BRADLEY LAKE HYDROELECTRIC PROJECT

FERC NO. 8221

BRADLEY LAKE EXPANSION NON-CAPACITY LICENSE AMENDMENT

EXHIBIT E
PRELIMINARY DRAFT ENVIRONMENTAL ASSESSMENT (PDEA)

https://www.ecfr.gov/current/title-18/part-4/subpart-F#p-4.51(b)

Prepared for:

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
2D	two-dimensional

A

AAC	Alaska Administrative Code
ABR	ABR, Inc.–Environmental Research & Services
ac	acre
ACCS	Alaska Center for Conservation Science (at the University of Alaska, Anchorage)
ACMP	Alaska Coastal Management Plan
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AEA	Alaska Energy Authority
AHPA	Alaska Historic Preservation Act
AHRS	Alaska Heritage Resources Survey
AOHA	Alaska Office of History and Archeology
APA	Alaska Power Authority
APE	Area of Potential Effect
AR	at-risk species
AS	Alaska Statute(s)
ATU	accumulated thermal unit
AVC	Alaska Vegetation Classification
AVCT	autonomous video counting tower
AWC	Anadromous Waters Catalogue

B

BCC	Bird(s) of Conservation Concern
BGEPA	Bald and Golden Eagle Protection Act
BLVD	Bradley Lake Vertical Datum
BMP	Best Management Practice
Bradley Lake Project	Bradley Lake Hydroelectric Project (FERC No. 8221)

C

CBSD	common birds in steep decline
CFR	Code of Federal Regulations

cfs	cubic feet per second
CHA	Critical Habitat Area
CI belugas	Cook Inlet stock of beluga whales
Commission	Federal Energy Regulatory Commission
CO	carbon monoxide
cm	centimeter
CRMP	Cultural Resources Management Plan
CS	Coho Salmon
CWA	Clean Water Act
CZMA	Coastal Zone Management Act

D

DAA	Draft Amendment Application
DAMF	Daily Average Minimum Flow
DO	dissolved oxygen
DPS	Distinct Population Segment
DSP	Draft Study Plan
DV	Dolly Varden

E

EAP	Emergency Action Plan
EFH	Essential Fish Habitat
EFMR	East Fork Martin River
El.	Elevation
ESA	Endangered Species Act
ESCMP	Erosion and Sediment Control Management Plan

F

FAA	Final Amendment Application
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
FR	Federal Register
ft	feet or foot
ft/s	feet per second

G

GMU	Game Management Unit

H

hp	horsepower

HPMP	Historic Properties Management Plan

I

ICD	Initial Consultation Document
IPaC	Information for Planning and Conservation
ITU	Integrated Terrain Unit

K

KNWR	Kenai National Wildlife Refuge
kV	kilovolt
kVA	kilovolt-ampere
kW	kilowatt

L

LUD	Land Use Designation

M

Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MBTA	Migratory Bird Treaty Act
mg/L	milligrams per liter
mi	mile
MIF	minimum instream flow
mllw	mean low low water
mm	millimeter
MMPA	Marine Mammal Protection Act
MSDS	Material Safety Data Sheet
msl	mean sea level
MVA	megavolt amperes
MW	megawatt
MWh	megawatt-hour

N

N/A	not applicable
NA	not available
NAVD 88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NERR	National Estuarine Research Reserve
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NTU	nephelometric turbidity unit
NWI	National Wetlands Inventory

O

OCH	off-channel habitat
OHW	ordinary high water

P

PCE	Power Cost Equalization
PDEA	Preliminary Draft Environmental Assessment
PM&E	protection, mitigation, and enhancement
PMF	Probable Maximum Flood
PRM	Project River Mile
Project	Bradley Lake Expansion Project

R

RM	River Mile
rpm	revolutions per minute

S

SGCN	species of greatest conservation concern
SHPO	State Historic Preservation Office
SPCC	Spill Prevention, Control, and Countermeasure
SS	Sockeye Salmon
SWAP	State Wildlife Action Plan

T

TDAT	Tribal Directory Assessment Tool
TDS	total dissolved solids

U

U.S.	United States
U.S. Census	United States Census Bureau
U.S.C.	United States Code

USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

W

WCA	Wetland Conservation Act
WFMR	West Fork Martin River
WFUBC	West Fork Upper Battle Creek
WL	watchlist (SGCN at the continental scale)
WLFZ	water level fluctuation zone
WNS	white nose syndrome
WOTUS	waters of the United States
WQC	Clean Water Act Section 401 Water Quality Certification
WSE	water surface elevation

Y

YOY	young-of-year

1.0 INTRODUCTION

The Alaska Energy Authority (AEA), licensee and owner of the 120-megawatt (MW) Bradley Lake Hydroelectric Project (Bradley Lake Project; Federal Energy Regulatory Commission [FERC or Commission] No. 8221), is pursuing a non-capacity FERC license amendment.

The Bradley Lake Project, located near the head of Kachemak Bay on the south shore about 25 miles east-northeast of Homer, Alaska (Figure 1.0-1), has supplied power to the Alaska's Railbelt[1] region serving nearly 75 percent of the state's population since it commenced commercial operations in 1991. The Bradley Lake Project currently generates about 10 percent of the total annual power used by Railbelt electric utilities at some of the lowest-cost power at $0.04 per kilowatt-hour. AEA proposes to build a new diversion dam (Dixon Diversion) to divert seasonal meltwater and surface runoff coming from the Dixon Glacier, located at the headwaters of the Martin River, into Bradley Lake. AEA also proposes to raise the normal maximum operating pool elevation of Bradley Lake by about 16 feet (Bradley Lake Pool Raise) through a combination of raising the concrete spillway crest elevation, adding spillway crest gates, and raising the dam embankment crest. Together, these two proposals comprise the Bradley Lake Expansion Project (or Project), which would increase the Bradley Lake Project's capacity from 119.7 MW to 122.8 MW and average annual power generation by approximately 38 percent, providing more power to the Railbelt to meet current and future demand.

[1] The Railbelt in Alaska refers to the region served by the Alaska Railroad and the Railbelt electrical grid, which extends from Homer to Fairbanks and easterly to the Delta Junction area.

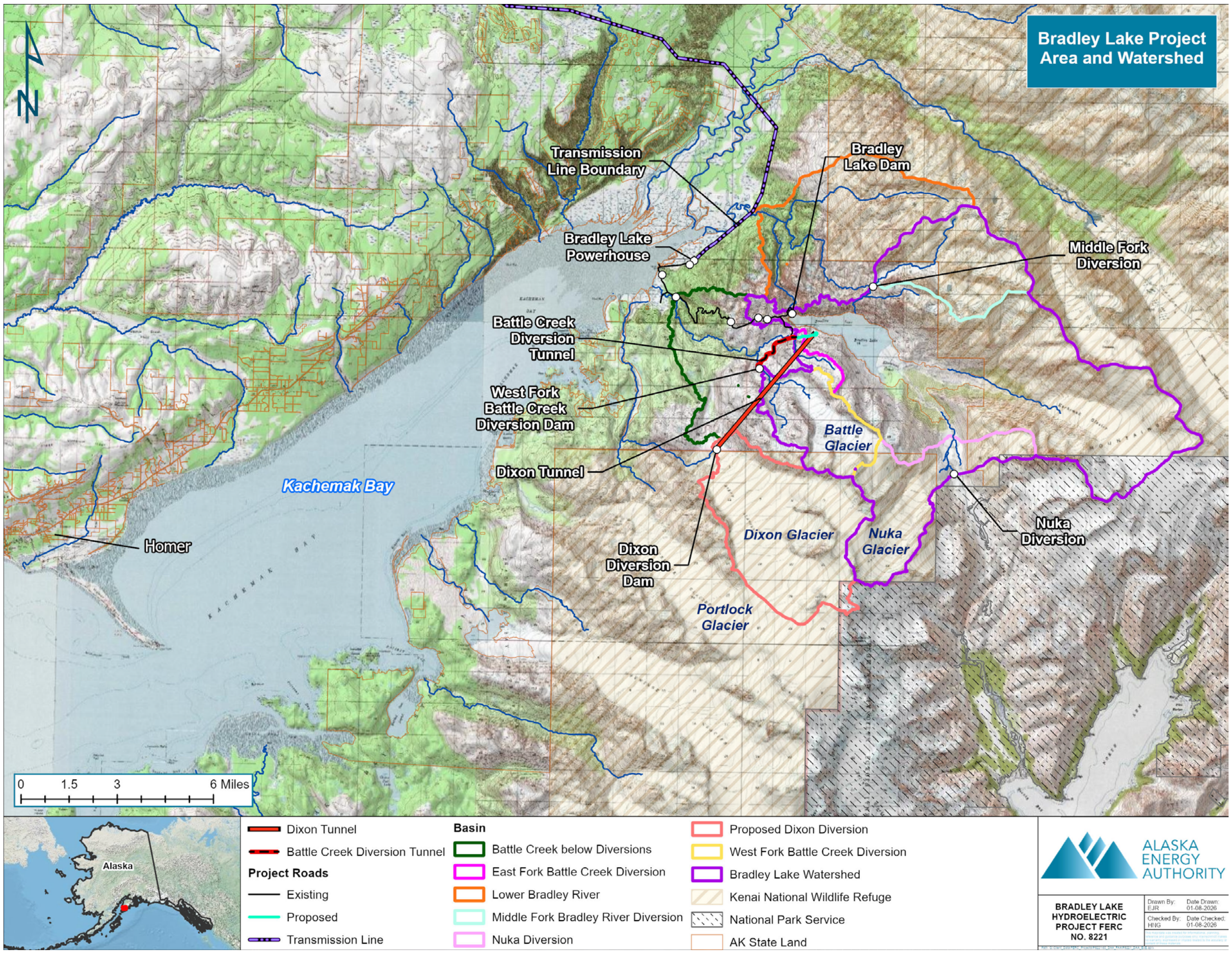

Figure 1.0-1 Location of Bradley Lake Hydroelectric Project and the proposed Bradley Lake Expansion Project near Kachemak Bay, Alaska.

1.1 Application

The Draft Amendment Application (DAA) is classified as a Non-Capacity Amendment pursuant to the Commission's regulations at 18 Code of Federal Regulations (CFR) 4.201. The total installed capacity of the Bradley Lake Project is expected to increase by 3.1 MW as a result of the 16-foot increase in the net head at normal maximum pool from 917 feet to 933 feet with the implementation of the Bradley Lake Pool Raise. However, the increase in hydraulic capacity would be minor (less than 15 percent).

Information presented in the DAA is commensurate with the scope of the Proposed Action. The DAA contains the following exhibits in accordance with 18 CFR 4.201(c): Exhibits A, B, C, D, E, and G. Exhibit F (Design Drawings and Supporting Report) will be filed separately pursuant to the requirements governing Critical Energy Infrastructure Information with the Final Amendment Application (FAA).

- Exhibit A – Project Description. This exhibit discusses proposed modifications to the Bradley Lake Project associated with construction of the Dixon Diversion and Bradley Lake Pool Raise.
- Exhibit B – Project Operation. This exhibit discusses the proposed operation of the Dixon Diversion and resulting Bradley Lake Project operations.
- Exhibit C – Project Schedule. In this exhibit, AEA provides a schedule for the construction of the Dixon Diversion and Bradley Lake Pool Raise as well as past construction history of the Bradley Lake Project.
- Exhibit D – Costs and Financing. This exhibit presents: the estimated cost of the new development work; a statement of the estimated annual value of Bradley Lake Project power; and a statement discussing how the improvements would be financed. Exhibit D will be finalized for filing with the FAA.
- Exhibit E – Environmental Report. In place of the Environmental Exhibit E as required by 18 CFR 4.51(f), AEA provides herein a Preliminary Draft Environmental Assessment (PDEA) that addresses the requirements of Exhibit E and the Commission's regulations implementing the requirements of environmental documents pursuant to National Environmental Policy Act (NEPA), 18 CFR 380 et seq.3. AEA consulted with resource agencies regarding substitution of the PDEA for the Exhibit E Environmental Report.
- Exhibit G – Project Boundary. An updated Exhibit G is provided to include the Dixon Diversion structures and expanded roadways within the Bradley Lake Project boundary.

1.2 Purpose and Need

1.2.1 Purpose of Action

The proposed Bradley Lake Expansion Project would allow the Bradley Lake Project to increase average annual generation from approximately 436,000 megawatt-hours (MWh)[2]

[2] Since the Battle Creek Diversion became operational in late 2020, the inflow to Bradley Lake from other sources has been lower than the normal long-term average. The actual average annual generation at the Bradley Lake Project from 2021 through 2025 was approximately 420,000 MWh while the expected long-term average based on the past 10 years of Bradley Lake generation plus the average output from the WFUBC diversion as if it had been online the entire 10-yr period is approximately 436,000 MWh.

to 601,000 MWh, which would help the Railbelt region offset its loads currently met by natural gas and ensure energy security.

1.2.2 Need

Power generated at the Bradley Lake Project is provided to the Alaska Railbelt region, which spans 700 miles from Fairbanks to Homer. The Railbelt electrical grid is defined as the service areas of five regulated public utilities: Homer Electric Association; City of Seward Electric System; Chugach Electric Association; Matanuska Electric Association; and Golden Valley Electric Association.

The Railbelt serves approximately 75 percent of Alaska's population and is currently facing an imminent energy crisis due to declining gas reserves in Cook Inlet (Department of Energy 2024). Currently, the Railbelt receives 70 percent of its electricity from natural gas, and shortfalls could begin as early as 2027. The southern portion of the Railbelt—Mat-Su Valley, Anchorage, and the Kenai Peninsula—are highly dependent on natural gas as a source of electricity and heat (FERC 2016). The northern portion of the Railbelt, including Fairbanks and other communities in the interior, relies on petroleum fuels in addition to natural gas, coal, and hydroelectric power imported from the south. The Bradley Lake Expansion Project[3] was part of the scenarios identified in the Railbelt Decarbonization Study conducted by the University of Alaska and Telos Energy (Cicilio et al. 2023).

1.3 References

Cicilio, P., J. VanderMeer, S. Colt, A. Francisco, E. S. Hernandez, C. Morelli, M. Wilber, C. Pike, D. Stenclik, M. Richwine, C. Cox, I. Anselmo and K. Ciemny. 2023. Alaska's Railbelt electric system: Decarbonization scenarios for 2050. Alaska Center for Energy and Power, University of Alaska, Fairbanks.

Department of Energy. 2024. Navigating energy solutions for Alaska's Railbelt. Available online at https://www.energy.gov/arctic/articles/navigating-energy-solutions-alaskas-railbelt.

Federal Energy Regulatory Commission. 2016. Final Environmental Assessment for a Non-capacity-related Amendment to License, Bradley Lake Hydroelectric Project – FERC Project No. 8221-094 Alaska. Prepared by Office of Energy Projects, Division of Hydropower Administration and Compliance. Washington D.C. July 2016.

[3] Referred to as the Dixion Diversion project in Cicilio et al. (2023).

2.0 PROPOSED ACTION AND ALTERNATIVES

2.1 No Action Alternative

Under the No Action Alternative, no construction would occur and the project would continue to operate under the terms and conditions of the existing license, and no new environmental protection, mitigation, or enhancement (PM&E) measures would be implemented.

As no development or changes to Bradley Lake Project generation would occur, there would be no impacts on geological and soil resources; water quality and quantity; fish and aquatic resources; wildlife and botanical resources; wetland resources; rare, threatened and endangered species; recreational, land use, and aesthetics; or cultural and Tribal resources. As such, there is no distinct analysis of the No Action Alternative under these sections below in Section 4.0 The No Action Alternative would potentially impact energy availability and costs as greater quantities of natural gas would continue to be used in the future.

2.1.1 Existing Facilities

The Bradley Lake Project works consists of: (a) a low diversion dike at the outlet of the Nuka Glacier pool into the upper Nuka River and a rock cut, diverting flow into the upper Bradley River; (b) a diversion on the Middle Fork Bradley River consisting of a small intake basin and two excavated reaches of open channel approximately 760 feet and 483 feet long, separated by a stilling basin conveys water from the Middle Fork of the Bradley River to Marmot Creek, a tributary to Bradley Lake; (c) a 22-foot-high diversion dam located on the West Fork Upper Battle Creek (WFUBC) diverting water through a 63-inch-diameter, 9,271-foot-long underground pipeline and 500-foot-long canal into a natural channel flowing into Bradley Lake; (d) a low diversion dam on the East Fork Upper Battle Creek (EFUBC) that diverts water to an unnamed tributary of Bradley Lake; (e) a 125-foot-high concrete-faced rockfill dam with crest El. 1,190 feet BLVD and a 4-foot-high parapet wall on the crest; (f) an ungated ogee spillway located on a saddle feature 150 feet east of the dam with crest El. 1,180 feet BLVD; (g) the existing Bradley Lake, which is raised 100 feet to a usable storage capacity of 280,000 acre-feet and a surface area of 3,802 acres at the maximum operating water surface elevation of El. 1,180 feet BLVD; (h) a 407.5-foot-long, 10.5-foot-nominal diameter horseshoe-shaped tunnel through the east abutment for emergency flow releases; (i) two 28-inch diameter pipes with motor-operated valves to release the required Bradley River minimum instream flows (MIFs) of 40-100 cubic feet per second (cfs); (j) a 360-foot-long intake channel; (k) a 42-foot-long intake structure with removable trashracks; (l) an 11-foot-diameter, concrete-lined power tunnel consisting of: (1) a 950-foot-long horizontal section with dual gates 800 feet downstream of the intake, operated through a vertical gate shaft; (2) an 810-foot-long inclined section; and (3) a 16,850-foot-long main section with steel lining on the downstream 2,400 feet; (m) a steel penstock consisting of a 9-foot-diameter roll-out section and a manifold section with three 5-foot-diameter outlets, one capped and two with 30- to 40-foot-long branches; (n) a 138-foot-long, 66-foot-wide, 112-foot-high reinforced concrete powerhouse containing two vertical shaft Pelton turbines each coupled with a 63-MVA rated generator and 0.95 power factor; (o) a tailrace channel with a bottom width of 67 feet discharging into Kachemak Bay; (p) the 13.8-kilovolt (kV) generator leads; (q) a 13.8/115-kV transformer; (r) a 20-mile-long, 115-kV, double circuit transmission line from the substation adjacent to Bradley Junction; (s) access facilities including a barge basin and ramp and project roads connecting powerhouse, lower and upper construction camps, the dam, and WFUBC Diversion; (t) recreation facilities consisting of camp sites near the barge basin dock and near Bradley Lake; and (u) appurtenant facilities.

