Thompson Falls Hydroelectric Project
FERC Project No. 1869

Final Study Report – Operations Study

Prepared by:
NorthWestern Energy
Butte, MT 59701

With Support From:
GEI Consultants, Inc.
Portland, OR 97202

American Public Land Exchange
Missoula, MT 59802

Pinnacle Research
Plains, MT 59859

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Table of Contents

List of Abbreviations and Acronyms

AIS	aquatic invasive species
ºF	degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
flow	Project discharge
ft	foot/feet
ft/hr	feet per hour
full pool	maximum elevation of the reservoir during normal operations
ILP	FERC's Integrated Licensing Process
ISR	Initial Study Report
MW	megawatt
NorthWestern	NorthWestern Energy
photo	photograph
Project	Thompson Falls Hydroelectric Project
SG	staff gauge
Study Plan	Revised Study Plan, NorthWestern Energy, April 2021
test	operations test
Thompson Falls Project	Thompson Falls Hydroelectric Project
U.S.	United States

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1.0 Introduction

The Thompson Falls Hydroelectric Project (Thompson Falls Project or Project) is located on the Clark Fork River in Sanders County, Montana. Non-federal hydropower projects in the United States (U.S.) are regulated by the Federal Energy Regulatory Commission (FERC) under the authority of the Federal Power Act. The Project's current FERC License expires December 31, 2025. As required by the Federal Power Act and FERC's regulations, on July 1, 2020, NorthWestern Energy (NorthWestern) filed a Notice of Intent to relicense the Thompson Falls Project using FERC's Integrated Licensing Process (ILP). Concurrently, NorthWestern filed a Pre-Application Document.

The ILP is FERC's default licensing process which evaluates effects of a project based on a nexus to continuing Project operations. In general, the purpose of the pre-filing stage of the ILP is to inform Relicensing Participants[1] about relicensing, to identify issues and study needs (based on a project nexus and other established FERC criteria), to conduct those studies per specific FERC requirements which are included in the FERC Study Plan Determination (FERC 2021), issued May 10, 2021, and to prepare the Final License Application.

NorthWestern filed the Initial Study Report (ISR) on April 28, 2022, held an ISR meeting on May 5, 2022, and filed an ISR meeting summary on June 9, 2022. Comments on the ISR and meeting summary were filed by FERC staff on July 5, 2022; the U.S. Forest Service on July 6, 2022; the Confederated Salish and Kootenai Tribes on July 7, 2022; the U.S. Fish and Wildlife Service on July 7, 2022; and the Montana Department Fish, Wildlife, and Parks on July 8, 2022. FERC issued a Determination on Requests for Study Modifications for the Thompson Falls Hydroelectric Project (Modified Study Plan) on September 1, 2022 (FERC 2022).

The Operations Study was initially to be completed in 1 year. However, in the Operations Study ISR, NorthWestern concluded that the first study season successfully tested the extent of flexible capacity available at the Project. However, the study tested the more extreme operational scenarios. Therefore, NorthWestern proposed a second season study to evaluate additional scenarios of the proposed operation. This Operations Study – Final Study Report has been prepared to comply with NorthWestern's Revised Study Plan (Study Plan) (NorthWestern 2021), filed April 12, 2021, as approved in FERC's Study Plan Determination (FERC 2021) and Modified Study Plan (FERC 2022).

[1] Local, state, and federal governmental agencies, Native American Tribes, local landowners, non-governmental organizations, and other interested parties.

1.1 Operations Study Background

The Thompson Falls Project is operated to provide baseload and flexible generation within the authorized reservoir elevation and minimum Project discharge (flow) requirements of the FERC License. During flexible generation operations, NorthWestern may use the top 4 feet of the reservoir while maintaining minimum flows.

From 1999 to 2014, the Project was owned and operated by PPL Montana, LLC (PPL Montana). PPL Montana was a non-regulated merchant power generating company and did not have responsibility for load balancing, grid stability, and associated compliance requirements that required frequent use of flexible capacity and full reservoir storage. NorthWestern acquired the Project in 2014. As a regulated utility and transmission operator, NorthWestern has responsibility for load balancing, load regulation, and all other associated grid stability requirements. Having the capacity to be flexible, by increasing and decreasing generation, helps meet these requirements. The storage capacity in Thompson Falls reservoir provides this needed generation flexibility. Flexible capacity needs on the system are dynamic and involve many difficult to predict variables such as customer demand and availability of other electric generation, (including intermittent renewables like wind and solar). The Project may be needed to provide flexible capacity as few as a couple times a day up to multiple times in an hour based on the dynamic variables.

In October 2019, NorthWestern conducted an operations test (test) to assess the potential impacts of routinely operating the Project within the 4-foot range authorized by the License. During the test, the reservoir elevation was lowered from normal full operating level down 4 feet, then raised in 1-foot increments. The plant was increased to full generation output to lower the reservoir. Level loggers were deployed in multiple locations to record water elevation changes. A time-lapse camera was deployed at a key location to capture visual changes at the mouth of the Thompson River. Resource professionals visited different locations to photograph (photo) conditions and make visual observations during active drawdown and at each elevation level for the test. Observations were made on:

- Operations – quantification of the flexible capacity available with the reservoir volume
- Shoreline Stability – bank stability and erosion
- Aquatic Vegetation/Aquatic Invasive Species – aquatic vegetation (emergent and submerged) and aquatic invasive species
- Fisheries – fish stranding, migration corridors to tributaries, and fish passage facility operations
- Recreation – effects to recreation site amenities including boat launches, boat docks and aesthetic conditions
- Public Safety – navigation hazards in the reservoir, rate of water elevation changes
- Water Quality – changes in water chemistry and/or physical properties

- Wetland/Riparian Habitats – available habitat relative to water level changes, duration of dewatering

Based on the results of the October 2019 test, NorthWestern concluded that drafting Thompson Falls Reservoir the full 4 feet as authorized by the current License on a regular and frequent basis would have an unacceptable level of impact to several of the resources identified above. Consequently, NorthWestern, in its relicensing application, will seek to continue to provide baseload generation and flexible capacity needs during the new license term using 2.5 feet of the reservoir. During normal operations, the reservoir would be maintained between 2396.5 and 2394.0 feet. While an authorized use of 2.5 feet is substantially less than the current authorized use of 4 feet, it will provide NorthWestern with important operational flexibility that is needed for grid stability and reliability.

During the 2021 study season, NorthWestern conducted an Operations Study of Project operations, including evaluating generation changes at multiple reservoir elevations and durations, allowing the resulting reservoir fluctuations to be observed and studied for potential impacts on Project resources. Operational scenarios for the Operations Study were within the proposed 2.5 feet of flexible reservoir elevation while maintaining minimum flows.[2]

The goal of the 2021 Operations Study was to understand the effects of proposed Project operations, and to evaluate possible impacts on Project resources. The study was designed to test the extremes of proposed operational limits, including using the maximum generation resulting in the rapid reduction in the reservoir elevation to the maximum drawdown of 2.5 feet. It was important to identify and understand the limitations of the facility and potential impacts on the Project resources.

NorthWestern continued the Operations Study into the second study season, to assess the real-time effects of flexible operations. The focus of the second season to the Operations Study was those resource areas where impacts were identified in the first study season and where further monitoring would refine the extent of impacts on operations, shoreline stability, riparian habitats, fisheries, recreation and aesthetics, and wetlands.

1.2 Value of Operational Flexibility

NorthWestern has responsibility for load balancing, load regulation, and all other associated grid stability requirements to support its customers per FERC, North American Electric Reliability Corporation, and Western Electricity Coordinating Council regulations. The storage in Thompson Falls reservoir provides the capacity to provide needed flexibility. This helps to balance the very dynamic changes that occur as energy use and energy production on

[2] A brief (30 minutes) minimum flow excursion occurred on July 26 during the Operations Study. NorthWestern notified FERC on August 3, 2021. On December 22, 2021, FERC issued a determination that the low flow deviation would not be considered a violation of the license.

the grid change throughout the day. Frequent increases or decreases in electric generation are needed to help maintain a stable and reliable grid.

Flexible capacity is very important for the needs described above and those needs will continue to grow as additional renewable and intermittent energy sources are added to the grid. The intermittent nature of wind and solar generation requires other sources to increase or reduce output on demand to maintain a steady, reliable grid. NorthWestern's ability to maintain current renewable sources, and to add more in the future, depends on its capability to balance those new intermittent resources with existing resources including the Thompson Falls Project.

1.3 Goals and Objectives of Operations Study

The goal of the modified study was to further evaluate the impacts on Project resources during transmission grid regulating operations.

The objectives of continuing the study into a second season were to better understand the current required frequency and magnitude of increases and decreases of generation, and to assess shoreline stability, riparian habitats, fisheries, recreation and aesthetics, and wetlands under real-world application of grid stabilizing operations.

2.0 Methods

2.1 Operations

2.1.1 Study Area

NorthWestern monitored reservoir and river stage during the second study season, March 15 through October 31, 2022. Permanently installed stage recording instruments and remotely installed stage loggers were used to capture elevation changes (**Figure 2-1**). NorthWestern monitored stage at the following sites that were also monitored during the first study season: Project Boundary, Above Islands, Islands, Main Dam, Tailrace, and Birdland Bay Bridge. Remotely installed stage loggers at the Project Boundary, Above Islands, Islands, and Birdland Bay Bridge, were installed on the falling limb of the hydrograph in order to minimize damage or loss of instruments due to debris during high water. Therefore, the period of record for the remote stations is shorter compared to the data collected from permanently installed instrumentation at the Project at the Main Dam and Tailrace.

2.1.2 Methods

In 2022, NorthWestern operated the Thompson Falls Project to provide baseload and flexible generation to support grid reliability and market conditions. The daily operations were determined in real-time as stable, increases, or decreases in generation were called upon to provide NorthWestern's grid reliability and meet market conditions needs. The operations ranged from little to no change to multiple changes in a 24-hour period. Available flexible capacity is determined by the capacity of the generating units to either increase or decrease output and the available reservoir volume to accommodate an increase or decrease in water level. The generating units can increase production up to full load output from their current baseload production and can decrease output from their baseload level down to minimum output. An increase in generation output will use available water in the reservoir resulting in a reduction in reservoir elevation. A decrease in generation output will decrease downstream flows which cause the reservoir elevation to rise. The magnitude of the generation increase or decrease dictates the rate of change of the reservoir elevation while the available storage in the reservoir dictates the maximum duration of the changed output. All operations during the 2022 Study Season maintained the reservoir elevation within the top 2.5 feet and provided a minimum flow of 6,000 cubic feet per second downstream of the Project.

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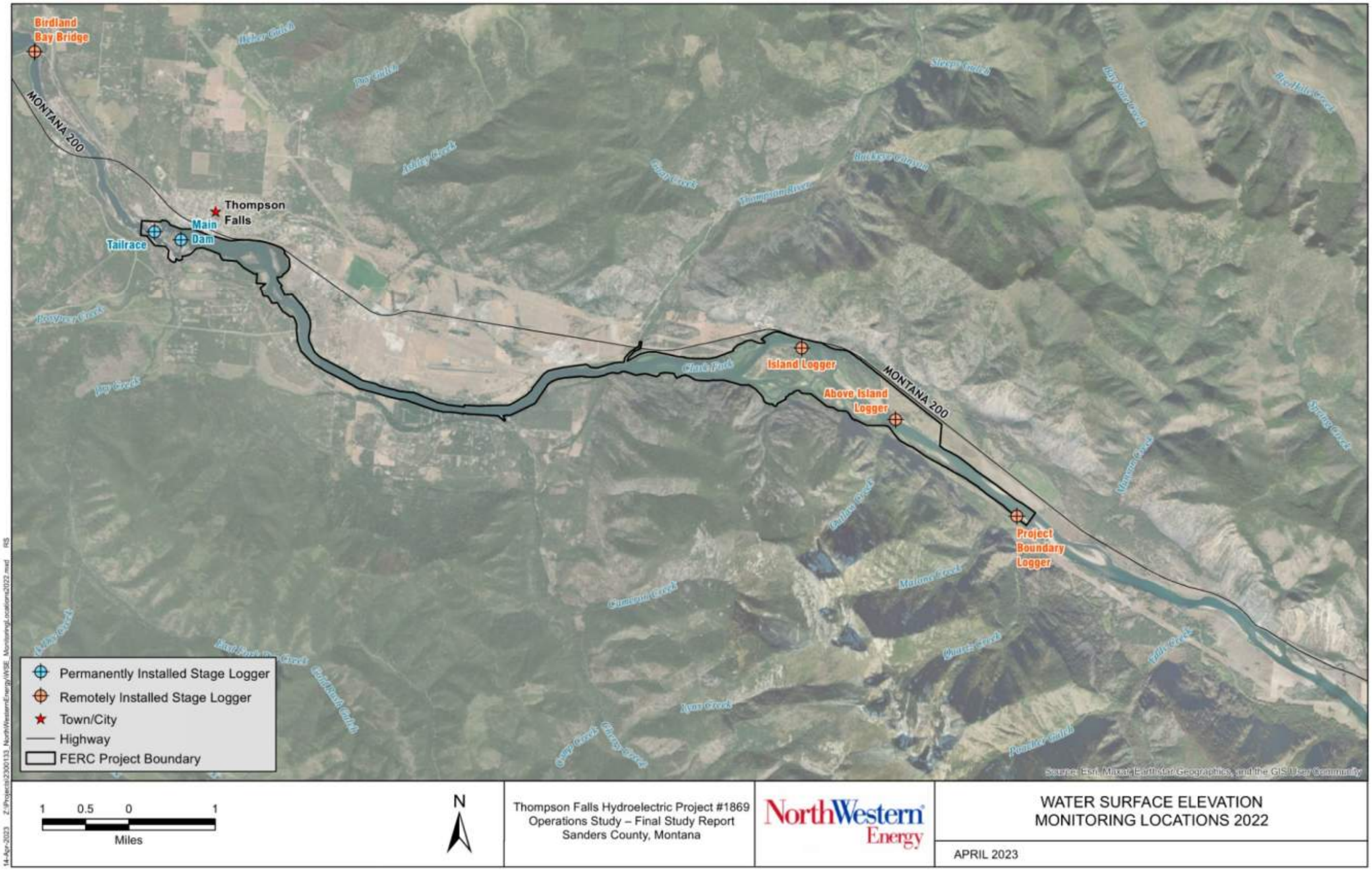
Figure 2-1. Water Surface Elevation Monitoring Locations 2022.



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2.1.3 Variances from the FERC-approved Study Plan

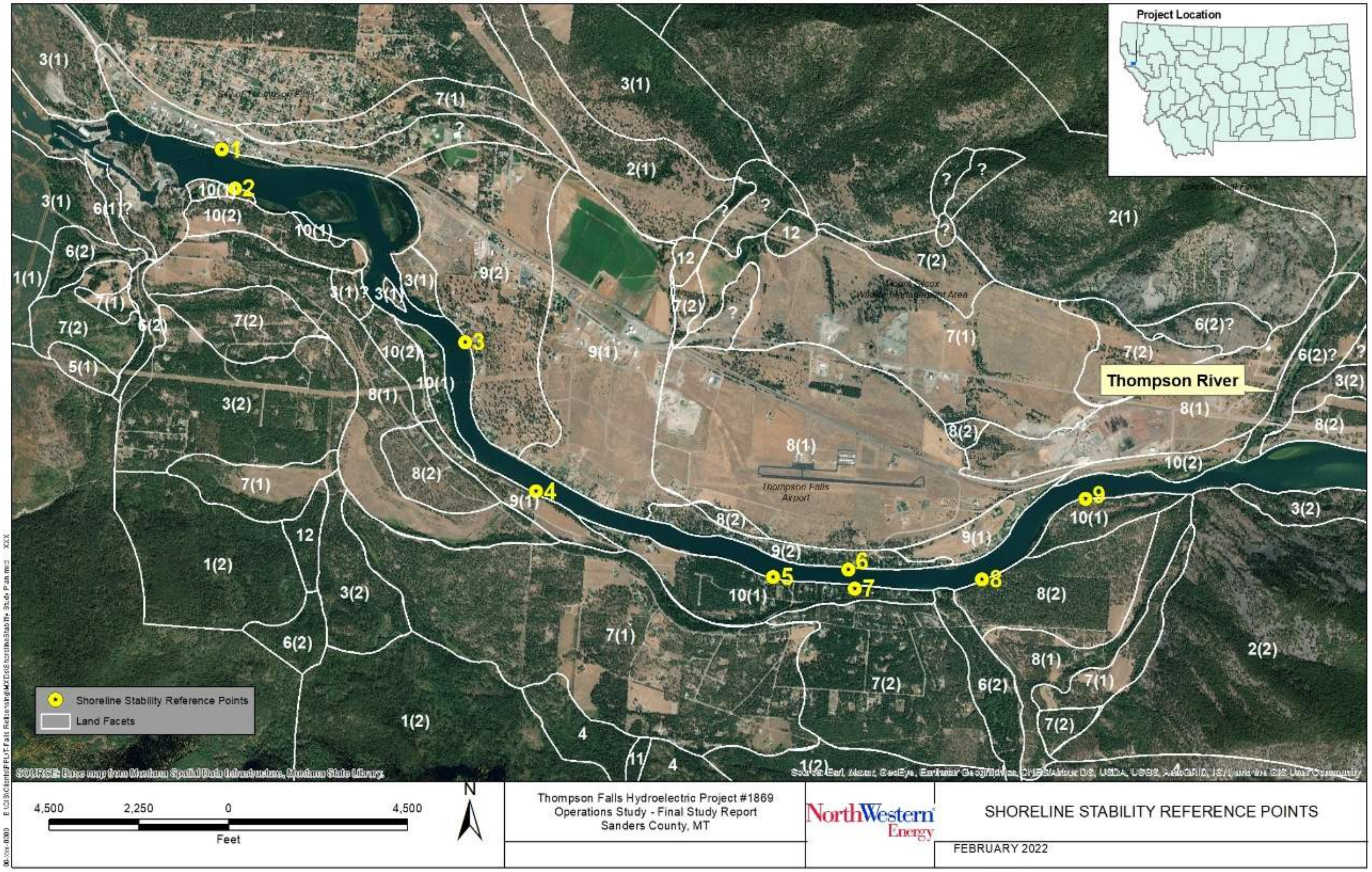
There were no variances from the Study Plan (NorthWestern 2021), filed April 12, 2021, as approved in FERC's Study Plan Determination (FERC 2021), and the Modified Study Plan (FERC 2022).

