Water Quality Monitoring

AMENDMENT TO BRADLEY LAKE HYDROELECTRIC PROJECT (FERC No. 8221)

Proposed Dixon Diversion

Prepared for:

Alaska Energy Authority

Prepared by:

Kleinschmidt Associates

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DEFINITIONS OF TERMS, ACRONYMS, AND ABBREVIATIONS

A	
AEA	Alaska Energy Authority
B	
Bradley Lake Project	Bradley Lake Hydroelectric Project (FERC No. 8221)
C	
°C	degrees Centigrade
cm	centimeter
cm	Centimeters
D	
Dixon Diversion Project	Proposed Dixon Diversion, Amendment to the Bradley Lake Hydroelectric Project
DO	dissolved oxygen
DSP	Draft Study Plan
E	
EFMR	East Fork Martin River
F	
FERC	Federal Energy Regulatory Commission
I	
ICD	Initial Consultation Document
M	
mg/L	milligrams per liter
MW	megawatt
N	
NTU	nephelometric turbidity unit
O	
OCH	off-channel habitat
Q	
QA	quality assurance
QC	quality control
R	
RM	river mile
U	
USGS	United States Geological Survey
W	
WFMR	West Fork Martin River

1.0 INTRODUCTION

The Alaska Energy Authority (AEA) is pursuing a Federal Energy Regulatory Commission (FERC) license amendment associated with the existing 120-megawatt (MW) Bradley Lake Hydroelectric Project (Bradley Lake Project, FERC No. P-8221). The Bradley Lake Project is located on the Bradley River in the Kenai Peninsula Borough northeast of the town of Homer in Southcentral Alaska. The purpose of the proposed amendment is to gain authorization to divert seasonal meltwater coming from Dixon Glacier, located in the Martin River basin, to Bradley Lake and to increase the maximum pool elevation of the Bradley Lake impoundment to increase power production at the Bradley Lake Project (Figure 1-1).

On April 27, 2022, AEA initiated the amendment process by filing its Initial Consultation Document (ICD) with FERC (18 Code of Federal Regulations [CFR] § 4.38). The ICD described existing facilities and current Bradley Lake Project operation; characterized the affected environment; and described the proposed Dixon Diversion project alternatives. AEA conducted consultation during 2022 and on November 2, 2022, submitted a Draft Study Plan (DSP) describing the studies to be conducted to collect relevant resource data associated with the proposed amendment. On March 2023, AEA filed a letter with FERC pausing the amendment process while the agency conducted additional feasibility analyses, collected Martin River hydrology data, and refined the selected Dixon to Bradley Lake alternative. During 2023, AEA collected water quality data at the Martin River stream gage locations as described in DSP Section 4.2 Water Quality Monitoring study. This report summarizes the 2023 study results.

Figure 1-1 Location of Proposed Dixon Diversion Project near Kachemak Bay, Alaska

1.1 Background

The Water Quality Monitoring study provides data to support evaluation of the potential effects of the Dixon Diversion Project on water quality with respect to state standards and habitat for fish and aquatic life. The Dixon Diversion Project proposes to divert water from the Dixon Glacier outflow from May through October (AEA 2022). This study characterized water quality conditions in 2023 by measuring parameters that have the potential to be impacted by the construction or operation of the proposed project.

1.2 Alaska State Water Quality Criteria

Criteria for relevant water quality parameters are summarized in Table 1-1.

Table 1-1 Water Quality Standards for Alaska Fresh Water Uses

Pollutant	Criteria*
Dissolved Gas	Dissolved oxygen (DO) must be greater than 7 milligrams per liter (mg/L) in waters used by anadromous or resident fish. In no case may DO be less than 5 mg/L to a depth of 20 centimeters (cm) in the interstitial waters of gravel used by anadromous or resident fish for spawning. For waters not used by anadromous or resident fish, DO must be greater than or equal to 5 mg/L. In no case may DO be greater than 17 mg/L. The concentration of total dissolved gas may not exceed 110 percent of saturation at any point of sample collection.
pH	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
Temperature	May not exceed 20°C at any time. The following maximum temperatures may not be exceeded where applicable: Migration routes 15°C Spawning areas 13°C Rearing areas 15°C Egg and fry incubation 13°C For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.
Turbidity	May not exceed 25 nephelometric turbidity units (NTUs) above natural conditions. For all lake waters, may not exceed 5 NTUs above natural conditions.

Source: ADEC (2020).

*The water quality standards listed in this table include the criteria for the growth and propagation of fish, shellfish, other aquatic life, and wildlife.

2.0 GOALS AND OBJECTIVES

The goal of the Water Quality Monitoring study is to characterize water quality in the Martin River basin. Waters potentially affected by the proposed Dixon Diversion Project are identified as Class C waters by the State of Alaska intended to protect the designated use of growth and propagation of fish, shellfish, other aquatic life, and wildlife. Characterization of current water quality conditions will support the evaluation of compliance with water quality criteria under current conditions and under the proposed project operation.

Study objectives for 2023 included collection of water quality data (temperature, pH, dissolved oxygen, turbidity) in the East Fork Martin River near the canyon outlet (EFMR RM 0.1), in the West Fork Martin River (WFMR) downstream of the Red Lake outlet (WFMR RM 0.1), in the outlet from the Martin River off-channel habitat (OCH) complex on river-right at RM 4.3 (RM4.3R OCH), and in the mainstem Martin River downstream of these sources as measured at the constriction near RM 1.9.

3.0 METHODS

Study schedule, monitoring locations, monitoring procedures and analytical methods are summarized below.

3.1 Monitoring Locations

Water quality monitoring was conducted at four locations in 2023 co-located with stream gaging sites (Figure 3-1):

- East Fork Martin River at the canyon outlet near EFMR RM 0.1 (2022 USGS Gage No. 15238951 location; Photo 3-1 and Photo 3-2)
- West Fork Martin River (WFMR) downstream of the Red Lake outlet (WFMR RM 0.1) (2022/2023 gage location; Photo 3-1, Photo 3-3, and Photo 3-4)
- Right bank Martin River off-channel site (RM4.3R OCH) in its outlet near RM 4.3 (2022/2023 gage location); Photo 3-5 and Photo 3-6)
- Mainstem Martin River at the downstream constriction near RM 1.9 (2023 gage; Photo 3-7 and Photo 3-8).