2.1.2 Existing Operations

The primary function of the Bradley Lake reservoir is to regulate streamflow and provide carryover storage for producing energy, in a peaking mode, throughout the year. The normal operating range of the reservoir is between elevations of 1,080 feet and 1,180 feet. The project is operated and monitored by remote control.

Bradley Lake is fed by both natural and diverted water sources. The two major natural inflow tributaries to the lake are Kachemak Creek, which begins at Kachemak Glacier, and the Upper Bradley River. The current project includes diversion structures to divert water from the Nuka Glacier, the Middle Fork Bradley River, and Upper Battle Creek into Bradley Lake. The Upper Bradley River begins at the Nuka Glacier and, historically, had a unique attribute in that natural flow from the Nuka Glacier periodically shifted between flowing north into the Upper Bradley River and draining south into the Nuka River (FERC 1985). Since the Nuka Diversion was constructed, the first 5 cfs of flow from Nuka Glacier that reached the glacial pond (Nuka Pool) on the divide flowed to the Nuka River, and the remainder flowed into the Upper Bradley River. However, sometime between 1996 and 2005, the flow pathway from the Nuka Glacier shifted and the majority of snow and glacier melt now bypasses the Nuka Diversion and flows directly into the Upper Bradley River to Bradley Lake.

The Middle Fork Diversion is located approximately one mile north of Bradley Lake in an adjacent drainage at elevation 2,160 feet on the Middle Fork Bradley River. It conveys water from the Middle Fork Bradley River to Marmot Creek, a tributary to Bradley Lake, and operates in all seasons.

There are two diversions in Upper Battle Creek. The EFUBC Diversion consists of a low diversion dam that diverts water to an unnamed tributary to Bradley Lake. The WFUBC Diversion diverts up to 600 cfs to Bradley Lake May through October while releasing the required minimum flow from the WFUBC diversion dam according to the following schedule[4]: 15 cfs, plus any additional flow exceeding the pipeline capacity of 600 cfs July 1 through September 15; 25 cfs, plus any flow exceeding the pipeline capacity, or all available flow if diversion is not occurring October 1 through November 30 or until the diversion is shut down for year; and 5 cfs, plus any additional flow exceeding the pipeline capacity, or all available flow if diversion is not occurring, at all other times.

Water is released from Bradley Lake through a 3.5-mile-long power tunnel to the project powerhouse, which is located near the shore of upper Kachemak Bay. Water from the powerhouse is released directly into Kachemak Bay via the tailrace channel. Project operation also includes minimum flow releases into the Lower Bradley River from Bradley Lake Dam. On September 8, 2020, the Commission issued an Order Amending Minimum Flows[5], which established the minimum flows presented in Table 2.1-1, as measured at the Bradley River near Tidewater gage (United States Geological Survey [USGS] Gage No. 15239070), located at River Mile (RM) 1.65 on the Lower Bradley River.

[4] Order Approving Diversion Release Plan, Modifying and Approving Stream Gaging Plan, and Amending Flow Release Schedule for West Fork Upper Battle Creek Pursuant to Amendment Order (172 FERC 62,025). Issued July 16, 2020.
[5] Order Amending Minimum Flows (172 FERC 62,132). Issued September 8, 2020.

Table 2.1-1 Bradley Lake Dam minimum instream flow releases to Lower Bradley River as measured at the Bradley River near Tidewater gage (USGS Gage No. 15239070).

Date	Daily Average Minimum Flow (DAMF)	Acceptable Short-term Deviations (rounded to whole numbers)
May 12 – Sept 14	100 cfs calendar day average	DAMF less 7.5% (93 cfs)
Sept 15 – 23	Decrease flow 5 cfs each calendar day to 50 cfs	DAMF less 7.5%
Sept 24 – Oct 31	50 cfs calendar day average	DAMF less 7.5% (46 cfs)
Nov 1	Decrease flows 5 cfs each calendar day to 40 cfs	DAMF less 7.5%
Nov 2 – Apr 30	40 cfs calendar day average	DAMF less 7.5% (37 cfs)
May 1 – 11	Increase flows 5 cfs each calendar day to 100 cfs	DAMF less 7.5%

2.1.3 Existing Environmental Measures

Pursuant to Article 60, as part of the WFUBC Diversion amendment, AEA has implemented the Lower Battle Creek Fish and Habitat Management and Implementation Plan, filed on March 6, 2017, and approved by FERC[6], pre-diversion and annually post-diversion for a period of 6 years. AEA filed the 5-year post diversion reports with FERC on January 30, 2026, and requested an extension to continue consultation with the agencies to develop a monitoring plan for 2026. AEA also continues to follow its Cultural Resources Management Plan (CRMP), filed on November 22, 1985.

2.2 Proposed Action

Under the Proposed Action, a new diversion dam would be constructed on the East Fork Martin River (EFMR) near the toe of Dixon Glacier to divert glacial meltwater and surface runoff to Bradley Lake via an underground conveyance tunnel, and the existing Bradley Lake Dam and spillway would be modified to raise the maximum pool elevation by 16 feet to increase the Bradley Lake Project's storage capacity and annual energy generation.

[6] Order Modifying and Approving Fish and Habitat Plan Required by Article 60 (159 FERC 62,257). Issued June 8, 2017.

While the Proposed Action does not include modification of the generation equipment in the powerhouse, the increase in net head from El. 917 feet to El. 933 feet at normal maximum pool would increase the capacity of the Bradley Lake Project from 119.7 MW to 122.8 MW. The additional water diverted into Bradley Lake would increase the average annual generation of the Bradley Lake Project by approximately 165,000 MWh.

2.2.1 Proposed Project Facilities and Construction Activities

The proposed development consists of two major components, as described below, that are separate and independent of each other and would be constructed in a phased sequence. Construction of the proposed development would require an expansion of the Bradley Lake Project boundary by approximately 272.6 acres, utilizing land owned by the State of Alaska.

Construction is anticipated to occur over a period of approximately 3 to 4 years. AEA may begin site preparations (e.g., clearing vegetation or blasting some areas) the year before construction begins to avoid interference with nesting migratory birds or raptors. Mobilization and worker camp development is anticipated to begin in spring of the first year. Equipment and supplies would be brought in from Homer via barge. Due to the shallow nature of upper Kachemak Bay, barges would only dock during the extreme high tides, which occur about 3 days per month. It is anticipated that up to ten barges may be needed during mobilization and again during demobilization each year. Unless traveling by barge, contractors would be transported to and from the Project site via aircraft using the existing airstrip. Contractors would be housed in a construction camp or at the existing Bradley Lake bunkhouse. Up to 100–110 contractors may be on site at one time.

The potential impact areas for the Proposed Action are displayed in Figure 2.2-1 and Table 2.2-1. Except for the Dixon Diversion, much of the proposed construction is located on or adjacent to lands already developed as part of the existing Bradley Lake Project. A worker camp (21.3 acres) would be established in the same area as camps that were developed for construction of the original Bradley Lake Project and used again for the WFUBC Diversion. Three existing developed areas adjacent to the existing Bradley Dam and WFUBC roads would be used as temporary staging areas (10.1 acres). The tunnel muck spoil areas and borrow sites are discussed in further detail under the following Dixon Diversion and Bradley Lake Pool Raise sections, respectively (Sections 2.2.1.1 and 2.2.1.2), as well as in several resource sections.

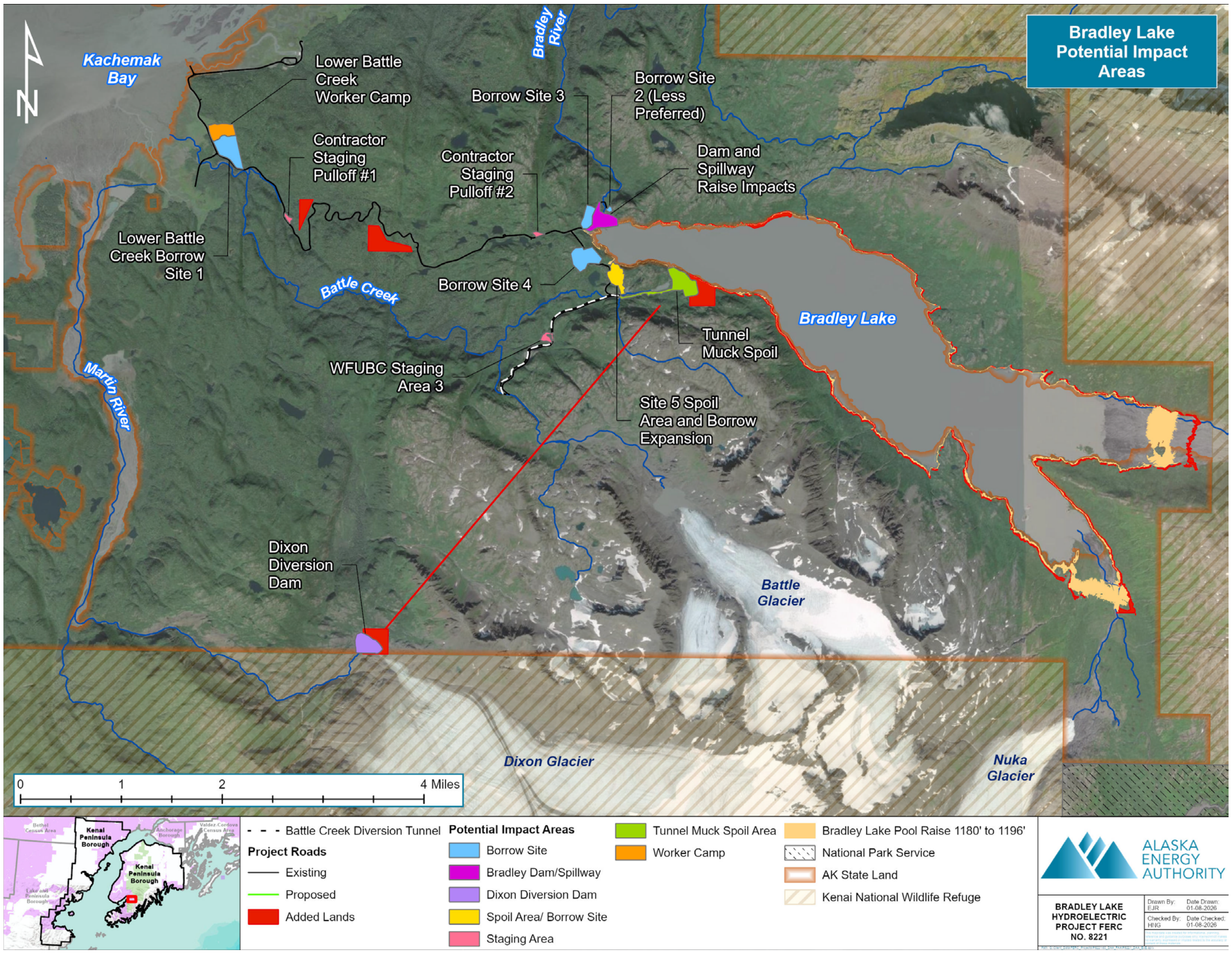

Figure 2.2-1 Bradley Lake Expansion Project potential impact areas.

Table 2.2-1 Areas of disturbance associated with Project construction.

Construction Area	Already Disturbed	Disturbance Area (acres)
LBC Worker Camp	Yes	21.3
Staging Area 1 (Bradley Rd East)	Yes	2.3
Staging Area 2 (Bradley Rd West)	Yes	2.5
Staging Area 3 (WFUBC Rd)	Yes	5.3
Dixon Diversion Dam	No	25.9
Tunnel Muck Spoil Disposal	No	40.6
Bradley Dam and Spillway Raise	Yes	25.9
Borrow Area (near LBC Camp)	Yes	35.4
Borrow Sites 1 and 5 (Dam West)	No	13.5
Borrow Site 3 (WFUBC Rd)	No	31.1

Construction Area	Already Disturbed	Disturbance Area (acres)
Borrow Site 4 Expansion and Spoil Area (WFUBC Rd)	Partially	21.1
Borrow Site 6 (Dam East) (Less Preferred)	No	1.5

LBC = Lower Battle Creek; Rd = road

2.2.1.1 Dixon Diversion

The proposed Dixon Diversion development consists of the diversion dam, diversion tunnel, a tunnel discharge channel to Bradley Lake, and a new access road to the proposed tunnel exit.

2.2.1.1.1 Diversion Dam and Tunnel Inlet Portal Features

The Dixon Diversion dam (59.6932° North/150.9180° West) would be constructed on state-owned land near the toe of Dixon Glacier, approximately 5.9 miles south of the existing Bradley Lake Project powerhouse. AEA anticipates that the diversion would be a concrete weir wall approximately 25 feet high by 135 feet long, with crest El. 1,276 feet (Figure 2.2-2). The approximate inlet elevation for the tunnel would be at El. 1,262 feet, subject to additional topographic surveys and design layout. The diversion pool is currently estimated to be approximately 3.5 surface acres with a storage capacity of approximately 37 acre-feet at El. 1,276 feet. Control to Bradley Lake would consist of maintaining a bypass MIF of 100 cfs to the EFMR canyon, with the remaining flow, up to the 1,650 cfs tunnel capacity, diverted to Bradley Lake. Excess flow greater than the capacity of the tunnel would spill over the diversion dam to the EFMR canyon.

The Dixon Diversion would consist of a 4-foot-wide by 4-foot-high motor-operated slide gate to regulate MIF, a 6-foot-wide by 6-foot-high motor-operated slide gate to provide a low-level outlet to maintain flow through the diversion dam during maintenance operations, two 30-foot-wide by 20-foot-tall “overshot” crest gates (tentatively Obermeyer), and a 14-foot-wide by 14-foot-high motor-operated slide gate at the inlet portal to the diversion tunnel.

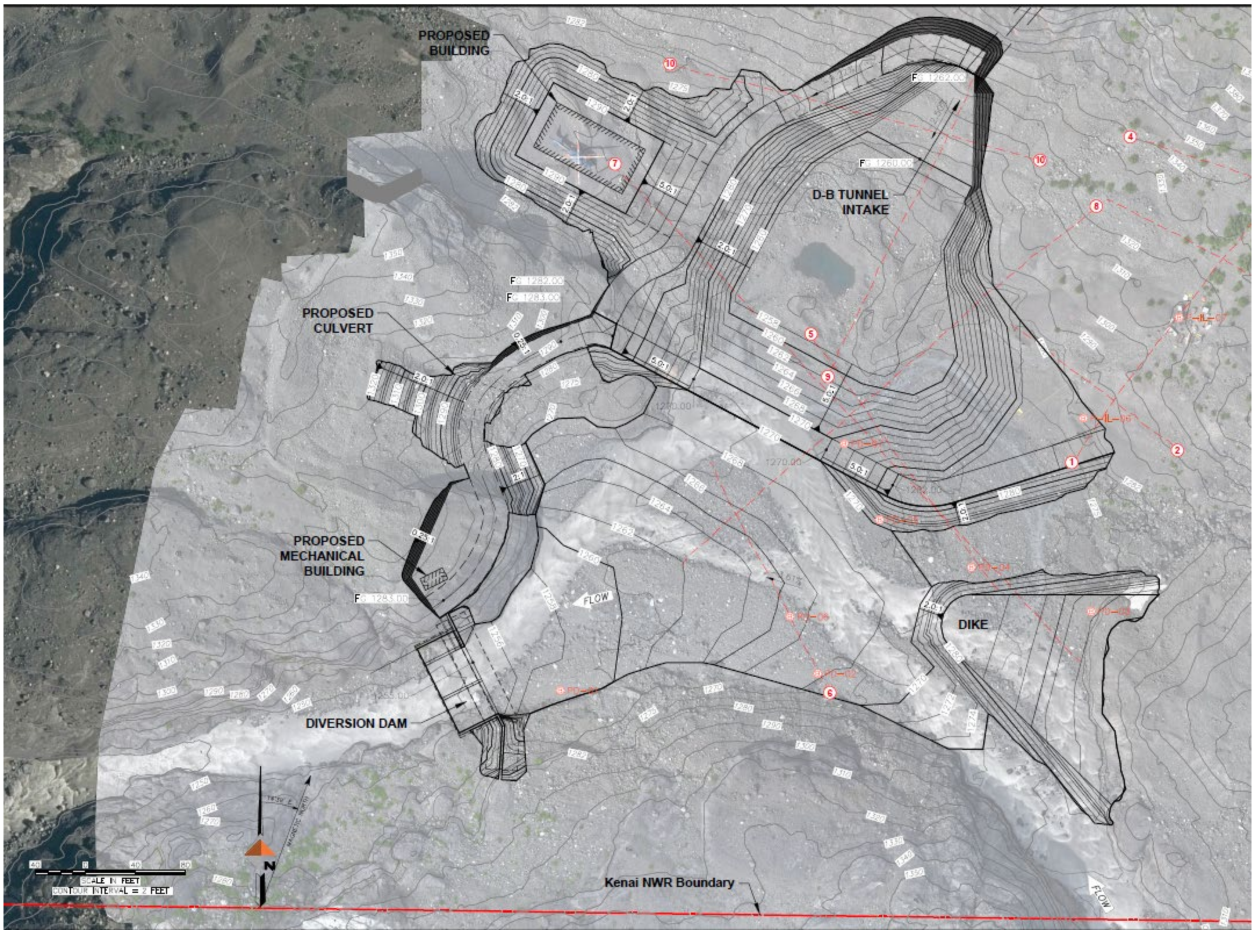

Figure 2.2-2 Schematic of proposed Dixon Diversion.

2.2.1.1.2 Diversion Tunnel

A tunnel would be bored to convey water northeast from the diversion to Bradley Lake. As proposed, diverted water would flow from the diversion pool into a 14-foot-diameter, 4.6-mile-long underground concrete-lined tunnel. Water would exit from this tunnel into a new tunnel discharge channel and flow into Bradley Lake. The invert of the tunnel entrance would be at approximately El. 1,262.5 feet, and the invert at the outlet would be at approximately El. 1,185 feet.