2.2 Shoreline Stability

2.2.1 Study Area

As part of the second season of the Operations Study, NorthWestern assessed shoreline stability. The same data and photos were collected at the same nine reference points as the first study season (**Figure 2-2**). These nine reference points extend from the boat restraint upstream to the mouth of the Thompson River and capture the majority of developed lands potentially affected by Project operations.

Figure 2-2. Shoreline Stability Reference Points.



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2.2.2 Study Methods

Nine reference points were established along the reservoir shoreline as shown in **Figure 2-2.** Each reference point is a 300-foot-long reach of shoreline. The reference points were chosen to represent variability in soil types, landform, slope, aspect, vegetation, shoreline management, flow velocity and land use that in turn represent the variability in shoreline stability along the reservoir.

The reference points were monitored on July 20 and September 13, 2022 by making visual observations of the shoreline describing parameters such as presence or absence of erosion, type of erosion, magnitude of erosion, potential causes of erosion, soil type, land management activities and shoreline erosion control measures (if any). The observations were recorded electronically and entered into a database. Five photos were taken at each reference point during each visit with three capturing the shoreline of the entire 300-foot-reach (taken perpendicular to the midpoint of three 100-foot sub-segments of the 300-foot-reach and about 120 feet back from the shoreline) and two photos taken from the mid-point of the reach, one facing upstream and the other facing downstream, about 15 feet back from the shoreline. Results from the two monitoring events were compared to identify changes in shoreline stability, assess impacts related to the reservoir fluctuation or natural conditions, or a combination of both.

2.2.3 Variances from the FERC-approved Study Plan

There were no variances from the Study Plan (NorthWestern 2021), filed April 12, 2021, as approved in FERC's Study Plan Determination (FERC 2021), and the Modified Study Plan (FERC 2022).

2.3 Riparian Habitats

2.3.1 Study Area

In this study, NorthWestern assessed aquatic vegetation and aquatic invasive species (AIS) at the same nine reference points that were monitored for shoreline stability. *See* Section 2.2, Shoreline Stability, for a more detailed description and a map of the nine reference points.

2.3.2 Study Methods

As defined in the 2021 Operations Study, riparian habitat is considered the vegetation above the full pool[3], and aquatic vegetation is considered the vegetation below that elevation, with the aquatic vegetation being either emergent (protruding above the water surface) or submergent (not protruding above the water surface). The results from the 2021 Operations Study indicated that operations had no impacts to riparian habitat, but potential impacts to aquatic vegetation were

[3] maximum elevation of the reservoir during normal operations

observed, particularly for submergent aquatic vegetation. Thus, the second study season focused solely on aquatic vegetation.

The same data on aquatic and AIS vegetation were collected at the nine shoreline stability reference points as in the first study season. Data collected included the percent linear distance (to a water depth of 4 feet at full pool) of the 300-foot-long reference point that had aquatic vegetation and/or AIS present, and, if known, the plant species. The observations were recorded electronically and entered into a database. Five photos were taken at each reference point (the same five photos taken for the shoreline stability evaluation) with three capturing the shoreline of the entire 300-foot-long reach (taken perpendicular to the midpoint of three 100-foot long sub-segments of the 300-foot-long reach and about 120 feet back from the shoreline) and two photos taken from the mid-point of the reach, one facing upstream and the other facing downstream, about 15 feet back from the shoreline.

There were two monitoring events, July 20 and September 13. Results from each monitoring event were compared to identify changes in the percent of aquatic vegetation and AIS and species composition, and whether the changes were related to operations, or baseline conditions, or a combination of both.

2.3.3 Variances from the FERC-approved Study Plan

There were no variances from the Study Plan (NorthWestern 2021), filed April 12, 2021, as approved in FERC's Study Plan Determination (FERC 2021), and the Modified Study Plan (FERC 2022).

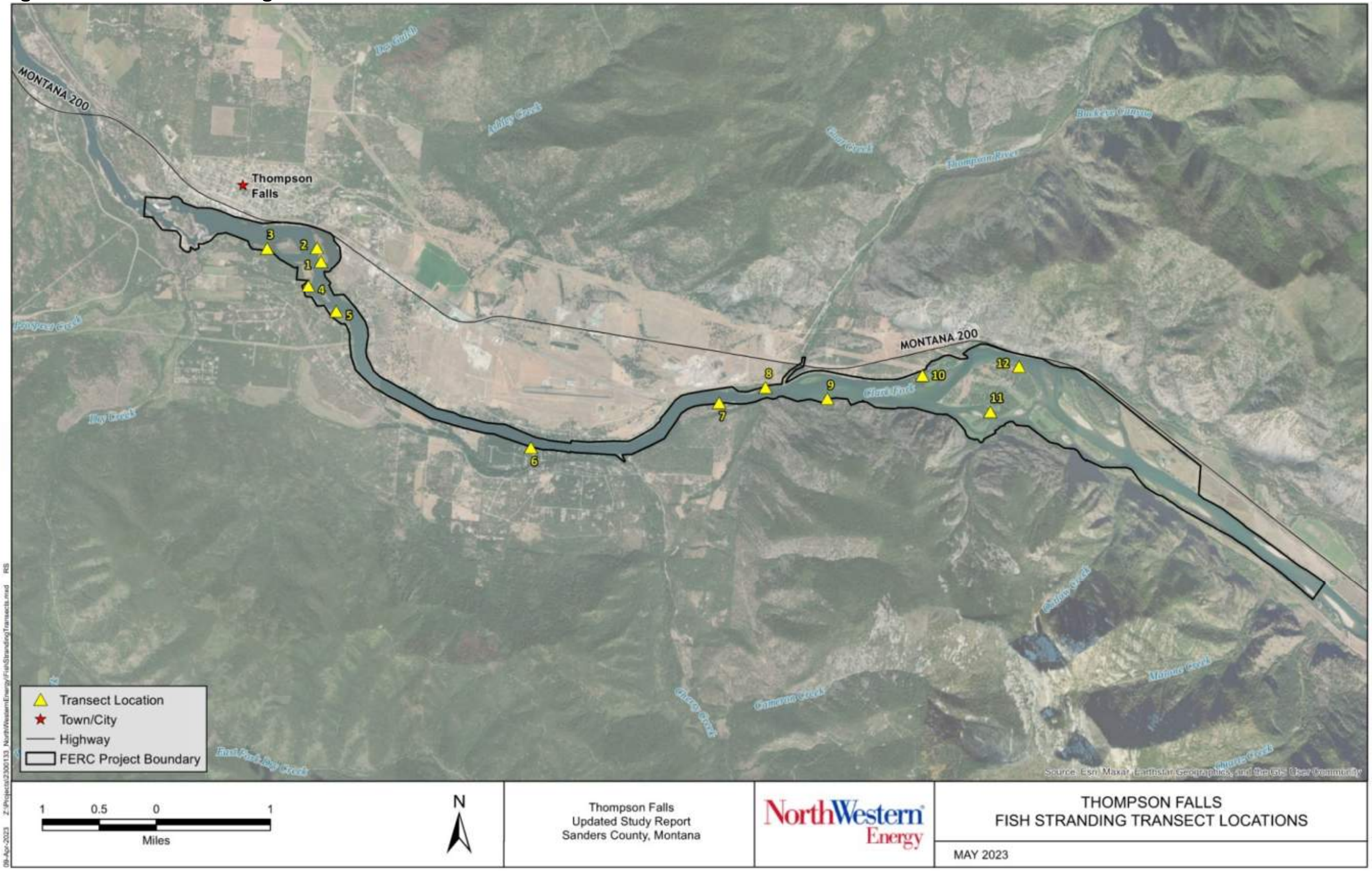
2.4 Fisheries

2.4.1 Study Area

Data on stranded fish were collected at the same twelve transects as during the first study season, during two monitoring events in 2022 (**Figure 2-3**). Each transect was walked and any stranded fish counted, and total length measured. Additionally, when traveling by boat to access the transect sites, stranded fish were noted.

Operations of the fish passage facility were monitored during the second study season to further evaluate impacts. Four staff gauges within the fish passage facility were manually recorded each time the facility was checked. Information from these gauges combined with observations by the fish passage facility operators provided data on the impact of reservoir elevation on the operation of the workstation or other fish passage facility components. The presence of aquatic vegetation mobilized within the reservoir and accumulating on the inlets of the fish passage facility was tracked, similar to the first year of study.

Figure 2-3. Fish Stranding Transect Locations.



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2.4.2 Study Methods

Transects (12 in total) were established to observe and measure fish stranding during different operational scenarios in the reservoir in shallow habitats less than 2.5 feet deep at full pool, fluctuation zones where fish stranding was most likely to occur. The transects were intended to capture the range of habitat characteristics where there is the potential for fish stranding. In the reservoir downstream of Cherry Creek, three 200-foot-long transects were surveyed on exposed mid-channel island areas, and three transects were surveyed along exposed shoreline habitats. The reservoir near the islands upstream of the Thompson River were also sampled with the same methodology, including three transects on exposed island areas and three along shoreline habitats.

Stranding transects were surveyed two different times during the 2022 Operations Study, the 2 days were randomly selected to complete the survey during August. Observations were made on August 24 and again on the 31st and represented reservoir elevations at 2395.8 and 2395.7 feet. All 12 transects were walked during each survey unless they were submerged.

Observers walked the transect and recorded species, total length, and weight of any fish observed within 30 feet (15 feet either side) of the transect line. Fish observed trapped in small pools along the transect were counted by species, and lengths estimated.

During year 2 of the Operations Study the fish passage facility was operated as normal, including flow in the step pools of the ladder and in the high velocity attraction jet. Operation of the workstation pumps was assessed. Observations of water levels in the fish passage facility were made, and corresponding reservoir elevations recorded. Three staff gauge levels within the ladder were recorded along with comments and observations. Staff gauge 1 (SG1) is located at the upstream end of Pool 48 (forebay) and represents the reservoir elevation, staff gauge 2 (SG2) is within the ladder in Pool 48, and staff gauge 5 (SG5) is in Pool 45.

2.4.3 Variances from the FERC-approved Study Plan

There were no variances from the Study Plan (NorthWestern 2021), filed April 12, 2021, as approved in FERC's Study Plan Determination (FERC 2021), and the Modified Study Plan (FERC 2022).

2.5 Recreation and Aesthetics

The effects of operations during the 2022 second study season on recreation access related to public and private docks were observed and assessed, as were impacts to aesthetic qualities of Thompson Falls Reservoir.

2.5.1 Study Area

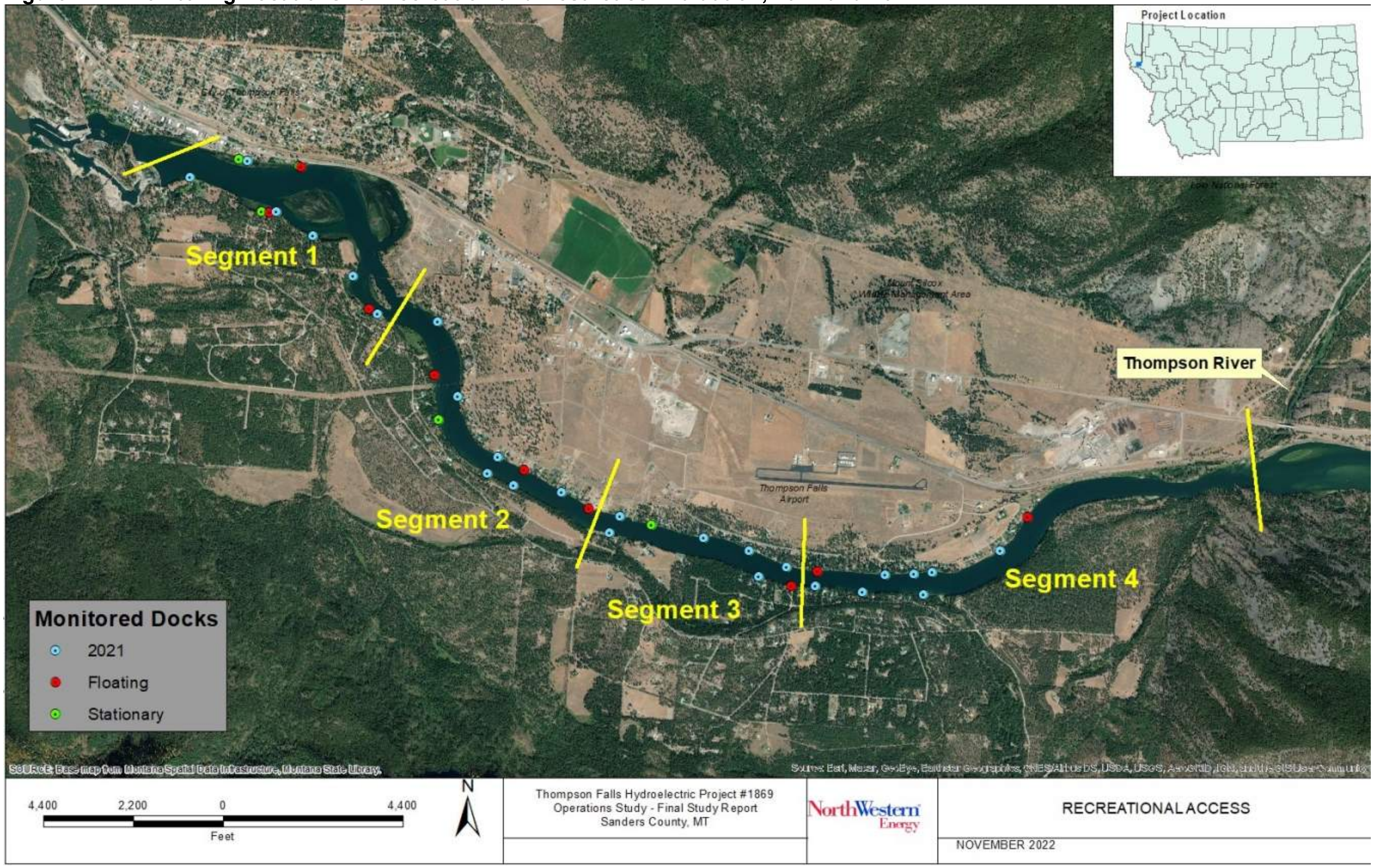
2.5.1.1 Recreation Access

Reference points were established during the 2021 Operations Study to monitor recreational access at public and private docks and the waterway. This included a subset of 39 docks that were representative of all docks located along reservoir shoreline. The monitoring locations were distributed throughout the reservoir in four segments:

1. From the boat barrier upstream to the upper end of Steamboat Island
2. From the upper end of Steamboat Island upstream to the private Salish Shores boat launch
3. From the Salish Shores boat launch upstream to the Cherry Creek Boat Launch
4. From the Cherry Creek Boat Launch upstream to Thompson River

Prior to the 2022 study season, a subset of 17 docks were selected from the set of 39 docks established in 2021. These points were monitored on five occasions during the Operations Study, between July 20 and August 30 (**Figure 2-4**). Of these 17 reference points, three of the docks were not installed, resulting in 14 reference docks monitored in 2022.

Figure 2-4 Monitoring Locations for Recreation and Aesthetics Evaluation, 2021 and 2022.



Notes: Red dots = floating docks monitored in 2021 and 2022. Green dots = stationary docks monitored in 2021 and 2022. Blue dots =docks monitored in 2021 only.

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2.5.1.2 Aesthetics

Aesthetic conditions were observed and documented through photos of exposed mud flats and presence of odor at established reference points in the following areas:

- Island Park between Gallatin Street Bridge and Dry Channel Dam.
- North shoreline of the main reservoir adjacent to the Gallatin Street Bridge, approximately 300 feet downstream of Wild Goose Landing Park, at the Wild Goose Landing boat launch, and at the North Shore Dispersed Use Area.
- South shoreline of the main reservoir across from Wild Goose Landing Park and behind Steamboat Island.
- South shoreline at the Cherry Creek boat launch.
- North and south shorelines areas with private docks at the upstream end of the study area.

These reference locations were selected due to their proximity to areas of public access and to provide a cross-section of the study area.

2.5.2 Study Methods

2.5.2.1 Recreation Access

During the second study season, an assessment was conducted to determine impacts of reservoir elevations on public and private docks, access to docks, and access to the waterway from docks.

Public docks are located at Wild Goose Landing Park and at the Cherry Creek Boat Launch. There are two docks at Wild Goose Landing, a floating dock and a stationary dock. The dock at Cherry Creek Boat Launch is a floating dock. All three public docks were monitored during both study seasons. All the other monitored docks were privately owned docks.

