Thompson Falls Hydroelectric Project
FERC Project No. 1869

NorthWestern Energy
Initial Study Report
Operations Study

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List of Abbreviations and Acronyms

AD	dry channel dam
AIS	aquatic invasive species
AWS	Auxiliary Water Supply
BBB	Birdland Bay Bridge
cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
flow	Project discharge
ft/hr	feet per hour
full pool	maximum elevation of the reservoir during normal operations
HVJ	high velocity jet
ILP	FERC's Integrated Licensing Process
Licensee	NorthWestern Energy
MW	megawatt
NorthWestern	NorthWestern Energy
PCS	Plant Control System
photo	photograph
Project	Thompson Falls Hydroelectric Project
SG	staff gauge
Study Plan	Revised Study Plan, NorthWestern Energy, April 2021
Thompson Falls Project	Thompson Falls Hydroelectric Project
U.S.	United States
USGS	United States Geological Survey
USR	Updated Study Report

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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 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, Licensee), the current licensee, 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, issued May 10, 2021, and to prepare the Final License Application.

This Operations Study Initial 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.

1.1 Operations Study Background

The Thompson Falls Project is operated to provide baseload and flexible generation within the reservoir elevation and minimum Project discharge (flow) requirements of the License issued by FERC. 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). PPL 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.

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

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 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 – riparian habitats, 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 the operational flexibility that is needed and important for grid stability and reliability.

1.1.1 *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 this needed flexibility. This helps to balance the very dynamic changes that occur as energy use and energy production on the grid constantly 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 new 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, is reliant on its capability to balance those new intermittent resources with existing resources including the Thompson Falls Project.

1.2 Goals and Objectives of Operations Study

During the 2021 study season, NorthWestern conducted a 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 (the "Operations Study"). 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 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, but typical operation of this flexible capacity would be moderated below these extremes. Therefore, NorthWestern is proposing to modify the Operations Study, continuing it into the second study season on a limited basis, which will assess the effects of more 'typical' operations. The proposed second season study plan is included in Appendix A.

The following resource areas were monitored during the Operations Study, with these specific objectives:

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[2] A brief (30 minutes) minimum flow excursion occurred on July 26 during the Operations Study. NorthWestern notified FERC on August 3, 2021.

Operations: The Operations Study simulated operational scenarios of flexible capacity. Objectives were to evaluate a wide range of flexible operational scenarios to determine plant generation outputs, rate, and degree of reservoir elevation changes that may result from these flexible operations.

Shoreline Stability: Data were collected to determine effects on shoreline stability around the reservoir. The objective of the monitoring was to identify Project-induced erosion, if any, associated with flexible operation and associated reservoir elevation changes.

Riparian Habitats: Data were collected regarding the presence of riparian habitats, aquatic vegetation and aquatic invasive species (AIS). The objective was to identify the presence or absence of riparian habitats, aquatic vegetation and AIS and any Project-induced changes to riparian habitats, aquatic vegetation, and AIS associated with flexible operation and associated reservoir elevation changes.

Fisheries: Data collected were evaluated to determine effects on fish populations, fish access to tributary streams, and to the operation of the Project's fish passage facility.

Recreation and Aesthetics: Data collected were evaluated to determine effects to public and private boat launches and docks and the aesthetic qualities of the reservoir.

Public Safety: Data collected were evaluated to determine effects the different operational scenarios have on the Project's public safety including changing water levels in the Project reservoir and below the powerhouses.

Water Quality: Data collected were evaluated to determine effects on water quality in the reservoir, downstream of the powerhouses and downstream at Birdland Bay Bridge.

Wetlands: Data collected were evaluated to determine effects on wetlands within and adjacent to the Project boundary.

Cultural: Data collected were evaluated to determine effects on three previously recorded cultural properties located in the reservoir fluctuation zone[3] and exposed in shoreline embankments at the face of the backshore zone.[4]

[3] Fluctuation Zone refers to lands exposed by any reservoir drawdown.
[4] Backshore Zone refers to the lands lying beyond the full reservoir contour.

2.0 Methods

The Operations Study simulated operational scenarios of flexible capacity at the Project. These scenarios included the extreme limits of the Project's operational capability. The Operations Study was implemented in three phases, each with different levels of generation and corresponding raising and lowering of the reservoir within 2.5 feet below full pool (the maximum elevation of the reservoir during normal operations). The three phases of the Operations Study were scheduled when inflows to the Project were expected to support flexible operations at the Project as planned in the Operations Study. Each of the three phases had differing magnitudes of changes in generation. Project flows represent all outflows (through the powerhouses, spillways, fish passage facility, and leakage). Reservoir elevation was reduced, increased, and held stable relative to the operational scenario being tested. Throughout the three-phase Operations Study, the reservoir was held static at every half foot elevation for the top 2.5 feet for extended observation (**Figures 2-1** through **2-3**). During each of the three Operations Study phases, changes in reservoir elevation were observed and recorded. The public was notified of the study dates prior to the Operations Study.

Figure 2-1. Reservoir Elevations during Phase 1 of Operations Study

Figure 2-2. Reservoir Elevations during Phase 2 of Operations Study

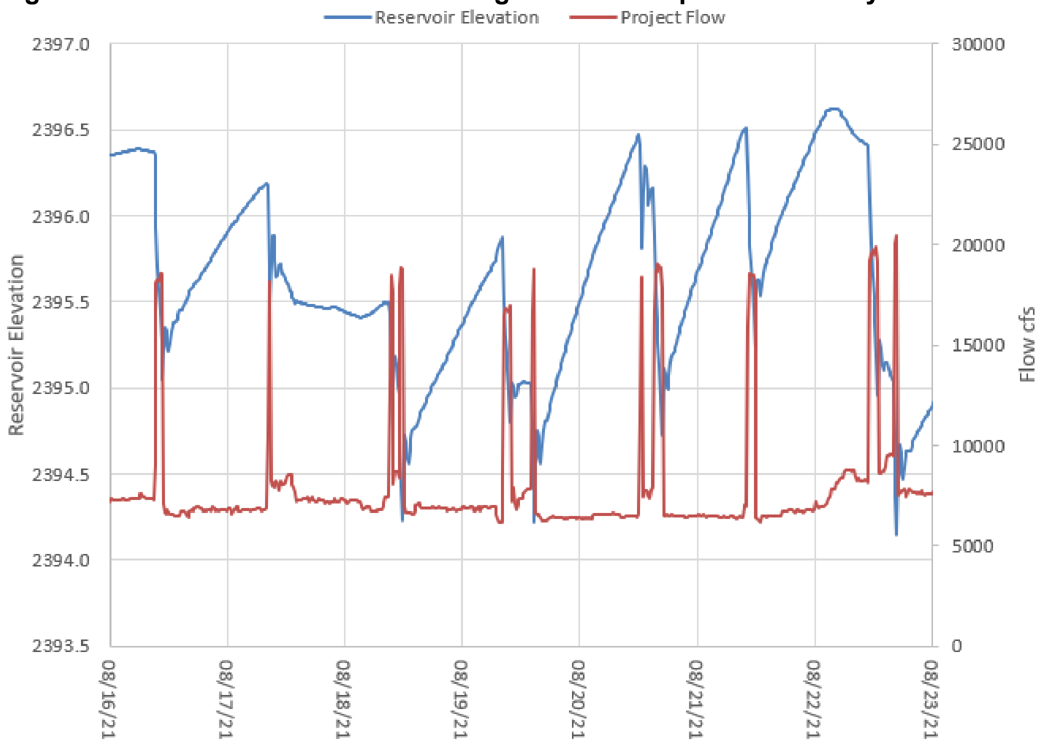
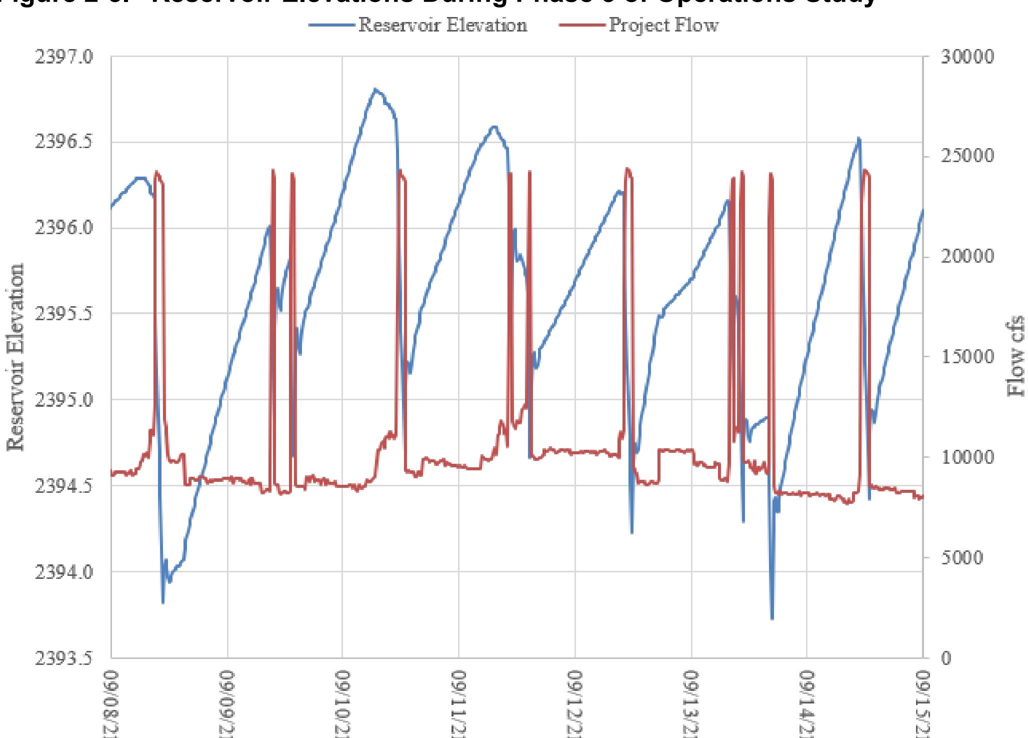


Figure 2-3. Reservoir Elevations During Phase 3 of Operations Study



Methods for each resource area studied are described below.

2.1 Operations

Each phase consisted of multiple daily operating scenarios for a continuous week (7 days). A minimum of 2 weeks were spaced between phases to reestablish a baseline condition in preparation for the subsequent phase.

For each 7-day phase of the Operations Study, two to four specific operating scenarios, randomly ordered, were conducted each day between 7 am and 5 pm (Mountain Daylight Time). These discrete operations of short-term generational changes were implemented to simulate flexible generation needed by NorthWestern for transmission grid regulation. A static hold at each 0.5-foot elevation was maintained for a minimum of 4 hours during the three-phase Operations Study.

The following operations were planned for the purposes of this Operations Study:

<u>Phase 1: 20-megawatt (MW) Generation change</u>

20 MW increase in generation for 30 minutes

20 MW increase in generation for 90 minutes

20 MW decrease in generation for 30 minutes

20 MW decrease in generation for 90 minutes

<u>Phase 2: 40 MW Generation change</u>

40 MW increase in generation for 30 minutes

40 MW increase in generation for 90 minutes

40 MW decrease in generation for 30 minutes

40 MW decrease in generation for 90 minutes

<u>Phase 3: Maximum[5] Generation Capacity change</u>

Maximum available increase in generation for 30 minutes

Maximum available increase in generation for 90 minutes

Maximum available decrease in generation for 30 minutes

Maximum available decrease in generation for 90 minutes

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[5] Maximum capacity change was determined at the time of the Operations Study based on available units in the plant and river baseflow.

Raising and lowering the reservoir was controlled by increasing or decreasing generation; as generation was increased, the reservoir went down and conversely, when generation was reduced, the level of the reservoir went up. Reservoir elevation changes were also influenced by the inflows at the time each phase was implemented and constrained to maintain the FERC-license required minimum outflow of 6,000 cubic feet per second (cfs). These conditions required that NorthWestern adapt the specific operations scheme during the Study to assure utilization of the entire 2.5 feet of the reservoir (*see* **Section 2.1.2 - Variances from the FERC-approved Study Plan**).

2.1.1 Reservoir Elevation Monitoring

Changes in releases from the spillways and powerhouses have a corresponding effect on water levels. Water surface elevations would change in a very uniform fashion, similar to draining a bathtub, if the reservoir had a uniform shape and the change in the release was slow. In reality, the reservoir contours are very diverse with varying widths, depths, and controlling features to change the flow of water and associated water level. The magnitude and rate of water surface elevation change is dependent not only on the amount of water released from the spillways and powerhouses, but also how much water enters the Project from the Clark Fork River and other tributaries. The changes observed in water surface elevation and the rate of those changes are unique to the Thompson Falls Reservoir and are influenced by the magnitude of the water release change, topography, and inflow.

To document water level changes during the Operations Study, NorthWestern used existing United States Geological Survey (USGS) data, stage loggers, Noxon Reservoir elevation data (Avista Corp 2021), and instruments installed at the Project to measure water levels in multiple locations in the reservoir and downstream in the river channel (**Figure 2-4**).

The following four areas were monitored:

1. The Clark Fork River upstream of the island complex to the Project boundary. This area is characterized as riverine with free-flowing Clark Fork River. Two sites, Project Boundary and Above Islands, were established to monitor water level changes in this reach. These two new sites, in conjunction with Clark Fork River flows measured at the USGS gaging station #12389000 on the Clark Fork near Plains, MT, were used to evaluate water levels for this area.
2. Upper Reservoir/Islands. This area is at the upstream end of Thompson Falls Reservoir and includes multiple channels that form islands. Immediately downstream of the islands the Reservoir is relatively narrow and confined on both sides by high banks. Two sites were used to document changes in water level in this reach: the Island site located on the largest channel through the island complex and at the mouth of the Thompson River (Thompson River site). Directly downstream of the Thompson River confluence the reservoir corridor becomes very narrow confined by high banks.

3. Lower Reservoir. This area is located downstream of Areas 1 and 2 and near the town of Thompson Falls where the Reservoir is shallow and wide with rock outcroppings. Instruments installed on the Main Dam were used to monitor water level in this reach.
4. Downstream of Dams. This area is located downstream of both the Main and Dry Channel dams and powerhouses, where water is released into a riverine section of the Clark Fork River. The intent of monitoring at these locations was to compare water level changes with the powerhouse tailwater elevation as they are attenuated by the Clark Fork River channel downstream. Noxon Reservoir elevation data was also obtained from Avista Corporation to evaluate if changes in the water surface elevation of Noxon Reservoir (downstream of the Project) has an influence on water surface elevation in the Project area. The Downstream of Dams area was evaluated at three sites using water level instruments:
    - In the tailrace near the powerhouses
    - Approximately 1,200 feet downstream of the powerhouses (Below Powerhouse site). This location recorded water level changes downstream of the Project where bedrock outcropping in the Clark Fork River channel form the pool into which both powerhouses discharge
    - Approximately 2.5 miles downstream at Birdland Bay Bridge. A Hydrolob HL7 instrument was deployed at the Birdland Bay Bridge site to measure both water quality parameters and water depth.

Water level sensors installed on the upstream face of the Main Dam and in the tailrace downstream of the powerhouse are used by Project operating staff to record reservoir and tailwater elevations. Data from the sensors are routinely logged into the Plant Control System (PCS). The PCS calculates total flows through the Project by a summation of estimates of flows for generation, spill, and leakage through the dam. NorthWestern utilized these data to inform and manage Project operations.

In addition to the permanently installed instruments on the Main Dam and in the tailrace, NorthWestern installed water level loggers throughout the Project at the locations described above to record reservoir elevation through the Operations Study. Onset water level recording instruments were installed at these locations to be consistent with the data collected during the 2019 test (**Figure 2-4**). These sites were originally chosen to provide a spatial distribution across the reservoir and to see how different areas of the reservoir respond to changes in reservoir elevation.

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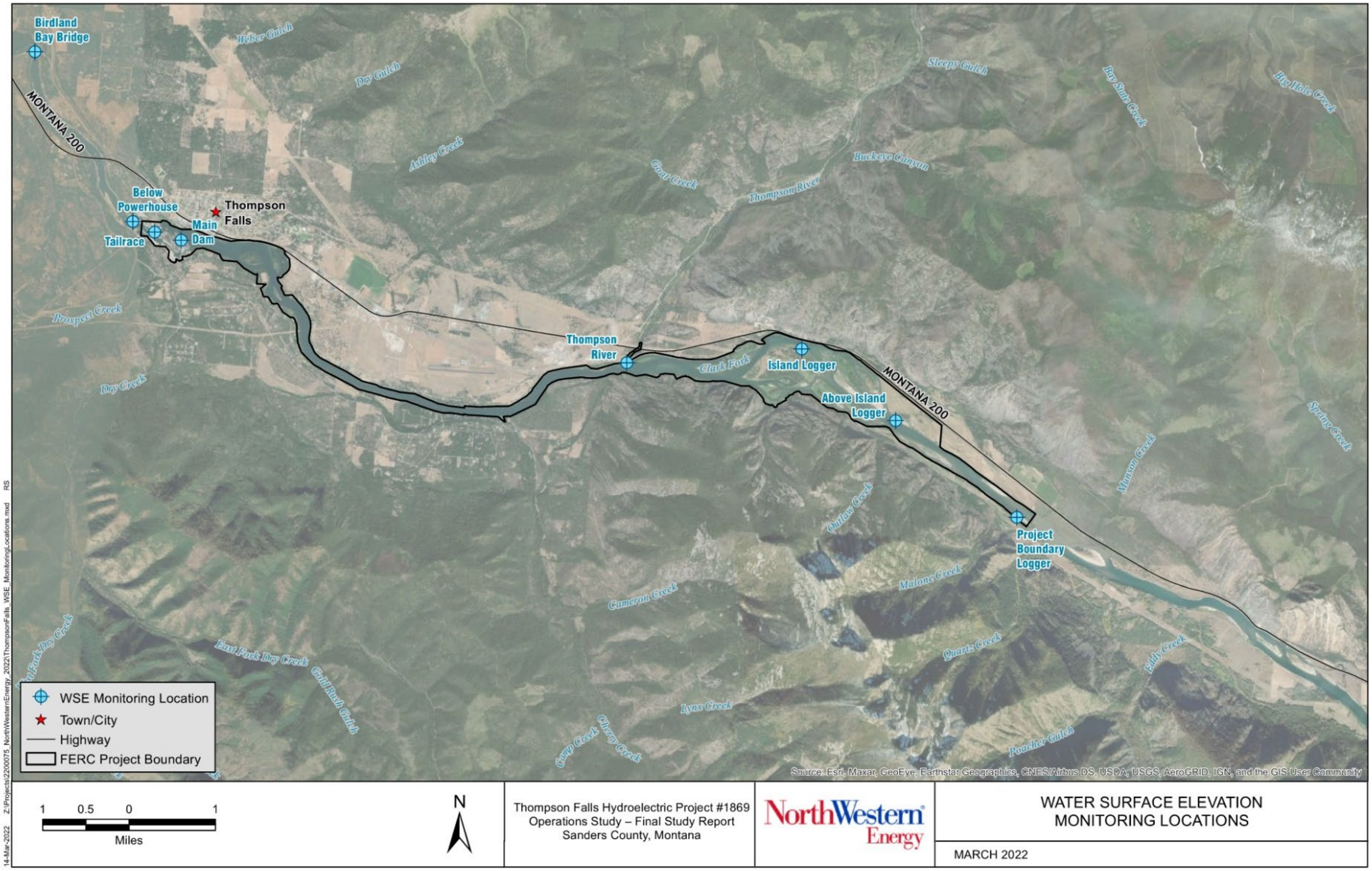
Figure 2-4. Water Surface Elevation Monitoring Locations.



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Two new sites were established for the Operations Study in addition to those used in the 2019 test. The purpose of these sites was to evaluate Project operations effect on water elevations in the riverine section upstream of the island complex and upstream to the Project boundary.

All water level data was set to defined elevations at the start of the Operations Study. This allowed for the water level at each location to be related to water level at other locations in order to track relative water level changes throughout the Project through all three phases of the Operations Study.

Water level instruments were programmed to record levels in 15-minute intervals to provide data on how different areas respond to the lowering of the reservoir elevation. Reservoir inflows affect level changes, so by studying level changes at different inflows, reservoir level dynamics under different conditions can be better understood.

2.1.2 Variances from the FERC-approved Study Plan

Low river inflows did not support the full magnitude of the planned decreases while maintaining required FERC-license required minimum outflow of 6,000 cfs. The magnitude of generation decrease is constrained to the flow differential between Project inflows and required minimum flows. The Study Plan was adjusted in both Phase 2 and Phase 3 to include only generation increases due to the low river flows. The reservoir elevation was allowed to slowly recover relying on inflows and decreased generation to support the ongoing test and to ensure that the reservoir was operated throughout the full 2.5 feet of elevation.

2.2 Shoreline Stability

2.2.1 Study Area

As part of the Operations Study, NorthWestern assessed shoreline stability. The assessment included reference points along the reservoir shorelines extending from the boat restraint upstream to the mouth of the Thompson River (**Figure 2-5**). This area captures the majority of developed lands potentially affected by Project-induced bank erosion. In addition, observations were made from the Thompson River to the upstream Project boundary. Upstream of the Thompson River, the reservoir becomes more riverine with higher current velocities, increased presence of bedrock, and larger substrate, and thus more resilient to erosion. Downstream of the dams, the river is bedrock-controlled, and shoreline erosion is not a concern.

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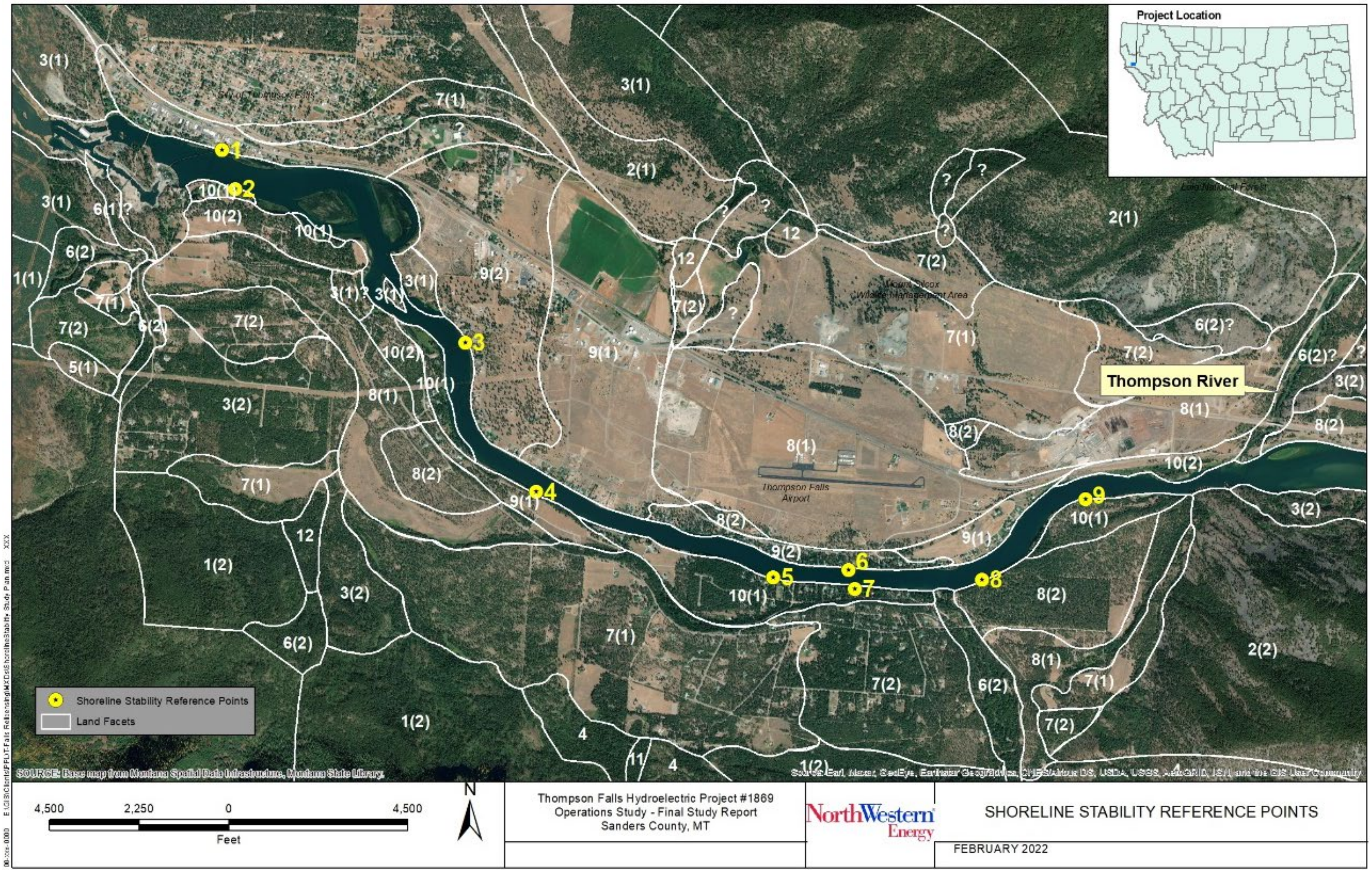
Figure 2-5. Shoreline Stability Reference Points.



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2.2.2 Study Methods

Nine reference points were established along the reservoir shoreline. **Figure 2-5** is a map showing the location of the reference points. Each reference point is a 300-foot-long reach of shoreline. The reference points were chosen to represent the broad 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 six times 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. Noticeable slope stability issues outside of the nine chosen reference points were documented with notes and photos.

The reference points were monitored on October 8, 2020, to gather baseline information. Two additional monitoring events occurred, one on April 19, 2021, after ice-off and before high spring runoff and another on July 13, 2021, after high spring runoff, to gather additional baseline information before Phase 1 of the Operations Study. The goal of establishing a baseline was to estimate the amount of observed shoreline erosion during a period when the reservoir was held near full pool. The observed erosion during this baseline period (October 2020 – July 2021) helped document natural and anthropogenic factors influencing the shoreline, not related to operational fluctuations in reservoir elevation. Additional monitoring events occurred between Phases 1 and 2 (August 6, 2021), between Phases 2 and 3 (September 1, 2021), and after Phase 3 (September 16, 2021). During each shoreline monitoring event the reservoir was held near full pool. Results from each monitoring event were compared to identify changes in shoreline stability, assess impacts related to the reservoir fluctuation or natural conditions, or a combination of both.

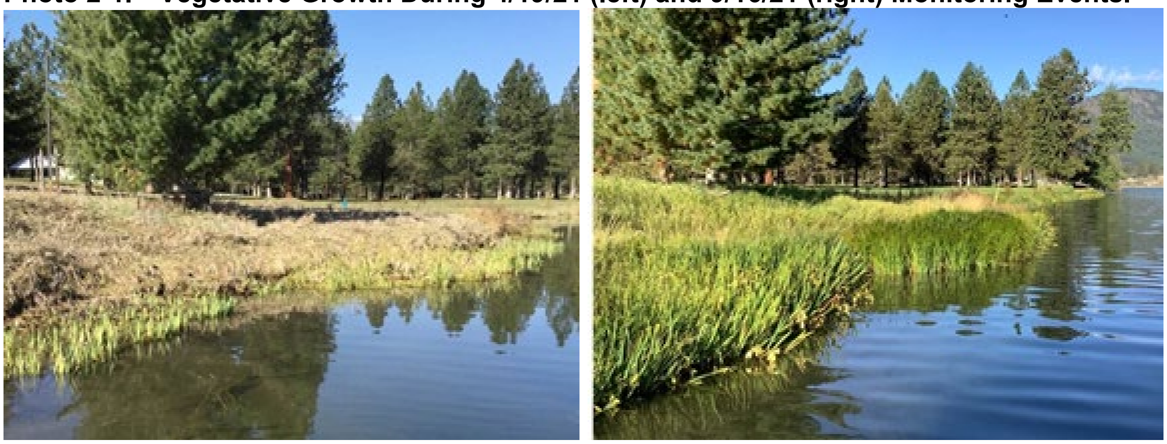
2.2.3 Quality Assurance

There are inherent limitations to studies that rely on visual observations over time. While these limitations do not undermine the conclusions of the Operations Study on shoreline stability, the limitations and NorthWestern's approach to addressing them are discussed here.

Shoreline vegetative conditions were dramatically different between both October 8, 2020 and April 19, 2021 when vegetation was dormant, as compared with the growing season monitoring events in the summer and early fall in 2021 when vegetation was present and much denser. This challenge arose at Reference Points #1, #2, and #3. This limited the ability to observe bank erosion at these three reference points which were heavily vegetated as can be seen in **Photo 2-1**.

NorthWestern compared photos and data from all six monitoring events at these three reference points, to determine if an adjustment was needed to account for the dense vegetation. Fortunately, erosion at all three reference points was low for all monitoring events, likely because the increased density of shoreline vegetation throughout the growing seasons helps to reduce the susceptibility to erosion. Therefore, no significant adjustments were needed.

Photo 2-1. Vegetative Growth During 4/19/21 (left) and 9/16/21 (right) Monitoring Events.



Precision of repetitive ocular estimations of specific conditions could be a limitation of the assessment, as it can be challenging to maintain a high level of precision during visual observations made by each individual or across the monitoring team during the six monitoring events spread over the course of about a year. To minimize the variation in observations, each member of the monitoring team performed the same role when feasible for each of the six monitoring events. Repeat observations by an individual likely reduced variation in the observation.

Finally, when observed condition falls on the boundary of a classification or category results may be perceived as more or less affected than the actual conclusion was. One example of this instance is an observation during a monitoring event of slightly more than 30 percent erosion would place it in the 31 to 50 percent category. An observation during another monitoring event of slightly less than 30 percent erosion would place it in the 11 to 30 percent category. The result would make this observation across the multiple monitoring events appear as a wide range of 11 to 50 percent, when in reality both observations were very similar at about 30 percent. The monitoring team identified any large range of observations during the data review and collectively reviewed the photos for all monitoring events for the corresponding site in order to identify is there was significant change or if the range in observation was a factor of the classification.

2.2.4 Variances from the FERC-approved Study Plan

There were no variances from the FERC-approved Study Plan (NorthWestern 2021).

2.3 Riparian Habitats

2.3.1 Study Area

As part of the Operations Study, NorthWestern assessed riparian habitats, aquatic vegetation and AIS, specifically curlyleaf pondweed, flowering rush, and yellow flag iris, along the reservoir shorelines extending from the dams upstream to the upstream end of the Project boundary. For this assessment, riparian habitat is considered the vegetation above the full pool, 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). Data were collected on riparian habitat, aquatic vegetation, and AIS – at the shoreline stability reference sites (*refer to* **Figure 2-5**); and the wetland monitoring sites (**Figure 2-6**). General observations were also made during the course of the Operations Study.

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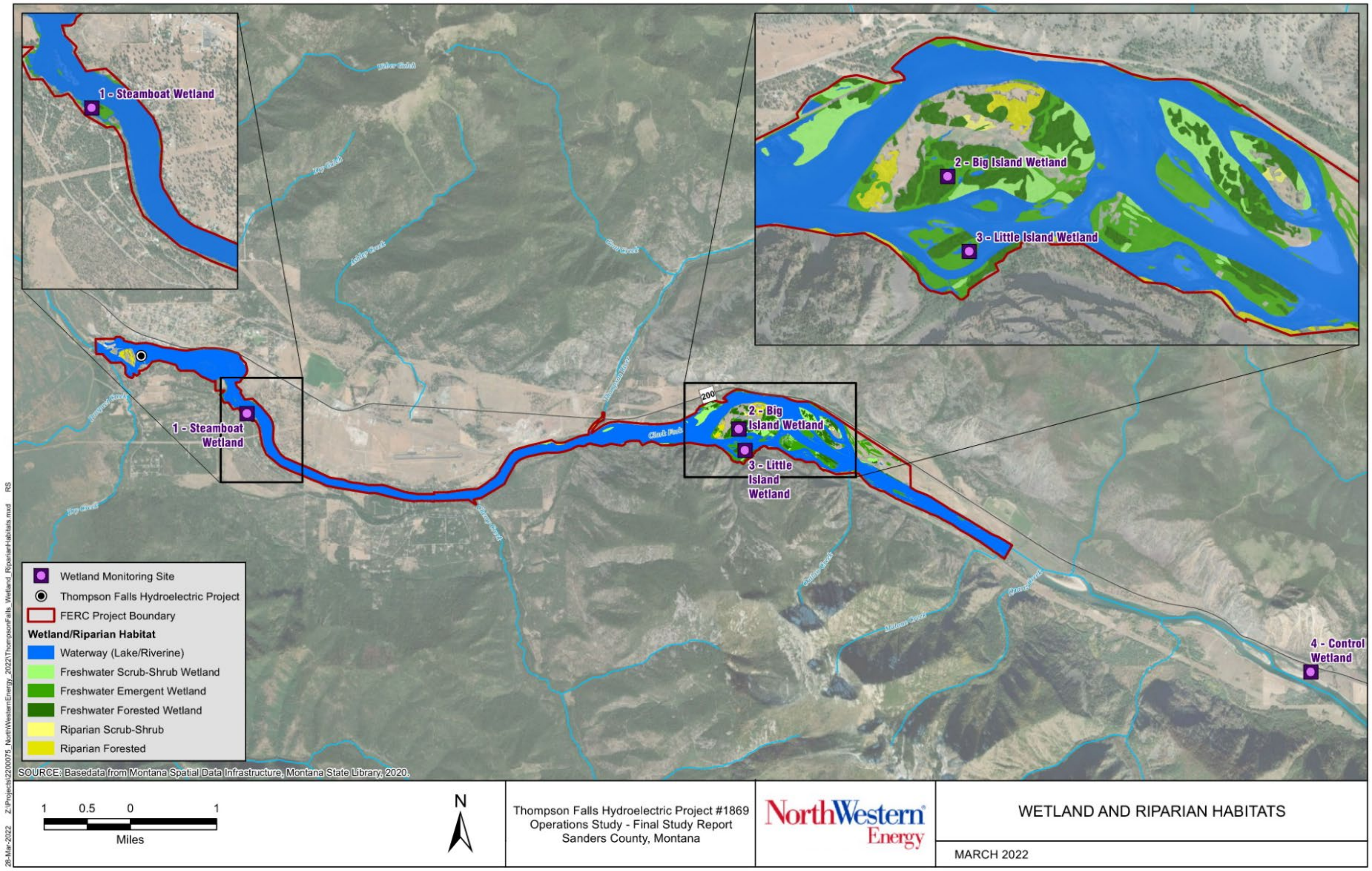
Figure 2-6. Wetland/Riparian Habitat Study Areas.



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2.3.2 Study Methods

Data Collection at Shoreline Stability Reference Points

Data were collected at the same nine reference points that were established along the reservoir shoreline for the shoreline stability evaluation (*refer to* **Figure 2-5)**. Each reference point is a 300-foot reach of shoreline. The reference points were chosen to represent the broad variability in soil types, landform, slope, aspect, vegetation, shoreline management, flow velocity and land use that in turn represent the variability in physical environment and stressors on habitats affecting aquatic vegetation and AIS along the reservoir.

The nine reference points were monitored five times. The reference points were monitored on April 19, 2021, after ice-off and before high spring runoff and on July 13, 2021, after high spring runoff, to gather baseline information before Phase 1 of the Operations Study. The goal of establishing a baseline was to determine the presence of riparian habitats, aquatic vegetation and AIS during a period when the reservoir was held near full pool and different growing seasons. Additional monitoring events occurred between Phases 1 and 2 (August 6, 2021), between Phases 2 and 3 (September 1, 2021), and after Phase 3 (September 16, 2021). During each monitoring event the reservoir was held near full pool. Results from each monitoring event were compared to identify changes in riparian habitats and changes in the percent of aquatic vegetation and AIS and species composition, and whether or not the changes were related to the Operations Study, or baseline conditions, or a combination of both. Riparian habitats, aquatic vegetation and AIS were not specifically monitored on October 8, 2020. However, photos taken during the October 8, 2020, shoreline stability monitoring were reviewed to get a general sense of riparian habitats, aquatic vegetation and AIS at that time.

During the five monitoring events, general visual observations were made of the type of plant species present in the riparian habitats, and visual observations were taken of the percent of linear distance (to a water depth of 4 feet at full pool) of the 300-foot-long reach of shoreline 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.