2.2.1.1.3 Diversion Tunnel Exit Portal Features

A 1,100-foot-long channel with a 16-foot bottom width would be constructed to convey the diverted flows into Bradley Lake.

2.2.1.1.4 Exit Portal Access Road

A new 16-foot-wide gravel spur road off the existing Upper Battle Creek Access Road would be constructed, extending approximately 1 mile to the downstream exit of the tunnel from the Dixon Diversion tunnel exit portal. No road would be constructed to the Dixon Diversion dam. Access to the dam would be via helicopter or through the tunnel while the dam is not in operation.

2.2.1.1.5 Tunnel Muck Spoil Sites

The proposal is to dispose of excavated material produced during Dixon Diversion tunnel construction at the north end of the tunnel, on the southwest corner of Bradley Lake, occupying approximately 41 acres (Figure 2.2-1). The muck would consist of rock and soil removed while boring or blasting the tunnel. Further discussion of potential effects of the tunnel muck spoil area is provided in Sections 4.2, 4.5, and 4.6. AEA is proposing to develop and implement an Erosion and Sediment Control Management Plan (ESCMP) and containment measures to address potential effects from this site.

2.2.1.2 Bradley Pool Raise

Under the Bradley Lake Pool Raise, the lake level of Bradley Lake would be increased by 16 feet to El. 1,196 feet. At full pool, this would result in an increase in the total surface area to 4,033 surface acres and an increase in storage capacity to approximately 342,000 acre-feet. The pool raise would be achieved through a combination of raising the concrete spillway crest elevation, adding spillway crest gates, and raising the embankment dam crest. With the pool raise, the Bradley Lake Project's operating net head would increase from El. 917 feet to El. 933 feet at full pool.

2.2.1.2.1 Modifications to Bradley Lake Dam

Modifications to Bradley Lake Dam would involve demolishing the existing concrete crest and parapet wall, adding rockfill to the downstream slope to raise the embankment, extending the concrete face, and constructing a new parapet at the higher crest elevation (Figure 2.2-3). The raised crest would provide about 4 feet of freeboard over the probable maximum flood (PMF) level.

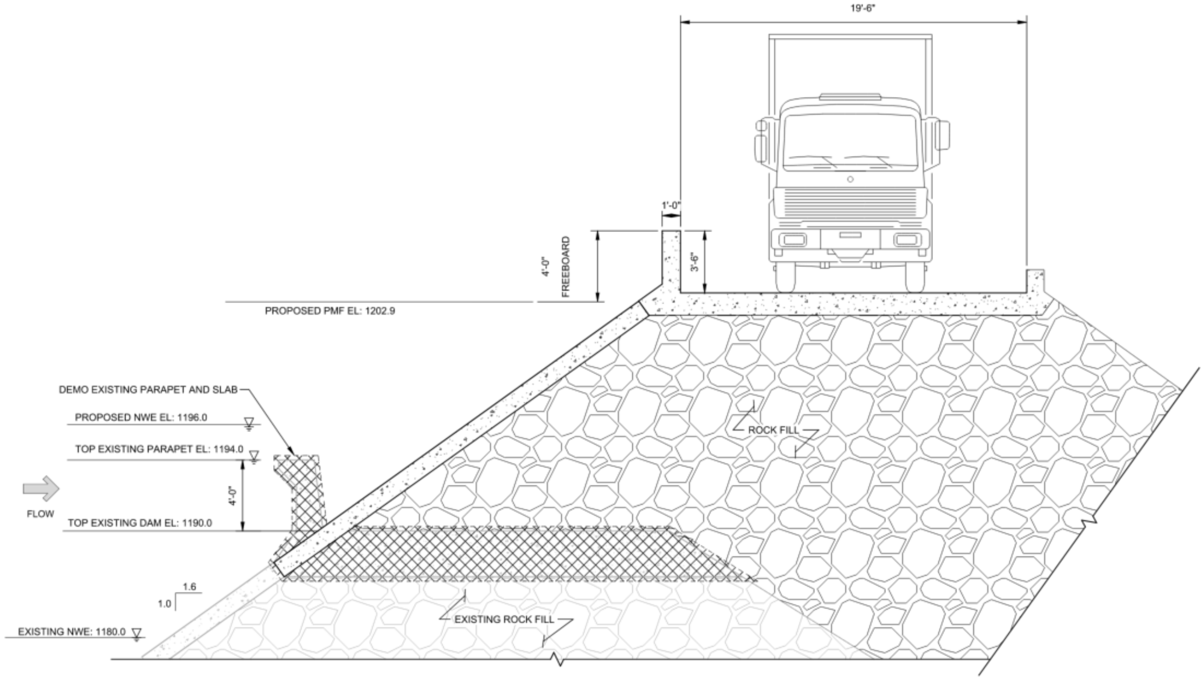

Figure 2.2-3 Schematic of proposed dam embankment for Bradley Lake Pool Raise.

Earthfill and structural additions on both abutments would maintain a continuous dam crest and preserve vehicle access to key facilities, including the power tunnel, diversion works, spillway, and outlet works. A new access road, ramps, retaining walls, and a staircase would be built to ensure operational access and avoid covering existing structures. The grout curtain would also be extended to maintain seepage control.

The embankment raise is expected to require roughly 100,000 cubic yards of rockfill, produced from nearby drill-and-blast quarry areas (i.e., borrow sites). Filter materials similar to the existing transition zones would be placed behind the concrete face.

2.2.1.2.2 Modifications to Bradley Lake Spillway

The Bradley Lake spillway would be raised by adding 8.5 feet of fixed concrete crest to El. 1,188.5 feet, topped with a 7.5-foot-high crest gate (tentatively Obermeyer) reaching El. 1,196.0 feet. To meet stability requirements, the spillway structure would be enlarged upstream, and the non-overflow abutments would be raised in the same manner, keeping the spillway aligned with the raised embankment (Figure 2.2-4).

The upgraded spillway would retain its current geometry, and at the spillway is expected to pass the preliminary PMF flow of 42,500 cfs at the elevated lake level. The expanded spillway would include reinforcement anchored into bedrock, a new grout curtain beneath the upstream heel, and redrilling of existing foundation drains to maintain seepage control.

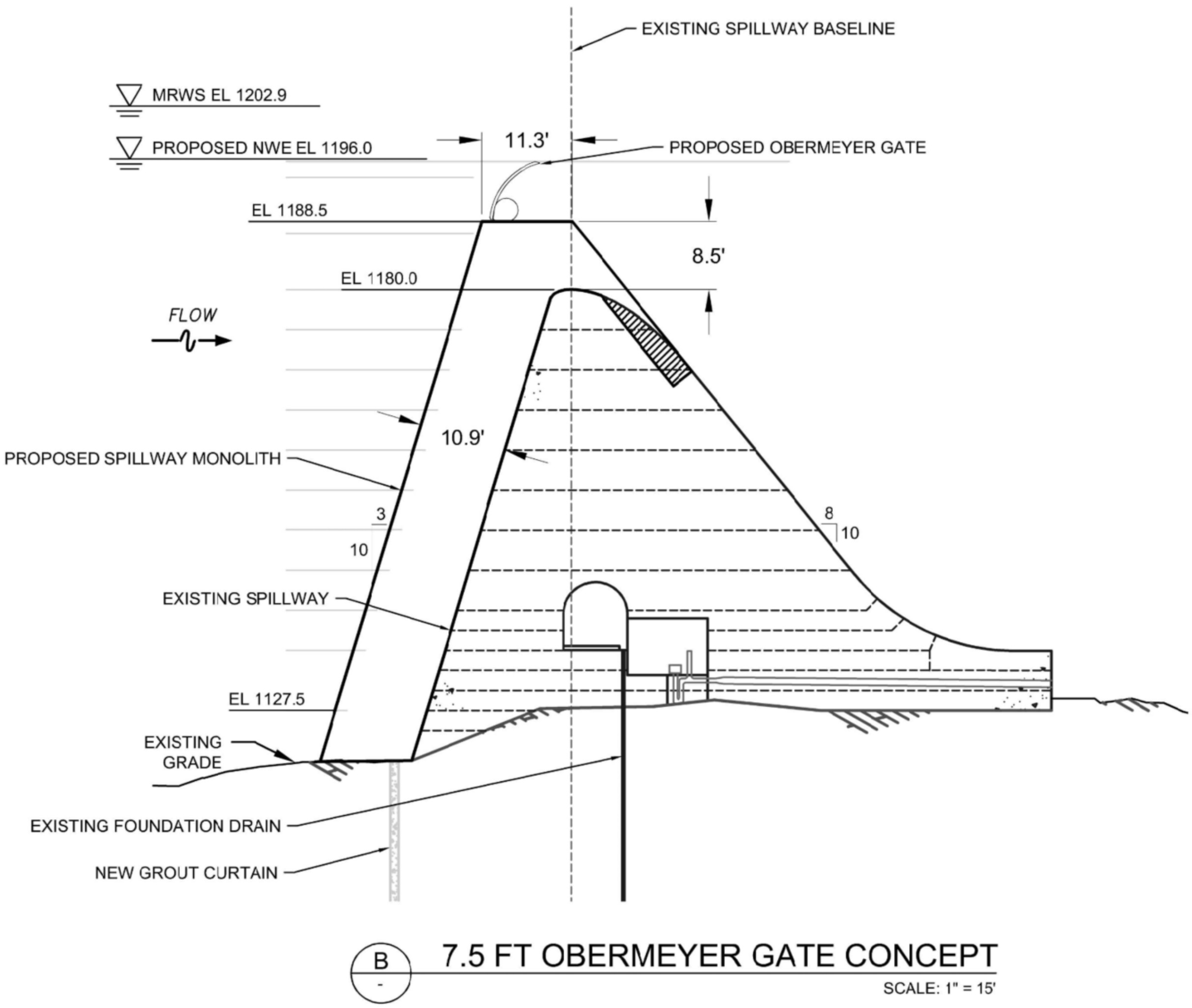

Figure 2.2-4 Schematic of proposed spillway for Bradley Lake Pool Raise with Obermeyer gates.

2.2.1.2.3 Borrow Sites

Construction activity associated with the Bradley Lake Pool Raise would include establishment or expansion of up to five borrow sites, all of which are located along the existing roads or near Bradley Lake Dam, for a total of 103 acres (Figure 2.2-1 and Table 2.1-1). Borrow sites are designated areas where construction materials are excavated for use elsewhere, in this case, the Bradley Lake Dam and spillway. Spoils from construction excavation and potentially tunnel boring may be deposited at one of these sites. The sites and their potential effects on environmental resources are discussed further in Sections

4.2, 4.5, and 4.6. Any impacts associated with the borrow sites would be addressed in the ESCMP to be developed by AEA.

2.2.1.3 Project Boundary Expansion

The Bradley Lake Dam modifications, new access road, and areas temporarily impacted by construction would be located on lands that are currently included within the licensed Bradley Lake Project boundary. As part of the proposed Project, approximately 272.6 acres of lands owned by the State of Alaska would be added to the existing Bradley Lake Project boundary for the Dixon Diversion and tunnel intake; a 25-foot-wide tunnel alignment extending from the tunnel intake to the outlet portal; additional buffer area adjacent to the proposed access road and the existing road to facilitate future maintenance and operations; and land surrounding Bradley Lake up to El. 1,210 feet (Figure 2.2-5).

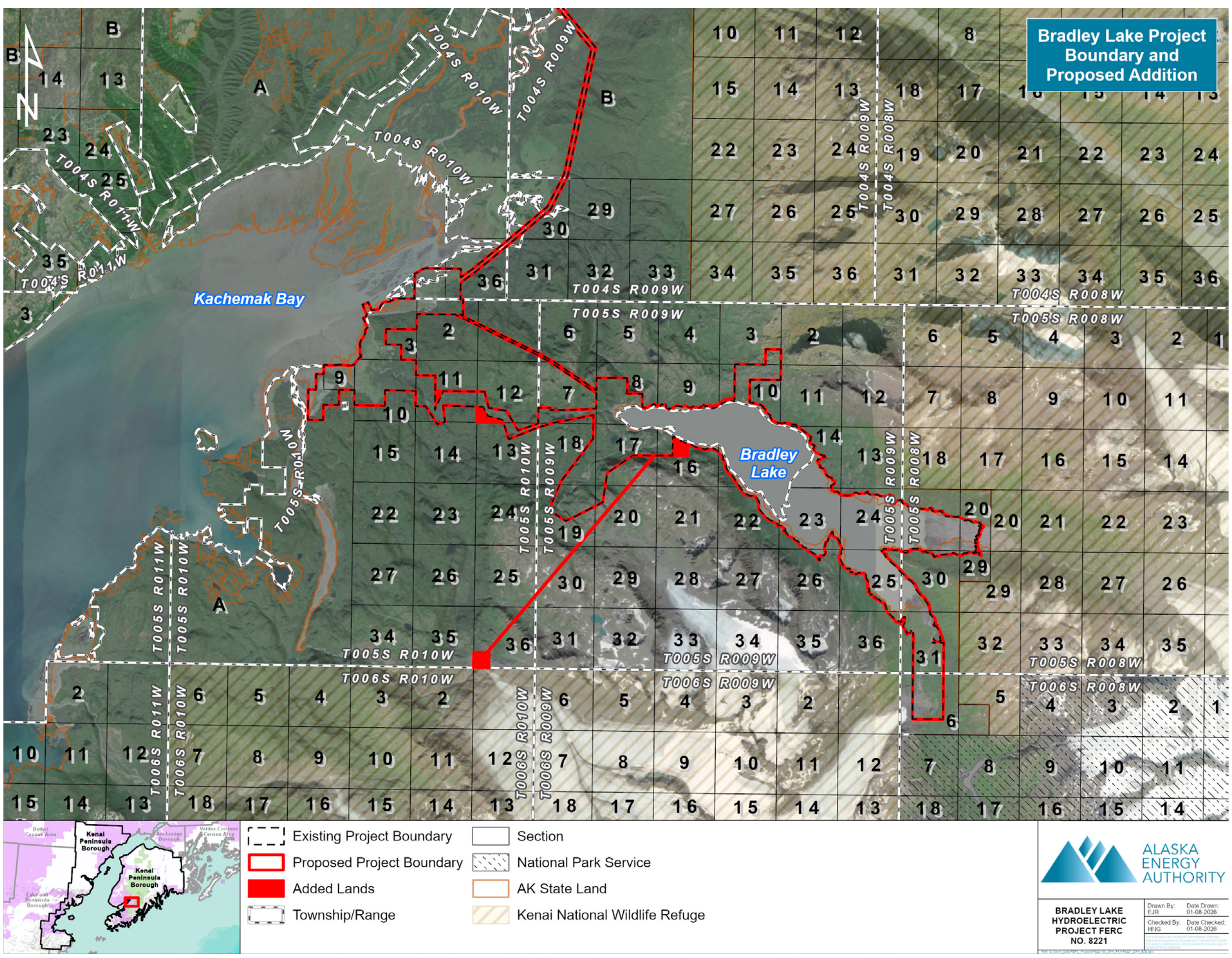

Figure 2.2-5 Map of proposed new Bradley Lake Project boundary.

2.2.2 Proposed Operations

Bradley Lake would continue to be operated in the same manner. There would be no change to the MIF releases from Bradley Dam to the Lower Bradley River. The pool raise would increase the usable storage capacity from 280,000 acre-feet to 342,000 acre-feet, and the Dixon Diversion would increase the volume of water diverted to Bradley Lake. Combined, the Bradley Lake Expansion Project would increase the amount of generation, and the duration generation could occur at maximum capacity.

The Dixon Diversion would be operated from spring thaw until winter freeze (May 1 through November 30), as flow conditions allow. Project operations would include a MIF of 100 cfs released to the EFMR from the Dixon Diversion. The Project would divert a maximum of 1,650 cfs from the EFMR to Bradley Lake. Excess flow greater than the capacity of the tunnel would spill over the diversion dam to the EFMR canyon. It is anticipated that the forebay pool would need to be flushed of sediment on at least an annual basis, possibly multiple times per year. Proposed sediment flush operations are to quickly drop one or more of the crest gates for 1 hour, then raise the gate(s) and visually assess the success of the flush. Based on two-dimensional (2D) hydraulic modeling, a flow of 500 cfs would flush most cobble and finer material through the forebay pool, and a flow of 1,000 cfs would flush all cobble but not boulder-sized materials. It is anticipated that higher flows would be released once a year, or as needed, to manage bedload accumulation upstream of the diversion dam. In addition, AEA proposes to release at least 1,000 cfs to the EFMR a minimum of 3 years out of each moving 10-year average for a duration of 12 hours to transport bedload through the EFMR canyon and the Martin River. This level of flushing may occur naturally, but if not, flow releases from the Dixon Diversion would be used to provide the recommended sediment movement. See Section 4.2 for further discussion.

2.2.3 Applicant-proposed Environmental Measures

As part of the Proposed Action, AEA proposes several PM&E measures in addition to implementing standard Best Management Practices (BMPs) to minimize the potential impacts the Proposed Action could have on the existing environment. All employees and contractors working on the Proposed Action would follow these BMPs, permit requirements, and FERC-adopted measures and plans.

2.2.3.1 Construction-related Environmental Measures

AEA proposes to provide an environmental compliance monitor to ensure license conditions are followed during construction and to ensure that no instream work is conducted without supervision.