The established reference points were evaluated during 5 days of the 2022 recreation season: July 20, August 1, August 9, August 17, and August 30 (**Table 2-1**). These dates were chosen due to the high daily temperatures forecasted. It was anticipated that the hottest days would require the greatest amount of flexible generation as the need to power air conditioners would be greatest on days when the temperatures were the highest. Generating a great amount of power requires use of more of the reservoir pool and thus results in reduction of the pool elevation. Monitoring during the 2021 study revealed that impacts to recreation access was greatest during times of the greatest elevation decreases, so the monitoring dates were chosen to evaluate larger drawdowns.

The reservoir elevation was different during each monitoring event, with reservoir elevations ranging from 0.7 to 1.8 feet below full pool. Air temperature during monitoring events ranged from 81 to 93 degrees Fahrenheit (°F) (**Table 2-1**).

Table 2-1. Monitoring Dates, Maximum Air Temperature, and Reservoir Elevation in 2021 and 2022

Monitoring Date 2021	7/28/21	8/17/21	8/19/21	7/30/21	9/8/21
Temperature (ºF)	85	55	65	80	74
Pool Elevation (ft)	2396.0’	2395.5’	2395.0’	2394.5’	2394.0’
Distance from Full Pool (2396.50 ft)	-0.5’	-1.0’	-1.5’	-2.0’	-2.5’
Monitoring Date 2022	**7/20/2022**	**8/1/2022**	**8/9/2022**	**8/17/2022**	**8/30/2022**
Temperature (oF)	81	93	82	91	82
Pool Elevation (ft)	2395.8’	2394.7’	2395.6’	2395.8’	2395.6’
Distance from Full Pool (2396.50 ft)	-0.7’	-1.8’	-0.9’	-0.7’	-0.9’

Notes: ºF = degrees Fahrenheit; ft = feet

2.5.2.1.1 Types of Docks Assessed

Two types of public and private docks primarily exist on the reservoir: stationary docks and floating docks. Docks typically have a gangway or access ramp[4] that is fixed to the shoreline. Stationary docks remain at the same elevation regardless of the water level, as do their gangways and access ramps. The elevation of floating docks changes with water levels, and the angle of associated gangways and access ramps also change as the docks move up and down in relation to the shoreline and anchor point of the ramp. Floating docks consist of a variety of materials and layouts. Many floating docks have foam-filled floats under wood or composite decking material. Some have aluminum pontoons under decking, and others consist of air-filled, low-density polyethylene segments, while still others are made from other materials such as logs and old tires.

Stationary docks represent roughly 20 percent of docks on the reservoir overall and floating docks represent about 80 percent of docks on the reservoir overall. Docks on Thompson Falls Reservoir are constructed of a variety of materials, have various layouts, and typically have an apparatus for tying boats. Boat cleats mounted to the surface of the dock are popular, though boat whips are used as well to secure a boat near the dock while preventing it from making contact with the dock (**Photos 2-1**).

[4] A gangway connects a dock to the shoreline and has handrails. An access ramp connects a dock to the shoreline but does not have handrails.

Photo 2-1 Images of Cleat, Boat Tied to cleats, and Boat Secured with Whips.

2.5.2.1.2 Assessment Methodology- Recreation Access

The subset of 17 docks that were chosen for monitoring in 2022 represented the 39 reference docks from 2021. This sub-set of docks were dispersed among the north and south shorelines, on the main reservoir and upstream of Steamboat Island, represented both floating and stationary docks, and included the public docks at Wild Goose Landing Park and Cherry Creek Boat Launch in addition to privately-owned structures. Roughly one-third were stationary docks and two-thirds were floating docks. Reducing the intended subset by three uninstalled docks did not significantly alter the distribution of docks. The sub-set was representative of all types of docks typically installed during the recreation season (Memorial Day – Labor Day), though stationary docks were slightly oversampled. Because stationary docks make up such a small percentage of all docks typically installed on the reservoir (approximately 20%), researchers felt that including more stationary docks in the monitoring (35% instead of 20%) would more accurately capture impacts related to those types of structures since impacts varied throughout the study area.

Monitoring events in both study years aimed to assess impacts to recreation access at various reservoir elevations in terms of:

1. Impacts to the physical condition of dock and gangway structures.
2. Impacts to access to docks from shorelines.
3. Impacts to access to the waterway from docks.
4. Impacts to access to boats moored at docks.

Three photos were taken of each dock during each monitoring event: one photo each from a point near the shoreline on the upstream and downstream side of the dock and one photo taken perpendicular to the shoreline. The photos helped to document impacts resulting from fluctuating water levels.

After monitoring assessments were completed, the impacts to docks were scored using a scale of 0 to -4, as below:

0: No impact. No structural impact or access is not limited or affected in any case.

-1: Slight impact. Access is minimally impacted in less than one-quarter of cases.

-2: Moderate impact. Access is impacted minimally or moderately in half or less of cases.

-3: Significant impact. Access is impacted moderately or significantly in more than half of cases.

-4: Severe impact. Access is prohibited in all or nearly all cases.

A rating of 0 indicates no change in access or in the condition of the structure, while ratings from -1 to -4 indicate decreasing levels of recreational access (or increasing levels of impacts to access).

2.5.2.2 Aesthetics

Monitoring was conducted to document conditions and impacts to aesthetic characteristics of the reservoir and shorelines during the second study season. Reference points established in 2021 were again evaluated in 2022 for influences from water level changes through photo documentation and observations. The reference points described in Section 2.5.1.1 provided a representative sample of viewpoints along reservoir shorelines that approximated views from public and privately-owned properties. Monitoring was conducted on 4 days: August 9, 17, 30, and September 6. Photos of reference points documented the linear distance of the exposed shoreline.

2.5.3 Variances from the FERC-approved Study Plan

NorthWestern proposed that the depth of the water at the end of floating docks would be measured during the 2022 study (NorthWestern 2022), however the duration of the drawdowns was so brief (less than an hour) that it was not possible to collect these additional measurements. There were no other variances from the Study Plan (NorthWestern 2021), as approved in FERC's Study Plan Determination (FERC 2021), and the Modified Study Plan (FERC 2022).

2.6 Wetlands

2.6.1 Study Area

Wetland data collected in the first study season indicated that operations may have some impact to wetlands that have a direct surface water connection to Thompson Falls Reservoir. These wetlands were identified using GIS based mapping and the Montana Natural Heritage Program wetland mapper (MTNHP 2020). Additional data were collected on other wetlands of this type (i.e., those with a direct surface water connection to the reservoir) to help further define potential impacts and the extent of potentially impacted wetlands in the Project area. **Table 2-2** lists the wetlands studied in 2022.

Table 2-2. Wetlands Evaluated in the Second Study Season.

Site Name[1]	Site Description	Primary Wetland Classification	Secondary Wetland Classification	Potential Risk of Alteration from Operations
Wetland 1	Side channel wetland near Steamboat Island in Lower Reservoir	Palustrine, Emergent, Temporarily Flooded	Riverine, Unconsolidated Bottom, Permanently Flooded	High
Wetland 4	Shoreline wetland near Steamboat Island in Lower Reservoir	Palustrine, Emergent, Temporarily Flooded	Palustrine, Emergent, Seasonally Flooded	High
Wetland Control	In Oxbow Upstream of Project Boundary	Palustrine, Aquatic Bed, Semi-permanently Flooded	Palustrine, Emergent, Temporarily Flooded	None (Control Site)

Note:
[1] Wetland sites were named to ensure continuity between wetlands studies in 2021 and wetlands studied in 2022.

2.6.2 Study Methods

Wetlands were monitored by measuring changes in water level and conducting visual observations of identified wetland areas. As the level of the reservoir decreases, the hydrological connection with adjacent wetlands areas has the potential to be altered.

A desktop exercise was used to identify and prioritize potential wetland monitoring sites. Wetland areas were identified using the Montana Spatial Data Infrastructure Wetlands Framework (2020). This information was utilized to locate the approximate location of identified wetlands, and the type and extent of these areas adjacent to the reservoir. The desktop exercise was used to rank sites as high, medium, or low risk. Risk was determined by multiple factors including the surface water connection, soil type, slope, and distance from the ordinary high-water mark of the reservoir. Wetland sites that receive a low-risk rating were unlikely to be affected by reservoir operations and were not considered as suitable monitoring sites for this Operations Study.

Wetland sites that receive a high or medium risk rating were considered as potential sites for data collection. Ground-truthing of the high or medium risk rated sites was used to validate the results of the desktop exercise and to identify sites for monitoring during the Operations Study. During the ground-truthing effort, some sites were eliminated from consideration for lack of hydrologic connectivity to the Thompson Falls Reservoir or being perched at an elevation high enough that reservoir fluctuations are unlikely to alter the hydrology of that wetland. For the second study season, two representative wetland sites within the Project boundary were chosen, plus an additional control site that had similar characteristics to the other wetland sites but is located upstream of the Project boundary (*refer to* Table 2-2).

In the early summer of 2022, level loggers were deployed at the three wetland monitoring sites to track water level changes in these areas (*refer to* **Figure 2-1).** The purpose of the 2022 wetland monitoring was to determine if the effects from reservoir operations observed at Wetland 1 in 2021 were observed at that site again in 2022 and to also look at other wetlands that exhibited like characteristics to see if those wetlands were similarly affected by reservoir operations. To properly isolate environmental variability from reservoir operations effects, a wetland control site was selected upstream of the reservoir (Wetland Control). The control site was of a similar wetland type and physical characteristics as the other two wetland sites chosen for this Operations Study. Visual observations were used to identify any areas that become disconnected from the reservoir. Data collected was analyzed to determine any potential operational impacts on wetland areas.

2.6.3 Variances from the FERC-approved Study Plan

There were no variances from the Study Plan (NorthWestern 2021), filed April 12, 2021, as approved in FERC's Study Plan Determination (FERC 2021), and the Modified Study Plan (FERC 2022). The FERC-approved Study Plan (NorthWestern 2021) described the riparian evaluation as being part of the wetlands' evaluation. Riparian habitat monitoring results are being reported with the aquatic vegetation and AIS information in this Study Report.

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3.0 Results

3.1 Operations

3.1.1 Available Flexible Capacity

The available flexible capacity is calculated through two variables. The current operating output of the generation units and the current reservoir elevation dictate the quantity and duration of generation increases and decreases. Baseflows dictate the configuration and output of the generation units. Flexible capacity is calculated in real-time as plant configuration and reservoir elevation dynamically change. Full quantification of flexible capacity was verified in year 1 of this study.

The plant performed well and showed no operational obstacles to the provision of flexible capacity. Through the 2022 study period decreases in generation from 4 megawatt (MW) to 34 MW were provided with an average decrease of 17 MW. Increases in generation were provided from 7 MW to 30 MW with an average of 18 MW. Typical durations during the 2022 Study Season were 15 to 45 minutes, although it is noted that the duration is a function of available water storage.

There were timeframes within the study period when no flexible capacity was offered from the site due to baseflow conditions, unit status, or planned outages.

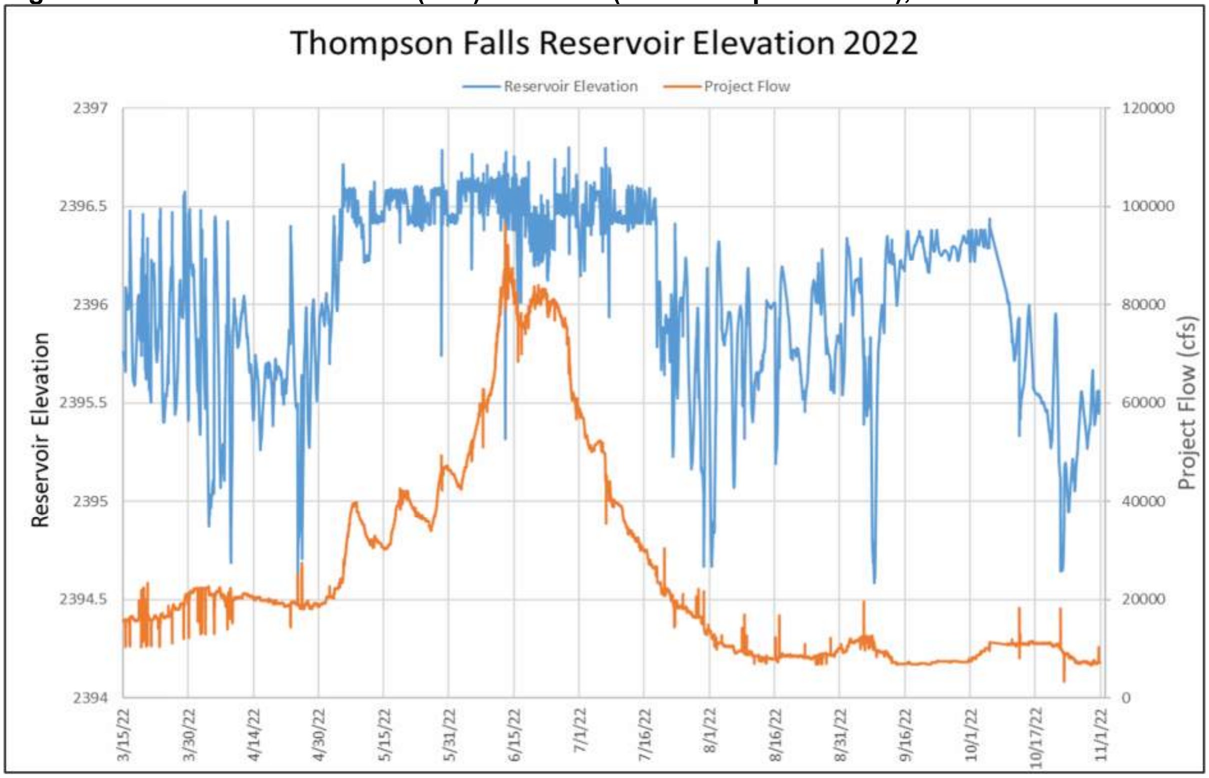
3.1.2 Plant Operational Observations

The plant operated well both mechanically and electrically throughout the test with no observed issues from the provision of flexible capacity. The operations are programmed into the plant control system to monitor and control generation increases and decreases within defined parameters, such as reservoir elevation and minimum downstream flow.

3.1.3 Reservoir Elevation Change

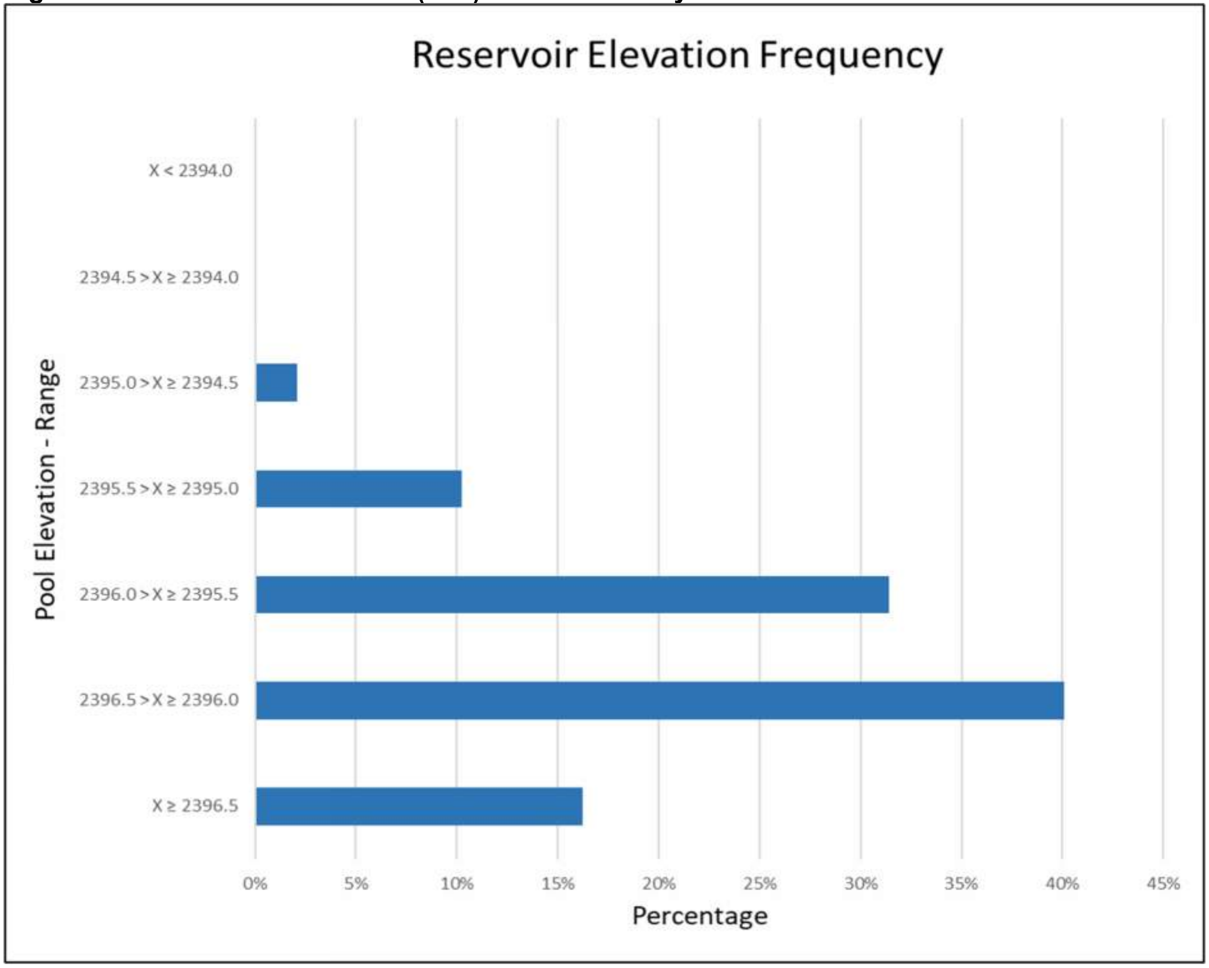
Figure 3-1 displays reservoir elevation and flow through the Project during the second study season (March 15, 2022 – October 31, 2022). Reservoir levels were at or above 2394.6 feet throughout the study period. The Project was operated to utilize flexible capacity based on river flows, reservoir elevation, and available unit capacity. Flows in excess of powerhouse capacity, which occurred from early May to the middle of July in 2022, were passed over the spillways.

