Final

McNary Dam Annual Temperature Report, 2024

Prepared for

US Army Corps of Engineers

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ACRONYMS AND ABBREVIATIONS

JFF	Juvenile Fish Facility
kcfs	kilo cubic feet per second
km	kilometer
MCN	McNary Dam
NOAA	National Oceanic and Atmospheric Administration

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Introduction

McNary Dam (MCN), located at river mile 292 (470 km), is the first dam encountered by downstream migrating juvenile Columbia River fall Chinook (*O. tshawytscha*) salmon originating from the Hanford Reach and Priest Rapids Hatchery. These fish comprise the largest component of subyearling fall Chinook salmon passing MCN, though smaller numbers of Endangered Species Act-listed Snake River fall Chinook salmon also pass the dam.

The migration of juvenile fall Chinook salmon typically peaks from June through July when water temperatures are warming. High water temperatures may have adverse effects on migrating salmonids. High juvenile salmonid mortality has been associated with high water temperatures at MCN in the past.

Forebay surface temperatures are warmed by solar radiation and warm air temperatures, though deeper forebay water may remain cooler. Moderate wind speeds (greater than 13 miles per hour [mph]) can mix water in the forebay and decrease surface water temperature. Warm, windless days are typically experienced in July and August and allow surface water to warm unabated.

Juvenile salmonids passing MCN are sampled (0.5% to 25%) and held for examination to determine species composition and condition and then released to the tailrace. Fish entering the bypass system from the forebay are guided into turbine gatewells (three gatewells for each of the 14 turbines, totaling 42 gatewells) and away from turbine intakes by extended-length submersible bar screens. In the gatewells, 12-inch orifices lead into the collection channel and the full-flow bypass system that direct fish to the Juvenile Fish Facility (JFF) during sampling under secondary bypass operations. Water from the collection channel is diverted over the wet separator at the JFF, where smolts and smaller fish are separated from adults and larger fish. While in secondary bypass, most of the separated fish are passed through the JFF system and returned to the river via the JFF outfall pipe.

High water temperatures in the juvenile bypass system can be mitigated through powerhouse operations. A turbine operational strategy that balances the turbines in operation and those in standby across the powerhouse can decrease the water temperature during the bypass. Operating turbines draw in warmer surface water while standby turbines allow cooler, deeper water to passively enter the gatewells.

The objective of the 2024 Temperature Monitoring Program at MCN was to monitor water temperature patterns during the juvenile salmonid passage, including the powerhouse, gatewells, collection channel, and the JFF. Water temperatures were monitored in half-hour increments to identify temperature conditions that might contribute to increased mortality of fish passing through the juvenile bypass system.

Thank you to the staff at the MCN JFF for its advice and support. Bobby Johnson, Paul Bertschinger, and the US Army Corps of Engineers staff at the JFF provided invaluable assistance during each phase of this work. Thank you to Thomas VanNice, Wes Stonecypher, and Izzy Levy of Pacific States Marine Fisheries Commission for the valuable suggestions and assistance.

Methods

Water temperatures were measured at 30-minute intervals (0000 and 0030) from 0700 hours on June 16 to 0700 hours on August 31, 2024. Measurements were taken using Onset Computer Corporation HOBO U22-001 data loggers with an accuracy of ±0.38°F and a precision of 0.04°F. A total of 385 (0.39%) hours of temperature data were lost during the 2024 temperature monitoring season due to corrupt data files on eight of the loggers and early removal of one of the loggers due to an inaccessible location. Upon discovery of a failed data logger, a replacement logger that was cleared and set for relaunch was deployed in its place (Appendix A). Each data logger was suspended by a length of paracord that was attached to the handrail on the pier nose at each location.

The loggers were deployed at 27 locations throughout MCN—1 under the separator booth porch, 8 in the forebay, 13 in the gatewells, 3 in the collection channel, and 2 in the JFF, detailed as follows:

- Separator booth porch out of direct sunlight to measure the ambient air temperature.
- Powerhouse forebay (referred to herein as forebay), near elevation 335 feet. The trolley pipes were being used by another contractor and thus were not available during the season. The data loggers were placed near the locations of previous seasons at the pier nose of Units 1, 3, 5, 7, 8, 10, 12, and 14 (8 total), submerged to a depth of approximately 10 feet below the forebay water surface.
- Gatewells at Units 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, and 14 (13 total). The data loggers were placed in the "B" slot of the gatewell except for Units 12 and 14, which were placed in the "C" slot because the "B" slot was closed for the season. The loggers were submerged to a depth of approximately 3 feet below the water surface in the gatewell. No temperature logger was deployed at gatewell unit 7 due to work being done in the area and the gatewell plates being covered for the season.
- Collection channel, downstream of gatewell orifices 12B and 8B, and upstream of the incline dewatering screen south of Unit 1 (3 total). Each logger was submerged approximately 2 feet below the water surface.
- JFF, in the fish separator underneath the bars in the "B" section, submerged to a depth of approximately 1 foot, and in the "B" sample tank, submerged to a depth of 2 feet below the water surface (2 total).

Prior to 2017, water temperature loggers were deployed along the spillway and in the tailrace at Units 1 and 14, on the transportation barge dock, and the tailrace navigation lock wing wall. Since 2016, the spillway and outfall pipe have not been monitored.

Smolt Monitoring Program personnel also recorded daily water temperatures at 0700 hours in sample tank "B" using a Fluke 52-2 digital thermometer with a precision of 0.1°F and an accuracy of ±0.54°F. These temperatures were recorded once daily and reported to the MCN biologists.

