ADDENDUM TO THE MARTIN RIVER TEMPERATURE IMPACT ASSESSMENT

BRADLEY LAKE HYDROELECTRIC PROJECT

BRADLEY LAKE EXPANSION

FERC NO. 8221

Prepared for:

Alaska Energy Authority

Prepared by:

Kleinschmidt Associates

June 2026

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
7DADM	7-day average of the daily maximum

A

ADF&G	Alaska Department of Fish and Game

C

cfs	cubic feet per second

E

EFMR	East Fork Martin River

K

Kleinschmidt	Kleinschmidt Associates

N

NA	not available

P

Project	Bradley Lake Expansion Project

W

WFMR	West Fork Martin River

1.0 PURPOSE

The *Martin River Temperature Impact Assessment* (Kleinschmidt Associates [Kleinschmidt] 2026c) was completed earlier this year with a goal of quantifying the potential impacts of the Bradley Lake Expansion Project (Project) on water temperature in the mainstem Martin River assuming a minimum instream flow (MIF) in the East Fork Martin River (EFMR) of 100 cubic feet per second (cfs) throughout operation May through October. Since then, AEA has conducted additional 2D hydraulic modeling at different EFMR flow releases (Kleinschmidt 2026b) and consulted with the Alaska Department of Fish and Game (ADF&G) and United States Fish and Wildlife Service (USFWS) and developed a seasonally variable EFMR MIF with the goal of balancing the need for power with maintaining habitat connectivity for migrating salmon and sediment delivery and transport in the Martin River. The rationale for the proposed EFMR MIF regime can be found in Kleinschmidt (2026a). The potential effects of the new proposed EFMR MIF regime on Martin River water temperature were analyzed, and the results are presented in this addendum. Responses to the stakeholder comments received on the *Martin River Temperature Impact Assessment* (Kleinschmidt 2026c) are provided in Appendix A.

2.0 PROPOSED INSTREAM FLOW SCHEDULE

The proposed EFMR instream flow schedule provided in Table 2-1 is similar, but not exactly the same as that discussed with ADF&G. Similar to the previous analysis, flows in the EFMR were assumed to be those dictated by the instream flow schedule even additional water would be flowing downstream as would be expected due to the occurrence of sediment management flushing flows, proposed channel maintenance flows, or natural flows in excess of the diversion tunnel capacity (1,650 cfs).

Table 2-1 Proposed East Fork Martin River minimum instream flow schedule.

Period	Flow (cfs)
May 1 – May 15	50 cfs
May 16 – May 31	Increase by 5 cfs/day to 130 cfs
June 1 – June 25	150 cfs
June 26 – September 25	75 cfs
September 26 – October 15	150 cfs
October 16 – October 22	100 cfs
October 23 – April 30	50 cfs

3.0 ADDITIONAL ASSESSMENT METHODS

Similar methods as presented in the *Martin River Temperature Impact Assessment* (Kleinschmidt 2026c) were applied for the analysis presented in this addendum. The same mass balance approach and computations of direct solar radiation were applied. This approach assumed full mixing between the EFMR and the WFMR and the Martin River and Swan Lake Outlet. In addition, water temperature increases were estimated using direct solar radiation, which is the amount of solar energy that reaches the top of the atmosphere before being filtered by any atmospheric factors such as clouds, wind, shade, and moisture. This approach represents a worst-case condition by applying the maximum possible energy the earth's surface could receive, which translates into the highest possible temperature increase. The main difference with the additional results presented in this addendum is that the increase in water temperature from direct solar radiation will change depending on the MIF flow rate. The direct solar radiation calculation uses estimates of travel time and stream width in the calculation, which changes depending on the flow and requires simulation of the hydraulic model at different flow rates. To simplify the analysis, the hydraulic model was simulated at only five flow rates and the results interpolated. The hydraulic model was simulated at flow rates of 50 cfs, 75 cfs, 100 cfs, 125 cfs, and 150 cfs. Each flow rate was simulated assuming two tributary flows, one for spring with higher tributary inputs (13.7 cfs) and one for fall that assumed lower tributary inputs (2.2 cfs).