Figure 3-1. Reservoir Elevation (feet) and Flow (cubic feet per second), March – October 2022.



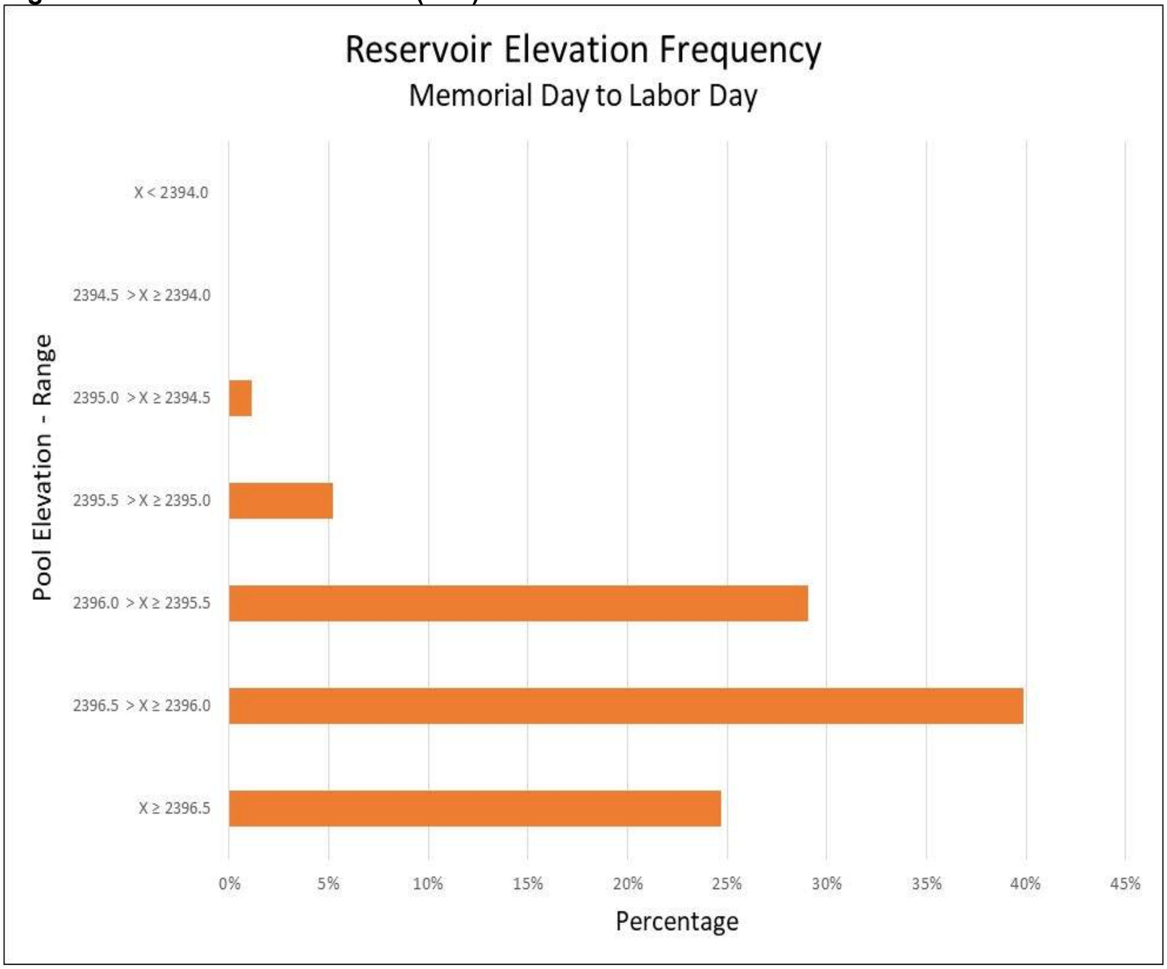
The frequency when flexible operations resulted in drafting the reservoir was calculated for the second study season. Thompson Falls Reservoir was at 2396.0 feet or above for 56 percent of the second study season (**Figure 3-2**). The reservoir was between 2395.5 and 2396.0 feet for 31 percent of the season, and below 2395.5 feet for 13 percent of the second study season.

Figure 3-2. Reservoir Elevation (feet) – Second Study Season 2022.



The frequency of the Reservoir elevation was also calculated from Memorial Day through Labor Day, typically, the recreation season. Thompson Falls Reservoir was at 2396.0 feet or above for 65 percent of the recreation season (**Figure 3-3**). The reservoir was between 2395.5 and 2396.0 feet for 29 percent of the recreation season, and below 2395.5 feet for 6 percent of the recreation season, with a minimum elevation of 2394.7 feet during the recreation season.

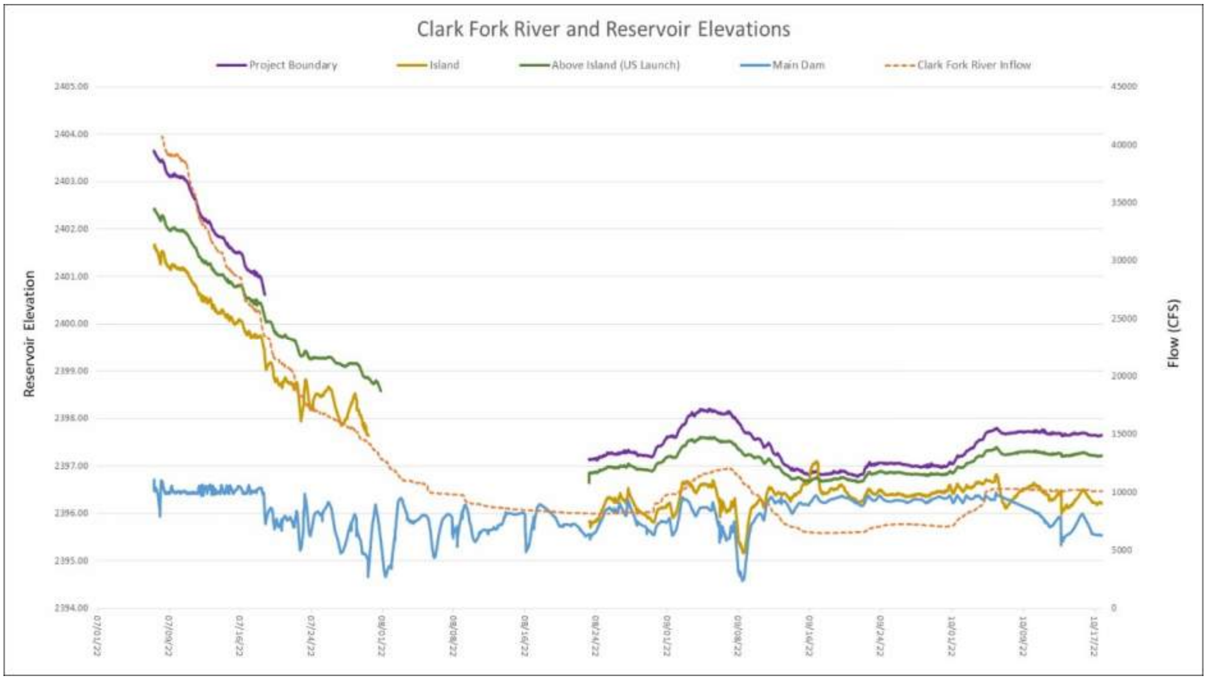
Figure 3-3. Reservoir Elevation (feet) – Recreation Season.



3.1.3.1 Clark Fork River and Reservoir Elevations above Thompson Falls Dam

NorthWestern monitored water surface elevations throughout the Project during the second study season. Stage loggers were deployed at remote sites to measure stage (water surface elevation) change during flexible operations. Instruments were deployed on July 7 when spring runoff was subsiding in order to minimize damage or loss of instruments. Water surface elevations are presented in **Figure 3-4**.

Figure 3-4. Water Surface Elevations at Monitoring Locations in the Project Area Upstream of the Dams.



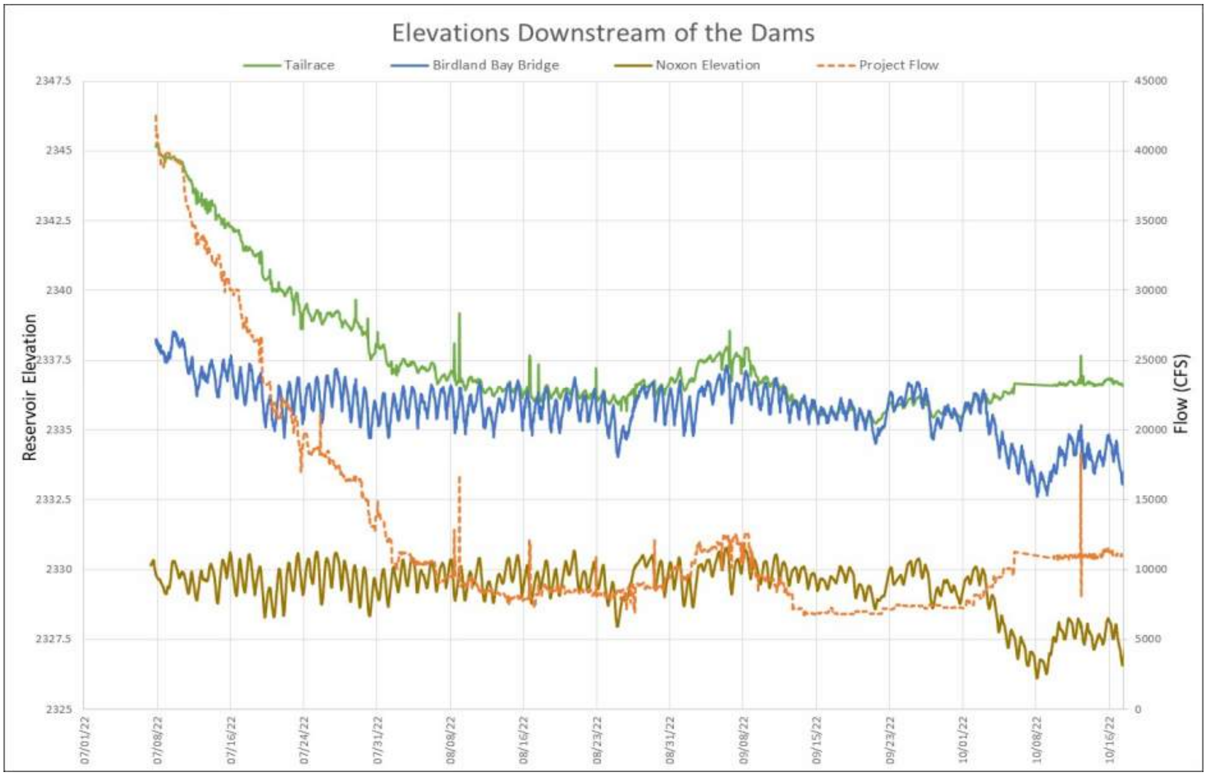
The gap in the data at the three upstream remote sites is due to the significant drop in stage exceeding the measurement range on the instruments. The instruments were moved to a lower elevation once they were discovered to be above the water surface elevation.

Water surface elevations measured at the Project responded to flexible operations similarly as during the 2021 season. The magnitude of change at the Island site ranged very close to that measured at the Main Dam. The two sites above the island complex responded very differently than the two lower monitoring locations. These two sites are above the complex of islands which act as a grade control for the Clark Fork River. The observed influence of the operation of the Project on stage at this location is minimal. The Project Boundary and Above Island site elevations are closely aligned with the changing flows in the Clark Fork River upstream of the Project (*refer to* **Figure 3-4**).

3.1.3.2 Downstream of Dams

Water surface elevations were measured downstream of the dams in the tailrace and at Birdland Bay Bridge. Avista Corporation provided Noxon Reservoir elevation data (Avista personal communication, 2022) for the 2022 study season. **Figure 3-5** presents the stage data at each of the locations downstream of the dams.

Figure 3-5. Water Surface Elevations at Monitoring Locations in the Project Area Downstream of the Dams.



Tailrace elevations are related to the total volume of water passing through the Project. The tailrace elevation rises with increased flow through the Project while reduced flows result in lower tailrace elevations. At Birdland Bay Bridge downstream, stage is relatively stable and is influenced predominately by Avista's Noxon Reservoir.

3.1.4 Reservoir Elevation Rate of Change

The rate of change in water surface elevation was calculated during the second study season. The rates presented below are normalized to foot of elevation change per hour (ft/hr) with a positive rate reflecting an increase in stage whereas a negative rate reflects a decrease in stage. An hourly rate of change of zero reflects stable elevations. Reservoir rates of change observed in the second study season resulted in an average of near 0.1 ft/hr for reservoir elevation increases and decreases. The maximum rates of change ranged from 1.0 ft/hr for reservoir elevation increases to a maximum draft of the reservoir of 1.1 ft/hr, as measured at the Main Dam (**Table 3-1**). The rate of change attenuates upstream of the Islands and little influence is observed at this site in response to Project operations as indicated by the maximum rate of change at the Project boundary of 0.07 ft/hr (Table 3-1).

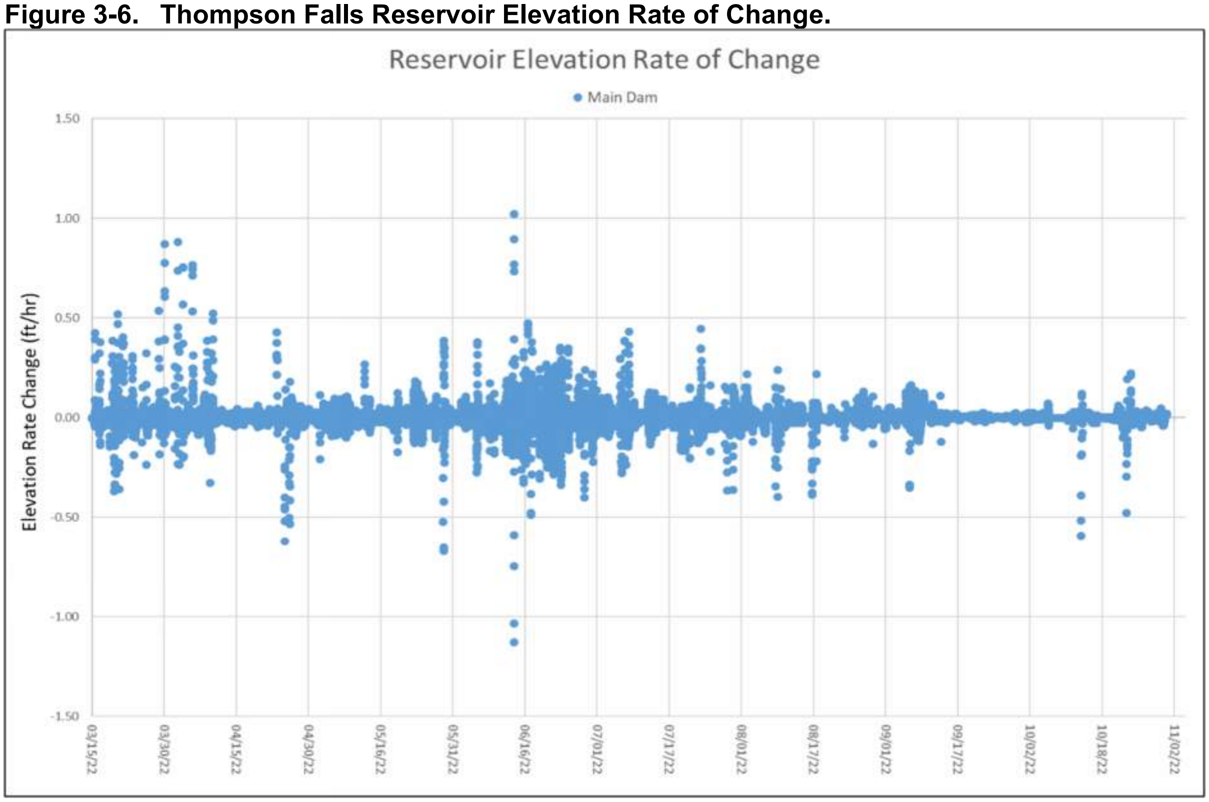
Table 3-1. Maximum Rate of Change in Reservoir Stage.

Season	Maximum Rate of Change Main Dam (ft/hr)		Maximum Rate of Change Project Boundary (ft/hr) (7/7/2022-10/25/2022*)	
	Increase	Decrease	Increase	Decrease
Phase 1 2021	0.3	-0.5	0.05	-0.08
Phase 2 2021	0.4	-0.91	0.05	-0.2
Phase 3 2021	0.65	-1.46	0.05	-0.15
Study Season 2022 (3/15-10/31)	1	-1.1	.07*	-.07*

Notes: ft/hr = feet per hour; *Data available for 7/7/2022-10/25/2022 at the Project boundary site.