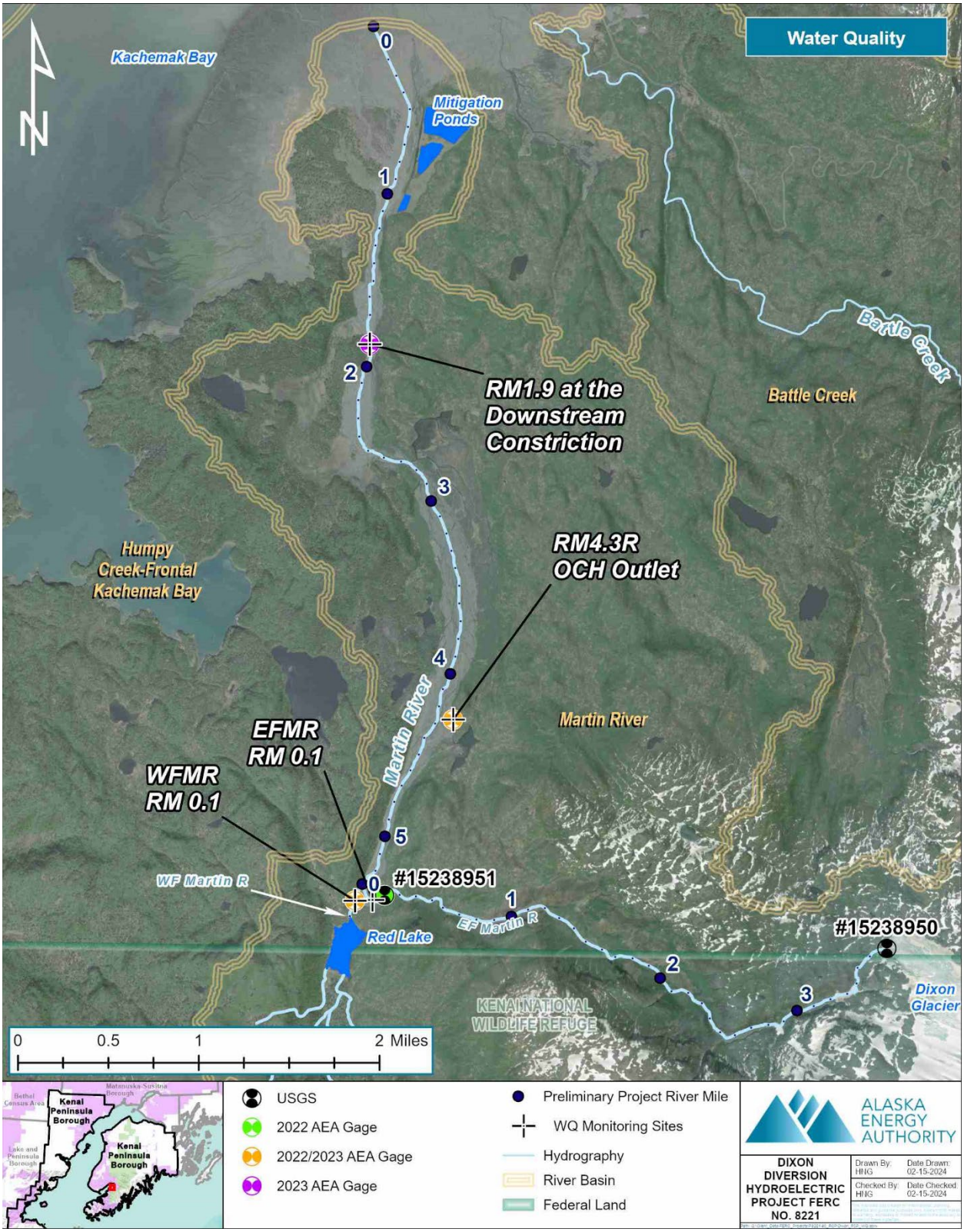

Figure 3-1 Martin River Basin Stream Gages and 2023 Water Quality Monitoring Locations

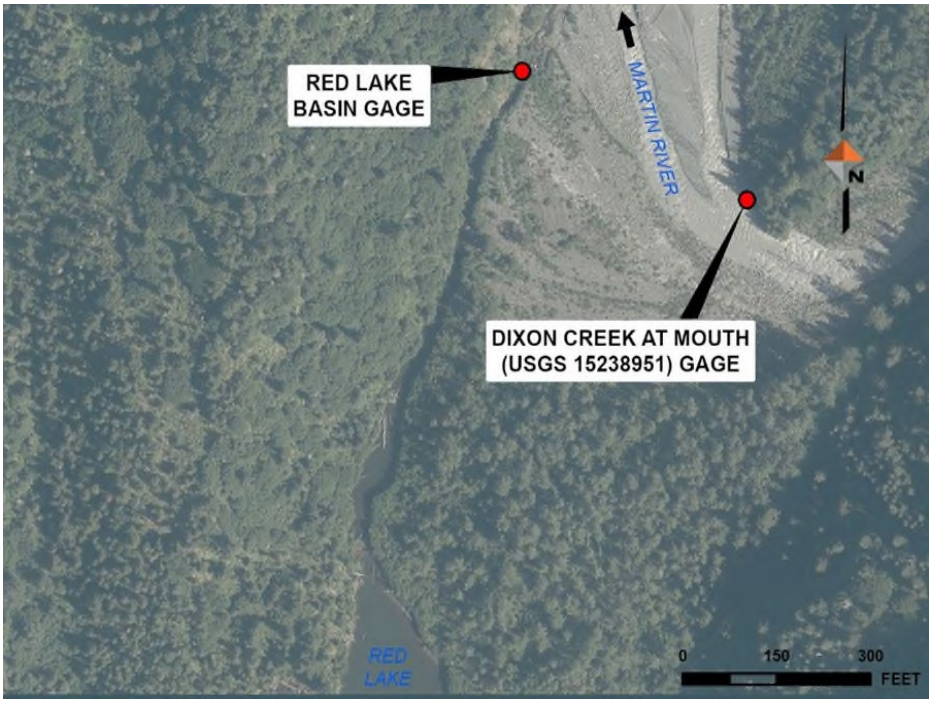

Photo 3-1 Stream Gage and 2023 Water Quality Monitoring Sites in the West Fork Martin River near WFMR RM 0.1 and East Fork Martin River near EFMR RM 0.1 (Source: DOWL Alaska 2023)

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Photo 3-3 West Fork Martin River AEA Stream Gage and 2023 Water Quality Monitoring Site near WFMR RM 0.1 (Source: DOWL Alaska 2023)

Photo 3-4 Confluence of East Fork Martin River and West Fork Martin River downstream of Red Lake, April 24, 2023 (Source: DOWL Alaska 2023)

