologic Engineering Center, Hydrologic Engineering Center River Analysis System (HEC-RAS) (http://www.hec.usace.army.mil/software/hec-ras/).

Institute for Water Resources, Hydrologic Engineering Center, Hydrologic Engineering Center Reservoir System Simulation (HEC-ResSim) (http://www.hec.usace.army.mil/software/hec-ressim).

Appendix A – Unit Specific Generation Modeling

Due to the potential impacts at Ft. Peck and the unique setup of the power distribution to both east and west sectors, a unit specific modeling effort was undertaken to determine whether the western side of the Ft. Peck generation would experience large impacts due to the limited ability of the region to obtain power from other sources.

The overall modeling for this effort including several assumptions that may need to be revisited if further consideration of these impacts are warranted. Currently, the modeling assumes that units will be dispatched according to the most efficient use given the flow and reservoir elevation at any given time. Further modeling efforts could use a different objective, such giving priority to the units that send power west (subject to any actual additional limitations).

The modeling also made some simplifying assumptions with regard to plant setup and distribution. Units 4 and 5 are always assumed to provide power to the eastern side of the service region. Units 1, 2, and 3 can serve either side of the service region. However, for the purposes of this modeling, all power from these units was assumed to go to the western region. This assumption was made up to the transmission limitation for the western connect, which is 90 MW. Further modeling efforts could adjust these assumptions relative to realistic limitations as well as include additional operational realities.

The tables below show the estimated total change in generation for units 1, 2, and 3 for all the years over the period of record for each of the alternatives from No Action.

The alternative with the smallest impact on west-side generation at Fort Peck is Alternative 1 – Variation A with an average annual decrease of 519 MWh. However, there are still some large single year impacts to generation under that alternative. The largest impact occurs under Alternative 2 – Variation A with a decrease of 4,643 on average.

Table 19. Total Annual Generation Change from No Action (MWh), Ft. Peck Units 1, 2, and 3

Year	Alternative 1	Alternative 1A	Alternative 1B	Alternative 2	Alternative 2A	Alternative 2B
1931	-	-	7,872	-	-	(20,921)
1932	-	-	109	-	-	(1,235)
1933	-	-	(90)	-	-	(102)
1934	-	-	1,233	-	-	1,226
1935	-	-	(1,644)	-	-	(1,644)
1936	-	-	-	-	-	-
1937	-	-	-	-	-	-
1938	-	-	-	-	-	-
1939	-	-	-	-	-	-
1940	-	-	-	-	-	-
1941	-	-	-	-	-	-
1942	-	-	30	-	-	18
1943	-	(16)	220	(16)	(16)	115
1944	-	-	(2,362)	-	-	(4)

1945	-	-	(1,362)	-	-	37
1946	-	-	(331)	-	-	39
1947	-	(14)	(22,754)	(14)	(14)	(39,631)
1948	-	-	4,214	-	-	(10,296)
1949	-	-	6,399	-	-	(3,804)
1950	-	(15)	(11,756)	(15)	(15)	(22,270)
1951	-	-	9,284	-	-	448
1952	-	(32)	(736)	(32)	(32)	189
1953	9,250	6,877	16,517	12,513	9,506	1,558
1954	(28,530)	(2,646)	(18,369)	(26,685)	(24,554)	(23,246)
1955	(9,143)	(3,303)	(10,208)	(23,634)	(16,384)	(23,693)
1956	(35)	(220)	28	(20)	(265)	54
1957	(22)	(1,441)	76	929	(1,517)	1,029
1958	(20)	1	17	(419)	(29)	(368)
1959	(51)	1	36	(48)	(96)	59
1960	27	0	(64)	(13)	21	667
1961	(16)	0	24	(10)	(17)	(5)
1962	(94)	0	127	(90)	(93)	(40)
1963	(79)	2	8	(78)	(80)	(646)
1964	(21)	0	24	(16)	(71)	32
1965	10	-	26	12	(4)	(4)
1966	11,972	25,605	8,012	(1,927)	(4,635)	(1,953)
1967	(13,005)	(9,816)	4,915	(30,680)	(25,014)	(21,855)
1968	(5,899)	(19,827)	(17,497)	(10,569)	(19,382)	(19,263)
1969	3,473	13,266	8,949	(1,239)	1,349	8,992
1970	2,636	1,270	(19,056)	(3,398)	(1,663)	(9,375)
1971	2,407	2,201	1,488	2,276	2,569	380
1972	835	713	38	663	853	2
1973	(20,133)	(19,145)	(15,056)	(20,460)	(12,569)	(37,442)
1974	796	(14,619)	(3,277)	26,789	(20,329)	9,993
1975	125	11,251	1,528	(2,926)	(12,635)	(1,413)
1976	(345)	(23,738)	(323)	(6,447)	(33,858)	(346)
1977	7,278	3,374	7,782	586	(22,076)	446
1978	(4,166)	(5,146)	177	11,705	(288)	(2,242)
1979	1,849	8,553	8,837	3,077	2,006	2,759
1980	(31,068)	(27,831)	(35,732)	(19,927)	(19,353)	(18,223)
1981	(3,519)	(12,176)	(8,496)	(10,068)	(10,102)	(10,098)
1982	13,713	13,377	16,470	9,354	3,916	14,252
1983	(50,587)	(18,913)	(39,407)	(36,086)	(17,696)	(19,153)
1984	23,385	38,883	39,573	24,803	29,256	44,063
1985	(26,053)	(22,036)	(26,020)	(17,349)	(24,346)	(20,705)
1986	(25,133)	(2,010)	(11,153)	(13,093)	(15,434)	(31,406)
1987	4,246	8,819	8,153	617	2,148	5,538
1988	(17,259)	(7,984)	(2,765)	(36,258)	(35,616)	(35,672)
1989	(6,426)	(5,749)	(8,631)	(18,165)	(13,361)	(13,463)

1990	(71)	(2,318)	321	(2,066)	(1,865)	(2,364)
1991	(140)	(506)	(31)	(670)	(530)	(541)
1992	(234)	18	(28)	(195)	(7)	(15)
1993	156	107	(27)	181	(3)	(12)
1994	4,474	12,054	14,175	160	(2)	15,760
1995	6,106	11,784	10,396	885	(974)	(16,636)
1996	(258)	4,276	(3,010)	(61)	(198)	3,799
1997	(127)	(637)	(2,015)	(526)	(2,507)	(228)
1998	(3,480)	22,339	5,975	(350)	(4,769)	1,999
1999	(27,109)	1,347	(12,602)	(43,633)	(15,738)	(5,202)
2000	(654)	(28,473)	1,010	12,975	(35,075)	(40,514)
2001	(6,077)	(5,130)	(2,672)	(5,991)	(12,874)	(6,851)
2002	(50)	5,346	(95)	(47)	(43)	1,733
2003	(64)	14	(118)	312	321	(122)
2004	(9)	(10)	(9)	(32)	(15)	(13)
2005	(31)	(28)	(45)	(10,044)	(10,026)	(10,020)
2006	176	174	1,058	2,488	2,502	2,505
2007	16	3	2	1	17	19
2008	(5)	(8)	1,127	1,127	1,137	1,120
2009	(134)	(128)	(1,879)	(1,878)	(527)	(1,874)
2010	(488)	(482)	887	885	2,019	1,309
2011	620	179	643	(640)	638	(403)
2012	(15,653)	(18)	(8,794)	(23,775)	(22,256)	(8,966)
Total Over the POR	(202,639)	(42,577)	(100,649)	(257,251)	(380,697)	(364,138)
Average Annual MWh Change	(2,471)	(519)	(1,227)	(3,137)	(4,643)	(4,441)

The table below shows the estimated annual impact in value of the change from no action for each alternative, with totals for the period of record at the bottom of the table. Over the long term, Alternative 1A has the least amount of overall impact with an average annual decrease of $87,277 with Alternative 2A having the most impact over the long term with $217,467. These totals were obtained using monthly average of NorthWest Energy imbalance market prices for 2015-2019.

Again, these results show that while on average the impacts are relatively small, there are some years under each alternative where there will be a large, adverse impact on Fort Peck west-side generation.

Table 20. Total Annual Generation Value Change for Units 1, 2, and 3 at Ft. Peck (2020 Dollars)

Year	Alternative 1	Alternative 1A	Alternative 1B	Alternative 2	Alternative 2A	Alternative 2B
1931	$0	$0	$99,630	$0	$0	($741,628)
1932	$0	$0	$2,318	$0	$0	($29,624)
1933	$0	$0	($2,876)	$0	$0	($3,133)

1934	$0	$0	$32,578	$0	$0	$32,444
1935	$0	$0	($28,521)	$0	$0	($28,521)
1936	$0	$0	$0	$0	$0	$0
1937	$0	$0	$0	$0	$0	$0
1938	$0	$0	$0	$0	$0	$0
1939	$0	$0	$0	$0	$0	$0
1940	$0	$0	$0	$0	$0	$0
1941	$0	$0	$0	$0	$0	$0
1942	$0	$0	$866	$0	$0	$509
1943	$0	($229)	$4,980	($229)	($229)	$2,338
1944	$0	$0	($59,962)	$0	$0	($69)
1945	$0	$0	($31,033)	$0	$0	$1,264
1946	$0	$0	($7,424)	$0	$0	$755
1947	$0	($192)	($875,582)	($192)	($192)	($1,428,156)
1948	$0	$0	$105,974	$0	$0	($257,545)
1949	$0	$0	($123,561)	$0	$0	($579,043)
1950	$0	($207)	($274,349)	($207)	($207)	($574,976)
1951	$0	$0	$226,985	$0	$0	$5,442
1952	$0	($486)	($14,537)	($486)	($486)	$5,131
1953	$74,376	$45,783	$389,075	$105,985	($75,903)	($18,447)
1954	($1,121,452)	($221,058)	($952,798)	($1,294,872)	($1,215,165)	($1,227,391)
1955	($227,362)	($82,193)	($254,564)	($587,550)	($407,326)	($588,534)
1956	($862)	($6,236)	$684	($505)	($7,328)	$1,313
1957	($522)	($20,454)	$1,355	$29,016	($21,847)	$30,938
1958	($496)	$24	$425	($11,652)	($707)	($10,425)
1959	($1,443)	$33	$935	($1,366)	($2,568)	$1,488
1960	$245	$2	($620)	($297)	$118	$22,091
1961	($323)	$9	$549	($180)	($345)	($117)
1962	($2,807)	$1	$3,454	($2,716)	($2,862)	($1,262)
1963	($1,549)	$39	$183	($1,530)	($1,599)	($17,460)
1964	($543)	$15	$653	($418)	($1,409)	$847
1965	($93)	$0	$680	($57)	($423)	$233
1966	($236,978)	$91,861	($273,365)	($775,511)	($868,579)	($747,477)
1967	($409,500)	($320,009)	$161,394	($1,020,365)	($942,481)	($666,885)
1968	($422,136)	($719,251)	($684,893)	($504,295)	($775,098)	($727,447)
1969	$53,138	$341,152	$200,369	($65,527)	$33,406	$201,388
1970	($89,324)	($82,555)	($610,911)	($158,723)	($186,446)	($215,040)
1971	$46,424	$42,070	$40,348	$43,282	$48,648	$7,486
1972	$19,243	$13,350	$731	$12,678	$19,992	$50
1973	($603,222)	($737,404)	($554,871)	($773,436)	($668,306)	($1,263,572)
1974	$23,057	($603,895)	($37,776)	$761,404	($878,073)	$348,992
1975	($13,943)	$264,494	$37,067	($99,853)	($339,416)	($35,778)

1976	($5,952)	($687,420)	($5,359)	($159,927)	($818,315)	($5,992)
1977	($39,495)	($155,762)	($39)	$18,476	($559,651)	($532,844)
1978	($143,434)	($122,719)	($89,663)	$59,832	($3,727)	($288,676)
1979	$60,187	$189,964	$194,997	$87,425	$64,060	$79,268
1980	($1,127,381)	($1,108,605)	($1,178,313)	($988,184)	($997,012)	($930,390)
1981	($71,293)	($272,295)	($210,411)	($237,995)	($239,144)	($239,054)
1982	$129,954	$102,824	$245,117	($163,474)	($397,497)	$67,883
1983	($1,693,644)	($772,496)	($1,332,971)	($1,268,343)	($754,576)	($738,993)
1984	$316,574	$724,002	$818,955	$288,532	$365,573	$833,729
1985	($1,248,195)	($989,844)	($1,155,247)	($1,016,840)	($1,210,520)	($1,087,361)
1986	($1,053,735)	($535,298)	($487,399)	($774,707)	($957,063)	($1,167,516)
1987	($419,348)	($321,336)	($253,887)	($595,404)	($575,171)	($427,153)
1988	($584,523)	($355,995)	($229,791)	($1,163,845)	($1,147,577)	($1,149,063)
1989	($160,045)	($161,368)	($198,406)	($436,718)	($332,663)	($353,810)
1990	($1,654)	($68,315)	$8,133	($61,857)	($57,951)	($69,575)
1991	($3,348)	($13,617)	($754)	($17,145)	($14,196)	($14,467)
1992	($5,024)	$418	($646)	($4,063)	($179)	($357)
1993	$48	$2,089	($699)	$556	($54)	($297)
1994	($217,523)	($83,951)	($12,433)	$2,933	($53)	($23,514)
1995	$120,481	$295,319	$240,875	$28,352	($27,244)	($366,752)
1996	($6,664)	$100,441	($75,972)	($1,489)	($6,305)	$88,113
1997	($2,584)	($2,160)	($28,640)	($17,096)	($42,930)	$7,586
1998	($562,224)	$138,968	($272,650)	($610,433)	($734,684)	($472,611)
1999	($846,606)	$38,363	($617,446)	($1,128,367)	($392,333)	($152,619)
2000	($497,932)	($1,030,026)	($381,644)	($195,212)	($1,322,610)	($1,363,937)
2001	($149,753)	($96,482)	($60,587)	($148,457)	($320,077)	($151,541)
2002	($795)	$206,294	($1,501)	($715)	($657)	$51,897
2003	($1,390)	$959	($2,394)	$8,896	$9,134	($2,487)
2004	($171)	($197)	($147)	($706)	($277)	($240)
2005	($729)	($671)	($1,073)	($278,419)	($277,953)	($277,838)
2006	$3,418	$3,364	$28,447	$49,735	$50,051	$50,118
2007	$605	$210	$58	$24	$128	$176
2008	($253)	($344)	($4,188)	($4,211)	($3,783)	($4,331)
2009	($2,548)	($2,407)	($47,046)	($47,027)	($11,875)	($46,915)
2010	($14,093)	($13,979)	$25,143	$25,114	$37,632	$37,608
2011	$15,695	$3,056	$17,025	($17,662)	$15,984	($7,578)
2012	($706,946)	($172,391)	($476,020)	($868,405)	($873,913)	($415,039)
Total Over POR	($11,836,396)	($7,156,744)	($9,022,982)	($13,984,429)	($17,832,259)	($17,574,394)
Average Annual Impact	($144,346)	($87,277)	($110,036)	($170,542)	($217,467)	($214,322)

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Fort Peck Flows Plan
and Environmental Impact Statement

Thermal Power
Environmental Consequences Analysis

Technical Report

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1.0 Introduction

The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Fort Peck Dam Test Releases – Environmental Impact Statement (FPDTR – EIS). The purpose of the Environmental Impact Statement (EIS) is to assess the potential impacts of a range of test flow release alternatives from Fort Peck Dam designed to benefit reproduction and recruitment of pallid sturgeon to avoid jeopardizing their continued existence in the Missouri River.

The purpose of the Thermal Power Technical Report is to provide additional information on the impact analysis and results relevant to thermal power that was completed for the FPDTR-EIS. Additional details on the National Economic Development (NED) methodology and results are provided in this technical report. In addition, data to support the Regional Economic Development (RED) evaluation are also included in this report. The Other Social Effects (OSE) are presented in the FPDTR-EIS, Chapter 3 Environmental Consequences, Section 3.8 Thermal Power. No Environmental Quality (EQ) analysis was undertaken for thermal power.

1.1 Summary of Alternatives

The FPDTR-EIS evaluates the following alternatives. A detailed description of the alternatives is provided in Chapter 2 of the FPDTR-EIS.

No Action Alternative: The impacts of the No Action Alternative serve as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. When modeling the No Action Alternative, local inflows are adjusted by the difference between the historic and present level depletions to ensure the period-of-record (POR) datasets are homogenous and reflect current water use. All modeled flood targets are as outlined in the 2018 Master Manual (USACE,2018) and reservoir storages are based on current reservoir surveys. All four navigation target locations are used when setting navigation releases and the model balances system storage by March 1. It is assumed that other activities and actions for pallid sturgeon in the Upper Basin would be implemented as described in the FPDTR-EIS and 2018 Biological Opinion and the Yellowstone Intake Bypass EIS. These actions include fish bypass construction at Yellowstone Intake, continued propagation and stocking of pallid sturgeon in the Upper Basin, and continued pallid sturgeon science and monitoring activities in the Upper Basin.

Alternative 1: System operations under this alternative are based on those described under the No Action Alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon.

The attraction flow regime begins on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in the given year. For example, the typical early spring release from Fort Peck Dam is approximately 8,000 cubic feet per second (cfs); therefore, the attraction flow regime peak flow would be 16,000 cfs as measured at the Wolf Point gage. Beginning on April 16, spring release flows are increased by 1,700 cfs per day until the peak flow is reached at the Wolf Point gage. The peak flow is held for 3 days and then decreases by

1,300 cfs per day until the retention flow is reached. The retention flow is 1.5 times the Fort Peck Dam early spring release as measured at the Wolf Point gage, 12,000 cfs using the example. The retention flow is held until May 28 when the spawning cue flow regime is initiated.

The spawning cue flow regime under Alternative 1 begins on May 28 and is 3.5 times the Fort Peck Dam spring flow release in the given year. Assuming 8,000 cfs as the typical spring flow, this equates to approximately 28,000 cfs at the peak as measured at the Wolf Point gage. Beginning on May 28, the release is increased by 1,100 cfs per day until the peak flow is reached as measured at the Wolf Point gage. The peak is held for 3 days and then decreases by 1,000 cfs per day for 12 days, then decreases by 3,000 cfs per day until the drifting flow regime of 8,000 cfs is reached. The 8,000 cfs drifting flow regime is held until September 1 when releases to balance storage resume.

Variation 1A: This test flow is a variation of Alternative 1. The parameters for Variation 1A are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The April 9 initiation date is closer to the timing of the initial pulse shown on the unregulated hydrograph. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases. In Alternative 1, the later initiation date of April 16 is designed to enhance the contrast between Missouri River and Yellowstone River discharges by moving the start date approximately two weeks later than the initial pulse shown on the unregulated hydrograph.

Variation 1B: This test flow is another variation of Alternative 1. The parameters for Variation 1B are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 23 and the spawning cue flow regime is initiated on June 4. Similar to the concept described in 1A, the later initiation date is intended to provide contrast and explore any differences in forecasted impacts from a later flow initiation date.

Alternative 2: The parameters for Alternative 2 are the same as described for Alternative 1 except that the attraction flow regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at the Wolf Point gage are held at 14,000 cfs until the spawning cue flow release is initiated. The rationale for keeping the releases high through this period—foregoing the inter-pulse saddle—is the hypothesis that persistent high flows are needed to hold migrated, reproductive adult pallid sturgeon upstream near the dam.

Variation 2A: This test flow is a variation of Alternative 2. The parameters for Variation 2A are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The difference in timing follows the same reasoning as described for Variation 1A.

Variation 2B: This test flow is another variation of Alternative 2. The parameters for Variation 2B are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 23, rather than April 16, and the spawning cue flow regime is initiated on June 4, rather than May 21. The difference in timing follows the same reasoning as described for Variation 1B.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the FPDTR-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the FPDTR-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR 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 FPDTR-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 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 RED account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The EQ account displays non-monetary effect of significant natural and cultural resources.
- The OSE account registers plan effects from perspective 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 thermal power include NED, RED, and OSE.

1.3 Approach for Evaluating Environmental Consequences to Thermal Power from the FPDTR-EIS

There are six coal-fired thermal power plants located along the Upper Mainstem of the Missouri River and its reservoirs in North Dakota. One power plant is located on Lake Sakakawea and five are located on the river below Garrison Dam in North Dakota. In addition, there is an electricity conversion station operated by Minnesota Power that uses power from the Milton R. Young Station.

Evaluation of the environmental consequences of the FPDTR-EIS alternatives to thermal power requires an understanding of how the physical conditions of the river would change under each of the alternatives. Generally, thermal power plants are impacted by the Missouri River flows, stages and temperature conditions thereby affecting an intake’s access to water, the ability to discharge cooling water, and power plant operations and generation. Power plants need sufficient river stages to accommodate intake elevations. River temperatures can also affect power plant operational efficiency and power generation.

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 thermal power operations and power generation. This figure also shows the intermediate factors and criteria that were applied in assessing the NED, RED, and OSE consequences to thermal power.

The environmental consequences analysis first focused on an analysis of the river stages and river flows at specified locations near power plants along the river relative to important intake thresholds under each of the FPDTR-EIS alternatives. Water temperatures were not modeled for the river reaches. In addition, the power plants in the upper river rarely have issues with temperatures affecting power generation because of the relatively low ambient temperatures.

The results of this analysis provided important inputs for the NED, RED, and OSE evaluation, the second step in the process. The NED, RED, and OSE evaluation estimated impacts associated with changes in power plant operations and power generation under the FPDTR-EIS alternatives. Figure 1 illustrates an overview of the approach for the thermal power evaluation.

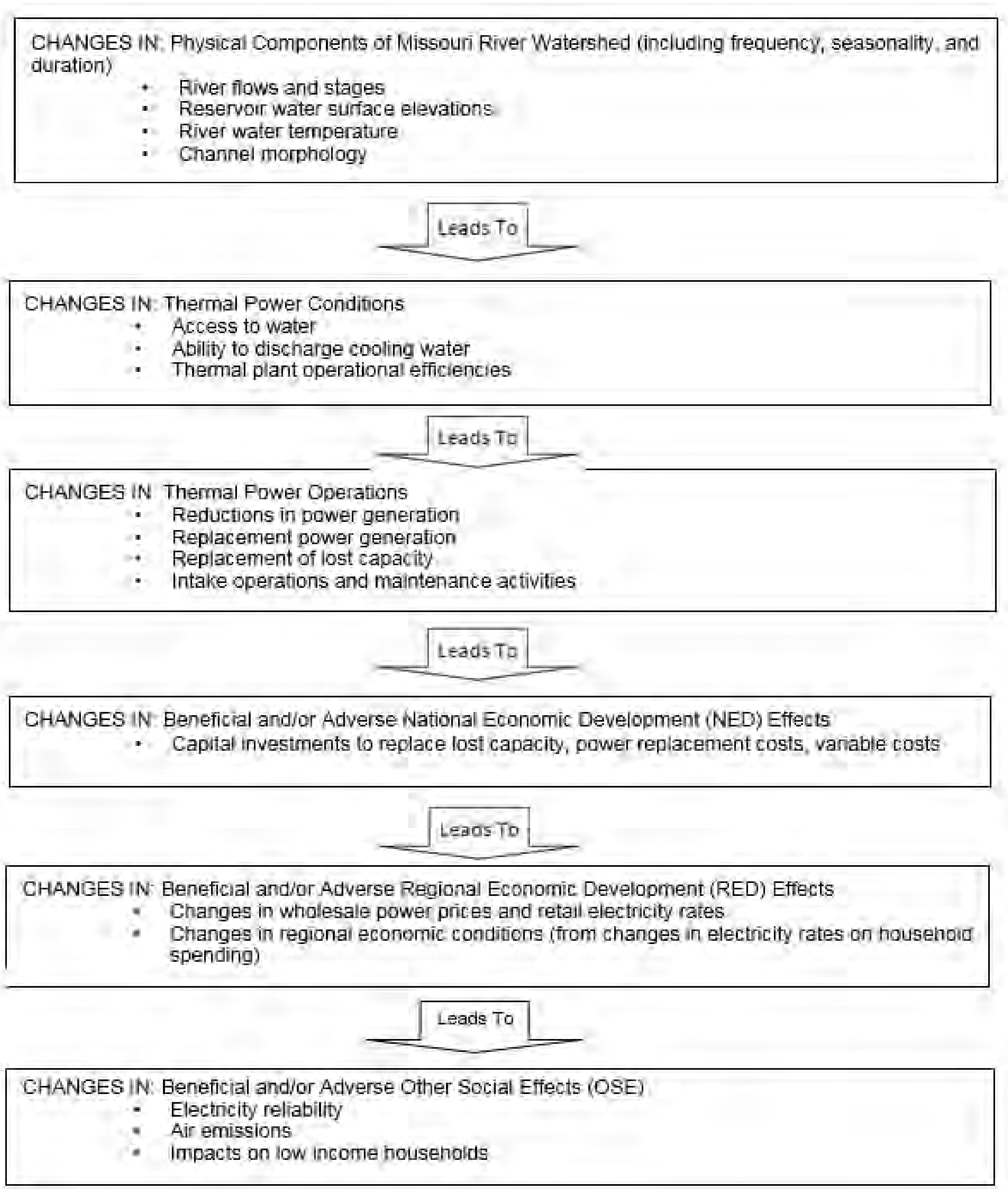

Figure 1. Flow Chart of Inputs Considered in Thermal Power Evaluation

2.0 Methodology and Assumptions

The methodology includes an evaluation of the relationship between river conditions and thermal power plants and uses this information to assess the NED, RED, and OSE impacts; these steps in the process are described in these sections.

2.1 Assumptions and Limitations

In modeling the environmental consequences to thermal power plants from the FPDTR-EIS alternatives, the project team established a set of assumptions. The following discussion highlights these assumptions to give the reviewer a better understanding of the objectives for the modeling effort. In addition, this section discusses the limitations of this modeling effort.

The key assumptions used in the modeling effort are as follows.

- The analysis uses data from the hydrology and hydraulics (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 FPDTR-EIS alternatives as well as No Action.
- As part of the previous Missouri River Recovery Management Plan- Environmental Impact Statement (MRRMP-EIS), the project team conducted considerable outreach to power plants to understand how various river stages, flows, and temperature conditions adversely impact power plants (i.e., reduced power generation, increased costs). The project team has utilized information from interviews with power plants to assess how adverse effects would affect power generation and variable costs. Some of these conditions have not occurred in the recent past and therefore represent the anticipated operational response of a power plant to a hypothetical situation. It is assumed that the information provided by power plant officials adequately describes the impacts included in the modeling effort.
- Unit capacity values, estimated by the Federal Energy Regulatory Commission (FERC) and provided by the USACE Hydropower Analysis Center, are used to represent the capital cost or major investment needed to replace lost capacity. The unit values are assumed to represent the cost to replace the capacity with an alternative source – combined cycle natural gas.
- Investments to replace lost capacity during peak power demand seasons in this modeling effort may not reflect specific plant requirements and constraints. For consistency across all power plants, a standard approach to replacing changes in dependable capacity (used in hydropower evaluations) was used.
- The analysis depicts relatively large adverse impacts to power generation expected during dry years under current system operations. Some of these impacts would occur when river stages fall below critical intake thresholds. Recent bed degradation is likely causing water surface elevations to fall below critical thresholds in some locations. Since these conditions exist under current system management, which are modeled with a 2012 channel geometry, power plants would need to improve intakes to address these issues. The analysis presented here does not attempt to evaluate intake modifications

resulting from bed degradation issues, but instead focuses on change in power generation and capacity relative to No Action as a result of the action alternatives.

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 FPDTR-EIS 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 USACE's Hydrologic Engineering Center's River Analysis System (HEC-RAS) models or carried through to the thermal power model described in this document. The project team has attempted to address risk and uncertainty in the FPDTR-EIS 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 thermal power plants.

A source of uncertainty associated with the thermal power analysis is predicting how thermal power plants would react to long-term changes in river and reservoir conditions. The project team has utilized information from interviews with power plants to assess how adverse effects would affect power generation and variable costs. Some of these river conditions have not occurred in the recent past and therefore represent the anticipated operational response of a power plant to a hypothetical situation. However, while these operational responses may be reasonable under current conditions or in the near future, unforeseen conditions may arise that may alter the operational response to the adverse conditions.

2.3 Geographic Areas

The study area includes six power plants in the upper river. One power plant is located on Lake Sakakawea and five are located on the river below Garrison Dam in North Dakota. In addition, there is an electricity conversion station operated by Minnesota Power that uses power from the Milton R. Young Station.

2.4 Evaluation of the Relationship between River Conditions and Thermal Power

The purpose of this analysis is to link the HEC-RAS modeling efforts, which simulate river operations of the Missouri River under each of the FPDTR-EIS alternatives, with the economic analysis necessary to estimate the consequences to thermal power plants. Specialized software was used to simulate river and reservoir operations for planning studies and decision support developed by the Institute for Water Resources, Hydrologic Engineering Center (HEC). The analysis used Microsoft Excel® to evaluate potential effects of changes in river flows and stages on thermal power operations and power generation.

2.4.1 Thermal Power Intake Elevation and Flow Analysis

The following section describes the approach and structure of the analysis used to measure impacts to thermal power plant operations from changes in Missouri River flows and stages. The intake elevation and flow analysis was used to evaluate when changes in river stages and flow levels would adversely affect thermal power plant intakes. Generally, power plants have specified two intake elevations: minimum intake elevation and shut down intake elevation. Minimum intake elevations are the water surface levels below which there would be small adverse impacts to power plant operations, such as additional pumping requirements as well as higher operations and maintenance costs for cleaning debris and sediment, compared to river stages at the shutdown intake elevation. When river stages fall below shut down intake elevations, more severe impacts occur to plants and most plants must shut down. HEC-RAS data was used to provide a profile of river behavior at locations that approximately corresponded to locations of thermal power plants intakes. River behavior for each location was modeled over a period of 82 years, from 1931 to 2012.

The USACE developed the initial list of thermal power plants along the upper part of the Missouri River as well as one conversion station that could be potentially affected by changes in Missouri River flows and stages. One of the power plants in the upper Missouri River, Stanton Station, was decommissioned in October 2018, so was not included in the evaluation. As a result, six thermal power plants located along the Missouri River were included in the analysis. One power plant in the upper river did not have any days below shut down intake elevations (and also had a cooling tower) and therefore was removed from further evaluation in the NED, RED, and OSE evaluation.

All of the upper Missouri River power plant representatives and utilities provided input on the specific river stages and river flows that would adversely impact access to water for cooling. All intake elevation thresholds in the analysis are shown in feet above mean sea level (FAMSL) in the North American Vertical Datum of 1988 (NAVD88). Many of the intake elevations were converted from National Geodetic Vertical Datum of 1929 (NGVD29) to NAVD88 to be consistent with the H&H models.

Inclusion of critical flows in the analysis was based on feedback from utilities and power plant operators. Specifically, a number of power plants indicated a critical low flow, while others indicated that specific intake elevations were sufficient conditions to evaluate potential adverse impacts to power plants. Power plant representatives that provided critical low-flow thresholds indicated that power generation would be reduced below these thresholds.

Table 1 identifies the specific measures that were calculated for the thermal power intake elevation and flow analysis. As previously described, only those measures identified by the plants/utilities as important to consider were included in the NED analysis for the specific power plant.

Table 1. Thermal Power Intake Elevation and Flow Analysis Conditions

River Conditions	Measure	Description
Condition 1 – Number of days river stages fall between the minimum intake elevation and the shut down intake elevation	Number of days by season	This measure is an estimate of the number of days in a season that a thermal power plant intake would experience minor adverse operating conditions (i.e., impacts to pumping, sediment clogging of intake, etc.). The focus was on operating conditions (and not shut down conditions).
Condition 2 – Number of days river stages fall below the shut down intake elevation	Number of days by season	This measure is an estimate of the number of days in a season that river stages fall below the shutdown intake elevation and the plant will have to shut down due to low water elevations. The focus was on shut down conditions.

River Conditions	Measure	Description
Condition 3 – Number of days river flows will fall below plant operating flow requirements	Number of days by season	This measure is an estimate of the number of days in a season that river flows fall below an important operating threshold when plants will incur severe operational impacts and will reduce power generation. The focus was on shut down conditions.

This analysis specifically evaluated the number of days river flows and stages are below intake thresholds on a seasonal basis each year. Seasons are important to consider when power reductions occur because replacement costs for electricity (i.e., energy values) vary based on peak periods when demand for energy is greatest in the winter and summer months. In addition, plants also tend to produce more energy during peak periods when demand for electricity is highest, often operating close to full capacity.

2.4.2 Thermal Power Temperature Analysis

River temperatures can affect the cooling efficiency of plants, with potential impacts to power generation. However, of the six power plants in the upper Missouri River, four have recirculating towers or cooling systems in place. Two power plants could potentially be affected by river temperatures. Temperature modeling was not conducted under the FPDTR-EIS alternatives. Because changes in river flows and stages are very small in the Garrison reach and in Lake Sakakawea, changes to river temperatures under the action alternatives are anticipated to be negligible compared to river temperatures under No Action.

2.5 National Economic Development

An economic analysis was developed that builds upon the evaluation of river conditions to evaluate the change in NED associated with thermal power operations and power generation as a result of the FPDTR-EIS alternatives. Thermal power NED impacts include: 1) energy values and power replacement costs (changes in energy values); 2) capacity values and costs to replace loss capacity; and 3) variable costs. Because the modeling indicated no impacts to dependable capacity would occur under the action alternatives, the NED impacts include power replacement costs and variable costs.

The evaluation of the impact of river conditions on thermal power generation was based on interviews with power plant operators and utilities. Unit energy and capacity values were obtained from the hydropower analysis and were applied to the estimates of power generation and capacity. Unit energy values represent the cost or price to replace reductions in power generation with electricity generation from the regional transmission organizations (RTOs). The changes in variable costs and energy values were aggregated for all power plants to estimate the NED impacts for each alternative. This section describes each of the steps included in the NED thermal power analysis and data sources used in the analysis.

2.5.1 Estimate Average Daily Seasonal Generation

One of the first steps in the NED analysis process was to obtain the available power generation for potentially affected plants. Monthly generation was obtained from the U.S. Energy Information Administration (EIA) for the net generation for each power plant. Net generation is the amount of gross generation less the electrical energy consumed at the generating station(s) for station service or auxiliaries (EIA 2018b). Power plants are obligated to report their monthly net generation through a form titled EIA 923. Monthly net generation was obtained for 2015 to 2017, and any months with lower generation were removed from averages and replaced with "typical" generation as power plants are periodically taken off-line for repairs and maintenance.

Power generation was assessed seasonally because replacement costs of power (energy values) vary by season, with peak demand for electricity driving power replacement prices higher in the winter and summer months. In addition, power generation is also affected by demand for electricity, generally with higher generation during the peak summer and winter seasons. The determination of the seasons for the analysis included an assessment of the monthly energy prices (i.e., energy values), estimated through locational marginal pricing (described in Section 2.5.4). The months were grouped into seasons that reflected similar monthly prices. The seasons for the analysis were: spring (March through June), summer (July and August), fall (September through December), and winter (January and February).

The next step in the process was to estimate the average seasonal daily net generation. The monthly net generation from EIA for the appropriate units was aggregated for the months in each season. To estimate the average daily generation for each season, the total seasonal generation for each plant was divided by the number of days in each season to estimate the daily seasonal generation for each affected plant or unit.

2.5.2 Obtain Information from Power Plants on Adverse Conditions

Representatives from the six power plants were contacted as part of the MRRMP-EIS evaluation to provide information regarding how river conditions affect power generation and variable costs (variable costs are described further Section 2.5.6). In addition, there is an electricity conversion station that can be affected when one thermal power plant is shut down. All power plant operators or utilities provided input on the shut down and minimum intake elevations for their associated power plants.

Adverse Effects Associated with River Stage Thresholds

Critical intake elevation thresholds were confirmed with all of the power plants, including both the shut down intake elevation and the minimum intake elevation. Most power plants were assumed to fully shut down when river stages drop below the shut down intake elevations, which was consistent with input from power plant representatives. For most plants, it is assumed that average daily net power generation for the season (estimated under Section 2.4.1) would be lost for every day that river stages are below the shut down intake elevation. There are exceptions to this approach when plants have reserve supplies of water; two such plants were identified in the outreach to power plants (see Additional Plant Input on Shutdown Conditions Section for additional details).

Power plant operators were also asked to describe adverse impacts associated with power plant operations below minimum intake elevation, but above the shut down intake elevation. Only one utility indicated that power generation would be affected under these river stage conditions, which was included in the analysis. A few power plants indicated that variable costs would be affected when river stages are below shut down intake elevations (see Section 2.5.6 for additional details).

Adverse Effects Associated with River Flows Thresholds

Due to a dynamic channel in the Bismarck reach and the river flow/river stage relationship built into the HEC-RAS model, one power plant representative indicated that river flow levels would provide a better indicator for simulating potential effects to their plant.

Additional Plant Input on Shut Down Conditions

Input was also obtained from two plants with reserve supplies of water. One power plant has a reserve of water that would allow it to continue to operate for approximately two weeks with the Missouri River intake shut down. However, these reserves would take about 10 days to replenish once the intake was able to access the water. Because the number of days shut down is dependent on the consecutive nature of the days, an assessment was undertaken using HEC-RAS daily stage data for the alternatives to evaluate when the plant would be affected.

Similar to the aforementioned plant, another intake pumps water to a lake and a separator impoundment. The lake and separator impoundment provide approximately 25 days of water supply. A similar evaluation was undertaken on the consecutive days below the shut down intake elevation, along with input from the utility on the evaporation and refill factors, to assess when the plant and the conversion station would be affected. A conversion facility is affected when the Missouri River intake is shut down and cannot transmit production tax credits (wind energy) during the summer.

In addition, one of the intakes in the Bismarck reach provides water to an electricity conversion station, which is affected when river stages fall below shut down intake elevations in the summer. Under these conditions, the conversion facility would result in a 50 percent loss of energy generation and transmission, or approximately 6,600 Megawatt hour (MWH) per day.

2.5.3 Estimate Power Generation

The evaluation of river conditions described under section 2.4 was used along with the average daily seasonal generation described in section 2.5.1 and the information obtained from power plants in section 2.5.2 to estimate power generation over the period of record. An Excel®-based model was used to estimate the seasonal, yearly estimates of power generation over the 82-year period of analysis.

2.5.4 Estimate Energy Benefits

In general energy benefits are calculated as the product of energy generation and the appropriate energy price in terms of $/MWH. Energy benefits are also called energy values. The approach to estimate the power generation was described in Sections 2.4, 2.5.1, 2.5.2 and 2.5.3. The energy prices used are based on the cost of energy from a combination of generation plants that would replace the lost energy from the thermal plants.

The energy price was based on the cost to purchase electricity in the market. Energy values for the Missouri River were estimated by the Hydropower Analysis Center using locational marginal pricing (LMP) from the Western Area Power Administration hub of both the Midwest Independent System Operator (MISO) Regional Transmission Organization (RTO) and the Southwest Power Pool (SPP). LMP is a computational technique that determines a shadow price for an additional MWh of demand.

Power plants along the Missouri River are members of the MISO and SPP RTOs. The MISO and SPP energy prices were used for the member plants in the analysis.

The energy prices represent the full cost of the replacement energy, and they are inclusive of any variable costs associated with changes in power generation. The energy prices include "blocks" based on peak and non-peak times, and vary by month as well as weekends and weekdays. Because the thermal power plants are generally base load plants, an average price by month for weekday and weekend was estimated and used in the evaluation. A seasonal energy value (spring, summer, fall, and winter) was estimated from the monthly and weekend/weekend energy prices; months with similar energy values were combined to estimate the seasonal values. The seasonal energy prices (2020 present value of forecasted values) were estimated by weighing the number of the weekend days and weekdays in the relevant season. The peak seasons of summer (July and August) and winter (January and February) reflect higher values than other months of the year. The seasons were defined as follows:

- Winter: January and February
- Spring: March through June
- Summer: July and August
- Fall: September through December

The energy prices used in the analysis are shown in Table 2.

Table 2. MISO and SPP Energy Prices, 2020$

Season	MISO Weighted Seasonal Energy Price ($/MWH)	SPP Weighted Seasonal Energy Price ($/MWH)
Summer	$20.06	$19.87
Fall	$18.02	$16.34
Winter	$19.28	$17.71
Spring	$16.49	$16.91

Source: Hydropower Analysis Center, 2019

The energy prices were applied to the estimated power generation under the various conditions for each power plant, for each year and season, and for each alternative to estimate energy values and replacement costs for changes in energy generation.

2.5.5 Estimate Capacity Values

Capacity values represent the cost to construct and operate a new power plant or a major investment to replace lost capacity. Capacity values are relevant when a new plant needs to be constructed or large capital investment needs to be made. Capacity values should be applied when an investment is needed to replace lost capacity with a new source. The potential need to replace capacity is estimated through an evaluation of the long-term effects of the alternative on the power plant and its estimated reduced power generation, especially during peak periods when all capacity is being used. The approach to estimate the capacity values through a dependable capacity approach is provided in the following subsections.

Estimate Dependable Capacity

The dependable capacity of a thermal power plant or unit is a measure of the amount of capacity that the unit or power plant can reliably contribute towards meeting system peak power demands. Dependable capacity can be computed in several ways. The method that is appropriate for evaluating the dependable capacity of a predominantly thermal-based power system such as the Missouri River Basin is the specified availability method, which is described in Section 6 of Engineer Manual (EM) 1110-2-1701, Hydropower Engineering and Design (USACE 1985). The following steps were used to model dependable capacity.

1. Estimate the amount of power generation that would occur in the peak seasons (winter and summer) by power plant in each year.

2. Estimate the number of hours within each season, which is the number of days in the season multiplied by 24 hours/day.

3. Estimate the capacity for each year, peak season, and plant: divide the amount of power generated in the peak seasons (step 1) by the total number of hours in the season (step 2).

4. Estimate the dependable capacity: Based on discussions with the Hydropower Analysis Center and guidance in the Hydropower EM 1110-2-1701, the 15th percentile (85th percent exceedance) of the annual peak season capacity estimates for each power plant was estimated to represent dependable capacity. This represents the amount of capacity that a plant can reliably contribute to meeting peak season needs (pers. comm. Hydropower Analysis Center 2015; USACE 1985).

Estimate Unit Capacity Values

Capacity values represent the cost to construct and operate a new power facility or major investment to replace lost capacity. Capacity values are reported as a dollar amount per kilowatt (KW) or megawatt (MW) per year and include fixed plant costs and variable operating costs. The unit capacity value is applied to the dependable capacity to estimate the capacity values under each alternative for each plant and each peak season.

The unit capacity values are based on a FERC spreadsheet model that estimates annual regional capacity values for different generating resources (Hydropower Analysis Center, 2019). The capacity values for the Midwest Reliability Council -- West (MROW) electricity market module as defined by the EIA are:

- Coal $334.73 per KW-year
- Combined cycle $139.86 per KW-year
- Combustion turbine $119.04 per KW-year

Because a combined cycle gas-fired thermal plant would most likely replace a coal or nuclear-fired plant (Hydropower Analysis Center, pers. comm. 2018), the capacity value that was used for this analysis is $139.86/KW-year. For consistency with the dependable capacity unit (MW), the capacity value was multiplied by 1,000 to provide a unit capacity value of $139,860 per MW-year in 2019 dollars. Capacity values do not include decommissioning costs if a plant or a unit would need to be retired or decommissioned. Therefore, these capacity values (i.e., capital cost estimates) reflect low estimates of the possible capital costs to replace the capacity under the alternatives.

Estimate Capacity Values

The unit capacity value of $139,860 was applied to the dependable capacity (15th percentile of the capacity in each year for each peak season). The focus of the capacity value impacts was on the change in capacity (replacement capacity costs) under the action alternatives compared to No Action. The capacity values were assessed for summer and winter to account for both peak periods of electricity demand. If there was no change in capacity relative to No Action, the change in capacity value would be zero.

The final step in the process was to choose the larger of the two changes in capacity values (from No Action) for summer and winter for each power plant under each action alternative, which represents the worst-case requirement to replace capacity. The change in capacity value represents an annualized capital cost (or decrease in capital cost), and therefore the capacity value is applied to each year to estimate the capital cost impacts (fixed and variable costs) to replace lost capacity under the FPDTR-EIS alternatives.

2.5.6 Estimate Variable Costs

The power plant representatives were asked how river conditions, specifically river stage and flows, could affect their operations, other than power generation, and to specify the associated variable costs. Any costs incurred when power generation was also being reduced were assumed to be captured within the energy values analysis because energy values reflect the full replacement cost of the power to be purchased in the market. Two power plant operators located in the Garrison reach were able to specify increased variable costs incurred during periods when river stages were between minimum and shut down intake elevations when the power plants were not reducing their power generation.

In addition, one of the intakes in the Bismarck reach provides water to an electricity conversion station, which is affected when river stages fall below shut down intake elevations in the summer. Under these conditions, the conversion facility cannot transmit production tax credits (wind), resulting in lost revenue during shut down conditions during the summer months. These impacts were estimated as increased variable costs in the NED evaluation.

2.6 Regional Economic Development

The RED analysis used the estimated changes in power generation in the evaluation along with power generation information from the Regional Transmission Organizations (RTO) to assess the context of the changes in power generation on wholesale electricity prices and how changes to those prices could impact consumer electricity rates that are set by retail electricity providers. The RED analysis used power generation information from the SPP and MISO Regional Transmission Organizations (RTOs). Any changes in retail electricity rates could impact household and business spending, with implications for jobs and income in regional economies. If consumers must spend more of their income on higher electricity rates, they would have less disposable income to spend on other goods and services, which could adversely impact jobs and income in affected industries. The RED analysis considered the overall percentage of the RTO generation that would be impacted between the lowest and highest generation seasons under No Action and the difference in the power generation relative to No Action.

Power generation from the MISO 2013 Annual Market Assessment Report and the SPP 2014 State of the Market Report were obtained to better understand the level of generation and relative importance of the reductions in power generation in each of the RTO markets from Missouri River plants during peak seasons (MISO 2014; MISO 2016; SPP 2015; SPP 2016). The average power generation during these two years for each RTO is presented seasonally in the analysis (Tables 3 and 4). The analysis considers the variation in power generation under No Action, the largest adverse difference in power generation during peak seasons between the action alternatives and No Action, and the percent of the RTO generation affected over the 82-year period. The RED evaluation used the RTO average season power generation to qualitatively assess potential impacts to wholesale electricity prices, consumer electricity rates, and regional economic conditions. Tables 3 and 4 summarize the total generation in megawatt hours (MWh) by month within each RTO.

Table 3. Annual Generation within SPP by Month (Monthly Average 2014-2015)

Month	Total SPP Gen (MWh)
1	20,674,110
2	18,739,453
3	18,332,751
4	16,364,566
5	17,476,396
6	20,568,204
7	23,198,268
8	23,251,014
9	19,782,663
10	18,162,332
11	18,502,615
12	20,054,707

Source: SPP 2015; SPP 2016

Table 4. Total Generation within MISO by Month (Monthly Average 2013-2014)

Month	Total MISO Generation (MWh)
1	51,691,786
2	45,020,612
3	45,675,629
4	40,455,915
5	42,552,243
6	45,990,174
7	49,928,354
8	51,024,159
9	43,827,539
10	42,308,793
11	44,092,782
12	50,577,387

Source: MISO 2014; MISO 2016

2.7 Other Social Effects

The OSE account includes measures to evaluate air emissions associated with power generation under the alternatives. The power plants included in this evaluation include only coal-fired power plants. Because there is so little change in power generation under Alternatives 1 and 2 and the variations compared to No Action, changes in air emissions were not quantified but are described qualitatively with emissions information from the EPA on power plant-specific and market replacement emissions factors (EPA 2018) and on the social cost of carbon (EPA 2016). When compared to other sources of power in the market, coal-fired power plants generate higher air emissions and greenhouse gas emissions than renewable, hydropower, natural gas, and nuclear sources of energy. Increases in air emissions would result in adverse environmental impacts, while decreases in air emissions would result in environmental benefits. It is assumed that changes in thermal power generation under the FPDTC-EIS alternatives would be replaced with power generation from the market. The changes in the fuel source mix is likely to affect air emissions. Different regions have different electricity-generating resource (fuel) mixes, resulting in varying emissions factors for replacement power generation (EPA 2016).

3.0 Environmental Consequences Results

3.1 Summary of Environmental Consequences

In general, the FPDTR alternatives are expected to have short- and long-term negligible impacts to thermal power plants in the upper river because river stage and flows under the FPDTR alternatives would change only slightly compared to No Action. The environmental consequences relative to thermal power are summarized in Table 5.

Table 5. Environmental Consequences Relative to Thermal Power

Alternative	NED Impacts	RED Impacts	OSE Impacts
No Action	Average Annual NED Value: $505,100,000. Range of Annual NED Values: $458,700,000 to $510,500,000). Power generation from the upper Missouri River power plants would continue to provide large and long-term thermal power NED benefits. Small and temporary adverse impacts in some years would occur from the variability in hydrology and change in hydrologic conditions over the POR.	Thermal power plants in the upper river would continue to provide low-cost electricity, supporting relatively lower rates, with benefits to household and business spending. There would be negligible to small adverse effects to RED associated with reduced power generation during drought and drier conditions.	The upper Missouri River power plants would continue to contribute to greenhouse gas and other air emissions associated with power generation, with long-term adverse OSE impacts.
Alternative 1	Change in Average Annual NED Value: +$221,000 or 0.04%. Negligible changes in thermal power NED values from slight changes in river flows and stages associated with the Fort Peck Dam test flows.	Negligible change in RED impacts.	Negligible change in OSE impacts.

Variation 1A	Change in Average Annual NED Value: +$115,000 or 0.02%. Negligible changes in thermal power NED values from slight changes in river flows and stages associated with the Fort Peck Dam test flows.	Negligible change in RED impacts.	Negligible change in OSE impacts.
Variation 1B	Change in Average Annual NED Value: -$41,000 or -0.01%. Negligible changes in thermal power NED values from slight changes in river flows and stages associated with the Fort Peck Dam test flows.	Negligible change in RED impacts.	Negligible change in OSE impacts.
Alternative 2	Change in Average Annual NED Value: +$20,000 or 0.0%. Negligible changes in thermal power NED values from slight changes in river flows and stages associated with the Fort Peck Dam test flows.	Negligible change in RED impacts.	Negligible change in OSE impacts.
Variation 2A	Change in Average Annual NED Value: +$68,000 or 0.01%. Negligible changes in thermal power NED values from slight changes in river flows and stages associated with the Fort Peck Dam test flows.	Negligible change in RED impacts.	Negligible change in OSE impacts.
Variation 2B	Change in Average Annual NED Value: +$70,000 or 0.01%. Negligible changes in thermal power NED values from slight changes in river flows and stages associated with the Fort Peck Dam test flows.	Negligible change in RED impacts.	Negligible change in OSE impacts.

* Fiscal year 2020 prices

3.2 No Action

Under the No Action alternative, operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. As noted above, it is considered the baseline against which the other alternatives are measured. System operations under No Action would be consistent with current operations. However, as described in Section 3.1, Introduction, the impacts modeled do not account for the ability of water management to adapt to changing conditions on the System to serve authorized purposes, such as water supply for thermal power plants. It also does not account for what activities may be implemented in the future relative to bed degradation which may be influencing model results. This is because the 2012 river geometry used in HEC-RAS modeling reflects a level of bed degradation that was not present in prior years included in the POR analysis. These impacts are discussed in more detail in Section 3.2, River Infrastructure and Hydrologic Processes.

Consistent water supply for thermal power plants requires intakes to be submerged in the water at all times and but not be buried by sediment deposits. Thermal power intakes are thus affected from the variability in hydrology and change in hydrologic conditions over the POR as well as aggradation and degradation processes (see Section 3.2 “River Infrastructure and Hydrologic Processes”). The POR is characterized by substantial variability in hydrologic conditions which includes periods of drought (i.e., 1930s, mid-1990s, and 2000s) and high runoff. This variation results in variability in impacts to thermal power plants which can be adverse or beneficial depending on the conditions at the site of the intake.

Modeling results for the No Action indicate that thermal power intakes, if they were to remain at existing elevations, would experience adverse impacts under drought and relatively drier conditions with continuation of current System operations. These impacts would be due to instances when water surface elevations fall below critical shut down operating thresholds. Two power plants experience no days below shut down intake elevations under No Action. The remaining four power plants on average experience between 3 and 19 days per year when water surface elevations fall below critical shut down operating thresholds over the 82-year period of analysis.

National Economic Development

Management of the Missouri River system under No Action would result in an annual average generation of 28.2 million MWH for the power plants in the upper river, equivalent to $505 million in energy values over the 82-year period of record. Power generation would vary over the period of record, with drier and drought periods (1930s, mid-1990s and 2000s) reducing water surface elevations below intake elevations, affecting power generation. Typical power generation is about 28.5 million MWH, which occurs in most of the years over the period of record (Figure 2). During the drought periods, power generation can reach approximately 26 million MWH, a reduction of up to 2.5 million MWH compared to typical power generation years.

Capacity values are defined as the amount of capacity that a power plant can reliably contribute to meeting peak season needs (USACE EM 1110-2-1701). The total value of dependable capacity in the summer would be $427 million (3,053 MW) and $415 million in the winter (2,970 MW) for all power plants in the upper river. Average annual variable costs would be small under No Action, averaging $217,000 annually over the period of record. The NED analysis for No Action is summarized in Table 6, and the annual power generation and NED values under No Action are presented in Figures 2 and 3.

Table 6. Summary of Thermal Power NED Values for No Action, 1931-2012 (2020$)

NED Values	Upper River[a]
Average Annual Missouri River Power Generation (MWh)	28,245,000
Average Annual Energy Values	$505,360,000
Average Annual Dependable Capacity -- Summer (MW)	3,053
Average Annual Dependable Capacity Value – Summer	$426,993,000
Average Annual Dependable Capacity – Winter (MW)[a]	2,971
Average Annual Dependable Capacity Value – Winter	$415,384,000

Average Annual Variable Costs[b]	-$217,100
Average Annual NED Values[c]	$505,143,000

Notes:

a Capacity values are estimated by multiplying the15th percentile of the available seasonal capacity during the summer and winter peak seasons from 1931 to 2012 by the unit capacity value. Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $139,860 /MW-year (Hydropower Analysis Center 2019).

b Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

c NED values for No Action do not include capacity values because there are no capacity impacts under Alternatives 1 and 2, compared to No Action. NED values include the energy values less the variable costs.

Figure 2: Annual Power Generation Between 1931 and 2012 under No Action

Figure 3: Thermal Power NED Values Between 1931 and 2012 under No Action (2020$)

Regional Economic Development

Under No Action, there would be varying impacts to power generation, with some of the lower power generation years occurring in the 1930s, early 1990s, and mid-2000s, when drought conditions would reduce river flows and water surface elevations. In the worst-case years (as modeled in 1937 and 1993), power generation from power plants along the upper Missouri River would be reduced by an estimated 2.9 MWh, which is approximately 10% reduction from power generation with no adverse conditions (28.5 million MWh). This reduction in power generation represents less than a 1 percent decrease of SPP and MISO annual power generation (see Tables 3 and 4).

In some years during drought conditions, it is possible that seasonal reductions in power generation from multiple plants could occur during one period of time during peak power demand seasons, when replacement power from MISO, SPP or other markets may be scarce. If these conditions occur repeatedly, there could be the rationale for retail electricity providers to increase consumer electricity rates compared to current rates because of the higher prices to purchase the wholesale electricity. However, as modeled, the power reductions from drought and relatively drier conditions would be temporary and would likely represent negligible to small impacts on wholesale power prices, with negligible impacts to electricity rates and household and business spending.

Other Social Effects

In general, the coal-fired power plants emit more per unit carbon dioxide and nitrous oxide emissions than the average replacement power sources from the market. Plant-specific methane emission sources have both higher and lower emissions from the power plant when compared with the average replacement power sources from the market. Under No Action, during drought and relatively drier conditions, replacement power from the MROW West would have fewer nitrous oxide and carbon dioxide air emissions than during power generation with no adverse conditions, while methane emissions would be both higher and lower when the power generation is replaced with market fuel sources.

3.3 Alternative 1

System operations under Alternative 1 are based on those described under the No Action alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon.

An Attraction Flow Regime would begin on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in a given year. The Spawning Cue Flow Regime under Alternative 1 begins on May 28 and would be 3.5 times the Fort Peck Dam spring flow release in the given release year. A further description of Alternative 1 is detailed in Chapter 2, Section 2.5 Alternatives Carried Forward for Detailed Evaluation.

National Economic Development

Alternative 1 would result in an average annual increase in thermal power NED values compared to No Action of $221,000 for the upper Missouri River power plants. On average, variable costs for power plants in the upper river under Alternative 1 would be slightly lower than the costs incurred under No Action and energy values would be slightly higher compared to No Action. Table 7 summarizes the thermal power NED values. There are no changes in capacity under Alternative 1 compared to No Action.

Table 7. Summary of Thermal Power NED Values for Alternative 1, 1931-2012 (2020$)

NED Values	Upper River
Average Annual Missouri River Power Generation (MWh)	28,253,000
Change in Average Annual Generation from No Action (MWh)	+8,705
Average Annual Energy Values	$505,519,000
Change in Average Annual Energy Values from No Action	+$159,000
Percent Change in Average Energy Values from No Action	+0.03%
Average Annual Dependable Capacity -- Summer (MW)	No Change from No Action
Average Annual Dependable Capacity – Winter (MW)	No Change from No Action
Average Annual Variable Costs[a]	-$155,000
Change in Average Annual Variable Costs from No Action	+$62,000
Average Annual NED Values	$505,364,000
Change in Average Annual NED Values from No Action[c]	+$221,000
Percent Change in Average Annual NED Values	+0.04%

Notes:

a The table reflects power generation, energy values, and variables costs associated with five power plants and one electricity conversion station. The Montana Dakota Utilities Coyote Plant would not be affected by changes in water surface elevations under the FPDTR-EIS alternatives and is not included in the evaluation.

b Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

c. Calculated by adding Change in Average Annual Energy Values from No Action + Change in Average Annual Variable Costs from No Action.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figure 3 illustrates the annual thermal power NED values for all power plants in the

Upper Missouri River. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Over the period of record, there are negligible changes in annual thermal power NED values in most years. However, in the simulated years of 1983 and 1986, when a simulated full and partial release would occur, there would be beneficial impacts relative to No Action. Higher releases from Garrison Dam in the summer and early fall would occur as a result of the Fort Peck flow releases; during July, August, and September, the releases from Garrison Dam would be higher under Alternative 1 compared to No Action, which would increase river flows and stages in the Garrison reach. With fewer days below shut down intake elevations for two power plants and one conversion station, there are increase in power generation and energy values under Alternative 1 compared to No Action.

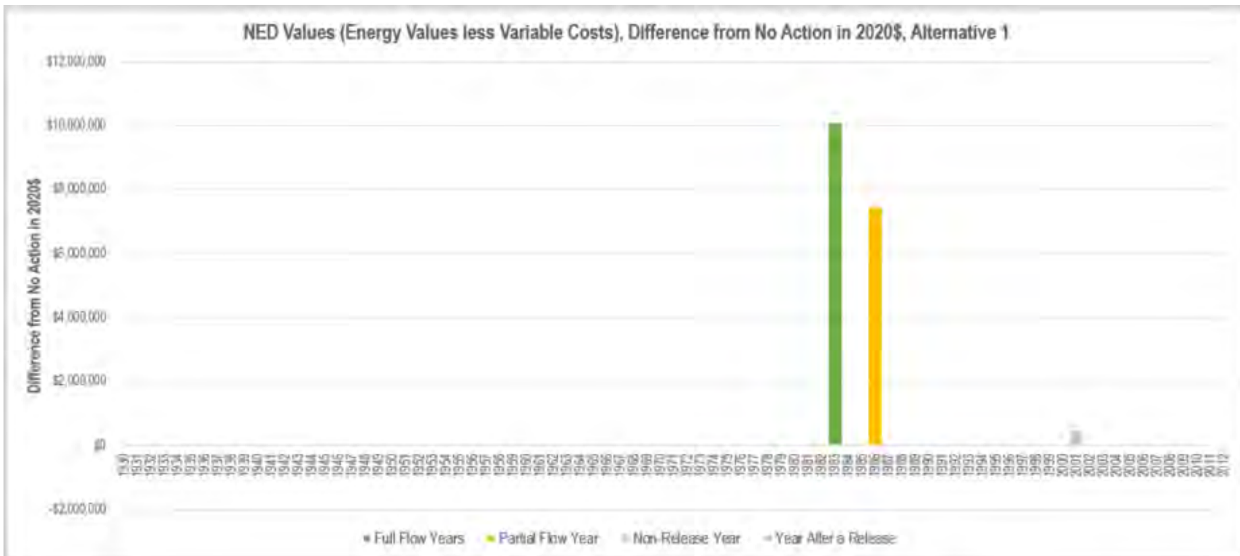

Figure 4. Alternative 1 Change in Thermal Power NED Values from No Action

Regional Economic Development

Impacts to power generation during peak seasons would be very similar to those described under No Action, with drier and hotter periods potentially impacting consumer electricity rates associated with higher wholesale electricity prices. Alternative 1 would not contribute to these impacts. There would be a negligible change in the impacts to consumer electricity rates and household spending and associated regional economic conditions compared to No Action.

Other Social Effects

Under Alternative 1, the changes in power generation compared to No Action would be negligible, with negligible changes in air emissions and the social cost of carbon.

3.3.1 Alternative 1 – 1A Variation

Variation 1A is a test flow variation of Alternative 1. The parameters for 1A are the same as described for Alternative 1 except that the Attraction Flow is initiated on April 9, rather than April

16, and the Spawning Cue Flow Regime is initiated on May 21, rather than May 28. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases.

National Economic Development

Variant 1A would result in an average annual increase in thermal power NED values compared to No Action of $115,000 or 0.02 percent for the upper Missouri River power plants. On average, variable costs for power plants in the upper river under Variation 1A, would be slightly lower than the costs incurred under No Action, and energy values would be slightly higher compared to No Action (an increase in $104,000). There are no changes in capacity under Variation 1A compared to No Action. Table 9 summarizes the thermal power NED values under Variation 1A.

Table 9. Summary of Thermal Power NED Values for Variation 1A, 1931-2012 (2020$)

NED Values	Upper River
Average Annual Missouri River Power Generation (MWh)	28,250,000
Change in Average Annual Generation from No Action (MWh)	+5,700
Average Annual Energy Values	$505,464,000
Change in Average Annual Energy Values from No Action	+$104,000
Percent Change in Average Energy Values from No Action	+0.02%
Average Annual Dependable Capacity -- Summer (MW)	No Change from No Action
Average Annual Dependable Capacity – Winter (MW)	No Change from No Action
Average Annual Variable Costs[a]	-$206,000
Change in Average Annual Variable Costs from No Action	+$11,000
Average Annual NED Values	$505,258,000
Change in Average Annual NED Values from No Action[c]	+$115,000
Percent Change in Average Annual NED Values	+0.02%

Notes:

a The table reflects power generation, energy values, and variables costs associated with five power plants and one electricity conversion station. The Montana Dakota Utilities Coyote Plant would not be affected by changes in water surface elevations under the FPDTR-EIS alternatives and is not included in the evaluation.

b Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

c. Calculated by adding Change in Average Annual Energy Values from No Action + Change in Average Annual Variable Costs from No Action.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figure 4 illustrates the annual thermal power NED values for all power plants in the Upper Missouri River. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Over the period of record, there are negligible changes in annual thermal power NED values in most years. However, in the simulated years of 1983 and 1986, when a simulated full release would occur, there would be beneficial impacts relative to No Action. Higher releases from Garrison Dam in the summer and early fall as simulated in 1986 would occur as a result of the Fort Peck flow releases; during July, August, and September, the releases from Garrison Dam would be higher under Variation 1A compared to No Action, which would increase river flows and stages in the Garrison reach. With fewer days below shut down intake elevations, there are increases in power generation and energy values for two power plants and one conversion station under Variation 1A compared to No Action. In 1983 as simulated, only one conversion station would be beneficially impacted (higher power generation) by higher river stages at the intake location when compared to No Action associated with the full flow release at Fort Peck Dam. These changes are less than a percent change in compared to No Action in these years.

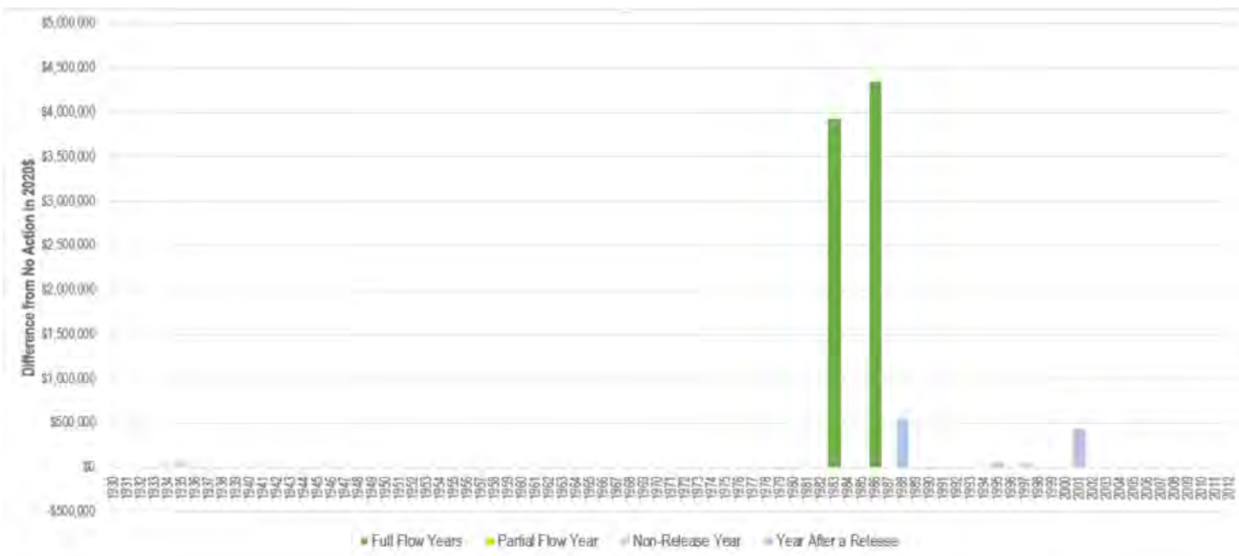

Figure 5. Variation 1A Change in Thermal Power NED Values from No Action

Regional Economic Development

Impacts to power generation during peak seasons would be very similar to those described under No Action and Alternative 1, with drier and hotter periods potentially impacting consumer electricity rates associated with higher wholesale electricity prices. Variation 1A would not contribute to these impacts. There would be a negligible change in the impacts to consumer electricity rates and household spending and associated regional economic conditions compared to No Action.

Other Social Effects

Under Variation 1A, the changes in power generation compared to No Action would be negligible, with negligible changes in air emissions and the social cost of carbon compared to No Action.

3.3.2 Alternative 1 – 1B Variation

Variation 1B is another test flow variation of Alternative 1. The parameters for 1B are the same as described for Alternative 1 except that the Attraction Flow is initiated on April 23 and the Spawning Cue Flow is initiated on June 4. Similar to the concept described in Variation 1A, the later initiation date is intended to provide a contrast to explore any differences in forecasted impacts from a later flow initiation date.

National Economic Development

Variation 1B would result in a slight decrease in average annual thermal power NED values of $41,000 compared to No Action for the upper Missouri River power plants. On average, variable costs for power plants in the upper river under Variation 1B would be slightly lower ($2,800) than the costs incurred under No Action, and energy values would be slightly lower (-$44,000) compared to No Action. There are no changes in capacity under Variation 1B compared to No Action. Table 10 summarizes the thermal power NED values.

Table 10. Summary of Thermal Power NED Values for Variation 1B, 1931-2012 (2020$)

NED Values	Upper River
Average Annual Missouri River Power Generation (MWh)	28,242,000
Change in Average Annual Generation from No Action (MWh)	-2,900
Average Annual Energy Values	$505,316,000
Change in Average Annual Energy Values from No Action	-$44,000
Percent Change in Average Energy Values from No Action	-0.01%
Average Annual Dependable Capacity -- Summer (MW)	No Change from No Action
Average Annual Dependable Capacity – Winter (MW)	No Change from No Action
Average Annual Variable Costs[a]	-$214,000
Change in Average Annual Variable Costs from No Action	+$2,800
Average Annual NED Values	$505,102,000
Change in Average Annual NED Values from No Action[c]	-$41,000
Percent Change in Average Annual NED Values	-0.01%

Notes:

a The table reflects power generation, energy values, and variables costs associated with five power plants and one electricity conversion station. The Montana Dakota Utilities Coyote Plant would not be affected by changes in water surface elevations under the FPDTR-EIS alternatives and is not included in the evaluation.

b Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

c. Calculated by adding Change in Average Annual Energy Values from No Action + Change in Average Annual Variable Costs from No Action.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figure 5 illustrates the annual thermal power NED values for all power plants in the Upper Missouri River. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Over the period of record, there are negligible changes in annual thermal power NED values in most years. In 1983, when partial releases would be simulated to occur, there would be increases in power generation, energy values, and thermal power NED values impacts compared to No Action. Higher releases from Garrison Dam in the summer and early fall as simulated in 1983 would occur as a result of the Fort Peck flow releases; during July, August, and September, the releases from Garrison Dam would be higher under Variation 1B compared to No Action, which would increase river flows and stages in the Garrison reach. With fewer days below shut down thresholds for one power plant and one conversion station, there would be a very small increase in power generation and energy values under Variation 1B compared to No Action.

In 1986, as simulated, there would be a partial release from Fort Peck Dam in early June, followed by lower releases in July compared to No Action, which results in lower releases from Garrison Dam as the system rebalances. As a result, lower river flows and stages in the Garrison reach under Variation 1B compared to No Action would result in decreases in thermal power NED values for one power plant and an electricity conversion station; the decreases in NED values compared to No Action for all power plants (and the conversion station) are estimated to be $6.6 million or 1.3 percent decrease compared to NED values under No Action as simulated in 1986.

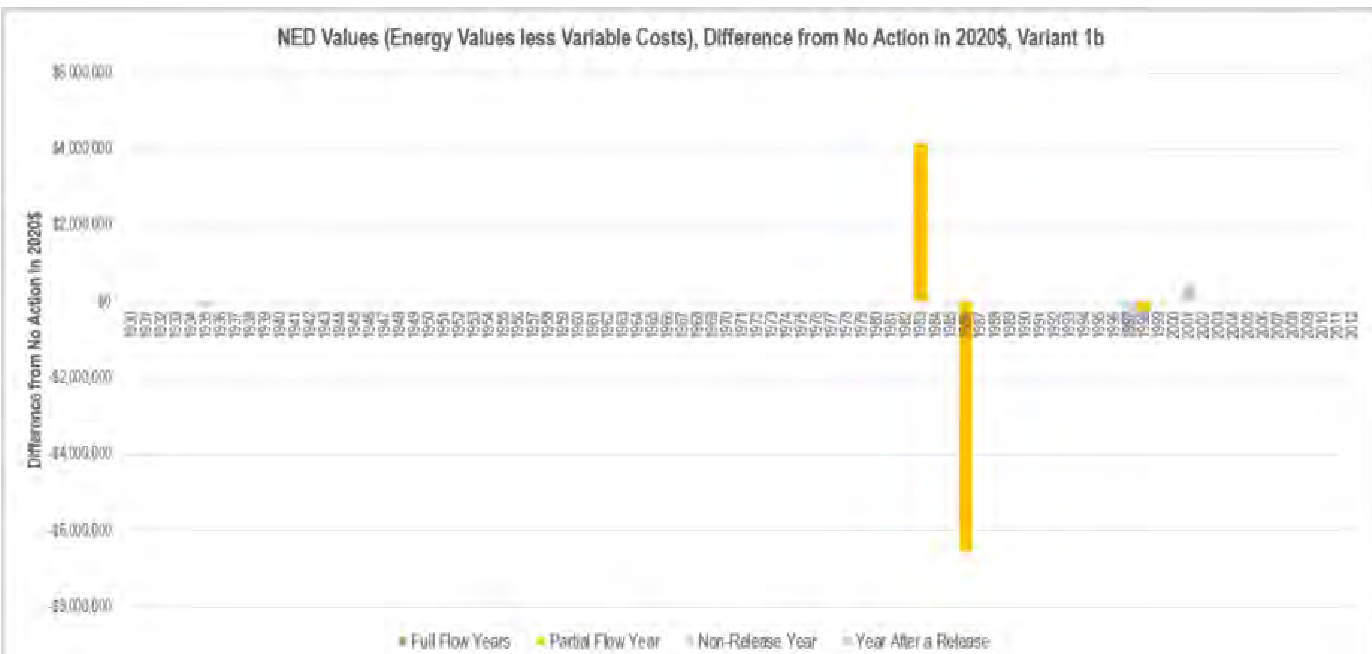

Figure 6. Variation 1B Change in Thermal Power NED Values from No Action

Regional Economic Development

Impacts to power generation during peak seasons would be very similar to those described under No Action, with drier and hotter periods potentially impacting consumer electricity rates associated with higher wholesale electricity prices. Variation 1B would not contribute to these impacts. There would be a negligible change in the impacts to consumer electricity rates and household spending and associated regional economic conditions compared to No Action.

Other Social Effects

Under Variation 1B, the changes in power generation compared to No Action would be negligible, with negligible changes in air emissions and the social cost of carbon.

3.3.3 Conclusions – Alternative 1 including Variants 1A and 1B

Under Alternative 1, including variations 1A and 1B, there would be negligible changes in power generation, energy values, variable costs, and thermal power NED values compared to No Action. Changes in river flows and stages, including during full and partial release years, would result in slight increases (Alternative 1 and Variation 1A) and slight decreases (Variation 1B) in average annual NED values (Table 11). In years over the period of record when a partial or full flow release would be simulated, the percentage change in NED values would range from -0.01% to +0.11% (Table 11).

Variations 1 and 1A would result in very small increases in power generation and NED values compared to No Action in two years from higher releases from Garrison Dam increasing flows and stages in the Garrison reach, with benefits to some power plants. In one year over the period of record under Variation 1B, a partial release from Fort Peck Dam would decrease releases from Garrison Dam, reducing river stages compared to No Action, with adverse effects to power generation to one power plant and a conversion station. Table 11 provides a summary of the NED impacts for Alternative 1 including variations 1A and 1B in all years and in years when a partial or full flow release would be simulated to occur.

Table 11. Summary of National Economic Development Analysis for Alternative 1

NED Values	Alternative 1	Variation 1A	Variation 1B	Range across all Variations
All Years over the Period of Analysis				
Annual Average NED Value**	$505,364,000	$505,258,000	$505,102,000	$262,000
Difference in Annual Average NED Value from No Action	+$221,000	+$115,000	-$41,000	$263,000
Percentage Difference from No Action	+0.04%	+0.02%	-0.01%	0.05%
Full or Partial Release Years over the Period of Analysis				
Annual Average NED Value**	$508,511,000	$508,165,000	$508,232,000	$346,000
Difference in Annual Average NED Value from No Action	+$565,000	+$301,000	-$60,000	$625,000
Percentage Difference from No Action	+0.11%	+0.06%	-0.01%	0.12%

* Fiscal year 2020 prices.

** NED Value = Energy Value Less Variable Costs

3.4 Alternative 2

The parameters for Alternative 2 are the same as described for Alternative 1 except that the Attraction Flow Regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at Wolf Point gage are held at 14,000 cfs until the Spawning Cue release is initiated.

National Economic Development

Alternative 2 would result in an increase in thermal power NED values compared to No Action of +$20,500 for the upper Missouri River power plants. On average, variable costs for power plants in the upper river under Alternative 2 would be slightly more than the costs incurred under No Action, and energy values would be slightly higher (+$22,000) compared to No Action. There are no changes in capacity under Alternative 2 compared to No Action. Table 12 summarizes the thermal power NED values.

Table 12. Summary of Thermal Power NED Values for Alternative 2, 1931-2012 (2020$)

NED Values	Upper River
Average Annual Missouri River Power Generation (MWh)	28,246,000
Change in Average Annual Generation from No Action (MWh)	+1,500
Average Annual Energy Values	$505,382,000
Change in Average Annual Energy Values from No Action	+$22,000
Percent Change in Average Energy Values from No Action	0.00%
Average Annual Dependable Capacity -- Summer (MW)	No Change from No Action
Average Annual Dependable Capacity – Winter (MW)	No Change from No Action
Average Annual Variable Costs[a]	-$218,000
Change in Average Annual Variable Costs from No Action	-$1,100
Average Annual NED Values	$505,163,000
Change in Average Annual NED Values from No Action[c]	+$20,500
Percent Change in Average Annual NED Values	0.00%

Notes:

a The table reflects power generation, energy values, and variables costs associated with five power plants and one electricity conversion station. The Montana Dakota Utilities Coyote Plant would not be affected by changes in water surface elevations under the FPDTR-EIS alternatives and is not included in the evaluation.

b Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

c. Calculated by adding Change in Average Annual Energy Values from No Action + Change in Average Annual Variable Costs from No Action.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figure 6 illustrates the annual thermal power NED values for all power plants in the Upper Missouri River. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Over the period of record, there are negligible changes in annual thermal power NED values in most years. There are two years with notable changes in power generation and thermal power NED values, in the simulated years of 1986 and 2005. In 1986 as simulated, a full release from Fort Peck Dam would occur, which would result in higher releases from Garrison Dam in the summer and early fall; during July, August, and September, the releases from Garrison Dam would be higher under Alternative 2 compared to No Action, which would increase river flows and stages in the Garrison reach. With fewer days below shut down intake elevations for two power plants, there are increase in power generation and energy values under Alternative 2 compared to No Action.

In 2005, there would be decreases in thermal power NED values under Alternative 2 compared to No Action when releases from Garrison Dam would be lower under Alternative 2 by about 1,000 cfs compared to No Action. These decreased releases are likely the result of the system rebalancing after a full release in 2000. The lower releases from Garrison Dam result in more days below critical thresholds under Alternative 2 compared to No Action, with adverse impacts to two power plants during this year, resulting in a 1.2 percent decrease in NED values under Alternative 2 relative to No Action as simulated in 2005.

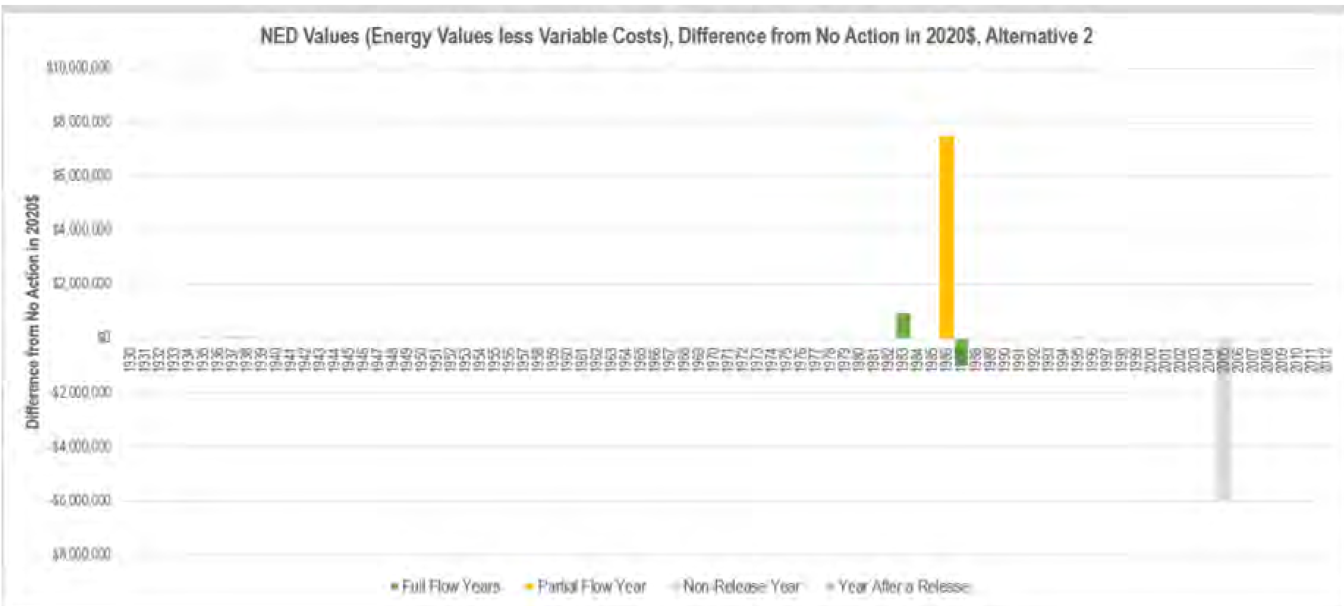

Figure 7. Alternative 2 Change in Thermal Power NED Values from No Action

Regional Economic Development

Impacts to power generation during peak seasons would be very similar to those described under No Action, with drier and hotter periods potentially impacting consumer electricity rates associated with higher wholesale electricity prices. Alternative 2 would not contribute to these impacts. There would be a negligible change in the impacts to consumer electricity rates and household spending and associated regional economic conditions compared to No Action.

Other Social Effects

Under Alternative 2, the changes in power generation compared to No Action would be negligible, with negligible changes in air emissions and the social cost of carbon.

3.4.1 Alternative 2 – 2A Variation

Variation 2A is a test flow variation of Alternative 2. The parameters for Alternative 2A are the same as described for Alternative 2 except that the Attraction Flow is initiated on April 9, rather than April 16, and the Spawning Cue flow would be initiated on May 21, rather than May 28. Again, moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases.

National Economic Development

Variant 2A would result in average annual increase in thermal power NED values of $68,000 compared to No Action for the upper Missouri River power plants. On average, variable costs for power plants in the upper river under Alternative 1 would be lower (-$30,000) than the costs incurred under No Action, and energy values would be slightly higher (+$38,000) compared to No Action. There are no changes in capacity under Variation 2A compared to No Action. Table 13 summarizes the thermal power NED values.

Table 13. Summary of Thermal Power NED Values for Variation 2A, 1931-2012 (2020$)

NED Values	Upper River
Average Annual Missouri River Power Generation (MWh)	28,247,000
Change in Average Annual Generation from No Action (MWh)	+2,300
Average Annual Energy Values	$505,398,000
Change in Average Annual Energy Values from No Action	+$38,400
Percent Change in Average Energy Values from No Action	0.01%
Average Annual Dependable Capacity -- Summer (MW)	No Change from No Action
Average Annual Dependable Capacity – Winter (MW)	No Change from No Action
Average Annual Variable Costs[a]	-$187,000
Change in Average Annual Variable Costs from No Action	+$29,800
Average Annual NED Values	$505,211,000
Change in Average Annual NED Values from No Action[c]	+$68,000
Percent Change in Average Annual NED Values	+0.01%

Notes:

a The table reflects power generation, energy values, and variables costs associated with five power plants and one electricity conversion station. The Montana Dakota Utilities Coyote Plant would not be affected by changes in water surface elevations under the FPDTR-EIS alternatives and is not included in the evaluation.

b Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

c. Calculated by adding Change in Average Annual Energy Values from No Action + Change in Average Annual Variable Costs from No Action.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figure 7 illustrates the annual thermal power NED values for all power plants in the Upper Missouri River. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Similar to Alternative 2, over the period of record, there are negligible changes in annual thermal power NED values in most years. There are three years with notable changes in power generation and thermal power NED values, in the simulated years of 1983, 1986 and 2005. There are very similar effects under Variation 2A compared to Alternative 2 (1986 and 2005 effects are similar across all variations under Alternative 2), except that 1983, as simulated, under Variation 2A and 2B, would also result in higher NED values compared to No Action.

In 1983 and 1986 as simulated, full releases from Fort Peck Dam would occur, which would result in higher releases from Garrison Dam in the summer and early fall; during July, August, and September, the releases from Garrison Dam would be higher under Variation 2A compared to No Action, which would increase river flows and stages in the Garrison reach. With fewer days below shut down intake elevations, there are increases in power generation and energy values under Variation 2A compared to No Action. Two power plants and one conversion station would be affected in 1986, while in 1983, one power plant and the conversion station would be affected.

In 2005, there would be decreases in thermal power NED values under Variation 2A compared to No Action when releases from Garrison Dam would be lower under Variation 2A by about 1,000 cfs compared to No Action. These decreased releases are likely the result of the system rebalancing after a full release in 2000. The lower releases from Garrison Dam result in more days below critical thresholds under Variation 2A compared to No Action, with adverse impacts to two power plants during this year, resulting in a 1.2 percent decrease in NED values under Variation 2A relative to No Action in this year.

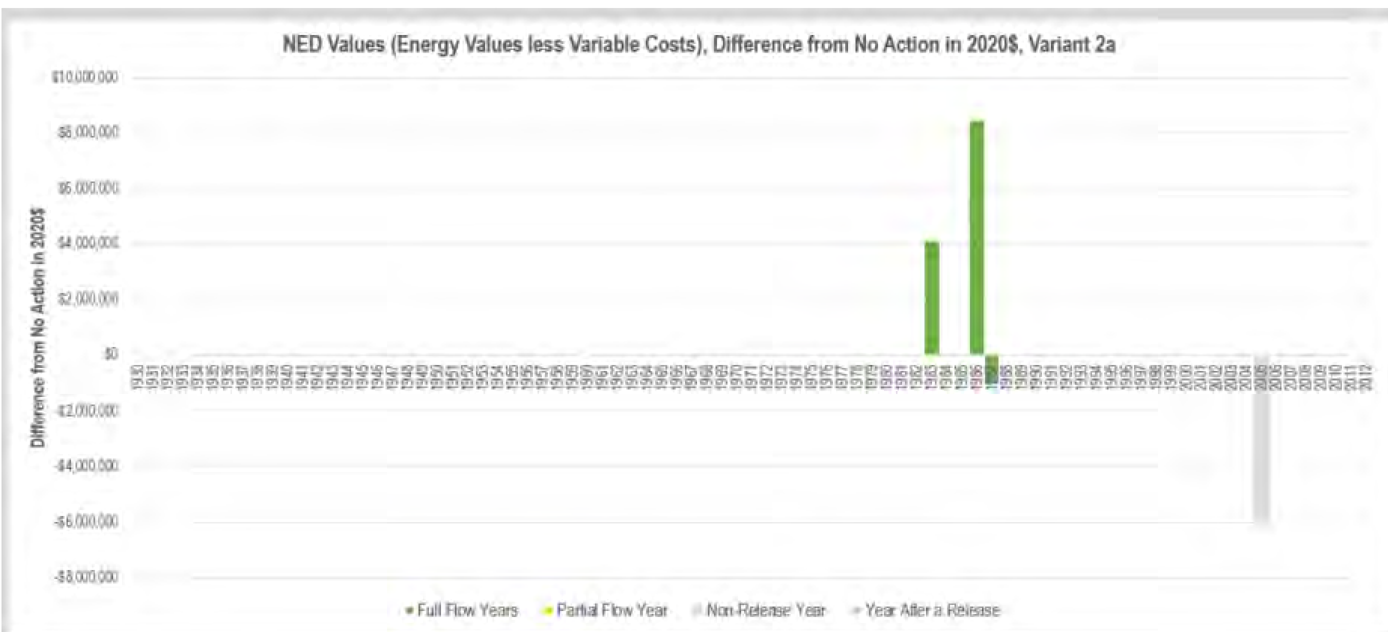

Figure 8. Variation 2A Change in Thermal Power NED Values from No Action

Regional Economic Development

Impacts to power generation during peak seasons would be very similar to those described under No Action, with drier and hotter periods potentially impacting consumer electricity rates associated with higher wholesale electricity prices. Variation 2A would not contribute to these impacts. There would be a negligible change in the impacts to consumer electricity rates and household spending and associated regional economic conditions compared to No Action.