The thermal accumulation as a result of direct solar radiation following the proposed MIF schedule is summarized in Table 3-1 and shown in Figure 3-1. The direct solar radiation calculation used a declination angle that varied with the day of the year (previously the angle was assumed to be from solar noon on the longest day of the year). Note that water temperature increases from direct solar radiation were interpolated for those dates not provided in Table 3-1. The values in Table 3-1 were applied in the temperature calculation for each reach depending on the season and flow rate.

Table 3-1 Thermal accumulation by date from direct solar radiation.

Season	Date	EFMR Flow (cfs)	Thermal Accumulation (°C)	
			EFMR/WFMR Confluence to Swan Lake Reach	Swan Lake to Constriction Reach
Spring Tributary Flow	May 1	50	5.61	2.08
	May 15	50	5.61	2.08
	May 20	75	4.93	1.74
	May 25	100	4.08	1.56
	May 30	125	3.77	1.49
	June 1	150	3.27	1.36
	June 25	150	3.27	1.36
	June 26	75	5.17	1.82
Fall Tributary Flow	September 25	75	3.74	1.29
	September 26	150	2.14	1.08
	October 15	150	2.14	1.08
	October 16	100	2.12	0.85
	October 22	100	2.12	0.85

°C = degrees Celsius; cfs = cubic feet per second; EFMR = East Fork Martin River; WFMR = West Fork Martin River.

