LEWIS AND CLARK LAKE SEDIMENT MANAGEMENT PLAN STUDY

PHASE TWO REPORT

<u>ECONOMICS APPENDIX</u>

OMAHA DISTRICT

NORTHWESTERN DIVISION

IN PARTNERSHIP WITH

MISSOURI SEDIMENTATION ACTION COALITION

August 2023

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Executive Summary

Lewis and Clark Lake is a reservoir on the Missouri River, created by the closure of Gavins Point Dam. It is the farthest downstream dam on the Mainstem Missouri River and is operated by the U.S. Army Corps of Engineers (USACE). The Section 22 Planning Assistance to States and Tribes (PAS) program, as outlined by the Water Resources Development Act of 1974 (PL 93-251), allows USACE to partner with the Missouri Sedimentation Action Coalition (MSAC) and a collective group of sponsors to examine solutions to ongoing sedimentation issues that affect a wide area of the river corridor around Lewis and Clark Lake. The lake is the smallest of the mainstem Missouri River reservoirs. The dam is five miles west of Yankton, South Dakota and twelve miles north of Crofton, Nebraska.

Sedimentation behind dams presents a serious issue[1] for both the reservoir pool and the dam. Lewis and Clark Lake has experienced rapidly changing conditions based on sediment deposits from the upstream rivers including the Missouri and Niobrara, which can be seen in the cover image (headwaters of Lewis and Clark Lake in 2016, upstream from Springfield, SD). The delta in Lewis and Clark Lake has changed dramatically since the completion of the reservoir and subsequent filling of the pool, as seen in Figure 1. Without water and sediment management changes, the effects of sedimentation will increasingly limit the benefits provided by the Federal project.

This report describes the lost benefits in both a qualitative and quantitative manner due to availability of information and a broader scope of economics. This study considers economic benefits that extend longer than the USACE's traditional 50-year period of analysis, and explores effects associated with a 150-year study window. This allows USACE and the sponsors to better assess decisions based on a life-cycle approach to sediment management within the reservoir.

Importantly, recreation on Lewis and Clark Lake will be impacted by sedimentation. This is a critical issue, as recreation is expected to expand in the short term with heavy investment from both South Dakota and Nebraska. These states plan to build both water-specific and general recreational facilities adjacent to the lake. Because of this, recreation is expected to remain vibrant over the short term before sedimentation begins to restrict recreational activities.

This economic appendix provides historical, existing, and future without action conditions. A variety of economic business lines and social effects are affected by sedimentation of Lewis and Clark Lake. These include water supply, irrigation, recreation, agriculture, flood risk management, and hydropower.

[1] Annandale, G. W., Morris, G. L., & Karki, P. (2016). Extending the life of reservoirs: sustainable sediment management for dams and run-of-river hydropower. The World Bank.

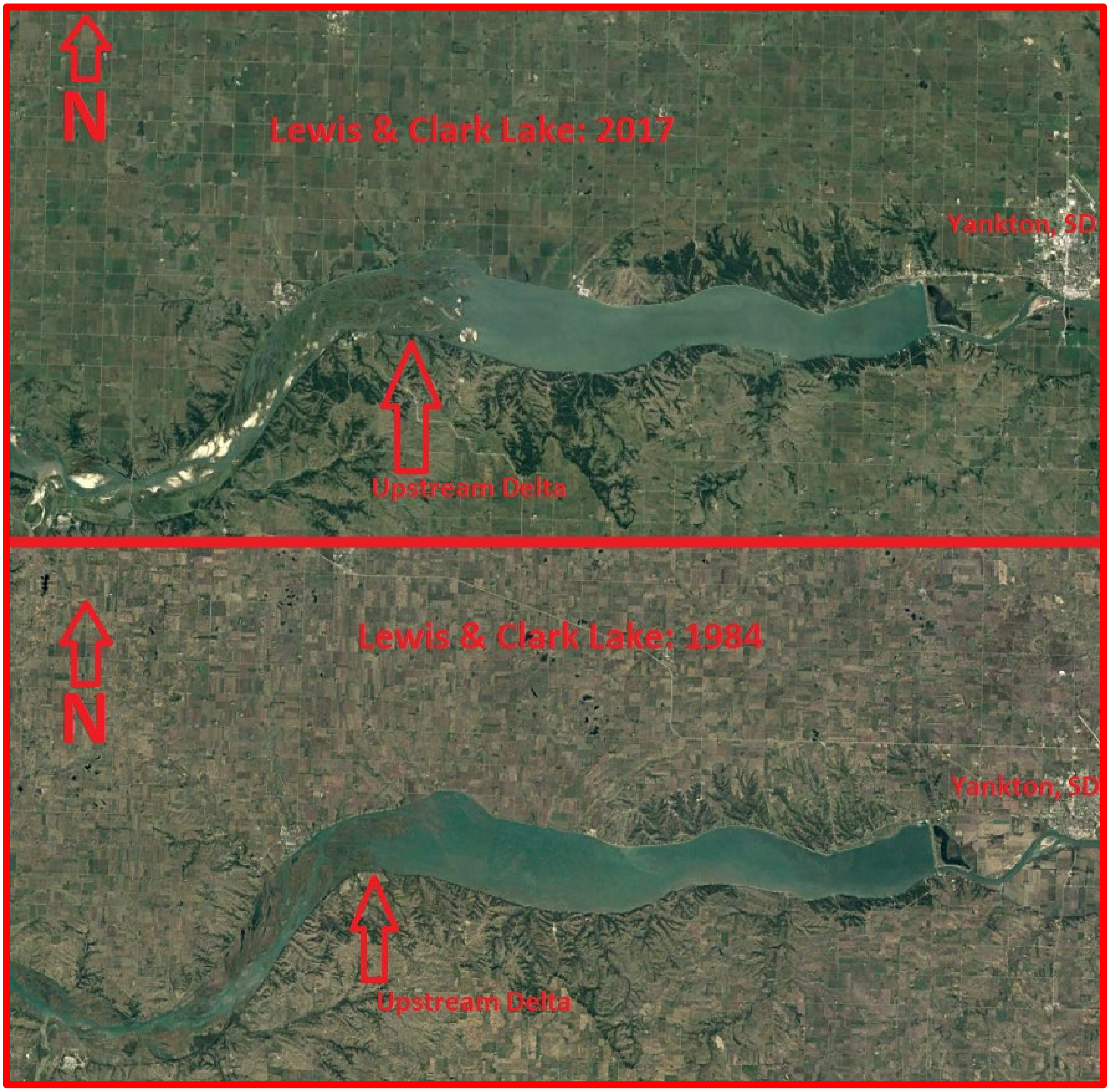

Figure 1: Upstream Delta and Sedimentation, 1984 versus 2017

Table of Contents

List of Figures

List of Tables

1 HISTORICAL CONDITIONS

During its history, sedimentation has been a constant issue for Lewis and Clark Lake which has been disproportionately degraded by droughts and floods that impact the Upper Missouri River region. It is the smallest lake of the mainstem Missouri River reservoirs and has the smallest sediment inflow in absolute terms but has the highest sediment inflow as a ratio of sediment inflow to storage area. This is estimated to have resulted in more than 30 percent storage loss to date. The states of South Dakota and Nebraska, USACE, and third-party contractors have produced many reports on the past conditions and impacts of sedimentation in and around Lewis and Clark Lake. These reports contain detailed measures employed by both local and Federal governments to mitigate the impacts of sedimentation. These mitigation projects incur large economic costs and can create negative outcomes for nearby ecosystems. A detailed aggregation of these quantitative costs as well as qualitative costs to the community and the nation are detailed in this section. The costs represented here also provide the current existing conditions of the lake.

1.1 History of Gavins Point Dam and Lewis and Clark Lake

Construction on Gavins Point Dam began in 1952 with dam closure in 1955, which impounded 574,930 acre-feet of water at an elevation of 1210.0 feet (NGVD 1929). A post-2011 Flood survey indicated the dam lost approximately 26 percent of its initial storage capacity to sedimentation, leaving it with 425,829 acre-feet that year. During this period (1955-2011), the delta moved downriver at approximately 550 feet per year; however, this rate is expected to slow as the delta reaches the deeper parts of Lewis and Clark Lake[2]. The storage loss per-year at the time of the 2011 report was approximately 2,660 acre-feet.

While some of Lewis and Clark's pool is allocated for flood risk management, only about 138,000 acre-feet is officially designated for such, representing less than one percent of the total storage volume of the Missouri River Reservoir System. This has remained relatively unchanged between 1955 and the production of the post-2011 Flood report.

Gavins Point Dam sits downstream of the Missouri River's confluence with the Niobrara River. The Niobrara River Watershed drains the North-Central Nebraska region where the Sandhills are located. Due to the Sandhills' unique geomorphic features, the Niobrara transports and deposits a large amount of sediment relative to its size. This, combined with the sediment moving down the mainstem Missouri below Fort Randall Dam, creates a unique sedimentation situation for Lewis and Clark Lake and Gavins Point Dam, as it has filled up faster than most other reservoirs in the United States[3]. As of 2022, Lewis and Clark Lake had recorded the third highest total storage loss of any reservoir in the USACE portfolio.

1.2 History of Economic Benefits

A brief economics section was included in the pre-project report for the construction of Gavins Point Dam. This section included a qualitative discussion on the benefits for recreation, flood control, and hydropower, and indicated these benefits greatly outweighed any costs. The report

[2] USACE NWO and WEST Consultants. (2013). SEDIMENTATION CONDITIONS AT LEWIS AND CLARK LAKE OCTOBER 2013. M.R.B. Sediment Memorandum 29.
[3] USACE NWO. (2001). Niobrara and Missouri Rivers, South Dakota, and Nebraska Sediment Strategies. Section 905(B) (WRDA 86) Analysis Reconnaissance Report.

did not include a discussion on the continuing operations and maintenance on the dam. It also failed to fully account for issues associated with sedimentation and the affect it could have on the dam's business lines. While some mention of sedimentation was included, it did not predict the current rates of sedimentation.

Lewis and Clark Lake has been a popular destination for tourists, boaters, anglers, hunters, and campers since it was filled. Figure 2 shows boaters recreating on the lake. The windy conditions and large, open waters make this an excellent place for sailing.

Figure 2: Recreation Activities on Lewis and Clark Lake (credit: NPS)

Photo Credit: National Park Service

1.3 The Village of Niobrara and Nebraska Highway 12

Sedimentation of this Missouri River corridor and the Niobrara River Delta led to the expansion of marshland near the town of Niobrara, Nebraska in the two decades after the dam was constructed. This forced the town to relocate to higher elevation farther south.[4] The new town was officially dedicated on July 4, 1977, and cost $7,000,000 in 1977 dollars or $12,443,201 in 2022 dollars. The infrastructure that remains at lower elevations still experiences flooding when releases from Fort Randall Dam exceeds 50,000 cubic feet of water per second (cfs). This is equivalent to an annual exceedance probability (AEP) event of 20 percent or what is commonly referred to as a five-year flood. The rising water table of Lewis and Clark Lake, due to the sedimentation trapped behind Gavins Point Dam, could threaten the town of Niobrara regularly. The land just north of the town is currently swampy grassland that has given up several feet of shoreline each year, as the water table continues to rise.

Nebraska Highway-12 is a regional highway that runs through Niobrara and extends from Willis, Nebraska near Sioux City to Valentine in western Nebraska. Frequent flooding on and along

[4] https://history.nebraska.gov/blog/niobrara-town-too-tough-stay-put

Highway-12 as it runs through the Missouri River valley has forced Nebraska and USACE officials to plan to raise the highway. This is a direct result of sedimentation behind Gavins Point Dam and shifting lake elevations. The current Environmental Impact Statement (EIS) for the movement of Highway-12 estimates the total costs to be $161-$340 million, depending on the selected alternative. This ongoing project plans to raise the highway by multiple feet, reducing the frequency of closure due to flooding. A Federal court held USACE responsible for the flooding near Highway-12, because of the sedimentation caused by Missouri River water management and Gavins Point Dam.

1.4 Relocation of the Water Intake for the Town of Springfield, SD

The town of Springfield, SD is currently constructing a new pump house and intake for the public water supply facility. The town produces approximately 73 million gallons of drinking water per year. About half of the water is used by the Mike Durfee State Prison, which has about 1,000 inmates. This intake is currently planned to extend further into the Missouri River while keeping the current intake as a backup. They are exploring options that include installing two new intakes and abandoning the current one. They would be at different lengths into the river to provide protection from sedimentation.

The new pump house will be placed higher up on the bluff to protect from flooding on the Missouri River. In an email dated Sept. 28, 2023[5] the Mayor of Springfield indicated that the cost of the new water treatment plant project, which includes new water intakes and pumphouse, is $1.8 million.

1.5 Emergent Sandbar Habitat Program

The Emergent Sandbar Habitat Program is designed to repair sandbars in the reaches of the Missouri River below Gavins Point Dam. These habitats have been slowly disappearing due to a lack of sediment flowing from the upper reaches of the Missouri River. The sandbar program builds new habitat in the form of sandbars along the banks of the Missouri River for birds and aquatic animals. USACE program managers are currently working on providing the costs of this program. This will include an overview of the historical costs of the program and the current costs of maintaining the habitat.

1.6 Other Historical and Ongoing Costs for Sedimentation Remediation

There are numerous costs associated with sedimentation, both historical and ongoing. While this report tries to capture as many impacts as possible, there are likely more effects that have not made themselves known. Below includes a list and a description of some of the issues increased sedimentation has caused. During this phase of the report, these costs have been described qualitatively as more information is gathered about the damages due to sedimentation and rising water tables.

- Agricultural land that has flowage easements, homesites, wells, access roads: damage and costs associated with the rising water tables above Lewis and Clark Lake.
- S54d Spur Road: damages to the road due to sedimentation.
- Roadway between Hwy 12 to Center, NE: damage to the road due to increased sedimentation.

[5] The email conversation was made known to USACE courtesy of MSAC.

- Rader Swanson Road: damage to the road due to increased sedimentation.
- Community of Niobrara: many of the low-lying areas around the Missouri River and the delta of the Niobrara River have seen increased water tables due to sedimentation.
- Lazy River Acres: rising water tables that affect the homes and access roads, as well as low lying areas in the fields.
- Dredging Improvement Projects because of increased sedimentation: Springfield Recreation Area Bay, Sand Creek LUA Bay, Gavins Bay LCRA, Midway Bay LCRA.
- Relocated Springfield Recreation Area Cabins: rising water tables and 2011 flooding that moved the recreational area.
- Tabor LUA Boat Ramp: requires continual cleaning due to increased sedimentation (every two weeks during the summer). This is typical due to wood type debris and shale/chalk rock, etc.
- Bottom Road repairs/improvements, Bon Homme County, NE: damage to the road due to increased sedimentation.
- Water, Sewer Systems Niobrara: have become threated because of rising water tables upstream of Lewis and Clark Lake.
- Niobrara Boat Ramp: became unusable after 2019 flooding event.
- Niobrara Golf Course: repaired following 2019 flooding event.
- Yankton County Fleeg's Bridge: erosion on Johnson Bridge 303rd Avenue on James River; (The James River bridge (Fleeg's Bridge) on Whiting Drive/309th Street/Old Highway 50 east of Yankton) due to lack of sediment releases downstream of Gavins Point Dam.
- Niobrara State Park: relocated following increased sedimentation and rising water tables upstream of Lewis and Clark Lake.

1.7 Prior USACE Sedimentation Studies

USACE has studied the issues of sedimentation between Gavins Point and Fort Randall Dams for more than four decades, producing a variety of reports. Most of these reports have involved at least some level of economic analysis on the existing and future conditions of the Missouri River between these two dams.

1.7.1 1994 Lewis and Clark Lake Sedimentation Study

This report addressed the "continued sedimentation in the head waters above Lewis and Clark Lake and aggradation of the Missouri River above its confluence with the Niobrara River" because of a potential loss of benefits. The report quantified economic damages for several business lines including flood control, hydropower, recreation, real estate, water supply, and upstream water supply.

1.7.2 2003 Niobrara and Missouri Rivers Sedimentation Strategy

The most recent USACE report was the 2003 sediment strategy report that attempted to provide economic justification for three different alternatives. The first proposed to dredge the Missouri River between River Miles 843.8 and 851.1. The second proposal was a relocation of the mouth of the Niobrara River. The third proposal was the "Coker Proposal – Dredging" that would keep Lewis and Clark Lake at its current levels. The costs for these three projects were $33.4 million,

$12.4 million, and $21.2 million in 2021 Dollars, respectively. None of these proposals were economically justified, as the respective benefit cost ratios (BCRs) were 0.77, 0.004, and 0.10. These BCRs were considered high because the cost of real estate for each plan was not fully developed. The overall conclusion at the time of this draft report was there were no feasible alternatives suggested based on a 50-year period of analysis and the Fiscal Year (FY) 2003 Federal discount rate of 6.375 percent.

1.8 Total Historical Costs

The total costs that have been spent in the history of Gavins Point Dam in order to cope with the increased sedimentation behind the dam, and the lack of sediment below the dam. The costs that are known to USACE at the time of this report are included in this figure. The total historical costs to the local communities, the state, and the nation total $362,743,000.

2 EXISTING CONDITIONS

The current sediment deposition in Lewis and Clark Lake affects nearly all parts of the reservoir; however, these issues are most impactful from the visible face of the delta in the lake and extending above the mouth of the Niobrara on the Missouri River reach. As seen in Figure 1, the present-day delta has slowly encroached upon the open waters of Lewis and Clark Lake. Many of the current issues with this sedimentation are explained in the following sections and contribute to the raising of Nebraska Highway 12 near the town of Niobrara, Nebraska, and other sediment related impacts. The delta's expansion into Lewis and Clark Lake and up the Missouri and tributaries concerns the residents of the nearby counties in both South Dakota and Nebraska, as well as travelers who come to recreate on or near the lake.

The economic conditions of Lewis and Clark Lake are continually changing, and the next five years will bring new development to the lake. These existing conditions describe current community and economic makeup of the region; however, there are many specific areas of development that are currently planned or ongoing. The majority of these are designed to improve the recreational experience of visitors to Lewis and Clark Lake. For example, one estimate indicates there will be nearly $40 million in new development at Niobrara State Park/Weigend Area alone. To understand the extent of potentially effected regions, the study area must be considered.

The study area extends along the Missouri River from Fort Randall Dam to the city of Ponca, Nebraska below Gavins Point Dam. The economic impacts are quantitatively considered from above the Niobrara River to Gavins Point Dam. Figure 3 shows the study area counties. The Nebraska counties are outlined in red, while the South Dakota counties are outlined in black.