The rate of change during the second study season is presented in **Figure 3-6.**

Figure 3-6. Thompson Falls Reservoir Elevation Rate of Change.



3.1.5 Elevation Rate of Change Downstream of Dams

Downstream of the dams, water surface elevation rates of change were calculated for the second-year study season. The maximum elevation rates of change below the dams ranged from 2.5 ft/hr for tailrace elevation increases and -2.3 ft/hr for elevation decreases. Rates were generally below 1 foot/hour for increases and decreases throughout the second study season (**Figure 3-7**).

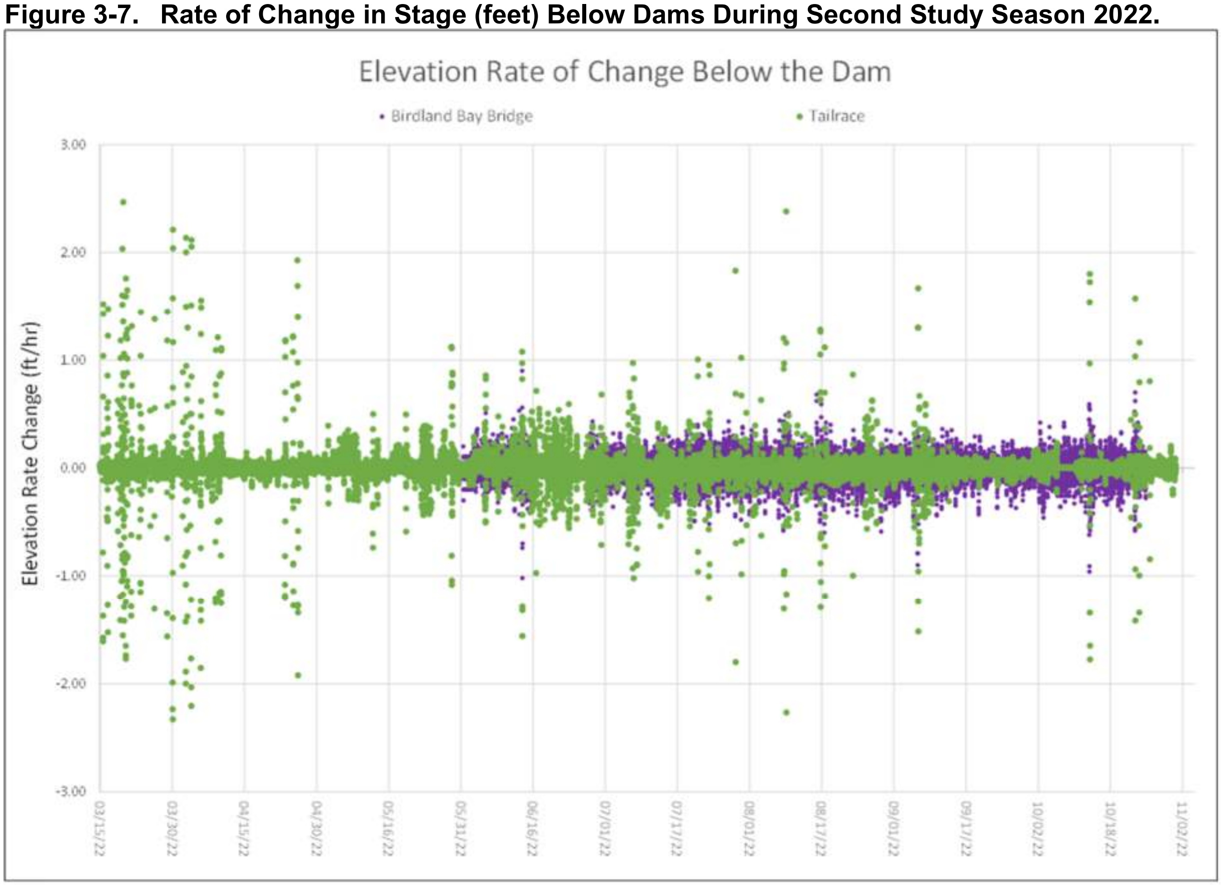
Elevation rates of change are also illustrated at Birdland Bay Bridge in Figure 3-7. This site is predominantly influenced by operation of Noxon Rapids Dam. Rates of change at Birdland Bay Bridge were lower for both increases and decreases in elevation than those observed in the tailrace below Thompson Falls Dam (**Table 3-2**).

Table 3-2. Maximum Rate of Change Below the Dams.

Season	Maximum Rate of Change Tailrace (ft/hr)		Maximum Rate of Change Birdland Bay Bridge (ft/hr)	
	Increase	**Decrease**	**Increase**	**Decrease**
Phase 1 2021	1.5	-2.1	0.8	-0.7
Phase 2 2021	3.3	-3.6	1.4	-1.5
Phase 3 2021	4.2	-4.4	1.2	-1.7
Study Season 2022 (3/15-10/31)	2.5	-2.3	0.9	-1.0

Notes: ft/hr = feet per hour

Figure 3-7. Rate of Change in Stage (feet) Below Dams During Second Study Season 2022.



3.2 Shoreline Stability

3.2.1 Summary of Shoreline Evaluation Results

As was the case in the first study season, erosion related to fluctuating reservoir levels was not observed. Where there was evidence of erosion (**Table 3-3**), the causes of the erosion were concluded to be high flows associated with spring runoff, boat wakes, wave action from wind, overland flow of water due to rainfall or snowmelt events, and wildlife or human paths.

Types of erosion observed included bank undercutting, bank sloughing, and rill or gully erosion. With the exception of Reference Point #2, the amount, type and causes of erosion changed minimally over the course of the 2 years of the Operations Study (Table 3-3) within each reference point. The amount of erosion varied significantly between reference points, from the lowest category of 0 to 10 percent on some reaches to the highest category of 71 to 100 percent on others.

Table 3-3. Summary of Observations of Shoreline Stability.

Ref Point	Land Facet	North or South Shore	Percent Erosion 7/20/22	Percent Erosion 9/13/22	Comments
1	unk	North	0-10	0-10	Minimal rill and gully erosion associated with foot paths; erosion close to 0%
2	10(1)	South	51-70	11-30	Minor bank undercutting due to spring runoff.
3	9(2)	North	0-10	0-10	Highly stable, rill or gully erosion caused by a footpath, became exacerbated by placement of wood railing along trail.
4	9(1)	South	71-100	51-70	Significant amount of bank slumping and undercutting caused by spring runoff and periodic falling of trees and associated bank damage.
5	10(1)	South	11-30	11-30	Shoreline stabilization project completed in 2020 at this site. Bank undercutting was the most common, caused by spring runoff and boat wakes.
6	9(2)	North	0-10	11-30	Rill or gully erosion caused by footpaths and removal of native vegetation. Highly stable.
7	10(1)	South	0-10	0-10	Minor undercutting underneath a short section of the rock toe caused by spring runoff. Historic shoreline instability, but shoreline stabilization project in last 10-20 years.
8	8(2)	South	11-30	11-30	Undercutting and associated slumping caused by spring runoff and potentially ice scour. Rill or gully erosion caused by falling trees further upslope and wildlife trails. Erosion in this Land Facet is anomalous because bouldery substrates tend to be more stable. Increased fetch distances may be creating more wave

Ref Point	Land Facet	North or South Shore	Percent Erosion 7/20/22	Percent Erosion 9/13/22	Comments
					erosion. A native rock armored shoreline above the water's edge is resistant to current active erosion.
9	10(1)	South	71-100	71-100	Actively eroding shoreline with near vertical banks, slumps, and undercutting caused by spring runoff and potential ice scour.

Note: unk = unknown

NorthWestern has historically observed more shoreline instability on the south shoreline than on the north, especially on Land Facet 10(1): Lower Recent Terrace, Sandy Variant and Land Facet 8(2): Lower Wisconsin Terrace, Bouldery Variant (NorthWestern 2020). The results of this shoreline evaluation support these historic observations, with much more shoreline instability noted on the south shoreline than the north (**Table 3-3**). Six of the nine reference points (numbers 2, 4, 5, 7, 8 and 9) were located on the south shore because of previously observed instability on this shoreline.

Land Facet 10(1)

Reference Point #2 is in Land Facet 10(1), suggesting the potential for shoreline instability, but a short and less steep bank, combined with a well-established population of upland and aquatic vegetation, likely creates a stable shoreline. Reference Point #2 did exhibit notable current erosion in the second study season as compared to the first study season, having 51 to 70 percent erosion on the July 20, 2022 monitoring event versus all six monitoring events in 2021 ranging from 0 to 30 percent. This was due to some minor bank undercutting due to spring runoff and was not related to Project operations. However, in general, the shoreline did not exhibit significant current or historic shoreline stability issues.

Reference Point #5 had a significant amount of erosion in the past, but a shoreline stabilization project completed in 2020 has successfully resulted in a stable shoreline and only minor new erosion was noted.

Reference Point #7 a shoreline stabilization project completed sometime in the last 10 to 20 years has successfully resulted in a stable shoreline and no new erosion was noted.

Reference Point #9 displayed the most shoreline instability of all reference points. The reservoir is mostly riverine in this area and higher water velocities during spring runoff and/or ice scour events may be impacting this area more than areas further downstream.

Other Land Facets

Reference Point #4 is in Land Facet 9(1) which is not one identified as a facet that is prone to shoreline instability, but it nonetheless had a significant amount of shoreline instability caused by high spring flows.

Reference Point #8 is in Land Facet 8(2) which is a bouldery variant, and as noted in NorthWestern (2020), the shoreline erosion in this Land Facet is anomalous because bouldery substrates tend to be more stable. Increased fetch distances may be creating more wave erosion in this Land Facet (NorthWestern 2020).

Reference Points #1, #3, and #6 were on the north shoreline and were all highly stable.

Following is a more detailed description of the results from each of the nine reference points.

3.2.2 Reference Point-Specific Results

Reference Point #1

This point is a 300-foot segment of shoreline on the north shore upstream of where the boat barrier connects to the shore. The Land Facet for this reference point is unknown. Shoreline bank height is 1 to 2 feet tall with slopes of 6 to 23 percent. Shoreline bank vegetation is predominantly grasses and forbs. NorthWestern owns the land, but it is interspersed with city-owned street rights-of-way. Land management is open-space next to shoreline, and behind the shoreline land management is recreation and urban. **Photo 3-1** contains two representative photos of this reference point. It is important to note that the City of Thompson Falls is installing a new sewer mainline in the area behind this reference point, and therefore the photos look different than in 2021, even though the shoreline itself has not changed.

Both monitoring events indicated 0 to 10 percent erosion, with minimal erosion observed (closer to 0% than 10%). This is no change from the six monitoring events completed in the first study season (NorthWestern 2022). The only type of erosion noted was rill or gully erosion and the only cause noted was human-created footpaths to the reservoir's edge. Once created, the footpaths in turn collected and funneled water from rainfall or snowmelt resulting in the rills or gullies.

Photo 3-1. Representative Photos of Shoreline Stability Reference Point #1.

Bank profile looking upstream from mid-point, and middle 100 feet of the 300-foot reach.

Reference Point #2

This point is a 300-foot segment of shoreline on the south shore, roughly across from the North Shore boat barrier connection. It is in Land Facet 10(1). The shoreline bank height is about 7 feet tall with predominant slopes of 23 to 58 percent. Shoreline bank vegetation is a mix of forested shoreline and grassy areas. The land is privately-owned and land management is private residential. **Photo 3-2** contains two representative photos of this reference point.

The first monitoring event indicated 51 to 70 percent erosion, which is higher than the second monitoring event which indicated 11 to 30 percent erosion. It was also higher than all six monitoring events completed in the first study season (NorthWestern 2022), which at most indicated 11 to 30 percent erosion. The monitoring team discussed these results, and reviewed the photos, and determined three reasons for the higher erosion for the July 20 monitoring event. The first reason is due to what was a delayed and drawn-out spring runoff event. The second reason is that the water level was about 4 inches below full pool, exposing areas of bank undercutting that would otherwise be hidden if the reservoir was at full pool, and thus making the erosion more visible and giving the appearance of more erosion than other monitoring events. The third reason is the lack of vegetation due to a delayed spring green-up, resulting in less vegetation obscuring signs of erosion and, in turn, a higher reported number than when obscured by vegetation. The most common type of observed erosion was bank undercutting about 1 to 2 feet tall and 0.5 to 1 foot deep with the cause of this erosion attributable to spring runoff. Increase in the density of vegetation through the summer growing season protected the bank from further erosion from wave action.

Photo 3-2. Representative Photos of Shoreline Stability Reference Point #2.

Bank profile looking downstream from mid-point, and upper 100 feet of the 300-foot reach.

Reference Point #3

This point is a 300-foot segment of shoreline on the north shore downstream of the Yellowstone Pipeline crossing. It is in Land Facet 9(2). Shoreline bank height is about 25 feet tall with predominant slope of 16 to 45 percent. Shoreline bank vegetation is a mix of trees, shrubs, grasses and forbs. The land is privately owned, and land management is a pipeline tower for about 150 feet of the width, and the other 150 feet is private residential. **Photo 3-3** contains two representative photos of this reference point.

Both monitoring events indicated 0 to 10 percent erosion. This is no change from the six monitoring events completed in the first study season (NorthWestern 2022). Rill or gully erosion caused by a footpath, and surface runoff from the pipeline tower pad located at the top of this reference point was determined to be the cause of the rill or gully erosion.

Photo 3-3. Representative Photos of Shoreline Stability Reference Point #3.

Bank profile looking downstream from mid-point, and lower 100 feet of the 300-foot reach.

Reference Point #4

This point is a 300-foot segment of shoreline on the south shore, part way between the Cherry Creek Boat Launch on the upstream side and the pipeline crossing on the downstream side. It is in Land Facet 9(1). Shoreline bank height is a combination of about a 7-foot-tall bank with predominant 37 to 58 percent slopes and then an additional 50 feet of bank height with predominant 16 to 37 percent slopes. Shoreline bank vegetation is forested. Approximately half, located on the downstream side, is privately owned, and the other half is NorthWestern owned. Land management is a single residence in the flatter area behind the shoreline, whereas the shoreline itself is open space. **Photo 3-4** contains two representative photos of this reference point.

The first monitoring event indicated 71 to 100 percent erosion, and the second indicated 51 to 70 percent erosion. These figures are similar to those reported in first study season (NorthWestern 2022). This reference site falls within a geology more susceptible to erosion due to the fine-grained soils and relatively steep bank angles. These conditions create a dynamic shoreline, a lot of woody debris, and falling trees. It is also sometimes challenging to differentiate between current erosion, and older erosion that has since stabilized. The two most common types of erosion are bank slumping and undercutting. Slumping averaged about 7 feet tall and 3 feet deep and undercutting averaged about 4 feet tall and 2 feet deep. The major cause of the slumping and undercutting was attributed to spring runoff, but the periodic falling of trees and associated bank damage is also a likely contributing cause. Operations were not a contributing cause as fluctuating water levels below the normal full pool elevation did not exert any erosive forces on the slumping and undercutting banks which are above the normal full pool elevation.

Photo 3-4. Representative Photos of Shoreline Stability Reference Point #4.

Bank profile looking downstream from mid-point, and upper 100 feet of the 300-foot reach.

Reference Point #5

This point is a 300-foot-long segment of shoreline on the south shore. It is in Land Facet 10(1). Shoreline bank height is about 10 feet tall with predominant slopes of 29 to 58 percent. The shoreline is forested. Land along shore is owned by NorthWestern, and land behind the shoreline is owned by private parties. Land management is private residential and open space. **Photo 3-5** contains two representative photos of this reference point.

This reference point mostly consists of a 200-foot-long shoreline stabilization project completed by the adjacent landowner and NorthWestern in 2020 as a pilot project to test a bio-engineered shoreline stabilization treatment as an alternative to the commonly used rock rip-rap. The pilot project consisted of using 20 conifer trees from on-site to create a stable toe of woody debris, sloping back the bank from near vertical to a 2:1 to 3:1 slope, and planting 230 native species shrubs and 1,400 willow and dogwood cuttings. Before the pilot project (**Photo 3-6**) was completed, the shoreline was an 8- to 12-foot-tall eroding vertical bank with little protection from further erosion.

Both monitoring events indicated 11 to 30 percent erosion, similar to 2021, which ranged from 0 to 30 percent. Bank undercutting was the most common form of erosion caused by spring runoff and boat wakes attributed to be the causes. The height of the undercutting is 1 to 2 feet tall, and the depth is 1 to 2 feet deep. There was also minor (less than 10 feet of shoreline) slumping observed within the pilot project and some additional slumping outside the pilot project. Erosion within the pilot project appears to be tapering off and reaching a point of stability. However, an erosion nick point, associated with a tree root, is also starting to form on the upstream end of the pilot project.

Photo 3-5. Representative Photos of Shoreline Stability Reference Point #5

Bank profile looking downstream from mid-point, and lower 100 feet of the 300-foot reach.

Photo 3-6. Photos of Eroding Bank Before Shoreline Stabilization Pilot Project.

Bank profile looking at a slight downstream angle from the upstream end of the segment.