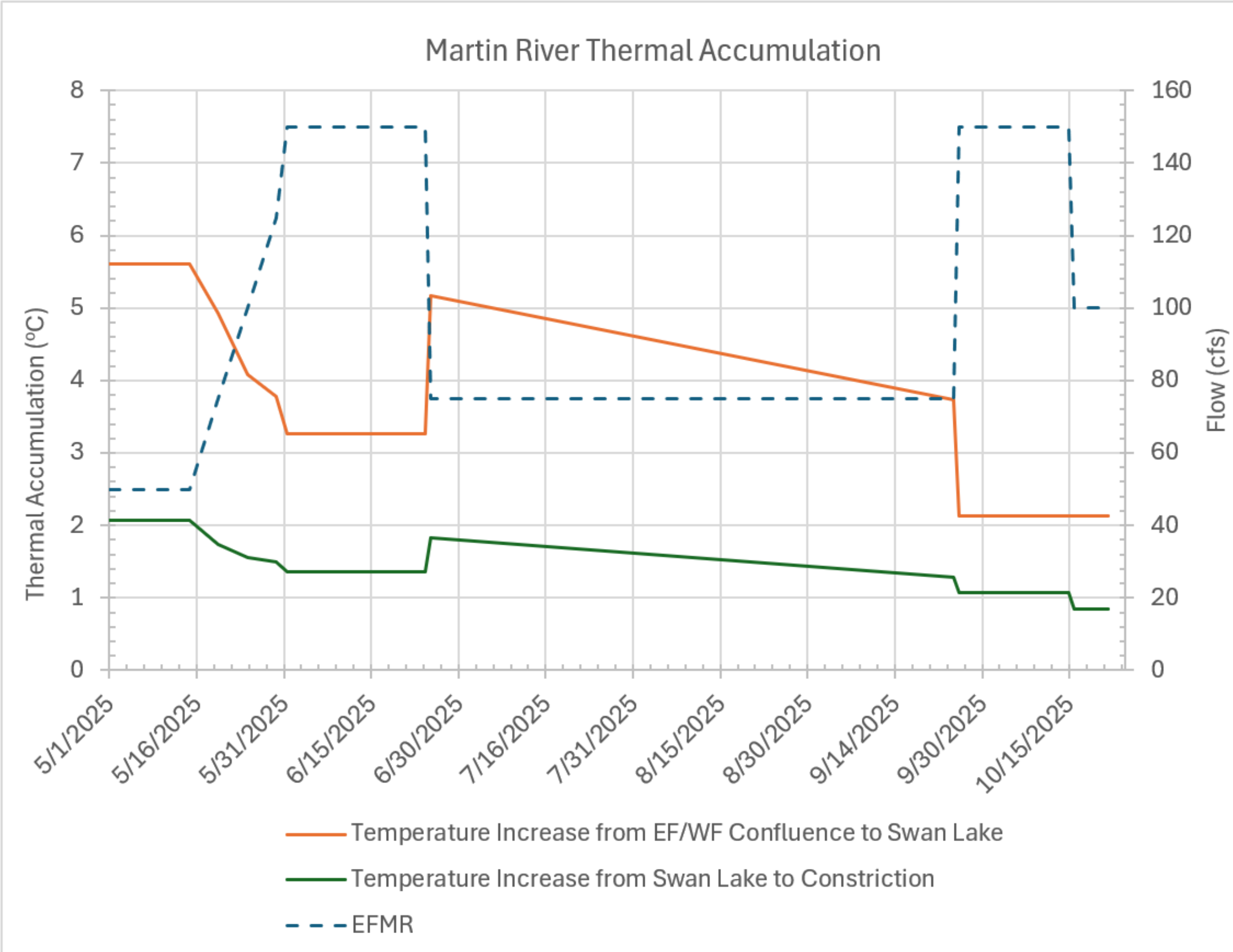

Figure 3-1 Minimum instream flows (dashed blue line) and thermal accumulation in the Martin River between the East Fork/West Fork confluence to above Swan Lake (solid orange line) and the Martin River from Swan Lake Outlet to the constriction (solid green line).

4.0 RESULTS

Results for the 2 years with available data are presented in the sections below.

4.1 2024

The calculated temperatures for the Martin River below the EFMR/West Fork Martin River (WFMR) confluence and the Martin River above Swan Lake are shown in Figure 4-1. As can be seen from this figure, temperatures in the Martin River at both locations below the EFMR/WFMR confluence were below the Alaska Department of Environmental Conservation (ADEC) standard of 15 degrees Celsius (°C) for migration routes (ADEC 2024). No baseline temperature data were available for comparison. Water temperature at the Swan Lake Outlet was not collected in 2024, so the analysis downstream of Swan Lake could not be conducted. Temperatures in the WFMR come close to the standard and in some cases exceeded it, but the Project is located outside of the WFMR basin and would not impact either the flow or temperature in the WFMR.