Wind-related weather data in this report were obtained from the Hermiston Airport in Hermiston, Oregon, a National Oceanic and Atmospheric Administration (NOAA) weather station, via the MesoWest database managed by the University of Utah and the Department of Atmospheric Sciences.[1] Air temperature and wind velocity were downloaded and recorded every half hour to determine the daily average for this report.

Daily temperature reports were compiled using water temperatures and weather data collected from 0700 hours of the previous day to 0700 hours of the current day. This timeframe coincided with sampling activities at the JFF.

Results

Weather Conditions

Air temperature maximums were recorded between 1300 and 2030 hours, and minimums between 2000 and 1000 hours (Table 1). The maximum air temperature for the monitoring season (110.2°F) was measured at 1830 hours on July 16 and the minimum temperature (50.0°F) was recorded on June 17 at 0430 hours (Figure 1).

Wind velocity was highly variable throughout the day. The highest daily average wind velocity was in June and the lowest was in August. The highest singular wind velocity measurement was 32.2 mph on August 17 at 2100 hours.

[1] https://mesowest.utah.edu/

Table 1. Air Temperatures and Wind Velocity at McNary Dam from 0700 on June 16 to 0700 on August 31, 2024

Month	Daily Avg. (°F)	Daily Max. Avg. (°F)	Daily Min. Avg. (°F)	Max. Range (°F)	Min. Range (°F)	Days >90°F[a]	Daily Wind Avg. (mph)	Days >3 mph[b]
June[c]	71.35	89.15	58.40	71.4–99.5	50.0–64.0	8	10.25	10
July	78.47	95.82	66.03	81.6–110.2	59.6–71.3	24	8.60	16
August	74.75	86.57	64.37	66.8–101.7	53.5–75.1	10	8.53	17

Notes:
a Count of days with highs exceeding 90°F
b Days with a daily average wind velocity exceeding 3 mph
c Monitoring occurred June 16 to June 30
°F = degree Fahrenheit; mph = miles per hour

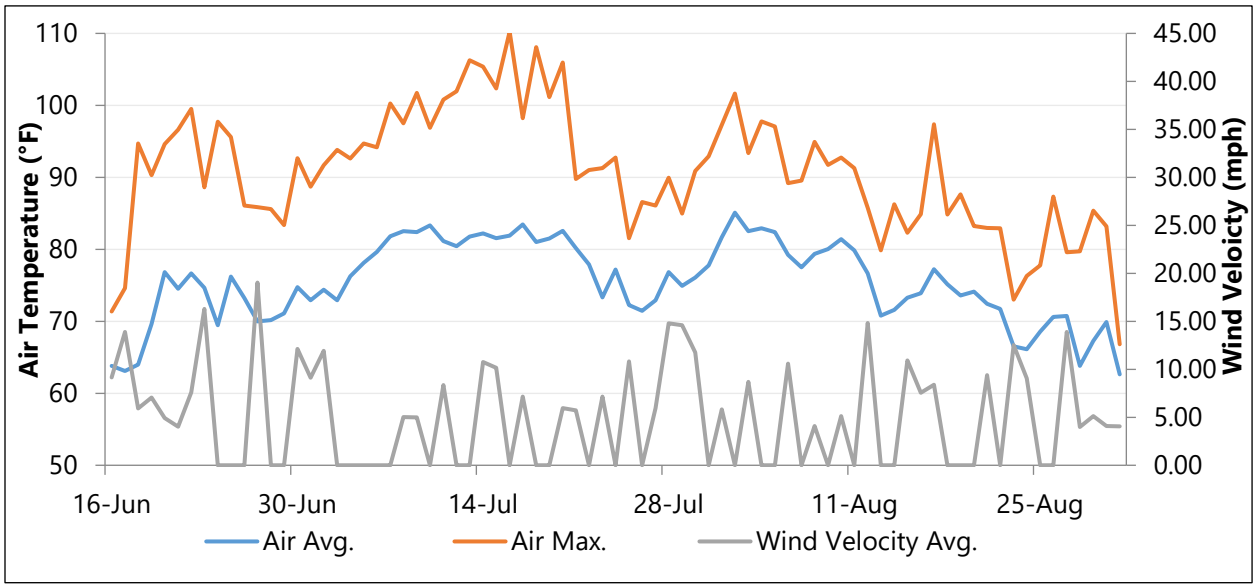

Figure 1. Average and Maximum Daily Air Temperatures and Average Wind Velocity from 0700 on June 16 to 0700 on August 31, 2024

River Flow and Spill

Total river flow from June 16 to August 31 averaged 140.0 kilo cubic feet per second (kcfs). The peak average daily total river flow (186.6 kcfs) was recorded on July 2. The minimum average daily total river flow (97.5 kcfs) was recorded on August 26 (Figure 2). The monthly average total river flow over the monitoring period in June, July, and August was 166.4, 150.8, and 117.2 kcfs, respectively. Monthly average spill for June, July, and August was 96.7, 85.3, and 28.4 kcfs, respectively, with spill constituting 58.2%, 56.6%, and 23.9% of the total flow for June, July, and August.

