McNary Dam Annual Temperature Report, 2022

Prepared by

Jeff Christopherson
Matt Paulsen
Eric Harries

Environmental Assessment Services, LLC

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INTRODUCTION

McNary Dam, located at river mile 292, is the first dam encountered by Columbia River fall Chinook salmon originating from the Hanford Reach and Priest Rapids Hatchery. These fish comprise the largest component of subyearling fall Chinook salmon migrating through McNary Dam, though smaller numbers of Endangered Species Act-listed Snake River fall Chinook salmon also navigate the dam. The migration of juvenile fall Chinook salmon typically peaks in summer months when water temperatures are the highest of the season. High water temperatures may have adverse effects on migrating salmonids. High juvenile salmonid mortality has been associated with high water temperatures at McNary Dam 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 3 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.

A portion (0.5% to 25%) of the juvenile salmonids passing McNary Dam are collected 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 (3 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 delivers 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. Using a turbine operational strategy that balances the turbines in operation and those in standby across the powerhouse can decrease the magnitude of the temperature and temperature gradients. Operating turbines draw in warmer surface water while standby turbines allow cooler, deeper water at orifice depth to passively enter the gatewells. This warm water turbine management pattern can decrease the temperature of water along bypass routes.

The objective of the 2022 Temperature Monitoring Program at McNary Dam was to monitor water temperature patterns in juvenile salmonid passage areas, including the powerhouse, gatewells, collection channel, and the JFF. Daily temperatures were monitored to identify temperature conditions that might contribute to increased mortality for fish passing through the juvenile bypass system.

Thank you to the staff at the McNary Dam JFF for their advice and support. Bobby Johnson, Paul Bertschinger, and the U.S. Army Corps of Engineers staff at the JFF provided invaluable assistance during each phase of this work. Thank you to Thomas VanNice, Amber Johnson, and Kathleen Carter of Pacific States Marine Fisheries Commission for providing suggestions, assisting with equipment deployment, and drafting this document. Thank you also to Leah Libow, Lucas Stonehouse, and Anchor QEA, LLC, staff Kristi Geris and Celia Baker for their advice and support over the season.

METHODS

Water temperatures were measured at 0.5-hour intervals (0000 and 0030) from 1200 hours on June 14 to 0700 hours on August 31, 2022. 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 732 (0.3%) hours of water temperature data were lost during the 2022 temperature monitoring season due logger malfunctions. These outages were sporadic and usually occurred in 0.5-4.5 hour increments.

The loggers were deployed at 28 locations throughout the McNary Dam Project including the forebay, gatewells, collection channel, and the JFF as follows:

- Powerhouse forebay (referred to herein as forebay), near elevation 335 feet in the trolley pipes fitted to the "C" 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, in the center of each "B" slot at each unit (14 total): submerged to a depth of approximately 3 feet below the water surface in the gatewell. The temperature logger for Gatewell 5 was deployed at 1030 hours on August 10 after the fish diversion screen was operational.

- Collection channel, downstream of gatewell orifices 12B and 8B, and upstream of the incline dewatering screen south of Unit 1: submerged to a depth of approximately 2 feet below the water surface in the collection channel.

- JFF, in the fish separator underneath the bars in the "B" section, in the "B" sample tank: submerged to a depth of 2 feet below the water surface, and under the separator booth porch: hanging by paracord and out of direct sunlight to record ambient air temperature.

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. A logger placed at the JFF outfall pipe has replaced the tailrace navigation lock wing wall logger since 2016; however, the JFF outfall pipe was not accessible this year due to damage from high flows in 2019. The spillway has not been monitored since 2016.

Daily water temperatures were also recorded 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. The daily temperature value was reported to McNary Dam biologists as part of the Smolt Monitoring Program. The temperatures recorded at 0700 hours are considered a minimum daily temperature and do not reflect any diurnal fluctuation.

Air temperature was recorded with a temperature logger below the separator building and was downloaded for daily and weekly reports. For this report, all weather data were obtained from the Hermiston Airport in Hermiston, Oregon via the MesoWest database managed by the University of Utah

and the Department of Atmospheric Sciences[1]. Air Temperature and Wind velocity from each hour and half hour were averaged and summarized in 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 time frame coincided with sampling activities at the JFF.

RESULTS

Weather Conditions

Maximum air temperatures occurred between 1300 and 2030 hours and minimum air temperatures occurred between 2000 and 1000 hours (Table 1). The maximum air temperature for the monitoring season, 113.3°F, was measured at 1900 on August 7 (Figure 1).

Wind velocity was highly variable throughout the day. The highest average wind velocity occurred in June and the lowest average wind velocity occurred in July. The highest average daily wind velocity was 27.6 mph at 1200 hours on August 27.