- Limited contractor use of Project facilities
  - Worker camp, crew quarters, roads, and staging areas would be used only for activities directly associated with the operation, maintenance, and development of Project facilities.
- Equipment and vehicle operation restrictions on Project lands
  - There would be no motorized wheeled access to any roads on Bradley Lake Project lands other than official use vehicles.
  - Equipment and vehicles would be cleaned prior to their delivery on Bradley Lake Project lands to reduce the risk of spreading non-native invasive species.
  - There would be no operation of equipment or vehicles below the ordinary high water (OHW) mark of Kachemak Bay.
  - There would be no equipment refueling within 100 feet of a body of water's OHW line.
- Waste disposal
  - Outside garbage storage is prohibited. All garbage would be brought back to the road system for proper disposal.
  - Chemical and petroleum products would be removed and properly disposed of off-site.
- Protection of all survey monuments, witness corner, reference monument, and bearing trees from any damage during construction activities
- Protection of aquatic resources, water quality, and wetlands
  - Develop and implement an ESCMP that includes the following:
    - identification of construction limits, staging, and erosion and sediment control impact areas;
    - identification of and commitment to implement erosion and sediment control permit requirements;
    - erosion and sediment control measures following BMPs for soil stabilization, slope protection, and maintenance;

        - stormwater pollution prevention strategies to reduce contaminants and sediments larger than naturally occurring suspended glacial silt from entering waterbodies and associated aquatic vegetation types;
        - sediment and turbidity monitoring standards and techniques;
        - daily and weekly reporting procedures;
        - schedule for erosion and sediment control implementation measures and removal of the erosion and sediment control facilities;
        - identification of the duties and authorities of the environmental compliance monitor as they relate to the ESCMP;
        - identification of notifications and timing of notification of non-compliance events and follow-up actions to be taken due to a non-compliance event.
    - Develop and implement a Fuel and Hazardous Substances Management Plan.
        - The contractor would be required to provide AEA with a job-specific Spill Prevention, Control, and Countermeasure (SPCC) plan that complies with 40 CFR Section 112.
        - All diesel fuel, refined oil, gasoline, hydraulic fluids, anti-freeze, lubricants, solvents, rust inhibitors, and used oils must be stored in containers suitable for the product and placed within secondary containment as required by 40 CFR Section 112.
        - The contractor would be required to report any spills to AEA immediately and to report spills to the Alaska Department of Environmental Conservation (ADEC), and any spills in saltwater to the United States Coast Guard.
        - The contractor must maintain an accounting and product information system for all hazardous materials and fuels on the Bradley Lake Project site. All hazardous materials coming onto site must be accompanied by a Material Safety Data Sheet (MSDS).
- Obtain appropriate permits where in-water work is required
    - The work may only occur within the window as specified by the Alaska Department of Fish and Game (ADF&G).
    - No in-water work shall be conducted prior to notifying AEA, and any instream work in the absence of the environmental compliance monitor shall be prohibited.

    - ADF&G would be notified 10 days prior to any diversion or reduction of flows in the Martin River; minimum instream flows would be maintained in the Martin River during construction.

- Protection of botanical resources
    - Segregate and stockpile surface organic material from the borrow sites for use in reclamation efforts after construction is completed, including using the reserved organic material to help revegetate the tunnel muck spoils at Bradley Lake.
- Minimize harm to wildlife and wildlife habitat.
    - Employees and contractors would be prohibited from hunting, trapping, and fishing in the Project area during construction.
    - A Bear Safety Plan would be developed and implemented that includes: (1) identifying practices that would minimize possible bear-human conflicts while working in areas frequented by bears, including installation of bear-proof garbage receptacles and other measures during construction to prevent bears from obtaining food or garbage; (2) identifying practices employed during field activities associated with various monitoring plans to minimize conflicts and provide guidance to contractors; (3) establishing procedures for handling problematic bears; and (4) reporting requirements for any bear-human conflicts.
    - Develop a Goat Monitoring Plan in consultation with ADF&G and fund the agency to implement the plan
    - Use of helicopters or airplanes would be minimized near mountain sides adjacent to Bradley Lake and EFMR canyon. If mountain goats (*Oreamnos americanus*) are observed, a 1,500-foot vertical or horizontal clearance would be maintained to the maximum extent practicable.
    - Agencies would be consulted regarding the appropriate timing and location of site clearing to minimize any effects on migratory birds potentially nesting in the area. Contractors would follow the United States Fish and Wildlife Service (USFWS) guidelines (USFWS 2009), which recommend all vegetation clearing be avoided between May 1 and July 15 to protect nesting birds. If an active nest is encountered at any time, it would be left in place until the young hatch and depart.
    - A qualified biologist would conduct Bald Eagle (Haliaeetus leucocephalus) and Golden Eagle (Aquila chrysaetos) nest surveys pre-construction and consult with USFWS on appropriate buffer distances from active nests and

avoidance windows for each species during blasting and other construction activities to prevent disturbance or take.

- Protection of archaeological resources
    - Implement AEA's CRMP. Require the contractor to stop work and notify AEA immediately if any archaeologically significant materials or sites are discovered during the work and implement the procedures outlined in the CRMP. Consult with a qualified archaeologist and the Alaska State Historic Preservation Office (SHPO) if any previously unidentified unrecorded archaeological or historical sites are discovered during construction.

2.2.3.2 Operations-related Environmental Measures and Monitoring Plans

To protect aquatic resources and minimize potential effects of the Project, AEA proposes MIF releases and channel maintenance releases, as described above, and several monitoring plans to evaluate the effects of the proposed flow regime on fish passage and habitat connectivity, water quality, and bedload transport. The monitoring plans summarized below would be developed through consultation with the regulatory agencies.

2.2.3.2.1 Dixon Diversion Flow Release Management Plan

To protect salmon habitat connectivity within the Martin River basin and maintain bedload transport through the system, AEA proposes to develop and implement a Dixon Diversion Flow Release Management Plan that would do the following:

- Provide MIF of 100 cfs to the EFMR from the Dixon Diversion during all months of operation (May to November) or bypass all available flow to the EFMR if flows are less than 100 cfs.
- Provide channel maintenance flows to the Martin River by releasing flows of 1,000 cfs a minimum of 3 years out of each moving 10-year average of Project operation.

2.2.3.2.2 EFMR Flow Measurement Plan

AEA proposes to develop and implement an EFMR Flow Measurement Plan that includes provisions for measuring and monitoring flows diverted to Bradley Lake, MIFs bypassed to the EFMR with the Dixon Diversion dam as the point of compliance, and flows released to the EFMR in excess of MIFs; and funding USGS to maintain a stream gage in the EFMR. The plan would include compliance requirements; identification of an instream flow compliance method; monitoring measures and procedures; reporting requirements that identify notifications and timing of notification of non-compliance events; and an implementation schedule. AEA proposes to continue monitoring discharge annually May through November until diversion operations begin in 2031 and then throughout the period of operation.

2.2.3.2.3 Martin River Sediment Transport Monitoring Plan

AEA proposes to develop a sediment transport monitoring plan through consultation with the agencies and would implement the plan to capture at least 10 sediment/channel maintenance flow releases. The goal of the plan is to determine if sediment management at the Dixon Diversion dam and the proposed channel maintenance flow regimes maintain bedload movement and limit aggradation in the mainstem Martin River.

The plan would include conducting channel-spanning pebble counts at 10 representative locations along the Martin River and noting any areas of fine sediment accumulation (during Connectivity Monitoring as described in Section 4.4). Monitoring would be conducted annually in the spring (clear low flow conditions) for 3 years to establish a baseline and in the spring every year following a sediment management or channel maintenance flow for at least 10 sediment/flow releases. Reporting the findings and consultation with the resource agencies would occur annually. Five years after the start of operation, the effects of the flow regime on sediment transport would be evaluated.

2.2.3.2.4 Water Temperature and Turbidity Monitoring Plan

AEA proposes to continue monitoring continuous water temperature and turbidity in the Martin River annually May through November until diversion operations begin in 2031 and for 5 years post-diversion operations. AEA would provide annual reports to the agencies. Following 5 years of operation, AEA would compare the pre- and post-diversion temperature and turbidity in the mainstem Martin River and consult with the agencies on the need for continued monitoring of these parameters. The plan would also include monitoring measures and procedures for measuring turbidity and temperature upstream and downstream of the Dixon Diversion during sediment management flows.

2.2.3.2.5 Martin River Fish and Fish Habitat Monitoring Plan

AEA proposes to develop and implement a Martin River Fish and Fish Habitat Monitoring Plan through consultation with the agencies. The plan would have two components: Red Lake autonomous video count (AVCT) fish counts and stream surveys to determine if the proposed flow regime maintains connectivity between Kachemak Bay and Red Lake and between the mainstem and other off-channel habitat (OCH)-tributary complexes.

Red Lake AVCT Fish Counts

AEA proposes to continue the Red Lake AVCT fish counts at Red Lake pre- and post-diversion to determine if the proposed flow regime maintains connectivity between Kachemak Bay and Red Lake. AEA would fund ADF&G to continue the Red Lake AVCT fish counts annually May through October for the next 3 years pre-diversion (2026–2028) to count adult salmon, document run timing, and correlate the fish counts with Martin River discharge. Fish counts would continue annually for a period of 5 years post-diversion. AEA would consult with the agencies annually on the findings. After 5 years, the effects on the proposed Project operation flow regime on Sockeye Salmon (*Oncorhynchus nerka*) and Coho Salmon (*O. kisutch*) migration would be evaluated.

Martin River Habitat Connectivity

AEA identified key habitat areas used by salmonids and collected habitat and connectivity data during 2024 and 2025. AEA proposes to conduct pedestrian surveys of the mainstem Martin River and the confluences of key OCH complexes and at the mouth of the EFMR annually for 3 years post-diversion to document connectivity and identify areas of aggradation. Water depth would be measured in the Martin River thalweg and at the OCH connections. Monitoring would occur annually during the spring and again in the fall while mainstem flows are low and clear to establish a post-diversion baseline, and aggraded areas would be monitored periodically following sediment management operations or channel maintenance flow releases. Annual reports would be prepared and shared with the regulatory agencies. After 5 years of operations, the effects of the proposed flow regime on habitat connectivity would be evaluated.

2.2.3.2.6 Martin River Geomorphology and Riparian Vegetation Monitoring Plan

AEA proposes to develop a Martin River Geomorphology and Riparian Vegetation Monitoring Plan through consultation with the agencies and would implement the plan beginning 5 years post-diversion operations. The goal of the plan is to determine if the proposed flow regime maintains connectivity with tributaries and OCHs and limits aggradation in the mainstem Martin River.

The plan would entail collecting aerial imagery and LiDAR data after 5 years post-diversion during low, clear flow; mapping channel location and vegetation growth from aerial imagery and comparing topographic/bathymetric changes to pre-diversion conditions (May 2024 imagery/LiDAR). AEA would consult with the resource agencies on the findings and the need and timing for subsequent monitoring.

2.3 Alternatives Considered but Dismissed

2.3.1 Dixon–Martin Alternative

During the initial development phase, a powerhouse on Martin River was considered, called the Dixon–Martin Alternative (AEA 2022). The powerhouse would have been located approximately 5 miles upstream of the mouth of the Martin River, on the eastern shore near the confluence of the EFMR and the outflow from Red Lake. The reinforced concrete powerhouse footprint would have been approximately 100 feet by 60 feet and house a 55-MW vertical Pelton turbine.

An approximately 6.3-mile-long road segment would have extended from the existing Bradley Lake Access Road to the new Dixon Diversion, and a spur would have extended about 3.8 miles to the Martin River powerhouse.

AEA would have installed a new, approximately 6.9-mile-long, 115-kV transmission line to connect the new Martin River powerhouse to the existing substation at the Bradley Lake Project powerhouse. AEA intended this transmission line to parallel the access roads described above. From the existing Bradley Lake Project powerhouse substation, the Martin River powerhouse would have connected to Bradley Junction via the existing 115-kV transmission line.

A power tunnel would have been bored between the powerhouse on the Martin River and the Dixon Diversion intake on state-owned land near the toe of Dixon Glacier. The pressurized tunnel would have been approximately 2.75 miles long with a diameter of approximately 10 feet. The invert of the tunnel entrance would have been at approximately El. 1,263 feet and would have conveyed water to the powerhouse on the Martin River at an elevation of approximately El. 300 feet.

2.3.2 7-foot Bradley Pool Raise Alternative

The 7-foot Bradley Pool Raise Alternative would have involved increasing the level of Bradley Lake to El. 1,187 feet by adding 7-foot-high spillway crest gates over the fixed (concrete) spillway crest. The crest of the embankment would not have needed to be raised, as the design flood could have been passed through the spillway with the spillway crest gates opened. This would have resulted in an increase in the total surface acreage to 3,914 surface acres and an increase in storage capacity to approximately 312,000 acre-feet.

2.3.3 28-foot Bradley Pool Raise Alternative

The 28-foot Bradley Pool Raise Alternative would have involved increasing the normal full pool level of Bradley Lake to El. 1,208 feet through a combination of raising the concrete spillway crest elevation and adding spillway crest gates. Under this alternative, the dam crest would also have been raised 21 feet through a combination of increased rockfill and a new parapet wall that would have been extended to the left abutment; the diversion tunnel gatehouse would also have been raised. This would have resulted in an increase in the total surface area to 4,224 surface acres and an increase in storage capacity to approximately 389,000 acre-feet. The maximum flood pool level would have remained on lands owned by the State of Alaska.

2.4 References

Alaska Energy Authority (AEA). 2022. Initial Consultation Document. Amendment to Bradley Lake Hydroelectric Project. Prepared for Alaska Energy Authority by Kleinschmidt Associates. Filed with the Federal Energy Regulatory Commission on April 26, 2022.

United States Fish and Wildlife Service (USFWS). 2009. Land clearing timing guidance for Alaska: Plan ahead to protect nesting birds. Available at: http://www.fws.gov/alaska/fisheries/fieldoffice/anchorage/pdf/vegetation_clearing.pdf. Accessed January 4, 2016.

3.0 CONSULTATION AND COMPLIANCE

3.1 Review and Consultation

AEA held numerous in-person meetings / conference calls (Table 3.1-1) to discuss the Proposed Action with several key entities including representatives from: Kenai National Wildlife Refuge (KNWR), National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS), United States Army Corps of Engineers (USACE), USFWS, ADF&G, Alaska Department of Natural Resources (ADNR), Alaska Office of History and Archeology (AOHA) / SHPO, as well as several Tribes and Native Corporations, local governmental organizations, and non-profits. Comments received on documents provided to regulatory agencies, Tribes, and other stakeholders are presented in a matrix included in Appendix E1 of this PDEA. Responses to comments and the remaining consultation documentation will be provided with the FAA.

Table 3.1-1 Summary of consultation meetings.

Date	Meeting Purpose
June 14, 2022	Joint Agency/Public Meeting
September 9, 2022	Site Visit
November 17, 2022	Draft Study Plan Review
March 5, 2024	Final Study Plan: Martin River Aquatic Resources
March 19, 2024	Final Study Plan: Terrestrial Resources
April 1, 2024	Final Study Plan: Terrestrial Resources Part 2
May 7, 2024	Final Study Plan: Wetland Resources
June 11, 2024	Final Study Plan / Section 106: Cultural Resources
January 30, 2025	Study Results / Section 106: Cultural Resources
January 30, 2025	1st Year Study Results / 2nd Year Study Plan: Terrestrial Resources
February 12, 2025	1st Year Study Results: Martin River Aquatic Resources
March 28, 2025	1st Year Study Results / 2nd Year Study Plan: Martin River Aquatic Resources Part 2 – Review stakeholder comments to 1st year study reports
April 7, 2025	2nd Year Study Plan: Martin River Aquatic Resources Part 3 – Respond to stakeholder comments and discuss 2nd year study plan modifications
November 13, 2025	AEA-Proposed Protection Mitigation and Enhancement Measures: Martin River Flow Releases

On April 27, 2022, AEA filed an Initial Consultation Document (ICD) beginning the process of a license amendment to develop the outflow from the Dixon Glacier for additional water supply for increased Bradley Lake Project generation purposes (AEA 2022a); they hosted a Joint Agency and Public Meeting in Homer, Alaska on June 14, 2022, to provide additional information and the opportunity for questions. Table 3.1-2 provides record of the comments received regarding the ICD and study requests associated with the license amendment as well as comments on study reports.

AEA provided the Draft Study Plan (DSP) on November 2, 2022 (AEA 2022b), for proposed studies which included a summary of the agency and stakeholder requested studies, AEA's response to the study requests, and AEA's proposed 2023 field season studies. Comments received to the DSP are provided in Table 3.1-2. AEA paused the amendment process in March 2023 to focus on feasibility assessment and associated study needs to better refine the Proposed Action. AEA reinitiated the license amendment process in February 2024 and held additional meetings with regulatory agencies, Tribes, and stakeholders to describe the proposed project and modifications to the DSP that were incorporated into a Final Study Plan (FSP). The FSP was developed based on comments received on the DSP and discussion held during the spring 2024 meetings.

The 2024 reports were provided to stakeholders in February 2025, and a meeting was held on March 28, 2025, to review and discuss the reports. Comments on the 2024 reports were received from two entities as shown in Table 3.1-2, and the second year of studies were modified as needed to address stakeholder comments and collect additional data. All meeting materials and annual reports were provided via AEA's Project website.[7]

Table 3.1-2 Summary of consultation correspondence.

Date	Correspondence
Initial Consultation Document Comments and Study Requests	
August 9, 2022	Alaska Department of Fish and Game
August 12, 2022	Cook Inletkeeper
August 15, 2022	National Ocean and Atmospheric Administration, National Marine Fisheries Service
August 15, 2022	United States Fish and Wildlife Service

[7] https://www.akenergyauthority.org/What-We-Do/Railbelt-Energy/Bradley-Lake-Hydroelectric-Project/Bradley-Lake-Expansion-Project

Date	Correspondence
Draft Study Plan	
December 29, 2022	United States Fish and Wildlife Service
December 30, 2022	Alaska Department of Fish and Game
December 30, 2022	Water Policy Consulting, LLC
March 22, 2024	Alaska Department of Fish and Game
March 29, 2024	United States Fish and Wildlife Service
2024 Reports	
March 21, 2025	Alaska Department of Fish and Game
March 25, 2025	Water Policy Consulting, LLC
March 26, 2025	United States Fish and Wildlife Service

3.2 Regulatory Compliance

3.2.1 Water Rights

Water rights in Alaska are issued by the ADNR under the Alaska Water Use Act (AS 46.15). AEA has water rights with the State of Alaska for the Bradley Lake Project, including all portions of the Bradley River and Bradley Lake (LAS 2836; LAS 6998), an unnamed tributary to Upper Battle Creek (EFUBC) (LAS 13370), the West Fork of Upper Battle Creek (LAS 27720), and the Bradley Lake Project waterfowl nesting site located to the west of Bradley Lake near Kachemak Bay (LAS 2837; LAS 14316).

AEA submitted an application for Water Rights for 480,000 acre-feet per year from the Martin River (LAS 33602). The application was accepted with a provisional priority date of March 24, 2021. As this is a FERC-regulated hydroelectric project, the ADNR will adjudicate the water rights after FERC authorizes the Project and the Project becomes operational.