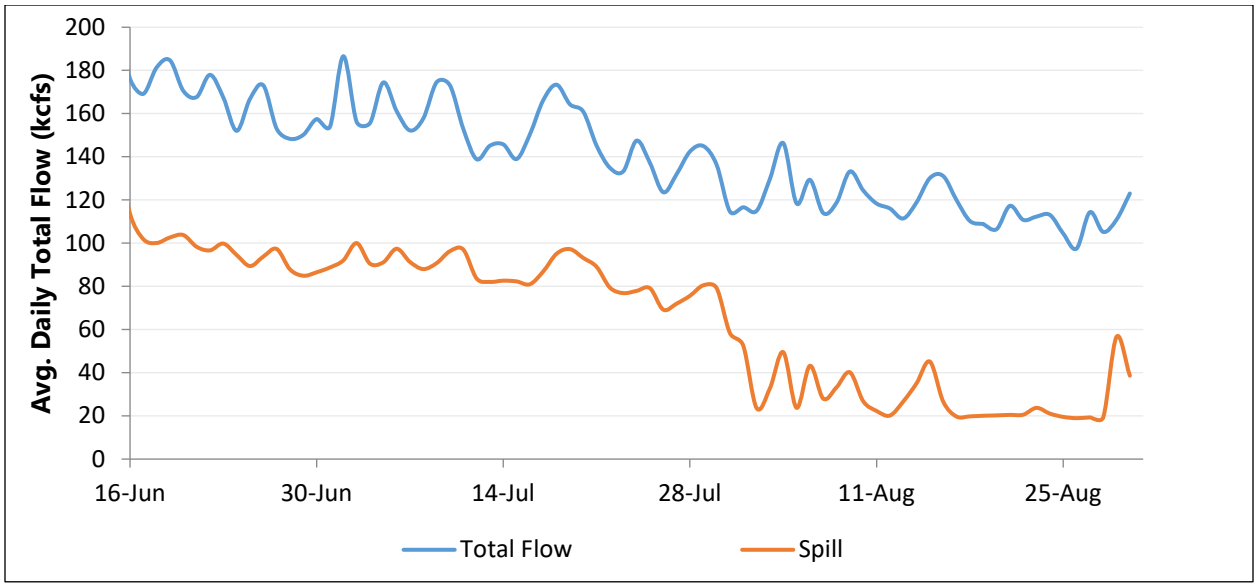

Figure 2. Daily Average Total River Flow and Spill from 0700 on June 16 to 0700 on August 31, 2024

Powerhouse Forebay and Gatewell Temperatures

Daily water temperatures in the forebays and gatewells corresponded to air temperatures and wind velocity. Daily maximum forebay water temperatures were recorded predominately between 1400 and 2100 hours and most frequently recorded at 1600 hours. Daily minimum forebay water temperatures were recorded between 2330 to 1200 hours and most frequently recorded at 0600 hours.

Average forebay water temperature exceeded 68°F for the first time on June 28 and remained consistently above 68°F from July 4 through the remainder of the season. MCN began warm water turbine operations on July 3 at 0600 hours, operating units in a “sawtooth” pattern. The sawtooth pattern remained in place for the season. The average total temperature in the forebay reached a seasonal maximum of 75.9°F at 2200 hours on August 10. The maximum water temperature data point recorded in the forebay was 80.8°F at 1630 hours on July 8 at Unit 8. The average forebay water temperature across all probes was 72.9°F at that time. Average monthly forebay and gatewell water temperatures are provided in Table 2.

The average water temperature gradient across the forebay was 2.3°F from June 16 to August 31 and ranged between 0.1°F and 12.3°F. The largest gradients across the forebay formed between 1500 and 2100 hours. The largest water temperature gradient across the forebay was 12.3°F on July 8 (Figure 3). Figure 4 displays the daily average temperatures of all forebay and gatewell probes.

Table 2. Daily Average Forebay and Gatewell Water Temperatures Across all Probes in June, July, and August 2024

Location	June[a]	July	August
Forebay	63.0	69.7	71.3
Gatewell	62.3	68.4	70.5

Note:
a June 16 to June 30

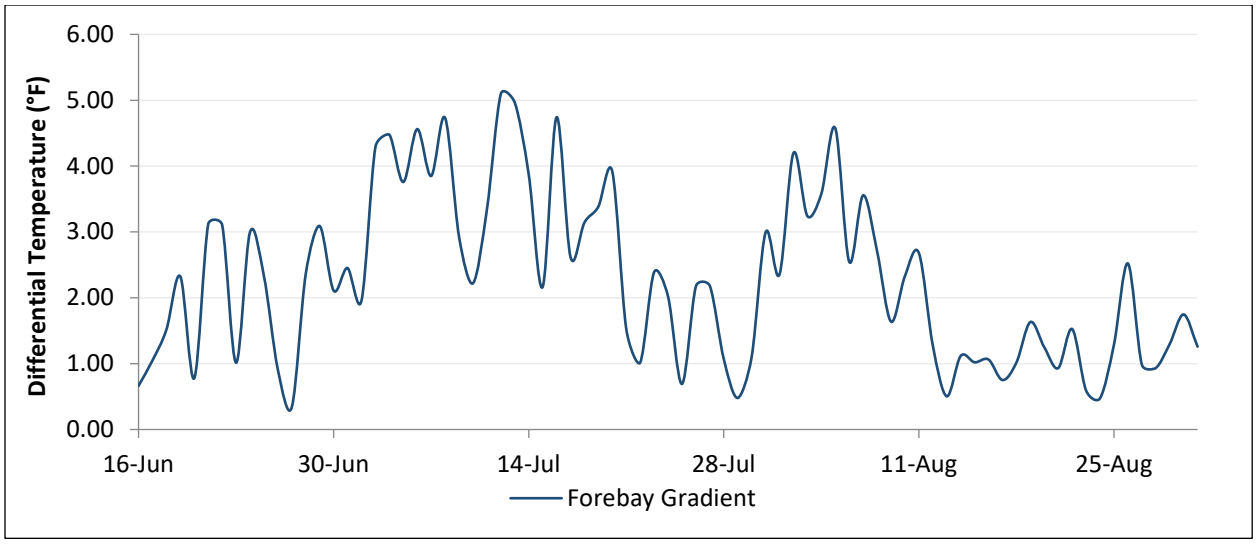

Figure 3. Temperature Gradient between Daily Minimum and Maximum Water Temperatures Recorded Across 8 Forebay Positions from 0700 on June 16 to 0700 on August 31, 2024