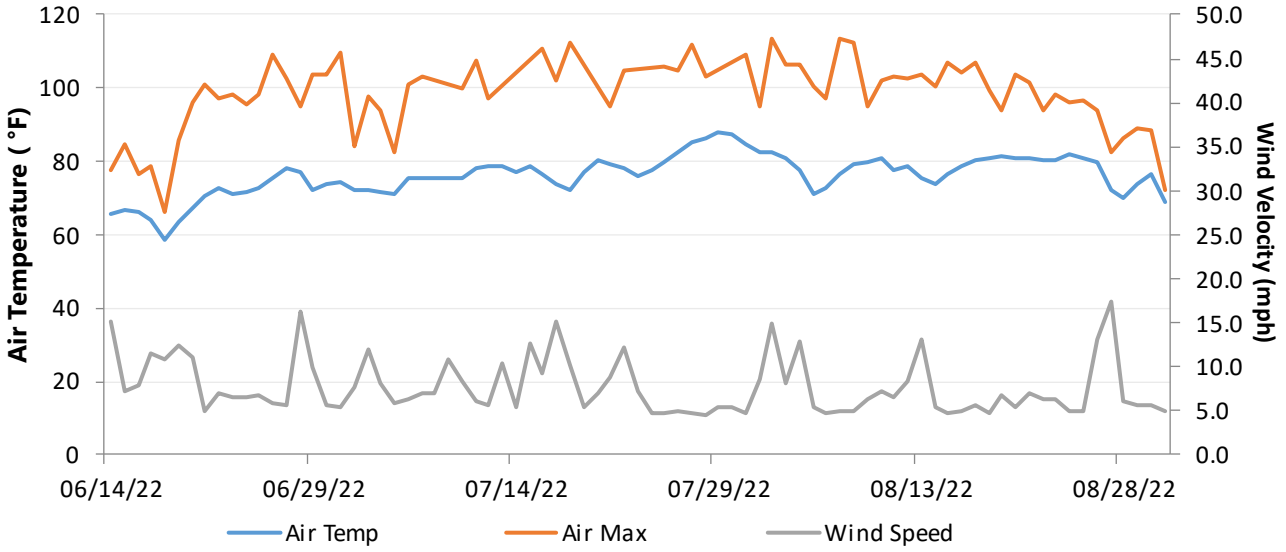
Table 1. Air Temperatures and Wind Velocity at McNary Dam from 1200 on June 14 to 0700 on August 31, 2022

Month	Daily Avg. (°F)	Daily Max. Avg. (°F)	Daily Min. Avg. (°F)	Max. Range (°F)	Min. Range (°F)	Days >90°F*	Wind Avg. (mph)	Days >3 mph**
June†	68.9	91.7	56.1	67.9-109.0	51.0-67.3	12	9.0	15
July	77.5	99.3	65.4	82.5-107.7	59.3-72.6	28	7.5	31
August	78.4	99.7	66.5	82.8-113.3	59.4-73.1	27	7.6	31

Notes:
* Count of days with highs exceeding 90°F
** Days with at least one 0.5-hour period with wind velocity exceeding 3 mph
† Monitoring occurred June 14 to June 30
mph: miles per hour

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

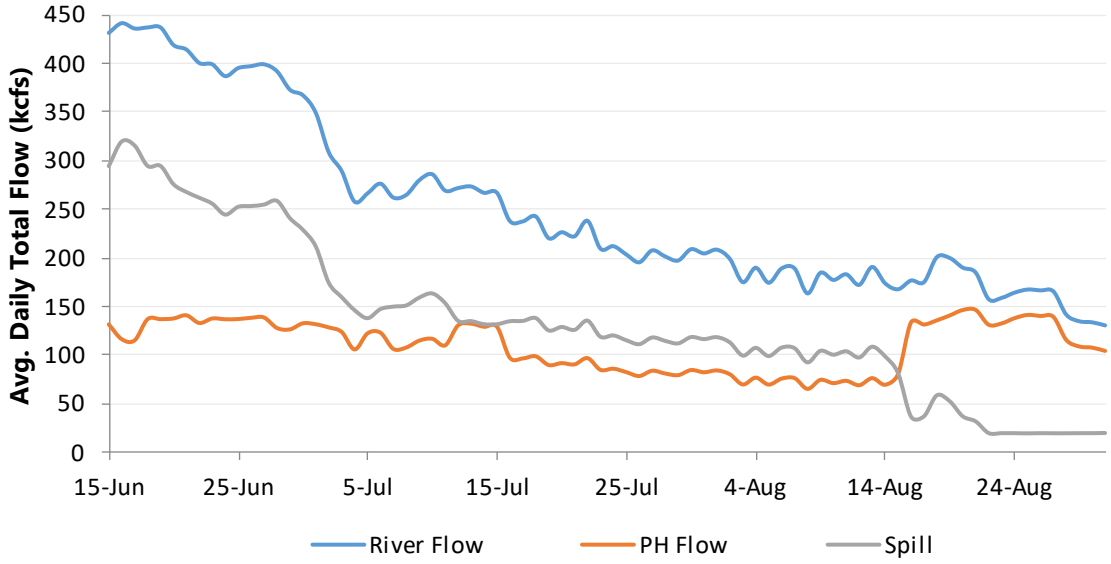
Figure 1. Average and Maximum Daily Air Temperatures and Average Wind Velocity from 1200 on June 14 to 0700 on August 31, 2022



River Flow and Spill

Total river flow during the monitoring period from June 15 to August 31 averaged 249.5 kilo cubic feet per second (kcfs). The peak average daily total river flow (441.2 kcfs) was recorded on June 16. The minimum average daily total river flow (129.5 kcfs) was recorded on August 31 (Figure 2). Monthly average total river flow over the monitoring period in June, July, and August was 405.8, 245.5, and 172.8 kcfs. Monthly average spill for June, July, and August was 268.0, 137.5, and 64.6 kcfs, with spill constituting 65.9%, 56.1%, and 36.2% of the total flow for June, July, and August.