Reference Point #6

This point is a 300-foot-long segment of shoreline on the north shore, across from and just upstream of the Cherry Creek Boat Launch. It is in Land Facet 9(2). Shoreline bank height is about 20-foot-tall with predominant slopes of 29 to 58 percent, and then lessening to 16 to 29 percent. Shoreline bank vegetation is a mix of trees, shrubs, grasses and forbs. Land along shore is owned by NorthWestern, and behind the shoreline by private parties. and land management is private residential and open space. **Photo 3-7** contains two representative photos of this reference point.

The first monitoring event indicated 0 to 10 percent erosion and the second monitoring event 11 to 30 percent erosion, similar to the results noted in 2021. The most common type of erosion was rill or gully erosion caused by footpaths and removal of native vegetation allowing rain and other runoff to erode soils. The increase in erosion between the two monitoring events is thought to be due to a significant rain event of 1.7 inches on August 21, 2022. This reference point has a steeper slope with little vegetation cover, making it more susceptible to erosion during this rain event, and more susceptible than the other eight reference points. However, it is still a very stable land type with a natural rock toe extending into the reservoir creating shoreline conditions resistant to other types of erosion such as undercutting and slumping.

Photo 3-7. Representative Photos of Shoreline Stability Reference Point #6

Bank profile looking upstream from mid-point, and lower 100 feet of the 300-foot reach.

Reference Point #7

This point is a 300-foot segment of shoreline on the south shore, located a short distance upstream of the Cherry Creek Boat Launch. It is in Land Facet 10(1). Shoreline bank height is 8 feet tall, and the slope is variable with predominant slopes of 16 to 29 percent in areas where it appears shoreline stabilization work has been completed, and predominant slopes of 37 to 58 percent where stabilization work was not completed. Shoreline bank vegetation is mostly lawns (i.e., grass) associated with private residences, with a few trees and shrubs. Land along shore is owned by NorthWestern, and behind the shoreline by private parties. Land management is private residential and open space. **Photo 3-8** contains two representative photos of this reference point, which appears to show a shoreline stabilization project completed years ago and consists of a sloped-back bank with a rock toe.

Both monitoring events indicated 0 to 10 percent erosion. This is no change from the six monitoring events completed in the first study season (NorthWestern 2022). There is minor (less than 10 feet of shoreline) undercutting about 1 foot tall and 0.5 foot in depth underneath a short section of the rock toe that was attributed to spring runoff.

Photo 3-8. Representative Photos of Shoreline Stability Reference Point #7

Bank profile looking upstream from mid-point, and middle 100 feet of the 300-foot reach.

Reference Point #8

This point is a 300-foot-long segment of shoreline on the south shore, just upstream of the mouth of Cherry Creek. It is in Land Facet 8(2). Shoreline bank height exceeds 50 feet (contour data did not go beyond that) with predominant slopes of 29 to 58 percent. However, there is a small toe slope of 16 to 29 percent. Shoreline bank vegetation is forested. However, some areas are stable forest to water's edge, and another area appears to have historical erosion which has stabilized and now has younger trees present. Land along shore is owned by NorthWestern, and behind the shoreline by private parties. Land management is forested open space. **Photo 3-9** contains two representative photos of this reference point.

Both monitoring events indicated 11 to 30 percent erosion. This is very similar to the six monitoring events completed in the first study season (NorthWestern 2022). This reference point shows a native rock armored shoreline above the water's edge that is resistant to active erosion. Common types of erosion include undercutting and associated slumping which were attributed to spring runoff and potential ice scour. Rill or gully erosion was also present which was caused by falling trees further upslope and wildlife trails that in turn caused water to channelize and create erosion.

Photo 3-9. Representative Photos of Shoreline Stability Reference Point #8.

Bank profile looking upstream from mid-point, and upper 100 feet of the 300-foot reach.

Reference Point #9

This point is a 300-foot-long segment of shoreline on the south shore, across from the old pumphouse located on the north shore by the mill site. It is in Land Facet 10(1). Shoreline bank height is about 12 feet tall, and its slope is predominantly 16 to 58 percent. Shoreline bank vegetation is a mix of forest, shrubs, grass, and forbs. Land along shore is owned by NorthWestern, and behind the shoreline by private parties. Land management is natural forest transitioning to private residential, as the area was recently subdivided and is currently used for camping. **Photo 3-10** contains two representative photos of this reference point.

Both monitoring events indicated 71 to 100 percent erosion. This is very similar to the six monitoring events completed in the first study season (NorthWestern 2022). In general, the site is an actively eroding shoreline with near vertical banks up to 10 feet tall and slumps and undercutting up to a few feet in depth. The causes of erosion are attributed to spring runoff and potential ice scour. Water marks and scraped bark on trees (from potential ice scour or spring runoff pushing flood debris against the trees) were observed multiple feet above the full pool level of the reservoir during the monitoring events.

Photo 3-10. Representative Photos of Shoreline Stability Reference Point #9.

Bank profile looking upstream from mid-point, and upper 100 feet of the 300-foot reach.

3.3 Riparian Habitats

The spring and early summer of 2022 were unseasonably cool and spring runoff was delayed and prolonged. In the 2021 study season, June 20 was the last day that NorthWestern spilled water at the dam, whereas in 2022 that date was July 20, a full month later. These conditions appear to have delayed aquatic vegetative growth in 2022, in particular submergent aquatic vegetation, as compared with the 2021 study season. For example, at Reference Point #5, the July 13, 2021 monitoring data indicate 91 to 100 percent aquatic vegetation, whereas the July 20, 2022 monitoring data indicate 0 to 10 percent aquatic vegetation (**Photos 3-11** and **3-12**). Another example is Reference Point #7 where aquatic vegetation was 0 to 10 percent in 2022 and 61 to 70 percent in 2021 on those same dates. **Photos 3-13 and 3-14** are of reference points #5 and #7 on those two dates. In the 2021 photos, dense beds of submergent aquatic vegetation can be seen, whereas in 2022 they were more or less not present.

Photo 3-11. Reference Point #5 July 13, 2021.

Photo 3-12. Reference Point #5 July 20, 2022.

Photo 3-13. Reference Point #7, July 12, 2021.

Photo 3-14. Reference Point #7, July 20, 2022.

At Reference Points #5 and #7, almost all of the aquatic vegetation is the submergent type. Even though the July 20, 2022 data indicate 0 to 10 percent aquatic vegetation present in depths to 4 feet, there was actually a significant amount of submergent aquatic vegetation present at depths greater than 4 feet. As discussed in the Methods *see* Section 2.3.2, 4 feet is the cutoff depth for recording aquatic vegetation data under this study. At the second monitoring event on September 13, 2022, aquatic vegetation was 91 to 100 percent at Reference Point #5 and 81 to 90 percent at Reference Point #7, at depths to 4 feet. The beds of submergent aquatic vegetation had grown and expanded into the shallower water between July 20 and September 13. They had not grown and expanded into the shallower water before July 20, presumably due to the delayed and prolonged runoff which would have created higher volume and current velocities along the shoreline, reducing the potential for submergent aquatic vegetation to become established.

While a number of the reference points had a high presence of submergent aquatic vegetation, especially by the second monitoring event on September 13, 2022, it was not equally distributed within that 0- to 4-foot-depth. The density of submergent aquatic vegetation was noticeably less in the 0- to 18-inch-depth range. Fluctuating water levels due to the 2022 operating regime caused frequent dewatering and rewatering in the 0- to 18-inch-depth range. It is believed that those conditions greatly reduced the potential for submergent aquatic vegetation growth. For example, a dewatered state would expose the vegetation to the hot and dry summer air, and submergent aquatic vegetation likely has a low tolerance for those conditions. Another example is that the stems of submergent aquatic vegetation are supported by the water column, and when dewatered, the stems lose that support which may cause stem breakage. **Photos 3-15** and **3-16** are of two reference points showing the lower density of submergent aquatic vegetation in the 0- to 18-inch-depth range, and dense beds of submergent aquatic vegetation at depths greater than 18 inches.

Photo 3-15. Reference Point #5 September 13, 2022.

Note lower density of submergent aquatic vegetation in the 0- to 18-inch-depth range, and dense submergent aquatic vegetation at depths greater than 18 inches.

Photo 3-16. Reference Point #8, September 13, 2022

Note lower density of submergent aquatic vegetation in the 0- to 18-inch-depth range, and dense submergent aquatic vegetation at depths greater than 18 inches.

The variability in aquatic vegetation discussed in the above paragraphs is largely limited to submergent aquatic vegetation. In general, the same variability was not observed for emergent aquatic vegetation. Emergent aquatic vegetation can likely better tolerate a delayed and prolong spring runoff, and fluctuating water levels in the 0- to 18-inch-depth range. For example, **Photos 3-17** and **3-18** are of two reference points showing the high density of emergent aquatic vegetation along the shoreline.

Photo 3-17. Reference Point #1, September 13, 2022.

Note high density of emergent aquatic vegetation along the shoreline.

Photo 3-18. Reference Point #2, September 13, 2022.

Note high density of emergent aquatic vegetation along the shoreline.

3.4 Fisheries

3.4.1 Stranding

During surveys completed on August 24 and 31, no stranded fish were observed on dry ground or within isolated pools. In many cases, the full 200 foot transect was not surveyed because portions of the survey transect were submerged. Other areas outside the transects were also surveyed for stranded fish, and none were found.

3.4.2 Operation of the Upstream Fish Passage Facility

Observations of the upstream fish passage facility primarily occurred during the morning hours when the facility was being checked for fish. At no time during the March – October operating season was the upstream fish passage facility unable to fully function due to the variable forebay water elevations caused by flexible generation. There were occasional times when the operation of the sampling pump and the pump to fill the lock took longer than average. However, this did not impede operations for more than 30 minutes. This primarily occurred during the fall months when aquatic vegetation plugged the upstream water intakes. Increased generation and associated flow pulled vegetation that was floating in the reservoir towards the upstream side of the fish passage facility.

3.5 Recreation and Aesthetics

3.5.1 Recreation Access

Thompson Falls Reservoir has public docks at Wild Goose Landing Park and Cherry Creek Boat Launch. There are two docks at Wild Goose Landing, a floating dock and a stationary dock. The dock at Cherry Creek Boat Launch is a floating dock.

During the 2022 recreation season, all these public docks remained usable during flexible capacity operations. As demonstrated during the 2021 operations study, public docks remain usable at pool elevations down to 2.5 feet below full pool, the lowest elevation that NorthWestern seeks to retain for flexible operations purposes under the new license. During periods that the reservoir level is reduced to 2.5 feet below full pool (observed in 2021 only), the water level was noticeably low at the stationary dock at Wild Goose Landing, which makes boat access to and from the stationary dock more challenging, but the floating dock remained watered and provided access. The public floating dock at Cherry Creek became pitched at the lowest elevations due to grounding of near-shore floats, but was still usable at this elevation.

Public docks are typically used to access boats for relatively brief periods of time, while recreationists launch or retrieve their boats for example. In contract, boats may be moored to private docks for extensive periods of time. For this reason, access to boats is less effected at the public docks since fluctuations in water level are not large in the short time that boats are moored to the dock.

With regard to privately owned docks, for the majority of the 2022 recreation season, flexible capacity operations fluctuated the reservoir elevation 1 foot or less. At those elevations, access to moored boats from private, stationary docks was only slightly impacted and no other impacts occurred. At elevations of 1.8 ft below full pool, slight or moderate recreational access impacts to private, stationary docks were observed with the greatest impact being to access to boats and the waterway from stationary docks. However, since stationary docks account for only 20 percent of all docks on Thompson Falls Reservoir, less than one-quarter of private recreational access to and from all docks combined were impacted by reservoir fluctuations resulting from flexible capacity operations in 2022.

The lowest reservoir elevation observed during the recreation season in 2022 was 1.8 feet below full pool. The 2021 operations study evaluated impacts to recreation and aesthetics at elevations down to 2.5 feet below full pool (*refer to* Table 2-1). To evaluate potential impacts over the full range of potential reservoir fluctuations, 2021 data are discussed in this section alongside 2022 results. Together, the two assessments provide a basis for determining the severity of impacts, if any, to recreation access at the full range of reservoir elevations below full pool.

During 2022 flexible capacity generation, reservoir elevations were 1 foot or less below full pool elevation the majority of the recreation season while the planned drawdowns in 2021 varied (*refer to* **Figure 3-3**).

3.5.1.1 Impacts to Dock and Gangway Structures

The elevation of stationary docks does not fluctuate with water levels, so there is no impact to the configuration of those docks or gangway structures resulting from changing water levels. The elevation of floating docks, however, changes with the reservoir elevation. As dock levels recede with water levels, gangways of floating docks become steeper. If the angle of gangways is somewhat steep at full pool or gangways are not constructed to adapt to reservoir fluctuations, the added strain on the connecting hinges and hardware of the gangways can become great at reduced water levels and gangways may become damaged. However, this was only witnessed in one case in 2021 when the reservoir elevation was 2.0 feet below full pool. All other floating docks and associated gangways sustained no visible harm due to the elevation fluctuations in either year (**Photos 3-19)**. It is unclear whether damage may occur to floats of gangways and docks that become grounded at the near-shore edge (or entirely) as a result of reduced water elevations. At 2.5 feet below full pool, grounding occurred for just under half of floating docks, while one-third of floating docks were grounded entirely. At elevations observed during the flexible capacity operations in 2022, there were no impacts to dock structures. (**Table 3-4**)

Table 3-4. Rating of Impacts to Dock Structures and Recreational Access to and from Docks on a scale of 0 to -4.

Reservoir Level Below Full Pool	0	-0.5 ft	-1 ft	-1.5 ft	-2.0 ft*	-2.5 ft*
Stationary Docks						
Physical Condition of Dock and Gangway	0	0	0	0	0	0
Access to Dock	0	0	0	0	0	0
Access to Water from Dock	0	0	0	-1	-2	-2
Access to Boat Moored to Dock	0	-1	-1	-1	-3	-3
Floating Docks						
Physical Condition of Dock and Gangway	0	0	0	0	-1	-2
Access to Dock	0	0	0	-1	-1	-2
Access to Water from Dock	0	0	0	0	-1	-2
Access to Boat Moored to Dock	0	0	0	0	**	**

Notes:
ft = foot/feet
* = These impacts occurred only during the 2021 study season.
** = No data available, no boats observed moored to docks at lower water elevations.
0 = No impact. No structural impact or access is not limited or affected in any case.
-1 = Slight impact. Access is minimally impacted in less than one-quarter of cases.
-2 = Moderate impact. Access is impacted minimally or moderately in half or less of cases.
-3 = Significant impact. Access is impacted moderately or significantly in more than half of cases.
-4 = Severe impact. Access is prohibited in all or nearly all cases.

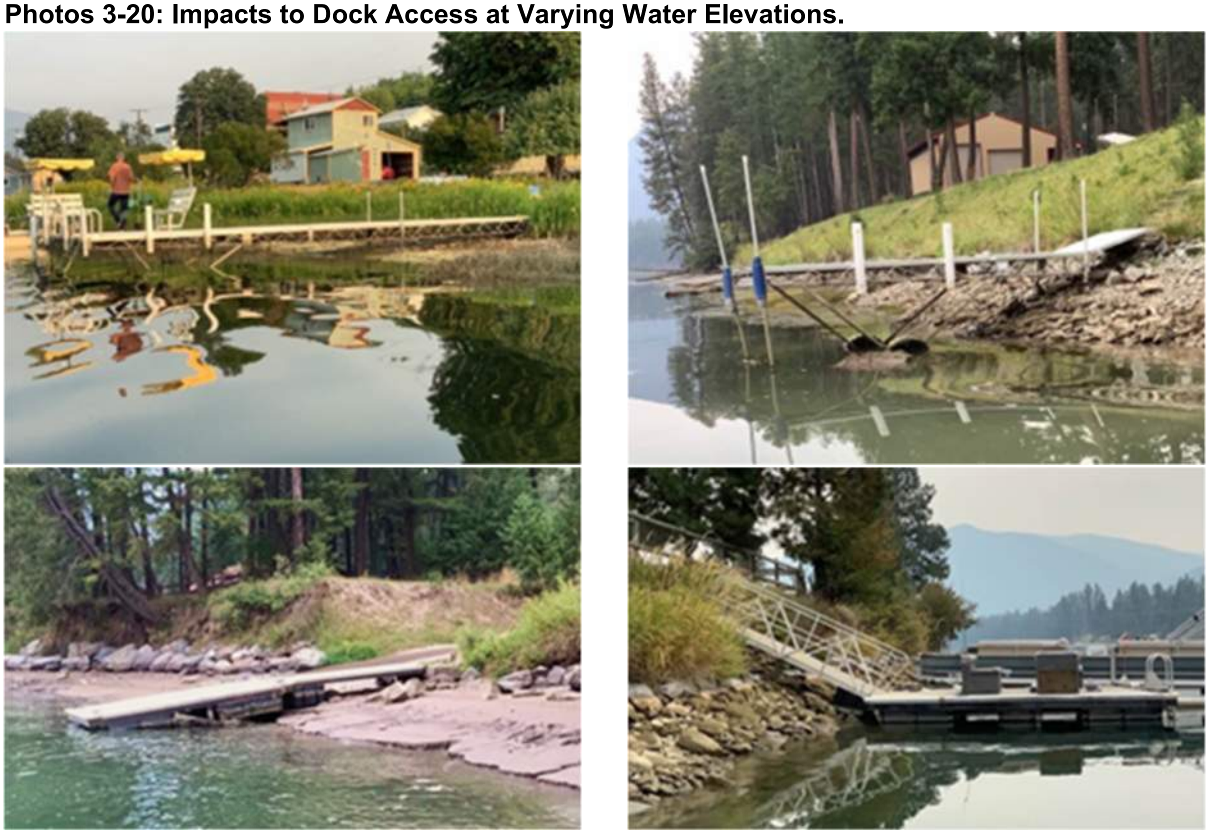
Photos 3-19. Impacts to Docks at Varying Water Elevations.