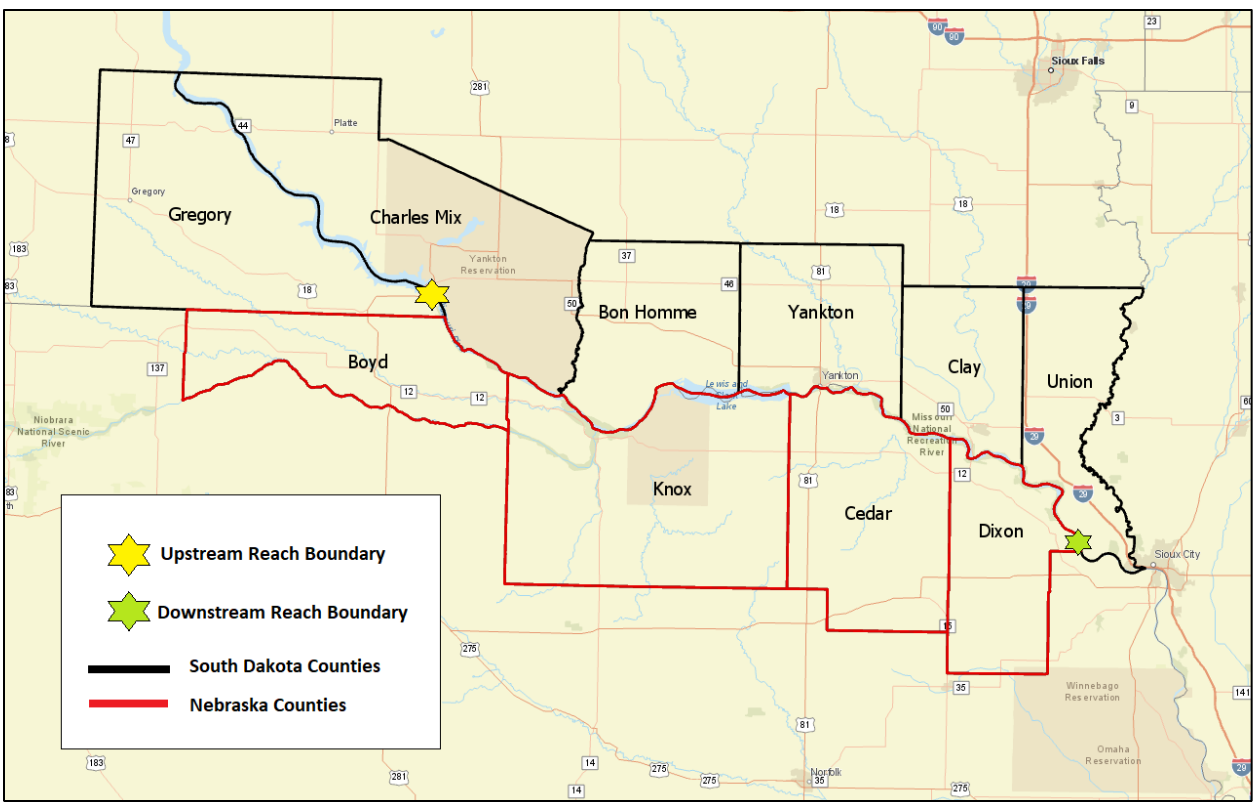

Figure 3: Lewis and Clark Study Area

The counties directly affected are Boyd, Cedar, Holt, and Knox in Nebraska and Bon Homme, Charles Mix, Gregory, and Yankton in South Dakota. Nearby cities in these affected counties include Yankton and Springfield, South Dakota; and Niobrara, Nebraska. Two Tribes have reservations in the affected counties, and both border the Missouri River: the Santee-Sioux Tribe in Nebraska and the Yankton-Sioux in South Dakota. Table 1 below shows the population of the impacted towns and reservations. It is important to note that Lazy River Acres has approximately 50 permanent residents, while the rest of the residents in that area are seasonal.

Table 1: 2021 Centers of Population[6]

Location	State	Population	Tribal Land
Yankton	South Dakota	15,453	No
Niobrara	Nebraska	363	No
Santee Village	Nebraska	406	Yes
Yankton-Sioux Tribe	South Dakota	6,824	Yes

In total, there are 74,000 people living in the study area counties. Several of the counties in this study area have a larger Native American population than the state averages, highlighting some of the diversity within this study area. The tables below show statistics on population and employment statistics (from the Census Bureau's American Community Survey: 2022 5-year estimates; Census Bureau Tables). Table 2 shows general statistics for population, age, and race broken down into state- and county-level aggregations.

[6] Source: 2020 Census and Bureau of Indian Affairs

Table 2: Statistics on Population, Age, and Race

General Statistics				Statistics by Race				
Geographic Area Name	**Total Population**	**Percent Male**	**Median Age**	**Percent White**	**Percent Black or African American**	**Percent American Indian and Alaska Native**	**Percent Asian**	**Percent Some other race**
South Dakota	**870,638**	**50.4%**	**37**	**84.3%**	**2.0%**	**8.8%**	**1.5%**	**0.8%**
Bon Homme County	6,929	58.7%	42.3	88.5%	1.5%	7.2%	0.4%	0.6%
Charles Mix County	9,349	50.3%	35.8	63.2%	0.1%	31.3%	0.1%	0.2%
Clay County	13,957	48.9%	24.9	90.4%	1.7%	4.2%	2.5%	1.1%
Gregory County	4,186	51.3%	45.4	88.1%	0.0%	6.7%	1.8%	0.5%
Union County	15,638	50.2%	40.0	91.8%	1.1%	0.9%	1.6%	1.5%
Yankton County	22,717	52.1%	41.8	92.4%	1.6%	3.3%	0.2%	0.4%
Nebraska	**1,914,571**	**49.9%**	**36.5**	**87.1%**	**4.8%**	**0.9%**	**2.4%**	**2.1%**
Boyd County	1,937	49.7%	54.3	95.8%	0.6%	1.0%	1.0%	0.2%
Cedar County	8,498	50.9%	42.7	97.4%	0.2%	0.8%	0.1%	0.9%
Dixon County	5,719	50.2%	40.8	84.5%	0.3%	0.6%	0.4%	7.3%
Holt County	10,177	50.4%	42.8	97.6%	0.1%	0.6%	0.6%	0.2%
Knox County	8,426	49.6%	45.6	86.8%	0.4%	9.5%	0.3%	0.7%

These counties are primarily rural and rely on agriculture for their economies. For the communities close to Lewis and Clark Lake, especially Yankton, South Dakota, a larger share of their economy relies on tourism from the lake.

Table 3: South Dakota Income & Employment

Geographic Area /Category	South Dakota	Bon Homme County	Charles Mix County	Gregory County	Yankton County	Clay County	Union County
Estimate Median income (dollars)	**$69,728**	$54,737	$50,481	$43,438	$58,342	$50,724	$70,378
Civilian Employed Population by Industry							
Agriculture, forestry, angling and hunting, and mining	**29,549**	397	584	302	555	250	284
Construction	**29,549**	188	261	126	542	164	349
Manufacturing	**33,992**	341	139	43	2,180	325	1,332
Wholesale trade	**45,709**	96	106	43	304	67	314
Retail trade	**9,692**	263	390	207	1,501	348	389
Transportation and warehousing, and utilities	**52,733**	148	222	128	279	209	463
Information	**20,313**	11	45	11	90	119	126
Finance and insurance, and real estate and rental and leasing	**6,686**	146	195	103	867	227	513
Professional, scientific, and management, and administrative and waste management services	**27,514**	146	153	84	412	273	334
Educational services, and health care and social assistance	**31,058**	693	904	594	2,892	1,331	1,212
Arts, entertainment, and recreation, and accommodation and food services	**121,289**	88	447	175	745	237	220
Other services, except public administration	**40,464**	109	198	97	575	175	233
Public administration	**19,684**	206	257	67	507	108	160

Table 3 details the number of working civilians over the age of 16 as well as the number of persons employed in each industry.

Table 4: Nebraska Income & Employment

Category	Nebraska	Boyd County	Cedar County	Dixon County	Holt County	Knox County
Estimate Median income (dollars)	**$61,439**	$47,778	$61,869	$56,905	$60,387	$52,332
Civilian Employed Population by Industry						
Agriculture, forestry, angling and hunting, and mining	**43,391**	200	866	222	989	807
Construction	**70,129**	94	347	153	385	219
Manufacturing	**102,303**	34	569	518	282	256
Wholesale trade	**27,429**	18	101	69	173	125
Retail trade	**112,221**	144	439	173	462	402
Transportation and warehousing, and utilities	**58,257**	91	201	123	333	234
Information	**18,402**	11	67	7	58	56
Finance and insurance, and real estate and rental and leasing	**75,245**	28	274	99	309	189
Professional, scientific, and management, and administrative and waste management services	**87,511**	43	124	78	221	178
Educational services, and health care and social assistance	**243,998**	196	1,114	471	1,552	1,034
Arts, entertainment, and recreation, and accommodation and food services	**76,154**	45	177	96	239	251
Other services, except public administration	**43,870**	40	143	131	379	198
Public administration	**40,302**	41	162	107	303	290

Table 4 details the income and employment information for the affected counties in Nebraska along with a breakdown of employment activity for the state and each of the counties in the study area.

These communities also rely on the lake as a source of irrigation, power generation, and flood risk reduction. They enjoy the passive use values associated with Lewis and Clark Lake provided by the views, plants, and animals. Furthermore, the communities above and below the lake rely on the pool to maintain a relatively constant level and rely on the fact that Gavins Point Dam is safe. This means the water behind the Dam is safe for recreation while the communities below the Dam are safe from potential failures. This Existing Conditions chapter details the current environment for the affected business lines in this study area including recreation, flood risk management, hydropower, water supply, and irrigation, as well as other social effects.

2.1 Recreation

One of the most important resources that Lewis and Clark Lake provides is the access to recreation on and near the lake. Both South Dakota and Nebraska have state parks and recreation areas adjacent to the lake. Lewis and Clark Boy Scout Camp also owns property along the north-central shore of the lake. These recreation areas have many facilities onsite for visitors to participate in many different types of activities. Table 5 below details the activities offered from the state-owned recreation areas on/near the lake.

Table 5: Recreation Facilities and Activities

Archery Range & Trails	Electrical Campsite(s)	Picnic Tables
Basketball Hoops	Fish Cleaning Station(s)	Playground(s)
Biking Trail(s)	Angling Pier(s)	Shore Angling Access
Boat Ramp(s)	Group Picnic Shelter(s)	Showers & Flush Toilets
Campground(s)	Hiking Trail(s)	Swim Beach(es)
Camping Cabin(s)	Horse Campsite(s)	Tent-only Campsite(s)
Concessions	Horse Trail(s)	Track Trail(s)
Dump Station	Paved Trail(s)	Visitor Center(s)

These recreation facilities allow for a variety of activities and enjoyment. There are also three marinas on Lewis and Clark Lake: two in Nebraska and one in South Dakota. The Lewis and Clark Marina in South Dakota is a privately owned and operated marina, offering 400 slips with service for boats up to 48 feet in length. The Weigand Marina in Nebraska operates under the Nebraska Game and Parks Commission. Hoffman's Marina in Nebraska is a privately owned and operated marina. These marinas operate convenience stores, boat refueling services, and boat ramps. They also allow for day-use boating and offer parking lots for visitors.

All the facilities listed above allow for recreators to enjoy a wide range of activities on or near the lake. Table 6 shows a breakdown of different activities including those on the water as well as on state park lands. These figures are taken from the Missouri River Recovery Management Plan (MRRMP) EIS economics appendix for recreation[7]. The data has been supplemented with more recent data from the South Dakota Game, Fish and Parks and the Nebraska Game and Park commissions.

[7] https://www.nwo.usace.army.mil/mrrp/mgmt-plan/

Table 6: Visitor Activity by Recreation Category

Activity	Percent of Recreators
Camping	4.3%
Picnicking	3.0%
Boating	7.3%
Hunting	0.9%
Skiing	2.1%
Swimming	9.5%
Sightseeing	46.4%
Other	17.4%

Swimming and boating are among the more popular recreational activities, along with general sightseeing. This can be broken down further into generalized and specialized numbers. The most recent total visitor numbers indicate that there is an increasing number of recreators visiting Lewis and Clark Lake. While many people travel to recreate on the lake, a majority of the visitors to the lake live in the counties within the study area or in adjacent towns. Approximately 57 percent of the visitors to the lake are local. The information in the MRRMP was obtained from state sources, angler and visitor surveys, and published reports to estimate the percent of local and non-local visitors.

Using recent visitation estimates from the Nebraska and South Dakota State Parks, internal USACE numbers, and visitation estimates from the MRRMP, an estimated 1.03 million total recreation days occurred on the lake in 2021. The number of visits is adapted from the MRRMP EIS which uses 2018 as a base-year estimate for the number of visitations the lake received in a year. This figure was updated to 2020 population baselines based on the total change in the local and U.S. populations. Table 7 shows the recreation days for Lewis and Clark Lake. Visitor days per year is measured by the number of visits that equate to one day recreating on the lake. This means if someone comes to the lake for one day in June and one day in August, it would count as two recreation days rather than one.

Table 7: Lewis and Clark Lake Recreation Visitor Days per year

Season	Number of Days
Winter Recreation Visitor Days	108,802
Spring, Summer, and Fall Visitor Days	924,277
Total Recreation Visitor Days:	**1,033,079**

Because alternatives to reduce sedimentation involve seasonality, this report adapts the seasonality component used in the MRRMP.

- Winter visitation: all visits between the months of December and March.
- Spring, summer, and fall lake elevation-affected visitation: angler, boaters, skiers, campers, and sightseers.

For the months of December, January, February, and March, the primary activities on/near the lake involve ice angling, camping, cross country skiing, hunting, and sightseeing. Generally, fewer boats are launched onto the lake during these months, however there are still some access points. During the summer months, recreators enjoy increased camping activities as well as boating, angling, hunting, and sightseeing. There are currently 22 boat ramps between the Fort Randall and Gavins Point dams. Table 8 provides the name, state, and river location of each of the boat ramps on the river.

Table 8: Boat Ramp Description

Name	State	Location on the River
Sunshine Bottom	Nebraska	Between Ft. Randall and Niobrara
Verdel	Nebraska	Between Ft. Randall and Niobrara
Ft. Randall Spillway	South Dakota	Between Ft. Randall and Niobrara
Randall Creek	South Dakota	Between Ft. Randall and Niobrara
Sand Creek	South Dakota	Between Niobrara and Open Lake
NE Ferry Landing	Nebraska	Between Niobrara and Open Lake
Niobrara	Nebraska	Between Niobrara and Open Lake
Running Water	South Dakota	Between Niobrara and Open Lake
Springfield	South Dakota	Between Niobrara and Open Lake
Santee	Nebraska	Between Niobrara and Open Lake
Bazille	Nebraska	Between Niobrara and Open Lake
Midway	South Dakota	Open Lake
West Midway	South Dakota	Open Lake
Gavins Point Marina	South Dakota	Open Lake
Tabor	South Dakota	Open Lake
Navratil Landing	South Dakota	Open Lake
Miller Creek	Nebraska	Open Lake
Bloomfield	Nebraska	Open Lake
Weigand	Nebraska	Open Lake
Walkers Valley	Nebraska	Open Lake
Hideaway Acres	Nebraska	Open Lake
SD Marina	South Dakota	Open Lake

These include all private and public ramps. Since 1984, three boat ramps have seen the open water of Lewis and Clark Lake reduced to a marshy delta: Springfield, Santee, and Sand Creek. Since the closure of Gavins Point Dam, the sediment-laden delta has crept into the lake, affecting many boat ramps by reducing their access to the river, and ease of access to the open water on Lewis and Clark Lake. Figure 4 shows the locations of the 22 boat ramps on Lewis and Clark Lake and those upriver to Fort Randall Dam.

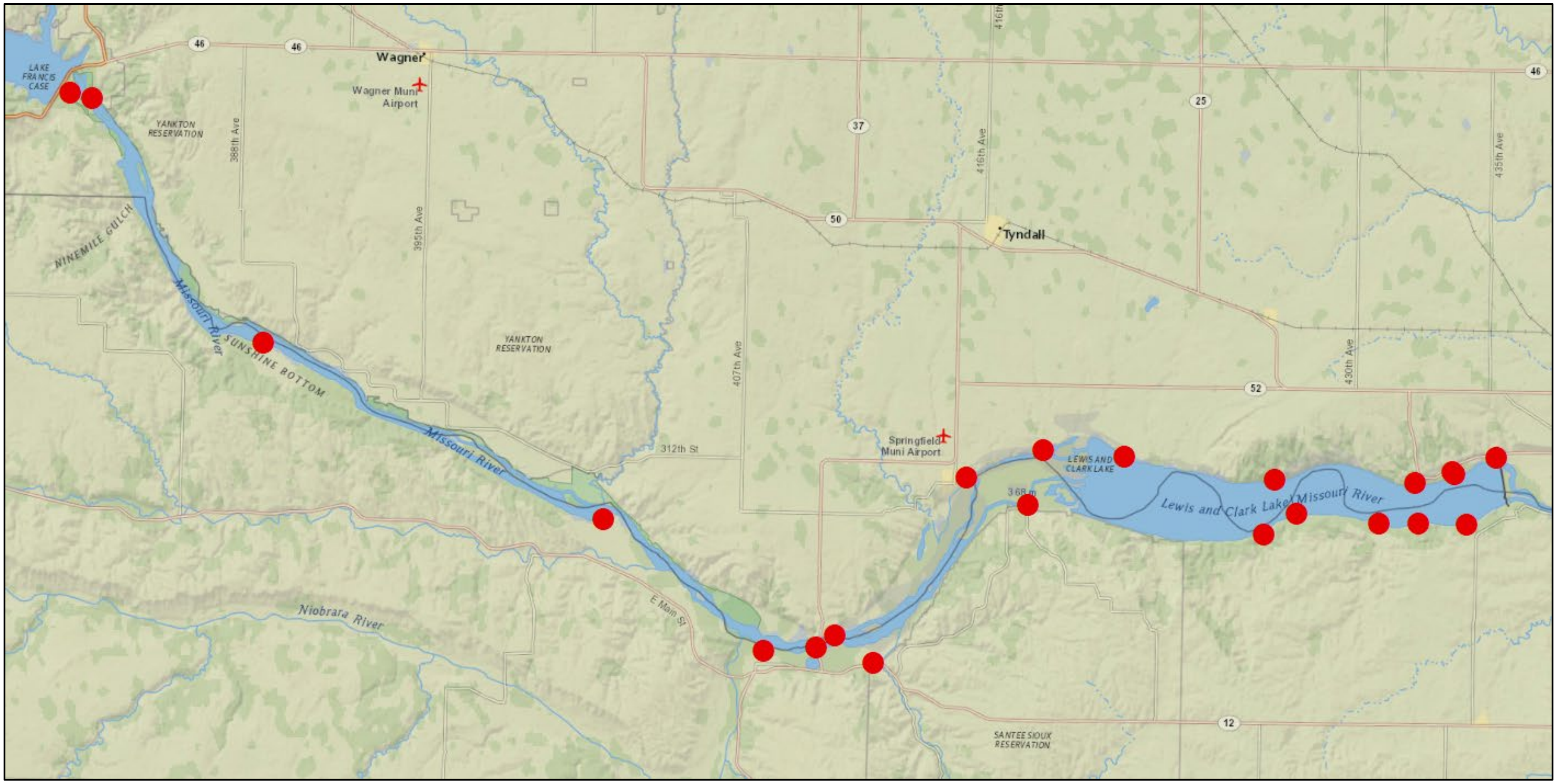

Figure 4: Boat Ramps Between Gavins Point and Fort Randall Dams

Despite the recent sedimentation issues on Lewis and Clark Lake, the new marshland created by the sedimentation has created vast waterfowl habitat and hunting ground. The creation of these sediment islands has attracted waterfowl hunters from around the country; the creep of the delta onto the open lake has allowed for more of this hunting in recent years.[8] Waterfowl hunting is popular on the land adjacent to Lewis and Clark Lake, along with whitetail, upland fowl, and turkey hunting. The creation of new habitat in recent years has expanded recreators' interest in hunting.

2.2 Irrigation

The counties surrounding Lewis and Clark Lake and the stretch of the Missouri River between Fort Randall Dam and Gavins Point Dam provide fertile lands for farmers to grow many different crops. Many of the farmers along the river and lake, as well as farmers with land a few miles inland, utilize intake valves from the surface of the lake and river. Increased sedimentation upstream of Gavins Point Dam has changed the shape of the river, forcing some farmers to move the intakes closer to the new path of the river. Downstream of Gavins Point Dam to Ponca, Nebraska, intakes are having the opposite problem. A reduction in sediment flowing through these downstream reaches has caused significant channel degradation and erosion in riverbanks where intakes are placed, forcing them to be moved further inland.