Other Social Effects

Under Variation 2A, the changes in power generation compared to No Action would be negligible, with negligible changes in air emissions and the social cost of carbon.

3.4.2 Alternative 2 – 2B Variation

Variation 2B is another test flow variation of Alternative 2. The parameters for Alternative 2B are the same as described for Alternative 2 except that the Attraction Flow is initiated on April 23, rather than April 16, and the Spawning Cue flow is initiated on June 4, rather than May 21. Again, the difference in timing is intended to provide a contrast to explore any differences in forecasted impacts from a later flow initiation date.

National Economic Development

Variation 2B would result in average annual increase in thermal power NED values compared to No Action of $70,000 for the upper Missouri River power plants. On average, variable costs for power plants in the upper river under Variant 2B would be slightly lower ($35,000) than the costs incurred under No Action, and energy values would be slightly higher ($35,000) compared to No Action. There are no changes in capacity under Variant 2B compared to No Action. Table 14 summarizes the thermal power NED values.

Table 14. Summary of Thermal Power NED Values for Variation 2B, 1931-2012 (2020$)

NED Values	Upper River
Average Annual Missouri River Power Generation (MWh)	28,247,000
Change in Average Annual Generation from No Action (MWh)	+2,000
Average Annual Energy Values	$505,395,000
Change in Average Annual Energy Values from No Action	+$35,000
Percent Change in Average Energy Values from No Action	0.01%
Average Annual Dependable Capacity -- Summer (MW)	No Change from No Action
Average Annual Dependable Capacity – Winter (MW)	No Change from No Action
Average Annual Variable Costs[a]	-$182,000
Change in Average Annual Variable Costs from No Action	+$35,000
Average Annual NED Values	$505,213,000
Change in Average Annual NED Values from No Action[c]	+$70,000
Percent Change in Average Annual NED Values	+0.01%

Notes:

a The table reflects power generation, energy values, and variables costs associated with five power plants and one electricity conversion station. The Montana Dakota Utilities Coyote Plant would not be affected by changes in water surface elevations under the FPDTR-EIS alternatives and is not included in the evaluation.

b Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

c. Calculated by adding Change in Average Annual Energy Values from No Action + Change in Average Annual Variable Costs from No Action.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figure 8 illustrates the annual thermal power NED values for all power plants in the Upper Missouri River. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Similar to Alternative 2, over the period of record, there are negligible changes in annual thermal power NED values in most years. There are three years with notable changes in power generation and thermal power NED values, in the simulated years of 1983, 1986 and 2005. There are very similar effects under Variation 2B compared to Variation 2A, with the same years affected under both variations.

In 1983 and 1986 as simulated, full releases from Fort Peck Dam would occur, which would result in higher releases from Garrison Dam in the summer and early fall; during July, August, and September, the releases from Garrison Dam would be higher under Variation 2B compared to No Action, which would increase river flows and stages in the Garrison reach. With fewer days below shut down intake elevations, there are increases in power generation and energy values under Variation 2B compared to No Action. Two power plants and one conversion station would be affected in 1986, while in 1983, one power plant and the conversion station would be affected.

In 2005, there would be decreases in thermal power NED values under Variation 2B compared to No Action when releases from Garrison Dam would be lower under Variation 2B by about 1,000 cfs compared to No Action. These decreased releases are likely the result of the system rebalancing after a partial release in 2000. The lower releases from Garrison Dam result in more days below critical thresholds under Variation 2B compared to No Action, with adverse impacts to two power plants during this year, resulting in a 1.2 percent decrease in NED values under Variation 2B relative to No Action as simulated in 2005.

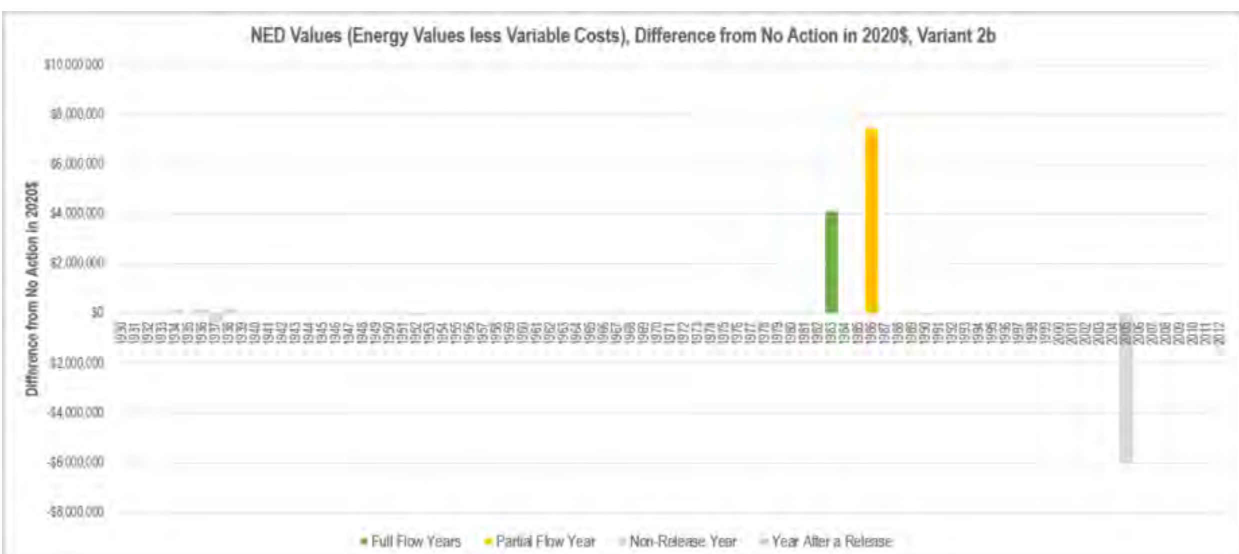

Figure 9. Variation 2B Change in Thermal Power NED Values from No Action

Regional Economic Development

Impacts to power generation during peak seasons would be very similar to those described under No Action, with drier and hotter periods potentially impacting consumer electricity rates associated with higher wholesale electricity prices. Variant2B would not contribute to these impacts. There would be a negligible change in the impacts to consumer electricity rates and household spending and associated regional economic conditions compared to No Action.

Other Social Effects

Under Variation 2B, the changes in power generation compared to No Action would be negligible, with negligible changes in air emissions and the social cost of carbon.

3.4.3 Conclusions – Alternative 2 including Variants 2A and 2B

Under Alternative 2, including variations 2A and 2B, there would be negligible changes in power generation, energy values, variable costs, and thermal power NED values compared to No Action. Changes in river flows and stages, including during full and partial release years, would result in slight increases in average annual NED values. In years over the period of record when a partial or full flow release would be simulated, the percentage change in average annual NED values would range from no change to +0.08% (Table 15).

Under Alternative 2, there would be one year with a notable increase in NED value compared to No Action, while in Variation 2A and 2B, there would be two years with beneficial effects compared to No Action. These relative increases in NED value would result from higher releases from Garrison Dam increasing flows and stages in the Garrison reach associated with full or partial releases in these years from Fort Peck Dam.

In one year over the period of record under Alternative 2 and Variations 2A and 2B, a partial or full release from Fort Peck Dam would decrease releases from Garrison Dam in a subsequent year, reducing river flows and stages compared to No Action, with adverse effects to power generation. However, the decreases in NED value in this year would be very small compared to No Action (1.2%) and would be offset by years with higher NED values compared to No Action. Table 15 provides a summary of the NED impacts for Alternative 2 including variations 2A and 2B in all years and in years when a partial or full flow release would be simulated to occur.

Table 15. Summary of National Economic Development Analysis for Alternative 2

NED Values	Alternative 2	Variation 2A	Variation 2B	Range across all Variations
All Years over the Period of Analysis				
Annual Average NED Value**	$505,163,000	$505,211,000	$505,213,000	$50,000
Difference in Annual Average NED Value from No Action	+$20,000	+$68,000	+$70,000	$50,000
Percentage Difference from No Action	0.00%	+0.01%	+0.01%	0.01%
Full or Partial Release Years over the Period of Analysis				

Annual Average NED Value**	$508,992,000	$509,082,000	$508,606,000	$476,000
Difference in Annual Average NED Value from No Action	+$250,000	+$400,000	+$314,000	$150,000
Percentage Difference from No Action	+0.06%	+0.08%	+0.06%	0.03%

* Fiscal year 2020 prices.

** NED Value = Energy Value Less Variable Costs

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Fort Peck Dam Test Releases
Environmental Impact Statement

Water Supply
Environmental Consequences Analysis

Technical Report

August 2021

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Acronyms and Abbreviations

DSS	Data Storage System
EIS	environmental impact statement
EQ	environmental quality (account)
ER	Engineering Regulation
FPDTR-EIS	Fort Peck Dam Test Releases - Environmental Impact Statement
H&H	hydrologic and hydraulic (model)
HC	human considerations
HEC	Hydrologic Engineering Center
M&I	municipal and industrial
NED	national economic development (account)
O&M	operations and maintenance
OSE	other social effects (account)
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
POR	period of record
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

1.0 Introduction

The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Fort Peck Dam Test Releases – Environmental Impact Statement (FPDTR-EIS). The purpose of the FPDTR-EIS is to assess the potential impacts of a range of test flow release alternatives from Fort Peck Dam designed to benefit reproduction and recruitment of pallid sturgeon to avoid jeopardizing their continued existence in the Missouri River.

The purpose of this Water Supply Environmental Consequences Analysis Technical Report is to provide additional information on the impact analysis and results relevant to water supply that was completed for the FPDTR-EIS. Additional details on the National Economic Development (NED) methodology and results are provided in this technical report. The Regional Economic Development (RED) and Other Social Effects (OSE) are presented in the FPDTR-EIS, Chapter 3 Environmental Consequences, Water Supply. No Environmental Quality (EQ) analysis was undertaken for water supply.

1.1 Summary of Alternatives

The FPDTR-EIS evaluates the following alternatives. A detailed description of the alternatives is provided in Chapter 2 of the FPDTR-EIS.

No Action Alternative: The impacts of the No Action Alternative serve as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. When modeling the No Action Alternative, local inflows are adjusted by the difference between the historic and present level depletions to ensure the period-of-record (POR) datasets are homogenous and reflect current water use. All modeled flood targets are as outlined in the 2018 Master Manual (USACE, 2018) and reservoir storages are based on current reservoir surveys. All four navigation target locations are used when setting navigation releases and the model balances system storage by March 1. It is assumed that other activities and actions for pallid sturgeon in the Upper Basin would be implemented as described in the FPDTR-EIS and 2018 Biological Opinion and the Yellowstone Intake Bypass EIS. These actions include fish bypass construction at Yellowstone Intake, continued propagation and stocking of pallid sturgeon in the Upper Basin, and continued pallid sturgeon science and monitoring activities in the Upper Basin.

Alternative 1: System operations under this alternative are based on those described under the No Action Alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon.

The attraction flow regime begins on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in the given year. For example, the typical early spring release from Fort Peck Dam is approximately 8,000 cubic feet per second (cfs); therefore, the attraction flow regime peak flow would be 16,000 cfs as measured at the Wolf Point gage. Beginning on April 16, spring release flows are increased by 1,700 cfs per day until the peak flow is reached at the Wolf Point gage. The peak flow is held for 3 days and then decreases by 1,300 cfs per day until the retention flow is reached. The retention flow is 1.5 times the Fort Peck Dam early spring release as measured at the Wolf Point gage, 12,000 cfs using the example. The retention flow is held until May 28 when the spawning cue flow regime is initiated.

The spawning cue flow regime under Alternative 1 begins on May 28 and is 3.5 times the Fort Peck Dam spring flow release in the given year. Assuming 8,000 cfs as the typical spring flow, this equates to approximately 28,000 cfs at the peak as measured at the Wolf Point gage. Beginning on May 28, the release is increased by 1,100 cfs per day until the peak flow is reached as measured at the Wolf Point gage. The peak is held for 3 days and then decreases by 1,000 cfs per day for 12 days, then decreases by 3,000 cfs per day until the drifting flow regime of 8,000 cfs is reached. The 8,000 cfs drifting flow regime is held until September 1 when releases to balance storage resume.

Variation 1A: This test flow is a variation of Alternative 1. The parameters for Variation 1A are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The April 9 initiation date is closer to the timing of the initial pulse shown on the unregulated hydrograph. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases. In Alternative 1, the later initiation date of April 16 is designed to enhance the contrast between Missouri River and Yellowstone River discharges by moving the start date approximately two weeks later than the initial pulse shown on the unregulated hydrograph.

Variation 1B: This test flow is another variation of Alternative 1. The parameters for Variation 1B are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 23 and the spawning cue flow regime is initiated on June 4. Similar to the concept described in 1A, the later initiation date is intended to provide contrast and explore any differences in forecasted impacts from a later flow initiation date.

Alternative 2: The parameters for Alternative 2 are the same as described for Alternative 1 except that the attraction flow regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at the Wolf Point gage are held at 14,000 cfs until the spawning cue flow release is initiated. The rationale for keeping the releases high through this period—foregoing the inter-pulse saddle—is the hypothesis that persistent high flows are needed to hold migrated, reproductive adult pallid sturgeon upstream near the dam.

Variation 2A: This test flow is a variation of Alternative 2. The parameters for Variation 2A are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The difference in timing follows the same reasoning as described for Variation 1A.

Variation 2B: This test flow is another variation of Alternative 2. The parameters for Variation 2B are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 23, rather than April 16, and the spawning cue flow regime is initiated on June 4, rather than May 21. The difference in timing follows the same reasoning as described for Variation 1B.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the FPDTR-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the FPDTR-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR 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 FPDTR-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 NED account displays changes in the economic value of the national output of goods and services expressed in monetary units.
- The RED account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The EQ account displays non-monetary effect on significant natural and cultural resources.
- The OSE account registers plan effects from perspective 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 water supply include NED, RED, and OSE.

1.3 Approach for Evaluating Environmental Consequences to Water Supply Access of the FPDTR-EIS

This evaluation assessed 26 municipal and commercial intakes located along the upper Missouri River and its reservoirs from Fort Peck Dam to Lake Oahe. While there are other intakes located along the Missouri River from Fort Peck to Oahe, including domestic and public water supply intakes, the analysis focused on those with sufficient information to evaluate potential impacts. When river flows and reservoir elevations fall below minimum operating requirements, intakes are unable to access water for municipalities, Tribes, commercial operations, and others. This in turn can drive changes in costs to access water. 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 reservoirs can lead to changes in costs of water supply access.

The evaluation of environmental consequences to water supply access was completed by evaluating how water supply intake operations would be affected by changes in river and reservoir conditions as modeled by the Hydrologic Engineering Center River Analysis System (HEC-RAS) and Reservoir System Simulation (HEC-ResSim) models developed by the Institute for Water Resources, Hydrologic Engineering Center (Figure 2). Data from these models provided a profile of river and reservoir behavior at locations that approximately correspond to locations of water supply intakes, in the form of HEC-DSS (Data Storage System) flat files. River and reservoir behavior for each location were modeled over a period of 82 years, from 1930 to 2012. This analysis provided important inputs for the second step, the NED analysis, which estimated the change in water supply costs resulting from changes in access to water from the Missouri River. The following sections provide further details on the methodology.

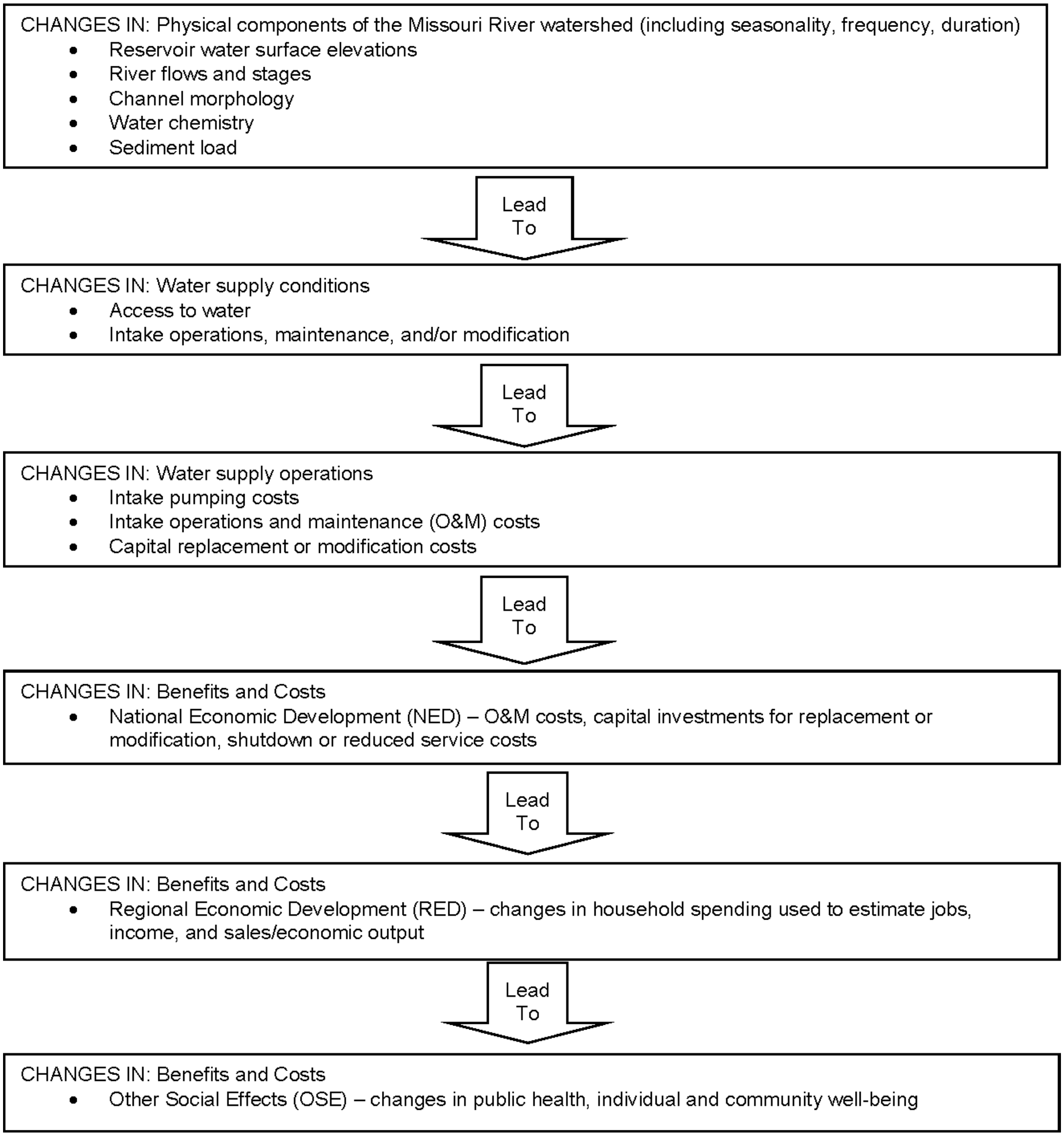

Figure 1. Flow Chart of Inputs Considered in Evaluation of Impacts to Water Supply Access

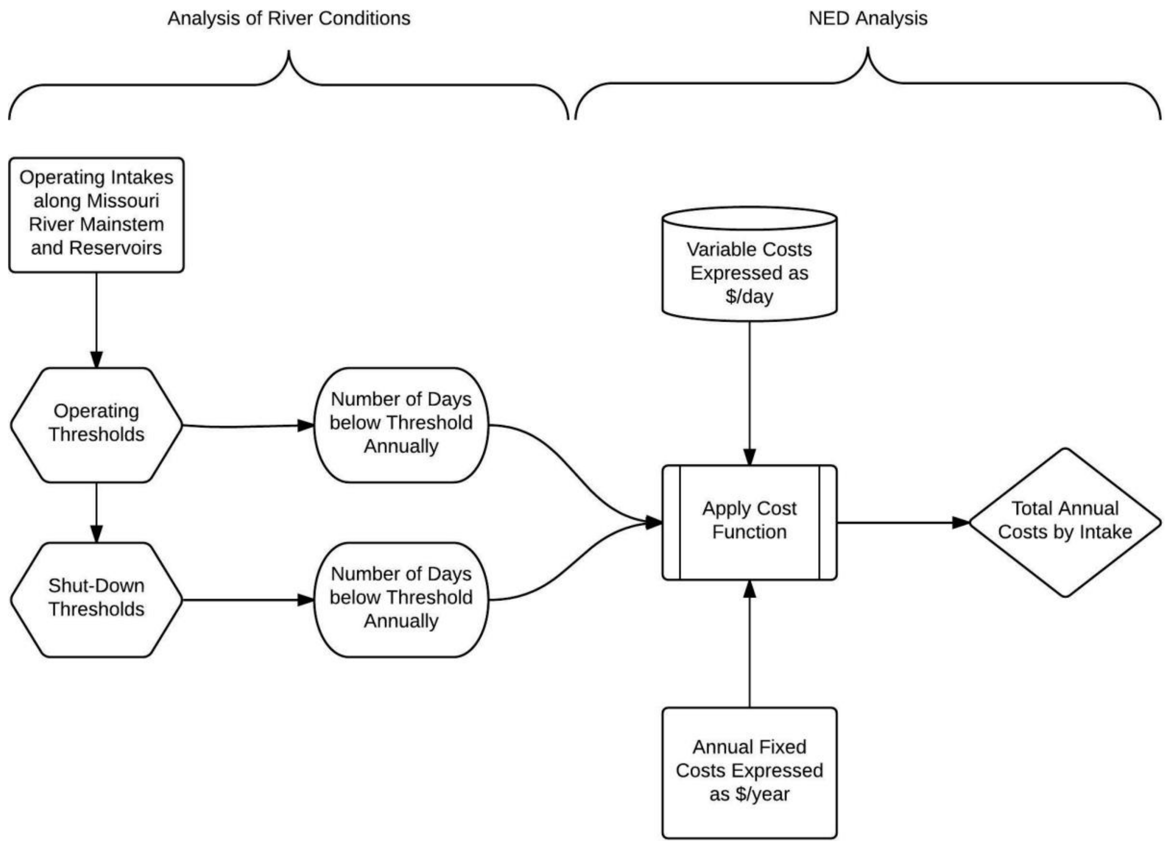

Figure 2. Approach for Evaluating Environmental Consequences to Water Supply Access

2.0 Assumptions, Limitations, and Risks

2.1 Assumptions and Limitations

In modeling the environmental consequences to water supply access from the FPDTR-EIS alternatives, the project team established a set of assumptions. The important assumptions used in the modeling effort are as follows.

- The river conditions analysis and 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 POR under each of the FPDTR-EIS alternatives including the No Action alternative.
- Based on interviews with a representative sample of water supply managers it was assumed that water supply operations can adapt to small, infrequent changes in river flows and reservoir elevations under the FPDTR-EIS alternatives by using different-sized portable submersible pumps.

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 FPDTR-EIS 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 POR. Extreme scenarios of climate change and/or unprecedented 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 in the water supply model described is this document. The project team has attempted to address the uncertainty in the type and magnitude of impacts by defining and evaluating a reasonable range of plan alternatives of test flows from the Fort Peck Dam. All of the alternatives were modeled to estimate impacts to municipal, Tribal, and commercial water supplies.

Another source of uncertainty associated with the water supply analysis is predicting how water supply managers would react to long-term changes in river and reservoir conditions. The project team has utilized information from interviews with water supply managers to assess how adverse effects would affect operation of intakes. In all cases, the project assumed that submersible pumps would be used to adapt to changing conditions that are temporary in nature. However, in some cases, water supply managers may decide that it is more cost effective to make modifications to the intake to adjust to these conditions. For consistency across all water supply intakes, a standard approach of estimating costs for deploying portable, submersible pumps was used.

However, while these operational responses may be reasonable under current conditions or in the near future, unforeseen conditions may arise that may alter the operational response to the adverse conditions.

2.3 Geographic Areas

The study area includes municipal and industrial water supply intakes and rural water districts that are located on the lakes and the river reaches from Fort Peck Dam to Lake Oahe.

3.0 River Conditions Analysis

The purpose of the water supply river conditions analysis was to link H&H modeling efforts that simulate river and reservoir operations of the Missouri River under each of the FPDTR-EIS alternatives with economic analysis necessary to determine environmental consequences. The river conditions analysis used Microsoft Excel® to evaluate potential effects of changes in river flows, river stages, and reservoir elevations to water supply operations accessing water from the upper Missouri River.

The analysis evaluated how access to water supply would be affected by changes in river and reservoir conditions. As river flows/levels and reservoir elevations fall below minimum operating requirements, intakes become unavailable to provide water to municipalities, Tribes, commercial operations, and others. This in turn can require changes to how water supply providers access water including extending intakes or using submersible pumps on a temporary basis, which lead to an increase in costs for water supply providers. The river conditions analysis used outputs from H&H models developed by the USACE o simulate river and reservoir operations for planning studies and decision support developed by the Hydrologic Engineering Center. HEC-RAS and HEC-ResSim data were used to provide a profile of river and reservoir behavior at locations that approximately corresponded to locations of water supply intakes, in the form of HEC-DSS flat files. River and reservoir behavior for each location were modeled over the POR.

The project team identified and evaluated 26 municipal and commercial intakes located along the upper Missouri River and its reservoirs that are expected to be operational during plan implementation for this analysis. For each of the intakes, the project team evaluated the parameters described in Table 1. The NED analysis used the results of the river condition analysis including the number of days below operating thresholds and the number of days below shut-down thresholds for each of the 26 intakes. The results were used to estimate changes in costs to water supply operations due to changes in river and reservoir operations from the FPDTR-EIS alternatives.

Table 1. Water Supply River Conditions Analysis Metrics

Metric	Performance Measure	Description
Metric 1 – Number of days river/reservoir levels fall below minimum access requirements for regular operation	Number of days	This measure is an estimate of the number of days in a calendar year that a water supply intake will not have access to water from either a river or reservoir. The focus of the metric is on operating conditions.
Metric 2 – Number of days river/reservoir levels falls below shutdown elevation.	Number of days	This measure is an estimate of the number of days in a calendar year that a water supply intake will not have access to water from either a river or reservoir. The focus of the metric is on shutdown conditions.

3.1 River Conditions Results

The primary purpose of the river conditions analysis was to better understand how each of the proposed alternatives might impact water supply access and to understand and describe the relationship between the H&H models and economic consequences. A summary of the river conditions analysis is discussed below for each alternative.

3.1.1 No Action (Current System Operations)

Over the POR, 15 of the 26 intakes experience adverse impacts associated with operating conditions under the No Action alternative with on average 57.1 days when water surface elevations fall below operating thresholds. In addition, 12 of the 26 intakes experience adverse impacts associated with shut-down elevations with on average 8.6 days per year when water surface elevations are below shut-down thresholds.

The river conditions analysis for the shut-down parameter for the No Action alternative over the POR is summarized in Figure 3. The figure shows that intakes in the area of analysis are experiencing some impacts under the No Action alternative in less than half of the years in the period of analysis. Many of these impacts are occurring during drought conditions such as during the 1930s, 1990s and the 2000s.

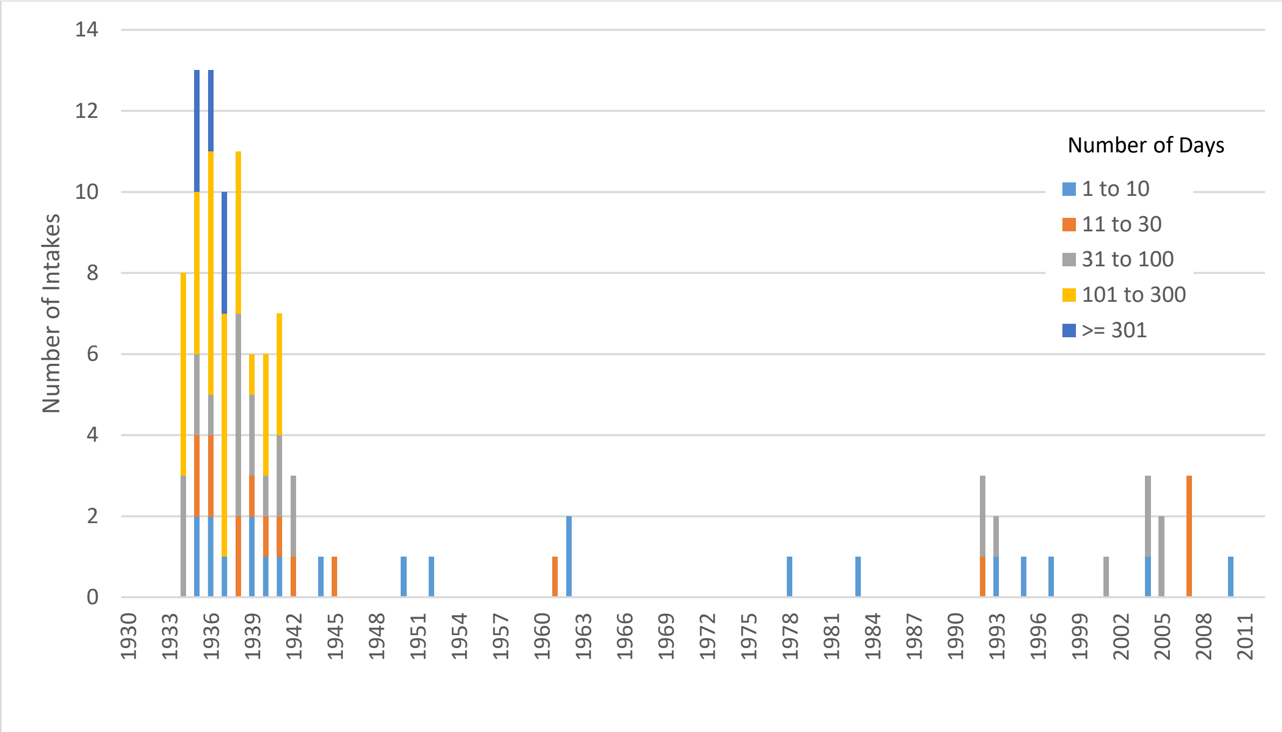

Figure 3. Number of Intakes and Days below Shut-Down under No Action

3.1.2 Alternative 1

Over the POR, 15 intakes would experience impacts at some point under Alternative 1. On average, intakes would experience 57 days when water surface elevations fall below operating thresholds. The number of intakes experiencing effects under Alternative 1 compared to the No Action alternative is the same. However, the average number of days below operating thresholds is slightly less under Alternative 1 than the No Action alternative. In addition, 12 of the 26 intakes would experience impacts associated with shut-down thresholds under Alternative 1. On average, these intakes would experience 8.6 days when water surface elevations are below shut-down thresholds. The number of intakes experiencing effects and the average number of days where water surface elevations fall below shut-down thresholds are the same under Alternative 1 compared to the No Action alternative.

The river condition analysis for Alternative 1 are summarized in Figure 4 which shows the difference in the number of intakes and the days below shut-down conditions between Alternative 1 and No Action over the POR. As shown in Figure 4, there are no changes to the total number of intakes impacted over the POR from the No Action alternative. This figure shows the same intake impacted in 1978 under the No Action moves from the category for 1 to 10 days below shut-down conditions under the No Action alternative to the 11 to 30 day category under Alternative 1.

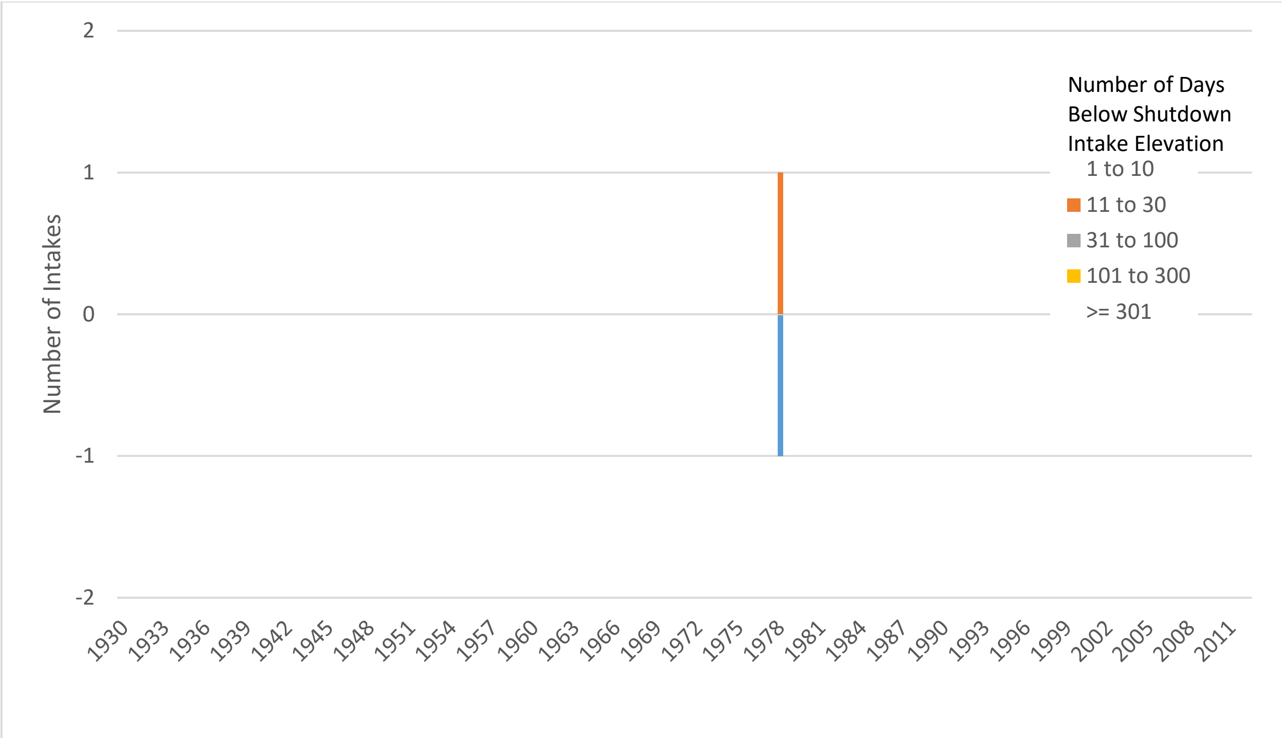

Figure 4. Number of Intakes with Changes in Number of Days below Shut-Down under Alternative 1 (Difference from No Action)

3.1.2.1 Alternative 1 – Variation 1A

Under Variation 1A, 15 intakes would experience impacts at some point. On average, intakes would experience 57.1 days when water surface elevations fall below operating thresholds. The number of intakes experiencing effects and the number of days where water surface elevations fall below operating thresholds are the same under Variation 1A compared to the No Action alternative. In addition, 12 of the 26 intakes would experience impacts associated with shut-down thresholds under Variation 1A. On average, these intakes would experience 8.6 days when water surface elevations are below shut-down thresholds. The number of intakes experiencing effects and the average number of days where water surface elevations fall below shut-down thresholds are the same under Variation 1A compared to the No Action alternative. The river condition analysis for Variation 1A are summarized in Figure 5 which shows the difference in the number of intakes and the days below shut-down conditions between Variation 1A and the No Action alternative over the POR. As shown in Figure 5, one intake that is not impacted under the No Action Alternative in 1983 is impacted between 1 to 10 days under Variation 1A. The total number of affected intakes remains the same between Variation 1A relative to the No Action alternative over the POR.

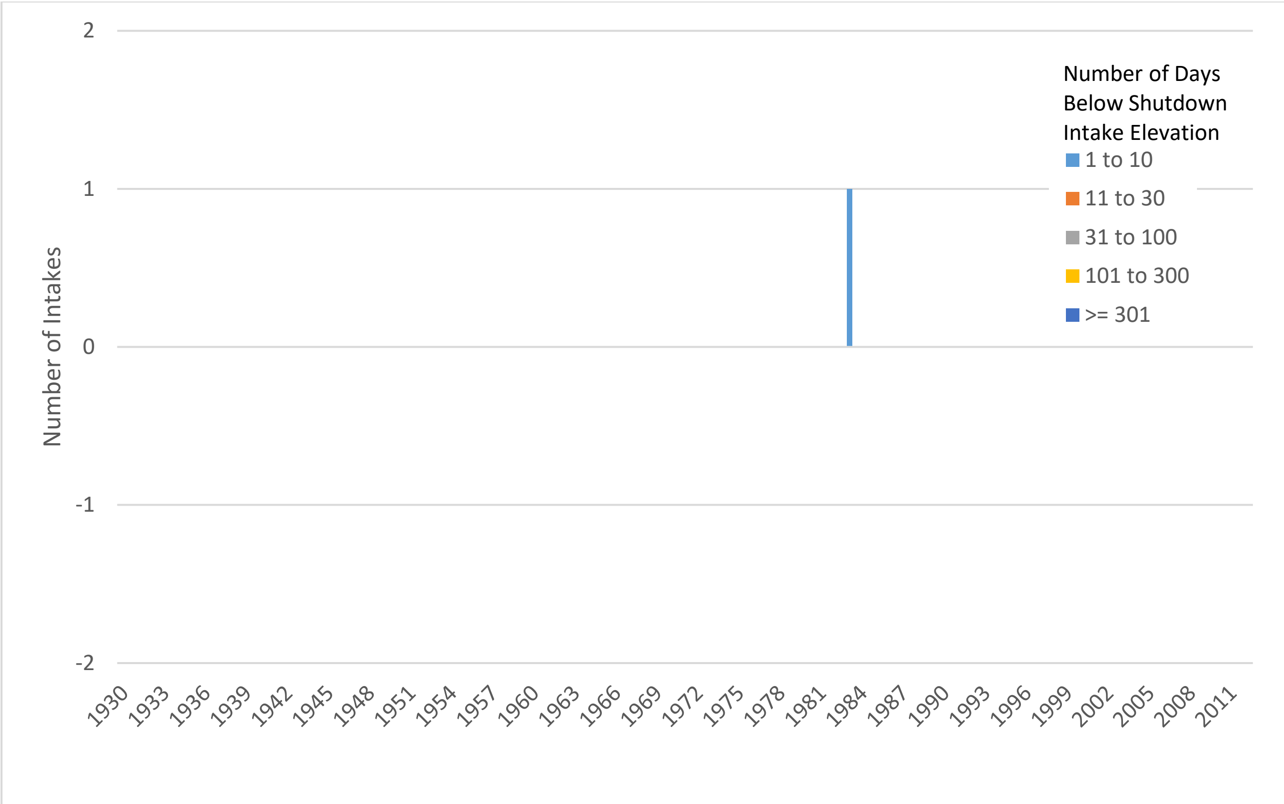

Figure 5. Number of Intakes with Changes in Number of Days below Shut-Down under Variation 1A (Difference from No Action)

3.1.2.2 Alternative 1 – Variation 1B

Under Variation 1B, 15 intakes would experience impacts at some point. On average, intakes would experience 57.1 days when water surface elevations fall below operating thresholds. The number of intakes experiencing effects and the number of days where water surface elevations fall below operating thresholds are the same under Variation 1B compared to the No Action alternative. In addition, 12 of the 26 intakes would experience impacts associated with shut-down thresholds under Variation 1B. On average, these intakes would experience 8.6 days when water surface elevations are below shut-down thresholds. The number of intakes experiencing effects and the average number of days where water surface elevations fall below shut-down thresholds are the same under Variation 1B compared to No Action. The river condition analysis for Variation 1B are summarized in Figure 6 which shows the difference in the number of intakes and the days below shut-down conditions between Variation 1B and the No Action alternative over the POR. As shown in Figure 6, one intake that is impacted for 1 to 10 days under the No Action alternative in 1978 is impacted slightly more, between 11 to 30 days, under Variation 1B. This same intake is not impacted under the No Action alternative in 1983 but is impacted between 1 to 10 days under Variation 1B.

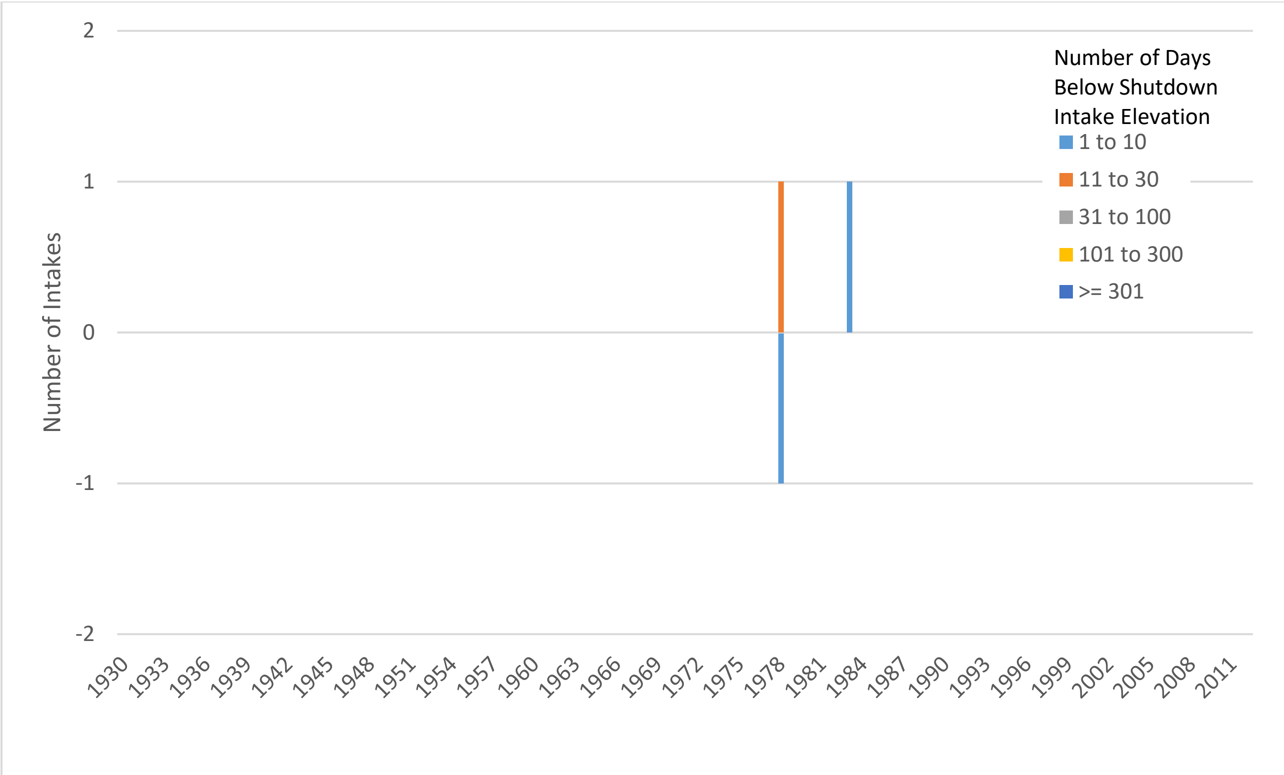

Figure 6. Number of Intakes with Changes in Number of Days below Shut-Down under Variation 1B (Difference from No Action)

3.1.3 Alternative 2

Under Alternative 2, 15 intakes would experience impacts at some point. On average, intakes would experience 57.1 days when water surface elevations fall below operating thresholds. The number of intakes experiencing effects and the number of days where water surface elevations fall below operating thresholds are the same under Alternative 2 compared to the No Action alternative. In addition, 12 of the 26 intakes would experience impacts associated with shut-down thresholds under Alternative 2. On average, these intakes would experience 8.7 days when water surface elevations are below shut-down thresholds. While the number of intakes experiencing impacts associated with shut-down thresholds are the same under Alternative 2 as they are under the No Action alternative, the average number of days where these impacts are experienced are slightly higher under Alternative 2 compared to the No Action Alternative.

The river condition analysis for Alternative 2 are summarized in Figure 7 which shows the difference in the number of intakes and the days below shut-down conditions between Alternative 2 and the No Action alternative over the POR. As shown in Figure 7, one intake that is impacted for 1 to 10 days under the No Action alternative in 1978 is impacted slightly more, between 11 to 30 days, under Alternative 2. Another intake that is not impacted under the No Action alternative in 2005 is impacted between 11 to 30 days under Alternative 2. The total number of affected intakes remains the same between Alternative 2 relative to No Action alternative over the POR.

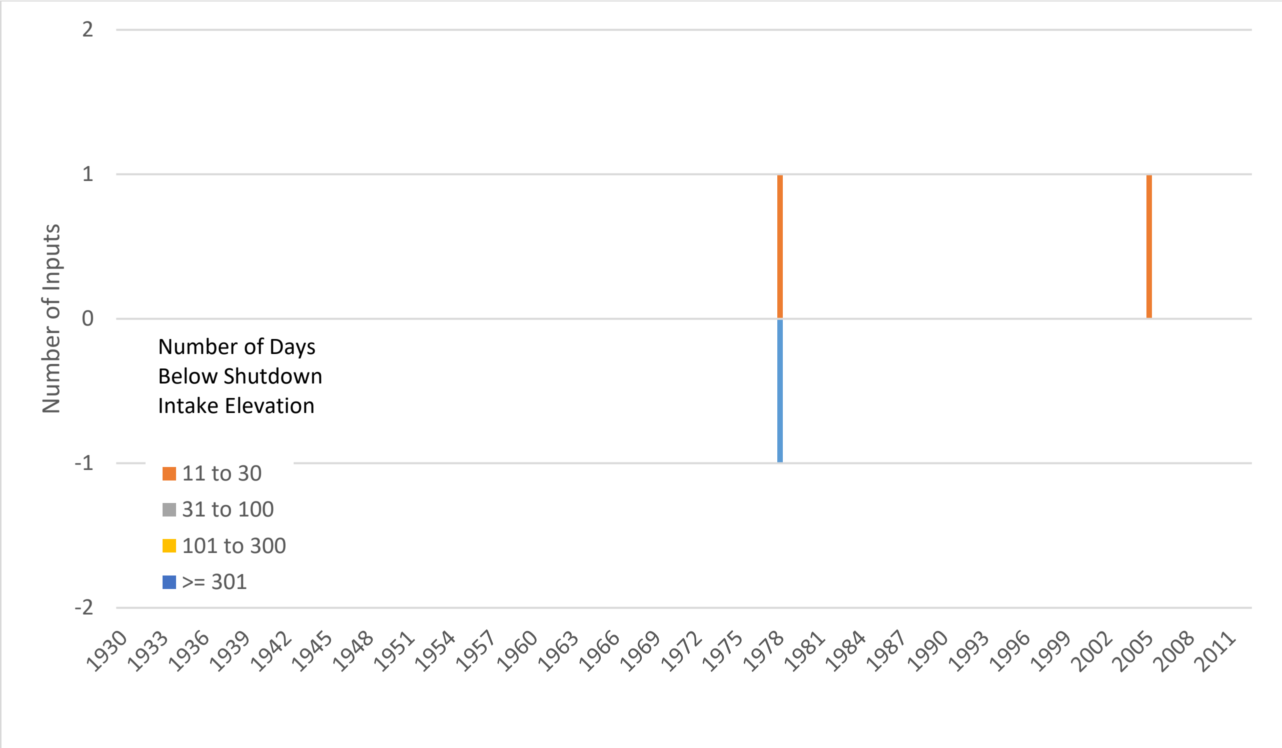

Figure 7. Number of Intakes with Changes in Number of Days below Shut-Down under Alternative 2 (Difference from No Action)

3.1.3.1 Alternative 2 – Variation 2A

Under Variation 2A, 15 intakes would experience impacts at some point. On average, intakes would experience 57.1 days when water surface elevations fall below operating thresholds. The number of intakes experiencing effects and the number of days where water surface elevations fall below operating thresholds are the same under Variation 2A compared to the No Action alternative. In addition, 12 of the 26 intakes would experience impacts associated with shut-down thresholds under Variation 2A. On average, these intakes would experience 8.7 days when water surface elevations are below shut-down thresholds. While the number of intakes experiencing impacts associated with shut-down thresholds are the same under Variation 2A as they are under the No Action alternative, the number of days where these impacts are experienced are slightly higher under Variation 2A compared to the No Action alternative.

The river condition analysis for Variation 2A are summarized in Figure 8 which shows the difference in the number of intakes and the days below shut-down conditions between Variation 2A and the No Action alternative over the POR. As shown in Figure 8, one intake that is not impacted under the No Action alternative in 1978 is impacted between 1 to 10 days under Variation 2A. Another intake that is not impacted under the No Action alternative in 2005 is impacted between 11 to 30 days under Variation 2A. The total number of affected intakes remains the same between Variation 2A relative to No Action alternative over the POR.

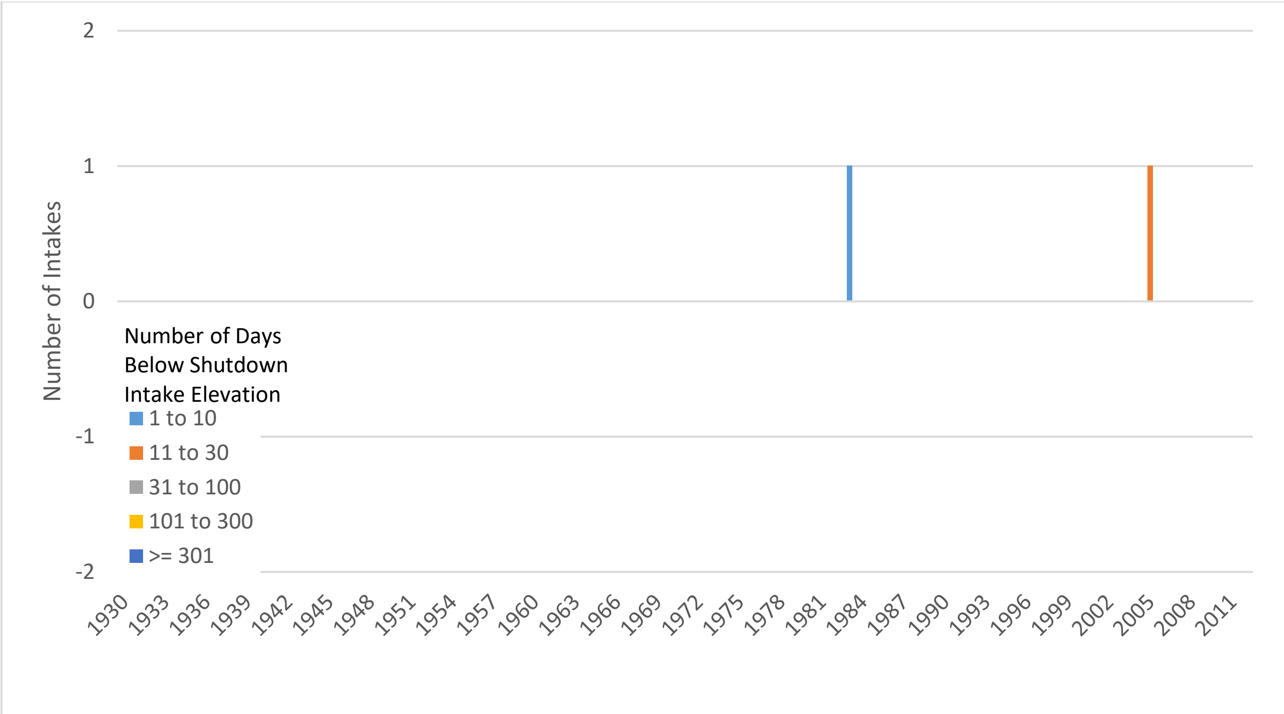

Figure 8. Number of Intakes with Changes in Number of Days below Shut-Down under Variation 2A (Difference from No Action)

3.1.3.2 Alternative 2 – Variation 2B

Over the POR, 15 intakes would experience impacts at some point under Variation 2B. On average, intakes would experience 57 days when water surface elevations fall below operating thresholds. The number of intakes experiencing effects under Variation 2B compared to the No Action alternative is the same. However, the average number of days below operating thresholds is slightly less under Variation 2B. In addition, 12 of the 26 intakes would experience impacts associated with shut-down thresholds under Variation 2B. On average, these intakes would experience 8.6 days when water surface elevations are below shut-down thresholds. The average number of intakes experiencing effects and the average number of days where water surface elevations fall below shut-down thresholds are the same under Variation 2B compared to the No Action alternative.

The river condition analysis for Variation 2B are summarized in Figure 9 which shows the difference in the number of intakes and the days below shut-down conditions between Variation 2B and the No Action alternative over the POR. As shown in Figure 9, one intake that is not impacted under the No Action alternative in in 1949, 1977, and 1983 is impacted between 1 to 10 days under Variation 2B. Two intakes that are impacted for 1 to 10 days under the No Action alternative in 1952 and 1978 are impacted between 11 to 30 days under Variation 2B. Finally, one intake that is not impacted under the No Action alternative is impacted between 11 and 30 days under Variation 2B in 2005. The total number of affected intakes remains the same between Variation 2B relative to the No Action alternative over the POR.

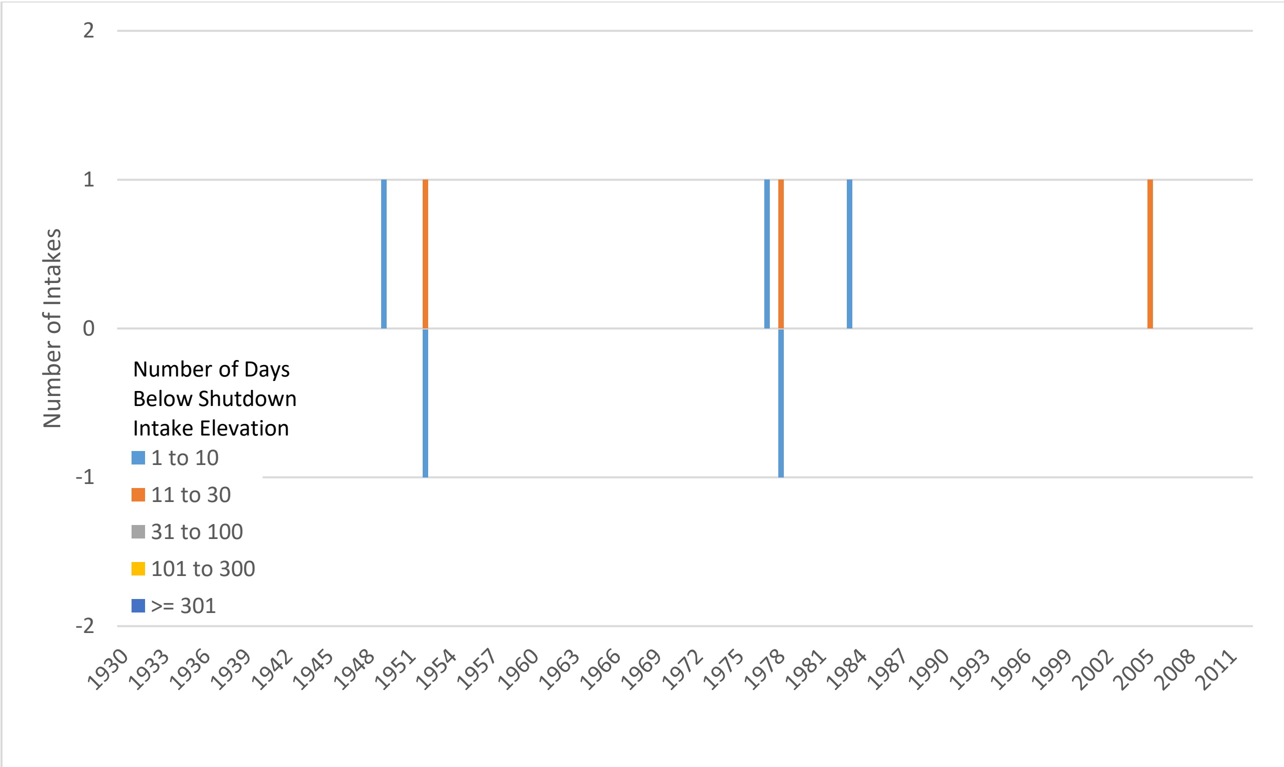

Figure 9. Number of Intakes with Changes in Number of Days below Shut-Down under Variation 2B (Difference from No Action)

4.0 Methodology

Water supply access is sensitive to changes in elevations of the Missouri River and reservoirs. As water flow/elevation falls below minimum access requirements, water intakes become unable to provide water for local municipalities, Tribes, commercial operators, and others.

Furthermore, a change in the cost of maintaining or operating intakes affects the residents and firms that rely on the intakes.

4.1 National Economic Development Approach

An Excel-based economic analysis was developed that builds upon the river conditions analysis to evaluate the change in NED benefits for water supply access as a result of implementing the FPDTR-EIS alternatives. The NED analysis of water supply access was defined as changes in variable and fixed costs as a result of changing physical conditions along the upper Missouri River.

The river conditions analysis showed that water surface elevations would fall below both operating and shut-down elevations for many of the intakes evaluated under all the FPDTR-EIS alternatives as well as the No Action Alternative.

Modeling results show that there would be a negligible difference between the FPDTR-EIS alternatives compared to No Action for the annual average number of days that water surface elevations would fall below operating or shut-down thresholds for water supply intakes. The project team concluded from the river conditions analysis that any impacts that would occur to water supply intakes under the FPDTR-EIS alternatives would be negligible and temporary to those that are observed under the No Action Alternative.

Given that the FPDTR-EIS alternatives are not expected to cause a decrease in river stages beyond those experienced under No Action, it was concluded that the FPDTR-EIS alternatives would not result in additional intake modifications or replacements beyond what would be planned or undertaken under No Action. Thus, the NED analysis for water supply access focused on estimating the incremental changes in operations under the action alternatives to address temporary increases in the number of days below shut-down or operational thresholds that would occur.

Interviews with water supply managers along with published information[1] provided some insight on how water supply managers may adjust to temporary changes in river or reservoir conditions, like those observed under the FPDTR-EIS alternatives. Operators indicated that when water surface elevations temporarily fall below operating elevations, submersible pumps can be used to pump water to collection basins or the intake and maintain operations.[2]

The project team used this information to estimate additional costs associated with conditions occurring under the FPDTR-EIS alternatives relative to No Action including the fixed and operating costs of submersible pumps needed to maintain operations at various water supply intakes along the river and reservoirs.

The NED analysis for water supply access focused on the change in variable and fixed costs under each of the FPDTR-EIS alternatives to municipal and commercial water facilities. The following section explains the NED analysis in detail, including data sources and assumptions.

4.1.1 Estimate Intake Capacity

In order to determine the size of the pumps that would be required at each intake location, the project team first needed to estimate the capacity of each of the 26 water supply intakes. Where possible, the project team obtained this information directly from water supply managers, especially commercial operators. Where this information was not available, the project team estimated daily water demand for each intake based on the population served which was obtained from the Master Manual and interviews with water supply operators and a daily per capita water usage rate. Per capita water usage rates were estimated for each state in the study area using data obtained from the U.S. Geological Survey (USGS 2010). For intakes where capacity values were unknown, the daily water use estimate was multiplied by the population served for each intake resulting in a daily capacity value.[3]

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[1] A presentation provided by WaterOne dated August 15, 2007, indicates a temporary solution used to address low river flows was to rent pumps. This temporary approach was used prior to a $2 million investment in a low water level pumping facility could be completed (WaterOne 2007).
[2] Note that if several pumps were to be affected by low flows there may be added pressure on the supply of pumps available to be rented.
[3] Note that water supply intakes would likely use pumps with capacity two times average daily demand to meet water supply needs. This operating parameter was not applied here given the small differences between the alternatives.

4.1.2 Estimate Pumping Requirements for Each Intake

Once the capacity for each intake was estimated, the project team used that information to determine the number and size of submersible pumps that would be needed to maintain each intake if water surface elevations fall below operating or shut-down levels under any of the alternatives. The project team contacted a manufacturing representative of Gorman-Rupp for information on their S-Series Submersible Dewatering Pumps (White 2016). These pumps come in a variety of sizes and horsepower and are routinely used for pumping water under conditions similar to those encountered by water supply managers along the Missouri River. Table 2 summarizes the pumps used for the analysis.

4.1.3 Estimate Pump Fixed Costs

The project team estimated an annual fixed cost for each pump used at each of the intakes. This fixed cost for each pump includes three components: (1) pump capital cost; (2) operations and maintenance (O&M) costs; and (3) permitting and regulatory requirements. Because it was assumed under the No Action and test release alternatives that the pumps would be used on a temporary basis (several days at a time), a daily fixed cost was estimated for each sized pump. The daily rate was estimated by annualizing the capital cost of each pump considering an average life expectancy of ten years, and a discount rate of ten percent.[4] This annual cost was then converted to a daily cost by dividing the annual rate by 365. The fixed cost for each pump also includes a cost for maintenance activities and environmental permits and regulatory requirements. These additional costs were estimated as ten percent of the annualized cost of the pumps. Table 2 summarizes the fixed costs for each pump size.

Table 2. Submersible Pumps Costs (FY2021 Dollars)

Submersible Pumps Model Number	Horse-power	Capacity (gpm)	Capital Cost (2020$) [a]	Useful Life	Daily Fixed Costs (2020$) [b]	Annual Operations and Maintenance Costs (2020$) [c]	Annual Environmental Permitting and Regulatory Costs (2020$) [c]
S4E1-E20	20	450	$13,881	8–12 years	$6.19	$225.90	$225.90
S4B1-E50	50	750–1,000	$20,818	8–12 years	$9.28	$338.81	$338.81
S6A1-E60	60	750–2,100	$24,003	8–12 years	$10.70	$390.63	$390.63
S6E1-E60	60	750–2,100	$30,458	8–12 years	$13.58	$495.69	$495.69
S8D1-E275	275	750–2,500	$98,265	8–12 years	$43.81	$1,599.21	$1,599.21
S12A1-E140	140	750–7,000	$32,449	8–12 years	$14.47	$528.09	$528.09

Notes: gpm = gallons per minute
a (White 2016)
b Daily fixed costs were calculated for each pump based on a 10-year life and discount rate of 10 percent.
c Estimated as ten percent of annual fixed costs.

4 This rate is expected to reflect the private cost of capital. In fall 2019, the prime rate was estimated to be between 4.75 and 5.0 percent. Because the analysis is using a higher interest rate than the current private cost of capital, the fixed costs are higher than expected under current conditions. Using the higher interest rate may overstate the actual costs that would be incurred by operators but it does not change the comparison of alternatives because all are affected equally.

Using the information on the intake capacity and the capacity of submersible pumps, the project team determined the appropriate size of pumps and number of pumps that would be needed to extend operations for each water supply intake. For some of the larger intakes, multiple pumps would be needed to extend operations.

4.1.4 Estimate Pump Variable Costs

After estimating the number and size of pumps for each water supply intake, the project team estimated the daily energy costs for each size pump. Based on the horsepower rating for each pump size, the team used the following calculation to show the energy requirements in watts:

$$1\ horsepower = 745\ watts$$

The number of hours each pump would operate was determined from the capacity of the pump and the amount of water that would need to be pumped per day. The calculation showing daily energy requirements per pump follows:

$$\frac{Water\ Amount\ (gallons)}{Pump\ Capacity\ (\frac{gallons}{hours})} * watts = \frac{watt}{hours}$$

The daily energy requirements were then converted to kilowatt-hours and multiplied by the average price for electricity ($/kWh) for the West North Central region of the United States as reported by the Energy Information Agency (EIA 2015). This resulted in an average energy cost per pump per day (FY2021 Dollars).

4.1.5 Estimate Costs for Changing River Conditions under each Alternative

The project team used the variable and fixed costs for each pump with the river conditions analysis results to estimate the costs to access water under each alternative. As discussed above, the river conditions results indicated that several of the intakes evaluated would experience many instances when water surface elevations would fall below either operating or shut-down elevations under the No Action Alternative. It is assumed that these operators would undertake some measures to modify or replace intakes that experience frequent operational impacts. However, in order to compare the FPDTR-EIS alternatives with No Action, the project team applied the same assumptions of using submersible pumps when water surface elevations fall below operating conditions for No Action. The costs were estimated using the following rules:

- For every day that water surface elevations fall below intake operating elevations, half of the daily energy costs per pump are applied (assumes intakes would still be operational when water surface elevations fall below operating thresholds (water surface elevations) but would not be as efficient).
- For every day that water surface elevations fall below intake shut-down elevations, the daily energy costs per pump are applied.
- For every day that a pump is used, a daily fixed cost is applied.

These assumptions were applied to all 26 water supply intakes evaluated which resulted in an annual cost per alternative over the POR.

4.2 Regional Economic Development Methodology

The RED water supply evaluation included a qualitative discussion of impacts of the FPDTR-EIS alternatives. The project team utilized the results of the NED evaluation in describing potential RED effects. Because there were minimal changes in NED costs to access water for municipal and industrial (M&I) facilities, the analysis did not quantify potential changes in rates. However, because there is likely a small impact or an uncertain impact on rates, these impacts were described qualitatively.

4.3 Other Social Effects Methodology

Changes in water supply operations have a potential to cause other types of effects on individuals and communities. For example, if an alternative reduced or eliminated a facility's ability to access the water, this could affect the local community in several ways, such as the community's ability to grow and attract investment without a reliable water supply and a community's sense of well-being. The water supply analysis used the results of the NED and RED analysis to determine the scale of impacts to the OSE account. Based on the NED and RED results, a qualitative assessment was included for other social effects to water supply.

Data collected from water supply facilities and others was used to determine potential impacts to individual and community well-being, access to safe water sources, and economic vitality. Any changes to these areas of concern that would occur under FPDTR-EIS alternatives were examined to the extent possible. Any potential issues with water quality and treatment were considered a health and safety concern as well. Interviews with a sample of M&I water supply providers were conducted to inform the qualitative discussion of the social and public health effects possible under the FPDTR-EIS alternatives.

5.0 National Economic Development Evaluation Results

The NED analysis for water supply focused on the changes in operational and fixed costs as a result in changing physical conditions along the Missouri River. The results of the H&H modeling showed that water surface elevations would fall below both operating and shut-down elevations for many of the intakes evaluated under all the FPDTR-EIS alternatives including No Action. The impact to water supply operators is an increase or decrease in costs associated with adapting to these changing conditions. Table 3 provides an overall summary of the NED analysis for each of the FPDTR-EIS alternatives. Table 3 summarizes the results for all of the water supply intakes including Tribal intakes in the upper basin over the POR. Total costs over this time period (82 years) range from $7.35 million under Variation 2B to $7.36 million under No Action. Average annual costs range from $89,678 under Variation 2B to $89,812 under No Action. Relative to No Action, all alternatives have a decrease in costs with Variation 2B resulting in the largest decrease in costs (0.2 percent) or $135 fewer on average per year. Alternative 2 showed the least reduction in average costs (0.002 percent) or $2 fewer on average per year.

Table 3. National Economic Development Analysis of FPDTR-EIS Alternatives to Water Supply Access (FY2021 Dollars)

Intakes between Fort Peck Lake and Lake Oahe	No Action Alternative	Alt. 1	Var. 1A	Var. 1B	Alt. 2	Var. 2A	Var. 2B
Variable Costs (POR)[a]	$5,825,893	$5,821,824	$5,823,906	$5,824,707	$5,826,125	$5,819,698	$5,817,547
Fixed Costs (POR)[b]	$1,538,725	$1,537,527	$1,538,200	$1,538,457	$1,538,343	$1,536,782	$1,536,023
Total Costs (POR)	$7,364,619	$7,359,351	$7,362,106	$7,363,163	$7,364,468	$7,356,480	$7,353,570
Difference in Total Costs from No Action	NA	-$5,267	-$2,512	-$1,455	-$151	-$8,139	-$11,049
Percentage Difference in Costs from No Action	NA	-0.1%	-0.03%	-0.02%	-0.002%	-0.1%	-0.2%
Annual Average Total Costs [c]	$89,812	$89,748	$89,782	$89,795	$89,811	$89,713	$89,678
Total Difference in Annual Average Costs from No Action	NA	-$64	-$31	-$18	-$2	-$99	-$135
Difference in Annual Costs per Intake	$3,454	-$2	-$1	-$1	-$0.1	-$4	-$5

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

c Average annual costs are calculated over the 82-year period of record.

5.1 No Action

The No Action Alternative serves as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow.

The NED analysis for No Action is summarized in Table 4. Water supply intake operators would incur an average annual cost of $89,812 to adapt to changing conditions of the river. Total annual costs for all 26 intakes evaluated range over the POR from $31,778 to $239,832. The management actions that would occur under No Action would have negligible to small contribution to the costs to adapt to changing conditions on the Missouri River.

Table 4. Summary of National Economic Development Analysis for No Action (FY2021 Dollars)

Costs	All Intakes
Total Variable Costs (POR)[a]	$5,825,893
Total Fixed Costs (POR)[b]	$1,538,725
Total Costs (POR)	$7,364,619
Annual Average Total Costs [c]	$89,812
Annual Average Total Costs per Intake	$3,454
Maximum Annual Costs	$239,832
Minimum Annual Costs	$31,778

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
c Average annual costs are calculated over the 82-year period of record.

5.2 Alternative 1 including Variations 1A and 1B

5.2.1 Alternative 1

The NED Analysis for Alternative 1 is summarized in Table 5 and Table 6. Table 5 includes a summary of the impacts based on all the years in the period of analysis, whereas Table 6 is based on only those years in which there is a partial or full flow release from Fort Peck. As noted in Table 5, water supply operations along the Missouri River to Lake Oahe would incur on average $89,748 per year to adapt to changing conditions of the river. Total annual costs range from $31,687 to $239,832. This represents an overall small decrease in costs to water supply intakes of 0.1 percent relative to the No Action Alternative.

Table 5. Summary of National Economic Development Analysis for Alternative 1 – All Years in the Period of Record

Costs [a]	All Reaches and Intakes
Total Variable Costs (POR) [b]	$5,821,824
Total Fixed Costs (POR) [c]	$1,537,527
Total Costs (POR)	$7,359,351
Difference in Total Costs from No Action	-$5,267
Percentage Difference from No Action	-0.1%
Annual Average Total Costs [d]	$89,748
Difference in Annual Average Costs from No Action	-$64
Difference in Annual Costs per Intake	-$2
Maximum Annual Costs	$239,832
Minimum Annual Costs	$31,687

a FY 2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 82-year period of record.

As noted in Table 6, in years with a partial or full flow release from Fort Peck, water supply operations along the Missouri River from Fort Peck Lake to Lake Oahe would incur on average $67,468 per year to adapt to changing conditions of the river. Total annual costs range from $41,267 to $98,789. This represents an overall small decrease in costs to water supply intakes of 0.33 percent relative to the No Action Alternative.

Table 6. Summary of National Economic Development Analysis for Alternative 1 – Partial or Full Flow Release Years Only

Costs [a]	All Reaches and Intakes
Total Variable Costs (POR) [b]	$1,748,719
Total Fixed Costs (POR) [c]	$410,264
Total Costs (POR)	$2,158,983
Difference in Total Costs from No Action	-$7,129
Percentage Difference from No Action	-0.33%
Annual Average Total Costs [d]	$67,468
Difference in Annual Average Costs from No Action	-$223
Difference in Annual Costs per Intake	-$8.58
Maximum Annual Costs	$98,789
Minimum Annual Costs	$41,267

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 22 years in which full or partial flow releases occur.

5.2.2 Alternative 1 – Variation 1A

The NED Analysis for Variation 1A is summarized in Table 7 and Table 8. Table 7 includes a summary of all the years in the period of analysis, whereas Table 8 includes only those years in which there is a partial or full flow release from Fort Peck Dam. As noted in Table 7, water supply operations along the Missouri River from Fort Peck to Lake Oahe would incur on average $89,782 per year to adapt to changing conditions of the river. Total annual costs range from $31,943 to $239,832. This represents an overall small decrease in costs to water supply intakes of 0.03 percent relative to the No Action Alternative.

Table 7. Summary of National Economic Development Analysis for Variation 1A – All Years in the Period of Record

Costs [a]	All Reaches and Intakes
Total Variable Costs (POR) [b]	$5,823,906
Total Fixed Costs (POR) [c]	$1,538,200
Total Costs (POR)	$7,362,106
Difference in Total Costs from No Action	-$2,512
Percentage Difference from No Action	-0.03%
Annual Average Total Costs [d]	$89,782
Difference in Annual Average Costs from No Action	-$31
Difference in Annual Costs per Intake	-$1
Maximum Annual Costs	$239,832
Minimum Annual Costs	$31,943

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 82-year period of record.

As noted in Table 8, in years with a partial or full flow release from Fort Peck, water supply operations along the Missouri River from Fort Peck Lake to Lake Oahe would incur on average $68,456 per year to adapt to changing conditions of the river. Total annual costs range from $41,979 to $98,773. This represents an overall small decrease in costs to water supply intakes of 0.13 percent relative to the No Action Alternative.

Table 8. Summary of National Economic Development Analysis for Variation 1A – Partial or Full Flow Release Years Only

Costs [a]	All Reaches and Intakes
Average Annual Variable Costs [b]	$55,440
Average Annual Fixed Costs [c]	$13,015
Annual Average Total Costs [d]	$68,456
Difference in Annual Average Costs from No Action	-$88
Percentage Difference from No Action	-0.13%
Maximum Annual Costs	$98,773
Minimum Annual Costs	$41,979

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 22 years in which full or partial flow releases occur.

5.2.3 Alternative 1 – Variation 1B

The NED Analysis for Variation 1B is summarized in Table 9 and Table 10. Table 9 includes a summary of all the years in the period of analysis, whereas Table 10 includes only those years in which there is a partial or full flow release from Fort Peck. As noted in Table 9, water supply operations along the Missouri River from Fort Peck Lake to Lake Oahe would incur on average $89,795 per year to adapt to changing conditions of the river. Total annual costs range from $35,515 to $240,051. This represents an overall small decrease in costs to water supply intakes of 0.02 percent relative to the No Action Alternative.

Table 9. Summary of National Economic Development Analysis for Variation 1B – All Years in the Period of Record

Costs [a]	All Reaches and Intakes
Total Variable Costs (POR) [b]	$5,824,707
Total Fixed Costs (POR) [c]	$1,538,457
Total Costs (POR)	$7,363,163
Difference in Total Costs from No Action	-$1,455
Percentage Difference from No Action	-0.02%
Annual Average Total Costs [d]	$89,795
Difference in Annual Average Costs from No Action	-$18
Difference in Annual Costs per Intake	-$1
Maximum Annual Costs	$240,051
Minimum Annual Costs	$35,515

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 82 year period of record.

As noted in Table 10, in years with a partial or full flow release from Fort Peck, water supply operations along the Missouri River from Fort Peck Lake to Lake Oahe would incur on average $70,259 per year to adapt to changing conditions of the river. Total annual costs range from $40,734 to $99,109. This represents an overall small decrease in costs to water supply intakes of 0.17 percent relative to the No Action Alternative.

Table 10. Summary of National Economic Development Analysis for Variation 1B – Partial or Full Flow Release Years Only

Costs [a]	All Reaches and Intakes
Average Annual Variable Costs [b]	$56,883
Average Annual Fixed Costs [c]	$13,375
Annual Average Total Costs [d]	$70,259
Difference in Annual Average Costs from No Action	-$123
Percentage Difference from No Action	-0.17%

Costs [a]	All Reaches and Intakes
Maximum Annual Costs	$99,109
Minimum Annual Costs	$40,734

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 24 years in which full or partial flow releases occur.

5.2.4 Summary Results for Alternative 1 including Variations 1A and 1B

Table 11 provides a summary of the NED impacts for Alternative 1 including Variations 1A and 1B in years when a partial or full flow release occurs. Ove all intake locations, annual average costs in partial or full release years would decrease between $88 and $223 (0.13 – 0.33 percent) relative to No Action. Variation 1B has the largest impact on water supply access with a maximum annual cost of $99,109, but this is still below the maximum annual cost for No Action. While water supply intakes would experience small adverse impacts in some years during a partial or full flow release, these would be small, short-term impacts and it is expected that Alternative 1 would not have a significant impact to water supply access. It is also anticipated that Alternative 1 would have negligible RED and OSE impacts.

Table 11. Summary of National Economic Development Analysis for Alternative 1 – Full or Partial Years

Costs*	Alternative 1	Variation 1A	Variation 1B	Range across the alternative and variants
Annual Average Total Costs [a]	$67,468	$68,456	$70,259	$2,791
Difference in Annual Average Costs from No Action	-$223	-$88	-$123	$135
Percentage Difference from No Action	-0.33%	-0.13%	-0.17%	0.26%
Difference in Annual Costs per Intake	-$8.58	-$3.38	-$4.73	$5.2
Maximum Annual Costs	$98,789	$98,773	$99,109	$336
Minimum Annual Costs	$41,267	$41,979	$40,734	$1,245

* FY2021 Dollars.
a Average annual costs are calculated over the 22-24 years in which full or partial flow releases occur, depending on the Alternative or Variation.

5.2.5 Annual Impacts for Alternative 1 including Variations 1A and 1B

5.2.5.1 Alternative 1

When evaluating the impacts for each of the FPDTR-EIS alternatives, it is helpful to also examine the annual impacts. Figure 10 shows the annual NED impacts to water supply intakes, including Tribal intakes, in the upper river for Alternative 1 relative to No Action. The differences in annual NED costs between No Action and Alternative 1 are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences in annual costs for water supply access range from a reduction in costs of $3,388 in 1984 to an increase in costs of $2,178 in 1985.

Figure 10 shows that intakes are experiencing cost increases in more years than cost decreases for Alternative 1 relative to No Action. However, the overall costs are dominated by four years when costs would decrease by more than $1,000 relative to No Action. These impacts are occurring in years with partial or full releases, or years following a release. Intakes under Alternative 1 experience reductions in average annual costs of $2 relative to the No Action Alternative.

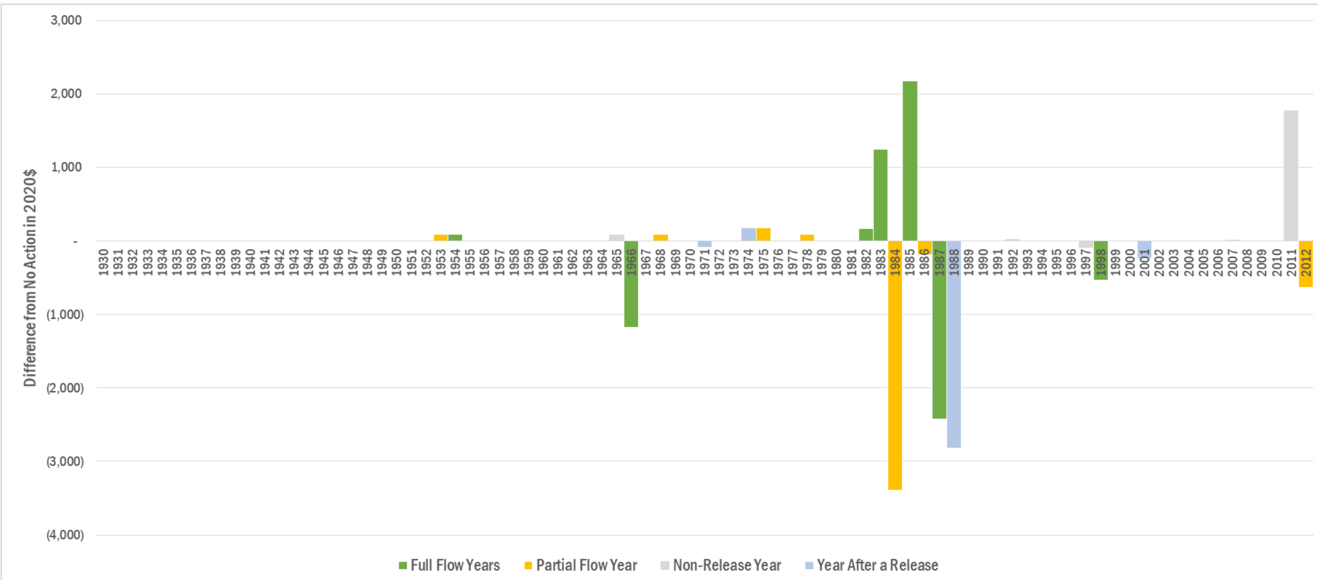

Figure 10. Difference Costs under Alternative 1 from No Action Alternative for Water Supply Access from Fort Peck to Oahe (FY2021 Dollars)

5.2.5.2 Alternative 1 – Variation 1A

Figure 11 shows the annual NED impacts to water supply intakes, including Tribal intakes, in the upper river for Variation 1A relative to No Action. The differences in annual NED costs between No Action and Variation 1A are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences in annual costs for water supply access range from a reduction in costs of $5,249 in 1976 to an increase in costs of $4,803 in 1995.

Figure 11 shows that while intakes are experiencing cost increases in more years than cost decreases for Variation 1A relative to No Action, most years do not show a significant difference between Variation 1A relative to No Action. Two exceptions are the $5,249 reduction in costs relative to No Action in 1976 and the increase $4,803 increase in costs relative to No Action in 1995.These impacts are occurring in years with partial or full releases, or years following a release. Intakes under Variation 1A experience reductions in average annual costs of $1 relative to the No Action Alternative.

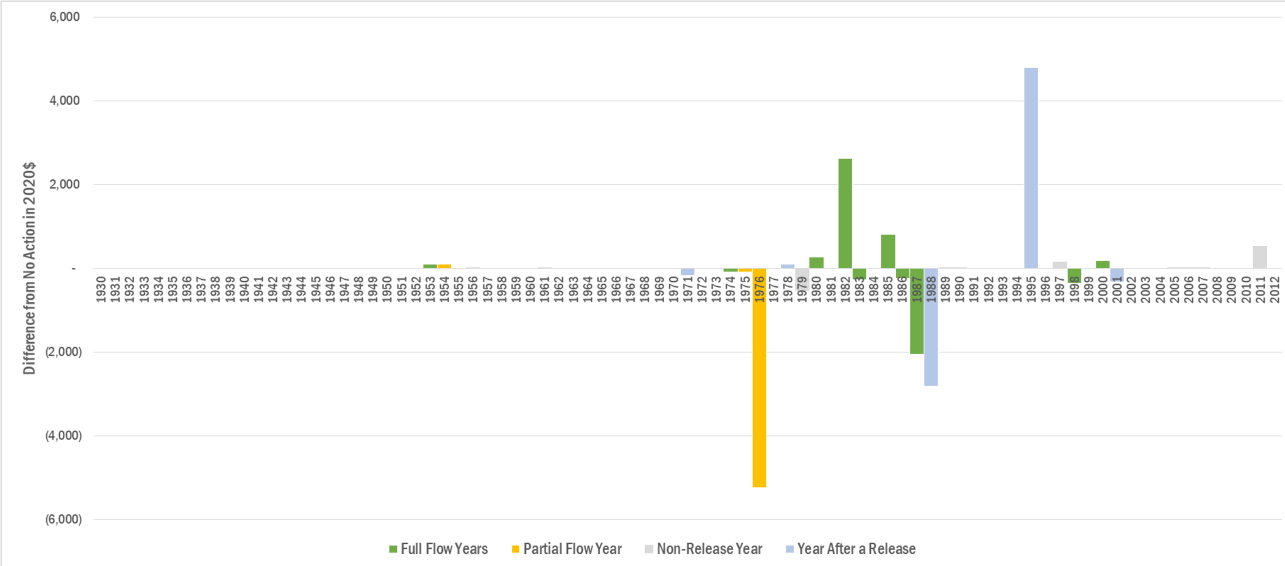

Figure 11. Difference Costs under Variation 1A from No Action Alternative for Water Supply Access from Fort Peck to Oahe (FY2021 Dollars)

5.2.5.3 Alternative 1 – Variation 1B

Figure 12 shows the annual NED impacts to water supply intakes, including Tribal intakes, in the upper river for Variation 1B relative to No Action. The differences in annual NED costs between No Action and Variation 1B are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences in annual costs for water supply access range from a reduction in costs of $4,455 in 1984 to an increase in costs of $3,737 in 1997.

Figure 12 shows that while intakes are experiencing cost increases in more years than cost decreases for Variation 1B relative to No Action, most years do not show a significant difference between Variation 1B relative to No Action. There are exceptions in 1984, 1987, and 1988 when costs decrease more than $2,000 relative to No Action and exceptions in 1982, 1985, and 1997 when costs increase more than $2,000 relative to No Action. These impacts are primarily occur in years with partial or full releases, or years following a release, except for the increase in 1997 which is a non-release year. Intakes under Variation 1B experience reductions in average annual costs of $1 relative to the No Action Alternative.

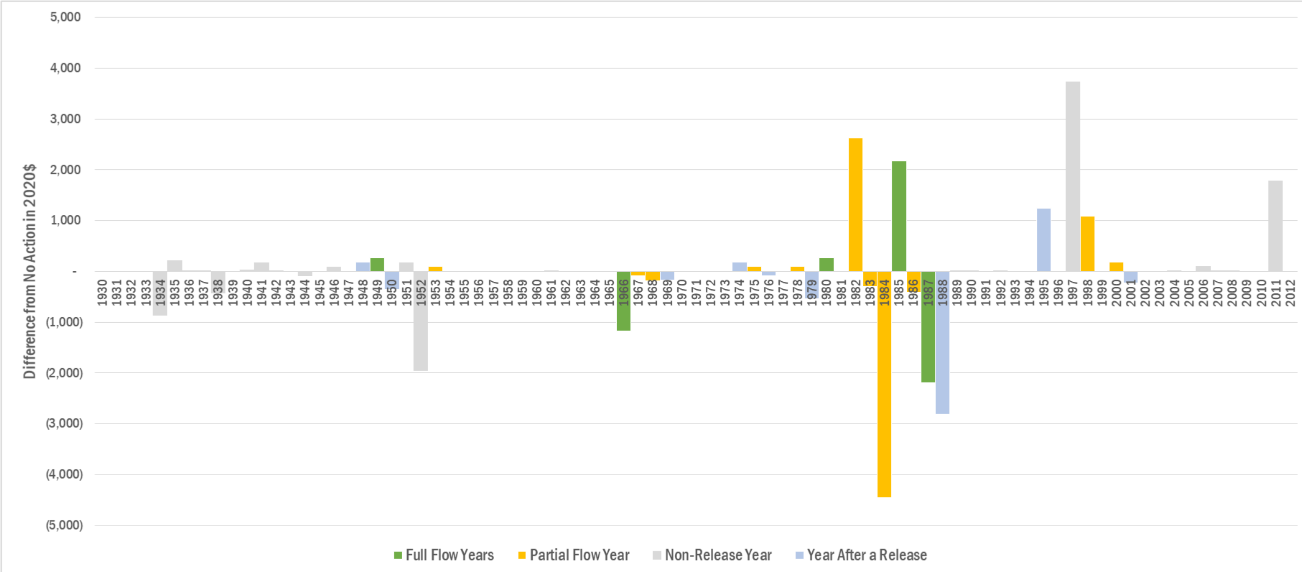

Figure 12. Difference Costs under Variation 1B from No Action Alternative for Water Supply Access from Fort Peck to Oahe (FY2021 Dollars)

5.2.6 Summary of Annual Impacts for Alternative 1 including Variations 1A and 1B

In comparing the annual impacts over the POR across all variations of Alternative 1, the differences in costs relative to No Action are similar. Differences in costs for water supply access across Alternative 1 variations relative to No Action range from a reduction in costs of $5,249 under Variation 1A in 1976 to an increase in costs of $4,803 under Variation 1A in 1995.