Notes: Stationary dock, Wild Goose Landing (public dock), no structural impact to the dock at -2.5 feet reservoir elevation (top left). A floating dock with near-shore grounding at -2.5 feet reservoir elevation (top right). Floating docks with no structural impacts at -2.5 feet reservoir elevation (middle). Floating dock gangway damaged at -2.0 feet reservoir elevation (bottom). These photos are from the 2021 Study Season.

3.5.1.2 Impacts to Access to Docks from Shorelines

The elevation of stationary docks does not fluctuate with water levels, so access to those docks from the shoreline remains constant at all reservoir elevations. Since the elevation of floating docks changes with the reservoir elevation, the angle of gangways and access ramps that link those docks to the shoreline also changes. As dock levels become lower, gangways become steeper. Similarly, as near-shore floats or entire docks become grounded, docks may pitch forward as the outer edge floats or rests at a lower elevation than the near-shore edge. Floating docks or associated gangways became only slightly steeper (increasing an estimated 10 degrees or less from full-pool levels) for roughly 50 percent of floating docks at a reservoir elevation 2.5 feet below full pool, while about 40 percent became moderately steeper (increasing more than 10 degrees, as estimated) and a small percentage (roughly 10%) remained relatively unchanged. At elevations observed under flexible capacity operations during the recreation season of 2022, access to floating docks from shore was only slightly impacted (*refer to* Table 3-4**, Photos 3-20**).

Photos 3-20: Impacts to Dock Access at Varying Water Elevations.



Notes: Access to stationary docks remains unchanged at low water elevations (top). The outer edge of the floating dock at Cherry Creek Boat Launch (public dock) remains floating at -2.5 feet reservoir elevation but the dock becomes pitched (middle left). A private dock on the south shoreline with a steep gangway and entirely floating dock that minimally impacts access at -2.5 feet reservoir elevation (middle right). A floating dock and gangway ramp at full pool (bottom left) and at -2.5 feet below full pool, with minimally impacted access (bottom right). These photos are from the 2021 Study Season.

3.5.1.3 Impacts to Access to the Waterway from Docks

The distance between the top of stationary docks and the water surface becomes greater at reduced reservoir elevations and utilizing stationary docks for access to the waterway itself (such as for swimming) becomes challenging at lower elevations. While only one-third of stationary docks had swim ladders, ladders that were installed on docks remained submerged and usable at 2.5 feet below full pool elevation. However, only half of stationary docks remained watered at 2.5 feet below full pool elevation, and the water was quite shallow and was often too inundated with aquatic vegetation to provide meaningful access. The other half of stationary docks were dewatered at 2.5 feet below full pool. Under flexible capacity operations in 2022, access to the waterway was slightly or moderately impacted during the recreation season.

Floating docks, however, retain the same vertical distance between the top of the dock and the water surface and ladders on docks that provided them (including about 20% of floating docks) all remained submerged at 2.5 feet below full pool. While 70 percent of floating docks remained in the water at 2.5 feet below full pool reservoir elevation, the water was shallow (and often densely vegetated) in some cases and only about half of floating docks functioned adequately at that elevation. The remaining 30 percent of floating docks became dewatered at 2.5 feet below full pool. Access to the waterway from floating docks was only slightly impacted during the recreation season in 2022 under flexible capacity operations (*refer to* Table 3-4, **Photos 3-21**).

Photos 3-21. Impacts to Waterway Access from Docks at Varying Water Elevations.

Notes: Stationary docks that remain watered (though shallow) with swim ladders that reach the water surface at -2.5 feet reservoir elevation (top). Floating docks that are appropriate for waterway access at -2.5 feet reservoir elevation (middle). Dewatered floating docks at -2.5 feet reservoir elevation (bottom). These photos are from the 2021 Study Season.

3.5.1.4 Impacts to Access to Boats Moored at Docks

Access to moored boats from floating docks is not impacted at reservoir elevations down to 2.0 feet below full pool since boats and docks float at the same level relative to one another. At elevations 2.5 feet below full pool, 30 percent of floating docks become dewatered and thus boats moored to them would become grounded. However, there were no observations of cases of grounded boats moored to dewatered floating docks during the 2021 study.

At water surface elevations of 2.0 feet below full pool and less, access to boats moored at stationary public and private docks can become quite challenging due to the increased vertical distance between the dock surface and the inside of the vessel, with significant impacts to boat access observed at all stationary docks. In addition, moored boats can become damaged if they are tied to stationary docks with too little slack to allow them to remain floating as water elevations recede and may become pinned beneath stationary docks when the water level rises back to full pool. Access to the moored boats from stationary docks was either slightly or moderately impacted during the 2022 recreation season under flexible capacity generation (*refer to* Table 3-4**, Photos 3-22**).

Photos 3-22: Impacts to Boats Moored at Docks at Varying Reservoir Elevations.

Notes: Floating docks allow access to boats at all elevations (top). Increase in vertical distance to boat from stationary dock at -2.0 feet reservoir elevation (second row). Boats tightly tied to stationary docks may not remain floating when water levels recede (third row). Boat pinned under stationary dock when reservoir elevation returned to full pool from reduced elevations (bottom). These photos are from the 2021 Study Season.

3.5.1.5 Summary: Impacts to Recreational Access Related to Stationary Docks

Recreational access to stationary docks from shorelines is not impacted by reduced reservoir elevations, nor are stationary dock structures themselves impacted since their elevation does not fluctuate with reservoir elevations. While swim ladders provide access to the waterway from stationary docks at all study elevations, only about one-third of docks had swim ladders. In addition, moderate impacts occurred when half of stationary docks were dewatered (rendering swim ladders irrelevant in these locations) at 2.5 feet below full pool. The remaining half of stationary docks – those that remained watered at -2.5 feet reservoir elevation - had shallow water that was often inundated with aquatic vegetation. Access to boats moored at stationary docks is significantly impacted at -2.0 feet reservoir elevation due to the increased distance between the dock surface and the inside of the vessel. Under flexible capacity generation in 2022, only slight impacts occurred related to access to boats moored at stationary docks.

3.5.1.6 Summary: Impacts to Recreational Access Related to Floating Docks

Recreational access to floating docks from shorelines is moderately impacted by reduced reservoir elevations due to steepening gangways and stress on dock and gangway components for systems that are not adaptable to fluctuating water levels. Access to the waterway from floating docks is moderately impacted by dewatering of docks or shallow water. Access to boats moored to floating docks remains adequate at all reservoir elevations. Under flexible capacity generation in 2022, there were no impacts related to recreational access to and from floating docks.

3.5.2 Aesthetics

The minimum reservoir elevation during aesthetics monitoring events was -1.0 foot reservoir elevation on September 6, 2022, when the air temperature was 79ºF. The hottest of the monitoring days was August 17, 2022 at 91ºF and the reservoir elevation was -0.7 foot reservoir elevation. Aesthetic qualities related to views of the shoreline and presence of decaying organic matter that could introduce unpleasant or offensive odors were key elements of the monitoring. Approximations of the amount of exposed mud in this discussion refer to the horizontal distance from shore and not the depth of the mud. **Table 3-5** summarizes monitoring results at the lowest reservoir elevation and on the hottest day of the monitoring events.

Table 3-5. Estimated Amount of Exposed Shoreline and Odor.

Assessment location	Elevation compared to full pool and air temperature during assessment.	
	0.7 foot below full pool, 91 F	**1.0 foot below full pool, 79 F**
North shoreline of Island Park, between the Main Dam and Dry Channel Dam.	2 feet of exposed mud and rock. No odor.	2-5 feet of exposed mud and rock. No odor.
North shoreline adjacent to the Gallatin Street Bridge.	1 foot or less of exposed shoreline rock. No odor.	1-2 feet of exposed mud and rock. No odor
North shoreline at Wild Goose Landing Park.	1-2 feet of exposed mud and gravel. No odor.	1-3 feet of exposed mud and gravel. No odor.
North shore of the main reservoir, upstream and downstream of Wild Goose Landing Park.	1-3 feet of exposed mud and rock. No odor. Aquatic vegetation prominent in shallow areas.	1-5 feet of exposed mud and rock. No odor. Aquatic vegetation prominent in shallow areas.
South shoreline of the main reservoir.	1-5 feet of exposed mud and rock. No odor.	1-5 feet of exposed rock and mud. No odor.
South shoreline behind Steamboat Island.	1-5 feet of exposed mud and rock. No odor.	5-10 feet of exposed mud and rock. No odor.
South shoreline upstream of Steamboat Island.	5-10 feet of exposed mud and rock. No odor.	5-10 feet of exposed mud and rock. No odor.
Cherry Creek Boat Launch.	1-5 feet of exposed mud and rock. No odor.	1-5 feet of exposed mud and rock. No odor.
North shoreline upstream of Steamboat Island.	1-5 feet of exposed mud and rock. No odor.	5-10 feet of exposed mud and rock. No odor.

Photos 3-23 illustrate views of the shoreline at reference points at 1.0 foot below full pool, the lowest reservoir elevation reached during the monitoring events. Viewpoints at Wild Goose Landing Park and at Cherry Creek Boat Launch also include photos at 1.8 feet below full pool as they were monitored for recreational access on August 1, 2022.

Photos 3-23. Shoreline Areas at 1.0 foot below full pool.


Shoreline areas at Island Park and the north shoreline adjacent to the Gallatin Street Bridge at 1.0 foot below full pool.


Shoreline areas at Wild Goose Landing Park at 1.0 foot below full pool.


Shoreline areas at Wild Goose Landing Park at 1.0 foot below full pool (left, 2021 photo) and at 1.8 feet below full pool (right, 2022 photo).

North reservoir shoreline areas downstream of Wild Goose Landing Park (top left) and upstream of Wild Goose Landing Park along the North Shore Dispersed Use Area (top right and bottom photos) at 1.0 foot below full pool.

South shoreline areas upstream of Steamboat Island at 1.0 foot below full pool.

South shoreline area at Cherry Creek Boat Launch (public dock) at 1.0 foot below full pool.

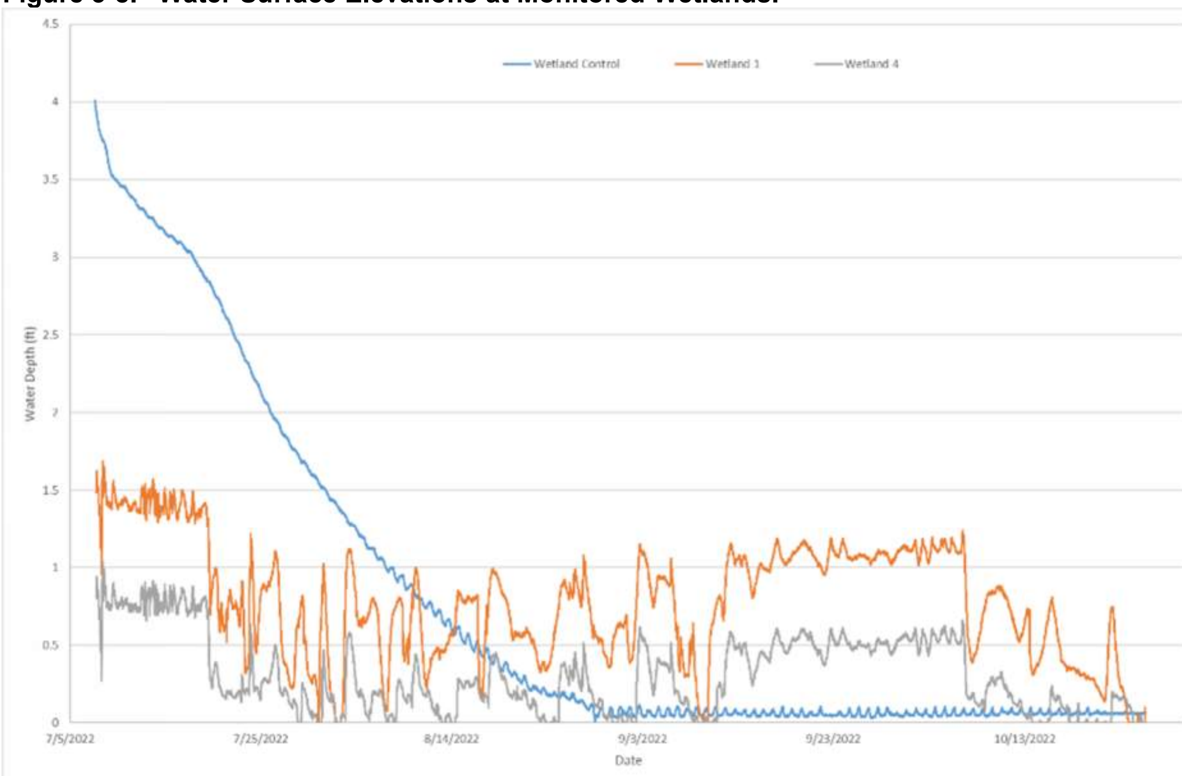
South shoreline area at Cherry Creek Boat Launch (public dock) at 1.0 foot below full pool (left, 2021 photo) and at 1.8 feet below full pool (right, 2022 photo).

North shoreline areas upstream of Steamboat Island at 1.0 foot below full pool.

3.6 Wetlands

Results from the stage monitoring at all wetland sites is shown below in **Figure 3-8**. This figure graphically displays the response or lack of response of each individual wetland site to changes in Project operations throughout the second study season. Further details of each study wetland and a description of the physical site characteristics are provided in the sections below.

Figure 3-8. Water Surface Elevations at Monitored Wetlands.



3.6.1 Wetland Control Site

3.6.1.1 Physical Characteristics

The Wetland Control site is located approximately 3.9 miles upstream of the current upstream Project boundary in an oxbow channel of the Clark Fork River. The site was chosen because it contains similar physical characteristics to the other two wetlands in this Operations Study but is upstream of any influences of Thompson Falls Dam operations. This wetland is classified as palustrine and contains both an aquatic bed and emergent vegetation (MTNHP 2021). This site does not have a visible surface water inlet and is bisected by a railroad grade and highway on the upstream end of the oxbow. When this wetland was monitored in 2021, there was no visible surface water outlet, but due to the high river stage experienced in 2022, a surface water outlet was observed as the high flows were receding in early July (**Photo 3-24**). Based on these observations, it is likely that this wetland is hydrologically connected to the Clark Fork River *via* surface water in the spring and early summer and *via* groundwater throughout the remainder of the year. When the stage in the Clark Fork River receded throughout the summer, the water surface elevation of the Wetland Control site was slowly reduced through evaporation and discharge to surface water and groundwater until August 29, when the location where the stage logger was placed went dry. **Photo 3-25** shows a photo of the Wetland Control site on July 7 when the stage logger was installed, while **Photo 3-26** shows the Wetland Control site on October 25, which was the day that the logger was removed.

Photos 3-24. Wetland Control Site Outlet July 7, 2022.

Photos 3-25. Wetland Control Site July 7, 2022

Photos 3-26. Wetland Control Site October 25, 2022

3.6.1.2 Influence of Project Operations

There is no influence of Project operations at this site (*refer to* **Figure 3-8**), as it is located approximately 3.9 miles upstream of the Project boundary. This site was the control site for the Operations Study.

3.6.2 Wetland 1

3.6.2.1 Physical Characteristics

Wetland 1 is located on a side channel of the reservoir near Steamboat Island and was selected in the first study season as a representative site for conditions in the lower reservoir. This wetland contains features that are classified as palustrine with emergent vegetation, as well as riverine features that have an unconsolidated bottom (MTNHP 2021). There is a visible surface water inlet and outlet to Wetland 1. Due to the surface water connectivity at this site, it was classified as having a high potential risk for alteration of the site from Project operations. **Photo 3-27** shows a photo of Wetland 1 on July 14 in 2021 (no photo from July 2022) when the reservoir was operating at full pool. **Photo 3-28** shows the wetland on October 25, 2022 when the stage logger was removed and the reservoir was at an elevation of 2395.0 feet, or approximately 1.5 feet below the full pool elevation. Flowering rush and curly leaf pondweed are present at the Wetland 1 site and those species to be contained in the open water portion of the wetland, while the wetland fringes are mostly comprised of native sedges and rushes.