Data Collection at the Wetland Monitoring Sites

The second component is the collection of riparian habitats, aquatic vegetation and AIS data at the three wetland monitoring sites established for the wetland habitat evaluation. One monitoring site was selected in the lower portion of the reservoir near Steamboat Island (Wetland 1), and two sites were selected in and around the island complex upstream of the confluence with the Thompson River (Wetland 2 and Wetland 3) (*refer to* **Figure 2-6**).

All wetland sites were initially evaluated on April 19, 2021, as a part of the site selection process. At the time, there was little vegetative growth at these sites, and it was hard to positively identify components of the plant community at each site. A follow-up site visit was conducted on July 19, 2021, to install stage loggers at the selected wetland sites. This time frame provided a suitable window to positively identify plant species present at each of the three wetland sites. Dominant plant species at each site were recorded, as well as any AIS present at the site. This data collection was done to provide a general site characterization but was not intended to catalogue every plant species present at each site. Additional follow-up visits were conducted on July 29 and September 15 to observe any changes in the plant community that may have occurred throughout the duration of the Operations Study.

General Observations

The third component of this Operations Study involved making general observations about the presence, absence and density of riparian habitats, aquatic vegetation and AIS within the reservoir over the course of the Operations Study.

2.3.3 Variances from the FERC-approved Study Plan

The FERC-approved Study Plan (NorthWestern 2021) stated that NorthWestern would record AIS when observed during the Operations Study. Riparian vegetation, aquatic vegetation, and AIS were monitored at the nine shoreline stability monitoring sites on five occasions, and at the wetland monitoring sites as well. This additional monitoring was an enhancement to the FERC-approved Study Plan (NorthWestern 2021).

Also, although not a variance, 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 Initial Study Report.

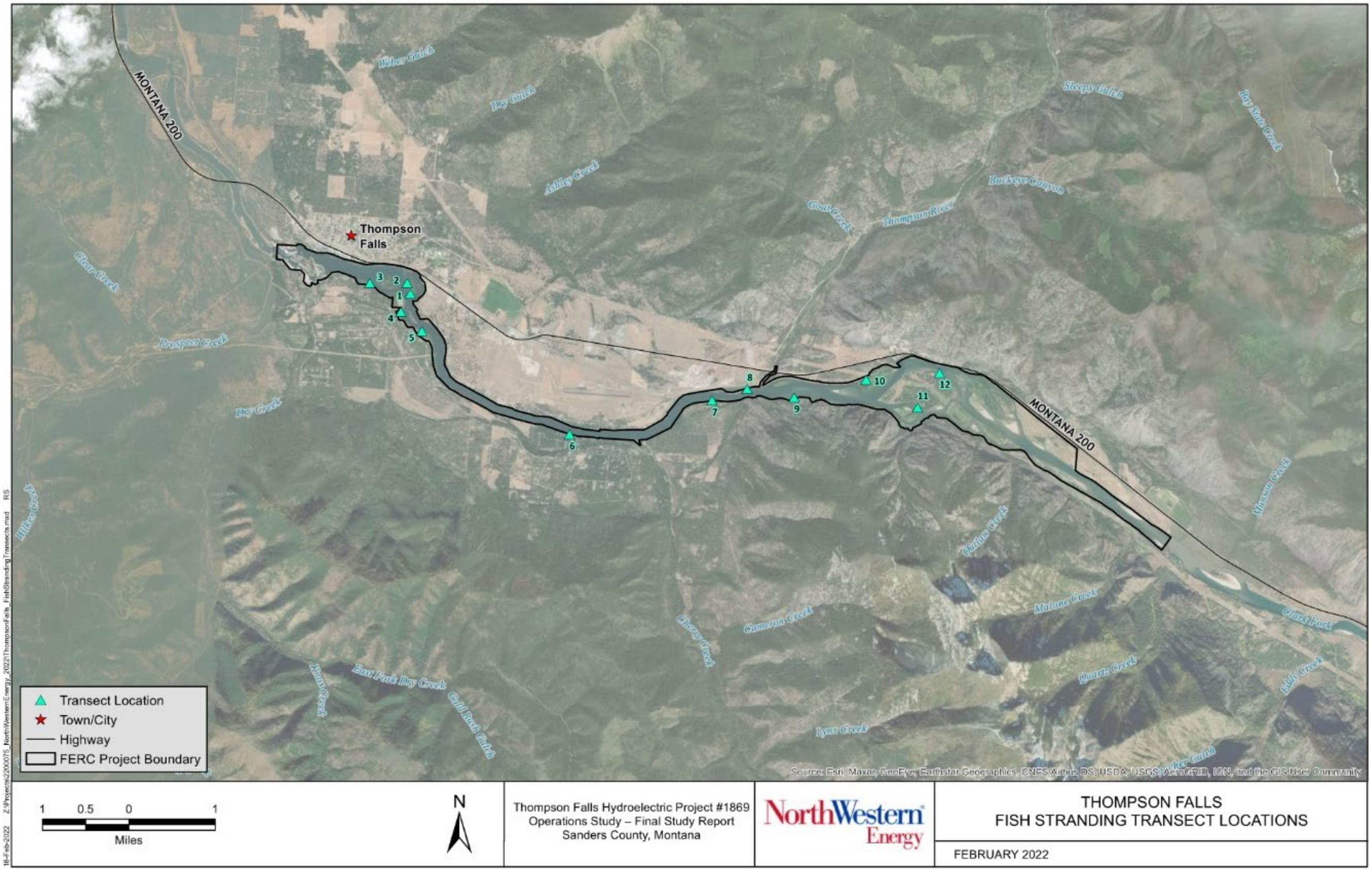
2.4 Fisheries

The assessment of effects of operational fluctuations on fisheries included evaluating the potential for fish stranding, habitat changes at the mouths of Cherry Creek and Thompson River and impacts to the fish passage facility.

2.4.1 Study Area

Fish stranding was monitored on exposed island areas, and along exposed shoreline habitats in Thompson Falls Reservoir, downstream of the confluence with Cherry Creek, and near the islands upstream of the Thompson River (**Figure 2-7**). In addition, photo points were established at the confluences of Cherry Creek and the Thompson River. Conditions in the fish passage facility were also evaluated.

Figure 2-7. 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 five different times during the Operations Study, twice during Phase #1, twice during Phase #2, and once during Phase #3. Observations were made during static holds of the reservoir and represented reservoir elevations at 2396.0, 2395.5, 2395.0, 2394.5, and 2394.0 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.

Cherry Creek and the Thompson River are important spawning and rearing habitats for salmonids. Different reservoir elevations have the potential to modify the areas at the tributary/reservoir confluence and potentially modify or impede the migration of salmonids into and out of these streams. Photo points were established during the Operations Study at the confluence and 500 feet upstream to visually capture any changes to habitats at different reservoir elevations. Level loggers were also employed to measure elevation changes near the tributary confluences.

During all three phases 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. Observations were made in 10- to 30-minute increments to observe the impacts of lowering the reservoir level. 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

Cross sections of the Thompson River and Cherry Creek were not completed based on observations of flows and water levels. No impacts to fish access to these tributaries were noted. Level loggers (*see* **Section 2.1.1 – Reservoir Elevation Monitoring**) accurately described the stage change at the mouth of tributaries.

2.5 Recreation and Aesthetics

The effects of the operational scenarios on public recreation facilities and privately-owned improvements used for recreation were observed and assessed, as were aesthetic qualities associated with Thompson Reservoir.

2.5.1 Study Area

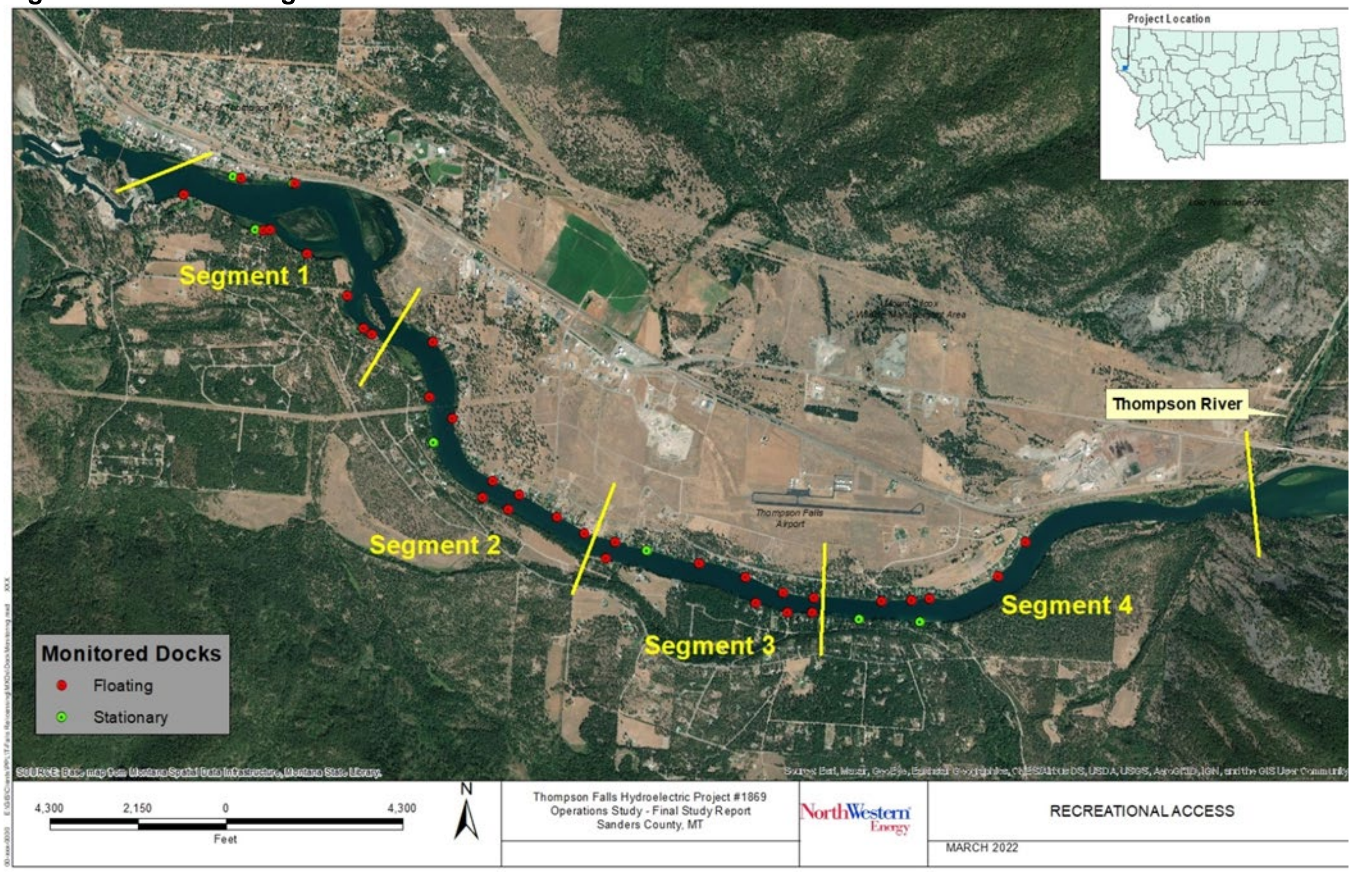
Recreation facilities assessed included facilities along the reservoir shoreline, from the dams upstream to the mouth of the Thompson River. This area includes the two publicly available boat launches at Wild Goose Landing Park and Cherry Creek Boat Launch, as well as facilities associated with private properties and subdivisions. There are no publicly-available and few privately-owned recreation facilities upstream of the Thompson River or downstream of the dams in close proximity to the Project. However, dispersed recreation occurs downstream of the dams. Sandy Beach was monitored for effects to accessibility when flows change.

2.5.2 Study Methods

Reference points were established to monitor recreational access (**Figure 2-8**). These points included a subset of 39 docks that are representative of all docks located along reservoir shorelines and the two public boat launch sites (Wild Goose Landing Park; Cherry Creek Boat Launch), as well as the Salish Shores and North Shore Estates community subdivision boat launches and the privately-owned float plane launch about 600 feet upstream of the boat barrier. To establish the subset of monitoring locations, the reservoir was divided into 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 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

Figure 2-8. Monitoring Locations for Recreation and Aesthetics Evaluation



Due to the shallow and highly varied nature of shoreline access in the reservoir just upstream of the dams, it was anticipated that docks closest to the dams would bear more impact than docks in the upper region of the reservoir, which is deeper and more uniform. Therefore, all docks between the boat barrier and the upper end of Steamboat Island (12 docks) were monitored. Upstream of Steamboat Island, 25 percent of docks (approximately every 4th dock) were monitored in each of the three segments, distributed between the North and South shorelines according to the distribution of all docks that existed at the time of the Operations Study. Monitoring every fourth dock in these three segments resulted in the monitoring of 27 docks in the upper sections, totaling 39 docks on the reservoir overall (18 at south shoreline; 21 at north shoreline).

These established reference points were evaluated during full pool prior to Phase 1 to establish baseline conditions, and then during each half-foot elevation downstream of full pool to observe any impacts to facilities that result from operational fluctuations. Observations targeted changes to the usability of gangways, ramps, and docks, as well as the extent of exposed shoreline or vegetation that may impact accessibility. 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 the impacts to docks and gangways or access ramps resulting from fluctuating water levels.

Public boat launch sites were monitored to determine water depth at the end of the boat ramps as well as at a standard distance of 60 feet from the shoreline measured from the full pool mark. Since the community subdivision boat ramps were gravel and thus had no established end, standardizing the length of the ramps as 60 feet from shoreline allows for comparison across sites. Downstream of the dams, water elevation changes were monitored for impacts to public recreation at Sandy Beach. Reference points along the upstream edge of the Sandy Beach swimming hole and adjacent to the natural pool at the beach were established to monitor and observe the variation in water level and the rate at which those variations occurred. Since each phase of the Operations Study employed different magnitudes of operational changes, it was necessary to evaluate the water elevation at Sandy Beach during all three phases of the Operations Study.

Observations of changes in sediment depth were based on professional judgment and noted as appropriate.

Effects on aesthetic qualities of the Project reservoir were similarly documented. Reference points were established and evaluated for influences from water level changes through photo documentation and observations. Reference points at common public viewing areas including the upper end of Island Park and Wild Goose Landing Park, and at various points upstream of Steamboat Island. These reference points provided a representative sample of viewpoints along reservoir shorelines that approximated views from public and privately-owned properties.

2.5.3 Variances from the FERC-approved Study Plan

The FERC-approved Study Plan (NorthWestern 2021) specified that docks would be monitored twice, once at the full pool elevation prior to the start of the study and once during the lowest reservoir elevation. However, they were monitored more frequently than required by the Study Plan. The docks were monitored at each half-foot elevation below full pool, rather than just the lowest elevation, to provide additional information regarding effects of water level changes on access to docks, which was an enhancement to the Study Plan (NorthWestern 2021).

Water depth at boat launches was measured at the end of the ramps when there was a clear demarcation of the end of the ramp. The boat ramps at Salish Shores and North Shore Estates were gravel and did not have a clear end point. A distance of 60 feet from shore at the full pool elevation was established to standardize monitoring of the Salish Shores and North Shore Estates subdivision gravel ramps as well as the privately-owned sea plane ramp located about 600 feet upstream of the boat barrier on the south shore. Since these gravel-surface ramps have no obvious end point, this standardized distance in lieu of the end of the ramp allows for comparison of water depths.

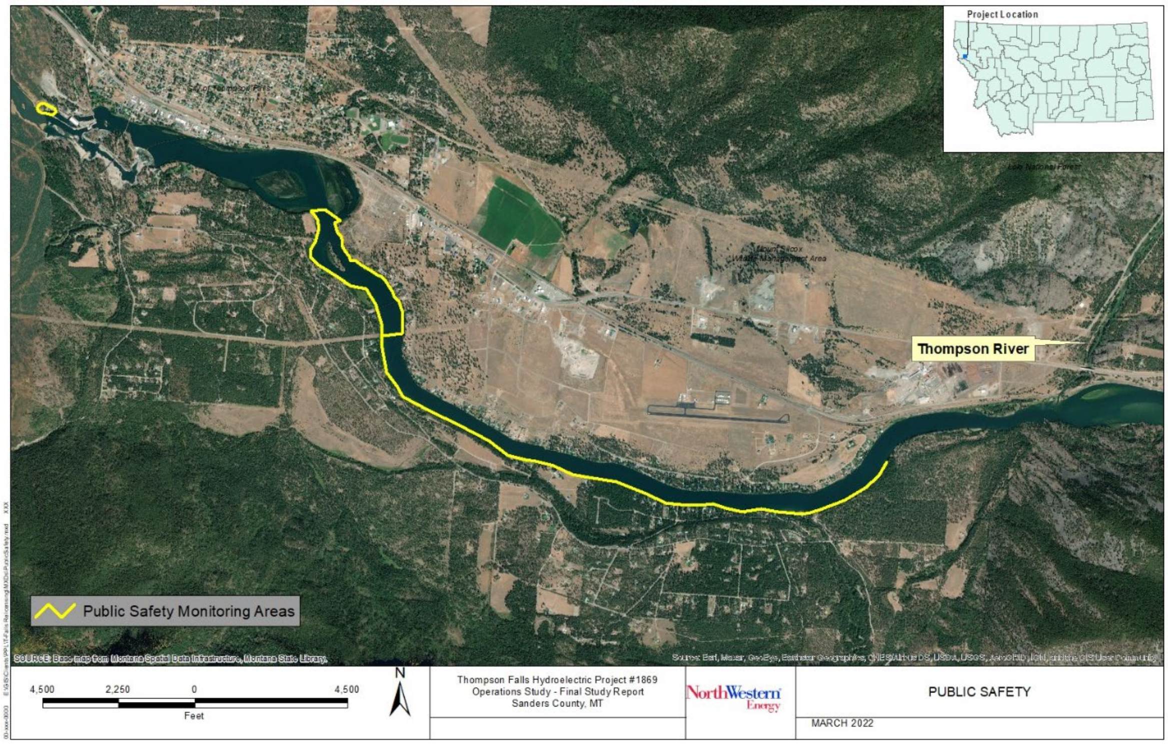
2.6 Public Safety

Impacts to public safety related to water elevation and flow changes were evaluated and monitored during the Operations Study.

2.6.1 Study Area

Water level changes at Sandy Beach, downstream of the original powerhouse, and high-traffic areas in Thompson Falls Reservoir, were monitored for potential hazards relative to public safety (**Figure 2-9**).

Figure 2-9. Areas Monitored for Public Safety



2.6.2 Study Methods

In-water obstacles may become more or less apparent as water conditions change. To better understand the effect of changing reservoir elevations on in-water obstacles, high-traffic areas in Thompson Falls Reservoir were monitored at each half-foot elevation. These assessments aimed to determine the extent of public safety risk, if any, associated with obstacles entering the contact zone[6] due to changing water levels. Reservoir areas of potential shallow water or with known obstacles were the areas of focus.

There are four known rock features within a quarter mile upstream of the upper end of Steamboat Island that have high potential for becoming exposed or are within the depth a boat may encounter. These known locations were monitored for obstacle depth at each half-foot change in elevation. In

[6] Generally defined as the top 2.5 ft of water based on average boat draft (for the types of small power boats used at Thompson Falls Reservoir), which is the distance between the waterline and the deepest part of a boat, or the minimum amount of water required to float a boat without touching the bottom (Boat Draft, 2022).

addition, many areas of the south shoreline are shallow and contain obstacles, so the south shoreline was monitored during static hold times as well. The north shoreline, in general, is much deeper and poses minimal risk to public safety from in-water obstacles.

The main body of the reservoir (from the boat barrier to Steamboat Island) encompasses a number of inundated islands and shoals as well as shallow shoreline areas. These features are generally visible at full pool and lower water levels and thus were not specifically targeted for monitoring.

Sandy Beach, a dispersed recreation area downstream of the original powerhouse, was monitored to determine if the risk to public safety is heightened during flexible generation. As generation increased, the amount of water flowing from the powerhouse also increased. This, in turn, raised the water level and increased flows at areas downstream of the powerhouse, including Sandy Beach. The intent of assessing flow differentials downstream of the powerhouse – both observationally at Sandy Beach and *via* the "Below Powerhouse" water level logger just downstream of there (*see* **Figure 2-4**) - was to determine relative public safety risk to recreationists at Sandy Beach.

2.6.3 Variances from the FERC-approved Study Plan

There were no variances from the FERC-approved Study Plan (NorthWestern 2021).

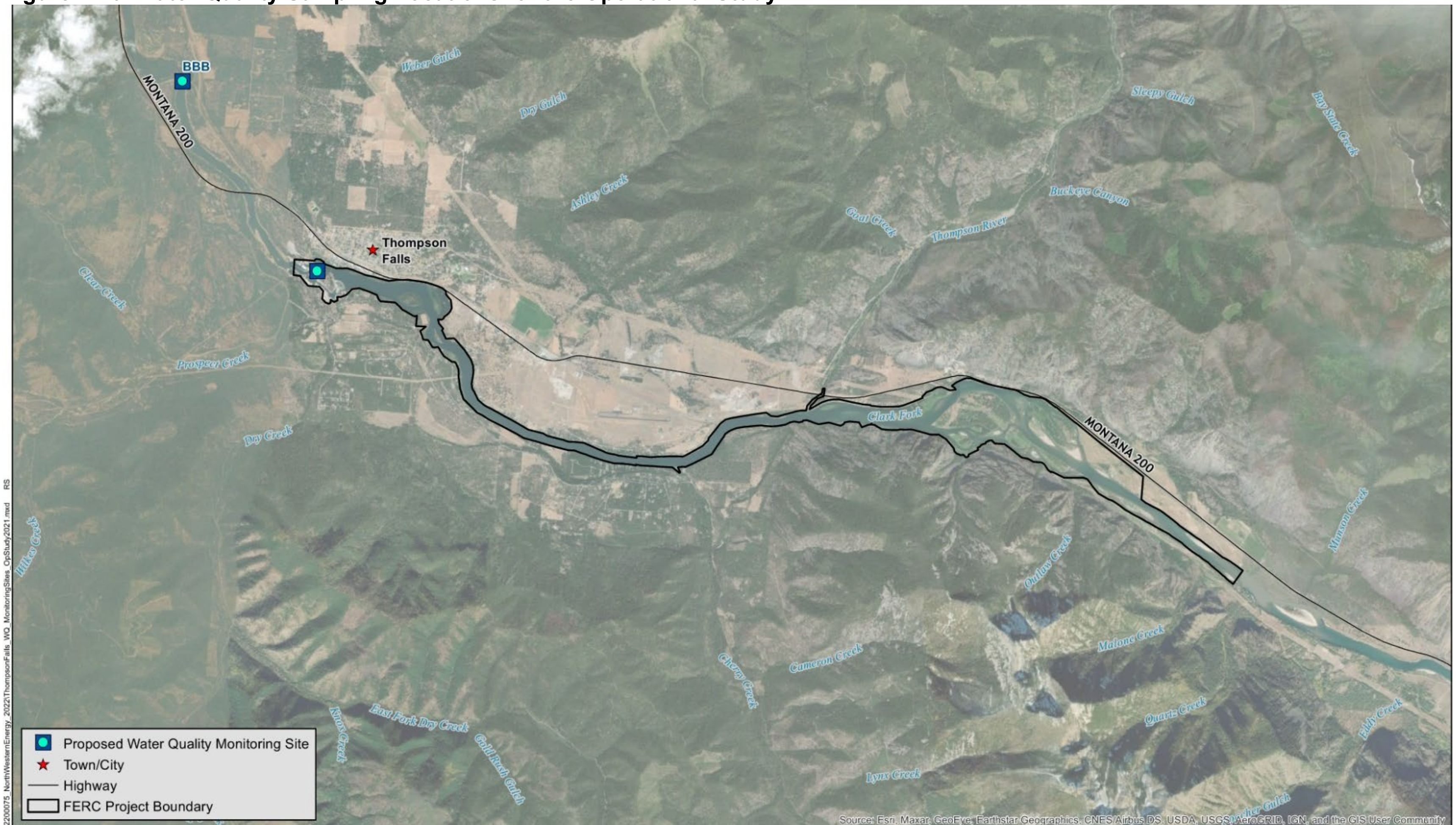
2.7 Water Quality

Water quality was monitored by measuring changes in turbidity and other water quality field parameters upstream and downstream of the Project's facilities. As reservoir levels decreased, the rate of decrease, in conjunction with the reservoir pool level, could potentially have an effect on downstream turbidity.

2.7.1 Study Area

Water quality instruments were deployed on the upstream face of the Dry Channel Dam, and downstream of the Project at Birdland Bay Bridge (**Figure 2-10**).

Figure 2-10. Water Quality Sampling Locations for the Operational Study



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2.7.2 Study Methods

Water quality parameters were measured by two Hydrolab HL7 sondes at 15-minute intervals throughout the three Operations Study phases. One sonde was placed on the upstream face of the dry channel dam (Site AD), and one sonde was placed downstream of the Project at Birdland Bay Bridge (Site BBB). The AD site characterizes the incoming upstream water quality from the reservoir, and the BBB site captures the water quality leaving the Project before it enters the Noxon Reservoir Pool. Any changes to water quality from re-suspension of sediments or other material in the reservoir would be captured at the AD site, while the BBB site shows how that water changes as it passes through either the powerhouse, dam spillway, or both. These sondes collected water temperature, pH, specific conductivity, turbidity, and dissolved oxygen data which were analyzed and compared to reservoir operations data to see if the reservoir operations had an effect on water quality.

2.7.3 Variances from the FERC-approved Study Plan

There were no variances from the FERC-approved Study Plan (NorthWestern 2021).

2.8 Wetlands

2.8.1 Study Area

The wetlands habitat evaluation was conducted at discrete wetland sites in the Project area adjacent to Thompson Falls Reservoir (*refer to* **Figure 2-8**). Sites were selected in the lower (adjacent to and downstream of Steamboat Island) and upper (upstream of the Thompson River confluence) portions of the reservoir where the majority of the wetland habitat exists.

2.8.2 Study Methods

Wetlands were monitored during the Operations Study 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. Ultimately three 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 (**Table 2-1**).

Table 2-1. Wetland Monitoring Sites

Site Name	Site Description	Primary Wetland Classification	Secondary Wetland Classification	Potential Risk of Alteration from Operations
Wetland 1	Side channel near Steamboat Island in Lower Reservoir	Palustrine, Emergent, Temporarily Flooded	Riverine, Unconsolidated Bottom, Permanently Flooded	High
Wetland 2	On Large Island in Upper Reservoir	Palustrine, Aquatic Bed, Semi-permanently Flooded	Palustrine, Forested, Temporarily Flooded	Medium
Wetland 3	On Small Island in Upper Reservoir	Palustrine, Aquatic Bed, Semi-permanently Flooded	Palustrine, Emergent, Temporarily Flooded	Medium
Wetland Control	In Oxbow Upstream of Project Boundary	Palustrine, Aquatic Bed, Semi-permanently Flooded	Palustrine, Emergent, Temporarily Flooded	None (Control Site)

Prior to the Operations Study, level loggers were deployed at the four wetland monitoring sites to track water level changes in these areas throughout the duration of the Operations Study (*refer to* **Figure 2-5).** One monitoring site was selected in the lower portion of the reservoir near Steamboat Island (Wetland 1), two sites were selected in and around the island complex upstream of the confluence with the Thompson River (Wetland 2 and Wetland 3), and one control site was selected upstream of the reservoir (Wetland Control). The purpose of the control site was to capture any natural environmental variability that may occur outside of the influence of dam operations. The control site was of a similar wetland type and physical characteristics as the other three 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.

2.8.3 Variances from the FERC-approved Study Plan

There were no variances from the FERC-approved Study Plan (NorthWestern 2021). 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 Initial Study Report.

2.9 Cultural

2.9.1 Study Area

The Operations Study area consisted of the locations of known archaeological properties that lay at or near the reservoir high water line. These properties are Salish House (24SA0130), for which the specific location is suspected but not verified, a prehistoric and historic artifact scatter (24SA0291), and a Chinese railroad encampment (24SA0593).

2.9.2 Study Methods

NorthWestern conducted a cultural resource reconnaissance during the peak drawdown on September 8, 2021. Reconnaissance efforts were conducted primarily by using a motorized boat drifting at low speed along the exposed reservoir shoreline. Pedestrian inventory was conducted in localized areas where property ownership and shoreline conditions afforded access.

The reconnaissance focused on four segments of the reservoir shoreline. The first of those is the segment along the north shore within Section 22, Township 21 North, Range 29 West. That area is the reported, but unconfirmed, location of Salish House (24SA0130).

The second reconnaissance segment is at the mouth of Cherry Creek and the nearby public boat launch in Section 23, Township 21 North, Range 29 West. There are no previously recorded cultural properties along the shoreline segment, but it is considered a high site probability area because of its proximity to the Cherry Creek confluence.

The third reconnaissance segment was on the north shore at the mouth of the Thompson River in Township 21 North, Range 28 West, Section 18. Meandering pedestrian transects were completed along an exposed gravel bar west of the Thompson River confluence. That gravel bar is within the bounds of 24SA0593, reported to be a railroad construction camp occupied by Chinese laborers.

Finally, pedestrian inventory was conducted along the margin of an elevated wetland area on the reservoir's south shore in Sections 16 and 17, Township 21 North, Range 28 West. There are no previously documented cultural properties in proximity to that wetland area.

2.9.3 Variances from the FERC-approved Study Plan

There were no variances from the FERC-approved Study Plan (NorthWestern 2021).

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3.0 Results

3.1 Operations

The intent of the operations evaluation was to confirm available flexible capacity in the top 2.5 feet of the reservoir, determine reservoir elevation change rates at the different generation rates, and identify any potential operational issues or constraints within the plant and units.

3.1.1 Available Flexible Capacity

Table 3-1 summarizes the available flexible capacity at different reservoir elevations throughout the Operations Study. The average available flexible capacity was 40.5 MW-hour/foot of reservoir, or 101 MW-hour available with the full 2.5 feet of reservoir elevation. The variation in available flexible capacity at different reservoir elevations was relatively minimal, corresponding to the small variance in storage volume at these elevations.

Table 3-1. Average Available Generation Capacity by Elevation.

Elevation Range		Available Flex Capacity
High	Low	(MW-hour/feet)
2396.5	2394.0	40.5
2396.5	2396.0	41.5
2396.0	2395.5	43.3
2395.5	2395.0	38.4
2395.0	2394.5	40.6
2394.5	2394.0	40.5

3.1.2 Plant Operational Observations

The plant and units performed well throughout all three Operations Study phases. No mechanical issues or constraints were identified. The results indicate that NorthWestern can realize the benefits described above.

Note, one issue was identified in the plant controls system logic that allowed the plant to briefly drop below the 6,000 cfs minimum flow during Phase 1. The issue has been rectified and future operations will safeguard against a drop below minimum flow.

3.1.3 Reservoir Elevation Change

Reservoir elevation change is presented for the four identified distinct areas of the Project: Clark Fork River upstream of Thompson Falls Reservoir, Upper Reservoir/Islands, Lower Reservoir, and Downstream of Dams. The results for the Lower Reservoir are presented first as the conditions in this area are described using the output of the instrumentation logged into the PCS. These data therefore represent Project Operations.

3.1.3.1 Lower Reservoir

NorthWestern utilized PCS data to inform and manage Project operations during each phase of the Operations Study. **Figures 3-1, 3-2, and 3-3** illustrate reservoir elevations during the three phases of the Operations Study. These graphs illustrate the random schedule of increasing and decreasing generation, combined with static holds, to evaluate conditions at varying reservoir elevations.

Figure 3-1. Lower Reservoir Elevations during Phase 1 of Operations Study

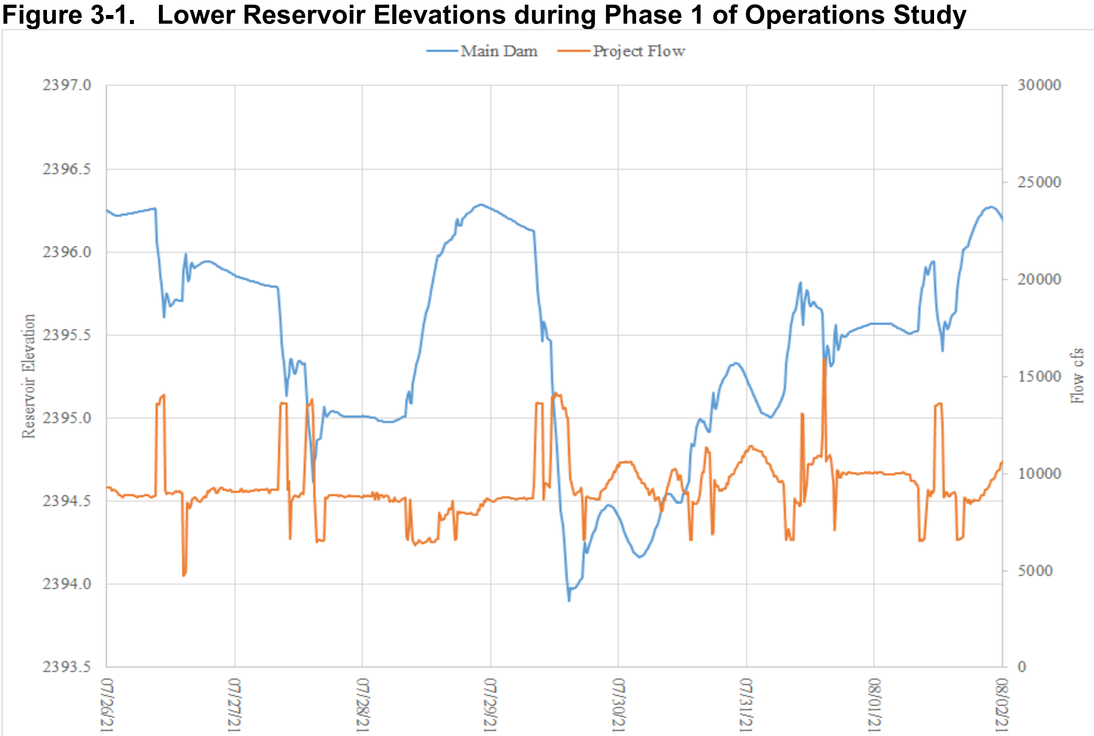


Figure 3-2. Lower Reservoir Elevations during Phase 2 of Operations Study

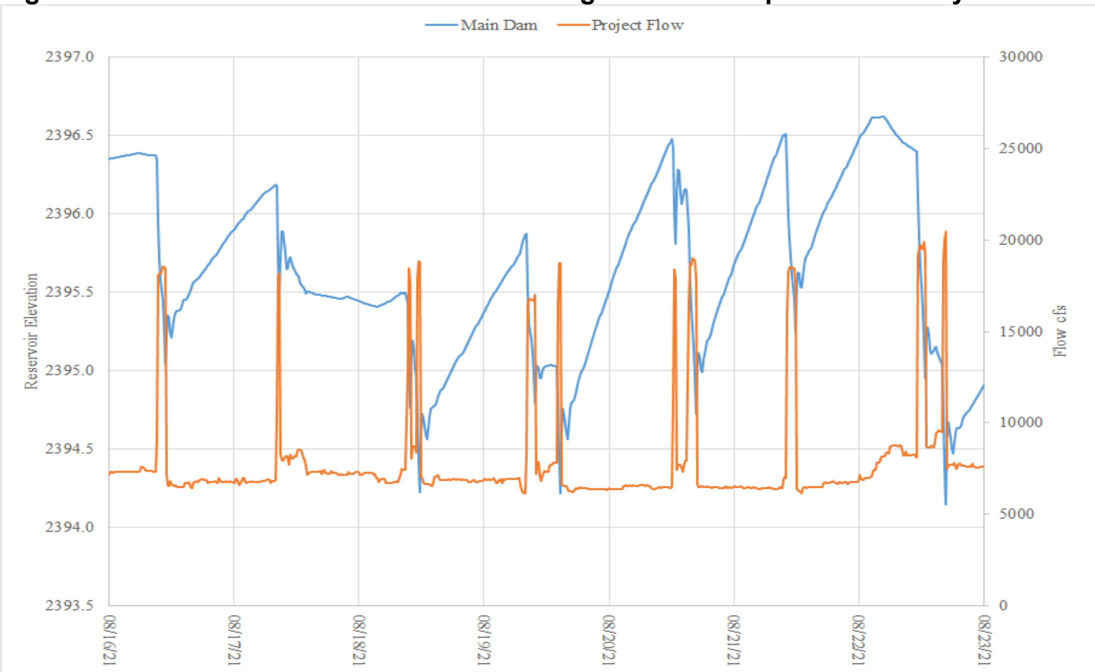
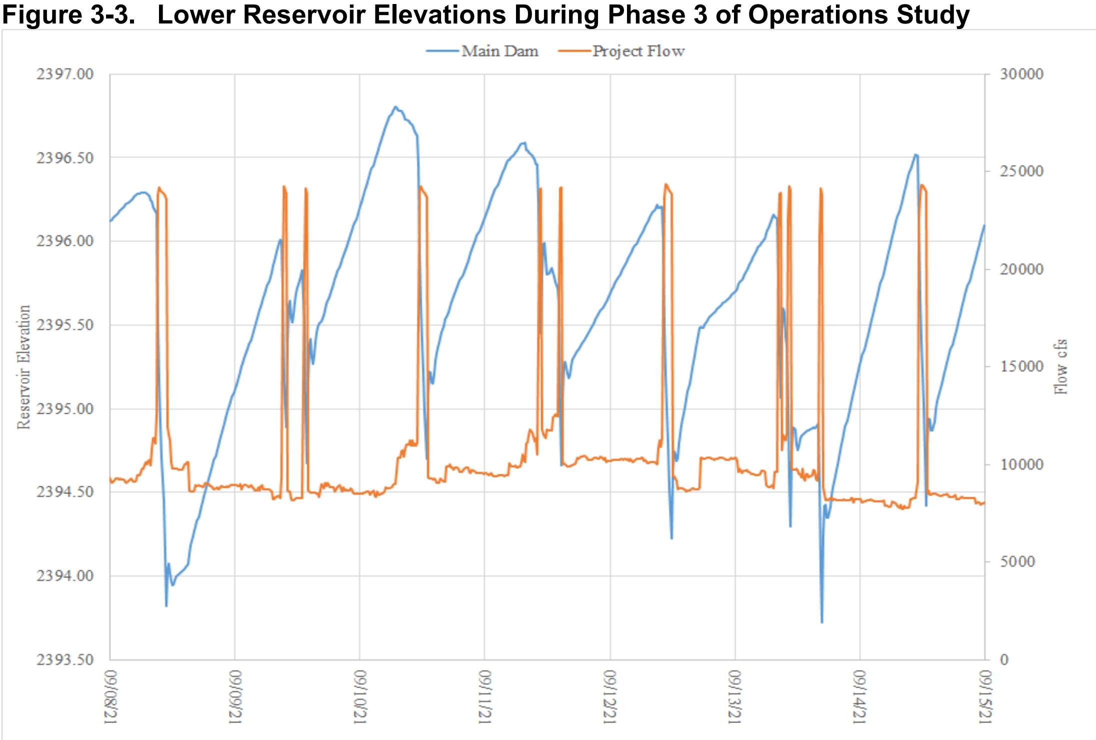


Figure 3-3. Lower Reservoir Elevations During Phase 3 of Operations Study



3.1.3.2 Clark Fork River Upstream of Thompson Falls Reservoir

The magnitude of change to water elevations upstream of the island complex in the upper reaches of the Project were significantly less than those recorded at the Main Dam. Elevation change remained within 0.5 foot during the Phase 1 at the upper sites while the lower reservoir elevation changed 2.5 feet. Similar patterns were observed during Phase 2 with a slightly increased range in elevation change at the upper sites at 0.6 foot. Elevation changes during Phase 3 returned to what was observed during Phase 1 at 0.5 foot.