Across all variations of Alternative 1, intakes are experiencing cost increases in more years than cost decreases for relative to No Action. However, the average annual costs are dominated by years when costs would decrease relative to No Action.

5.3 Alternative 2 including Variations 2A and 2B

5.3.1 Alternative 2

The NED Analysis for Alternative 2 is summarized in
Table 12 and Table 13.
Table 12 includes a summary of all the years in the period of analysis, whereas Table 13 includes only those years in which there is a partial or full flow release from Fort Peck. As noted in
Table 12, water supply operations along the Missouri River from Fort Peck Lake to Lake Oahe would incur an average of $89,811 per year to adapt to changing conditions of the river. Total annual costs range from $32,121 to $239,832. This represents an overall small decrease in costs to water supply intakes of 0.002 percent relative to the No Action Alternative.

Table 12. Summary of National Economic Development Analysis for Alternative 2 – All Years in the Period of Record

Costs [a]	All Reaches and Intakes
Total Variable Costs (POR) [b]	$5,826,125
Total Fixed Costs (POR) [c]	$1,538,343
Total Costs (POR)	$7,364,468
Difference in Total Costs from No Action	-$151
Percentage Difference from No Action	-0.002%
Annual Average Total Costs [d]	$89,811
Difference in Annual Average Costs from No Action	-$2
Difference in Annual Costs per Intake	-$0.1
Maximum Annual Costs	$239,832
Minimum Annual Costs	$32,121

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 82-year period of record.

As noted in Table 13, in years with a partial or full flow release from Fort Peck, water supply operations from Fort Peck Lake to Lake Oahe would incur on average $67,839 per year to adapt to changing conditions of the river. Total annual costs range from $41,267 to $98,764. This represents an overall small decrease in costs to water supply intakes of 0.25 percent relative to the No Action Alternative.

Table 13. Summary of National Economic Development Analysis for Alternative 2 – Partial or Full Flow Release Years Only

Costs [a]	All Reaches and Intakes
Average Annual Variable Costs [b]	$54,951
Average Annual Fixed Costs [c]	$12,888
Annual Average Total Costs [d]	$67,839
Difference in Annual Average Costs from No Action	-$173
Percentage Difference from No Action	-0.25%
Maximum Annual Costs	$98,764
Minimum Annual Costs	$41,267

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 20 years in which full or partial flow releases occur.

5.3.2 Alternative 2 – Variation 2A

The NED Analysis for Variation 2A is summarized in Table 14 and
Table 15. Table 14 includes a summary of all the years in the period of analysis, whereas Table 15 includes only those years in which there is a partial or full flow release from Fort Peck. As noted in Table 14, water supply operations along the Missouri River from Fort Peck Lake to Lake Oahe would incur on average $89,713 per year to adapt to changing conditions of the river. Total annual costs range from $33,045 to $239,832. This represents an overall small decrease in costs to water supply intakes of -0.1 percent relative to the No Action Alternative.

Table 14. Summary of National Economic Development Analysis for Variation 2A – All Years in the Period of Record

Costs [a]	All Reaches and Intakes
Total Variable Costs (POR) [b]	$5,819,698
Total Fixed Costs (POR) [c]	$1,536,782
Total Costs (POR)	$7,356,480
Difference in Total Costs from No Action	-$8,139
Percentage Difference from No Action	-0.1%
Annual Average Total Costs [d]	$89,713
Difference in Annual Average Costs from No Action	-$99
Difference in Annual Costs per Intake	-$4
Maximum Annual Costs	$239,832
Minimum Annual Costs	$33,045

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 82-year period of record.

As noted in
Table 15, in years with a partial or full flow release from Fort Peck, water supply operations along the Missouri River to Lake Oahe would incur on average $68,388 per year to adapt to changing conditions of the river. Total annual costs range from $41,979 to $98,764. This represents an overall small decrease in costs to water supply intakes of 0.79 percent relative to the No Action Alternative.

Table 15. Summary of National Economic Development Analysis for Variation 2A – Partial or Full Flow Release Years Only

Costs [a]	All Reaches and Intakes
Average Annual Variable Costs [b]	$55,393
Average Annual Fixed Costs [c]	$12,995
Annual Average Total Costs [d]	$68,388
Difference in Annual Average Costs from No Action	-$547
Percentage Difference from No Action	-0.79%
Maximum Annual Costs	$98,764
Minimum Annual Costs	$41,979

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 20 years in which full or partial flow releases occur.

5.3.3 Alternative 2 – Variation 2B

The NED Analysis for Variation 2B is summarized in Table 16 and Table 17. Table 16 includes a summary of all the years in the period of analysis, whereas Table 17 includes only those years in which there is a partial or full flow release from Fort Peck. As noted in Table 16, water supply operations along the Missouri River to Lake Oahe would incur on average $89,678, per year to adapt to changing conditions of the river. Total annual costs range from $32,564 to $240,074. This represents an overall small decrease in costs to water supply intakes of 0.2 percent relative to the No Action Alternative.

Table 16. Summary of National Economic Development Analysis for Variation 2B – All Years in the Period of Record

Costs [a]	All Reaches
Total Variable Costs (POR) [b]	$5,817,547
Total Fixed Costs (POR) [c]	$1,536,023
Total Costs (POR)	$7,353,570
Difference in Total Costs from No Action	-$11,049
Percentage Difference from No Action	-0.2%
Annual Average Total Costs [d]	$89,678
Difference in Annual Average Costs from No Action	-$135
Difference in Annual Costs per Intake	-$5
Maximum Annual Costs	$240,074
Minimum Annual Costs	$32,564

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 82-year period of record.

As noted in Table 17, in years with a partial or full flow release from Fort Peck, water supply operations from Fort Peck Lake to Lake Oahe would incur on average $69,947 per year to adapt to changing conditions of the river. Total annual costs range from $41,267 to $98,857. This represents an overall small decrease in costs to water supply intakes of 0.62 percent relative to the No Action Alternative.

Table 17. Summary of National Economic Development Analysis for Variation 2B – Partial or Full Flow Release Years Only

Costs [a]	All Reaches and Intakes
Average Annual Variable Costs [b]	$56,639
Average Annual Fixed Costs [c]	$13,307
Annual Average Total Costs [d]	$69,947
Difference in Annual Average Costs from No Action	-$434
Percentage Difference from No Action	-0.62%
Maximum Annual Costs	$98,857
Minimum Annual Costs	$41,267

a FY2021 Dollars.
b Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.
c Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.
d Average annual costs are calculated over the 24 years in which full or partial flow releases occur.

5.3.4 Summary of Results for Alternative 2 including Variations 2A and 2B

Table 18 provides a summary of the NED impacts for Alternative 2 including Variations 2A and 2B in years when a partial or full flow release occurs. Over all intake locations, annual average costs in partial or full release years would decrease between $173 and $547 (0.25 – 0.79 percent) relative to No Action. Alternative 2 and Variation 2A has the largest impact on water supply access with maximum annual costs of $98,764 for both, but this is still below the maximum annual cost for No Action. While water supply intakes would experience small adverse impacts in some years during a partial or full flow release, these would be small, short-term impacts and it is expected that Alternative 2 would not have a significant impact to water supply access. It is also anticipated that Alternative 2 would have negligible RED and OSE impacts.

Table 18. Summary of National Economic Development Analysis for Alternative 2 – Full or Partial Years

Costs*	Alternative 2	Variation 2A	Variation 2B	Range across the alternative and variants
Annual Average Total Costs [a]	$67,839	$68,388	$69,947	$2,108
Difference in Annual Average Costs from No Action	-$173	-$547	-$434	$374
Percentage Difference from No Action	-0.25%	-0.79%	-0.62%	0.54%
Difference in Annual Costs per Intake	-$6.65	-$21.04	-$16.69	$14.39
Maximum Annual Costs	$98,764	$98,764	$98,857	$93
Minimum Annual Costs	$41,267	$41,979	$41,267	$712

* FY2021 Dollars.
a Average annual costs are calculated over the 20-24 years in which full or partial flow releases occur, depending

on the Alternative or Variation.

5.3.5 Annual Impacts for Alternative 2 including Variations 2A and 2B

5.3.5.1 Alternative 2

When evaluating the impacts for each of the FPDTR-EIS alternatives, it is helpful to also examine the annual impacts. Figure 13 shows the annual NED impacts to water supply intakes, including Tribal intakes, in the upper river for Alternative 2 relative to No Action. The differences in annual NED costs between No Action and Alternative 2 are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences in annual costs for water supply access range from a reduction in costs of $4,990 in 1988 to an increase in costs of $5,462 in 1983.

Figure 13 shows that while intakes are experiencing cost increases in more years than cost decreases for Alternative 2 relative to No Action, most years do not show a significant difference between Alternative 2 relative to No Action. There are exceptions in 1984 and 1988 when costs decrease more than $4,000 relative to No Action and exceptions in 1983 and 2005 when costs increase more than $4,000 relative to No Action. These impacts are primarily occurring in years with partial or full releases, or years following a release, except for the increase in 2005, which occurs in a non-release year. Intakes under Alternative 2 experience reductions in average annual costs of $0.1 relative to the No Action Alternative.

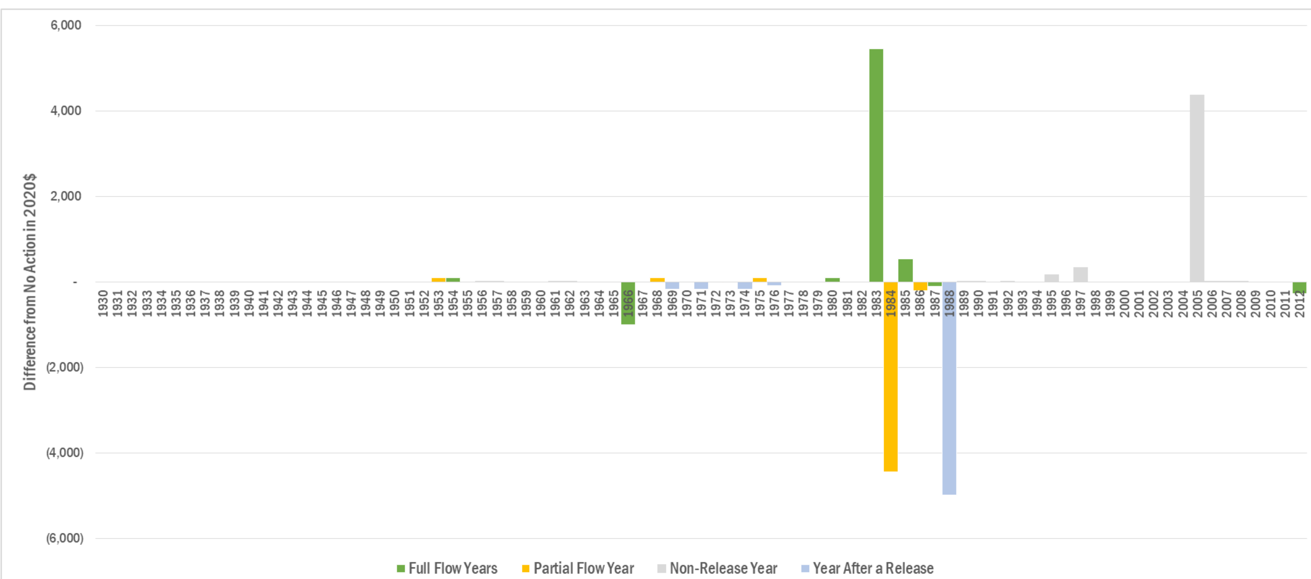

Figure 13. Difference Costs under Alternative 2 from No Action Alternative for Water Supply Access from Fort Peck to Oahe (FY2021 Dollars)

5.3.5.2 Alternative 2 – Variation 2A

Figure 14 shows the annual NED impacts to water supply intakes, including Tribal intakes, in the upper river for Variation 2A relative to No Action. The differences in annual NED costs between No Action and Variation 2A are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences in annual costs for water supply access range from a reduction in costs of $5,262 in 1988 to an increase in costs of $4,389 in 2005.

Figure 14 shows that intakes are experiencing cost increases in more years than cost decreases for Variation 2A relative to No Action. However, the overall costs are dominated by three years when costs would decrease by more than $4,000 relative to No Action, with only one year, 2005, where the costs increase more than $4,000 relative to No Action. These impacts are occurring in years with partial or full releases, or years following a release, except for the increase in 2005, which occurs in a non-release year. Intakes under Variation 2A experience reductions in average annual costs of $4 relative to the No Action Alternative.

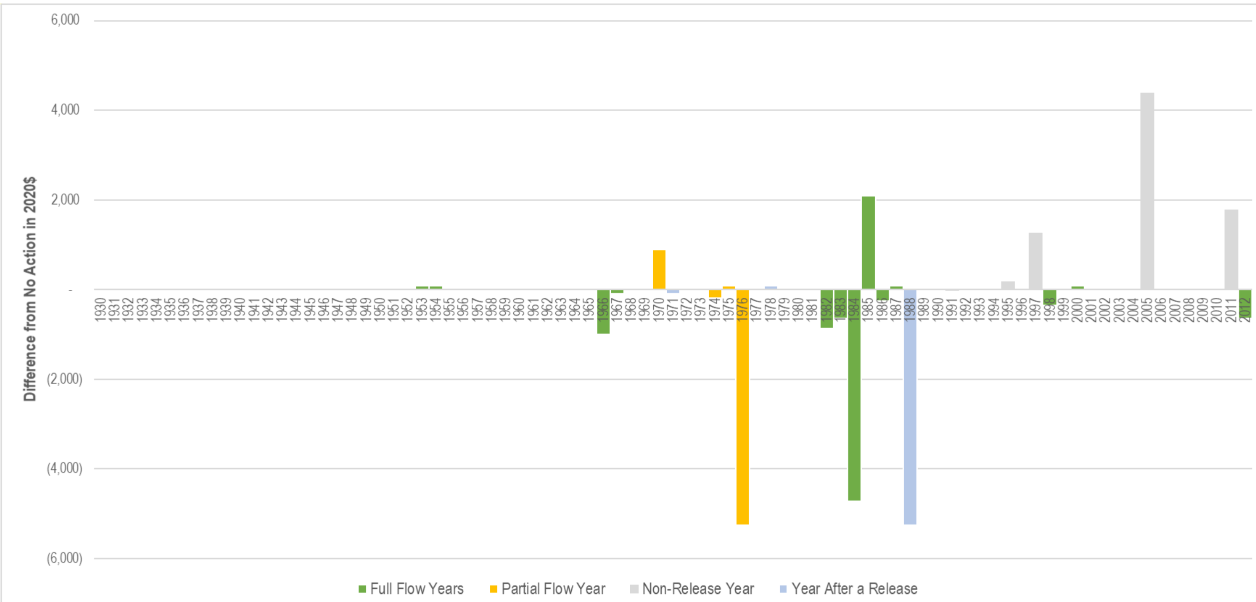

Figure 14. Difference Costs under Variation 2A from No Action Alternative for Water Supply Access from Fort Peck to Oahe (FY2021 Dollars)

5.3.5.3 Alternative 2 – Variation 2B

Figure 15 shows the annual NED impacts to water supply intakes, including Tribal intakes, in the upper river for Variation 2B relative to No Action. The differences in annual NED costs between No Action and Variation 2B are plotted and color-coded based on the type of release occurring each year (full release year, partial release year, non-release year, and year after a release). Differences in annual costs for water supply access range from a reduction in costs of $5,601 in 1987 to an increase in costs of $4,389 in 2005.

Figure 15 shows that intakes are experiencing cost increases in more years than cost decreases for Variation 2B relative to No Action. However, the overall costs are dominated by three years when costs would decrease by more than $4,000 relative to No Action, with only one year, 2005, where the costs increase more than $4,000 relative to No Action. These impacts are occurring in years with partial or full releases, or years following a release, except for the increase in 2005, which occurs in a non-release year. Intakes under Variation 2B experience reductions in average annual costs of $5 relative to the No Action Alternative.

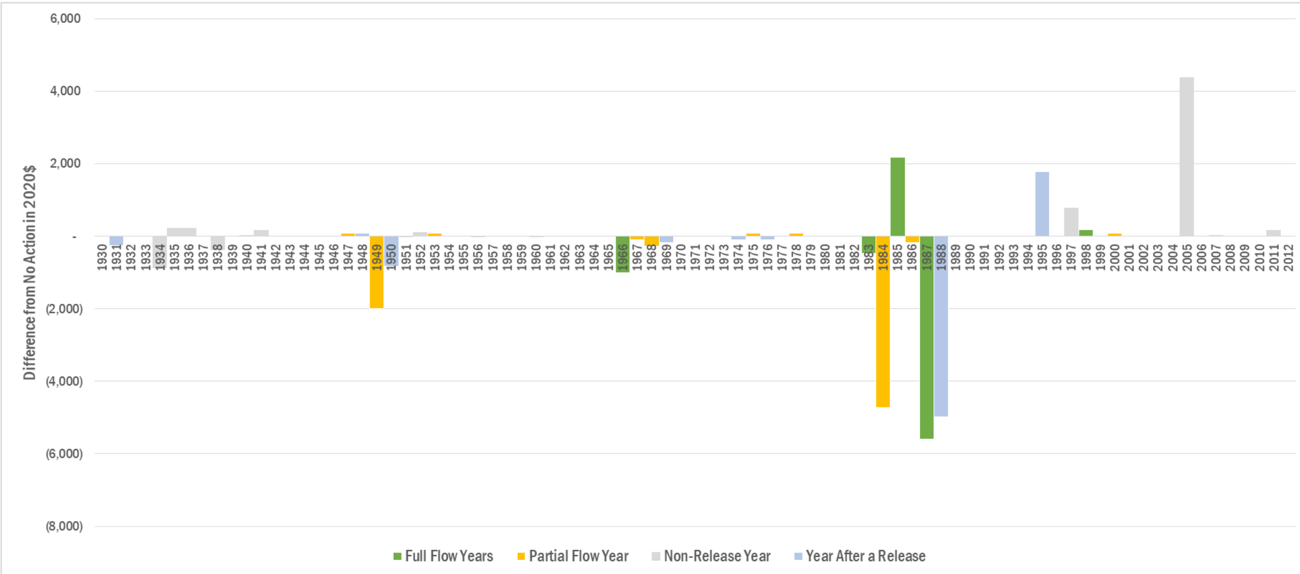

Figure 15. Difference Costs under Variation 2B from No Action Alternative for Water Supply Access from Fort Peck to Oahe (FY2021 Dollars)

5.3.6 Summary of Annual Impacts for Alternative 2 including Variations 2A and 2B

In comparing the annual impacts over the POR across all variations of Alternative 2, the differences in costs relative to No Action are similar. Differences in costs for water supply access across Alternative 2 variations relative to No Action range from a reduction in costs of $5,601 under Variation 2B in 1987 to an increase in costs of $5,462 under Alternative 2 in 1983.

Across all variations of Alternative 2, intakes are experiencing cost increases in more years than cost decreases for relative to No Action. However, the average annual costs are dominated by years when costs would decrease relative to No Action.

6.0 Regional Economic Development Evaluation Results

The RED analysis focused on whether changes in costs to water supply intakes due to the FPDTR-EIS alternatives would have a measurable impact on water rates to local customers. A qualitative discussion of the RED impacts on water supply intakes is provided in Chapter 3, Section 3.18 of the FPDTR-EIS.

7.0 Other Social Effects Results

The OSE analysis for water supply relied on the results of the NED and RED analysis to determine the scale of impacts that could occur to individual and community well-being, access to safe water sources, and economic vitality. A qualitative discussion of the OSE impacts on water supply intakes is provided in Chapter 3, Section 3.18 of the FPDTR-EIS.

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Fort Peck Flows and Environmental Impact Statement

Recreation
Environmental Consequences Analysis

Technical Report

August 2021

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Acronyms and Abbreviations

AIC	Akaike Information Criteria
BiOp	2003 Amended Biological Opinion
cfs	cubic feet per second
EGM	Economic Guidance Memorandum
EIS	environmental impact statement
EQ	environmental quality
ER	Engineering Regulation
ESA	Endangered Species Act
ESH	emergent sandbar habitat
FPDTR	Fort Peck Dam Test Release
GDP	gross domestic product
H&H	hydrologic and hydraulic (Model)
HC	human considerations
HEC	Hydrologic Engineering Center
MRRMP	Missouri River Recovery Management Plan
MRRP	Missouri River Recovery Program
NED	national economic development
OHV	off-highway vehicle
OMBIL	Operations and Maintenance Business Information Link
OMRR&R	operation, maintenance, repair, replacement, and rehabilitation
OSE	other social effects
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
POR	period of record
RAS	River Analysis System
RECONS	Regional Economic System
RED	regional economic development
ResSim	Reservoir System Simulation
RPA	reasonable and prudent alternative
RR&R	repair, replacement, and rehabilitation
TCM	travel cost method
UDV	unit day value
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VERS	Visitation Estimating and Reporting System

VIF	variable inflation factor

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1.0 Introduction

The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Fort Peck Dam Test Releases – Environmental Impact Statement (FPDTR – EIS). The purpose of the Environmental Impact Statement (EIS) is to assess the potential impacts of a range of test flow release alternatives from Fort Peck dam designed to benefit reproduction and recruitment of pallid sturgeon to avoid jeopardizing their continued existence in the Missouri River.

The purpose of the Recreation Technical Report is to provide additional information on the impact analysis and results relevant to water supply that was completed for the FPDTR-EIS. Additional details on the National Economic Development (NED) methodology and results are provided in this technical report. The Other Social Effects (OSE) are presented in the FPDTR-EIS, Chapter 3 Environmental Consequences, Section 3.18 Recreation. No Environmental Quality (EQ) analysis was undertaken for Recreation.

1.1 Summary of Alternatives

The FPDTR-EIS evaluates the following alternatives. A detailed description of the alternatives is provided in Chapter 2 of the FPDTR-EIS.

No Action Alternative: The impacts of the No Action Alternative serve as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. When modeling the No Action Alternative, local inflows are adjusted by the difference between the historic and present level depletions to ensure the period-of-record (POR) datasets are homogenous and reflect current water use. All modeled flood targets are as outlined in the 2018 Master Manual (USACE,2018) and reservoir storages are based on current reservoir surveys. All four navigation target locations are used when setting navigation releases and the model balances system storage by March 1. It is assumed that other activities and actions for pallid sturgeon in the Upper Basin would be implemented as described in the FPDTR-EIS and 2018 Biological Opinion and the Yellowstone Intake Bypass EIS. These actions include fish bypass construction at Yellowstone Intake, continued propagation and stocking of pallid sturgeon in the Upper Basin, and continued pallid sturgeon science and monitoring activities in the Upper Basin.

Alternative 1: System operations under this alternative are based on those described under the No Action Alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon.

The attraction flow regime begins on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in the given year. For example, the typical early spring release from Fort Peck Dam is approximately 8,000 cubic feet per second (cfs); therefore, the attraction flow regime peak flow would be 16,000 cfs as measured at the Wolf Point gage. Beginning on April 16, spring release flows are increased by 1,700 cfs per day until the peak flow is reached at the Wolf Point gage. The peak flow is held for 3 days and then decreases by 1,300 cfs per day until the retention flow is reached. The retention flow is 1.5 times the Fort Peck Dam early spring release as measured at the Wolf Point gage, 12,000 cfs using the example. The retention flow is held until May 28 when the spawning cue flow regime is initiated.

The spawning cue flow regime under Alternative 1 begins on May 28 and is 3.5 times the Fort Peck Dam spring flow release in the given year. Assuming 8,000 cfs as the typical spring flow, this equates to approximately 28,000 cfs at the peak as measured at the Wolf Point gage. Beginning on May 28, the release is increased by 1,100 cfs per day until the peak flow is reached as measured at the Wolf Point gage. The peak is held for 3 days and then decreases by 1,000 cfs per day for 12 days, then decreases by 3,000 cfs per day until the drifting flow regime of 8,000 cfs is reached. The 8,000 cfs drifting flow regime is held until September 1 when releases to balance storage resume.

Variation 1A: This test flow is a variation of Alternative 1. The parameters for Variation 1A are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The April 9 initiation date is closer to the timing of the initial pulse shown on the unregulated hydrograph. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases. In Alternative 1, the later initiation date of April 16 is designed to enhance the contrast between Missouri River and Yellowstone River discharges by moving the start date approximately two weeks later than the initial pulse shown on the unregulated hydrograph.

Variation 1B: This test flow is another variation of Alternative 1. The parameters for Variation 1B are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 23 and the spawning cue flow regime is initiated on June 4. Similar to the concept described in 1A, the later initiation date is intended to provide contrast and explore any differences in forecasted impacts from a later flow initiation date.

Alternative 2: The parameters for Alternative 2 are the same as described for Alternative 1 except that the attraction flow regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at the Wolf Point gage are held at 14,000 cfs until the spawning cue flow release is initiated. The rationale for keeping the releases high through this period—foregoing the inter-pulse saddle—is the hypothesis that persistent high flows are needed to hold migrated, reproductive adult pallid sturgeon upstream near the dam.

Variation 2A: This test flow is a variation of Alternative 2. The parameters for Variation 2A are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The difference in timing follows the same reasoning as described for Variation 1A.

Variation 2B: This test flow is another variation of Alternative 2. The parameters for Variation 2B are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 23, rather than April 16, and the spawning cue flow regime is initiated on June 4, rather than May 21. The difference in timing follows the same reasoning as described for Variation 1B.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the FPDTR-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the FPDTR-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR 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 FPDTR-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 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 RED account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The EQ account displays non-monetary effect of significant natural and cultural resources.
- The OSE account registers plan effects from perspective 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 recreation include NED, RED, and OSE.

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

The Missouri River and its surrounding floodplain support a wide range of recreational activities. These include both land and water-based activities, such as camping; swimming; floating; boating; sightseeing; picnicking; hiking; fishing; and hunting. The environmental consequences evaluation to recreational opportunities and experiences as a result of the FPDTR-EIS alternatives requires an understanding of how the physical conditions of the river would change under each of the FPDTR-EIS alternatives. The conceptual flow chart shown in Figure 1 demonstrates, in a stepwise manner, how changes in the physical conditions of the Missouri River and its floodplain can impact recreation along the river.

The recreation analysis assessed how changes in physical river and reservoir conditions under the FPDTR-EIS alternatives would affect visitation from Fort Peck Lake to Lake Oahe over the period of record (POR) between 1931 and 2012. The estimated changes in visitation for the river reaches and the lower three reservoirs were evaluated based on boat ramp operability. For the upper three reservoirs, multiple regressions were undertaken to identify the best explanatory variables and to estimate annual visitation at the reservoirs under the FPDTR-EIS alternatives. The results of this analysis served as inputs in the NED, RED, and OSE evaluations.

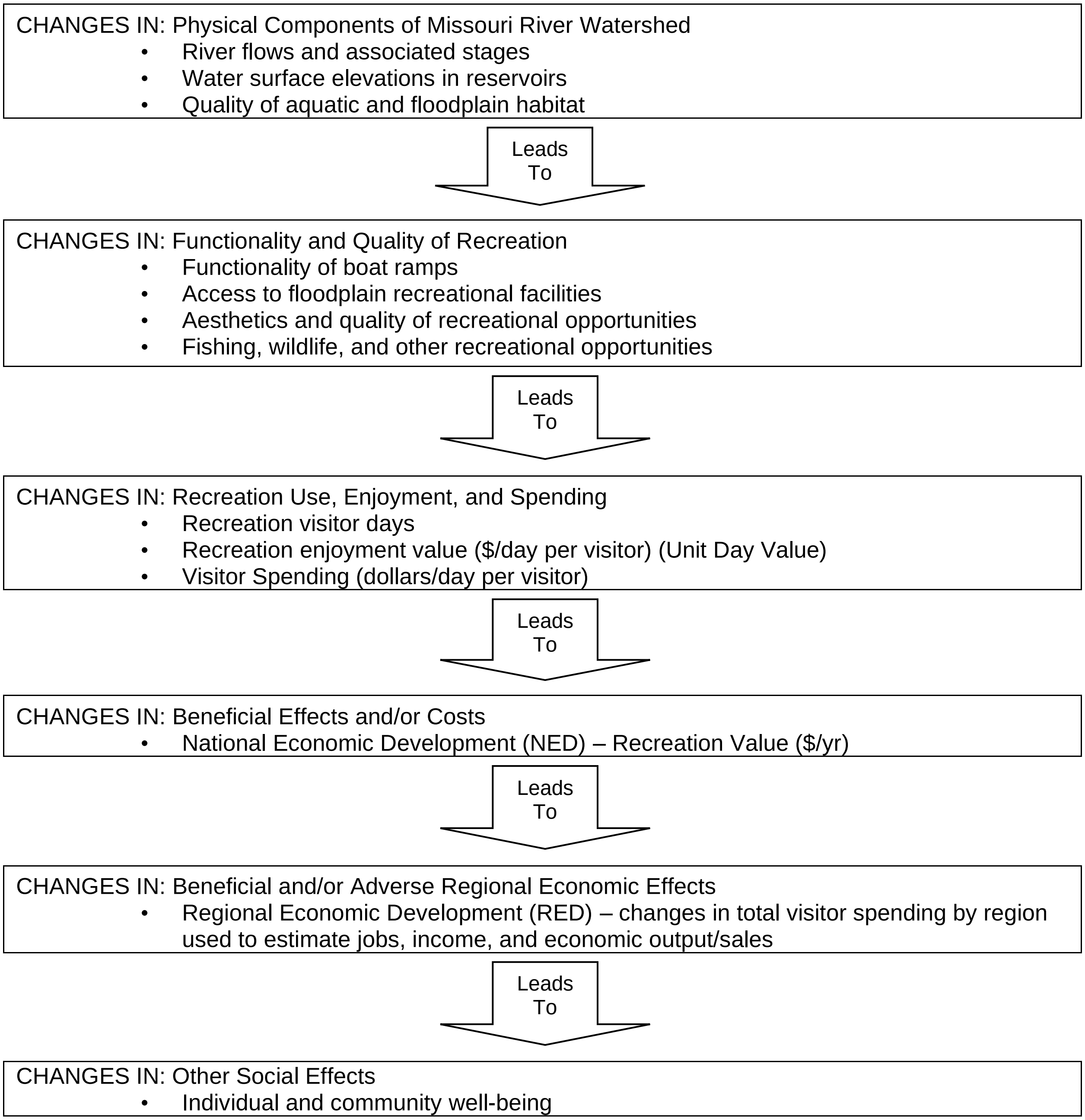

Figure 1. Flow Chart of Inputs Considered in Recreation Evaluation

2.0 Methodology and Assumptions

The methodology includes a summary of assumptions and risk and uncertainty considerations. The initial step in the process, evaluating the relationship between river conditions and recreational opportunities and experiences, is then described, as well as the subsequent steps to assess the NED, RED, and OSE impacts.

2.1 Assumptions

In modeling the environmental consequences to recreation from the FPDTR-EIS alternatives, the project team established a set of assumptions, which are described below.

- The analysis uses data from the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) and Hydrologic Engineering Center Reservoir Simulation (HEC-RESSIM) of the river and reservoir system. The analysis assumes that the HEC-RAS models reasonably estimate river flows and reservoir levels over the 82-year POR under each of the FPDTR-EIS alternatives as well as for the No Action Alternative.
- Baseline visitation data was used from a number of sources and is assumed to represent accurate visitation to the river and reservoirs.
- It is assumed that the boat ramp operability is an indicator of plan-affected visitation in some locations. Visitation is assumed to be proportionally impacted depending on the operability of boat ramps in the river reaches and winter visitation at the reservoirs.

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 FPDTR-EIS 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 POR. 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 recreation model described is this document. The project team has attempted to address risk and uncertainty in the FPDTR-EIS 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 recreation along the Missouri River.

A source of uncertainty associated with the recreation analysis is predicting how visitors would react to changes in river and reservoir conditions. The project team has utilized information collected during the Missouri River Recovery Management Plan-Environmental Impact Statement (MRRMP-EIS) recreation evaluation from interviews with recreation, wildlife, and natural resource management specialists along the river to assess how adverse effects would affect recreation use. It may be possible that prolonged adverse river or reservoir conditions may have long-term impacts to visitation and associated businesses that support visitors, especially in the upper three reservoirs where drought conditions have adverse impacts to recreation.

2.3 Evaluation of River and Reservoir Conditions for Recreation

The purpose of this analysis is to link hydraulic and hydrologic (H&H) modeling efforts, which simulate river operations of the Missouri River under each of the FPDTR-EIS alternatives, with the economic analysis necessary to estimate the consequences to recreation. Specialized software was used to simulate river and reservoir operations for planning studies and decision support developed by the Institute for Water Resources, Hydrologic Engineering Center. HEC-RAS and Reservoir System Simulation (HEC-ResSim) models were used to provide a profile of river conditions at locations that approximately correspond to recreational areas within river reaches and upper three reservoirs. The analysis used Microsoft Excel® to evaluate potential effects of changes in river flows, river stages and reservoir elevations on recreation visitation under the FPDTR-EIS alternatives.

2.3.1 Boat Ramp Operability

Visitation to the upper Missouri River is influenced in part on the accessibility of boat ramps at the upper three reservoirs and the inter-reservoir river reaches. Thus, boat ramp operability can be an indicator for river and reservoir access. An Excel®-based model was developed to estimate how often boat ramps would be accessible based on the top and bottom operating elevations of boat ramps relative to the river stages and reservoir pool elevations modeled for different flow regimes under the FPDTR-EIS alternatives. When flows or reservoir elevations are above the boat ramp operating elevations, the water levels may be too high for the boat ramps to be accessible. Similarly, when river stages and reservoir elevations are below the operating elevations, access to the river and reservoirs decreases as launches from boat ramps become more difficult. The “operable” condition is defined as the number of total days when the river stages or reservoir elevations are between the top and bottom operating elevation of the boat ramp. At the upper three reservoirs, there are both “normal water” and “low-water” boat ramps.

Boat ramp data, including the river mile for boat ramps, longitude and latitude coordinates, and top and bottom elevations was provided by the USACE Omaha District as well as various state and local governments. A list of the sources contacted to obtain boat ramp data is provided in the MRRMP-FEIS Recreation Environmental Consequences Technical Report (USACE 2019a). In addition, the latest boat ramp data was obtained from the natural resource managers at Fort Peck Lake (McMurry 2019). The number of boat ramps with useable data for each of the reservoirs and river reaches is provided in Table 1.

The bottom elevation of the ramp was assumed to be the lowest engineered elevation of the ramp. Minimum operating boat ramp elevations need to account for the draft of boat, the vertical distance between the waterline and the bottom of the hull of the boat. The approximate draft of a typical boat on the upper Missouri River was estimated to be 3 feet (Peake pers. comm. 2014). Therefore, the bottom engineered elevation of each boat ramp was increased by 3 feet to estimate the bottom operating elevation of the boat ramp. There were a few instances (less than one percent), where the top and bottom elevations of the boat ramps were less than 3 feet apart. In these cases, engineered bottom elevation of the ramp was used.

Table 1. Number of Total Boat Ramps in the Recreation Analysis

Reservoir or River Reach	Number of Boat Ramps
Fort Peck Lake	21
Fort Peck Dam to Lake Sakakawea	7
Lake Sakakawea	87
Garrison Dam to Lake Oahe	8
Lake Oahe	68
Total Boat Ramps	191

Two seasons were defined for the evaluation as: 1) spring, summer, and fall; and 2) winter. The seasons were defined from information obtained from natural resource managers at the reservoirs and other recreation area managers. For the upper Missouri River, the spring, summer, and fall was defined as between April 1st and November 30th, and the winter season occurs between December 1st and March 31st. Because some of the visitation data was only available on an annual basis, the spring, summer, and fall season was defined broadly to include most of the peak season visitors.

Some boat ramps were identified as being used in the winter to access frozen reservoirs, primarily for ice fishing. In the winter, when the lake is frozen, boat ramps can be used when the lake falls to the bottom of the engineered elevation of the ramp. In some cases, visitors in the winter can access the lakes through the shore and without the use the boat ramps; however, when lake elevations fall, there are longer distances to travel to the lakes and other impediments to access (i.e., snow fields, etc.) which can limit access during these conditions. The project team worked with recreation specialists to identify which boat ramps on the reservoirs were used for winter recreation (Longhenry pers. comm. 2015a). The bottom engineered elevations of these normal boat ramps were used to estimate impacts to visitation in the winter season at the upper three reservoirs.

The analysis of boat ramp operability used an Excel®-based model to compare the top and bottom operating elevations of 191 boat ramps to the HEC-RAS daily stage in the cross section closest to each boat ramp; for Fort Peck Lake, the RES-SIM reservoir elevations were used to estimate winter boat ramp operability. The model calculated the number of days that stages or elevations at a ramp were within the top and bottom operating elevations or “operable” during each season. An evaluation of boat ramp operability at Fort Peck Lake under the No Action and action alternatives is provided in Appendix A of this report.

2.3.2 Mid-August Water Elevations

Mid-August reservoir elevations are an important variable used to predict visitation at the upper three reservoirs (Chipps and Fincel 2015) because they are an indicator for lake access as well as the quality of fishing opportunities. Reservoir elevations in the upper three reservoirs can vary depending on the natural hydrologic cycles. Generally, with lower lake elevations at the upper three reservoirs, there can be issues with accessing lakes from the boat ramps and fishing opportunities are diminished. Conversely, higher reservoir elevations support greater lake access, increasing fishing and of other visitation at the lakes. Research on fishing pressure (also known as angler effort) in Lake Oahe and Lake Sakakawea has shown that in addition to biological variables (such as the abundance of rainbow smelt and walleye), reservoir elevations are an important variable in predicting angler effort (often measured in angler hours for the summer season). The pool elevations from the H&H data at the upper three reservoirs were used in an Excel®-based model to estimate mid-August water elevations by averaging lake elevations between August 12 and 18 each year over the POR; these dates were based on three days before and three days after August 15.

2.3.3 Fishing Success

A fishing success metric was developed for the three upper reservoirs with input from fisheries biologists at Missouri River reservoirs. Based on these interviews, it was determined that fishing success can be very important for visitation at the reservoirs. In addition, reservoir elevations can have a large impact on the health of the fishery as well as fishing success of anglers. Based on historic H&H modeling data, it is known that the pool elevations at the upper three reservoirs fluctuate more than those of the lower three reservoirs.

Biological and other variables, such as the biomass of smelt, abundance of sport fish such as walleye, angler effort, and catch rates can influence boating and fishing visitation to the lakes. However, because these variables cannot be estimated over the 82-year period of analysis as required for the regression modeling, the fishing success metric was developed, using lake elevations to evaluate the conditions needed to support adequate fishing success in a given season. Lake elevations are available from the H&H data over the period of record (daily data, 1931-2012).

Working with the fisheries biologists, the project team developed criteria to capture both the rising spring pools and the improved fishing success at the initial onset of drought (Longhenry pers. comm. 2015b; Fincel pers. comm. 2015; Fincel pers. comm. 2014). A rising pool in the spring is important for habitat for spawning and nutrient productivity, both of which improve sport fishing at the reservoirs. State agencies have fisheries management guidelines on the upper three reservoirs that include recommendations for minimum lake elevation changes and spring reservoir elevation increases to support the fisheries, fish and spawning habitat, and nutrient productivity. Fisheries biologists have indicated that to sustain good to improved fishing in the reservoir in a given season, the reservoir should rise at least once in that spring *or* the past two consecutive springs (Longhenry pers. comm. 2015b; Fincel pers. comm. 2014; Fryda pers. comm. 2015). In addition, fishing success also occurs when the fishery is in a healthy state and the pool drops, often at the onset of a drought, which serves to concentrate the fish allowing for greater fishing catch rates.

The fishing success analysis was developed with an Excel-based model which analyzed H&H data depicting reservoir elevations. The model was used to analyze the effects of changes in pool elevations on fishing success. The elevation data from the upper three reservoirs was used to identify years during the spring season when the reservoir rose by at least the specified amount (specified in the fisheries management plans: North Dakota Game and Fish 2015; Montana Fish Wildlife and Parks 2012), but also did not fall by more than 0.2 feet per day during the season. For example, for Fort Peck Lake, spring pool rise is important between April 7th and May 5th (Montana Fish Wildlife and Parks, 2021). These successful spring pool rise years were then analyzed further to identify whether the spring rising reservoir criteria is met at least one time during the current spring and two previous springs prior to a given recreational (or fishing) season. This is known as the “spring pool rise” criteria.

In addition, fishing success is improved when reservoir pool elevations decrease (often at the onset of a drought) when the fishery in the lakes are in good condition, which can concentrate fish in the reservoirs, improving fishing success. When reservoirs are dropping, there are fewer nutrients coming into the reservoirs and lower pool elevations concentrate fish, resulting in higher catch rates for anglers. However, sustained decreases in pool elevations (i.e., drought conditions) for more than two years will result in reduced fishing success. The PDT conducted a number of steps to assess this criteria (“initial onset of drought” criteria) in the Excel-based model:

1. Estimate the average mid-August pool elevations for a given year,
2. Determine if the pool elevations have fallen compared to the previous year,
3. Determine if the pool elevations had been falling for the previous two years; this was known as sustained decreasing pool levels, and

4. Identify the years when the pool elevations have fallen compared to the previous year, but not in the previous two years.

If either the "spring pool rise criteria" (at least once in three years) was met *or* the "initial onset of drought" was met, the criteria for fishing success would be met in a given recreational season. For modeling purposes, these criteria were translated to a dummy variable: 1 indicating that fishing success criteria were met in a given year; and 0 indicating that fishing success criteria were not met in a given year.

2.4 National Economic Development

National Economic Development (NED) effects are defined as changes in the net value of the national output of goods and services, expressed in monetary units. NED benefits are the recreation benefits that accrue in the planning area and the rest of the nation. In the case of recreation, the conceptual basis for the NED impacts analysis is society's willingness to pay for recreation, also known as consumer surplus value. These NED effects are measured using the Travel Cost Method (TCM) and Unit Day Value (UDV) approach (U.S. Water Resources Council 1983; ER 1105-2-100 Appendix E (USACE 2000); Economic Guidance Memorandum (EGM) 20-03 (USACE 2020)), and reflect the maximum amount visitors are willing to pay to engage in recreation activities on the Missouri River, rather than forego them (Walsh 1986). The UDV method of estimating willingness to pay relies on expert and informed opinion to assign relative values to recreation days based on the quality of recreational opportunities supported by individual recreation areas. The TCM is a revealed preference method of economic valuation that deduces willingness to pay through observing human behavior (i.e., the number and trips and costs per trip to a recreation area). Additional information is provided in section 2.4.3.

FPDTR-EIS alternatives could affect the functionality and quality of recreation resources, such as availability and accessibility of boat ramps and other recreational facilities, aesthetic resources, and fishing opportunities. The methodology to evaluate the NED impacts to recreation from the alternatives focuses on how changes in reservoir elevations, river stages, and the prevalence of habitat will affect visitation at lakes and river reaches.

Because data and methods are different for the locations across the Missouri River, the following description is focused on the general locations in the upper Missouri River: the upper three mainstem reservoirs; and the two inter-reservoir river reach between these three reservoirs. In general, this section includes the following subsections and within each of these subsections the approaches for the reservoirs and inter-reservoir river reaches are described:

- Identify the plan-affected recreation
- Estimate changes in visitation
- Calculate and apply consumer surplus values
- Estimate NED benefits of recreation

2.4.1 Identify Plan-Affected Recreation

This section describes the current visitation for the upper three reservoirs and the two inter-reservoir river reaches as well as the types of visitors anticipated to be affected by the FPDTR-EIS alternatives.

Upper Three Reservoirs

There are six mainstem reservoirs on the Missouri River, located in Montana, North Dakota, and South Dakota. The focus of the FPDTR recreation evaluation was on the upper three reservoirs where the storage volumes and lake elevations can vary (Lake Oahe, Lake Sakakawea, and Fort Peck Lake). Visitation at the upper three reservoirs can be largely affected by changes in reservoir elevations.

As part of the MRRMP-EIS recreation evaluation, the project team interviewed USACE lake managers to gain an understanding of the relationship between water elevations and recreational use, and identify the types of visitors likely to be affected by changes in lake elevations. USACE recreation specialists provided visitation data at the reservoirs as well as activity distribution reports. The most recent year in which visitor counts were available was for 2018, while activity distributions were available recreational sites for 2012. The 2012 activity distributions were applied to the baseline visitation in 2018. Visitation and activity distribution percentages at the upper three reservoirs (excluding downstream and upstream recreation areas not on the lakes) are shown in Table 2. Since activity participation is not mutually exclusive, annual activity distributions include visitors who participate in more than one activity.

Table 2. Annual Visitation (2018) and Distribution of Activities (2012)

Activity	Fort Peck Lake	Lake Sakakawea	Lake Oahe
Camping	12.6%	9.2%	3.5%
Picnicking	9.0%	6.2%	1.6%
Boating	24.8%	23.2%	24.7%
Fishing	21.5%	23.7%	37.1%
Hunting	3.8%	2.6%	2.6%
Skiing	1.2%	1.4%	0.5%
Swimming	3.9%	4.6%	3.4%
Sightseeing	12.0%	15.7%	16.1%
Other	11.3%	13.4%	10.6%
Total 2018 Recreation Visitor Days	**529,987**	**2,746,293**	**1,531,417**

Source: USACE Visitation Estimation and Reporting System (VERS) 2019b and USACE VERS 2012. Note that the percentages do not sum to 100% because visitors can participate in more than one activity.

Popular water-based activities at the upper three reservoirs during the spring, summer, and fall season include fishing, boating, waterskiing, and jet skiing. Typically, these visitors can access the lake directly from boat ramps between April and November, with peak use occurring between the months of June and October. When water elevations drop below the bottom operating elevations of the non-low water boat ramps, anglers, boaters, and skiers have difficulty accessing the water. Low lake elevations during these months can also adversely affect the health of fisheries and lead to reduced fishing opportunities at the upper three reservoirs.

Recreation specialists at the lakes also indicated that low lake elevations could affect shoreline recreation (McMurry pers. comm. 2015; Voehler and Sheffield pers. comm. 2015; Bultsma pers.

comm. 2015; Busche pers. comm. 2015). Many visitors during the spring, summer, and fall months are attracted to recreation sites on reservoirs because of their scenic quality and easy access to both facilities and water. At the upper three reservoirs, the potential changes in spring, summer, and fall visitation associated with fluctuating reservoir elevations was evaluated through regression techniques to best explain the changes in visitation (see section 2.4.2).

During winter months, reservoir visitors primarily participate in ice fishing as well as other winter activities, including cross-country skiing, sight-seeing, and birding. Although many boat ramps close at the end of November (and re-open or put back in the water in April), several boat ramps continue to provide access to the reservoirs during the winter months (Lepisto and Longhenry pers. comm. 2015; Longhenry pers. comm. 2015a). When lake levels fall below the engineered bottom of the boat ramps open in the winter, access to the lake is difficult because of the relatively longer distance to the lake from the parking area, sometimes as much as a half mile to a mile. In addition, lower lake elevations can cause “river” conditions in the reservoir, which can also affect safety and perceptions of safety on the reservoirs. Boat ramp operability (considering the bottom engineered elevation) was used to evaluate the impacts to winter visitation at the upper three reservoirs.

The visitation data was obtained from the USACE Visitation Estimation and Report System (VERS) and was adjusted to reflect recreation visitor days by adding an additional day for the overnight visitors. In addition, recreation areas that were not located on the reservoir (e.g., downstream of the dam) were removed to reflect only visitation associated with the reservoir. Table 3 summarizes the 2018 recreation visitor days by season.

Table 3. Reservoir Recreation Visitor Days by Season, 2018

Reservoir	Winter Recreation Visitor Days	Spring, Summer, and Fall Recreation Visitor Days	Total Recreation Visitor Days
Fort Peck Lake	69,885	618,832	688,717
Lake Sakakawea	338,142	3,046,258	3,384,400
Lake Oahe	323,203	1,212,192	1,535,395
Total	731,230	4,877,282	5,608,512

Source: USACE Visitation Estimation and Reporting System (VERS) 2019b.

Note: Reservoir visitation in this table for 2018 removes visitation at the recreation areas above and below the reservoirs; this visitation has been added to visitation in the appropriate inter-reservoir reach. Spring, summer, and fall includes visitation in April through November, while winter reflects December, January, February, and March visitation.

Inter-reservoir River Reaches

Recreational sites along the riverine segments are administered by private entities and federal, state, and local agencies. Two riverine reaches have the potential to be affected under the FPDTR alternatives:

- Fort Peck Dam to Lake Sakakawea
- Garrison Dam to Lake Oahe

Current visitation data for USACE recreation areas in the inter-reservoir river reaches were obtained from VERS and supplemental data collected for non-USACE recreation areas in 2010 and 2011. VERS visitation data was available monthly between 2014 and 2018 and was adjusted to reflect recreational visitor days by adding an additional day for overnight visitors. A data collection effort in 2010 and 2011 (supplemental data collection) yielded the greatest number of recreation area sampling in 2009 for recreation areas not covered in the VERS data. Because of the different years of the visitation data, the non-VERS visitation data was adjusted to reflect a baseline year of 2018. Population changes were used as a proxy to reflect potential changes in visitation between 2009 and 2018. The 2009 baseline data was updated to 2018 levels based on population growth in the counties along the river reaches between these years.

Interviews with the recreation area managers were conducted to gain an understanding of the types and seasons of river use as well as how river stages and the operability of boat ramps can potentially affect various types of visitation. Recreational use of the river slows considerably during the winter months, while the majority of visitation occurs in the spring, summer, and fall seasons. Visitation during the winter months on the inter-reservoir reaches were assumed to not be affected by boat ramp access and the FPDTR-EIS alternatives.

Thousands of visitors enjoy recreational activities along the banks of the Missouri River during the spring, summer, and fall months. Pleasure boaters, skiers, and a large portion of hunters and anglers access the river by boat.[1] These visitors launch boats from public and private ramps along the main channel and are directly affected by river stages when they fall above or below the operating elevations of the boat ramps. Visitors accessing the river by boat generally use boat ramps from April through November, with peak use occurring between June and October. When river stages rise above or fall below the operating elevations of boat ramps, these facilities become inoperable, access becomes limited, which tends to limit visitation.

Visitation was segmented into the following types of visitors for the inter-reservoir river reaches.

- **Spring, summer, and fall boat-accessed visitation:** includes all boaters, water-skiers, and half of the anglers and hunters;
- **Spring, summer, and fall non-boat accessed visitation:** campers, picnickers, sight-seers, OHVs, sunbathing, hikers, and half of the anglers and hunters
- **Winter visitation:** all visitation between the months of December and March.

The first category (boat-accessed visitation) was assumed to be directly affected by changes in boat ramp operability. Visitors partaking in non-boat-accessed recreation were assumed to not be impacted by changes in rivers flows and stages, including sightseers, campers, and half of the anglers and hunters. Winter visitation would not be affected by the FPDTR-EIS alternatives because boat ramps are typically not operable in the winter and visitation along the river in the winter typically does not involve water-based recreation.

For the inter-reservoir river reaches, total visitation for spring, summer, and fall was categorized by the type of activity based on the activity distributions for the recreation areas in these river reaches. Activity distributions for the inter-reservoir river reaches are summarized in Table 4.

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[1] It was assumed that approximately half of the hunters and anglers use boats to fish and hunt in the inter-reservoir river reaches (USACE 2011).

Table 4. Distribution of Activities in the Inter-Reservoir River Reaches

Activity	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe
Camping	18.5%	11.4%
Picnicking	15.0%	6.5%
Boating	19.7%	14.2%
Fishing	16.7%	19.7%
Hunting	3.2%	1.6%
Skiing	0.7%	0.4%
Swimming	4.1%	3.5%
Sightseeing	10.7%	24.6%
Other	11.4%	18.1%

Source: VERS databases (USACE 2012); USACE data collection efforts.

The above activity distributions were then applied to the visitation in the respective river reaches. The total recreational visitor days for various types of visitors or activities updated to 2018 levels are provided in Table 5.

Table 5. Recreation Visitor Days in the Inter-reservoir River Reaches, 2018

River Reaches	Total Annual Recreation Visitor Days	Winter Recreation Visitor Days	Spring, Summer, and Fall Recreational Visitor Days	
			Boat- Accessed Recreation Visitor Days[a]	Non-Boat Accessed Recreation Visitor Days
Fort Peck Dam to Lake Sakakawea	288,320	26,525	79,379	182,416
Garrison Dam to Lake Oahe	577,950	78,023	126,046	373,881

a Boat accessed recreation includes motorized boating, waterskiing, jetskiing, cruise operations, and half of the hunting and fishing in riverine areas.

Note: Spring, summer, and fall includes visitation in April through November, while winter reflects December, January, February, and March visitation.

Once the baseline plan-affected visitation was specified, the next step in the methodology was to assess how the visitation at the upper three reservoirs and inter-reservoir river reaches would be affected by the FPDTR-EIS alternatives.

2.4.2 Estimate Changes in Visitation

This section describes the approach to estimate changes in visitation under the FPDTR-EIS alternatives for the upper three reservoirs, and the inter-reservoir river reaches.

Upper Three Reservoirs

In the MRRMP-EIS recreation evaluation, the project team explored the relationships between visitation, boat ramp operability, lake elevations, fishing success, and gas prices in a number of time series regressions for the upper three reservoirs. The project team used actual total 8-month (spring, summer, and fall) visitation at the recreation areas located on the lake as the dependent variable from 2001 to 2012. Although updated visitation data is now available for 2014 to 2018, according to USACE recreation specialists, the approach to collect the new data is different from the old visitation data collection, so the 2015-2018 visitation data is not comparable with the 2001 to 2012 visitation data previously collected. Therefore, the relationships estimated during the MRRMP-EIS recreation evaluation with the 2001 to 2012 visitation was used in the FPDTR-EIS recreation analysis. To update the visitation data in the regressions to reflect 2018 figures, the 2012 recreation visitor day estimates were increased proportionally to reflect the 2018 recreation visitor days under the No Action Alternative. This percent increase was then applied across the visitation estimates for all alternatives and across all years in the period of record for each reservoir. A description of the regression analysis undertaken for the recreation evaluation is provided in this section.

Independent variables that were analyzed included the fishing success metric as a dummy variable, price of gas, mid-August lake elevations, total 8-month boat-ramp operability for all boat ramps, total boat ramp operability for all non-low water boat ramps (defined by each lake) for the 8-month period, and the average of the monthly mid-point lake elevations for the 8-month period (see section 2.3.1 and 2.3.2 for additional details on these estimates).

In addition, other economic variables can affect visitation at recreational sites. Generally, more recreation occurs during upswings or booms in the economy and less visitation occurs during times of recession or economic downturns. However, visitation at some sites can benefit from economic downturns if recreation areas have nearby residents that choose to visit proximate sites close to home during economic downturns. Gross domestic product (GDP) and personal income for the nation were also used in the regressions to test their impact on visitation.

Based on an approach undertaken by fisheries biologists, regressions were estimated with several relevant variables (Chipps and Fincel 2015). To screen through independent variables and choose the best model, the Akaike Information Criteria (AIC) was used. The AIC process uses the statistical information on the goodness of fit and the complexity of the model to estimate the quality of each model in explaining the change in visitation between 2001 and 2012. The AIC process indicated that variables predictive for visitation included the price of gas, fishing success dummy variable, and mid-August elevations. In addition, the GDP and personal income variables were significant variables in the Lake Oahe and Lake Sakakawea regressions but were not included in the equations to estimate visitation over the POR (1931–2012). The positive correlation between GPD/personal income and visitation between 2001 and 2012 (for the regressions) was not appropriate to apply over the POR because of the large change in GDP/income, which would render the visitation estimates to be negative in most years. For these reasons, the GDP and personal income variables were not chosen to be included in the final regression models. However, the mid-August elevation variables were just as predictive for visitation in the regressions equations and were used in the estimation of visitation. The regressions used to estimate visitation included the following variables: mid-August elevations, the price of gas, and the fishing success dummy variable; the regressions are shown for the three reservoirs in the Table 6.

Table 6. Linear Regression Results for the Upper Three Reservoirs

Reservoir	Independent Variables	Coefficient	T-Statistics	Significance	Goodness of Fit
Fort Peck Lake	Mid-August Elevation	2,419	3.096	0.0128	0.838
	Fishing Success Dummy Variable	104,251	5.459	0.0004	
Lake Sakakawea	1-Year Lag Mid-August Elevation	6,529	6.699	0.0000	0.880
	Price of Gas	−93,920	−4.759	0.0010	
Lake Oahe	Mid-August Elevation	6,529	4.106	0.0034	0.638

The best regressions were tested for multi-collinearity by calculating their Variable Inflation Factor (VIF). This approach quantifies the degree of multi-collinearity in the regression analyses and provides an index value that measures how much the variance of a regression is impacted due to collinearity. For this analysis, a VIF value of 2 or lower was considered to show that a regression lacked multi-collinearity. All regressions estimated here had VIF values below 2.

The relationships identified under these regressions were used with various independent variables to estimate the change in spring, summer, and fall visitation for the upper three reservoirs. Mid-August lake elevations, 1-year lagged mid-August elevations, the fishing success dummy variable, and the price of gas were used to develop a predictive model for each lake, based on the regression equations. Visitation was estimated for 81 years over the POR; an 82-year POR could not be evaluated because of the lagged variable in the visitation estimates.

Changes in 2018 winter visitation (December through March) on the upper three reservoirs were estimated through boat ramp operability. Because the majority of the winter recreation involves ice fishing, accessing the lakes is an important part of the recreational activity. When the lake elevations in the winter fall below the bottom engineered elevation of the non-low water boat ramps, recreational access to the river is difficult as visitors must travel much farther from the parking lots to access the reservoir. The boat ramp operability (number of boat-ramp days operable) for the 4 winter months when elevations fall above the engineered bottom elevation and below the top operational elevation for the specified winter boat ramps was used to estimate how winter visitation would be affected; the change in visitation was based on a proportional change in winter boat ramp operability. All winter visitation was anticipated to be affected by these water surface elevation changes.

Inter-Reservoir River Reaches

For the inter-reservoir river reaches, the change in visitation was based on the proportional change in boat ramp operability under the FPDTR-EIS alternatives for each of the 81 years Baseline visitation in 2018, for the boat-accessed visitation—boaters, skiers, and half of the hunters and anglers—was used to estimate changes in visitation for the spring, summer, and fall season.

2.4.3 Calculate and Apply the Consumer Surplus Values

Total recreation benefits are defined as the sum of the maximum amount individuals are willing to pay to engage in a recreation activity, rather than forego it (Walsh, 1986). Willingness to pay includes entry and use fees actually paid for site use, plus any unpaid value (surplus) enjoyed by visitors. The procedures described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council 1983) (Principles and Guidelines) and USACE ER 1105-2-100 Appendix E outline three generally accepted methods for measuring recreational benefits: the unit day value (UDV), the travel cost method TCM, and contingent valuation.

A hybrid method based on both the UDV and the TCM was used for this effort given consideration of the recreation evaluation criteria established in the Principles and Guidelines. The method to estimate the consumer surplus recreation values uses both the UDV, which is based on USACE guidance and site-specific ratings and activities, but also recognizes that the UDV may reflect a relatively lower estimate of the consumer surplus value for a recreation visitor-day. Therefore, the TCM study conducted as part of the Master Water Control Manual Missouri River Review and Update (USACE 1994) was also considered in the evaluation.

This section describes the approach and steps taken to estimate the consumer surplus values.

Overview of UDV Approach

The UDV method of estimating average willingness to pay relies on expert or informed opinion and judgment. This method of estimating recreational benefits involves the assignment of relative values to individual sites based on the quality of recreation areas. The USACE EGM 20-03 provides guidelines for assigning points on a 100-point scale based on five criteria. The five criteria and total possible points that can be assigned to each criterion are as follows:

1. the quality of the recreation experience as affected by congestion (0–30 points);
2. availability of substitute areas in terms of travel time (0–18 points);
3. carrying capacity determined by level of facility development (0–14 points);
4. accessibility as affected by road and parking conditions (0–18 points); and
5. environmental quality based on aesthetics (0–20 points).

Recreation managers rate the recreation areas based on these 5 criteria and each site is identified as a type of site (general recreation, general hunting and fishing, specialized hunting and fishing, and other specialized activities). The point ratings for each recreation area were obtained from the USACE Rec-BEST database and averaged over a 4-year period for the most recent data available (2015 to 2018). To obtain a value associated with each reservoir or river reach, the UDV points were specified for all of the recreation areas in each geographic location by type of site and then weighted by visitation.

Point ratings were then converted into a monetary value based on values published in EGM 20-03 for each type of recreation (general recreation, general hunting and fishing, specialized hunting and fishing, and other specialized activities). Table 7 provides the points to monetary value conversion from the EGM. The distribution of the visitation to the four different types of values is described in the following section.

Table 7. Unit Day Values for Recreation, Fiscal Year 2020

Point Values	General Recreation Values (other than fishing and hunting)[a]	General Fishing and Hunting Values[a]	Specialized Fishing and Hunting Values[b]	Specialized Recreation Values other than Fishing and Hunting[b]
0	$4.21	$6.06	$29.49	$17.12
10	$5.00	$6.85	$30.28	$18.17
20	$5.53	$7.37	$30.81	$19.49
30	$6.32	$8.16	$31.60	$21.07
40	$7.90	$8.95	$32.39	$22.38
50	$8.95	$9.74	$35.55	$25.28
60	$9.74	$10.80	$38.71	$27.91
70	$10.27	$11.32	$41.08	$33.71
80	$11.32	$12.11	$44.24	$39.24
90	$12.11	$12.38	$47.40	$44.66
100	$12.64	$12.64	$50.04	$50.04

Source: USACE EGM 20-03.

a General recreation refers to an area with recreation activities that are attractive to the majority of outdoor users. These activities generally require easy access with facilities and amenities that most individuals take advantage of while utilizing a USACE-administered Recreation Area.

b Specialized recreation refers to an area that supports activities for which opportunities are limited, density of use is low, and a high degree of skill, knowledge, and appreciation of the activity by the user are often involved. In the reservoirs, salmon fishing with downriggers and ice fishing are an example of specialized fishing recreation.

General and Specialized Visitation

Hunting, fishing, and boating visitation from OMBIL and VERS[2] databases for the activity distributions were used for the evaluation. The Recreation Economics Volume 6C of the Missouri River Mainstem Reservoir System Master Water Control Manual (USACE 1994) was used to identify the amount of visitation that is allocated to specialized fishing and hunting categories. The OMBIL and VERS databases were used to identify the proportion of general hunting, general fishing, and boating visitation. Natural resource managers at each reservoir were interviewed to verify whether the proportions of specialized fishing recreation at the reservoirs were still consistent with those reported in the Recreation Appendix of the Master Water Control Manual. Boating visitation was assigned to the specialized recreation category, which is associated with higher-valued activities.[3] The remaining percentage of visitors were

[2] The VERS data was obtained by recreation area, and the participation rates were estimated by focusing on the recreation areas at the lakes; visitation at the recreation areas located below the dams were assigned to the appropriate river reach.

[3] The UDV guidance (USACE 2020) indicates that the general category should comprise activities such as swimming, picnicking, and boating. However, based on professional judgment and a review of other studies (Loomis 2005; USACE 2002), boating on the river and reservoirs was allocated to a specialized recreation category with a relatively higher value per day than the general recreation activities.

allocated to general recreation. Table 8 summarizes the allocation among the general and specialized recreational activities.

Table 8. Distribution of Specialized and Generalized Recreation Opportunities in the Reservoirs and River Reaches

Recreation Category/Location	Percent of Visitation
Fort Peck	
General Recreation (other than fishing and hunting)	41.0%
General Fishing	21.4%
General Hunting	3.7%
Specialized Fishing	5.0%
Specialized Hunting	4.0%
Specialized Recreation (other than fishing and hunting	24.8%
Fort Peck Dam to Lake Sakakawea	
General Recreation (other than fishing and hunting(	52.3%
General Fishing	16.7%
General Hunting	3.2%
Specialized Fishing	5.0%
Specialized Hunting	3.1%
Specialized Recreation (other than fishing and hunting)	19.7%
Lake Sakakawea	
General Recreation (other than fishing and hunting)	36.5%
General Fishing	23.7%
General Hunting	2.6%
Specialized Fishing	12.0%
Specialized Hunting	2.0%
Specialized Recreation (other than fishing and hunting)	23.2%
Garrison Dam to Lake Oahe	
General Recreation (other than fishing and hunting)	61.4%
General Fishing	19.7%
General Hunting	1.6%
Specialized Fishing	0.0%
Specialized Hunting	3.1%
Specialized Recreation (other than fishing and hunting)	14.2%
Lake Oahe	
General Recreation (other than fishing and hunting)	26.4%
General Fishing	37.1%
General Hunting	2.6%

Recreation Category/Location	Percent of Visitation
Specialized Fishing	9.0%
Specialized Hunting	0.2%
Specialized Recreation (other than fishing and hunting)	24.7%

* Calculated based on activity distribution for VERS (2012); and the 1991 Angler Survey from the Master Manual (USACE 1994) for the specialized hunting and hunting percentages.

Estimate the Consumer Surplus Values

The UDV point values were obtained from the Rec-BEST database and averaged for 2015 to 2018, weighted based on visitation, and aggregated to provide a single point value for each reservoir or inter-reservoir river reach. The final step was to weight UDVs based on the allocation of activities among general and specialized recreation for each geographic location. The UDVs are summarized in the second column of Table 9.

As part of the Master Manual evaluation (USACE 1994), a TCM survey was conducted to estimate the willingness to pay to recreate along the Missouri River. Travel cost zones of visitor origin were identified around each recreation area for the purpose of estimating travel costs. A travel cost measure was constructed to estimate the round-trip cost of travel per visitor from the origin. The evaluation used regression analysis and other data, including population from zone of origin, various site facility amenities, substitute recreation opportunities, and numerous other demographic variables, to specify visitation rates as a function of travel costs.

The TCM values and UDVs estimated as part of the recreation economics evaluation for the Master Manual (USACE 1994), shown in Table 9, were used to increase the estimated 2020 UDV to estimate consumer surplus values for this study. Column “a” was then multiplied by column “b” to estimate the consumer surplus values for a recreation visitor day, noted in column “c” which was used in the NED evaluation.

Under the MRRMP-EIS recreation evaluation, the consumer surplus values were increased for areas along the river where emergent sandbar habitat was anticipated to be created. These habits provide critical nesting and add to the natural aesthetics of the Missouri River floodplain. In addition to supporting native species, these areas are generally viewed as natural features that contribute topographic diversity and increase scenic values associated with the surrounding viewshed. The prevalence of these habitat types benefit visitors, increasing the quality of their recreational experiences. Consistent with the MRRMP-EIS evaluation, additional habitat creation in the Garrison Dam to Lake Oahe river reach could increase the value of recreational experiences. To account for how many visitors would experience the higher-valued habitat experience, the prevalence (i.e., proportion) of target habitat acres in the channel compared to all channel acres in the river reach was estimated. As estimated in the MRRMP-EIS recreation evaluation, under Alternative 3 (the preferred and selected alternative, and the No Action alternative under the FPDTR-EIS evaluation), the target habitat acres would represent 3 percent of the channel in the Garrison Dam to Lake Oahe river reach. It was therefore assumed that 3 percent of the boat-accessed visitation in this inter-reservoir reach would have the higher-value experience, a consumer surplus value of $36.42, which would apply to all of the alternatives including No Action (Table 9).

Table 9. Estimates of Consumer Surplus Values Per Recreation Visitor Day for Each Reservoir and River Reach

River Reach or Reservoir	UDV (2020$) (a)	Master Manual, Volume 6C: Recreation Economics			Consumer Surplus Value (2020$) (c)
		UDV (1993$)	TCM (1993$)	Ratio Difference (TCM/UDV) (b)	
Fort Peck Lake	$18.03	$7.03	$10.66	1.52	$27.35
Fort Peck Dam to Lake Sakakawea	$15.56	$7.07	$8.19	1.16	$18.03
Lake Sakakawea	$19.22	$6.96	$15.06	2.16	$41.58
Garrison Dam to Lake Oahe	$13.67	$6.09	$14.94	2.45	**$33.54** **(Habitat value-$36.42)**
Lake Oahe	$17.99	$6.90	$9.21	1.33	$24.02

2.4.4 Recreation Benefits of Visitation (NED Benefits)

The NED benefits of visitation were estimated by applying the appropriate consumer value to the estimated annual spring, summer, and fall; and the winter seasonal visitation under each alternative. The difference in the values between the action alternatives and the No Action alternative represents the change in NED value associated with each alternative. The NED benefits are provided in 2020 dollars.

2.5 Regional Economic Development

The RED account evaluates how changes under the FPDTR-EIS alternatives would affect regional economic conditions, including labor income, employment, and sales. These effects are typically expressed in monetary values or other numeric units (i.e., number of jobs) and are classified as either a direct or secondary (indirect and induced) effects. Direct effects represent the impacts of non-local visitor spending and resulting sales that are generated to tourism industries near the recreation areas. 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 changes by all affected workers spending their income in the local or regional economy.

The RED effects associated with recreation along the upper Missouri River stem from non-local visitor spending in communities adjacent to recreation areas. Visitors traveling to the Missouri River spend their income in communities where they eat in restaurants, stock up on gas and supplies at local retailers, and stay in overnight accommodations while at their recreation destination. The visitor spending and resulting sales to local businesses provide a measure of the direct effect of outdoor recreation on the regional economy. An economic impact analysis measures the changes in economic activity associated with an industry, event, or policy in an existing regional economy (Watson et al. 2007). In the case of recreation on the Missouri River, this type of analysis examines how visitors who reside outside of the local region (non-local visitors) inject spending into local economies while visiting the area, and how this spending creates multiplier effects in the local economies stimulating additional economic activity.

Although recreation opportunities enjoyed by local residents contribute to personal well-being, spending by residents is generally not included in regional economic analyses because these expenditures would not inject new money or spending into the local economy; spending would occur by local residents regardless of visitation to the recreation area.

The RED recreation analysis uses the results from the NED analysis to assess how changes in visitation under the FPDTR-EIS alternatives would affect regional economic conditions. The inter-reservoir river reaches were excluded from the RED analysis since these river reaches primarily wind through private lands where public access is limited, and previous reports have indicated that visitation was mostly by residents who live nearby (USACE 2006; USACE 2011).

Non-local visitation at the upper three reservoirs were used as inputs in an economic impact analysis to estimate how changes in visitor spending will affect jobs and income under the FPDTR-EIS alternatives. The USACE-certified RED model, Regional Economic System (RECONS) was used to estimate the economic impacts. The non-local visitor spending would occur in the communities and counties adjacent to the USACE project area, generally within 50 miles from the USACE project area.

The estimates of annual visitation over the 81-year POR for the plan-affected and No Action visitation were further analyzed to focus on scenarios for the economic impact analysis. Five scenarios were developed on which to estimate the economic impacts under each of the FPDTR-EIS alternatives: lowest annual visitation; highest annual visitation; annual average visitation; average of the eight years with the lowest visitation difference from No Action; and average of the eight years with the highest visitation difference from No Action.

The RECONS model, by default, estimates the economic impacts of visitor spending for three study areas: local, state, and the nation. The local study area is specified by default based on USACE project areas. The local study area usually includes the counties within and surrounding the project boundary, including counties generally within 50 miles of the project area. The state study area includes the state or states in which the local study area is located. After reviewing the local study areas for the three reservoirs, the project team felt that there were a number of counties missing from the local study areas. Given this and because the results of the economic impact analysis for the local and state study areas were very similar, the economic impact analysis was based on the state study area results. This state level analysis was also consistent with the RED analysis for other resource topics. Although some of the economic impacts may be experienced over the wider state geographic area, the vast majority of the jobs, income, and sales would be supported and generated in the counties within 50 miles of the reservoirs where the non-local visitor spending occurs. Table 10 summarizes the state study areas for each of the three reservoirs.

As described previously, the focus of the economic impact analysis was on visitor spending from non-local visitors. The NED analysis provided estimates of recreation visitor days over the 81-year POR for each reservoir under each of the FPDTR-EIS alternatives. Information was obtained from state sources to estimate the percent of local and non-local visitors (Longhenry 2016; Fryda 2016). Table 11 summarizes the residency of visitors to the upper three reservoirs.

Table 10. Regional Economic Development (RED) Study Areas

Reservoir	State Study Area
Fort Peck Lake	Montana
Lake Sakakawea	North Dakota
Lake Oahe	South Dakota and North Dakota

Note: State study areas are defined in the RECONS model.

It should be noted that Lake Oahe extends into North Dakota, but most of the recreation areas at Lake Oahe are located in South Dakota.

Table 11. Residency of Visitors to the Reservoirs

Reservoir	Visitors from Counties Surrounding or Adjacent to Project Area (Local Visitors)	Non-local Visitors[a]
Fort Peck Lake	8%	92%
Lake Sakakawea	22%	78%
Lake Oahe	30%	70%

Source: Longhenry pers. comm. 2016; Fryda pers. comm. 2016; South Dakota Game Fish and Parks 2016; U.S. Geological Survey 2011.

a Non-local visitors include visitors from counties with population centers greater than 50 miles from the reservoir project area.

Non-local visitation was further segmented into visitor groups consistent with those defined in the RECONS model (Table 12). The proportion of boating and camping visits were obtained from the USACE VERS data (USACE 2012). The boating proportions was applied to the local percentages to estimate the number of visitors that were local boaters and non-boaters. The camping visitors were assumed to be part of the non-local visitors. The camping boaters were estimated by applying the percentage of campers and boaters to the non-local percentage of visitors, and the remaining non-boating campers were assumed to be the remainder of the camping visitors. Similarly the percentage of non-local non-boaters were assumed to be non-local and non-boating visitors less the camper non-boaters. The non-local boating visitors were estimated in a similar approach. Table 12 summarizes the segments of visitors used in the RECONS models.

Table 12. Visitor Activity Distributions for RECONS

Reservoir	Local/Boater	Local/Non-Boater	Non-local/ Boater	Non-Local/ Non-Boater	Camper (non-local)/Boater	Camper (non-local)/Non-Boater
Fort Peck Lake	2%	6%	20%	60%	3%	9%
Lake Sakakawea	6%	17%	17%	51%	2%	7%
Lake Oahe	8%	23%	15%	46%	2%	7%

Source: Estimated with data and information from VERS (USACE 2012) and RECONS (USACE 2019b).

Visitor spending profiles for the types of visitors were specified in RECONS; the visitor spending profiles are built into the RECONS database and include spending in ten categories, as shown in Table 13. Total spending is then estimated for each type of visitor by multiplying the number of visits times the average spending profile. Although the number of visitors (not recreation visitor days) is the input into RECONS, RECONS model then converts the number of visits to visitor party-days to estimate visitor spending per party per trip.[4]

Table 13. RECONS Visitor Spending by Type of Visitor ($ per party per trip, 2020$)

	Non-Boating Trip			Boating Trip		
Spending Category	**Local Day visitor**	**Non-Local Day Visitor**	**Camper**	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper**
Hotels	$0.00	$0.00	$2.18	$0.00	$0.00	$4.58
Camping Fees	$0.00	$0.00	$53.92	$0.00	$0.00	$94.66
Restaurants and Bars	$9.70	$21.03	$34.19	$19.47	$27.39	$38.11
Groceries	$22.87	$24.33	$60.92	$37.87	$28.94	$63.97
Gas & Oil	$24.72	$40.24	$118.08	$73.87	$120.13	$120.13
Other Auto Expenses	$0.52	$0.52	$0.73	$0.52	$0.52	$9.46
Other Boat Expenses	$0.00	$0.00	$0.00	$16.16	$16.16	$38.68
Attractions, Entertainment, and Recreation Fees	$4.22	$4.22	$6.44	$8.80	$8.80	$13.23
Sporting Goods	$8.26	$8.26	$10.32	$17.55	$19.62	$22.71
Souvenirs and Other Expenses	$6.38	$6.38	$12.03	$11.31	$13.03	$16.04
Total	$76.67	$104.99	$298.83	$185.55	$234.59	$421.56

Source: RECONS (2012).

The RECONS recreation module then applies these spending profiles to annual visitation counts for each type of visitor to estimate visitor expenditures. In RECONS, the visitor expenditures are assumed to be spent in the communities within 50 miles from the reservoir. The ten categories of spending are then mapped to industry sectors to quantify the direct and secondary (i.e., indirect and induced) effects of visitor spending on regional sales, employment, and labor income. RECONS uses IMPLAN® multipliers and ratios, which is an industry-standard input-output model to estimate the multiplier impacts. Since RECONS and IMPLAN® are linear models and the distribution of visitors and associated spending profile are the same across alternatives, results from the No Action can be scaled up or down based on the proportional difference in visitation under the other alternatives and scenarios to quantify the RED effects of visitor spending.

[4] For further information on the RECONS methods and assumptions, refer to the RECONS User Guide and Methodology Manual at https://www.iwr.usace.army.mil/Missions/Economics/Regional-Economic-System-RECONS/.

2.6 Availability of Substitute Recreation Areas

The availability and accessibility of alternative recreation sites may have an impact on the recreation economic evaluation, notably the RED evaluation. When reservoir or river conditions on the Missouri River result in reduced visitation, there may not be a proportional impact on jobs and income if there are sufficient recreational sites in the region to attract visitors and visitor spending to those substitute recreational areas. Depending on where the visitors decide to recreate during adverse conditions on the Missouri River, there would likely be a transfer in visitors spending and associated economic activity from one region (for example, surrounding a reservoir) to the substitute recreation site.

Because of the prevalence of local visitors (river reaches) and relatively small impacts to visitation in the inter-reservoir river reaches, an evaluation of the availability of substitute sites was not conducted for the river reaches. Therefore, the focus of this section is on the availability of alternative recreational opportunities in proximity to the upper three reservoirs and the potential impacts on the NED and RED values.

Fort Peck Lake, Lake Sakakawea and Lake Oahe are world-famous for their walleye, northern pike, and other boating and fishing opportunities. In general, the upper three reservoirs provide a remote and unique recreational experience. There are limited recreational opportunities located within the local region (defined at 50 miles from the lakes) that provide similar opportunities. A number of reservoirs have been identified as potential recreational areas that provide similar opportunities for sport fishing and boating within 300 miles of the reservoirs (Table 14). The closest lake with similar amenities to those at the upper three reservoirs was identified as Nelson Reservoir in Montana, located approximately 73 miles from Fort Peck Lake.

Table 14. Other Lakes with Similar Amenities to the Upper Three Reservoirs

Reservoir	Closest Missouri River Reservoir	Approximate Distance to Missouri River Reservoir
Nelson Reservoir, Montana	Fort Peck	73 miles
Bighorn Reservoir, Montana	Fort Peck	300 miles
Jamestown Reservoir, North Dakota	Lake Sakakawea	270 miles
Shadehill Reservoir, South Dakota	Lake Oahe	170 miles

Although there are other lakes that provide similar fishing and boating opportunities, they would be relatively far away from the adjacent communities to the upper three reservoirs; that is, visitors would not be staying in the communities surrounding the Missouri River reservoirs while visiting other substitute sites. During adverse recreation conditions on the Missouri River reservoirs, it is possible that visitors would choose to visit these substitute or alternative reservoirs; therefore, the visitor spending and associated regional jobs and income would be reduced in the communities surrounding the Missouri River reservoirs, but could still remain within the state. However, changes in visitation, visitor spending, NED, and RED benefits estimated through this evaluation that are associated with the alternatives affecting reservoir conditions at the upper three Missouri River reservoirs would not likely be affected by alternative sites because there are limited proximate recreational opportunities.[5]

3.0 National Economic Development Results

This section presents the results of the NED analysis. The first section provides the NED impacts across all alternatives, and the following section provides a summary of NED impacts specific to each alternative. Results are presented for five locations, Fort Peck Lake, Lake Sakakawea, Lake Oahe, Fort Peck inter-reservoir river reach, and Garrison inter-reservoir river reach.

3.1 Summary Across Alternatives

This section describes the impacts to recreation NED benefits under the FPDTR-EIS alternatives at the upper three reservoirs and the inter-reservoir reaches. The recreation NED tables in this section include total benefits and changes in benefits relative to No Action over the 81-year period of analysis, including visitation, recreation NED benefits, and changes in average annual benefits. In addition, the recreation NED tables include two statistics that focus on the differences from No Action: the average of the eight best difference years (highest visitation years compared to No Action); and the average eight worst visitation years (lowest visitation years compared to No Action). These statistics allow an understanding of the skewness of impacts and magnitude of impacts in these largest difference years. Additional details on the alternative-specific impacts are provided in sections 3.3 and 3.4.

3.1.1 Upper Three Reservoirs

The recreation visitor days and recreation NED benefits for Fort Peck Lake, Lake Sakakawea, and Lake Oahe are each summarized respectively in Tables 15, 16, and 17. Alternatives 1 and 2 and the variations would result in adverse impacts on average to recreational NED benefits at Fort Peck Lake, beneficial recreational NED benefits to Lake Sakakawea, and very little change in benefits at Lake Oahe. The largest reduction in benefits at Fort Peck Lake would occur under Variation 2B, with an average annual reduction of NED benefits of $282,000 or 2.0 percent. The smallest reduction in recreation NED benefits at Fort Peck Lake would occur under Variation 2A with an average annual reduction in $82,000 or 0.6 percent. Increases in recreation NED benefits would occur at Lake Sakakawea with minor increases in the pool elevations; the increase in average annual recreation NED benefits would range from $70,000 to $370,000 (Variation 1A and Variation 2b, respectively). The average annual changes in recreation NED benefits at Lake Oahe are very small and would result in both minor increases and decreases compared to No Action.

[5] It should be noted that as part of regional economic analysis for the recreation evaluation for the Missouri River Master Water Control Manual, Review and Update, Volume 6C: Recreation Economics (USACE 1994), the modeling indicated that there was not a statistically significant association between substitute recreation opportunities and visitation to the upper three reservoirs (see Table 1 in Recreation Economics Technical Report Appendix D within Volume 6C).

Table 15. Summary of Recreation NED Benefits for Fort Peck Lake (Thousands of 2020 Dollars)

Visitation/Recreation NED Benefits	NA	Alternative 1			Alternative 2		
		1	1A	1B	2	2A	2B
Average Annual Recreation Visitor Days	526,704	520,155	523,721	520,455	521,876	521,830	516,380
Change in Average Annual Recreation Visitor Days	NA	-6,549	-2,983	-6,249	-4,828	-4,874	-10,324
Percent Change in Average Annual Recreation Visitor Days	Na	-1.24%	-0.57%	-1.19%	-0.92%	-0.93%	-1.96%
Total Recreation NED Benefits	$1,166,678	$1,152,172	$1,160,071	$1,152,836	$1,155,983	$1,155,882	$1,143,809
Average Annual NED Benefits	$14,403	$14,224	$14,322	$14,233	$14,271	$14,270	$14,121
Change in Average Annual NED Benefits from No Action	NA	-$179	-$82	-$171	-$132	-$133	-$282
Percent Change from No Action	NA	-1.24%	-0.57%	-1.19%	-0.92%	-0.93%	-1.96%
Ave of 8 Lowest Visitation Years Relative to No Action	NA	-$2,339	-$2,235	-$2,324	-$1,821	-$1,814	-$2,516
Ave. of 8 Highest Visitation Years Relative to No Action	NA	$710	$1,493	$705	$730	$779	$40

Table 16. Summary of Recreation NED Benefits for Lake Sakakawea (Thousands of 2020 Dollars)

Visitation/Recreation NED Benefits	NA	Alternative 1			Alternative 2		
		1	1a	1b	2	2a	2b
Average Annual Recreation Visitor Days	3,360,637	3,366,031	3,362,312	3,365,451	3,367,055	3,368,111	3,369,558
Change in Average Annual Recreation Visitor Days from No Action	NA	5,393	1,674	4,814	6,418	7,474	8,920
Percent Change in Average Annual Recreation Visitor Days from No Action	NA	0.16%	0.05%	0.14%	0.19%	0.22%	0.27%
Total Recreation NED Benefits	$11,318,672	$11,336,836	$11,324,311	$11,334,884	$11,340,286	$11,343,844	$11,348,715
Average Annual NED Benefits	$139,737	$139,961	$139,806	$139,937	$140,004	$140,047	$140,108
Change in Average Annual NED Benefits from No Action	NA	$224	$70	$200	$267	$311	$371
Percent Change from No Action	NA	0.16%	0.05%	0.14%	0.19%	0.22%	0.27%
Ave of 8 Lowest Visitation Years Relative to No Action	NA	-$244	-$875	-$386	-$564	-$721	-$245
Ave. of 8 Highest Visitation Years Relative to No Action	NA	$1,971	$1,213	$1,793	$2,530	$2,784	$2,529

Table 17. Summary of Recreation NED Benefits for Lake Oahe (Thousands of 2020 Dollars)

Visitation/Recreation NED Benefits	NA	Alternative 1			Alternative 2		
		1	1a	1b	2	2a	2b
Average Annual Recreation Visitor Days	1,323,821	1,323,773	1,323,315	1,323,044	1,324,004	1,323,600	1,324,432
Change in Average Annual Recreation Visitor Days from No Action	NA	-47	-506	-777	183	-221	611
Percent Change in Average Annual Recreation Visitor Days	NA	0.00%	-0.04%	-0.06%	0.01%	-0.02%	0.05%
Total Recreation NED Benefits	$2,575,124	$2,575,032	$2,574,140	$2,573,613	$2,575,480	$2,574,695	$2,576,313
Average Annual NED Benefits	$31,792	$31,791	$31,780	$31,773	$31,796	$31,786	$31,806
Change in Average Annual NED Benefits from No Action	NA	-$1	-$12	-$19	$4	-$5	$15
Percent Change from No Action		0.00%	-0.04%	-0.06%	0.01%	-0.02%	0.05%
Ave of 8 Lowest Visitation Years Relative to No Action	NA	-$103	-$164	-$246	-$150	-$187	-$121
Ave. of 8 Highest Visitation Years Relative to No Action	NA	$122	$70	$122	$202	$143	$250

3.1.3 Inter-Reservoir River Reaches

Table 18 and 19 summarizes the recreation NED benefits for the two inter-reservoir river reaches. Under all of the alternatives and variations, Fort Peck inter-reservoir and Garrison inter-reservoir river reaches would support $1.2 million and $3.9 million in average annual recreation NED benefits, respectively, with very little changes under the action alternatives when compared to No Action.

In general, there would be very small increases in visitation and recreation NED benefits associated with the releases increasing boat operability in the Fort Peck Dam to Lake Sakakawea reach compared to No Action. Average NED benefits in the 8 lowest visitation years relative to No Action in the Fort Peck Dam to Lake Sakakawea river reach would result in a decrease of recreation NED benefits between $17,000 (Variation 1A) and a decrease of $40,000 (Variation 2B). Average NED benefits in the 8 lowest visitation years relative to No Action in the Garrison Dam to Lake Oahe river reach would result in a decrease of recreation NED benefits between $19,000 (Variation 1A) and a decrease of $83,000 (Alternative 2). On average, the changes in the inter-reservoir river reaches would be both positive and negative relative to No Action across the alternatives, although the changes would be negligible.