The most popular crops grown include corn, soybeans, alfalfa, oats, winter wheat, and hay. Table 9 shows a breakdown of all use-types for the counties adjacent to Lewis and Clark Lake, broken down by acreage. These figures come from the United State Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) database, and land use types included are those with 100 or more acres in use.

Table 9: Study Area Land Use

Land Use	Acres	Land Use	Acres
Grassland/Pasture	2,108,596	Shrubland	9,772
Corn	1,626,201	Developed/Med Intensity	7,820
Soybeans	1,320,541	Pop Corn	6,971
Deciduous Forest	305,352	Millet	4,237
Alfalfa	303,012	Rye	3,971
Developed/Open Space	200,141	Barren	2,956
Open Water	160,631	Spring Wheat	2,921
Fallow/Idle Cropland	134,933	Sod/Grass Seed	2,447
Other Hay/Non-Alfalfa	127,614	Developed/High Intensity	2,100
Herbaceous Wetlands	115,506	Sunflower	1,994
Winter Wheat	38,555	Mixed Forest	1,362
Oats	38,079	Dry Beans	1,324
Woody Wetlands	37,906	Potatoes	1,204
Developed/Low Intensity	31,193	Other Crops	415
Evergreen Forest	22,637	Switchgrass	157
Sorghum	12,932	Barley	127

[8] http://outdoornebraska.gov/lewisandclark/

Corn and soybeans are the two main crops and represent a majority of all crops planted in this region. These crops are important to both the state and national economies. Figures 5 and 6 show maps of the Upper Midwest Region, with the figure in each state representing its annual contribution to the nation's total corn and soybean production, respectively.[9] The counties within the study area produce at least 35,000 metric tons of corn per year, with one county in Nebraska, Boyd County, producing over 325,000 metric tons of corn per year, on average. The counties within the study area also produce between 50,000 and 275,000 metric tons of soybeans each year, on average.

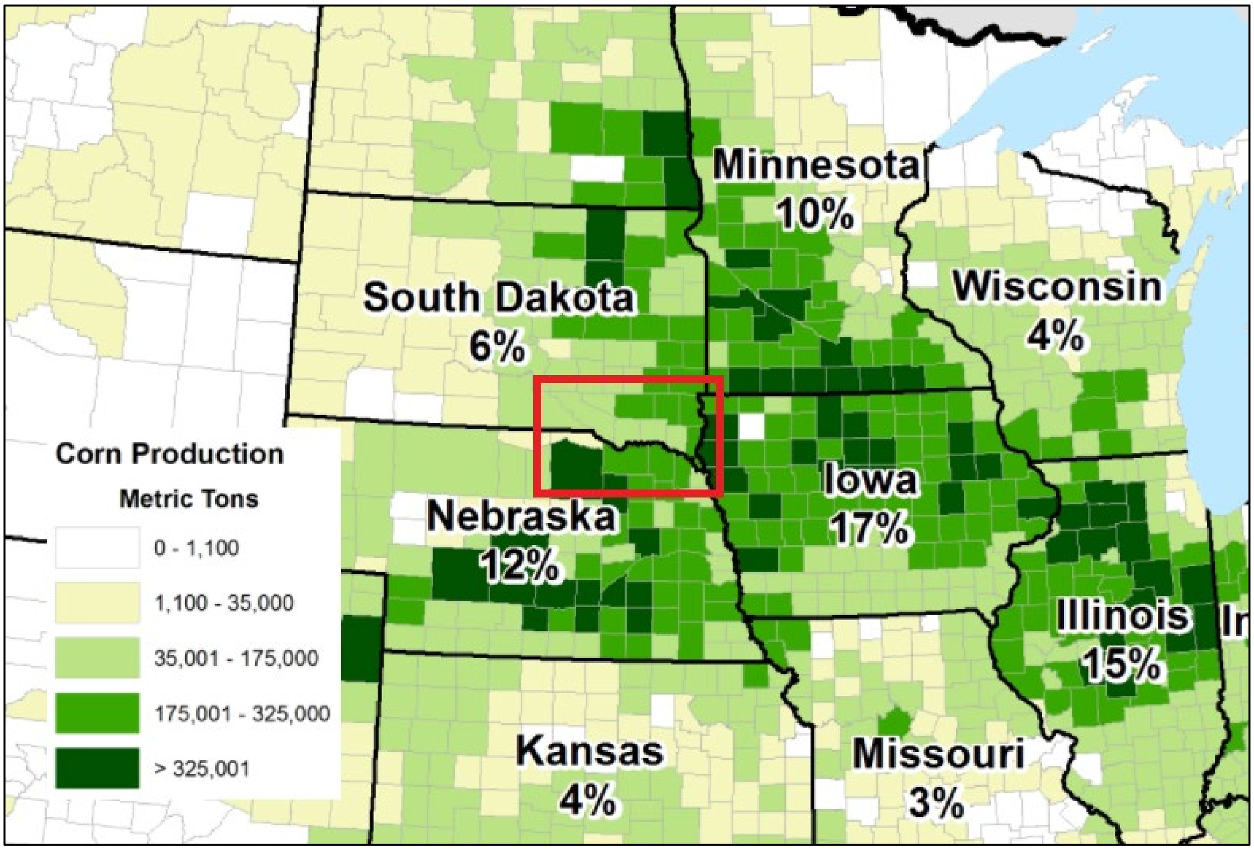

Figure 5: Midwest Corn Production by County

Note: Study area depicted as red rectangle.

[9] https://ipad.fas.usda.gov/rssiws/al/us_cropprod.aspx

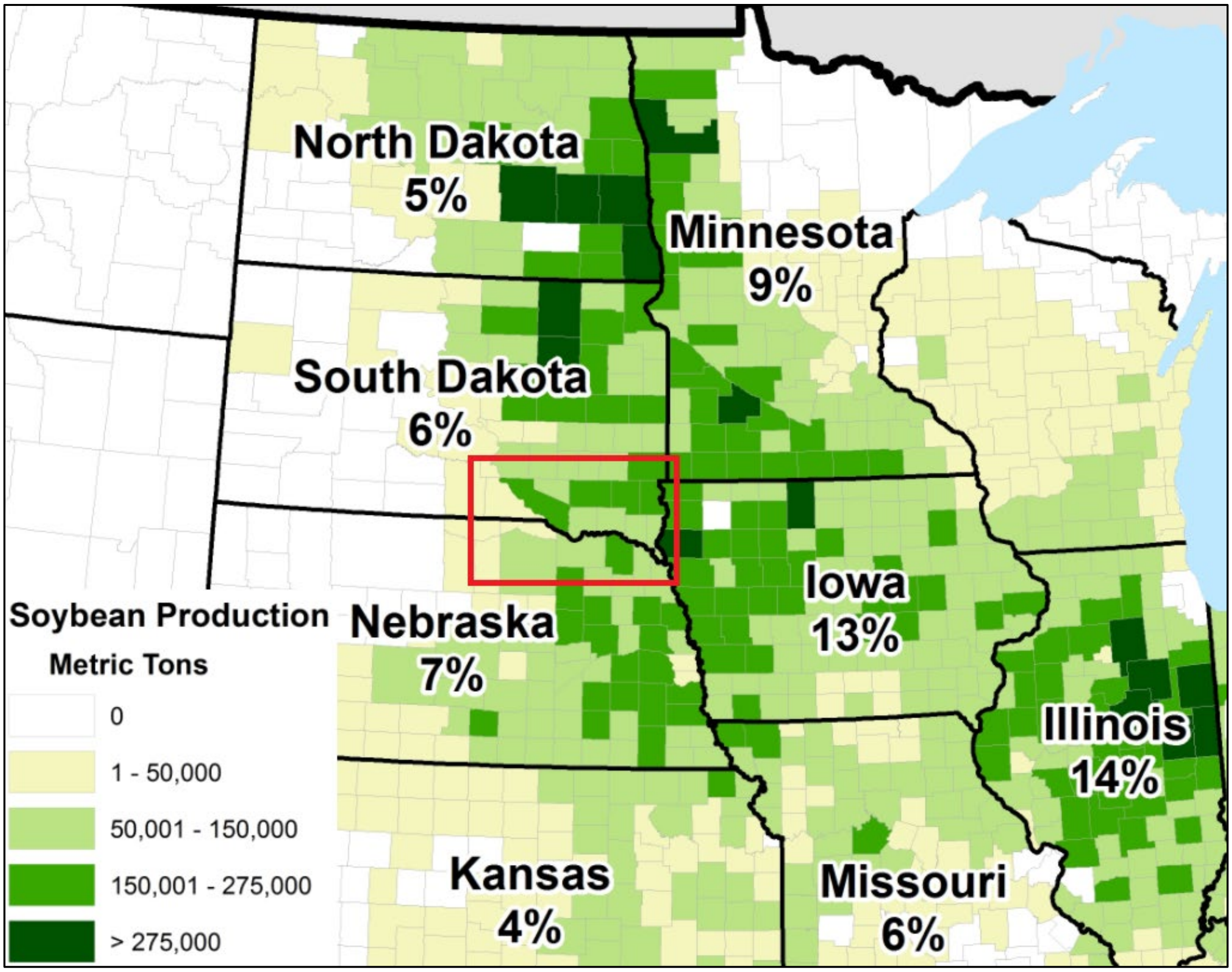

Figure 6: Midwest Soybean Production by County

Note: Study area depicted as red rectangle.

In South Dakota, there are more than 150 private and public water intakes from the Missouri River for the four counties in the study area.[10] A total of more than 30,000 acres are irrigated from these intakes per year. The publicly owned intakes use approximately 85 CFS. Table 10 details the usage for South Dakota's intakes.

[10] https://danr.sd.gov/OfficeOfWater/WaterRights/Databases/WaterRights.aspx

Table 10: South Dakota Water Intakes on the Missouri River

Owner	Irrigated Acres
Private – Bon Homme County	9,483
Private – Clay County	1,203
Private – Charles Mix County	19,056
Private – Gregory County	971
Private – Union County	938
Private – Yankton County	776
Private total	32,427

For Nebraska, data from the State of Nebraska Department of Natural Resources (DNR) show far fewer intakes along with fewer acres of cropland irrigated.[11] There are also only three non-private pumps in Nebraska. Table 11 shows the breakdown of pumps on the Missouri River in Nebraska for the counties in the study area.

Table 11: Nebraska Water Intakes on the Missouri River

Owner	Acres
Private – Boyd County	397
Private – Cedar County	1,319
Private – Dixon County	1341
Private – Holt County	(No approved pumps)
Private – Knox County	316
Total Private	4,081

For all eight counties in the study area, the Missouri River provides water for approximately 32,000 acres for irrigation and 54 cfs of water for public organizations. This is a general summary of the counties adjacent to Lewis and Clark Lake and the direct upstream reach to Fort Randall Dam. The irrigation intakes that are currently being affected by sedimentation on the Missouri River in this reach are between Springfield, SD and Niobrara, NE in Bon Homme County, South Dakota and Knox County, Nebraska.

2.3 Non-Irrigation Water Supply

The Missouri River reach between Ponca, Nebraska and Fort Randall Dam provides public water to a variety of communities. These entities have permits to draw water from the river measured in cfs. Some of these intakes have had issues with changing riverbanks due to increased sedimentation upstream of Gavins Point Dam – especially near Springfield, South Dakota. Intakes downstream of Gavins Point Dam have also been affected because of bed degradation in the downstream reach.

In South Dakota, the publicly owned intakes use approximately 85 cfs. Table 12 details the usage for South Dakota's intakes. On the Nebraska side, the publicly owned water intakes

[11] http://nednr.nebraska.gov/Dynamic/WaterRights/WaterRights/SelectSearchOptions

supply 2.3 cfs. There are also only three non-private pumps in Nebraska. Table 13 shows the breakdown of pumps on the Missouri River in Nebraska for the counties in the study area.

Table 12: South Dakota Non-Irrigation Water Supply

User	Pump Rate (cfs)
B-Y water district	29.5
City of Springfield	=<1
City of Lake Andes	=<1
Lake Andes - Wagner irrigation district	=<1
South Central Water Dev	=<1
City of Sioux Falls	=<1
US Fish/Wildlife Service	16
Yankton fire protection district	<1
McCook Lake Recreation Association	41
Total Public	**87.5**

Table 13: Nebraska Non-Irrigation Water Supply

User	Pump Rate (cfs)
Santee Sioux Tribe of Nebraska	0.79
City of Crofton	0.44
Cedar-Knox Water	1.6
Cedar-Knox Water	3.1
National Park Service	1.07
Total Public	**7**

2.4 Hydropower

The pool elevation of Lewis and Clark Lake and the amount of water moving through the lake impact the hydropower production of Gavins Point Dam. Current hydropower generation at Gavins Point Dam is estimated to power 68,000 homes with operation for baseload production. Therefore, the dam cannot ramp up power production during peak demand, rather it provides a continuous energy supply given the water surface elevation of Lewis and Clark Lake. The dam provides a total of 132 megawatts (MW) of electricity. More details can be seen in Table 14[12].

[12] https://www.nwo.usace.army.mil/Missions/Dam-and-Lake-Projects/Missouri-River-Dams/Gavins-Point/Hydropower/

Table 14: Gavins Point Dam Descriptive Values

Data Point	Value
Generators/Turbines	3- Variable Pitch, Kaplan Turbines, 75 rpm
Nameplate Capacity	132.3 MW/44.1 MW each
Percent of NWO Capacity	5.30%
Average Gross Head	48 feet
Number & size of conduits	None: direct intake
Surge Tanks	None
Discharge Capacity	48 feet at 36,000 cfs
Average annual energy	726 M kWh

The value provided from the hydropower generators at Gavins Point Dam is based on the cost of energy from a combination of generation plants that would replace the lost energy from the hydropower plant if operation ceased, (i.e., the opportunity cost of power). Energy prices vary from hour to hour, between weekdays and weekends, and between different months. One difficulty of computing energy costs and 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 requires 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.

Using analyses from the MRRMP EIS, this report utilizes the Locational Marginal Pricing (LMP) from the Western Area – Upper Great Plains East (WAUE) hub of the SPP to calculate energy values. LMP is a computation technique that determines a shadow price for an additional MWh of demand. Historical LMP values for WAUE for 2014 to 2016 were downloaded from the Southwest Power Pool (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 2015, the Western Area Power Administration (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.

These price estimates are used in conjunction with the dependability of the reservoir to determine energy values. The dependable capacity of a hydropower project is a measure of the amount of capacity that the project can reliably contribute toward meeting system peak power demands. Gavins Point Dam maintains fairly consistent head unless the flood storage is needed. If a hydropower project maintains a consistent head, the full installed generator capacity can be considered dependable. Using these assumptions from the MRRMP EIS, this report adapts the results from the analysis that represents current operations at Gavins Point Dam to show current price levels (2022) of hydropower benefits. Table 12 shows the average annual generation, based on dependability estimates, the value of this generation, then the dam's dependability for summer and winter seasons, where energy demand and production can be much different.

Table 15: Gavins Point Hydropower Value: 2022 Dollars

Data Point	Value
Average Annual Generation (MWh)	726,921
Average Annual Generation Value	$17,945,000
Average Annual Dependable Capacity in Summer (MW)	119.044
Average Annual Dependable Capacity Value in Summer	$14,746,000
Average Annual Dependable Capacity in Winter (MW)	111.416
Average Annual Dependable Capacity Value in Winter	$13,802,000

While Gavins Point Dam provides hydropower benefits, it currently doesn't require any special maintenance due to the sedimentation of the lake. If coarse sediment (sand size and larger) passes through the turbines of a hydropower dam, it can cause damage, sometimes catastrophic. Currently, Gavins Point Dam turbines do not require any special attention due to sediment, as the sediment currently collects on the lakebed and on the western end.

2.5 Flood Risk Management

Gavins Point Dam releases water from the lake for a variety of reasons including navigation, fish and wildlife habitats, and flood risk management. The record outflow from Gavins Point Dam was 160,000 cfs, during the flood of 2011, more than doubling its previous record of 70,000 cfs during the flood of 1997. Lewis and Clark Lake has a storage capacity of about 425,000 acre-feet of water as of the 2011 survey; however, this depends on rainfall in the basin and seasonality. The lake can provide around 50,000 acre-feet of storage to reduce downstream flood risk. This study looks at the Missouri River reach between Fort Randall Dam and Ponca, Nebraska.

Currently, upstream sediment has only partially limited the ability of Gavins Point Dam to reduce flood risk. In a post-2011 Flood Study, USACE found that about 26 percent of the reservoir's total storage capacity had been diminished by sedimentation at the western part of the lake. The total current loss of storage due to sedimentation is unknown. New reservoir surveys by 2023 are expected to update this value. Sediment can deposit in any of the three pools (permanent, multi-purpose and carryover, and flood control). The type of sediment inflow and reservoir management directly affect where sediment deposits. All three pools have seen some volume lost to sedimentation. So, while there has been some flood control pool storage lost due to sedimentation, that volume of storage lost at Lewis and Clark Lake can be re-allocated to upstream reservoirs, reducing the impact of the storage loss.

The post-2011 flood study also highlighted the loss of sediment in the Missouri River directly downstream of Gavins Point Dam. Because the sediment is not flowing over the dam, the streambanks have eroded faster than normal, and the riverbed has degraded. The lack of sediment is noticeable much further downstream, and these issues stretch to the Louisiana Coastline.[13] Sediment is important to ecosystem maintenance and the development of barrier

[13] The Sediment We Need is Behind Missouri River Dams – Greater New Orleans Interfaith Climate Coalition (gnoicc.org)

islands in the Mississippi River Delta, and the lack of sediment requires measures to create new sediment islands along the Louisiana coastline.

The reaches of the Missouri River between the river delta in Lewis and Clark Lake and the town of Niobrara, Nebraska have been the most affected in terms of changes in AEP events. Near the town of Niobrara, low lying roads that were once subject to flooding at the four-percent AEP (25-year flood) are now affected by water at the 20-percent AEP (5-year flood). This is due to rising water surface elevations caused by sediment deposition.

2.6 Agricultural and Structural Buyouts

Real estate along the Missouri River is currently being affected by the increased sedimentation in Lewis and Clark Lake. The overall impact of sedimentation has led to rising water surface elevations in the lake and river and widening of the Missouri's footprint. Since the construction of Gavins Point Dam, several easements have been purchased by USACE because sedimentation of the lake has led to a degradation of the private land. The land, often farmland, slowly turns from farmable cropland into hay land, then into marshland. Because the land is unusable, FEMA purchases an easement for the Federal government. Some farmlands on the upstream reach of the Niobrara and Missouri Rivers have already been purchased by the Federal government as the rising water tables makes it nearly impossible to farm. USACE does not have current records of recent structural buyouts upstream because of rising water tables; however, many structures are currently at risk from these effects. Following 2011, there were only FEMA-funded buyouts at Lazy River Acres.

2.7 Risk, Uncertainty, and Climate Change

This existing conditions chapter contains various forms of risk and uncertainty that should be addressed. First, the uncertainty in existing conditions is primarily a result of measurement error and availability of data. Some sources used in this report are up to ten years old, and thus have likely changed over time. Due to the lack of other suitable data, it is important to include all relevant sources that represent the most accurate measures of the current conditions involving sedimentation on Lewis and Clark Lake. Risk comes from multiple sources including inaccuracy of data, where the information used to inform these existing conditions may mislead due to inefficacies.

Because Lewis and Clark Lake straddles both Nebraska and South Dakota, data on yearly visitation comes from two sources, and some visitors may visit both sides of the lake. Because this lake is predominately rural, it presents a unique challenge for collecting data because of variability in collection sources. Both state recreation areas, as well as USACE provide annual visitation estimates for the total number of visitors to the lake. This can be used to index existing data from the MRRMP EIS to estimate the number of people that recreate under each category. There is uncertainty associated with these estimates because over time, visitors may change their preferences from one activity to another. These types of changes would not be captured in our visitation estimates.