Figures 3-4, 3-5, and 3-6 represent the elevation changes recorded at the Main Dam and the two upstream-most monitoring sites during the three phases of the Operations Study.

Figure 3-4. Phase 1 Reservoir Elevations at the Main Dam and the Upstream-Most Monitoring Locations and Clark Fork River Inflow

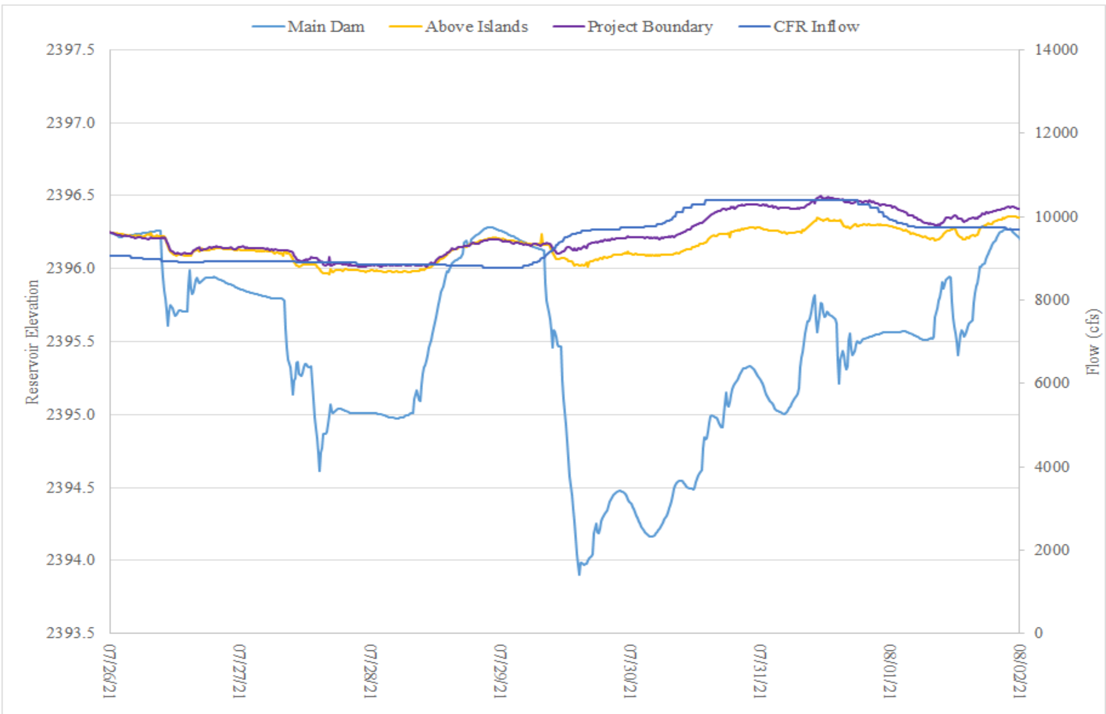


Figure 3-5. Phase 2 Reservoir Elevations at the Main Dam and the Upstream-Most Monitoring Locations and Clark Fork River Inflow

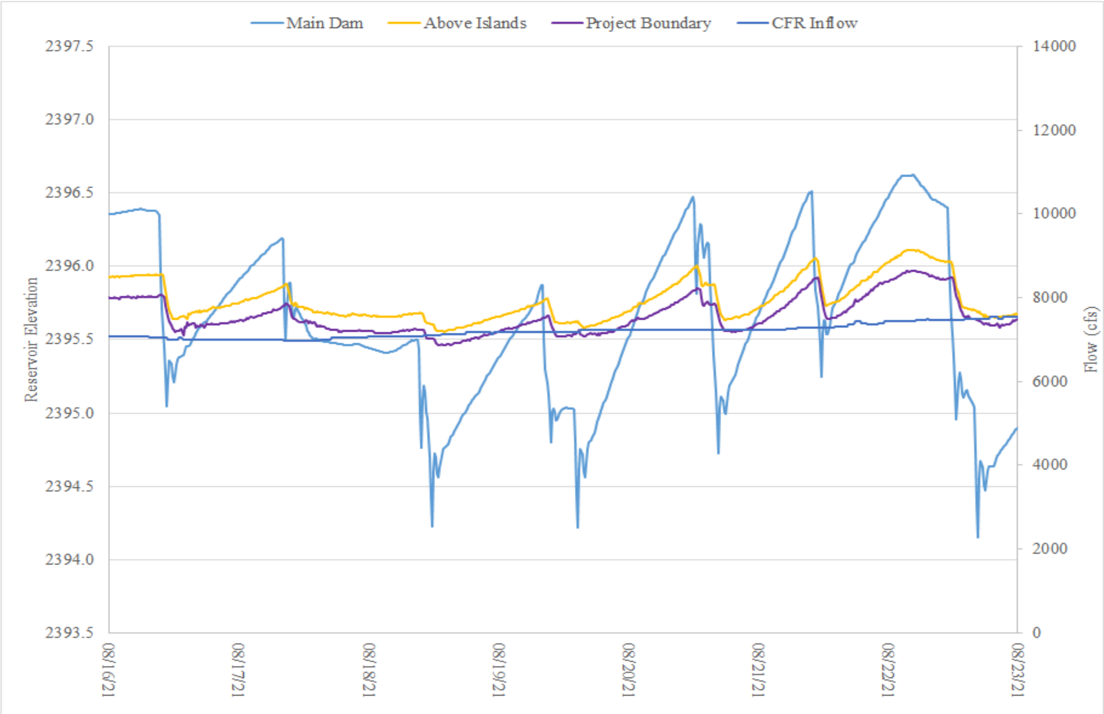
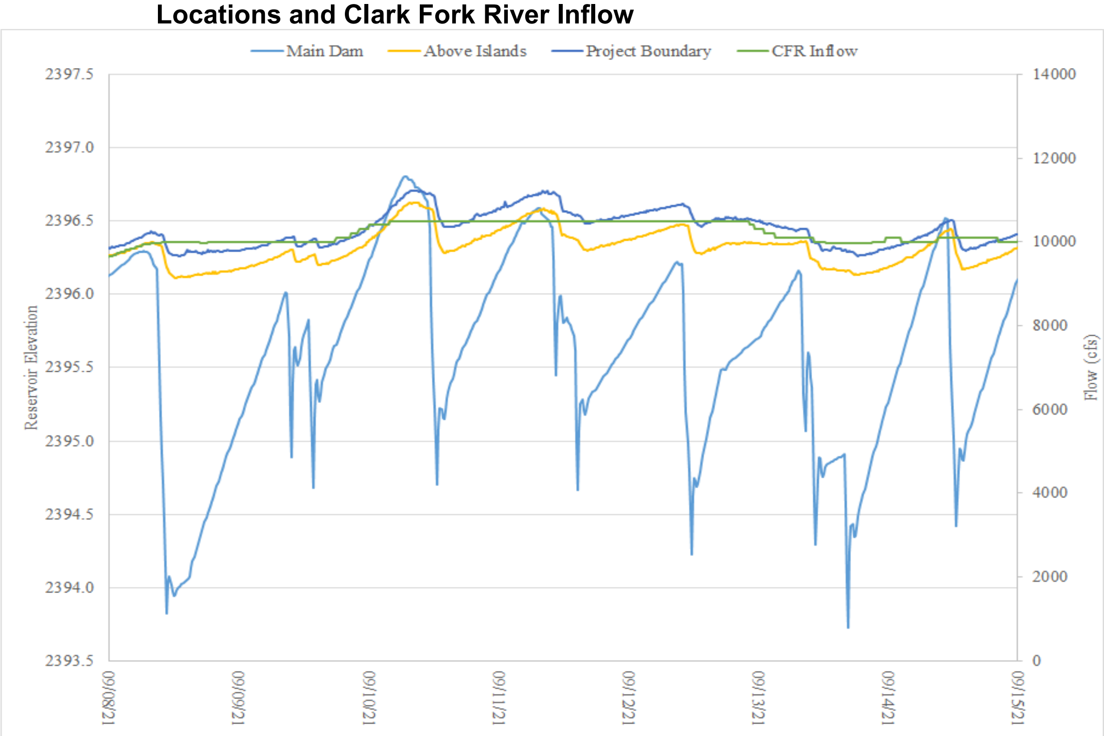


Figure 3-6. Phase 3 Reservoir Elevations at the Main Dam and the Upstream-Most Monitoring Locations and Clark Fork River Inflow



3.1.3.3 Upper Reservoir

The water elevations in the upper reservoir were similar to those observed at the Main Dam during all three Phases of the Operations Study. During Phase 1, the elevation recorded at the Thompson River followed those at the Main Dam with a slight (less than 15 minutes) time delay. The Island site followed the same pattern but the maximum decrease in elevation was about 0.2 foot less than that observed at the Thompson River and the Main Dam.

Patterns of elevation change remained very similar during Phase 2 with a slight increase in elevation differences between sites observed. The minimum elevation observed at the Thompson River was higher than the Main Dam by about 0.1 foot with the minimum elevation increased from the Main Dam at the Island site by 0.6 to 1.2 feet.

Patterns during Phase 3 continued to hold true with more separation observed between minimum elevations at the Main Dam and the Thompson River increasing to 0.3 foot. Minimum elevations observed at the Island site were consistently a foot higher than at the Main Dam during Phase 3.

Figures 3-7, 3-8, and 3-9 demonstrate the elevation changes during Phase 3 at the upper Reservoir monitoring locations.

Figure 3-7. Phase 1 Reservoir Elevations at Upper Reservoir Monitoring Sites

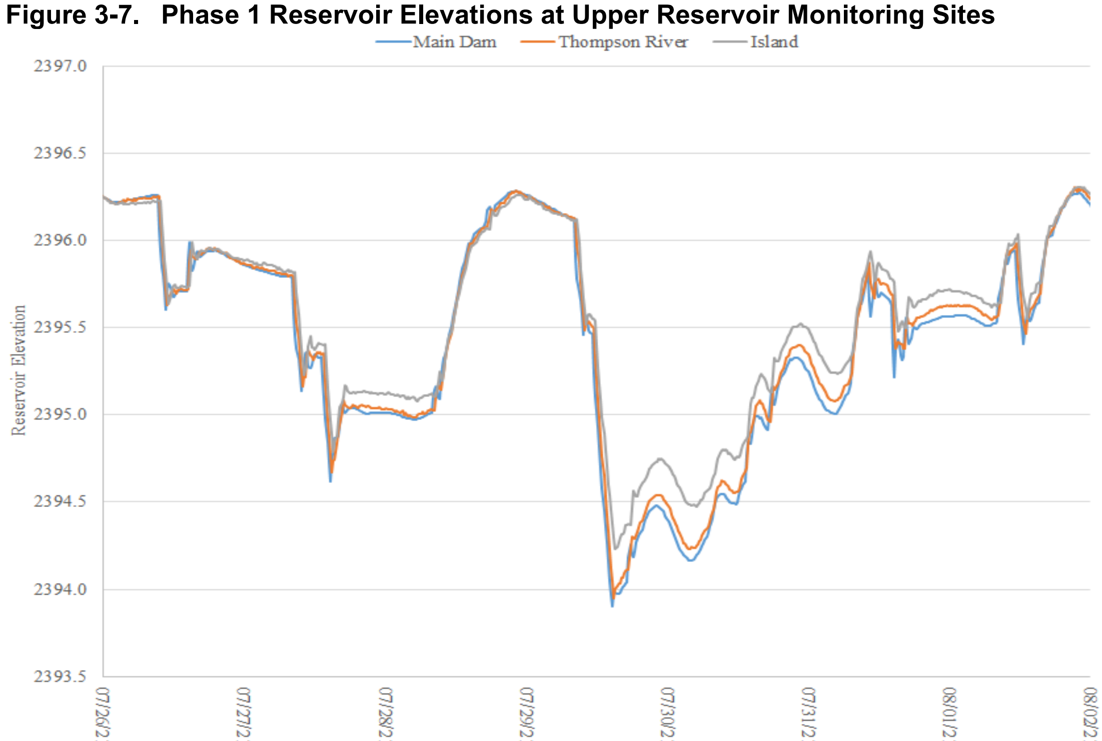


Figure 3-8. Phase 2 Reservoir Elevations at Upper Reservoir Monitoring Sites

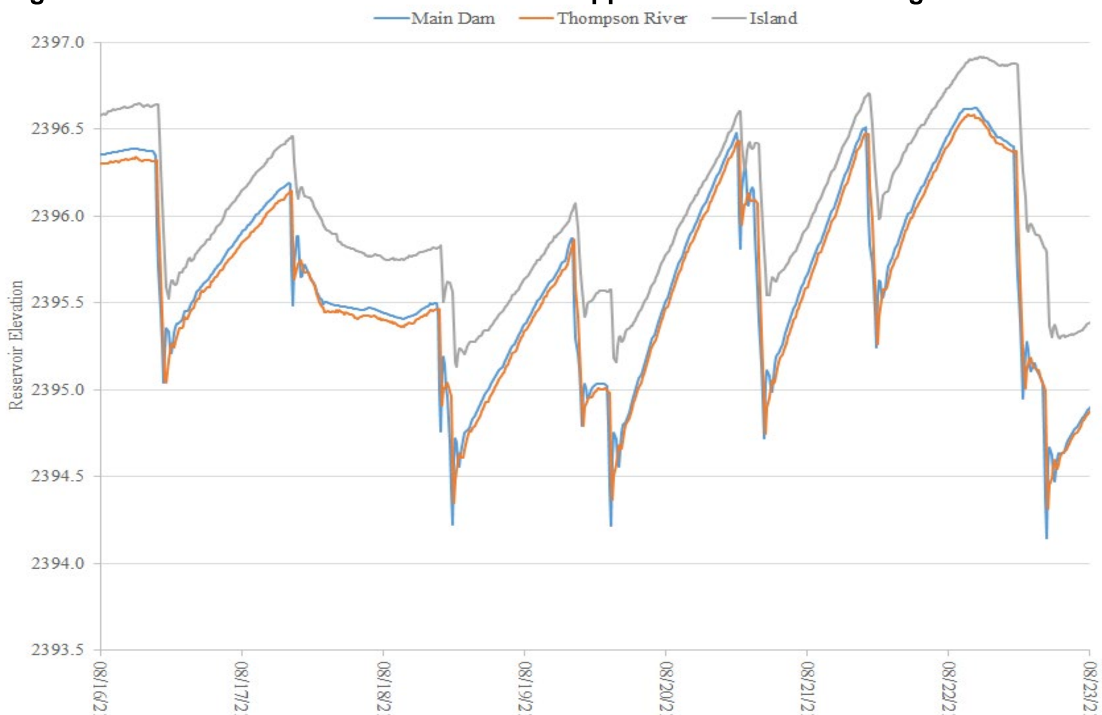
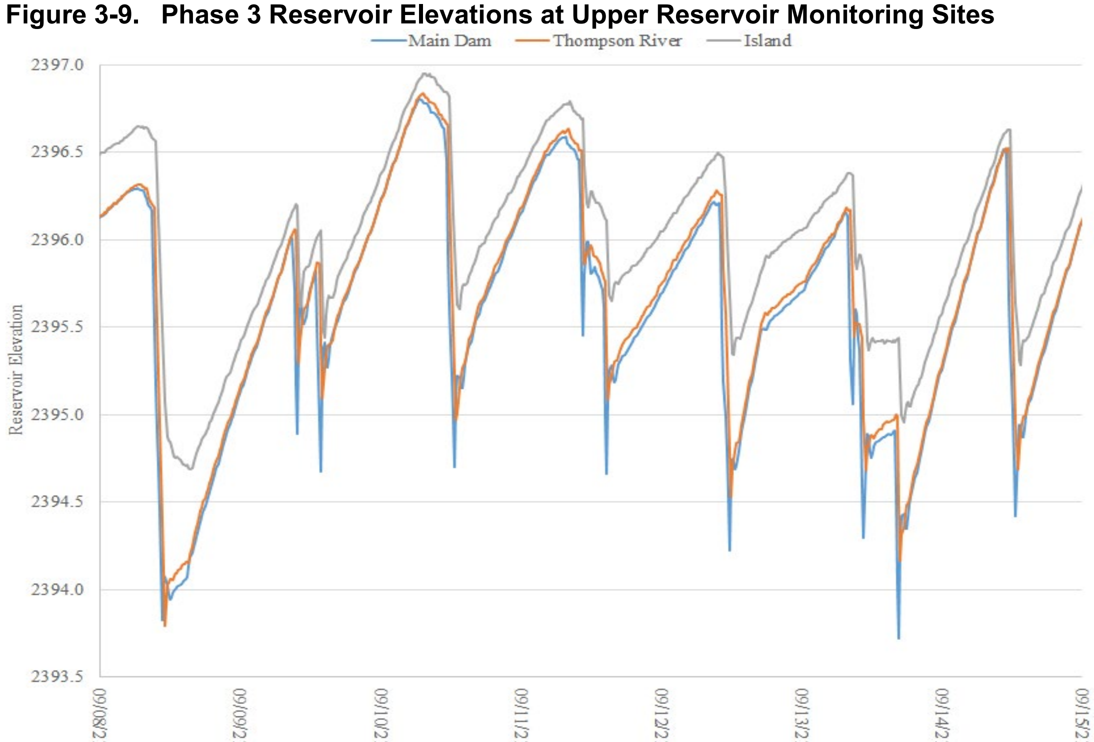


Figure 3-9. Phase 3 Reservoir Elevations at Upper Reservoir Monitoring Sites



3.1.3.4 Downstream of Dams

Elevations downstream of the dam responded to changes in Project operations during all three Phases of the Operations Study. Increases in generation resulted in increased Clark Fork River stage downstream of the Project and reduction in generation resulted in a decrease in stage. Maximum elevation changes of up to 2.4 feet were observed during Phase 1 of the Study at the Tailrace and Below Powerhouse sites. The magnitude of change at Birdland Bay Bridge was reduced to a maximum of about 1.5 feet per operation, with the exception of a reducing trend from July 29 through July 31, which is related to change in elevation in Noxon Reservoir, downstream (Avista Corp., personal communication, March 2, 2022).

Increases in the magnitude of elevation change were observed during Phase 2 with elevations ranged by 3.9 feet. Elevations at BBB ranged 1.9 feet during this same duration. A similar decreasing trend in elevation to that observed during Phase 1 corresponds to changes in Noxon Reservoir elevation from August 18 through August 20.

Elevations fluctuated between 3.9 and 4.1 feet during Phase 3 at the Tailrace and Below Powerhouse sites. Another similar trend related to Noxon Reservoir elevations change was observed during Phase 3 as was seen in Phases 1 and 2 except for in Phase 3 the trends was slightly increasing elevation between September 10 and September 12.

Figures 3-10, 3-11, and 3-12 show the elevations at the three monitoring sites downstream of the powerhouse and flows through the Project.

Figure 3-10. Phase 1 Water Surface Elevations Downstream of the Powerhouses and Project Flow.

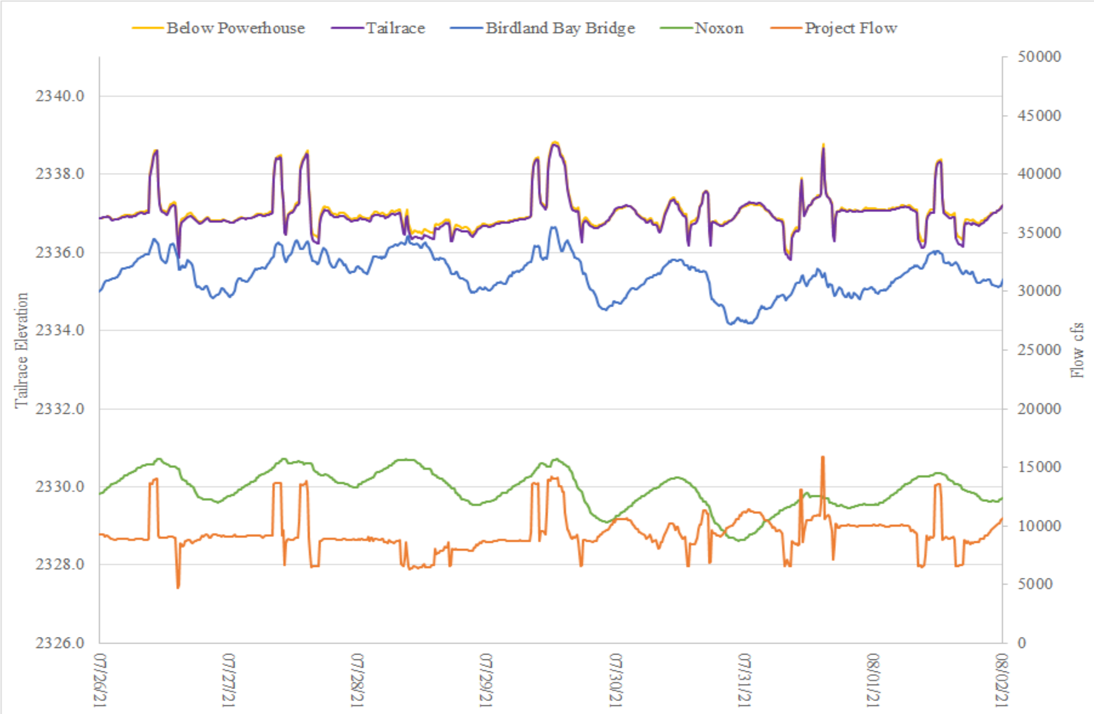


Figure 3-11. Phase 2 Water Surface Elevations Downstream of the Powerhouses and Project Flow.

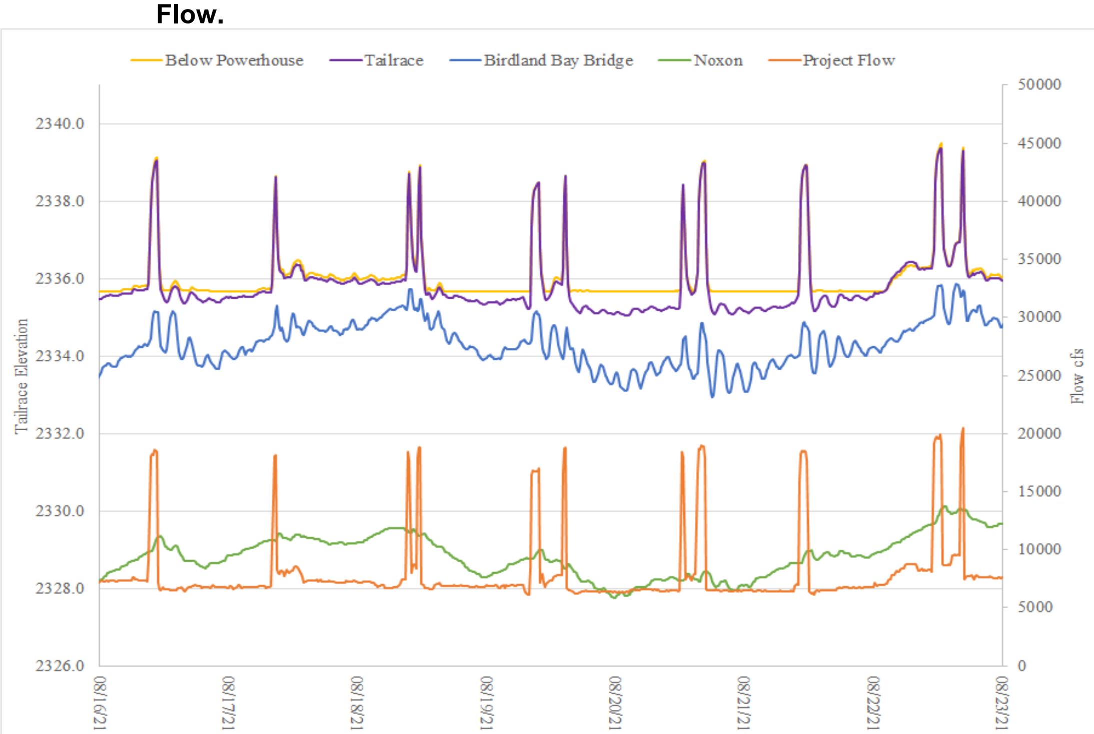
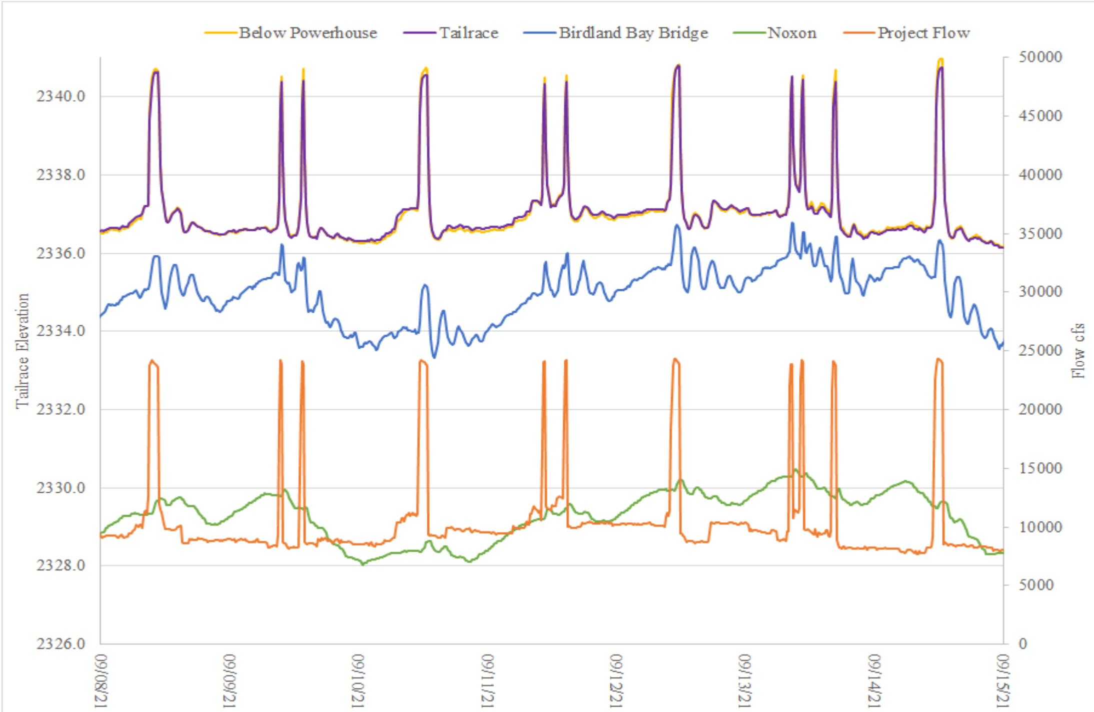


Figure 3-12. Phase 3 Water Surface Elevations Downstream of the Powerhouses and Project Flow.



3.1.4 Reservoir Elevation Rate of Change

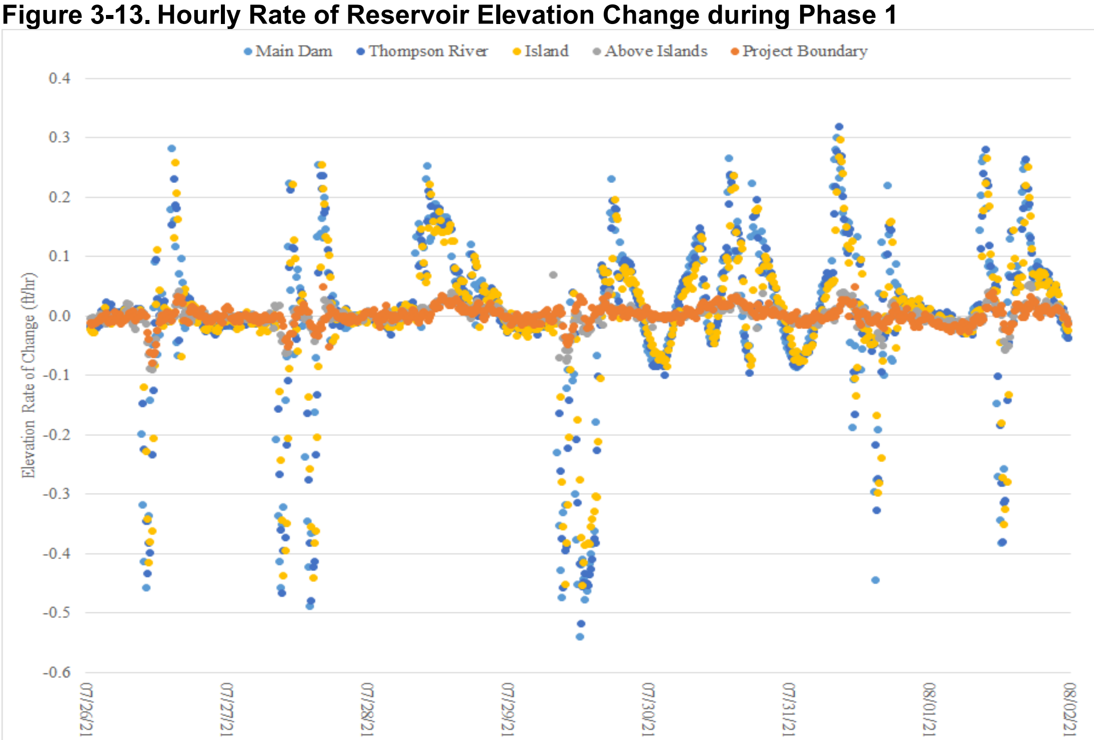
Table 3-2 summarizes the reservoir elevation rate of change at different reservoir elevations throughout all three phases of the Operations Study. These are displayed per 10 MW of flexible capacity. The average throughout the Operations Study was a drop or rise rate of 0.27 foot/hour per 10 MW. Thus a 20 MW increase or decrease action would result in a drop or rise rate of 0.54 foot/hour and a 40 MW increase or decrease action would result in a drop or rise rate of 1.08 foot/hour, on average. There was only minimal variation of the average rate of elevation change at the different elevation levels of the Operations Study.

Table 3-2. Average Elevation Rate of Change by Elevation.

Elevation Range		Average Elevation Rate of change
High	Low	(feet/hour) / 10 MW
2396.5	2394.0	0.27
2396.5	2396.0	0.25
2396.0	2395.5	0.24
2395.5	2395.0	0.29
2395.0	2394.5	0.26
2394.5	2394.0	0.27

Though there was minimal variation in the average rate of change based on reservoir elevation during the Operation Study, variation in the rate of change was observed at different parts of the reservoir. The upper reservoir near the Thompson River downstream to the Main Dam had similar rates of reservoir elevation change. At the Islands site the rate was slightly reduced from the lower reservoir and the area upstream of the islands and at the Project boundary had significantly reduced rate of elevation change throughout each phase of the Study. **Figure 3-13**, **Figure 3-14**, and **Figure 3-15** show the rate of change at all reservoir sites through each phase of the Operations Study. The rates presented below are normalized to foot of elevation change per hour with a negative rate reflecting a drop in reservoir elevation whereas a positive rate reflects an increase in reservoir elevation. An hourly rate of change of zero reflects conditions where inflows to the Project are approximately equal to the Project outflows resulting in no change in reservoir elevation.

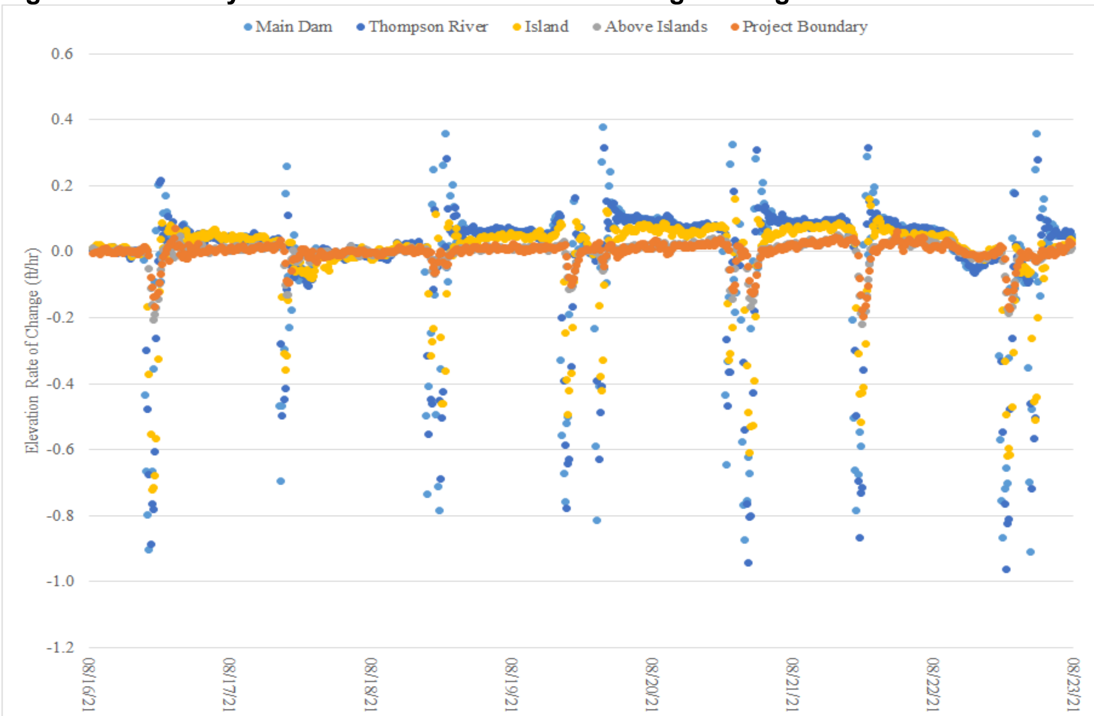
Figure 3-13. Hourly Rate of Reservoir Elevation Change during Phase 1



The most rapid elevation reduction recorded during Phase 1 of the Operation Study was at the Main Dam with a rate of approximately 0.5 foot per hour (ft/hr). Rates at the Thompson River and the Island sites were very similar to those observed at the dam. At the Above Islands site, the maximum rate of elevation reduction observed was about 0.09 ft/hr and 0.08 ft/hr at the Project Boundary.