Table 18. Summary of Recreation NED Benefits for Fort Peck Dam to Lake Sakakawea Inter-reservoir River Reach (Thousands of 2020 Dollars)

Visitation/Recreation NED Benefits	No Action	Alternative 1			Alternative 2		
		1	1A	1B	2	2A	2B
Average Annual Recreation Visitor Days[a]	66,784	66,828	66,938	66,854	66,792	66,995	66,795
Change in Average Annual Recreation Visitor Days	NA	44	154	70	8	211	11
Percent Change in Average Annual Recreation Visitor Days	NA	0.07%	0.23%	0.11%	0.01%	0.32%	0.02%
Total Recreation NED Benefits	$97,520	$97,584	$97,744	$97,622	$97,532	$97,828	$97,536
Average Annual NED Benefits	$1,204	$1,205	$1,207	$1,205	$1,204	$1,208	$1,204
Change in Average Annual NED Benefits from No Action	NA	$1	$3	$1	$0	$4	$0
Percent Change from No Action		0.07%	0.23%	0.11%	0.01%	0.32%	0.02%
Ave of 8 Lowest Visitation Years Relative to No Action	NA	-$22	-$17	-$32	-$36	-$24	-$40
Ave. of 8 Highest Visitation Years Relative to No Action	NA	$29	$43	$43	$34	$49	$38

a The recreation visitor day estimates include only spring, summer, and fall boat-accessed recreation visitor days and do not include all visitation at the inter-reservoir river reaches.

Table 19. Summary of Recreation NED Benefits for Garrison Dam to Lake Oahe River Reach (Thousands of 2020 Dollars)

Visitation/Recreation NED Benefits	Alternative						
	NA	1	1a	1b	2	2a	2b
Average Annual Recreation Visitor Days[a]	116,029	116,181	116,081	115,974	115,949	115,994	115,998
Change in Average Annual Recreation Visitor Days	NA	151	52	-56	-81	-35	-31
Percent Change in Average Annual Recreation Visitor Days	NA	0.13%	0.04%	-0.05%	-0.07%	-0.03%	-0.03%
Total Recreation NED Benefits	$316,131	$316,544	$316,272	$315,979	$315,912	$316,035	$316,046
Average Annual NED Benefits	$3,903	$3,908	$3,905	$3,901	$3,900	$3,902	$3,902
Change in Average Annual NED Benefits	NA	$5	$2	-$2	-$3	-$1	-$1
Percent Change from No Action	NA	0.13%	0.04%	-0.05%	-0.07%	-0.03%	-0.03%
Ave of 8 Lowest Visitation Years Relative to No Action	NA	-$27	-$19	-$51	-$83	-$76	-$64
Ave. of 8 Highest Visitation Years Relative to No Action	NA	$78	$34	$37	$61	$65	$54

a The recreation visitor day estimates include only spring, summer, and fall boat-accessed recreation visitor days and do not include all visitation at the inter-reservoir river reaches.

3.2 No Action

Under the No Action alternative, operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. As noted above, the No Action alternative is considered the baseline against which the other alternatives are measured.

Under No Action, average annual recreation NED benefits in the upper three reservoirs and the two inter-reservoir river reaches would be $191 million, which is associated with approximately 5.4 million average annual recreation visitor days (Table 20). On annual average, Fort Peck Lake, Lake Sakakawea, and Lake Oahe would support $14 million, $140 million, and $32 million recreation NED benefits, respectively.

The two river reaches would support approximately $5 million in average annual recreation NED benefits, with the majority of the benefit from recreation in the Garrison Dam to Lake Oahe inter-reservoir river reach. Overall, recreation NED benefits supported by the upper Missouri River under No Action would be large and long term, providing local residents and non-local visitors with considerable recreational opportunities. Table 20 summarizes the recreation NED benefits under Alternative 1.

Table 20. Summary of NED Analysis for No Action, 1932–2012 (Thousands of 2020 Dollars)

Recreation NED Benefits	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe	All Locations
Average Annual Recreation Visitor Days	526,704	3,360,637	1,323,821	66,784	116,029	5,393,975
Average Annual NED Benefits	$14,403	$139,737	$31,792	$1,204	$3,903	$191,039
Maximum Annual NED Benefits	$20,427	$171,888	$39,761	$1,407	$4,240	$235,898
Minimum Annual NED Benefits	$0	$87,102	$14,661	$980	$2,813	$109,801

a Visitation benefits include all visitors at the upper three reservoirs and boat-accessed visitation in the inter-river reaches. Winter visitors are included for the reservoirs but are not included as plan-affected visitors in the river reaches.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual effects to better understand under what conditions beneficial or adverse impacts would occur. Figure 2 illustrates the annual NED recreation benefits for all locations. Annual recreation NED benefits would range from $94 million during drought years to $200 million during normal water conditions. Notable periods of drought or relatively drier conditions include the 1930s to early 1940s; mid-1950s, late 1980s to early 1990s, and mid-2000s. The largest annual decreases in the recreation NED benefits under No Action would occur on the upper three reservoirs when access to the lakes and fishing opportunities are directly affected by lower lake elevations during the natural cycles of drought and relatively drier periods.

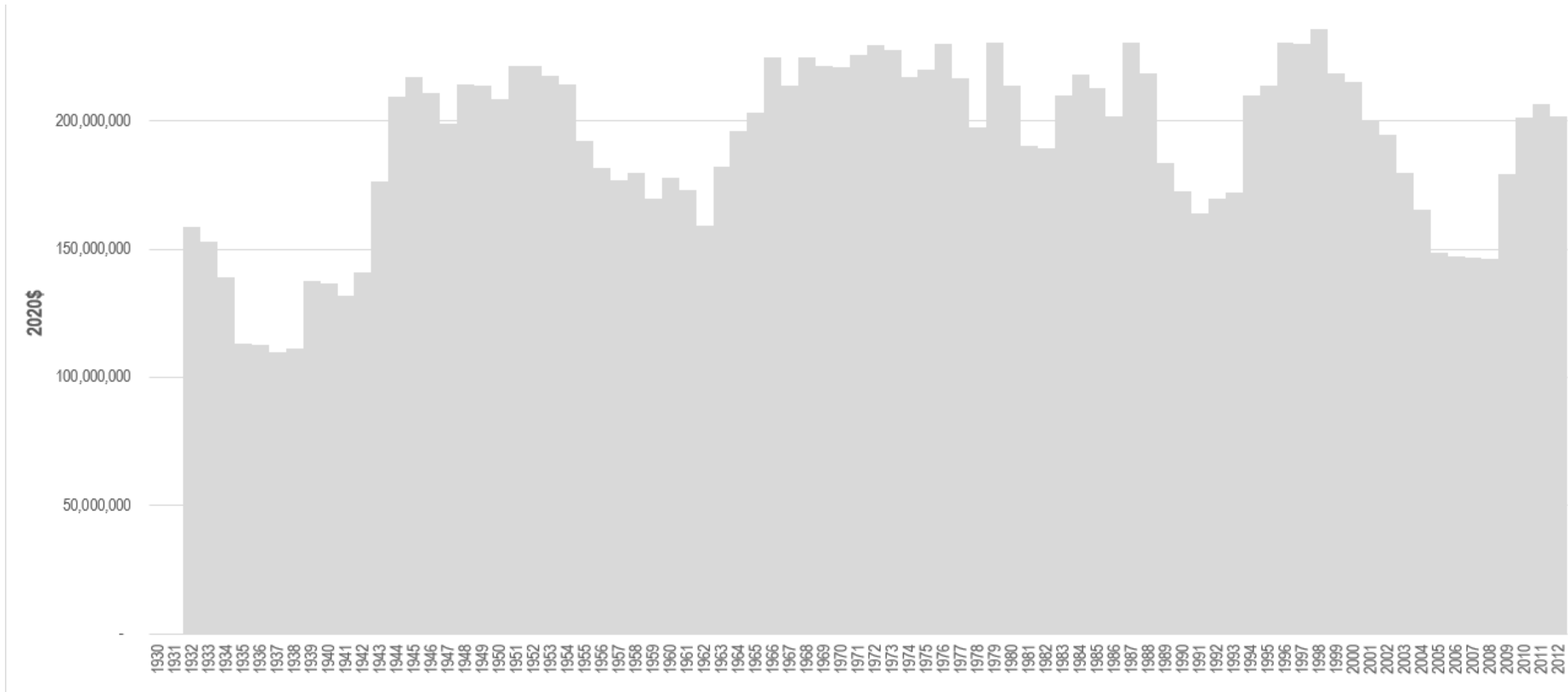

Figure 2. Annual Recreation NED Benefits Under No Action at All Locations (2020$)

3.3 Alternative 1, Including Variations 1A and 1B

System operations under Alternative 1 are based on those described under the No Action alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon. An Attraction Flow Regime would begin on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in a given year. The Spawning Cue Flow Regime under Alternative 1 begins on May 28 and would be 3.5 times the Fort Peck Dam spring flow release in the given release year. A further description of Alternative 1 is detailed in Chapter 2, Section 2.5 Alternatives Carried Forward for Further Evaluation.

Under Alternative 1, the upper Missouri River would support on average $191 million in recreation NED benefits per year, an increase of $50,000 (0.03 percent) compared to No Action (Table 21). The largest variation in recreational benefits would occur at Fort Peck Lake and Lake Sakakawea, where management actions under Alternative 1 would cause annual average NED benefits to decrease by 1.2 percent at Fort Peck Lake and increase by 0.2 percent at Lake Sakakawea. The flow releases would decrease Fort Peck Lake pool elevations affecting recreational access and fishing conditions, while visitation at Lake Sakakawea would increase from relatively higher pool elevations on average; there would be very little changes in visitation and recreation NED benefits at Lake Oahe and the inter-reservoir river reaches.

On average, Fort Peck Lake would experience a decrease in annual visitation of over 6,500 recreation visitor days, with a decrease in average annual recreation NED benefits of $179,000 (-1.2%). On the other hand, on average, Lake Sakakawea would experience an increase in annual visitation of over 5,400 recreation visitor days, with an increase in average annual recreation NED benefits of $224,000 (+0.2%).

Table 21. Summary of NED Analysis for Alternative 1, 1932–2012 (Thousands of 2020 Dollars)

Recreation NED Benefits or Costs	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe	Total
Annual Average Recreation Visitor Days	520,155	3,366,031	1,323,773	66,828	116,181	5,392,967
Change in Average Annual Recreation Visitor Days from No Action	-6,549	5,393	-47	44	151	-1008
Annual Average NED Benefits	$14,224	$139,961	$31,791	$1,205	$3,908	$191,088
Change in Average Annual NED Benefits from No Action	-$179	$224	-$1	$1	$5	$50
Percent Change in Average Annual NED Benefits from No Action	-1.24%	0.16%	0.00%	0.07%	0.13%	0.03%
Ave of 8 Lowest Visitation Years Relative to No Action	-$2,339	-$244	-$103	-$22	-$27	NA

Ave. of 8 Highest Visitation Years Relative to No Action	$710	$1,971	$122	$29	$78	NA

a Visitation benefits include all visitors at the upper three reservoirs and boat-accessed visitation in the inter-river reaches. Winter visitors are included for the reservoirs but are not included as plan-affected visitors in the river reaches.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figures 3, 4, 5, and 6 illustrate the annual NED recreation benefits for all locations, Fort Peck Lake, Lake Sakakawea, and Lake Oahe, respectively. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Annual recreation benefits supported by the all locations range between $5.6 million lower and $6.6 million higher per year than those under No Action. Three years with relatively higher adverse impacts would be simulated to occur in 1987, 1988, and 1994 (two when a flow release would occur and one in a year following a release) when lower reservoir elevations impact recreational fishing opportunities at Fort Peck Lake, ranging from $5.5 to $5.8 million per year lower than under No Action (Figure 4). In these three years, Fort Peck Lake would be approximately 2 to 3 feet lower than would be simulated under No Action.

At Lake Sakakawea, the flow releases would generally increase reservoir elevations during full and partial releases and in the years following the release. In three years as simulated over the period of record, recreation NED benefits would be between $2.5 and $3.8 million higher per year than under No Action (Figure 5).

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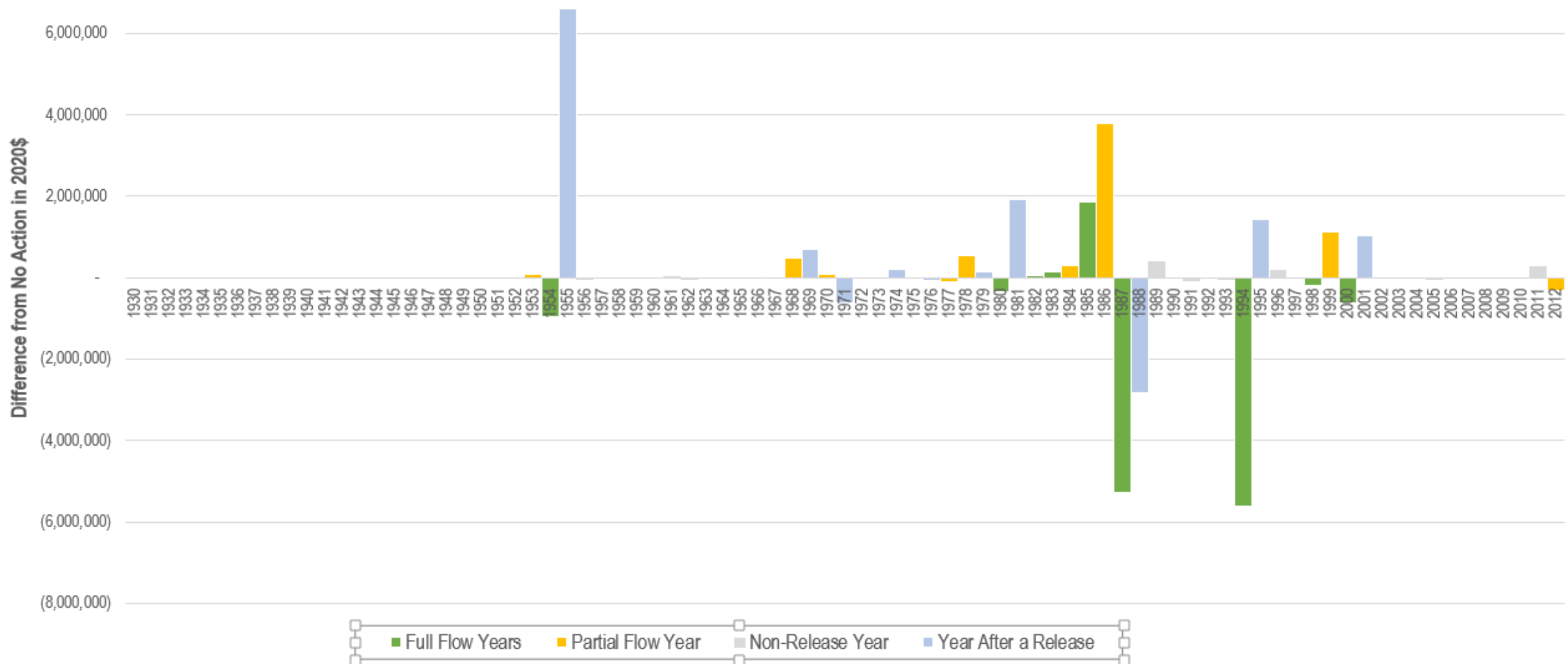

Figure 3. Annual Difference in Recreation NED Benefits Under Alternative 1 Relative to No Action for All Locations (2020$)

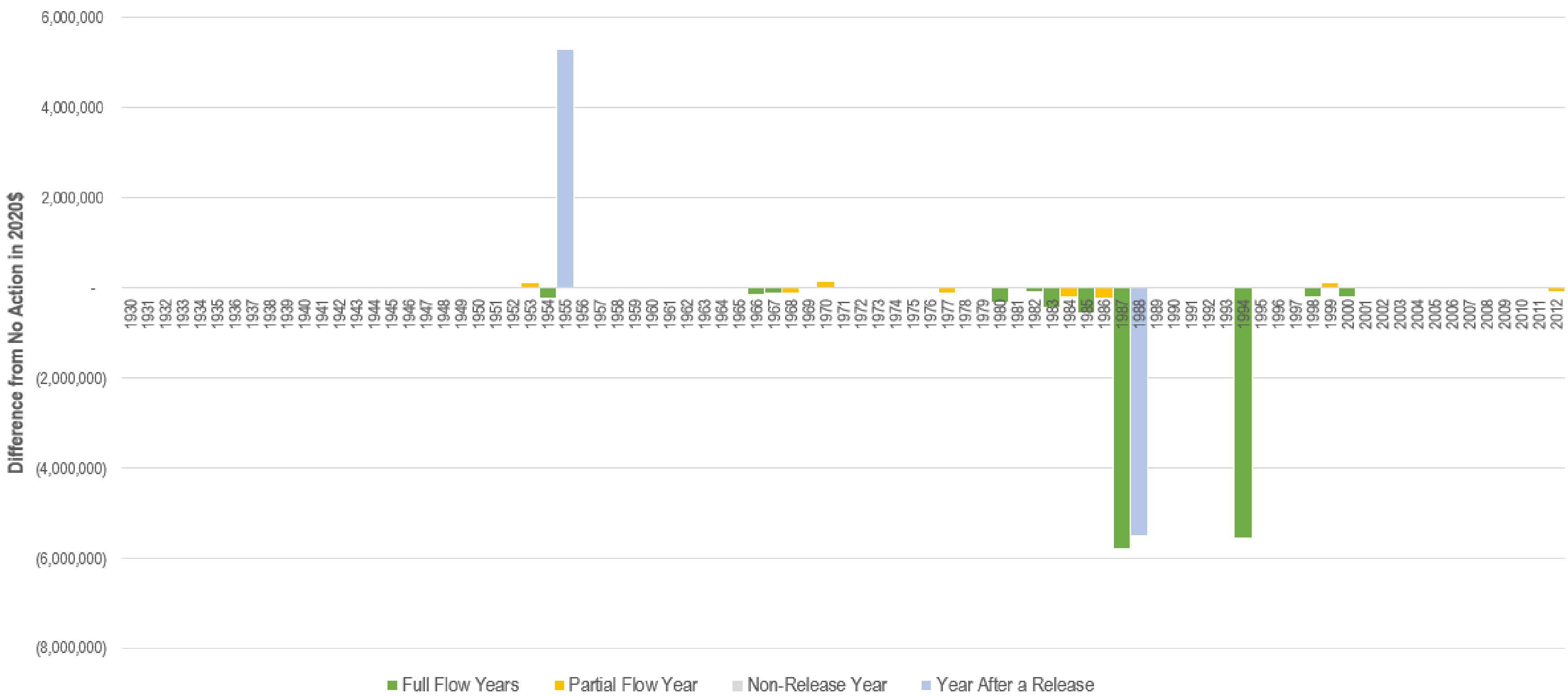

Figure 4. Annual Difference in Recreation NED Benefits under Alternative 1 compared to No Action at Fort Peck Lake (2020$)

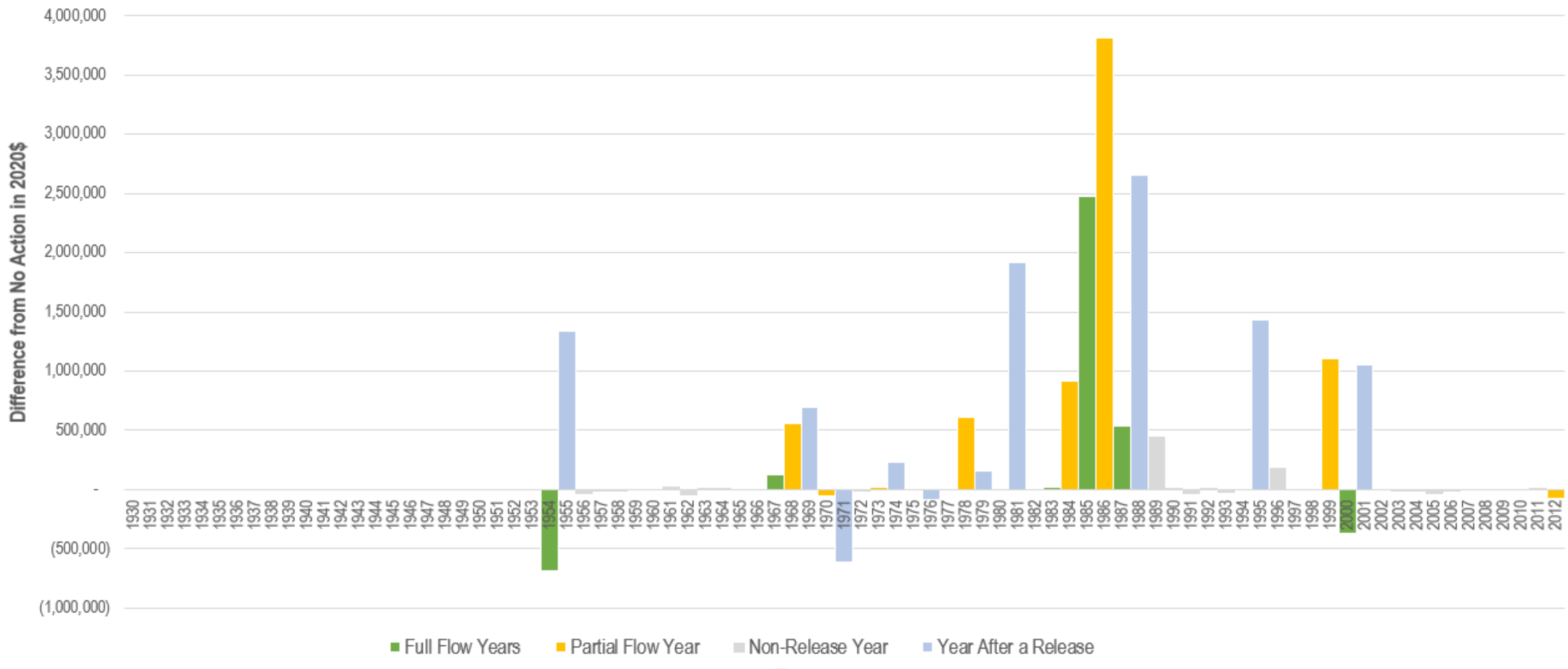

Figure 5. Annual Difference in Recreation NED Benefits under Alternative 1 Compared to No Action at Lake Sakakawea (2020$)

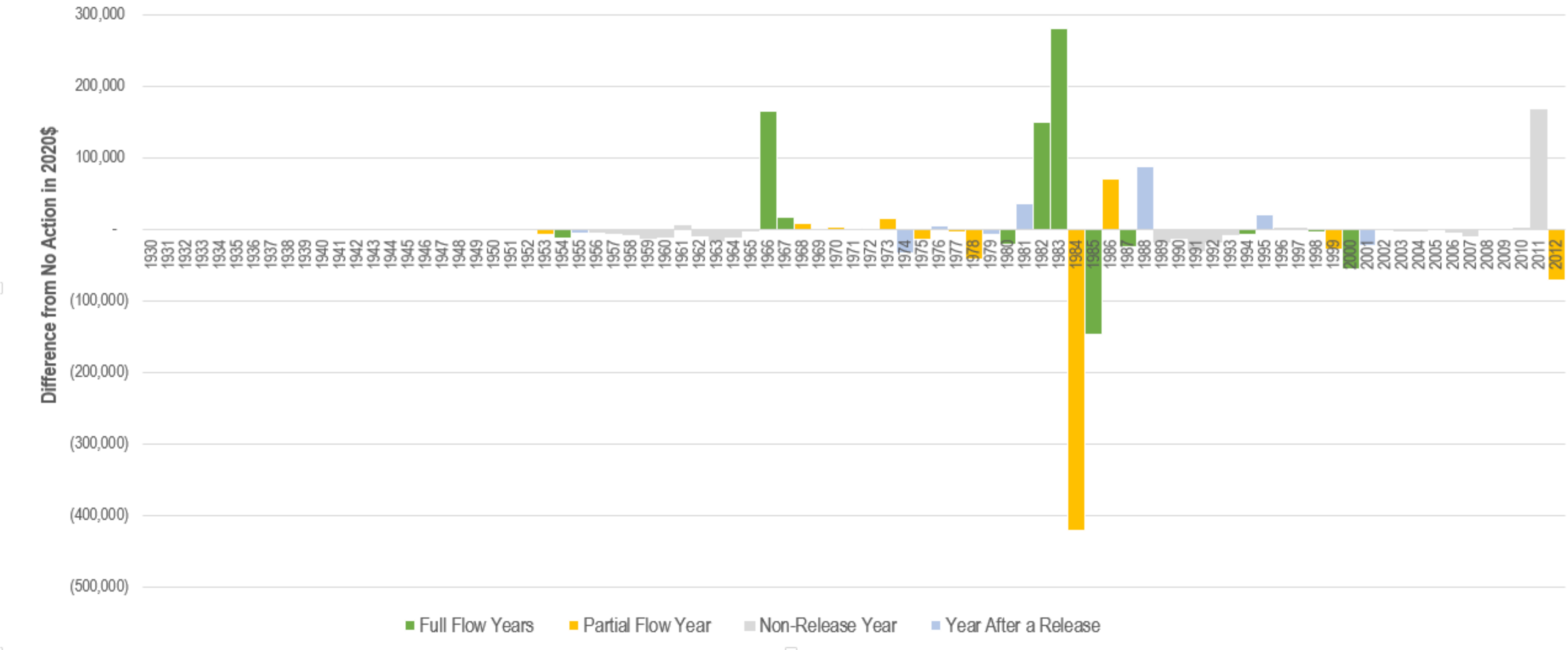

Figure 6. Annual Difference in Recreation NED Benefits under Alternative 1 Compared to No Action at Lake Oahe (2020$)

At Fort Peck Lake, an important metric to predict visitation is fishing success. Changes in fishing success has implications for fishing conditions and recreational fishing opportunities at Fort Peck Lake. The partial or full releases would occur as simulated in 22 years over the period of record. As simulated, Alternative 1 would result in three years when the fishing success criteria would not be met at Fort Peck Lake (and would be met under No Action) and one year when the fishing success criteria would not be met under No Action (and would be met under Alternative 1). There are changes in the timing and frequency of the years when the fishing success is met under Alternative 1 and No Action at Fort Peck Lake. The changes in the fishing success metric occur in 1955, 1987, 1988, and 1994. In all other years, the fishing success metric was the same under both Alternative 1 and No Action. Table 22 summaries the results of the fishing success metrics when they differ between Alternative 1 and No Action.

Under No Action, there is spring pool rise in 1986 and 1994 that meets the fishing success criteria, while under Alternative 1, the pool would not rise under Alternative 1 due to partial and full releases in these years. The fishing success metric requires that a sufficient pool rise occur at least in the current spring *or* springs of the previous two years. The lack of pool rise in 1986 affects the fishing success metric in 1987 and 1988. The lack of the pool rise in 1994 affects the fishing success metric in 1994 because the previous two years (1993 and 1992) also do not have sufficient pool rise. Under No Action, the spring pool rise in 1986 and 1994 allow for the fishing success metric and criteria to be met in 1987, 1988, and 1994.

Under Alternative 1, in 1955 as simulated, there would be rising mid-August pool elevations in the previous two years but this would not occur under No Action. The releases in the two previous simulated years (1953 and 1954) would cause rising pool elevations in consecutive years, which is one of the criteria in the fishing success metric. Under No Action, the mid-August pool elevations would not increase in these years, and the fishing fish metric would not be met in 1955 under No Action.

Table 22. Summary of Fishing Success Metric at Fort Peck Lake

Year	No Action	Alternative 1
1955	Fishing success criteria not met	Fishing success criteria met
1987	Fishing success criteria met	Fishing success criteria not met
1988	Fishing success criteria met	Fishing success criteria not met
1994	Fishing success criteria met	Fishing success criteria not met

Note: Fishing success criteria is met if: 1) the spring pool rise occurs in the current or previous two years and there has been no drop in the mid-August pool in the previous two summers (drought conditions); or 2) if the mid-August reservoir elevation has dropped in the past year (since the previous August), but has not dropped consecutively for the 2 prior years.

3.3.1 Alternative 1 – Variation 1A

Variation 1A is a test flow variation of Alternative 1. The parameters for 1A are the same as described for Alternative 1 except that the Attraction Flow is initiated on April 9, rather than April 16, and the Spawning Cue Flow Regime is initiated on May 21, rather than May 28. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases.

Under Variation 1A, the upper Missouri River would support on average $191 million in recreation NED benefits per year, a decrease of $20,000 (0.01 percent) compared to No Action (Table 23). The impacts would be like Alternative 1, with adverse impacts to Fort Peck Lake and beneficial impacts at Lake Sakakawea compared to No Action. However, compared to Alternative 1 on average, there would be fewer adverse impacts to Fort Peck Lake (0.6 percent decrease from No Action) and fewer beneficial impacts to Lake Sakakawea (0.05 percent increase from No Action) under Variation 1A. Compared to Alternative 1, there is one more year when the fishing success metric would be met at Fort Peck Lake under Variation 1A, which reduces the adverse effects of Variation 1A when compared to Alternative 1. At Fort Peck Lake, there would be an average annual reduction in visitors days of 3,000 and $82,000 in recreation NED benefits (-0.6%).

On the other hand, on average, Lake Sakakawea would experience an increase in annual visitation of over 1,700 recreation visitor days, with an increase in average annual recreation NED benefits of $70,000. Compared to Alternative 1, the recreation NED benefits under Variation 1A would be lower, associated with the earlier release not having as much of an increase in mid-August pool elevations at Lake Sakakawea. There are very little changes in visitation and recreation NED benefits at Lake Oahe and the inter-reservoir river reaches.

Table 23. Summary of NED Analysis for Alternative 1 – Variation 1A, 1932–2012 (Thousands of 2020 Dollars)

Recreation NED Benefits or Costs	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe	Total
Average Annual Recreation Visitor Days	523,721	3,362,312	1,323,315	66,938	116,081	5,392,367
Change in Average Annual Recreation Days from No Action	-2,983	1,674	-506	154	52	-1,608
Annual Average NED Benefits	$14,322	$139,806	$31,780	$1,207	$3,905	$191,019
Change in Average Annual NED Benefits from No Action	-$82	$70	-$12	$3	$2	-$20
Percent Change in Average Annual NED Benefits from No Action	-0.57%	0.05%	-0.04%	0.23%	0.04%	-0.01%
Ave of 8 Lowest Visitation Years Relative to No Action	-$2,235	-$875	-$164	-$17	-$19	NA
Ave. of 8 Highest Visitation Years Relative to No Action	$1,493	$1,213	$70	$43	$34	NA

a Visitation benefits include all visitors at the upper three reservoirs and boat-accessed visitation in the inter-river reaches. Winter visitors are included for the reservoirs but are not included as plan-affected visitors in the river reaches.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figures 7, 8, 9, and 10 illustrate the annual NED recreation benefits for all locations, Fort Peck Lake, Lake Sakakawea, and Lake Oahe, respectively. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Annual recreation benefits supported by the all locations range between $5.6 million lower and $5.8 million higher than those under No Action. Four years with relatively higher adverse impacts would be simulated to occur in 1977, 1987, 1988, and 1994 (three when a flow release would occur and one in a year following a release). Similar to Alternative 1, Variation 1A would result in lower reservoir elevations that would impact recreational fishing opportunities at Fort Peck Lake, with notable decreases in three years when recreation NED benefits would range from $5.5 to $5.8 million per year lower than under No Action (Figure 8). In these three years, Fort Peck Lake would be approximately 2 to 3 feet lower than would be simulated under No Action.

At Lake Sakakawea, visitation is influenced by the previous year mid-August elevations, generally with higher elevations benefiting recreational conditions and visitation to the reservoirs. In one year, reservoir elevations at Lake Sakakawea would be1 to 5 feet lower in 1976 between July and November from target minimum flows under Variation 1A, which would affect visitation and recreation NED benefits in 1977 relative to No Action (figure 9).

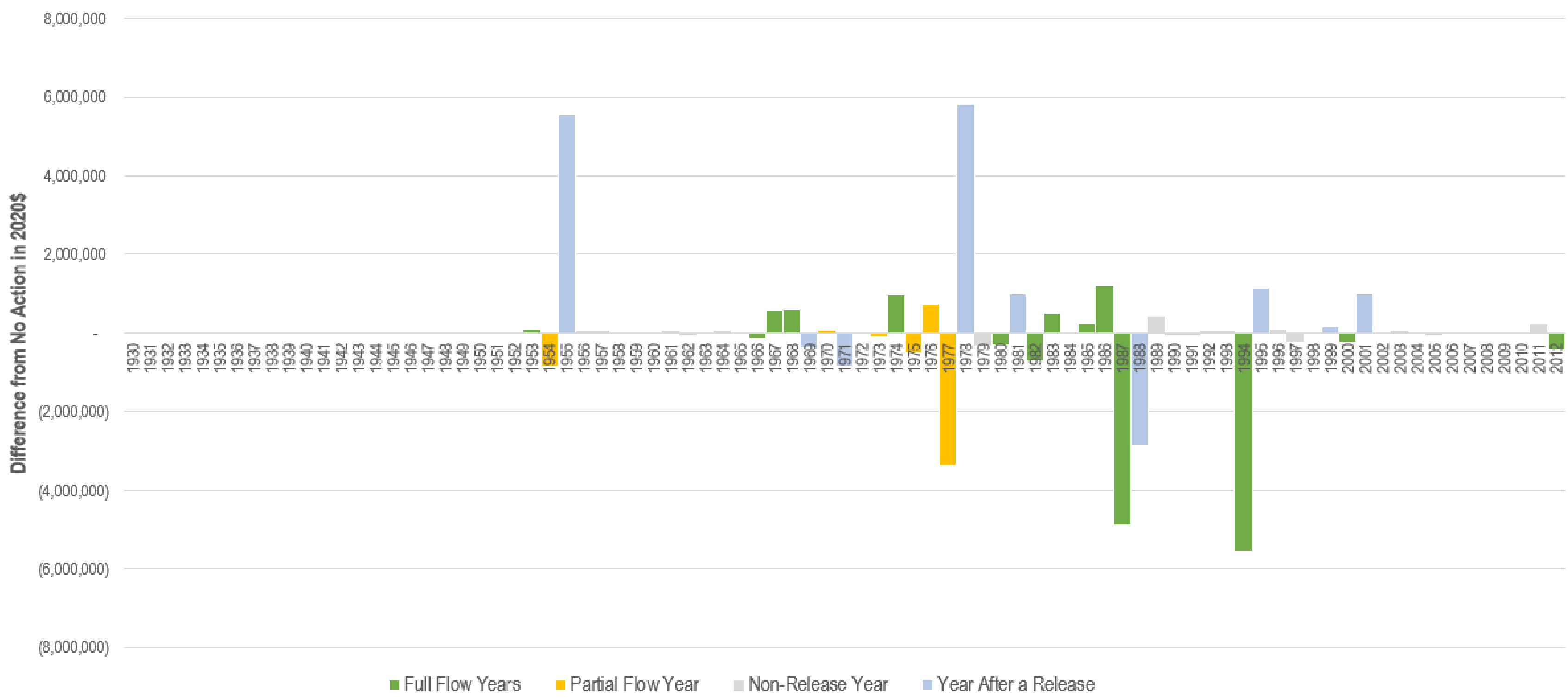

Figure 7. Annual Difference in Recreation NED Benefits under Variation 1A Compared to No Action at All Locations (2020$)

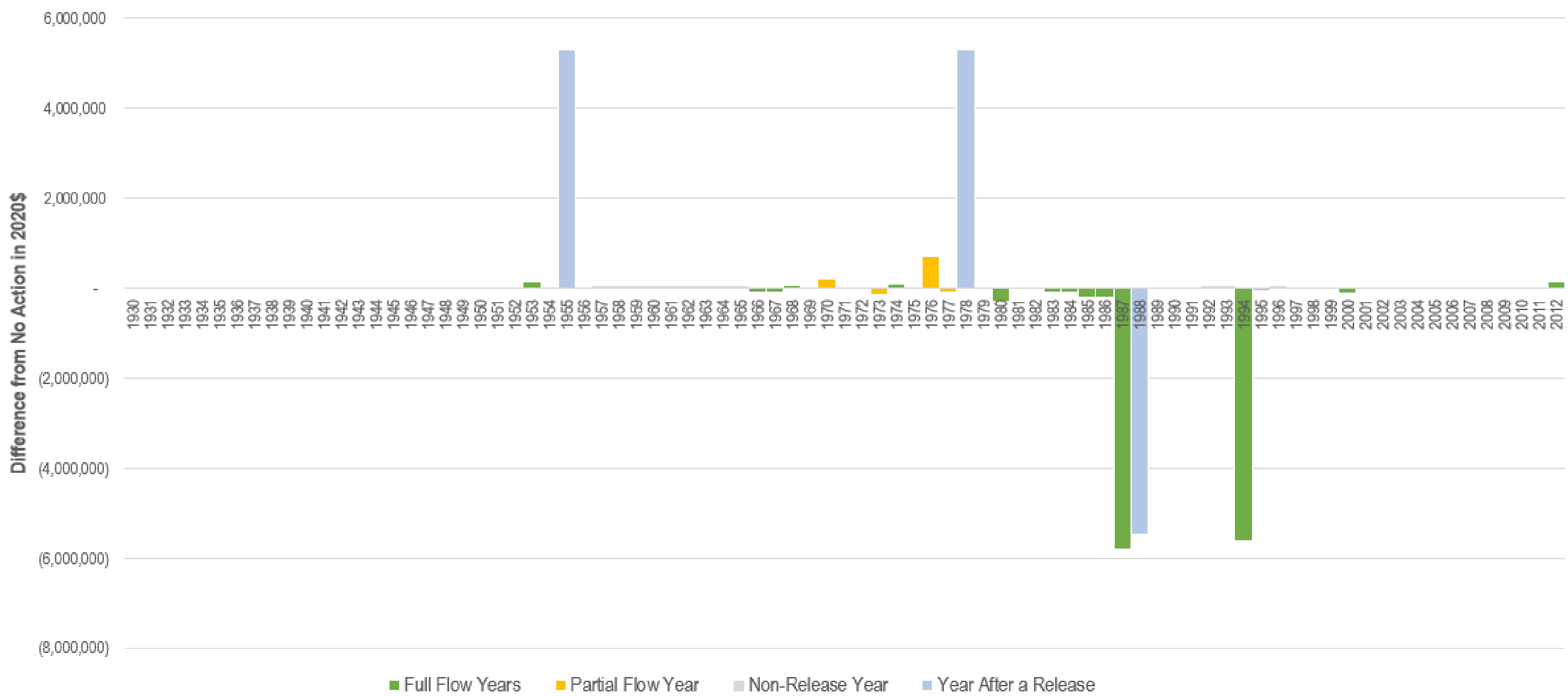

Figure 8. Annual Difference in Recreation NED Benefits under Alternative 1, Variation 1A, Compared to No Action at Fort Peck Lake (2020$)

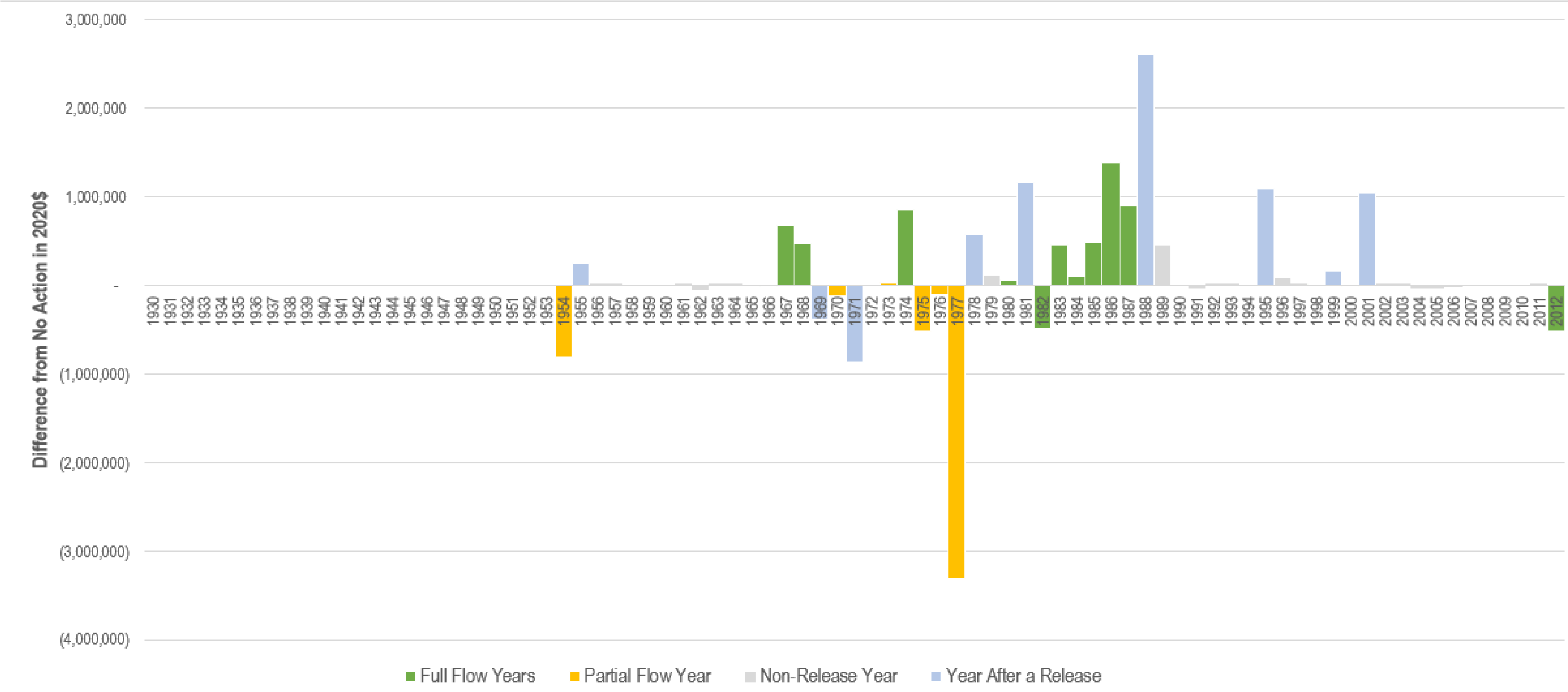

Figure 9. Annual Difference in Recreation NED Benefits under Alternative 1, Variation 1A, Compared to No Action at Lake Sakakawea (2020$)

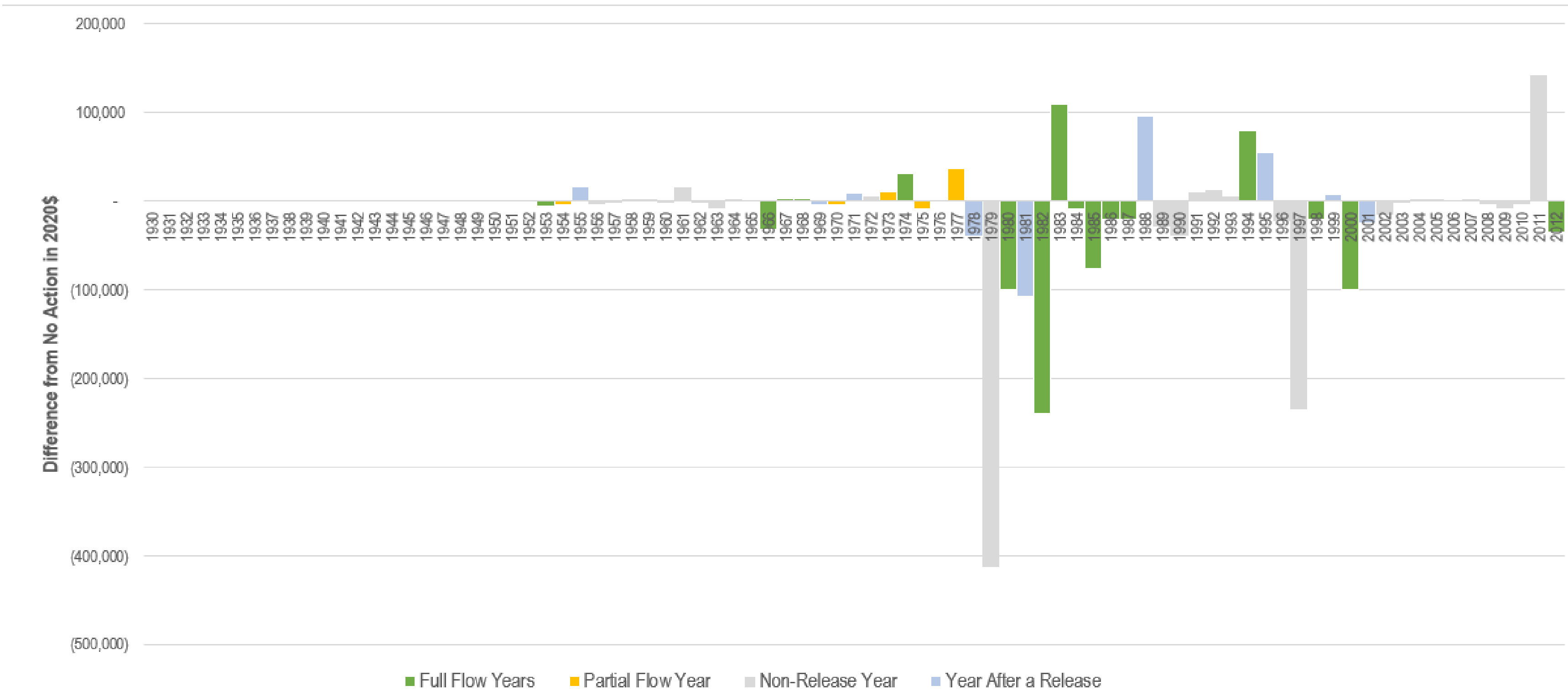

Figure 10. Annual Difference in Recreation NED Benefits under Alternative 1, Variation 1A, Compared to No Action at Lake Oahe (2020$)

Similar to the impacts described in Alternative 1, changes in the fishing success metric at Fort Peck Lake would have a notable impact on recreation NED benefits in some years for Variation 1A. The partial or full releases would occur as simulated in 22 years over the period of record. The same years would be affected in terms of meeting the fishing success metric under Variation 1A as under Alternative 1, although one additional year would be affected, 1978. Table 24 summaries the results of the fishing success metrics when they differ between Variation 1A and No Action.

Under Variation 1A, in 1955 and 1978 as simulated, there would be rising mid-August pool elevations in the previous two years but this would not occur under No Action. The releases in the two previous simulated years (1953 and 1954 and 1976 and 1977) would cause rising pool elevations in consecutive years, which is one of the criteria in the fishing success metric. Under No Action, the mid-August pool elevations would not increase in these years.

Table 24. Summary of Fishing Success Metric at Fort Peck Lake

Year	No Action	Alternative 1A
1955	Fishing success criteria not met	Fishing success criteria met
1978	Fishing success criteria not met	Fishing success criteria met
1987	Fishing success criteria met	Fishing success criteria not met
1988	Fishing success criteria met	Fishing success criteria not met
1994	Fishing success criteria met	Fishing success criteria not met

Note: Fishing success criteria is met if: 1) the spring pool rise occurs in the current or previous two years and there has been no drop in the mid-August pool in the previous two summers (drought conditions); or 2) if the mid-August reservoir elevation has dropped in the past year (since the previous August), but has not dropped consecutively for the 2 prior years.

3.3.2 Alternative 1 – Variation 1B

Variation 1B is another test flow variation of Alternative 1. The parameters for 1B are the same as described for Alternative 1 except that the Attraction Flow is initiated on April 23 and the Spawning Cue Flow is initiated on June 4. Similar to the concept described in Variation 1A, the later initiation date is intended to provide a contrast to explore any differences in forecasted impacts from a later flow initiation date.

Under Variation 1B, the upper Missouri River would support on average $191 million in recreation NED benefits per year, with an increase of $10,000 compared to No Action (Table 25). The largest variations in recreational benefits would occur at Fort Peck Lake and Lake Sakakawea, where management actions under Variation 1B would cause annual average NED benefits to decrease by 1.2 percent at Fort Peck Lake and increase by 0.1 percent at Lake Sakakawea. The flow releases would decrease Fort Peck Lake pool elevations affecting recreational access and fishing conditions, while visitation at Lake Sakakawea would increase from relatively higher pool elevations on average; there would be very little changes in visitation and recreation NED benefits at Lake Oahe and the inter-reservoir river reaches.

On average, Fort Peck Lake would experience a decrease in annual visitation of over 6,200 recreation visitor days, with a decrease in average annual recreation NED benefits of $171,000 (-1.2%). On the other hand, on average, Lake Sakakawea would experience an increase in annual visitation of over 4,800 recreation visitor days, with an increase in average annual recreation NED benefits of $200,000 (+0.1%).

Table 25. Summary of NED Analysis for Alternative 1 – Variation 1B, 1932–2012 (Thousands of 2020 Dollars)

Recreation NED Benefits or Costs	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe	Total
Average Annual Recreation Visitor Days	520,455	3,365,451	1,323,044	66,854	115,974	5,391,778
Change in Average Annual Recreation Days from No Action	-6,249	4,814	-777	70	-56	-2,198
Annual Average NED Benefits	$14,233	$139,937	$31,773	$1,205	$3,901	$191,049
Change in Average Annual NED Benefits from No Action	-$171	$200	-$19	$1	-$2	$10
Percent Change in Average Annual NED Benefits from No Action	-1.19%	0.14%	-0.06%	0.11%	-0.05%	0.01%
Ave of 8 Lowest Visitation Years Relative to No Action	-$2,324	-$386	-$246	-$32	-$51	NA
Ave. of 8 Highest Visitation Years Relative to No Action	$705	$1,793	$122	$43	$37	NA

a Visitation benefits include all visitors at the upper three reservoirs and boat-accessed visitation in the inter-river reaches. Winter visitors are included for the reservoirs but are not included as plan-affected visitors in the river reaches.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figures 11, 12, 13, and 14, illustrate the annual NED recreation benefits for all locations, Fort Peck Lake and Lake Sakakawea, respectively. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Annual recreation benefits supported by all locations range between $5.6 million lower and $6.8 million higher than those under No Action. Similar to Alternative 1, three years with relatively higher adverse impacts would be simulated to occur in 1987, 1988, and 1994 (two years when the flow release would occur and one in a year following a release) when lower reservoir elevations impact recreational fishing opportunities at Fort Peck Lake, approximately $5.4 to $5.8 million per year lower than under No Action (Figure 12). Similar to Alternative 1 and Variation 1A, in these three years, Fort Peck Lake would be approximately 2 to 3 feet lower than would be simulated under No Action.

At Lake Sakakawea, the flow releases would generally increase reservoir elevations during full and partial releases and in the years following the releases. In five years as simulated over the period of record, recreation NED benefits would be between $1.5 and $3.4 million higher than under No Action (Figure 13).

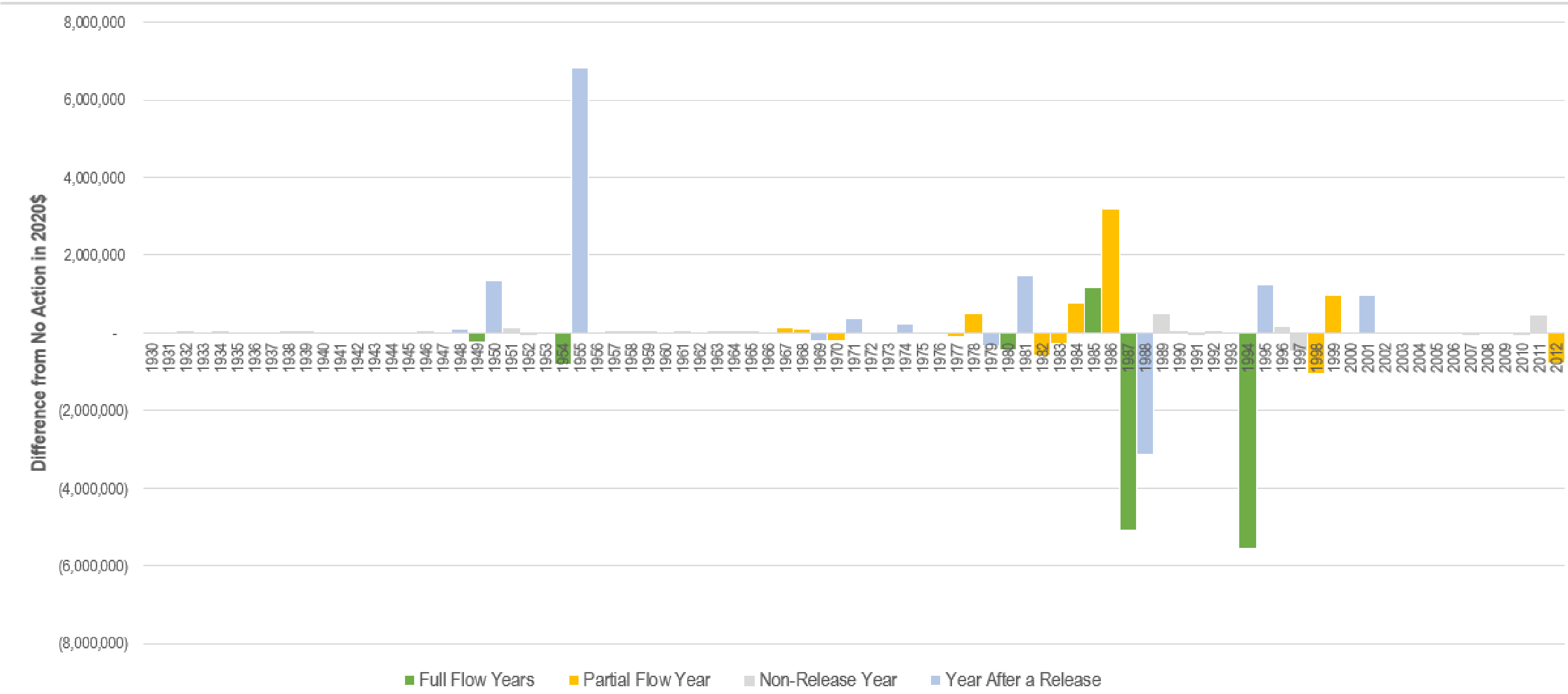

Figure 11. Annual Difference in Recreation NED Benefits under Alternative 1, Variation 1B, Compared to No Action at All Locations (2020$)

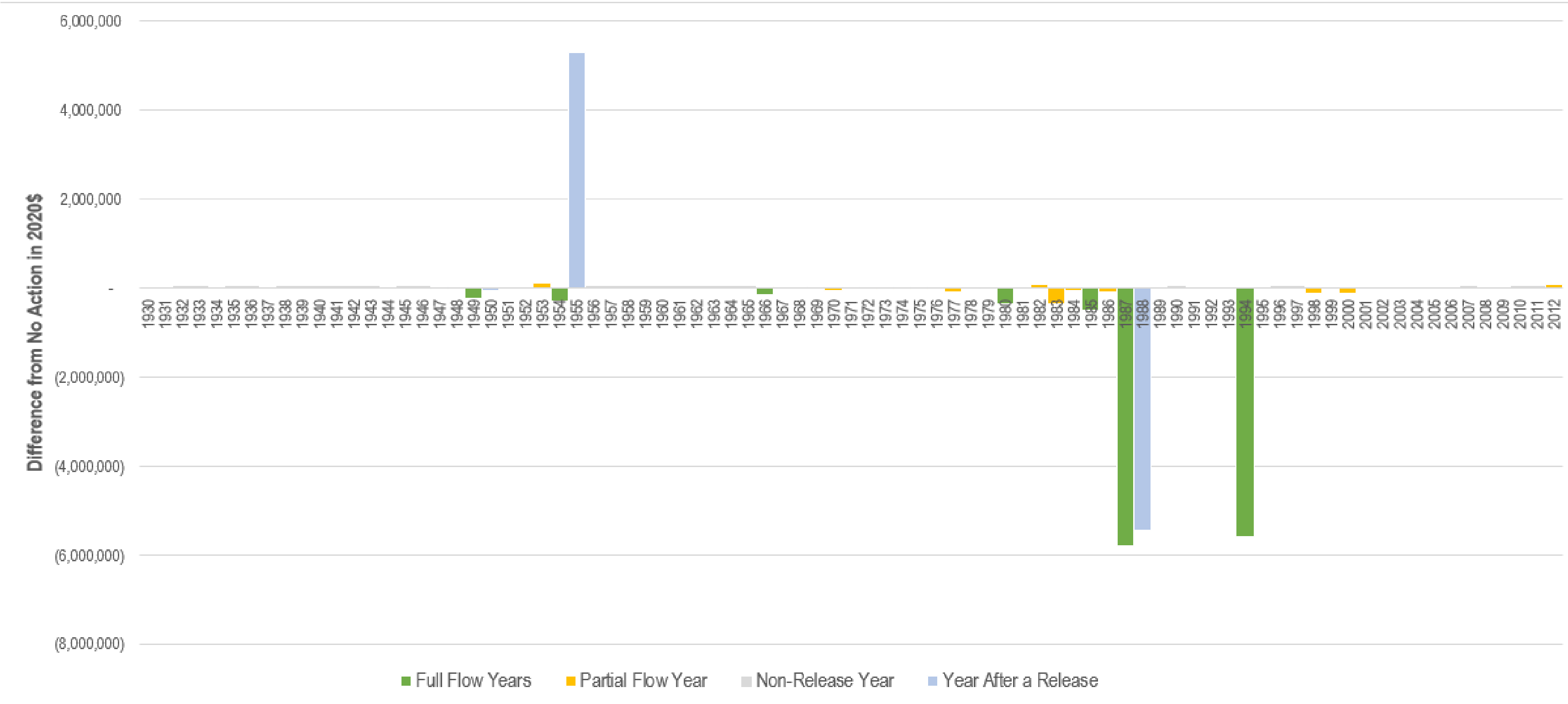

Figure 12. Annual Difference in Recreation NED Benefits under Alternative 1, Variation 1B, Compared to No Action at Fort Peck Lake (2020$)

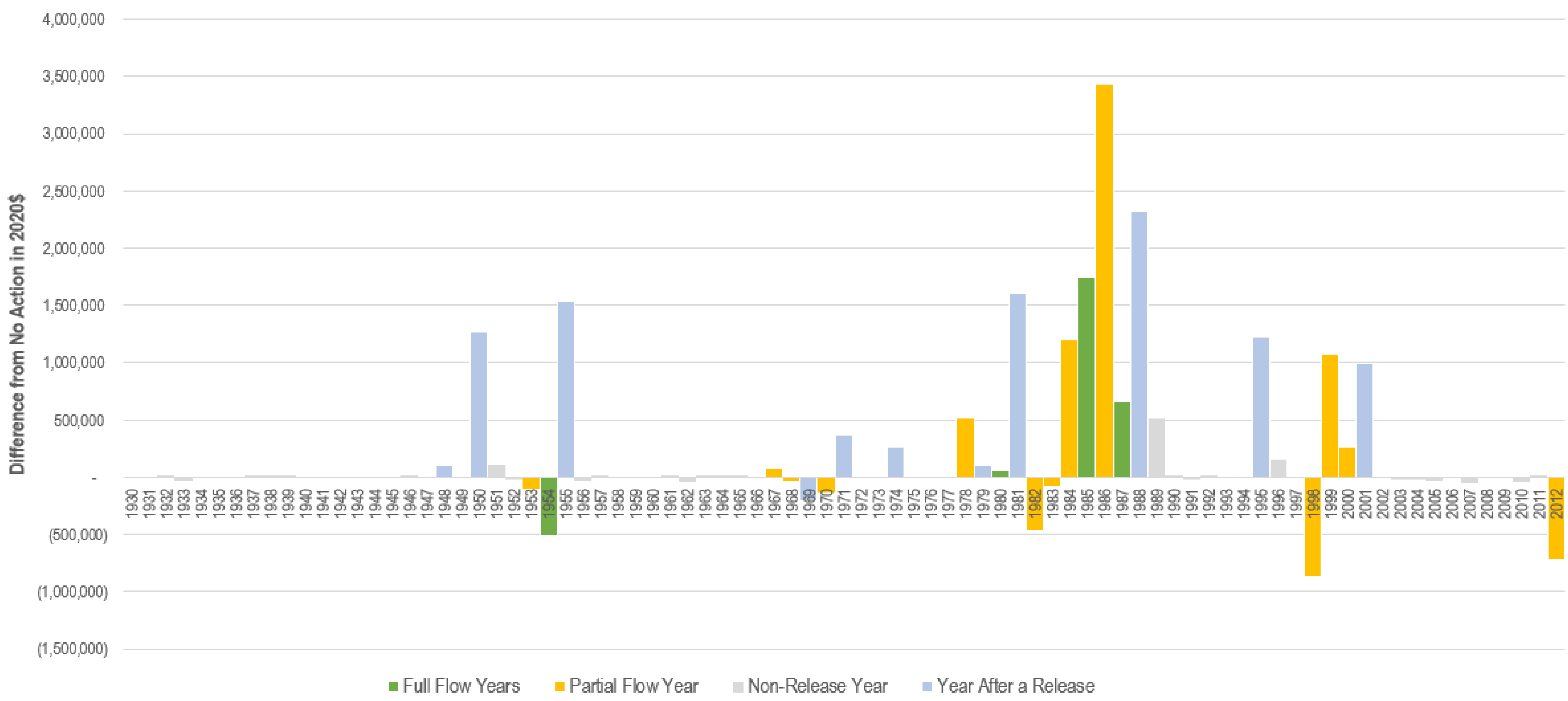

Figure 13. Annual Difference in Recreation NED Benefits under Alternative 1, Variation 1B, Compared to No Action at Lake Sakakawea (2020$)

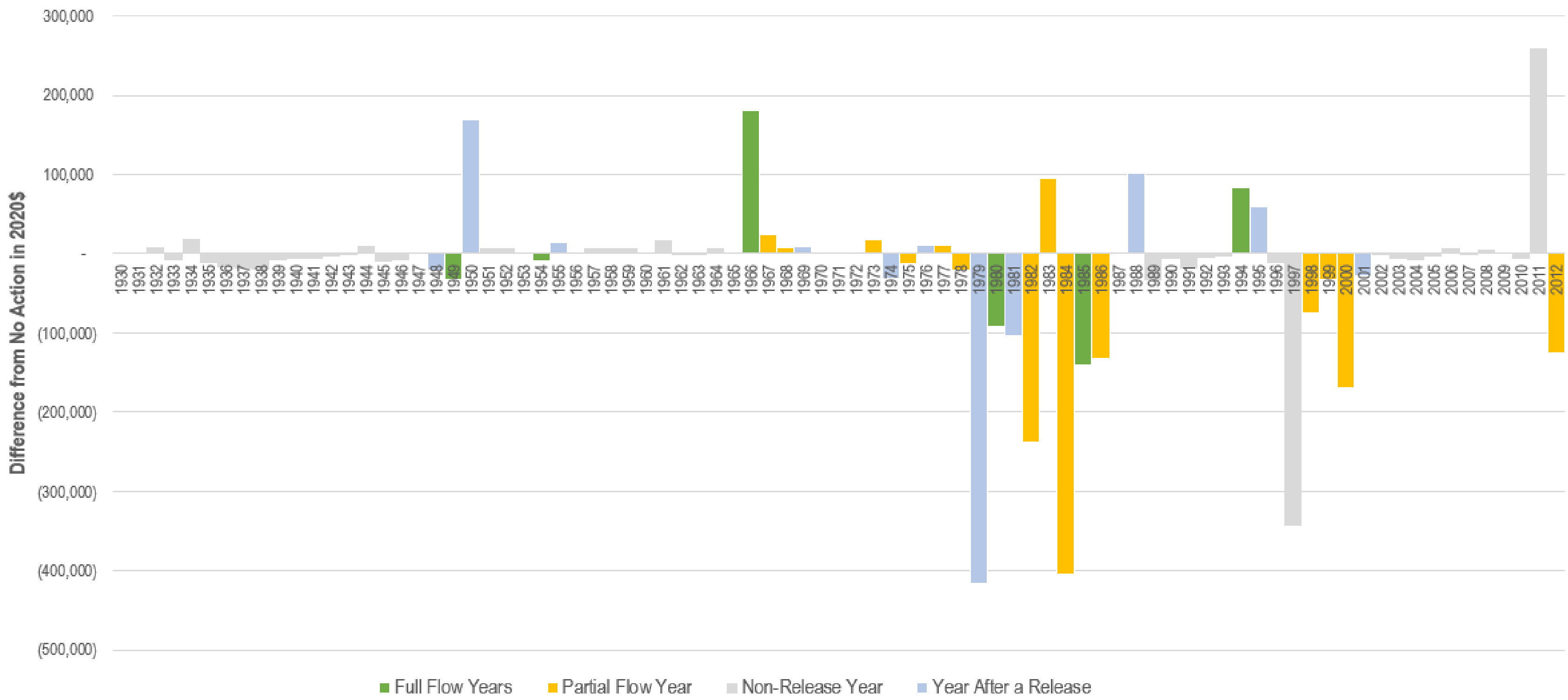

Figure 14. Annual Difference in Recreation NED Benefits under Alternative 1, Variation 1B, Compared to No Action at Lake Oahe (2020$)

Similar to the impacts described in Alternative 1, changes in the fishing success metric have a notable impact on recreation NED benefits in some years. The partial or full releases would occur as simulated in 24 years over the period of record. As simulated, Variation 1B would result in three years when the fishing success criteria would not be met at Fort Peck Lake (and would be met under No Action) and one year when the fishing success criteria would not be met under No Action (and would be met under Variation 1B), which is the same as simulated under Alternative 1. Table 26 summaries the results of the fishing success metrics when they differ between Variation 1B and No Action.

Table 26. Summary of Fishing Success Metric at Fort Peck Lake

Year	No Action	Variation 1B
1955	Fishing success criteria not met	Fishing success criteria met
1987	Fishing success criteria met	Fishing success criteria not met
1988	Fishing success criteria met	Fishing success criteria not met
1994	Fishing success criteria met	Fishing success criteria not met

Note: Fishing success criteria is met if: 1) the spring pool rise occurs in the current or previous two years and there has been no drop in the mid-August pool in the previous two summers (drought conditions); or 2) if the mid-August reservoir elevation has dropped in the past year (since the previous August), but has not dropped consecutively for the 2 prior years.

3.3.3 Summary Results for Alternative 1, including Variations 1A and 1B

Table 27 provides a summary of the NED impacts for Alternative 1 including variations 1A and 1B in years when a partial or full flow release would be simulated to occur. Over all locations, average annual recreation NED benefits would increase under Alternative 1 and Variation 1B between $14,000 and $115,000 (0.01 to 0.05 percent) relative to No Action. Variation 1A would result in a decrease in average annual NED benefits of $48,000 of -0.02 percent.

Visitation and recreation NED benefits would decrease at Fort Peck Lake compared to No Action during flow release years, ranging from a decrease of 14,000 to 16,000 visitors and decrease of $211,000 (-1.2%) to $450,000 (-2.6%) in recreation NED benefits. It appears that Variation 1A is slightly better for Fort Peck Lake relative to Alternative 1 and Variation 1B. While Fort Peck Lake would experience small adverse impacts in most years during a partial or full flow release, in some years the releases cause impacts to fishing success, specifically reducing a rising pool in the spring, with estimated reductions in visitation and recreation NED benefits of approximately 31 percent compared to No Action. In these years (three over the period of record under Alternative 1 and each of its variations), there could be the potential for large adverse impacts; the effects could persist as the lower lake conditions continue but would be short-term as hydrology and precipitation return the reservoir to relatively higher pool elevations and adequate fishing conditions.

At Lake Sakakawea, in most years there would be increased visitation and recreation NED benefits under Alternative 1 and its variations compared to No Action. Variation 1A would be least beneficial relative to No Action, while Alternative 1 would be most beneficial. Lake Oahe would experience slight decreases in visitation and recreation NED benefits during flow release years, while the inter-reservoir river reaches would experience slight increases in visitation and recreation NED benefits compared to No Action (except for the Garrison Reach under Variation

1B). In all locations aside from Fort Peck Lake, all impacts under Alternative 1 and its variations would be negligible and adverse or beneficial compared to No Action.

Table 27. Summary of NED Analysis for Alternative 1, Variations 1A and 1B, 1932–2012, during Partial or Full Release Years (2020 Dollars)

Recreation NED Benefits	Alternative 1	Variation 1A	Variation 1B	Range in Variation
All Locations				
Change in Ave. Annual Recreation Visitor Days from No Action	-2,831	-3,811	-5,136	2,305
Change in Ave. Annual NED from No Action	$114,964	-$48,460	$13,510	$163,424
Percent Change in Ave. Annual NED from No Action	0.05%	-0.02%	0.01%	0.07%
Fort Peck Lake				
Change in Ave. Annual Recreation Visitor Days from No Action	-16,473,	-7,714	-14,085	8,759
Change in Ave. Annual NED from No Action	-$450,487	-$210,962	-$385,185	$239,525
Percent Change in Ave. Annual NED from No Action	-2.62%	-1.23%	-2.23%	1.39%
Lake Sakakawea				
Change in Ave. Annual Recreation Visitor Days from No Action	13,390	4,005	10,498	9,385
Change in Ave. Annual NED from No Action	$556,765	$166,512	$436,498	$390,253
Percent Change in Ave. Annual NED from No Action	0.36%	0.11%	0.28%	0.25%
Lake Oahe				
Change in Ave. Annual Recreation Visitor Days from No Action	-88	-538	-1,502	1,414
Change in Ave. Annual NED from No Action	-$2,105	-$12,930	-$36,080	$33,975
Percent Change in Ave. Annual NED from No Action	-0.01%	-0.04%	-0.10%	0.09%
Fort Peck Dam to Lake Sakakawea				
Change in Ave. Annual Recreation Visitor Days from No Action	41	370	11	359
Change in Ave. Annual NED from No Action	$745	$6,677	$207	$6,470
Percent Change in Ave. Annual NED from No Action	0.06%	0.53%	0.02%	0.51%
Garrison Dam to Lake Oahe				

Change in Ave. Annual Recreation Visitor Days from No Action	299	67	-57	3663
Change in Ave. Annual NED from No Action	$10,046	$2,242	-$1,931	$11,977
Percent Change in Ave. Annual NED from No Action	0.25%	0.06%	-0.05%	0.30%

3.4 Alternative 2

The parameters for Alternative 2 are the same as described for Alternative 1 except that the Attraction Flow Regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at Wolf Point gage are held at 14,000 cfs until the Spawning Cue release is initiated.

Under Alternative 2, the upper Missouri River would support on average $191 million in recreation NED benefits per year, an increase of $137,000 (0.1 percent) compared to No Action (Table 28). The largest variations in recreational benefits would occur at Fort Peck Lake and Lake Sakakawea, where management actions under Alternative 2 would cause average annual NED benefits to decrease by 0.9 percent at Fort Peck Lake and increase by 0.2 percent at Lake Sakakawea. The flow releases would decrease Fort Peck Lake pool elevations affecting recreational access and fishing conditions, while visitation at Lake Sakakawea would increase from relatively higher pool elevations on average; there would be very little changes in visitation and recreation NED benefits at Lake Oahe and the inter-reservoir river reaches.

On average, Fort Peck Lake would experience a decrease in annual visitation of 4,800 recreation visitor days, with a decrease in average annual recreation NED benefits of $132,000 (-0.9%). On the other hand, on average, Lake Sakakawea would experience an increase in annual visitation of over 6,500 recreation visitor days, with an increase in average annual recreation NED benefits of $267,000 (+0.2%).

Table 28. Summary of NED Analysis for Alternative 2, 1932–2012 (Thousands of 2020 Dollars)

Recreation NED Benefits or Costs	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe	Total
Annual Average Recreation Visitor Days	521,876	3,367,055	1,324,004	66,792	115,949	5,395,675
Change in Average Annual Recreation Visitor Days from No Action	-4,828	6,418	183	8	-81	1,700
Annual Average NED Benefits	$14,271	$140,004	$31,796	$1,204	$3,900	$191,175
Change in Average Annual NED Benefits from No Action	-$132	$267	$4	$0	-$3	$137
Percent Change in Average Annual NED Benefits from No Action	-0.92%	0.19%	0.01%	0.01%	-0.07%	0.07%
Ave of 8 Lowest Visitation Years Relative to No Action	-$1,821	-$564	-$150	-$36	-$83	NA
Ave. of 8 Highest Visitation Years Relative to No Action	$730	$2,530	$202	$34	$61	NA

a Visitation benefits include all visitors at the upper three reservoirs and boat-accessed visitation in the inter-river reaches. Winter visitors are included for the reservoirs but are not included as plan-affected visitors in the river reaches.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figures 15, 16, 17, and 18 illustrate the annual NED recreation benefits for all locations, Fort Peck Lake Lake Sakakawea, and Lake Oahe, respectively. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Annual recreation benefits supported by all the locations range between $5.6 million lower and $7.4 million higher per year than those under No Action. In Figure 16, two years with relatively higher adverse impacts would be simulated to occur in 1987 and 1988 (one year when a flow release would occur and one in a year following a release) when lower reservoir elevations impact recreational fishing opportunities at Fort Peck Lake, ranging from $5.8 to $6.1 million per year lower than under No Action. In these two years, Fort Peck Lake would be approximately 3 to 7 feet lower than would be simulated under No Action.

At Lake Sakakawea, the flow releases would generally increase reservoir elevations during full and partial releases and in the years following the release. In three years as simulated over the period of record, recreation NED benefits would be between $3.0 and $4.8 million higher per year than under No Action (Figure 17).

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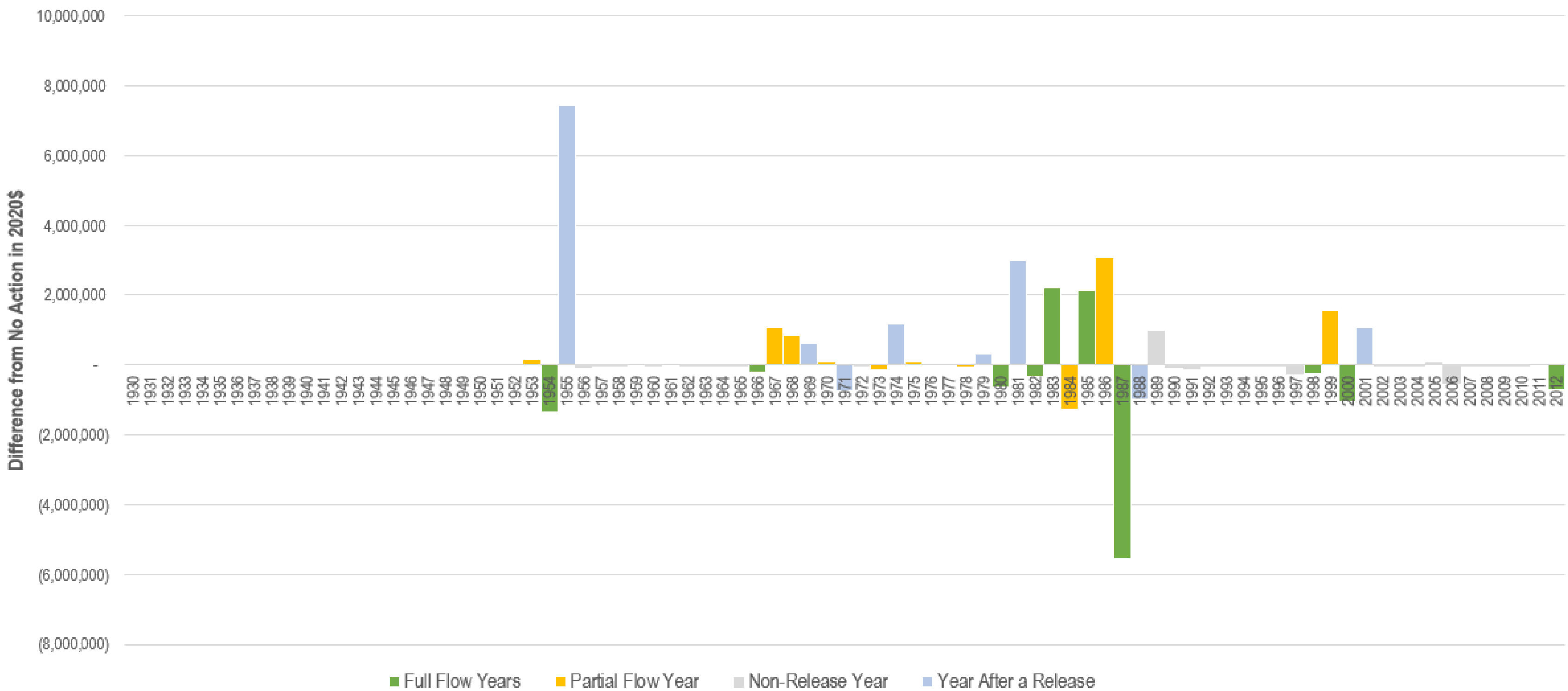

Figure 15. Annual Difference in Recreation NED Benefits Under Alternative 2 Relative to No Action for All Locations (2020$)

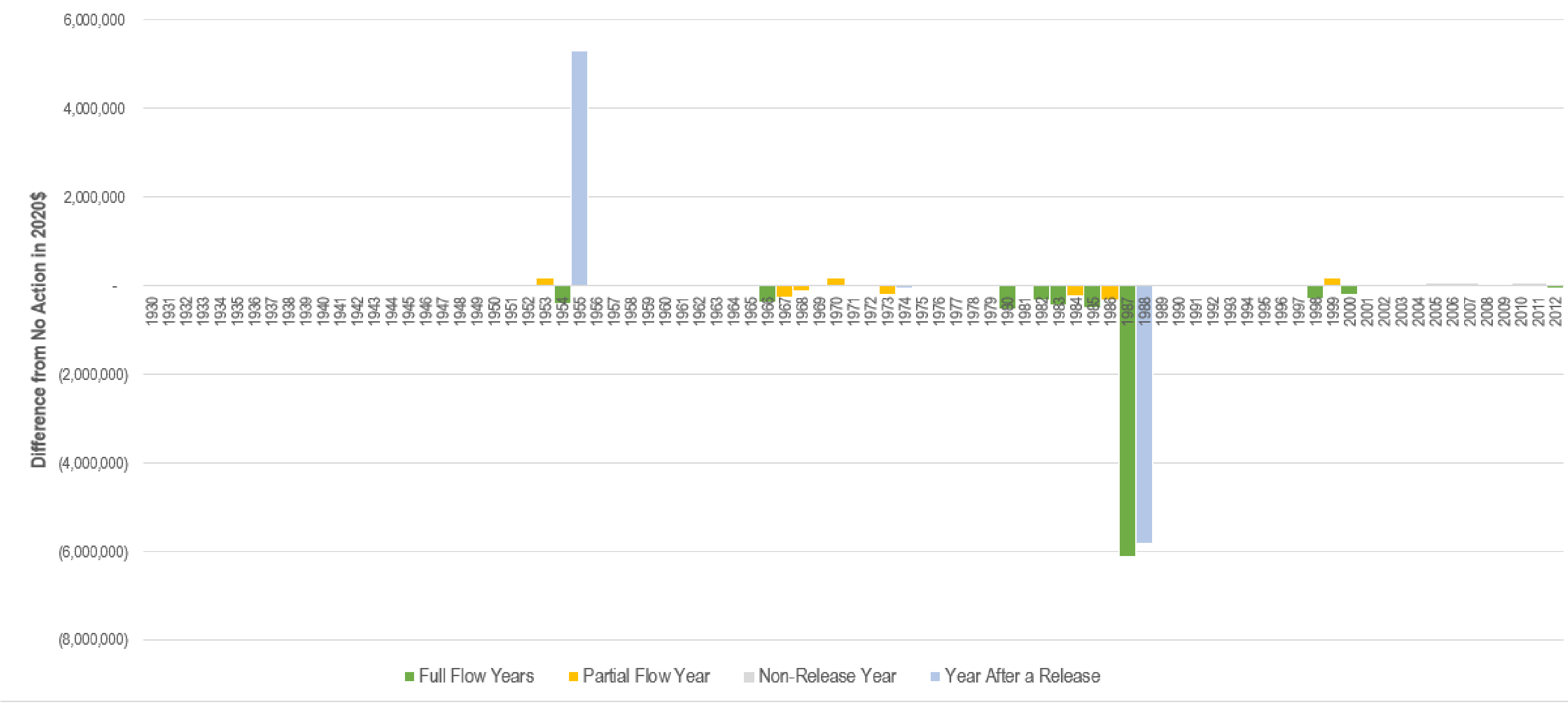

Figure 16. Annual Difference in Recreation NED Benefits under Alternative 2 compared to No Action at Fort Peck Lake (2020$)

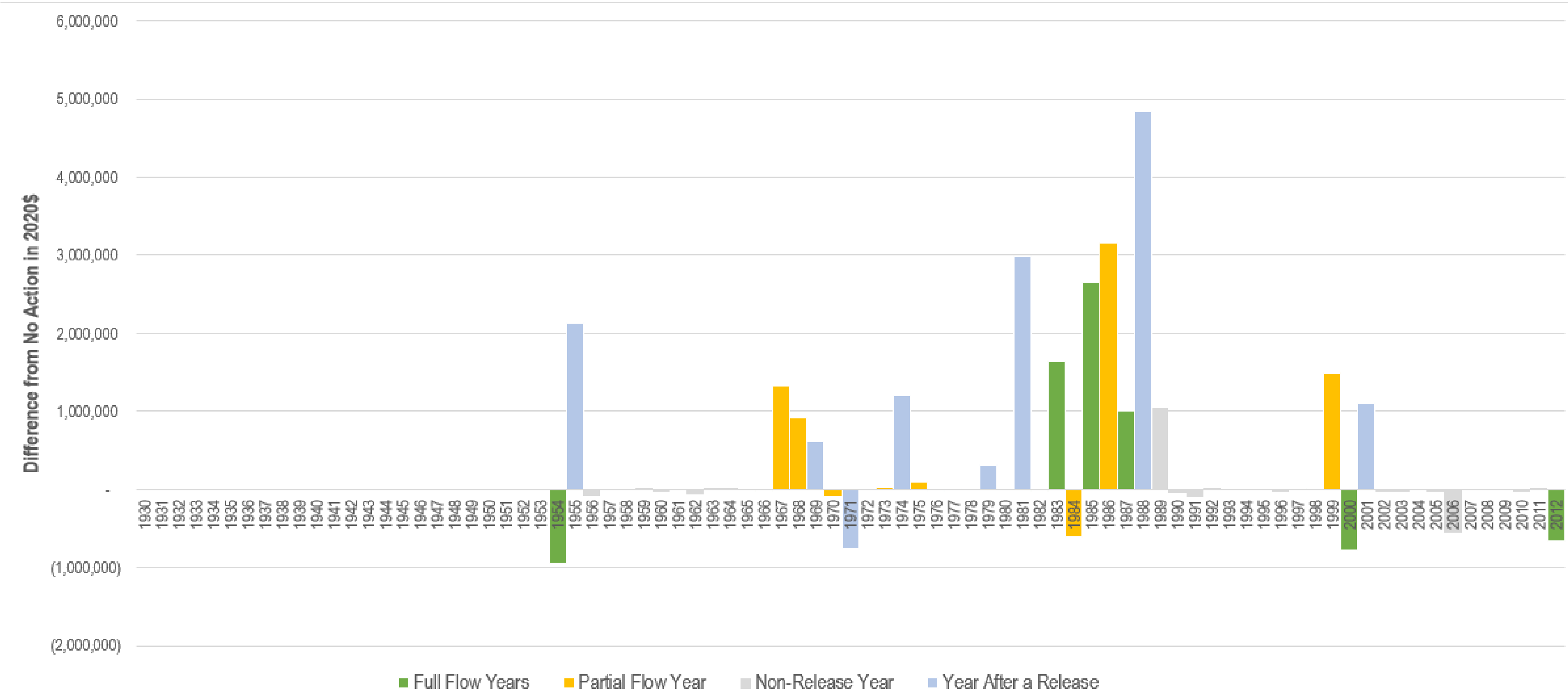

Figure 17. Annual Difference in Recreation NED Benefits under Alternative 2 Compared to No Action at Lake Sakakawea (2020$)

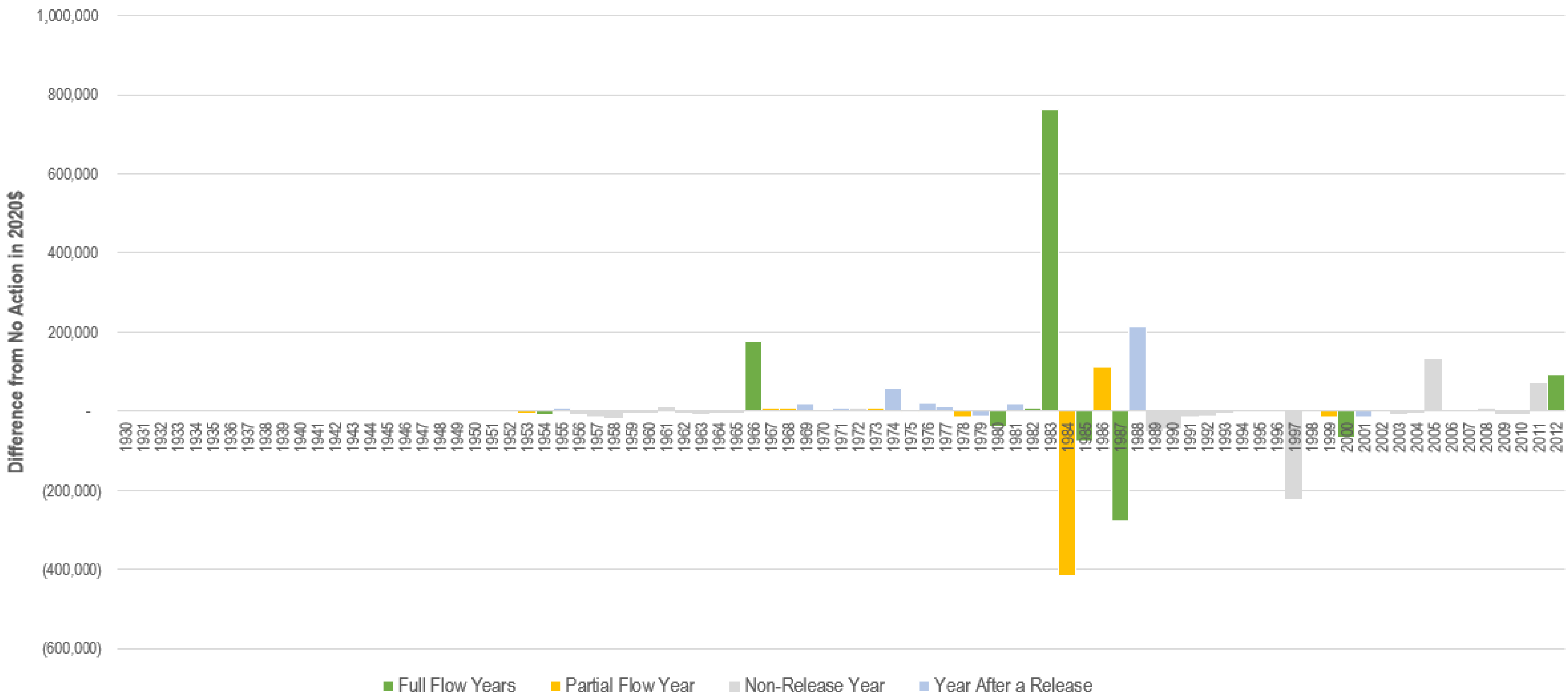

Figure 18. Annual Difference in Recreation NED Benefits under Alternative 2 Compared to No Action at Lake Oahe (2020$)

At Fort Peck Lake, an important metric to predict visitation is fishing success. Changes in fishing success has implications for fishing conditions and recreational fishing opportunities at Fort Peck Lake. The partial or full releases would occur as simulated in 20 years over the period of record. As simulated, Alternative 2 would result in two years when the fishing success criteria would not be met at Fort Peck Lake (and would be met under No Action) and one year when the fishing success criteria would not be met under No Action (and would be met under Alternative 2). The changes in the fishing success metric occur in 1955, 1987, and 1988. In all other years, the fishing success metric was the same under both Alternative 2 and No Action. Table 29 summaries the results of the fishing success metrics when they differ between Alternative 2 and No Action.