Also important is the impact of climate change on these existing conditions (Missouri River ECB 18-14). With more frequent flood and drought events, there is likely an effect on sedimentation; where droughts create drier and dustier soils, and subsequent floods push this sediment into the lake. While there is no conclusive report that points to a direct effect of climate change on the existing sediment conditions on Lewis and Clark Lake, the likelihood that more frequent and serious weather events can lead to an increase in sedimentation is clear.

2.8 Other Social Effects

2.8.1 Community Cohesion

The current communities in the study area rely heavily on recreational visitors to stimulate their economy. Current community cohesion is under threat from the expansion of the sediment islands further into the open lake. The towns most affected by increased sedimentation include Springfield, SD and Niobrara, NE, along with the Ponca Tribal Lands in Nebraska. These towns, along with Yankton, SD rely heavily on the lake as a source of jobs and income. A loss of recreation in the lake would hurt these local communities because their residents would have to move elsewhere to find jobs as existing jobs in activities such as recreation would be more competitive. This could hurt community cohesion.

2.8.2 Environmental Justice

Executive Order 12898 directs Federal agencies to address the impacts to low income and minority groups. Several nearby communities in both Nebraska and South Dakota are Native American Tribal lands. The Santee Sioux Community in Nebraska and the Yankton Sioux Tribe in South Dakota border the Missouri River in the study area. Like the nearby communities of Yankton, the Tribes benefit from the recreation and water rights associated with Lewis and Clark Lake. Worries about future conditions where there is no longer a lake, but a riverine segment, may already be affecting these important Tribal communities.

3 FUTURE WITHOUT ACTION CONDITIONS

This section describes the most likely future that will occur if no action is taken to control the sedimentation issues on the Missouri River behind Gavins Point Dam. This future without action extends 150 years to 2173 (2024 is assumed to be an action's first year). The analyses in this section describe the expected economic damages that will likely occur over this 150-year period of analysis. These damages are associated with losses in recreation, hydropower, real estate, water supply, irrigation, and flooding. USACE Omaha District economists provide the yearly NED benefit as well as the net present value of benefits that may vary from the current conditions. A real estate team was not part of this project, so structural buyouts or easements in the study area were not considered. In lieu of these values, structure locations and values are shown. Other sections, such as community cohesion and environmental justice, are qualitative in nature and described that way.

3.1 Future Conditions in the Study Area

The shape of Lewis and Clark Lake, the Missouri River, and the Niobrara River will look much different by the year 2150. USACE engineers have mapped the progression of sediment in future decades in attempt to show possible future conditions. These maps show three different stages: effects in the Lake, effects upstream on the Missouri River, and effects upstream on the Niobrara River. Each of these effects requires special consideration because the sedimentation of these areas can have different economic impacts. Figures 8-10 are projected maps of what the delta face may look like in Lewis and Clark Lake.

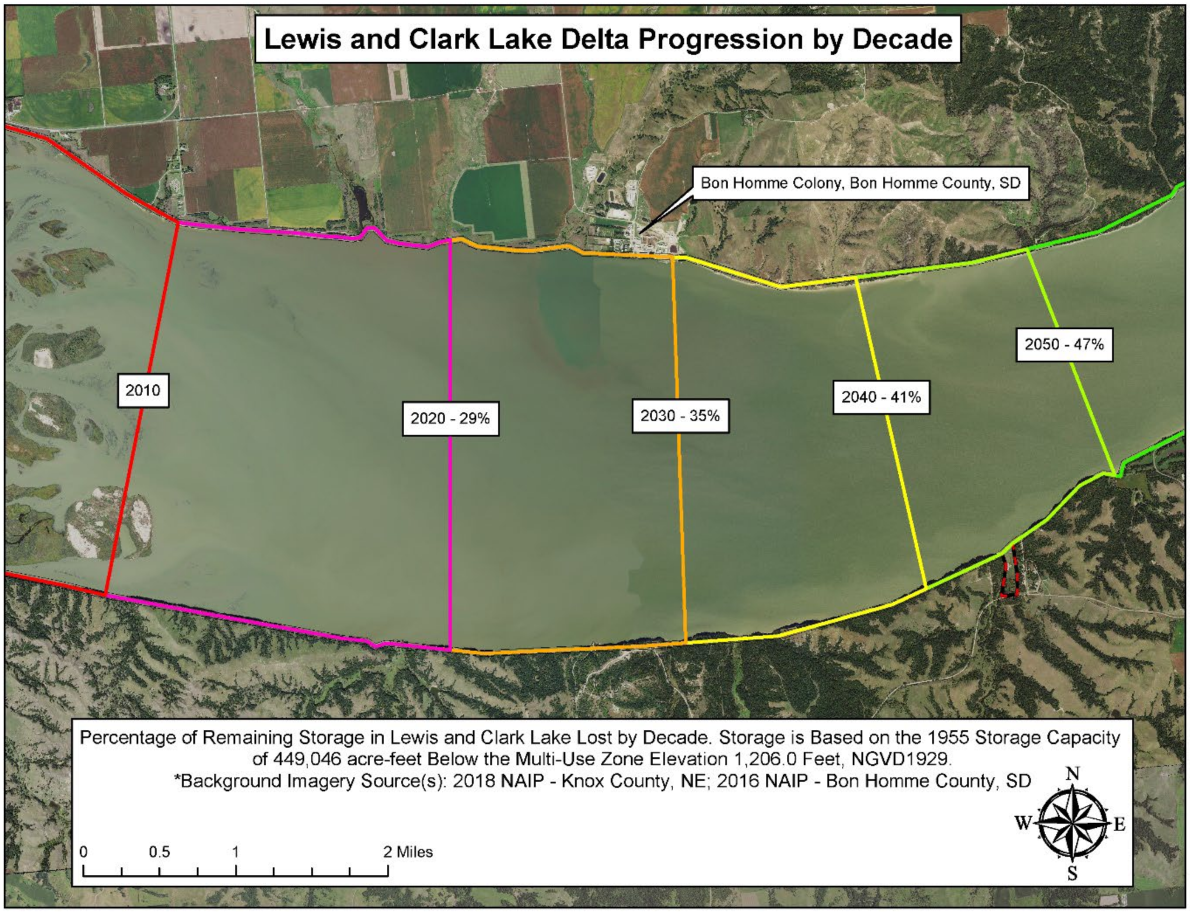

Figure 7: Lewis and Clark Lake Delta, 2010 to 2050

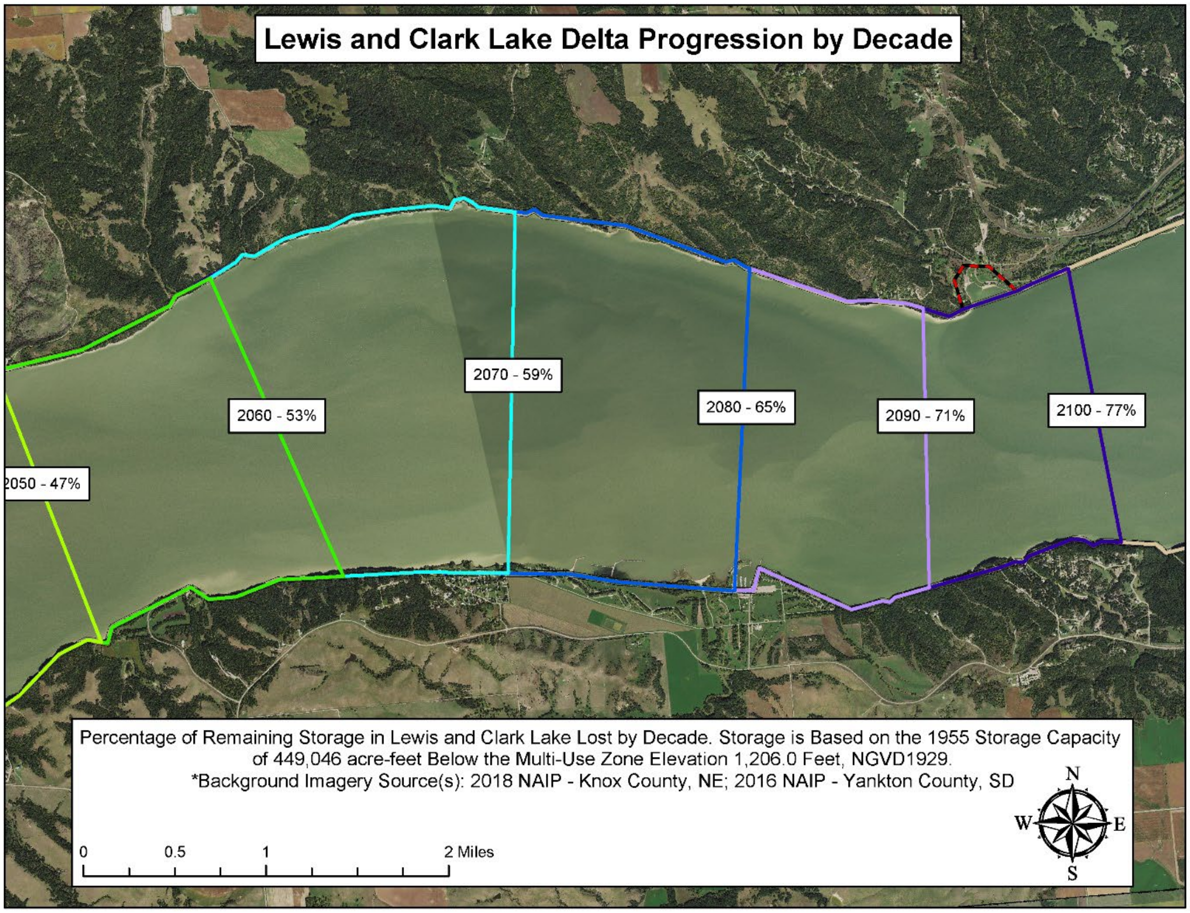

Figure 8: Lewis and Clark Lake Delta 2050-2100

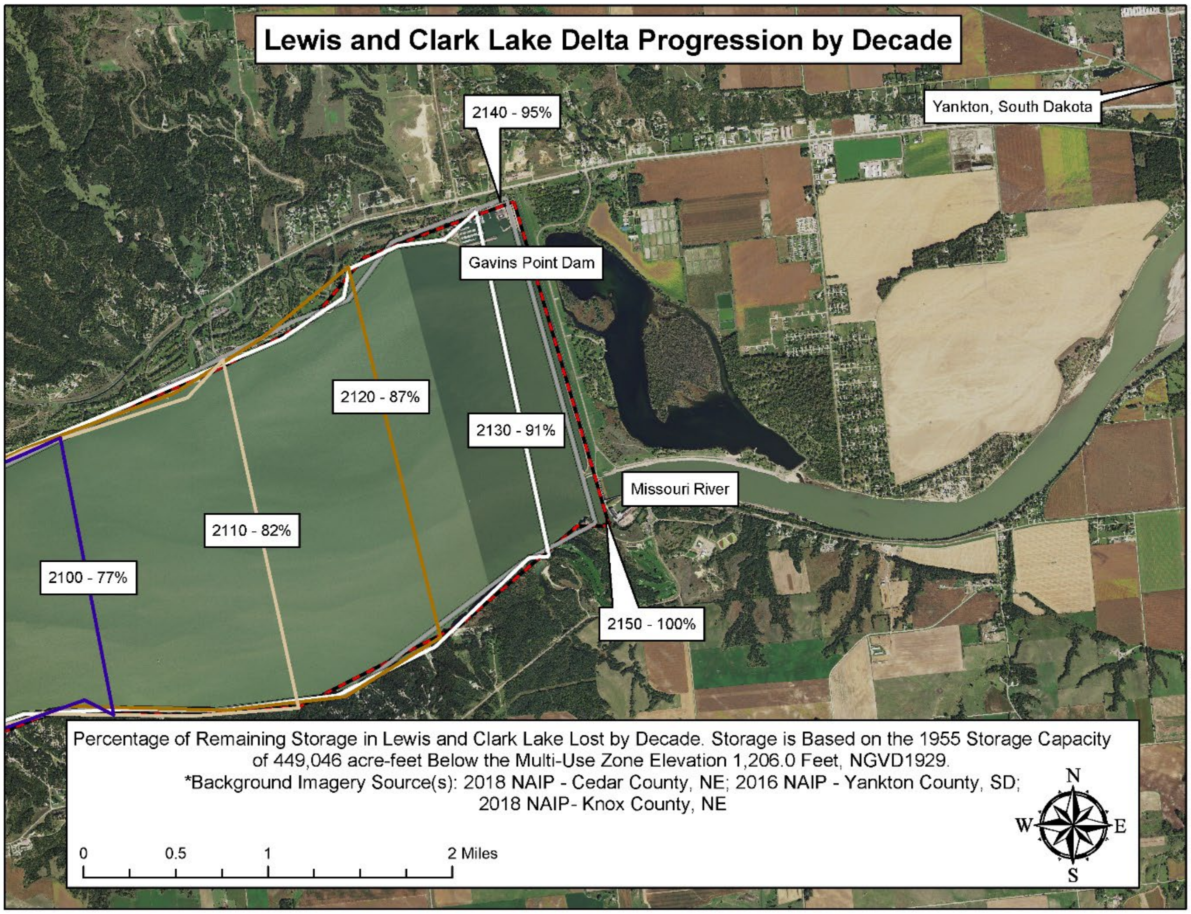

Figure 9: Lewis and Clark Lake Delta 2100-2150

Figures 7-9 show the encroachment of the sediment delta in polygons that gradually approach the embankment of Gavins Point Dam. When the sediment fills these areas in, they will likely look like the current delta: sandy and marshy fields with a shallower Missouri River running through them. Figure 10 is a depiction of how far sedimentation may extend upstream on the Missouri River. Here, the future river will likely look somewhat like the current reach between the mouth of the Niobrara River and the open lake.

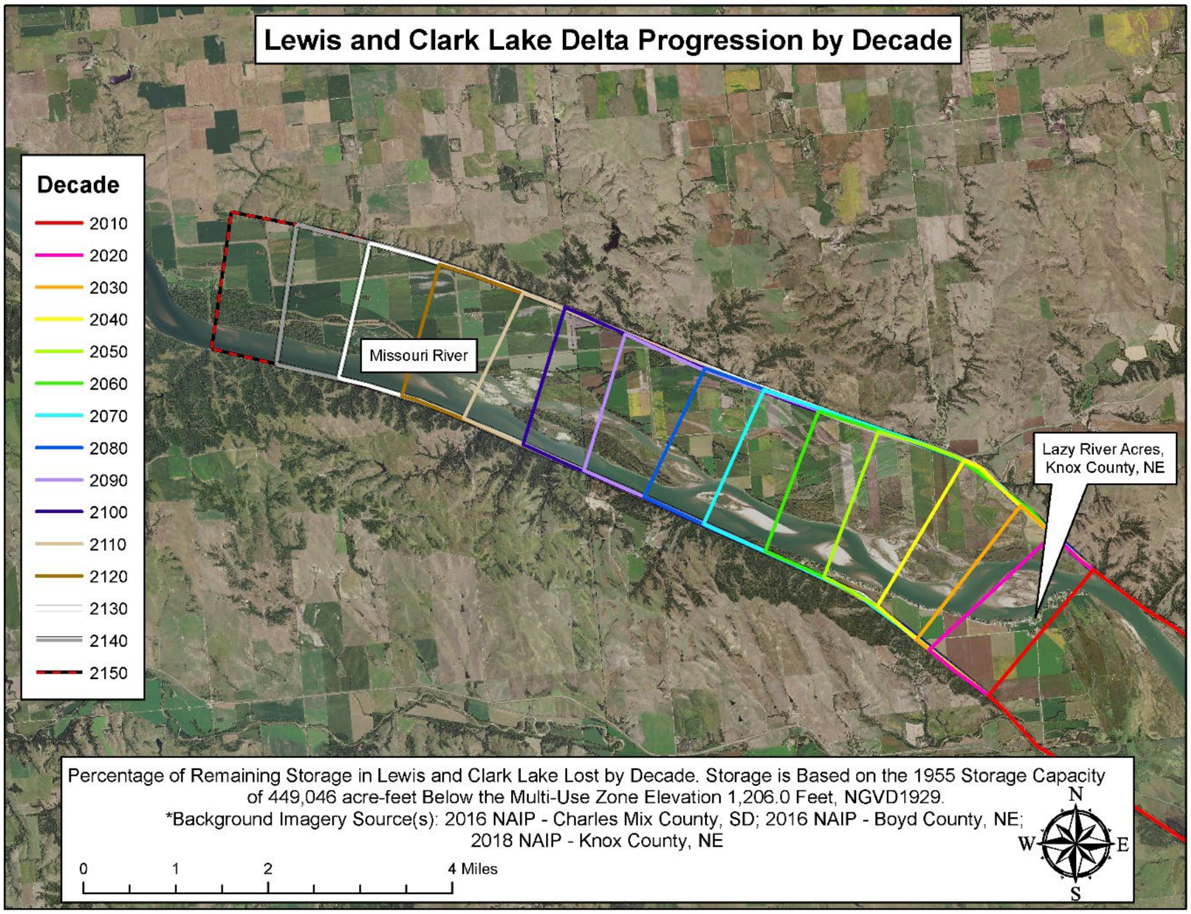

Figure 10: Upstream Missouri River Sedimentation

Figure 10 shows that the sedimentation will affect the entire river valley, from bluff to bluff. This means that the existing lowlands near the river on the South Dakota side will see a rising water table. The river will flood in these more often and will begin to reroute itself through some of this existing agricultural land. The estimated location of future sedimentation impacts is the most uncertain in this reach due to the competing effect of channel degradation below Fort Randall Dam. If the future sees higher flows than the past, the growth of the sedimentation footprint will be reduced, with the converse also being true. Figure 11 is the third and final depiction of future without action conditions, this time upstream on the Niobrara River.