3.2.2 Clean Water Act

Under section 401(a)(1) of the Clean Water Act (CWA), 33 United States Code (U.S.C.) § 1341(a)(1), a license applicant must obtain either a water quality certification (WQC) from the appropriate state pollution control agency verifying that any discharge from a project would comply with applicable provisions of the CWA, or a waiver of the WQC by the appropriate state agency. The failure to act on a request for certification within a reasonable period of time, not to exceed one year after receipt of the request, constitutes a waiver.

On May 20, 1999, ADEC filed a letter with the Commission waiving WQCs for Commission jurisdictional hydroelectric projects in Alaska. Pursuant to State law, the State of Alaska does not issue 401 WQCs for hydropower projects. Nonetheless, AEA will consult with ADEC to seek confirmation that the Proposed Action would be waived from certification.

3.2.3 Coastal Zone Management Act

Under section 307(c)(3)(A) of the Coastal Zone Management Act (CZMA), 16 U.S.C. §1456(3)(A), the Commission cannot issue a license for a hydropower project within or affecting a state's coastal zone unless the state's coastal zone management agency concurs with the license applicant's certification of consistency with the state's CZMA program, or the agency's concurrence is conclusively presumed by its failure to act within 6 months of its receipt of the applicant's certification.

The federally approved Alaska Coastal Management Program (ACMP) expired on July 1, 2011, resulting in Alaska's withdrawal from the CZMA's National Coastal Management Program. On July 7, 2011, the National Oceanic and Atmospheric Administration (NOAA) issued a notice regarding the ACMP withdrawal from the CZMA program. There is no state department in effect to apply for a determination of consistency, and section 307 of the CZMA does not currently apply in Alaska.

3.2.4 Section 18 Fishway Prescription

Section 18 of the Federal Power Act (FPA), 16 U.S.C. § 811, states that the Commission is to require a licensee to construct, operate, and maintain fishways as may be prescribed by the Secretaries of the U.S. Department of Commerce for anadromous salmon species or the U.S. Department of the Interior for non-salmon fish species.

The Martin River Basin provides habitat for resident and anadromous fishes as described in Section 4.4. However, the Dixon Diversion would not impede anadromous fish migration because it would be located several miles upstream of a series of natural fish passage barriers, the most downstream of which is located approximately 2.5 miles from the confluence of the East Fork and West Fork of the Martin River. Furthermore, there is no suitable fish habitat present in the EFMR upstream of the proposed Dixon Diversion, which would be located near the toe of the Dixon Glacier.

No fishes have been documented in Bradley Lake or the Upper Bradley River Basin within the zone of potential effects (USACE 1982, FERC 1985) and there are natural barriers to anadromous fish passage in the lower Bradley River. No fishway prescriptions or reservations of authority were filed with FERC for the original Bradley Lake Project.

3.2.5 Section 10(j) Recommendations

Under section 10(j) of the FPA, 16 U.S.C. § 803(j), each hydroelectric license issued by the Commission must include conditions based on recommendations provided by federal and state fish and wildlife agencies for the PM&E of fish and wildlife resources affected by the project. The Commission is required to include these conditions unless it determines that they are inconsistent with the purposes and requirements of the FPA or other applicable law.

AEA will include a summary of any such recommendations, if made for the Proposed Action, in the FAA.

3.2.6 Endangered Species Act

Section 7 of the Endangered Species Act (ESA), 16 U.S.C. § 1536, requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of the critical habitat of such species. NMFS has jurisdiction over ESA-listed species in the marine environment and anadromous fish species, while USFWS has jurisdiction over terrestrial and freshwater species. ESA-listed species are discussed in Section 4.7.

Three ESA-listed species managed by USFWS may potentially occur within the vicinity of the Project area; the northern sea otter (*Enhydra lutris kenyoni*; Southwest Alaska Distinct Population Segment [DPS]), Short-tailed Albatross (*Phoebastria albatrus*), and Steller's Eider (*Polysticta stelleri*). Five ESA-listed species and/or DPS's managed by NMFS may potentially occur within the vicinity of the Project area: the beluga whale (*Delphinapterus leucas*; Cook Inlet DPS), the fin whale (*Balaenopter physalus*), the humpback whale (*Megaptera novaeangliae*; Mexico DPS), the leatherback sea turtle (*Dermochelys coriacea*), and the Steller sea lion (*Eumetopias jubatus*).

All the ESA-listed species potentially occurring in the Project vicinity use marine habitats. None of these species occur in the area of the proposed construction footprint of the Dixon Diversion or Bradley Lake Pool Raise and changes in operations associated with the Project is not anticipated to affect these species. With the exception of the Steller's Eider, these ESA-listed species are unlikely to occur in the shallow waters of Kachemak Bay except as a rare visitor, if at all. Steller's Eiders are known to overwinter in the bay. Northern sea otters (Southcentral stock) are numerous and commonly found in the bay, but the Southwest Alaska DPS of northern sea otters are not. The limited number of additional barge trips to transport equipment and supplies during construction mobilization and demobilization are not anticipated to have any adverse effect on these species. These species and potential Project effects are discussed in greater detail in Section 4.7.

AEA was designated by FERC via letter dated June 22, 2022, to be its Non-Federal Representative pursuant to the ESA to consult with USFWS and NMFS regarding any listed and candidate species. A summary of consultation and any recommendations, if made, will be included in the FAA.

3.2.7 Marine Mammal Protection Act of 1972

The Marine Mammal Protection Act (MMPA) of 1972 protects all marine mammals, prohibiting "take" in U.S. waters and by U.S. citizens on the high seas, and import of marine mammals and marine mammal products into the United States.

As discussed in further in Section 4.4, marine mammals are common in Kachemak Bay, but the Proposed Action is expected to have minimal effects on marine mammals.

3.2.8 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) mandates consultation with NMFS for any activities that "may adversely impact" Essential Fish Habitat (EFH) for federally managed marine, estuarine, and anadromous fish species. Waterbodies used by salmon, historically or currently, are included as EFH. The ADF&G's Anadromous Waters Catalog (AWC) designates freshwater EFH for salmonids in Alaska. A stream, river, or lake is included in the AWC because it is "important to anadromous fish species and therefore afforded protection under the [Anadromous Fish Act, Alaska Statute] AS 16.05.871" (ADF&G 2024). AS 16.05.871 requires ADF&G to "specify," or list, "the various rivers, lakes, and streams or parts of them that are important for the spawning, rearing, or migration of anadromous fish." It also requires anyone wanting to construct a hydraulic project; use, divert, obstruct, pollute, or change the natural flow or bed of a specified waterbody; or operate a vehicle in these specified waterbodies to contact ADF&G for written approval before beginning the construction, activity, or use.

Kachemak Bay provides designated marine EFH habitat for Pink Salmon (*O. gorbuscha*), Chum Salmon (*O. keta*), Coho Salmon, Chinook Salmon (*O. tshawytscha*), and Sockeye Salmon. Designated freshwater EFH for all five Pacific salmon species exists within the lower Bradley River (AWC Codes 241-14-10625 and 241-14-10625-2010), which includes tidally influenced habitat and distributary channels near its confluence with Kachemak Bay (ADF&G 2024). The Martin River Basin (AWC Code 241-14-10600) is designated as freshwater EFH for Dolly Varden (*Salvelinus malma*), Coho Salmon, Sockeye Salmon, and Pink Salmon, while tidal flats around the mouth of the Martin River are also recognized as EFH for rearing Chum Salmon. EFH is discussed further in Section 4.4.

AEA was designated by FERC via letter dated June 22, 2022, to be its Non-Federal Representative pursuant to the Magnuson-Stevens Act to consult with NMFS regarding EFH. A summary of consultation and any recommendations, if made, will be included in the FAA.

3.2.9 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA), 54 U.S.C. § 306108, requires that a federal agency consider how its undertakings could affect historic properties. Historic properties are districts, sites, buildings, structures, traditional cultural properties, and objects significant in American history, architecture, engineering, and culture that are eligible for inclusion in the National Register of Historic Places (NRHP).

In addition, the proposed Project, which is wholly located on state land, falls under the jurisdiction of the Alaska Historic Preservation Act (AHPA) and the Alaska SHPO. AHPA governs the protection and preservation of historic, prehistoric, and archaeological resources in Alaska on lands owned or controlled by the state.

AEA continues to follow its FERC-approved CRMP, filed on November 22, 1985, to avoid impacts on the historic Hilmar Olsen Fox Farm site and the Jansen-Zanitowski Fox Farm site. If any previously unrecorded archeological or historical areas are discovered during project construction, operation, or project-related activities, AEA would cease the activity immediately and consult with a qualified archaeologist and the SHPO.

Four Federally recognized Tribes and five Native Corporations have been identified as either having an interest in, or potentially affected by, the proposed Project. The Federally recognized Tribes are: Seldovia Village Tribe, Native Village of Nanwalek, Native Village of Port Graham, and Kenaitze Tribe. The Native Corporations that may be impacted include: Seldovia Native Association, Inc., English Bay Corporation, Port Graham Corporation, Chugach Alaska Corporation, and Cook Inlet Regional, Inc.

AEA conducted cultural resources surveys associated with the Proposed Action; there were no archeological or historical areas discovered. AEA was designated by FERC via letter dated June 22, 2022, to be their Non-Federal Representative pursuant to Section 106 of the NHPA to consult with the Alaksa SHPO, Tribes, and Native Corporations regarding cultural and tribal resources. A summary of consultation and any recommendations, if made, will be included in the FAA. See Section 4.9 for additional information.

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4.0 ENVIRONMENTAL ANALYSIS

4.1 General Description of the River Basins

The Bradley Lake Project is located near the head of Kachemak Bay on the Kenai Peninsula approximately 25 miles northeast of Homer, Alaska, within the Kenai-Chugach Mountain physiographic area. With the exception of the project facilities, the area is remote and undeveloped. The Kenai Peninsula extends approximately 150 miles southwest from the Chugach Mountains, south of Anchorage. It is separated from the mainland on the west by Cook Inlet and on the east by Prince William Sound. More than half of the peninsula's 6 million acres have a history of federal management, including establishment of predecessors to the current Chugach National Forest in 1907, KNWR in 1941, and Kenai Fjords National Park in 1978 (Morton et al. 2015). The 2-million-acre KNWR stretches from the northern tip of the peninsula to the south side of Kachemak Bay and includes parts of the Harding Icefield (USFWS 2010). Kenai Fjords National Park protects 670,000 acres including portions of the Harding Icefield and its outflowing glaciers and coastal fjords along the Gulf of Alaska on the Kenai Peninsula's southern shore (National Park Service [NPS] 2020). Other nearby protected areas include the 380,000-acre combination of the adjacent Kachemak Bay State Park and Kachemak Bay State Wilderness Park near the mouth of Kachemak Bay (ADNR 2020).

The heavily glaciated area is characterized by steep, mountainous terrain. Primary tributaries to Bradley Lake are the Upper Bradley River, Kachemak Creek, and Marmot Creek. The lake is also fed by diversions from the Middle Fork Bradley River, Nuka River, EFUBC and WFUBC. Outflows from Bradley Lake include the Lower Bradley River and the project power tunnel.

4.1.1 Bradley River

The drainage area of the Bradley River is estimated to be approximately 86.2 square miles, in addition to the Upper Battle Creek diversions that divert water from an 8.7 square mile area to Bradley Lake (Figure 4.1-1). Primary tributaries to Bradley Lake are the Upper Bradley River, Kachemak Creek, and Marmot Creek. The lake is also fed by several diversions. Outflows from Bradley Lake include the Lower Bradley River and the power tunnel to the Bradley Lake Project powerhouse where the majority of the water flows. From Bradley Lake, the Bradley River flows northward for approximately 5 miles and discharges into Kachemak Bay. The North Fork of the Bradley River and the bypass reach of the Middle Fork flow into the mainstem about 3.3 miles downstream of Bradley Lake Dam. USGS operates several gages in the Bradley River basin. USGS Gage No. 15239001 Bradley River below Dam measures discharge downstream of Bradley Lake Dam (USGS 2026c). USGS Gage No. 15239060 Middle Fork Bradley River below North Fork measures flows of the Middle Fork bypass reach between its confluence with the North Fork Bradley River and the Bradley River (USGS 2026e). USGS Gage No. 15239070 Bradley River near Tidewater measures the discharge of the Bradley River downstream of its confluence with the Middle Fork bypass reach and is the point of compliance for the required Bradley Lake Dam minimum flow releases (USGS 2026f).

4.1.1.1 Bradley Lake

Bradley Lake is fed by both natural and diverted water sources (Figure 4.1-1). The Bradley Lake watershed currently drains an area of approximately 76.3 square miles, including diverted drainage areas. As a part of the original development of the Project, the upper Middle Fork of the Bradley River, a portion of the outflow from the Nuka Glacier, and the East Fork of Upper Battle Creek were diverted into the reservoir. The Battle Creek Diversion was expanded to include WFUBC with construction of the WFUBC Diversion Project occurring in 2018-2020. The two major natural inflow tributaries to the lake are Kachemak Creek, which begins at Kachemak Glacier, and the Upper Bradley River. There are also numerous unnamed first-order streams draining off the mountainside into the lake.

4.1.1.1.1 Nuka Diversion

The Upper Bradley River receives most of its flow from the Nuka Glacier. When the project was constructed, glacial melt formed a pond called Nuka Pool at the terminus of the Nuka Glacier. Nuka Pool lies on the divide between two drainages, the Upper Bradley River which flows into Bradley Lake and the Nuka River which flows to the east to Kenai Fjords National Park. The original project included construction of the Nuka Diversion which was designed to divert the glacial melt water flowing through the Nuka Pool to flow in the Upper Bradley River, except for a minimum flow of 5 cfs which must be provided to the Nuka River in accordance with the June 1986 Contract between the Alaska Energy Authority and the U.S. Department of Interior. However, since the project was constructed, the Nuka Glacier has receded and the meltwater now flows through a natural channel directly to the Upper Bradley River bypassing the Nuka Pool. The Nuka Subbasin of the Upper Bradley River basin drains an area of 11.1 square miles. USGS Gage No. 15238990 has measured discharge of the Nuka Subbasin continuously since October 1, 1991 (USGS 2026b).

4.1.1.1.2 Middle Fork Diversion

The Middle Fork Diversion is located approximately one mile north of Bradley Lake in an adjacent drainage at elevation 2,160 feet on the Middle Fork Tributary of the Bradley River. The Diversion consists of a small intake basin and two reaches of open channel approximately 760 feet and 483 feet long, separated by a stilling basin which is located in a natural bog area, all of which were established by excavation. The Diversion conveys water from the Middle Fork of the Bradley River to Marmot Creek, a tributary to Bradley Lake, and operates in all seasons. The Middle Fork Diversion drains an area of 10.1 square miles. USGS Gage No. 15239050 has measured discharge continuously within the Middle Fork Diversion Subbasin since September 1979 (USGS 2026d).

4.1.1.1.3 Upper Battle Creek Diversion

The EFUBC Diversion is located at elevation 1,342 approximately 0.7 miles south-southeast of Bradley Lake Dam and diverts a small tributary of Upper Battle Creek into the reservoir adding 0.9 square miles of drainage area to the Project.

The WFUBC Diversion was constructed in 2018-2020. The diversion captures flows from the 7.56 square mile WFUBC basin above the diversion. The diversion operates from spring thaw until winter freeze-up and is shut down during the winter. A 30-inch bypass gate and pipe serve to maintain the MIFs of 5 to 25 cfs. The next 600 cfs of flow is diverted from the Battle Creek drainage to Bradley Lake through a pipeline that conveys the water to the EFUBC Diversion area. Stream flows exceeding the pipeline capacity flow over the spillway and remain in the Battle Creek drainage.

As part of the construction of the WFUBC Diversion, the EFUBC Diversion was modified and consists of a small, talus dike along the west side of the channel directing flows to a new (2018) excavated channel at the base of a waterfall. The flow is directed to join the WFUBC discharge in the first of three interconnected ponds as the flow drops about 150 feet to Bradley Lake.

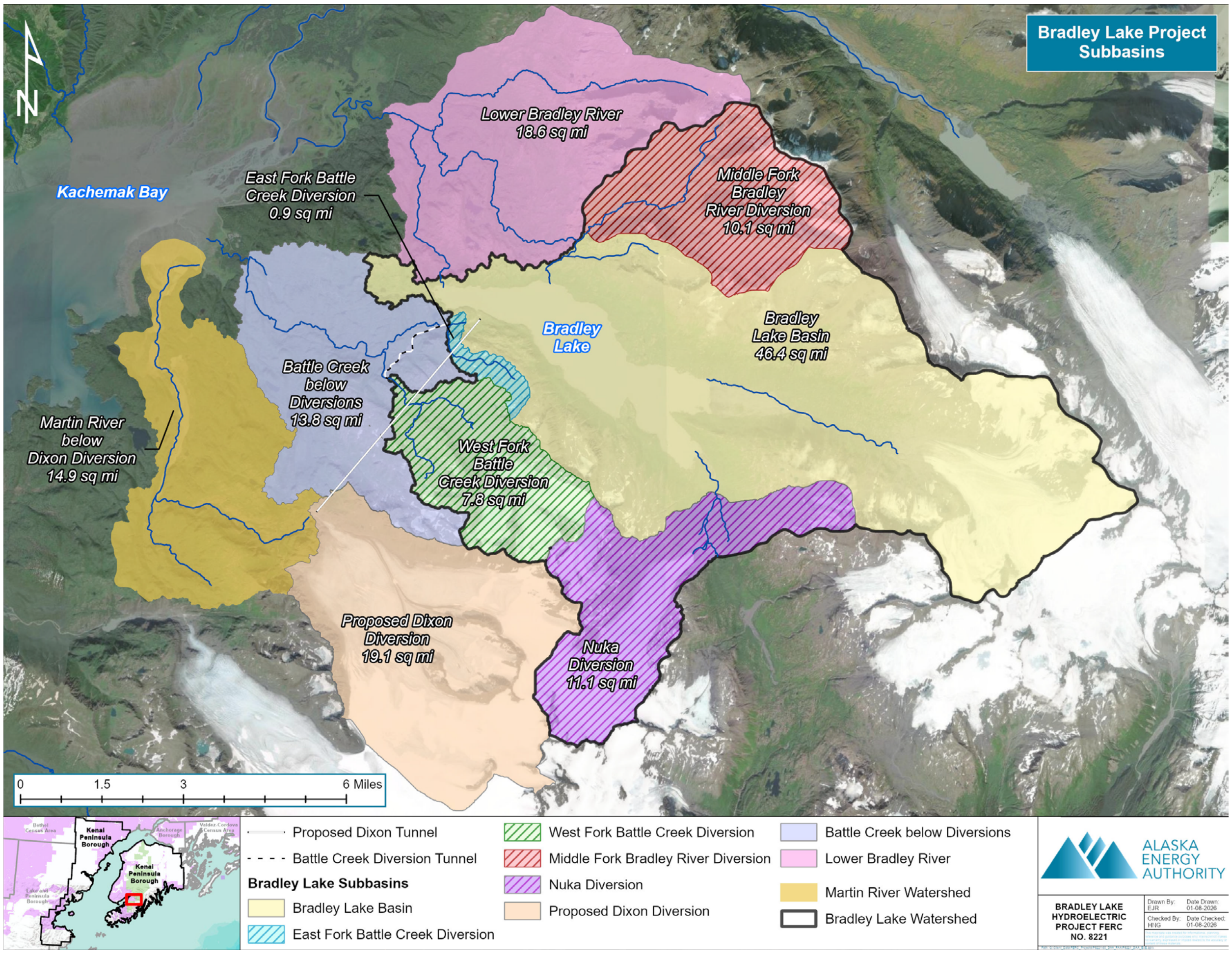

Figure 4.1-1 Subbasins of the Bradley River, Battle Creek and Martin River watersheds.