Under No Action, there is spring pool rise in 1986 that meets the fishing success criteria, while under Alternative 2, the pool would not have a sufficient spring rise in the spring from the partial and full release in this year The fishing success metric requires that a sufficient pool rise occur at least in the current spring *or* spring in the previous two years. The lack of pool rise in 1986 affects the fishing success metric in 1987 and 1988. Under No Action, the reservoir elevations in the spring increase in 1986, which allows for the fishing success metric and criteria to be met in 1987 and 1988.

Under Alternative 2, in 1955 as simulated, there would be rising mid-August pool elevations in the previous two years but this would not occur under No Action. The releases in the two previous simulated years (1953 and 1954) would cause rising pool elevations in consecutive summers, which is one of the criteria in the fishing success metric. Under No Action, the mid-August pool elevations would not increase in these years, and the fishing fish metric would not be met in 1955 under No Action.

Table 29. Summary of Fishing Success Metric at Fort Peck Lake

Year	No Action	Alternative 2
1955	Fishing success criteria not met	Fishing success criteria met
1987	Fishing success criteria met	Fishing success criteria not met
1988	Fishing success criteria met	Fishing success criteria not met

Note: Fishing success criteria is met if: 1) the spring pool rise occurs in the current or previous two years and there has been no drop in the mid-August pool in the previous two summers (drought conditions); or 2) if the mid-August reservoir elevation has dropped in the past year (since the previous August), but has not dropped consecutively for the 2 prior years.

3.4.1 Alternative 2 – Variation 2A

Variation 2A is a test flow variation of Alternative 2. The parameters for Alternative 2A are the same as described for Alternative 2 except that the Attraction Flow is initiated on April 9, rather than April 16, and the Spawning Cue flow would be initiated on May 21, rather than May 28. Again, moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases.

Under Variation 2A, the upper Missouri River would support on average $191 million in recreation NED benefits per year, an increase of $175,000 (0.1 percent) compared to No Action (Table 30). The impacts would be very similar to Alternative 2, with adverse impacts to Fort Peck Lake and beneficial impacts at Lake Sakakawea compared to No Action. There would be slightly higher beneficial impacts to recreation NED benefits at Lake Sakakawea (0.2 percent increase from No Action) under Variation 2A compared to Alternative 2. The flow releases under

Variation 2A would decrease Fort Peck Lake pool elevations affecting recreational access and fishing conditions, similar impacts as under Alternative 2, with a decrease in visitation of 4,900 and $133,000 in recreation NED benefits compared to No Action. There are very little changes in visitation and recreation NED benefits at Lake Oahe and the inter-reservoir river reaches.

Table 30. Summary of NED Analysis for Alternative 2 – Variation 2A, 1932–2012 (Thousands of 2020 Dollars)

Recreation NED Benefits or Costs	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe	Total
Average Annual Recreation Visitor Days	521,830	3,368,111	1,323,600	66,995	115,994	5,396,531
Change in Average Annual Recreation Days from No Action	-4,874	7,474	-221	211	-35	2,556
Annual Average NED Benefits	$14,270	$140,047	$31,786	$1,208	$3,902	$191,213
Change in Average Annual NED Benefits from No Action	-$133	$311	-$5	$4	-$1	$175
Percent Change in Average Annual NED Benefits from No Action	-0.93%	0.22%	-0.02%	0.32%	-0.03%	0.09%
Ave of 8 Lowest Visitation Years Relative to No Action	-$1,814	-$721	-$187	-$24	-$76	NA
Ave. of 8 Highest Visitation Years Relative to No Action	$779	$2,784	$143	$49	$65	NA

a Visitation benefits include all visitors at the upper three reservoirs and boat-accessed visitation in the inter-river reaches. Winter visitors are included for the reservoirs but are not included as plan-affected visitors in the river reaches.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figures 19, 20, 21, and 22illustrate the annual NED recreation benefits for all locations, Fort Peck Lake, Lake Sakakawea, Lake Oahe, respectively. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Annual recreation benefits supported by all the locations range between $5.3 million lower and $5.3 million higher per year than those under No Action. Two years with relatively higher adverse impacts would be simulated to occur in 1987 and 1988 (one year when a flow release would occur and one in a year following a release) when lower reservoir elevations impact recreational fishing opportunities at Fort Peck Lake, ranging from $5.8 to $6.1 million per year lower than under No Action (Figure 20). In these two years, similar to Alternative 2, Fort Peck Lake would be approximately 3 to 7 feet lower than would be simulated under No Action.

At Lake Sakakawea, the flow releases would generally increase reservoir elevations during full and partial releases and in the years following the release. In three years as simulated over the period of record, recreation NED benefits would be between $3.0 and $4.9 million higher per year than under No Action (Figure 21).

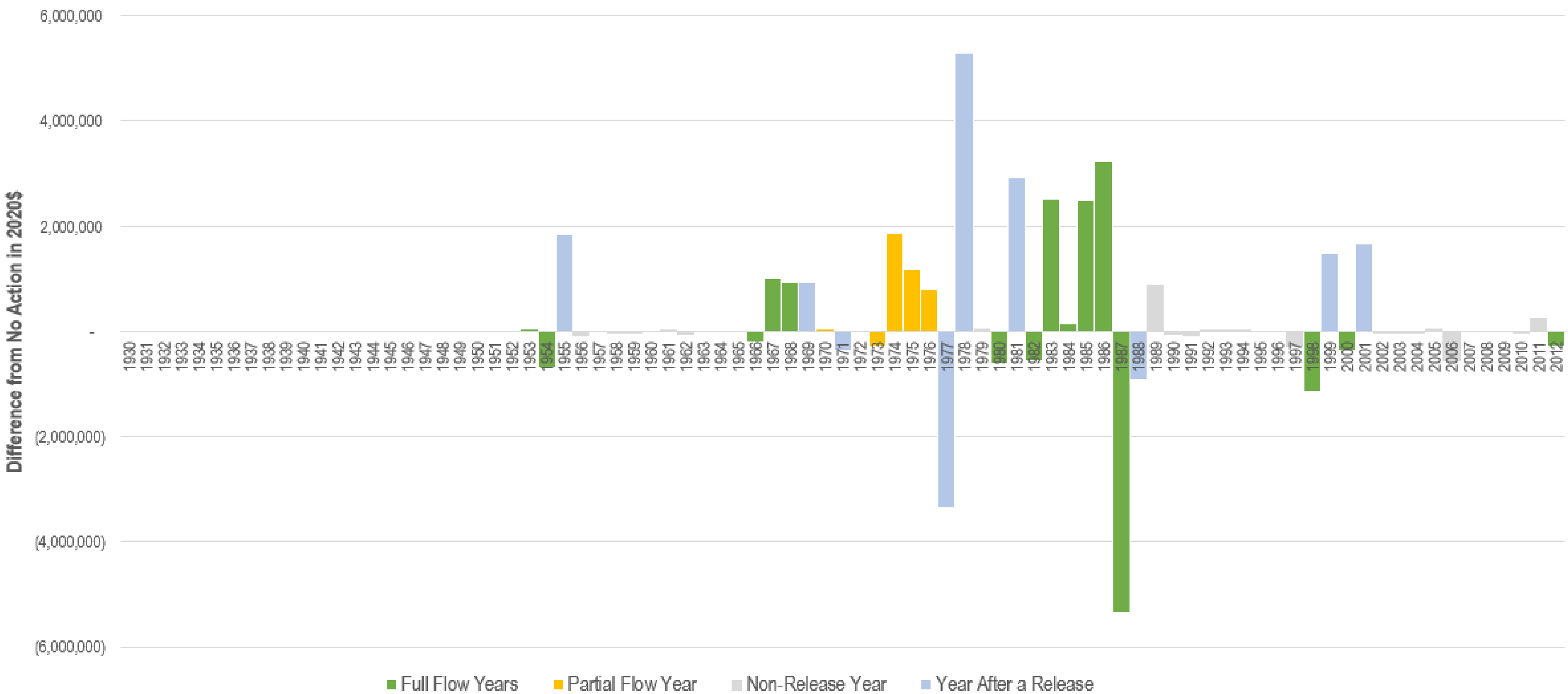

Figure 19. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2A, Compared to No Action at All Locations (2020$)

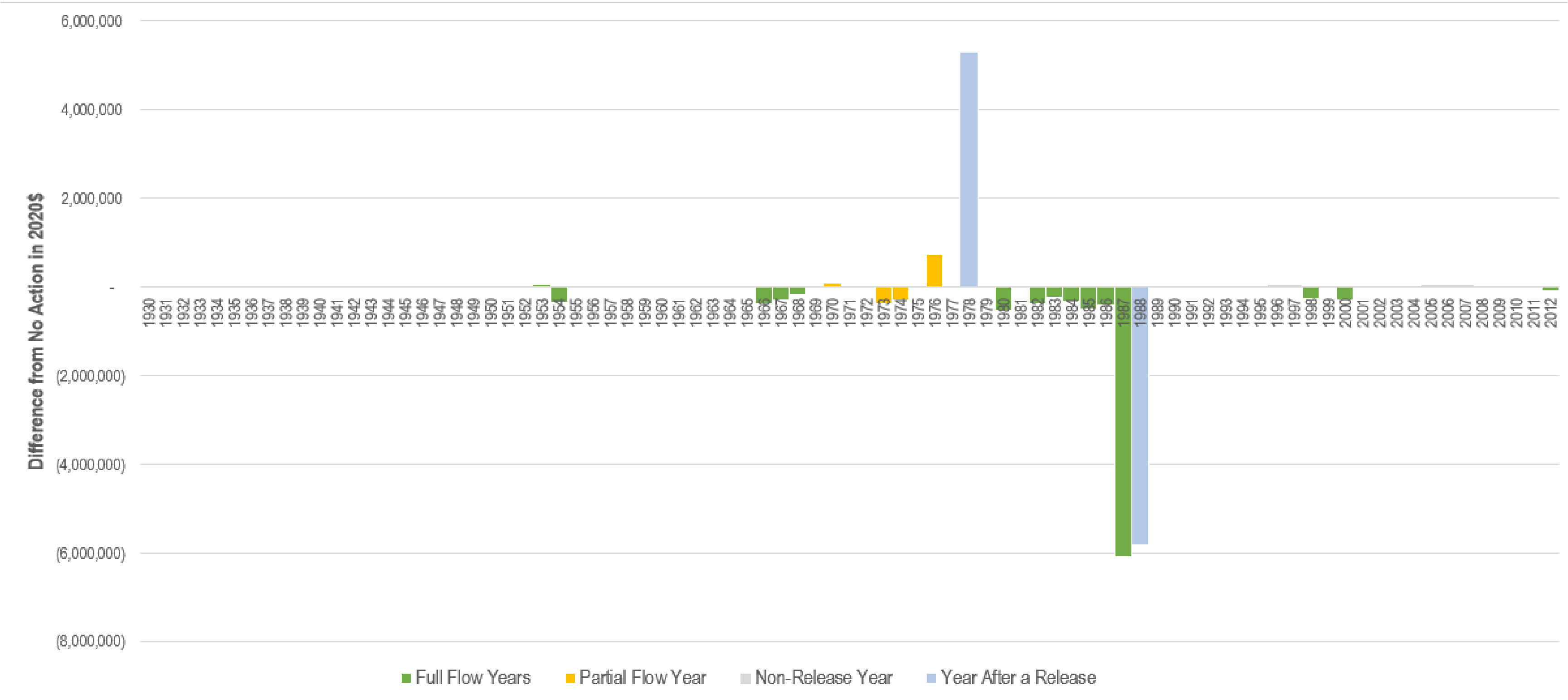

Figure 20. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2A, Compared to No Action at Fort Peck Lake (2020$)

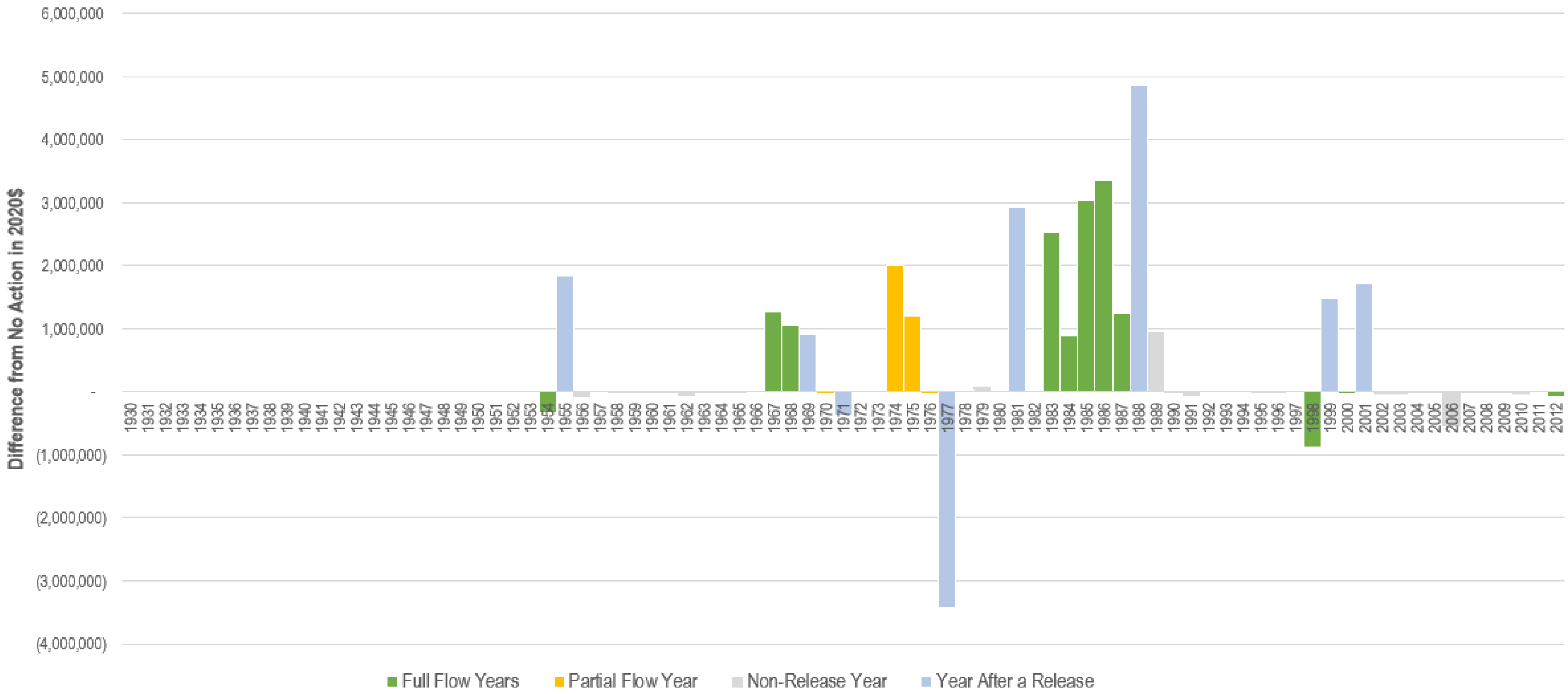

Figure 21. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2A, Compared to No Action at Lake Sakakawea (2020$)

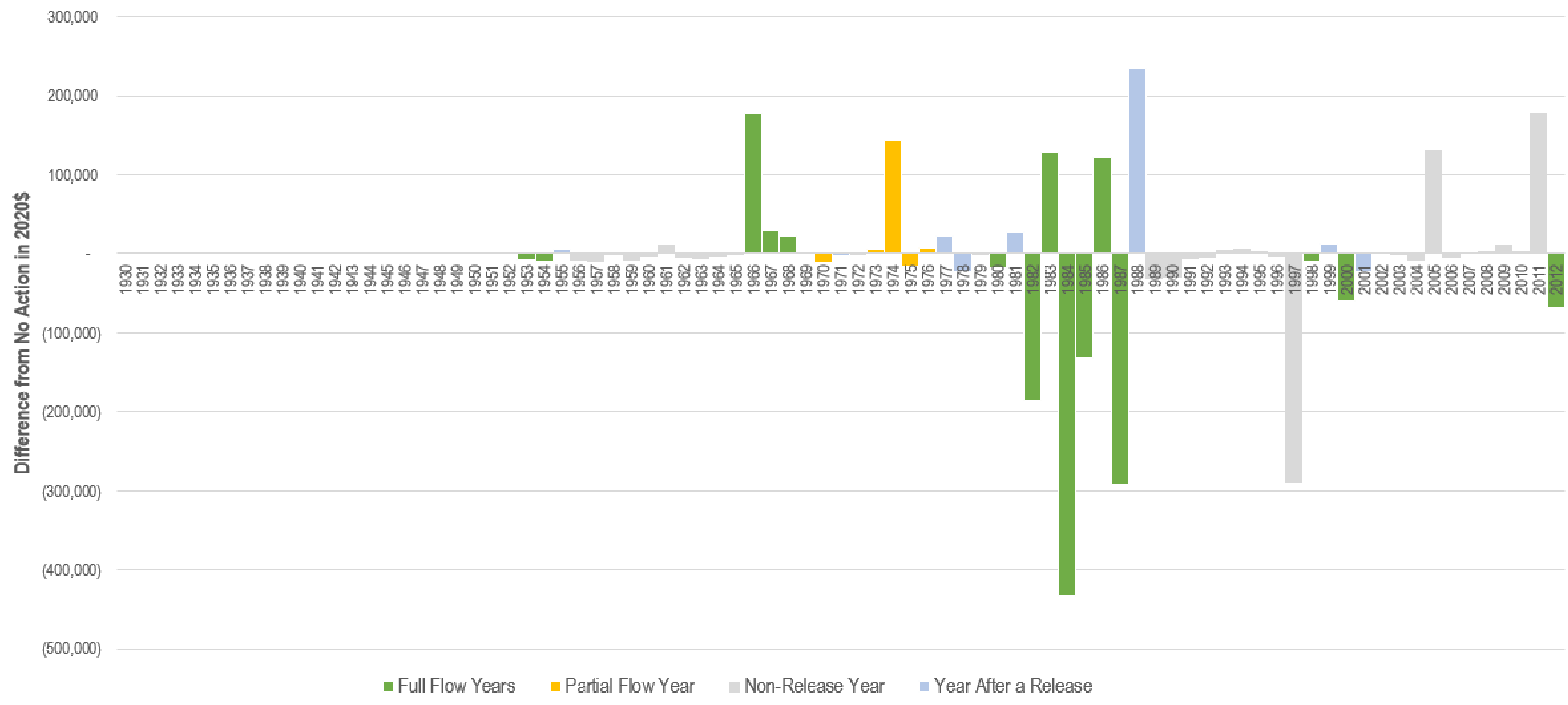

Figure 22. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2A, Compared to No Action at Lake Oahe (2020$)

As simulated, Variation 2A would result in two years when the fishing success criteria would not be met at Fort Peck Lake (and would be met under No Action) and one year when the fishing success criteria would not be met under No Action (and would be met under Alternative 2). The changes in the fishing success metric occur in 1978, 1987, and 1988. In all other years, the fishing success metric was the same under both Variation 2A and No Action. Table 31 summaries the results of the fishing success metrics when they differ between Variation 2A and No Action.

Similar to the impacts described in Alternative 2, changes in the fishing success metric have a notable impact on recreation NED benefits in some years. The partial or full releases would occur as simulated in 20 years over the period of record. The same two years would be affected under Variation 2A as under Alternative 2 (1987 and 1988), where the release in 1986 would cause an insufficient pool rise in that year, which affects the fishing success metric in 1987 and 1988.

Under Variation 2A, in 1978 as simulated, there would be rising mid-August pool elevations in the previous two years but this would not occur under No Action. The release in 1976 would cause rising pool elevations in consecutive years (1977 and 1978), which is one of the criteria in the fishing success metric. Under No Action, the pool elevations would not rise during this period so the fishing success metric was not met under No Action.

Table 31. Summary of Fishing Success Metric at Fort Peck Lake

Year	No Action	Variation 2A
1978	Fishing success criteria not met	Fishing success criteria met
1987	Fishing success criteria met	Fishing success criteria not met
1988	Fishing success criteria met	Fishing success criteria not met

Note: Fishing success criteria is met if: 1) the spring pool rise occurs in the current or previous two years and there has been no drop in the mid-August pool in the previous two summers (drought conditions); or 2) if the mid-August reservoir elevation has dropped in the past year (since the previous August), but has not dropped consecutively for the 2 prior years.

3.4.2 Alternative 2 – Variation 2B

Variation 2B is a test flow is another variation of Alternative 2. The parameters for Alternative 2B are the same as described for Alternative 2 except that the Attraction Flow is initiated on April 23, rather than April 16, and the Spawning Cue flow is initiated on June 4, rather than May 21. Again, the difference in timing is intended to provide a contrast to explore any differences in forecasted impacts from a later flow initiation date.

Under Variation 2B, the upper Missouri River would support on average $191 million in recreation NED benefits per year, an increase of $102,000 compared to No Action (Table 32). The largest variations in recreational benefits would occur at Fort Peck Lake and Lake Sakakawea, where management actions under Variation 2B would cause annual average NED benefits to decrease by 2.0 percent at Fort Peck Lake and increase by 0.3 percent at Lake Sakakawea. The flow releases would decrease Fort Peck Lake pool elevations affecting recreational access and fishing conditions, while visitation at Lake Sakakawea would increase from relatively higher pool elevations on average; there would be very little changes in visitation and recreation NED benefits at Lake Oahe and the inter-reservoir river reaches.

On average, Fort Peck Lake would experience a decrease in annual visitation of approximately 10,000 recreation visitor days, with a decrease in average annual recreation NED benefits of $282,000 (-2.0%). On the other hand, on average, Lake Sakakawea would experience an increase in annual visitation of over 8,900 recreation visitor days, with an increase in average annual recreation NED benefits of $371,000 (+0.3%).

Table 32. Summary of NED Analysis for Alternative 2 – Variation 2B, 1932–2012 (Thousands of 2020 Dollars)

Recreation NED Benefits or Costs	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Fort Peck Dam to Lake Sakakawea	Garrison Dam to Lake Oahe	Total
Average Annual Recreation Visitor Days	516,380	3,369,558	1,324,432	66,795	115,998	5,393,162
Change in Average Annual Recreation Days from No Action	-10,324	8,920	611	11	-31	-813
Annual Average NED Benefits	$14,121	$140,108	$31,806	$1,204	$3,902	$191,141
Change in Average Annual NED Benefits from No Action	-$282	$371	$15	$0	-$1	$102
Percent Change in Average Annual NED Benefits from No Action	-1.96%	0.27%	0.05%	0.02%	-0.03%	0.05%
Ave of 8 Lowest Visitation Years Relative to No Action	-$245	-$245	-$121	-$40	-$64	NA
Ave. of 8 Highest Visitation Years Relative to No Action	$2,529	$2,529	$250	$38	$54	NA

a Visitation benefits include all visitors at the upper three reservoirs and boat-accessed visitation in the inter-river reaches. Winter visitors are included for the reservoirs but are not included as plan-affected visitors in the river reaches.

When evaluating impacts associated with each FPDTR-EIS alternative, it is useful to analyze annual impacts to better understand under what conditions beneficial or adverse impacts would occur. Figures 23, 24, 25, and 26 illustrate the annual NED recreation benefits for all locations, Fort Peck Lake, Lake Sakakawea, Lake Oahe, respectively. The bars in the figures are color-coded based on the type of release occurring each year (i.e., full release, partial release, year after a full release, or non-release years).

Annual recreation benefits supported by the all locations range between $5.6 million lower and $3.5 million higher than those under No Action. There are three years with relatively higher adverse impacts that would be simulated to occur in 1987, 1988, and 1994 (two years when the flow release would occur and one in a year following a release) when lower reservoir elevations impact recreational fishing opportunities at Fort Peck Lake, from $5.7 to $6.1 million per year lower than under No Action (Figure 24). Similar to Alternative 2 and Variation 2B, in these three years, Fort Peck Lake would be approximately 3 to 7 feet lower than would be simulated under No Action.

At Lake Sakakawea, the flow releases would generally increase reservoir elevations during full and partial releases and in the years following the releases. In five years as simulated over the period of record, recreation NED benefits would be between $2.5 and $3.5 million higher than under No Action (Figure 25).

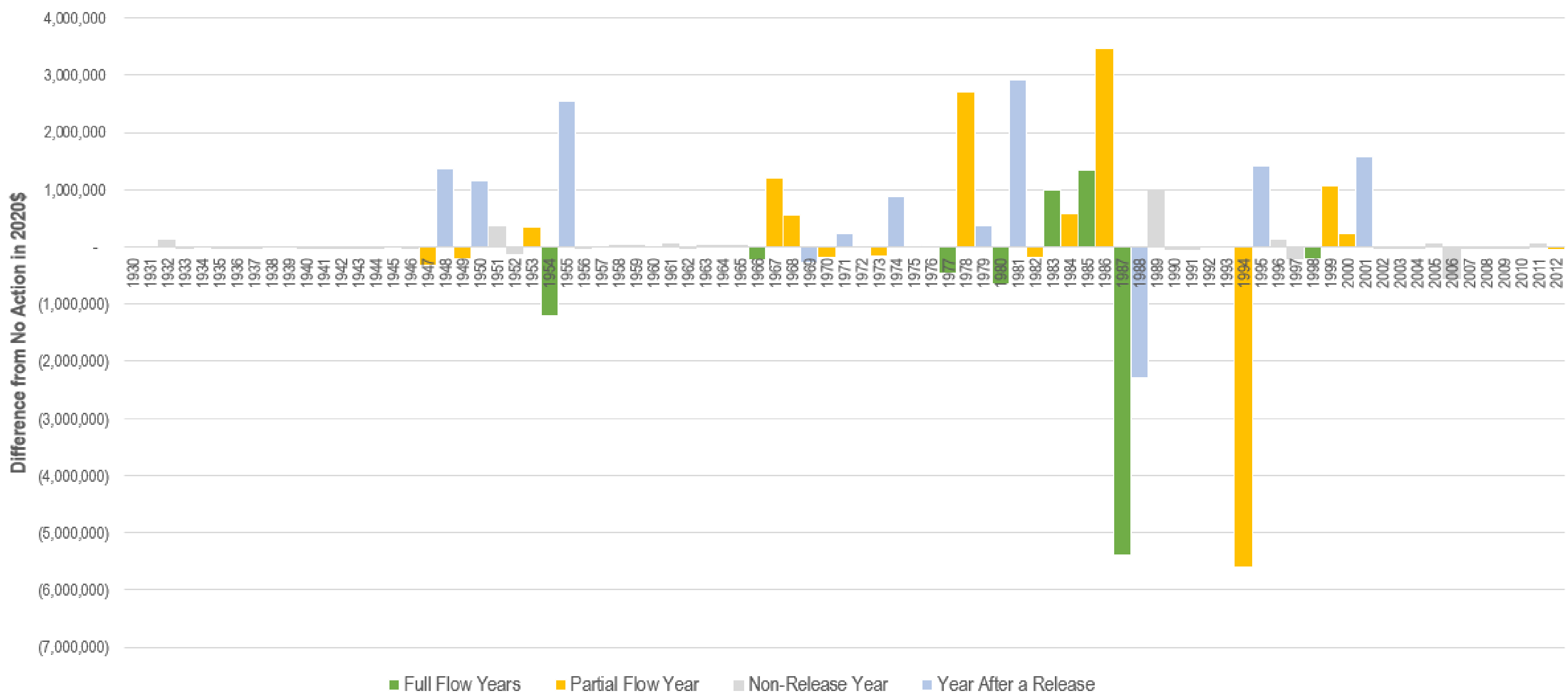

Figure 23. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2B, Compared to No Action at All Locations (2020$)

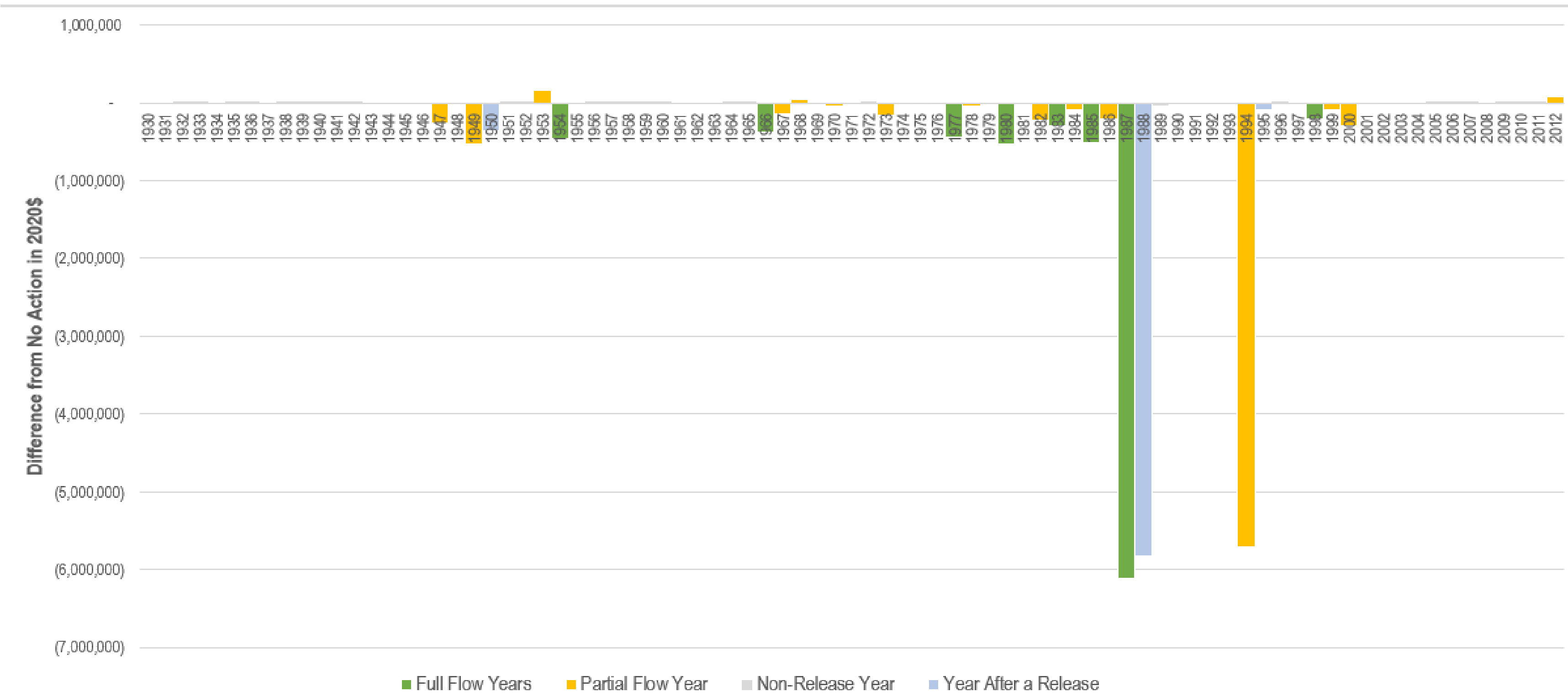

Figure 24. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2B, Compared to No Action at Fort Peck Lake (2020$)

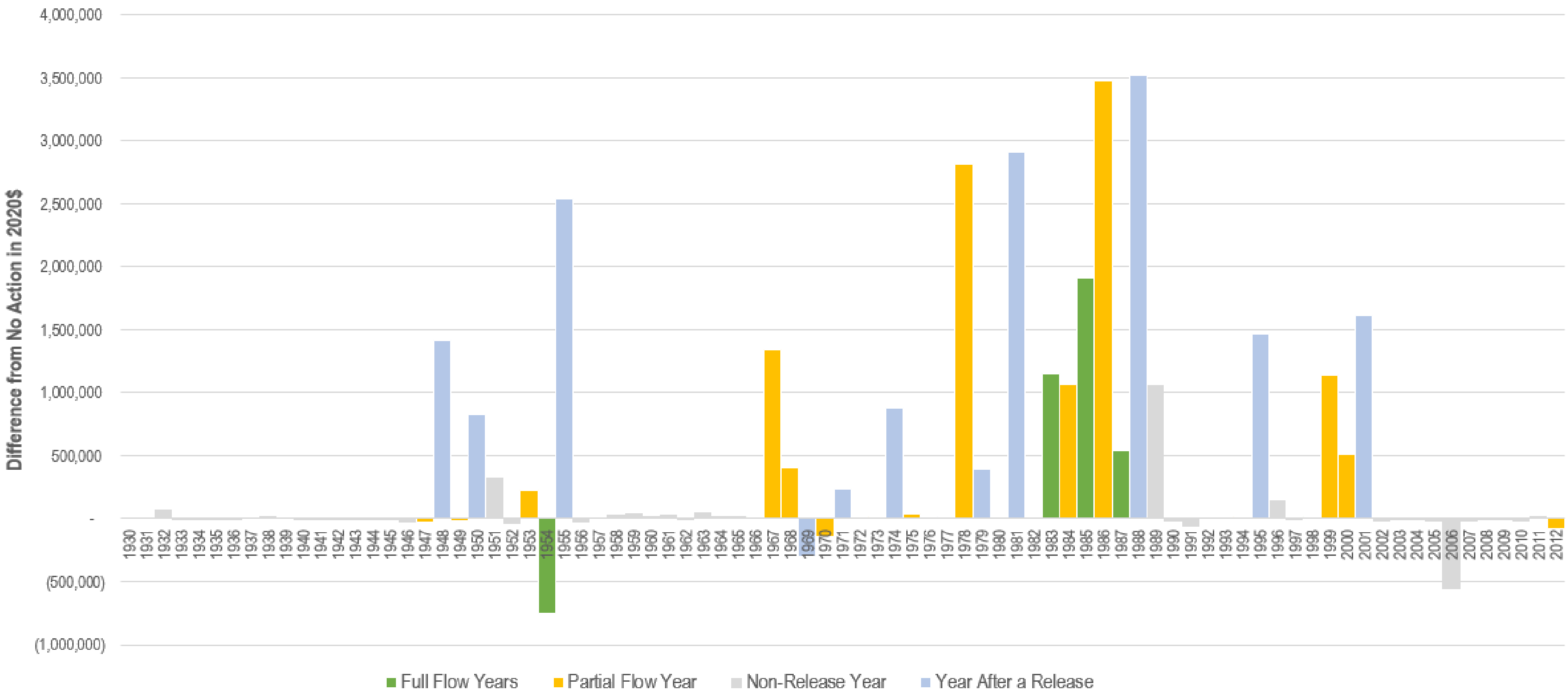

Figure 25. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2B, Compared to No Action at Lake Sakakawea (2020$)

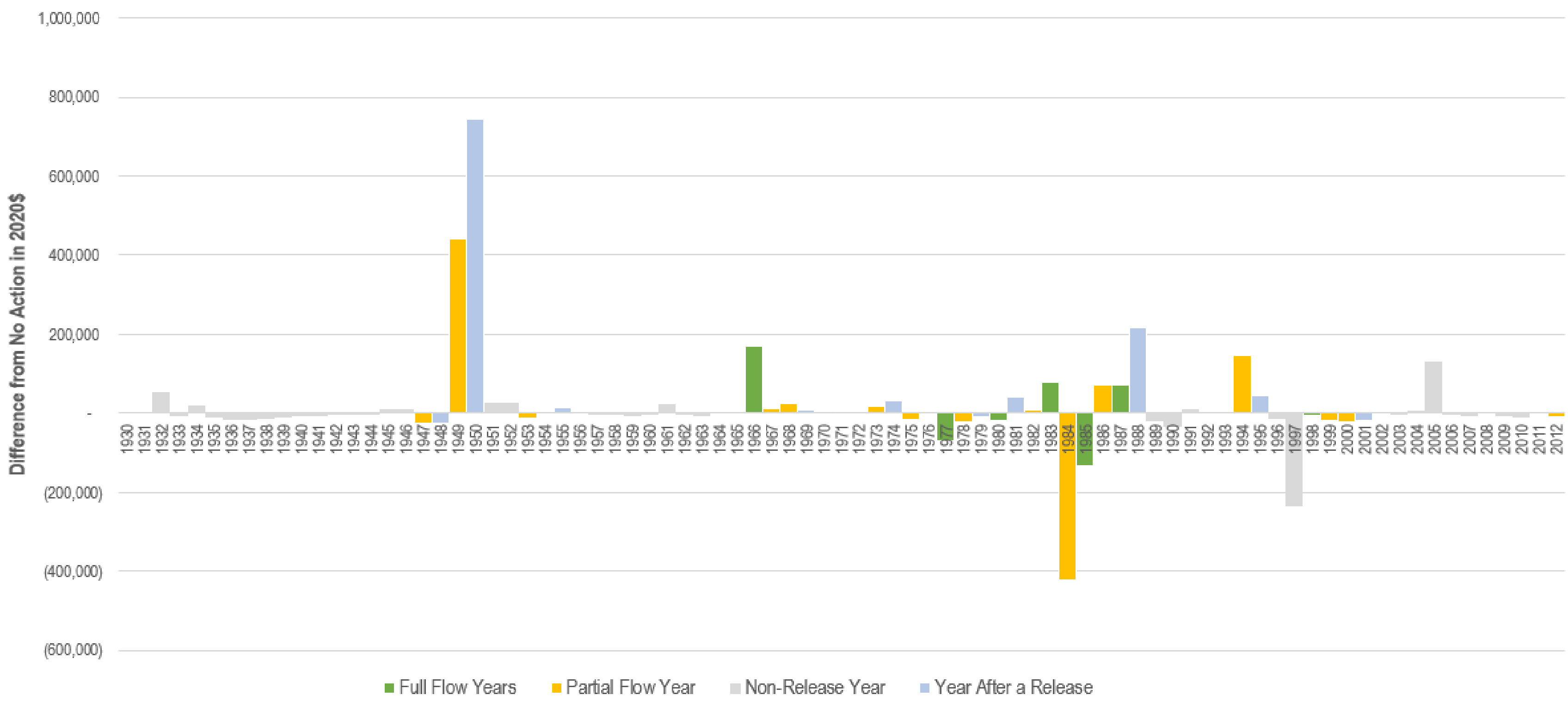

Figure 26. Annual Difference in Recreation NED Benefits under Alternative 2, Variation 2B, Compared to No Action at Lake Oahe (2020$)

Similar to the impacts described in Alternative 2, changes in the fishing success metric have a notable impact on recreation NED benefits in some years. The partial or full releases would occur as simulated in 24 years over the period of record. Under Variation 2B, there would be three years when the fishing success metric would not be met compared to No Action. The changes in the fishing success metric occur in 1987, 1988, and 1994. In all other years, the fishing success metric was the same under both Variation 2B and No Action. Table 33 summaries the results of the fishing success metrics when they differ between Variation 2B and No Action.

Under No Action, there is spring pool rise in 1986 and 1994 that meets the fishing success criteria, while under Variation 2B, the pool would not rise due to partial and full releases in these years. The fishing success metric requires that a sufficient pool rise occur at least in the current spring *or* springs of the previous two years. The lack of pool rise in 1986 affects the fishing success metric in 1987 and 1988. The lack of the pool rise in 1994 affects the fishing success metric in 1994 because the previous two years (1993 and 1992) also do not have sufficient pool rise. Under No Action, the spring pool rise in 1986 and 1994 allow for the fishing success metric and criteria to be met in 1987, 1988, and 1994.

Table 33. Summary of Fishing Success Metric at Fort Peck Lake

Year	No Action	Variation 2B
1987	Fishing success criteria met	Fishing success criteria not met
1988	Fishing success criteria met	Fishing success criteria not met
1994	Fishing success criteria met	Fishing success criteria not met

Note: Fishing success criteria is met if: 1) the spring pool rise occurs in the current or previous two years and there has been no drop in the mid-August pool in the previous two summers (drought conditions); or 2) if the mid-August reservoir elevation has dropped in the past year (since the previous August), but has not dropped consecutively for the 2 prior years.

3.4.3 Summary Results for Alternative 2, including Variations 2A and 2B

Table 3-34 provides a summary of the NED impacts for Alternative 2 including Variations 2A and 2B in years when a partial or full flow release would be simulated to occur. Over all locations, average annual recreation NED benefits would increase under Alternative 2 and the variations between $212,000 and $494,000 (0.1 to 0.2 percent) relative to No Action.

Average annual visitation and recreation NED benefits would decrease at Fort Peck Lake compared to No Action during flow release years, ranging from a decrease of 13,000 to 23,000 visitors, a decrease between $353,000 (-2.1%) to $635,000 (-3.7%) in recreation NED benefits. It appears that Alternative 2 and Variation 2A are slightly better for Fort Peck Lake relative to Variation 2B. While Fort Peck Lake would experience small adverse impacts in most years during a partial or full flow release, in some years the releases cause impacts to fishing success, specifically reducing a rising pool in the spring, with estimated reductions in visitation and recreation NED benefits of approximately 33 percent compared to No Action. In these years (two over the period of record under Alternative 2 and Variation 2A and three years under Variation 2B), there could be the potential for large adverse impacts; the effects could persist as the lower lake conditions continue but would be short-term as hydrology and precipitation return the reservoir to relatively higher pool elevations and adequate fishing conditions.

At Lake Sakakawea, in most flow release years, there would be increased visitation and recreation NED benefits under Alternative 2 and its variations, ranging from $722,000 (0.5%)

and $869,000 (0.6%) compared to No Action. Lake Oahe would experience slight decreases in average annual visitation and recreation NED benefits during flow release years under Variation 2A and slight increases under Alternative 2 and Variation 2B. The Fort Peck Dam to Lake Sakakawea river reaches would experience slight increases in visitation and recreation NED benefits compared to No Action on average in flow release years, while Garrison Dam to Lake Oahe would have varied changes from No Action. In all locations aside from Fort Peck Lake, all impacts under Alternative 2 and its variations would be negligible and adverse or beneficial compared to No Action.

Table 34. Summary of NED Analysis for Alternative 2, Variations 2A and 2B, 1932–2012, during Partial or Full Release Years (2020 Dollars)

Recreation NED Benefits	Alternative 2	Variation 2A	Variation 2B	Range in Variation
All Locations				
Change in Ave. Annual Recreation Days from No Action	5,215	7,330	-2,191	9,521
Change in Average Annual NED Benefits from No Action	$386,467	$493,705	$212,112	$281,593
Percent Change in Average Annual NED Benefits from No Action	0.18%	0.23%	0.10%	0.13%
Fort Peck Lake				
Change in Ave. Annual Recreation Days from No Action	-12,911	-13,509	-23,219	10,308
Change in Average Annual NED Benefits from No Action	-$353,059	-$369,425	-$634,952	$281,893
Percent Change in Average Annual NED Benefits from No Action	-2.06%	-2.17%	-3.68%	1.61%
Lake Sakakawea				
Change in Ave. Annual Recreation Days from No Action	17,375	20,890	19,476	3,515
Change in Average Annual NED Benefits from No Action	$722,451	$868,620	$809,807	$146,169
Percent Change in Average Annual NED Benefits from No Action	0.46%	0.56%	0.52%	0.1%
Lake Oahe				
Change in Ave. Annual Recreation Days from No Action	793	-501	1,512	2,013
Change in Average Annual NED Benefits from No Action	$19,036	-$12,030	$36,319	$48,349
Percent Change in Average Annual NED Benefits from No Action	0.05%	-0.03%	0.10%	0.13%
Fort Peck Dam to Lake Sakakawea River Reach				
Change in Ave. Annual Recreation Days from No Action	36	550	25	525
Change in Average Annual NED Benefits from No Action	$645	$9,910	$455	$9,455

Percent Change in Average Annual NED Benefits from No Action	0.05%	0.79%	0.04%	0.75%
Garrison Dam to Lake Oahe River Reach				
Change in Ave. Annual Recreation Days from No Action	-77	-100	14	114
Change in Average Annual NED Benefits from No Action	-$2,606	-$3,370	$483	$3,853
Percent Change in Average Annual NED Benefits from No Action	-0.06%	-0.08%	0.01%	0.09%

4.0 Regional Economic Development Results

This section provides results from the RED analysis. The economic impact analysis was analyzed at state levels. Most of the visitor spending occurs in the communities surrounding the lakes, where visitor stay in hotels, spend money on equipment, restaurants, retail, and other outlets. The spending typically occurs within communities 50 miles from the reservoir, and therefore, most of the economic impacts are likely to be generated from and supported by the communities surrounding the reservoirs.

The employment and income estimates include industries and businesses directly benefitting from non-local visitor spending (i.e., those who provide goods and services to non-local visitors), as well as secondary jobs and income in industries that support recreation and tourism-related businesses (indirect impact) and jobs and income supported by local workers spending their income in the local economy (induced impact). The employment estimates are provided in full-time equivalent jobs.

Recreation RED effects were presented for the following scenarios so as to limit the number of years for which the RED estimates were calculated: the lowest visitation year; the highest visitation year; annual average visitation over the 81-year POR; the average difference during the 8 worst years (lowest visitation years) relative to No Action; and the average difference during the 8 best years (highest visitation years) relative to No Action.

The degree to which recreation at the reservoirs contributes to regional employment and income at each reservoir is based on the number of non-local visitors and the types of recreational activities in which visitor participate. Under No Action, non-local visitor spending at the upper three reservoirs would support in an average year 378 jobs at Fort Peck Lake, 2,275 jobs at Lake Sakakawea, and 1,026 jobs at Lake Oahe. Labor income would vary on average, from $13 million at Fort Peck Lake to $106 million at Lake Sakakawea per year.

Tables 35, 36, and 37 summarize employment, labor income, and sales, respectively, supported by non-local visitor spending under the FPDTR-EIS alternatives for each of the upper three reservoirs. Under No Action, reservoir elevations can affect visitation, which in turn can affect the amount of visitor spending in local economies. As a result, there can be substantial variations in employment and income impacts over the POR under No Action. For example, Lake Oahe supports between 473 and 1,283 jobs and $19 million and $53 million in labor income depending on lake conditions and visitation at the lake. Lake elevations are the main driver of changes in visitation at the upper three reservoirs, with drought and relatively drier climactic and hydrologic conditions adversely affecting recreation access and fishing opportunities at the lakes.

The bulk of the jobs and income would be associated with Lake Sakakawea because of the relatively larger amount of visitation at the lake. Lake Sakakawea would experience both increases and decreases in regional economic effects although on average, there would be increased regional economic benefits, ranging from 1 to 6 additional jobs and $46,000 to $275,000 in labor income under Alternative 1 and 2 and variations relative to No Action. In general, Variation 2A and 2B are slightly better than the other variations relative to No Action from higher lake elevations at Lake Sakakawea.

The Fort Peck releases under Alternatives 1 and 2 and its variations would cause visitation to Fort Peck Lake to decrease in some of the years when a release would occur or the year following a release, when reservoir elevations are lower than under No Action. Reduced non-local visitation would result in a reduction in recreation RED benefits at Fort Peck Lake while these conditions persist. The changes in regional economic benefits at Fort Peck Lake under all of the alternatives are similar compared to No Action. Variation 1A and Alternative 2 are slightly better that the other variations relative to No Action, while Variation 2B appears to be the worst option for recreation at Fort Peck Lake. On average, there would be a reduction between 2 and 7 jobs compared to No Action at Fort Peck Lake. During the eight lowest visitation years relative to No Action, average annual RED benefits supported by Fort Peck Lake would be reduced between 48 jobs (Alternative 2 and Variation 2A) and 67 jobs (Variation 2B) compared to No Action.

In years when the conditions adversely affect the fishery at Fort Peck Lake (typically when a release is implemented at the beginning of a relatively drier period), recreation visitor days and jobs and income would be reduced by up to 40 percent compared to average annual conditions under Alternative 1 and its variations and up to 43 percent of average annual conditions under Alternative 2 and its variations. Although these effects as modeled, would be temporary and fall within the range of visitation at Fort Peck Lake over the period of record, the reduced lake elevations and reductions in visitation could have large and adverse impacts for tourism industries and businesses and small communities that support these recreational activities.

The fishing success metric (modeled as a dummy variable) has a large impact on visitation estimates in the regression analysis, with large changes in visitation (and NED benefits) from No Action (beneficial and adverse) with changes in the fishing success metric (0-1 variable). The USACE would work with the natural resource specialists at the Lake and state fishery biologists to minimize the adverse impacts to the fishery and visitation. Therefore, in reality, it is likely the changes would not be as dramatic and possibly would take longer to be experienced and the ability of the fishery to recover to normal conditions may also be prolonged.

There would be very little changes in regional economic effects at Lake Oahe under the alternatives compared to No Action. On average, there would be a reduction of 0 to 1 jobs, and changes in labor income would range between +$16,000 and -$29,000 compared to No Action.

Table 35. Direct, Indirect, and Induced Employment Impacts from Non-Local Visitor Spending under the FPDTR-EIS Alternatives

Reservoir	Alternative						
	No Action	Alt 1			Alt 2		
		1	1A	1B	2	2A	2B
Fort Peck Lake							
Lowest Visitation Year	0	0	0	0	0	0	0
Highest Visitation Year	535	535	535	536	535	536	535
Annual Average	378	373	375	373	376	374	370
Change in Annual Average Relative to No Action	NA	-5	-2	-5	-2	-4	-7
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	19	40	19	19	21	1
Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-62	-59	-62	-48	-48	-67
Lake Sakakawea							
Lowest Visitation Year	1,429	1,429	1,429	1,429	1,429	1,429	1,429
Highest Visitation Year	2,791	2,791	2,791	2,776	2,791	2,776	2,791
Annual Average	2,275	2,278	2,276	2,278	2,277	2,280	2,281
Change in Annual Average Relative to No Action	NA	3	1	3	2	5	6
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	32	20	29	41	45	41
Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-4	-15	-7	-9	-12	-4
Lake Oahe							
Lowest Visitation Year	473	473	473	474	473	218	219
Highest Visitation Year	1,283	1,283	1,275	1,278	1,276	1,275	1,275
Annual Average	1,026	1,026	1,026	1,025	1,026	1,026	1,026
Change in Annual Average Relative to No Action	NA	0	0	-1	0	0	0

Ave. of the 8 Highest Visitation Years Relative to No Action	NA	4	2	4	6	5	8
Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-3	-5	-8	-5	-6	-4

Note: Estimated with the USACE RECONS model (USACE 2012b).

Table 36. Direct, Indirect, and Induced Labor Income Impacts from Non-Local Visitor Spending under the FPDTR-EIS Alternatives (Thousands of 2020 Dollars)

	Alternative						
		Alt 1			Alt 2		
Reservoir	No Action	1	1A	1B	2	2A	2B
Fort Peck Lake							
Lowest Visitation Year	$0	$0	$0	$0	$0	$0	$0
Highest Visitation Year	$18,051	$18,051	$18,051	$18,063	$18,051	$18,068	$18,033
Annual Average	$12,733	$12,573	$12,660	$12,580	$12,651	$12,614	$12,481
Change in Annual Average Relative to No Action	NA	-$160	-$73	-$153	-$82	-$119	-$252
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	$635	$1,336	$630	$35	$697	$35
Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-$2,091	-$1,999	-$2,078	-$1,625	-$1,619	-$2,247
Lake Sakakawea							
Lowest Visitation Year	$66,801	$66,801	$66,801	$66,817	$66,801	$66,801	$66,815
Highest Visitation Year	$130,498	$130,498	$130,501	$129,829	$130,504	$129,824	$130,508
Annual Average	$106,383	$106,546	$106,429	$106,529	$106,507	$106,612	$106,658
Change in Annual Average Relative to No Action	NA	$163	$46	$146	$124	$229	$275
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	$1,491	$916	$1,355	$1,919	$2,111	$1,915

Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-$200	-$683	-$304	-$440	-$564	-$199
Lake Oahe							
Lowest Visitation Year	$19,438	$19,434	$19,434	$19,460	$19,434	$8,964	$8,980
Highest Visitation Year	$52,700	$52,696	$52,383	$52,479	$52,397	$52,372	$52,380
Annual Average	$42,141	$42,136	$42,121	$42,112	$42,142	$42,130	$42,130
Change in Annual Average Relative to No Action	NA	-$5	-$20	-$29	$1	-$11	$16
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	$160	$91	$161	$266	$190	$330
Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-$140	-$223	-$330	-$205	-$252	-$165

Note: Estimated with the USACE RECONS model. It should be noted that labor income per worker is relatively small (approximately $22,000) due to the relatively lower paying jobs associated with the services sectors (retail, accommodations, and restaurants) and because part-time employees are included in the employment estimates. The ratios and multipliers embedded in RECONS are from IMPLAN®.

Table 37. Direct, Indirect, and Induced Sales from Non-Local Visitor Spending under the FPDTR-EIS Alternatives (Thousands of 2020 Dollars)

Reservoir	Alternative						
		Alt 1			Alt 2		
	No Action	1	1A	1B	2	2A	2B
Fort Peck Lake							
Lowest Visitation Year	$0	$0	$0	$0	$0	$0	$0
Highest Visitation Year	$54,005	$54,005	$54,005	$54,040	$54,005	$54,055	$53,951
Annual Average	$38,094	$37,615	$37,876	$37,637	$37,809	$37,739	$37,341
Change in Annual Average Relative to No Action	NA	-$479	-$218	-$457	-$285	-$355	-$753
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	$1,901	$3,997	$1,886	$1,954	$2,085	$106

Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-$6,256	-$5,979	-$6,218	-$4,863	-$4,845	-$6,724
Lake Sakakawea							
Lowest Visitation Year	$172,768	$172,768	$172,768	$172,808	$172,768	$172,768	$172,802
Highest Visitation Year	$337,523	$337,506	$337,515	$335,775	$337,521	$335,762	$337,532
Annual Average	$275,138	$275,561	$275,256	$275,515	$275,534	$275,730	$275,850
Change in Annual Average Relative to No Action	NA	$423	$118	$377	$396	$592	$712
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	$3,857	$2,370	$3,504	$4,963	$5,459	$4,952
Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-$517	-$1,767	-$787	-$1,139	-$1,458	-$516
Lake Oahe							
Lowest Visitation Year	$54,757	$54,746	$54,746	$54,817	$54,746	$25,253	$25,284
Highest Visitation Year	$148,453	$148,444	$147,560	$147,831	$147,600	$147,529	$147,554
Annual Average	$118,710	$118,695	$118,654	$118,630	$118,715	$118,679	$118,754
Change in Annual Average Relative to No Action	NA	-$15	-$56	-$80	$5	-$31	$44
Ave. of the 8 Highest Visitation Years Relative to No Action	NA	$451	$256	$452	$749	$534	$534
Ave. of the 8 Lowest Visitation Years Relative to No Action	NA	-$394	-$627	-$929	-$576	-$709	-$464

Note: Estimated with the USACE RECONS model (USACE 2019c).

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Appendix A: Boat Ramp Operability Results

A supplemental analysis was conducted to assess boat ramp operability at Fort Peck Lake. Tables A-1 and A-2 provide a summary of the results. Table A-1 provides a summary of the average number of days during the summer when boat ramps would be operable as well as the change in the number of days for the action alternatives compared to No Action. The summer period was defined as between April and November.

This analysis compares the H&H RESSIM Fort Peck Lake water surface elevations with the boat ramp elevations at Fort Peck Lake. No low water boat ramps were included in the evaluation. Three feet was added to the bottom engineering elevation of the boat ramp to estimate the bottom operating elevation of the boat ramp to account for the draft of the boat. Boat ramp operability is defined as when water surface elevations fall within the lower and upper operating elevations of the boat ramp.

Table A-2 provides a summary of the changes in the average number of days during the summer period when boat ramps would be operable compared to No Action boat ramp operability in the years when the test releases are implemented (partial and full release years). The boat ramps most adversely affected by the test releases are Hell Creek Marina, Crook Creek, and Rock Creek State Park. Considering only the years when a full or partial release would occur, Hell Creek Marina boat ramp would experience an average decrease between 12 and 28 days of operability (-6 to -13 percent change) during the summer period compared to No Action, depending on the alternative. Considering only the years when a full or partial release would occur, Crooked Creek boat ramp would experience an average decrease between 5 and 22 days of operability (-2 to -9 percent change) during the summer period compared to No Action, depending on the alternative. Alternative 2 and its variations are more adverse than Alternative 1 and its variations, and notably Variation 2B is worse than Alternative 2 and Variation 2A in terms of decreased operability at these three boat ramps.

Table A-1. Fort Peck Lake Boat Ramp Operability, No Action - Period of Record (1931-2012)

Boat Ramp Name	Average Summer Boat Ramp Days Operable	Change in Average Summer Boat Ramp Days Operable from No Action (Percent Change in Average Summer Boat Ramp Days)					
	No Action	1	1A	1B	2	2a	2b
Crooked Creek	126	-3.4 (-2.7%)	-2.1 (-1.7%)	-3.7 (-2.9%)	-4.3 (-3.3%)	-4.2 (-3.3%)	-8.7 (-6.8%)
Devils Creek	172	-0.1 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	-0.1 (0.0%)	0.0 (0.0%)	-0.1 (-0.1%)
Duck Creek	166	-0.1 (0.0%)	-0.1 (0.0%)	-0.1 (0.0%)	-0.1 (0.0%)	-0.1 (-0.1%)	-0.2 (-0.1%)
Flat Lake	194	-0.1 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Fourchette Bay	194	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Hell Creek Marina	102	-4.4 (-4.3%)	-3.1 (-3.0%)	-3.3 (-3.2%)	-4.8 (-4.6%)	-6.6 (-6.4%)	-7.3 (-7.1%)
Nelson Creek	139	-0.2 (-0.2%)	-0.3 (-0.2%)	-0.4 (-0.3%)	-0.4 (-0.2%)	-0.4 (-0.3%)	-2.4 (-1.7%)
Pines Area	164	0.0 (0.0%)	-0.1 (-0.1%)	0.0 (0.0%)	-0.1 (0.0%)	-0.1 (0.0%)	-0.2 (-0.1%)
Rock Creek Marina	194	-0.1 (0.0%)	0.0 (0.0%)	-0.1 (0.0%)	-0.1 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Rock Creek State Park	137	-0.7 (-0.5%)	-0.6 (-0.5%)	-0.8 (-0.5%)	-0.5 (-0.4%)	-0.4 (-0.3%)	-2.3 (-1.7%)
The Pines	155	-0.1 (0.0%)	-0.1 (-0.1%)	0.0 (0.0%)	-0.3 (-0.2%)	-0.2 (-0.2%)	-0.4 (-0.3%)

Notes: The summer period is defined as April through November. No low water boat ramps are included in the table.

Table A-2. Fort Peck Lake Boat Ramp Operability, only Partial and Full Release Years

Boat Ramp Name	Change in Average Summer Boat Ramp Days Operable (Percent Change in Average Summer Boat Ramp Days)					
	1	1A	1B	2	2A	2B
Crooked Creek	-10.6 (-4.6%)	-5.8 (-2.5%)	-10.3 (-4.3%)	-11.9 (-5.0%)	-11.7 (-4.9%)	-21.6 (-9.0%)
Devils Creek	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.1 (0.0%)	0.1 (0.0%)	0.0 (0.0%)
Duck Creek	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.1 (0.0%)	0.0 (0.0%)
Flat Lake	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.1 (0.0%)	0.0 (0.0%)
Fourchette Bay	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.1 (0.0%)	0.1 (0.0%)	0.0 (0.0%)
Hell Creek Marina	-16.5 (-8.5%)	-11.9 (-6.1%)	-11.6 (-6.0%)	-19.3 (-9.2%)	-27.6 (-13.2%)	-24.4 (-12.7%)
Nelson Creek	0.2 (0.1%)	-0.1 (0.0%)	-0.3 (-0.1%)	0.8 (0.3%)	0.6 (0.2%)	-4.6 (-1.8%)
Pines Area	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Rock Creek Marina	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.1 (0.0%)	0.0 (0.0%)
Rock Creek State Park	-1.9 (-0.8%)	-1.7 (-0.7%)	-1.7 (-0.7%)	0.0 (0.0%)	0.1 (0.0%)	-4.8 (-1.9%)
The Pines	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)

Notes: The summer period is defined as April through November. No low water boat ramps are included in the table.

The change in boat ramp operability is compared to the No Action operability in the years in which the partial and full releases are implemented; these years are not the same across the alternatives. Partial and/or full releases are implemented in 22, 22, 24, 20, 20, and 24 years for Alternative 1, Variation 1A, Variations 1B, Alternative 2, Variation 2A, and Variation 2B, respectively.

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Fort Peck Dam Test Releases
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Acronyms and Abbreviations

BiOp	Biological Opinion (amended in 2003)
CSREES	Cooperative State Research, Education, and Extension Service
DSS	Data Storage System
EQ	environmental quality (account)
ER	Engineering Regulation
ERS	(USDA) Economic Research Service
FAMSL	feet above mean sea level
FPDTR-EIS	Fort Peck Dam Test Releases - Environmental Impact Statement
FSA	(USDA) Farm Service Agency
H&H	hydrologic and hydraulic (model)
HC	human considerations
HEC	Hydrologic Engineering Center
NED	national economic development (account)
NOAA	National Oceanic and Atmospheric Administration
O&M	operations and maintenance
OSE	other social effects (account)
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
POR	period of record
RAS	River Analysis System
RED	regional economic development (account)
ResSim	Reservoir System Simulation
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

1 Introduction

The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Fort Peck Dam Test Releases – Environmental Impact Statement (FPDTR-EIS). The purpose of the environmental impact statement (EIS) is to assess the potential impacts of a range of test flow release alternatives from Fort Peck Dam designed to benefit reproduction and recruitment of pallid sturgeon to avoid jeopardizing their continued existence in the Missouri River.

The purpose of the Irrigation Technical Report is to provide additional information on the impact analysis and results relevant to irrigation that was completed for the FPDTR-EIS. Additional details on the national economic development (NED) and regional economic development (RED) methodology and results are provided in this technical report. The other social effects (OSE) are presented in Section 3.7, Irrigation, of the FPDTR-EIS.

1.1 Summary of Alternatives

The FPDTR-EIS evaluates the following alternatives. A detailed description of the alternatives is provided in Chapter 2 of the FPDTR-EIS.

No Action Alternative: The impacts of No Action Alternative serve as the baseline of comparison for the impacts of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck Dam are assumed to closely follow the Master Manual (USACE 2018a) with no deviations for a pallid sturgeon test flow. When modeling the No Action Alternative, local inflows are adjusted by the difference between the historic and present level depletions to ensure the period-of-record (POR) datasets are homogenous and reflect current water use. All modeled flood targets are as outlined in the 2018 Master Manual and reservoir storages are based on current reservoir surveys. All four navigation target locations are used when setting navigation releases and the model balances system storage by March 1. It is assumed that other activities and actions for pallid sturgeon in the Upper Basin would be implemented as described in the FPDTR-EIS and 2018 Biological Opinion (USFWS 2018) and the Yellowstone Intake Bypass EIS (USACE 2016). These actions include fish bypass construction at Yellowstone Intake, continued propagation and stocking of pallid sturgeon in the Upper Basin, and continued pallid sturgeon science and monitoring activities in the Upper Basin.

Alternative 1: System operations under this alternative are based on those described under the No Action Alternative except that it includes a flow release regime from Fort Peck Dam to benefit pallid sturgeon.

The Attraction Flow Regime begins on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in the given year. For example, the typical early spring release from Fort Peck Dam is approximately 8,000 cfs; therefore, the Attraction Flow Regime peak flow would be 16,000 cfs as measured at the Wolf Point gage. Beginning on April 16, the spring release flow is increased by 1,700 cfs per day until the peak flow is reached at the Wolf Point gage. The peak flow is held for three days and then decreases by 1,300 cfs per day until the Retention Flow is reached. The Retention Flow is 1.5 times the Fort Peck Dam early spring release as measured at the Wolf Point gage, 12,000 cfs using the example. The Retention Flow is held until May 28 when the Spawning Cue Flow Regime is initiated.

The Spawning Cue Flow Regime under Alternative 1 begins on May 28 and is 3.5 times the Fort Peck Dam spring flow release in the given year. Assuming 8,000 cfs as the typical spring flow, this equates to approximately 28,000 cfs at the peak as measured at the Wolf Point gage. Beginning on May 28, the release is increased by 1,100 cfs per day until the peak flow is reached as measured at the Wolf Point gage. The peak is held for three days and then decreases by 1,000 cfs per day for 12 days then decreased by 3,000 cfs per day until the Drifting Flow Regime of 8,000 cfs is reached. The 8,000 cfs Drifting Flow Regime is held until September 1 when releases to balance storage resume.

Variation 1A: This test flow is a variation of Alternative 1. The parameters for 1A are the same as described for Alternative 1 except that the Attraction Flow is initiated on April 9, rather than April 16, and the Spawning Cue Flow Regime is initiated on May 21, rather than May 28. The April 9 initiation date is closer to the timing of the initial pulse shown on the unregulated hydrograph. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases. In Alternative 1, the later initiation date of April 16 is designed to enhance the contrast between Missouri River and Yellowstone River discharges by moving the start date approximately two weeks later than the initial pulse shown on the unregulated hydrograph.

Variation 1B: This test flow is another variation of Alternative 1. The parameters for 1B are the same as described for Alternative 1 except that the Attraction Flow is initiated on April 23 and the Spawning Cue Flow is initiated on June 4. Similar to the concept described in Variation 1A, the later initiation date is intended to provide contrast explore any differences in forecasted impacts from a later flow initiation date.

Alternative 2: The parameters for Alternative 2 are the same as described for Alternative 1 except that the Attraction Flow Regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck Dam spring flow in the given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at Wolf Point gage are held at 14,000 cfs until the Spawning Cue release is initiated. The rationale for keeping the releases high through this period – foregoing the inter-pulse saddle – is the hypothesis that persistent high flows are needed to hold migrated, reproductive adult pallid sturgeon upstream near the dam.

Variation 2A: This test flow is a variation of Alternative 2. The parameters for Variation 2A are the same as described for Alternative 2 except that the Attraction Flow is initiated on April 9, rather than April 16, and the Spawning Cue flow would be initiated on May 21, rather than May 28. The difference in timing follows the same reasoning as described for Variation 1A.

Variation 2B: This test flow is a variation of Alternative 2. The parameters for Variation 2B are the same as described for Alternative 2 except that the Attraction Flow is initiated on April 23, rather than April 16, and the Spawning Cue flow is initiated on June 4, rather than May 21. The difference in timing follows the same reasoning as described for Variation 1B.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the FPDTR-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the FPDTR-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR 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 FPDTR-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 NED account displays changes in the economic value of the national output of goods and services expressed in monetary units.

The RED account registers changes in the distribution of regional economic activity (i.e., jobs and income).

The EQ account displays non-monetary effect on significant natural and cultural resources.

The OSE account registers plan effects from perspective 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 irrigation include NED, RED, and OSE.

1.3 Approach for Evaluating Environmental Consequences to Irrigation Operations from the FPDTR-EIS Alternatives

The study area for the low flow analysis includes irrigation operations in 23 counties in Montana, North Dakota, and South Dakota adjacent to the Missouri River from Fort Peck Dam to Oahe Dam. These operations hold permits to use water from the Missouri River for the purpose of agricultural production. A total of 770 intakes were identified by USACE from the Master Manual for this analysis. The irrigation intakes permitted on the Missouri River are a mix of semi-permanent (portable) and permanent structures. Under favorable operating conditions, water intakes are located below the water surface, enabling water from the reservoirs and river reaches to be pumped to agricultural fields within the floodplain. When river stages and reservoir elevations fall below required minimum operating requirements for irrigation intakes, intakes can no longer access the water. These shutdowns adversely affect farm production, especially when water access is inhibited for consecutive days.

The study area for the high flow analysis includes irrigation operations in four counties in Montana and two counties in North Dakota adjacent to the Missouri River and stretching from Fort Peck Dam to Lake Sakakawea. High river flows can lead to an increase in operations and maintenance costs for irrigation intakes located on the mainstem of the Missouri River. In addition, high river flows followed by low flows can adversely impact intakes located on side channels as these channels could become silted-in by these types of conditions. If these channels are silted in, then no water can reach the irrigation pump, which would affect both farm production and operations and maintenance costs to clear the irrigation channel feeding water to the pump from the mainstem of the Missouri River.

The conceptual flow chart in Figure 1-1 demonstrates, in a stepwise manner, how changes to the physical conditions of the Missouri River and its floodplain can affect irrigation and crop yields and operations and maintenance costs. This figure also shows the intermediate factors and criteria that were applied in assessing the NED, RED, and OSE consequences to irrigation.

CHANGES IN: Physical Components of Missouri River Watershed

- Reservoir elevations
- River flows and stages

Leads To

CHANGES IN: Irrigation Conditions and Operations and Maintenance Costs for Irrigation Pumps

- Access to Water During Irrigation Season
- Costs to operate and maintain pumps

Leads To

CHANGES IN: Irrigation Activity

- Yield from irrigated acreage

Leads To

CHANGES IN: Beneficial Effects and/or Costs

- NED – Net farm income, as influenced by changes in access to water for irrigation
- NED – Operations and maintenance costs, as influenced by high water flow impacts to intakes

Leads To

CHANGES IN: Beneficial and/or Adverse RED

- RED – Economic output/sales, income, employment by industry and region, and tax receipts to local governments

Leads To

CHANGES IN: OSE

- Individual and community well-being, traditional ways of life

Figure 1-1. Flow Chart of Inputs Considered in the Irrigation Evaluation

The analysis of impacts due to low flows followed a three-step process (Figure 1-2). The first step evaluated the changes in river conditions including changes in river stage, river flow and reservoir elevations at specified intervals along the river under each of the FPDTR-EIS alternatives. The results of this step were then integrated into the economic analysis, which estimated the change in yields due to changes in access to water from the Missouri River for irrigation. The calculations are performed over a modeled 82-year POR. Further details on the methodology are provided in the following sections. Figure 1-2 summarizes the overall analysis.

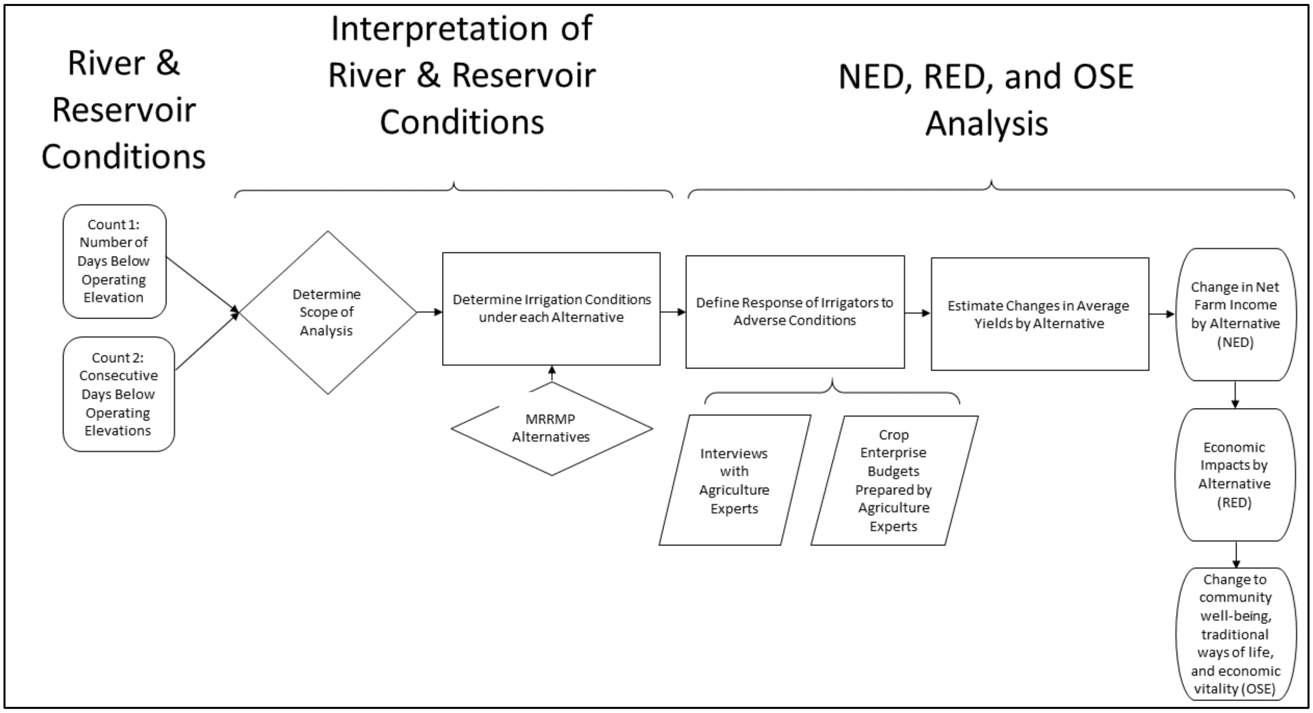


Figure 1-2. Approach for Evaluating Environmental Consequences to Irrigation from Low Flows

The environmental consequences analysis for evaluating high flow impacts on irrigation intakes takes separate approaches for Missouri River mainstem and side channel irrigation intakes. The mainstem irrigation intake analysis uses a two-step process and calculates the operations and maintenance costs associated with high flow events at these pumps. The first step of this analysis evaluates potential effects to intakes from changes in river stage or flow at each irrigation intake along the river under each FPDTR alternative for two separate flow tiers. The second step in this process applies a weighted average operations and maintenance (O&M) cost by flow tier to determine the change in costs to irrigation intakes due to high flow events. These changes in operations and maintenance costs are considered NED effects. The calculations are performed over the 82-year period or record. Further details on the methodology and structure of the analyses are discussed in the following sections. Figure 1-3 summarizes this analysis approach.

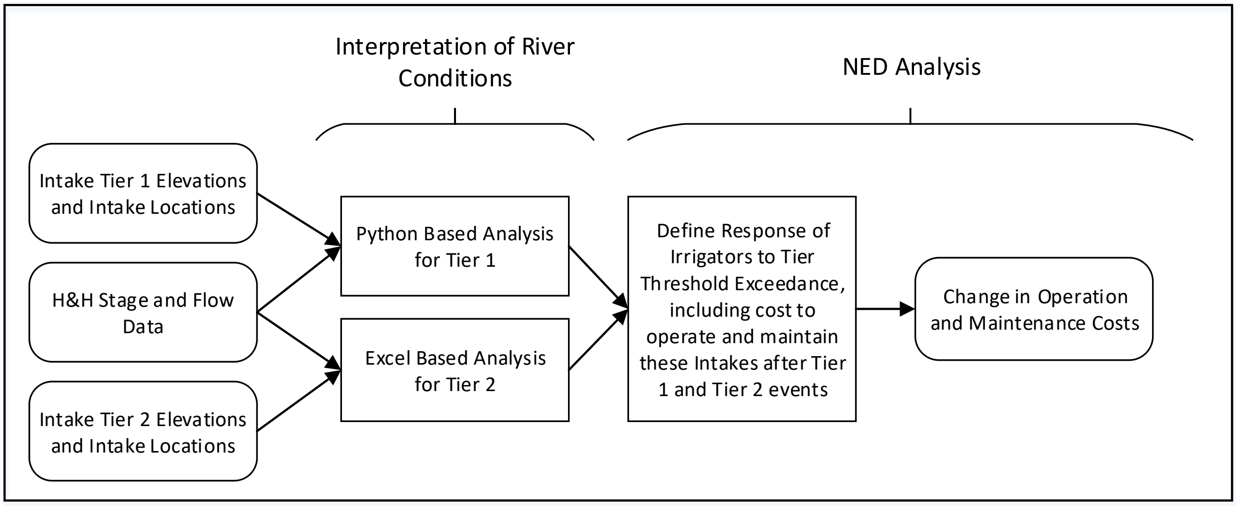


Figure 1-3. Approach for Evaluating Environmental Consequences to Irrigation Intakes on Mainstem of Missouri River from High Flows

A side channel case study was also performed to determine the NED and RED impacts when side channel intakes are impacted from high flow events. Under this case study, impacts from changes in operations and maintenance costs as well as crop losses are considered. The operations and maintenance costs and crop losses result in impacts to the net farm income of farmers, with NED and RED effects. This approach primarily uses the approach used in the low flow analysis, except that the outputs from the H&H model are not used and instead a specific number of intakes are impacted during for the full duration of the irrigation season during full flow years. The NED, RED and OSE portion of Figure 1-2 above generally describes the process used in the side channel case study. Details on the methodology and structure of this analysis are discussed in the following sections.

2 Assumptions

The following discussion highlights the assumptions used in the evaluation of impacts to irrigation operations from the FPDTR-EIS alternatives:

- 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 POR under each of the FPDTR-EIS alternatives and variations, as well as No Action.
- No Action is considered the baseline against which the other alternatives and their variations are measured. Under No Action, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1 of the FPDTR-EIS, Impact Assessment Methodology**,** No Action does not reflect actual past or future conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.
- It is assumed that if the water surface elevations or river flows fall below a minimum operating requirements the irrigation intake will lose access to water for a full day.
- Where available, detailed information on irrigation intake operating requirements were used in the analysis. When not available, the project team assumed that certain reported

minimum operating requirements given for single irrigation intakes would apply to similar intakes located in the general vicinity.

- Based on interviews with irrigation intake owners and farm operators, it was assumed that impacts will increase as the number of consecutive days without access to water increases.
- Impacts to irrigation intakes from low flows are assumed to take the form of declining crop yields. As the number of days increases in which access to water is curtailed, the expected yield per acre is expected to decrease.
- Water used for irrigation is assumed to be constant for all irrigators and equal to the state average estimated in the 2013 Farm and Ranch Irrigation Survey (USDA 2013).
- Crop harvest patterns (i.e., the percentage of corn, alfalfa, and barley) for crops harvested using only Missouri River water are assumed to be equal to the harvest patterns for crops irrigated with water from any source, as reported in the 2019 Crop Acreage Data Reported to USDA Farm Service Agency (FSA) (USDA 2019a).
- Because irrigators in Montana are not required to report actual acreage that is irrigated (versus permitted), it was assumed that all acres permitted for irrigation use with water withdrawn from the Missouri River use this water. In addition, the Fort Peck Tribe has an allotment of 19,000 irrigated acres from the Missouri River. These acres were apportioned into Valley and Roosevelt counties based on the relative percentage of riverfront lands that the reservation touches in these two counties in Montana.
- Crop enterprise budgets were used for irrigation costs per acre and crop yields per acre (both irrigated and dryland). Every effort was made to use a budget that included the county under study. In the event that a suitable budget was not available, a budget prepared for a similar geography and rainfall pattern was used.
- The price per unit of crop production is assumed to be equal to the state-level normalized price estimates for commodities, as provided by the USDA Economic Research Service (ERS) for 2018 (USDA 2019b).
- For the high flow mainstem analysis, It is assumed that if the water surface levels rise above a certain threshold, classified as a tier 1 event, as established through the USACE irrigation intake surveys completed in the summer of 2020, this would result in some additional operations and maintenance costs associated with high flows. This includes costs associated with cleaning of intake’s screen or clearing of debris that a land-based dredge or backhoe could resolve.
- For the high flow mainstem analysis, It is assumed that if water surface levels rise above a higher threshold, classified as a tier 2 event, as established through the USACE irrigation intake surveys completed in the summer of 2020, there may be an inundation of shore-side infrastructure, such as electrical subpanels that operate intake pumps; destruction of the intake due to large debris collisions; and sedimentation or siltation of the pump area such that a water-based dredge is required to move the river’s water channel back to the pump’s location.
- For tier 1 events occurring during the irrigation season, operations and maintenance costs would be incurred on the day after a tier 1 event ceases, assuming a three-day period of flows including this day and two days after would not result in the tier 1 threshold being breached again.

- For tier 1 events occurring during the non-irrigation season, operations and maintenance costs would be incurred only once immediately prior to the start of the irrigation season if the tier 1 threshold was exceeded at all during the non-irrigation season.
- For tier 2 events, operations and maintenance costs would be incurred the day after flows or water elevations drop below the tier 1 threshold of the intake as flows would need to pass through this level prior to taking action to repair the intake or its associated infrastructure. As tier 2 events are rare, the model currently only considers if these events occur once per irrigation season.
- Assessment of flooding impacts from high flows to agricultural operations are assessed in the Flood Risk Management (FRM) analysis (section 3.4 of the FPDTR Draft Environmental Impact Statement).
- Historic, daily riverine flow and stage levels at various cross section of the river (referred to as H&H model outputs or H&H cross sections) are assigned to each irrigation intake based on the closest riverine cross section that has been mapped by USACE.
- In the side channel case study, if any full flow event occurs in a certain year, it is assumed that no irrigation occurs at side channel intakes, and all crop production that occurs is dryland production.
- Crop losses in the side channel case study only occur from high flows in years with full flows. The acreage of crops impacted is, on average, 414 acres per impacted side channel intakes. This is based on the average acreage obtained from intake operators during surveys of operators undertaken in the summer of 2020 and winter of 2021.
- The percentage of surveyed intakes classified as side channel intakes in each county in Montana is equal to the overall percentage of side channel intakes obtained from surveys of intake operators during 2020 in Montana.
- Based on surveys undertaken in the summer of 2020 with intake operators, it was determined that when a side channel intake is silted in due to high flows followed by low flows. On average, irrigators reported a operations and maintenance cost of $10,000 to clear the channel. For the purposes of the side channel case study, it is assumed this cost is incurred in every test flow year.

2.1 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 FPDTR-EIS 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 POR. 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 Hydrologic Engineering Center - River Analysis System (HEC-RAS 2013) models or carried through to the irrigation model described in this document. The project team has attempted to address risk and uncertainty in the FPDTR-EIS 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. The HEC RAS data as simulated over the POR was used to estimate the impacts to irrigation intakes and agricultural production under each of the FPDTR-EIS alternatives.

3 Analysis of River and Reservoir Conditions

The purpose of the river conditions analysis was to link the H&H model outputs (e.g., HEC-RAS and ResSim) of river/reservoir operations under each of the FPDTR-EIS alternatives with minimum irrigation intake operating requirements and high flow thresholds associated with operations and maintenance costs of intakes. This analysis was completed in Microsoft Excel® and Python®. The analysis of the minimum irrigation intake operating requirements provided an estimate of the number of days irrigation intakes would have access to water at various locations along the river. The output of this minimum flow model was used in the economic model to evaluate potential NED and RED effects on changes in river flows, river stages, and reservoir elevations to irrigation operations accessing water from the Missouri River. An analysis of impacts due to high flows was undertaken separately and analyzed operations and maintenance costs for intakes associated with high flows. An additional case study of side channel intakes was undertaken to determine potential crop yield losses associated with the siltation and closure of these side channels following specific high flow events. These high flow impacts were used to determine NED and RED effects.

3.1 Low Flows

As river flows and reservoir elevations fall below irrigation intake minimum operating requirements, intakes become unavailable to provide water for crops. Minimum operating requirements for intakes were obtained from the Master Manual, verified by stakeholders, and represent the best available data on the actual flow/elevation requirements at each individual intake. For example, in Montana, the minimum operating flow threshold for intakes is 6,000 cfs and varies between 6,000 and 12,000 cfs in the North Dakota reach of the Missouri River. Some North Dakota irrigation intakes have river stage based thresholds that vary by intake. Changes to flows or river elevation at intakes can drive changes in crop yields and operation and maintenance costs of the intakes. The analysis of river conditions was developed using outputs from H&H models developed by the USACE. HEC-RAS and Hydrologic Engineering Center - Reservoir System Simulation (HEC-ResSim 2016) data was used to provide a profile of river and reservoir behavior at locations that approximately corresponded to locations of irrigation intakes, in the form of HEC-DSS (Data Storage System) flat files. River and reservoir behavior for each location was analyzed over a period of 82 years, from 1930 to 2012.

The USACE developed an initial list of 1,027 irrigation intakes that were used in the low flow analysis for irrigation along the river from Montana to Nebraska from the Master Manual, which included minimum operating requirements at many of those intakes for analysis in the MRRMP-EIS (USACE 2018b). This FPDTR-EIS analysis uses a portion of this list of intakes, 770 intakes, for the 23-county study area in the FPDTR-EIS between the Fort Peck Dam in Montana and Lake Oahe, South Dakota.

In order to reduce the processing time, individual intake locations were categorized into 171 groups that were located in close proximity and had similar access requirements. Groups did not cross county lines, shared a common required intake operating flow/elevation, were within ten river miles, and did not cross tribal boundaries. Each group included approximately four intakes. An Excel®-based analysis was developed to identify whether or not the river and reservoir conditions fell within the access requirements of the irrigation intake group.

Two metrics were developed to approximate access to water for irrigation under the FPDTR-EIS alternatives. The first metric was an estimate of the number of days river flows or reservoir elevations fall below minimum operating requirements. The total number of days below minimum operating requirements was estimated for each group of intakes in each county for each alternative for each year. The second metric was an estimate of the average consecutive length of time, in days, for all occurrences of river flows or reservoir elevations falling below minimum operating requirements during the irrigation season. The results obtained were assumed to be consistent for all intakes in the group. Results by intake group were then aggregated and averaged across the entire county for every county in the study area. Henceforward, whenever ‘minimum operating requirements for irrigation intakes’ is referenced, this refers to the average behavior for all irrigation intakes in a county.

3.1.1 Defining Scope of Analysis

The results of the river conditions analysis were used in part to define the extent of the economic analysis for irrigation operations under each of the FPDTR-EIS alternatives. In particular, the results of the river condition analysis were used to identify which intake groups by counties should be subject to further evaluation in the FPDTR-EIS. The team evaluated the river conditions to determine potential impacts for irrigation intakes in each county under each of the FPDTR-EIS alternatives (Alternatives 1 and 2 and their variations) compared to the No Action Alternative.

A county was selected for further analysis if the river conditions results indicated that the county would experience a notable increase in the number of days river flows or reservoir elevations fall below minimum operating requirements for irrigation intakes under the FPDTR-EIS alternatives relative to No Action. Note that because all alternatives showed considerable impacts during the drought years of the 1930s and early 1940s, the screening process largely focused on annual river conditions for years between 1942 and 2012. For more information on historic drought periods, refer to Section 3.2 in the FPDTR-EIS

Three screening criteria were developed to determine the scope of analysis for irrigation. As the minimum operating requirements for irrigation intakes was completed at the county level, the screening criteria was also developed to apply to the county level. The screening criteria are defined as follows.

Considerable number of days with water levels below minimum operating requirements in a single year compared to No Action. Counties were selected for further analysis if there was an increase in the number of days with water levels below minimum operating requirements by at least 30 days in any single year under any of the action FPDTR-EIS alternatives compared to No Action. This criterion was designed to represent an infrequent event that could have the potential to have large impacts on irrigation operations. For example, the minimum operating requirements for irrigation intakes analysis showed that Valley County, Montana would experience an increase in the number of days below minimum operating requirements of 30 days in 1983 under Variation 1A, and in 1986 in Variation 2B, which resulted in this county being selected for further analysis.

Measurable increases in water levels below minimum operating requirements over several years. This criterion evaluated the counties that may experience a moderate increase in the number of days with water surface elevations below minimum operating requirements during several years under the FPDTR-EIS alternatives compared to No Action. This criterion was calculated in two steps. First, a moderate increase in the number of days below minimum operating requirements was defined as approximately 10 percent of the growing season or an increase of 15 days in a single year, relative to No Action. Second, the annual frequency with which counties experienced this moderate increase under any alternative was calculated.

Counties that experienced a moderate increase in the number of days below minimum operating requirements in six or more years (the 90th percentile of such occurrences) were selected for additional evaluation. For example, under Variation 2A, intakes in Valley County, Montana would experience seven years in which intakes would experience an increase of at least 15 days per year (primarily between 1983 and 1987) when water surface elevations would fall below minimum operating requirements and, as a result, this county was selected for additional analysis.