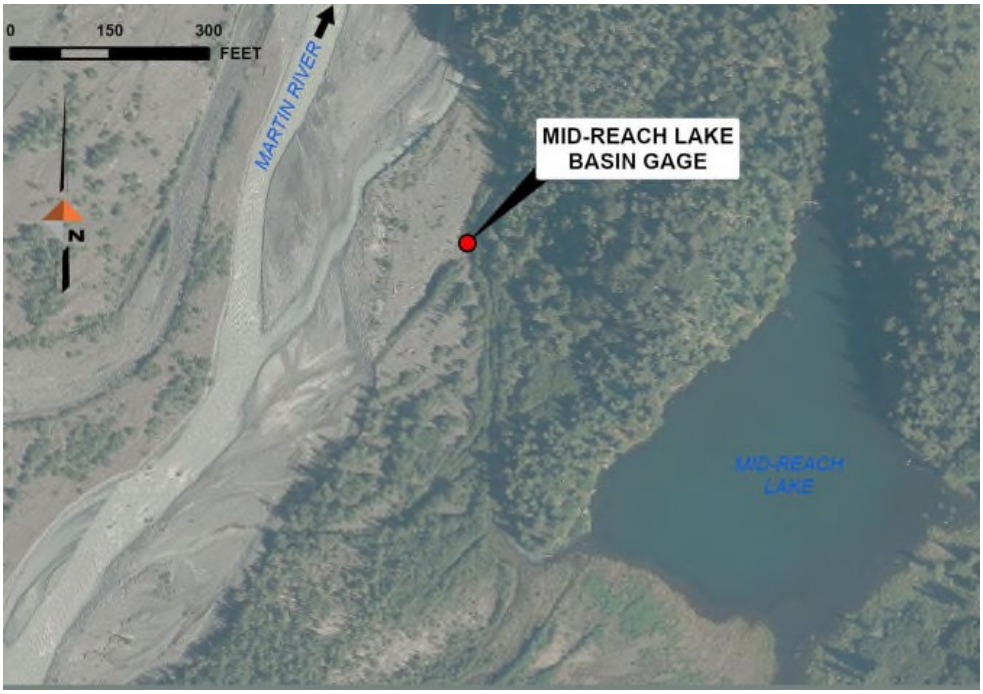

Photo 3-5 Martin River Off-Channel Outlet Stream Gage and 2023 Water Quality Monitoring Site RM4.3R OCH near RM 4.3. (Source: DOWL Alaska 2023)

Photo 3-6 Martin River Off-Channel Stream Gage and 2023 Water Quality Monitoring Site RM4.3R OCH near RM 4.3 (Source: DOWL Alaska 2023)

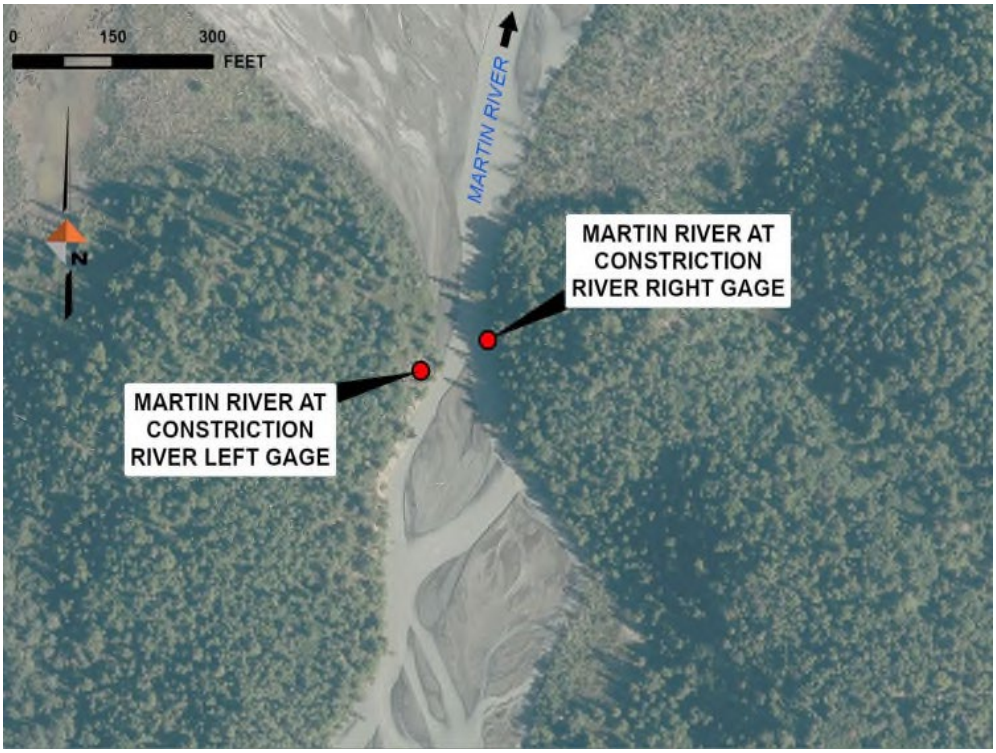

Photo 3-7 Mainstem Martin River Stream Gage and 2023 Water Quality Monitoring Site at the constriction near RM 1.9 (Source: DOWL Alaska 2023)

Photo 3-8 Mainstem Martin River Stream Gage and 2023 Water Quality Monitoring Site at the constriction near RM 1.9. River-Left Gage (Left) and River-Right Gage (Right) (Source: DOWL Alaska 2023)

3.2 Monitoring Schedule

Water quality monitoring was conducted throughout the period of proposed water diversion, May through October. Monthly synoptic or "snapshot" sampling was conducted at all four sites; continuous temperature monitoring was completed at the West Fork Martin River site and the Martin River off-channel outlet site (RM4.3R OCH) (Table 3-1). Monitoring began on April 24, 2023 at three of the sites and was completed on November 17, 2023 (Table 3-1). Water quality monitoring at the East Fork Martin River site began on June 23, 2023.

Table 3-1 Martin River Basin 2023 Water Quality Monitoring Locations

Date	EFMR RM0.1	WFMR RM0.1		RM4.3R OCH Outlet		Martin River RM1.5	
	Monthly WQ	Monthly WQ	Continuous Temperature	Monthly WQ	Continuous Temperature	Monthly WQ	Continuous Temperature
4/24/23		x	x	x	x	x	*
5/26/23		x	x	x	x	x	*
6/23/23	x	x	x	x	x	x	*
7/20/23	x	x	x	x	x	x	*
8/24/23	x	x	x	x	x	x	*
9/19/23	x	x	x	x	x	x	*
10/20/23	x	x	x	x	x	x	*
11/17/23	x	x	*	x	x	x	*

*Planned but not able to be retrieved

Continuous temperature loggers described in more detail below (Section 3.3), were installed at three sites on April 24, 2023 (Photo 3-1). Due to concerns about the risk of logger damage under high flow conditions in the mainstem Martin River, a redundant second logger was placed at the Martin River RM 1.9 site. Both loggers installed at Martin River RM 1.9 were not accessible during the monthly site visits due to high flows and both loggers were lost during high flow conditions before it was safe to retrieve the loggers and download the data. Monthly synoptic or "snapshot" data collection was the only effective approach for temperature data collection at the Martin River mainstem site. The logger installed at the RM4.3R OCH outlet location was found transported downstream and partially exposed during the September 19, 2023 site visit. It appeared that a high flow event in late August provided an upstream connection to the Martin River, which inundated the off-channel habitat and dislodged the duckbill anchor from the channel. Fortunately, the logger was retrieved, and stored temperature data were recovered during the September site visit when the logger was reinstalled. Due to the uncertainty around

the timing that this logger was out of water and which habitats the temperature data may have represented, the data between site visits on August 24 and September 19 were removed from analysis. Continuous temperature data were collected in the West Fork Martin River near WFMR RM 0.1 throughout the monitoring period, although the logger was found to be missing during the final site visit on November 17, 2023

3.3 Monitoring Equipment and Procedures

Continuous temperature monitoring was conducted at 30-minute intervals following the data standards outlined in Mauger et al. (2015) using calibrated, continuous temperature loggers. Onset Hobo U22-001 temperature loggers were capable of accuracy ±0.2°C and a range of −40°C to 50°C in water. Pre- and post-deployment accuracy checks were used to screen for defective equipment and qualify data reporting if measurement drift occurred. Accuracy checks were conducted at two temperatures (0°C and approximately 20°C).