The maximum rate of increase in reservoir elevation during Phase 1 was approximately 0.3 ft/hr as observed at the Thompson River site and at the Main Dam. The smallest rate of increase of elevation was observed at the Project Boundary site at 0.05 ft/hr.

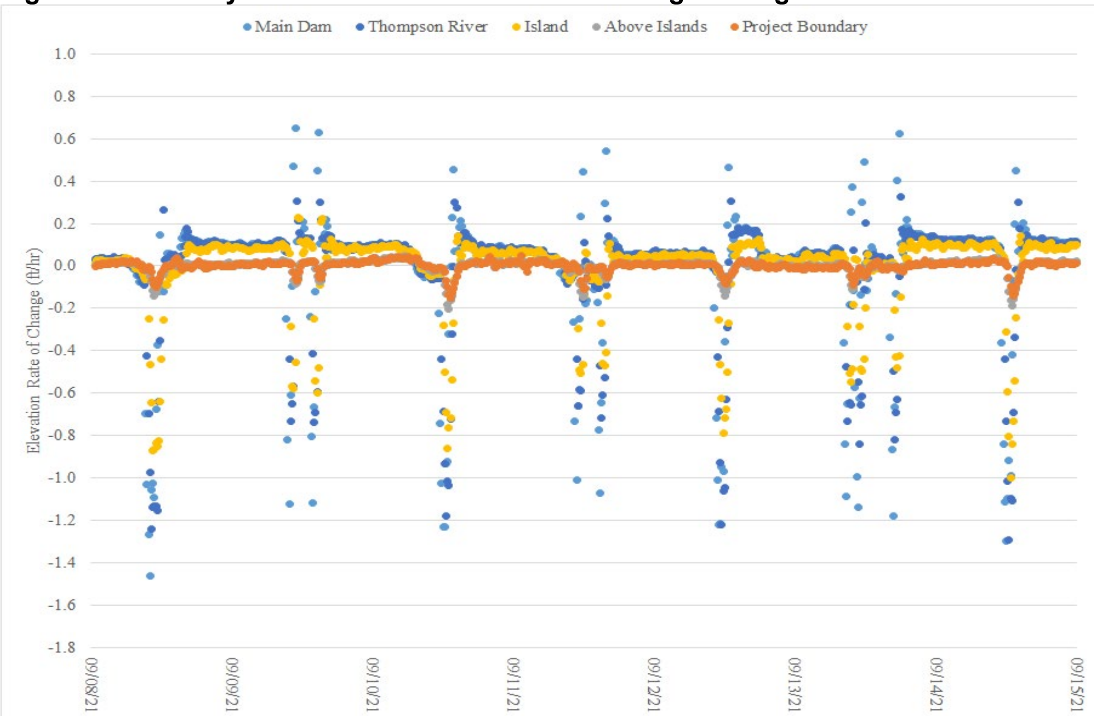
Figure 3-14. Hourly Rate of Reservoir Elevation Change during Phase 2



The largest rate of elevation reduction recorded during Phase 2 of the Operation Study was at the Thompson River and the Main Dam at 0.96 and 0.91 ft/hr, respectively. Rates at the Island site were reduced at 0.7 ft/hr and upstream of the island complex the maximum rate of elevation reduction observed at about 0.2 ft/hr at both the Above Island and Project Boundary sites.

The maximum rate of increase in reservoir elevation during Phase 2 was approximately 0.4 ft/hr as observed at the Main Dam. The smallest rate of increase of elevation was observed at the Above Island site at 0.05 ft/hr.

Figure 3-15. Hourly Rate of Reservoir Elevation Change during Phase 3



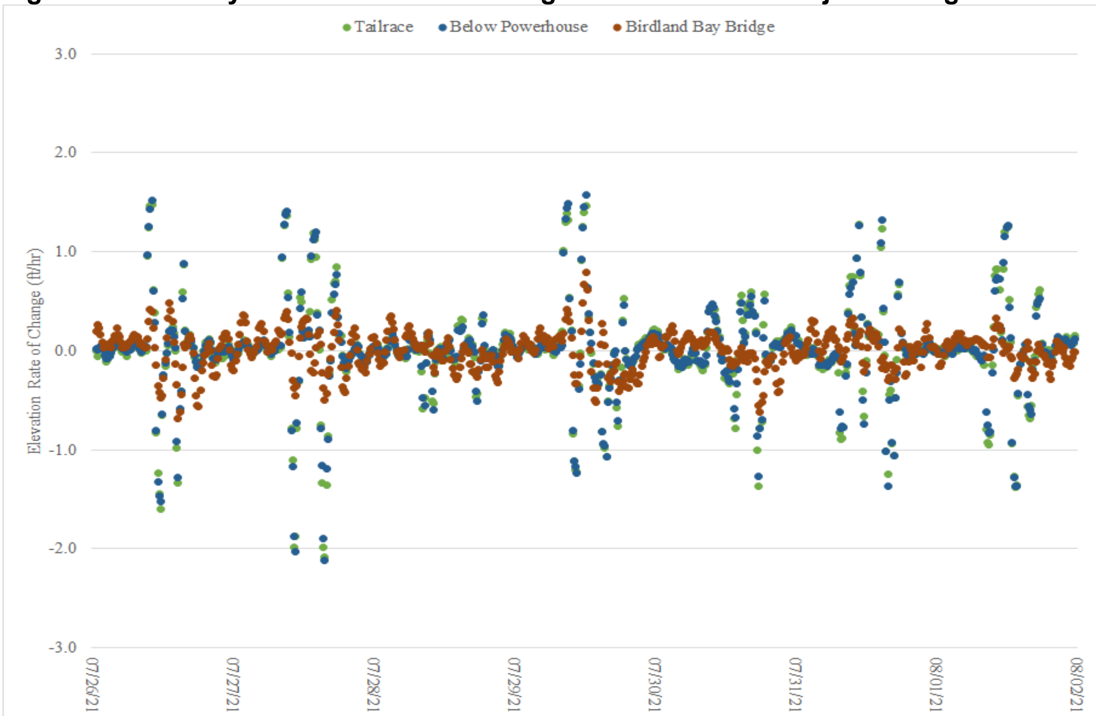
The fastest rate of elevation reduction recorded during Phase 3 of the Operation Study was at the Main Dam at 1.46 ft/hr, at 1.25 ft/hr at the Thompson River, and 1.0 ft/hr at the Island site. Upstream of the island complex the rate was significantly reduced at 0.20 and 0.15 ft/hr at the Above Island and Project Boundary sites, respectively.

The maximum rate of increase in reservoir elevation during Phase 3 was approximately 0.65 ft/hr observed at the Main Dam. The smallest rate of increase of elevation was observed at the Above Island and Project Boundary sites at 0.05 ft/hr.

3.1.5 Downstream of Dam Elevation Rate of Change

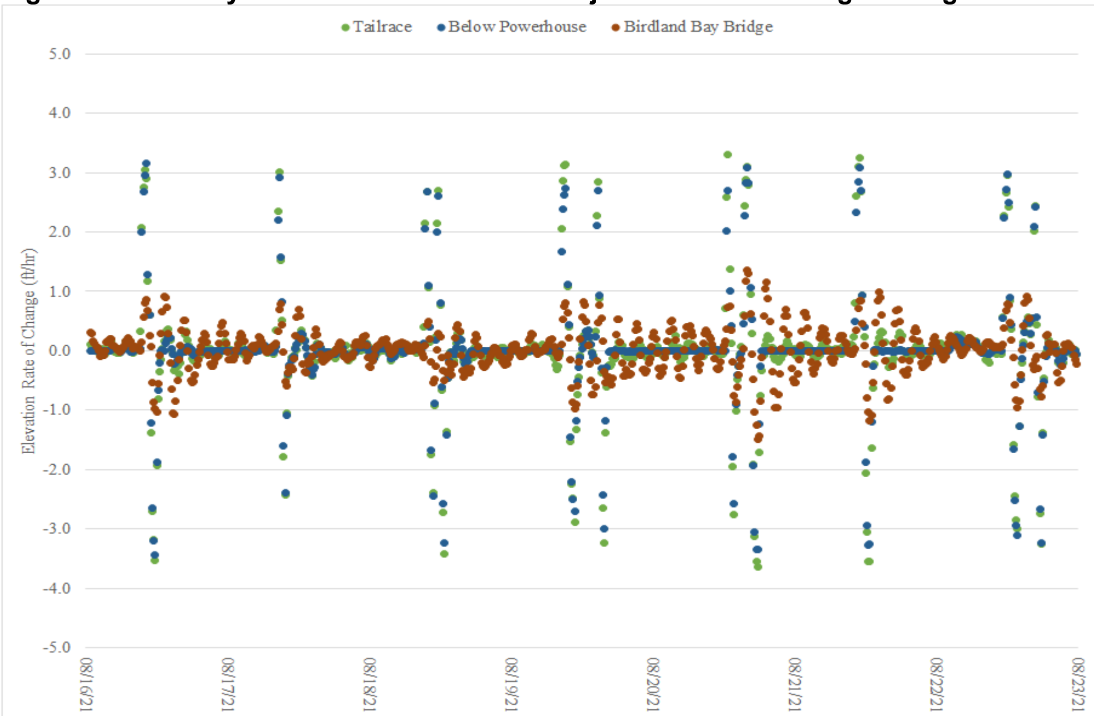
Variation in rates of change of Clark Fork River elevation (stage) were observed downstream of the Project during the Operation Study with the rate of change attenuated in the downstream direction. The observed rates of change were very similar in the tailrace directly downstream of the powerhouses and 0.3 miles downstream at the Below Powerhouse Site. Reduced rates were observed at Birdland Bay Bridge, approximately 2.5 miles downstream. **Figure 3-16, Figure 3-17, and Figure 3-18** show the rate of change at the Clark Fork River sites downstream of the Project through each phase of the Operations Study. The rates presented below are normalized to foot of elevation change per hour with a positive rate reflecting an increase in Clark Fork River stage whereas a negative rate reflects a decrease in river stage. An hourly rate of change of zero reflects a stable river stage resulting in a relatively uniform flow condition downstream of the Project.

Figure 3-16. Hourly Rate of Elevation Change Downstream of Project during Phase 1



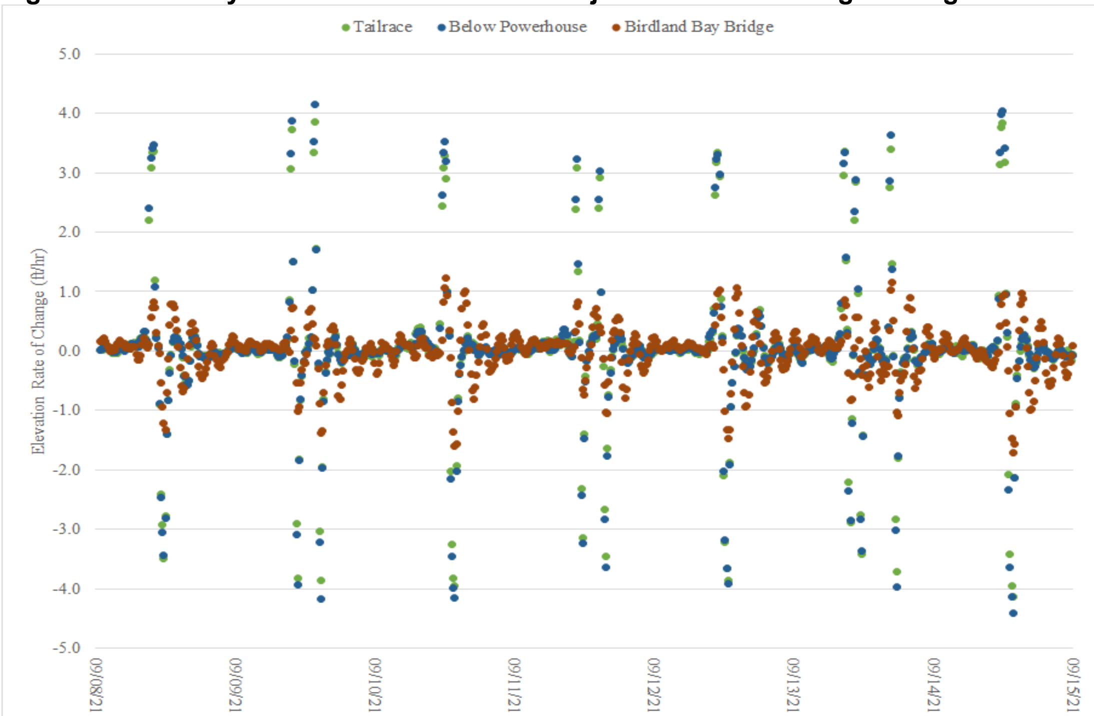
Rates of change downstream of the Project during Phase 1 ranged from a maximum increase in stage of 1.5 ft/hr downstream of the powerhouse to about 0.8 ft/hr at Birdland Bay Bridge downstream. Rates of decreasing stage were recorded at approximately 2.1 ft/hr at the Tailrace and Below Powerhouse sites and reduced to 0.7 ft/hr at Birdland Bay Bridge. Rates recorded at the Tailrace and Below Powerhouse sites were very close for both increases and decreases in stage, within 0.1 ft/hr, during Phase 1.

Figure 3-17. Hourly Rate of Downstream of Project Elevation Change during Phase 2



During Phase 2, maximum rates of increasing stage were observed at 3.30 ft/hr in the Tailrace, were very slightly reduced to 3.2 ft/hr at Below Powerhouse, and at 1.4 ft/hr at Birdland Bay Bridge. The maximum rate of decreasing stage recorded during Phase 2 was also in the Tailrace, at 3.6 ft/hr, and 1.5 ft/hr at Birdland Bay Bridge. The difference between the Tailrace and Below Powerhouse sites were slightly greater during Phase 2 than Phase 1, with about 0.2 ft/hr difference observed between the Tailrace and Below Powerhouse sites.

Figure 3-18. Hourly Rate of Downstream of Project Elevation Change during Phase 3



Largest rates of stage increase during Phase 3 were observed at the Below Powerhouse site at 4.2 ft/hr. The rate of increasing stage at BBB during Phase 3, at 1.2 ft/hr, was reduced slightly from Phase 2 at 1.4 ft/hr. Rates of decreasing stage were also observed to be the greatest at the Below Powerhouse site at 4.4 ft/hr and much reduced at BBB at 1.7 ft/hr. The differences observed for increasing and decreasing rates between the Tailrace and Below Powerhouse sites increased slightly during Phase 3 to 0.3 ft/hr.

3.2 Shoreline Stability

3.2.1 Summary of Shoreline Evaluation Results

Erosion related to fluctuating reservoir levels was not observed. However, the 300-foot long reaches at all nine study reference points showed 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. The amount, type and causes of erosion changed minimally over the course of the Operations Study (Table 3-3). For example, a mostly vertical bank that was experiencing bank undercutting and sloughing due to spring runoff did not perceptibly change through all six monitoring events. 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.

NorthWestern has historically observed more shoreline instability on the south shoreline than on the north[7], especially on Land Facet[8] 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.

[7] Quaternary geomorphic mapping specific to the Project was conducted by Geowest (1981). Geowest mapped a series of units along the Project defined as “land facets”. The land facets are divided based on the geomorphic characteristics (fluvial terrace, alluvial fans, etc.), topographic position, as well as the material properties of the land facet verified through test pitting.

[8] A land facet is a recurring area of relatively uniform topographic and soil attributes

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Table 3-3. Summary of Observations of Shoreline Stability

Ref Point	Land Facet	North or South Shore	Percent Erosion 10/8/20	Percent Erosion 4/19/21	Percent Erosion 7/13/21	Percent Erosion 8/6/21	Percent Erosion 9/1/21	Percent Erosion 9/16/21	Comments
1	unknown	North	0-10	0-10	0-10	0-10	0-10	0-10	Minimal rill and gully erosion associated with foot paths; erosion close to 0%
2	10(1)	South	0-10[9]	0-10	0-10	0-10	11-30	11-30	Minor bank undercutting due to spring runoff. No notable current or historic shoreline stability issues.
3	9(2)	North	0-10	0-10	0-10	0-10	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	51-70	31-50	71-100	31-50	71-100	71-100	Significant amount of bank slumping and undercutting caused by spring runoff and periodic falling of trees and associated bank damage.
5	10(1)	South	0-10	0-10	11-30	0-10	0-10	11-30	Shoreline stabilization project completed in 2020 at this site. Bank undercutting was the most common, with spring runoff and boat wakes causes.
6	9(2)	North	0-10	0-10	11-30	0-10	11-30	11-30	Rill or gully erosion caused by footpaths and removal of native vegetation. Highly stable.
7	10(1)	South	0-10	0-1-	0-10	0-10	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.

[9] Reference point shift upstream between monitoring events 4 and 5 to an area with 11 – 30% erosion

Ref Point	Land Facet	North or South Shore	Percent Erosion 10/8/20	Percent Erosion 4/19/21	Percent Erosion 7/13/21	Percent Erosion 8/6/21	Percent Erosion 9/1/21	Percent Erosion 9/16/21	Comments
8	8(2)	South	11-30	11-30	0-10	11-30	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 erosion. A native rock armored shoreline above the water's edge is resistant to current active erosion.
9	10(1)	South	71-100	51-70	71-100	71-100	71-100	71-100	Actively eroding shoreline with near vertical banks, slumps, and undercutting caused by spring runoff and potential ice scour.

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 not exhibit notable 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 resolved the issue. Reference Point #7 likely had a significant amount of shoreline instability at one time, but a shoreline stabilization project completed sometime in the last 10 to 20 years has addressed this issue. Reference Point #9 displayed the most shoreline instability of all reference points. The reservoir is mostly riverine in this area and higher water velocities of 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 having more shoreline instability, but it nonetheless had a significant amount of shoreline instability.

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.

In addition to specific data collected at the nine reference points, general observations were also made of both the south and north shorelines during the Operations Study. As has been the case historically, more shoreline instability was observed on the south shoreline than the north.

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.

All six monitoring events indicated shoreline erosion was 0 to 10 percent, with minimal erosion observed (closer to 0% than 10%). 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. A slight increase in this type of erosion was observed due to increased foot traffic after public recreation improvements (picnic tables, docks, and lawn) were placed within the 300-foot reach between the July 13 and August 6, 2021, monitoring events. Anecdotal evidence suggests little public use occurred in this area before these recreation improvements were erected in July 2021, and more use occurred afterwards.

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 four monitoring events indicated 0 to 10 percent erosion and the last two indicated 11 to 30 percent. However, it was determined afterwards that the location of the reference point was shifted upstream by approximately 15 feet between monitoring events four (August 6, 2021) and five (September 1, 2021) which encompassed an area with more erosion. Upon review of the reference point photos, it was determined that erosion remained in that 0 to 10 percent range if the shift had not occurred. 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. A less common type of observed erosion was rill or gully erosion caused by a footpath created by human traffic and perhaps accentuated by wildlife use.

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 by the Yellowstone pipeline crossing (downstream 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. 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.

All six monitoring events indicated 0 to 10 percent erosion. Rill or gully erosion caused by a footpath was observed and became exacerbated by the placement of a wood railing along the trail by a third party. The wood railing channeled water from runoff and irrigation above concentrating the volume, velocity and erosive power of the water. Surface runoff from the pipeline tower pad located at the top of this reference point also caused some 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.

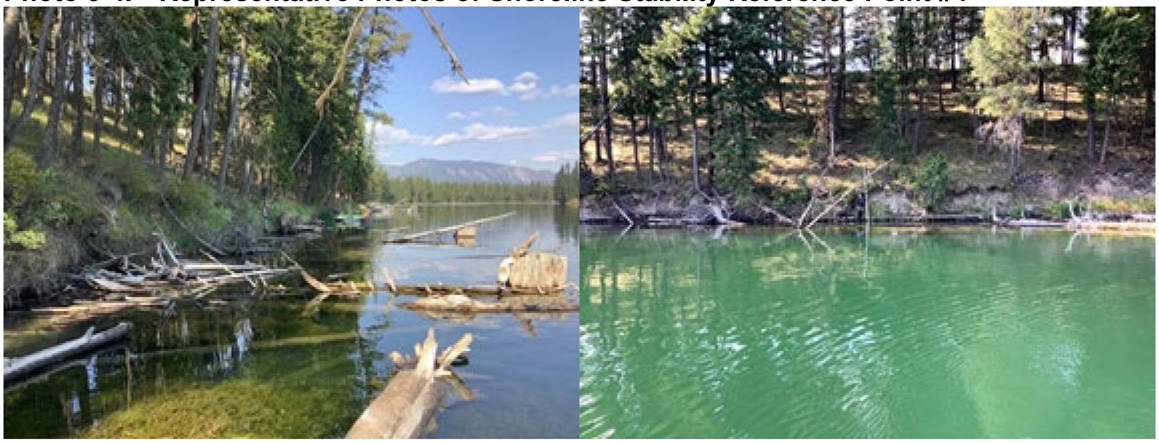
Reference Point #4

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. Land is privately owned on approximate downstream half, and NorthWestern-owned on the approximate upstream half. 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.

Two of the six monitoring events indicated 31 to 50 percent erosion, one indicated 51 to 70 percent erosion and three indicated 71 to 100 percent erosion. Review of the photos from all six monitoring events suggests the variability in the percentages had more to do with the data collection challenges such as changes in shoreline vegetation. 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 (including 1 that fell during the Operations Study). 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 cause.

Visits to this reference point provided valuable observations regarding boat wakes and their impact on shoreline stability. A few boats passed by while conducting monitoring at this reference point allowing for their wakes to be observed. Where the wakes encountered woody materials (e.g., stumps and logs) the wake tended to be quickly dissipated with little, if any, of the wake reaching the shore. Likewise, when wakes encountered emergent aquatic vegetation. For submergent aquatic vegetation, there was some dissipation, but much less. Boat wakes did cause the sediment to be stirred up along the shoreline creating some turbidity about a foot out from the shore. However, this was just resuspension of deposited sediment next to the shore *versus* erosion of upland soils.

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 entities. 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 (pilot 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. 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.

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

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.

The six monitoring events indicated 0 to 10 percent or 11 to 30 percent erosion. Bank undercutting was the most common form of erosion with 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.

Reference Point #6

This point is a 300-foot-long segment of shoreline on the north shore, across from and just a little 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 entities. and land management is private residential and open-space. **Photo 3-7** contains two representative photos of this reference point.

All six monitoring events indicated either 0 to 10 percent or 11 to 30 percent erosion. 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. However, this reach is a generally 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 downstream 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, but a few trees and shrubs. Land along shore is owned by NorthWestern, and behind the shoreline by private entities. Land management is private residential and open-space. **Photo 3-8** contains two representative photos of this reference point, which appears to be a shoreline stabilization project completed years ago and consists of a sloped-back bank with a rock toe.

All six monitoring events indicated 0 to 10 percent erosion. 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 entities. Land management is forested open-space. **Photo 3-9** contains two representative photos of this reference point.

Five of the six monitoring events indicated 11 to 30 percent erosion and one indicated 0 to 10 percent. 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 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 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 entities. Land management is natural forest transitioning to private residential, as the area was recently subdivided; campers are appearing, and homes may follow. **Photo 3-10** contains two representative photos of this reference point.

Five of the six monitoring events indicated 71 to 100 percent erosion and one indicated 51 to 70 percent erosion. 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.

3.2.3 Additional Shoreline Stability Observations

Notable shoreline stability issues occurred in a few areas along the shoreline outside of the nine reference points. Two windstorms occurred in the spring of 2021, resulting in eight uprooted trees that were observed along the reservoir's edge between the boat barrier and the islands during the April 19, 2021, monitoring event. Uprooted trees created pockets of erosion as the uprooting tore out sections of the bank (**Photo 3-11**). In most cases, the landowner or adjacent homeowner took measures to remove the tree and stabilize the shoreline.

Photo 3-11. Tree Uprooted by Windstorm and Resulting Damage to the Bank

A 15-foot-long and 4-foot-high section of shoreline near the last few developed properties on the south shore, just upstream of the mouth of Cherry Creek, was observed to have slumped off into the reservoir (**Photo 3-12**). Based on conversations with neighboring landowners, the erosion had been occurring for a while (not just since spring 2021) and the cause of the bank slumping is attributed to the rock rip-rap just upstream (on the left side of the photo) which may have created a nick point.

Photo 3-12. Slumped Shoreline – Nick Point Created by the Upstream Rock Rip-rap (left side of photo)

On August 31, 2021, observations were made of shoreline stability from the Thompson River to the upstream end of the Project boundary. This area is more riverine than the area downstream of the Thompson River, and the observations are consistent with riverine conditions. Erosion, deposition, and August water levels well below the high-water mark were all observed. The area around the islands in particular demonstrated active bank sloughing and undercutting (**Photo 3-13**) from spring runoff and perhaps even from lower water flows. Where the shoreline is composed of finely grained material (sands/silts/clay), vertical banks up to 6 feet tall were common, with bank sloughing also common. This shoreline condition existed on both the island shorelines and the mainland shoreline, but more prevalent on the island shorelines since some of the mainland shoreline in this area is bedrock or large rock. The water is shallower in this area, and it is located further away from the City of Thompson Falls and public boat launches, so this area likely gets much less boat traffic than other portions of the reservoir. Erosion in this area is most likely due to ice scour and water current since it is more riverine in nature. Erosion is not the only process that is occurring, however, as areas of deposition were also noted in the islands area (**Photo 3-14**). In essence, the shapes, sizes and locations of the islands are always shifting which would be expected in a normally functioning riverine system.

Photo 3-13. Example of Bank Sloughing and Undercutting in Island Area

Photo 3-14. Sediment Deposition in Islands Area

The August 31, 2021, water levels were far below the high-water mark even though the Project was considered to be at full pool (**Photo 3-15**). This suggests Project operations have little if any influence on shoreline stability, erosion and deposition in the area upstream of the islands, and instead spring runoff is the dominant influence in this area.

Photo 3-15. High-water Mark, Upper End of the Project Boundary. Reservoir at Full Pool

3.3 Riparian Habitats

3.3.1 Shoreline Stability Reference Points

Riparian habitats were observed at all nine reference points, but the species composition of the vegetation and density varied significantly (**Table 3-4**). Changes to riparian habitats were not observed as a result of fluctuating water levels during the Operations Study. See the representative photos of the nine reference points in Section 3.2.2 (*refer to* Photo 3-1 through Photo 3-10), which also provide representative photos of the riparian habitats at each of the nine reference points.

Table 3-4. Riparian Vegetation at Reference Points

Reference Point Number	Description
1	Dense stand of non-native forbs and grasses, which were mostly mowed to the water's edge as part of the landscaping for this recreation site
2	Dense stand of grasses with a few interspersed conifer trees.
3	Dense mixture of grass and shrub species such as chokecherry, black hawthorn and service berry, and also a few interspersed conifer trees
4	Less dense riparian vegetation due to more active erosion and the species mix consisted of grasses, shrubs and trees
5	Shoreline stabilization pilot project and dominated by a dense stand of grasses, with mixed survival of the shrub species that were planted for this pilot project

Reference Point Number	Description
6	Low density stand of mostly grasses, with a few interspersed shrubs and conifer trees.
7	Dense stand of grasses, with a dense pocket of shrubs mixed in
8	Less dense riparian vegetation due to a bouldery substrate not conducive to plant growth, and the plant species that do exist are mostly grasses
9	Less dense riparian vegetation due to more active erosion and also a bouldery substrate that is not conducive to plant growth, and the plant species that do exist are a mixture of grasses, shrubs and conifer trees.

Aquatic vegetation was observed at eight of the nine reference points, ranging from a trace of aquatic vegetation to almost 100 percent (i.e., 300 linear feet of aquatic vegetation). **Photo 3-16** contains photos from the August 6 monitoring event at Reference Points #3 and #6 showing the difference in the amount of aquatic vegetation between two reference points. The percent coverage often varied over the course of the year. Typically, a lower percentage of aquatic vegetation was present during the April 19 monitoring event, then a higher percentage during the July 13 and August 6 monitoring events during the prime growing season. A gradual decline was observed September 1 and September 16 when vegetation began going dormant. The gradual decline was more noticeable in submergent vegetation than emergent vegetation. **Photo 3-17** contains two photos of Reference Point #2, taken on the April 19 monitoring event when the growing season was beginning and on September 16 when the growing season was complete.

Photo 3-16. Aquatic Vegetative Growth on 8/6/21 at Reference Point #3 (left) and Reference Point #6 (right)

Photo 3-17. Aquatic Vegetative Growth between 4/19/21 and 9/16/21 Monitoring Events at Reference Point #2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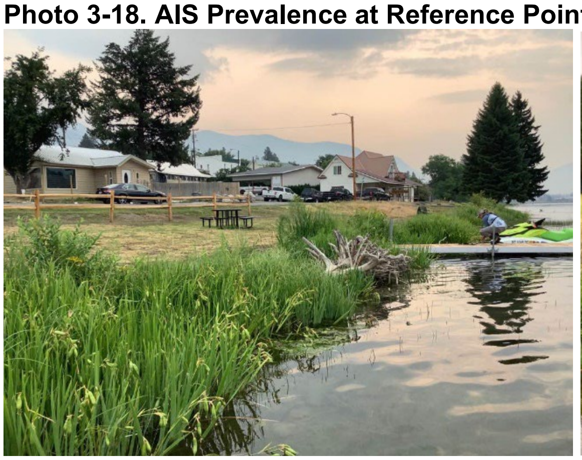
AIS were observed at six of the nine reference points with flowering rush and yellow flag iris being the species observed. Curlyleaf pondweed was not observed at any of the nine reference points. The presence of yellow flag iris and flowering rush varied greatly from being a few isolated plants to close to 100 percent of the 300-foot-long reach. The prevalence of these species also varied depending on time of year. **Photo 3-18** contains two photos from the August 6 monitoring event, one of Reference Point #1 which shows a high prevalence of yellow flag iris and flowering rush, and one of Reference Point #2 which shows a high prevalence of yellow flag iris (other species in photo mostly native species).

Photo 3-18. AIS Prevalence at Reference Point #1 (left) and Reference Point #2 (right), 8/6/21




3.3.2 Wetland Monitoring Sites

Wetland 1 contains a mixture of emergent and submergent vegetation with native species and AIS present at this site. The extent of the emergent vegetation at this site is depth-limited, as the center part of the wetland is semi-permanently flooded. Emergent vegetation consists of native sedge and rush species, broadleaf cattail, and flowering rush (which is an AIS). The depth of water at the center of this wetland provides some habitat for submergent species such as arrowhead, and curlyleaf pondweed (which is an AIS). There was no observed change in vegetation at this site throughout the 2021 operations study season.

Wetland 2 is comprised of primarily submergent vegetation consisting of elodea, coontail, and duckweed. The fringes of the wetland were dominated by reed canarygrass, but this wetland also supports a woody component comprised of black cottonwood, and alder. No AIS species were observed at Wetland 2, and there was no observed change in the vegetation at this site during the 2021 operations study season.

Wetland 3 is a mix of native and non-native aquatic vegetation. The wetland is comprised of primarily submergent vegetation with leafy pondweed and coontail being the two dominant species and curlyleaf pondweed being found in small concentrations. Flowering rush was also observed at Wetland 3, but few other native emergent species were present. The fringes of the wetland and associated upland areas were almost entirely comprised of a monoculture of reed canarygrass. There was no observed change in vegetation at this site throughout the 2021 operations study season.

General Observations

Riparian habitats are present along most of the entire reservoir shoreline, other than where infrastructure is in place such as boat ramps, docks and rock rip-rap. However, the density and species composition vary significantly. The reservoir shoreline downstream of the islands tends to have steeper shoreline slopes and rockier soils that create narrow riparian habitats consisting of low to high density stands of grasses, forbs, shrubs and trees. The mouths of Cherry Creek and Thompson River are exceptions, each having a larger riparian habitat area as compared to the adjacent reservoir shoreline. The reservoir shoreline in the islands area, as well as the islands themselves, have less-steep slopes and finer soils creating large riparian habitat areas often densely vegetated including iconic riparian habitat species such as black cottonwood and willow species, which are much less common in the reservoir downstream of the islands. The reservoir shoreline upstream of the islands is more like the lower reservoir with narrower strips of riparian habitats with low to high density stands of vegetation.

Aquatic vegetation and AIS are common along the reservoir shorelines where the substrate is comprised of silt, sand and other fine materials, and much less common where the substrate is comprised of gravels, cobbles and other coarse materials. Upstream of the islands, aquatic vegetation and AIS are less prevalent since the shoreline tends to be comprised of coarse substrates, and/or the reservoir is more riverine in nature such that current flows and velocity reduce the ability for aquatic vegetation and AIS to become established. Flowering rush and yellow flag iris are AIS species that are fairly common in the reservoir. Flowering rush is particularly prevalent in the lower reservoir in areas of significant sediment deposition, close to the water’s surface. **Photo 3-19** is a photo of such an area with a high prevalence of flowering rush (photo taken in 2018 but represents conditions during Operations Study). Curlyleaf pondweed, an AIS, is less prevalent with none being observed except at Wetlands 1 and 3, but also known to be present from historic observations. Eurasian watermilfoil, an invasive species common in the region and especially prevalent downstream of the Thompson Falls Project area, was not observed though native northern watermilfoil is prevalent.

Photo 3-19. Lower Reservoir Area with a High Prevalence of Flowering Rush

3.4 Fisheries

3.4.1 Stranding

Photo points document the locations and associated habitat types of the 12 transects (Appendix B). Transects typically intersected habitat types that contained silt or sand substrate and/or were heavily vegetated where plants covered more than 50 percent of the area. One transect (#5) was dominated with cobble substrate along the shoreline.

Phase 1

Surveys were completed at all transects on July 28 when the reservoir elevation was at 2396 feet. At only 0.5 foot below full pool half of the selected transects still were submerged or partially submerged and exposed areas were minimal. No fish were stranded or found to be trapped in small pools. Two days later on July 30 the reservoir elevation was 2 feet below full pool at 2394.5 feet and stranding surveys were repeated in the morning hours. Four fish were stranded including one Black Bullhead, two Largemouth Bass, and one Pumpkinseed Sunfish. The largest individual was an 82 mm total length Largemouth Bass and the smallest was a 64 mm Black Bullhead (**Table 3-5**).

Phase 2

Two surveys were done during the second operations test, on August 17 and August 19. The first survey was completed at reservoir elevation 2395.5 feet and 29 stranded fish were found. The second survey identified four stranded fish at reservoir elevation 2395.0 feet (**Table 3-4**). All fish appeared to be juveniles, with the largest being a 92 mm Largemouth Bass. Based on the condition of stranded fish in the second survey it appeared that most may have been about 1 day old and could have died during the first 40 megawatt increase on August 17.