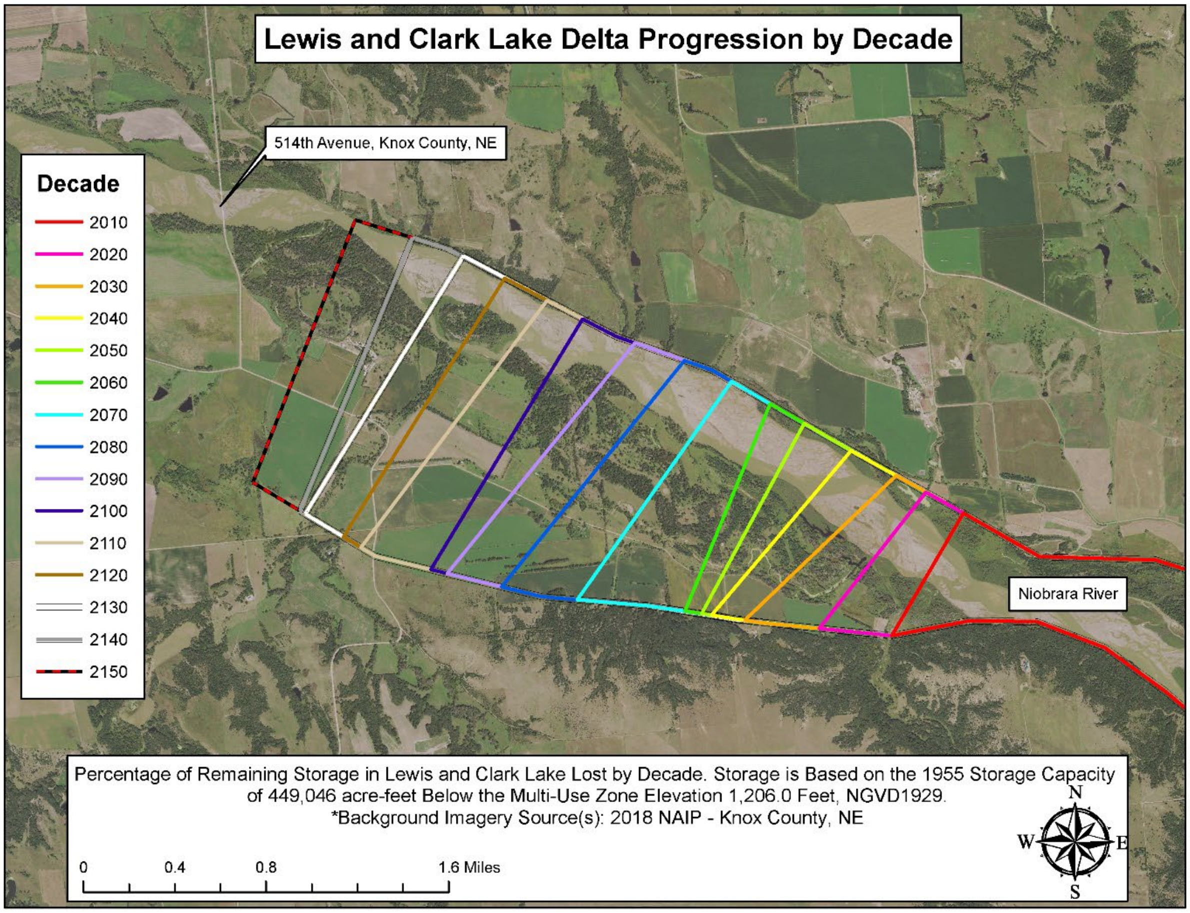

Figure 11: Upstream Niobrara River Sedimentation

These maps show the potential future without action conditions that could occur, and help guide the decision making for USACE economists determining benefits. These polygons show when items such as recreation would be lost, and about how much will be lost each decade or year. The engineering team for this USACE effort also calculated the percent loss of the lake for each decade. These values are critical to economic benefit calculations because some decades have a slower percent growth in sediment. These calculations for sediment growth, shown as both annual percent lake loss and cumulative lake loss can be shown in Table 16.

Table 16: Lake Loss by Year (%)

Year	Yearly Lake Loss (for the decade)	Cumulative Loss	Year	Yearly Lake Loss (for the decade)	Cumulative Loss
2024	0.60	31.40	2100	0.50	76.90
2030	0.60	35.00	2110	0.50	81.90
2040	0.60	41.00	2120	0.40	86.80
2050	0.60	47.00	2130	0.40	90.80
2060	0.60	53.00	2140	0.50	94.90
2070	0.60	59.00	2150	0.50	99.90
2080	0.60	65.00	2160	0.00	99.90
2090	0.60	71.00	2170	0.00	99.90

3.2 Recreation

Without action, Lewis and Clark Lake will continue to fill and the sandy delta currently near Springfield, South Dakota will migrate into the open lake. As time passes, this sedimentation will reduce recreation opportunities for visitors. As mentioned in the existing conditions section, Lewis and Clark Lake is an important regional landmark for recreation because of its size and facilities. Visitors that come to the lake for both water-specific reaction such as boating and angling, as well as those who enjoy non-water-specific recreation will see diminished value from increased sedimentation. Many boaters enjoy the open water that this large lake provides; however, this would be greatly reduced by the year 2100, and essentially eliminated by 2130 (see Figures 9 and 10 above).

Lewis and Clark Lake is a multipurpose project that was designed to provide recreation to many different types of visitors. The sedimentation of the lake diminishes this purpose and causes damages to the national economy. This reduction in National Economic Development (NED) is the central focus of this economic analysis on recreation. Using data from the Nebraska and South Dakota Game and Parks departments, as well as the MRRMP EIS and USACE analyses, this report details a total NED loss for recreation.

The estimated number of visitation days to Lewis and Clark Lake and the surrounding recreation areas totaled 1,033,079 in 2021. It is likely this number would continually decline over the next 150 years as the lake becomes clogged with sediment. Visitors must choose other reservoirs, either nearby in South Dakota, or farther away in neighboring states. Based on a 2023 unit day value (UDV) of $32.86[14], the current annual economic benefit from recreation is $33,946,973.87.

This figure represents the sum of value from all possible recreation activities. As noted, visitors that wish to enjoy water-specific recreation will be greatly affected by the sedimentation of the open lake. As the total number of visitor days decline in the future without action condition, the

[14] This is calculated from the MRRMP 2018 UDV of $7.60 as an average of all recreation from Lewis and Clark Lake. This considers type activities available, nearby recreation activities, and the quality of activities. This was determined to be the best estimate for recreation value, given the scope of this report. The MRRMP conducted extensive research on recreational opportunities and facilities along the Missouri River. Expert analysis suggests this number is sufficiently accurate, especially considering the short period of time between the release of the MRRMP (2018) and this report.

different types will decline at different rates. Water-specific activities such as boating, skiing, swimming, angling, and water-specific sightseeing will see a larger year-over-year loss of benefits compared to non-water-specific activities. These non-water specific activities involve camping, picnicking, hunting, sightseeing, and other/general recreation. Table 17 shows a breakdown of these activities and their contribution to the overall recreation NED.

Table 17: Visits by General versus Water-Specific

Water-Specific		
Activity	**Percent**	**Total Number of Visitors**
Boating	7.3	75,415
Skiing	2.1	21,695
Swimming	9.5	98,142
Angling	9.1	94,010
Sightseeing	34.8	359,511
Total	62.8	648,774
General		
Activity	**Percent**	**Total Number of Visitors**
Camping	4.3	44,422
Picnicking	3.0	30,992
Hunting	0.9	9,298
Sightseeing	11.6	119,837
Other	17.4	179,756
Total	37.2	384,305

For each category, a different slope was determined for the declining number of visits. When the lake delta reaches the embankment of Gavins Point Dam in 2150, it is assumed there will be very little water-specific recreation. The total number of visits is estimated to be around 1,000 per year in 2150, given the size of the open channel, the lack of available boat ramps, and shoreline access points. As the sedimentation accelerates the delta's movement, boat ramps will become unusable because the channel of the river will be pushed farther into the existing lake. Likewise, the current angling docks and swimming beaches will no longer be on the lakefront because of the shifting channel.

Given that the current number of water-specific visits is 648,774 and the future in 2150 will have around 1,000 water specific visits, there will be an annual decline of 5,141 visits. This is expected to be a constant yearly decline (i.e., a linear slope). Because the lake fills up in 2150, and the study period extends 150 years to 2173, there will be a constant number of visitors year over year at 1,000 visits.

The non-water-specific recreation is determined to decline at a slower rate of 2,306 visits per year, until 2150. The total number of visits in 2150 for non-water-specific recreation would equal 121,056. The lake would experience these number of visits for each consecutive year until the end of the study period in 2173. This was calculated from assumptions used in the MRRMP EIS based on water surface areas of the reservoirs in the Missouri River Basin.

Specifically, this rate of annual decline in visits is based on the changing rates of fill. For example, in 2025, the number of visitors is calculated by taking one minus the current cumulative percent loss (32.0 percent) and adding it to the current level of lake loss (31.4 percent), multiplied by the total current number of visits (384,305). This equation essentially captures the inverse relationship between the increase in sediment with the decline in visits. The annual decline of 2,306 visits is based on the cumulative loss table shown above. This is different than the lake-specific number of visits, where the yearly decline is calculated from an expected "final" count of recreators when the lake is 100 percent full. The two different rates of recreation over the study period can be seen in Figure 12.

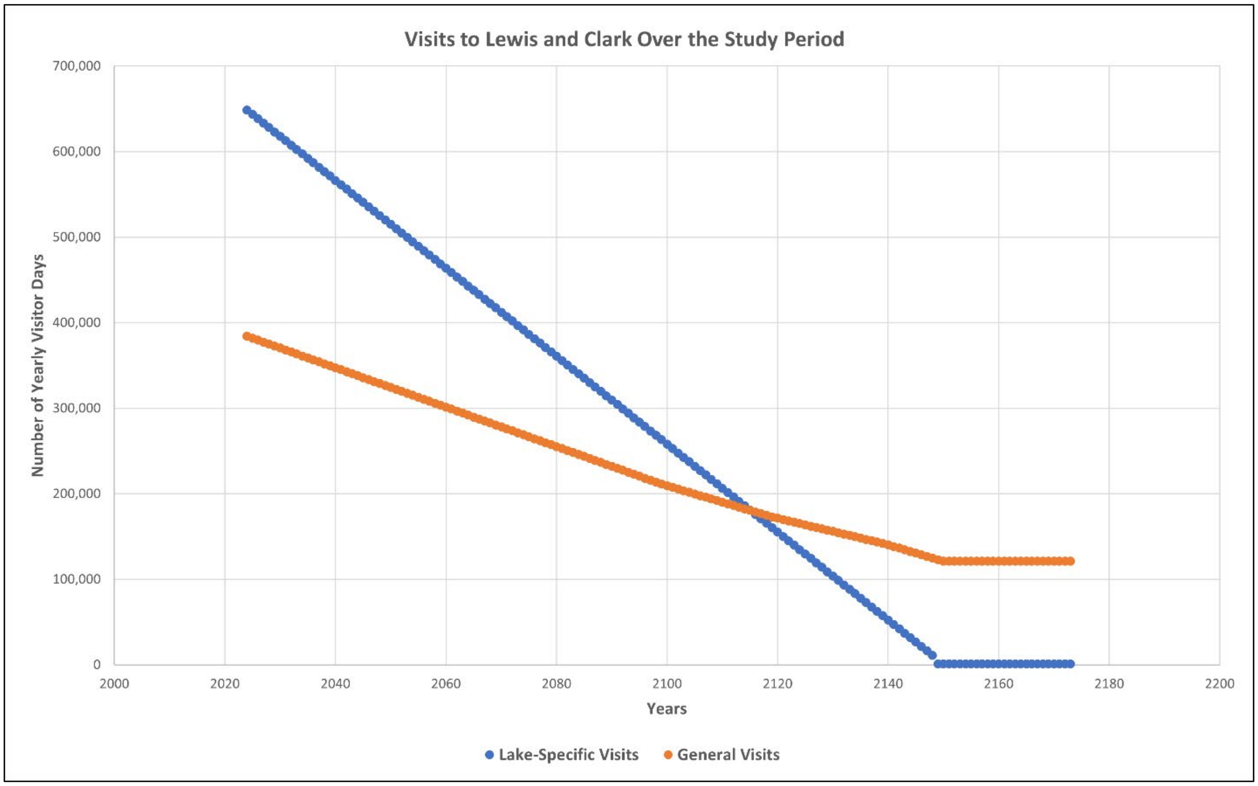

Figure 12: Lewis and Clark Lake Rates of Recreation

The Nebraska and South Dakota Game and Parks commissions have also invested heavily into facilities at Lewis and Clark Lake including boat ramps, marinas, campsites, and parks. These state agencies currently have plans that will continue to develop recreational facilities to attract more visitors. These projects, however, will not see any benefit if the lake they are built on becomes filled with sediment.

While these recreational activities may be negatively impacted by sedimentation, the marshlands created by this sediment offer more opportunities for waterfowl hunting. In recent communications with the South Dakota and Nebraska Game and Parks Commissions, they suggested many more hunters would be attracted to this area because of these conditions. However, these experts did not know how many hunters visited annually for waterfowl-specific hunting, or how many more would come should sedimentation increase.

It is also important to note that recreation may increase in the first few years of the project life because of state-level investments being made into recreational facilities along Lewis and Clark

Lake. While these are not directly modeled because of the degree of uncertainty associated with the inclusion of such figures, it is important to keep in mind this could be a conservative estimate of recreational activity.

3.3 Recreation Sensitivity Analysis

In addition to this recreation analysis, another, more rigorous analysis was performed that assumed higher visitor accounts and larger UDVs for each hour of recreation. This was developed using the USACE EGM 23-03 titled “Unit Day Values for Fiscal Year 2023.” This analysis, assumed the maximum possible points for each category, breaking from the detailed analysis that was performed as a part of the MRRMP. Furthermore, this unit day value assumed more specialized recreation was taking place, rather than generalized recreation. Under this new assumption, half of the recreation was assumed to be specialized. This resulted in a new UDV of $32.86. This UDV represents the maximum possible recreation benefits that could occur, for this makeup of increased specialized recreation. Each visit was then multiplied by this new UDV and included in the total calculation of benefits. Compared to earlier versions of this report, this allows for a much greater recreation total lost benefit.

3.4 Hydropower

Impacts to hydropower generation will not occur for at least another sixty years, according to engineers with expertise in sediment and hydropower operations. Omaha District currently estimates the leading edge of the delta in Lewis and Clark Lake will reach in the intake gates of the powerhouse when the lake is approximately 70 percent full. This will occur around 2088. The intake gates for the powerhouse have a lower elevation than spillway gates but are adjustable. The intake gates can be raised to extend the time until they are buried in sediment, but at the expense of reduced generation efficiency from intake of warmer water closer to the lake surface. The location of the powerhouse intake gates can be seen in Figure 13.

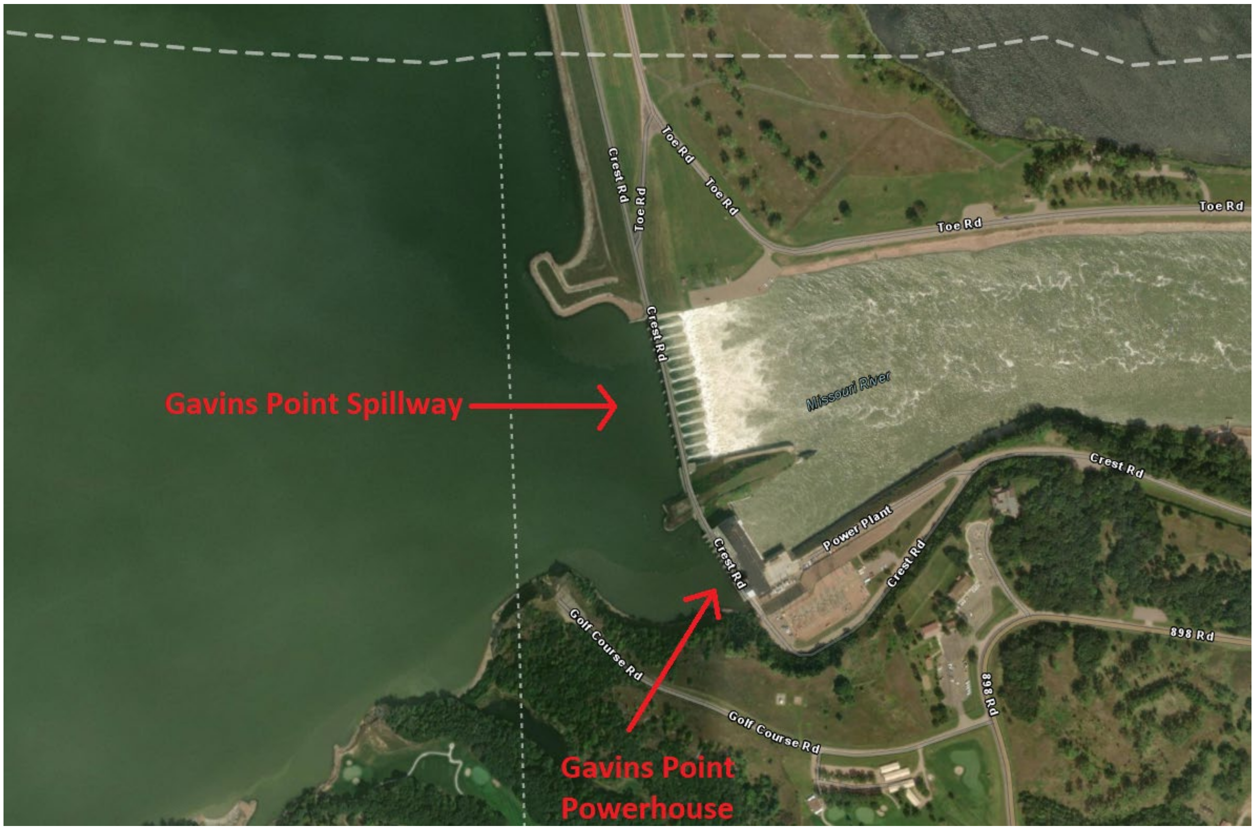

Figure 13: Gavins Point Powerhouse Location

A simplified version of a lake profile can be seen in Figure 14. This shows that sediment will fill on top of the existing lakebed and reach the powerhouse gates, even before the sediment starts to accumulate at the surface of the lake.

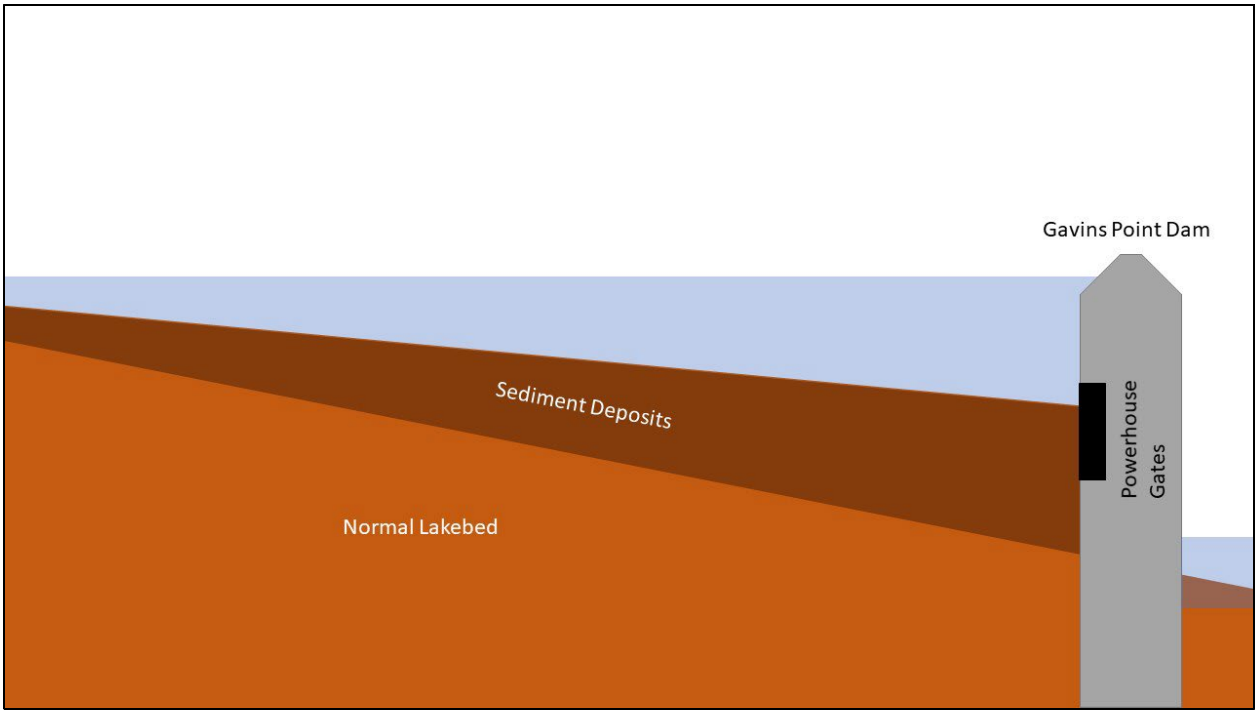

Figure 14: Cross Section of Lewis and Clark Lake; Gavins Point Dam

To be conservative, this report assumes that the hydropower plant at Gavins Point would need to reconsider operational activities around the year 2088, as this is the most likely year when sediment reaches the powerhouse gates.