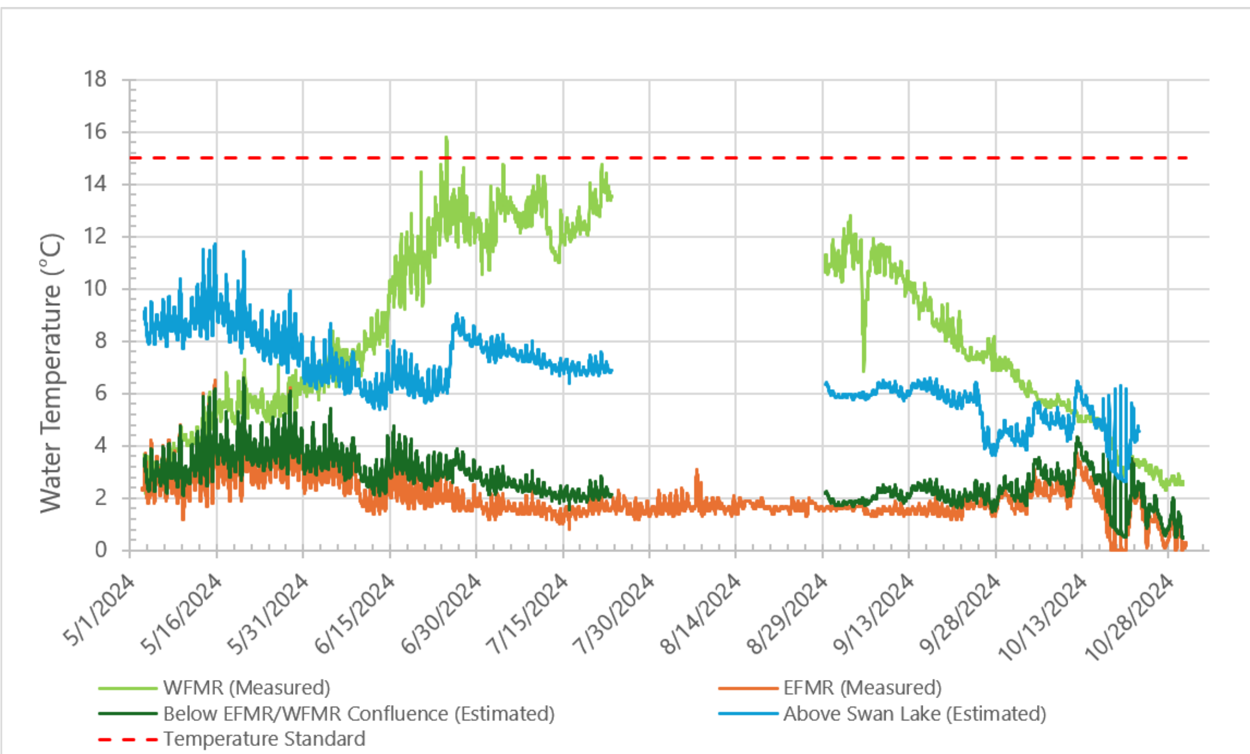

Figure 4-1 Calculated Martin River temperature with proposed Project operations, 2024, under the ADF&G minimum instream flow schedule.

4.2 2025

The calculated temperature for the Martin River at various locations is shown in Figure 4-2. As can be seen from this figure, temperatures in the Martin River at the three locations below the EFMR/WFMR confluence were below the 15°C ADEC standard. The estimated temperature at the constriction of the mainstem Martin River under Project operations using the proposed EFMR MIF schedule came close to exceeding the standard in mid-May and represents an increase in temperature as compared to the results using a flat MIF rate of 100 cfs. The reason for the difference is that the lower flow in mid-May of 50 cfs results in a longer travel time for a smaller body of water, which allows more warming overall. However, the estimated temperatures in the Martin River as shown in Figure 4-2 represent worst-case conditions for 2025 because flows in the EFMR were assumed to be the MIF at all times, the maximum solar radiation inputs were used which assumed sunny no cloud conditions on all days, and no shade from riparian vegetation was included. In reality, water temperatures in the Martin River are expected to be lower than those predicted as atmospheric conditions such as cloud cover, shade, wind, and moisture will work to dampen warming effects. Increases in shading alone can decrease warming by 0.5°C to several degrees (Amaranthus et al. 1989; Fuller et al. 2022; Kalny et al. 2017). With operation of the Dixon Diversion, the Martin River is anticipated to transition from a multi-channel braided system with a wide gravel floodplain to a more single thread stable system allowing for the development of a vegetated riparian corridor that would provide shade to the river.

Water temperatures in the WFMR exceeded the standard in July and August, but the Project is located outside of the WFMR basin and would not impact either the flow or temperature in the WFMR. A jump in water temperature at the constriction and at Swan Lake can be seen on June 26, with a corresponding drop in temperature on September 26. These shifts are associated with direct solar radiation input, which significantly increased when the MIF dropped from 150 cfs to 75 cfs on June 25 to June 26 and decreased when the MIF increased from 75 cfs to 150 cfs on September 25 to September 26.

A comparison between baseline and with-Project Martin River temperature conditions at the constriction is provided in Figure 4-3, which shows that the temperature in the Martin River at the constriction was as much as 8°C warmer under the with-Project condition than under baseline based on worst-case assumptions as previously described. Calculated temperatures only approach the 15°C ADEC standard in May. Temperatures from June through October were less than 12°C.