4.1.2 Martin River

The headwaters of the Martin River are within the KNWR (Figure 2.2-5). The Martin River historically drained from both the Dixon Glacier and the Portlock Glacier, but glacial retreat has isolated the Portlock Glacier runoff, and the Martin River now receives water from primarily the Dixon Glacier (CoastView 2019; Freethey and Scully 1980). The EFMR begins at the Dixon Glacier and then flows west through a steep canyon for approximately 3.4 miles, dropping approximately 900 feet in elevation where it is joined by the West Fork Martin River (WFMR) at the outflow channel of Red Lake, a small (approximately 25-acre) lake that discharges into the Martin River from the southwest (Figure 4.1-1).

Downstream of EFMR/WFMR confluence, the Martin River is braided and meanders approximately 5 miles, dropping 300 feet to Kachemak Bay. During construction of the

Bradley Lake Project, gravel was mined from the Martin River delta, leaving three remediated borrow pits as ponds adjacent to the river near its mouth (Parry and Seaman 1994), referred to as the mitigation ponds. The Martin River has recently migrated across the delta at its mouth and now flows through the mitigation ponds and enters Kachemak Bay on the east side of the delta. The total drainage area of the Martin River is estimated to be approximately 34.0 square miles; the drainage area above the proposed Dixon Diversion is 19.1 square miles (Figure 4.2-1). USGS Gage No. 15238951 was established near the mouth of the EFMR to measure discharge and temperature in 2023 and turbidity beginning in 2024 (USGS 2026a).

4.1.3 Kachemak Bay

Kachemak Bay is on the southwest tip of the Kenai Peninsula and is 39 miles long and 24 miles wide at its entrance, with more than 320 miles of shoreline. Kachemak Bay is split into inner and outer bays by Homer Spit, which extends 4 miles into the bay from the northern shoreline. The Bradley Lake Project and proposed Dixon Diversion are near the head of Kachemak Bay, on its southern shore. The area in the vicinity of the Bradley Lake Project is characterized by extensive tidal flats and shifting river deltas (FERC 1985). Watersheds at the head of the bay, and most watersheds on the bay’s south side, are fed by glaciers lying on the north and west slopes of the Kenai Mountains. The southern slopes of Kachemak Bay are a steep, mountainous ice field, with tree line at approximately El. 1,600 feet and the glacier-covered Kenai Mountains ultimately rising to over El. 5,000 feet (ADNR 2020). The Harding Icefield is approximately 31 miles by 50 miles and includes glaciers in the Grewingk-Yalik Glacier Complex that flow into Kachemak Bay (Adalgeirsdottir et al. 1998).

The tides at Kachemak Bay are extreme, with an average vertical difference (also called mean range) of over 15 feet (15.8 feet; ADNR 2020). Average high tides are about +18 feet but can reach +28 feet. Low tide reaches -5.9 feet as measured at the Seldovia Tide Station (ADNR 2020). In general, water flows into Kachemak Bay on the southern side and out of the bay on the northern side. The inflowing water is more marine, while the outflowing water is more estuarine, being more turbid and less saline, due to the outflow of several rivers and streams that terminate in the bay (ADNR 2020).

4.1.4 Major Land and Water Uses

Major land use and water use of the Bradley Lake and Bradley River are associated with the Bradley Lake Project. Surrounding areas include the KNWR, Kenai Fjords National Park, Kachemak Bay State Park, and Kachemak Bay State Wilderness Park near the mouth of Kachemak Bay (USFWS 2010; NPS 2020; ADNR 2020).

As part of the CZMA, NOAA designated Kachemak Bay as a National Estuarine Research Reserve (NERR) in 1999 (Field and Walker 2003). The Kachemak Bay NERR encompasses over 365,000 acres of almost exclusively state-managed lands and includes the waters of Kachemak Bay east of the line connecting Bluff Point in the north with Point Pugibshi in the south, the Fox River Flats, a large portion of Kachemak Bay State Park/Wilderness Park, the Beluga Slough property in public ownership, and city-owned tidelands and marshlands along the Homer Spit (Field and Walker 2003).

Kachemak Bay is also designated by the State of Alaska as a Critical Habitat Area for the purpose of protecting and preserving habitat areas that are especially crucial to the endurance of fish and wildlife (Field and Walker 2003). The majority of the Kachemak Bay NERR falls within either the Kachemak Bay and Fox River Flats Critical Habitat Areas managed by ADF&G or Kachemak Bay State Park, managed by the Alaska Division of Parks and Outdoor Recreation (Field and Walker 2003). Kachemak Bay NERR is also used as a resource to conduct research, monitoring, education, trainings, and community engagement, particularly by the Alaska Center for Conservation Science (ACCS) at the University of Alaska, Anchorage. Therefore, administratively, Kachemak Bay NERR is managed collectively by NOAA and ADF&G with input from a council of agency and Kachemak Bay community stakeholders (Field and Walker 2003). However, ACCS is considered the lead agency according to NOAA, as ACCS provides daily oversight in addition to conducting research (NOAA 2022a). Processes that support the region’s high productivity of fish, shellfish, birds, and mammals are extensively studied, along with the impacts of climate change and human activities to these resources.

4.1.5 Climate

The climate of Southcentral Alaska is subarctic. The hours of daylight per day vary from almost 19 hours in June to 6 hours in December (NOAA 2022b). Kachemak Bay has a subarctic coastal climate; its weather is moderate compared to interior Alaska (ADNR 2020). Winters are snowy and long, with the average January high temperature only slightly below freezing. In Halibut Cove, snow averages 88 inches per season, falling primarily from November through March, with some accumulation in October and April, and rarely in May (ADNR 2020). Rainfall is spatially variable around Kachemak Bay. Homer receives only about 25 inches of rain annually due to the influence of the Kenai Mountains to the southeast, which shelter it from the Gulf of Alaska (USACE 1982). The outlet of Bradley Lake was estimated to receive 40 inches of rain annually while Kachemak Glacier, less than 11 miles from Bradley Lake, averages approximately 180 inches per year (USACE 1982). Most of the rain falls between September and December (United States Climate Data 2022).

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4.2 Geology, Soils, and River Geomorphology

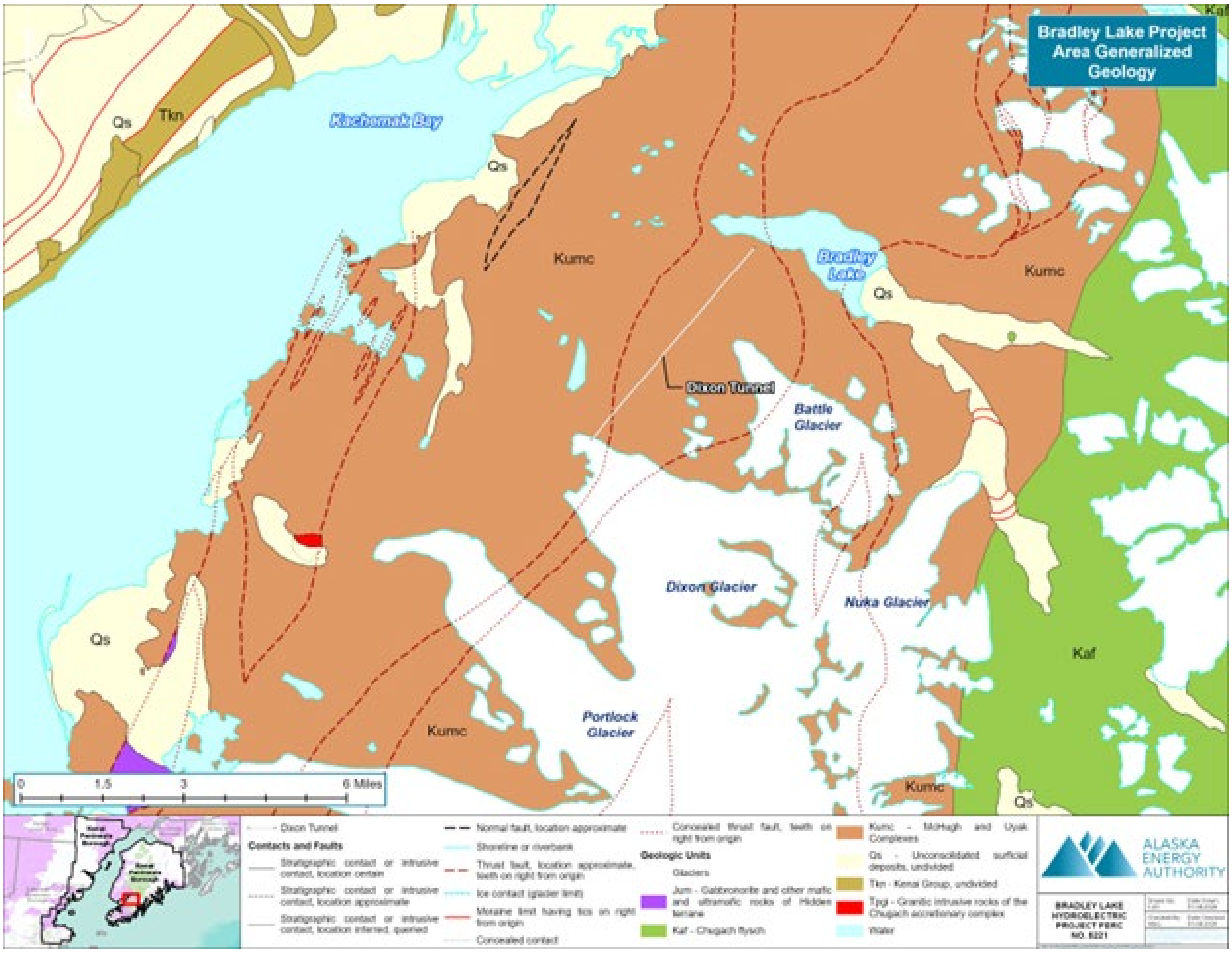
4.2.1 Affected Environment

The proposed Bradley Lake Expansion Project area lies within the Kenai-Chugach Mountain physiographic province near the head of Kachemak Bay on the Kenai Peninsula. This area is characterized by steep, mountainous terrain dissected by streams and rivers. The geology, soils, and geomorphology of the area are affected by nearby glaciers that emanate from the Harding Ice Field.

4.2.1.1 Geology

The Kenai Mountains are part of a band of intensely deformed sedimentary and volcanic rocks. These rocks are part of the Chugach geologic terrane that formed as oceanic sediments and volcanic rocks were scraped off the subducting Pacific Plate as it dove under the North American Plate, between 250-66 million years ago (Mesozoic-Cenozoic). As the rocks were scraped off the northward-moving Pacific Plate, they were subject to intense pressure, resulting in folding and faulting that metamorphosed the sediments and volcanic rocks and stacked packets of rocks from oldest on the northern edge of the mountain range to youngest on the southern edge of the mountain range (Bradley and Kusky 1982; Bradley et al. 1999). Geologists call this an accretionary prism or a mélange because the rock layers are so deformed and mixed compared to their original state. The rocks were also pushed upward, resulting in the high mountain range seen today.

The northern parts of the Project area, including the Martin and Bradley river valleys, the proposed Dixon Diversion intake and tunnel, and the existing Bradley Dam and lower Bradley Lake are underlain by the McHugh Complex (Kpm and Kpms,). The upper end of Bradley Lake is underlain by the late Cretaceous age Valdez Group (Kvm), composed of weakly metamorphosed greywacke and slate.



Source: Bradley et al. (1999).

Figure 4.2-1 Generalized geologic map.

The McHugh Complex is composed of turbidites that have been slightly to moderately metamorphosed. Rock types encountered are graywacke, argillite, chert, dacite, metatuff, and greenstone. The graywacke, argillite, and mixtures of these rocks are dominant. Chert occurs as nodules and lenses in the argillite and metatuff, with some massive beds up to 15 feet thick. The diabase occurs as intrusive dikes generally 10 to 20 feet in width, with some dikes about 40 feet thick. The metatuff is metamorphosed, volcanic pyroclastic debris. Frequently it is intermixed with argillite, but some layers up to 15 feet thick were encountered. Overall, it constitutes less than 5 percent of the rock mass. The greenstone is metamorphosed volcanics and constitutes less than 3 percent of the rock mass.

Except where severely weathered, the argillite is moderately hard to hard. The graywacke, chert, dacite, and greenstone are hard to very hard. Foliation (cleavage) is poorly developed in the argillite, and bedding, when identifiable, is poorly preserved. The graywacke is massive and displays neither bedding nor foliation. The chert, dacite, and metatuffs are generally massive and show no foliation.

Jointing is well developed and is widely spaced in the graywacke and moderately to widely spaced in the argillite. Generally, three or more sets are observed, resulting in blocky structures. There are some open joints in the abutment of the dam and spillway, especially in the rock knob between these structures. Hydro splitting tests made along the nearby Battle Creek tunnel alignment showed low in situ horizontal stresses ranging from 0.9 to 0.5 of overburden pressure at the depth tested.

Mapped thrust faults separate the packets of rock in the Kenai Mountain mélange. The Eagle River and Chugach Bay thrust faults strike in the general northeast-southwest direction.

Both the McHugh Complex and Valdez Group rocks are cut by early Tertiary (60-50 million years ago) intrusive rocks that form small dikes to larger batholiths composed of granodiorite to rhyolite to basalt. An example of these intrusive rocks can be seen in the bright white rhyolite dike that contrasts with the darker greywacke just west of the proposed Dixon Diversion intake structure location.

A variety of Quaternary deposits mantle the bedrock, including glacial till and outwash and recent river alluvium. The till is generally a thin layer of sand to boulders that is particularly evident in areas that have been recently deglaciated (e.g., proposed Dixon Diversion intake area). The Dixon Glacier and glaciers upstream from Bradley Lake carry large loads of sediment, depositing sand, gravel, and boulders in broad outwash plains characterized by braided river patterns. Non-glacial river alluvial deposits form in other river valleys in the area that no longer carry glacial runoff.

4.2.1.2 Geologic Hazards

4.2.1.2.1 Earthquakes

The Project area is an active seismic zone, with frequent small-magnitude tremors and occasional larger magnitude earthquakes associated with the subduction of the Pacific Plate under the North American Plate at the Aleutian Arc-Trench, which lies 185 miles southeast of the Project. This subduction zone largely controls the regional faulting and seismic activity in the area.

The primary source of megathrust earthquakes is the Benioff zone, which lies about 18 miles beneath the earth's surface near the Project. This zone was the focus of several major historic earthquakes in Southern Alaska. Between 1900 and 2023, 25,829 earthquakes have occurred within 200 miles of the Project; the number within magnitude ranges is listed below (DOWL 2023):

- Magnitude 2.5 – 3: 16,032
- Magnitude 3 – 4: 7,976
- Magnitude 4 – 5: 1,484
- Magnitude 5 – 6: 278
- Magnitude 6 – 7: 53
- Magnitude 7 – 8: 6

There are four known late-stage brittle faults in the general Project area that typically align with a northeast-southwest strike, and these faults have not been known to be historically active. These faults include the Border Ranges fault, which lies under Kachemak Bay, and the Eagle River Fault, which crosses Bradley Lake near its head. Both faults trend northeast-southwest (about 45° east of north) parallel to regional structure. Three smaller faults were found within the area during previous work on the Bradley Lake Project and the Battle Creek Hydroelectric Project. These are the Bull Moose Fault, the Bradley River Fault, and the Bear Cub Fault. These smaller faults trend approximately north-south. The Bull Moose and Bradley River are the larger of these faults. Where crossed by the power tunnel, they consisted of a series of gouge-filled anastomosing shears, a few feet to possibly 20 feet wide, separated by sound rock and extending over a width of 300 to 400 feet. Lineations and minor shears parallel these faults.

4.2.1.2.2 Volcanic Hazards

The nearest active volcanoes are Mt. St. Augustine and Mt. Spurr, which are more than 100 miles from the site across Cook Inlet. The most likely volcanic hazard from these volcanoes is ashfall. Less likely volcanic threats include possible development of a tsunami due to large mudflows or slides from Mt. St. Augustine that could affect the Bradley Lake powerhouse.

4.2.1.2.3 Tsunamis and Seiches

The coast of Alaska has been subjected to tsunamis generated by uplift due to offshore earthquakes. This hazard was investigated by Stone & Webster Engineering Corporation (1988), and the report indicated an annual probability (combined earthquake and volcanic activity) of about 0.007 for a wave height at the powerhouse reaching El. 25 feet BLVD (El. 38.63 feet mean lower low water datum). The powerhouse is designed to withstand water to this level without damage.

The hazards of seiche in Bradley Lake due to earthquake and the possibility of a wave generated in the lake by a liquefaction-generated slide in the Bradley Glacier delta were investigated. The team concluded waves from these sources would not damage the dam or spillway. The mountain sides surrounding Bradley Lake are bedrock that has been scoured by late Pleistocene and recent glaciation. Minor rockfalls may result from earthquakes, but slides that could cause overtopping are not a hazard. The Kachemak and Nuka glaciers are sufficiently far from the lake that ice falls or slides that might result from an earthquake would not reach the lake.