Figure 2. Total River Flow and Spill from 0700 on June 14 to 0700 on August 31, 2022



Powerhouse Forebay and Gatewell Temperatures

Daily water temperatures in the forebays and gatewells corresponded to air temperatures and wind velocity. Daily maximum average forebay water temperatures were recorded predominately between 1330 and 2100 and most frequently recorded at 1800 hours. Daily minimum average forebay water temperatures were recorded between 2330 and 1200 hours and most frequently recorded at 0830 hours.

Forebay water temperature reached 68°F for the first time at 1530 hours on July 6 at Unit 10 and averaged 68ºF across the forebay on July 8 for short periods of time (Figure 3). The forebay was consistently above 68°F starting on July 19. McNary Dam began warm water turbine operations, operating Units in "sawtooth" pattern on July 24. The forebay reached seasonal maximum average water temperatures of 76.0°F at 2030 hours on July 30. The maximum water temperature recorded in the forebay was 79.9°F at 1700 hours on July 29 at Unit 10. The average forebay water temperature was 74.4°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 2.0°F from June 14 to August 31 (Figure 4) and ranged from 0.2°F to 9.9°F. The largest gradients across the forebay formed between 1330 and 2200 hours. The largest water temperature gradient across the forebay was 9.9°F at 1900 hours on July 20.

Figure 3. Average Water Temperatures of 8 Forebay and 14 Gatewell Locations from 1200 on June 14 to 0700 on August 31, 2022

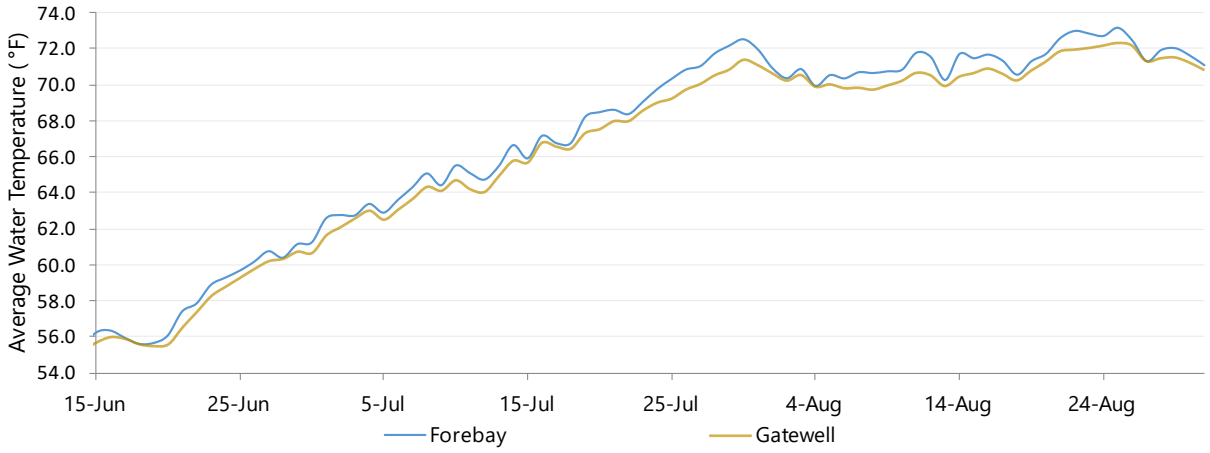
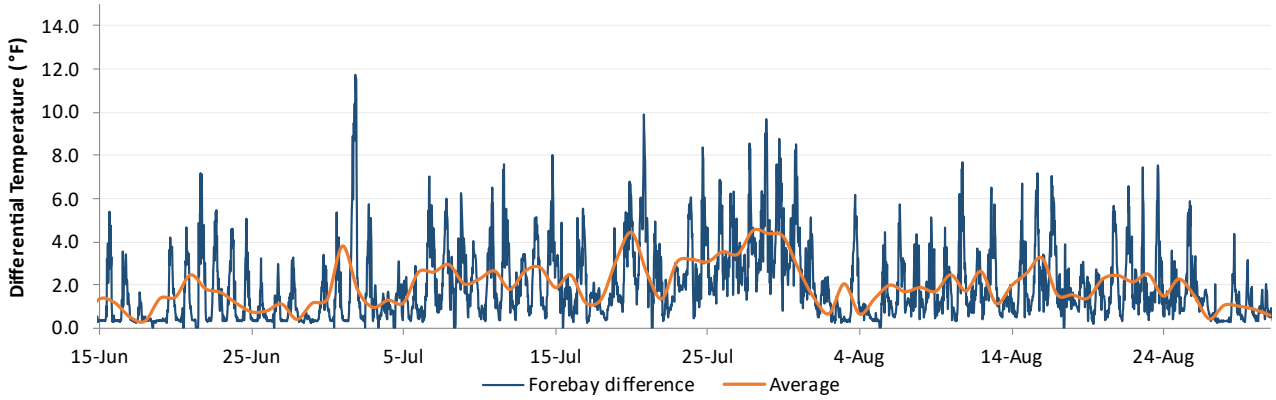