Phase 3

On September 8, a survey was completed when the reservoir elevation was 2.5 feet below full pool at elevation 2394 feet. This phase had the fastest rate of change in elevation of all three testing periods, resulting in 105 stranded fish representing 5 different species (**Table 3-4**). All stranded fish located were juveniles and were less than 115 mm in total length. Of note is that 87 of the 105 total were located at one transect site, with the majority (83) being Black Bullheads.

Table 3-5. Total Count of Stranded Fish for Each Survey Event during Thompson Falls Reservoir Operations Study in 2021

Operations Phase #	Date	Reservoir Elevation (ft)	BBH	LMB	SMB	YP	NPM	PUMP	Total
1	7/28/2021	2396	-	-	-	-	-	-	**0**
	7/30/2021	2394.5	1	2	0	0	0	1	**4**
2	8/17/2021	2395.5	19	9	-	-	1	-	**29**
	8/19/2021	2395.0	3	1	-	-	-	-	**4**
3	9/8/2021	2394	89	9	2	4	1	-	**105**
		TOTAL	**112**	**21**	**2**	**4**	**2**	**1**	**142**

Notes: BBH = Black Bullhead, LMB = Largemouth Bass, SMB = Smallmouth Bass, YP = Yellow Perch, NPM = Northern Pikeminnow, PUMP = Pumpkinseed Sunfish

In the lower reservoir at transects 1 and 2 a new amphibian species was identified during September sampling. Five American bullfrog tadpoles (*Lithobates catesbeianus*) were located in the large midchannel island area (**Photo 3-20**). This is the first known finding of this species in Thompson Falls Reservoir. Bullfrogs are non-native and invasive in the western U.S. where they have caused issues for other native amphibians through competition and chytrid fungus. Another non-native species that was identified during the Operations Study was Virile Crayfish

(Faxonius virilis). This omnivorous species is native to eastern Montana but has been invading westward.

Photo 3-20. American Bullfrog Located During Fish Stranding Transects

3.4.2 Fish Passage into Cherry Creek and the Thompson River

Cherry Creek and Thompson River are tributaries that enter the Thompson Falls Reservoir. Cherry Creek enters on the south side of the reservoir and Thompson River on the north. Both tributaries are known to contain salmonids, and Thompson River is a tributary important for trout spawning and rearing. Observations at the confluence of these tributaries were made to ensure that connections to the reservoir remained and that fish continued to have access to and from both Cherry Creek and Thompson River.

Cherry Creek is a relatively small tributary and averages 16 feet across at its mouth and quickly narrows to 11 feet across within about 200 feet upstream of its confluence with the Clark Fork River. The point where Cherry Creek enters the reservoir there is a large plunge pool that is greater than 5 feet deep. Observations were made during the static holds in each phase and at varying reservoir elevation levels. At no point would fish be impeded from moving up or downstream at various reservoir elevations. **Photo 3-21** shows adequate flow and depths for fish movement at the lowest reservoir elevation of 2394 feet. Because of the quick narrowing and steeper gradient of Cherry Creek upstream from the confluence there was no discernable change in stream water levels due to changing reservoir elevations.

Photo 3-21. Mouth of Cherry Creek at Reservoir Elevation 2394 Feet

The Thompson River is a considerably larger tributary than Cherry Creek and has more variable habitat at the confluence with Thompson Falls Reservoir. As seen in the aerial view (**Photo 3-22**) there is a midchannel bar along the left side of the channel with the thalweg flowing on the right. Only when a combination of high spring flows in both the Clark Fork River and Thompson River occur is this gravel deposit submerged for a short time. Measured stream widths right at the mouth are 122 feet when including this deposit. During the summer when river flows are low and the Thompson Falls Reservoir is at full pool (2396.5 feet) only the main channel thalweg to the right is watered and the width is 53 feet. During all three phases of the Operations Study the main channel area was flowing water, and similar to Cherry Creek, plunged into a deep pool within the reservoir. The Thompson River remains 10 to 16 feet in depth within the main channel all the way upstream to the railroad bridge crossing (about 200 feet). There were no flow or depth barriers to upstream or downstream fish movement at the mouth of Thompson River at any reservoir elevations.

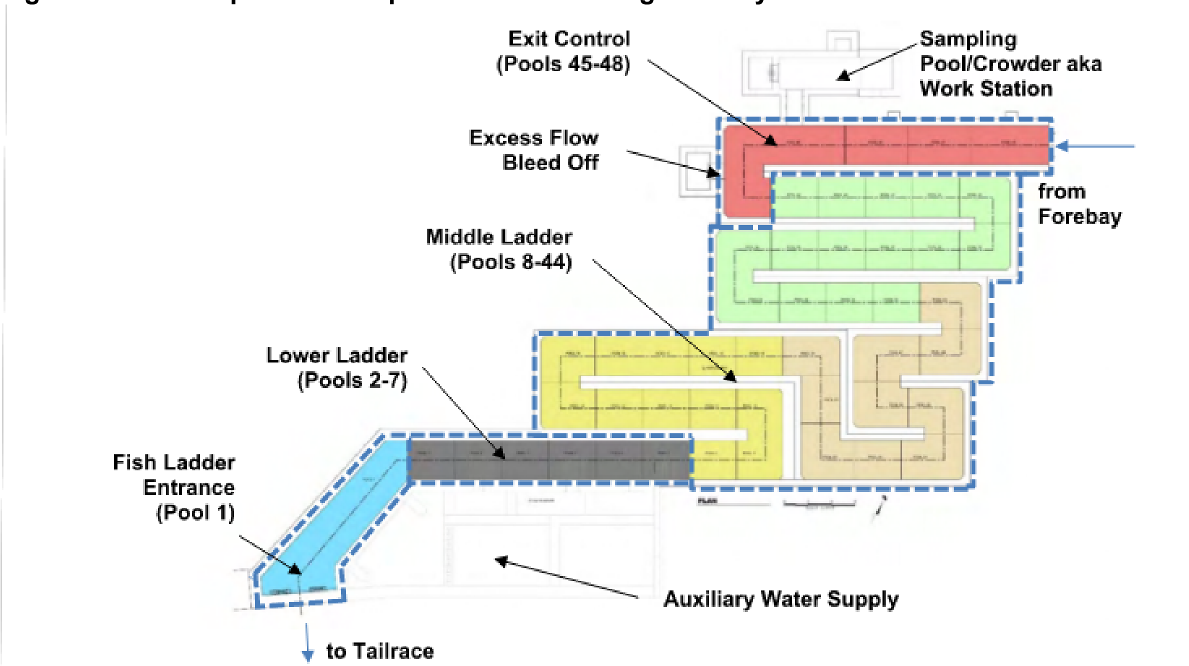
Photo 3-22. Aerial view of the Mouth of Thompson River

Notice mid-channel bar along at the mouth of Thompson River, and main tributary channel.

3.4.3 Operation of the Upstream Fish Passage Facility

The fish passage facility utilizes 3 cfs to operate the workstation and 6 cfs flowing pool-to-pool with the option of additional attractant flows from the auxiliary water system (AWS) (maximum 54 cfs) and high velocity jet (HVJ) (20 cfs). Total flow available for operating the fish passage facility and producing the maximum attractant flow at the fish passage facility entrance is 83 cfs. The fish passage facility has operated when the elevation of Thompson Falls Reservoir was near full pool providing the required 9 cfs (6 cfs down the ladder; 3 cfs *via* the fish workstation) for functionality. The orifices between Pools 45 to 48 are designed to modulate minor flow changes due to minor forebay pool fluctuations, and Pool 45 (**Figure 3-19**) has a design elevation target of 2393 feet.

Figure 3-19. Thompson Falls Upstream Fish Passage Facility

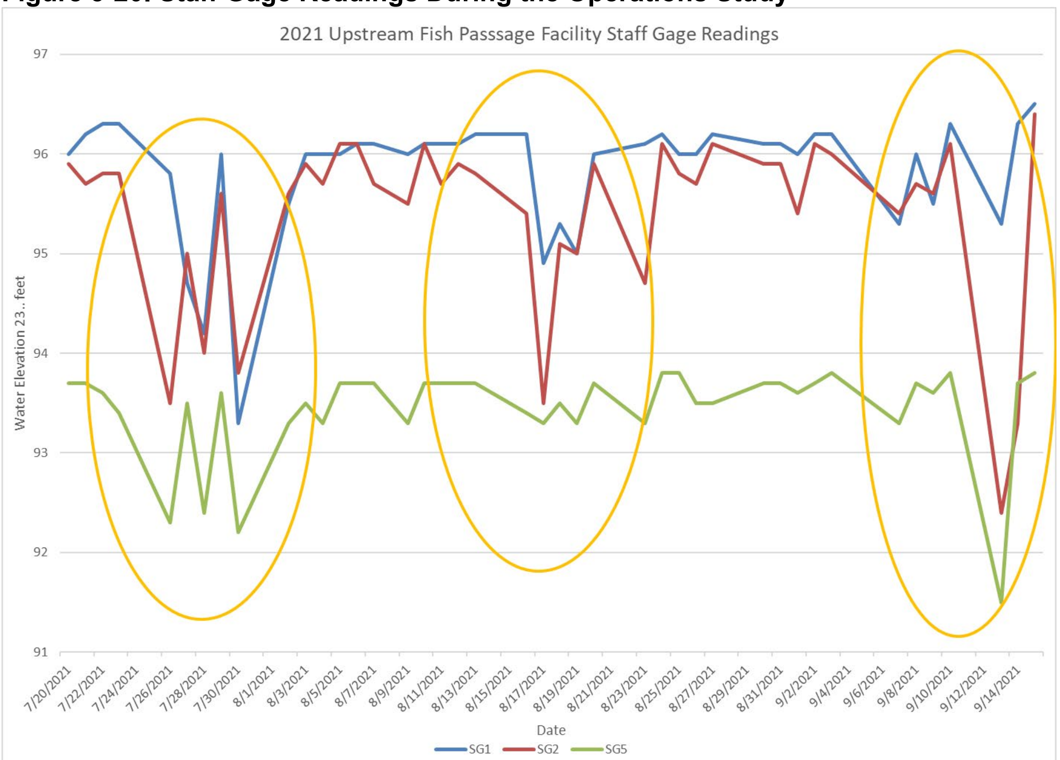


Water enters the fish passage facility in four different locations; at the fish passage facility exit (into Pool 48), the attraction flow pipe, the sampling water pipe, and the AWS. Water entering the fish ladder exit flows through each ladder pool from top to bottom. The intake pipe is a 3-foot diameter opening with the lower pipe elevation being 2393 feet. The attraction flow intake is a 2-foot diameter pipe with a bottom elevation at 2392.3 feet which adds an additional attraction flow stream directly to the tailrace near the fish passage facility entrance. The 12-inch diameter sampling water pipe also sits at elevation 2392.3 feet and transports water to the fish handling facility. The 30-inch diameter auxiliary water supply intake sits at a lower elevation at 2385.5 feet and provides additional water into Pools 7, 5, and 3 for attraction.

As the reservoir levels fluctuate, the water levels within the ladder follow this pattern in a delayed sense as the available water running through the ladder takes time to drain (or fill) from Pool 48 to the lower Pools 2 to 7. When excessive flow into Pool 45 occurs from the forebay it is drained off at a screened overflow weir, to set the appropriate water surface level. As currently configured, a reduction of flow into Pool 45 does not allow the flexibility to increase water elevations through the rest of the ladder.

Observations within 0.5-foot of full pool elevation showed little change in fish passage facility dynamics or operability. When pool elevations were approximately 2395.5 feet a noticeable difference in pool hydraulics and total flow from Pools 32 to 48 was apparent. Hydraulics within the pools changed flow paths, and a 2- to 5-inch elevation drop in water levels occurred in these pools. Although the fish passage facility was still operating and functioning to some degree, it was clearly outside of the original design. Slightly reduced water flow was observed through the ladder compared to original design flows, and hydraulic patterns within pools appeared to be different. As the Operations Study continued this trend of dewatering continued with lowered reservoir elevations. **Figure 3-20** shows the daily elevations at the ladder exit or reservoir elevation (SG1) and in Pool 48 (SG2) and Pool 45 (SG5) during the three phases of the Operations Study. Water depths within the fish ladder followed similar patterns as the reservoir elevation throughout the Operations Study.

Figure 3-20. Staff Gage Readings During the Operations Study



Three phases of the Operations Study are circled and show water level changes within the ladder and corresponding reservoir elevation.

When the reservoir elevation was 2.3 feet down (2,394.2 feet) the fish passage facility began to have operating issues. The HVJ slowed down considerably and there was reduced water being fed to this feature. The fish sampling loop was inoperable due to the lack of water to fill the fish lift and anesthetizing tank. Pumps were shut off as they were drained, and the entire fish passage facility lacked sufficient flow and water to effectively capture fish.

Another issue observed during Phase 3 was that as reservoir elevation decreased, and flows toward the powerhouse increased, a large quantity of floating vegetation was pulled past the water intakes and vegetation began plugging both the traveling screen which feeds the AWS, HVJ, and sampling station in addition to the pool-to-pool entrance. The traveling screen had to be operating the entire time and the debris screen in Pool 48 was manually lifted and cleaned during testing operations. The excessive quantity of floating vegetation and frequency of fish passage facility plugging made the fish passage facility inoperable during Phase 3.

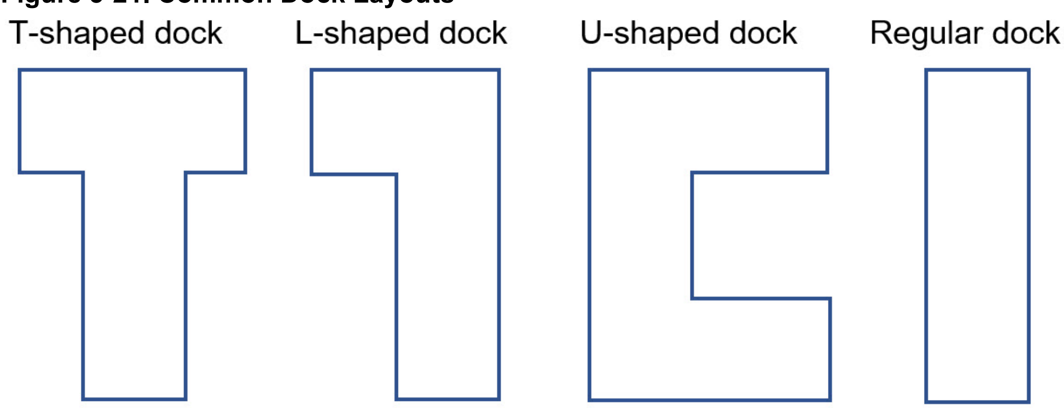
3.5 Recreation and Aesthetics

3.5.1 Impacts on Docks

In general, two types of public and private docks exist on the reservoir: stationary docks and floating docks. Stationary docks represent roughly 20 percent of docks on the reservoir overall and typically have a gangway or access ramp[10] that is fixed to the shoreline. Because they are stationary, these docks remain at the same elevation regardless of the water level, as do their gangways and access ramps. Floating docks represent about 80 percent of docks on the reservoir overall and 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 (such as EZ Docks), while still others are made from other materials such as logs and old tires. The elevation of a floating dock changes with water levels, and the angle of associated gangways and access ramps also changes as the docks move up and down in relation to the shoreline and anchor point of the ramp.

Both stationary and floating docks are aligned in a variety of ways. Some rectangular docks are aligned with the long axis of the dock parallel to the shoreline, and some with the long axis perpendicular to the shoreline. A few are configured in a T or L formation and others are in a U--shaped layout (**Figure 3-21**). Most have boat tie-off cleats mounted to the surface of the dock, but some have boat whips that secure a boat near the dock while preventing it from making contact with the dock (**Photos 3-23**). Different dock configurations are intended to accommodate different uses.

Figure 3-21. Common Dock Layouts



[10] 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 3-23. Images of Cleat, Boat Tied to cleats, and Boat Secured with Whips

Docks were monitored at each half-foot elevation below full pool to record and document with photos the impact of changing reservoir elevations on public and private docks. Stationary dock structures and accompanying gangways and ramps were not impacted by the changing water levels because these facilities are mounted on solid posts that remain stable and at the same height regardless of water levels. Impacts due to changing water levels associated with stationary docks pertain to boats tied to those docks and ease of access to and from those boats.

Boats tied to cleats on stationary docks may be impacted when the water level decreases if they are tightly tied to the dock and there is not enough slack in the rope to allow the boat to remain floating as the water recedes. Boats tied with boat whips are able to move with the water level while remaining securely fastened to the dock. When cleat-tied boats do remain floating the distance between the top of the dock and the boat increases and it may become difficult to access the boat from the dock due to the vertical drop. Also, boats tied closely to stationary docks can become pinned under the dock as the water levels rise to full pool (**Photo 3-24**).

Photo 3-24. Boats Tied to Stationary Docks with Fluctuating Water Levels

Canoe tied to stationary dock at full pool and -2.0 ft reservoir elevation.

Increased distance between dock and boat resulting from decreased reservoir elevation.

Boat pinned beneath stationary dock when water level rose to full pool.

3.5.1.1 Stationary Docks

Throughout the Operations Study, stationary dock structures were not adversely impacted due to fluctuating water levels since they did not move, but recreational access to moored boats and access to the waterway from stationary docks became more challenging as water levels declined. At elevations down to 1.0 foot below full pool, all stationary docks could still be used for boat mooring. The challenge of getting in and out of boats moored at docks became more substantial starting around the -1.5 feet elevation, however, and access to moored boats remained adequate at only a third of stationary docks at this elevation. At elevations 2.0 feet below full pool and lower, access to moored boats was significantly reduced at all stationary docks. This is especially true for docks in the main reservoir and along the south shoreline upstream of Steamboat Island. In addition to the challenges posed by the increased vertical distance between docks and moored boats, declines in water elevations resulted in water receding from the end of many docks, leaving the water depth very shallow or the area completely dewatered and making water access from those docks impossible. In addition, aquatic vegetation that was submerged at full pool became prominent in the upper region of the water column (**Photo 3-25**). There is one publicly accessible stationary dock structure at

Wild Goose Landing Park. This dock was unaffected by changing reservoir elevations, though access to the water was challenging at reservoir elevations beyond 1.5 ft below full pool (**Photo 3-25**).

In all, the water reached about half of the stationary docks at 2.5 feet below full pool but was generally too shallow to provide good waterway access. The other half of stationary docks became dewatered at elevations of 1.5 and 2.0 feet below full pool. While this dewatering did not impact the dock structures, it impacted recreation by preventing access to the waterway from those docks.

Photo 3-25. Stationary Docks at Full Pool and Lower Water Elevations

North shoreline stationary dock with boat whips at full pool and -2.0 feet elevation, and south shoreline stationary dock mostly dewatered at -2.5 feet elevation.

South shoreline main reservoir stationary dock North shoreline main reservoir stationary dock mostly dewatered at -2.5 feet elevation with aquatic vegetation at -2.5 feet elevation.

Wild Goose Landing stationary boat launching dock, north shore main reservoir, at full pool and -2.5 feet elevation.

3.5.1.2 Floating Docks

Impacts to floating docks were more varied with fluctuating water levels, mainly due to their location and configuration. As water levels dropped, so did the elevation of floating docks and thus the angle of gangways and access ramps increased. In most cases, floating docks were usable and accessible down to 1.0 foot below full pool elevation. At 1.5 feet below full pool, many gangway floats became grounded and the near-shore edge of floating docks in the main reservoir and along the south shoreline upstream of Steamboat Island became grounded, though the outer edge remained afloat and the docks remained usable **(Photos 3-26).**

Photos 3-26. Floating Docks at Full Pool and -1.5 Feet Elevation

Wild Goose Landing floating dock, north shore main reservoir, at full pool and -1.5 feet elevation.

North shoreline floating dock at full pool and with steep gangway angle at -1.5 feet elevation.


South shoreline main reservoir floating dock at full pool and mostly dewatered at -1.5 feet elevation.


South shoreline floating dock at full pool and -1.5 feet elevation.

When reservoir elevations dropped lower than 1.5 feet below full pool, access ramps on floating docks became very steep in some cases. Many docks with access ramps or gangways that were either short or were more than a few degrees from horizontal at full pool became steep and possibly unusable as water elevations dropped. In one instance the gangway broke free from the onshore abutment due to the added pressure on the hinges resulting from the low elevation of the floating dock. In some cases, floating docks became grounded entirely or at the near-shore end. Floating docks aligned with their long axis perpendicular to the shoreline generally extended out into the waterway further than docks aligned parallel to the shoreline and, therefore, were able to withstand fluctuating elevations better (**Photos 3-27**). In all, about 90 percent of floating docks functioned well at 1.5 feet below full pool. About two-thirds were satisfactory at 2.0 feet below full pool, and about half functioned adequately at -2.5 feet.

Publicly accessible floating docks are located at Cherry Creek and Wild Goose Landing Park (**Photos 3-27**). At Cherry Creek, the floating dock remained usable at elevations down to 1.5 feet below full pool, though the gangway and near-shore end of the dock were grounded. As elevations dropped below that level, the dock became steeply angled and inaccessible as the end of dock remained floating while the near-shore portion was grounded.

The floating dock at Wild Goose Landing Park remained accessible at all elevations though usability was reduced at the lowest elevations. The dock became angled at low elevations, offered access to little water at the lowest reservoir elevation, and the accessible water near the dock was inundated with aquatic vegetation.

Photos 3-27. Floating Docks at Full Pool and Lower Water Elevations

Upper north shore floating dock and south shore floating dock near Steamboat Island at -2.0 feet elevation.

North shore floating dock at full pool and with very steep gangway at -2.5 feet elevation.

Wild Goose Landing (north shoreline main reservoir) and Cherry Creek Boat Launch (south shoreline) mostly grounded docks at -2.5 feet elevation.

North shoreline and south shoreline floating EZ docks located opposite each other about a half mile upstream of Steamboat Island at -2.5 feet elevation. North shore dock is floating, south shore dock is completely grounded.

North shoreline docks aligned parallel (left) and perpendicular (right) to shoreline at -2.5 feet elevation. Parallel dock with short ramp is grounded, perpendicular dock with longer gangway is floating.

3.5.2 Boat Launches

Boat launches were monitored to determine if fluctuating reservoir elevations impacted the ability of users to utilize ramps for launching and loading watercraft. A total of 5 launches were monitored at each half-foot elevation below full pool. The approximate water depth at the end of the ramp was measured at Wild Goose Landing and Cherry Creek Boat Launch (both public boat launches). The gravel or native surface launches at the Salish Shores and North Shore Estates subdivision community ramps and the float plane ramp on the south shoreline of the main reservoir just upstream of the boat barrier were measured approximately 60 feet from the full pool elevation mark on the shoreline.

Boating information sources reveal that most small power boats of the type typically used in Thompson Falls Reservoir draft in 2.5 feet of water or less. Therefore, the minimum depth target at boat launches is 2.5 feet of water at the end of the ramp to allow watercraft continued access to the reservoir.

At a reservoir elevation of 2.5-feet below full pool, the water was 6.2 feet deep at the end of the ramp at Wild Goose Landing and 2.7 feet deep at the end of the Cherry Creek Boat Launch ramp. Water levels at these ramps were above the minimum depth target at the lowest reservoir level. Water at the Salish Shores boat launch was 6.2 feet deep at 60 feet off shore when the reservoir elevation was 2.0 feet below full pool, and 2.4 feet deep when the elevation was 2.5 feet below full pool. Water at the North Shore Estates launch, by contrast, was much deeper at all reservoir elevations, to a low of 8.4 feet deep at 60 feet off shore at the lowest elevation (**Table 3-6 and Figures 3-22 and 3-23**). The lakebed extending from the sea plane ramp appears to be quite varied and shallow, but it is unclear how much water is required to utilize a float plane.

Table 3-6. Water Depth at End of Ramp and 60 Feet Off Shore at Decreasing Reservoir Elevations

Water depth at end of ramp at each half-foot elevation below full pool					
Elevation	**-0.5 foot**	**-1.0 ft**	**-1.5 ft**	**-2.0 ft**	**-2.5 ft**
Wild Goose Landing	8 ft	7.5 ft	7.3 ft	6.8 ft	6.2 ft
Cherry Creek	4.5 ft	3.6 ft	3.0 ft	2.8 ft [e]	2.7 ft

Water depth 60 ft from shore at each half-foot elevation below full pool					
Elevation	**-0.5 ft**	**-1.0 ft**	**-1.5 ft**	**-2.0 ft**	**-2.5 ft**
Salish Shores	7.2 ft	7.0 ft [e]	6.6 ft	6.2 ft	2.4 ft
North Shore Estates	15.1 ft	15.2ft	14.6 ft	13.3 ft [e]	8.4 ft
Float Plane	4.3 ft	2.7 ft	3.2 ft	1.9 ft	2.3 ft

Note: *e* = estimated

Figure 3-22. Water Depth at End of Ramp at Decreasing Reservoir Elevations *versus* Minimum Depth Target

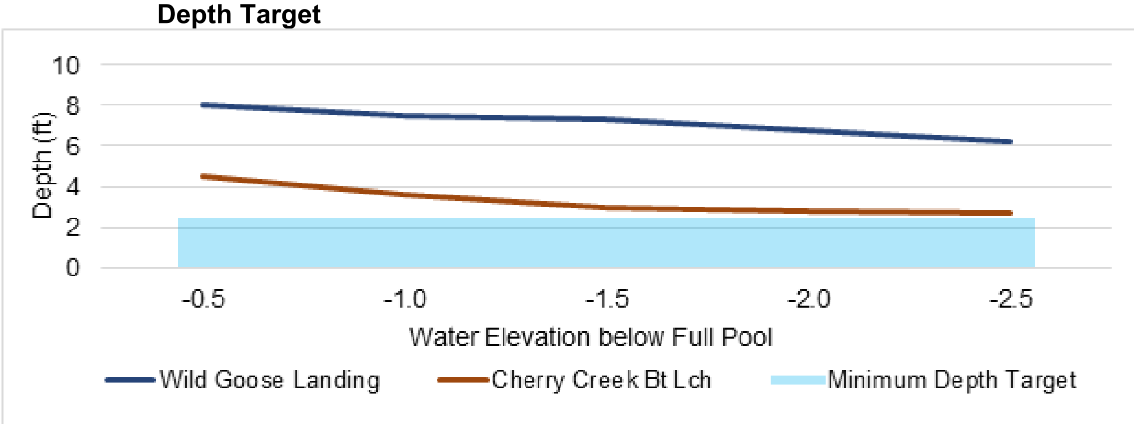
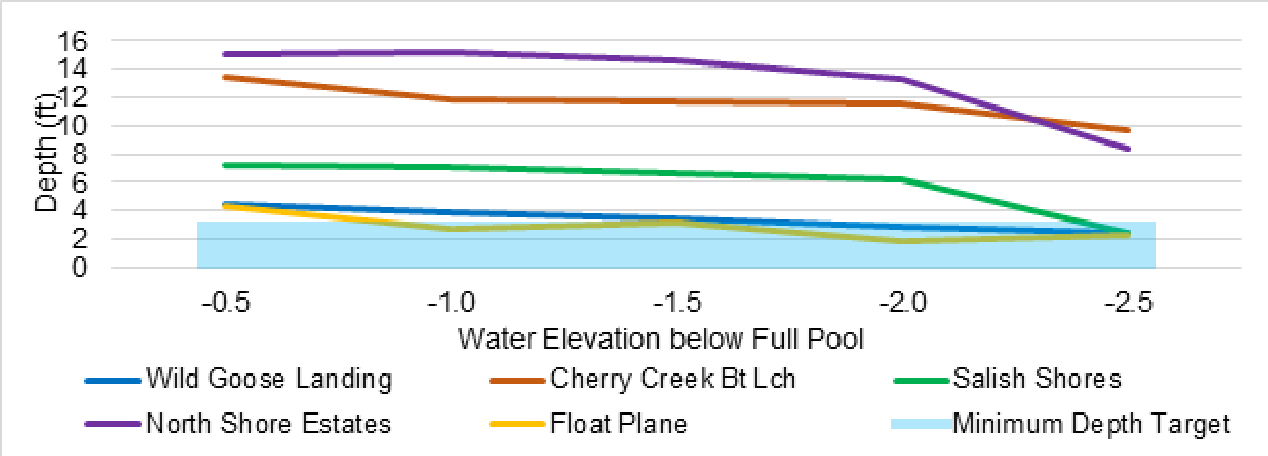


Figure 3-23. Water Depth 60 Feet Off-Shore at Reducing Reservoir Elevations *versus* Minimum Depth Target Feet.



3.5.3 Swimming Areas

Sandy Beach and the associated swimming hole downstream of the dams and original powerhouse experienced increased water elevations due to the additional water flowing through the generating units. The water level changes were apparent and observable during the Operations Study, but the swimming hole is protected by a substantial gravel bar and rock outcrop on its outer edge that temper flows. The beach area and swimming hole remained accessible during increased generation, though portions of the shoreline area of the beach were inundated. Additional discussion related to flows and elevations at Sandy Beach, along with photos, can be found in the Public Safety section.

3.5.4 Aesthetics

Aesthetics were monitored during each study phase to determine impacts associated with fluctuating water levels. Views of shorelines, presence of unpleasant or offensive odors (such as that of decaying organic matter) and exposed mud were key elements of 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 3-7** summarizes the results of the evaluation at various elevations at monitoring locations in the Project area.

Table 3-7. Estimated Amount of Exposed Shoreline and Odor at Various Reservoir Elevations

Assessment location	Elevation compared to full pool			
	-1.0	-1.5	-2.0	-2.5
North shoreline of Island Park, between the Main Dam and Dry Channel Dam.	1-5 feet of exposed mud. No odor.	No assessment.	10-20 feet of exposed mud. Strong odor.	20-60 feet of exposed mud. Very strong odor.
North shoreline adjacent to the Gallatin Street Bridge.	Minimal (<2 ft) amount of shoreline rock exposed. No odor.	No assessment.	3-6 feet of exposed mud and rock. Faint odor.	5-10 feet of mud and rock were exposed. Strong odor.
North shoreline at Wild Goose Landing Park.	1-5 feet of exposed mud. No odor.	5-10 feet of exposed mud. Faint odor.	20-30 feet of exposed mud. Strong odor.	30-40 feet of exposed mud. Strong odor.
North shore of the main reservoir, upstream and downstream of Wild Goose Landing Park.	1-5 feet of exposed mud. No odor	No assessment.	10-20 feet of exposed mud near the boat restraint. Up to 50 feet of exposed mud near the North Shore Dispersed Use Area. Strong odor.	10-20 feet of exposed mud near the boat restraint. Up to 100 feet of exposed mud near the North Shore Dispersed Use Area. Strong odor.
South shoreline of the main reservoir.	Minimal (<2 ft) exposed mud. Faint odor.	2-5 feet of exposed rock and mud. Faint odor.	5-10 feet of exposed mud. Faint to moderate odor.	10-20 feet of exposed mud. Moderate odor.
South shoreline behind Steamboat Island.	Minimal (<2 ft) exposed mud. Faint odor.	No assessment.	10-20 feet exposed mud. Faint to moderate odor.	No assessment.
South shoreline upstream of Steamboat Island.	1-5 feet of exposed mud. No odor.	5-10 feet of exposed mud. No odor.	5-20 feet of exposed mud. Faint odor.	10-30 feet of exposed mud. Moderate odor.
Cherry Creek Boat Launch.	Minimal (<2 ft) amount of exposed mud. No odor.	4-8 feet of exposed mud. No odor.	Approximately 10 feet of exposed mud. Moderate odor.	Approximately 10 feet of exposed mud. Moderate odor.
North shoreline upstream of Steamboat Island.	Minimal (<2 ft) amount of exposed rock. No odor.	Approximately 6 feet of exposed rock. No odor.	5-10 feet of mix of rock and mud exposed. Faint odor.	Approximately 6 feet of rocky toe bordered by 10 to 20 feet of mud. Moderate to strong odor.

Photos 3-28, 3-29, 3-30 and 3-31 illustrate aesthetic conditions at decreasing reservoir elevations.

Photos 3-28. Shoreline Areas at 1.0 Foot Below Full Pool

Shoreline areas at Island Park and Wild Goose Landing Park.

Shoreline areas at North Shore Dispersed Use Area and north shore upstream of Steamboat Island.

Shoreline areas at Cherry Creek Boat Launch and the south shore upstream of Steamboat Island.

Photos 3-29. Shoreline Areas at 1.5 Feet Below Full Pool

Shoreline areas at Wild Goose Landing Park and north shore upstream of Steamboat Island.

Shoreline areas at Cherry Creek Boat Launch and the south shore upstream of Steamboat Island.

Photos 3-30. Shoreline Areas at 2.0 Feet Below Full Pool.

Shoreline areas at Island Park and Wild Goose Landing Park.

Shoreline areas at the North Shore Dispersed Use Area and north shore upstream of Steamboat Island.

Shoreline areas at Cherry Creek Boat Launch and the south shore upstream of Steamboat Island.

Photos 3-31. Shoreline Areas at 2.5 feet Below Full Pool

Shoreline areas at Island Park and Wild Goose Landing Park.

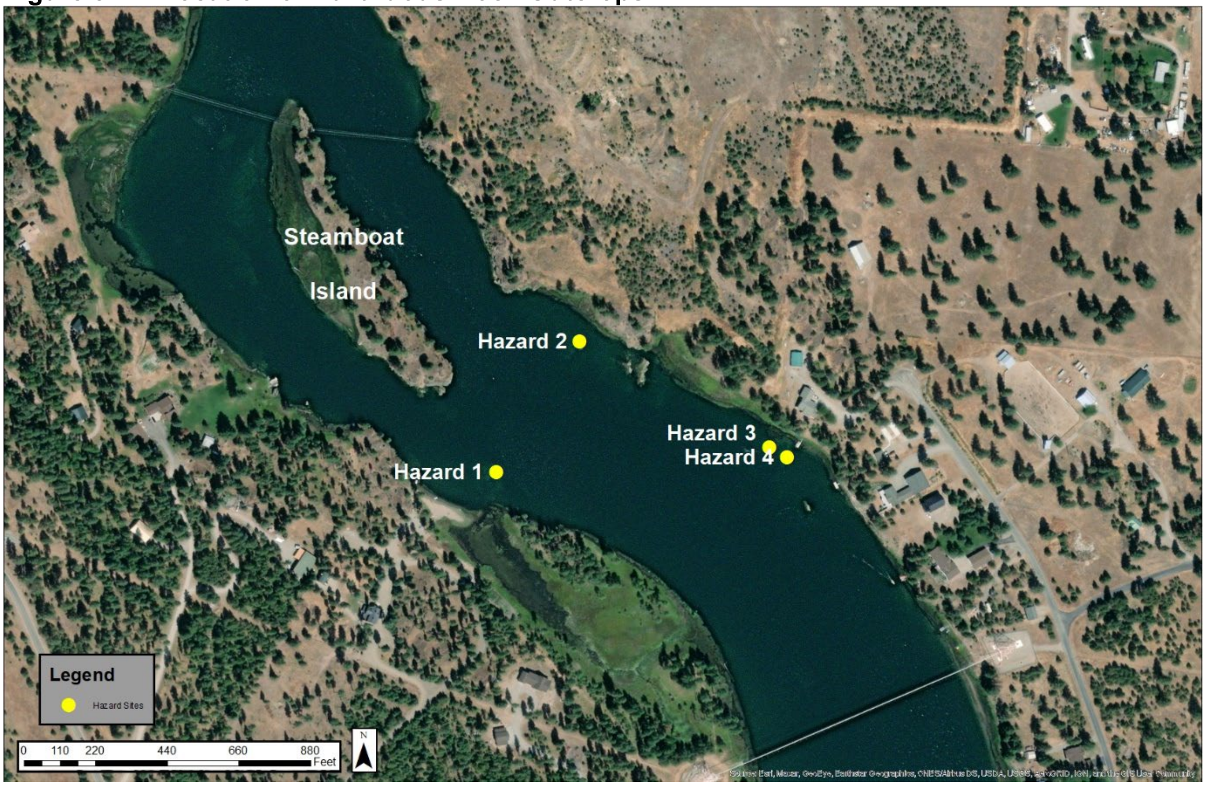

Shoreline areas at the North Shore Dispersed Use Area and north shore upstream of Steamboat Island.


Shoreline areas at Cherry Creek Boat Launch and the south shore upstream of Steamboat Island.