4.2.1.2.4 Mass Wasting (Landslides and Rockfall)

The steep terrain of the Project area, coupled with recent deglaciation that left unvegetated and unconsolidated deposits, resulted in small landslide and rockfall features in many areas. Bank erosion and small landslides occur in unconsolidated sediments around margins of Bradley Lake as wave action and reservoir fluctuations cause undercutting of the banks.

4.2.1.2.5 Flooding and Episodic Sediment Transport

The proposed Dixon Diversion structure location is close to the current terminus of the Dixon Glacier. During intense fall rainstorms, particularly if they are coupled with periods of glacial melt, flooding and/or high rates of sediment movement occur that could affect the proposed impoundment. The nearby Battle Creek Diversion/impoundment has periodically required maintenance and cleaning due to high coarse sediment loads.

4.2.1.3 Soils

Due to the remote and generally undeveloped location, soils in the area have not been mapped in detail. Soils are generally thin and poorly developed, with bedrock outcrops common. Parent materials include unconsolidated glacial till, outwash, river alluvium, and bedrock/colluvial deposits. The soils range from silty gravel with sand to silty sand with gravel and may include volcanic ash. Around alpine lakes or in lowland areas, soils consist of thin surficial alluvial deposits or organic soils (e.g., peat). The area is generally free of permafrost except for isolated locations at higher elevations.

4.2.1.4 Geomorphology

4.2.1.4.1 Martin River

The Martin River is a braided glacial river with a very high sediment load. Channel gradient is fairly consistent from the mouth to the EFMR canyon, with a slight increase in gradient upstream from Project River Mile (PRM) 2.5. Substrate is primarily gravel and cobble downstream from PRM 4, with cobble, gravel, and boulder upstream from PRM 4 (Watershed GeoDynamics 2025).

Under current conditions, sediment and water input to the Martin River come primarily from the Dixon Glacier because there are only a few small tributary streams in the watershed. Streamflow in the Martin River varies from just a few cfs in winter months to 500-1,000 cfs during the glacial melt season (June or July through September or October). Peak flows of several thousand cfs occur during large rainfall events, usually in August or September. No direct measurements of sediment input are available; however, based on measurements of glacial erosion at other Alaskan glaciers, total sediment output from the Dixon Glacier is likely over 600,000 cubic yards per year, with 30,000 to 300,000 cubic yards per year of coarse sediment (coarse sand to boulder) and the remainder fine-grained silt and clay that is carried through the river and into Kachemak Bay.

The Martin River has been actively aggrading for at least the last century. The braided channels migrate across the river valley, and bedload transport occurs multiple days per year, particularly in unconfined reaches. Current OCH areas connect to the mainstem river across the valley bottom. Off-channel areas were part of the active channel in the past and will likely be part of the active channel in the future as the river migrates across the valley bottom.

An analysis of timelapse camera images along the river suggests that bedload transport downstream from the EFMR/WFMR confluence occurs when flows reach approximately 1,000 cfs. Based on a long-term estimate of daily flow conditions, the Martin River exceeded 1,000 cfs an average of 25 days per year (Figure 4.2-2) over the past 45 years.

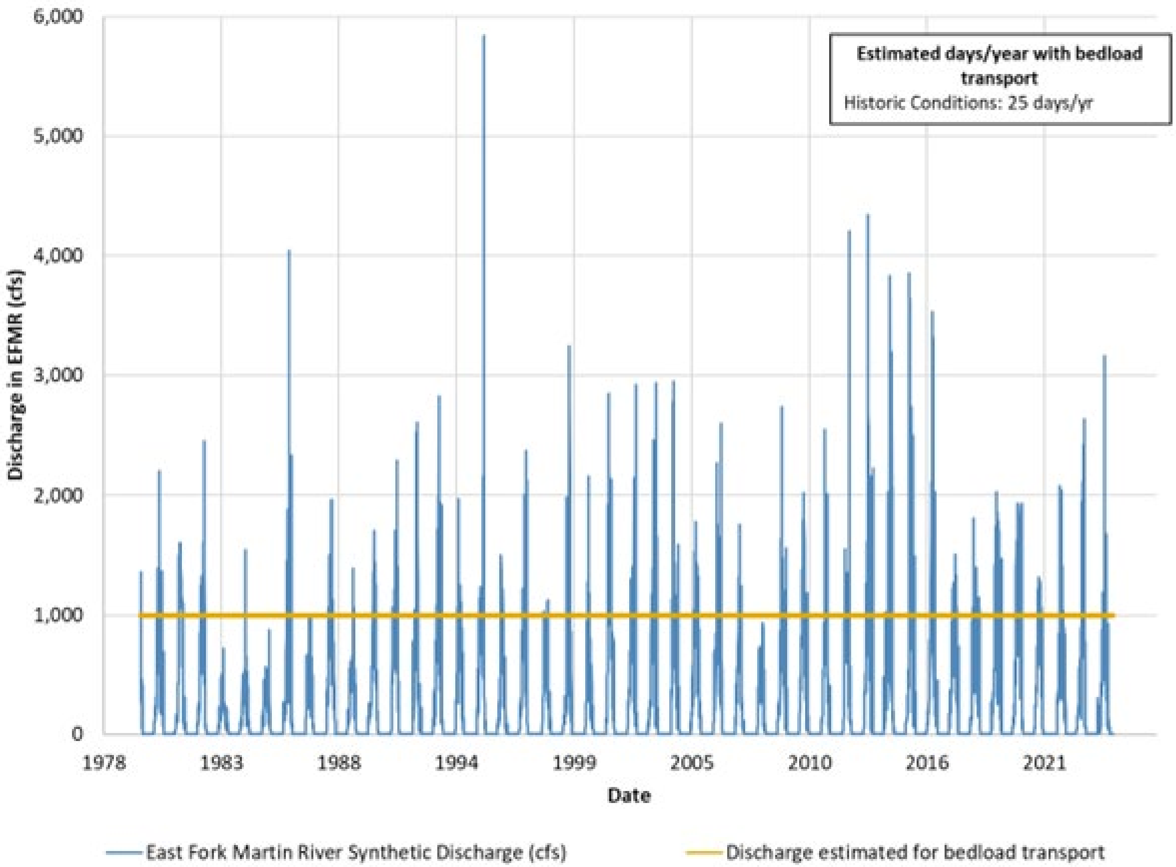


Figure 4.2-2 Estimated flow and days with bedload transport in the Martin River, historic conditions.

Aerial photograph analysis suggests that a large episodic input of sediment occurred from the early to mid-1900s following retreat of the Dixon Glacier Little Ice Age Maximum. This resulted in a sediment "slug" that has been moving and diffusing down the Martin River valley. As the sediment slug has moved down the valley, 5-7 feet of aggradation has occurred across the entire valley, followed by slow channel incision. It is anticipated that the sediment slug will continue to move through the lower valley for the next few decades before the river reaches a quasi-equilibrium with sediment and water input primarily coming from the Dixon Glacier.

In addition to the aggradation and subsequent incision caused by the sediment slug, the levee breach near the mouth of the river in August 2023 has been and will continue to be affecting channel dynamics as the river adjusts to the new base level. The levee breach resulted in (a) aggradation in the right bank mitigation ponds as a delta builds into the ponds and (b) headcutting upstream of the breach location as the river adjusts to the new channel configuration. Channel adjustment related to the breach will continue for years to decades until a new, more stable base level is reached.

4.2.1.4.2 Bradley Lake

Bradley Lake is part of the Bradley Lake Project and is impounded by a 125-foot-high dam. The shoreline of Bradley Lake is underlain by Mesozoic to Cenozoic rocks of the McHugh Complex and the younger Valdez Group. These rocks are a mélange of intensely deformed and faulted marine sedimentary and volcanic rocks. Overlying the bedrock units are varying thicknesses of glacial till, outwash, and colluvium. In some areas, bedrock has been scraped clean by glacial erosion. Shoreline areas are generally steep on the western (downstream) half of the reservoir and gentler on the eastern (upstream) half of the reservoir. Soils in the area have not been mapped but are young and of varying thickness.

The current shoreline is 28 miles long at El. 1,180 feet BLVD. Mapping of eroding shoreline areas using remote sensing and aerial observations suggest approximately 10 percent of the shoreline is eroding under current operations. Mapped areas of erosion include areas of bank erosion (approximately 1.7 miles of shoreline) and taller, shallow rapid landslides (approximately 1.2 miles of shoreline). Most eroding shorelines occur on the western half of the lake. The gentler sloping eastern half of the lake has fewer areas of erosion.

Areas classified as bank erosion have relatively shorter (less than 20 feet tall) eroding slopes with generally uniform bank heights. Areas classified as shallow rapid landslides have an arcuate eroding bank shape with heights up to 100 feet tall, and these areas appear to be primarily in colluvial deposits on very steep slopes.

Erosion mechanisms for both the bank erosion and shallow rapid landslide areas are presumed to be similar: erosion of unconsolidated material (till or colluvium) along shoreline areas by wave action that removes material from the base of the slope. In areas of bank erosion, removal of material from the base of the slope results in an undercut slope followed by toppling and/or raveling of overlying material. In areas of shallow rapid landslides, removal of material from the base of the slope destabilized the slope and has resulted in sliding of overlying material. In both cases, continued erosion of the base of the slope by wave action keeps the slopes unstable and unvegetated.

4.2.1.4.3 Bradley River

The Bradley River downstream from Bradley Lake flows through a confined bedrock canyon for most of its length. Operation of the Bradley Lake Project reduces the flow and sediment load of the river. As a result, there is minimal bedload transport or channel migration under current conditions.

4.2.1.5 Kachemak Bay

Both the Martin River and the Bradley River flow into Kachemak Bay, providing fresh water and sediment input to the eastern head of the bay. The Martin River forms a large gravel delta in Kachemak Bay. Prior to the 2023 levee breach, the delta was growing northward into the bay. Following the levee breach, the river flowed east into an embayment that includes the mouth of Battle Creek. The Martin River is currently depositing sand and gravel into this embayment over the existing sand/fine-grained substrate.

4.2.2 Environmental Analysis

The following potential impacts to geology, soils, and river geomorphology from Project construction and operation were evaluated:

- Disturbance to geology and soil resources from construction and operations
- Changes to Bradley Lake shoreline erosion resulting from lake level changes
- Changes to sediment transport and channel characteristics in the Martin River and Bradley River
- Changes to sediment input locations/volumes in Kachemak Bay

4.2.2.1 Construction

Construction of the proposed Bradley Lake Expansion Project would result in disturbance to and loss of soil resources in areas of new Project facilities as well as at camp and staging areas, borrow pits, and spoil disposal sites. The net area of disturbance for each activity is listed in Table 4.2-1 (see Figure 2.2-1 in Section 2.2 for visual). Some of the proposed areas are already disturbed from past construction activity (approximately 93 acres). Total new area of disturbance would be approximately 134 acres.

Table 4.2-1 Areas of disturbance associated with Project construction.

Construction Area	Already Disturbed?	Disturbance Area (acres)
LBC Worker Camp	Yes	21.3
Staging Area 1 (Bradley Rd East)	Yes	2.3
Staging Area 2 (Bradley Rd West)	Yes	2.5
Staging Area 3 (WFUBC Rd)	Yes	5.3
Dixon Diversion Dam	No	25.9
Tunnel Muck Spoil Disposal	No	40.6
Bradley Dam and Spillway Raise	Yes	25.9
Borrow Area (near LBC Camp)	Yes	35.4
Borrow Site (1 and 5 Dam West)	No	13.5
Borrow Site 3 (WFUBC Rd)	No	31.1
Borrow Site 4 Expansion and Spoil Area (WFUBC Rd)	Partially	21.1
Borrow Site 6 (Dam East) (Less Preferred)	No	1.5

LBC = Lower Battle Creek; Rd = road

In addition to disturbance, erosion of exposed soil, borrow materials, and tunnel muck during construction could occur. To limit the potential for adverse environmental effects to geology, soils, and geomorphology during construction, the licensee will require contractors to implement BMPs including but not limited to erosion and sediment control, fuel and chemical management, and stormwater management.

Potential construction effects specific to proposed actions are discussed below.

4.2.2.1.1 Dixon Diversion

Martin River

Construction of the Dixon Diversion would disturb approximately 26 acres around the diversion site adjacent to and within the EFMR. This area was recently deglaciated, so soil development is minimal; however, there are areas of unconsolidated till and outwash that would be disturbed, some on steep slopes, which could be destabilized when disturbed. Some areas of bedrock will also be removed for the tunnel and intake facilities. Disturbed material could reach the Martin River. Appropriate BMPs and erosion and sediment control measures will be implemented to minimize movement of soil and rock into the Martin River. The river naturally carries a very high sediment load, so it is anticipated that erosion of small amounts of material into the river would not result in substantial effects on river geomorphology.

The diversion structure will be built within the current EFMR channel. This will require temporary measures (e.g., cofferdams) to divert the Martin River around the diversion construction site. Proposed construction sequencing would drill the diversion tunnel prior to constructing the permanent diversion structure, so up to 1,650 cfs could be diverted into the tunnel during construction of the diversion structure. If the cofferdam were overtopped by a large flood flow, it could inundate the construction site and result in erosion. Proper cofferdam sizing would limit this risk.

Bradley Lake

Tunnel muck would be disposed of in a 41-acre area between the tunnel outlet and Bradley Lake. The muck is erodible and could be eroded and transported into Bradley Lake. An erosion and sediment control plan and containment measures will be implemented to minimize erosion.

Bradley River

Construction activity associated with the Dixon Diversion is not anticipated to impact geology, soils, or geomorphology in the Bradley River.

Kachemak Bay

Construction activity associated with the Dixon Diversion is not anticipated to impact geology, soils, or geomorphology in Kachemak Bay.

4.2.2.1.2 Bradley Lake Pool Raise

Bradley Lake

Construction activity associated with the Bradley Lake Pool Raise includes development or expansion of approximately 66 acres of borrow sites near Bradley Lake and construction on the current dam that impounds the lake, one of which would also be used as a spoils area if needed. Erosion of borrow material from the borrow sites could enter the lake; implementation of erosion and sediment control measures would limit the likelihood of erosion.

Bradley River

Construction activity associated with the Bradley Lake Pool Raise includes a potential 1.5-acre borrow site near the Bradley River and construction on the current dam across the river. Erosion of borrow material from the borrow site could enter the river; implementation of erosion and sediment control measures would limit the likelihood of erosion.

Kachemak Bay

Construction activity associated with the Bradley Lake pool raise is not anticipated to impact geology, soils, or geomorphology in the Kachemak Bay.

4.2.2.2 Operations

Operation of the Bradley Lake Expansion Project would affect the geology, soils, and geomorphology of the Martin River and Bradley Lake by altering flow, sediment input, bedload transport, and lake levels. Potential effects of Project operation are discussed in more detail below.

4.2.2.2.1 Martin River

Changes to Bedload Transport

The proposed Dixon Diversion intake and tunnel would be constructed in the EFMR just downstream from the current terminus of the Dixon Glacier. The diversion dam would be equipped with crest gates to flush accumulated sediment on a periodic basis. A forebay area would act as a stilling basin for the intake, estimated to include a storage capacity of approximately 5 acre-feet (7,000-8,000 cubic yards) at El. 1,275 feet. The diversion tunnel would have a capacity of 1,650 cfs and convey water from the EFMR to Bradley Lake. For analysis of changes to flows and sediment transport in the Martin River downstream from the diversion, it was assumed that all flows over the proposed 100 cfs MIF and up to tunnel capacity (1,650 cfs) would be directed into the tunnel to Bradley Lake and no longer flow down the Martin River.

As a result of Project operations, the total volume of coarse-grained sediment supplied to the Martin River would be similar to current conditions, but the timing of sediment supply would be altered. Coarse-grained sediment would be stored within the forebay pool and flushed periodically into the Martin River. Sediment input from the Dixon Glacier is episodic, but assuming an average annual supply of 30,000 cubic yards per year of coarse-grained material, the forebay pool would need to be flushed of sediment on at least an annual basis, possibly multiple times per year. Finer grained sediment (silt, clay, fine sand) supply to the Martin River would be greatly reduced, as that material would travel with the diverted flow into Bradley Lake. Proposed sediment flush operations are to quickly drop one or more of the crest gates for 1 hour, then raise the gate(s) and visually assess the success of the flush. Based on 2D hydraulic modeling, flow of 500 cfs would flush most cobble and finer material through the forebay pool, and flow of 1,000 cfs would flush all cobble (but not boulder-sized material).

Based on visual observations of existing bed material in the EFMR canyon, it is anticipated that most of the flushed material would be transported through the canyon (average 6.7 percent gradient). Based on 2D hydraulic modeling, larger material (cobble/boulders) would likely be deposited near the EFMR/WFMR confluence under a sediment flush flow of 500 cfs but would be transported farther downstream to approximately PRM 3.5-PRM 4.5 under a flow of 1,000 cfs.

Martin River flow and bedload transport potential would be reduced because of Project operations. Using a 45-year (1979-2024) synthetic flow record for the EFMR developed by DOWL (2025), and assuming a flow of 1,000 cfs is required to mobilize the bed in the Martin River downstream from the EFMR/WFMR confluence, bedload transport would occur an average of 0.9 days per year (Figure 4.2-3) compared to 25 days per year under historical conditions. Note that bedload transport is episodic, with some years having frequent bedload transport and a few with little or no bedload transport even under historical conditions.