Table 2. Average Forebay and Gatewell Water Temperatures in June, July, and August 2022

Location	June*	July	August
Forebay	58.1°F	67.4°F	71.4°F
Gatewell	57.7°F	66.7°F	70.8°F

Note:
* June 14 to June 30

Figure 4. Temperature Gradient Between Minimum and Maximum Water Temperatures Recorded Across Eight Forebay Positions for Each 0.5-Hour Period from 1200 on June 14 to 0700 on August 31, 2022



Gatewell water temperatures corresponded to forebay water temperatures but did not reach the same extremes (Figure 3). The average gatewell water temperatures reached 68°F on July 16 for short periods of time, and gatewell water temperatures were consistently above 68°F after July 23. The gatewells

reached a seasonal maximum average water temperature of 73.7°F on August 22. The maximum water temperature recorded in the gatewells was 77.2°F at 1730 hours on July 30 at Unit 11. The average temperature gradient across the gatewells was 2.0°F from June 14 to August 31 (Figure 5). The largest temperature gradient across the gatewells was 9.1°F at 2000 hours on July 1.

The water temperature gradient between the forebays and gatewells was 0.6°F on average (Figure 6). The forebay was warmer than the corresponding gatewell on average for each unit from June 14 to August 31. The maximum water temperature gradient was 10.9°F at 1900 hours on July 20 at Unit 7. On July 24 initiation of sawtooth strategy occurred, and more units in stand-by increased.

Figure 5. Temperature Gradient Between Minimum and Maximum Water Temperatures Recorded Across 14 Gatewell Positions for Each 0.5-Hour Period from 1200 on June 14 to 0700 on August 31, 2022

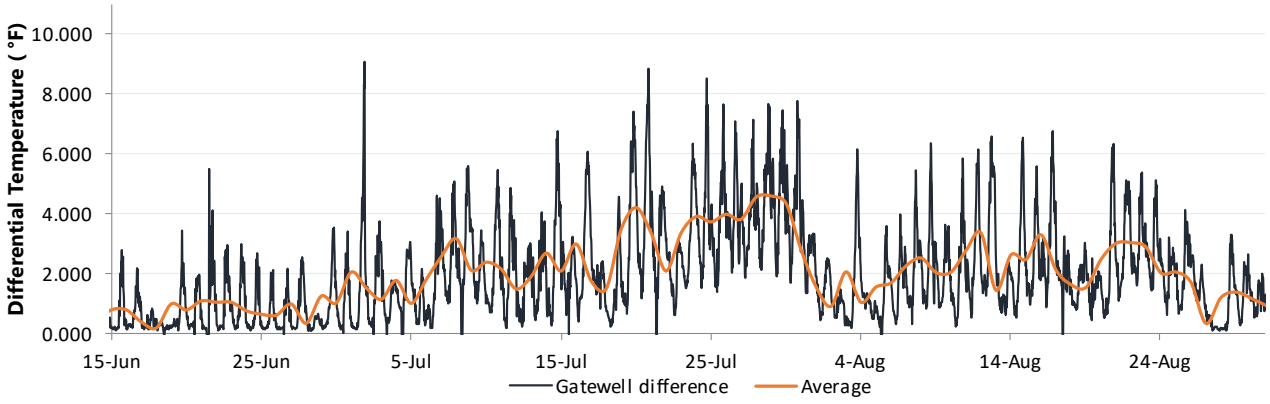
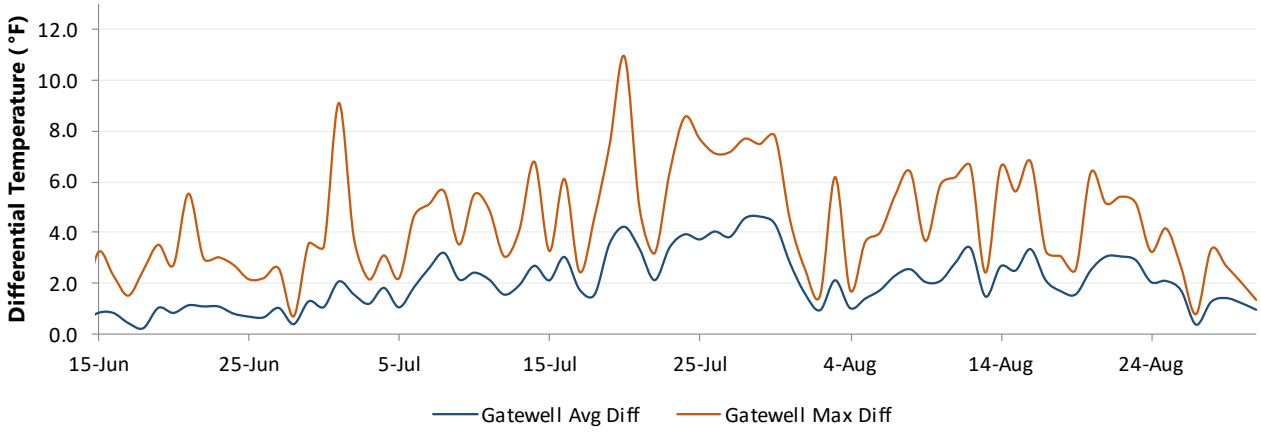