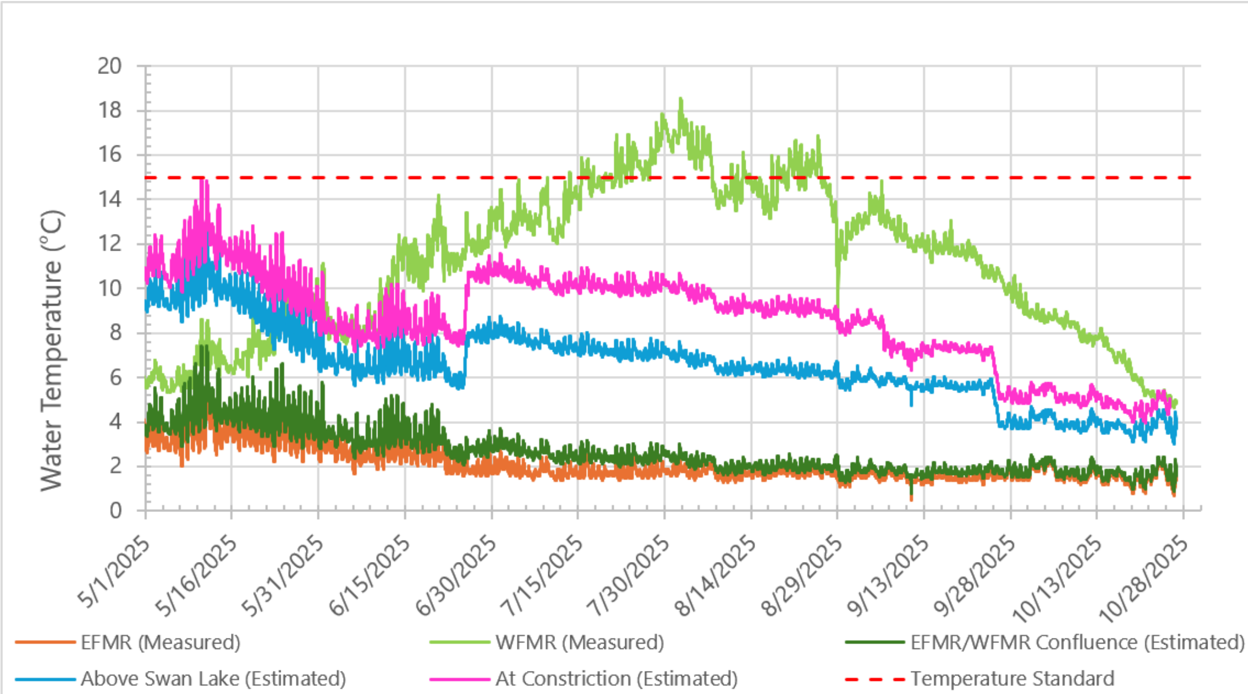

Figure 4-2 Calculated Martin River temperature with Project operations, 2025, under the ADF&G minimum instream flow schedule.

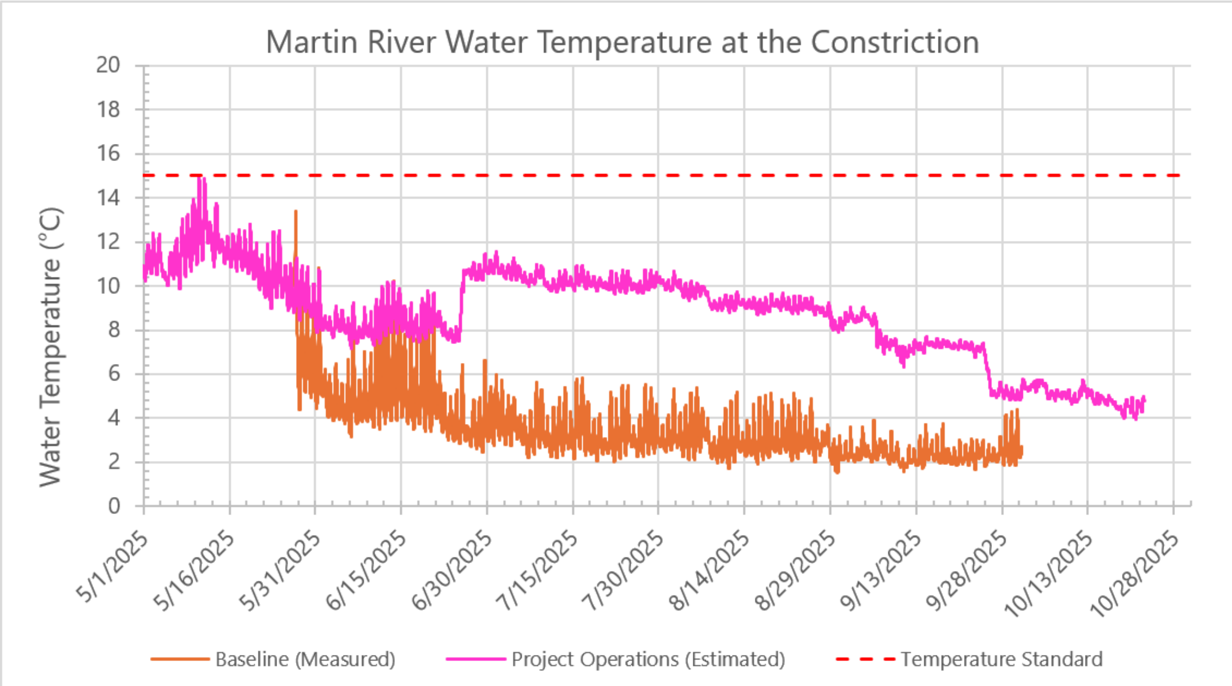

Figure 4-3 Comparison of Martin River at the constriction under baseline and Project operations, 2025, under the ADF&G minimum instream flow schedule.