During monthly synoptic or "snapshot" monitoring, the continuous temperature logger was audited by taking an independent measure of water temperature using a multi-parameter probe. A calibrated multi-parameter probe, a YSI ProDSS, was used to collect temperature, conductivity, DO, pH, and turbidity during monthly field data collection efforts. Given the prevalence of glacial inputs and high turbidity levels expected during the monitoring period, a transparency tube was also used to estimate turbidity in nephelometric turbidity units (NTUs) when probe readings exceed 5 NTUs. Transparency tubes, also called turbidity tubes, use a small secchi disk symbol at the bottom of a clear, narrow plastic tube to allow an observer to estimate the depth of water sufficient to obscure the secchi symbol; this measurement quantifies water transparency and can be used to estimate NTUs (Dahlgren et al. 2004).

Field data was recorded on datasheets. Records of accuracy checks and calibration events were maintained. Metadata for field water quality measurements included a unique site identifier, datum, latitude and longitude, date, and time. Data was entered and managed in Microsoft Excel. Field data collection followed the Dixon Diversion Project data quality assurance/quality control (QA/QC) protocol (see Draft Study Plan Section 1.3.4).

3.4 Analytical Methods

For continuous temperature sampling, data summaries include daily summaries of minimum, maximum, and mean stream temperatures for days within the monitoring

period that contained at least 90 percent of the 30-minute data for that day (i.e., 44 of the 48 30-minute measurements). Transparency tube readings were converted to NTUs using the conversion in Table 3-2.

Table 3-2 Turbidity Conversion Chart from Centimeters to NTUs

Distance from Bottom of Tube (cm)	NTUs	Distance from Bottom of Tube (cm)	NTUs
<6.25	>240	31.25-33.75	21
6.25-7	240	33.75-36.25	19
7-8	185	36.25-38.75	17
8-9.5	150	38.75-41.25	15
9.5-10.5	120	41.25-43.75	14
10.5-12	100	43.75-46.25	13
12-13.75	84	46.25-48.75	12
13.75-16.25	60	48.75-51.25	11
16.25-18.75	48	51.25-53.75	10
18.75-21.25	40	53.75-57.5	9
21.25-23.75	35	57.5-60	8
23.75-26.25	30	60-70	7
26.25-28.75	27	70-85	6
28.75-31.25	24	>85	<5

Source: USU (2022).

4.0 RESULTS

Water quality data collected in 2023 are summarized below by parameter.

4.1 Temperature

Martin River water temperatures, as recorded during monthly site visits to the outlet of the East Fork Martin River near EFMR RM 0.1 and the mainstem Martin River at the downstream constriction near RM 1.9 were relatively low throughout the monitoring period. Snapshot monthly temperature measurements at the EFMR RM 0.1 site ranged from 0 to 2°C and the RM 1.9 site at the downstream constriction ranged from 0.3 to 5.3°C (Figure 4-1,Table 4-1).

The monthly snapshot monitoring of the West Fork Martin River and Martin River off-channel habitat outlet site RM4.3R OCH documented water temperatures notably warmer than the East Fork Martin River or lower Martin River mainstem sites (Figure 4-1,Table 4-1). Monthly snapshot measurements at the West Fork Martin River site near WFMR RM 0.1 ranged from 2.0 to 15.6 °C and ranged from 1.4 to 16.2 °C at the Martin River off-channel habitat outlet site RM4.3R OCH. The monitoring period captured conditions in April and November, when temperatures were low and differences among the sites were relatively small (less than 2.5°C) as well as mid-summer conditions in July and August when these sites were considerably warmer than the glacially influenced East Fork and mainstem Martin River (more than 9.5 °C warmer).

Table 4-1 Martin River 2023 Monthly Snapshot Water Temperature (°C) Monitoring at Mainstem, Tributary and Off-Channel Monitoring Sites

Date	East Fork Martin River EFMR RM 0.1 Temperature (°C)	West Fork Martin River WFMR RM 0.1 Temperature (°C)	Martin River Off-channel Outlet RM4.3R OCH Temperature	Martin River RM 1.9 Temperature (°C)
4/24/23	-	2.0	1.5	2.5
5/26/23	-	5.3	8.5	5.1
6/23/23	1.7	11.1	13.5	2.9
7/20/23	2.0	14.3	16.2	4.3
8/24/23	1.9	15.6	12.1	2.5
9/19/23	1.1	9.4	10.6	3.3
10/20/23	0.1	4.6	5.2	1.4
11/17/23	0.0	2.3	1.4	0.3

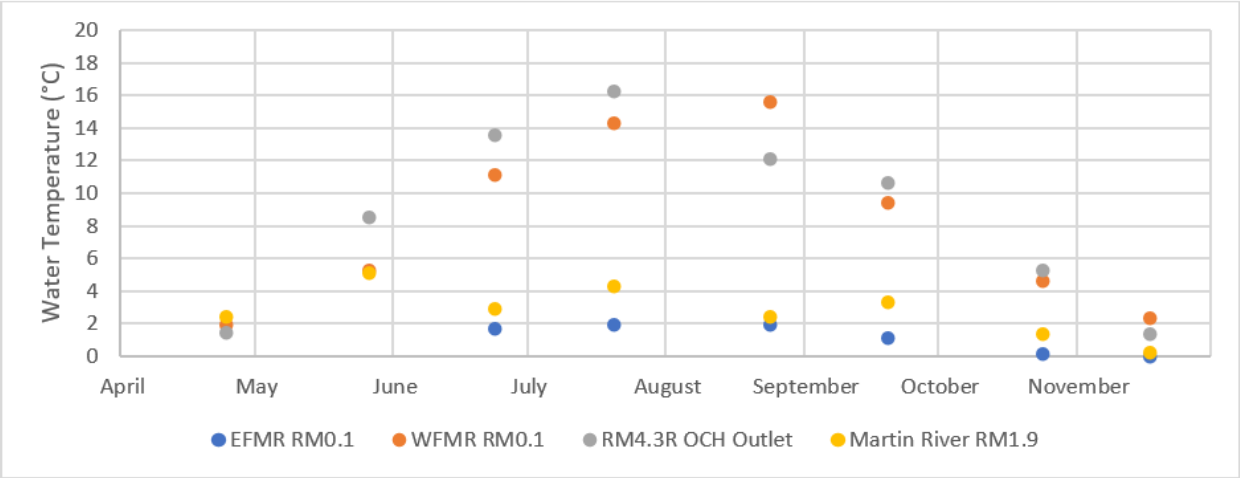

Figure 4-1 Martin River 2023 Monthly Snapshot Water Temperature Monitoring at Mainstem, Tributary and Off-Channel Monitoring Sites

The West Fork Martin River monitoring downstream of Red Lake characterized 178 complete days of water temperature at 30-minute intervals. Water temperatures ranged between 1.9 and 19.2 °C (Figure 4-2). Peak water temperatures were observed on August 2, 2023.