3.6 Public Safety

Four known hazards exist within a quarter mile upstream of the upper end of Steamboat Island (**Figure 3-24**). All four known hazards are large outcrops of bedrock that will be unmoved and unaffected by seasonal flows or ice buildup. Hazard 1 is about 100 feet from the outlet of the wetland on the south shoreline upstream of Steamboat Island. Hazard 2 is about 250 feet upstream of Steamboat Island and 75 feet off the north shore. Hazards 3 and 4 are 850 to 950 feet upstream of Steamboat Island and about 50 feet off the north shore.

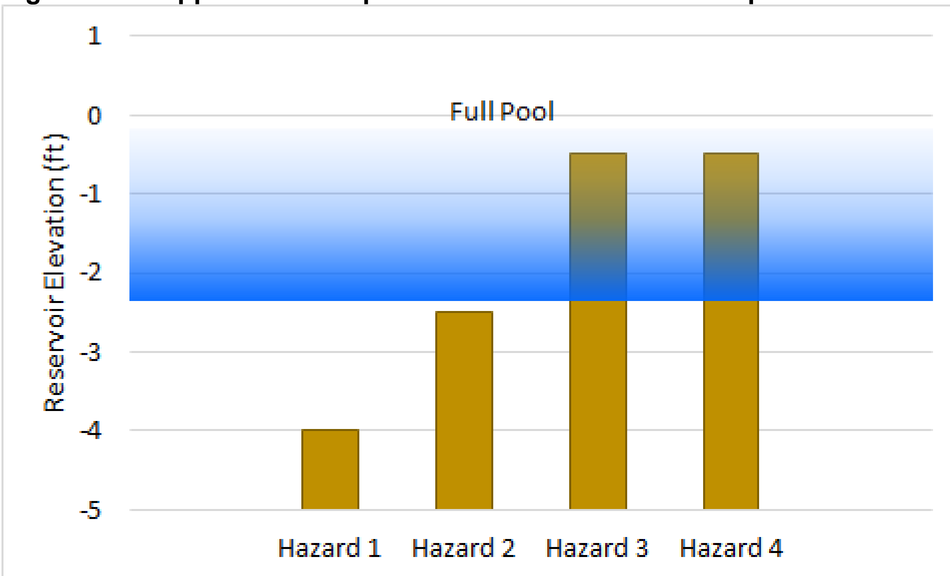
Figure 3-24. Location of Hazardous Rock Outcrops



The depths of these hazards were monitored during each half-foot static hold to determine how risk to public safety changes with water elevations in these four locations. Hazards 1 and 2 were submerged at full pool to depths of 4 and 2.5 feet respectively (**Figure 3-25**). As the reservoir elevation was lowered in response to increased generation, these hazards approached the surface. Hazard 1 remained submerged but high enough in the water column to pose a risk to watercraft at only 1.5 feet deep after the reservoir reached an elevation of 2.5 feet below full pool. Hazard 2 became visible when the reservoir elevation was down 2.5 feet and was within about 1 foot of the surface when the reservoir was down 1.5 feet. Since these hazards moved higher into the water column the risk of contact with these hazards increased as the reservoir elevation was lowered.

Hazards 3 and 4 were submerged 0.5 foot at full pool and became visible as the reservoir level was lowered. As such, they also became more visible at lower reservoir elevations and, therefore, the risk of contact associated with these hazards decreased as the reservoir elevation was lowered due to their increased visibility to recreationists. Also, these hazards, along with Hazard 2, are relatively close to shore (about 50-75 feet) so it is less likely that boats moving through the area at high rates of speed would do so in that close of a proximity to the shoreline, which reduced the chance of contact. Hazard 1, however, is about 100 feet off shore and closer to the deeper channel so contact is more likely.

Figure 3-25. Approximate Depth of Hazardous Rock Outcrops and Reservoir Elevation



The south shoreline of the reservoir upstream of Steamboat Island is shallow in places, and lower reservoir elevations resulting from increased generation may bring additional hazards into the contact zone of the water column for watercraft. These include submerged trees, stumps, and boulders. The shoreline can generally be described as having high risk of contact within 50 to 75 feet of the shoreline at reservoir elevations down to 2.5 feet below full pool. However, it is unlikely that boats would be traveling at high rates of speed within 75 feet of shore, where the topography and water depths vary, which reduces the risk of contact.

Water elevation changes at Sandy Beach were monitored over selected timeframes which were those that projected the greatest increase in generation over the shortest period of time for each phase[11]. Phase 1 testing aimed to increase generation by 20 MW, Phase 2 by 40 MW, and Phase 3 by the maximum MW capacity. To increase generation in the powerhouses, the amount of water flowing through the generating units increased, which resulted in greater flows and higher water elevations downstream. The increased water volume was not consistent across all phases but varied with flows required to reach generation goals. At Sandy Beach, the water elevation rose, on average, about 1.5 feet during Phase 1, about 2.75 feet during Phase 2, and nearly 3.5 feet during Phase 3 over timeframes ranging from 30 to 90 minutes (**Table 3-8** and **Figure 3-26**).

[11] Phase 1 timeframe included July 29, 8:15 am – 12:00 pm. Phase 2 timeframe included August 22, 11:00 am – 2:45 pm. Phase 3 timeframe included September 8, 9:00 am – 11:45 pm. *Refer to* Figures 2-1, 2-2, and 2-3 for additional information.

At these rates, which represent the quickest change in elevation over time, the average increase in the water level at Sandy Beach during Phase 1 was 0.5 inch per minute, during Phase 2 the rate was 0.6 inch per minute and during Phase 3 the rate was 1.3 inches per minute.

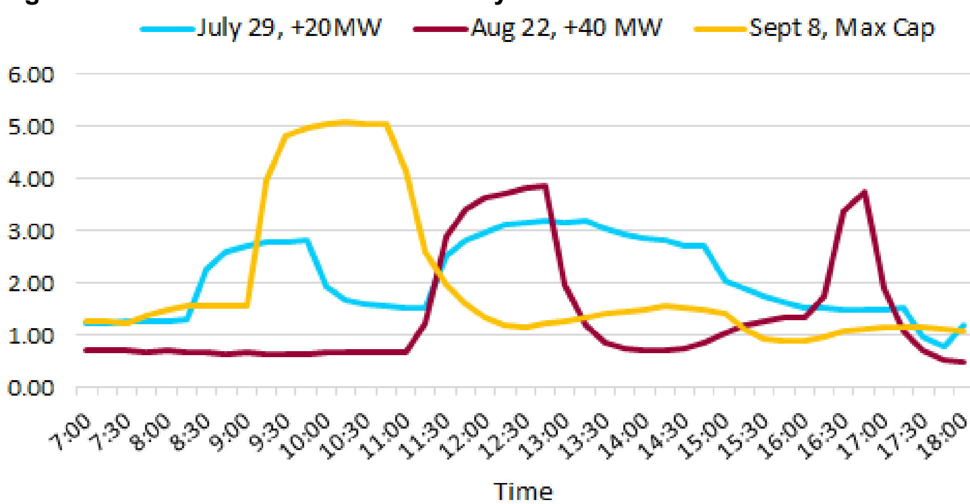
Once testing was complete, generation was reduced to normal capacity and downstream water elevations receded to pre-testing levels. The average rate of the receding water was about 0.5 inches per minute in Phase 1, 1 inch per minute in Phase 2, and 0.7 inch per minute in Phase 3.

Table 3-8. Water Elevation Data at Sandy Beach.

Phase	Change in Elevation (ft)	Duration (mins)	Rate (inches/min)
1	1.32	30	0.53
1	-1.15	30	-0.46
1	1.46	45	0.39
2	2.97	60	0.59
2	-2.66	30	-1.06
2	2.43	45	0.65
3	3.25	30	1.30
3	-3.44	60	-0.69

Notes: Ft = feet; mins = minutes; inches/min = inches per minute

Figure 3-26. Water Elevation near Sandy Beach.



Water elevation changes were noticeable in real-time at Sandy Beach during the testing. The swimming hole at the site is relatively small. The shoreline meets a rock outcrop on the inland portion of the site and a large rock outcrop and gravel bar define the outer edge to create a calm swimming hole. As the water level rose, it moved noticeably further up the shoreline (**Photo 3-32**) and rock outcrop.

Photo 3-32. Elevation Changes at 15-minute Intervals during Phase 3

Photos illustrate the limits of the elevation changes throughout all three Operations Study phases, which was about 3.5 feet total difference in depth (**Photos 3-33**). Though the rising water was noticeable during the study phases, the resulting current was minimal as flows into the swimming hole are attenuated by a gravel bar, a rocky embankment and an outcrop.

Photos 3-33. Upper and Lower Limits of Water Elevations at Sandy Beach at Shoreline and Beach Area and Outer Bounds of Swimming Hole

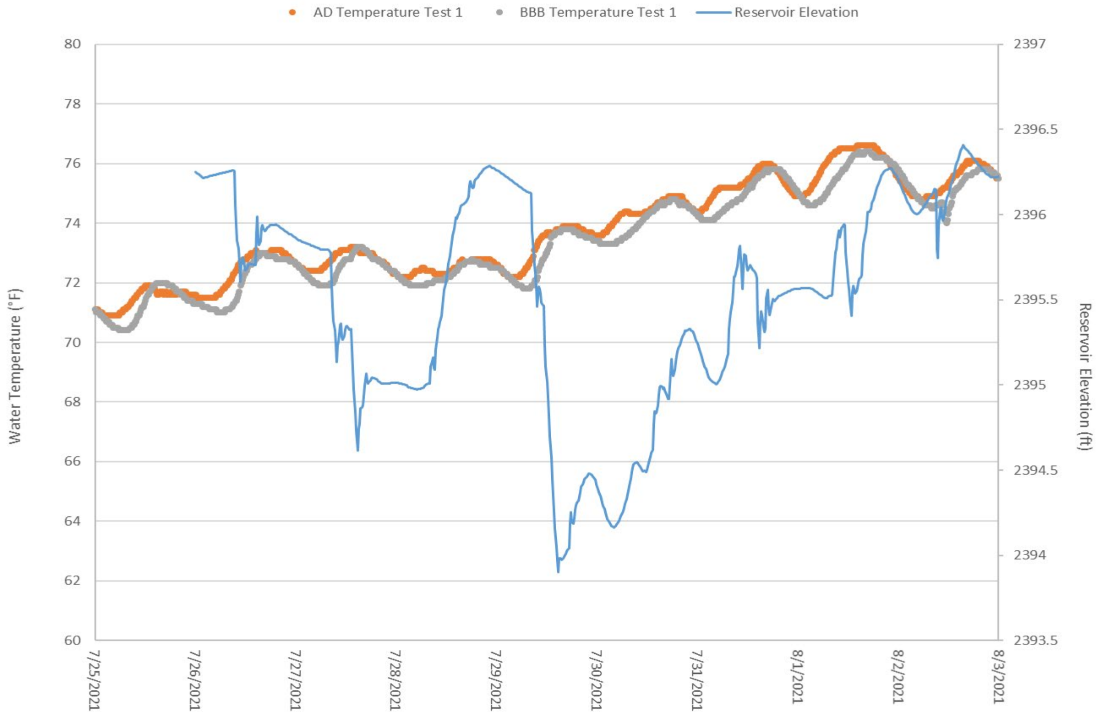
3.7 Water Quality

3.7.1 Operations Phase 1

Water quality data collected during Phase 1 showed that reservoir operations that occurred during this phase had little to no impact on water quality. Water quality parameters display natural variation as well as diurnal swings, but when plotted with fluctuations in reservoir elevation, there was no evident correlation in the data. **Figures 3-27 through 3-31** show each water quality parameter measured during Phase 1 plotted with the changes in reservoir elevation that occurred during that timeframe.

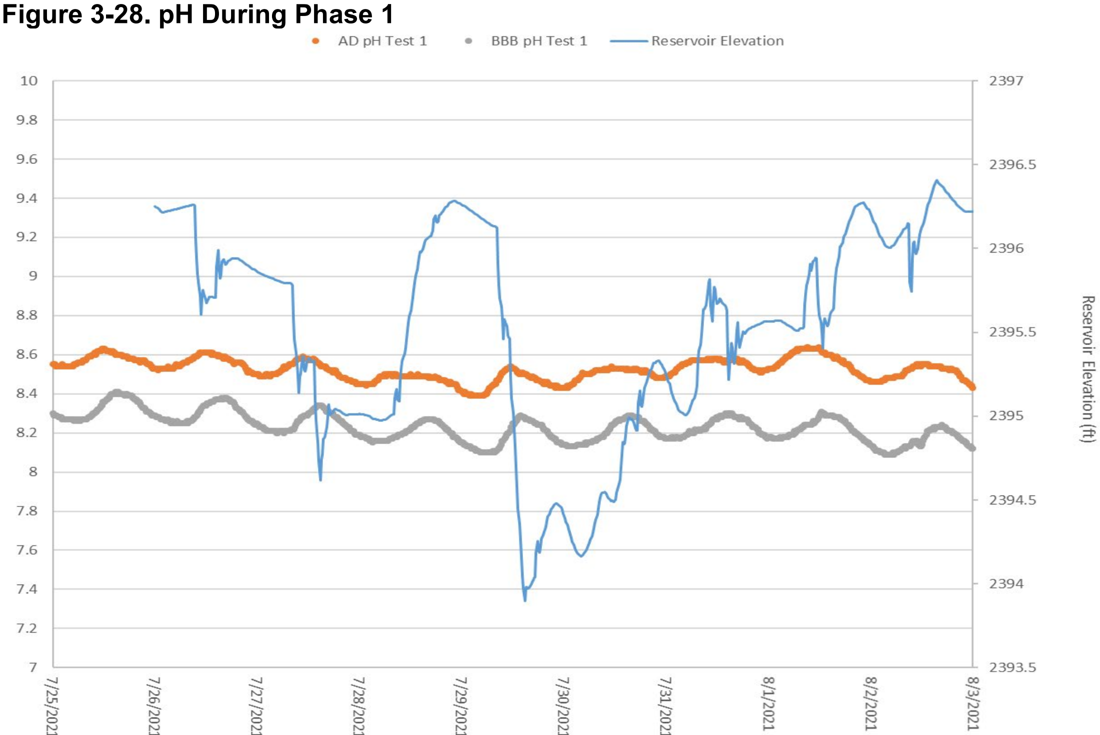
Water temperature (**Figure 3-27**) showed a warming trend throughout Phase 1, but this was more than likely due to atmospheric conditions, as that trend was not observed in the other two phases. Phase 1 was conducted during what is typically the warmest time of the year, so it is not surprising to see the water temperatures rising throughout this phase.

Figure 3-27. Water Temperature During Phase 1



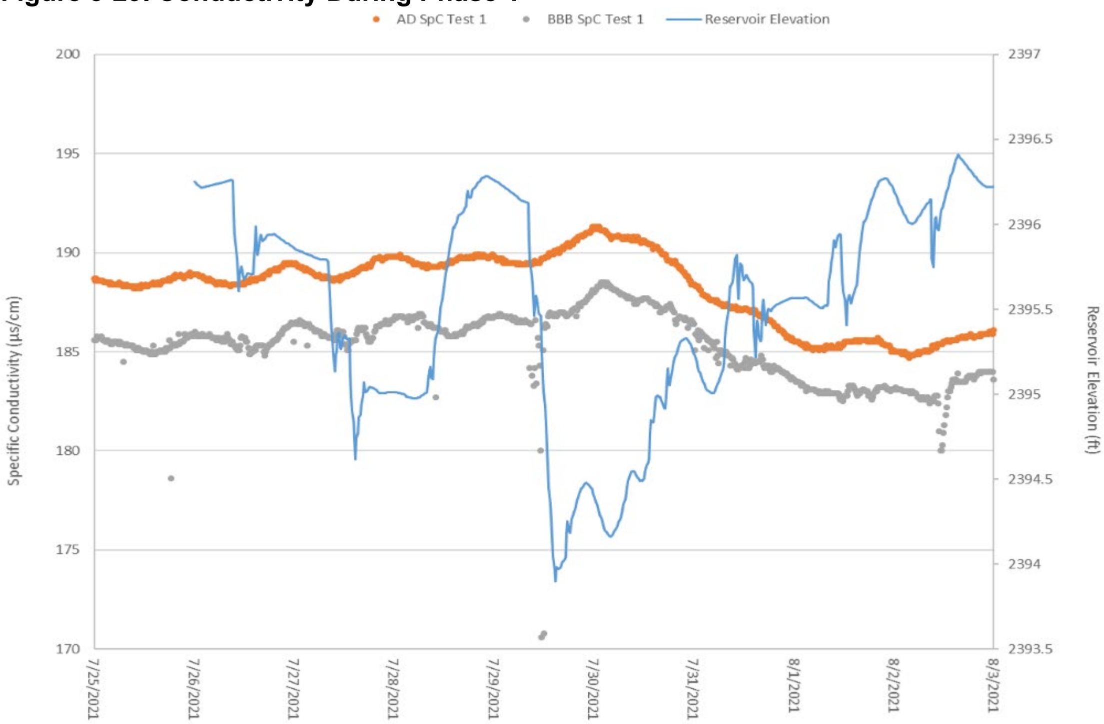
Water pH conditions remained stable throughout Phase 1 and showed no relationship to fluctuations in reservoir operations (**Figure 3-27**).

Figure 3-28. pH During Phase 1



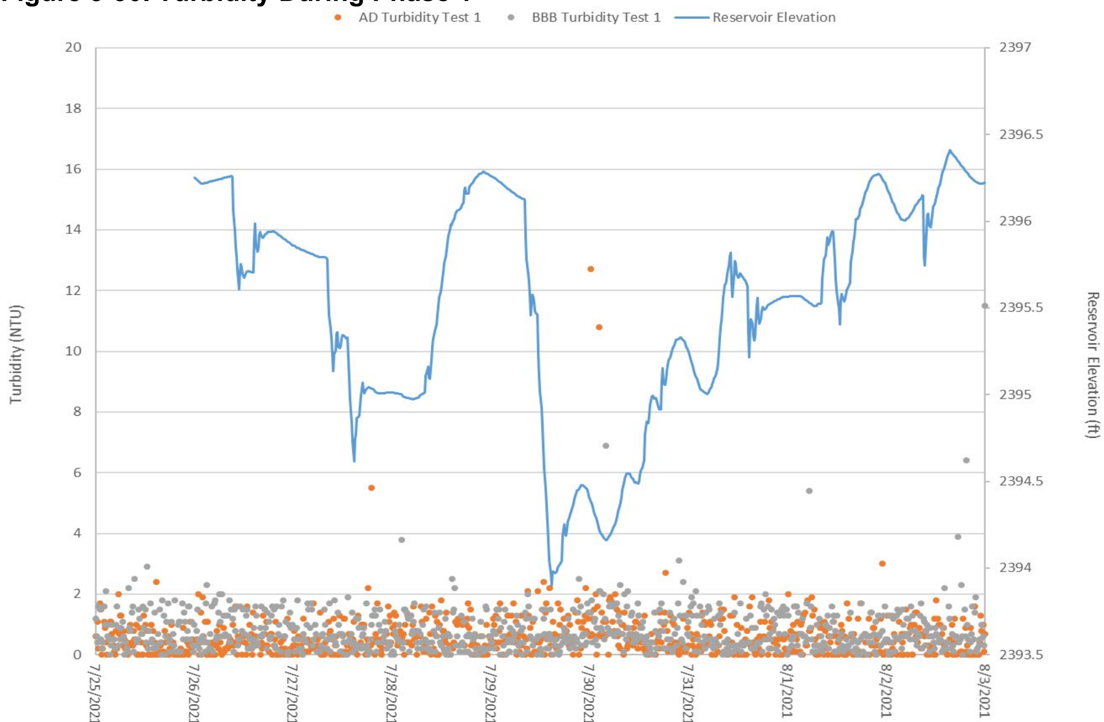
Specific conductivity showed a slight drop in conductance after July 30 as the reservoir was re-filling (**Figure 3-29**). This relationship of rising reservoir levels and decreasing conductivity was not evident in the Phase 2 or Phase 3, so it is possible that the drop in conductance could be related to factors unrelated to Project operations.

Figure 3-29. Conductivity During Phase 1



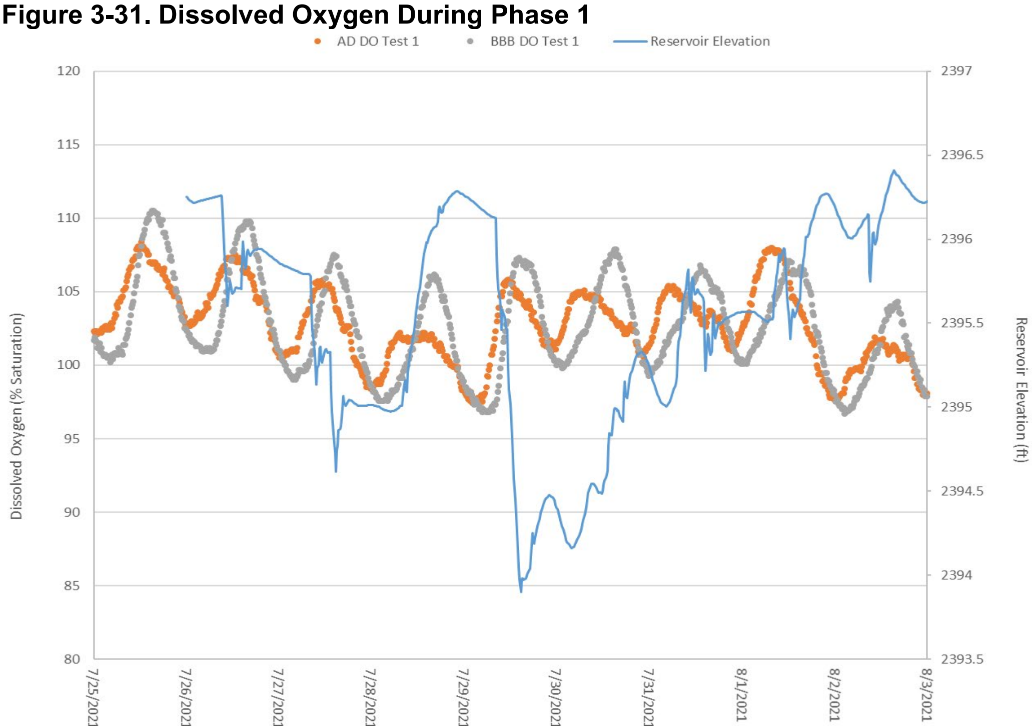
Turbidity levels during Phase 1 showed no apparent changes as reservoir levels fluctuated (**Figure 3-30**). This shows that lowering the reservoir to an elevation of 2394 feet is unlikely to re-suspend bed sediments in the reservoir which would result in increases in downstream turbidity.

Figure 3-30. Turbidity During Phase 1



Dissolved oxygen conditions remained stable throughout Phase 1 and showed no relationship to fluctuations in reservoir operations (**Figure 3-31**).

Figure 3-31. Dissolved Oxygen During Phase 1

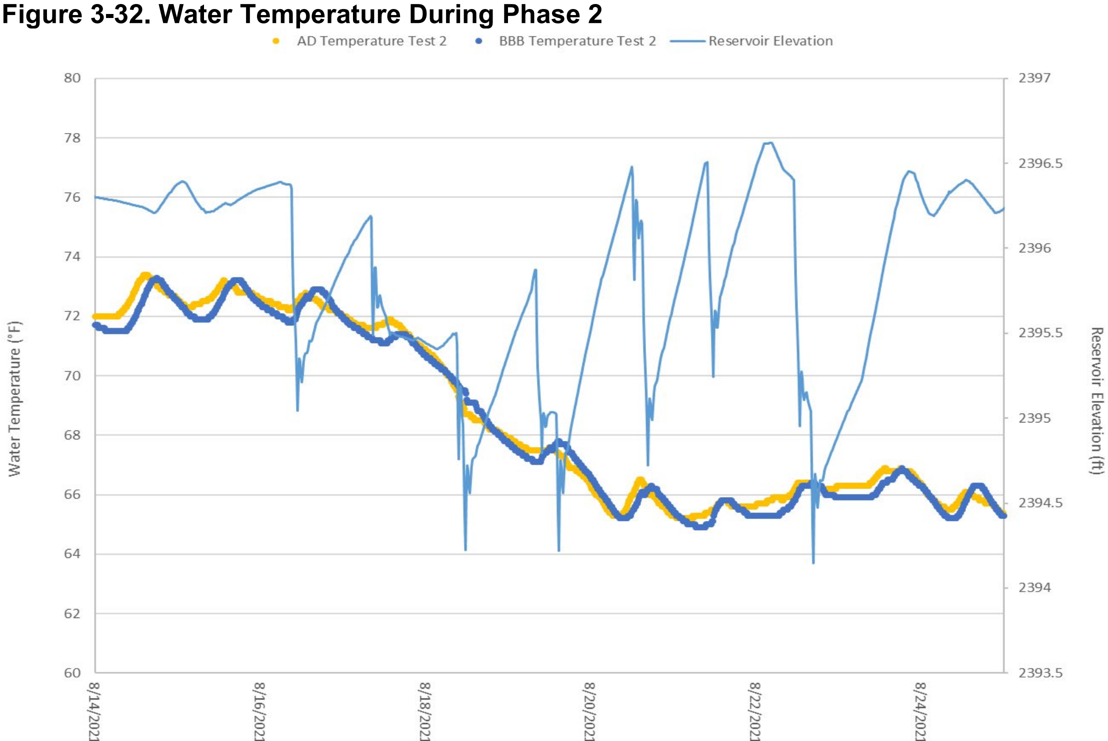


3.7.2 Operations Phase 2

During the Operation Study Phase 2, there was a significant weather pattern change, which could have possibly had an effect on some of the changes that were observed in the water quality data. The maximum daily air temperatures from August 11 through August 16 ranged from 94 to 99°F, and then quickly dropped to 69 and 67°F on August 17 and 18 respectively. Along with this change in air temperature, the weather station at the Thompson Falls Airport recorded 1.07 inches of rain on August 17 (Western Regional Climate Center, 2021). This weather event coincides with subsequent drops in water temperature, pH, specific conductivity, and dissolved oxygen at both the AD site and the BBB site. Because of this weather event, it is not possible to determine whether changes in water quality were due to operations or natural variability from the atmospheric conditions. These changes in water quality were not observed during either Phase 1 or Phase 3, therefore it is likely that the weather event that occurred on August 17 is the main factor in the changes observed in water quality for Phase 2. **Figures 3-32 through 3-36** show each water quality parameter measured during Phase 2 plotted with the changes in reservoir elevation that occurred during that timeframe.

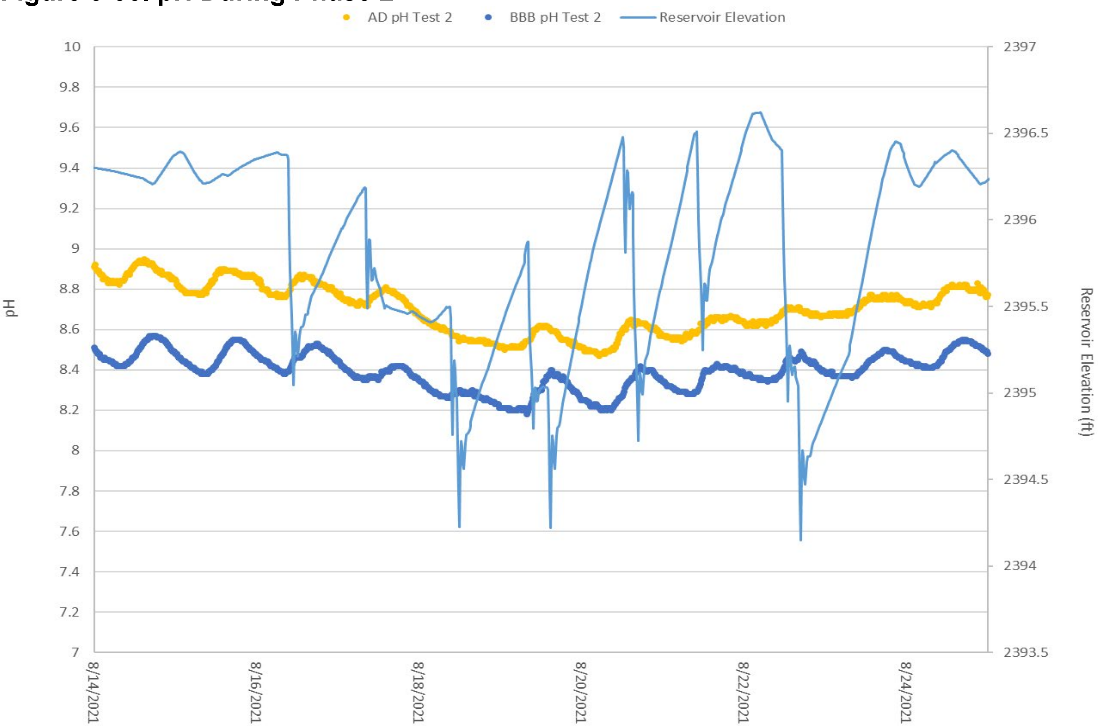
Water temperature showed a drastic decrease from August 17 through August 20, but then remained stable through the remainder of Phase 2 (**Figure 3-32**). As noted above, this appears to be due to changes in atmospheric conditions and not related to reservoir operations.

Figure 3-32. Water Temperature During Phase 2



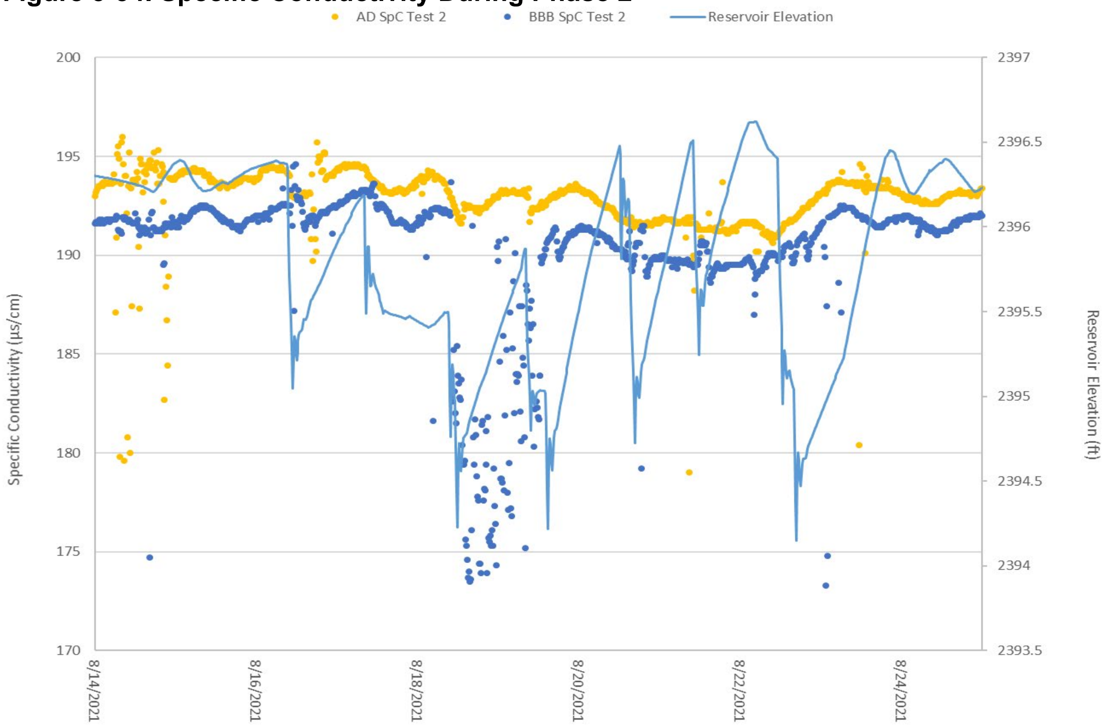
Water pH showed a very slight decrease from August 17 through August 20, but then remained stable through the remainder of Phase 2 (**Figure 3-33**). As noted above, this appears to be due to changes in atmospheric conditions and not related to reservoir operations.

Figure 3-33. pH During Phase 2



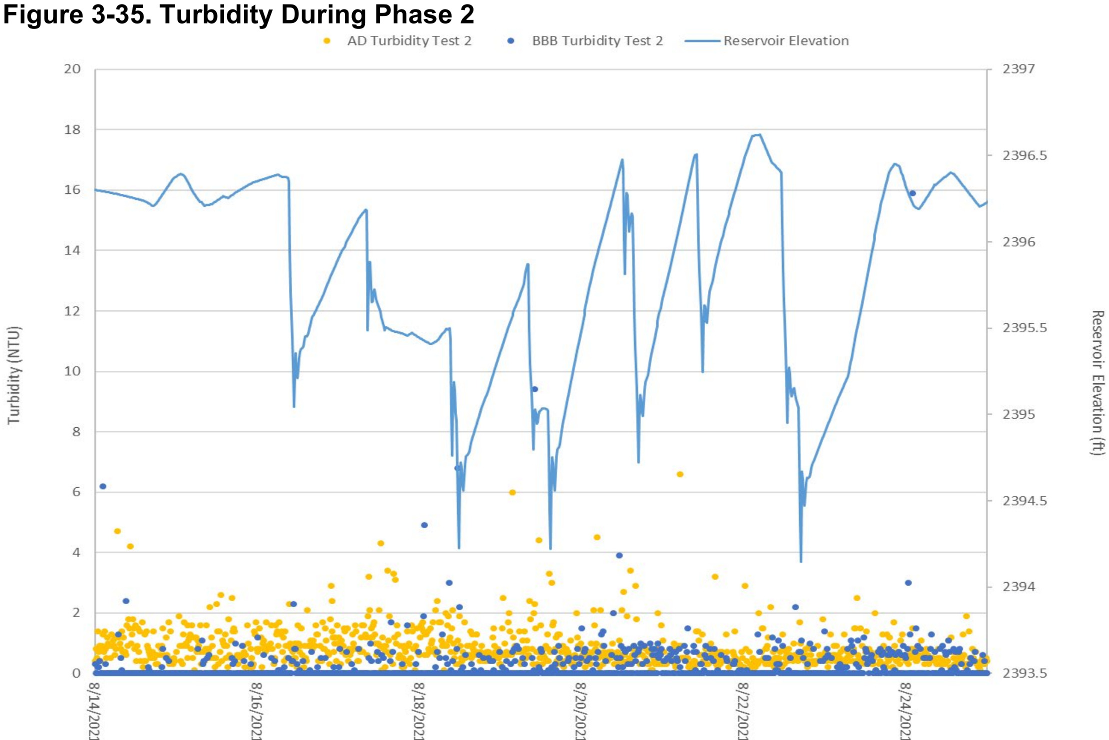
Specific conductivity showed little to no change at the AD site but showed a decrease in conductance at the BBB site from August 17 through August 20 (**Figure 3-34**). After that period, conductivity at both sites remained relatively stable. The decrease in conductivity at the BBB site aligns with the changes in atmospheric conditions, but it is unknown why the AD site did not display the same pattern in the data.