Figure 6. Maximum and Average Water Temperatures Gradient Recorded Between the Forebay and Gatewells for Each 0.5-Hour Period from 1200 on June 14 to 0700 on August 31, 2022



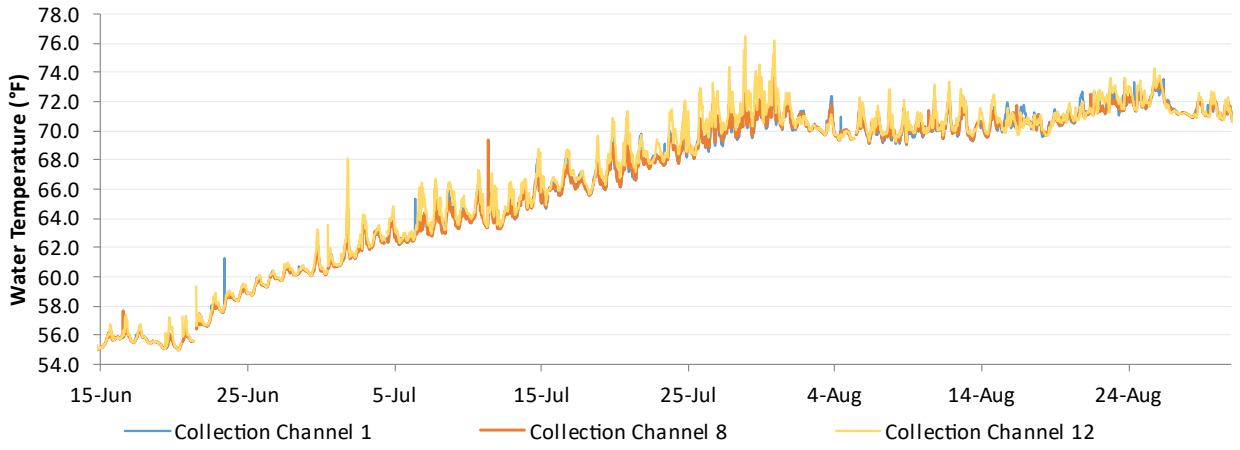
Collection Channel

Water temperatures in the collection channel were less variable than in the forebay and gatewells. Water temperatures across the collection channel averaged 66.5°F from June 14 to August 31 (Table 3). Collection channel water temperatures reached an average of 68°F on July 16 for short periods of time and were continuously exceeding 68°F after July 23 (Figure 7). The maximum water temperature of 76.5°F was measured at 2100 hours on July 28 at Unit 12.

Table 3. Water Temperatures in the Collection Channel from 1200 on June 14 to 0700 on August 31, 2022

Seasonal Average (°F)	Seasonal Maximum (°F)	Date of Maximum
66.5	76.5	July 28

Figure 7. Water Temperatures for Three Collection Channel Locations from 1200 on June 14 to 0700 on August 31, 2022



The average water temperature gradient between the gatewells and the collection channel was 0.6°F from June 14 to August 31 (Figure 8) and ranged from 0°F to 3.0°F. The collection channel was warmer on average than the gatewells at Units 1, 8, and 12. The maximum water temperature gradient was 4.6°F at 1800 hours on August 16 at Unit 1 and the collection channel was cooler than the gatewell. The average water temperature gradient between the collection channel at Unit 12 and Unit 1 was 0.3°F from June 14 to August 31 (Figure 9). The maximum water temperature gradient between the collection channel at Unit 12 and Unit 1 was 5.0°F at 2100 hours on July 28 with Unit 12 being warmer than Unit 1. On average, the collection channel was warmer at Unit 12 than at Units 1 and 8.

Figure 8. Water Temperature Gradient Recorded Between Three Gatewells and Corresponding Collection Channel Locations (Gatewell Minus Collection Channel) for Each 0.5-Hour Period from 1200 on June 14 to 0700 on August 31, 2022