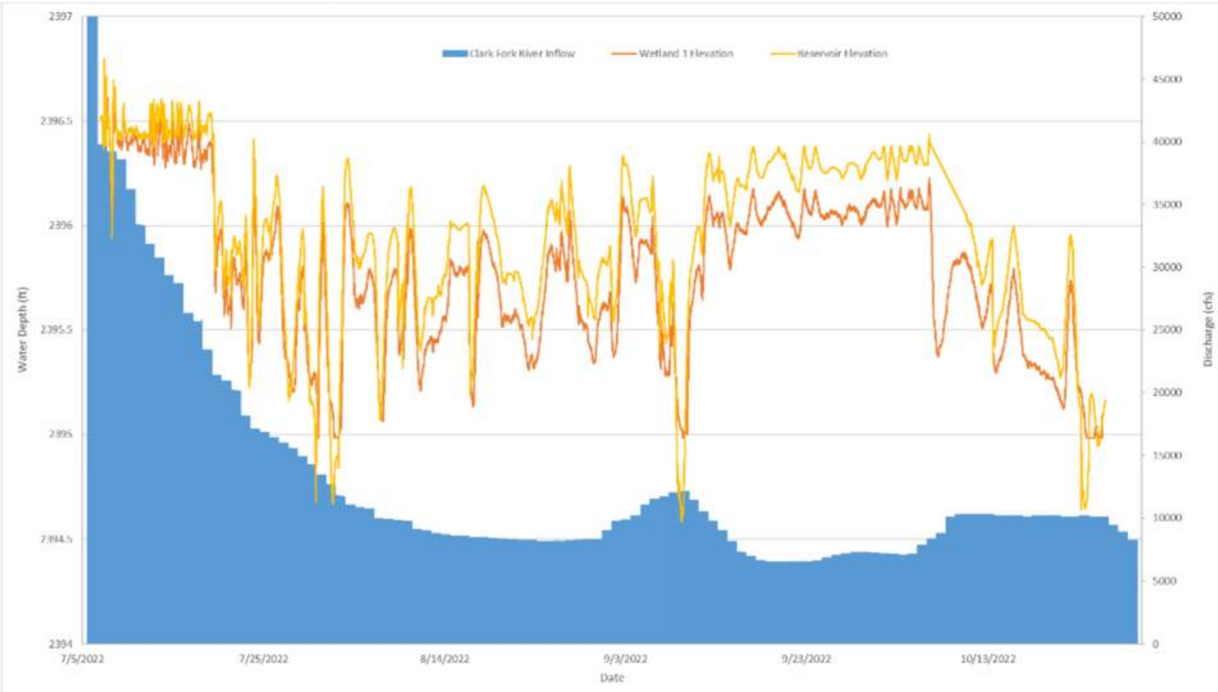
Photos 3-27. Wetland 1 Site July 14, 2021.

Photos 3-28. Wetland 1 Site October 25, 2022.

3.6.2.2 Influence of Project Operations

With its proximity to Thompson Falls Dam, and its surface water inlet and outlet, the water level of Wetland 1 was significantly affected by water level fluctuations in reservoir elevations. **Figure 3-9** shows how the water surface elevation of Wetland 1 mirrors the water surface elevation of Thompson Falls Reservoir. When the water surface elevation of the reservoir reaches approximately 2395 feet, the side channel that feeds Wetland 1 becomes deactivated and the water volume in the wetland is significantly reduced. Conversely, when the water surface elevation of the reservoir goes above 2395 feet, the side channel re-activates and the volume of water in Wetland 1 increases. **Photo 3-29** is a photo showing Wetland 1 when the water surface elevation of the reservoir is lower than 2395 feet. Potential impacts may be the temporary displacement of the fish, amphibian, and bird species that inhabit this wetland, as well as a potential reduction in the amount of submergent vegetation (including curly leaf pondweed) in the wetland. Wetlands that were classified as having a high potential risk of being impacted by dam operations (Wetland 1 and similar) encompass approximately 9.4 acres in the Project boundary as mapped by the Montana Natural Heritage Program through remote sensing data (MTNHP 2021). These wetlands are almost exclusively located on or near the shoreline areas of the reservoir and are generally small in size due to the shoreline topography of the reservoir. The observations throughout the second study season were similar to what was observed at Wetland 1 in the first study season.

Figure 3-9. Water Surface Elevations at Wetland 1 Compared to Reservoir Elevations and Clark Fork River Inflows.



3.6.3 *Wetland 4*

Physical Characteristics

Wetland 4 was studied in the second study season because it showed similar characteristics to Wetland 1. The purpose of monitoring Wetland 4 was to determine if reservoir operations affected this wetland in a similar manner as Wetland 1. This wetland contains features that are classified as palustrine with emergent vegetation (MTNHP 2021). Throughout the study season, there was little to no submergent vegetation observed at this site. The site is situated in a backwater area along the shoreline of the reservoir and is shallow and very small in size. Due to the surface water connectivity with the reservoir at this site, it was classified as having a high potential risk for alteration of the site from Project operations. **Photo 3-29** shows a photo Wetland 4 on July 7 in 2022 when the stage logger was installed, and the reservoir was operating at full pool. **Photo 3-30** shows the reservoir on October 25, 2022, when the stage logger was removed. There were no AIS observed at the Wetland 4 site during the second study season.

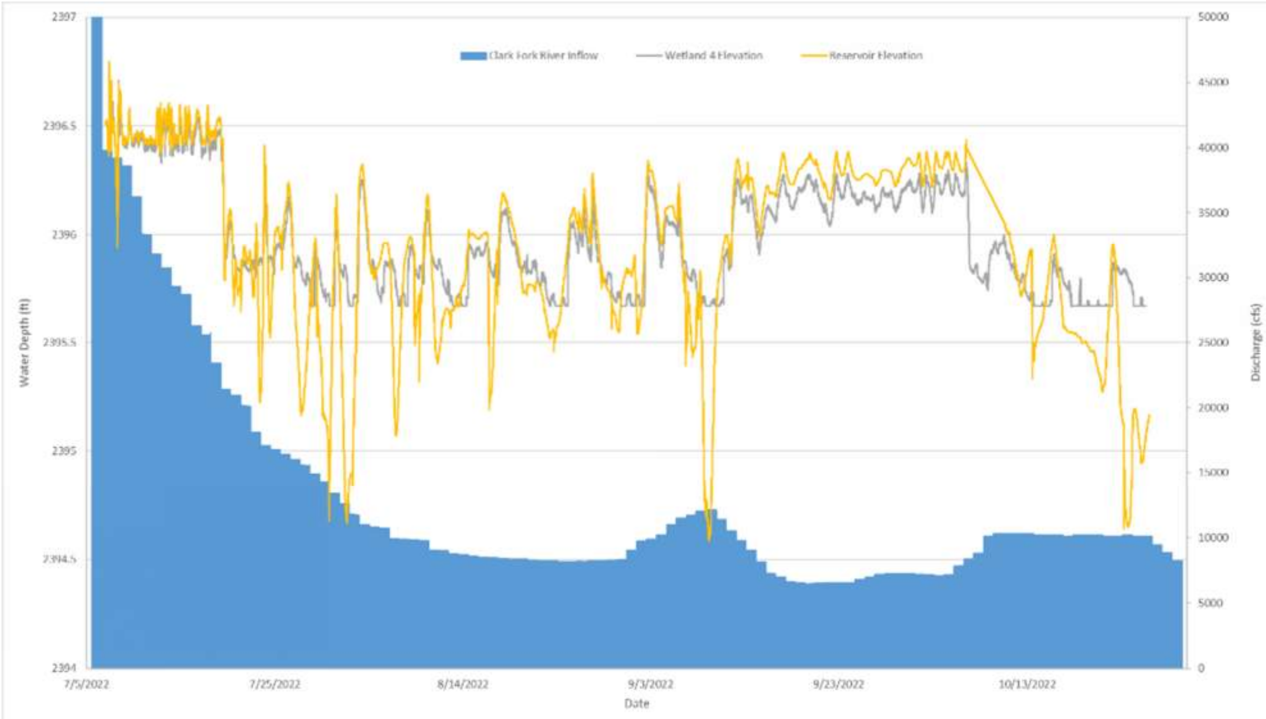
Photos 3-29. Wetland 4 Site July 7, 2022.

Photos 3-30. Wetland 4 Site October 25, 2022.

3.6.3.1 Influence of Project Operations

Wetland 4, due to its location along the shoreline of Thompson Falls Reservoir, is highly affected by changes in operations from Thompson Falls Dam. The wetland is very shallow and frequently goes dry throughout the summer months when the water surface elevation at the dam dips below approximately 2,395.7 feet (**Figure 3-10**). Unlike Wetland 1, there are no deeper areas in the wetland, nor is there a constricted inlet or outlet to buffer the effects of changing reservoir elevations. The frequent wet/dry cycles throughout the summer did not seem to have a negative effect on the emergent vegetation present at the site. There was no submergent vegetation present at this site, which may be a function of the limited water depth in the wetland. Fish habitat at the Wetland 4 site is limited due to very shallow water depth at the site, but the site provides excellent amphibian and shorebird habitat, which may be temporarily reduced when the wetland goes dry.

Figure 3-10. Water Surface Elevations at Wetland 4 Compared to Reservoir Elevations and Clark Fork River Inflows.



4.0 Conclusions

4.1 Operations

The second study season Operations Study assessed the effects of operations, including provision of flexible capacity, through an increase or decrease in plant output, based on grid reliability needs. The frequency of flexible capacity provision directly resulted from real-time system needs and the magnitude of available flexible capacity (both increase and decrease in output) resulted from the real time operating levels of the generation units. All operations were maintained within the reservoir elevation and minimum flow requirements through the study.

The study found that the Thompson Falls plant is well suited to provide flexible capacity in the form of generation increases and decreases to support grid stability and meet grid reliability requirements. Provision of this support is limited by available reservoir volume, river baseflows, and plant configuration. The current plant controls and automation program successfully calculate available capacity and duration with all needed inputs and the plant performs well in all aspects of providing flexible capacity while maintaining reservoir elevation and minimum flow requirements.

Grid reliability needs are dynamic and are driven by many variables. All energy coming into the grid must be balanced in real-time with all energy consumed on the grid. Electric consumption changes constantly throughout the hours of the day and seasons. Electric generation coming into the grid changes due to intermittent renewable resources and available baseload generation. Flexible capacity is needed to balance these dynamic changes to maintain frequency and voltage for a reliable electrical grid. Future grid reliability needs will change as conditions on the system change.

Operationally, the main difference observed during flexible operations in the second study season, was in applying real time frequency of flexible capacity operations rather than the scheduled, preset, output changes that were used in the first study season. The plant and controls systems worked well in calculating real-time capability and ultimately providing the output increase or decrease when called upon.

4.2 Shoreline Stability

With few exceptions, the shoreline monitoring data indicate no changes in the amount, type, or cause of erosion during the second study season. When changes did occur, the most common causes are use-based impacts such as human or wildlife footpaths, or natural events such as spring runoff, runoff in response to rain events, or wind-toppled trees. This is similar to the conclusions of the first study season.

The fluctuating water levels due to Project operations did not appear to change the amount, type or cause of erosion. Much of the reservoir bed near the shoreline is armored with rock, cobble, gravel, woody material and/or aquatic vegetation. Thus, lowering the reservoir results in the water's energy being exerted on these armored areas which are generally stable and resistant to erosion. An example of this is Reference Point #4 (**Photo 4-1**). While there is a fair amount of erosion and shoreline instability above the water's edge in the form of bank sloughing and undercutting, the reservoir bed that would be exposed by flexible Project operations would be armored by rock, cobble, gravel, woody material and aquatic vegetation. The water's energy would likely dissipate on those armored areas and not cause further erosion and shoreline instability. Reference Point #8 provides another example, whereby rock, cobble, and gravel would armor the area during flexible Project operations (**Photo 4-2**).

Photos 4-1. Reservoir shoreline at Reference Point #4.

Photos 4-2. Reservoir shoreline at Reference Point #8

In summary:

- The amount, type and cause of erosion varies greatly on the reservoir shoreline depending on slope, soils, vegetation, land use, location within the reservoir and other factors.
- Fluctuating water levels due to operations do not appear to increase shoreline erosion or instability.
- Other factors such as spring runoff, uprooted trees from windstorms, boat wakes, and wildlife/human paths appear to be the cause of shoreline erosion and instability.

4.3 Riparian Habitats

As previously stated, a cold spring delayed and prolonged runoff, which in turn delayed aquatic vegetation growth, in particular submergent aquatic vegetation. This demonstrates that a number of factors may influence aquatic vegetation and that it may be challenging to discern the extent, if any, that changes in aquatic vegetation are due to Project operations. Nonetheless, it did appear that fluctuating water levels due to operations caused a reduction in submergent aquatic vegetation growth in the 0- to18-inch-depth range.

4.4 Fisheries

No stranding was observed during the second study season; either as part of surveyed transects or during other times of general observation. Stranding within the bounds of the 2022 study elevations and rates of elevation change does not appear to be an issue in Thompson Falls Reservoir.

All components of the upstream fish passage facility worked as designed during the March through October timeframe. Annual fish captures were within the mean range of previous years, and 2022 reservoir operations did not appear to have an impact on operations of the upstream fish passage facility nor on catch rates.

4.5 Recreation and Aesthetics

4.5.1 Recreation Access

Over the two study seasons, NorthWestern assessed the effect of different reservoir elevations on the public's access to the reservoir via public and private docks. Impacts were documented to the physical structures, access to docks from the shoreline; access to the water from the dock; and if boats were moored to docks, how those might be impacted. The public docks at Wild Goose Landing and Cherry Creek remained accessible and undamaged during both seasons.

Physical impacts to gangways or access to floating private docks were not observed in 2022, but at the lower reservoir elevations observed in 2021 (2.0 and 2.5 feet below full), slight or moderate impacts were documented. Private stationary docks, which account for 20% of all docks, were still accessible from shore in both years but access to the water and to boats was impacted at the lower reservoir levels.

4.5.1.1 Impacts to Dock and Gangway Structures

Stationary dock structures did not appear damaged by reservoir fluctuations during both study seasons. No visible damage was observed to floating docks or gangway structures in 2022 when reservoir elevations were within 1.8 feet of full pool. Impacts to floating dock structures were rated at a slight to moderate level (-1 to -2) in 2021, only when reservoir elevations were 2.0 or more feet below full pool.

4.5.1.2 Impacts to Access - From Shorelines to Docks

Stationary docks were accessible from shore at all water levels observed in both study seasons.

Access to floating docks from shore was slightly impacted (rating -1) when reservoir elevations were lower than 1.5 below full pool. Impacts to shoreline access to floating docks became moderate (rating -2) when reservoir levels were 2.5 feet below full pool, an impact observed in 2021 only. The gangways of some floating docks were constructed at steep angles at full pool elevation and thus became steeper at water levels 1.5 feet below full pool and lower. Floating docks with long gangways or access ramps that were near level during full pool reservoir elevations were typically able to adjust well to water levels resulting from flexible capacity operations.

4.5.1.3 Impacts to Access - From Docks to the Waterway

Slight impacts (rated -1) occurred related to access to the water from stationary docks when reservoir levels were 1.5 feet below full pool. When reservoir levels declined to 1.8 feet below full pool or more, access to the water from stationary docks was moderately affected (rated -2). Access to the water from stationary docks was more affected on the south shore, where the slope of the shoreline is gradual, than on the north shore, where the slope is steeper allowing stationary docks access to deeper water.

Floating docks provide better recreational access to the water compared to stationary docks because the dock adjusts to pool elevation changes. Waterway access from floating docks was unaffected at reservoir elevations down to 1.8 feet below full pool. At lower reservoir elevations, observed in 2021 only, impacts to access to the water from floating docks were slight, or moderate when the reservoir was 2.5 feet below full pool.

The degree of impact of waterway access from floating docks depended on the length and configuration of the dock, the length of the gangway or access ramp, and the water depth and location of the dock. Impacts to water access was noted for floating docks that did not extend as far into the waterway, and thus had less access to deep water. While the majority of floating docks remained watered at all elevations, floating docks that were aligned perpendicular to the shoreline provided access to deeper water at lower pool elevations than docks aligned parallel to the shoreline. Floating docks with shorter gangways often had the near-shore floats of the dock grounded, though the outer edge remained watered. Floating docks also become pitched or angled if they become partly or entirely grounded at lower reservoir elevations.

4.5.1.4 Impacts to Access - From Docks to Boats Moored at Docks.

Boat access from stationary docks was unaffected when reservoir levels were within 0.5 foot of full pool. Slight impacts (rated -1) were noted from 0.9 foot to 1.8 feet below full pool, moderate impacts at 1.8 feet below full pool, and significant impacts (rated -3) when the reservoir was 2 feet below full pool or lower.

Boat access from floating docks was unaffected at reservoir levels above 2.0 feet below full pool.

4.5.2 Aesthetics

Impacts to aesthetic qualities (visual and olfactory) from fluctuating water levels associated with flexible capacity operations were minimal in 2022. While some mud and rock were exposed along the shoreline, there was no offensive odor of decaying organic matter.

4.6 Wetlands

The results of this Operations Study show that Project operations have the potential to affect some wetland habitats along the reservoir if they have a strong surface water connection to the reservoir. Wetland 1 and Wetland 4 are examples of this. These two sites and other comparable wetlands in the Project area, cover approximately 9.4 acres, as mapped by the Montana Natural Heritage Program using remote sensing data (MTNHP 2021).

Aquatic habitat within these types of wetlands will be temporarily reduced when the water surface elevation of the reservoir is down, which may temporarily displace some fish and wildlife species until the water surface elevation of the reservoir comes back up and that habitat becomes available once again. Project operations may impact the vegetative community of deeper wetlands like Wetland 1 by reducing the amount and species of submergent vegetation over time, whereas some wetlands like Wetland 4 are likely too shallow to support submergent aquatic vegetation and will not be affected in the same manner. Emergent vegetation at these sites is fairly resilient and may not be affected as much as the submergent vegetation. There were no changes observed in the vegetation community at either Wetland 1 or 4 throughout the second study season, and also no changes were noted between first and second study seasons at Wetland 1.

Wetlands which have a direct surface water connection to Thompson Falls Reservoir have a high risk of being affected by Project operations. The environmental effects on these wetlands are generally temporary in nature, and include loss of fish habitat, reduction of shallow water habitat for amphibians, birds, and other wildlife, and the potential reduction of submergent vegetation at some sites.

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