Figure 3-34. Specific Conductivity During Phase 2



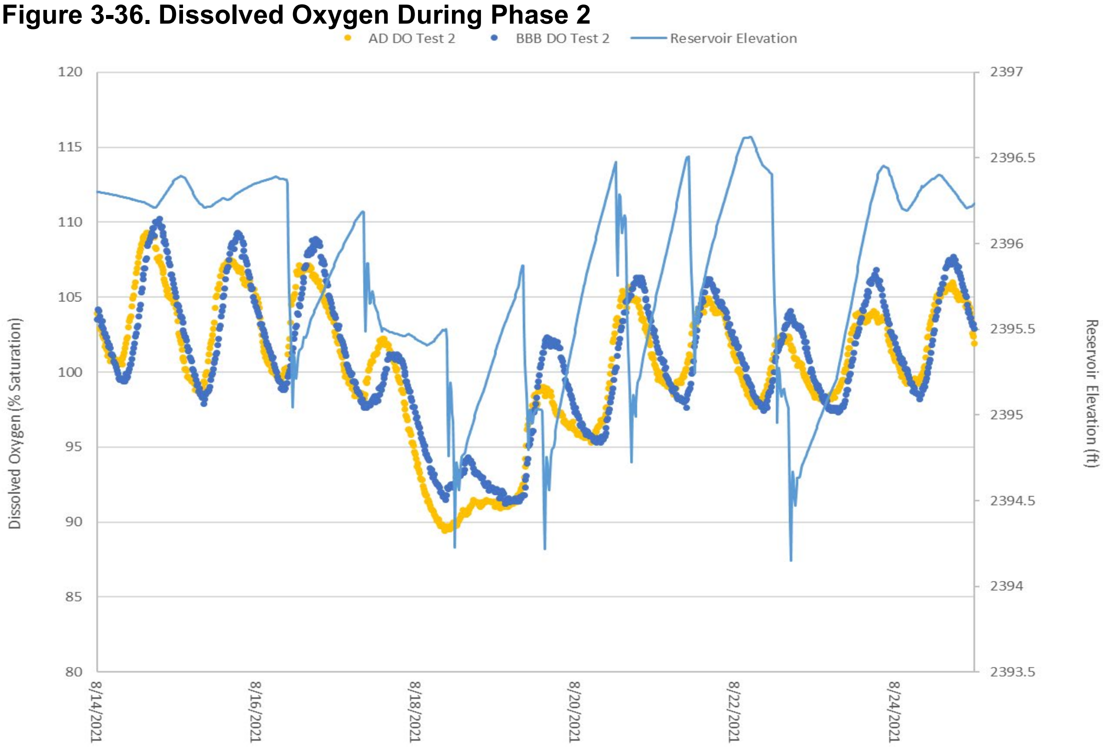
Turbidity levels during Phase 2 showed no apparent changes as reservoir levels fluctuated, therefore the operational scenarios tested during Phase 2 did not seem to have an effect on turbidity (**Figure 3-35**).

Figure 3-35. Turbidity During Phase 2



Dissolved oxygen showed a slight decrease from August 17 through August 20 but remained within the normal range for that parameter (**Figure 3-35**). After August 20, dissolved oxygen remained stable through the remainder of the testing period. Decreases in dissolved oxygen can be tied to lower air temperatures and increased cloud cover, which can lead to decreases in primary productivity and oxygen production in the reservoir. As noted above, the change in dissolved oxygen during Phase 2 appears to be due to changes in atmospheric conditions and not related to reservoir operations.

Figure 3-36. Dissolved Oxygen During Phase 2

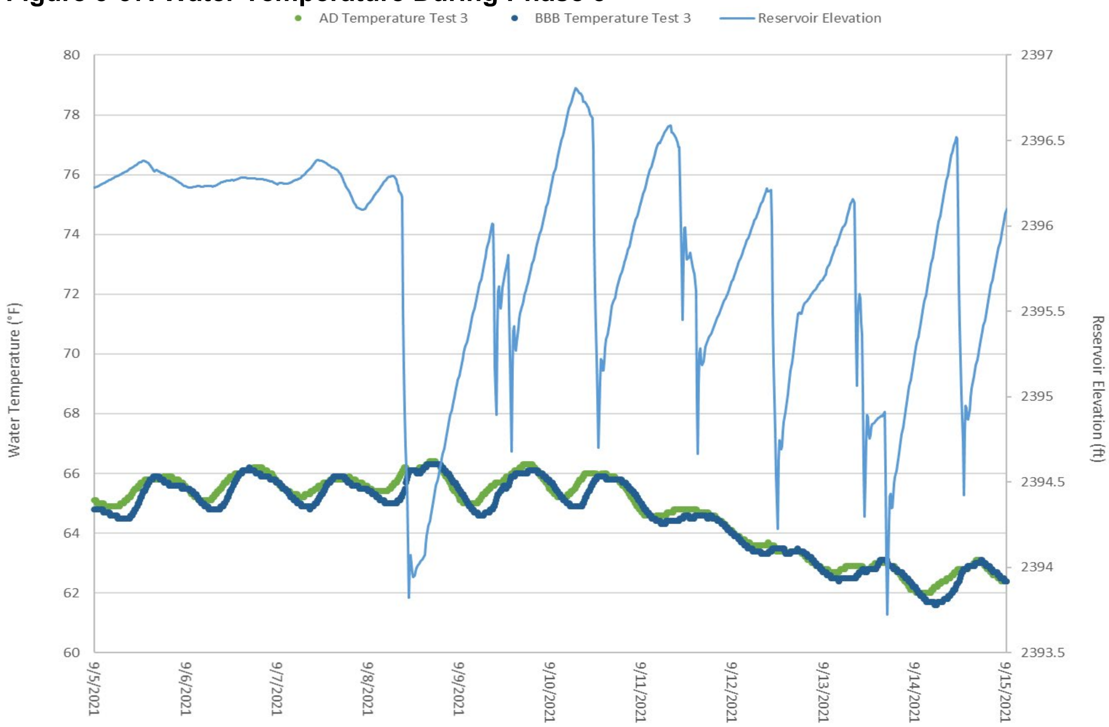


3.7.3 Operations Phase 3

Water quality data collected during Phase 3 showed that reservoir operations that occurred during this testing phase had little to no impact on water quality, with the exception of downstream turbidity caused from an increase in powerhouse discharge to reduce reservoir elevation on September 10. This increase in turbidity was captured at the BBB site but was not present at the upstream AD site. The remaining water quality parameters display some natural variation as well as diurnal swings in the data, but when plotted with fluctuations in reservoir elevation, there were no evident trends in those data. **Figures 3-37 through 3-51** show each water quality parameter measured during Phase 3 plotted with the changes in reservoir elevation that occurred during that timeframe.

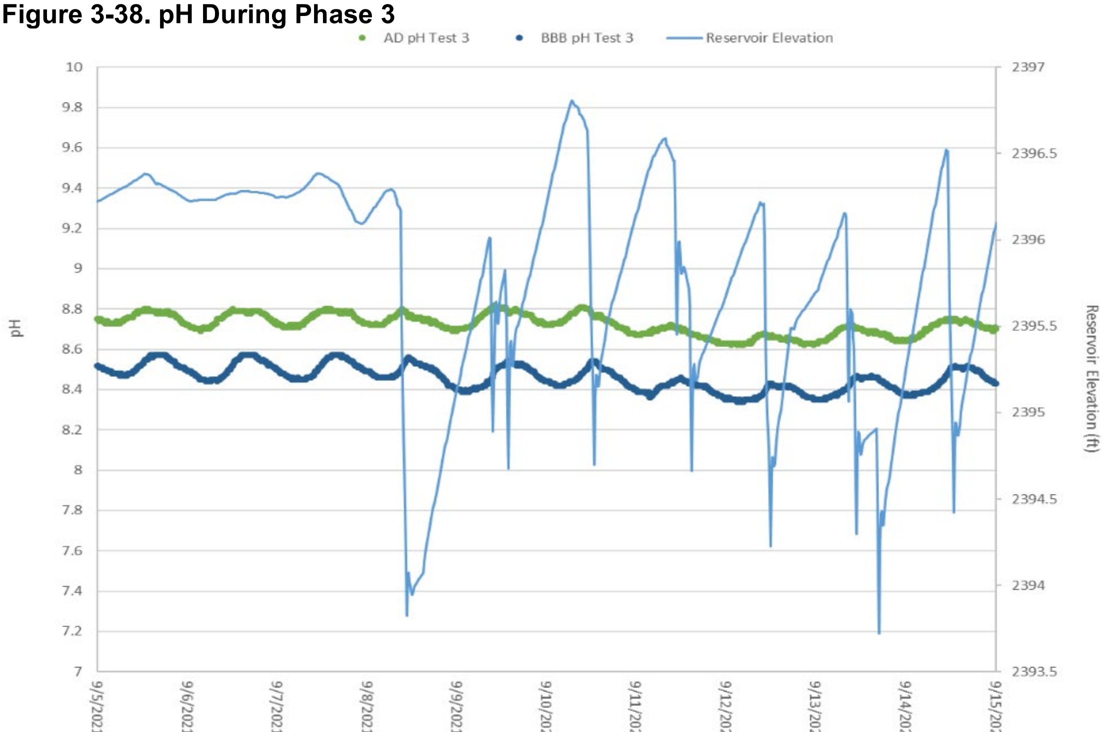
Water temperature remained stable throughout Phase 3 and showed no relationship to fluctuations in reservoir operations (**Figure 3-37**).

Figure 3-37. Water Temperature During Phase 3



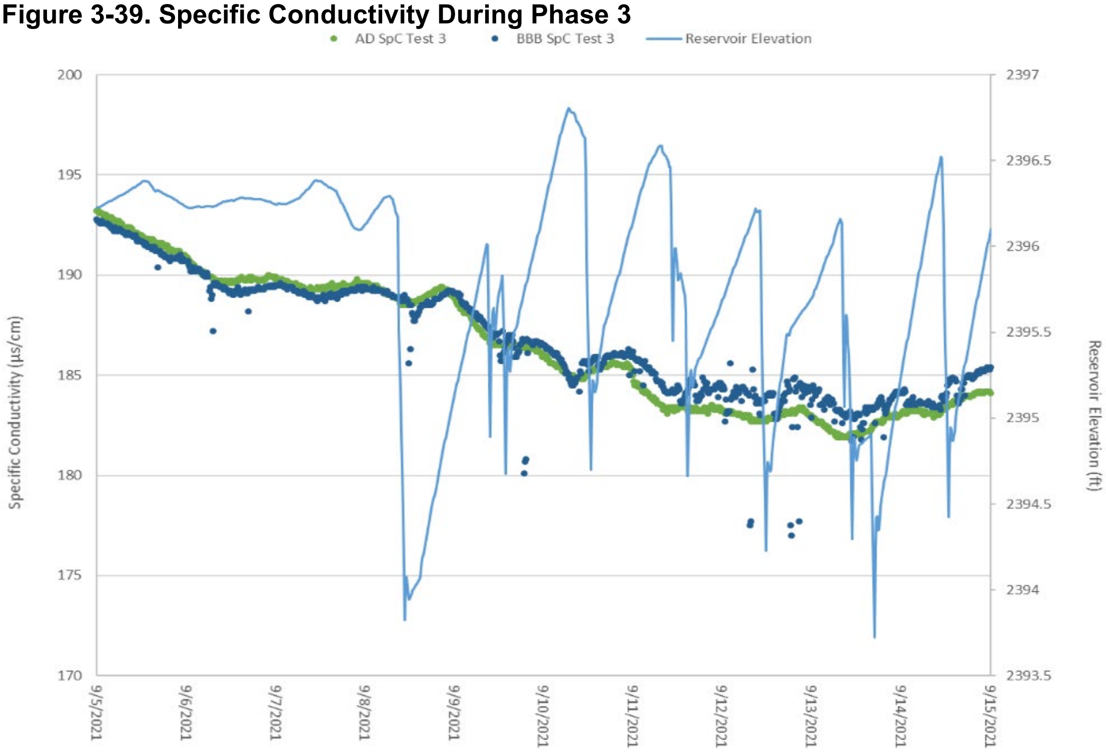
Water pH conditions remained stable throughout Phase 3 and showed no relationship to fluctuations in reservoir operations (**Figure 3-38**).

Figure 3-38. pH During Phase 3



Specific conductivity showed a slight drop throughout the testing period (**Figure 3-39**). Specific conductivity appeared to be trending downward before Phase 3 began, and the change in conductivity does not seem to align with any changes in reservoir elevation, so the cause of the drop in conductivity is likely due to other factors.

Figure 3-39. Specific Conductivity During Phase 3



Turbidity during Phase 3 remained stable through the largest drawdown at the start of the Operations Study, but when the reservoir elevations came back up, there was some downstream turbidity observed at the BBB site (**Figure 3-40).** During the refill of the reservoir, the elevation of the reservoir exceeded the planned elevation, which caused some spillage over the main and dry channel dams. To reduce reservoir elevation, discharge was increased through the powerhouse (**Figure 3-41**). This operation caused the stage downstream of the powerhouse to rapidly increase by approximately 4.5 feet, and the downstream river stage remained high for approximately 1.5 hours (**Figure 3-42**). This increase in river stage led to the temporary increase in turbidity observed at the BBB site. Once the powerhouse discharge was reduced, turbidity returned to normal background levels for the remainder of Phase 3. The turbidity during this event was observed at the BBB site and not the AD site, therefore, the data points to a source of turbidity originating downstream of the powerhouse and not originating in the reservoir.

Figure 3-40. Turbidity During Phase 3

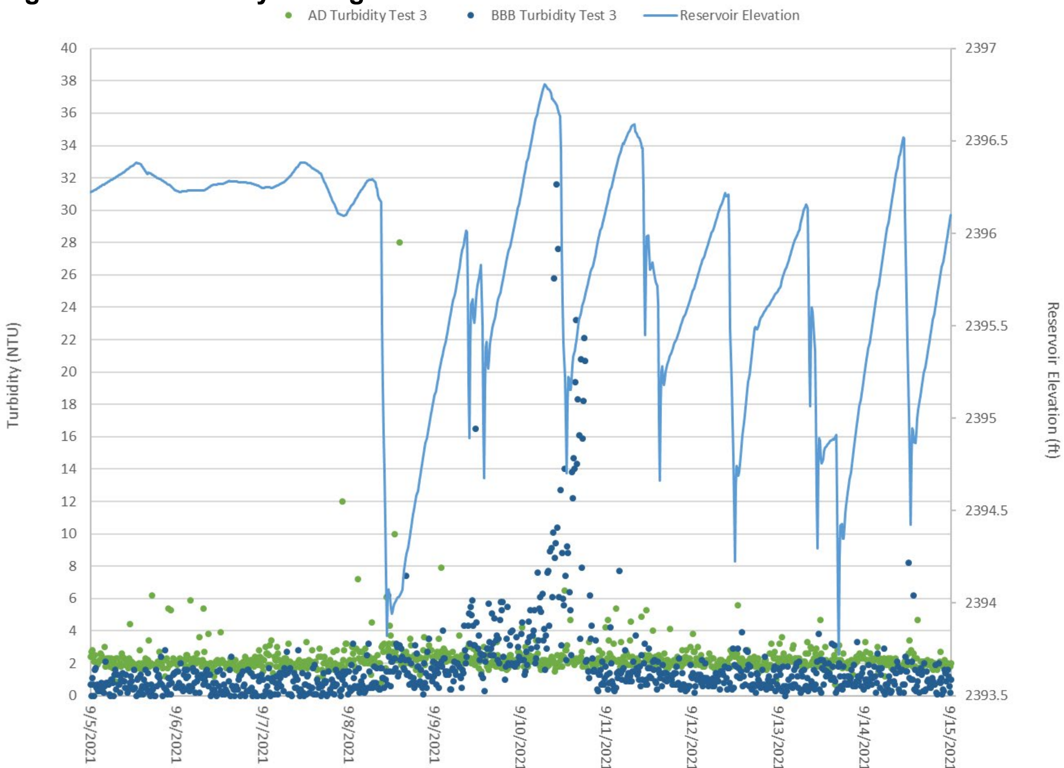


Figure 3-41. Turbidity in Relation to Outflow and Spill September 10, 2021

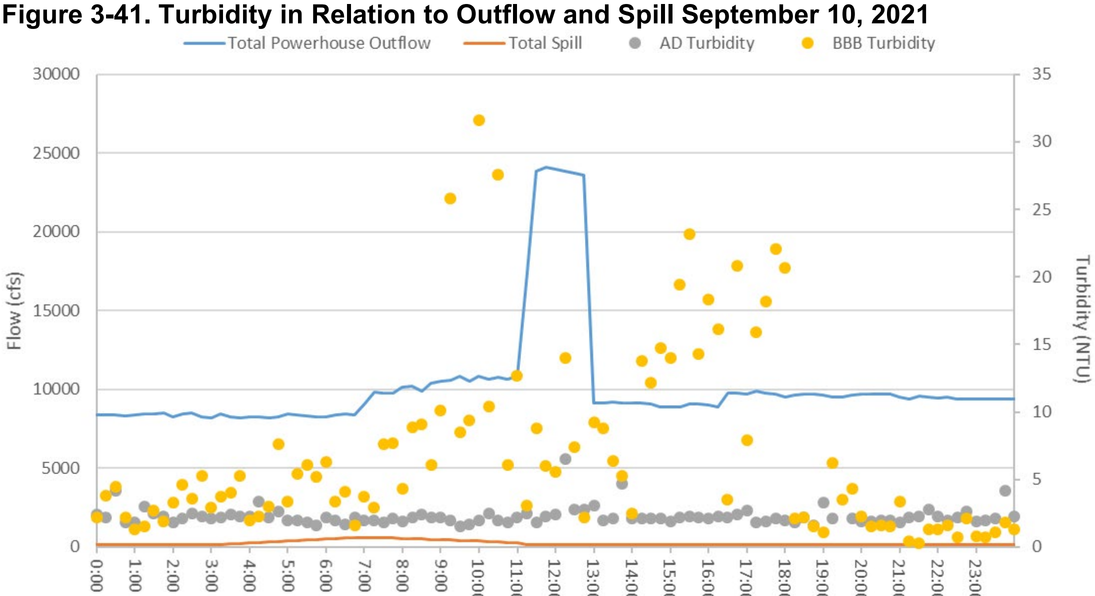
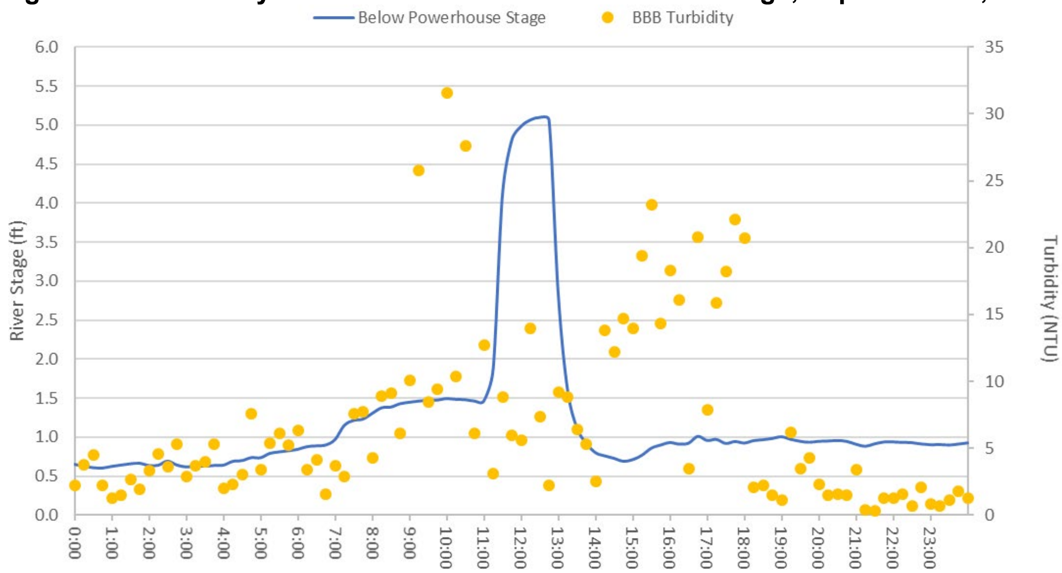
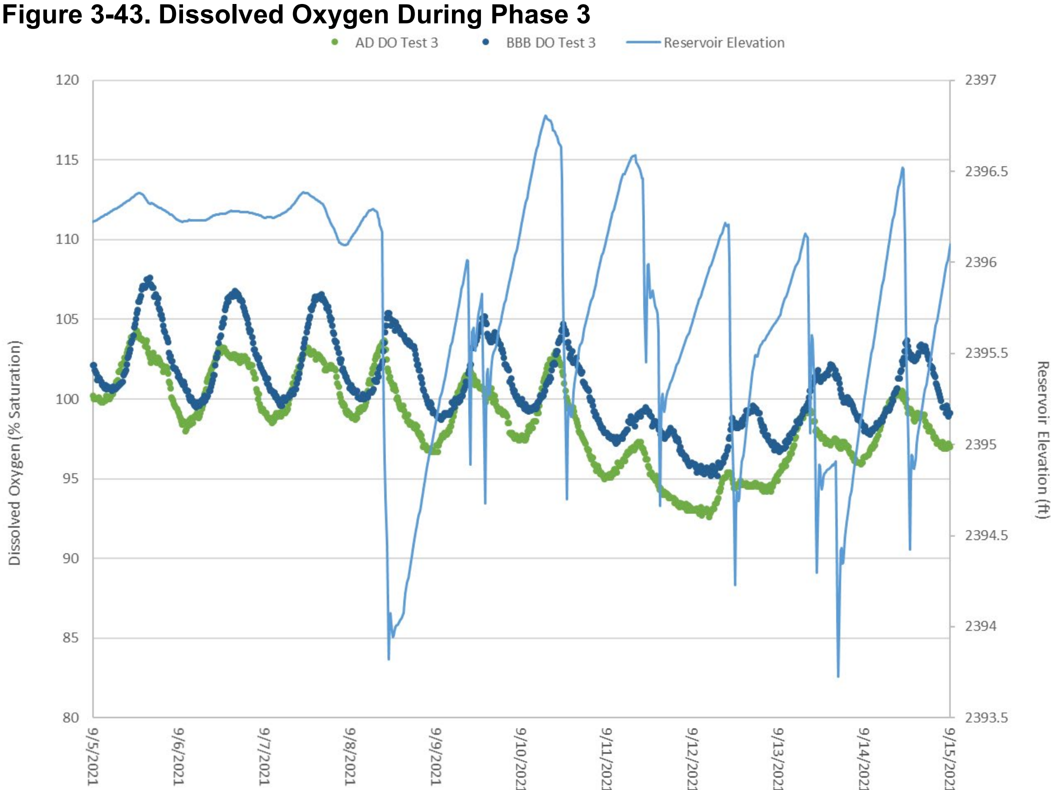


Figure 3-42. Turbidity at BBB in Relation to Downstream Stage, September 10, 2021



Dissolved oxygen remained stable throughout Phase 3 and showed no relationship to fluctuations in reservoir operations (**Figure 3-43**).

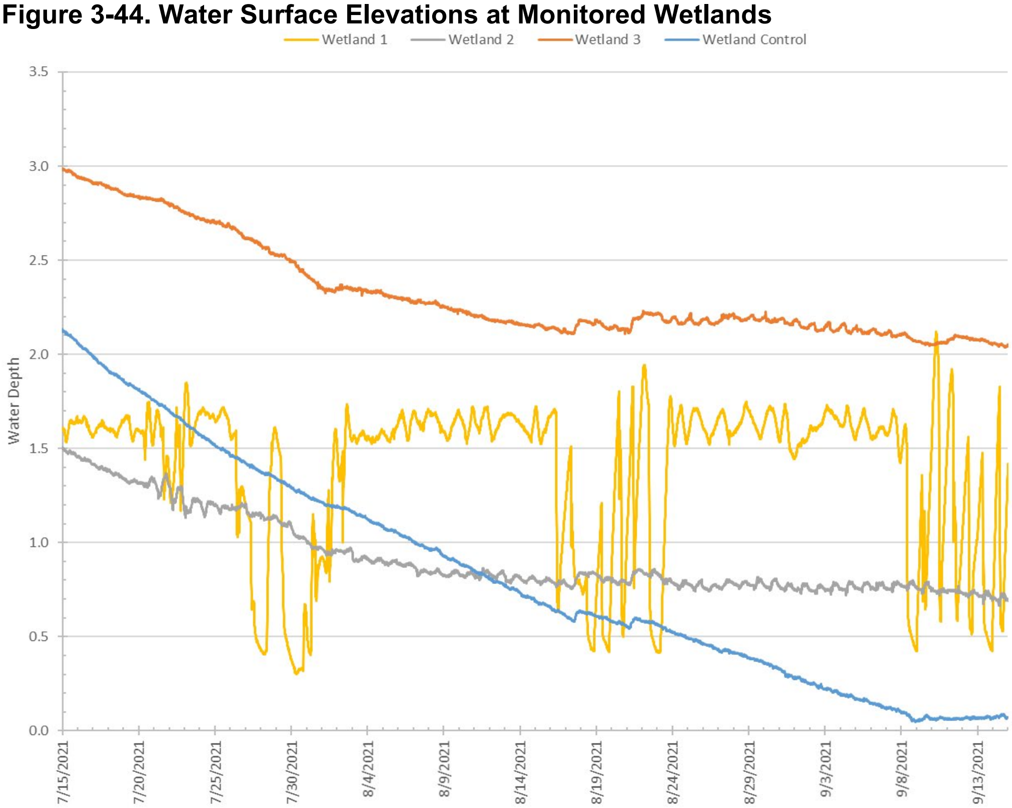
Figure 3-43. Dissolved Oxygen During Phase 3



3.8 Wetlands

Results from the stage monitoring at all wetland sites is shown below in **Figure 3-44**. This figure graphically displays the response or lack of response of each individual wetland site to changes in project operations throughout the 2021 study season. Further details of each study wetland and a description of the physical site characteristics are provided in the sections below.

Figure 3-44. Water Surface Elevations at Monitored Wetlands



3.8.1 Wetland Control Site

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 three 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 (Montana NHP 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. Although there was no visible surface water outlet observed at this site, based on its proximity to the Clark Fork River, there is a potential to have downstream surface water connectivity during high water events such as spring runoff. Based on these observations, it is likely that this wetland is hydrologically connected to the Clark Fork River *via* groundwater throughout most 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 groundwater until September 8, when the location where the stage logger was placed went dry. **Photo 3-34** shows a photo of the Wetland Control site on July 14 when the stage logger was installed, while **Photo 3-35** shows the Wetland Control site on September 16, which was the day that the logger was removed.

Photo 3-34. Wetland Control Site July 14, 2021

Photo 3-35. Wetland Control Site September 16, 2021

Influence of Project Operations

There is no influence of Project operations at this site (*refer to* **Photo 3-35**), as it is located approximately 3.9 miles upstream of the Project boundary. This site was the control site for the Operations Study.

3.8.2 Wetland 1

Physical Characteristics

Wetland 1 is located on a side channel of the reservoir near Steamboat Island and was selected 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 (Montana NHP 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 3-36** shows a photo Wetland 1 on July 14 when the stage logger was installed (note downstream surface water connection to Thompson Falls Reservoir in the background). **Photo 3-37** shows the upstream extent of this wetland, which is mainly palustrine with emergent vegetation and a small surface water inlet.

Photo 3-36. Wetland Site 1, July 14, 2021, Looking Downstream

Photo 3-37. Wetland Site 1, July 14, 2021, Looking Upstream

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 3-45** 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 2395.1 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 2395.1 feet, the side channel re-activates and the volume of water in Wetland 1 increases. **Figures 3-46 through 3-48** show the water stage in Wetland 1 in comparison to the other three wetlands for Phases 1, 2, and 3 respectively. **Photo 3-38** is a photo showing Wetland 1 when the water surface elevation of the reservoir is lower than 2395.1 feet. Potential impacts may be the temporary displacement of the fish and amphibian 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 (Montana NHP 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.

Figure 3-45. Wetland Site 1 Water Surface Elevation During Operations Study

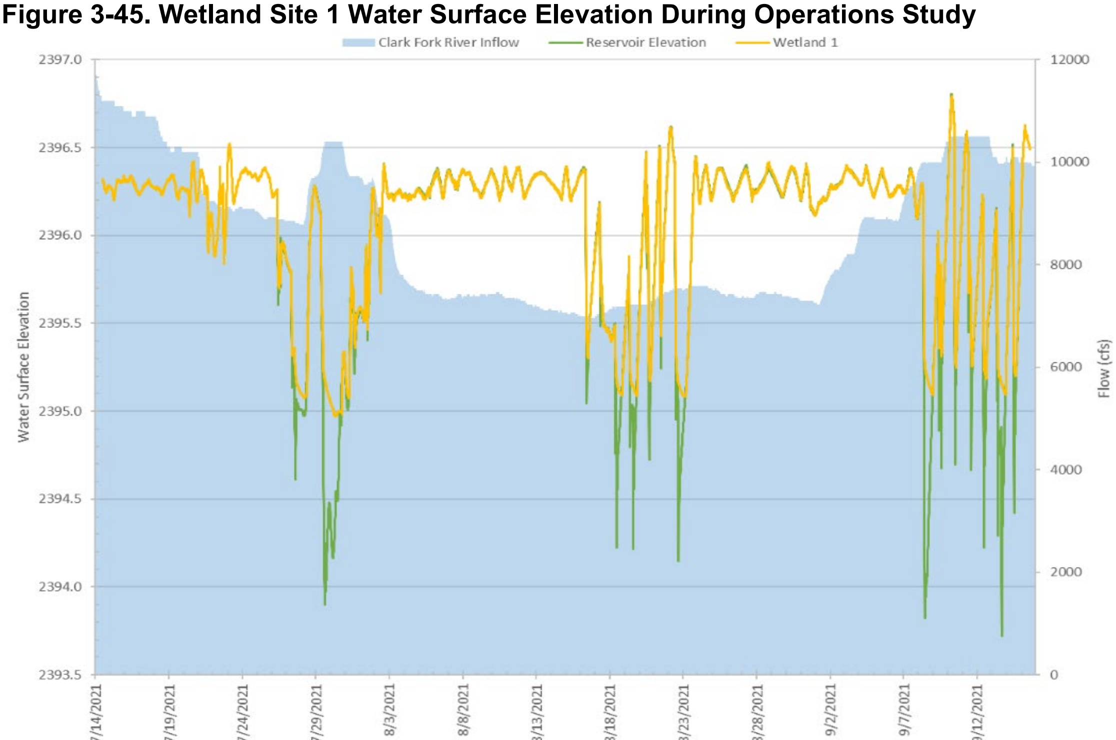


Figure 3-46. Water Surface Elevations of Test and Control Wetlands During Phase 1

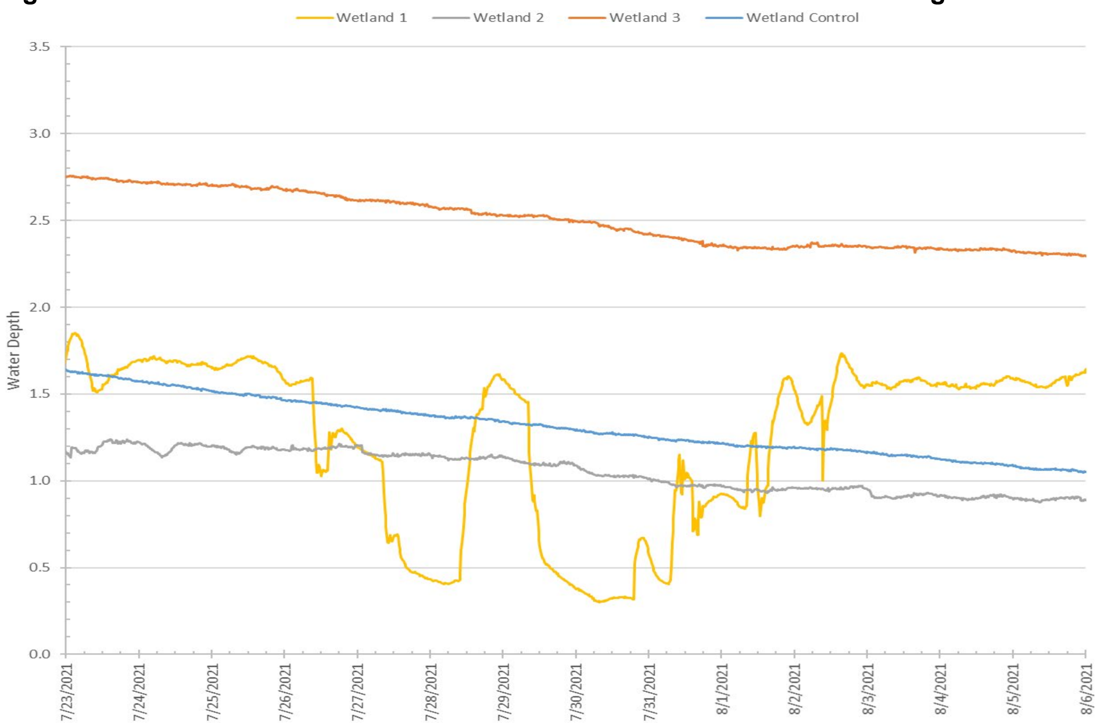


Figure 3-47. Water Surface Elevations of Test and Control Wetlands During Phase 2

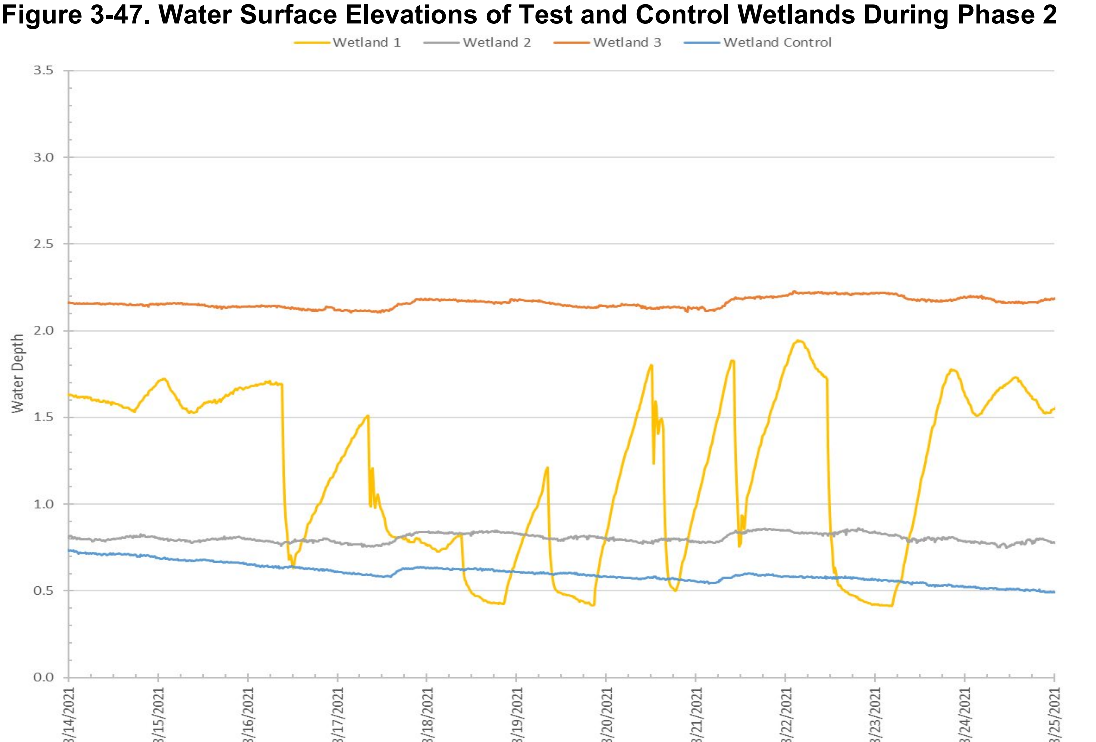


Figure 3-48. Water Surface Elevations of Test and Control Wetlands During Phase 3

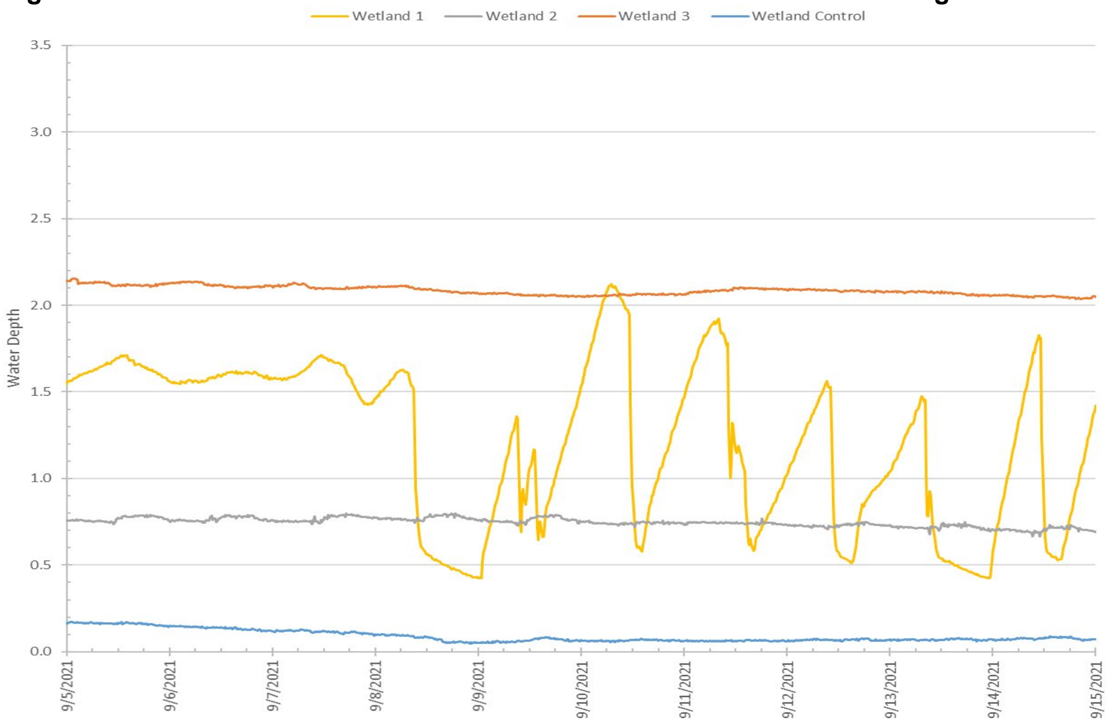


Photo 3-38. Wetland 1 When Water Surface Elevation Less Than 2395.1 Feet

3.8.3 Wetland 2

Physical Characteristics

Wetland 2 is located in the upper reservoir on the large island in the middle of the island complex upstream of the Thompson River confluence. This wetland is classified as palustrine and contains both aquatic bed and forested wetland features (Montana NHP 2021). During spring runoff and at times when the stage is high in the Clark Fork River, Wetland 2 can become flooded due to an influx of surface water. Evidence of this was found with the large amount of driftwood debris around the wetland. As the stage in the Clark Fork recedes, there is no longer an active surface water connection upstream or downstream of Wetland 2, and it appears that the wetland slowly discharges to groundwater throughout the rest of the year. Although this wetland has a close proximity to surface water in the reservoir, there is no visual surface water connection to the reservoir. Wetland 2 was classified as having a medium risk to potential alteration from operations. Wetlands of this type are generally located upstream of the Thompson River confluence and more specifically concentrated near the island complex. **Photo 3-39** shows a photo of Wetland 2 on July 14, when the stage logger was installed.