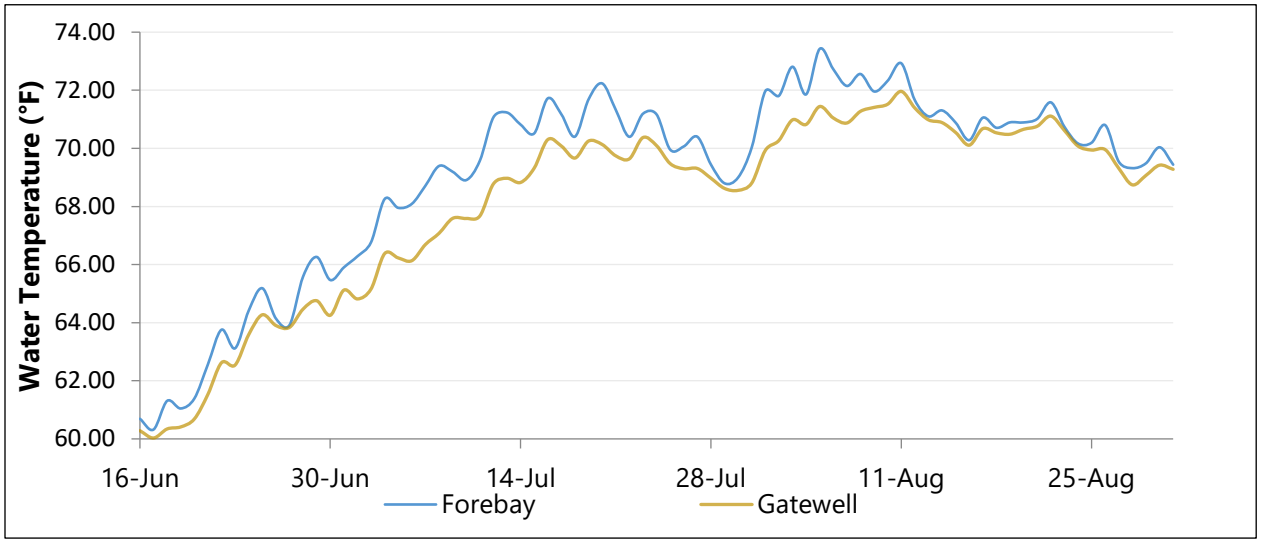

Figure 4. Daily Average Water Temperatures of 8 Forebay and 13 Gatewell Locations from 0700 on June 16 to 0700 on August 31, 2024

Gatewell water temperature was positively correlated to forebay water temperatures but did not reach the same extremes (Figure 4). The average gatewell water temperatures reached 68°F on July 4, and gatewell water temperatures were consistently above 68°F after July 11. The maximum water temperature data point recorded in the gatewells was 76.9°F at 2100 hours on July 16 at Unit 6. The average temperature gradient across the gatewells was 2.8°F from June 16 to August 31 (Figure 5). The largest temperature gradient across the gatewells was 11.1°F on July 8.

The average water temperature gradient between the average forebay and average gatewell temperatures was 0.9°F (Figure 6). The forebay was warmer than the corresponding gatewell on average for each unit from June 16 to August 31. The singular highest water temperature gradient between the forebay and gatewells was 12.5°F at 1430 hours on July 8 at Unit 3. On July 3, the sawtooth strategy was initiated, and the number of units in standby was increased.

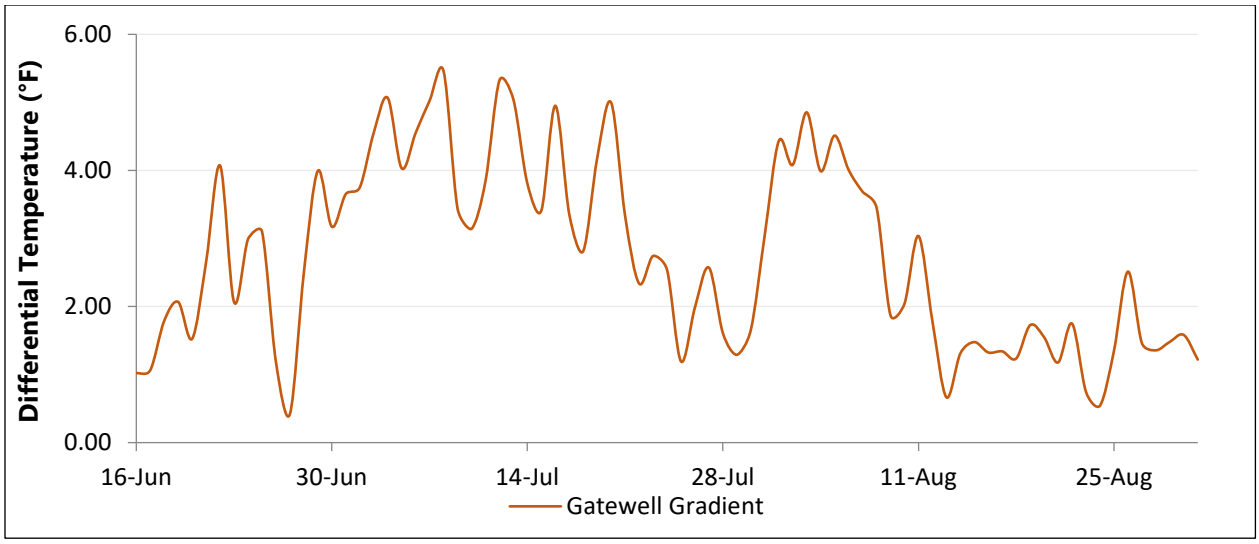

Figure 5. Temperature Gradient between Daily Average Minimum and Maximum Water Temperatures Recorded Across 13 Gatewell Positions from 0700 on June 16 to 0700 on August 31, 2024