Increase in the number of consecutive days. This criterion measured the relative increase in the average number of consecutive days that intakes experience water surface elevations below minimum operating requirements from 1942 to 2012 for all action alternatives compared to No Action. The sum of the average number of consecutive days per year over the total POR was analyzed for each county, and counties that fell into the 90th percentile (or top ten percent) for such occurrences were selected for further analysis to capture cumulative impacts of reductions in water access over time.

3.1.2 Initial Screening Results

Table 3-1 shows the results of the screening analysis described above and includes the counties that were identified for further analysis. There were five counties that were identified as meeting at least one of the criteria described above. Only one county was selected based on a single criterion: McLean County, North Dakota. Four counties, all in Montana, were identified based on meeting all three criteria.

Table 3-1. Counties Identified for Further Analysis in the Environmental Impact Statement

County	State	Single year impact	Moderate impact for several years	Cumulative impact on consecutive days
McCone	MT	x	x	x
Valley	MT	x	x	x
Roosevelt	MT	x	x	x
Richland	MT	x	x	x
Williams	ND			
McKenzie	ND			
Mountrail	ND			
Dunn	ND			
McLean	ND	x		
Mercer	ND			
Oliver	ND			
Burleigh	ND			
Morton	ND			
Emmons	ND			
Sioux	ND			
Corson	SD			
Campbell	SD			

County	State	Single year impact	Moderate impact for several years	Cumulative impact on consecutive days
Walworth	SD			
Dewey	SD			
Potter	SD			
Sully	SD			
Stanley	SD			
Hughes	SD			

3.1.3 Irrigated Acreage Criterion

Upon further review of the initial screening results, it was determined that all of the five counties met an additional criterion developed based on the number of irrigated acres (1,000 acres of irrigated croplands actually irrigated using water from the Missouri River) within in each county.

3.1.4 Scope of Analysis Results

Based on the results of the screening analysis, five counties in the upper basin were evaluated for potential for impacts of the FPDTR-EIS alternatives on irrigation operations. These five counties include approximately 86,228 permitted acres for irrigation using water from the Missouri River. The five identified counties for further analysis include the following:

- McCone, Montana
- Valley, Montana
- Roosevelt, Montana
- Richland, Montana
- McLean, North Dakota

3.2 High Flows

The high flow analysis includes two separate analyses to address impacts to intakes located on the main channel and on side channels. Because intakes located in different parts of the river would likely incur different types of impacts, the two analyses were designed to address those unique impacts separately. The high flow analysis of mainstem intakes evaluated how irrigation intakes' operations and maintenance costs could be affected by high flows of the Missouri River. As river flows or stages exceed the maximum operating thresholds of irrigation intakes, irrigators will incur additional operations and maintenance costs, such as cleaning and repair or replacement costs of intakes and other infrastructure, to mitigate impacts due to high flows. This analysis was developed using outputs from H&H models developed by the USACE described in section 3.1 above.

The project team determined that side channel and mainstem irrigation intakes react differently to high flow events. Therefore, the assessment of impacts to side channel intakes was undertaken separately, as a case study analysis which evaluated additional operations and maintenance costs as well as potential losses in crop productivity with a loss in access to water due to increases in sedimentation.

The universe of intakes used to estimate impacts in the high flow analysis comes from a 2001 survey of local irrigation districts in the four counties in Montana which indicated 142 intakes along the Missouri River (Goss pers comm 2019). This data set was determined to be the most complete, up-to-date inventory of operational irrigation intakes currently located along the Missouri River in Montana. However, data from the Montana Department of Natural Resources and Conservation's Water Rights Query System indicates there are 365 permitted irrigation water rights claims in the four counties in Montana while a recent analysis prepared by Bartlett & West (2019), which also relies on data from this system, indicates that there are 306 agricultural spraying and irrigation claims along the Missouri River in Montana. These higher estimates of intakes were not used in the analysis because conversations with irrigators and conversation districts indicated that several intakes may have been abandoned and not updated in the state's water right database. The project team felt that utilizing the estimate of 142 intakes would cover the number of intakes that are known to be operating in Montana and provide a buffer for others that may have not been accounted for at this time.

As 24 of the 111 (21.6%) identifiable irrigation intakes in Montana are located on the side channel of the Missouri River in Montana then, proportionally, 31 of the 142 irrigation intakes are assumed to be side channel intakes in Montana. Subsequently, as 87 of the 111 (78.4%) identifiable irrigation intakes in Montana are located on the main channel of the Missouri River in Montana then, proportionally, 111 of the 142 irrigation intakes were assumed to be main channel intakes in Montana. Additionally, this same proportion (78.4%) of main channel intakes was multiplied against the number of intakes in North Dakota (30) to obtain the number of mainstem intakes in North Dakota (24 intakes). Therefore, there were an estimated 135 main stem intakes between Fort Peck Dam and Lake Sakakawea. NED impacts were assessed for these 135 main stem intakes. The 31 side channel irrigation intakes in Montana are analyzed for NED and RED impacts. Impacts to the remaining side channel intakes in North Dakota were not analyzed here. Table 3-2 below indicates the number of mainstem and side channel intakes by county in the study area along with the assumed irrigated acreage for these groups of intakes, by county.

Table 3-2. Mainstem and Side Channel Intakes Used for High Flows Analysis

County	Mainstem Intakes	Side Channel Intakes	Average Irrigated Acreage Per Intake[1]
McCone, MT	111[2]	8	414
Richland, MT		9	414
Roosevelt, MT		10	414
Valley, MT		4	414
McKenzie, ND	24[2]	*not analyzed*	*not analyzed*
Williams, ND			
Total	135	31	-

Notes:
1 Average acres impacted only applies to side channel intakes for high flows. High flow impacts to crop production at mainstem intakes were not assessed. Only O&M impacts were assessed for these mainstem intakes.
2 The number of intakes are combined for the riverine analysis at state level as only the O&M impacts are assessed for these intakes and a per county crop impact analysis is not needed. O&M costs are the same for each intake regardless of location.

During the summer and fall of 2020, USACE staff along with staff from Montana Fish, Wildlife and Parks in cooperation with Richland County Conservation District surveyed or identified 119 active intakes along the Missouri River located in six counties between the Fort Peck Dam in Montana, and Lake Sakakawea in North Dakota. Surveys that were undertaken by USACE included an analysis of the intake locations, the location of various shore side and water-based infrastructure including the intake, costs and activities associated with high flows, and the number of irrigated agricultural acres that the intake services. Surveys undertaken by Montana Fish, Wildlife and Parks only classified the intake as being located on the mainstem or a side channel of the Missouri River. A total of 92 intakes were determined to be located on the main channel, 26 intakes were identified as being located along side channel and one was unclassified. Of these intakes, 111 intakes (24 side channel intakes and 87 mainstem intakes) are located in Montana.

3.2.1 Missouri River Side Channel Irrigation Intakes Case Study

Given the different ways in which side channel and mainstem irrigation intakes react to high flow events it was determined that the assessment of impacts to side channel intakes be undertaken separately, as a case study analysis. The side channel case study analysis utilized data and information collected during the survey of intakes in the summer and fall of 2021. Additionally, the project team conducted ten interviews with irrigators identified to have intakes located on side channels in the winter of 2021 with the results integrated into the case study analysis. During the survey and interviews with irrigators, it was determined that high flow events may cause sedimentation to side channels that render intakes inoperable for some of the irrigation season. The loss in irrigation can result in a reduction in crop yields as operations move from irrigated crop production to dryland crop production. For some crops, like sugar beets, a loss in irrigation can result in a total loss in the crop as it is heavily dependent on irrigation for its production. However, other crops depend less on irrigation and may not be as affected by a loss of irrigation water (see Table 4-3 in Section 4.1.1 below for dry and irrigated crop yields). Additionally, the analysis completed on the side channels may overestimate the crop yield reductions due to the assumption that irrigation would not be available during the entire irrigation season. For example, for some crops, if the high flow occurs after the critical growing season (June and July) then yields may not be notably affected by a loss in irrigation.

The proportion of surveyed intakes that were determined to be side channel irrigation intakes (21.6 percent), was applied to the total universe of irrigation intakes in Montana (142) and the proportion of pump permits in each county relative to the total number of pump permits to estimate the number of side channel intakes in that county. In total, there were estimated to be 31 intakes that are side channel intakes in the state of Montana as described above. Impacts to these intakes were assumed to occur only in full flow years because these are years where it is likely that side channel intakes would be inoperable due to sedimentation. While it is possible that intakes would become inoperable in partial flow years as well, these could not be modeled due to a lack of information on the specific conditions that would result in impacts to side channel intakes.

As this model assumes that there would be a complete loss of irrigation water available during full flow years, there are no H&H models to run against intake thresholds. Therefore, the technical description of this analysis is described entirely in the NED and RED sections below.

3.2.2 Missouri River Mainstem Irrigation Intakes - Operation and Maintenance Costs

Two metrics, identified as tier 1 and tier 2, defined two high flow levels at each surveyed intake located on the main channel where specific types of operations and maintenance costs would occur. Given that operations and maintenance costs associated with high river flows are diverse, ranging from small costs associated with cleaning an intake screen to large costs associated with water-based dredging or replacing infrastructure, it was important to define a set of metrics that differentiated a range of costs that may occur because of high flow events. Table 3-3 below defines the two metrics used for this analysis.

Table 3-3. Operations and Maintenance Levels

Metric	Performance Measure	Description
Metric 1 – Tier 1 Events	Number of events during an irrigation season by year where the tier 1 threshold was exceeded.	High riverine stage or flow where flows levels would result in normal operations and maintenance costs to irrigation intakes associated with high flows. These include costs associated with cleaning of intake's screen or clearing of debris that a land-based dredge or backhoe could resolve.
Metric 2 – Tier 2 Event	Number of events during an irrigation season by year where the tier 2 threshold was exceeded.	High riverine stage or flow where flows levels would result in larger than normal operations and maintenance costs to irrigation intakes. These costs are associated with impacts to shore-side infrastructure or result in water based-dredging or some combination of these two operations and maintenance costs.

As noted above there are an estimated 172 intakes in total along the stretch of the Missouri River between Fort Peck Dam in Montana and the beginning of Lake Sakakawea in North Dakota. Based on the description provided above 135 intakes were assumed to be located along the mainstem of the Missouri River between Fort Peck Dam in Montana and Lake Sakakawea in North Dakota. While the steps discussed below pertain to the analysis of the tier 1 and tier 2 thresholds associated with the surveyed intakes, the results of this analysis are ultimately extrapolated to this entire subset of intakes (135) that are assumed to be located along the mainstem of the Missouri River.

During the summer of 2020 USACE staff surveyed 64 irrigation intakes in the states of Montana and North Dakota. USACE determined that 45 of these intakes were located on the mainstem of the Missouri River and it is these intakes that were used for the tier 1 and tier 2 impact analysis described below. Some of the irrigation intake operators were unable to report a tier 1 level associated with their intake and only reported a tier 2 level. In total, survey crews and USACE staff were able to establish 40 intakes with tier 1 thresholds. All intakes have tier 2 thresholds associated with them. Therefore, the results of the tier 1 and tier 2 analyses described below are extrapolated the subset of intakes using slightly different multipliers: 3.371 for tier 1 and 2.997 for tier 2[1] to estimate the tier 1 and tier 2 impacts on all 135 intakes along the Missouri River mainstem.

[1] The multiplier value of 3.371 was obtained from 135 total intakes divided by 40 tier 1 intakes, while 2.997 was obtained from 135 total intakes divided by 45 for tier 2 intakes.

3.2.2.1 Structure of Tier 1 and Tier 2 Impact Analysis

The analyses described below were developed using an Excel®-based workbook that contained data necessary for the analysis of both metrics as well as data necessary to assess the NED impacts described further below in Section 4. Because the datasets under analysis are quite large, the tier 1 metric could not be efficiently analyzed in Microsoft Excel. Instead, the programing language, Python® 3.7 and supporting python code libraries were used to assess the tier 1 metric.

3.2.2.1.1 Tier 1 Impact Analysis

This section focuses on the analysis of the tier 1 impacts. Each surveyed intake was assigned a tier 1 flow or stage level where high flows would result in an increase in operations and maintenance (O&M) costs. These surveyed tier 1 levels were input into a Python® model along with each intake's closest cross section from the USACE H&H HEC RAS dataset described in section 3.1 above. The model determined the number of times a tier 1 threshold was crossed during the irrigation season based on the following set of rules:

- A tier 1 event occurs when flows are equal to or exceed the tier 1 threshold and then decrease below the tier 1 threshold for a period of three days or more.

- If flows cross the tier 1 threshold and then recede below the threshold for three days or more, the model resets and allows another tier 1 event to occur. If flows climb back to or above the tier 1 threshold within three days of receding below the threshold, then no new tier 1 event occurs and the same tier 1 event continues.

- More than one tier 1 event can occur during a season so long as the above rules are met.

- Tier 2 thresholds associated with each intake are input into the Python model. If the model determines that a tier 2 threshold is exceeded after a tier 1 threshold is exceeded, but before the water level recedes below the tier 1 threshold then it will not allow a tier 1 event to occur. Instead, the model will wait for water levels to go below the tier 1 threshold again for three days before resetting to monitor for a tier 1 event. Note that, in this case where a tier 2 threshold is exceeded, the model will not allow for a tier 1 event as costs associated with the tier 2 event would likely include the costs that would be associated with the tier 1 event. This avoids double counting of costs. Stated another way, large tier 2 events cause more operations and maintenance costs than tier 1 events and the costs associated with tier 2 events would cover any tier 1 costs that would otherwise be incurred.

The Python model also determined and reported whether a tier 1 threshold was crossed during the non-irrigation season. The irrigation season is defined as starting on May 1st and ending on September 31st annually.

3.2.2.1.2 Tier 2 Impact Analysis

This section focuses on the analysis of the tier 2 O&M impacts. Each surveyed intake was assigned a tier 2 flow or stage level where high flows would result in larger than normal operations and maintenance costs. These costs are associated with impacts to shore-side infrastructure, or result in water based-dredging, or some combination of these two operations and maintenance costs. This analysis was undertaken solely in Microsoft Excel® and was simpler in terms of processing than the tier 1 analysis as it only assessed whether a tier 2 threshold was exceeded during an irrigation season for an intake. If this threshold was exceeded, it was used as a bases for determining costs under a tier 2 event. This relatively simple approach was taken as it is assumed that cleanup from this type of event takes some time, on the order of months and occurs relatively infrequently throughout the historic period and may only occur once during an irrigation season of any year. Additionally, the operation and maintenance activities associated with this type of event also take some time to implement, on the order of weeks to months, and so it was decided to only note how many intakes incurred these types of events during an irrigation season.

3.2.2.2 Results of Tier 1 and 2 Impact Analysis

The findings of the analyses described above were summarized in two tables which counted the number of tier 1 and tier 2 events that occurred during an irrigation season by alternative or variation and by year. These results are discussed in the NED analysis below.

4 Methodology

4.1 Low Flows

4.1.1 National Economic Development

The NED analysis of low flows evaluated changes in net farm income from irrigated crop acreage using Missouri River water. The minimum operating requirements for irrigation intakes analysis showed that water surface elevations would fall below minimum operating requirements for many of the irrigation intakes evaluated under FPDTR-EIS alternatives, including the No Action Alternative. Because of the large variations in costs to access irrigation water and the difficulty in estimating these costs, the evaluation focused on the changes in crop yields resulting from reduced access to water and subsequent effects on net farm income.

A Microsoft Excel-based model was developed to evaluate the change in NED benefits for irrigation operations under the FPDTR-EIS alternatives for the five counties identified in the river condition analysis. The NED analysis for the five counties used data and information provided by the USACE, crop enterprise budgets developed by state agriculture extension agencies, state water permit data, crop data from the USDA, and weather information from the National Oceanic and Atmospheric Administration (NOAA). These data sources and the approach are described in this section.

4.1.1.1 Estimated Irrigated Acreage by Missouri River

Table 2 summarizes the acres permitted for irrigation from the Missouri River and actual acres irrigated according to survey data obtained from farm operators. The North Dakota State Water Commission require irrigation permittees to report annual acres irrigated. For the individual county in North Dakota the analysis utilized this data to estimate the number of acres irrigated with Missouri River water. Irrigators in Montana are not required to report actual irrigated acreage. Thus, the project team made a conservative estimate and assumed that the entirety of the acres permitted is the irrigation acreage in these counties. Additionally, 19,000 acres of irrigated croplands were apportioned to the total for Valley and Roosevelt counties based on a rough percentage of the Fort Peck Tribal Reservations' land that occupies the Missouri River floodplain in these two counties. This was done to add the allotment of water that the Fort Peck

Tribe withdraws from the Missouri River that is not included in the Department of Natural Resources and Conservation Water Right Query System for the state of Montana where the rest of the water withdrawals in that state are accounted for (Table 4-1).

Table 4-1. Estimated Irrigated Cropland Using Missouri River Water

County	State	Acres Permitted (Missouri River Only, 2018/2019[c])	Actual Acres Irrigated (Missouri River Only, 2018/2019[c])
McCone[a]	Montana	16,271	16,271
Valley[a]	Montana	11,049[b]	11,049[b]
Roosevelt[a]	Montana	34,515[b]	34,515[b]
Richland[a]	Montana	17,927	17,927
McLean	North Dakota	6,466	2,623

Sources: USDA 2019a; Montana Department of Natural Resources and Conservation 2019; pers comm Colby, 2019; pers comm Wright, 2019.

a Note that actual acres irrigated from Missouri River in Montana match the acres permitted for irrigation from the Missouri River in order to conservatively estimate the number of irrigated acres that might be impacted, Montana does not currently require irrigators to report the actual number of irrigated acres.

b 6,333 acres added to total for Valley County and 12,666 acres added to total for Roosevelt County to account for acres that are technically unpermitted by the state of Montana but allowed through tribal treaties on the Fort Peck Reservation.

c Data from the state of North Dakota is provided from the year 2018 while data from the state of Montana is provided as of the date that information is pulled from the DNRC's Water Right Query System. In this case that data was pulled on September 30, 2019 and should be referenced as up-to-date as of the year 2019.

4.1.1.2 Estimated Cropping Patterns by County

For each county, production data (e.g., crop type, number of irrigated acres harvested) was obtained from Crop Acreage Data reported to the FSA in the year 2018 (Table 4-2). A crop profile for each county was developed based on the number of irrigated acres harvested. In the case of North Dakota, the 'total' value is equal to the total number of acres irrigated by the Missouri River according to state permits. For North Dakota, the crop patterns in those acres are assumed to be identical to the Farm Service Agency's (FSA) crop acreage data (USDA 2019a). In Montana, actual acres irrigated was not provided, so the total permitted acres to be irrigated with water withdrawn from the Missouri River was used to estimate the crop patterns which are assumed to be equal to FSA's crop acreage data. Crops for which no acreage is reported, or which were suppressed by the USDA for privacy concerns, are not included.

Table 4-2. Estimated Crop Acres Irrigated by Missouri River

County	Barley	Beans	Canola	Corn	Field Crops, Other	Grasses	Hay	Oats	Peas	Sorghum	Soybeans	Sugar beets	Sunflower	Wheat	Potatoes	Vegetables	Fruit	Millet	Total
McCone, MT [a]	972	187	250	501	526	99	1,883	151						2,447	4	1.6	1.9	64	7,086
Valley, MT [a]	2,508		292	2,607	8,383	5,360	16,500	1,480	267	368	1,079			6,580					45,425
Roosevelt, MT [a]	855	510		790	2,009	281	3,245	84			2	2,521		5,376					15,672
Richland, MT [a]	3,812	167		6,570	1,814	219	7,666	613		50	1,664	14,166		14,756			17.82		51,515
McLean, ND [b]	417	345	201	5,768	101		289				3,622		237	805	1,558				13,344

a USDA 2019a

4.1.1.3 Estimated Crop Yields and Costs

To estimate crop yields per acre in the five counties evaluated, the project team utilized crop enterprise budgets. Crop enterprise budgets are prepared by land grant universities that are part of the county's Cooperative State Research, Education, and Extension Service (CSREES). The CSREES supports technology transfer between research-based institutions and the agricultural community. As part of the CSREES, North Dakota prepares crop enterprise budgets for the benefit of the farming communities in their respective states. These crop-specific budgets include estimated costs for common inputs, such as fertilizer and pest control products, but also provide an estimated yield (NDSU 2014, 2019).

Montana State University has not prepared updated crop enterprise budgets in more than ten years and a researcher at the university recommended that farmers use budgets prepared for western North Dakota until new crop budgets can be prepared (USACE 2018b). For the purposes of this project, the western North Dakota budgets were used to obtain an estimated per-acre cost for most crops grown using surface irrigation methods and an estimated per-acre yield for farms in Montana.

The only exceptions are crops identified as hay, hay and haylage, beans, lentils, peas, and sugar beets. Hay and hay and haylage were assumed to be alfalfa in the state budgets. Beans, lentils, and peas all use dry bean budgets. Beans were considered an appropriate choice because lentils are an edible pulse (i.e., the plant's seed or fruit) in the legume family, and field peas are an edible grain legume crop.

No budget was available for sugar beets or potatoes in Montana or North Dakota. However, comparable budgets were available for southeastern Idaho, where rainfall patterns are like the counties where sugar beets and potatoes are grown (University of Idaho 2017a, 2017b). All available information suggests that sugar beets cannot be grown in northern states without irrigation. Therefore, a conservative assumption was applied in the model that sugar beet yields would fall to zero with any reduction in irrigation.

Also, a budget was not available for dryland alfalfa for Montana or North Dakota. However, the South Dakota 2016 projections prepared by South Dakota State University estimate a three-ton yield per acre for alfalfa grown under dryland conditions in the state. In Montana, one estimate suggests that dryland alfalfa production from 1984 through 2005 averaged 2.5 tons per acre. Based on this estimate, and the lower rainfall in Montana compared to South Dakota, an estimated yield of 2.5 tons per acre was assumed for dryland alfalfa production in Montana (SDSU 2014, 2019).

Table 4-3 below provides the yields, selling price, and cost of production per acre for dryland and irrigated crops that were included in the analysis. Note that the yield and prices vary between crop type where soybeans are measured in bushels per acre and beans are measures in pounds per acre, for example.

Table 4-3. Yield, Selling Price and Cost of Production for Potentially Impacted Crops in Montana and North Dakota.

Crop	Dry Land Yield (units per acre)	Irrigated Land Yield (units per acre)	Selling Price Per Unit of Crop (FY2021 Dollars)	Irrigated Cost of Production Per Acre[1] (FY2021 Dollars)
Montana				
Wheat	37 bushels / acre	70 bushels / acre	$6.42 / bushel	$548.80 / acre
Hay	2.5 tons / acre	5.5 tons / acre	$144.99 / ton	$474.40 / acre
Barley	56 bushels / acre	100 bushels / acre	$6.07 / bushel	$470.98 / acre
Corn	94 bushels / acre	160 bushels / acre	$5.13 / bushel	$738.44 / acre
Canola	1,630 bushels / acre	3,084 bushels / acre	$0.17 / bushel	$680.81 / acre
Beans	1,400 cwt / acre	2000 cwt / acre	$0.29 / cwt	$528.51 / acre
Oats	64 bushels / acre	100 bushels / acre	$4.16 / bushel	$470.98 / acre
Grasses	37 bushels / acre	70 bushels / acre	$6.42 / bushel	$548.80 / acre
Sugar beets	0 tons / acre	41 tons / acre	$53.42 / ton	$1,648.05 / acre
Soybeans	29 bushels / acre	50 bushels / acre	$11.00 / bushel	$505.27 / acre
North Dakota				
Corn	110 bushels / acre	180 bushels / acre	$4.14 / bushel	$683.10 / acre
Soybeans	33 bushels / acre	55 bushels / acre	$11.00 / bushel	$468.33 / acre
Potatoes	220 cwt / acre	450 cwt / acre	$10.17 / cwt	$2,448.48 / acre
Wheat	49 bushels / acre	70 bushels / acre	$6.31 / bushel	$520.60 / acre
Barley	70 bushels / acre	100 bushels / acre	$5.46 / bushel	$447.89 / acre
Beans	1,760 cwt / acre	2,200 cwt / acre	$0.31 / cwt	$447.89 / acre
Hay	2.5 tons / acre	5.5 tons / acre	$89.95 / ton	$444.00 / acre
Canola	1,810 bushels / acre	2,586 bushels / acre	$0.17 / bushel	$547.21 / acre

Source: NDSU 2014, 2019; University of Idaho 2017a, 2017b; SDSU 2014, 2019
Notes:
[1] This value was used as the production cost per acre as it is a conservatively higher cost per acre compared to the dry land cost. Additionally, the majority of this cost may already be incurred by the farmer at the time that irrigated farming switches to dry land farming.

4.1.1.4 Estimate Irrigation Costs per Acre of Production

Numerous interviews conducted on this and prior projects with private irrigation intake maintenance providers, farmers, FSA representatives, local agriculture extension service representatives, and academics were unable to provide data that could be used to build a consistent cost function for irrigation based on the number of days a water intake was operable (USACE 2018b). Irrigation costs for each crop were assumed to be constant regardless of actual irrigation conditions. The cost per irrigated acre was used from the crop enterprise budgets described above using the budgets' total listed costs, including both direct costs (including seed, herbicides, fungicides, fertilizer, irrigation expenses) and indirect costs (including depreciation, overhead, and land charge).

In addition, because the river stages and reservoir levels are anticipated to be similar during extreme drought conditions under the No Action Alternative and the FPDTR-EIS alternatives, no significant investments in irrigation intakes are expected to be needed under the FPDTR-EIS alternatives.

4.1.1.5 Estimate Change in Yield Due to Reduced Access to Water

The project team estimated changes in yields due to different levels of low water access expected to occur under the FPDTR-EIS alternatives. Water access was defined as either minimum flow or water surface elevations at which irrigation intakes could access water; below these minimum operating requirements, irrigation intakes were assumed to become non-operable. Information on minimum operating requirements for irrigation intakes was obtained from the Master Manual, interviews with stakeholders, and from the MRRMP-EIS (USACE 2018a & b). The team conservatively assumed that average yields would begin to decline as soon as access to water became limited and would continue to decline to a level equivalent to yields that can be realized under dryland farming conditions.

4.1.1.5.1 Irrigation Water Needs

To evaluate changes in yields associated with water access under the alternatives, the project team needed to estimate water needs using dryland farming methods and when using surface water irrigation. To estimate average precipitation, or the amount of water that would be available for crop production under dryland farming conditions, the project team used average annual recorded precipitation in 2018 (NOAA 2018). This value represents precipitation recorded at all weather stations in each county averaged over the calendar year. This value was used as a baseline to estimate the number of inches of water available under dryland farming practices and was used to estimate the lowest potential yields that can be expected under any year evaluated.

In the twelve counties evaluated, the lowest recorded precipitation was in Valley County, Montana (Table 4-4). The average annual precipitation recorded at all weather stations in the county averaged just 12.1 inches over the calendar year. The highest recorded average precipitation was 18.3 inches, recorded in McLean County, North Dakota. Note that while this model does include precipitation in the analysis, evapotranspiration and crop soil properties are not considered.

To estimate the total number of acre-inches[2] of water applied using irrigation, the average recorded precipitation was added to the average acre-inches of water applied per irrigated acre. The source was the 2013 Farm and Ranch Irrigation Survey, which reports the average number of acre-feet of water applied for surface water operations (USDA 2013). Farmers using surface water on unenclosed (i.e., not protected by plastic greenhouse coverings) farms in Montana used the most water per irrigated acre, at 16.8 acre-inches. Farms in North Dakota applied the least per acre, only 6 acre-inches (Table 4-5).

[2] An acre-inch is equal to the volume of water that would cover one acre to a depth of one inch.

Table 4-4. Average Recorded County Precipitation, 2018

County	State	Inches
McCone	Montana	13.4
Valley	Montana	12.1
Roosevelt	Montana	13.1
Richland	Montana	15.7
McLean	North Dakota	18.3

Source: NOAA 2018.

Table 4-5. Estimated Quantity of Water Applied from On-Farm Surface Water, Only Source, Applied in the Open, 2013

State	Average Acre-Inches
Montana	16.8
North Dakota	6.0

Source: USDA 2013.

Note: 'In the open,' in this context, means that the farm is not covered by a plastic covering, such as used in a greenhouse.

4.1.1.5.2 Estimated Changes in Yield Associated with Water Access

The next step in the NED analysis was to estimate how crop yields vary with changes in access to Missouri River water for irrigation purposes. The project team first estimated water availability during any given calendar year according to the following formula.

$$W = \left(\frac{I_2 - I_1}{D_2}\right) * (D_2 - D_1) + I_1$$

Where:

W = acre-inches of water applied

I_2 = the maximum number of acre-inches that would be applied for an intake with full access

I_1 = the minimum number of acre-inches to be applied under zero access (i.e., rely only on rainfall)

D_2 = total possible days of irrigation in irrigation season

D_1 = number of consecutive days without access to water in the current year under each alternative

It was assumed that production levels (yields) increases linearly as acre-inches of water increases (as calculated above). The minimum achievable yield for each crop is assumed to be equal to the yield achieved using dryland production techniques, as reported by crop enterprise budgets.

$$yield\ per\ acre = \frac{(Y_2 - Y_1)}{(I_2 - I_1)} * (W - I_2) + Y_1$$

Where:

Y_1 = expected yield per acre under dryland conditions

Y_2 = expected yield under full irrigation conditions

W = acre-inches of water applied in the calendar year (see previous formula)

I_1 = the minimum number of acre-inches that would be applied under dryland conditions (i.e., average annual rainfall)

I_2 = the maximum number of acre-inches that would be applied under full operability

4.1.1.6 Estimate Crop Production Value

The analysis estimated net farm income by considering the value of crop production minus production costs as reported in annual farm budgets. The gross sales (value of crop production) were calculated per crop, per alternative, for all actual acres irrigated by the Missouri River, for each of the counties being evaluated. Gross sales were calculated by summing the total production for each crop, for each alternative, and multiplying by the normalized price per crop. Almost all crops reported on by the FSA were included in the prices developed by the ERS, except for lentils and peas, both of which are priced as dry beans, and canola, which is priced according to its price listed on the dryland crop budget. Commodity prices for 2018 that were used in the analysis are included in

Table 4-6.

An important point on net farm income is that, for all crop producers, the price received from year to year will vary considerably. The NED analysis used normalized 2018 commodity prices[3] as published by USDA in accordance with USACE economic guidance (U.S. Water Resources Council 1983; ER 1105-2-100 Appendix E; USACE Economic Guidance Memorandum) 16-02).

3 The USACE utilizes "normalized prices" developed by ERS which smooth out the effects of short-run seasonal and cyclical variations in prices for key agricultural crops. These prices are based on a five-year lagged average of actual market prices. For 2018, ERS estimated normalized prices for crops by multiplying the national-level normalized prices by the average ratios of the State-level market prices to the national market prices from 2015 through 2017 (USDA 2019b).

Table 4-6. State-Level Normalized Commodities Price Estimates, 2018

State		Wheat, all types (bushel)	Corn for grain (bushel)	Oats (bushel)	Barley (bushel)	Hay, all types, baled (ton)	Dry beans (cwt.)	Sugar beets (ton)	Soybeans for beans (bushel)	Flaxseed (bushel)	Potatoes (cwt.)
Montana		$6.17	$4.92	$4.00	$5.38	$139.27	$28.29	$51.31		$11.62	$13.00
North Dakota		$6.06	$3.97	$2.71	$5.25	$86.40	$29.93	$47.59	$10.57	$11.27	$9.77

Source: USDA 2019b

4.1.1.7 Calculation of Net Farm Income

The project team calculated net farm income that would be realized under different river conditions under each alternative. Note that in this analysis, ‘net farm income’ refers to income from crops, and not from livestock or other farm products. Net farm income was calculated as follows:

- Average yield per crop X normalized price per crop = Gross sales per acre irrigated
- Gross sales per acre – average production costs per acre = Net farm income per acre
- Net income per acre X number of acres irrigated = Total Net Farm income per county.

To adjust net farm income into FY21 dollars, the 2020 chained price index developed by the United States Office of Management and Budget’s Gross Domestic Product and Deflators Used in the Historical Tables: 1940–2024 (OMB 2019) was used to adjust annual values for inflation. Note that results presented in this analysis are presented in FY2021 dollars.

4.1.2 Regional Economic Development

The RED evaluation used information from the NED evaluation, specifically the change in gross sales (i.e., value of crop production) of irrigated crops grown in the five counties evaluated. The change in gross sales under each FPDTR-EIS alternatives relative to No Action was used to estimate change in regional economic activity measured by changes in employment, income, and sales. The analysis used outputs from the USACE-certified RED model, Regional Economic System (RECONS) for potentially impacted industries in the counties listed above to create economic multipliers that describe the economic impact on regional employment, income and sales from a change in industry spending. These multipliers show the impact of a flow of dollars from purchasers to producers. For example, agriculture production requires inputs from farm equipment manufacturing and fertilizer producers. In addition, the workers from the farming and supporting sectors spend their income in the local economy, supporting secondary jobs and income. The RED analysis used the appropriate state study area for the evaluation.

An external shock to a region can have a direct and secondary effect on the economy which are defined as follows:

- The *direct effect* includes the initial expenditures and production revenues made by the industry experiencing the economic change, much of which will be felt locally.
- Purchases made within the study area for goods and services required for production and local spending by employees on household goods and services represent the *secondary effects*.

4.2 High Flows

4.2.1 National Economic Development

The analysis of NED impacts associated with high flows was completed in two separate analyses. This includes an evaluation of changes in operations and maintenance costs results from high flows to intakes located on the mainstem of the river. The second analysis evaluated NED impacts that occur to intakes located on side channels of the Missouri River. NED impacts to mainstem intakes from high flows are limited to changes in operations and maintenance costs while NED impacts to side channel intakes include both changes in operations and maintenance costs and changes to irrigator's net income from changes in crop yields.

A Microsoft Excel-based model was used to evaluate NED impacts for the two separate analyses of high flows under the FPDTR-EIS alternatives for the four counties in Montana and two counties in North Dakota located along the riverine sections of the Missouri River. The NED analysis used data and information provided by the USACE, crop enterprise budgets developed by state agriculture extension agencies, state water permit data, crop data from the USDA, and weather information from the National Oceanic and Atmospheric Administration (NOAA). These data sources and the approach are described in this section.

NED results from both the high flows Missouri River mainstem irrigation intakes analysis and the side channel case study should not be combined with results from the low flow analysis as they use separate sets of input data. Instead, these results should be considered a snapshot of the possible NED impacts from a high flow event alone. Finally, the results for the side channel case study are reported solely for side channel intakes and do not represent impacts to net farm income for irrigated agriculture at the county or multi-county level.

4.2.1.1 Irrigation Intake Survey and Interviews

In response to comments provided to USACE from stakeholders on the irrigation analysis, the USACE completed a field survey of irrigation intakes in Montana and North Dakota that may be impacted by the test flows. New data was collected at several intakes in the summer of 2020 by USACE in July and the USFWS / Montana Game Fish & Parks (MT GF&P) in August. At each site, easting, northing, and elevation (XYZ) data points were collected to determine the pump site characteristics and potential damage levels for high flow events. Participating landowners were present and identified site-specific critical features such as electrical panels, pump operating levels, and shared concerns about possible impacts from alternatives.

The 2020 pump inventory also provided information and critical levels for low flow and high flow impacts based on individual site characteristics. Higher river levels and associated river processes may affect operation or damage one or more components of the intake (sandbar deposition, flooding of electrical panel, operating pump, and similar). Damage levels were defined in the field based on input from the local owner / operator of the intake as described in Table 4-7. Elevations for the Tier 1 and 2 levels were surveyed in 2020.

Table 4-7. Irrigation Intake Damage Level Descriptor

Damage Level	Description
Tier 1	Lowest river level at which debris/sediment deposition typically begins to significantly affect pump operation. This elevation is qualitative and relies on owner / operator input.
Tier 2	The lowest site elevation when critical damage occurs at the pump site to a fixed feature (pump, electrical panel, other supporting equipment). Tier 2 is a higher elevation and damage level than Tier 1).

Irrigation intakes in the reach are located either on the main channel or in a side channel connection. The results of the 2020 survey were used to determine the number of intakes located on the main channel and on side channels. Side channels were assigned for both naturally occurring side channels (perhaps around a sandbar or island) and constructed channels (perpendicular to river flow, for intake use). A full description of the field survey and the results are provided in Appendix D of the EIS.

In order to reduce uncertainty associated with assumptions used in the side channel analysis, additional data and information was collected through interviews with affected stakeholders and industry experts in January and February of 2021. The interviews were aimed at obtaining information related to:

- types of impacts incurred at side channel intakes under high flow conditions similar to the FPTR alternatives (e.g. 2018, 2019);
- techniques and costs used to clear side channels after a high flow event;
- likelihood that intakes would be inoperable due to sedimentation of side channel after a high flow event;
- description of high flow events that would cause impacts to side flow channels (e.g. particular flow level); and
- other information that may be relevant to the analysis.

Ten interviews were completed which collected information on eleven side channel intakes. One of the focus areas of the interviews was to have the irrigator describe what happened to their intake during high flow conditions that occurred during 2018 and 2019, Figure 4-1 provides a hydrograph that was sent to the interviewees to help with this discussion.

The results of the 2020 field survey and the interviews completed in early 2021 were integrated into the high flow analysis discussed below.

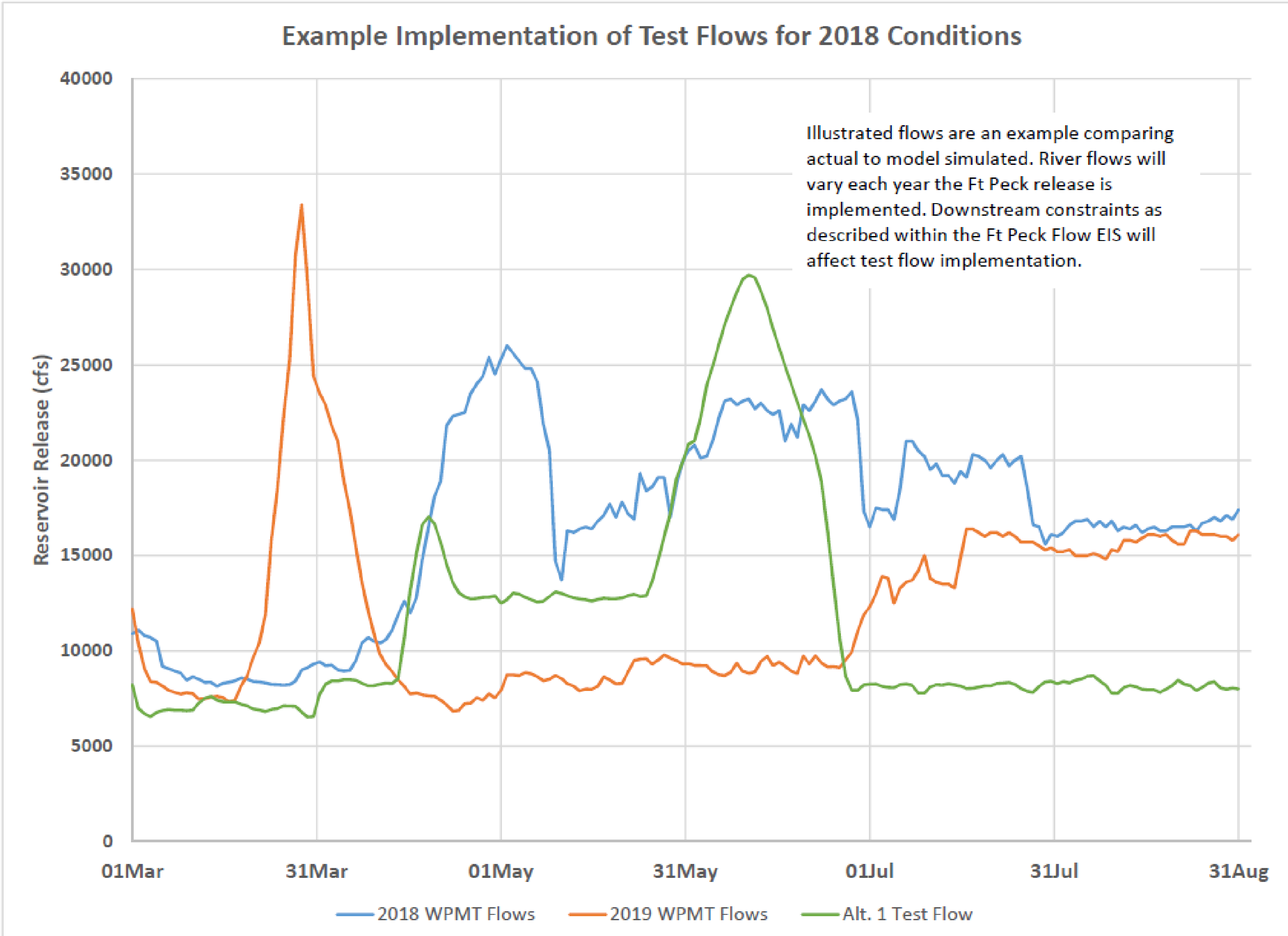


Figure 4-1 Missouri River Hydrograph at Wolf Point

4.2.1.2 Missouri River Side Channel Irrigation Intakes Case Study

The NED analysis for crop yield impacts due to siltation of side irrigation channels utilizes the same methodology applied to net income estimates for the low flow analysis. Only inputs from the proxy models and total irrigated acreage are changed. The changes to the proxy model inputs reflect an assumption that all side channel irrigation intakes would be impacted during full flow years and any irrigation intakes located within these channels would be shut down after the high flow event for the remainder of the irrigation season. This analysis was completed in Microsoft Excel.

This analysis used survey results and county specific crop patterns to determine annual net farm incomes for all side channel intakes in each county. In years with full flows, side channel intakes are assumed to be inoperable, resulting in only dryland crop production. Table 4-8 shows the number of full flow years by alternative. The change in the number of full flow years is therefore the primary driver in NED changes between the alternatives and their variations. The number of irrigated acres impacted is reflective of the total irrigated acreage that is likely served by side channel irrigation intakes, which is calculated from the average of acres irrigated by side channel intakes from the 2020 summer survey (414 acres). Local crop enterprise budgets are used to estimate the amount of yield a particular crop will return under irrigated and non-irrigated conditions. The change in yield between a non-irrigated and irrigated crop is used to determine the change in yield of the crop due to a loss in irrigation water during the irrigation season. The change in yield between the non-irrigated and irrigated crop acreage is multiplied by the state level normalized price estimates for commodities and used to define the revenue a crop would earn. The per acre cost to harvest each crop is multiplied by the number of acres reported for each crop which is then subtracted from the revenue of that crop to determine the net income by crop. All net income for each crop is summed by intake to return the net income for the alternative or its variation, providing NED impacts.

Finally, additional operation and maintenance costs are incorporated into the calculation of net farm income to account for side channel clearing that would be needed after a high flow event. A per season per intake operations and maintenance cost of $10,000 is added to each estimated side channel intake in each season in which it was impacted. This average value was obtained from interviews with side channel irrigation intake operators.

Table 4-8. Number of Full Flow Years by Alternative or Variation

Alternative or Variation	Number of Full Flow Events
1	11
1A	16
1B	8
2	10
2A	15
2B	8

4.2.1.3 Missouri River Mainstem Irrigation Intakes - Operation and Maintenance Costs

This NED analysis uses the results of the metric analysis described above in Section 3, combined with weighted average costs of a tier 1 or tier 2 event that were estimated with information and data from interviews with irrigators and industry experts. Costs were first provided by irrigators during the 2020 summer irrigation intake surveys. The USACE received a total of 64 responses on operation and maintenance costs associated with different flow events. These costs were then summarized into categories for further evaluation. Additional discussions were conducted with irrigation industry experts to determine if the range of these costs estimated for tier 1 and 2 events was reasonable. Further discussion determined the prevalence of each type of cost representing the likelihood that the cost would be incurred during a tier 1 or tier 2 event. Table 4-9 and Table 4-10 below show the cost categories and their estimated prevalence during a tier 1 or tier 2 event.

Table 4-9. Tier 1 Costs

No	Item	Cost	Prevalence
1	Dredging	$8,642.86	20%
2	Moving Pumps	$5,500.00	100%
3	General Maintenance Associated with Floods	$6,000.00	100%
4	Fixing Bank Degradation	$1,666.67	20%
	Weighted Cost of Tier 1 Event	*$13,561.90*	

Table 4-10. Tier 2 Costs

No	Item	Cost	Prevalence
1	Dredging	$8,642.86	75%
2	Moving Pumps	$5,500.00	100%
3	Electrical Panel Replacement	$7,375.00	50%
4	Replace Pump	$30,318.18	10%
5	Moving Site Infrastructure Other than Pump	$43,750.00	10%
6	Entire Site Replacement or Relocation	$55,000.00	10%
7	Larger Dredging Type Costs	$19,000.00	20%
	Weighted Average Cost of Tier 2 Event	*$32,376.46*	

The weighted average costs of a tier 1 or tier 2 event is multiplied against the sum of all tier 1 or tier 2 events in an irrigation season by year, by alternative to determine the total operations and maintenance costs associated with these events during the irrigation season. Results are presented in terms of the flow year type in which they occur and the difference in costs between the No Action Alternative and the Action Alternatives and their variations.

4.2.2 Regional Economic Development

The high flows RED evaluation for side channel intakes uses an approach like the low flow RED evaluation in that it uses the results of the NED evaluation, specifically the change in gross sales (i.e., value of crop production), under each of the FPDTR-EIS alternatives relative to No Action to estimate change in regional economic activity measured by changes in employment, income, and sales. This analysis used outputs from the USACE-certified RED model, Regional Economic System (RECONS) to estimate these changes. As noted in the NED analysis above, the results from the high flows side channel case study should not be combined with results from the low flow analysis as they use separate sets of input data. Instead, these results should be considered a snapshot of the possible RED impacts from a high flow event alone. Additionally, there is no RED analysis for the Missouri River mainstem irrigation intakes analysis as the operations and maintenance costs analyzed by this analysis only produce NED effects.

5 Low Flow Results

5.1 National Economic Development Results

The NED analysis focused on estimating change in net farm income (reported in FY2021 dollars) from irrigated agriculture using water from the Missouri River. For all counties, over the modeled POR, the alternative with the largest overall change in net farm income would be Variation 2B, with a decrease of $54.0M (Figure 5-1) compared to No Action. Alternative 2 would have the smallest adverse impact, with a decrease of $19.4M compared to No Action.

Table 5-1 summarizes the change in total net farm income for the modeled POR for each of the counties evaluated. Under Alternative 1, farm income would decline relative to No Action, with the individual county changes ranging from a decline of 3.4 percent to an increase of 0.6 percent. Under Variation 1A, counties experience a decrease in net farm income from 5.2 percent to an increase of 1.4 percent relative to No Action. Under Variation 1B, counties experience a decrease in net farm income from 4.3 percent to an increase of 0.2 percent relative to No Action. Under Alternative 2, counties experience a decrease in net farm income from 3.1 percent to an increase of 0.6 percent relative to No Action. Under Variation 2A, farm income would decline relative to No Action, with counties experiencing decreases from 5.9 percent to increases of 0.3 percent compared to No Action. Under Variation 2B, counties would see decreases in net farm income of 7.9 percent to increases in 0.5 percent relative to No Action, with net farm income declining overall. Estimated average annual net farm income is summarized in Table 5-2 and indicates a similar trend as the change in total net farm income across the alternatives.

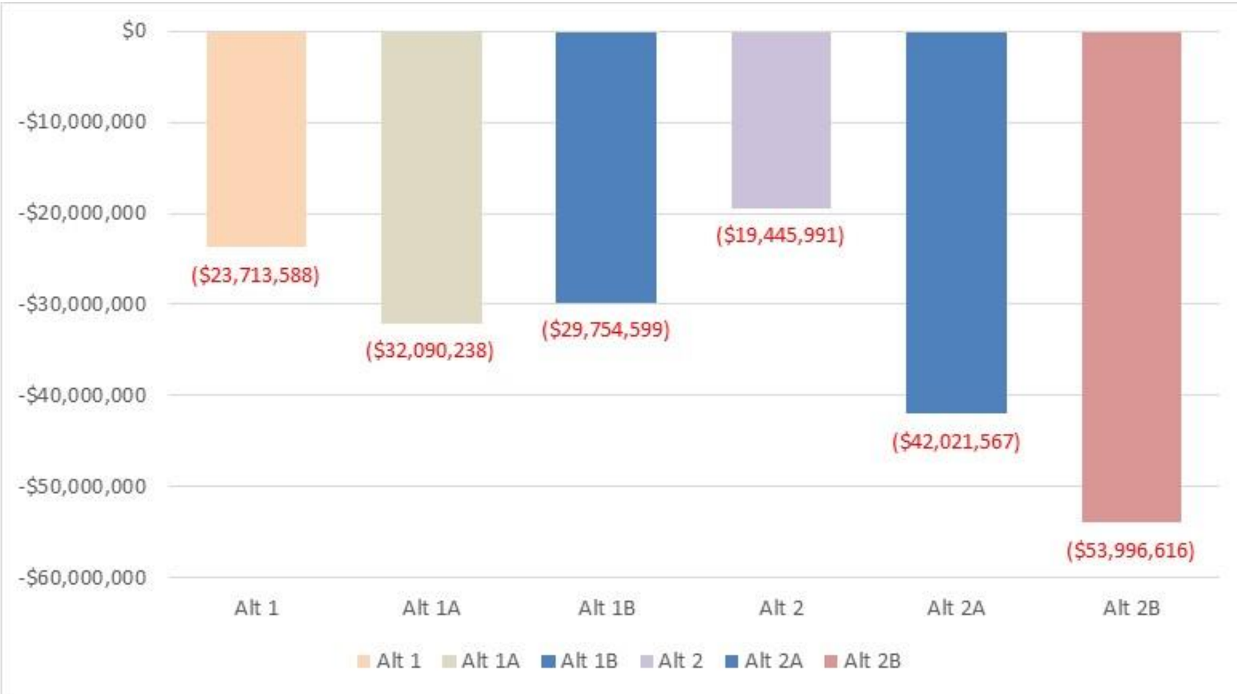


Figure 5-1. Change in Total Net Farm Income over the POR Relative to No Action, All Counties (FY2021 Dollars)

Table 5-1. Total Net Farm Income by FPDTR-EIS Alternative/Variation over the POR (Thousands of FY2021 Dollars)

Type of Impact	No Action	Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
McCone							
Total Net Farm Income	$82,219,805	$79,423,521	$77,945,497	$78,714,307	$79,640,619	$77,577,436	$76,727,910
Percent Change in Net Farm Income Relative to No Action	n/a	-3.4%	-5.2%	-4.3%	-3.1%	-5.6%	-6.7%
Change in Total Net Farm Income Relative to No Action	n/a	-$2,796,284	-$4,274,308	-$3,505,498	-$2,579,186	-$4,642,368	-$5,491,895
Valley							
Total Net Farm Income	$100,657,322	$98,235,327	$97,421,632	$97,365,056	$98,559,215	$96,644,778	$96,239,713
Percent Change in Net Farm Income Relative to No Action	n/a	-2.4%	-3.2%	-3.3%	-2.1%	-4.0%	-4.4%
Change in Total Net Farm Income Relative to No Action	n/a	-$2,421,995	-$3,235,690	-$3,292,266	-$2,098,108	-$4,012,544	-$4,417,609
Roosevelt							
Total Net Farm Income	$341,933,704	$330,718,337	$326,609,902	$328,428,899	$332,909,311	$322,205,832	$316,009,454
Percent Change in Net Farm Income Relative to No Action	n/a	-3.3%	-4.5%	-3.9%	-2.6%	-5.8%	-7.6%
Change in Total Net Farm Income Relative to No Action	n/a	-$11,215,367	-$15,323,802	-$13,504,805	-$9,024,393	-$19,727,872	-$25,924,250
Richland							
Total Net Farm Income	$232,443,286	$224,842,211	$222,415,089	$222,886,031	$226,398,563	$218,625,665	$214,002,367
Percent Change in Net Farm Income Relative to No Action	n/a	-3.3%	-4.3%	-4.1%	-2.6%	-5.9%	-7.9%
Change in Total Net Farm Income Relative to No Action	n/a	-$7,601,075	-$10,028,197	-$9,557,256	-$6,044,723	-$13,817,621	-$18,440,919

Type of Impact	No Action	Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
McLean							
Total Net Farm Income	$53,644,136	$53,965,269	$54,415,895	$53,749,361	$53,944,555	$53,822,974	$53,922,193
Percent Change in Net Farm Income Relative to No Action	n/a	0.6%	1.4%	0.2%	0.6%	0.3%	0.5%
Change in Total Net Farm Income Relative to No Action	n/a	$321,133	$771,759	$105,225	$300,419	$178,838	$278,057

Table 5-2. Average Annual Net Farm Income by FPDTR-EIS Alternative/Variation (Thousands of FY2021 Dollars)

County	Scenario	No Action	Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
McCone	Average Annual Net Farm Income	$1,003	$969	$951	$960	$971	$946	$936
	Change in Average Annual Net Income Relative to No Action	n/a	-$34	-$52	-$43	-$31	-$57	-$67
Valley	Average Annual Net Farm Income	$1,228	$1,198	$1,188	$1,187	$1,202	$1,179	$1,174
	Change in Average Annual Net Income Relative to No Action	n/a	-$30	-$39	-$40	-$26	-$49	-$54
Roosevelt	Average Annual Net Farm Income	$4,170	$4,033	$3,983	$4,005	$4,060	$3,929	$3,854
	Change in Average Annual Net Income Relative to No Action	n/a	-$137	-$187	-$165	-$110	-$241	-$316
Richland	Average Annual Net Farm Income	$2,835	$2,742	$2,712	$2,718	$2,761	$2,666	$2,610
	Change in Average Annual Net Income Relative to No Action	n/a	-$93	-$122	-$117	-$74	-$169	-$225
McLean	Average Annual Net Farm Income	$654	$658	$664	$655	$658	$656	$658
	Change in Average Annual Net Income Relative to No Action	n/a	$4	$9	$1	$4	$2	$3

In evaluating the NED results, it is important to note that when counties that have a higher proportion of high-margin crops are impacted by test flows under one of the alternatives, the change in total net farm income for all counties (Figure 3) under that alternative will also be larger. The highest-margin crops, for the counties included in this analysis, include hay, sugar beets, and beans while the lowest-margin crop is oats. These margins are defined as described above, using ERS prices and crop enterprise budgets relevant to each county.

The highest variation in annual net farm income for all alternatives would be in Roosevelt County, which would vary from -$1.5 million in a partial flow year (1983) under Variation 1B to $5.2 million during a different partial flow year (2012) under Variation 1B. The least amount of variation in annual average net farm income for all alternatives would be in McLean County, North Dakota, which would range from $150,000 to $760,000. McLean is the only county in this analysis where all three of the county's largest crops have a positive margin, though the county has a relatively small number of acres irrigated by the Missouri River (2,340 acres). Roosevelt has the most irrigated acres of any county in the analysis (34,516 acres), but not all the top three crops (wheat) have a positive margin, which accounts for the large variation in annual net farm income.

However, several modeled years clearly show a greater beneficial or adverse impact under the FPDTR-EIS alternatives (Figure 5-2). The worst years occur in 1983 and from 1985 through 1987 for all alternatives besides Alternative 2, which has a beneficial year in 1983. These years in the 1980s coincide with consecutive full flow and partial flow years for all alternatives.

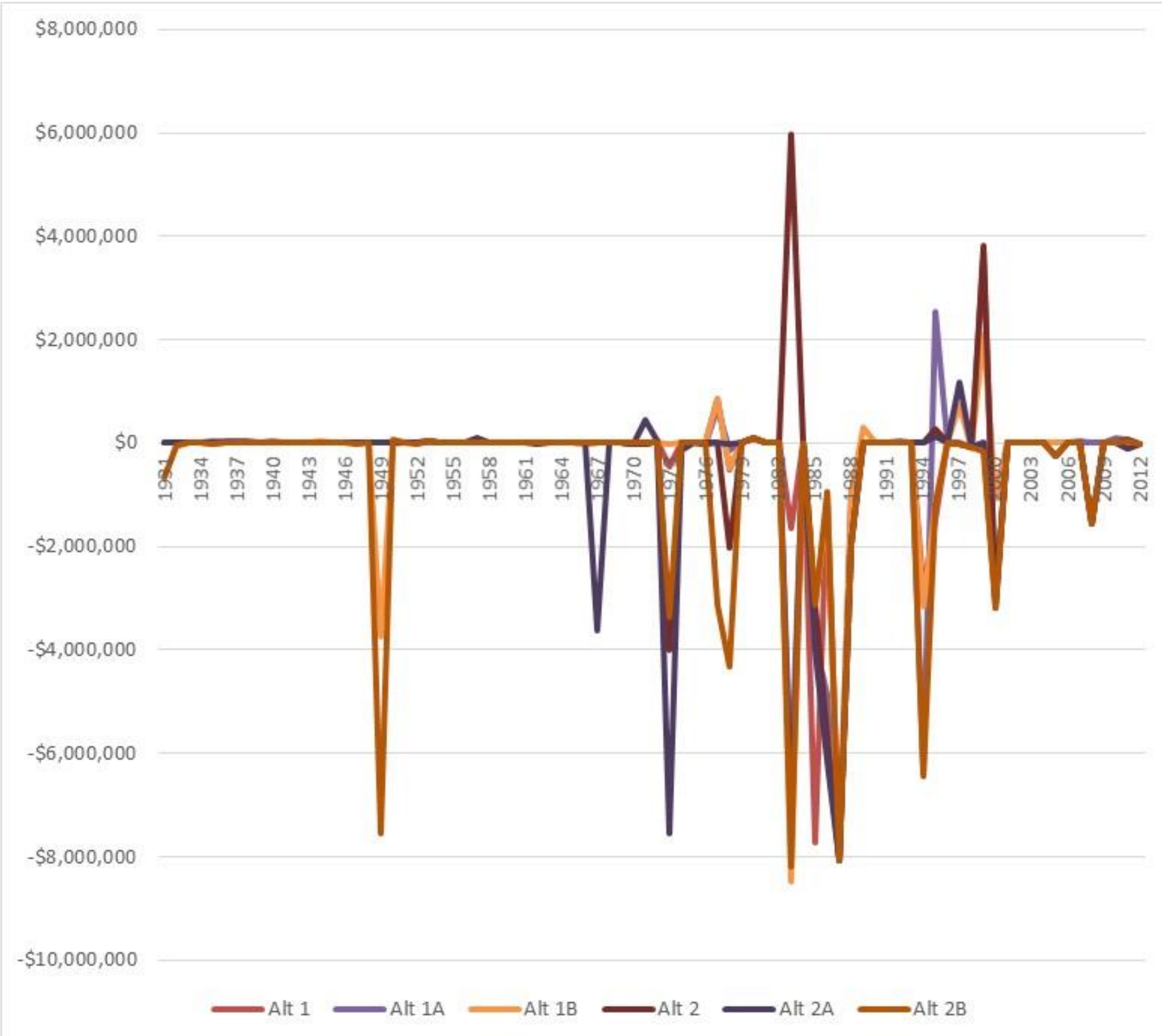


Figure 5-2. Change in Total Net Farm Income Relative to No Action, All Counties (FY2021 Dollars)

5.1.1 No Action

Table 5-3 summarizes the NED analysis for No Action. Overall, average annual net farm income for all five counties evaluated would be approximately $9.9 million. Under No Action, a negative net farm income does not imply a negative impact because of FPDTR-EIS implementation, but rather lower prices for crops grown in the counties under consideration. Much of the variation in annual net farm income is a result of drought conditions.

Table 5-3. Summary of National Economic Development Analysis for No Action (FY2021 Dollars)

State	County	Total Net Farm Income	Average Annual Net Farm Income	Annual Maximum	Annual Minimum	Total Acres Irrigated by Missouri River Water	Top Three Crops
Montana	McCone	$82,220,000	$1,003,000	$1,230,000	$436,000	16,271	Wheat (35%), Hay (27%), Barley (14%)
	Valley	$100,657,000	$1,228,000	$1,428,000	$640,000	17,927	Hay (36%), Wheat (14%), Grasses (12%)
	Roosevelt	$341,934,000	$4,170,000	$5,206,000	$447,000	34,516	Wheat (34%), Hay (21%), Sugar beets (16%)
	Richland	$232,443,000	$2,835,000	$3,539,000	$358,000	17,927	Wheat (29%), Sugar beets (27%), Hay (15%)
North Dakota	McLean	$53,644,000	$654,000	$760,000	$152,000	2,340	Corn (43%), Soybeans (27%), Potatoes (12%)
Total		$810,898,000	$9,889,000	$12,162,000	$2,596,000	88,981	Wheat (23%), Hay (22%), Sugar beets (13%)

5.1.2 Alternative 1

The NED results for Alternative 1 are summarized in Table 5-4. On average net farm income would total $9.6 million for all five counties per year under Alternative 1. This represents a slight decrease in average net farm income of $289,000 or 2.9 percent from the No Action Alternative. On average, all counties under this alternative would experience small adverse impacts, except McLean County in North Dakota, which would experience negligible impacts. These impacts in McLean County would be due to the spawning cue release increasing lake elevations at Lake Sakakawea in some full release years, which would increase access to water for irrigation.

During the eight years with the lowest crop production values relative to the No Action Alternative, the change in net farm income would be temporary and large across most counties, with Roosevelt County experiencing a decrease of $1.6 million in net farm income in the average of the eight worst difference years from the No Action Alternative. Irrigation in Richland County would experience decreases in net farm income in the eight worst difference years of $1.1 million. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to No Action Alternative, many of these adverse impacts would be offset, resulting in very small changes in average annual net farm income under Alternative 1 relative to the No Action Alternative.

The decline in annual average net farm income for all counties would be $289,000, with this decline occurring in McCone, Valley, Richland, and Roosevelt counties. Roosevelt and Richland Counties would experience the largest percentage decrease in net farm income, with a decline of 3.3 percent. McCone, Valley, Richland, and Roosevelt counties would be adversely impacted in the full flow years of 1985 and 1987, when higher spring releases would require lower fall releases from Fort Peck Reservoir to balance system storage. These lower fall flow releases decrease access to water for irrigation relative to the No Action Alternative late in the irrigation season. However, a reduction in flows during this latter part of the irrigation season would have a less adverse impact than a reduction in flows during the peak irrigation season, such as July. Therefore, the economic impacts due to these reduced at the end of the irrigation season may be overstated. Additionally, in partial flow years like 1986, counties would experience adverse impacts when flows decrease earlier in the year than they would have under the No Action Alternative to facilitate system rebalancing.

Table 5-4. Summary of National Economic Development Analysis for Alternative 1 (FY2021 Dollars)

State	County	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to the No Action Alternative	Percent Change Relative to the No Action Alternative	Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	% Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)	% Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)
Montana	McCone	$969,000	-$34,000	-3.4%	$52,000	5.2%	-$362,000	-36.1%
	Valley	$1,198,000	-$30,000	-2.4%	$32,000	2.6%	-$326,000	-26.6%
	Roosevelt	$4,033,000	-$137,000	-3.3%	$305,000	7.3%	-$1,647,000	-39.5%
	Richland	$2,742,000	-$93,000	-3.3%	$208,000	7.3%	-$1,137,000	-40.1%
North Dakota	McLean	$658,000	$4,000	0.6%	$43,000	6.6%	-$4,000	-0.7%
Total		$9,600,000	-$289,000	-2.9%	$591,000	6.0%	-$3,406,000	-34.4%

Additional modeling results are summarized in Figure 5-3 which shows the difference in annual net farm income during years when there is a release action. The year of highest adverse impact (-$8.1 million) occurred in conditions like 1987, when higher spring releases would require lower fall releases from Fort Peck Reservoir to balance system storage, which causes decreased flows, decreasing access to water for irrigation relative to the No Action Alternative. However, a reduction in flows during the latter part of the irrigation season would have a less adverse impact than a reduction in flows during the peak irrigation season, such as July. Because impacts in this economic analysis are not calculated based on the point in the irrigation season in which they occur, these impacts that are driven by decreased flows towards the end of the irrigation season may be overstated. Net farm income in Valley, Roosevelt, Richland, and McCone Counties would decrease relative to the No Action Alternative. The one-year decrease in net farm income for the most affected county (Roosevelt County, with a decline of $3.9 million) in 1987 represents 26 percent of net farm income of all farming operations in that county ($15.2 million) (USDA 2017).

Years with partial flow releases also correspond with lower annual net farm income. For example, in conditions similar 1986 where a partial flow release would occur, the adverse impact relative to the No Action Alternative would be a decrease of $944,000 for all counties. In this year, adverse impacts would be more concentrated downstream of Fort Peck Lake, with reductions in net farm income occurring in Richland County (with a decrease of $264,000 relative to the No Action Alternative), neighboring Roosevelt County (with a decrease of $424,000), and McCone County (with a decrease of $140,000 relative to the No Action Alternative). The decrease in net farm income in Roosevelt County would represent 3 percent of net farm income of all farm operations in the county ($15.2 million) (USDA 2017).

Increases in net farm income relative to No Action would also occur in some years, increasing by as much at $3.7 million across all counties. For example, Roosevelt and Richland Counties are beneficially impacted in 1977 when higher spring releases are possible under Alternative 1 compared to the No Action Alternative. Valley, Roosevelt, Richland, and McCone Counties are all beneficially impacted in 1999, when high flows are sustained longer into the fall season.

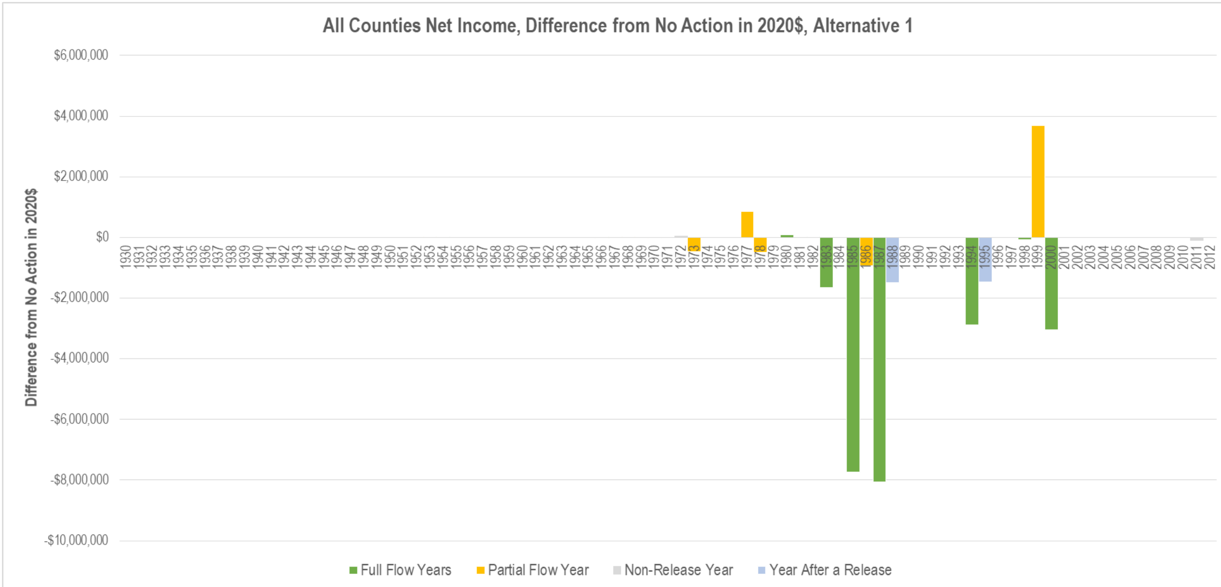


Figure 5-3. Annual Difference in Net Farm Income under Alternative 1 Relative to the No Action Alternative (FY2021 Dollars)

5.1.3 Alternative 1 – Variation 1A

Under Variation 1A, average annual net farm income would be approximately $9.5 million (Table 5-5). This represents a slight decrease from the No Action Alternative of $391,000 or 4.0 percent. On average, all counties under this alternative would experience small adverse impacts, except McLean County in North Dakota, which would experience negligible impacts. These impacts in McLean County would be due to the spawning cue release increasing lake elevations at Lake Sakakawea in some full release years, which would increase access to water for irrigation.

During the eight years with the lowest crop production values relative to the No Action Alternative, the change in net farm income would be temporary and large across most counties, with Roosevelt County experiencing a decrease of $2,104,000 in net farm income in the average of the eight worst difference years from the No Action Alternative. Irrigation in Richland County would experience decreases in net farm income in the eight worst difference years of $1,410,000. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to the No Action Alternative, many of these adverse impacts would be offset, resulting in small changes in average annual net farm income under Variation 1A relative to the No Action Alternative.

Table 5-5. Summary of National Economic Development Analysis for Variation 1A (FY2021 Dollars)

State	County	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to the No Action Alternative	Percent Change Relative to the No Action Alternative	Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	% Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)	% Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)
Montana	McCone	$951,000	-$52,000	-5.2%	$25,000	2.5%	-$549,000	-54.7%
	Valley	$1,188,000	-$39,000	-3.2%	$33,000	2.6%	-$436,000	-35.5%
	Roosevelt	$3,983,000	-$187,000	-4.5%	$215,000	5.2%	-$2,104,000	-50.4%
	Richland	$2,712,000	-$122,000	-4.3%	$169,000	5.9%	-$1,410,000	-49.7%
North Dakota	McLean	$664,000	$9,000	1.4%	$66,000	10.1%	-$9,000	-1.4%
Total		$9,498,000	-$391,000	-4.0%	$459,000	4.6%	-$4,467,000	-45.2%

The year of highest adverse impact ($8.1 million) occurred in conditions like 1987, when higher spring releases would require lower fall releases from Fort Peck Reservoir to balance system storage, which causes decreased flows. These lower fall flow releases decrease access to water for irrigation relative to the No Action Alternative late in the irrigation season. However, a reduction in flows during this latter part of the irrigation season would have a less adverse impact than a reduction in flows during the peak irrigation season, such as July. Therefore, the economic impacts due to these reduced at the end of the irrigation season may be overstated. Net farm income in Valley, Roosevelt, Richland, and McCone Counties would decrease in particular relative to the No Action Alternative. The one-year decrease in net farm income for the most affected county (Roosevelt County, with a decline of $3.9 million) in 1987 represents 26 percent of net farm income of all farming operations in that county ($15.2 million) (USDA 2017).

Overall, farms using Missouri River water for irrigation would experience relatively small, adverse impacts under Variation 1A relative to the No Action Alternative. Years of adverse impact typically happen in full flow years under this alternative where higher spring releases lead to decreased fall releases at the end of the irrigation season, which leads to more days below the irrigating threshold in Variation 1A during full flow years.

Figure 5-4 shows the annual NED impacts to irrigation intakes for all counties over the entire POR. The figure shows isolated large decreases in net farm income for irrigators throughout the POR, and isolated periods of small beneficial impacts. The most notable year of adverse impacts occurs in 1987, as explained above, due to decreases in water flow in the fall following high spring releases.

Similarly, very small increases in water flow relative to No Action can have small but measurable increases in net farm income under conditions like Variation 1A, such as in years 1995 and 1977. In 1977, higher flows in the early spring under Variation 1A in Roosevelt and Richland counties lead to a greater number of days above the irrigation threshold compared to the No Action Alternative, resulting in increases in net farm income.

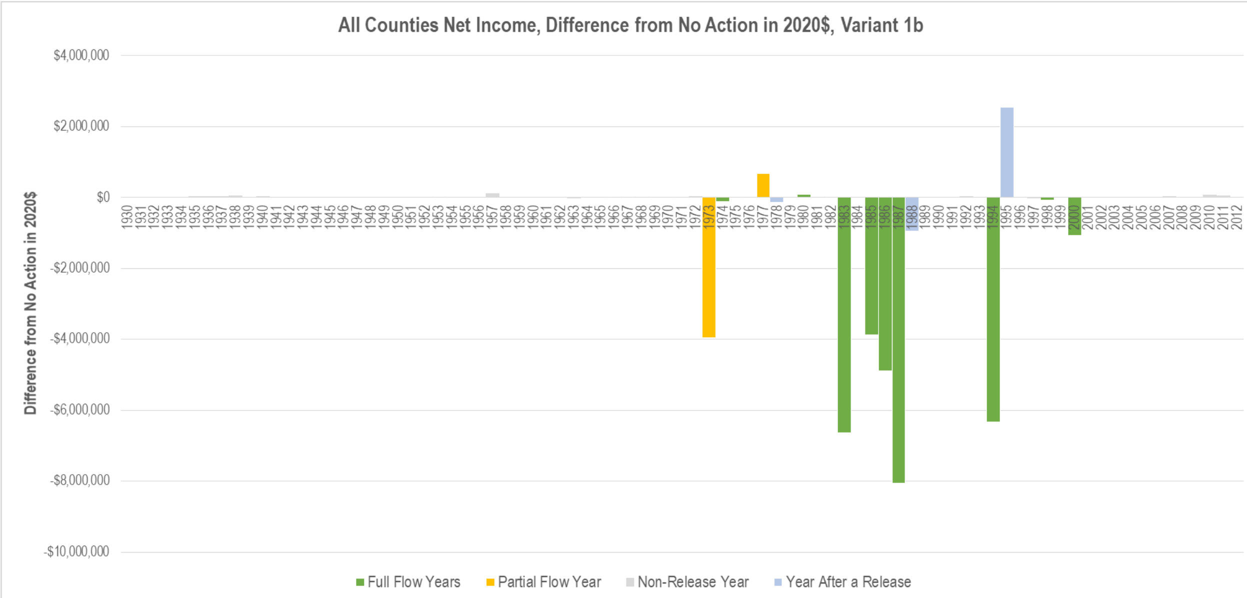


Figure 5-4. Annual Difference in Net Farm Income under Variation 1A Relative to the No Action Alternative (FY2021 Dollars)

5.1.4 Alternative 1 – Variation 1B

Table 5-6 summarizes the results for Variation 1B which would have a small, adverse impact on irrigation relative to No Action, with average annual net farm income of $9.5 million, a slight decrease of $363,000 from No Action (3.7%). McLean County in North Dakota, which would experience negligible impacts. These impacts in McLean County would be due to the spawning cue release increasing lake elevations at Lake Sakakawea in some full release years, which would increase access to water for irrigation. Net farm income would decrease relative to the No Action Alternative in Montana counties in full release years especially, where higher spring releases lead to decreased fall releases at the end of the irrigation season.

Table 5-6. Summary of National Economic Development Analysis for Variation 1B (FY2021 Dollars)

State	County	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to the No Action Alternative	Percent Change Relative to the No Action Alternative	Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	% Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)	% Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)
Montana	McCone	$960,000	-$43,000	-4.3%	$44,000	4.4%	-$435,000	-43.4%
	Valley	$1,187,000	-$40,000	-3.3%	$13,000	1.1%	-$401,000	-32.7%
	Roosevelt	$4,005,000	-$165,000	-3.9%	$293,000	7.0%	-$1,774,000	-42.5%
	Richland	$2,718,000	-$117,000	-4.1%	$193,000	6.8%	-$1,294,000	-45.6%
North Dakota	McLean	$655,000	$1,000	0.2%	$36,000	5.5%	-$24,000	-3.7%
Total		$9,526,000	-$363,000	-3.7%	$521,000	5.3%	-$3,812,000	-38.6%

Farms on Lake Sakakawea would experience temporary, relatively small, and beneficial impacts on net farm income relative to No Action. However, the spring release under Variation 1B would result in small adverse impacts in Montana counties. Elevations at Fort Peck Lake would be several feet lower during and following flow releases, and downstream counties that rely on these reservoirs (McCone, Valley, Richland, and Roosevelt Counties) would be adversely affected through decreases in access to water.

The largest losses in total net farm income under Variation 1B would occur in the Roosevelt County, Montana. The largest percentage decline in total net farm income would occur in McCone County, with a decline of 4.3 percent, with the worst change years occurring in 1987 (full release the year after a partial release), 1983 (partial release the year after another partial release), and 1949 (full release). For Roosevelt County, annual average net farm income would be $165,000 lower under Variation 1B relative to No Action, with the worst change years also occurring in 1987 (full release the year after a partial release), 1983 (partial release the year after another partial release), and 1949 (full release). The impacts to Roosevelt County reflect lower flows compared to the No Action Alternative in the full release years, as well as most partial and year after release years.

Figure 5-5 shows the annual NED impacts associated with different flow events compared to No Action. The most adverse impacts to net farm income would occur during a partial release event in 1983, with a decrease of $8.5 million across all counties. In this partial flow year, flows out of Lake Fort Peck decreased earlier in the year than they would have under the No Action Alternative to facilitate system rebalancing to compensate for low reservoir levels. This decrease began in July, peak irrigation season. All counties besides McLean County would be adversely impacted in 1983. The highest adverse impact would occur in Roosevelt County, with a decrease of $3.7 million due to river flows. In Roosevelt County, $3.7 million would represent approximately 23 percent of net farm income of all operations ($15.2 million) (USDA 2017). The second-highest year of adverse impact ($8.1 million) would occur in conditions similar to 1987, when higher spring releases would require lower fall releases from Fort Peck Reservoir to balance system storage, which causes decreased flows, decreasing access to water for irrigation relative to the No Action Alternative. However, a reduction in flows during this latter part of the irrigation season would have a less adverse impact than a reduction in flows during the peak irrigation season, such as July. Therefore, the economic impacts due to these reduced at the end of the irrigation season may be overstated.

Years with increases in net farm income compared to No Action would also occur, with the greatest increase in net farm income of $2.1 million across all counties in 1999. The counties that would experience the highest beneficial impact relative to No Action are Roosevelt and Richland Counties, where flows would result in more days above the threshold at the end of the irrigation season relative to the No Action Alternative. However, an increase in flows during the latter part of the irrigation season would have a less beneficial impact than an increase in flows during the peak irrigation season, such as July; therefore, these impacts may be overstated.

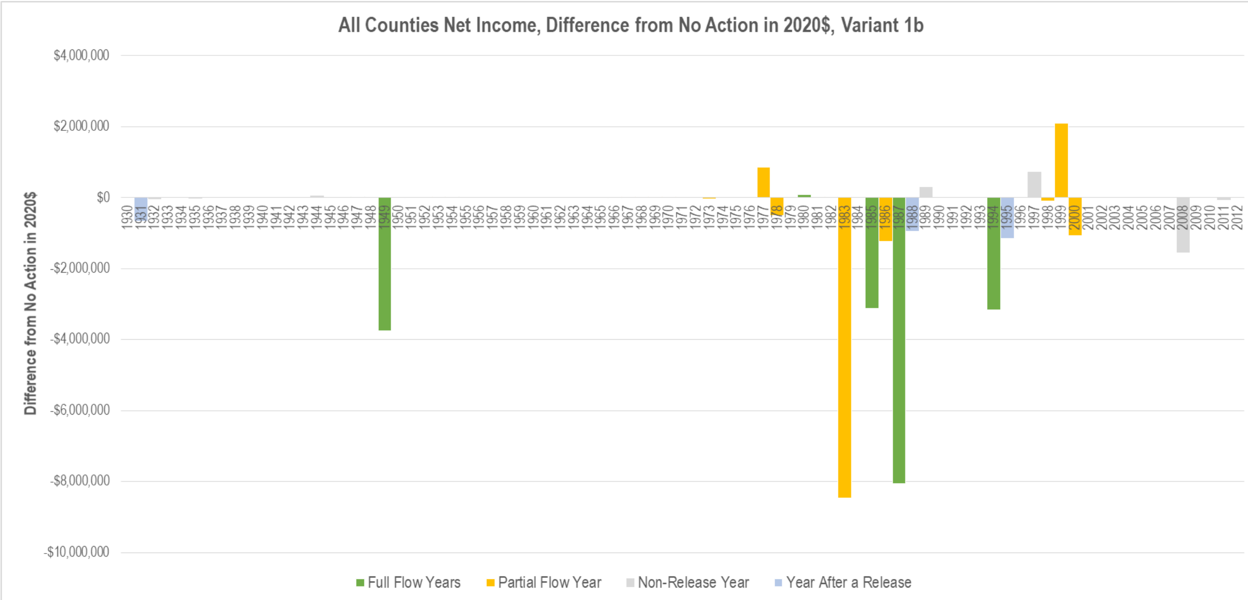


Figure 5-5. Annual Difference in Net Farm Income under Variation 1B Relative to No Action (FY2021 Dollars)

5.1.5 Alternative 2

The NED results for Alternative 2 are summarized in Table 5-7. Under Alternative 2, average annual net farm income would be approximately $9.7 million, a decrease of $237,000 (-2.4%) for all five counties relative to No Action. On average, all counties under this alternative would experience small adverse impacts, except McLean County in North Dakota, which would experience negligible impacts. These impacts in McLean County would be due to the spawning cue release increasing lake elevations at Lake Sakakawea in some full release years, which would increase access to water for irrigation. Net farm income would decrease relative to the No Action Alternative in Montana counties in full release years especially, where higher spring releases lead to decreased fall releases at the end of the irrigation season. However, a reduction in flows during the latter part of the irrigation season would have a less adverse impact than a reduction in flows during the peak irrigation season, such as July. Because impacts in this economic analysis are not calculated based on the point in the irrigation season in which they occur, these impacts that are driven by decreased flows towards the end of the irrigation season may be overstated.

Table 5-7. Summary of National Economic Development Analysis for Alternative 2 (FY2021 Dollars)

State	County	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to the No Action Alternative	Percent Change Relative to the No Action Alternative	Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	% Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)	% Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)
Montana	McCone	$971,000	-$31,000	-3.1%	$118,000	11.8%	-$440,000	-43.9%
	Valley	$1,202,000	-$26,000	-2.1%	$89,000	7.3%	-$351,000	-28.6%
	Roosevelt	$4,060,000	-$110,000	-2.6%	$636,000	15.3%	-$1,739,000	-41.7%
	Richland	$2,761,000	-$74,000	-2.6%	$425,000	15.0%	-$1,163,000	-41.0%
North Dakota	McLean	$658,000	$4,000	0.6%	$48,000	7.3%	-$12,000	-1.9%
Total		$9,652,000	-$237,000	-2.4%	$1,292,000	13.1%	-$3,682,000	-37.2%

Figure 5-6 summarizes changes in net farm income associated with different flow events compared to No Action. The greatest increases in net farm income would occur in full and partial flow years, with most of the beneficial effects to irrigation occurring in Montana counties when river stages and flows are relatively higher under Alternative 2.

The year of highest adverse impact to net farm income relative to No Action would occur under conditions like 1987, when higher spring releases would require lower fall releases from Fort Peck Reservoir to balance system storage. These lower fall flow releases decrease access to water for irrigation relative to the No Action Alternative late in the irrigation season. However, a reduction in flows during the latter part of the irrigation season would have a less adverse impact than a reduction in flows during the peak irrigation season, such as July. Because impacts in this economic analysis are not calculated based on the point in the irrigation season in which they occur, these impacts that are driven by decreased flows towards the end of the irrigation season may be overstated. Adverse impacts would be highest for the counties located downstream of Fort Peck Lake, ranging from a decrease of $3.9 million in Roosevelt County to a decrease of $680,000 in Valley County. In 1986, a partial release year, Roosevelt County would be the most adversely impacted county, with a decrease of $2.2 million in net farm income relative to No Action.

The increases in net farm income would occur in one full release year and one partial release year, when releases from Fort Peck Dam would be higher than under No Action, with small increases in net farm income for irrigators in the Montana counties.

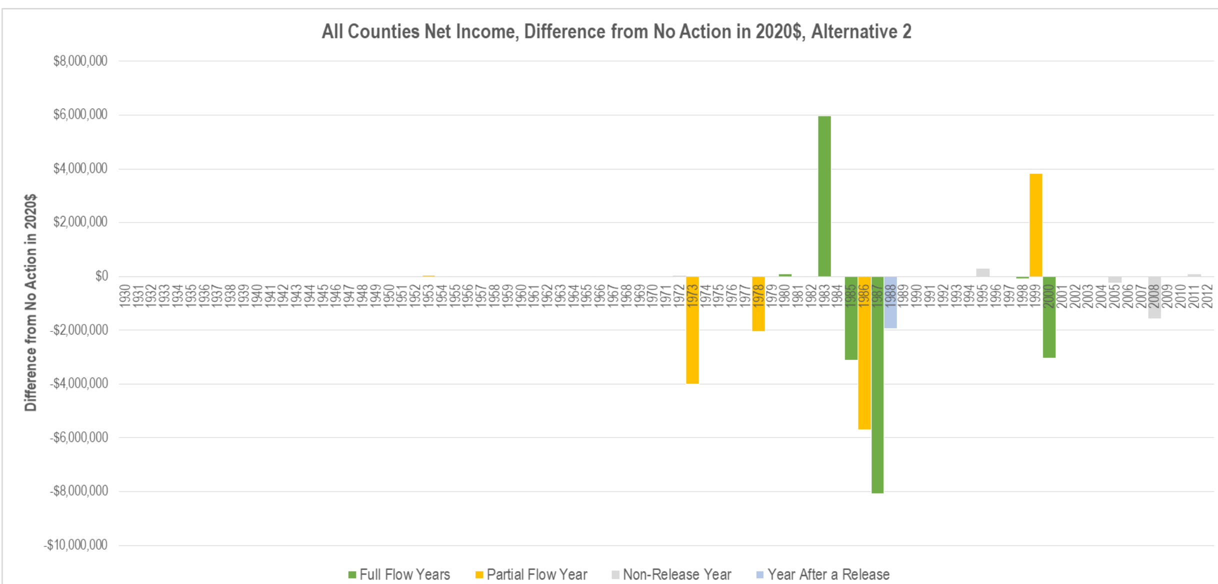


Figure 5-6. Annual Difference in Net Farm Income under Alternative 2 Relative to No Action (FY2021 Dollars)

5.1.6 Alternative 2 – Variation 2A

The NED results for Variation 2A are summarized in Table 5-8. Under Variation 2A, average annual net farm income would be $9.4 million, a decrease of $512,000 relative to No Action (-5.2%). On average, all counties under this alternative would experience small adverse impacts, except McLean County in North Dakota, which would experience negligible impacts. These impacts in McLean County would be due to the spawning cue release increasing lake elevations at Lake Sakakawea in some full release years, which would increase access to water for irrigation.

Roosevelt County would experience the greatest average annual decrease in net farm income (-$241,000) associated with reduced river flows during full flow and partial flow years. In the average of the eight worst years, Roosevelt County would experience a decrease in net farm income of $2.4 million. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to No Action, many of these adverse impacts would be offset, resulting in small changes on average to net farm income under Variation 2A relative to No Action.

Table 5-8. Summary of National Economic Development Analysis for Variation 2A (FY2021 Dollars)

State	County	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to the No Action Alternative	Percent Change Relative to the No Action Alternative	Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	% Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)	% Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)
Montana	McCone	$946,000	-$57,000	-5.6%	$44,000	4.4%	-$619,000	-61.7%
	Valley	$1,179,000	-$49,000	-4.0%	$28,000	2.3%	-$528,000	-43.0%
	Roosevelt	$3,929,000	-$241,000	-5.8%	$106,000	2.5%	-$2,429,000	-58.3%
	Richland	$2,666,000	-$169,000	-5.9%	$62,000	2.2%	-$1,690,000	-59.6%
North Dakota	McLean	$656,000	$2,000	0.3%	$44,000	6.7%	-$24,000	-3.6%
Total		$9,377,000	-$512,000	-5.2%	$256,000	2.6%	-$5,243,000	-53.0%

Net farm income would decrease under Variation 2B for counties in Montana, while McLean County in North Dakota would experience a slight increase in net farm income. Roosevelt ounty, would have the highest overall change in dollar value, relative to No Action, with an average annual decrease of $241,000 in net farm income. Richland County would experience the largest percentage decrease in net farm income relative to No Action, with a decrease of 5.9 percent.