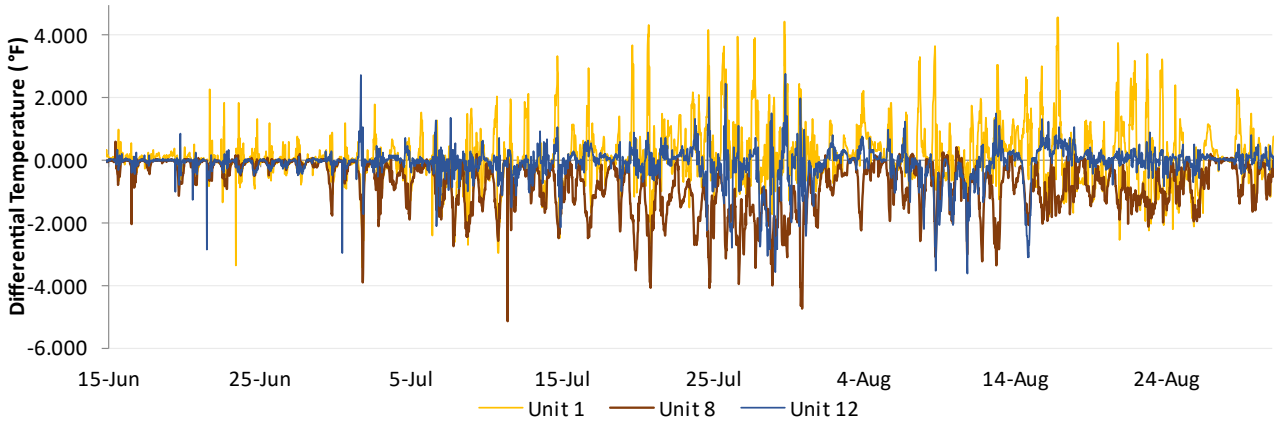
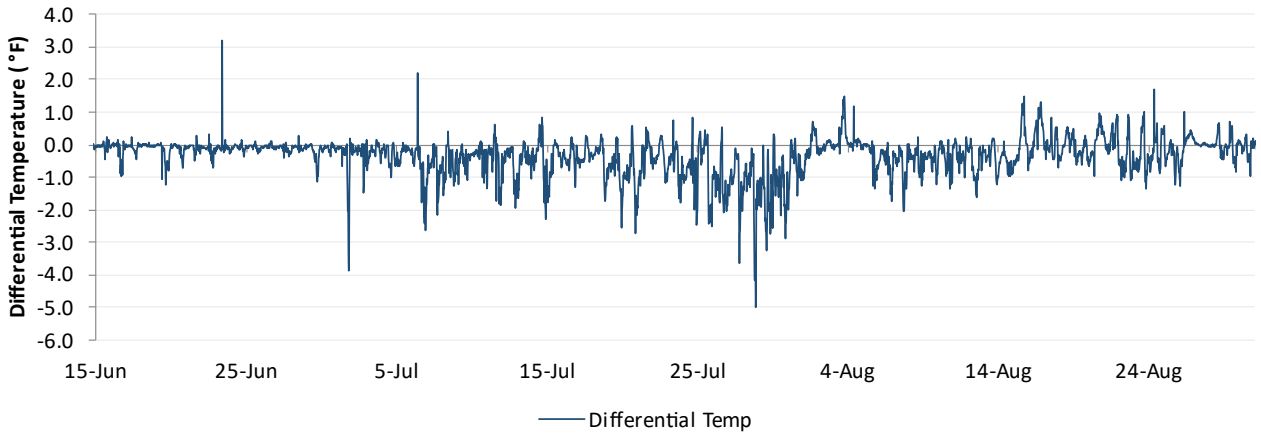


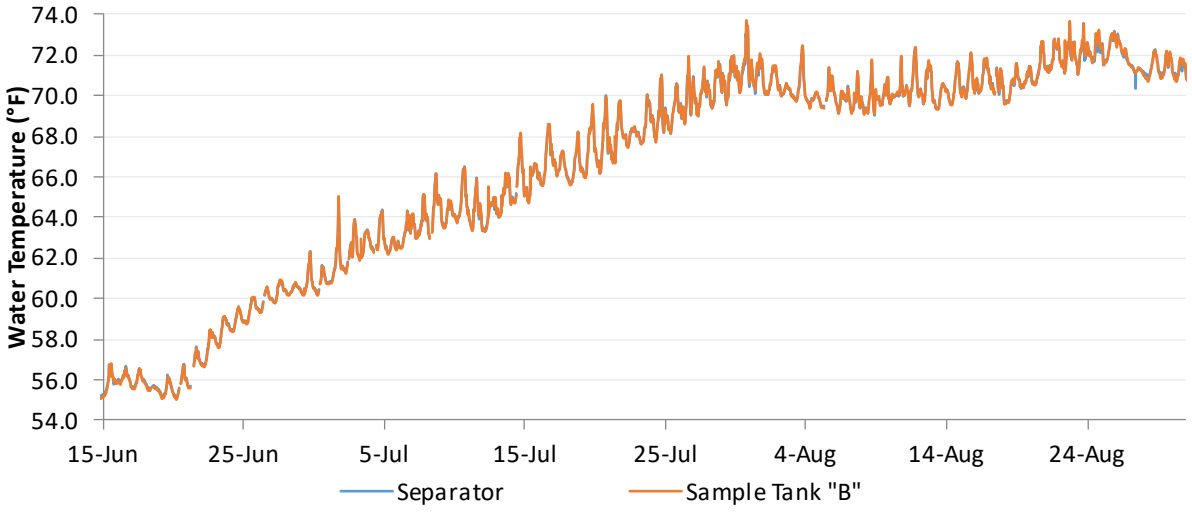
Figure 9. Gradient Recorded Between Water Temperatures at Collection Channel 1 and Collection Channel 12 from 1200 on June 14 to 0700 on August 31, 2022