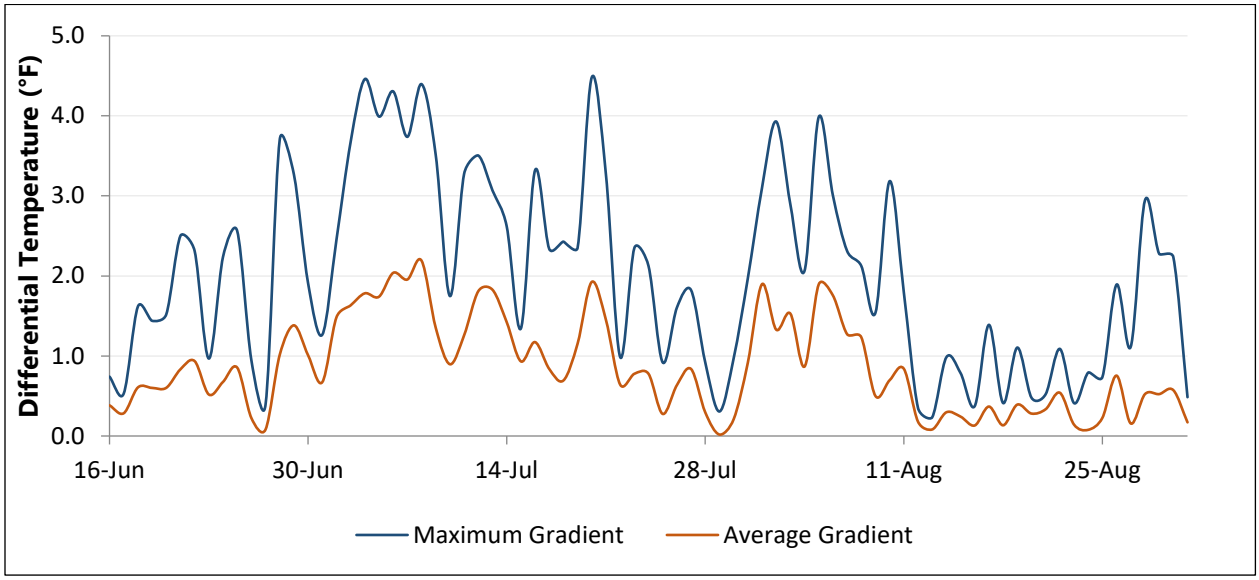

Figure 6. Daily Average and Maximum Water Temperature Gradient Recorded between the Forebay and Gatewells for each 24-Hour Period from 0700 on June 16 to 0700 on August 31, 2024

Collection Channel

Water temperatures in the collection channel were less variable than in the forebay and gatewells. Average water temperature in the collection channel was 67.9°F from June 16 to August 31 (Table 3). Collection channel water temperatures reached an average of 68°F on July 5 for short periods of time and were continuously exceeding 68°F after July 12 (Figure 7). The singular maximum water temperature data point of 73.2°F was measured at 0830 hours on August 6 at Unit 8.

Table 3. Water Temperatures in the Collection Channel from 0700 Hours on June 16 to 0700 Hours on August 31, 2024

Seasonal Average (°F)	Seasonal Maximum (°F)	Date of Maximum
67.9	71.9	11 August

°F = degree Fahrenheit

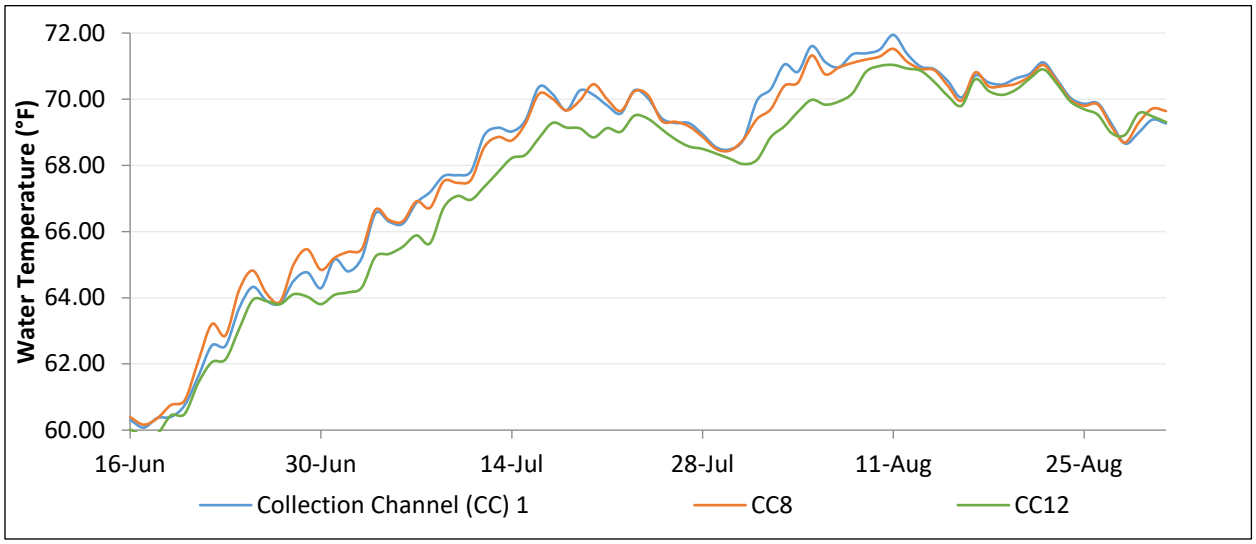

Figure 7. Daily Average Water Temperatures for Three Collection Channel Locations from 0700 Hours on June 16 to 0700 Hours on August 31, 2024