As stated in the existing conditions section of this report, Gavins Point Dam currently generates $19,239,606 worth of power each year. The dam generates 726 million kilowatt hours of electricity annually, sending power to South Dakota, Iowa, and Nebraska. A closure of dam's hydropower plant would cost the national economy in terms of alternate energy production, where new sources of power would have to be built, or these customers would have to rely on energy from the regional or national energy grid.

The total yearly cost of closure is the loss of the $19,239,606 in power generated for its current customers. There would also be some costs associated with closing down the hydropower facility. These costs have not been fully developed by USACE Omaha District operations or cost engineers, so they are highly preliminary and conservative. These costs are estimated based on the economic analysis performed for the Columbia River System Operations (CRSO) EIS. The CRSO EIS explored dam decommissioning costs associated with removing the four dams on the Lower Snake River in Washington. The costs for hydropower plant closure shown here are only calculated for the cost of closing the facilities, and not the entire process associated with dam removal and deconstruction[15].

[15] Gavins Point Dam would not be entirely removed because it would still provide benefits for navigation regulation. If Gavins Point Dam were removed, Fort Randall Dam would be required to regulate the lower Missouri River for navigation purposes. This would reduce the peak hydropower load from Fort Randall. These hydropower benefits from Fort Randall provide more power benefits than Gavins Point. The full

The costs for closure of the hydropower facilities include measures such as sealing hydropower gates, removal of equipment, and redeployment of power facilities. Based on the information provided from the CRSO EIS, Appendix Q (Cost Appendix) annual costs of $20 million per year would occur over a period of two years while the hydropower facility is being closed. These costs were cross-checked with USACE hydropower managers and were said to be reasonable.

3.5 Agricultural Buyouts

The sedimentation in Lewis and Clark Lake will continue to extend upstream and threaten land along the river toward Fort Randall Dam. This sedimentation causes many issues for landowners along the river, especially with agricultural landowners. One of the biggest issues with sedimentation upstream is the rising water table. When sediment collects in the riverbed downstream, the river adjusts by spreading out over land that was not previously part of the river. When flooding occurs, lands are impacted by more frequent, lower flow events. For example, where in the past land may have been impacted by the 2 percent AEP (50-year flood), it may now be impacted by the 10 percent AEP (10-year flood).

While a flow frequency analysis of the Missouri and Niobrara rivers has been conducted for the Missouri River, these numbers are difficult to extrapolate to this study. Such analysis would require involvement from hydraulic and hydrologic engineers and was determined to be outside the scope of this study. Further, this flow-frequency analysis would be highly uncertain, as the changes in the river would occur more frequently than other stretches of the Missouri River. Thus, agricultural flood damages are not included because of a changing flood frequency. Rather, the NED analysis for the report includes potential NED damages from agricultural buyouts.

The buyouts for this report, as well as prior USACE work in this area, estimate that the rising water tables and changing river paths would require the entire floodplain to be bought out. The agricultural land within the floodplain for the Missouri and Niobrara rivers can be seen in Figures 1 and 16, respectively. Even though there is agricultural land more than 400 yards from the current riverbank, this land would see serious detrimental effects when the sedimentation covers its adjacent river reach.

Information on these buyouts come from several different sources, including the 2001 Missouri and Niobrara River Sedimentation Report Economic Appendix. This report used information from the USACE Omaha District Real Estate office for land values and potential costs of easement. Because the issue of real estate purchases for easements is outside the purview of this economic appendix, values were obtained from South Dakota State University's Agricultural Extension website.[16]

The current estimate for farmland cost per acre in South Dakota is $3,814. This is a statewide average for all irrigated farmlands. This estimate is used for agricultural land in both South Dakota and Nebraska for this analysis. The upstream agricultural landowners affected by sedimentation would receive this payment when the sedimentation has severely degraded the quality of land and their ability to farm it. The land that would need to be bought out on the

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decommissioning and removal of the dam would reintroduce 300,000 acre-feet of sediment to the lower Missouri River. Source: personal discussion with USACE Northwest Division (NWD) Water Control personnel.

[16] South Dakota Agricultural Land Market Trends, 1991-2021 (sdstate.edu)

Missouri River can be seen in Figure 15. Each of the polygons are labeled with the decade the sedimentation begins to severely impact that river reach. For example, the 2010 polygon in Figure 15 shows very little active agricultural production occurring on the floodplain. The crops listed include corn, soybeans, and alfalfa, which are the main three crops grown in these two states. There are also areas of fallow or idle cropland. This is included in the calculation for potential buyouts, as this land could be farmed in the future; however, it is not currently under cultivation.

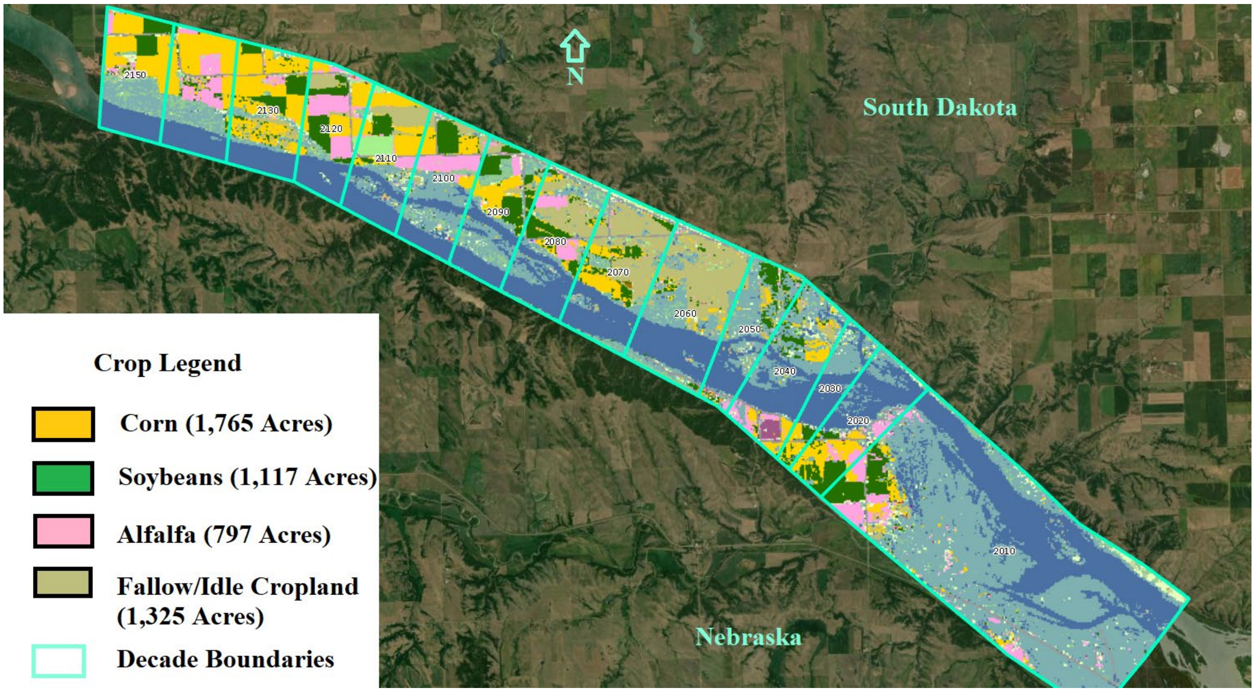

Figure 15: Future Conditions on Upstream Missouri Agriculture Land

This is a result of the sedimentation that has occurred over the last decade; several buyouts were needed for the landowners along this reach. There is a total of 5,619.47 acres on the Missouri River that that would require a buyout sometime within the next 150 years. This would result in a total cost of $21,432,671, without present valuing. The Niobrara River also borders cropland that would become threatened by increased sedimentation and rising water tables. The upstream map for the Niobrara River can be seen in Figure 16.

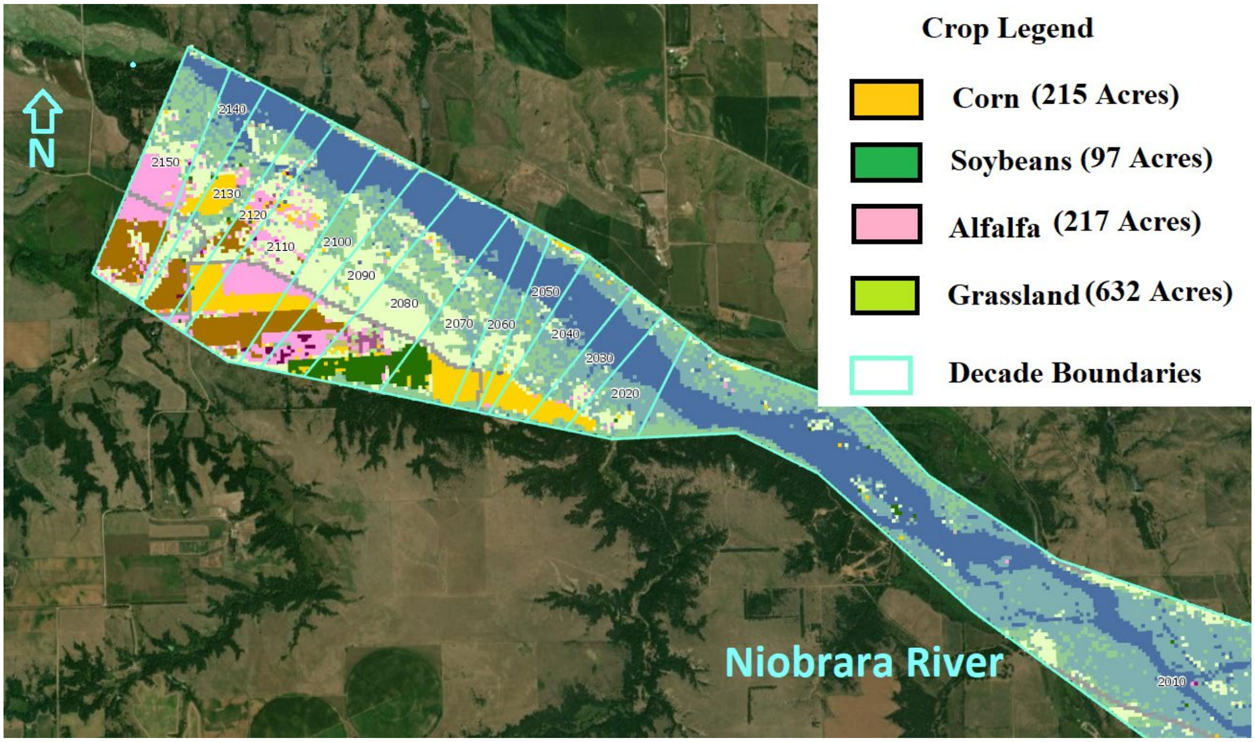

Figure 16: Future Conditions on Upstream Niobrara Agriculture Land

Fewer acres of upstream agricultural land on the Niobrara River are at risk, compared to the Missouri River land. Based on the three main crops (corn, soybeans, and alfalfa) there are 1,160 acres at risk from increased sedimentation on the Niobrara River. The total value of the agricultural land is $4,424,284. The combined number of acres that will likely need to be bought out under the future without action condition totals 6,780. The total (not present valued) cost for both the Niobrara and Missouri is $25,856,955. This report assumes the cost of buyouts will be incurred equally across all 150 years of the project. For the land along the Missouri River this results in $104,805 worth of land being bought each year. For the land along the Niobrara River, this results in $21,635 worth of land being bought each year.

It is important to note these values are preliminary and do not represent planned USACE action. Rather, they represent the possible future conditions if the sedimentation issue were to go untreated. Possible future actions from the Corps or other Federal agencies that result in buyouts of private property will be examined further in other reports. The purpose of this analysis is to present a possible future condition the sedimentation may create.

3.6 Public Water Supply

The water supply for nearby towns and rural areas will likely be threatened by increased sedimentation on Lewis and Clark Lake. In 1985, the Corps was required by Congress to study an alternate source of water for Springfield, South Dakota. At the time, Springfield relied on Lewis and Clark Lake for their public water intake; however, it was beginning to be affected by the increase in sedimentation on the lakeshore in front of the town. The sediment caused issues for the town’s pump because of changing river hydrology and sedimentation within the piping.

These issues for Springfield will affect public water users further downstream, into Lewis and Clark Lake. ER-1105-2-100 describes public water as water used for the purposes of municipal, rural, and industrial uses, excluding irrigation and single industrial users that account for a large percent of the water usage. There are several water intakes on Lewis and Clark Lake that will be affected under the future without action alternative. The four main water intakes included for NED analysis are the B-Y RWD intakes, and two Cedar-Knox County intakes. These provide water for municipal, rural, and industrial uses and not a single user. The current location of the B-Y RWD intakes is shown in Figure 17.

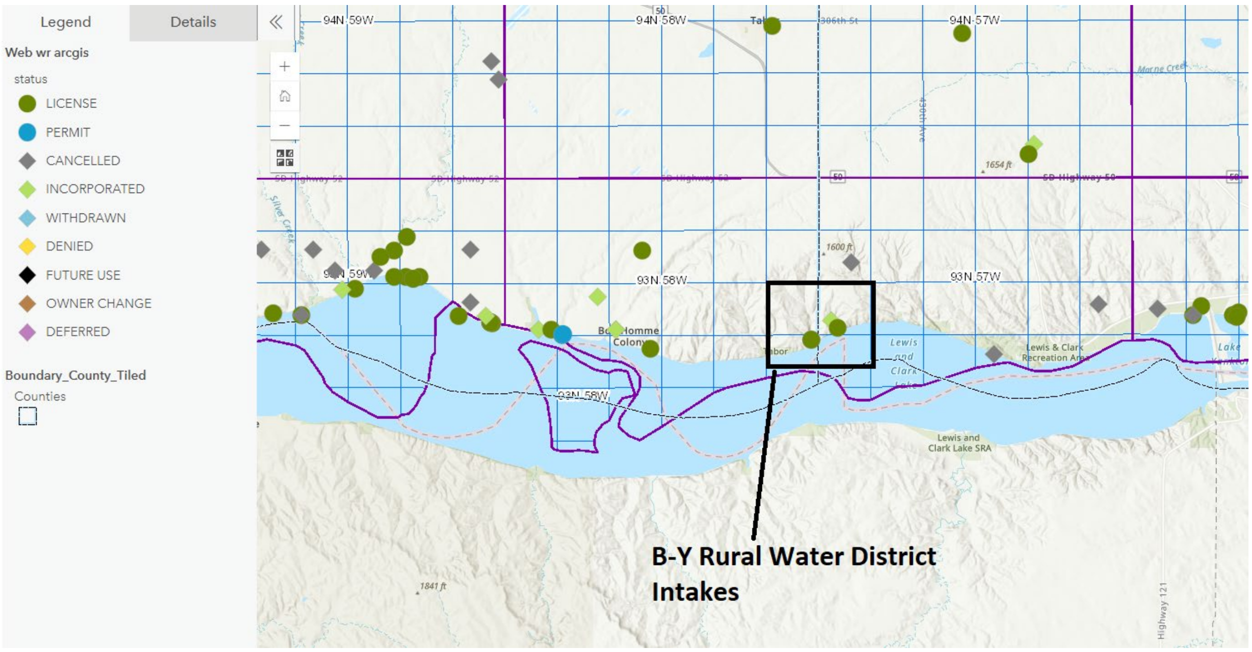

Figure 17: B-Y RWD Intakes - South Dakota

These facilities are designed to provide water to thousands of rural Nebraskans and South Dakotans. To keep these projects operating, they must be modified to either utilize a different water source or so they can reach farther into the new channel. As the lake fills with sediment, its surface will look like the current surface near Springfield. The new surface will likely be farther from the bank, so the current intakes that sit on the lakeside of Lewis and Clark Lake may become buried in sediment. Because of the uncertainty surrounding how sediment will deposit in the lakes, there is no way to predict how far into the existing lake the pipeline for each of these public water intakes must be extended. To be conservative, this analysis expects that the future channel will be of the same width as the channel currently at the far west end of the lake and run through the middle of the current lake.

At the B-Y RWD intakes, Lewis and Clark Lake is 1.5 miles wide. If the lake becomes filled with sediment, and there is only a river channel running through the middle of the lake, that channel is expected to be around 0.3 miles wide. This is based on several measurements of the channel's width upstream of the Niobrara River. For the B-Y RWD to extend their intake to reach the new shoreline, they would need an additional 0.6 miles of piping, as well as another pump.

The pumping licenses listed for the B-Y RWD on South Dakota's Water Resource's website show that the intake at this location can draw a maximum of 29.5 cfs from Lewis and Clark Lake. To build another 0.6 miles of piping to the edge of the new channel, estimates for piping must be made. Using a similar size of buried pipe from North Dakota's most recent water supply project[17] that supplies a maximum amount of water at around 30-37 cfs, the cost per mile was converted and used for this calculation.

The cost per mile for North Dakota's piping was $377,100 in 2015 dollars. Converting to 2021 dollars and for 0.6 miles, the cost would be around $546,795 for B-Y RWD to extend their pipe into the river. Based on the mapping provided above in Figures 7-9, a new pipe will need to be constructed between 2090 and 2110. Another pump would also need to be supplied and based on the MRRMP EIS estimates for an S12A1-E140 submersible pump of $31,169 in 2018 dollars, it would be $34,572 today. Between the new pipes and pumping mechanism, it would cost a total of $411,672 to extend this pipe to reliably supply water for B-Y RWD.

For the two Cedar-Knox County intakes, the cost would be slightly less because these intakes maximum cfs draw is lower than that of B-Y RWD's. Based on the piping cost estimates for the City of Springfield's alternate water sourcing project from 1985, the cost per mile is $77,500 in 1985 dollars. Indexing to 2021 dollars and using the 0.6-mile length required to reach the new shoreline, the total cost for each of the Cedar-Knox County intakes is $118,958, or $237,915 total. Each intake would need a new pump, and the most likely pump needed would be a S4B1-E50, using analysis from the MRRMP EIS. These pumps, in 2021 dollars, cost $22,180 each, or $44,361 for two intakes. The total cost for the two Cedar-Knox County's water district intakes to supply water is $282,276. The combined cost for the B-Y and Cedar Knox intakes is $693,948. These costs could occur anywhere between 2090 and 2110, however in the NED analysis, they occur in 2090 to represent the earliest possible years of construction.

3.7 Irrigation

Similar to public water supply, further sedimentation of Lewis and Clark Lake will create a new river channel further out into the existing lake, leaving the pumps at the current shoreline dry. There are currently more than 32,427 acres irrigated in South Dakota and 3,389 acres irrigated in Nebraska from the Missouri River between Fort Randall Dam and Ponca, Nebraska. There are fewer irrigation intakes that will be affected by the increased sedimentation over the next 150 years than in the entire reach of the Missouri River. The increased sedimentation of Lewis and Clark Lake will decrease the access of water to many farmers. Using the South Dakota State Water Resources mapping information there are 15 active irrigation permits for approximately 4,176 acres irrigated from the Missouri River within the 2020 to 2150 time period boxes shown in Figures 7-9.

Nebraska does not have a visible mapping service for locations of water permits; however, the only Nebraska county that would see lakeshore effects from increased sedimentation is Knox County. There are three private irrigation permits and 316 irrigated acres in Knox County that draw from the Missouri River.

While these permit owners could extend their intake pumps farther out from the existing shore to accommodate the shrinking channel, they could also receive water from a well. When considering alternative sources of water, ER-1105-2-100 requires researching the least-cost alternative for other sources that meet the same needs as existing sources. The average well depth in Nebraska is 125 to 150 feet below the surface[18]. While this study also considers wells that must be drilled in South Dakota, it assumes they have similar depth requirements, because

[17] 2015 North Dakota Northwestern Area Water Supply Project
[18] Bill Kranz, associate professor of biological systems engineering at the University of Nebraska – 2013

of the geographical proximity of the land in South Dakota under consideration. Most recent estimates for state-wide well drilling averages from 2013 indicate it costs between $85 and $95 (2013 dollars, which escalates to $101.44 and $113.38 in 2021 dollars) to build a well that pumps at a rate of at least six gallons per minute, for an average center pivot of 1,310 ft [19]. Thus, the deepest (150') and most expensive ($95 per foot) will cost $14,250.