The Martin River off-channel RM4.4R OCH outlet monitoring characterized 151 complete days of water temperature at 30-minute intervals between April 24 and October 20. Water temperatures ranged between 0.4 and 18.2 °C, with peak water temperatures also observed on August 2, 2023 (Figure 4-3). Although the temperature logger was not functional for a month in late August and early September, the pattern of monthly snapshot temperature decline over that period was consistent with the West Fork Martin River data (Figure 4-3). Data from October 20, 2023 to November 17, 2023 will be included in the 2024 water quality study report.

Minimum temperatures at this site demonstrated dips of more than 5 °C on July 6 and August 13. Based on site conditions, these short (less than one day) drops in temperature may represent Martin River mainstem inflows into this off-channel habitat complex under high flow conditions.

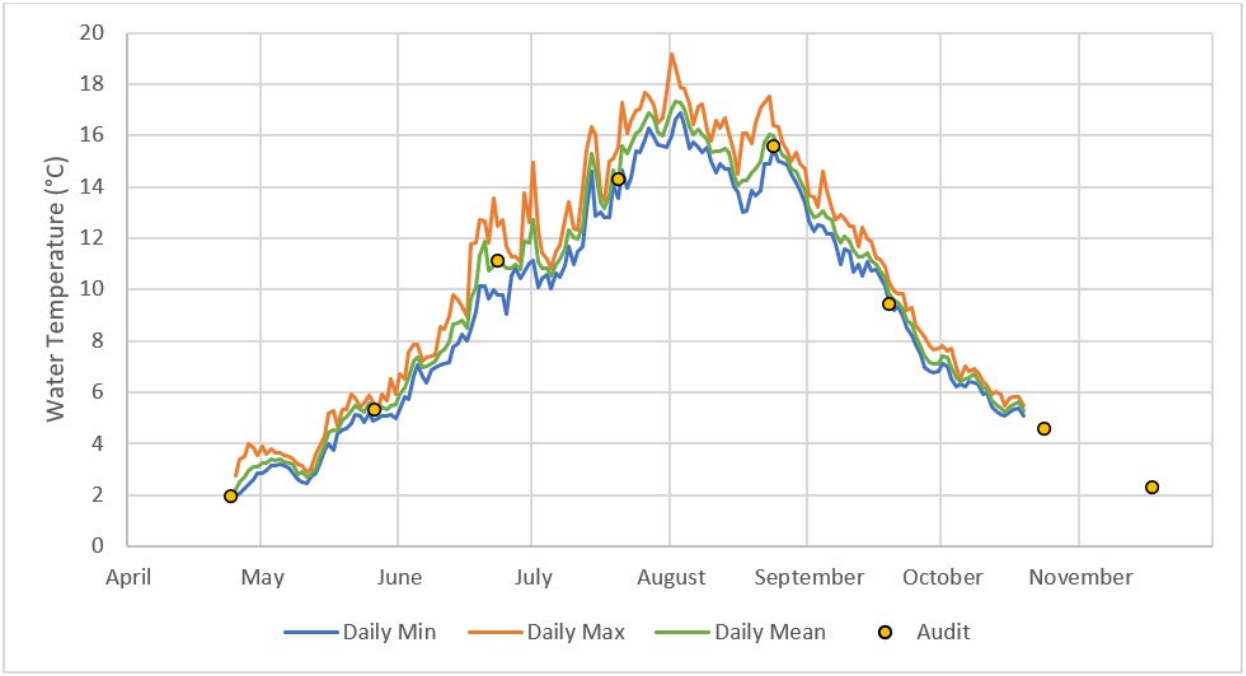

Figure 4-2 Daily Water Temperature Metrics from 2023 Continuous Monitoring at the West Fork Martin River WFMR RM 0.1 with Monthly Audit Snapshot Water Temperatures.

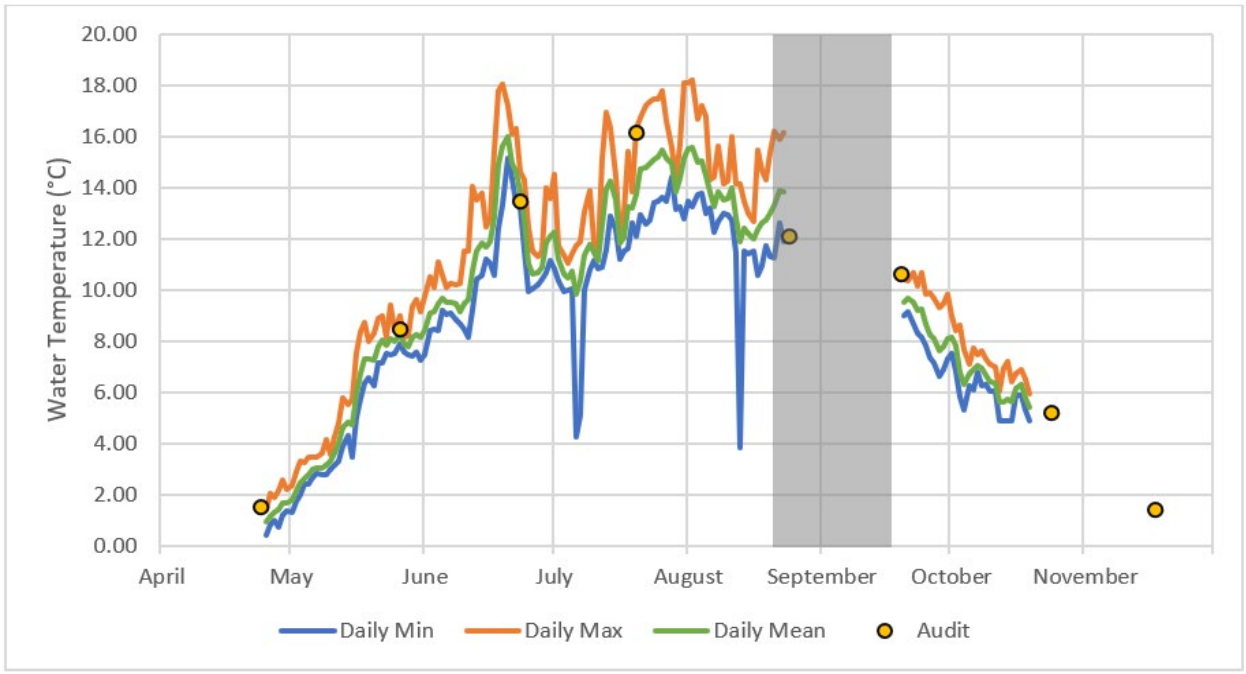

Figure 4-3 Daily Water Temperature Metrics from 2023 Continuous Monitoring at Martin River Off-channel RM4.3R OCH Outlet Site with Monthly Audit Snapshot Water Temperatures

4.1.1 Compliance With Water Quality Standards

Water temperature criteria for the growth and propagation of fish, shellfish, other aquatic life, and wildlife include criteria for various uses at temperature thresholds of 13°C, 15°C , and 20°C (Table 1-1). At the Red Lake outlet monitoring site (WFMR RM 0.1), daily maximum water temperatures exceeded the criteria for spawning areas and egg and fry incubation (13°C) for 61 days between June 22 and September 6 (Table 4-2, Figure 3-1). Daily maximum water temperatures exceeded the criteria for rearing areas and migration routes (15°C) for 43 days between July 13 and August 29. Water temperatures at the Red Lake outlet monitoring site did not exceed 20°C during the monitoring period.