The average water temperature gradient between the gatewells and the collection channel was 0.6°F from June 16 to August 31 (Figure 8) and ranged between -1.0°F and 3.1°F. The gatewell was warmer on average than the collection channel at Units 1, 8, and 12. The maximum water temperature gradient data point of 6.2°F was recorded at 1630 hours on July 8 at Unit 8. The collection channel temperature was lower on average than the gatewell.

The average water temperature gradient between the collection channel at Unit 12 and Unit 1 was 0.63°F from June 16 to August 31 (Figure 9). The maximum water temperature gradient reading between the collection channel at Unit 12 and Unit 1 was 3.9°F at 1730 hours on July 8, with Unit 1 being warmer than Unit 12. On average, the collection channel temperature was higher at Unit 1 than at Unit 12.

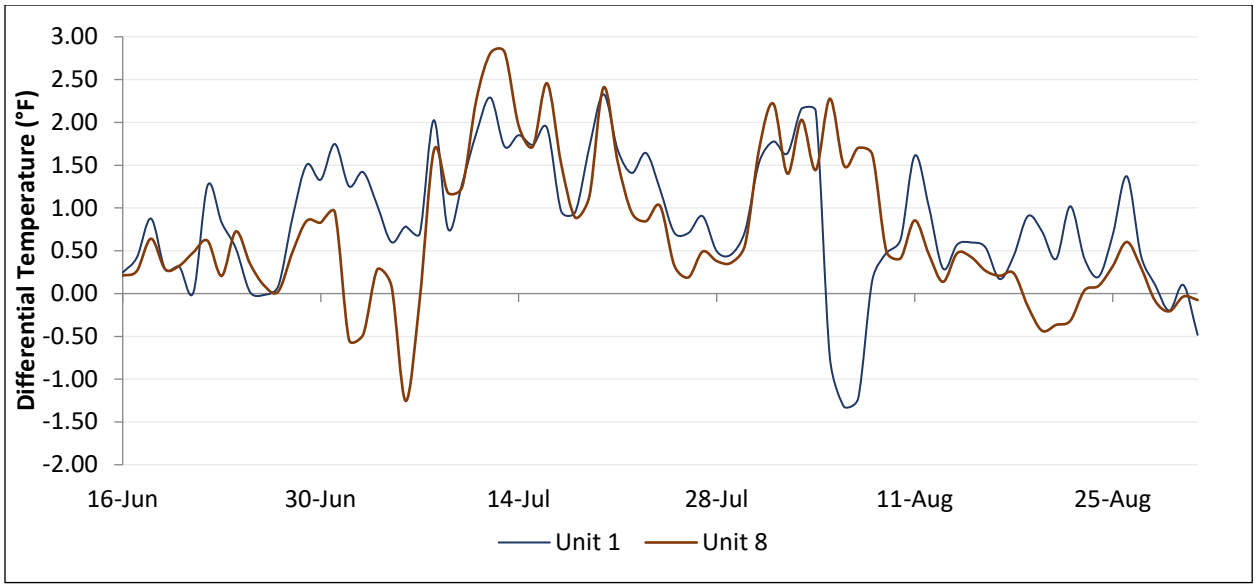

Figure 8. Daily Average Water Temperature Gradient Recorded between two Gatewells and Corresponding Collection Channel Locations (Gatewell Minus Collection Channel) from 0700 on June 16 to 0700 on August 31, 2024