Photo 3-39. Wetland 2 July 14, 2021

Influence of Dam Operations

Dam operations at Thompson Falls Dam do not appear to have an influence on Wetland 2. **Figures 3-46 through 3-48** above showed the stage of the water in Wetland 2, which did not vary throughout the Operations Study. The pattern in the stage of Wetland 2 appears to follow the Wetland Control site closely, which is not influenced by Thompson Falls Reservoir. During Phase 2, there were two precipitation events, which can be seen as a slight increase in stage in both Wetland 2 and the Control Wetland.

3.8.4 Wetland 3

Physical Characteristics

Wetland 3 is located in the upper reservoir on a small island near river left in the island complex upstream of the Thompson River confluence. This wetland is classified as palustrine and contains both aquatic bed and emergent wetland features (Montana NHP 2021). During spring runoff and at times when the stage is high in the Clark Fork River, Wetland 3 can become flooded due to an influx of surface water. Evidence of this was found with the large amount of driftwood debris around the wetland. As the stage in the Clark Fork recedes, there is no longer an active surface water connection upstream or downstream of Wetland 3, and it appears that the wetland slowly discharges to groundwater throughout the rest of the year. There is a significant log jam on the upstream side of the island, which appears to collect flood debris when the stage in the Clark Fork River is high. It is not known if this log jam and any associated beaver activity is affecting the physical characteristics of Wetland 3. Wetland 3 also has a very visible clay layer underneath it, which greatly reduces the risk of water transmissivity between Wetland 3 and Thompson Falls Reservoir. Although this wetland is in close proximity to surface water in the reservoir, there is no visual surface water connection to the reservoir. Wetland 3 was classified as having a medium risk to potential alteration from dam operations. Wetlands of this type are generally located upstream of the Thompson River confluence and more specifically concentrated near the island complex. **Photo 3-40** shows a photo of Wetland 3 on July 14, when the stage logger was installed, and **Photo 3-41** shows the log and debris jam on the upstream end of the island on April 19, prior to spring runoff.

Photo 3-40. Wetland 3 July 14, 2021

Photo 3-41. Wetland 3, April 19, 2021, Upstream End of Island

Influence of Dam Operations

Dam operations at Thompson Falls Dam do not appear to have an influence on Wetland 3. **Figures 3-45 through 3-47** above showed the stage of the water in Wetland 3, which did not vary throughout the Operations Study. The pattern in the stage of Wetland 3 appears to follow the Wetland Control site closely, which is not influenced by Thompson Falls Reservoir. During Phase 2, there were two precipitation events, which can be seen as a slight increase in stage of both Wetland 3 and the Control Wetland.

3.9 Cultural

3.9.1 Salish House

Boat reconnaissance of the exposed reservoir cutbank along a half mile long section of shoreline within the reported site bounds yielded no historic artifacts or features associated with Salish House. The site visit determined that the terrace surface at 24SA0130 has been substantially impacted by modern residential development. The Salish Shores subdivision consists of a series of small-acreage residential plots. Modern houses, cabins, outbuildings, driveways, lawns, and pathways leading to shoreline boat docks extend along the entire shoreline within the reported site bounds. Those developments have presumably resulted in impacts to historic archaeological deposits associated with Salish House.

3.9.2 Mouth of Cherry Creek

Boat reconnaissance along a 200-meter-long segment of shoreline at the mouth of Cherry Creek yielded no precontact or historic artifacts or features. Pedestrian inventory of the public boat launch also yielded no evidence of cultural remains in surface contexts or natural subsurface exposures.

3.9.3 Railroad Construction Camp

Bridge or retaining wall footings and scattered hardware were observed on the margin of the gravel bar incorporated within the railroad grade on the north shore at the mouth of the Thompson River, but the reconnaissance did not result in relocation of any artifacts or features associated with the Chinese occupation. The reconnaissance efforts did not extend north of the railway to the reported location of precontact cultural property 24SA0291.

3.9.4 Wetland Area

There are no previously documented cultural properties in proximity to the wetland area on the reservoir's south shore. Dense marsh grass growth restricted ground surface visibility to less than 5 percent during the visit, and the reconnaissance did not result in the location of new cultural properties.

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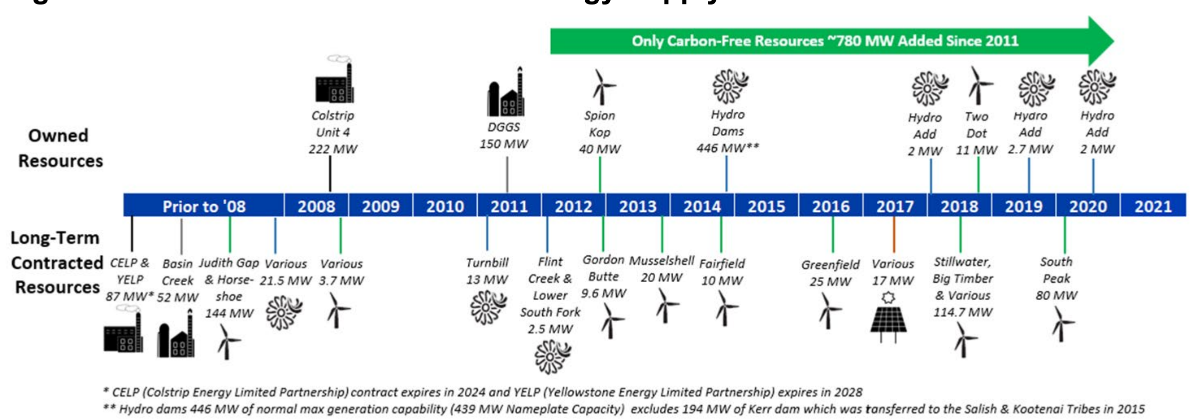
4.0 Discussion

4.1 Operations

The Operations Study demonstrated the availability of a valuable quantity (101 MW hours) of flexible capacity within the top 2.5 feet of the reservoir. This flexible capacity is needed and important for grid stability and reliability. The rapid growth in intermittently available renewable energy sources have greatly increased the need for flexible capacity to balance and offset changes in generation throughout NorthWestern's balancing area. **Figure 4-1** illustrates the increase in intermittent generation resources on NorthWestern's grid in recent years. These resources do not provide the necessary peaking or capacity power needed throughout the day to provide reliable energy for customers. The Thompson Falls Hydropower Project can play an important role in providing flexible capacity.

Figure 4-1. NorthWestern's Montana Energy Supply Portfolio Over Time



Source: NorthWestern 2022.

Reservoir rate of change rates were close to expected values and averaged 0.27 foot/hour per 10 MW throughout the Operations Study. Higher MW moves leads to more rapid increases or decreases in reservoir elevation (1.08 foot/hour at 40 MW).

Phase one of the study represented more typical scenarios while Phases two and three represented the upper bounds and extremes of the Project's operational limits. Typical operations throughout the year would be in the 10-30 MW range of flexible capacity.

While some minor improvements may be needed to the plant controls logic to best manage this flexible capacity within constraints, the physical units and plant performed well with no identified issues.

The low inflows encountered through the Operations Study phases (due to drought conditions in the basin) had a clear impact on the ability to study generation decreases.

4.2 Shoreline Stability

With few exceptions, the shoreline monitoring data indicate no changes in the amount, type or cause of erosion during the Operations Study. The most common causes are use-based impacts such as human or wildlife footpaths and removal of native vegetation. Other natural processes related to spring runoff, ice scour, runoff in response to rain events, or larger-scale impacts resulting from wind-toppled trees are also notable.

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**).

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

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

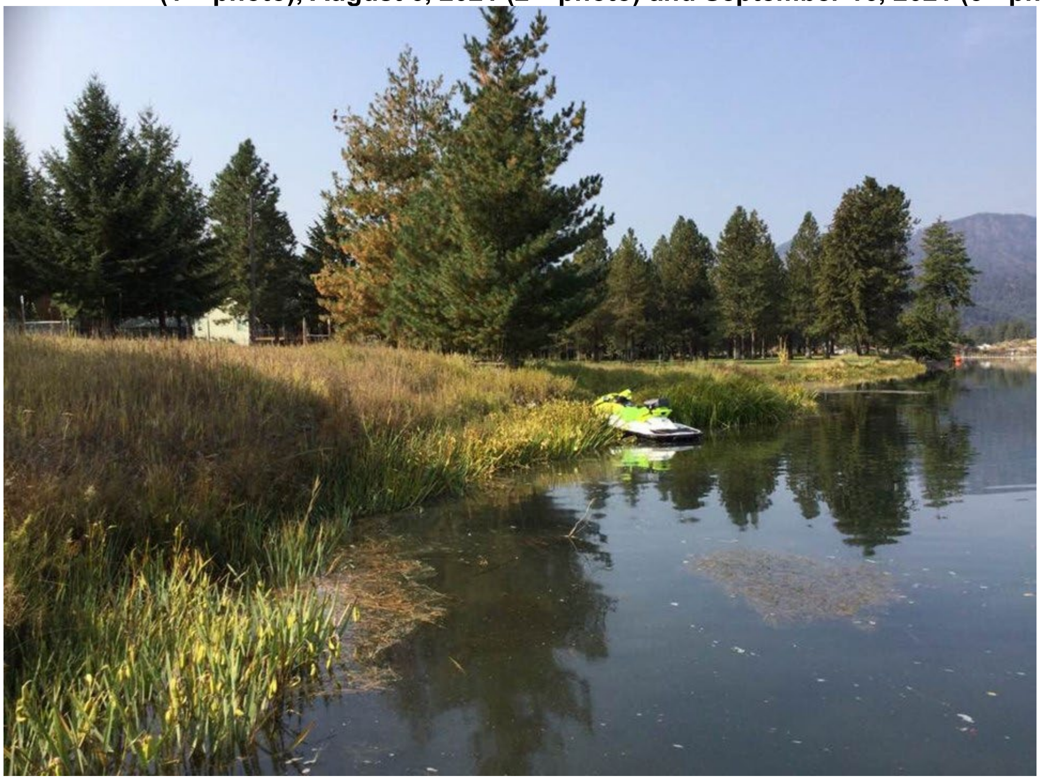
4.3 Riparian Habitats

4.3.1 Shoreline Stability Reference Points

Project operations did not appear to change the species composition or density of riparian habitats at the nine reference points. This was expected since riparian habitat species have naturally adapted to fluctuating water levels such as those experienced during the Operations Study, as well as even more dramatic fluctuations. Typical riparian habitats may be totally inundated at certain times of the year such as spring runoff or a significant summer rainfall event, and at other times of the year such as the late summer and early fall the water table may be below the root zone of the riparian plant species.

Project operations did appear to change the prevalence of aquatic vegetation and AIS at some of the nine reference points. The data generally indicate a downward trend in aquatic vegetation, particularly AIS and submergent vegetation, on September 1 and 16. It was initially theorized that this may be due to the normal process of vegetation going into fall dormancy and senescence, and unrelated to Project operations. However, review of photos from the October 8, 2020, monitoring event, which was a pre-study baseline monitoring event, indicate that the reference points did not show a similar decrease in aquatic vegetation at the time of year that would also be a period of dormancy and senescence. **Photo 4-3** is a series of three photos from Reference Point #2 from October 8, 2020, August 6, 2021, and September 16, 2021, which demonstrate the high prevalence of submergent aquatic vegetation on October 8 and August 6. On September 16, the emergent vegetation remained, but there was a lack of submergent vegetation.

Photo 4-3. Series of three photos from Reference Point #2 taken on October 8, 2020 (1ST photo), August 6, 2021 (2nd photo) and September 16, 2021 (3rd photo)



The reduction in aquatic vegetation and AIS during the two September 2021 monitoring events occurred after Phase 2 and Phase 3 respectively. Observations made from other studies and monitoring during these two Phases indicate a large amount of aquatic vegetation became mobilized in the system and was concentrating at the dams and the intake for the fish passage facility. It appears that dewatering beds of aquatic vegetation and AIS due to lowering water levels is dislodging (through uprooting or stem breakage) some of the vegetation and mobilizing it into the reservoir, and therefore reducing the amount of aquatic vegetation and AIS along the shoreline. **Photo 4-4** is a photo showing a dewatered patch of submergent vegetation near Reference Point #2 during Phase 3 of the Operations Study. At reference points where the water was deeper and dewatering did not occur, a similar reduction in aquatic vegetation and AIS was not observed. Fall dormancy and senescence is likely still a factor, and dormant and senescing vegetation is likely more prone to dislodgement, but it does appear that Project operations was an important factor in these changes.

Photo 4-4. Photo of dewatered patch of submergent vegetation near Reference Point #2 during Phase 3 of Operations Study

4.3.2 Wetland Monitoring Sites

At Wetland 1 there were no short-term changes in aquatic vegetation and AIS, but fluctuating water levels over time may cause a reduction in the amount and species of submergent vegetation. Emergent vegetation is fairly resilient, including AIS flowering rush and yellow flag iris, and may not be affected as much as the submergent vegetation.

Wetlands that do not have a surface water connection to Thompson Falls Reservoir, such as Wetland 2 and Wetland 3, are fairly resilient and do not appear to be affected by Project operations that cause the water surface elevation of the reservoir to fluctuate. Therefore, future dam operations are not expected to have an effect on aquatic vegetation and AIS that inhabit these wetlands.

4.3.3 General Observations

Project operations did not appear to change the species composition or density of riparian habitats along the shoreline in general. This was expected since riparian habitat species have naturally adapted to fluctuating water levels such as those experienced during the Operations Study, as well as even more dramatic fluctuations. Typical riparian habitats may be totally inundated at certain times of the year such as spring runoff or a significant summer rainfall event, and at other times of the year such as the late summer and early fall the water table may be below the root zone of the riparian plant species.

A large amount of aquatic vegetation was observed in the water column and accumulating against the dams and intake to the fish passage facility after both Phase 2 and Phase 3. This indicates that fluctuating water levels did cause changes to aquatic vegetation and AIS during the Operations Study.

4.4 Fisheries

Fish stranding information collected during all three phases indicated differing levels of stranding risk. Stranding potential appeared to be less associated with reservoir elevation levels and more with the rate of elevation change. During Phase 1, only four stranded fish were found during a 20 MW generation increase. In Phase 2, 33 stranded fish were found during a 40 MW generation increase. Phase 3 maximized available generation and was the fastest rate of change and 105 stranded fish were found. Stranding appeared to be more of an issue where topography sloped back into higher elevation areas, or within confined depressions. As water levels dropped, fish likely escaped by going with the flow of water. In most cases this led to the main body of reservoir and deeper water. However, this is not the case in all areas and stranded fish were most often found where the water flowed to dead end locations.

No dead adult fish were observed during the Operations Study that appeared to have succumbed to stranding-related deaths. Additionally, there were no dead or trapped salmonids found.

Access for fish to both Cherry Creek and Thompson River remained unimpeded during all phases. Reservoir elevations had minimal impact on habitats at the mouths of these tributaries. The relatively deep confluences with the reservoir for both tributaries help to mitigate possible fish passage issues.

From elevation 2396 to 2395.5 feet the quantity of water flowing between ladder pools and use for the fish workstation was reduced. Although reduced, the fish passage facility was still operable during these conditions and fish were using the fish passage facility and captured at the work station during this time. As reservoir elevations exceeded 2 foot below full pool (2394.5 feet) more impacts to the fish workstation were observed. Without an adequate supply of water to operate live well pumps at the workstation and to fill the lock to lift fish, the fish passage facility is unable to safely capture and pass fish.

Another observation during Phase 3, dying vegetation in the reservoir becomes dislodged and begins floating in large mats downstream. When reservoir levels drop and generation is rapidly increased, as in Phase 3, vegetation quickly plugs screens at the fish passage facility and significantly reduces waterflow through the facility and workstation. The current screens and cleaning systems are not adequate to rectify this issue.

4.5 Recreation and Aesthetics

Stationary docks were not negatively impacted by fluctuating water levels, but access to boats moored at stationary docks was substantially reduced at elevations 1.5 feet below full pool and lower. Damage may occur to boats that are tightly moored at stationary docks during water fluctuations. Access to the reservoir was also substantially impacted at half the stationary docks at 2.5 feet below full pool due to dewatering of the docks due to decreased water levels.

Floating docks were impacted by fluctuating water levels, but the degree of impact depends on many factors, including the length and configuration of the dock, the length of the gangway or access ramp, and the location of the dock. The type of floating dock – foam-filled floats, pontoons, polyethylene pillows, etc. – has little influence, if any.

While floating dock structures were more easily impacted by fluctuating water levels, they also provided better recreational access to the water, compared to stationary docks, if they remained floating. In general, floating docks aligned perpendicular to the shoreline remained more usable at lower water elevations than docks aligned parallel to the shoreline. Docks with longer gangways or access ramps that were near level during full pool reservoir elevations were typically able to adjust well to reducing water levels. Gangways that were angled more than about 5 degrees at full pool became very steep and possibly unusable as elevations dropped. The angle of gangways can be problematic in some cases at 2.5 feet below full pool. In all, more than 90 percent of floating docks functioned adequately at 1.5 feet below full pool elevation, and about two-thirds were sufficient at 2.0 feet below full pool. Approximately half of docks continued to provide recreational access at 2.5 feet below full pool.

Considering both floating and stationary docks, recreational access was adequate to elevations 1.0 foot below full pool and became more challenging at lower elevations. For about 70 percent of all docks, recreational access was adequate at 1.5 feet below full pool. For about 40 percent of all docks, recreational access was adequate at 2.0 feet below full pool, and adequate at 2.5 feet below full pool for about 35 percent of all docks.

Sediments and vegetation became exposed and problematic around docks as water levels were reduced. This is also true for much of the south shoreline upstream of Steamboat Island. Sediment deposits on the south shore result in shallower shorelines, compared to the north shore, and floating docks became grounded and surrounded by vegetation as the reservoir elevation declined and the shoreline was dewatered. The north shoreline upstream of Steamboat Island consists of more rock than sediment and drops off quickly to deeper elevations, so reductions in reservoir levels had less impact on floating docks and access along the north shoreline (*see* Figure 2-8).

The two public boat launches at Wild Goose Landing Park and Cherry Creek Boat Launch had at least 2.5 feet of water at the end of their ramps when the reservoir elevation was 2.5 feet below full pool, indicating that they remained usable at all elevations associated with the Operations Study. The native surface North Shore Estates ramp had more than 8 feet of water when the reservoir elevation was 2.5 feet below full pool and was sufficient for launching. The gravel surface Salish Shores ramp was more than 6 feet deep when the reservoir elevation was within 2.0 feet of full pool, then measured only 2.4 feet deep at 2.5 feet below full pool. This depth just barely surpasses the target depth of 2.5 feet. Overall, the majority of boat launch facilities and both of the developed public boat ramps remained sufficiently inundated at all reservoir elevations down to 2.5 feet below full pool to adequately launch watercraft. The water depth on the float plane ramp upstream of the boat barrier was 2.3 feet deep at 60 feet from shore when the reservoir elevation was 2.5 feet below full pool.

Recreational access to Sandy Beach was not negatively impacted by changes in operations beyond the changing water level in the adjacent swimming hole and the elevation of the water on the sandy shoreline.

Impacts to aesthetic qualities (visual and olfactory) of the reservoir increased as the water level decreased. Between full pool and 1.5 feet below full pool, the impacts were minimal. Some mud was exposed along the shoreline and in certain areas had a faint odor of decaying organic matter. In general, aesthetic impacts were greater when reservoir elevations were 2.0 feet or more below full pool. The exposed large mud flats along shorelines of Island Park and the main reservoir were unsightly and odorous, which was also true along much of the upstream shorelines. At 2.5 feet below full pool these conditions were exacerbated as mud flats became larger and the odor became stronger.

4.6 Public Safety

Monitoring of in-water reservoir hazards for public safety related to changing reservoir elevations revealed two types of hazards: those that are stationary and those that have potential to shift or move, both of which pose a risk for contact. The highest risk stationary hazards are known bedrock outcrops located in fairly close proximity to one another just upstream of Steamboat Island. The risk to watercraft users for contacting these hazards will remain consistent over time since these outcrops will remain stationary. Increased visibility of two of the hazards as they became visible at lower water elevations resulted in a decreased risk of contact. The other two rock outcrops rose higher into the water column as the reservoir elevation declined, bringing them within the contact zone but not visible until the lowest water elevations were reached. The contact risk with these two hazards increased as the water elevation decreased.

Hazards that have potential to shift or move include submerged debris, logs, and branches that float during high water and become lodged when the water recedes. These types of hazards are generally situated along the shallow south shoreline and at the mouths of Cherry Creek and Thompson River. The specific risk of contact associated with these hazards will change over time as high water, ice formation, and other forces move obstacles around. Based on the observations made during the Operations Study, Project operations are not expected to be of great enough force to relocate obstacles.

Hazards and obstacles in the main reservoir body are generally visible and easily identifiable. Lower water elevations will make these obstacles more prominent, but the associated contact risk due to Project Operations is unchanged or possibly reduced due to increased visibility. In addition, contact risk is less when boats travel at lower rates of speed in near shore areas where most hazards are located.

Water surface elevation changes are apparent at Sandy Beach when generation is increased. However, because the swimming hole at the site is protected by a substantial gravel bar and rock outcrop, elevation changes do not have associated high-velocity flows, even at the highest rates of change documented during the Operations Study. Therefore, the safety of swimmers is unaffected.

4.7 Water Quality

Water quality data collected during all three phases show that the various flexible operation scenarios tested do not appear to have a significant effect on water quality within the reservoir and downstream in the Clark Fork River. During Phase 3, there was a temporary increase in downstream turbidity at the BBB site that was due to an increase in powerhouse releases to reduce the reservoir elevation. This was an isolated event and not part of the Operations Study.

4.8 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 is an example of this. At Wetland 1, when the water surface elevation of the reservoir is lowered, the water surface elevation of the wetland is also lowered at the same corresponding rate. Wetland 1 and other wetlands in the Project area that of a comparable type and have the potential to be affected by Project operations collectively comprise approximately 9.4 acres (Montana NHP, 2021). During the Operations Study, downcutting of the Wetland 1 outlet was observed (**Photo 4-5**).

Photo 4-5. Outlet of Wetland 1

Aquatic habitat within wetlands like Wetland 1 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 wetlands like Wetland 1 by reducing the amount and species of submergent vegetation. Emergent vegetation is fairly resilient and may not be affected as much as the submergent vegetation.

Wetlands that do not have a surface water connection to Thompson Falls Reservoir, such as Wetland 2 and Wetland 3, are fairly resilient and do not appear to be affected by dam operations that cause the water surface elevation of the reservoir to fluctuate. This same assumption could be applied to other wetland sites within the Project boundary that are not hydrologically connected to the reservoir by a surface water connection. The area of Wetland 2 and Wetland 3 and wetlands of comparable type collectively comprise approximately 200.4 acres (Montana NHP 2021). Because these types of wetland sites are not affected by dam operations, future dam operations that fluctuate the water surface elevation of the reservoir should not be expected to have an effect on vegetation and any AIS that have colonized within these wetlands.

4.9 Cultural

All cultural resource work undertaken September 8, 2021, was conducted at the reconnaissance level. The shoreline segments visited in 2021 will require additional cultural resource inventory. Intensive cultural resource inventory is scheduled to be conducted during the 2022 field season.

5.0 Conclusions

5.1 Operations

1. 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 is proposing a second season study to evaluate more typical scenarios of the proposed operation (Appendix A).
2. The reservoir provided an approximate 101 MW-hours of flexible capacity which is important to the reliability and stability of NorthWestern's electric system and customers.
3. Reservoir elevation change rates are significant at higher extremes of MW moves, but are moderate at typical levels of flexible capacity (10-30 MW).
4. Plant and unit operation indicated no mechanical or electrical issues or constraints in performing the operational activities throughout the Operations Study.
5. Low inflows impact capability to decrease generation while maintaining required minimum outflows.

5.2 Shoreline Stability

1. 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.
2. Fluctuating water levels due to operations do not appear to increase shoreline erosion or instability.
3. 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.

5.3 Riparian Habitats

1. Fluctuating water levels did not appear to impact riparian habitats, as riparian habitats have naturally adapted to fluctuating water levels.
2. Fluctuating water levels appeared to change the prevalence of some aquatic vegetation and AIS, especially in areas that were dewatered.

3. Long term changes to aquatic vegetation species composition and prevalence, including AIS, may occur under proposed operations, especially in areas that are dewatered.
4. Changes to aquatic vegetation species composition and prevalence may have a positive, negative or neutral impact on other resource concerns and issues.

5.4 Fisheries

1. Fish stranding was limited to juvenile fish of only non-salmonid species. Fish stranding potential appeared to increase with the rate of elevation change, particularly in areas where topography sloped back into higher elevation areas, or within confined depressions.
2. The fish passage facility remained operable down to reservoir elevation 2394.5 feet. Below approximate elevation 2394.5 feet, water through the attraction flow pipe and the sampling workstation was reduced. As presently configured, near 2394.5 feet the sampling workstation did not consistently have sufficient water for processing fish.
3. During the late summer when generation rapidly increased, vegetation plugged screens at the fish passage facility, reducing waterflow through the facility and workstation, impeding functionality of the fish passage facility as presently configured.
4. Access for fish to both Cherry Creek and Thompson River remained unimpeded.

5.5 Recreation and Aesthetics

1. Assessment of boat ramps reveal that boat launching remains available at water elevations down to 2.5 feet below full pool.
2. Sandy Beach and its associated swimming hole remained accessible during all three phases of the Operations Study.
3. The public access docks remained usable at elevations down to 1.5 feet below full pool. Useability below that level varied depending on dock design, length, and location.
4. Impacts to private docks and associated recreation access varies with fluctuating water levels and with the type, configuration, and location of docks.
5. The amount of exposed mud and emergent aquatic vegetation varies throughout the Project, which may influence odor at lower water elevations.

5.6 Public Safety

1. Bedrock outcrops pose a risk of contact for watercraft users since they are stationary. Contact risk will increase and decrease as water elevations change and affect their depth.

2. Shoals and inundated islands in the main reservoir body are visible at full pool. Contact risk is unchanged or slightly improved (i.e., lessened) by lower water elevations resulting from Project Operations.
3. Sandy Beach water elevation increases are tempered by rock outcrops and gravel bars that define the outer bounds of the swimming hole.

5.7 Water Quality

1. Proposed reservoir operations generally do not affect the water quality of the reservoir and the Clark Fork River downstream.
2. Water quality appears to be independent of depth of drawdown, duration of drawdown, and drawdown frequency.

5.8 Wetlands

1. Wetlands with a surface water connection to the reservoir (approximately 9.4 acres total) may be temporarily dewatered when the elevation of the reservoir is lowered, but is restored when the reservoir is raised.
2. Wetlands hydrologically connected to the reservoir *via* groundwater (approximately 200.4 acres total), do not appear to be affected by fluctuations in the water surface elevation of the reservoir.

5.9 Cultural Resources

1. No effects to cultural resources were identified during the Operations Study.

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Appendix A – Modified Study Plan for Second Study Season

Introduction

NorthWestern proposes to modify the FERC-approved Operations Study. The modification involves monitoring and evaluating the effects to certain resources of actual (versus simulated) baseload and flexible capacity operations, as described in this Appendix.

The first study season was designed to simulate operational scenarios using the Project's generational flexible capacity utilizing the top 2.5 feet of the Thompson Falls Reservoir. Objectives included evaluating a broad spectrum of flexible operational scenarios to determine plant generation capacities and outputs, and rate and degree of reservoir elevation changes that may result from these flexible operations. The operational scenarios were designed to simulate the entire spectrum of flexible generation capacities available at the Project. During the first season of study, the scenarios implemented were at a larger magnitude and frequency than what may occur under actual flexible capacity operations at the Project. The study scenarios implemented during the first season represent the extreme bounds of operations and, therefore, may not represent actual impacts on Project resources during flexible capacity operations.

Instead of attempting to simulate flexible capacity based on the Project generation capacities, the second study season will implement baseload and flexible generation to provide grid regulation in real-time. This scenario will allow NorthWestern to monitor and evaluate potential impacts of realistic operations in the current energy market.

The focus of this modification to the Operations Study will be those resource areas where impacts were identified in the first study season and where further monitoring will refine the extent of impacts, in particular to operations, shoreline stability, riparian habitats, fisheries, recreation and aesthetics, and wetlands.

Goals and Objectives of Modified Study

The goal of the modified study is to refine the extent of impacts on Project resources from a real-world application of transmission grid regulating operations.

The objectives of the modified study season are to better understand the 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 transmission grid stabilizing operations.

Methods

Operations

NorthWestern will operate the Thompson Falls Project to provide baseload and flexible generation as needed to support grid reliability and market conditions. The daily operations will be determined in real-time as stable, increases, or decreases in generation are called upon to provide NorthWestern's grid reliability and market conditions needs. The operations will range from little to no change to multiple changes in a 24-hour period. The reservoir will rise or fall based upon the operations called upon and at a rate based upon the magnitude of the generation increase or decrease. All operations will maintain the reservoir elevation within the top 2.5 feet and will provide a minimum flow of 6,000 cfs downstream of the Project.

NorthWestern will monitor reservoir and river stage during the second study season. Permanently installed stage recording instruments and remotely installed stage loggers will be used to capture elevation changes. NorthWestern will monitor stage at the following sites that were monitored during the first study season: Project Boundary, Above Islands, Islands, Main Dam, Tailrace, and Birdland Bay Bridge.

Shoreline Stability

The same data and photos will be collected at the same nine reference points as the first study season. Two monitoring events, one in July and one in September, will coincide with the monitoring events for riparian habitats discussed below.

Riparian Habitats

The results from the first year of the study indicated that operations had no impacts to riparian habitat, but potential impacts to aquatic vegetation were observed, particularly for submergent aquatic vegetation. Thus, the modified study will focus solely on aquatic vegetation.

The same data on aquatic vegetation will be collected at the same nine shoreline stability reference points as in the first study season. Data collected will include the type of plant species present, 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. There will be two monitoring events, one in July when aquatic vegetation is near its maximum growth and vigor, and one in September when aquatic vegetation is starting to go dormant and into senescence. Observations of aquatic vegetation will also be made in the reservoir, to document the presence of dislodged aquatic vegetation.

Fisheries

Data on stranded fish will be collected at the same twelve transects as during the first study season, during two monitoring events in 2022. Each transect will be walked and any stranded fish will be counted, and total length measured. Additionally, when traveling by boat to access the transect sites, any stranded fish observed will be noted.

Operations of the fish passage facility will be monitored during the second study season to further evaluate impacts. One automated stage logger will be placed in the fish passage facility to record water levels in 30-minute increments. This will measure the potential water fluctuations in the fish passage facility pools during the second season operations study. Additionally, four staff gauges within the fish passage facility will be manually recorded each time the facility is checked. Information from these gauges combined with observations by the fish passage facility operators will provide 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 will be tracked, similar to the first year of study.

Recreation and Aesthetics

Sampling will be conducted to monitor conditions and document impacts to public and private docks, public boat launches, and aesthetics during the second study season. Monitoring will be conducted no fewer than four times during the peak recreation season in July and August.

A sub-set of docks that were monitored during 2021 will be monitored during 2022 to document impacts related to changing water levels. This sub-set of docks will be dispersed among the north and south shorelines, on the main reservoir and upstream of Steamboat Island, will represent both floating and stationary docks, and will include the public docks at Wild Goose Landing Park and Cherry Creek Access Site. Floating docks and adjacent gangways will be photographed and the depth of water at the outer edge of floating docks will be measured[12]. The depth of water will also be monitored at the end of stationary docks, as will the vertical distance between the dock surface and water surface. If the end of a dock is completely dewatered, the linear distance between the end of the dock and the water line will be estimated. In addition, the presence and general density of aquatic vegetation or other conditions pertaining to waterway access near monitored docks will also be noted.

Aesthetic conditions will be observed and documented through photos of exposed mud flats and presence of odor at established reference points, as follows:

- Island Park between Gallatin Street Bridge and Dry Channel Dam.
- North shoreline of the main reservoir adjacent to the Gallatin Street Bridge, at the North Shore Boat Restraint, approximately 300 feet downstream of Wild Goose Landing Park, at the Wild Goose Landing boat launch, and at the North Shore Dispersed Use Area.

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[12] Water depths 2.5’ or less will be measured for actual depth, while depths greater than 2.5’ will be documented as “More than 2.5 ft” since 2.5’ is the average depth required for boats to draft (Boat Draft, 2022).

- South shoreline of the main reservoir across from Wild Goose Landing Park.
- Cherry Creek Access Site boat launch.

These reference locations were selected based on study season one results that indicated impacts are generally adjacent to the town of Thompson Falls and public access sites.

Wetlands

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, 2022). Additional data will be 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 6-1** lists the wetlands that will be studied in 2022.

Table 6-1. Wetlands Proposed for Evaluation 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	Riverine, Unconsolidated Shore, Seasonally Flooded	High
Wetland 5	Side channel wetland near Thompson River Lumber	Riverine, Unconsolidated Shore, Seasonally Flooded	N/A	High
Wetland Control	In Oxbow Upstream of Project Boundary	Palustrine, Aquatic Bed, Semi-permanently Flooded	Palustrine, Emergent, Temporarily Flooded	None (Control Site)

Notes: [1]Additional sites added for year two of this study were named to maintain data continuity from year one sites. Wetland sites 4 and 5 were added in Study Season 2.

Data collection includes the placement of Onset stage logging instruments at each site to track potential stage changes in the wetlands over the course of the study season. This stage data will be related to the stage data collected at the wetland control site to determine what effect reservoir operations are having at each of these sites.

Stage logging instruments will be deployed in the spring of 2022 and removed in the fall of 2022. Data will be analyzed in the fall of 2022 and reported in the Updated Study Report (USR) due by May 10, 2023.

Reporting Plan

A Final Study Report providing the results of the Modified Operations Study will be filed no later than May 10, 2023, as part of the USR.

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Appendix B Photos of Fish Stranding Transects

Thompson Falls Operations Test Stranding Transect Photographs


ST3
7/30/21


ST4
7/30/2


ST5
7/30/21


ST6
7/30/21


ST7
7/30/21


ST8
7/30/21


ST9
7/30/21


ST10
7/30/21


ST11
7/30/21


ST12
7/30/21