Comparison of the monthly average temperature under baseline and the with-Project condition is provided in Table 4-1. Average differences ranged from 1.7°C to 7.0°C. Comparison of the monthly maximum of the 7-day average of the daily maximum (7DADM) is provided in Table 4-2. The 7DADM represents the arithmetic average of seven consecutive measures of daily maximum temperatures and was recommended by the U.S. Environmental Protection Agency 2021-2024 Triennial Review for adoption as a duration metric (ADEC 2021). The 7DADM is compared to the given standard and reflects an average of maximum temperatures that fish are exposed to over a week-long period and is not overly influenced by the maximum temperature of a single day. Average differences of the maximum 7DADM ranged from 1.7°C to 5.8°C.

It is important to note the estimated temperatures in the Martin River as shown in Figure 4-2 and Figure 4-3 and summarized in Table 4-1 and Table 4-2 represent worst-case conditions for 2025. This is because flows in the EFMR were assumed to never exceed the MIF, the maximum solar radiation inputs were used, and higher temperature and flow conditions than expected for Swan Lake Outlet were assumed during the period from June 19 to September 5, 2025. The maximum solar radiation inputs do not mimic natural temperature diurnal fluctuations but estimate a worst-case condition. Given the modeling approach and these assumptions, the estimates of temperature in the Martin River at the constriction are likely over-predicted and yet indicated the temperatures would remain below ADEC's water temperature standard for both salmonid migration routes and spawning areas (15°C).

Table 4-1 Monthly average water temperature for the Martin River at the constriction under baseline and proposed with-Project conditions (ADF&G minimum instream flow schedule).

Month	Baseline	With Project	Difference
May	NA	11.0	-
June	3.8	8.7	4.9
July	3.3	10.3	7.0
August	2.9	9.2	6.3
September	2.3	7.1	4.8
October	2.3	4.0	1.7

NA = not available.
*Average is based on only 7 days of data.

Table 4-2 Monthly maximum of the 7-day average of the daily maximum for the Martin River at the constriction under baseline and proposed with-Project conditions (proposed East Fork Martin River minimum instream flow schedule).

Month	Baseline	With Project	Difference
May	NA	13.8	-
June	NA	10.5	-
July	5.6	11.2	5.6
August	4.7	10.5	5.8
September	3.4	8.9	5.5
October	4.0	5.7	1.7

NA = not available.

5.0 TEMPERATURE DISCUSSION

The seasonally variable EFMR MIF schedule proposed was predicted to increase and decrease water temperature as compared to the continuous MIF releases set at 100 cfs throughout May to October. The proposed seasonally variable EFMR MIF schedule had higher water temperatures during periods when the MIFs were less than 100 cfs and lower water temperatures during periods when the MIFs were greater than 100 cfs. However, neither the continuous flat rate 100 cfs MIF or the seasonally variable MIF releases from 50 to 150 cfs was found to exceed the temperature standard. Further, given the calculation assumptions, actual water temperature should be lower than predictions.

6.0 REFERENCES

Alaska Department of Environmental Conservation (ADEC). 2021. ADEC Triennial Review 2021-2023 Report of Findings to EPA. Available online at https://dec.alaska.gov/media/22333/triennial-review-2021-2023-responsiveness-summary-final.pdf.

ADEC. 2024. Water Quality Standards, amended as of April 2024. 18 AAC 70.

Amaranthus, M., H. Jubas, and D. Arthur. 1989. Stream shading, summer streamflow and maximum water temperature following intense wildfire in headwater streams. In: Berg, Neil H. tech. coord. Proceedings of the Symposium on Fire and Watershed Management: October 26-28, 1988, Sacramento, California. Gen. Tech. Rep. PSW-109. Berkeley, Calif.: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station: 75-78. Available online at: https://research.fs.usda.gov/treesearch/26927.