Juvenile Fish Facility

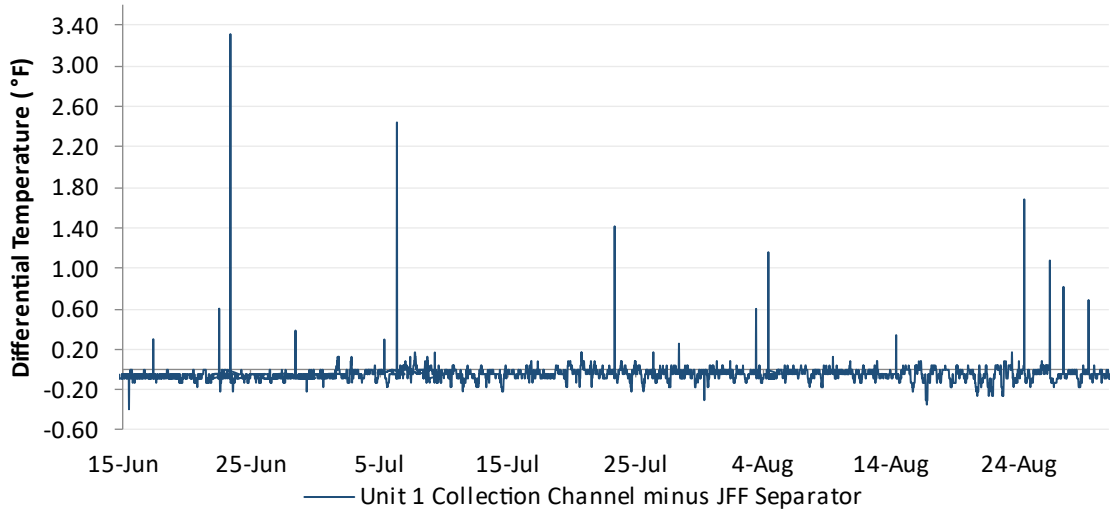
The average water temperature at the JFF from June 14 to August 31 was 66.4°F. Average water temperatures reached 68°F for the first time at 1900 hours on July 18 (Figure 10). Water temperatures continuously exceeded 68°F after July 24. The maximum temperature of 73.7°F was measured at 1830 hours on July 30 at the sample tank "B."

Figure 10. Average Water Temperatures for Two Juvenile Fish Facility Locations from 1200 on June 14 to 0700 on August 31, 2022



The temperature gradient between the collection channel at Unit 1 and the separator at the JFF averaged 0°F and ranged from 0°F to 3.3°F (Figure 11). The temperature gradient across the separator and sample tank "B" averaged 0.1°F. The maximum difference between the two JFF locations (1.5°F) occurred at 1000 hours on August 22 when the separator was cooler.

Figure 11. Water Temperature Gradient Recorded Between the Collection Channel at Unit 1 and Juvenile Fish Facility Separator from 1200 on June 14 to 0700 on August 31, 2022



Fish Passage and Mortality

At the McNary Dam JFF, fish sampling occurs every other day and collection estimates are derived from these sample counts. These estimates do not account for fish that pass the project on non-sample days. A total of 624,898 juvenile salmonids were estimated to have been collected at McNary Dam during the June 15 to August 31 temperature monitoring period (Table 4). Subyearling Chinook salmon was 98.2% of the total during this period. By July 26, 90% of fish migrating during the monitoring period had bypassed the dam. In previous years, high juvenile mortality at McNary Dam has been correlated with high water temperatures and large temperature gradients along juvenile bypass routes through the powerhouse and JFF. Mortality was low during this monitoring period. Total facility mortality for subyearling Chinook salmon alone, and for all salmon species combined, was estimated at 0.02% of bypassed fish over the monitoring period (subyearling Chinook salmon, 119 mortalities; all species combined, 124 mortalities).

The sample mortality rate may indicate the health status of the total population bypassing the facility since these fish are held for up to 24 hours and then go through the sampling process. The sample mortality rate for subyearling Chinook salmon alone was 1.2% of all fish sampled during the monitoring period (subyearling Chinook salmon, 90 sample mortalities; all species combined, 93 sample mortalities).

Table 4. Collection, Mortality, and Passage for Juvenile Salmonids in 2021 and 2022

Year	System			Sample			Passage			
	Collection	**Mortality**	**% Mortality**	**Sample**	**Sample Mortality**	**% Mortality**	**25%**	**50%**	**75%**	**90%**
2022	624,898	124	0.02%	7,741	93	1.2%	18-Jun	26-Jun	10-Jul	26-Jul
	Sample Tank "B" Temperature (°F)*						55.3	59.1	63.8	69.2
2021	306,978	62	0.02%	7,393	37	0.5%	24-Jun	24-Jun	28-Jun	4-Jul
	Sample Tank "B" Temperature (°F)*						65.1	65.1	66.2	68.6

Notes:
* Sample tank temperature was taken at 0700 daily.