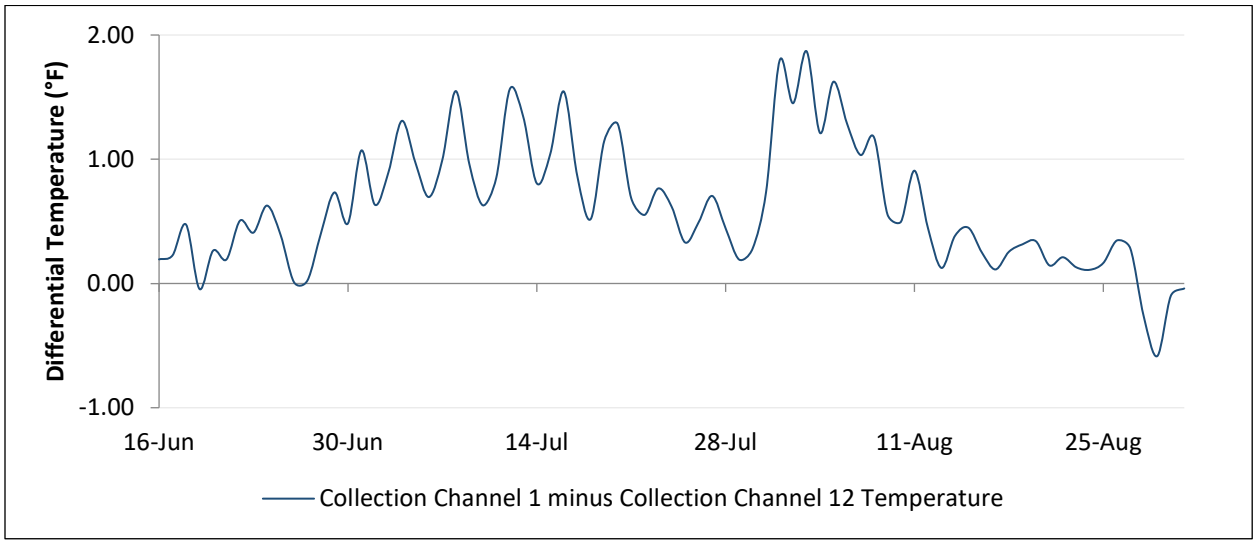

Figure 9. Daily Average Gradient Recorded between Water Temperatures at Collection Channel 1 and Collection Channel 12 from 0700 on June 16 to 0700 on August 31, 2024

Juvenile Fish Facility

The daily average water temperature at the JFF from June 16 to August 31 was 68.2°F. The average water temperature reached 68°F for the first time at 1500 hours on July 4, and water temperatures continuously exceeded 68°F after July 11 (Figure 10). The maximum singular temperature reading (72.7°F) was measured at 2030 hours on August 11 at sample tank "B."

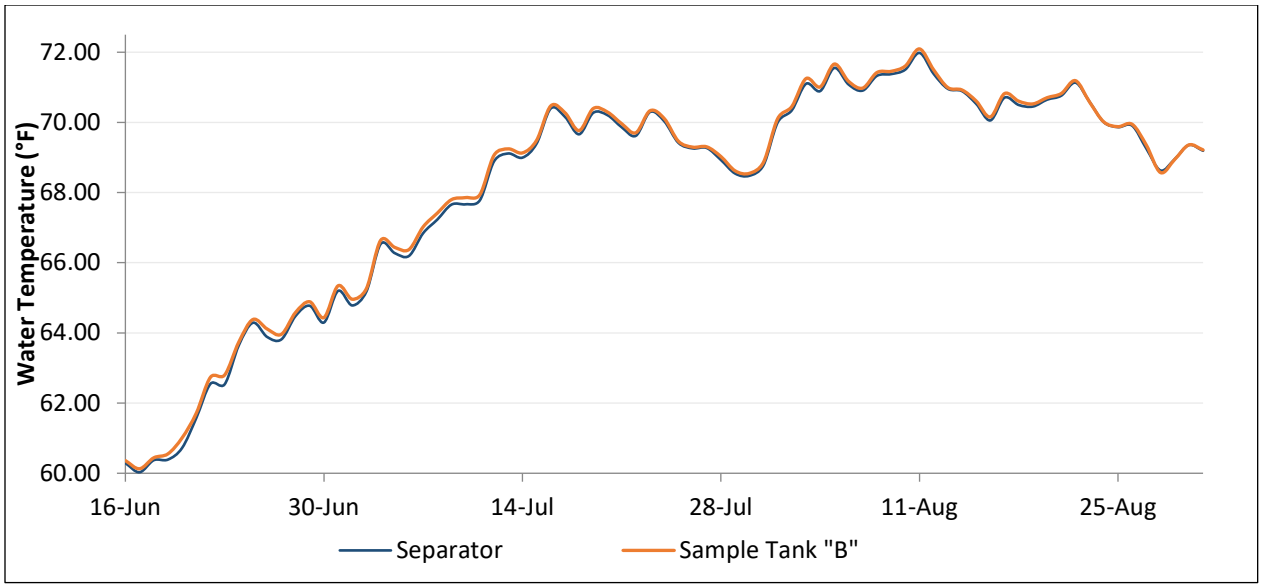

Figure 10. Daily Average Water Temperatures for the Two Juvenile Fish Facility Locations from 0700 Hours on June 16 to 0700 Hours on August 31, 2024

The temperature gradient average between the collection channel at Unit 1 and the separator at the JFF was 0.01°F and the daily averages ranged between -0.08°F and 0.08°F; the singular temperature range was broader, between -0.2 and 1.1. (Figure 11). The average temperature gradient across the separator and sample tank “B” was 0.1°F (Figure 10). The singular maximum difference recorded between the two JFF locations (1.1°F) occurred at 1100 hours on July 28. The sample tank was cooler.