Figure 5-7 shows the annual NED impacts tied to different flow events relative to No Action. The year of highest adverse impact to net farm income relative to No Action would occur under conditions like 1987, a full release year, when fall flows are lower than they would be under the No Action Alternative. These lower fall flow releases decrease access to water for irrigation relative to the No Action Alternative late in the irrigation season. However, a reduction in flows during this latter part of the irrigation season would have a less adverse impact than a reduction in flows during the peak irrigation season, such as July. Therefore, the economic impacts due to these reduced at the end of the irrigation season may be overstated. The counties in Montana would experience adverse impacts during this year, with decreases in net income as large as $8.1 million relative to No Action. Reservoir elevations at Fort Peck Lake would decrease by as much as 7 feet during this year relative to No Action, and Roosevelt County would experience the highest adverse impact to net farm income with a decrease of $3.9 million. This decrease in net income would represent 26 percent of net farm income of all farming operations in that county ($15.2 million) (USDA 2017).

Partial releases would also result in adverse impacts to net farm income. For example, the second-highest adverse impact year relative to No Action Alternative would occur in 1973, a partial release year when fall reservoir releases would be lower relative to the No Action Alternative. However, for the reasons stated above, since these impacts occur late in the irrigation season the overall impact to irrigators may be overstated. Net farm income would be $7.6 million lower than under the No Action Alternative, with decreases in net farm income ranging by county from $689,000 to $3.1 relative to No Action. The decrease in Roosevelt County, the county to experience the largest adverse impact in this year, would represent 24 percent of net farm income of all operations in that county (USDA 2017).

Generally, the greatest increases in net farm income relative to No Action would occur in McLean County. In some years over the POR, full spawning cue releases increase lake elevations at Lake Sakakawea which would increase access to water for irrigation. The greatest increase in net farm income would occur in 1997, a non-release year, with an increase of $1.2 million in net farm income compared to No Action. This is particularly true for Roosevelt County, which would experience an increase of $507,000 in net farm income relative to No Action, which would account for 3 percent of net farm income of all farming operations in that county (USDA 2017).

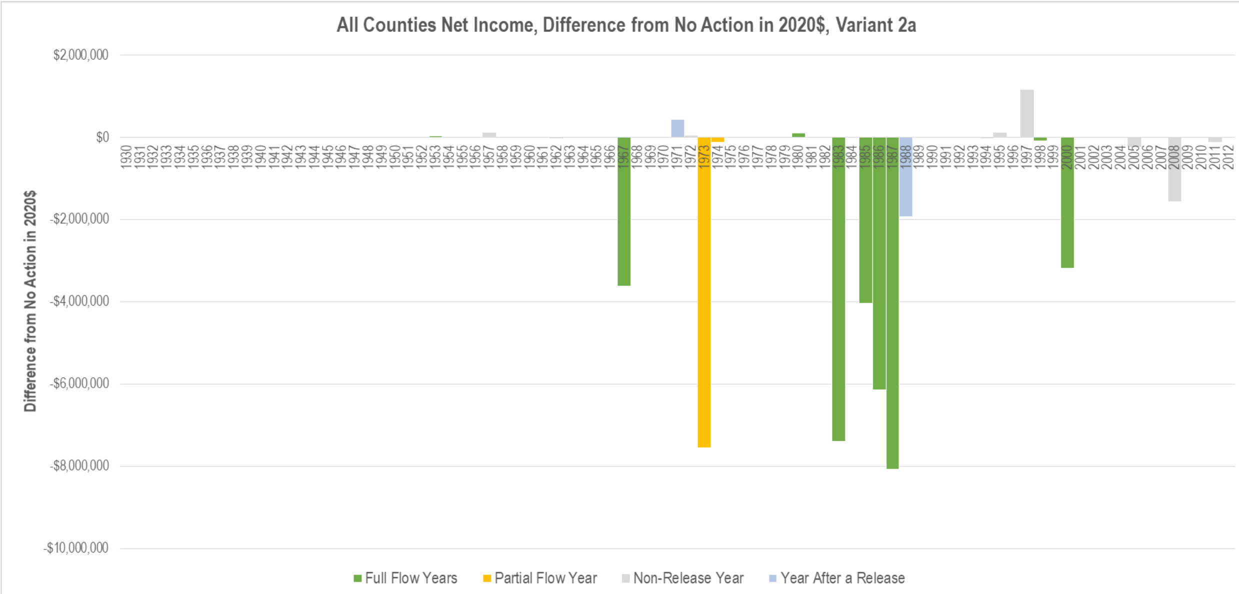


Figure 5-7. Annual Difference in Net Farm Income under Variation 2A Relative to No Action (FY2021 Dollars)

5.1.7 Alternative 2 – Variation 2B

The NED results for Variation 2B are summarized in Table 5-9. Under Variation 2B, average annual net farm income would be $9.2 million, a decrease of $658,000 relative to No Action (6.7%). On average, all counties under this alternative would experience small adverse impacts, except McLean County in North Dakota, which would experience negligible impacts. These impacts in McLean County would be due to the spawning cue release increasing lake elevations at Lake Sakakawea in some full release years, which would increase access to water for irrigation.

Roosevelt County would experience the greatest average annual decrease in net farm income (-$316,000) associated with reduced flows downstream from Lake Fort Peck following the spawning cue release. Other Montana counties would also experience similar adverse reductions in net farm income from relatively lower water releases from Lake Fort Peck following the spawning cue release to accommodate rebalancing of the reservoirs. In the average of the eight worst years, Roosevelt County would experience a decrease in net farm income of $1.6 million. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to No Action, many of these adverse impacts would be offset, resulting in small changes on average to net farm income under Variation 2B relative to No Action over the POR.

Table 5-9. Summary of National Economic Development Analysis for Variation 2B (FY2021 Dollars)

State	County	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to the No Action Alternative	Percent Change Relative to the No Action Alternative	Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	% Increase during eight greatest crop production value years compared to the No Action Alternative (average annual)	Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)	% Decrease during eight lowest crop production value years compared to the No Action Alternative (average annual)
Montana	McCone	$936,000	-$67,000	-6.7%	$6,000	0.6%	-$570,000	-56.8%
	Valley	$1,174,000	-$54,000	-4.4%	$1,000	0.0%	-$482,000	-39.2%
	Roosevelt	$3,854,000	-$316,000	-7.6%	$6,000	0.2%	-$2,646,000	-63.4%
	Richland	$2,610,000	-$225,000	-7.9%	$7,000	0.2%	-$1,943,000	-68.5%
North Dakota	McLean	$658,000	$3,000	0.5%	$43,000	6.5%	-$12,000	-1.9%
Total		$9,231,000	-$658,000	-6.7%	$35,000	0.4%	-$5,535,000	-56.0%

Net farm income would decrease under Variation 2B for counties in Montana, while McLean in North Dakota would experience a slight increase in net farm income. Roosevelt County would have the highest overall change in dollar value, relative to No Action, with an average annual decrease of $316,000 in net farm income. Richland County would experience the largest percentage decrease in net farm income relative to No Action, with a decrease of 7.9 percent.

Figure 5-8 shows the annual NED impacts tied to different flow events relative to No Action. The year of highest adverse impact to net farm income relative to No Action would occur under conditions like 1983, a full flow year when flows decreased earlier in the year than they would have under the No Action Alternative to facilitate system rebalancing. Flows decrease below the irrigating threshold in July in Variation 2B, versus August under the No Action Alternative. The counties in Montana would experience adverse impacts during this year, with decreases in net income as large as $8.2 million relative to No Action. Reservoir elevations at Fort Peck Lake would decrease by as much as 4 feet during this year relative to No Action, and Roosevelt County would experience the highest adverse impact to net farm income with a decrease of $3.5 million. This decrease in net income would represent 23 percent of net farm income of all farming operations in Roosevelt County (USDA 2017).

Partial releases would also result in adverse impacts to net farm income. For example, the third-highest adverse impact year relative to the No Action Alternative would occur in 1949 (decrease of $7.6 million), a partial release year when reservoir releases would be lower than under the No Action Alternative. Decreases in net farm income in the counties evaluated would range from $657,000 to $3.6 million relative to No Action. The decrease in Roosevelt County, the county to experience the largest adverse impact in this year, would equal a decrease of 24 percent of net farm income of all operations in that county (USDA 2017).

Generally, the greatest increases in net farm income relative to No Action would occur in McLean County. In some years over the POR, spawning cue releases increase lake elevations at Lake Sakakawea which would increase access to water for irrigation. The greatest increase in net farm income would occur in 1980, a full release year, with an increase of $100,000 in net farm income compared to No Action. All this increase would be concentrated in McLean County.

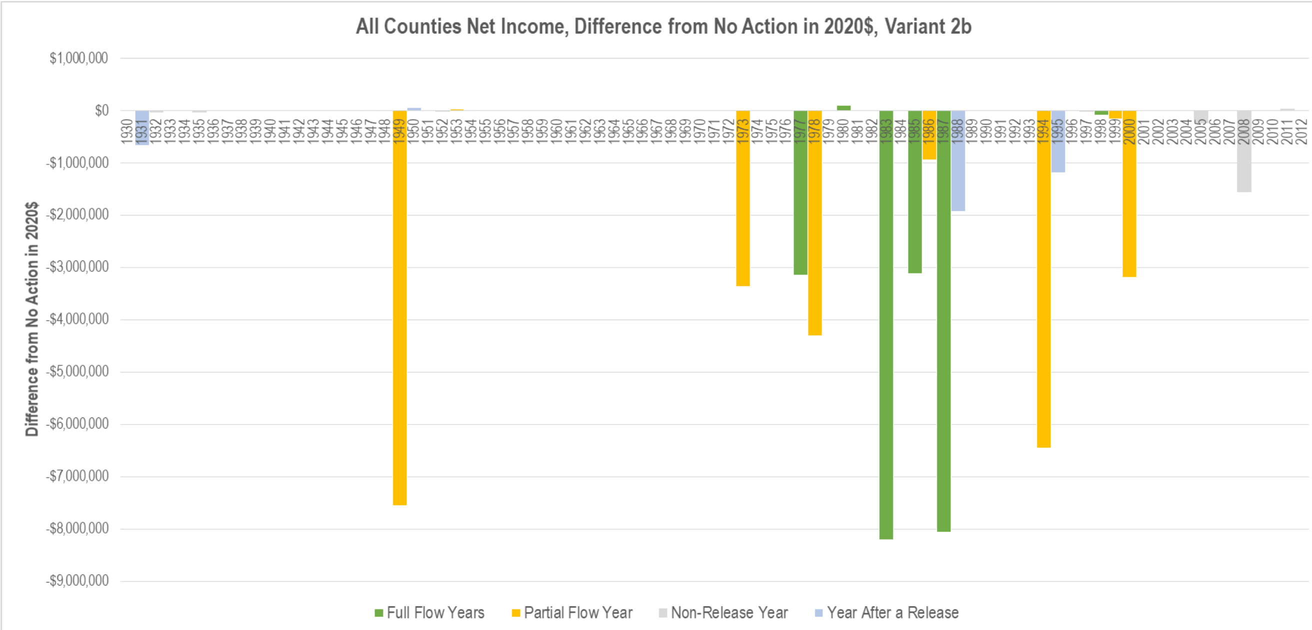


Figure 5-8. Annual Difference in Net Farm Income under Variation 2B Relative to No Action (FY2021 Dollars)

5.2 Regional Economic Development Analysis

The RED analysis focuses on changes in the distribution of economic activity at a local and regional scale. For irrigation, the RED analysis focused on the change in employment, income, and sales that would occur at the regional level for each of the FPDTR-EIS alternatives. The RED impacts were estimated by examining changes in gross sales of crops grown using water from the Missouri River for irrigation purposes. The methodology and results are discussed in detail in this section.

The results in this section focus on changes in sales, labor income, and employment in each county associated with the FPDTR-EIS alternatives. Economic impacts estimated with RECONS are reported on an annual basis. Three scenarios were developed that describe the range of RED impacts that can occur under each of the FPDTR-EIS alternatives. Each of the scenarios was based on net sales calculated for each county under each alternative. Each scenario is described in Table 5-10.

Table 5-10. Scenarios Considered in the Regional Economic Development Analysis

Scenario	Description
Average Annual Value of Crop Production	The average annual production value for each county for all years included in the POR by alternative.
Average of the 8 Greatest Production Value Years Compared to No Action	The average annual production value observed in the eight greatest crop production value years compared to No Action.
Average of the 8 Least Production Value Years Compared to No Action	The average annual production value observed in the eight lowest crop production value years compared to No Action.

5.2.1 Summary of Regional Economic Development Results

The RED analysis for each alternative is summarized in Table 5-11. The table shows the total average annual employment, labor income, and sales for all five counties. Across all alternatives, annual average employment varies only by 8 jobs. Tables 18, 19, and 20 summarize these results for each of the five counties analyzed. For all alternatives, the change in RED impacts relative to No Action would be small.

Table 5-11. Regional Economic Development Results for All Five Counties by Alternative/Variation Based on Average Annual Production Values

Type of Impact	No Action	Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
Employment	768	764	763	763	765	762	760
Labor Income	$36,460,000	$36,301,000	$36,244,00	$36,260,000	$36,330,000	$36,177,000	$36,096,000
Sales	$114,259,000	$113,765,00	$113,589,000	$113,639,000	$113,854,000	$113,384,000	$113,134,000

Note: All dollar values are in FY2021 Dollars.

The location of the county plays an important role in determining the modeled level of employment, labor income, or sales. Crops such as potatoes and hay require more labor than beans and soybeans, and RECONS assigns a higher number of jobs per million dollars of crop production for these farming sectors. Accordingly, when counties that grow more of those high-labor crops are impacted under an alternative, the modeled impact may be greater than with counties with relatively lower labor intensity are impacted.

Table 5-12 summarizes the change in employment based on the change in average annual net farm income from crop production as described in Section 4.1.7 (‘Calculation of Net Farm Income’). Because eight years is approximately equal to ten percent of the POR, the RED analysis also includes the change in employment during the average of the eight worst years and eight best years relative to No Action (‘Average Production Value for 8 Worst/Best Years’). Because this count is only calculated relative to No Action, the eight best and eight worst years are not analyzed under No Action.

Table 5-12. Employment Results by Alternative/Variation

County	Type of Impact	No Action Total Annual Average Employment	Change in Annual Average Employment Relative to No Action					
			Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
McCone	Annual Average Production Value	114	-0.4	-0.6	-0.5	-0.4	-0.7	-0.8
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-4.3	-6.4	-5.1	-5.2	-7.3	-6.7
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	0.6	0.3	0.5	1.4	0.5	0.1
Valley	Annual Average	103	-0.4	-0.6	-0.6	-0.4	-0.7	-0.8
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-4.8	-6.4	-5.9	-5.2	-7.8	-7.1
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	0.5	0.5	0.2	1.3	0.4	0.0
Roosevelt	Annual Average	331	-1.5	-2.1	-1.8	-1.2	-2.7	-3.5
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-18.4	-23.5	-19.8	-19.4	-27.1	-29.5
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	3.4	2.4	3.3	7.1	1.2	0.1
Richland	Annual Average	191	-1.0	-1.3	-1.2	-0.8	-1.8	-2.3
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-11.8	-14.7	-13.4	-12.1	-17.6	-20.2
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	2.2	1.8	2.0	4.4	0.6	0.1
McLean	Annual Average	29	0.0	0.1	0.0	0.0	0.0	0.0
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	0.0	-0.1	-0.3	-0.1	-0.3	-0.1
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	0.5	0.7	0.4	0.5	0.5	0.5

Table 5-13. Labor Income Results by Alternative/Variation (FY2021 Dollars)

County	Type of Impact	No Action	Relative to No Action					
			Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
McCone	Annual Average	$4,317,045	-$15,217	-$23,258	-$19,076	-$14,036	-$25,261	-$29,882
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$161,564	-$244,772	-$194,251	-$196,528	-$276,059	-$254,190
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$23,372	$11,278	$19,632	$52,874	$19,572	$2,473
Valley	Annual Average	$3,766,130	-$15,986	-$21,355	-$21,729	-$13,848	-$26,481	-$29,154
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$176,436	-$235,764	-$217,030	-$190,228	-$285,951	-$260,692
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$17,142	$17,599	$7,120	$48,285	$15,151	$323
Roosevelt	Annual Average	$16,645,643	-$76,694	-$104,771	-$92,341	-$61,717	-$134,858	-$177,171
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$923,725	-$1,179,365	-$994,609	-$975,270	-$1,361,747	-$1,482,558
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$171,121	$120,406	$164,107	$356,860	$59,143	$3,537
Richland	Annual Average	$10,595,983	-$53,324	-$70,340	-$67,039	-$42,410	-$96,896	-$129,276
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$654,003	-$810,954	-$744,242	-$669,178	-$971,801	-$1,116,870
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$119,393	$96,991	$111,197	$244,262	$35,863	$4,033
McLean	Annual Average	$1,134,753	$1,754	$4,215	$575	$1,641	$977	$1,519
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$1,937	-$4,022	-$10,862	-$5,451	-$10,600	-$5,448
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$19,327	$29,707	$16,147	$21,495	$19,767	$19,184

Table 5-14. Sales Results by Alternative/Variation (FY2021 Dollars)

County	Type of Impact	No Action	Relative to No Action					
			Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
McCone	Annual Average	$16,302,967	-$57,474	-$87,852	-$72,050	-$53,011	-$95,417	-$112,878
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$610,217	-$924,559	-$733,700	-$742,266	-$1,042,757	-$960,195
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$88,274	$42,598	$74,153	$199,699	$73,927	$9,340
Valley	Annual Average	$11,763,341	-$49,937	-$66,714	-$67,880	-$43,259	-$82,731	-$91,082
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$551,163	-$736,526	-$678,006	-$594,238	-$893,350	-$814,454
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$53,551	$54,979	$22,241	$150,833	$47,333	$1,008
Roosevelt	Annual Average	$50,730,128	-$233,835	-$319,490	-$281,567	-$188,155	-$411,307	-$540,487
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$2,816,385	-$3,596,377	-$3,032,768	-$2,973,294	-$4,153,232	-$4,522,772
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$521,739	$367,169	$500,397	$1,087,954	$180,382	$10,792
Richland	Annual Average	$31,590,293	-$159,054	-$209,840	-$199,986	-$126,488	-$289,130	-$385,864
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$1,950,736	-$2,419,253	-$2,220,172	-$1,995,805	-$2,899,790	-$3,333,646
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$356,120	$289,346	$331,715	$728,503	$107,012	$12,037
McLean	Annual Average	$3,872,101	$5,984	$14,381	$1,961	$5,598	$3,332	$5,181
	Average of the 8 Lowest Production Value Years Compared to No Action	N/A	-$6,610	-$13,722	-$37,063	-$18,598	-$36,170	-$18,589
	Average of the 8 Highest Production Value Years Compared to No Action	N/A	$65,945	$101,352	$55,096	$73,343	$67,450	$65,457

5.2.2 No Action

The RED analysis for No Action was focused on employment, labor income, and sales associated with the value of crop production from irrigated agriculture in the five counties being evaluated. Table 5-15 summarizes the economic contribution of irrigation for all counties. Note that employment, labor income, and total sales are described here as 'contribution' because regional economic benefits are currently being supported under existing conditions and do not represent an impact of FPDTR-EIS actions.

Under No Action, irrigated agriculture would support 768 jobs per year on average for all counties, $36.5 million in labor income, and $114.2 million in sales (Table 5-11). The number of jobs supported on average annually would be highest in Roosevelt County, with 331 jobs (Table 5-12). Average annual labor income would be highest in Roosevelt County at $16.6 million.[4] Average annual sales would also be highest in Roosevelt County at $50.7 million per year. Average annual labor income and sales would be lowest in McLean County at $1.1 million and $3.9 million, respectively.

Table 5-15. Regional Economic Development Effects for Irrigated Agriculture Using Missouri River Water: No Action (FY2021 Dollars)

Economic Contribution	Scenario	Total
Employment	Average Annual Value of Production	768
Labor Income	Average Annual Value of Production	$36,460,000
Total Sales	Average Annual Value of Production	$114,259,000

5.2.3 Alternative 1

Relative to No Action, average annual change in employment, labor income, and sales would be negligible under Alternative 1 (Table 5-16). For all five counties evaluated employment would decrease by three jobs per year. Roosevelt, Richland, McCone, and Valley County would account for much of the change in sales, employment, and labor income. The least affected county would be McLean County, with virtually no change in jobs, employment, or sales relative to No Action (Table 5-12, Table 5-13, and Table 5-14). Under the average eight worst years when the value of production would be lower than under No Action from relatively lower river flows affecting access for irrigation water, there would be a reduction of 40 jobs and $1.9 million in labor income across all counties affected. Most of these jobs would be lost in Roosevelt County, with a loss of 18 jobs in the average eight worst years, followed by Richland, with a loss of 12 jobs.

[4] In considering this labor income impact, it is worth noting that labor income is calculated based on sales, which do not account for the cost of production.

Table 5-16. Regional Economic Development Impacts of Alternative 1 Relative to No Action (FY2021 Dollars)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	764
	Change in Average Annual from No Action	-3.3
	Average of the 8 Greatest Production Value Years Compared to No Action	7.1
	Average of the 8 Least Production Value Years Compared to No Action	-39.3
Labor Income	Average Annual Value of Production	$36,301,000
	Change in Average Annual from No Action	-$159,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$350,000
	Average of the 8 Least Production Value Years Compared to No Action	-$1,918,000
Sales	Average Annual Value of Production	$113,765,000
	Change in Average Annual from No Action	-$494,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$1,086,000
	Average of the 8 Least Production Value Years Compared to No Action	-$5,935,000

5.2.4 Alternative 1 – Variation 1A

Variation 1A would have small, adverse RED impacts relative to No Action. All counties besides McLean would experience small adverse impacts, while McLean County would experience negligible impacts. The most adversely impacted county would be Roosevelt, where average annual labor income would be $104,771 lower when compared to No Action (Table 5-13). None of the counties would experience a change in average annual employment of more than two jobs relative to No Action (Table 5-12). During the average of the eight lowest value of production years compared to No Action, there would be a decrease of 51 jobs and $2.5 million in labor income (Table 5-17). The impact would be largest in Roosevelt County during the average of the eight lowest value production years, with a decrease of 24 jobs, $1.2 million in labor income, and $3.6 million in sales.

Table 5-17. Regional Economic Development Impacts of Variation 1A Relative to No Action (FY2021 Dollars)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	763
	Change in Average Annual from No Action	-4.4
	Average of the 8 Greatest Production Value Years Compared to No Action	5.7
	Average of the 8 Least Production Value Years Compared to No Action	-51.1
Labor Income	Average Annual Value of Production	$36,244,000
	Change in Average Annual from No Action	-$216,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$276,000
	Average of the 8 Least Production Value Years Compared to No Action	-$2,475,000
Sales	Average Annual Value of Production	$113,589,000
	Change in Average Annual from No Action	-$670,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$855,000
	Average of the 8 Least Production Value Years Compared to No Action	-$7,690,000

5.2.5 Alternative 1 – Variation 1B

Under Variation 1B, the counties located in Montana downstream of Fort Peck Dam would experience small, adverse RED impacts relative to No Action, while McLean County would experience negligible impacts. On average, the change in economic activity would lead to a decrease in annual employment of four jobs and a reduction in annual labor income of $200,000 across all five counties relative to No Action (Table 5-18). Roosevelt County would experience the largest impacts on average with average annual employment decreasing by two jobs, average annual labor income declining by $92,000, and average annual sales declining by $282,000. During the eight worst difference years compared to No Action, average labor income would be $2.2 million lower than No Action, and the number of jobs would decrease by almost 45. Effects under the eight lowest production years would be largest in Roosevelt County, which would experience a loss of 20 jobs, $994,000 in labor income, and $3.0 million in sales.

Table 5-18. Regional Economic Development Impacts of Variation 1B Relative to No Action (FY2021 Dollars)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	764
	Change in Average Annual from No Action	-4.1
	Average of the 8 Greatest Production Value Years Compared to No Action	6.4
	Average of the 8 Least Production Value Years Compared to No Action	-44.6
Labor Income	Average Annual Value of Production	$36,260,000
	Change in Average Annual from No Action	-$200,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$318,000
	Average of the 8 Least Production Value Years Compared to No Action	-$2,161,000
Sales	Average Annual Value of Production	$113,639,000
	Change in Average Annual from No Action	-$620,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$984,000
	Average of the 8 Least Production Value Years Compared to No Action	-$6,702,000

5.2.6 Alternative 2

Under Alternative 2, the counties located in Montana downstream of Fort Peck Dam would experience small, adverse impacts relative to No Action, while McLean County would experience negligible impacts (Table 5-19). On average, annual employment would decrease by three jobs for all counties. Roosevelt County would experience the largest adverse impacts compared to other counties in terms of impacts to jobs, labor income, and sales, with average annual decreases of approximately 1 job, $62,000 in labor income, and $188,000 in sales (Table 5-12, Table 5-13, and Table 5-14). Collectively, the four counties in Montana would experience a decrease in average annual labor income of approximately $132,000 relative to No Action. During the eight worst difference years modeled relative to No Action, average labor income would decrease by $2.0 million with a decrease of 42 jobs for all counties. As in the other FPDTR-EIS alternatives, the impacts under the eight worst difference years would be largest in Roosevelt County, with a decrease of 19 jobs, $975,000 in labor income, and $3.0 million in sales.

Table 5-19. Regional Economic Development Impacts of Alternative 2 Relative to No Action (FY2021 Dollars)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	765
	Change in Average Annual from No Action	-2.7
	Average of the 8 Greatest Production Value Years Compared to No Action	14.8
	Average of the 8 Least Production Value Years Compared to No Action	-42.0
Labor Income	Average Annual Value of Production	$36,330,000
	Change in Average Annual from No Action	-$130,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$724,000
	Average of the 8 Least Production Value Years Compared to No Action	-$2,037,000
Sales	Average Annual Value of Production	$113,854,000
	Change in Average Annual from No Action	-$405,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$2,240,000
	Average of the 8 Least Production Value Years Compared to No Action	764.9

5.2.7 Alternative 2 – Variation 2A

Under Variation 2A, the counties located in Montana downstream of Fort Peck Dam would experience small, adverse impacts relative to No Action, while McLean County would experience negligible impacts (Table 5-20). On average, employment would be reduced by six jobs for the five counties under Variation 2A relative to No Action (Table 5-12). The four counties in Montana would experience small adverse impacts relative to No Action, with decreases in annual average labor income ranging between $25,000 and $135,000. Roosevelt and Richland would experience a decline of $411,000 and $289,000 respectively, in average annual sales relative to No Action, and average employment in both counties would be reduced by less than three jobs each relative to No Action (Table 5-12). During the eight worst difference years relative to No Action, average annual employment would decrease by 60 jobs across all five counties and by $2.9 million in average annual labor income. During the eight worst difference years relative to No Action, Roosevelt County would experience the largest decline in jobs, labor income, and sales, with a decrease of 27 jobs, $1.4 million in labor income, and $4.2 million in sales.

Table 5-20. Regional Economic Development Impacts of Variation 2A Relative to No Action (FY2021 Dollars)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	762
	Change in Average Annual from No Action	-5.8
	Average of the 8 Greatest Production Value Years Compared to No Action	3.3
	Average of the 8 Least Production Value Years Compared to No Action	-60.0
Labor Income	Average Annual Value of Production	$36,177,000
	Change in Average Annual from No Action	-$283,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$149,000
	Average of the 8 Least Production Value Years Compared to No Action	-$2,906,000
Sales	Average Annual Value of Production	$113,384,000
	Change in Average Annual from No Action	-$875,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$476,000
	Average of the 8 Least Production Value Years Compared to No Action	-$9,025,000

5.2.8 Alternative 2 – Variation 2B

Under Variation 2B, the counties located in Montana downstream of Fort Peck Dam would experience small, adverse impacts relative to No Action, while McLean County would experience negligible impacts. On average, the change in economic activity would lead to a decrease in annual employment of seven jobs and a reduction in annual labor income of $364,000 across all five counties relative to No Action (

Table 5-21). Roosevelt County would experience the largest impacts on average with annual employment decreasing by four jobs, average annual labor income declining by $177,000, and average annual sales declining by $540,000. During the eight worst difference years compared to No Action, average labor income would be $3.1 million lower than No Action, and the number of jobs would decrease by almost 64. Effects under the eight lowest production years would be largest in Roosevelt County, which would experience a loss of 30 jobs, $1.5 million in labor income, and $4.5 million in sales.

Table 5-21. Regional Economic Development Impacts of Variation 2B Relative to No Action (FY2021 Dollars)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	760
	Change in Average Annual from No Action	-7.4
	Average of the 8 Greatest Production Value Years Compared to No Action	0.7
	Average of the 8 Least Production Value Years Compared to No Action	-63.7
Labor Income	Average Annual Value of Production	$36,096,000
	Change in Average Annual from No Action	-$364,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$30,000
	Average of the 8 Least Production Value Years Compared to No Action	-$3,120,000
Sales	Average Annual Value of Production	$113,134,000
	Change in Average Annual from No Action	-$1,125,000
	Average of the 8 Greatest Production Value Years Compared to No Action	$99,000
	Average of the 8 Least Production Value Years Compared to No Action	-$9,650,000

5.3 Other Social Effects

The OSE analysis for irrigation relied on the results of the NED and RED analysis to determine the scale of impacts that could occur to individual and community well-being, traditional ways of life, and economic vitality. A qualitative discussion of the OSE impacts on irrigation operations is provided in Chapter 3 of the FPDTR-EIS.

6 High Flow Results

6.1 National Economic Development Results

Side Channel Case Study

The NED analysis focused on estimating a change in net farm income (reported in FY2021 Dollars) for irrigated agriculture using water from the Missouri River from side channel irrigation intakes. On average across all side channel intakes in this case study in the four counties in Montana there would be a $245,000 loss in net farm income per intake during a high flow year. A portion of this loss is assumed to be operating and maintenance costs ($10,000) associated with clearing the side channel of debris following a high flow event and the remainder ($235,000) is the average, per intake, net income lost due to a switch from irrigated to non-irrigated crop production for the acreage irrigated by the intake.

There are an estimated 31 intakes located on side channels in the four counties in Montana evaluated in the case study. A high flow event would result in a total change in net farm income of $7.5 million in any full flow year when all these intakes are assumed to be impacted. Of this total NED impact, $300,000 is attributed to operations and maintenance costs associated with clearing debris from irrigation intake side channels and the remainder is associated with a reduction in crop yields. These results are summarized below in Table 6-1.

Impacts vary from county to county along the river as each county has different cropping patterns and a different number of side channel intakes. While the annual impacts are the same under each alternative as the per-intake change in net farm income during flow years is constant, impacts over the POR will vary and depend on the number of full flow release years expected to occur under each alternative, except for Variations 1B and 2B which each have nine full flow years. Because Variation 1A has 16 potential test flow years, the most out of any alternative, it shows the largest change in net farm income for side channel irrigation intakes compared to the No Action Alternative. Additionally, NED results of the side channel case study should not be combined with results from the low flow analysis as they use separate sets of input data. Instead, these results should be considered a snapshot of the possible NED impacts from a high flow event alone. Finally, these results are reported solely for side channel intakes and do not represent impacts to net farm income for irrigated agriculture at the county or multi-county level.

When counties that have a higher proportion of high-margin crops are impacted by high flows under one of the alternatives, the change in total net farm income for all counties under that alternative will also be larger. The highest-margin crops, for the counties included in this analysis, include hay, sugar beets, and beans while the lowest-margin crop is oats. These margins are defined as described above, using ERS prices and crop enterprise budgets relevant to each county. Amongst the four counties in this analysis, Richland County would experience the largest decrease in average annual net farm income relative to No Action across alternatives. This is because of its crop mix and its relatively high number of side channel intakes (9). Roosevelt County has more side channel intakes (10), but its crop mix leads to slightly smaller losses compared to Richland County. In high flow years, all counties would experience losses relative to No Action due to a need to switch completely to dryland crop production. The years with highest potential for decreases in net farm income relative to No Action are the years with the highest number of potential test flows.

Table 6-1. Average Annual Side Channel Impacts During Full Flow Years

Statistic	Value (FY2021 Dollars)
Per Full Flow Year	
Number of Intakes Impacted	31
Net Farm Income Loss	$7,500,000
Reduction in Crop Yields	$7,200,000
Operating and Maintenance Costs	$300,000
Per Intake Per Full Flow Year	
Net Farm Income Loss	$245,000
Reduction in Crop Yields	$235,000
Operating and Maintenance Costs	$10,000

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel irrigation intakes tier 1 average annual operations and maintenance costs would increase the most over the modeled POR under Variation 2B ($112,627) and the least under Variation 1A ($$65,234) compared to the No Action Alternative (Figure 6-1). For Tier 2, average annual operations and maintenance costs would increase the most over the modeled POR under Variation 2A ($133,698) and the least under Variation 1A ($49,693) compared to the No Action Alternative (Figure 6-2).

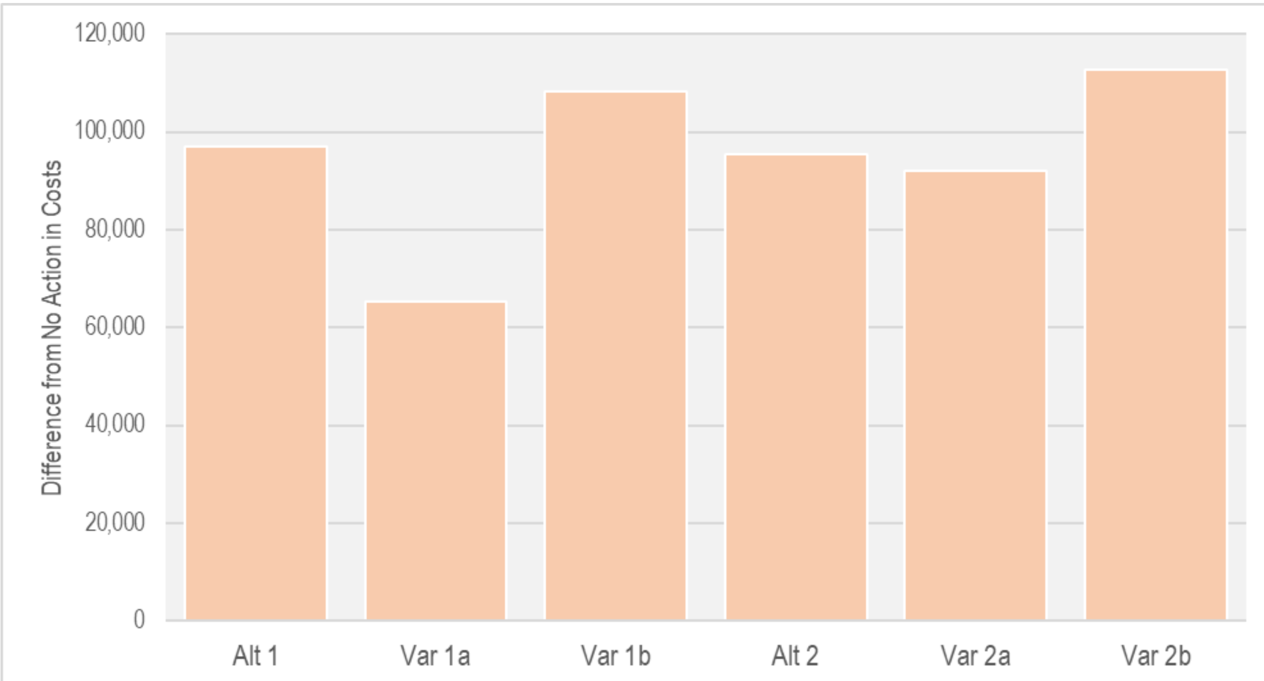


Figure 6-1. Average Annual Change in Tier 1 Operations and Maintenance Costs over the POR Relative to No Action, Missouri River Mainstem Irrigation Intakes (FY2021 Dollars)

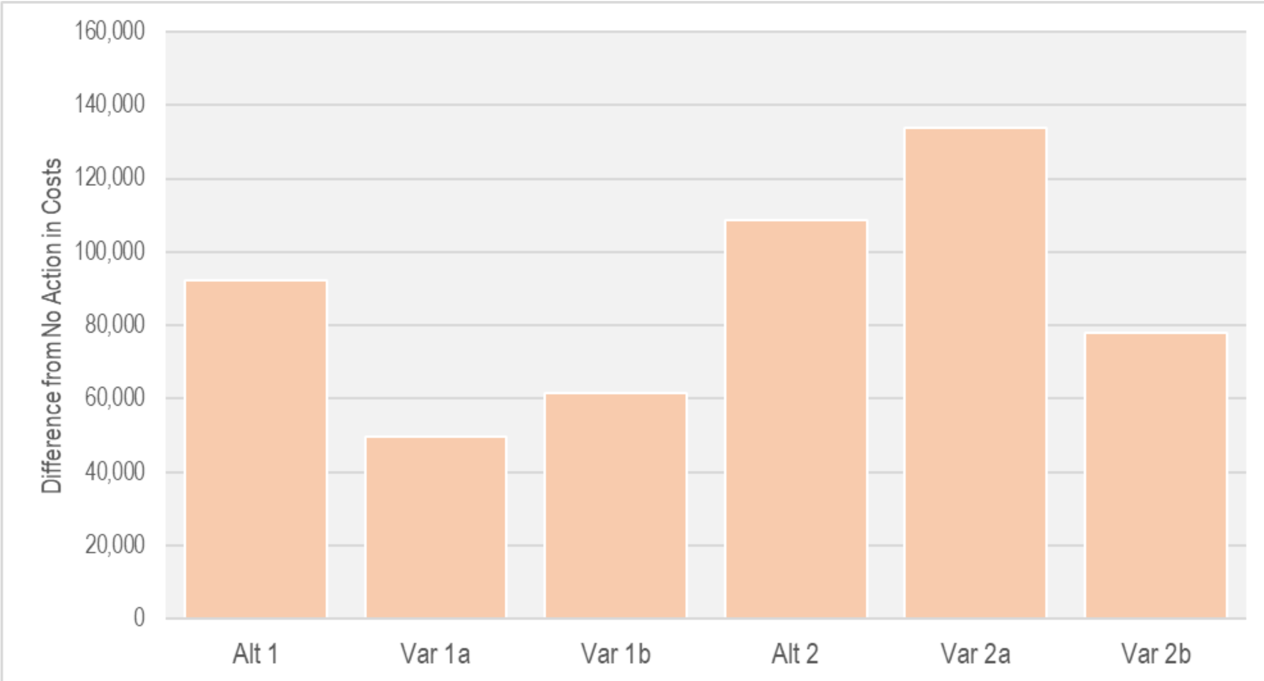


Figure 6-2. Average Annual Change in Tier 2 Operations and Maintenance Costs over the POR Relative to No Action, Missouri River Mainstem Irrigation Intakes (FY2021 Dollars)

6.1.1 No Action

Side Channel Case Study

Table 6-2 summarizes the NED analysis for No Action for the side channel case study. Overall, average annual net farm income for all four counties evaluated would be approximately $1.8 million. Total net farm income over the POR would be approximately $148 million for all four counties under the side channel case study. Under No Action, intakes on side channels do not experience additional high flow events that lead to loss of irrigation functions. Therefore, net farm income under No Action is a function of irrigated crop production, which remains consistent each year.

Table 6-2. Summary of National Economic Development Analysis for No Action During the Irrigation Season Over the Period of Record (Missouri River Side Channel Intakes in Montana) (FY2021 Dollars)

State	County	Total Net Farm Income over the POR	Average Annual Net Farm Income
Montana	McCone	$20,287,000	$247,000
	Valley	$16,226,000	$198,000
	Roosevelt	$52,514,000	$640,000
	Richland	$59,157,000	$721,000
Total		$148,184,000	$1,807,000

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel intakes, on average over the POR, 11 out of 135 intakes (8 percent) were impacted by tier 1 events while 4 intakes (3 percent) were impacted by tier 2 events. There were 18 tier 1 events and 4 tier 2 events annually during irrigation seasons on average over the POR. These impacts varied between a low of no tier 1 or 2 impacts during the lowest water flow years and 108 tier 1 events (occurring in 1975) and 135 tier 2 events (occurring in 2011) during the highest water flow years. The number of specific intakes that were impacted varied as well with a maximum of 81 intakes impacted under a tier 1 event during an irrigation season in a year like 1975 and a minimum of no intakes impacted during the irrigation season in a year like 1977. Under tier 2 events, there would be a maximum of 135 intakes impacted during an irrigation season in a year like 2011 and a minimum of no intakes impacted during the irrigation season in a year like 2010. Figure 6-3 and Figure 6-4 show the number of tier 1 and 2 events, respectively, occurring during the irrigation seasons in each year over the period of record while Figure 6-5 shows the number of intakes impacted by tier 1 events, over the same period. An intake experiencing a tier 2 event will count the event as occurring once per season; therefore, Figure 6-4 also represents the total number of intakes impacted by tier 2 events.

Average annual tier 1 costs of $241,981 and tier 2 costs of $137,248 occurred over the POR. Tier 1 costs reached a maximum of $1.5 million during the irrigation season in a year like 1975 and tier 2 costs reached a maximum of $4.4 million during the irrigation season in a year like 2011[5] (See Table 6-4).

Table 6-3. Summary of National Economic Development Analysis for No Action During the Irrigation Season Over the Period of Record (Missouri River Mainstem Intakes) (FY2021 Dollars)

Statistic	Average Annual Impacts	Year of Minimum Impacts	Year of Maximum Impacts
Tier 1 Events	18	0	108
Tier 2 Events	4	0	135
Tier 1 Costs	$241,981	$0	$1,463,037
Tier 2 Costs	$137,248	$0	$4,365,901
Tier 1 Intakes	11	0	81
Tier 2 Intakes	4	0	135

Note that the values presented in Table 6-3 above are annual averages during all years under the POR whereas the average annual impacts presented in the following high flows sections for each alternative or variation are annual averages during full or partial flow years. Therefore, it is not possible to subtract the “Delta from No Action” value from the “Value” column in the following tables in each section below and obtain the result presented in the “Average Annual Impacts” column in Table 6-3 above. This is because each action alternative or its variation runs during a different set of full or partial flow years over the POR, and the results for each of these years are compared against the No Action results in the year in which the flow event is run.

[55] Note that this model uses weighted average costs obtained from surveys and interviews. Therefore, these costs may underestimate the larger operations and maintenance costs seen in 2011 given the extreme high flow event that occurred in this year.

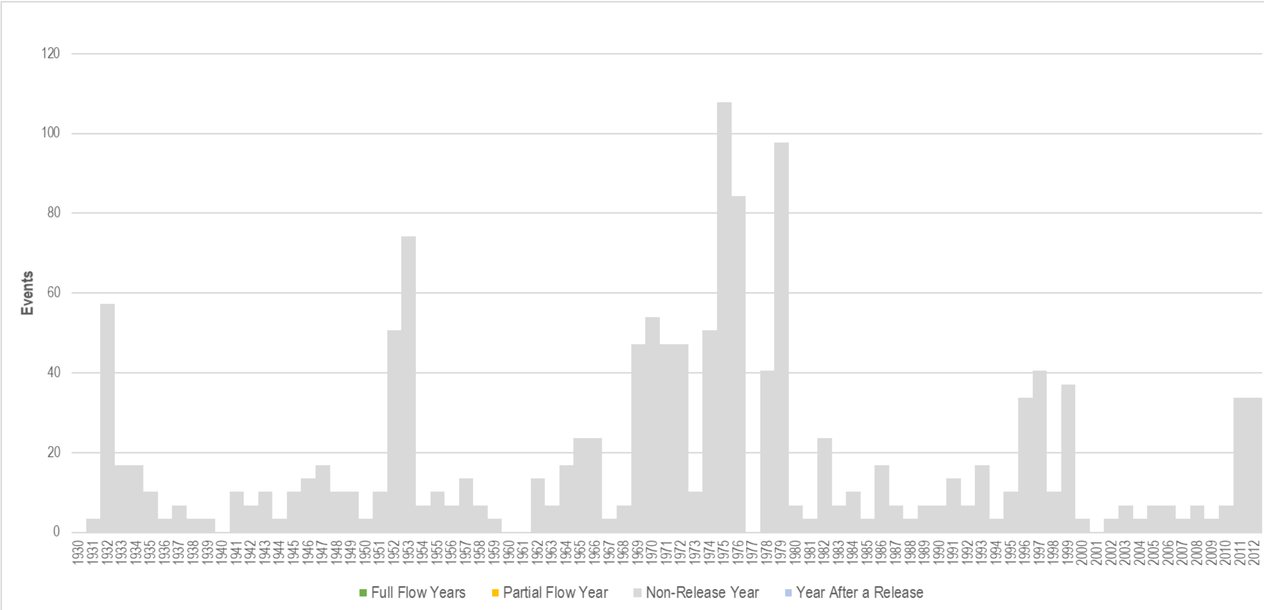


Figure 6-3. Number of Tier 1 Events Occurring Under No Action During the Irrigation Season (Missouri River Mainstem Intakes)

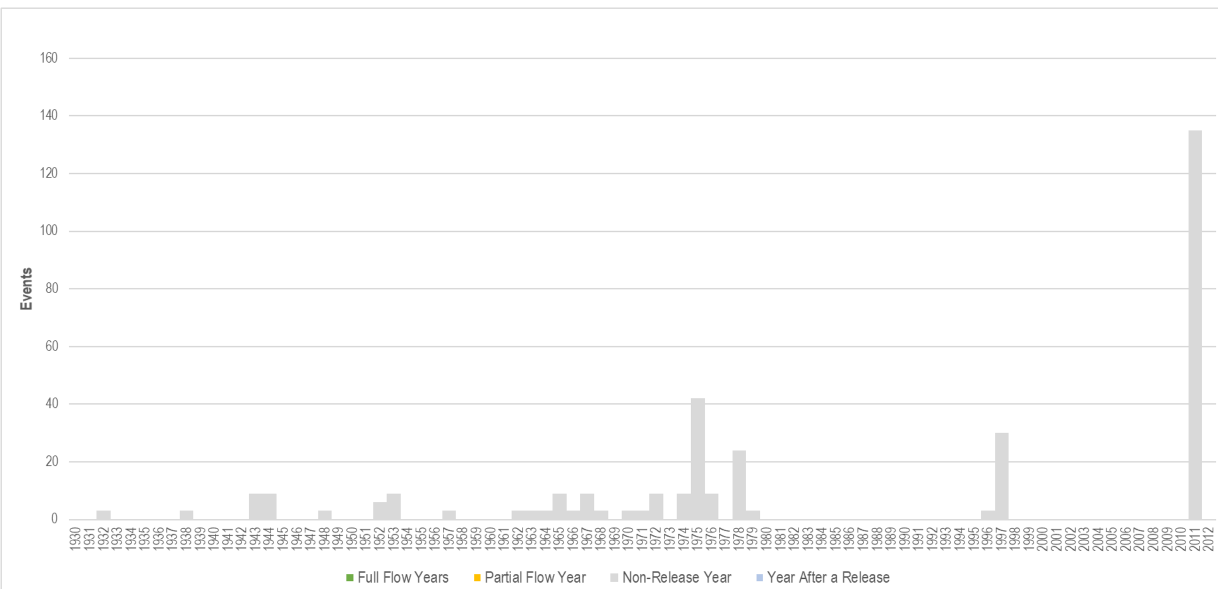


Figure 6-4. Number of Tier 2 Events Occurring Under No Action During the Irrigation Season (Missouri River Mainstem Intakes)

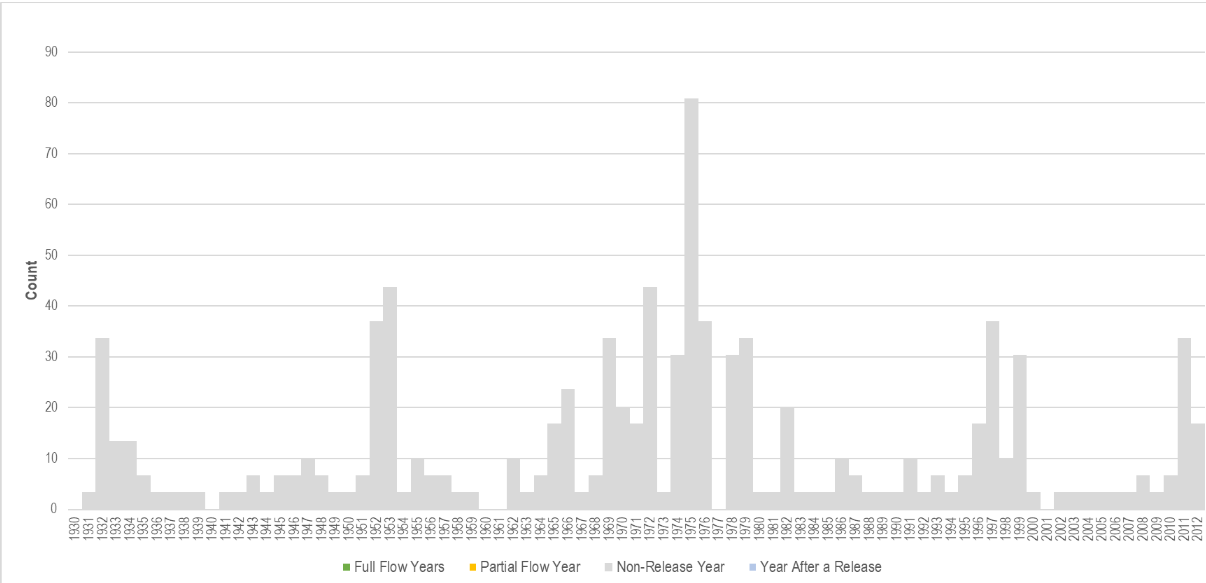


Figure 6-5. Number of Intakes Impacted by Tier 1 Events Occurring Under No Action During the Irrigation Season (Missouri River Mainstem Intakes)

6.1.2 Alternative 1

Side Channel Case Study

Under all alternatives, including Alternative 1, a high flow event would result in an estimated decrease in net farm income to intakes located on side channels of $7.5 million (See Table 6-4). Averaging across intakes and counties, this translates to a decrease of $245,353 per side channel intake during high flow events. Alternative 1 has 11 potential test flow years when losses in net farm income to intakes located on side channels could occur. Across counties, the estimate loss in net farm income varies depending on the crop mix and number of side channels in each county, with the highest losses occurring in Richland County and the lowest losses occurring in McCone County.

Table 6-4. Summary of National Economic Development Analysis for All Action Alternatives (FY2021 Dollars)

State	County	Decrease in Net Farm Income During Test Flow Years Compared to No Action	Average Change in Net Farm Income Per Side Channel Intake During Test Flow Years Compared to No Action
Montana	McCone	-$1,039,084	-$131,413
	Valley	-$534,437	-$144,398
	Roosevelt	-$2,816,081	-$274,411
	Richland	-$3,135,857	-$355,045
Total		-$7,525,459	-$245,353

A sensitivity analysis was undertaken to test the sensitivity of all alternatives to assumptions about the percent of intakes with crops impacted by test flows and differences in operations and maintenance costs (see Table 6-5). The default assumption of the model is that all side channel intakes are unable to irrigate following a high flow event. However, interviews with irrigators indicated that some side channel intakes may be able to continue irrigating after a high flow event. As a result, the model was tested with varying percentages of side channel intakes losing their ability to irrigate following a test flow. Under all alternatives, varying this assumption indicates that total annual decrease in net farm income during test flow years compared to the No Action Alternative can be as high as $7.5 million across all four counties if all intakes are unable to irrigate after a test flow but could be as low as $2.1 million if only 25% lose their ability to irrigate after a test flow.

Similarly, a sensitivity analysis was conducted by varying operation and maintenance costs that would be incurred after a high flow event. The default assumption of the model is that side channel intakes each incur costs of $10,000 following a test flow event. Interviews with irrigators revealed a range of possible costs however. Some irrigators reported costs as low as $2,000 per intake or as high as $30,000 per intake. The model was tested with this range of operation and maintenance cost parameters, which revealed that the total annual decrease in net farm income during test flow years compared to the No Action Alternative can be as high as $8.1 million across all four counties if the cost assumption was increased to $30,000 or as low as $7.3 million if the cost assumption was decreased to $2,000. Increasing the operation and maintenance cost assumption to $30,000 increase net income losses by 8% compared to the base case scenario, and decreasing the cost assumption to $2,000 decreases the losses in net income by 3%.

While it is not expected that none of side channel intakes would have their crops unaffected nor would irrigators incur additional operation and maintenance costs after a high flow event, these assumptions are included in the table below to provide a basis for understanding the magnitude of the impacts that could occur.

Table 6-5. Summary of Sensitivity Results for All Alternatives, Average Annual During Full Flow Year (FY2021 Dollars)

Variable	Assumption	All Alts, Average Annual Net Income, Delta from No Action	Relative Percentage Change from Base Case Assumptions
1. Percent of Intakes with Crops Impacted	100%*	-$7,525,459	0%
	75%	-$5,720,851	-24%
	50%	-$3,916,243	-48%
	25%	-$2,111,635	-72%
	0%	-$307,027	-96%
2. O&M Costs	$30,000	-$8,139,513	8%
	$10,000*	-$7,525,459	0%
	$2,000	-$7,279,838	-3%
	$0	-$7,218,432	-4%

*Note: These values are the base case values for each sensitivity variable.

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel intakes under Alternative 1, there would be 19 years when the both the number of intakes impacted by tier 1 events increased and the number of tier 1 events increased relative to the No Action Alternative (see Figure 6-6 and Figure 6-8). Adverse impacts occur in both full and partial flow years. There are four years when the number of tier 1 events decreased and one year (1988) where the number of intakes impacted by tier 1 events decrease. There would be 17 years when the number of intakes impacted by tier 2 events increased and no years when the number of events decreased (see Figure 6-7). The year with the largest increase for tier 1 impacts was a full flow year like 1983 and the year with the largest increase for tier 2 impacts was 1968, a partial flow year. Impacts in 1983 and 1968 were both driven by high flows out of Fort Peck Dam in June. Beneficial impacts, while limited to only four years for tier 1 impacts, are limited to partial flow release years and years after a full release. These benefits primarily occur because of lower summer flows in under Alternative 1 as compared to the No Action Alternative resulting in fewer tier 1 impacts.

There are 44 tier 1 events and 11 tier 2 events on average annually during full or partial flow years. These are 18 and 7 more tier 1 and 2 events, respectively, than occur during the same flow years under the No Action alternative. These changes in tier 1 and 2 events drive increases in operations and maintenance costs of $242,887 and $236,486 on average annually for tier 1 and 2 events, respectively, during these full and partial flow years relative to No Action (See Table 6-6).

Table 6-6. Summary of National Economic Development Analysis for Alternative 1 During the Irrigation Season During Full or Partial Flow Years (Missouri River Mainstem Intakes) (FY2021 Dollars)

Statistic	Average Annual Impacts		Year of Minimum Impacts		Year of Maximum Impacts	
	Value	Delta from No Action	Value	Delta from No Action	Value	Delta from No Action
Tier 1 Events	44	18	0	0	98	(10)
Tier 2 Events	11	7	0	0	42	-
Tier 1 Costs	$600,074	$242,887	$0	$0	$1,325,877	-$137,160
Tier 2 Costs	$354,729	$236,486	$0	$0	$1,358,280	$0
Tier 1 Intakes	34	19	0	0	81	-
Tier 2 Intakes	11	7	0	0	42	-

Note: Annual average impacts presented in this table are taken as annual average during full or partial flow years; whereas annual averages for the No Action Alternative presented in Table 6-3 above are taken as annual averages during all years under the POR. Therefore, it is not possible to subtract the values in the "Delta from No Action" column from the "Value" column in the table above and obtain the result presented in Table 6-3.

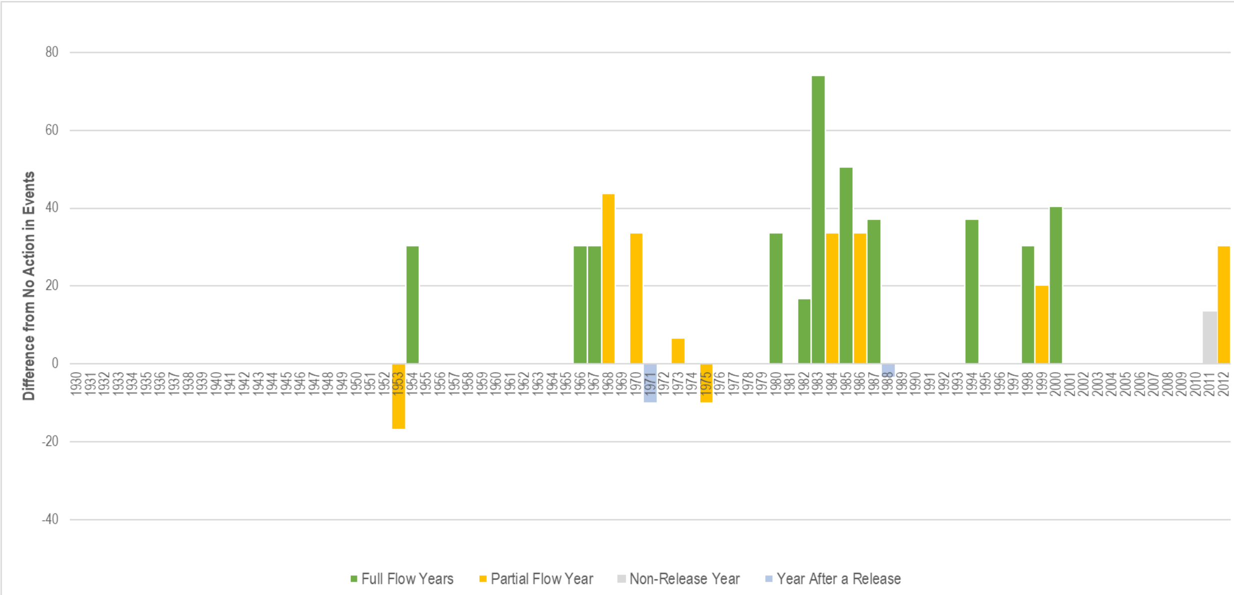


Figure 6-6. Number of Tier 1 Events Occurring under Alternative 1, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

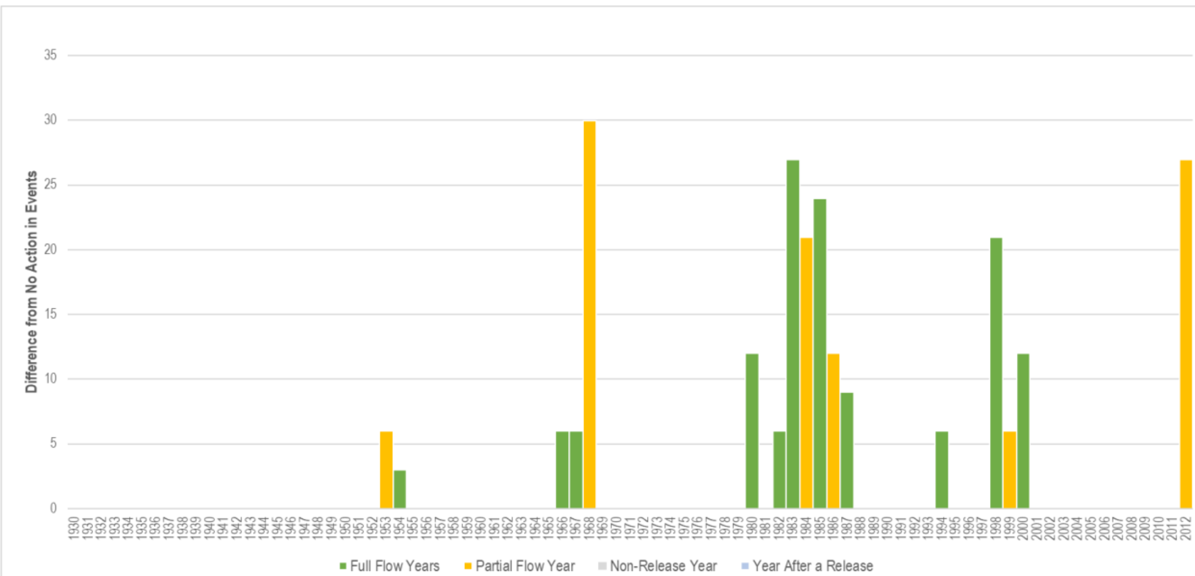


Figure 6-7. Number of Tier 2 Events Occurring under Alternative 1, Irrigation Season

(Difference from No Action, Missouri River Mainstem Intakes)

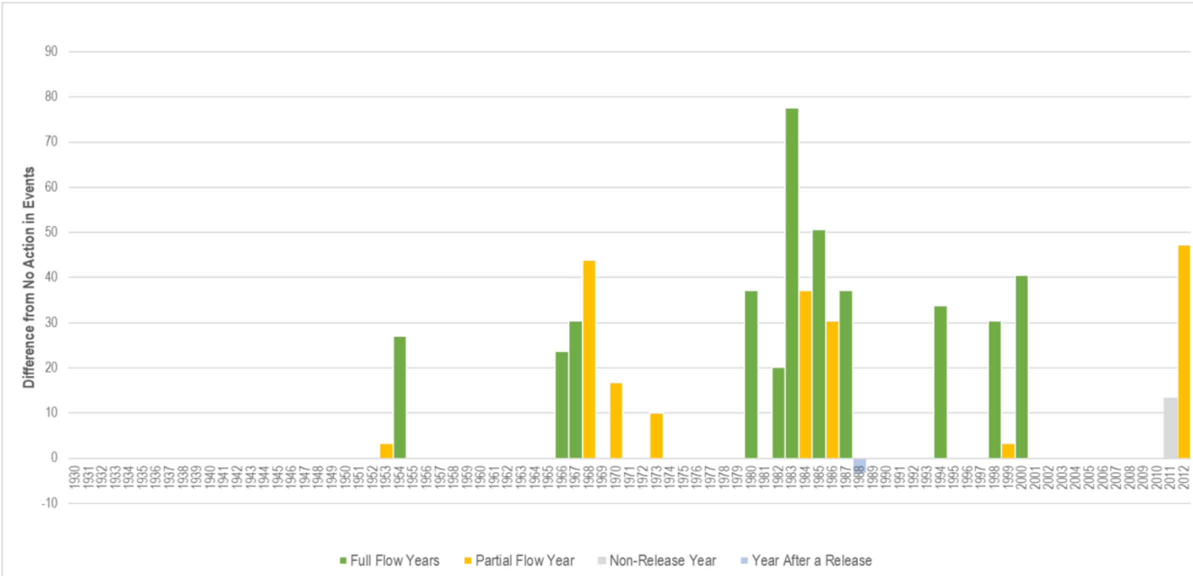


Figure 6-8. Number of Intakes Impacted under Tier 1 Events, Alternative 1, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

6.1.3 Alternative 1 – Variation 1A

Side Channel Case Study

Under all alternatives, including Variation 1A, the total decrease in net farm income due to impacts of high flows on side channel intakes during a test flow year would be $7.5 million. Averaging across intakes and counties, this translates to a decrease of $245,353 per side channel intake during test flow years. For all counties, over the modeled POR, the alternative with the largest potential for overall change in net farm income for side channel irrigation intakes would be Variation 1A. Because Variation 1A has 16 potential test flow years, the most out of any alternative, it has the potential for the largest change in net income for side channel irrigation intakes compared to No Action. The sensitivity analysis results that are discussed in Alternative 1 apply to this variation as well.

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel intakes under Variation 1A, there would be 18 years when the both the number of intakes impacted by tier 1 events increased and 17 years when the number of tier 1 events increased relative to the No Action Alternative (see

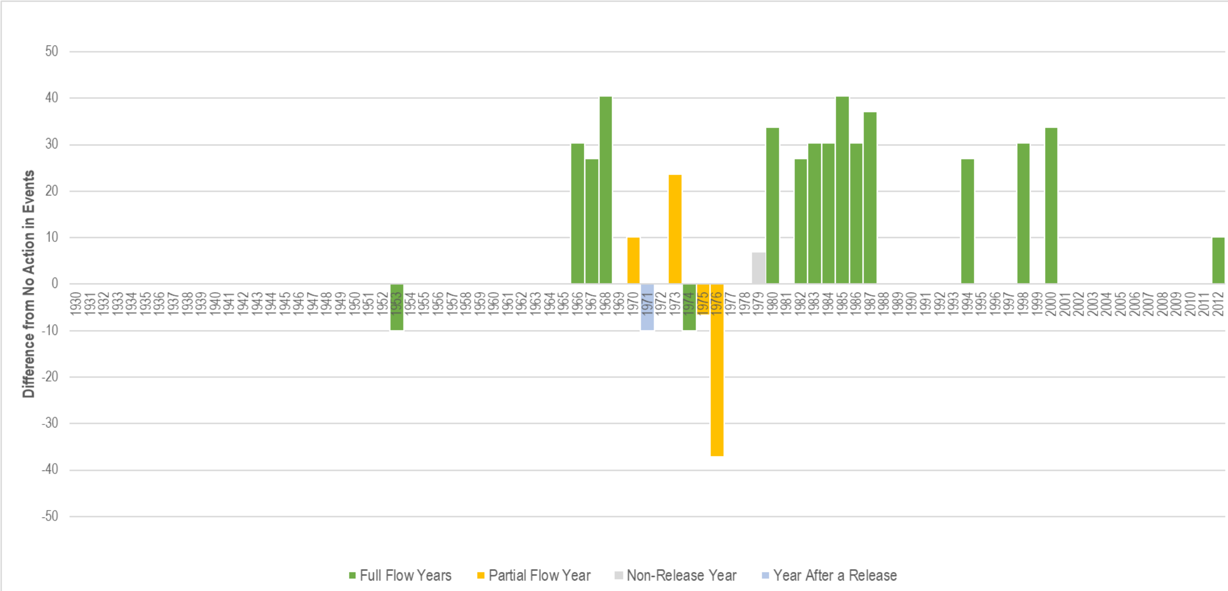
Figure 6-9 and Figure 6-11). Adverse impacts occur in both full and partial flow years. There are five years when the number of tier 1 events decreased and one year (1979) where the number of intakes impacted by tier 1 events decrease. There are 17 years when the number of intakes impacted by tier 2 events increased and one year when these types of events decreased (see Figure 6-10). Most of these adverse impacts are in full flow years except for two partial flow years with tier 1 and tier 2 impacts. The years with the largest increase in tier 1 impacts were full flow years like 1968 and 1985 and the year with the largest increase for tier 2 impacts was 1982, also a full flow year. Impacts in these years were all driven by high flows out of Fort Peck Dam in June. Beneficial impacts, while limited to only five years for tier 1 impacts, occur during full flow years, partial flow release years and a year after a full release. These benefits primarily occur because of lower summer flows under Variation 1A as compared to the No Action Alternative resulting in fewer tier 1 and tier 2 impacts.

There are 37 tier 1 events and 8 tier 2 events on average annually during full or partial flow years. These are 13 and 4 more tier 1 and 2 events, respectively, than occur during the same flow years under the No Action alternative. These changes in tier 1 and 2 events drive increases in operations and maintenance costs of $169,606 and $131,446 on average annually for tier 1 and 2 events, respectively, during these full and partial flow years relative to No Action (See Table 6-14).

Table 6-7. Summary of National Economic Development Analysis for Variation 1A During the Irrigation Season During Full or Partial Flow Years (Missouri River Mainstem Intakes) (FY2021 Dollars)

Statistic	Average Annual Impacts		Year of Minimum Impacts		Year of Maximum Impacts	
	Value	Delta from No Action	Value	Delta from No Action	Value	Delta from No Action
Tier 1 Events	37	13	0	0	101	(7)
Tier 2 Events	8	4	0	0	42	-
Tier 1 Costs	$495,545	$169,606	$0	$0	$1,371,597	-$91,440
Tier 2 Costs	$250,374	$131,446	$0	$0	$1,358,280	$0
Tier 1 Intakes	32	16	0	0	81	-
Tier 2 Intakes	8	4	0	0	42	-

Note: Annual average impacts presented in this table are taken as annual average during full or partial flow years; whereas annual averages for the No Action Alternative presented in Table 6-3 above are taken as annual averages during all years under the POR. Therefore, it is not possible to subtract the values in the "Delta from No Action" column from the "Value" column in the table above and obtain the result presented in Table 6-3.



Difference from No Action in Events
Full Flow Years
Partial Flow Year
Non-Release Year
Year After a Release

Figure 6-9. Number of Tier 1 Events Occurring under Variation 1A, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

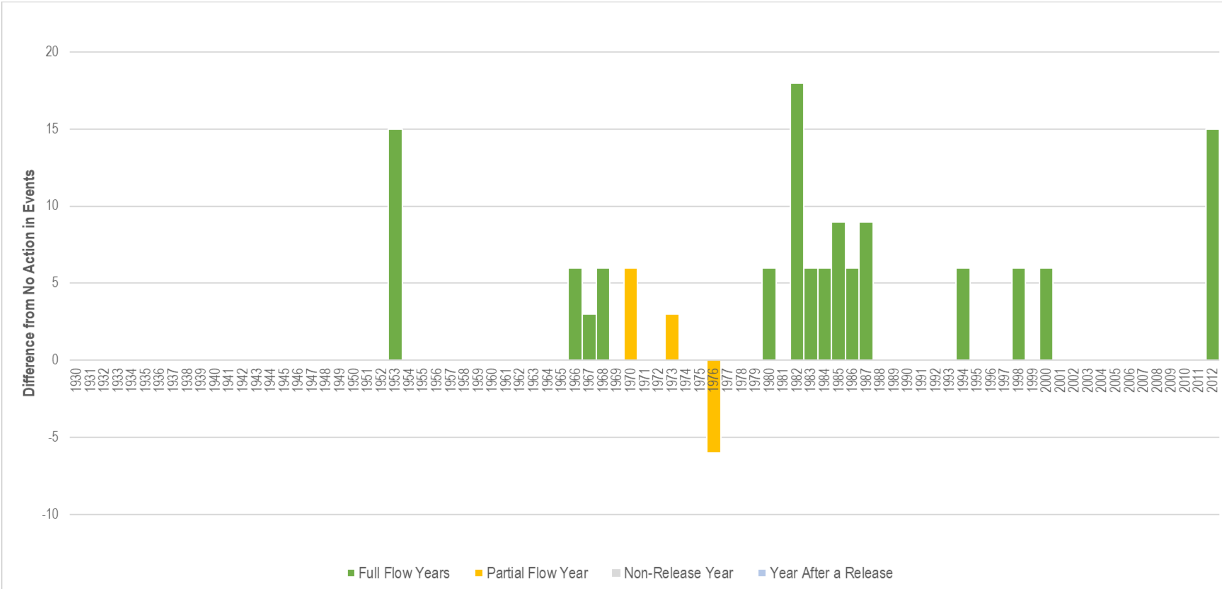


Figure 6-10. Number of Tier 2 Events Occurring under Variation 1A, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

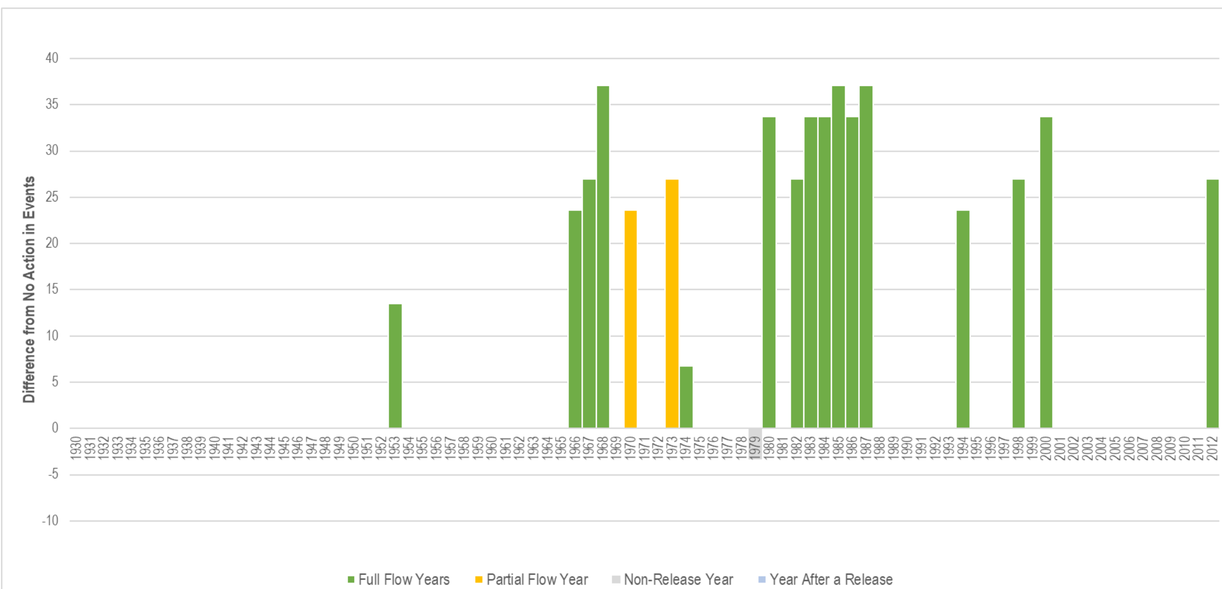


Figure 6-11. Number of Intakes Impacted under Tier 1 Events, Variation 1A, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

6.1.4 Alternative 1 – Variation 1B

Side Channel Case Study

Under all alternatives, including Variation 1B, the total decrease in net farm income to side channel intakes due to high flows during a test flow year would be $7.5 million. Averaging across intakes and counties, this translates to a decrease of $245,353 per side channel intake during test flow years. Variation 1B has eight potential test flow years where losses in net farm income could occur to side channel intakes as result of high flows. The sensitivity analysis results that are discussed in Alternative 1 apply to this variation as well.

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel intakes under Variation 1B, there are 21 years when the number of intakes impacted by tier 1 events increased and 23 years when the number of tier 1 events increased relative to the No Action (see Figure 6-12 and Figure 6-14). Adverse impacts occur in both full and partial flow years. There are two years where the number of tier 1 events decreased and three years where the number of intakes impacted by tier 1 events decrease. There are 15 years when the number of intakes impacted by tier 2 events increased and one year (1963) when this decreased (see Figure 6-13). The year with the largest increase for both tier 1 and tier 2 impacts was a partial flow year like 1983. Impacts in this year were driven by high flows out of Fort Peck Dam in June. Beneficial impacts, while limited to only two years for tier 1 impacts and one year for tier 2 impacts, are limited to partial flow release years. These benefits primarily occur because of lower summer flows in under Variation 1B as compared to the No Action Alternative resulting in fewer tier 1 and tier 2 impacts.

There are 41 tier 1 events and 7 tier 2 events on average annually during full or partial flow years. These are 17 and 4 more tier 1 and 2 events, respectively, than occur during the same flow years under the No Action alternative. These changes in tier 1 and 2 events drive increases in operations and maintenance costs of $229,835 and $133,730 on average annually for tier 1 and 2 events, respectively, during these full and partial flow years relative to No Action (See

Table 6-8).

Table 6-8. Summary of National Economic Development Analysis for Variation 1B During the Irrigation Season During Full or Partial Flow Years (Missouri River Mainstem Intakes) (FY2021 Dollars)

Statistic	Average Annual Impacts		Year of Minimum Impacts		Year of Maximum Impacts	
	Value	Delta from No Action	Value	Delta from No Action	Value	Delta from No Action
Tier 1 Events	41	17	0	0	111	3
Tier 2 Events	7	4	0	0	42	-
Tier 1 Costs	$554,817	$229,835	$0	$0	$1,508,756	$45,720
Tier 2 Costs	$238,617	$133,730	$0	$0	$1,358,280	$0
Tier 1 Intakes	29	15	0	0	81	-
Tier 2 Intakes	7	4	0	0	42	-

Note: Annual average impacts presented in this table are taken as annual average during full or partial flow years; whereas annual averages for the No Action Alternative presented in Table 6-3 above are taken as annual averages during all years under the POR. Therefore, it is not possible to subtract the values in the "Delta from No Action" column from the "Value" column in the table above and obtain the result presented in Table 6-3.

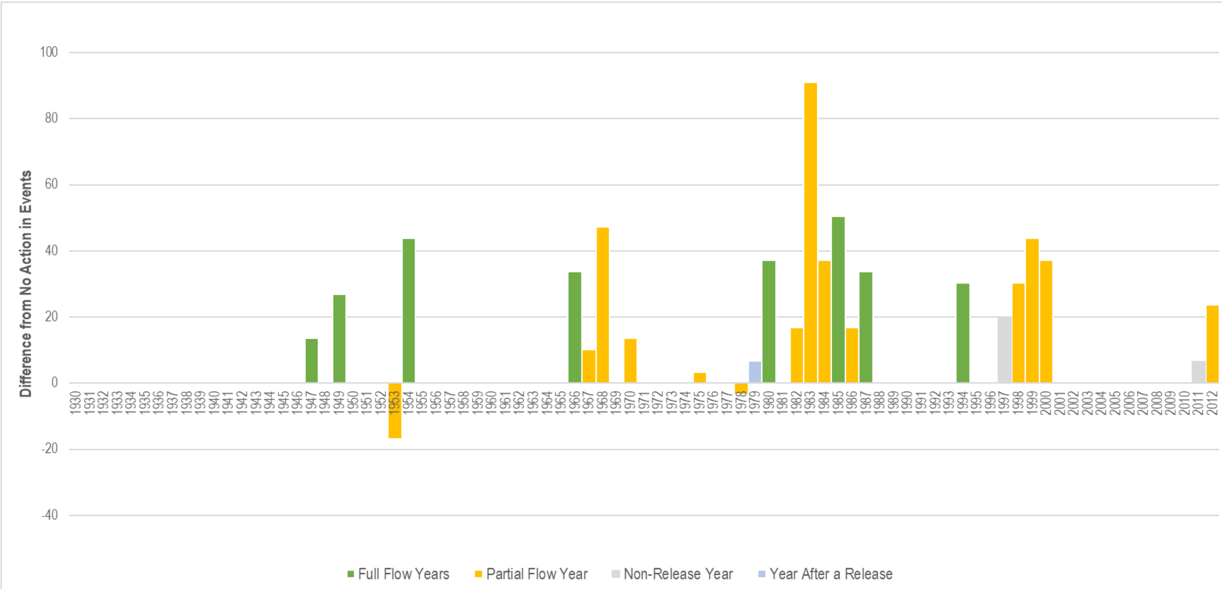


Figure 6-12. Number of Tier 1 Events Occurring under Variation 1B, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

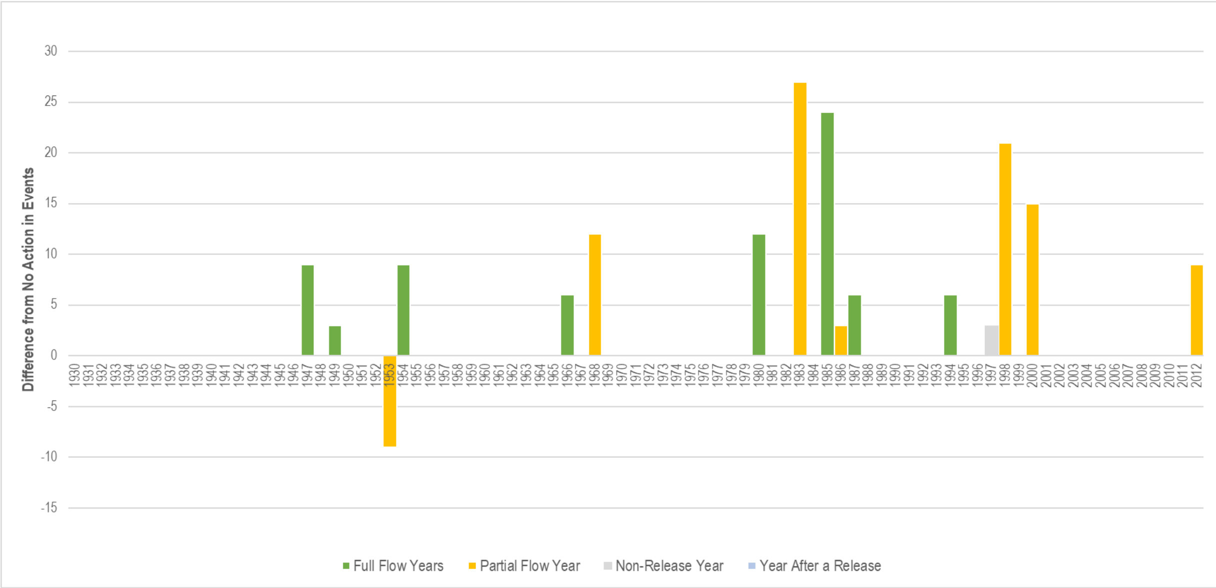


Figure 6-13. Number of Tier 2 Events Occurring under Variation 1B, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

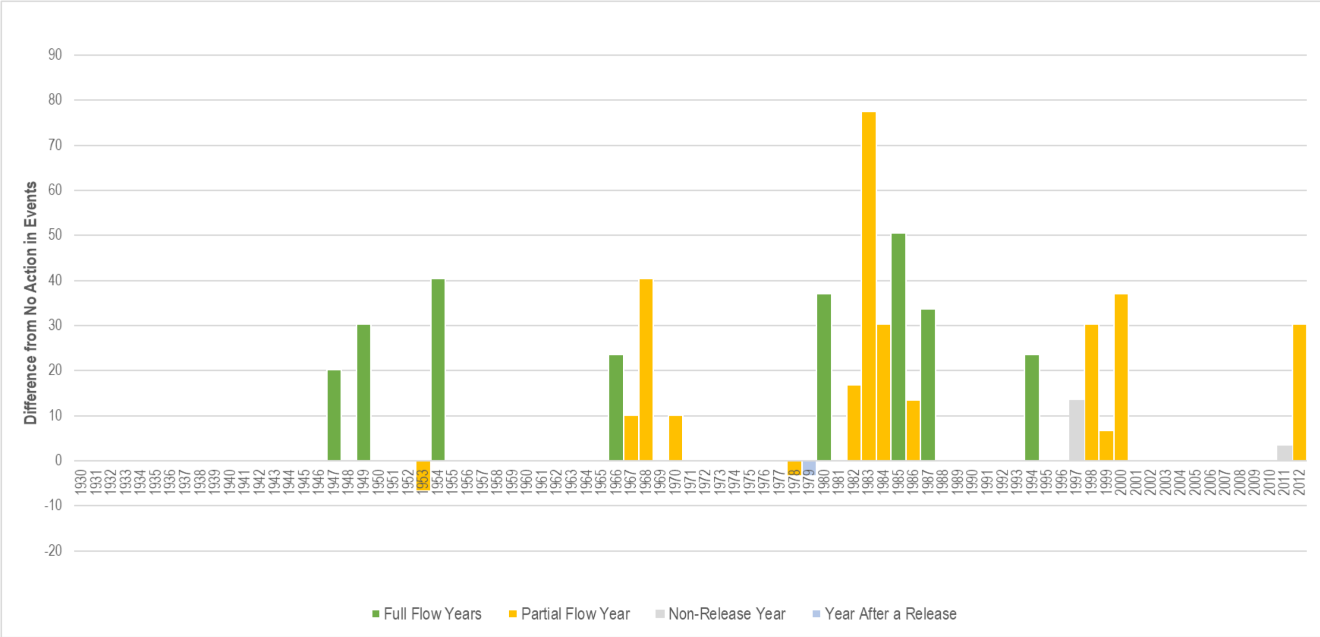


Figure 6-14. Number of Intakes Impacted under Tier 1 Events, Variation 1B, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

6.1.5 Alternative 2

Side Channel Case Study

Under all alternatives, including Alternative 2, the total decrease in net farm income to side channel intakes due to high flows during a test flow year would be $7.5 million. Averaging across intakes and counties, this translates to a decrease of $245,353 per side channel intake during test flow years. Alternative 2 has 10 potential test flow years where losses in net farm income could occur to side channel intakes resulting from a high flow event. The sensitivity analysis results that are discussed in Alternative 1 apply to this alternative as well.

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel intakes under Alternative 2, there are 19 years when the both the number of intakes impacted by tier 1 events increased and the number of tier 1 events increased relative to the No Action (see Figure 6-15 and Figure 6-17). Adverse impacts occur in both full and partial flow years. There are four years when the number of tier 1 events decreased and one year (1988) when the number of intakes impacted by tier 1 events decrease. There are 15 years when the number of intakes impacted by tier 2 events increased and one year (1970) when this decreased (see Figure 6-16). The years with the largest increase from the No Action Alternative for both tier 1 and tier 2 events were all partial flow release years. The largest tier 1 impact were partial flow years 1967 and 1986 and the largest tier 2 impacts were 1968, relative to the No Action Alternative. Impacts in these years were driven by higher flows out of Fort Peck Dam in June. Beneficial impacts, while limited to only four years for tier 1 impacts and one year for tier 2 impacts, are limited to partial flow release years and years after a full release. These benefits primarily occur because of lower summer flows in under Alternative 2 as compared to the No Action Alternative resulting in fewer tier 1 and tier 2 impacts.

There are 47 tier 1 events and 13 tier 2 events on average annually during full or partial flow years. These are 19 and 9 more tier 1 and 2 events, respectively, than occur during the same flow years under the No Action alternative. These changes in tier 1 and 2 events drive increases in operations and maintenance costs of $259,079 and $297,528 on average annually for tier 1 and 2 events, respectively, during these full and partial flow years relative to No Action (See

Table 6-9).

Table 6-9. Summary of National Economic Development Analysis for Alternative 2 During the Irrigation Season During Full or Partial Flow Years (Missouri River Mainstem Intakes) (FY2021 Dollars)

Statistic	Average Annual Impacts		Year of Minimum Impacts		Year of Maximum Impacts	
	Value	Delta from No Action	Value	Delta from No Action	Value	Delta from No Action
Tier 1 Events	47	19	0	0	101	(7)
Tier 2 Events	13	9	0	0	42	-
Tier 1 Costs	$633,983	$259,079	$0	$0	$1,371,597	-$91,440
Tier 2 Costs	$423,654	$297,528	$0	$0	$1,358,280	$0
Tier 1 Intakes	35	18	0	0	81	-
Tier 2 Intakes	13	9	0	0	42	-

Note: Annual average impacts presented in this table are taken as annual average during full or partial flow years; whereas annual averages for the No Action Alternative presented in Table 6-3 above are taken as annual averages during all years under the POR. Therefore, it is not possible to subtract the values in the "Delta from No Action" column from the "Value" column in the table above and obtain the result presented in Table 6-3.