APPENDIX A: Temperature Logger Problems and Missing Data

During the 2022 temperature monitoring season, a total of 732 hours (0.3%) of data were lost due to temperature probe malfunctions or user error. Most loggers experienced short disruptions (0.5-4.5 hours at a time) sporadically throughout the season. The sporadic disruptions appear to have usually occurred in the morning, between 0800 and 1100 hours. There were no complete failures of any temperature monitoring probes and no probes needed to be replaced during the 2022 monitoring season. Table A-1 shows the date and times of data loss, along with the HOBO logger location.

		HOBO Logger Location																										
DATE	TIME	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	F1	F3	F5	F7	F8	F10	F12	F14	C1	C8	C12	Sample Tank B	Separator	Separator Air
6/14	1230-1300														0.5														
6/18	0930-1230	1.5	2	2	2	2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2	2	1.5	1.5	1.5	1.5	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5
6/20	1030-1300	1.5	1.5	1.5	1.5	1.5	2	2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
6/21	0700-1130	3.5	3.5	3.5	3.5	4	4	4	4	4	4	4	4	4	4	3.5	3.5	4	4	4	4	4	4	4.5	4.5	4	4.5	4.5	4.5
6/24	1000-1030																0.5												
6/26	1000-1200	0.5	1	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1		0.5	1	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	1	1	1
6/27	0930-1000												0.5																
6/28	1030-1100	0.5	0.5	0.5						0.5	0.5	0.5				0.5				0.5	0.5								
6/30-7/1	0930-0830	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	0.5	22.5	0.5	0.5	1	1	1	1	1	0.5	1	1	0.5	1	1	1
7/2	1000-1200	1	1	1	1	0.5	0.5	1	1	1	1	1	1	1.5	1.5	1	1	0.5	1	1	1	1	1.5	1	1	1.5	1.5	1.5	1.5
7/3	0730-0930	1	1	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5	1	1	1	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	2	2
7/4	0730-1100	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3	3	3	3	3	2.5	2.5	2.5	2.5	2.5	3	3	3	3	3	3	3.5	3.5	3.5
7/7	1000-1030									0.5																			
7/8-7/9	0700-0800	2	2	2	2	2	2	2	2	2.5	2.5	2.5	2.5	2.5	2.5	2	2	2	2	2.5	25	2.5	2.5	2.5	2.5	2.5	3	3.5	3.5
7/12	1000-1030														0.5														
7/13	0800-0830	0.5																											
7/14	1000-1030											0.5	0.5								0.5						0.5	0.5	
7/15	0930-1230	0.5	0.5	0.5	0.5	1	1	2	1	1	1.5	1	1	1	1	0.5	1	2	1	1	1	2.5	1	1	1	1	1	1	1
7/21	0730-1000	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2	1	1.5	1.5	1.5	1.5	1.5	1.5	2	2	2	2	2	2.5	2.5
7/22	1030-1100											0.5																	
7/23	0900-0930												0.5																
7/24	0900-0930																	0.5											
7/27	0830-0930			0.5																			0.5						
7/29	0830-0900				0.5																					0.5			
7/30	0900-0930																					0.5							
8/1	0930-1000																			0.5									
8/4	0900-0930									0.5																			
8/5	0730-1030	2	2	2	2	2	2	2	2	2	2	2.5	2.5	2.5	2.5	2	2	2	2	2	2.5	2.5	2.5	2.5	2.5	2.5	3	3	3
8/6	0800-0830									0.5																			
8/7	0930-1030	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5
8/9	1000-1030										0.5																		
8/10	0830-0900					0.5																							
8/11	1030-1100																								0.5	0.5			
8/12	0830-0900											0.5																	
8/13	0930-1000																									0.5			
8/17	1000-1230	1.5	1.5	1.5	1.5	1.5	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1	1	1.5	1.5	1.5	1.5	1	1.5	1.5	1.5	1.5	1.5
8/22-8/23	0900-0830							0.5								23.5													
8/24	0830-0900																		0.5										
8/25	1000-1100							0.5																				0.5	
8/26	0830-0900									0.5																			
8/28	0800-0830									0.5																			
8/29	0900-0930																		0.5										
8/30	0930-1000														0.5														
Total Hours	**732**																												

RECOMMENDATIONS

High water temperature at McNary Dam is managed through modification of turbine operation. Turbines operating in alternating standby pattern reduces high water temperatures and temperature gradients in fish passage routes through the powerhouse and the JFF. This operation plan is most 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. McNary Dam should continue to employ this program.

Additional recommendations include:

- Continue to deploy temperature data loggers at strategic temperature monitoring sites.
- Work to establish full operation of the new weather station. Connectivity of this station with the on-site computer should be completed as soon as possible in the off-season. If this cannot be accomplished, then alternative sources of local atmospheric condition data will need to be established.
- Continue to use temperature data logger to monitor air temperatures at separator of the JFF throughout the monitoring season, either to replace the weather station or to provide backup data in the event of an in-season weather station failure.
- Obtain wind data from a local National Oceanic and Atmospheric Administration based weather station.
- Implement and assess (in 2023) additional protective measures, 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.