For an average center pivot irrigation system, it can cover approximately 133 acres of a 160-acre block of crops[20]. Table 18 below shows every irrigation intake for both South Dakota and Nebraska that could be impacted in these future conditions. Each permit will need at least one well, however if the total number of acres are greater than 133 then they will need two. The total cost for both states is $714,281.

Table 18: Well Construction for Irrigation (2022 Dollars)

South Dakota			
ID	**Acres**	**Wells Needed**	**Cost**
1	70	1	$17,006.70
2	158.7	2	$34,013.40
3	778	6	$102,040.20
4	680	6	$102,040.20
5	776	6	$102,040.20
6	128	1	$17,006.70
7	74	1	$17,006.70
8	72	1	$17,006.70
9	234	2	$34,013.40
10	194	2	$34,013.40
11	119	1	$17,006.70
12	70	1	$17,006.70
13	257	2	$34,013.40
14	155	2	$34,013.40
15	410	4	$68,026.80
Total	4175.7	38	$646,254.58
Nebraska			
ID	**Acres**	**Wells Needed**	**Cost**
1	135.4	2	$34,013.40
2	57.9	1	$17,006.70
3	123	1	$17,006.70
	316.3	4	$68,026.80
GRAND TOTAL		**42**	**$714,281.38**

It is assumed that these costs will be equally spread out until the lake is completely fill, as individual irrigators may choose to be proactive and dig wells earlier, while others may wait.

[19] 7 Questions to Ask Before Drilling an Irrigation Well | AgWeb
[20] Making the most of your pivot irrigation - Top Crop ManagerTop Crop Manager

Assuming that the lake is completely full in 2150 and the first year of the action is 2024 (126 years) the cost will be $5,669 per year. Once the lake is full, even though there are 24 years left in the 150-year study period, there are no changes because the lake's sedimentation will not change drastically and effect more than 100 percent of the irrigators.

3.8 Upstream Flooding and Structural Buyouts

While there will likely be agricultural buyouts as the sedimentation behind Gavins Point Dam increases and pushes the water tables higher upstream on the Missouri River, there could also be structural buyouts. The Lazy River Acres community, on the Nebraska side of the Missouri River, has experienced increasing effects of sedimentation over the past three decades. These include more frequent flooding, shifts in soil stability, and pooling in low-lying areas. As these issues become worse, the Corps may choose to buyout the homeowner affected. It is important to note, this plan is purely for the potential benefit analysis of this Section 22 project and does not represent planned action by the U.S. government.

Structures will likely have to be bought out once the full effects of upstream sedimentation are realized. For example, the structures in the 2010 polygon shown below in Figure 18 may be bought out in the first decade of the existing project. The structures in the 2020 polygon may be bought out in the 2030s, and so on. The source for the structure data comes from the NSI2022 dataset that was recently updated with price levels and property information that represents structures with reasonable accuracy. The structures come in shapefile format and were moved to match the world imagery of the houses they provide data for. A summary of this data can be seen in Table 19.

Table 19: Structure Details: Updated to 2023 Dollars

Item	Missouri	Niobrara	Total
Number of Structures	484	8	492
Structure Value	$65,799,191.54	$2,214,603.97	$68,013,795.52
Content Value	$40,703,406.83	$1,187,621.83	$41,891,028.66
Vehicle Value	$16,623,792.00	$370,872.00	$16,994,664.00
Number of Residents During Daytime	42	9	51
Number of Residents During Nighttime	51	16	67
Number of Residential Structures	470	7	477
Number of Non-Residential Structures	14	1	15
Number of Mobile Homes	375	0	375
Number of Homes other than Mobile	95	7	102

The total depreciated replacement value of the structures on the Missouri River upstream section is $65.799 million; for the Niobrara River that value is $2.215 million. For structural buyouts, only the value of the property itself is considered, not any of the content or vehicle values. These values are provided as a reference. If there were to be more frequent flooding, there could be more damage to vehicles and content, in additional to the structural damage. Using ArcGIS's spatial join function, each structure was assigned to the decade polygon it was located in. This was used to calculate when the structures would first become affected, and when buyouts could occur. The structures are first affected in the future year that matches the label on their polygon. This analysis assumes the buyouts would occur later. Table 20 shows this in more detail.

Table 20: Estimated Years for Structural Buyouts: 2023 Dollars

Structures First Affected Decade:					
Decade	**Missouri Count**	**Niobrara Count**	**Missouri Cost**	**Niobrara Cost**	**Total**
2010	13	0	$9,183,692.45	$0.00	$9,183,692.45
2020	388	0	$39,067,417.72	$0.00	$39,067,417.72
2030	11	0	$2,973,898.94	$0.00	$2,973,898.94
2040	31	0	$5,710,647.06	$0.00	$5,710,647.06
2050	17	0	$3,157,060.02	$0.00	$3,157,060.02
2060	21	1	$5,112,354.17	$588,710.82	$5,701,064.99
2070	0	1	$0.00	$136,513.62	$136,513.62
2080	0	2	$0.00	$357,669.68	$357,669.68
2090	3	0	$594,119.98	$0.00	$594,119.98
2100	0	0	$0.00	$0.00	$0.00
2110	0	1	$0.00	$141,955.50	$141,955.50
2120	0	0	$0.00	$0.00	$0.00
2130	0	1	$0.00	$183,096.84	$183,096.84
2140	0	1	$0.00	$183,096.84	$183,096.84
2150	0	1	$0.00	$623,560.67	$623,560.67
2160	0	0	$0.00	$0.00	$0.00
2170	0	0	$0.00	$0.00	$0.00
Structures Bought Out by Decade:					
Decade	**Missouri Count**	**Niobrara Count**	**Missouri Cost**	**Niobrara Cost**	**Total**
2010	0	0	$0.00	$0.00	$0.00
2020	13	0	$9,183,692.45	$0.00	$9,183,692.45
2030	388	0	$39,067,417.72	$0.00	$39,067,417.72
2040	11	0	$2,973,898.94	$0.00	$2,973,898.94
2050	31	0	$5,710,647.06	$0.00	$5,710,647.06
2060	17	0	$3,157,060.02	$0.00	$3,157,060.02
2070	21	1	$5,112,354.17	$588,710.82	$5,701,064.99
2080	0	1	$0.00	$136,513.62	$136,513.62
2090	0	2	$0.00	$357,669.68	$357,669.68
2100	3	0	$594,119.98	$0.00	$594,119.98
2110	0	0	$0.00	$0.00	$0.00
2120	0	1	$0.00	$141,955.50	$141,955.50
2130	0	0	$0.00	$0.00	$0.00
2140	0	1	$0.00	$183,096.84	$183,096.84
2150	0	1	$0.00	$183,096.84	$183,096.84
2160	0	1	$0.00	$623,560.67	$623,560.67
2170	0	0	$0.00	$0.00	$0.00

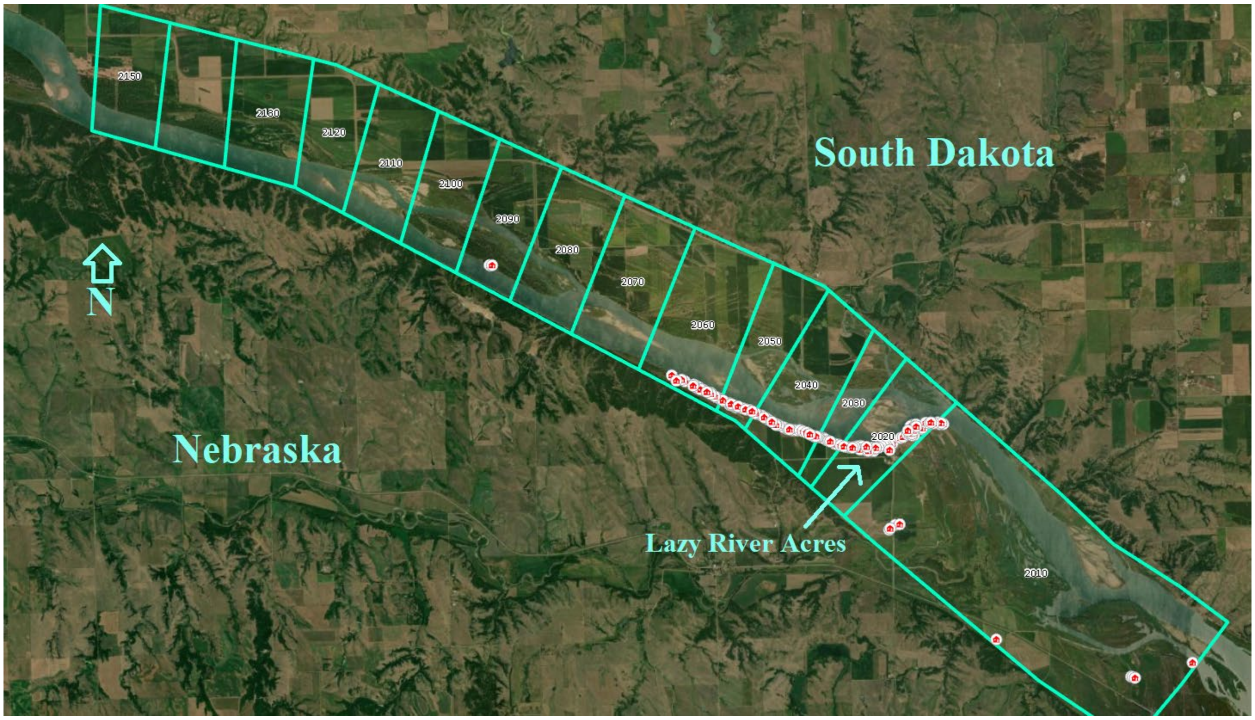

Figure 18: Structures within the Missouri River Future Affected Areas

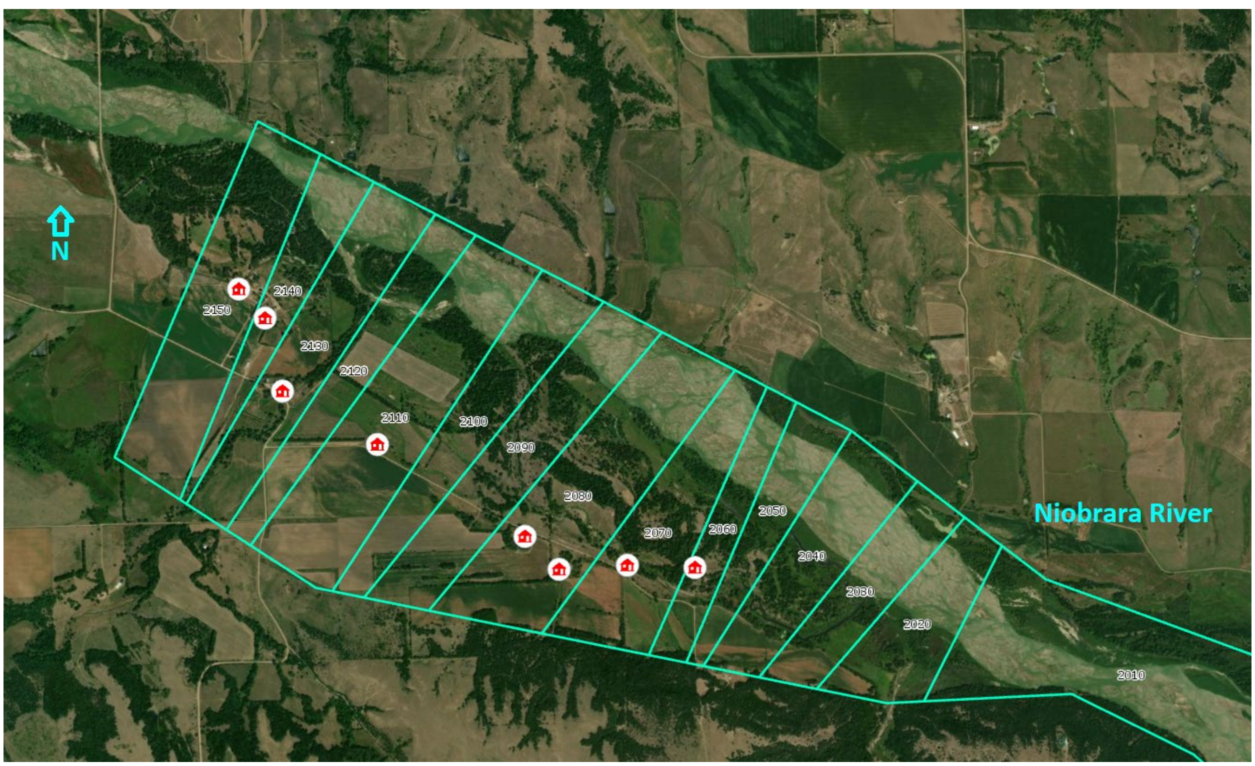

Figure 19: Structures within the Niobrara River Future Affected Areas

The buyout costs for these structures are assumed to accrue equally over the decade during their buyout. This is to simplify the process rather than predict which individual structures could be bought in a given year. Thus, for any given year, the buyout cost is the decade cost divided by 10, except for the years between 2024 and 2029, where the buyout costs are divided by 6, as that is the number of years in the 2020s decade where structures are affected.

3.9 Summary of NED Damages (Without Dam Removal)

The summary of NED damages involves calculating the total net present value (NPV) of the damages presented in the preceding sections. Traditional USACE NPV methodology involves using a single interest rate that discounts future values based on the current Federal interest rate. This is the exponential discounting function and is the formula Microsoft Excel® uses to calculate functions such as "PV" and "PMT." This analysis presents the NPV using this classic, or exponential discounting, but also uses eight other methods for discounting future values[21]. This sensitivity analysis was conducted to show alternate evaluations for assumptions on future costs. The nine functions used for this analysis are shown in Table 21, below.

Table 21: Discount Methods

Method	Equation
Exponential (Classic)	$D_n = \frac{1}{(1+r)^n}$
Ramsey	$D = \delta + \eta g$
Hyperbolic[22]	$D = \frac{1}{(1+r)^{\frac{\beta}{\alpha}}}$
Quasi-hyperbolic	$D = \beta(\delta^n)$
Gamma[23]	$D = \frac{1}{\beta^\alpha \tau(\alpha)} x^{\alpha-1}$
Weibull	$D = \left(\frac{1}{(1+r)}\right)^{n^{\frac{1}{s}}}$
Green Book[24]	*Changing formula based on t, where:* *rt_1=0,1,…30* *rt_2=31,32,…75* *rt_3=75,76,…125* *rt_4=126,127,…150*
Intergenerational[25]	*Changing formula based on t, r, G, and delta of t*
Logistic	$D = \frac{1}{1+r^{-n}}$

[21] Harpman, David A. (2014). Discounting for Long-Lived Water Resource Investments. Bureau of Reclamation Technical Memorandum Number S&T-2014-X3574 and Manuals and Standards Report M&S-2014-G4129. U.S. Department of the Interior, Bureau of Reclamation. Denver, Colorado
[22] Laibson, D. (1998). Life-cycle consumption and hyperbolic discount functions. European economic review, 42(3-5), 861-871.
[23] Weitzman, Martin, L. 2001. "Gamma Discounting." American Economic Review, 91 (1): 260-271.
[24] Freeman, M. C., & Groom, B. (2015). Positively gamma discounting: combining the opinions of experts on the social discount rate. The Economic Journal, 125(585), 1015-1024.
[25] Scarborough, H. (2011). Intergenerational equity and the social discount rate. Australian Journal of Agricultural and Resource Economics, 55(2), 145-158.

All of these equations use the FY2023 Federal discount rate of 2.5 percent, with the exception of the intergenerational discounting rate. These can be graphed over the 150-year study period to show the declining nature of these equations. This can be seen in Figure 20.

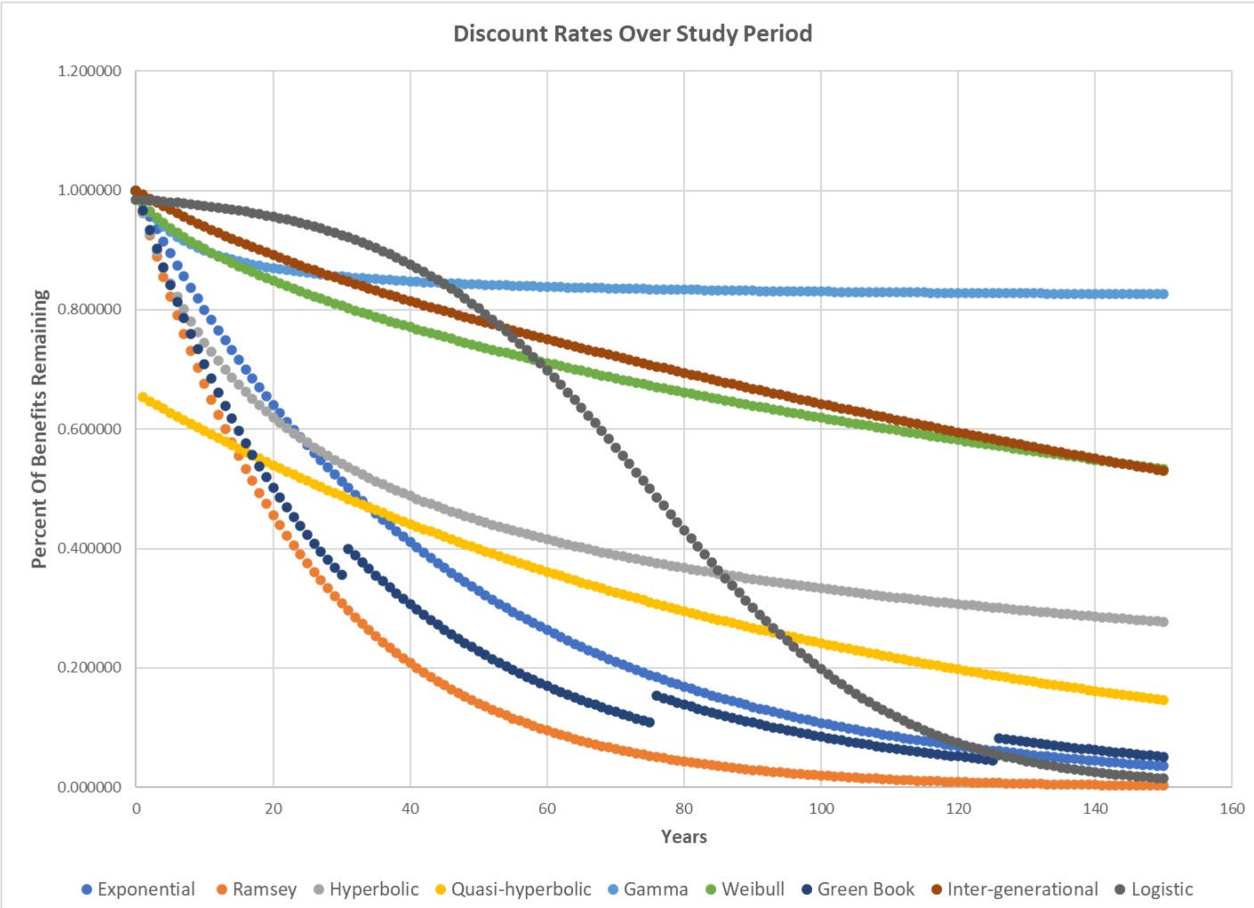

Figure 20: Discount Rates Over Time

Taking the sum of the yearly damages caused by increased sedimentation over the next 150 years from each of the proceeding sections and entering them into the different formulas results in the values show in Table 22.