Daily maximum water temperatures at the Martin River off-channel monitoring site RM4.4R OCH exceeded the criteria for spawning areas and egg and fry incubation (13°C) earlier, starting on June 12. and first exceeded the criteria for rearing areas and migration routes (15°C) on June 17 (Table 4-1,Figure 4-4). The duration of these exceedances was truncated by a gap in daily maximum estimates between August 24 and September 19 (Figure 4-3).

Table 4-2 Days Daily Maximum Temperature Exceeded Water Temperature Criteria at West Fork Martin River and Off Channel Monitoring Sites during 2023

Criterion	Fish Use	Number of Days Exceeding	
		Red Lake Outlet (WFMR RM 0.1)	RM4.3R OCH Outlet
<13 °C	Spawning areas, Egg & fry incubation	61	37
<15 °C	Migration routes, Rearing areas	43	11
<20 °C	Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	0	0

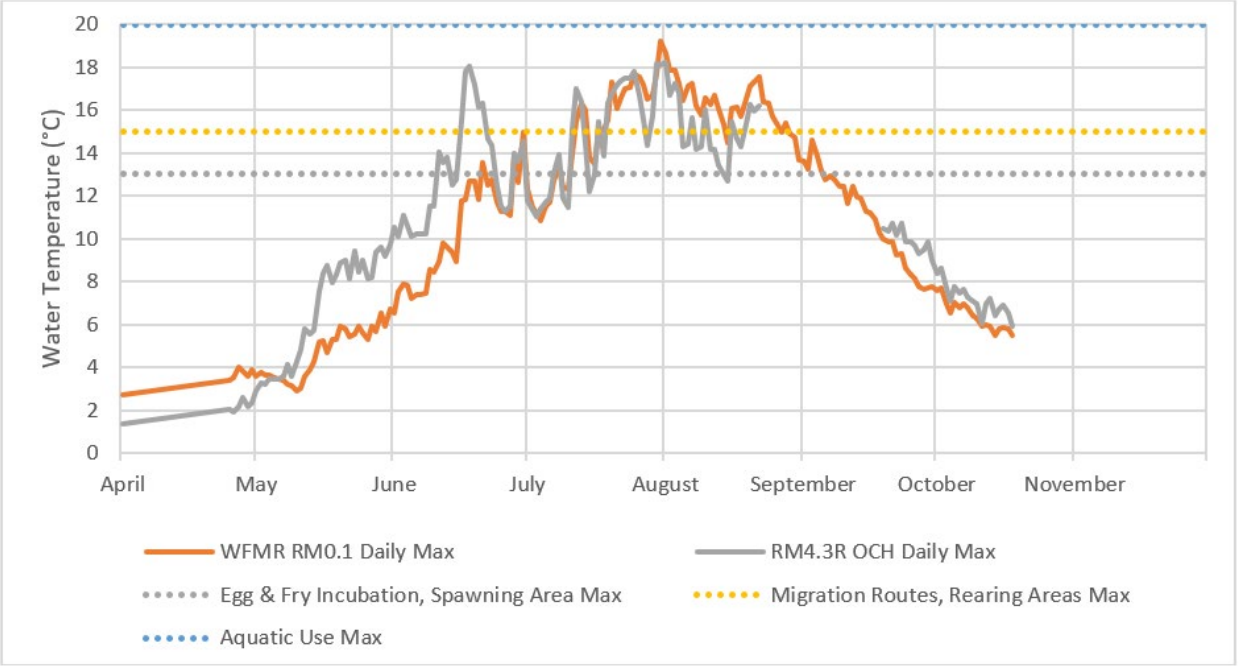

Figure 4-4 Daily Maximum Temperature Summary for 2023 Continuous Monitoring Sites

4.2 Dissolved Oxygen

Both dissolved oxygen metrics (concentration and saturation) characterized dissolved oxygen levels as relatively high in May through October across all monitoring sites. Dissolved oxygen concentrations (mg/L) were slightly lower in the warmer WF Martin River and Martin River off-channel habitat sites (Figure 4-5). However, all sites were similar in percent saturation in May through October, ranging from 88 to 113 percent (Figure 4-6).

In contrast, dissolved oxygen levels were lower in habitats under ice and snow. The lowest dissolved oxygen concentrations were observed at non-glacial sites in late April and concentrations started to drop again in November. On April 24, dissolved oxygen concentrations in the WF Martin River were 4.7 mg/L and only 34 percent saturated. April DO concentrations in the RM4.3R OCH outlet were 7.9 mg/L and 56 percent saturated.

4.2.1 Compliance With Water Quality Standards

Dissolved oxygen criteria applicable to these monitoring sites require concentrations greater than 7mg/L in waters used by anadromous or resident fish and concentrations of total gas may not exceed 110 percent of saturation (Table 1-1). The only site with values

outside these criteria was the WF Martin River site where concentrations were less than 7 mg/L on April 24 (Figure 4-5) and greater than 100 percent saturated on July 20 (Figure 4-6).