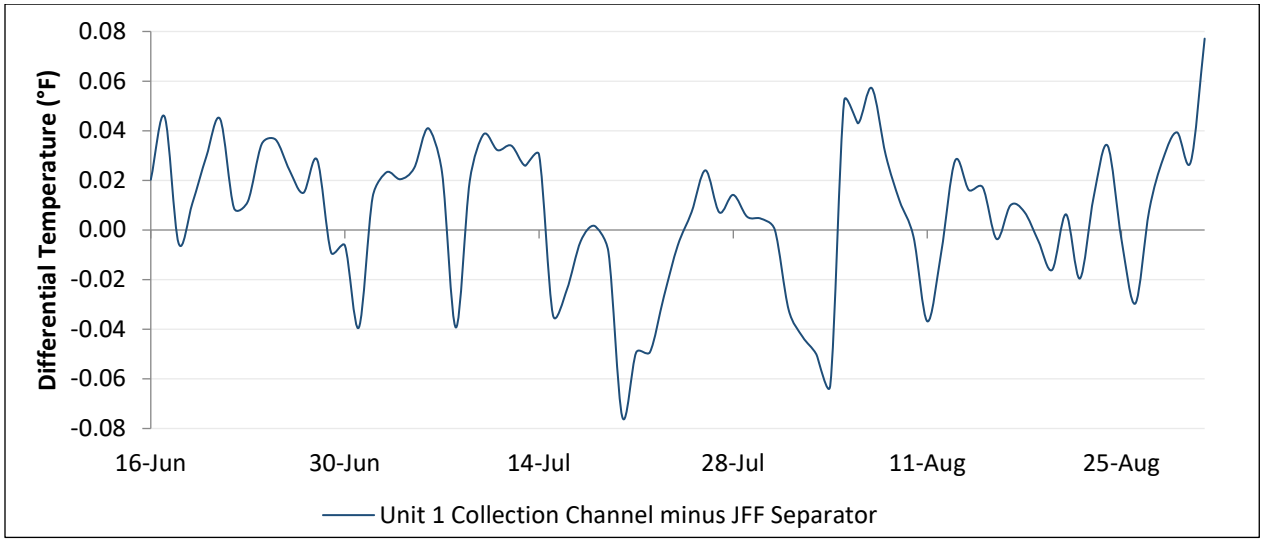

Figure 11. Daily Average Water Temperature Gradient Recorded Between the Collection Channel at Unit 1 and Juvenile Fish Facility Separator from 0700 Hours on June 16 to 0700 Hours on August 31, 2024

Fish Passage and Mortality

At the MCN JFF, fish were sampled every other day and collection estimates are derived from these sample counts. These estimates do not account for fish that pass the MCN on non-sample days. A total of 95,552 juvenile salmonids were estimated to have been collected at MCN during the June 16–August 31 temperature monitoring period (Table 4). Subyearling Chinook salmon was the dominant species, comprising 98.3% of the total collection during the monitoring period. By August 1, 90% of fish migrating during the monitoring period had bypassed the dam. In previous years, high juvenile mortality at MCN has been correlated with temperatures greater than 68°F and large temperature gradients along juvenile bypass routes through the powerhouse and JFF. There were 120 total facility mortalities during the 2024 temperature monitoring period, for a mortality rate of 0.13%, compared to 94 facility mortalities during the 2023 temperature monitoring period, a 0.05% mortality rate (Table 4).

The sample mortality rate may indicate the health status of the total population bypassing the facility as these fish are held for up to 24 hours followed by the condition-sampling process. The sample mortalities during the monitoring period were primarily subyearling Chinook salmon, with 51 mortalities; with all species combined, the sample mortality was 53. The sample mortality rate was 1.33% for subyearling Chinook salmon and 1.37% for all species combined.

Table 4. Collection, Mortality, and Passage for Juvenile Salmonids from June 16 to August 31 in 2024 and 2023

Year	System			Sample			Passage			
	Collection	Mortality	% Mortality	Sample	Sample Mortality	% Mortality	25%	50%	75%	90%
2024	95,552	120	0.13%	3,863	53	1.37%	20 June	26 Jun	2 July	1 August
	Sample Tank "B" Temperature (°F)[a]						61.01	64.11	64.96	70.11
2023	194,433	94	0.05%	4,271	50	1.20%	24 June	2 Jul	8 July	12July
	Sample Tank "B" Temperature (°F)[a]						63.3	67.5	68.5	68.8

Notes:
a Sample tank temperature was taken at 0700 hours daily.
°F = degree Fahrenheit

Recommendations

High water temperature at MCN is managed by modifying the turbine operations. Turbines operating in an alternating standby pattern reduces high water temperatures and temperature gradients in fish passage routes through the powerhouse and the JFF. This operation strategy is effective in reducing high water temperatures from the forebay in the early season because deeper forebay water has not been warmed by prolonged high air temperatures. MCN should continue to employ this strategy.

Additional recommendations are as follows:

- Continue to monitor temperatures among strategic sites passing juvenile fish.
- Obtain wind data from the local NOAA weather station at the Hermiston Airport in Hermiston, Oregon, to avoid the difficulties encountered during the previous attempt to install a weather station at the dam.
- Implement and assess additional protective measures for data loggers, such as weighting or armoring of loggers deployed in gatewells, as records from previous years suggest data loggers may be subjected to more damage in gatewell locations.
- Consider installing additional shuttle pipes in the forebay to allow for multiple contractors or agencies to deploy and protect equipment.

Appendix A
Temperature Logger Problems and Missing Data

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Appendix A Temperature Logger Problems

During the 2024 temperature monitoring season, a total of 385 hours (0.39%) of data were lost due to temperature probe malfunctions or inaccessibility during maintenance activities occurring at the dam. The malfunctions occurred infrequently and typically lasted for 24 hours or less. The data logger at gatewell 13 was removed about 10 days prior to the end of the monitoring season because the hatch for the gatewell was closed, making the probe inaccessible. Table A-1 shows the date and times of data loss, the number of hours a probe was down, and the HOBO logger location.

Table A-1. 2024 Season monitoring hours lost due to temperature logger failures or inaccessibility (HOBO U22-001)

HOBO Logger Locations									
Date Time	**G05**	**G06**	**G13**	**G14**	**F03**	**F05**	**F07**	**F08**	**F12**
16 June 00:00–09:00		9							
17 June 09:30–18 June 10:30							25		
17 June 10:00–18 June 10:30									24.5
22 June 10:00–10:30								0.5	
23 July 08:30–24 July 08:00	23.5								
24 July 08:30–25 July 08:00					23.5				
26 July 10:00–27 July 08:30				22.5					
21 August 14:30–31 August 07:00			232.5						
29 August 09:30–30 August 09:30						24			