Fuller, M.R., P. Leinenbach, N.E. Detenbeck, R. Labiosa, and D.J. Isaak. 2022. Riparian vegetation shade restoration and loss effects on recent and future stream temperatures. Restoration Ecology 30(7):e13626. https://doi.org/10.1111/rec.13626.

Kalny, G., G. Laaha, A. Melcher, H. Trimmel, P. Weihs, and H.P. Rauch. 2017. The influence of riparian vegetation shading on water temperature during low flow conditions in a medium sized river. Knowledge and Management of Aquatic Ecosystems 418(2017)5:14. https://doi.org/10.1051/kmae/2016037.

Kleinschmidt Associates. 2026a. East Fork Martin River Minimum Instream Flow Schedule. Draft Technical Memorandum. Amendment to Bradley Lake Hydroelectric Project (FERC No. 8221), Bradley Lake Expansion Project. June 11, 2026.

Kleinschmidt Associates. 2026b. Hydraulic Modeling and Aquatic Habitat Connectivity Study Report Addendum. Amendment to Bradley Lake Hydroelectric Project. (FERC No. 8221), Bradley Lake Expansion Project. June 2026.

Kleinschmidt Associates. 2026c. Martin River Temperature Impact Assessment. Bradley Lake Hydroelectric Project, Bradley Lake Expansion, FERC No. 8221. Prepared for Alaska Energy Authority by Kleinschmidt Associates. January 2026.

Appendix A

Martin River Temperature Impact Assessment Comment Matrix

No.	Entity	Comment Location	Stakeholder Comment	AEA Response
1	USFWS	Enclosure: Page 1, last paragraph – Page 2, first paragraph	Although the Dixon Glacier is not expected to disappear in the near term, it is one of several Alaska glaciers projected to be gone by 2100 (Rounce et al. 2023, Rozell 2023). If this occurs, the EFMR will transition to nonglacial temperature and flow regimes. Summer temperature regimes have been assessed in other nonglacial southcentral Alaska streams, with consideration for mean watershed elevation and thermal sensitivity (Mauger et al. 2016). What would the worst-case scenario be if the Dixon Glacier were gone and the EFMR temperatures resembled those of other rain-melt- or snow-melt-dominated watersheds with similar mean elevations in southcentral Alaska?	The size and life span of the glacier is not specifically known but is expected to be longer than the license timeframe, in which case a theoretical no-glacier condition is not expected to occur under the current application. However, the no-glacier condition is only expected to result in different water temperature results in the rainfall-driven periods. The Dixon Glacier drainage area is approximately 19 square miles, with the water at the point of diversion a combination of snowmelt in the spring, glacial melt in the summer and early fall, and rainfall in the late summer and fall. Climate change may act to increase the rate of glacial melt and may also act to bring more precipitation to the region. If the glacier is gone, water temperature in the spring and summer will be driven by snowmelt, which will be the same temperature as the glacial melt, so the current analysis still applies. In the late summer and fall, the water source will be driven by rainfall. It is difficult to predict the temperature of the rainfall, which is largely driven by air temperature. Regardless, a sensitivity analysis using the current calculations shows that water temperature in the East Fork Martin River would need to exceed 8.5 degrees Celsius before water temperatures at the constriction exceed the 15 degrees Celsius ADEC standard for migration route.
2	USFWS	Enclosure: Page 1, last paragraph – Page 2, first paragraph	How might different EFMR minimum instream flow regimes impact Martin River stream temperatures under the worst-case scenario?	The objective of the 2025 analysis was to evaluate a worst-case scenario using the proposed 100 cfs EFMR minimum instream flow (MIF) regime. However, in general because the EFMR is a source of cold water to the mainstem Martin River, a lower MIF would increase water temperature while a higher MIF would decrease water temperature. AEA has since proposed a seasonally variable MIF regime for the EFMR, in consultation with regulatory agencies, that ranges from 50 cfs to 150 cfs depending on the needs of migrating Sockeye and Coho salmon. AEA has developed an addendum to the 2025 analysis that evaluated the Martin River water temperature with Project operations and the proposed seasonally variable EFMR MIF under worst-case conditions. See *Addendum to the Martin River Tempoerature Impact Assessment* (Kleinschmidt 2026).