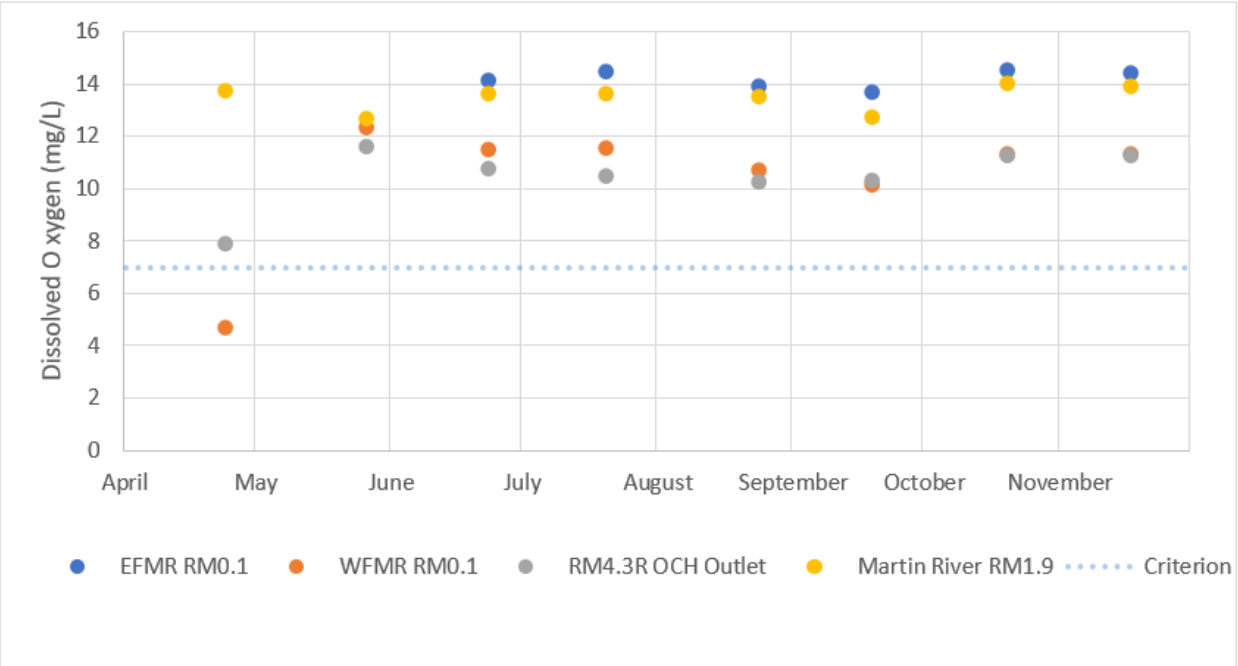

Figure 4-5 Monthly Snapshot of Dissolved Oxygen Concentration (mg/L) during 2023

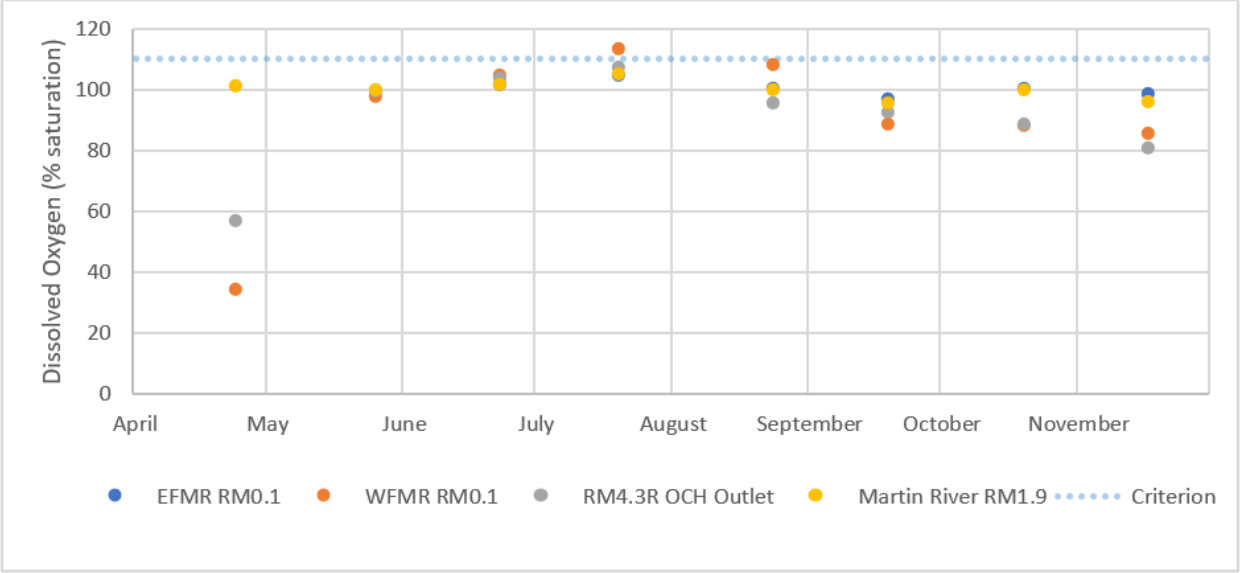

Figure 4-6 Monthly Snapshot of Dissolved Oxygen Saturation (%) during 2023

4.3 Specific Conductance

Specific conductance ranged between 0.021 and 0.124 mS/cm across sites and monitoring events (Figure 4-7). In general sites and events with higher proportions of glacial water sources had lower specific conductance levels. For example, the mainstem Martin River had lower specific conductance levels than the West Fork Martin River and off-channel habitat sites and specific conductance in the East Fork and lower mainstem Martin River was lower during the summer high flow conditions when glacial melt was highest.

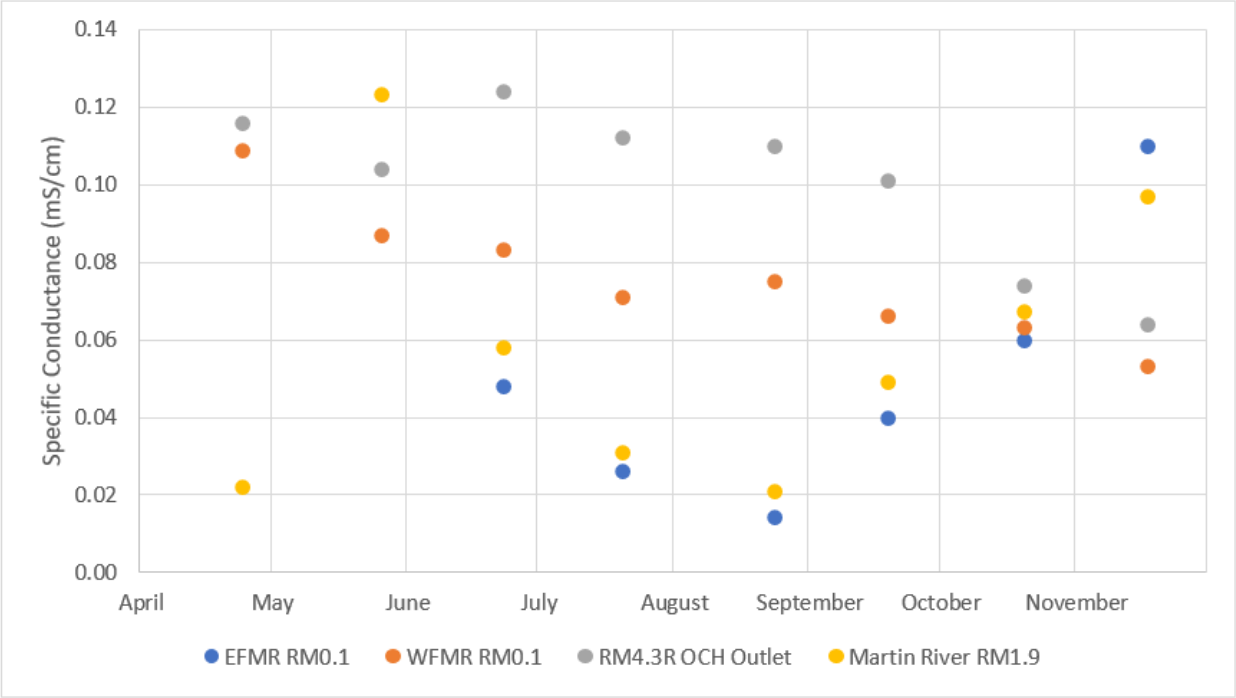

Figure 4-7 Monthly Snapshot of Specific Conductance during 2023.

4.4 pH

Monitoring documented pH levels ranging from 5.9 to 7.9 across sites over the monitoring period (Figure 4-8). No consistent differences in pH among the monitoring sites were observed. April in the Red Lake outlet was the only record outside of the pH criteria of 6.5 to 8.5.