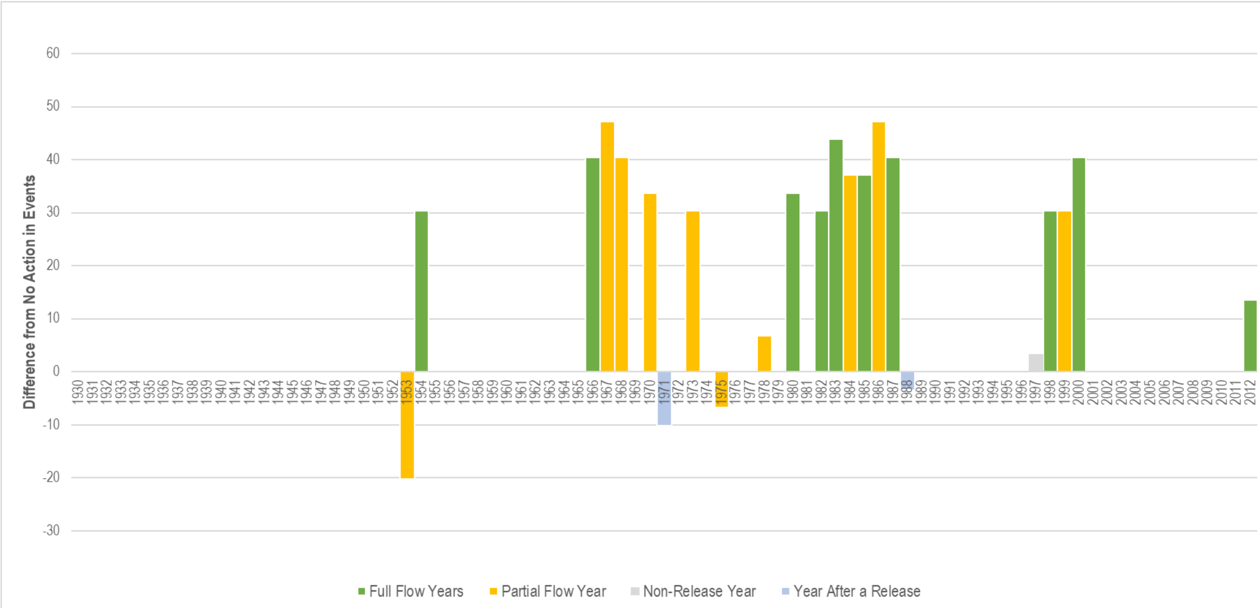


Figure 6-15. Number of Tier 1 Events Occurring under Alternative 2, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

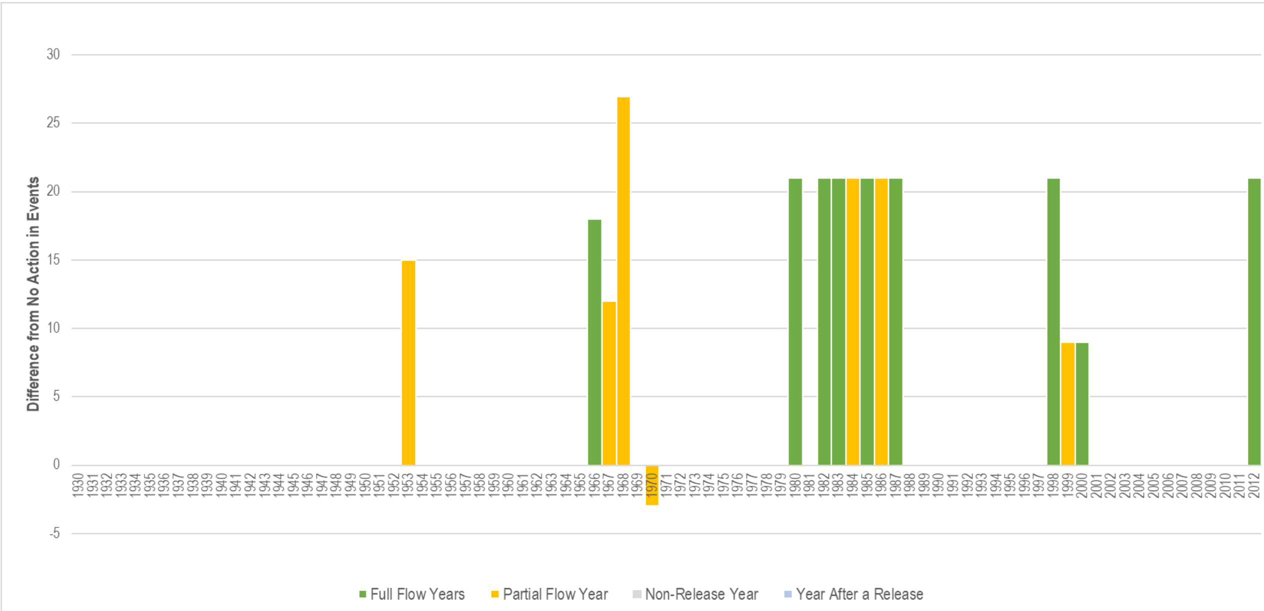


Figure 6-16. Number of Tier 2 Events Occurring under Alternative 2, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

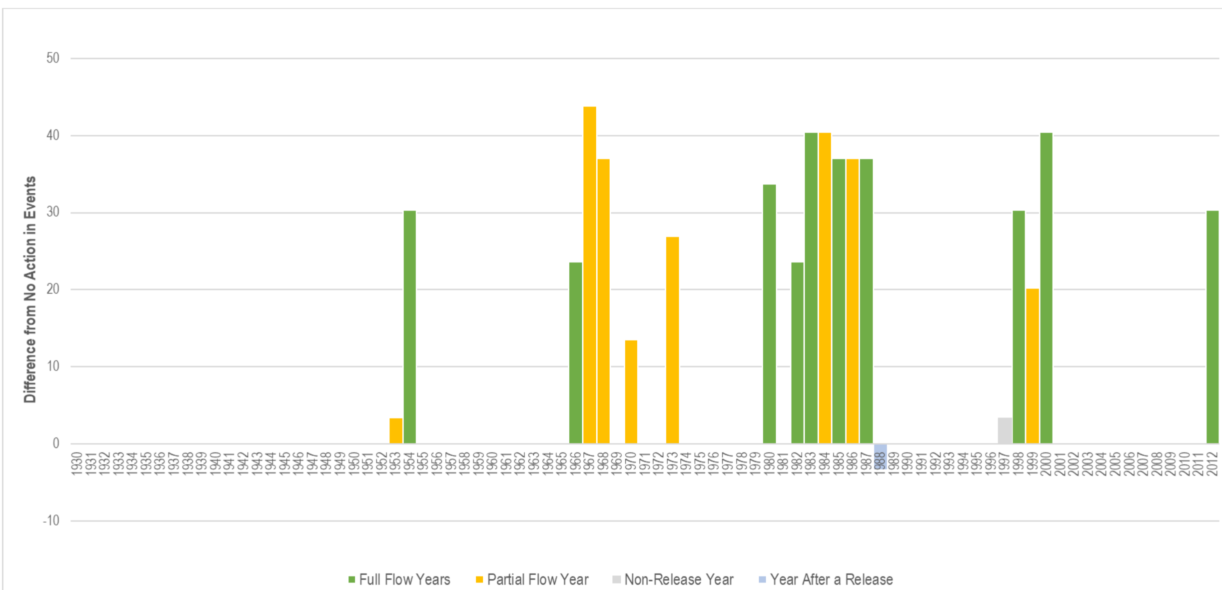


Figure 6-17. Number of Intakes Impacted under Tier 1 Events, Alternative 2, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

6.1.6 Alternative 2 – Variation 2A

Side Channel Case Study

Under all alternatives, including Variation 2A, the total decrease in net farm income to side channel intakes due to high flows during a test flow year would be $7.5 million. Averaging across intakes and counties, this translates to a decrease of $245,353 per side channel intake during test flow years. Variation 2A has 15 potential test flow years where losses in net farm income to side channel intakes could result from high flows. The sensitivity analysis results that are discussed in Alternative 1 apply to this variation as well.

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel intakes under Variation 2A, there are 21 years when the both the number of intakes impacted by tier 1 events increased and 19 years when the number of tier 1 events increased relative to the No Action (see Figure 6-18 and Figure 6-20). Adverse impacts occur in both full and partial flow years. There are four years when the number of tier 1 events decreased and one year (1988) when the number of intakes impacted by tier 1 events decrease. There would be 17 years when the number of intakes impacted by tier 2 events increased and no years when this decreased (see Figure 6-19). The year with the largest increase for tier 1 impacts was a full flow year like 1967 and the years with the largest increase for tier 2 impacts were 1968, 1982, and 2012, all full flow years. Impacts in these years were driven by high flows out of Fort Peck Dam in June. Beneficial impacts, while limited to only four years for tier 1 impacts, are limited to partial flow release years and years after a full release. These benefits primarily occur because of lower summer flows in under Variation 2A as compared to the No Action Alternative resulting in fewer tier 1 impacts.

There are 44 tier 1 events and 16 tier 2 events on average annually during full or partial flow years. These are 19 and 12 more tier 1 and 2 events, respectively, than occur during the same flow years under the No Action alternative. These changes in tier 1 and 2 events drive increases in operations and maintenance costs of $252,248 and $378,044 on average annually for tier 1 and 2 events, respectively, during these full and partial flow years relative to No Action (See Table 6-10).

Table 6-10. Summary of National Economic Development Analysis for Variation 2A During the Irrigation Season During Full or Partial Flow Years (Missouri River Mainstem Intakes) (FY2021 Dollars)

Statistic	Average Annual Impacts		Year of Minimum Impacts		Year of Maximum Impacts	
	Value	Delta from No Action	Value	Delta from No Action	Value	Delta from No Action
Tier 1 Events	44	19	0	0	105	(3)
Tier 2 Events	16	12	0	0	42	-
Tier 1 Costs	$594,359	$252,248	$0	$0	$1,417,317	-$45,720
Tier 2 Costs	$505,173	$378,044	$0	$0	$1,358,280	$0
Tier 1 Intakes	37	21	0	0	84	3
Tier 2 Intakes	16	12	0	0	42	-

Note: Annual average impacts presented in this table are taken as annual average during full or partial flow years; whereas annual averages for the No Action Alternative presented in Table 6-3 above are taken as annual averages during all years under the POR. Therefore, it is not possible to subtract the values in the "Delta from No Action" column from the "Value" column in the table above and obtain the result presented in Table 6-3.

Figure 6-18. Number of Tier 1 Events Occurring under Variation 2A, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

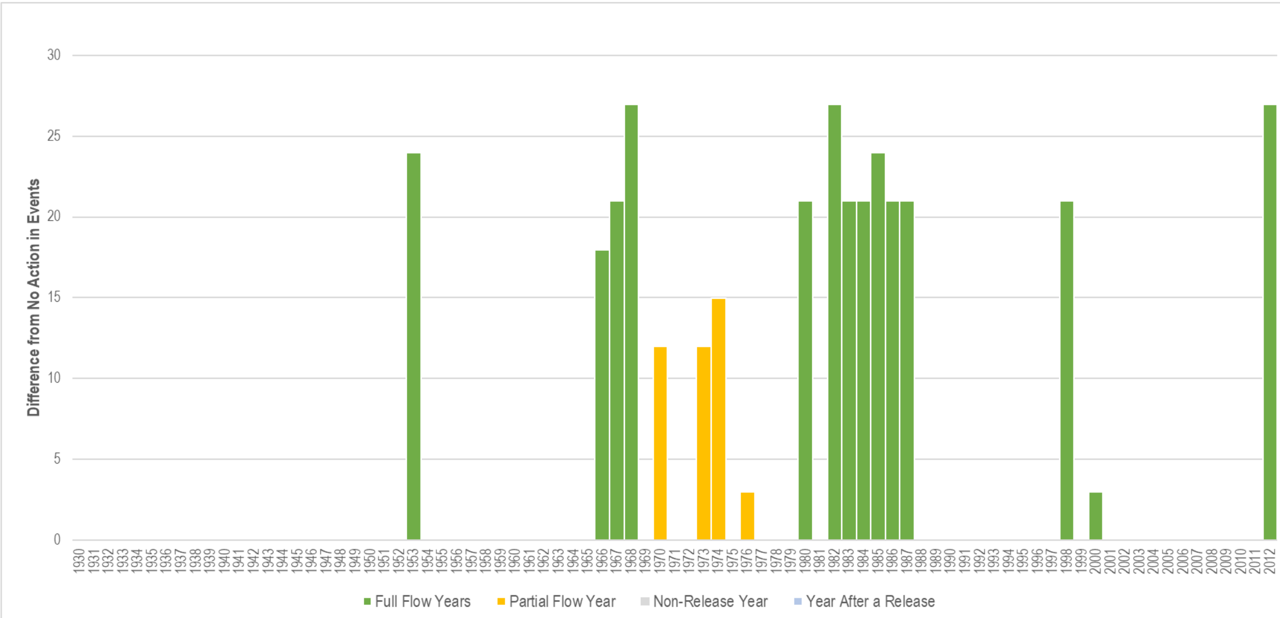


Figure 6-19. Number of Tier 2 Events Occurring under Variation 2A, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

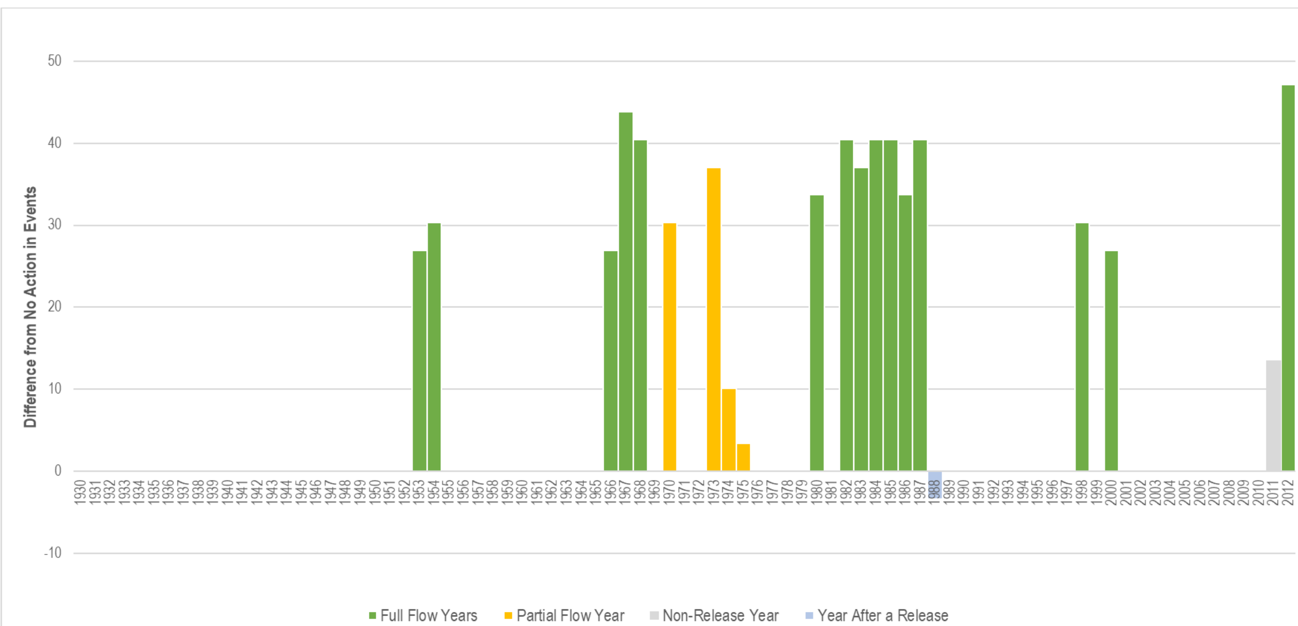


Figure 6-20. Number of Intakes Impacted under Tier 1 Events, Variation 2A, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

6.1.7 Alternative 2 – Variation 2B

Side Channel Case Study

Under all alternatives, including Variation 2B, the total decrease in net farm income to side channel intakes due to high flows during a test flow year would be $7.5 million. Averaging across intakes and counties, this translates to a decrease of $245,353 per side channel intake during test flow years. Variation 2A has eight potential test flow years where losses in net farm income to side channel intakes could result from high flows. The sensitivity analysis results that are discussed in Alternative 1 apply to this variation as well.

Missouri River Mainstem Irrigation Intakes Analysis

For Missouri River mainstem channel intakes under Alternative 2B, there would be 21 years when the number of intakes impacted by tier 1 events increased and 25 years when the number of tier 1 events increased relative to the No Action (see Figure 6-21 and Figure 6-23). Adverse impacts occur in both full and partial flow years. There are two years when both the number of tier 1 events and the number of intakes impacted by tier 1 events decrease. There are 15 years when the number of intakes impacted by tier 2 events increased and no years when this decreased (see Figure 6-22). The years with the largest increase for tier 1 impacts relative to the No Action Alternative are the full flow years 1966 and 1983 and the year with the largest increase for tier 2 impacts are six years, including 1949, a partial flow year, and 1980, and 1998, full flow years. Impacts in these years were driven by high flows out of Fort Peck Dam in June. Beneficial impacts, while limited to only two years for tier 1 impacts, and one year for tier 2 impacts are limited to partial flow release years and years after a full release. These benefits primarily occur because of lower summer flows in under Variation 2B as compared to the No Action Alternative resulting in fewer tier 1 impacts.

There are 42 tier 1 events and 9 tier 2 events on average annually during full or partial flow years. These are 18 and 5 more tier 1 and 2 events, respectively, than occur during the same flow years under the No Action alternative. These changes in tier 1 and 2 events drive increases in operations and maintenance costs of $248,370 and $173,063 on average annually for tier 1 and 2 events, respectively, during these full and partial flow years relative to No Action (See Table 6-11).

Table 6-11. Summary of National Economic Development Analysis for Variation 2B During the Irrigation Season During Full or Partial Flow Years (Missouri River Mainstem Intakes) (FY2021 Dollars)

Statistic	Average Annual Impacts		Year of Minimum Impacts		Year of Maximum Impacts	
	Value	Delta from No Action	Value	Delta from No Action	Value	Delta from No Action
Tier 1 Events	42	18	0	0	111	3
Tier 2 Events	9	5	0	0	42	-
Tier 1 Costs	$573,352	$248,370	$0	$0	$1,508,756	$45,720
Tier 2 Costs	$277,949	$173,063	$0	$0	$1,358,280	$0
Tier 1 Intakes	30	15	0	0	81	-
Tier 2 Intakes	9	5	0	0	42	-

Note: Annual average impacts presented in this table are taken as annual average during full or partial flow years; whereas annual averages for the No Action Alternative presented in Table 6-3 above are taken as annual averages during all years under the POR. Therefore, it is not possible to subtract the values in the "Delta from No Action" column from the "Value" column in the table above and obtain the result presented in Table 6-3.

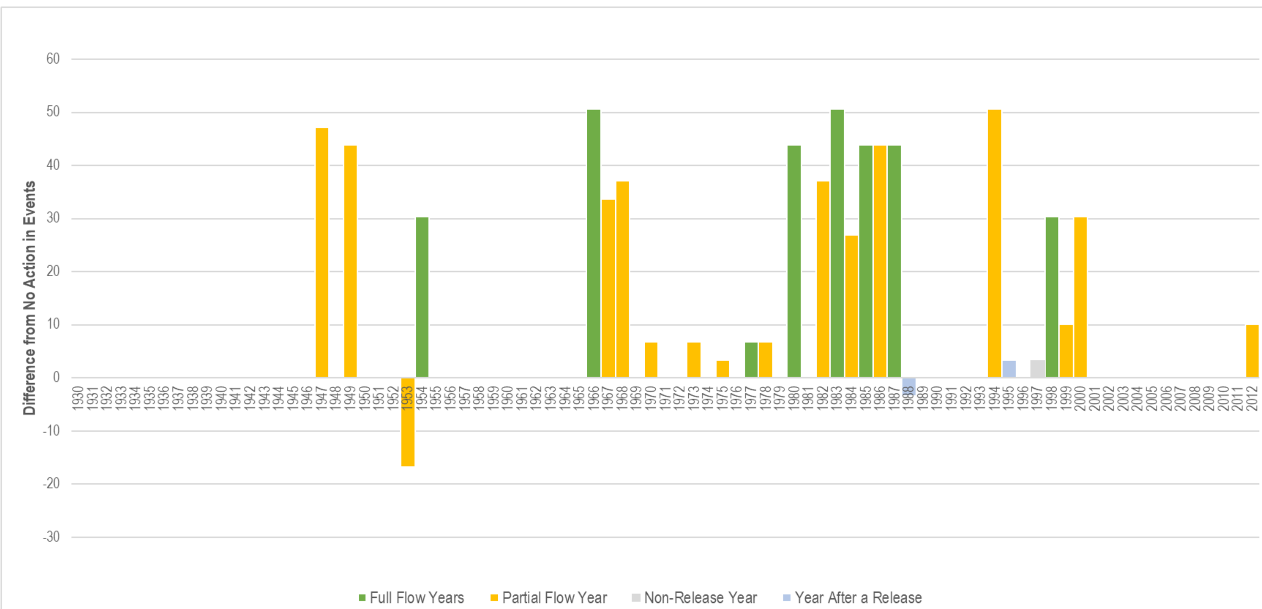


Figure 6-21. Number of Tier 1 Events Occurring under Variation 2B, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

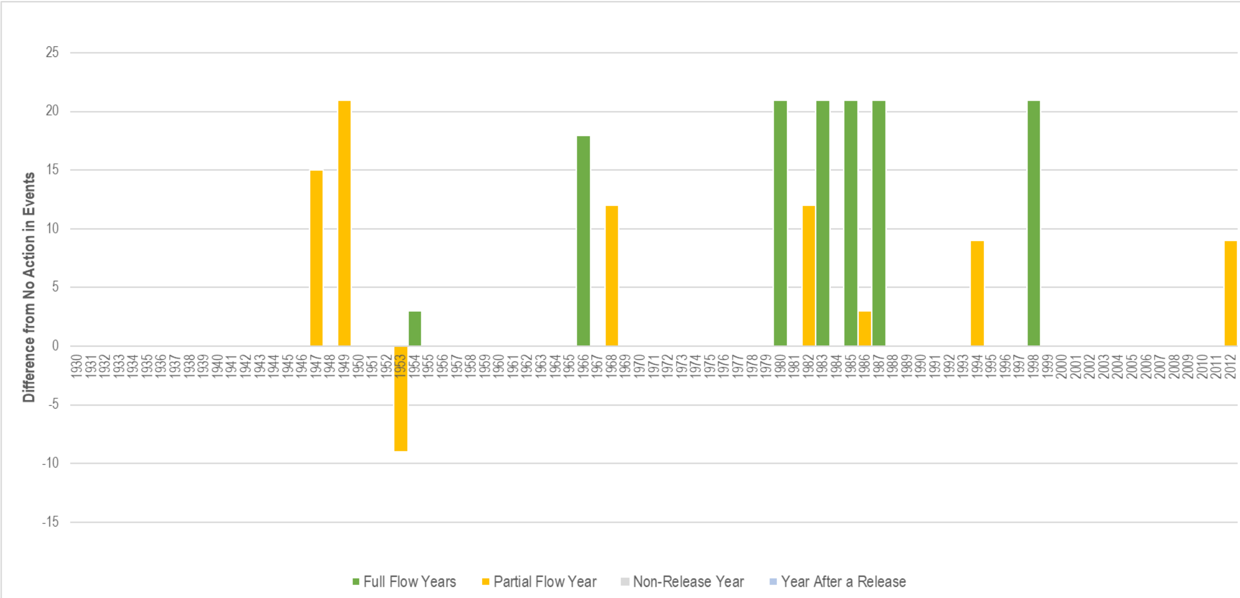


Figure 6-22. Number of Tier 2 Events Occurring under Variation 2B, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

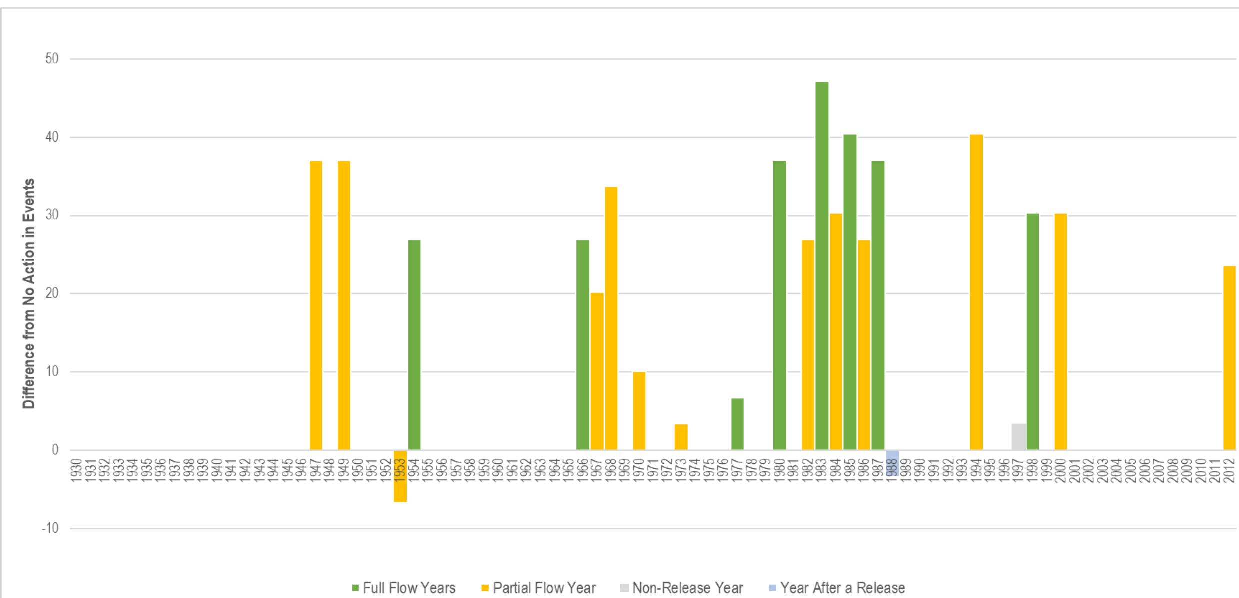


Figure 6-23. Number of Intakes Impacted under Tier 1 Events, Variation 2B, Irrigation Season (Difference from No Action, Missouri River Mainstem Intakes)

6.2 Regional Economic Development Results

The RED analysis focused on estimating change in regional economic activity measured by changes in employment, income, and sales based on changes from irrigated agriculture using water from the Missouri River from side channel irrigation intakes. To understand the regional economic impacts of high flows on side channel intakes, 31 side channel intakes were assessed to represent sales associated with crops that these intakes support. In the high flows analysis, test flow years in the alternatives result in crop losses, resulting from loss in access to water for irrigation. As a result, there are no differences in RED impacts during test flow years between alternatives. Because Variation 1A has 16 possible test flow years, the highest number of potential test flow years out of all alternatives, it has the largest possible decreases in employment, labor income, and sales compared to No Action. In years without test flows, there are no difference sales, jobs, or labor income between No Action and any of the alternatives.

Across all alternatives, a test flow year would result in an average loss of 80 jobs, $3.9 million in labor income, and $12.3 million in sales compared to No Action (Table 6-12).

Table 6-12. Regional Economic Development Results for All Four Counties in Montana by Alternative/Variation Based on Annual Production Values

Type of Impact	No Action	Decrease of Alternatives and Variations Compared to No Action in Test Flow Years
Employment	121	-80
Labor Income	$5,804,000	-$3,949,000
Sales	$18,181,000	-$12,323,000

6.2.1 No Action

The RED analysis for No Action for the side channel case study analysis was focused on employment, labor income, and sales associated with the value of crop production from irrigated agriculture in the four counties being evaluated. Table 17 summarizes the economic contribution of irrigation for all counties. Note that employment, labor income, and total sales are described here as 'contribution' because regional economic benefits are currently being supported under existing conditions and do not represent an impact of FPDTR-EIS actions. Values for RED impact categories are consistent each year for the period of record for No Action in the high flows case study because each year has the same conditions under the assumptions of this case study. There are no RED impacts for the Missouri River Mainstem Irrigation Intakes Analysis as operations and maintenance costs were limited to NED impacts only.

Under No Action, irrigated agriculture would support 121 jobs per year for all counties, $5.8 million in labor income, and $18.2 million in sales (Table 6-13). The number of jobs supported annually would be highest in Roosevelt County, with 42 jobs. Average annual labor income would be highest in Richland County at $2.3 million. Average annual sales would also be highest in Richland County at $6.69 million per year. Average annual labor income and sales would be lowest in Valley County at $540,000 and $1.7 million, respectively.

Table 6-13. Regional Economic Development Effects for Irrigated Agriculture Using Missouri River Water: No Action (FY2021 Dollars)

Economic Contribution	Scenario	McCone	Valley	Roosevelt	Richland	Total, All Counties
Employment	Annual Value of Production	23	15	42	40	121
Labor Income	Annual Value of Production	$890,000	$540,000	$2,130,000	$2,250,000	$5,804,000
Total Sales	Annual Value of Production	$3,360,000	$1,680,000	$6,460,000	$6,690,000	$18,180,000

6.2.2 Alternatives 1 and 2 and Their Variations

Under all alternatives, each test flow year would result in the same number of lost jobs, labor income, and sales because each test flow would result in the same magnitude of reduction in irrigated crop production. These average production losses would not vary across test flow years. The total decrease in employment during a test flow year compared to No Action would be 80 jobs, combined across all counties. In addition, $3.9 million in labor income and $12.3 in sales would be lost during a test flow year. Richland County would experience the largest job, labor income, and sales losses during test flow years compared to No Action, with annual decreases of 32 jobs, $1.7 million in labor income, and $5.2 million in sales. Valley County would experience the fewest job, labor income, and sales losses, with annual decrease of 7 jobs, $0.3 million in labor income, and $0.8 million in sales (Table 6-14). Variation 1A has the most test flow years where these impacts could occur, with 16 possible test flows, while Variation 1B and 2B both have the fewest test flow years where these impacts could occur, with eight possible test flows each.

Table 6-14. Regional Economic Development Impacts of Test Flow Years Relative To No Action (FY2021 Dollars)

Type of Impact	Annual Value for No Action	Change in Annual Value of Impact in Test Flow Years Relative to No Action				
		McCone	Valley	Roosevelt	Richland	Total, All Counties
Employment	121	-11	-7	-30	-32	-80
Labor Income (millions)	$5.8	-$0.4	-$0.3	-$1.5	-$1.7	-$3.9
Sales (millions)	$18.2	-$1.6	-$0.8	-$4.6	-$5.2	-$12.3

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Fort Peck Dam Test Releases
Environmental Impact Statement

Cultural Resources
Environmental Consequences Analysis

Technical Report

August 2021

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Acronyms and Abbreviations

cfs	cubic feet per second
EIS	environmental impact statement
EQ	environmental quality
ER	Engineering Regulation
ESA	Endangered Species Act
famsl	feet above mean sea level
FPDTR-EIS	Fort Peck Dam Test Releases – Environmental Impact Statement
H&H	hydrologic and hydraulic (model)
HC	human considerations
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HEC-ResSim	Hydrologic Engineering Center - Reservoir System Simulation
NED	national economic development
NRHP	National Register of Historic Places
OSE	other social effects
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
PDT	project delivery team
POR	period of record
RED	regional economic development
SHPO	State Historic Preservation Office
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

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1.0 Introduction

The U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Fort Peck Dam Test Releases – Environmental Impact Statement (FPDTR – EIS). The purpose of the Environmental Impact Statement (EIS) is to assess the potential impacts of a range of test flow release alternatives from Fort Peck dam. The releases are being designed to benefit the reproduction and recruitment of the endangered pallid sturgeon in the Missouri River. This Cultural Resources Environmental Consequences Analysis Technical Report provides detailed information on the cultural resources analysis and results to supplement the information presented in the FPDTR-EIS. Additional details on the Environmental Quality (EQ) methodology and results are also provided in this technical report. The Other Social Effects (OSE) impacts are presented in the FPDTR-EIS, Chapter 3, Cultural Resources, Environmental Consequences section. No National Economic Development (NED) or Regional Economic Development (RED) analyses were undertaken for cultural resources.

1.1 Summary of Alternatives

The FPDTR-EIS evaluates the following alternatives, described in Chapter 2 of the FPDTR-EIS.

No Action Alternative: The impacts of the No Action Alternative serve as the baseline for comparison of the potential impacts resulting from implementation of the other alternatives. It assumes that no test flow release for pallid sturgeon would occur from Fort Peck Dam. Operations at Fort Peck are assumed to closely follow the Master Manual with no deviations for a pallid sturgeon test flow. When modeling the No Action Alternative, local inflows are adjusted by the difference between the historic and present level depletions to ensure the period-of-record (POR) datasets are homogenous and reflect current water use. All modeled flood targets are as outlined in the 2018 Master Manual (USACE 2018) and reservoir storages are based upon current reservoir surveys. All four navigation target locations are used when setting navigation releases, and the model balances system storage by March 1. It is assumed that other activities and actions benefitting pallid sturgeon in the Upper Basin would be implemented as described in the FPDTR-EIS, the 2018 Biological Opinion, and the Yellowstone Intake Bypass EIS. These actions include fish bypass construction at Yellowstone Intake, continued propagation and stocking of pallid sturgeon in the Upper Basin, and continued pallid sturgeon science and monitoring activities in the Upper Basin.

Alternative 1: System operations under this alternative are on the same as those described under the No Action Alternative except that it includes a flow release regime originating from Fort Peck Dam for the benefit of pallid sturgeon.

The attraction flow regime begins on April 16 and the peak flow would be twice as large as the spring release from Fort Peck Dam in a given year. For example, the typical early spring release from Fort Peck Dam is approximately 8,000 cubic feet per second (cfs); therefore, the attraction flow regime peak flow would be 16,000 cfs as measured at the Wolf Point gage. Beginning on April 16, spring release flows are increased by 1,700 cfs per day until the peak flow is reached at the Wolf Point gage. The peak flow is held for 3 days and then decreases by 1,300 cfs per day until the retention flow is reached. The retention flow is 1.5 times the Fort Peck Dam early spring release as measured at the Wolf Point gage, 12,000 cfs using the example. The retention flow is held until May 28 when the spawning cue flow regime is initiated.

The spawning cue flow regime under Alternative 1 begins on May 28 and is 3.5 times the Fort Peck Dam spring flow release in a given year. Assuming 8,000 cfs as the typical spring flow, this equates to approximately 28,000 cfs at the peak as measured at the Wolf Point gage. Beginning on May 28, the release is increased by 1,100 cfs per day until the peak flow is reached as measured at the Wolf Point gage. The peak is held for 3 days and then decreases by 1,000 cfs per day for 12 days, then decreases by 3,000 cfs per day until the drifting flow regime of 8,000 cfs is reached. The 8,000 cfs drifting flow regime is held until September 1 when releases to balance storage level resume.

Variation 1A: This test flow is a variation of Alternative 1. The parameters for Variation 1A are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The April 9 initiation date is closer to the timing of the initial pulse shown on the unregulated hydrograph. Moving the initiation date earlier in April is intended to analyze the differences in forecasted impacts that may result from altering the start of the test releases. In Alternative 1, the later initiation date of April 16 is designed to enhance the contrast between Missouri River and Yellowstone River discharges by moving the start date approximately two weeks later than the initial pulse shown on the unregulated hydrograph.

Variation 1B: This test flow is another variation of Alternative 1. The parameters for Variation 1B are the same as described for Alternative 1 except that the attraction flow regime is initiated on April 23 and the spawning cue flow regime is initiated on June 4. Similar to the concept described in Variation 1A, the later initiation date is intended to provide contrast and explore any differences in forecasted impacts from a later flow initiation date.

Alternative 2: The parameters for Alternative 2 are the same as described for Alternative 1 except that the attraction flow regime peak is 14,000 cfs (the maximum powerhouse capacity) rather than twice the average Fort Peck spring flow in a given year. The maximum amount of flow that can be run through the generators is 14,000 cfs. Any additional flow is run through the spillway and does not generate hydroelectricity. Additionally, releases as measured at the Wolf Point gage are held at 14,000 cfs until the spawning cue flow release is initiated. The rationale for keeping the releases high through this period—foregoing the inter-pulse saddle—is the hypothesis that persistent high flows are needed to hold migrated, reproductive adult pallid sturgeon upstream near the dam.

Variation 2A: This test flow is a variation of Alternative 2. The parameters for Variation 2A are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 9, rather than April 16, and the spawning cue flow regime is initiated on May 21, rather than May 28. The difference in timing follows the same reasoning as described for Variation 1A.

Variation 2B: This test flow is another variation of Alternative 2. The parameters for Variation 2B are the same as described for Alternative 2 except that the attraction flow regime is initiated on April 23, rather than April 16, and the spawning cue flow regime is initiated on June 4, rather than May 21. The difference in timing follows the same reasoning as described for Variation 1B.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the FPDTR-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the FPDTR-EIS are required under the National Environmental Policy Act (NEPA) and its implementing regulations (40 CFR 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 FPDTR-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 NED account displays changes in the economic value of the national output of goods and services expressed in monetary units.
- The RED account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The EQ account displays non-monetary effect on significant natural and cultural resources.
- The OSE account registers plan effects from perspective 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 account evaluated for cultural resources includes OSE.

1.3 Approach for Evaluating Environmental Consequences of FPDTR-EIS

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

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

Evaluation of the potential impacts to historic properties resulting from implementation of the FPDTR-EIS requires an understanding of how the physical conditions of the river would change under each alternative. Cultural resource sites may be affected by river flows, reservoir levels, channel movement, and river-floodplain connectivity. River flows and geomorphologic changes could influence erosion rates, deposition of sediment, and river-floodplain connectivity. Changes in river flows and reservoir elevations could impact cultural resource sites through burial, inundation, exposure, erosion, and flooding. All such changes could also affect exposure to vandalism. Some risk to historic properties will occur under any future scenario. The purpose of this analysis is to measure how these risks might differ across the alternatives when compared to the No Action Alternative.

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 affect historic properties as they are defined under NHPA (National Historic Preservation Act of 1966 as amended through 1992 - 16USC470). Figure 2 shows the intermediate factors and criteria that were applied in assessing consequences to cultural resources.

The analysis of changes in river stages (relative to cultural resource site elevations) and river flows uses USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) data for the POR between 1931 and 2012 to assess when and how often fluctuating water levels affect cultural resources. The following sections in this report provide further details on the methodology.

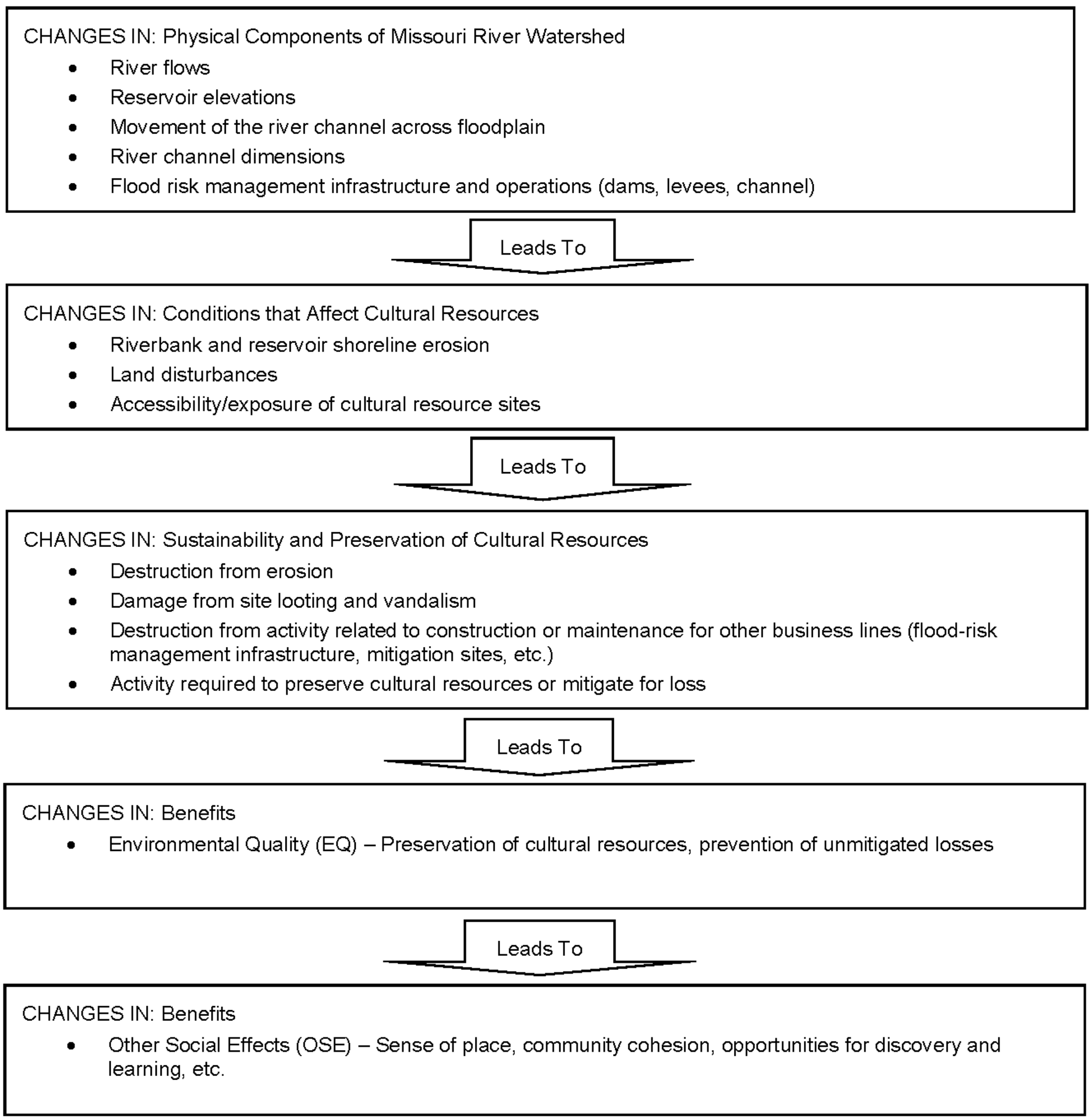


Figure 1. Flow Chart of Inputs Considered in Cultural Resource Impact Evaluation

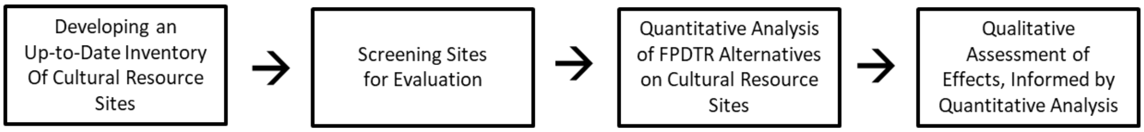


Figure 2. Environmental Consequences Approach for Cultural Resources

2.0 Methodology and Assumptions

The methodology includes a summary of assumptions and risk and uncertainty considerations. The initial step in the process, evaluating the relationship between river conditions and cultural resource sites, is described, followed by the subsequent steps to assess the EQ and OSE impacts.

2.1 Assumptions

The primary risk of impacts to cultural resource sites from the FPDTR-EIS alternatives would be related to modifications of flow and changes in reservoir pool elevations. These alterations could change the magnitude and frequency of erosion, or vandalism and looting. The analysis was based on an assumption that cultural resource sites that are typically submerged (or partially submerged) face a greater risk of exposure to vandalism and looting as well as erosion when river/pool elevations decrease within proximity of the site. Modeled impacts to cultural resource sites that are typically above (or partially above) the normal river/reservoir surface level elevation are subject to greater risk of erosion when river/pool elevations increase to within proximity of the site. More simply, the integrity of cultural resource sites (whether located on reservoirs or riverine reaches) is sensitive to changes in water surface elevations.

The following assumptions were used in the evaluation:

1. Cultural resource sites are equally susceptible to damage, vandalism, or looting. In reality, some sites will be more/less resistant to damage from waves and erosion, and some sites will be more/less accessible and desirable targets for looters/vandals (Lenihan et al. 1981; Dunn 1996).
2. Cultural resource sites are equally susceptible to damage at all times of the year. Submerged sites on the Mainstem reservoirs may, in fact, be at greater risk during the recreation season, or may be at greater risk during winter seasons, due to physical erosion from ice cracking, snow runoff, etc.
3. Cultural resource sites are considered equally in the estimation of the overall risk. In reality, the cultural value placed on the protection of all sites might not be equal. For example, many people would identify the protection of sites with human remains to be more important than the protection of other sites.
4. In general, any potential beneficial effects for protection of cultural resource sites due to temporary inundation of the floodplain in riverine reaches (i.e., continued productivity of natural riparian vegetation or wetlands) are overwhelmed by the negative effects of that inundation (i.e., increasing risk of erosion). Additionally, the damageability/susceptibility of sites to erosion or vandalism does not vary significantly among different types of sites (Lenihan et al. 1981; Dunn 1996).

5. All calculations are based on known cultural resource site information. It is understood that there may be many unknown cultural resource sites existing on the landscape, as well as important cultural resources that do not necessarily meet the definition of a historic property as defined under the NHPA. The inventory of known sites used in the analysis is intended to serve as a representative sample, indicating which FPDTR-EIS alternatives have greater or lesser impacts to cultural resources in general.
6. The modeling efforts focused on changes in hydrologic and hydraulic (H&H) modeling outputs: river flows, river stages, and reservoir elevations. The model is unable to evaluate changes in other physical aspects of the river that could impact cultural resources (e.g., sedimentation, geomorphology).
7. The analysis uses data from the HEC-RAS modeling of the river and Reservoir System Simulation (HEC-ResSim) modeling of the reservoir System. The analysis assumes that the HEC-RAS and HEC-ResSim models reasonably estimate river flows and reservoir levels over the 82-year POR under each of the action alternatives as well as under the No Action Alternative.

While imperfect, the use of these assumptions allowed for an analysis that shows (broadly) how FPDTR-EIS alternatives would impact the risk to cultural resources.

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 within the overall FPDTR-EIS 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 POR. 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 H&H models or carried through to the cultural resources model described in this document. The project delivery team has attempted to address risk and uncertainty in the FPDTR-EIS 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 cultural resources.

Another source of uncertainty associated with the cultural resources analysis is predicting how long-term changes in river and reservoir conditions would affect cultural resources. To address this uncertainty, project team archeologists have made assumptions about impacts based on professional experience and observations of similar long-term adverse effects to cultural resources through resources such as the USACE Cultural Resources Data Management System (CRDMS). Some of these conditions have not occurred in the recent past and therefore represent the anticipated impacts to cultural resources under a hypothetical situation.

2.3 Methodology

The purpose of the cultural resources analysis is to link H&H modeling efforts, which simulate river operations of the Missouri River under each of the FPDTR-EIS alternatives, with the analysis necessary to estimate the environmental consequences to cultural resource sites along the reservoirs and riverine sections of the Missouri River. This analysis to evaluate potential effects of changes in reservoir elevations and river stages on cultural resource sites was completed within Microsoft Excel. For cultural resources impacts, the analysis evaluated the number of days and number of sites where cultural resources are at greater-than-normal risk to either erosion or vandalism as a result of changes in reservoir elevations or river stage. "Greater-than-normal risk" is defined as a site experiencing a greater risk for erosion or vandalism than it would when reservoir conditions are between the minimum and maximum normal pool elevations or when riverine levels exceed more than a few feet from the bottom of the site. The results are presented by reservoir or riverine reaches within specific geographic areas.

Three measures were used to estimate greater-than-normal risk to cultural sites:

1. **Site-Days** [*The Primary Measure*]: This is the total number of days in each year over the 82-year POR that cultural resource sites were at greater-than-normal risk along a riverine reach or reservoir of the Missouri River. If more than one site was at greater-than-normal risk on a given day, the total number of sites at risk for that day was reflected in this statistic. For example, if 4 out of 11 submerged sites were at greater-than-normal risk in Lake Sakakawea from December 2 to December 3, for the modeled 1951 year, then there were a total of eight site-days under greater-than-normal risk on Lake Sakakawea over those two days because four sites were impacted for two days each. This measure is also presented on an average annual basis as "average annual site-days."
2. **Average Days**: This is the average number of days each year that a site was under greater-than-normal risk. This statistic was obtained by taking the total site-days in a given time-period and reach or reservoir and dividing that number by the maximum number of sites impacted under any alternative in that reach or reservoir. Each alternative's denominator is the same value, which is the maximum number of sites impacted under any alternative, in that reach or reservoir. For consistency, this same denominator value was used for all alternatives, because some sites in the inventory are not affected by one or more alternative. These average-days statistics are calculated for each type of site (e.g., sites above normal pool, sites below normal pool, etc.) for each reservoir and riverine reach of each state along the Missouri River Mainstem.
3. **Sites**: This is the total number of sites of each type impacted in any year in a reach or reservoir regardless of the amount of time that each site was impacted. For example, if two submerged cultural resource sites are impacted on Lake Sakakawea in the modeled 2010 year and one is impacted for 2 days at greater-than-normal risk and the other is impacted for 75 days at greater-than-normal risk then the total number of submerged sites impacted in Lake Sakakawea in the modeled 2010 year would be two sites. This measure can also be presented as the "maximum number of impacted sites" which is the maximum number of impacted sites in any year under the POR for an alternative.

2.3.1 Geographic Scope and Screening

The cultural resources information used to conduct this analysis was obtained from existing inventories. Within the Mainstem Reservoir System, USACE Omaha District maintains an inventory of sites that has been developed based upon archaeological surveys of most of their fee-title lands in compliance with Sections 110 and 106 of the National Historic Preservation Act. USACE obtained location data for sites on non-federally owned lands in riverine settings from the various SHPOs in the basin. Inventories of sites on non-federally owned lands are less common, and consequently the inventories from the SHPOs are typically less complete. As discussed above, it is expected that although the total number of sites is likely much greater, these "unrecorded" cultural resource sites would be impacted by FPDTR-EIS alternatives in a similar manner to sites included in this analysis. Additionally, riverine or reservoir cultural resources sites that lack specific locational data, including elevation data, were not included in this analysis.

After the collection of archaeological sites inventory data, sites that had previously been formally determined to be ineligible for the National Register of Historic Places (NRHP) were removed from further analysis, unless the ineligible site had associated human remains. Further, sites at elevations that were higher or lower than any foreseeable changes to the minimum and maximum operational water levels under either of the FPDTR-EIS alternatives were also eliminated from further modeling analysis.

The study area used in the analysis was the Mainstem of the Missouri River from Fort Peck Reservoir in Montana to Oahe Dam in South Dakota. Figure 3 below provides a map overview the entire study area, and identifies the Missouri River, the watershed boundary, and each of the Mainstem reservoirs, all of which are key geographic regions in this study. For the purpose of this study, all recorded archeological sites located within the bluffs of the Missouri River floodplain were identified. The analysis was categorized between sites located on the federally managed lakes (reservoir sites), and sites located within the riverine environment of the Missouri River floodplain (riverine sites). The analysis for each of the Mainstem reservoirs included all of the historic properties located on federal land within the individual reservoir project. This data was obtained from the USACE Omaha District's Cultural Resources Data Management System which includes data provided by local SHPOs and THPOs. The riverine sites were subdivided by state because each SHPO maintains its own individual database of cultural resource sites, which is where data on riverine sites was derived. The geographic extent for riverine reaches were identified as follows:

Montana: The relevant riverine setting on the Missouri River flows from Fort Peck Dam to the border between Montana and North Dakota. This section includes all cultural resources within the Missouri River floodplain contained within the expanse until approximately river mile 1587 at which point the river enters North Dakota. All cultural resources sites located within Fort Peck Reservoir are also accounted for in this state.

North Dakota: There are two riverine settings in North Dakota, the first flows from the border between Montana and North Dakota to river mile 1563 where Lake Sakakawea begins and the second begins at Garrison Dam and flows south to river mile 1308 where Lake Oahe begins. These two riverine sections include all cultural resources within the Missouri River floodplain. This analysis also accounts for all cultural resources sites located within the boundaries of the state of North Dakota at Lake Sakakawea and Lake Oahe.

South Dakota: All sites that are located within the boundaries of the state of South Dakota at Lake Oahe are analyzed.

Table 1 shows the total number of recorded cultural resource sites located within the meander belt of the Missouri River before sites were screened as potentially affected during model analysis. The cultural resource sites are categorized by state for sites in riverine settings, and by reservoir for sites in the three upper Mainstem reservoirs. Preliminary analysis indicated that many of these sites would not be impacted by any of the alternatives. Tables 5 and 6 (later in the report) show the total number of sites by geographic region that are affected under each of the alternatives. Due to the sensitive nature of cultural resource site location information, all results of this analysis are reported in aggregate, as averages for each of the three upper Mainstem reservoirs and as averages across the riverine reaches of each state.

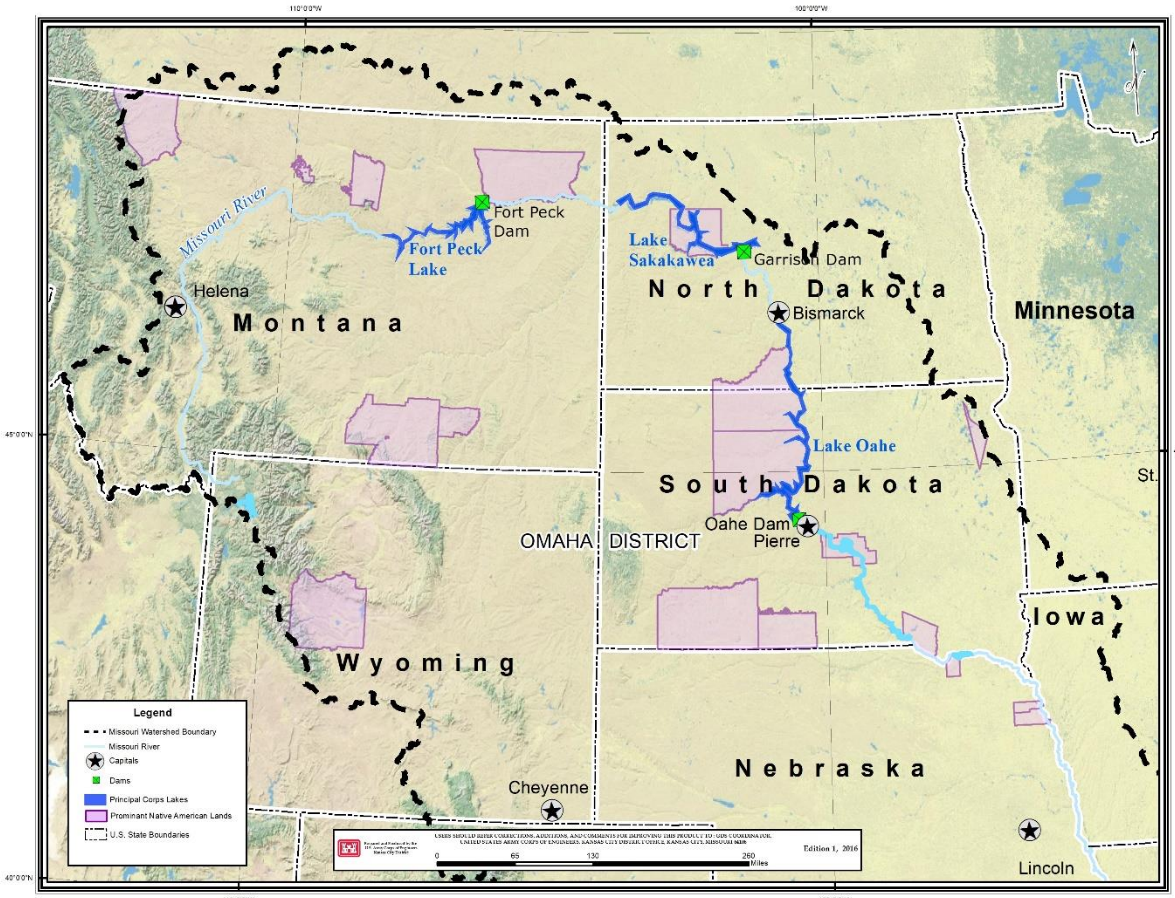


Figure 3. Upper Missouri River Basin and Reservoirs

Table 1. Total Number of Cultural Resource Sites Considered by Geographic Region

Geographic Area	Number of Sites
Fort Peck Lake	53
Montana Riverine Sections	136
North Dakota Riverine Sections	444
Lake Sakakawea	838
Lake Oahe	1,066

2.3.2 Measures for the Analysis of Cultural Resources

Impacts to cultural resources in proximity to the Missouri River in reservoir settings were estimated by modeling the elevation of the sites relative to the operational elevation levels under the proposed alternatives. Sites above the maximum-normal and below the minimum-normal operating elevations of the reservoirs were the focus of the evaluation (Table 2). The minimum-normal pool elevation is the elevation of the top of each reservoir's "Carryover Multiple Use

Zone” while the maximum-normal pool elevation as the elevation of the top of each reservoir’s “Annual Flood Control and Multiple Use Zone.” Table 2 provides the elevations of these “normal” pool levels.

Table 2. Maximum and Minimum Normal Reservoir Pool Elevations

Reservoir	Minimum Normal Pool Elevation (FAMSL)	Maximum Normal Pool Elevation (FAMSL)
Fort Peck Lake	2,234.0	2,246.0
Lake Sakakawea	1,837.5	1,850.0
Lake Oahe	1,607.5	1,617.0

Note: FAMSL = feet above mean sea level

Site-specific critical thresholds were established for sites located above and below these normal operating elevation levels. For sites above normal pool elevation the critical threshold is 3 feet below the bottom elevation of the site. Sites more than 3 feet above normal operating level are at risk of erosion or damage from waves. For sites that are typically submerged below the minimum-normal pool elevation, the critical threshold is a pool elevation of one foot above the top of the site (or lower). These sites are considered to be at greater-than-normal risk of exposure to wave action, looting, or other damage when the pool elevation falls below this critical threshold. Table 3 details the specific measures used in this analysis.

Table 3. Reservoir Analysis Measures for Sites at Greater-than-Normal Risk

Reservoir Conditions	Measure	Description
1. Number of days reservoir elevations are one foot above the site or lower for sites that are below normal reservoir pool elevations (summed across all applicable sites)	Number of site-days	This measure is an estimate of the number of days in a year that reservoir elevations are one foot above the cultural resource site or lower for sites that are below minimum-normal reservoir pool elevations. Once water elevations are at least one foot or lower than the top of a cultural resource site for sites that are below the minimum-normal pool elevation for the reservoir, the site is considered to be at “very high risk” for vandalism. The focus of this measure is on greater-than-normal risk to cultural resource sites.
2. Number of days reservoir elevations are 3 feet or less from the bottom of sites that are above normal pool elevations (summed across all applicable sites)	Number of site-days	This measure is an estimate of the number of days in a year that reservoir elevations are within 3 feet from the bottom of a cultural resource site for sites that are above normal pool elevations for the reservoir. Once water elevations are within 3 feet from the bottom of a cultural resource site for sites that are above the normal pool elevation for the reservoir, the site is considered to be at “high risk” for erosion. Once the water level touches the bottom of these sites the site is considered to be at “very high risk” of erosion. The focus of this measure is on greater-than-normal risk to cultural resource sites and impacted sites.

Reservoir Conditions	Measure	Description
3. Number of days reservoir elevations are above or below the normal operating elevations of the reservoir for sites that span the normal operating elevation range of the reservoir (summed across all applicable sites)	Number of site-days	This measure is an estimate of the number of days in a year that reservoir elevations are either above or below the normal operating range of pool elevation for a reservoir. Once reservoir elevations are outside of the normal range, sites that have elevations spanning this range can be subject to greater-than-normal risk of vandalism or erosion. The focus of this measure is on greater-than-normal risk to cultural resource sites.

Sites are considered to be at "very high" risk of exposure to looting/vandalism on days when the pool elevation falls (below minimum-normal pool elevation) to within one foot of the top of the site or lower (Figure 4) and for sites below the normal range of pool elevations (Figure 5). For the purposes of simplifying terms in this analysis, the term "site-days" is used to reflect the number of days that a site has the potential to experience "high" or "very high" risk of erosion or vandalism due to changing water elevations either inundating or exposing a site.

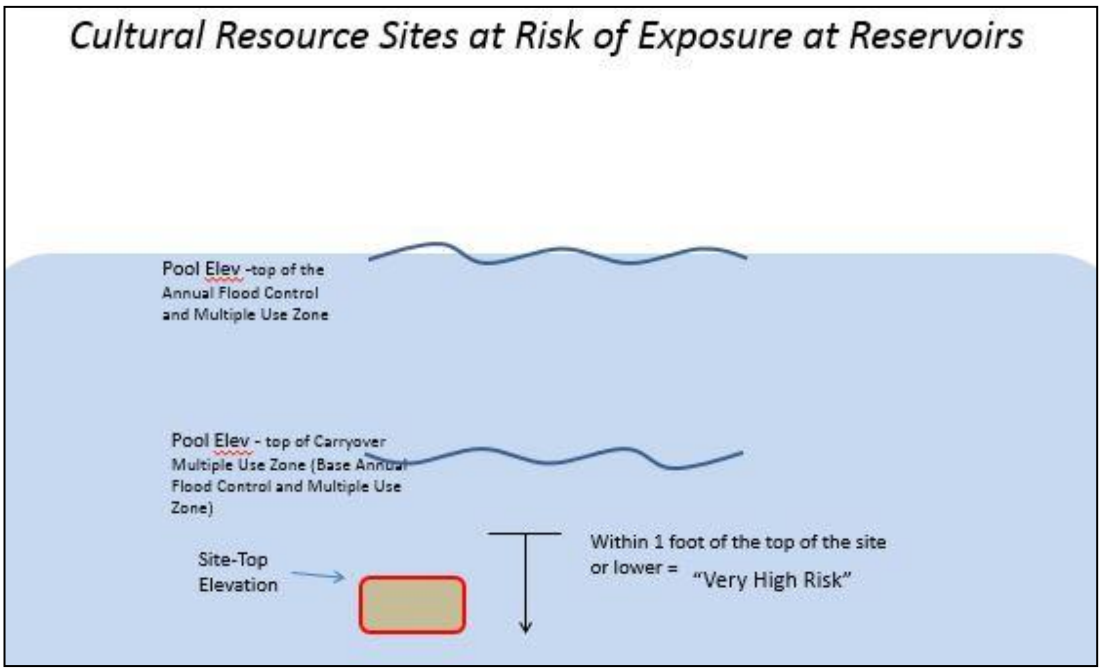


Figure 4. Reservoir Measure: Sites Below Normal Range of Pool Elevations at Reservoirs

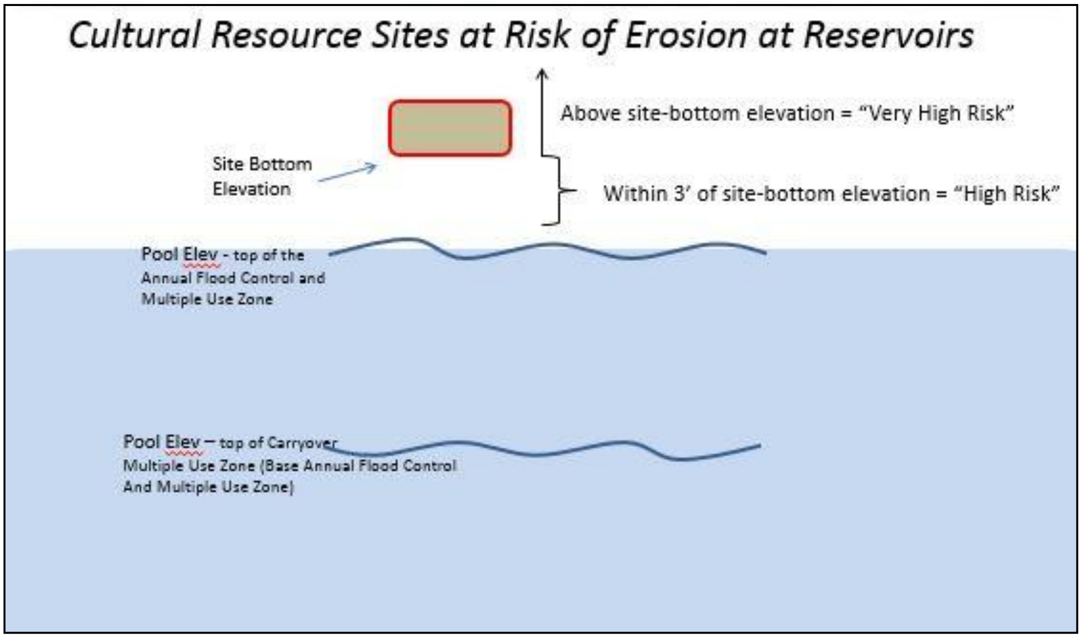


Figure 5. Reservoir Measure: Sites Above the Normal Range of Pool Elevations at Reservoirs

A site that is typically above normal pool elevations is at "high" risk of erosion on days when the pool elevation rises to within 3 feet of the bottom of the site (Figure 6). If the pool elevation rises further, to the point where the pool elevation is as high as (or higher than) the elevation of the bottom of the site, the site would be at "very high" risk. When the pool elevation is more than 3 feet lower than the bottom of a site of this type, the site is at relatively low risk. For simplicity, the combined site-days of "high" risk and "very high" risk are reflective of "greater-than-normal risk" and are described as "site-days" for sites above the normal range of pool elevations.

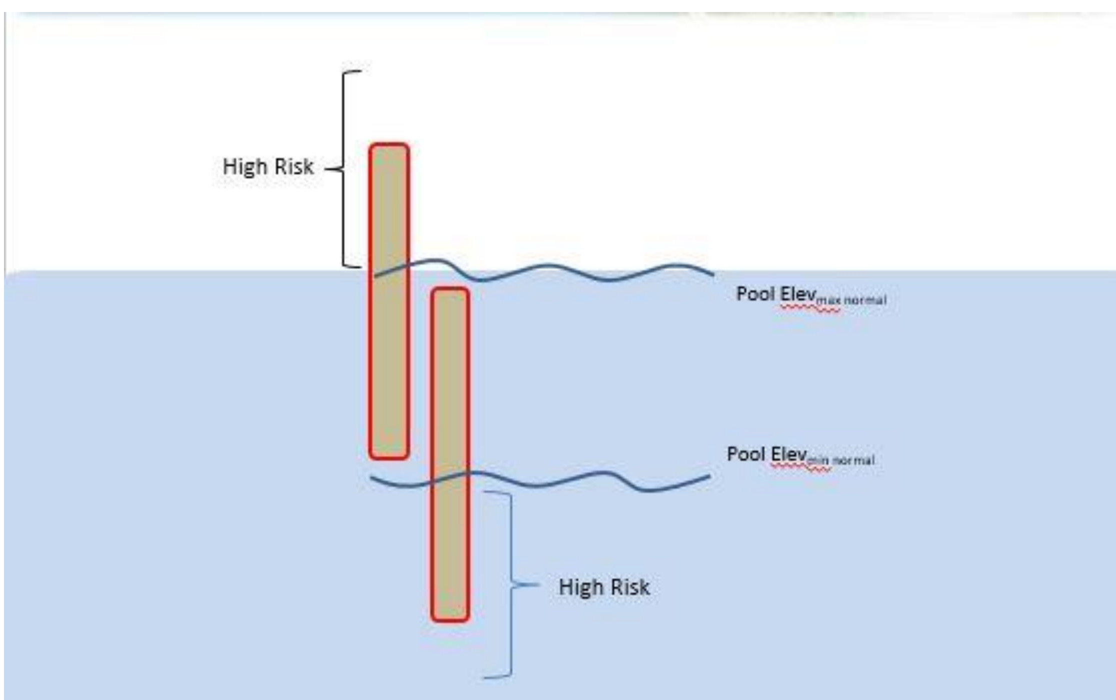


Figure 6. Reservoir Measure: Sites which Span the Normal Range of Pool Elevations at Reservoirs

A site that spans (or partially spans) the normal range of pool elevations is at relatively greater risk on days when pool elevations fall below the normal range of pool elevations (exposing part of the site that is typically submerged) or when pool elevations rise above the normal range of pool elevations (subjecting the higher part of the site to increased erosion risk). When the pool elevations are within their normal range, the site is considered to be at relatively low risk, because at least part of the site is relatively safe from exposure and/or erosion. Therefore, only sites that are *entirely* above or *entirely* below the normal range of pool elevations are included in the assessment of cultural resources in this evaluation.

The risks to cultural resources of the Missouri River in riverine settings are evaluated by the frequency that water surface elevations rise above critical thresholds in proximity to the sites. For example, cultural resource sites that are typically above the river's surface face an increased risk of erosion when river stages reach the bottom of the cultural resource sites. Table 4 details the specific measure used in this analysis.

Table 4. Riverine Analysis Measure

River Conditions	Measure	Description
Number of days riverine stages are at or above the bottom of sites (summed across all applicable sites)	Number of site-days	Once water elevations are above the bottom of a cultural resource site (or above the top of a levee), then the site is considered to be at greater-than-normal for erosion. The focus of this measure is on greater-than-normal risk to cultural resource sites.

A site in a riverine reach that is not behind a levee will be at relatively "high risk" of erosion on days when river stage rises higher than the bottom of the site (i.e., floodwater reaching the site) (Figure 7). A site in a riverine reach that is behind a levee will only be at relatively "high risk" of erosion when river stage rises higher than the top of the levee, overtopping the levee with higher risks to cultural resource sites located in the floodplain behind the levee. Cultural resource sites located both in similar locations and behind levees were grouped together for the purposes of analysis and were associated with the closest gage location along the Missouri River. We were thus able to determine the elevation at which the levee would be overtopped and at which the sites would be at risk of impact due to flood waters. These sites are otherwise at relatively low risk when river stage is lower than these critical thresholds. For simplicity, the Environmental Consequences chapter of the EIS referred to site-days of high risk as "site-days of greater-than-normal risk" for sites in riverine reaches.

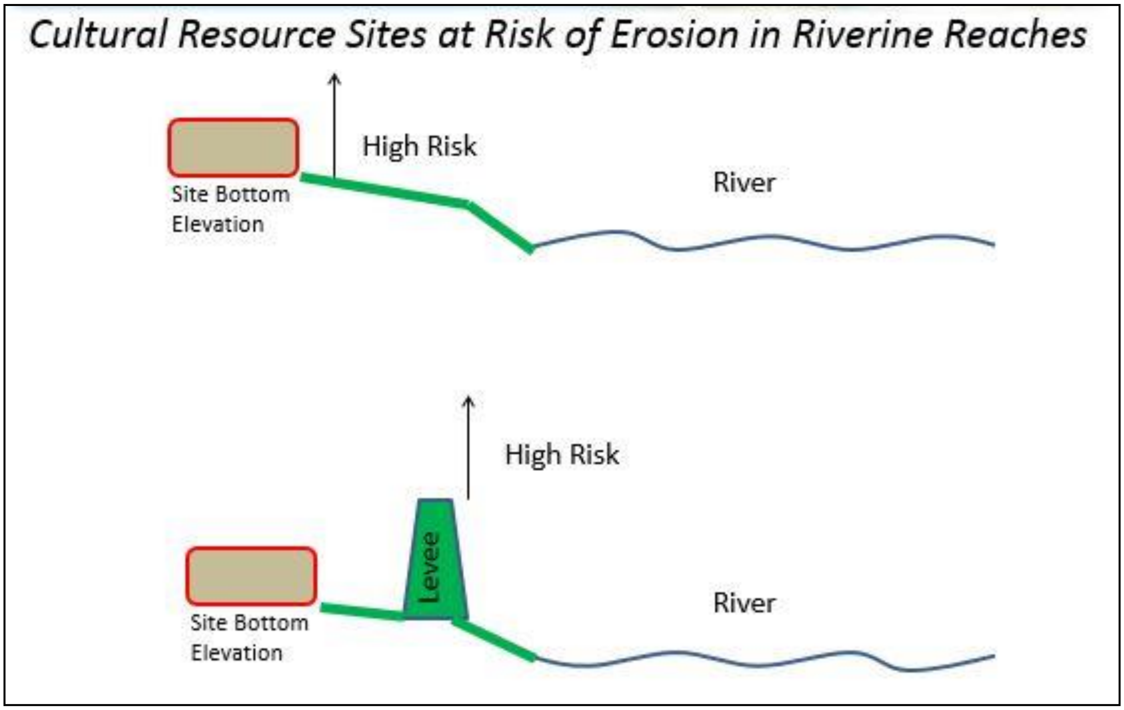


Figure 7. Riverine Measures: Sites located in Riverine Reaches

3.0 Environmental Quality Results

3.1 Summary of Impacts

Both alternatives and their variations would impact the same number of individual sites, although the frequency of site-days differs between the alternatives and their variations. Tables 5 and 6 provide a summary of the number of individual cultural resource sites impacted by each alternative or variation. These modeled impacts are related to fluctuations in water levels which would result in greater-than-normal risk to sites either from erosion or access that correlates to increased likelihood of looting. In general, the more water levels fluctuate, the greater the magnitude of impacts to cultural resource sites.

The primary differences between the FPDTR-EIS alternatives and their variations were changes in total days when sites were subject to greater risk, rather than disparities in the number of sites affected. That is to say that the same sites are subject to greater risk of erosion or looting at least one day over the 82-year POR under each alternative and variation, with the difference between alternatives and their variations occurring in the number of days that sites were subject to greater risk relative to the No Action Alternative. Further analysis of specific sites may need to be undertaken to better understand impacts should management actions under the Adaptive Management Plan require modifications to water storage and releases within the System. A description of increases and decreases to risk in each geographic area for all alternatives is presented in this section based on comparison with the No Action Alternatives. On average, there are minimal differences in the annual number of site-days when sites were exposed to risk compared to the No Action Alternatives and across all action alternatives and their variations in all geographic locations (Table 6).

Table 5 summarizes the maximum number of sites in reservoir settings subject to modeled impacts over the 82-year POR for each alternative. Each of the reservoirs has the same maximum number of affected cultural resource sites. Lake Oahe and Lake Sakakawea have the largest number of affected sites. There are no differences among the impacts for any alternative or variation for riverine sites, and the maximum number of impacted riverine sites (5 sites) is the same under the No Action Alternative and all action alternatives and variations.

Table 5. Maximum Number of Affected Reservoir Sites Over All Years (Outside Normal Pool Elevations)

Location	Location Relative to Normal Pool Elevation	No Action Alternative	Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
Fort Peck Lake	Above	22	22	22	22	22	22	22
	Below	6	6	6	6	6	6	6
Lake Sakakawea	Above	405	405	405	405	405	405	405
	Below	63	63	63	63	63	63	63
Lake Oahe	Above	219	219	219	219	219	219	219
	Below	196	196	196	196	196	196	196

Table 6 summarizes the difference in average annual site-days of increased risk, the primary measure, across the FPDTR-EIS alternatives. Alternative 2 and Variation 2B are the only alternatives with a decrease in the average annual number of site-days for sites at reservoirs and riverine sites during full or partial flow years. Variation 2B is the only action alternative with a decrease in average annual number of site-days in all years under the POR for sites reservoirs and riverine sites. Alternative 1 and Variations 1A, 1B, and 2A would result in an increase in the average annual number of site-days for reservoir sites.

Table 6. Average Annual Site-Days of Impact

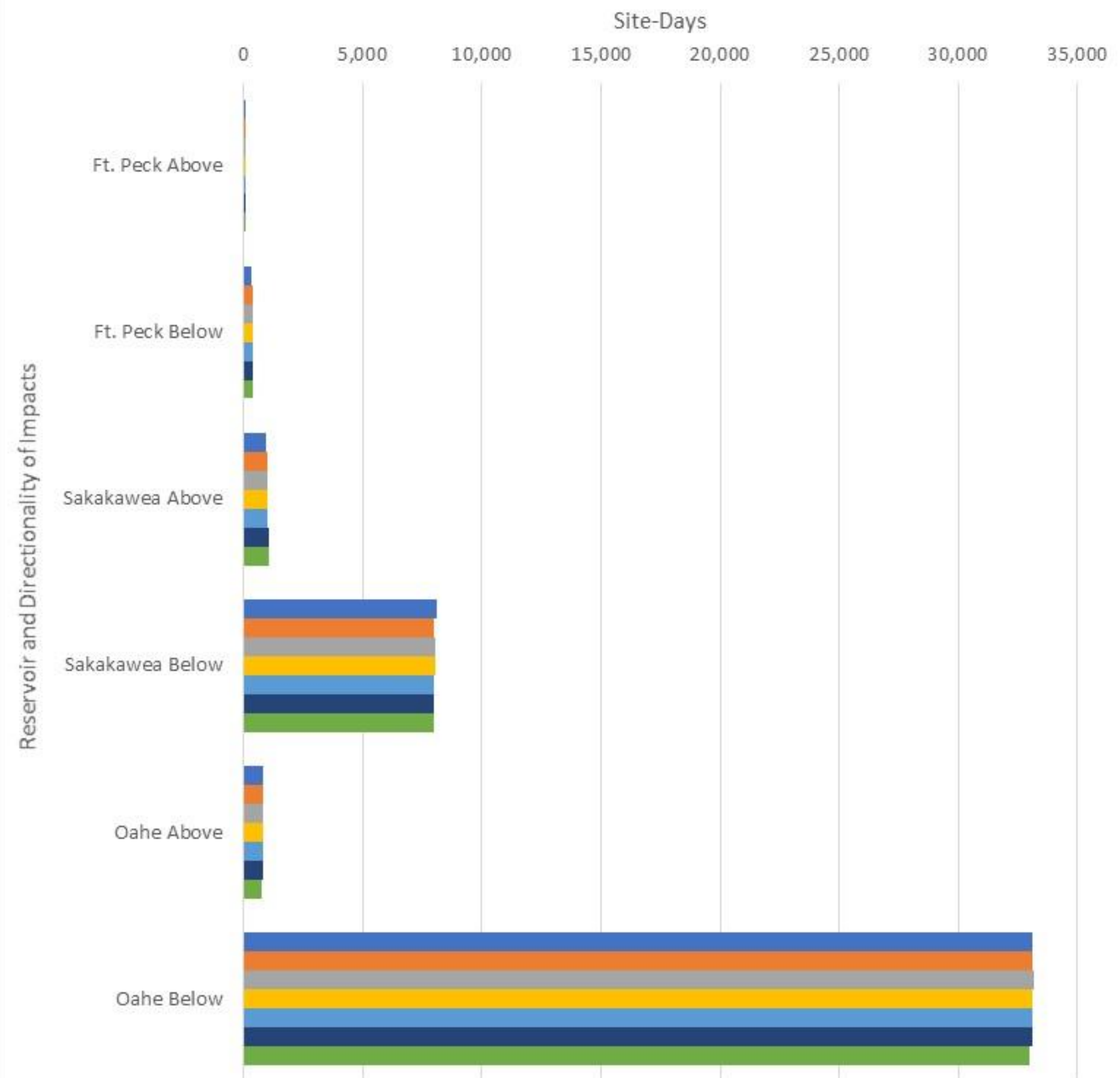
Geography	Sum of Average Annual Site-Days No Action	Difference Relative to No Action					
		Alt 1	Var 1A	Var 1B	Alt 2	Var 2A	Var 2B
Reservoir Sites	43,319	26	75	69	(17)	27	(175)
Percent Change from Alt 1	NA	0.1%	0.2%	0.2%	0.0%	0.1%	-0.4%
Riverine Sites	1.6	0	0	0	0	0	0
Percent Change from Alt 1	NA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

3.2 Impacts to Cultural Resources in Reservoir Settings

Within reservoir settings, cultural resource sites are subject to small changes in risk across all alternatives relative to the No Action Alternative. The model results indicated that the greatest differences between the alternatives (in terms of average risk) would be at Lake Sakakawea and Lake Oahe, partially because these lakes have the largest number of known cultural resource sites that could be affected by changes in flow releases and reservoir elevations. There would be minimal differences in risk compared to the No Action Alternative for sites at Fort Peck Lake, with the exception of Variation 1B. Under Variation 1B a delayed reduction in the elevation of the reservoir relative to the No Action Alternative in a modeled year (such as 1997) would lead to an increase in the number of site-days. Figures 8 and 9 illustrate the average annual site-days of greater-than-normal risk for cultural resource sites at all reservoirs above and below normal pool elevations.

All action alternatives and variations may result in negative impacts to cultural resource sites that are located below the normal operating elevation of Fort Peck Lake, and above the normal operating elevation of Lake Sakakawea. Beneficial impacts would accrue to sites located below the normal operating elevation of Lake Sakakawea under all action alternatives and variations relative to the No Action Alternative due to relatively higher water levels in this reservoir and resulting reduction in exposure of sites located below the reservoir's normal operating elevation. The release events under all of the action alternatives and variations would reduce reservoir elevations at Fort Peck Lake and increase reservoir elevations at Lake Sakakawea and Lake Oahe in the year of, and years following, full and partial flow releases. This would result in an increase in site-days between 1 and 13 percent higher than the No Action Alternative. Cultural resources sites above the normal pool elevation of Lake Sakakawea would be most affected. However, some of these impacts would be offset by beneficial impacts to sites located below the normal pool elevation of Lake Sakakawea as they would be impacted less often than they are under the No Action Alternative.

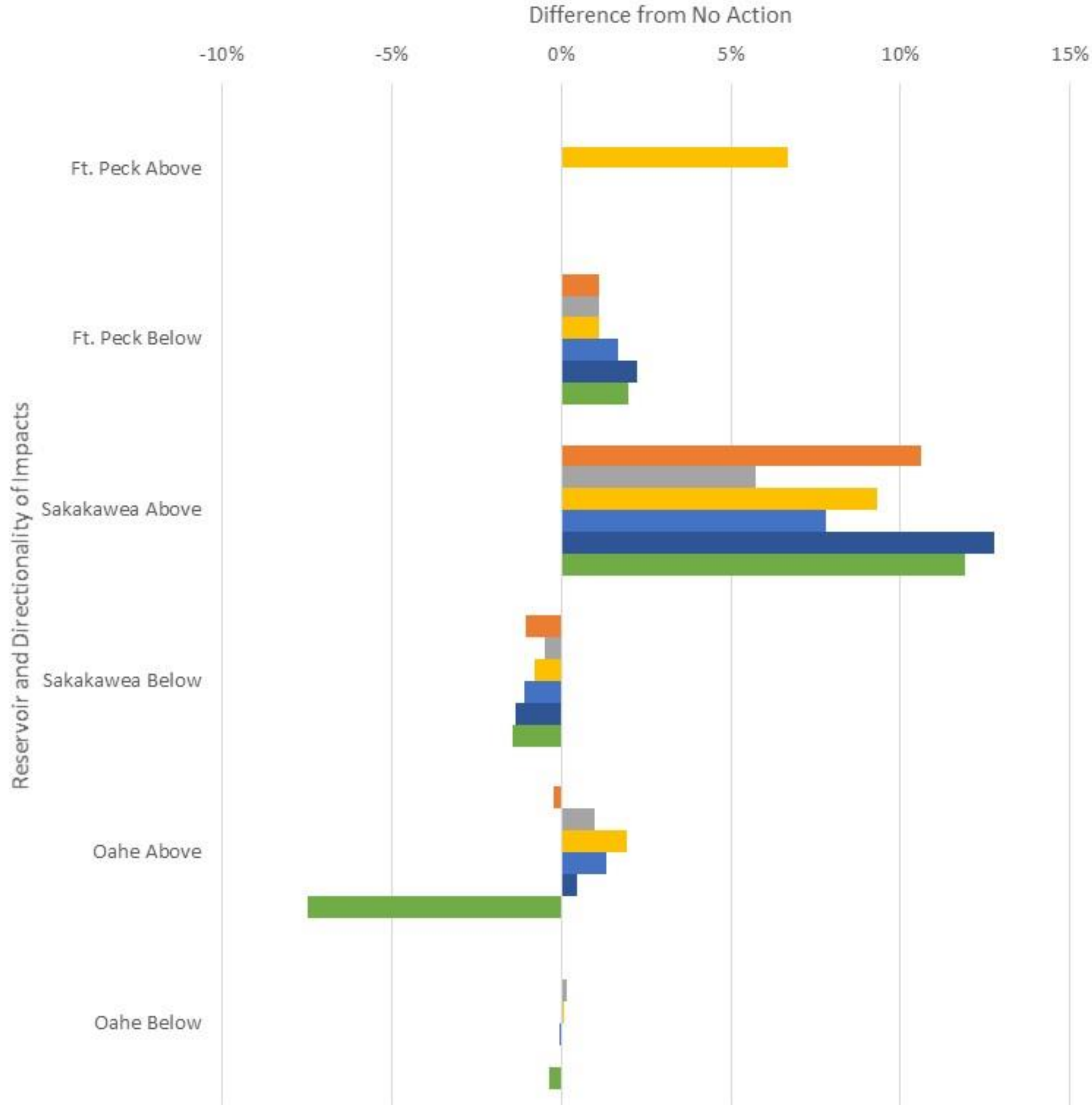
Alternative 1 results in slightly beneficial impacts to sites above the normal operating elevation of Lake Oahe relative to Variations 1A, 1B, and 2A and Alternative 2. Variation 1A, Alternative 2, and Variation 2A have similar impacts to sites at all reservoirs. Variation 2A has the greatest negative impact to these sites with the exception of sites located above the normal operating elevation of Lake Oahe, where Alternative 2 shows slightly more impact. As noted above, Variation 1B results in a noticeable negative impact at Fort Peck Lake relative to the other alternatives, due to changes in reservoir elevations in one modeled year over the POR. Finally, impacts under Variation 2B are similar at all of the reservoirs except for sites located above the normal operating elevation of Lake Oahe where impacts are beneficial relative to the No Action Alternative. This was primarily due to a relatively lower reservoir elevation occurring in the summer of the modeled year 1995, a year after a partial flow event, that resulted in 44 fewer sites being impacted in that year.



	Oahe Below	Oahe Above	Sakakawea Below	Sakakawea Above	Ft. Peck Below	Ft. Peck Above
Alt NA	33,105	829	8,088	924	358	15
Alt 1	33,116	827	8,003	1,022	362	15
Var 1a	33,153	837	8,050	977	362	15
Var 1b	33,132	845	8,025	1,010	362	16
Alt 2	33,086	840	8,001	996	364	15
Var 2a	33,111	833	7,980	1,042	366	15
Var 2b	32,992	767	7,971	1,034	365	15

Alt NA   Alt 1   Var 1a   Var 1b   Alt 2   Var 2a   Var 2b

Figure 8. Average Annual Site-Days of Greater-than-Normal Risk in Reservoir Settings over the 82-Year POR



	Oahe Below	Oahe Above	Sakakawea Below	Sakakawea Above	Ft. Peck Below	Ft. Peck Above
Alt 1	0%	0%	-1%	11%	1%	0%
Var 1a	0%	1%	0%	6%	1%	0%
Var 1b	0%	2%	-1%	9%	1%	7%
Alt 2	0%	1%	-1%	8%	2%	0%
Var 2a	0%	0%	-1%	13%	2%	0%
Var 2b	0%	-7%	-1%	12%	2%	0%

Figure 9. Summary of Percentage Difference of Site-Days of Greater-than-Normal Risk in Reservoir Settings Compared to No Action

3.3 Impacts to Cultural Resources in Riverine Settings

Similar to cultural resource sites located above normal pool elevation at a reservoir, cultural resource sites located along river banks or in riverine floodplains are also subject to increased risk of erosion when river stages rise during periods of high water. Unlike reservoir sites, which are located on federal fee title land, most of the sites in riverine settings are located on land that is not federally owned. Cultural resource sites located close to river banks (and not behind levees) can be affected by erosion on a daily basis or during relatively minor high-water events. Erosion affects these sites by destroying cultural materials and degrading intact cultural deposits. Exposed cultural resources can lead to greater risk of vandalism and looting.

There are no differences amongst the impacts resulting from any alternative or variant for riverine sites; the maximum number of impacted riverine sites (5 sites) and average annual site-days (1.6 site-days) are the same under the No Action Alternative and all action alternatives and variants.

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