Table 22: Discounting Results: 2022 Dollars (2.25% Discount Rate)

Method	Total	Annualized
Combined Damages (Unannualized)	$4,364,705,797	$29,098,039
Exponential	$625,570,037	$4,170,467
Ramsey	$223,100,693	$1,487,338
Hyperbolic	$1,521,411,462	$10,142,743
Quasi-hyperbolic	$1,106,075,055	$7,373,834
Gamma	$3,636,401,437	$24,242,676
Weibull	$2,730,859,235	$18,205,728
Green Book	$505,608,750	$3,370,725
Inter-generational	$2,821,280,958	$18,808,540
Logistic	$1,197,974,496	$7,986,497

These values range from $223.1 million for the Ramsey method to $3.6 billion for the Gamma method. Annualizing the total damages (dividing by 150) gives the average annual lost damages from the increased sedimentation at Lewis and Clark Lake. A bar graph depicting these results can be seen in Figure 21. The annualized damages represent the maximum amount that could be spent while keeping the benefit-cost ratio (BCR) above 1.0. For example, for using the Gamma Method of Discounting, $24.243 million could be spent each year in order to keep the BCR above one.

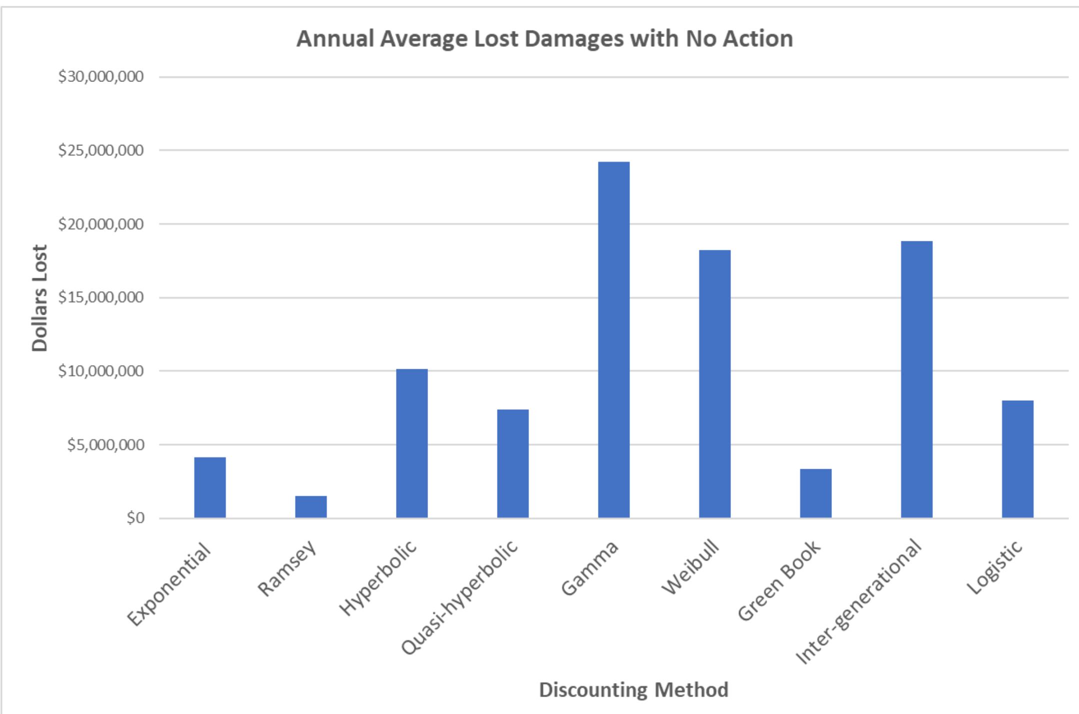

Figure 21: Discounting Results

3.10 End of Reservoir Life

There are three potential “end of life” scenarios that could occur if the lake is completely full of sediment at the end of this study period. These three options were developed by USACE Omaha District water control and systems engineers and are displayed below.

1. The first option is where Gavins Point operates as a reregulation dam with a small pool only for flood storage. It would exist mainly to support navigation operations. The dam safety program would continue as well. All other benefits of the reservoir would be lost. The cost of this would remain low, approximately in line with current USACE expenditures for dam operation and maintenance.
2. The second option is where the structure would remain intact however there would be no active management of the pool. All other benefits of the reservoir would be lost. The cost of this would remain low, approximately in line with current USACE expenditures for dam operation and maintenance.
3. The third option is removal of the embankment and a return to a more riverine flow for this portion of the Missouri River. This would occur over a period of approximately forty years, so that sediment can be slowly released back into the system. This would cost between $200 million and $1 billion over the course of these forty years.

3.11 Other Non-Quantified NED Damages

There are many effects to the national economy that are difficult to quantify because of the uncertainty associated with their future conditions. The current engineering models are not able to build a full understanding of many of these future conditions because of their difficulty and ambiguity.

The conditions downstream of Gavins Point Dam would likely continue to get worse in terms of a lack of sediment. The erosion of the riverbank would stretch to Ponca, NE under the future conditions without action. This would cause the land along the river to become increasingly unstable, especially the land closer to Gavins Point Dam. Agricultural land near the river may become unstable and shift in its place. Water intakes on the side of the river may see the land underneath become unstable, which will require these intakes to be relocated.

Downstream flooding could also increase because of the sedimentation in Lewis and Clark Lake, however there will still be the available flood storage pool between the elevations of 1206’ and 1212’. As the lake becomes more like a river, the Corps will lose its ability to attenuate the effects of flooding between the 1204’ and 1206’ pools.

Another issue flooding would impact is the ability to push water out of the lake. During a large flood like the Flood of 2019, the releases from Gavins Point Dam could be up to 20 percent higher. This flow will also come entirely from the spillway if the powerhouse gates are closed. The powerhouse can move approximately 35,000 cfs of water at maximum capacity and reduce the pressure on the spillway and gates. This will increase the need to monitor the spillway for dam safety impacts and increase the operations and maintenance (O&M) costs associated with keeping the spillway and weirs operating normally.

3.12 Community-Level Effects

Under the future without action condition, there would be many negative impacts to the communities in this region. Because increased sedimentation will cause buyouts, recreation loss, and water-related impacts, the communities in this area will be strained. This section qualitatively describes a few of the impacts to the community for the different events that can affect it.

First, if structural buyouts become necessary upstream on the Niobrara and Missouri rivers, then the people within those structures will need to be relocated. There has been significant academic work in this area that details the strain individuals feel when they are required to move, and the harm this can cause to the community[26]. Even though it may take many decades to buyout houses affected by increased upstream sedimentation, there will be community trauma associated with this event. These communities are disproportionately small, which is an important concern.

For public water supply and irrigation, the shuffling and relocation of these water sources may also cause issues within the community because of uncertainty, stress, and loss of incomes[27]. Similarly, when local businesses are lost because of natural causes such as flooding, drought, or sedimentation that drastically changes the hydrology, there are serious impacts to the community[28]. This can involve personal withdrawal, fracturing of relationships, stress, and community abandonment, all of which can harm the community and its remaining residents. As recreators' ability to enjoy the lake diminishes over time, the money spent on local businesses will be reduced, leading to these outcomes.

3.13 Environmental Justice

Executive Order (EO) 12898[29] advised Federal Agencies to address environmental justice issues in minority and low-income population. This stretch of the Missouri River is home to two Native American communities: the Santee Sioux and the Yankton Sioux Tribes. These Tribes' land sits adjacent to Lewis and Clark Lake and the Missouri River, and they will be exposed to the effects of the increased sedimentation behind Gavins Point Dam. Under the future no action condition, these groups would be faced with a weakening local economy and community, which would further harm their position.

3.14 Regional Economic Development

The local economies for Yankton and Springfield, South Dakota and Crofton and Niobrara, Nebraska are heavily reliant on recreation from Lewis and Clark Lake, because the over one million plus visitors to the lake spend their money in these communities. Further sedimentation and reduction in the lake's surface would lead to fewer local jobs and a shrinking regional

[26] Kleinhans, R., & Kearns, A. (2013). Neighbourhood restructuring and residential relocation: Towards a balanced perspective on relocation processes and outcomes. Housing Studies, 28(2), 163-176.
[27] Edwards, Jane, Brian Cheers, and Henning Bjornlund. "Social, economic, and community impacts of water markets in Australia's Murray-Darling Basin region." In Proceedings, International Water Conference, Montpelier, pp. 1-11. International Water Resources Association, 2008.
[28] Zhang, Y., Lindell, M. K., & Prater, C. S. (2009). Vulnerability of community businesses to environmental disasters. Disasters, 33(1), 38-57.
[29] https://www.archives.gov/files/federal-register/executive-orders/pdf/12898.pdf

economy[30]. Furthermore, if structural buyouts occur, some of the residents may relocate outside of the region, taking their jobs and discretionary spending with them. If the hydropower facility at Gavins Point Dam were to be shut down because of sedimentation concerns, the people who were employed at the facility will no longer have a job in the region.

3.15 Risk, Uncertainty, and Climate Change

Because this analysis looks at a 150-year period of analysis, there are many risks and uncertainties associated with the conclusions made. Notably, the risks associated with accurately describing change over time is difficult because of the features of this study. Specifically, climate change's impacts on the sedimentation and hydrology processes remains unknown. The Flood of 2019 caused Nebraska Public Power District's Spencer Dam to fail, releasing millions of cubic yards of sediment downstream into the Niobrara River. Most of this sediment will end up in the Missouri River and Lewis and Clark Lake pool. Climate change could cause an increase or a decrease in floods; however, there are uncertainties with attempting to calculate the direction of nature based on recent climatological changes[31]. While an increase in the number of events similar to the floods of 2011 and 2019 would likely increase the rate of sedimentation, droughts in the Niobrara or Upper Missouri river watersheds could decrease sediment delivery; however, the exact balance of changes sedimentation remains unknown because of the impacts of reservoir operations and human activities.

[30] Gu, Huimin, and Chris Ryan. "Place attachment, identity and community impacts of tourism—the case of a Beijing hutong." Tourism management 29, no. 4 (2008): 637-647.
[31] Heikkinen, R. K., Luoto, M., Araújo, M. B., Virkkala, R., Thuiller, W., & Sykes, M. T. (2006). Methods and uncertainties in bioclimatic envelope modelling under climate change. Progress in Physical Geography, 30(6), 751-777.

4 SUMMARY OF ECONOMIC ANALYSES

To summarize what this economic analysis has stated hitherto, this section describes the NED portion of the report. The economic benefits have been updated since earlier versions of this draft were delivered to the sponsor – specifically the recreation analysis where sensitivities have been included that maximize the specialized recreation at the lake, following discussions with recreation managers and experts on the lake's recreational features.

As a whole, this report and subsequent analysis finds that actional projects can be commenced on the lake should they cost less than approximately $24 million annually. This estimate is provided by an annualization using a Gamma distributional equation, an alternative to the USACE traditional discounting method that uses an exponential discount function. The other present valuing equations return between approximately $1 million and $18 million for annual benefits that could be saved by keeping the reservoir as is. It is important to note, however, that the inclusion of a dam decommissioning project, while unlikely, could influence these results. In terms of end-of-life for the reservoir, this report highlights three potential options USACE has when considering what tasks to perform. Further efforts and analyses could explore how these potentially add into the potential saved benefits the project accrues.

4.1 RECONS Regional Economic Analysis Under Existing Conditions

This analysis also includes a detailed estimate of the local and regional economic impacts from local and non-local visitors. Regional Economic Development (RED) is another account that the Corps uses to determine impacts to the region the project being studied is located in. This is different from NED, which uses unit day values for recreation. The RED focuses on the local impacts based on consumer spending that boosts the local economy. Using the current number of visitors (1,033,079) and the FY2022 price levels, this calculates the spending from visitors to Lewis and Clark Lake based on research conducted by the Corps' Institute for Water Resources (IWR) and Michigan State University. Table 23 details the breakdown of visits for inputs into the model based on current estimates and the MRRMP EIS.

Table 23: Number of Visits and Party Size by Visitor Segment

Visitor Segment	Visits	Party Size
Local Non-Boating Visitor	545,869	2.6
Non-Local Non-Boating Visitor	220,112	2.6
Non-Boating Camper	220,112	3.5
Local Boating Visitor	42,986	2.6
Non-Local Boating Visitor	1,999	2.6
Boating Camper	1,999	3.5
Total	**1,033,077**	

RECONS (Regional ECONomic System) is a tool that provides estimates of jobs and other economic measures such as labor income, value added, and sales that are supported by USACE programs, projects, and activities. This modeling tool automates calculations and generates estimates of jobs, labor income, value added, and sales using IMPLAN's multipliers and ratios, customized impact areas for USACE project locations, and customized spending profiles for USACE projects, business lines, and work activities. RECONS allows USACE to evaluate the regional economic impact and contribution associated with USACE expenditures, activities, and infrastructure.

The visitation at Lewis & Clark Lake would result in $42,235,499 in visitor spending on accommodations, restaurants, retail, and other purchases. Of this total expenditure, $20,777,841 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $42,235,499 support a total of 288.0 full-time equivalent jobs, $8,120,574 in labor income, $15,256,923 in the gross regional product, and $29,218,100 in economic output in the local impact area. More broadly, these expenditures support 534.4 full-time equivalent jobs, $28,281,351 in labor income, $50,302,064 in the gross regional product, and $99,722,694 in economic output in the nation. A summary of these impacts can be seen in Table 24.

Table 24: Summary of Economic Impacts; 2022 Dollars

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
Direct Impact		$20,777,841	237.6	$5,892,918	$11,182,593
Secondary Impact		$8,440,259	50.3	$2,227,655	$4,074,329
Total Impact	$20,777,841	$29,218,100	288.0	$8,120,574	$15,256,923
State					
Direct Impact		$22,611,070	245.5	$7,436,504	$13,006,481
Secondary Impact		$16,264,813	86.0	$5,010,513	$8,670,380
Total Impact	$22,611,070	$38,875,883	331.5	$12,447,016	$21,676,861
US					
Direct Impact		$39,470,103	272.5	$10,042,102	$18,568,187
Secondary Impact		$60,252,591	261.9	$18,239,249	$31,733,876
Total Impact	$39,470,103	$99,722,694	534.4	$28,281,351	$50,302,064
** Jobs are presented in full-time equivalence (FTE)*					

For more information on the underlying assumptions and the inputs used to calculate these economic impacts, see Addendum A, at the end of this report.

4.1.1 Summary

This report details the benefits that would be lost from continued sedimentation of Lewis and Clark Lake over the next 150 years. The lake will likely become filled in the year 2150. One measure for reducing the sedimentation in the lake are studied here: dredging. There are many different dredging scenarios that are being studied. The quantifiable benefits shown for the BCR calculations only estimate some of the possible detrimental effects to the economy and the ecosystem, especially for impacts downstream of Gavins Point Dam. The regional economy will begin to see these effects proliferate in the next few decades, and these impacts will get worse as time goes on if no action is taken.

4.1.2 Addendum A: RECONS Details

The tables below detail the assumptions, inputs, multipliers, and statistics used to calculate economic impacts.

Table 25: Visitor Spending Profile – Average Spending Per Trip Per Party (2022 Dollars)

Non-Boating Trip			
Spending Category	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper**
Hotel	$0.00	$0.00	$2.36
Camp	$0.00	$0.00	$58.27
Restaurants and Bars	$12.12	$26.30	$42.75
Groceries	$25.73	$27.38	$68.56
Gas and oil	$34.77	$56.59	$166.08
Other auto expenses	$0.62	$0.62	$0.88
Other boat expenses	$0.00	$0.00	$0.00
Attractions/Entertainment and recreation fees	$4.89	$4.89	$7.47
Sporting goods	$9.17	$9.17	$11.46
Souvenirs/other	$6.39	$6.39	$12.03
Total	$93.69	$131.34	$369.86
Boating Trip			
Spending Category	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper**
Hotel	$0.00	$0.00	$4.95
Camp	$0.00	$0.00	$102.31
Restaurants and Bars	$24.34	$34.24	$47.64
Groceries	$42.62	$32.57	$71.99
Gas and oil	$103.90	$168.97	$168.97
Other auto expenses	$0.62	$0.62	$11.27
Other boat expenses	$19.25	$19.25	$46.09
Attractions/Entertainment and recreation fees	$10.19	$10.19	$15.33
Sporting goods	$19.48	$21.77	$25.20
Souvenirs/other	$11.31	$13.04	$16.05
Total	$231.73	$300.65	$509.79

Table 26: Total Visitor Spending by Categories ($1,000): 2022 Dollars

Non-Boating Trip			
Spending Category	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper**
Hotel	$0	$0	$42,518
Camp	$0	$0	$1,050,106
Restaurants and Bars	$2,595,453	$2,269,978	$770,270
Groceries	$5,508,773	$2,363,363	$1,235,497
Gas and oil	$7,442,098	$4,884,830	$2,992,789
Other auto expenses	$133,192	$53,708	$15,780
Other boat expenses	$0	$0	$0
Attractions/Entertainment and recreation fees	$1,047,547	$422,407	$134,541
Sporting goods	$1,962,007	$791,148	$206,450
Souvenirs/other	$1,367,526	$551,433	$216,861
Total	$20,056,595	$11,336,866	$6,664,811
Boating Trip			
Spending Category	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper**
Hotel	$0.00	$0.00	$810.03
Camp	$0.00	$0.00	$16,742.94
Restaurants and Bars	$405,606.88	$26,530.66	$7,796.44
Groceries	$710,156.99	$25,233.42	$11,781.43
Gas and oil	$1,731,134.70	$130,918.30	$27,652.00
Other auto expenses	$10,366.62	$482.08	$1,844.14
Other boat expenses	$320,789.15	$14,917.82	$7,542.50
Attractions/Entertainment and recreation fees	$169,814.45	$7,896.97	$2,508.22
Sporting goods	$324,502.90	$16,865.88	$4,124.81
Souvenirs/other	$188,479.66	$10,101.47	$2,625.96
Total	$3,860,851.36	$232,946.60	$83,428.48

Table 27: Local Purchase Coefficients: 2022 Dollars

IMPLAN Code	Industry	Expenditure	Local Purchase Coefficients		
			Local	State	US
103	All other food manufacturing	$6,109,979	$0.01	$0.08	$0.90
154	Petroleum refineries	$10,841,936	$0.04	$0.04	$0.89
382	Sporting and athletic goods manufacturing	$1,388,141	$0.00	$0.02	$0.60
391	All other miscellaneous manufacturing	$1,191,884	$0.02	$0.08	$0.61
396	Wholesale - Other durable goods merchant wholesalers	$1,466,270	$0.11	$0.76	$1.00
398	Wholesale - Grocery and related product wholesalers	$985,480	$0.22	$0.51	$1.00
399	Wholesale - Petroleum and petroleum products	$3,269,790	$0.91	$0.91	$1.00
406	Retail - Food and beverage stores	$2,759,345	$1.00	$1.00	$1.00
408	Retail - Gasoline stores	$3,097,696	$1.00	$1.00	$1.00
410	Retail - Sporting goods, hobby, musical instrument and book stores	$495,765	$1.00	$1.00	$1.00
412	Retail - Miscellaneous store retailers	$794,589	$1.00	$1.00	$1.00
417	Truck transportation	$305,477	$0.64	$0.90	$1.00
504	Other amusement and recreation industries	$1,784,714	$1.00	$1.00	$1.00
507	Hotels and motels, including casino hotels	$43,328	$1.00	$1.00	$1.00
508	Other accommodations	$1,066,849	$1.00	$1.00	$1.00
509	Full-service restaurants	$6,075,634	$1.00	$1.00	$1.00
512	Automotive repair and maintenance, except car washes	$558,622	$1.00	$1.00	$1.00
	Total	**$42,235,499**			