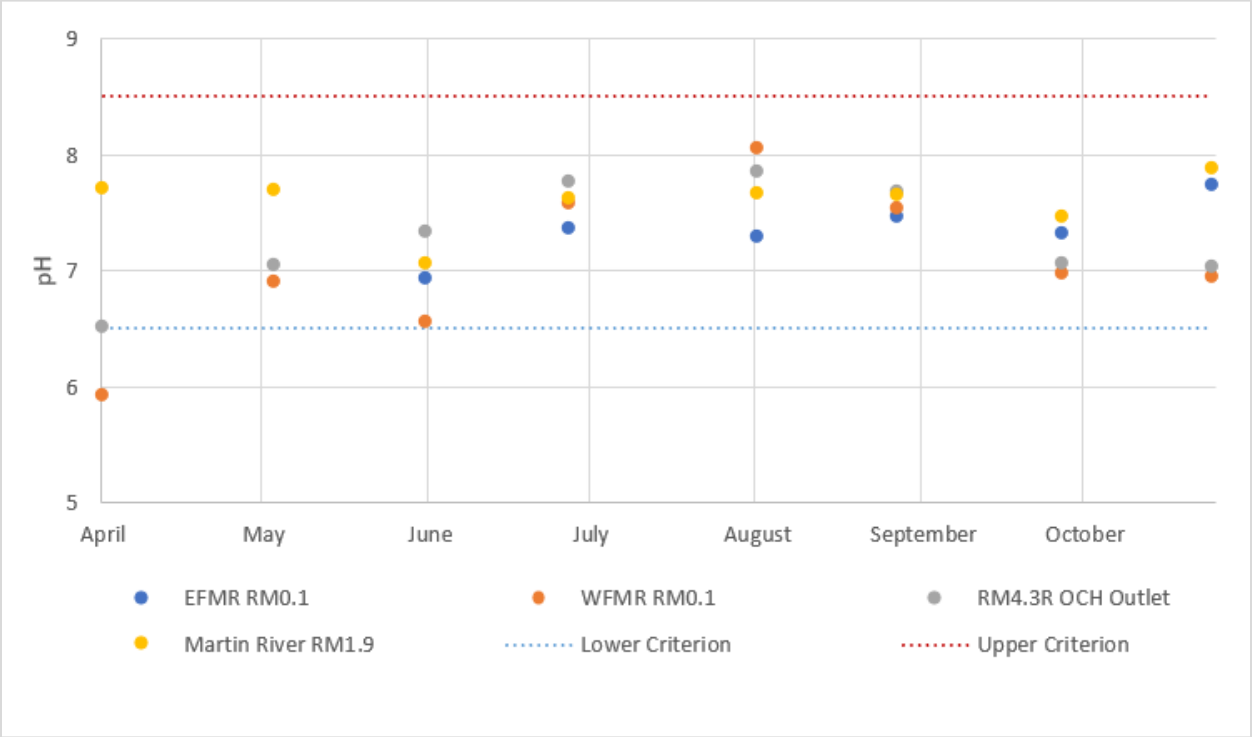

Figure 4-8 Monthly Snapshot of pH Measured at 2023 Water Quality Monitoring Sites

4.5 Turbidity

Monthly monitoring of the East Fork and mainstem Martin River sites documented turbidity levels notably higher than the West Fork Martin River and off-channel sites in June through October (Figure 4-9). Turbidity levels were highest (438 NTU) on August 24 at the Martin River RM 1.9 monitoring site. Monthly measurements at the Red Lake outlet site near WFMR RM 0.1 and the Martin River off-channel RM4.3R OCH site ranged from 0 to 4.0 NTU. The monitoring period also captured conditions in April through May and November when turbidity levels were relatively low (less than 2.5 NTU) across all monitoring sites.

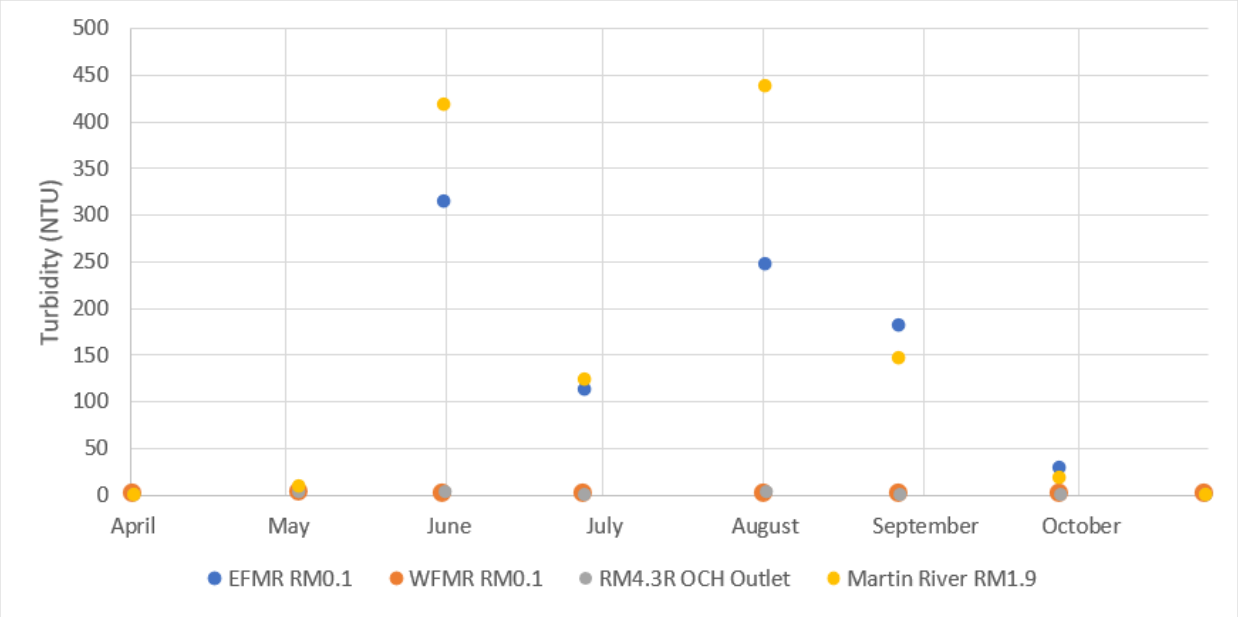

Figure 4-9 Monthly Snapshot of Turbidity Levels (NTU) Measured during 202

5.0 DISCUSSION

The general pattern of temperature increases between the upstream and downstream sites over approximately 3.6 river miles appeared to be influenced by both season and river flows. When the non-glacial West Fork Martin River and Martin River off-channel habitats cooled in the fall, the longitudinal difference between the mainstem site and the East Fork Martin River decreased. Similarly, when river flows were high and the Dixon Glacier contributed the highest proportion of total Martin River flow, as represented by conditions on August 24, the difference between the East Fork and lower mainstem Martin River site also decreased.

The Martin River water temperature data collected at RM 1.9 are cooler than the water temperature collected at the USGS Gage on the Bradley River near Tidewater Near Homer, Alaska (USGS 15239070). For example, the highest temperature recorded during monthly visits to the Martin River at RM 1.5 was 4.3 °C on July 20. The temperature of the Bradley River at the same time was 10.7 °C.

In April, both the West Fork Martin River and Martin River off-channel habitat sites were open water outlet channels of water bodies covered by ice and snow (Photo 3-4). Water quality monitoring documented low dissolved oxygen and low pH, consistent with light-limited conditions. Dissolved oxygen and pH were low enough at the West Fork Martin River Red Lake outlet in April that they failed to meet water quality standards.

6.0 REFERENCES

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