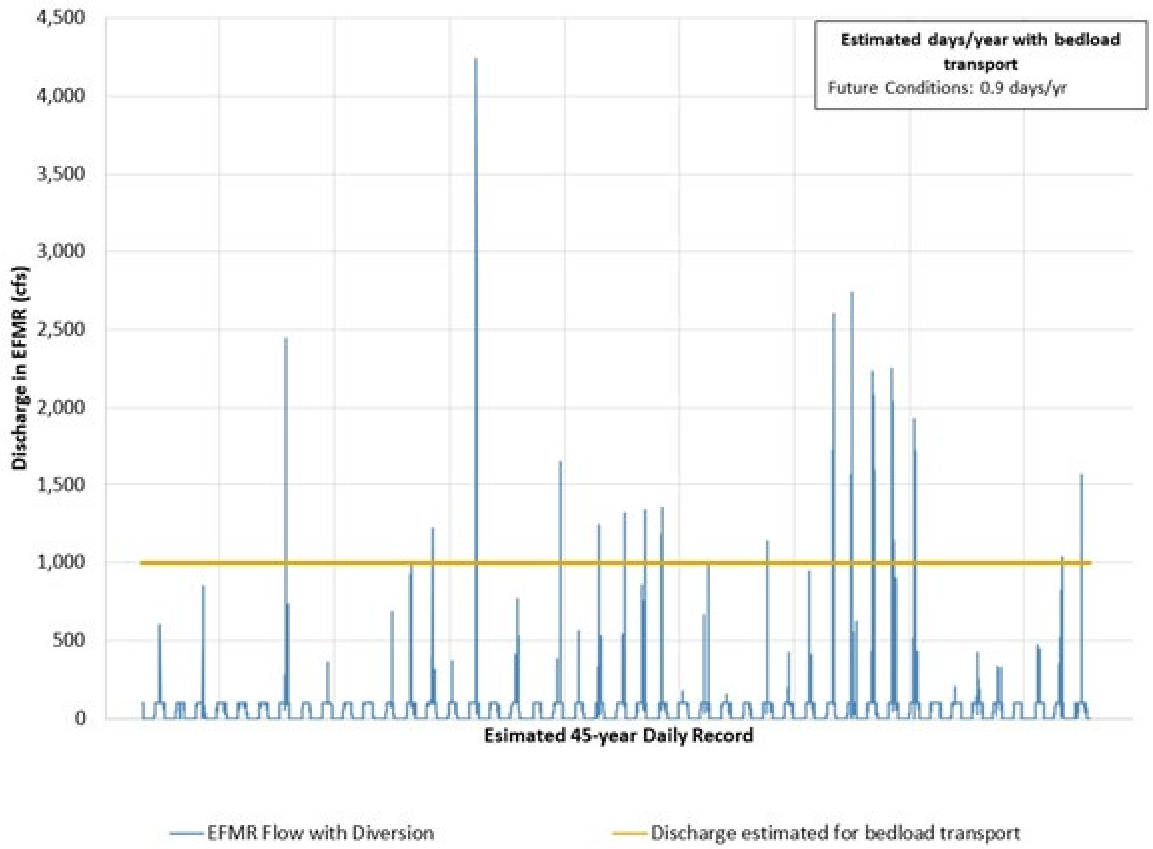


Figure 4.2-3 Estimated flow and days with bedload transport in the Martin River, future conditions with operation of the Dixon Diversion.

If sediment is deposited in the upper reaches of the Martin River following a sediment flush, it may remain there for several years because no bedload transport in the Martin River would be anticipated for many years. In addition, based on observations in the Martin River during fall time periods, fine- to medium-gravel accumulations may occur within the river channel on the waning limbs of peak flow events, and finer sediment deposition may occur in side channels or areas of slow-moving water. To help this material move through the river system, a flushing flow regime of 1,000 cfs for 12 hours a minimum of 3 years out of each moving 10-year average of project operation is recommended. This level of flushing flow may occur naturally, but if not, flow releases from the diversion dam would be used to provide the recommended sediment movement. Due to uncertainty around the exact amount and timing of sediment flushes and exact flows to transport bed material through the Martin River, monitoring of sediment accumulations and grain size in the Martin River is a proposed Project PM&E measure to assess the realized effects of the proposed flow regime and the ability to maintain a passage corridor for aquatic species.

Channel Changes in the Martin River

As a result of reduced flow in the Martin River, it is most likely that river would evolve into a more stable, primarily single-channel system. However, there may be some areas that develop temporary multiple or braided characteristics following an extreme flow event. The stable channel configuration would allow riparian vegetation to become established along the channel margins. Root strength associated with the vegetation would help to stabilize the streambanks and further reduce channel planform movement. The current Martin River valley is characterized by a wide, sparsely vegetated cobble/gravel braid plain. This area would also begin to be colonized by riparian vegetation.

It is likely that the new mainstem flow regime would result in a more stable main channel and that connectivity with tributary and off-channel areas would be maintained. However, as this connectivity is crucial to provide passage for adult and juvenile fish to tributaries and off-channel areas, monitoring connectivity will be part of the proposed Project PM&E measures.

4.2.2.2.2 Bradley Lake

The proposed increase in reservoir elevation will move the location of the high pool shoreline and erosive wave action 16 vertical feet up the sides of the reservoir. This will result in continued erosion of the existing shoreline erosion areas around Bradley Lake and further destabilization of areas of shallow rapid landsliding. It is possible that additional areas of erosion would occur if new areas of unconsolidated colluvium or till are encountered by the new shoreline, but based on LiDAR mapping, it does not appear that there are substantial new areas of colluvium or till that would intersect with the new shoreline position.

The amount of fine-grained sediment (silt/clay) supplied to Bradley Lake would increase as turbid water from the EFMR is diverted into the lake. As the lake is already turbid from glacial melt and the volume of diverted water is small compared to the total lake volume, it is not anticipated that the sediment would markedly reduce the storage capacity of the lake.

4.2.2.2.3 Bradley River

No flow changes are proposed in the Bradley River, so no changes to sediment transport or geomorphology are anticipated.

4.2.2.2.4 Kachemak Bay

The supply of water and sediment from the Martin River into Kachemak Bay would be reduced. The growth rate of the Martin River delta would likely slow and become less frequent as high flow events that transport coarse sediment to the delta decrease.

The volume of fine-grained sediment transported into Kachemak Bay from the Martin River would be greatly reduced because sediment suspended in the EFMR water would be diverted, along with the water, into Bradley Lake. It is not anticipated that the reduction in fine-grained sediment would result in marked changes in Kachemak Bay because there are many glacial rivers that supply the bay with fine-grained sediment.

4.2.3 Applicant-Proposed Measures

The following sections discuss proposed measures to minimize and/or monitor effects to geology, soils, and geomorphology.

4.2.3.1 Construction

Temporary construction-related impacts—such as those associated with intake modification or conveyance structures—will be avoided or minimized through implementation of standard BMPs, the ESCMP, and the Fuel and Hazardous Substances Management Plan.

4.2.3.2 Operations

During Project operations, accumulated sediment would be flushed from the diversion dam forebay on an as-needed basis. The frequency of sediment flushing would vary based on the rate of sediment supply from the Dixon Glacier, but it is anticipated that flushing would occur at least annually. Sediment flushing would ideally occur when flows exceed 500 cfs to maximize sediment movement through the forebay.

To help maintain bedload transport in the Martin River, channel maintenance flows are proposed. Channel maintenance flows of 1,000 cfs for 12 hours will be released a minimum of 3 years out of each moving 10-year average of project operation. These flows may occur as part of regular Project operations if inflow to the Dixon Diversion exceeds 2,650 cfs (1,650 cfs tunnel capacity plus 1,000 cfs flow into the EFMR) or by decreasing flow diverted into the tunnel to provided 1,000 cfs into the EFMR.

4.2.3.3 Proposed Monitoring Measures

Proposed monitoring measures pertaining to geology, soil, and geomorphology are described in the sections below. Monitoring connectivity of the mainstem Martin River with tributary and OCH areas is described in Section 4.4.

4.2.3.3.1 Sediment Transport Monitoring Plan

Monitoring goal: to determine if sediment management at the Dixon Diversion dam and channel maintenance flow regimes maintain bedload movement and limit aggradation in the mainstem Martin River.

Duration: Post-Diversion (2030/2031 through 2040/2041)

Actions:

- Complete channel-spanning pebble counts at 10 representative locations along the Martin River
- Note any areas of fine sediment accumulation (during Connectivity Monitoring as described in Section 4.4)
- Conduct monitoring annually in the spring (clear low flow conditions) for 3 years to establish a baseline and in the spring every year following a sediment management or channel maintenance flow for at least 10 sediment/channel maintenance flow releases
- Consult with agencies on findings annually

- After 5 years, evaluate effects of the flow regime on sediment transport

4.2.3.3.2 Geomorphology and Riparian Vegetation Monitoring Plan

Monitoring goal: to determine if the flow regime maintains connectivity with tributary and OCHs and limits aggradation in the mainstem Martin River.

Duration: Post-Diversion (2036 and onward)

Actions:

- Collect aerial imagery and LiDAR data every 5 years post-diversion
- Map channel location and vegetation growth from aerial imagery and compare topographic/bathymetric changes to pre-diversion conditions (May 2024 imagery/LiDAR)
- Capture LiDAR data at 5 years post-diversion during low, clear flow
- Consult with agencies on findings and re-evaluate need and timing for additional monitoring

4.2.4 References

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4.3 Water Quality and Quantity

ADEC is responsible for establishing Alaska Water Quality Standards (18 Alaska Administrative Code [AAC] 70). The purpose of the water quality standards is to protect each of the designated uses of waterbodies in the state. Except as specified in 18 AAC 70 Article 2, all waters in Alaska are protected for all uses according to standards outlined in the Alaska Water Quality Standards (ADEC 2024) regardless of their actual use. Freshwater streams in the Project area, including the Bradley River and Martin River watersheds, are protected for water supply (drinking, agriculture, aquaculture, and industrial); water recreation (contact and secondary); and growth and propagation of fish, shellfish, other aquatic life, and wildlife. All the marine waters, such as Kachemak Bay, are protected for water supply (aquaculture, seafood processing, and industrial); water recreation (contact and secondary); growth and propagation of fish, shellfish, other aquatic life, and wildlife; and harvesting for consumption of raw mollusks or other raw aquatic life.

ADEC established numeric criteria for water quality standards according to protected use classes and subclasses (18 AAC 70.020). If a waterbody is protected for more than one use class, the most stringent water quality criteria for all the included use classes apply. This water quality section is focused on the parameters that have the potential to affect anadromous and resident fish. Table 4.3-1 lists the criteria for freshwater streams in Alaska for growth and propagation of fish, shellfish, other aquatic life, and wildlife.

Table 4.3-1 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 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% of saturation at any point of sample collection.
Dissolved Inorganic Substances	Total dissolved solids (TDS) may not exceed 1,000 mg/L. A concentration of TDS may not be present in water if that concentration causes or reasonably could be expected to cause an adverse effect to aquatic life.
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.

Pollutant	Criteria
Sediment	The percent accumulation of fine sediment in the range of 0.1 millimeters (mm) to 4.0 mm in the gravel bed of waters used by anadromous or resident fish for spawning may not be increased more than 5% by weight above natural conditions (as shown from grain size accumulation graph). In no case may the 0.1 mm to 4.0 mm fine sediment range in those gravel beds exceed a maximum of 30% by weight (as shown from grain size accumulation graph). In all other surface waters no sediment loads (suspended or deposited) that can cause adverse effects on aquatic animal or plant life, their reproduction or habitat may be present.
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 & 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 (NTU) above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.

4.3.1 Affected Environment

4.3.1.1 Martin River

The Martin River is located about 5 miles southwest of Bradley Lake and extends about 8.5 miles from the present terminus of the Dixon Glacier to the mouth of the Martin River at Kachemak Bay. The total drainage area of the Martin River is estimated to be approximately 34.0 square miles; the drainage area above the proposed Dixon Diversion is 19.1 square miles (Figure 4.2-1). The portion of the Martin River upstream of its confluence with Red Lake at about PRM 5.1 is referred to as the EFMR. To understand the water resources in the Martin River basin and potential effects of the Project, AEA monitored continuous stream temperature and discharge for 2022-2025 (DOWL 2023, 2025) and discrete parameters including water temperature, DO, pH, specific conductivity, and turbidity (Kleinschmidt 2025, 2026a, 2026b; Figure 4.3-1). Water resource information is summarized below. Detailed study methods and results can be found in the study reports posted to AEA's Project website.[7]

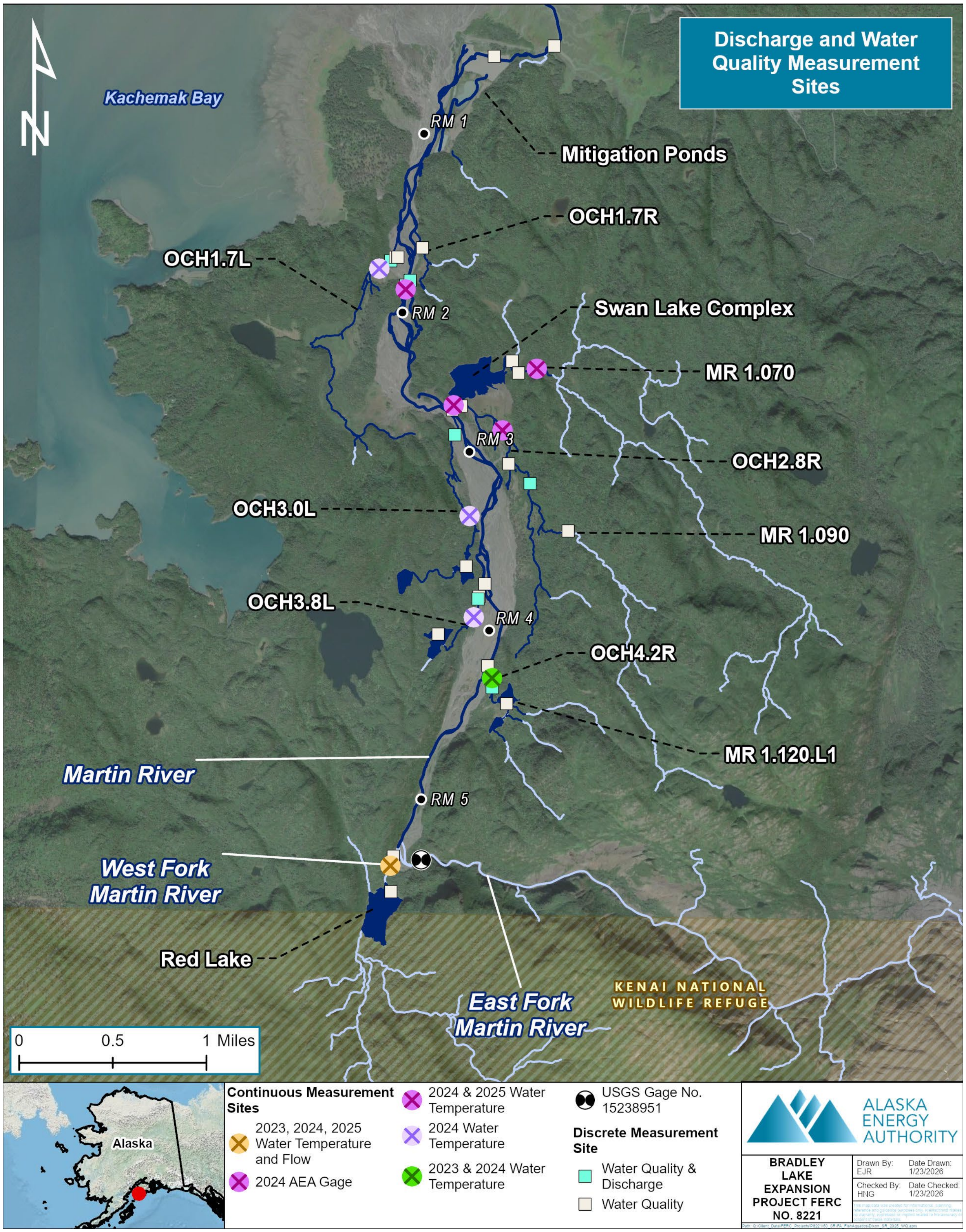

Figure 4.3-1 Location of 2023-2025 discharge and water quality monitoring sites in the Martin River basin.

Discharge in the Martin River is dominated by snowmelt during the spring, glacial runoff from the Dixon Glacier in the summer months, and precipitation events in late summer and fall, with a minimal base flow in the winter months. Between late May and October, the Martin River functions primarily as a glacial-dominated system, with EFMR input driving cold, turbid mainstem flows, while smaller rain- and snow-fed tributaries contribute limited amounts of clearer, warmer water. Within this timeframe, there are three distinguishable water quality and quantity regimes. Spring (May) is characterized by low flows that increase as snow melts. Summer (June to early September) is characterized by increased glacial melt resulting in the highest flows during the proposed operation timeframe. Fall (mid-September through October) sees decreased glacial input, with increased precipitation events that drive fluctuation in mainstem flow. Photos 4.3-1 through Photo 4.3-4 show the mainstem Martin River at various flows.

Photo 4.3-1 Typical spring low-flow conditions (~68 cfs) in the Martin River on May 22, 2025. The PRM 1.9 constriction is visible upstream.

Photo 4.3-2 Typical summer turbid flow conditions (~820 cfs) in the mainstem Martin River on July 31, 2025. The PRM 1.9 constriction is visible upstream.

Photo 4.3-3 Pre-rainfall flow conditions (~150 cfs) in the mainstem Martin River on September 29, 2025. The PRM 1.9 constriction is visible downstream.

Photo 4.3-4 Post-rainfall flow conditions (~690 cfs) in the mainstem Martin River on October 6, 2025. The PRM 1.9 constriction is visible downstream.

4.3.1.1.1 Water Quantity

The Martin River watershed is 34 square miles, 56 percent of which lies above the proposed Dixon Diversion (Figure 4.1-1). Discharge monitoring occurred at several locations within the Martin River watershed from 2022–2025, including the EFMR near its mouth, WFMR downstream from Red Lake, and the mainstem Martin River at its constriction near PRM 1.9. The latter provides the only continuous monitoring of flow in the mainstem Martin River (Figure 4.3-2).

Over the 2023–2025 May-through-October monitoring period, Martin River at PRM 1.9 had an average flow of about 503 cfs. Average monthly flows ranged from a low of about 80 cfs in May to a high of 963 cfs in August.

The Martin River flow is dominated by the EFMR, with mainstem flows comprised of about 50 percent EFMR flows in early May, rapidly increasing to more than 98 percent in late July. Multiple smaller snowmelt, spring, and rainfed tributaries that join the mainstem

Martin River downstream of the EFMR contribute modestly to the overall flow in the system, with greater flow contributions in the spring from snowmelt (~50 cfs), to very little contribution during the summer months (<10 cfs), to greater contributions during fall precipitation events. Of these smaller tributaries, the WFMR and the Swan Lake complex contribute the most flow.

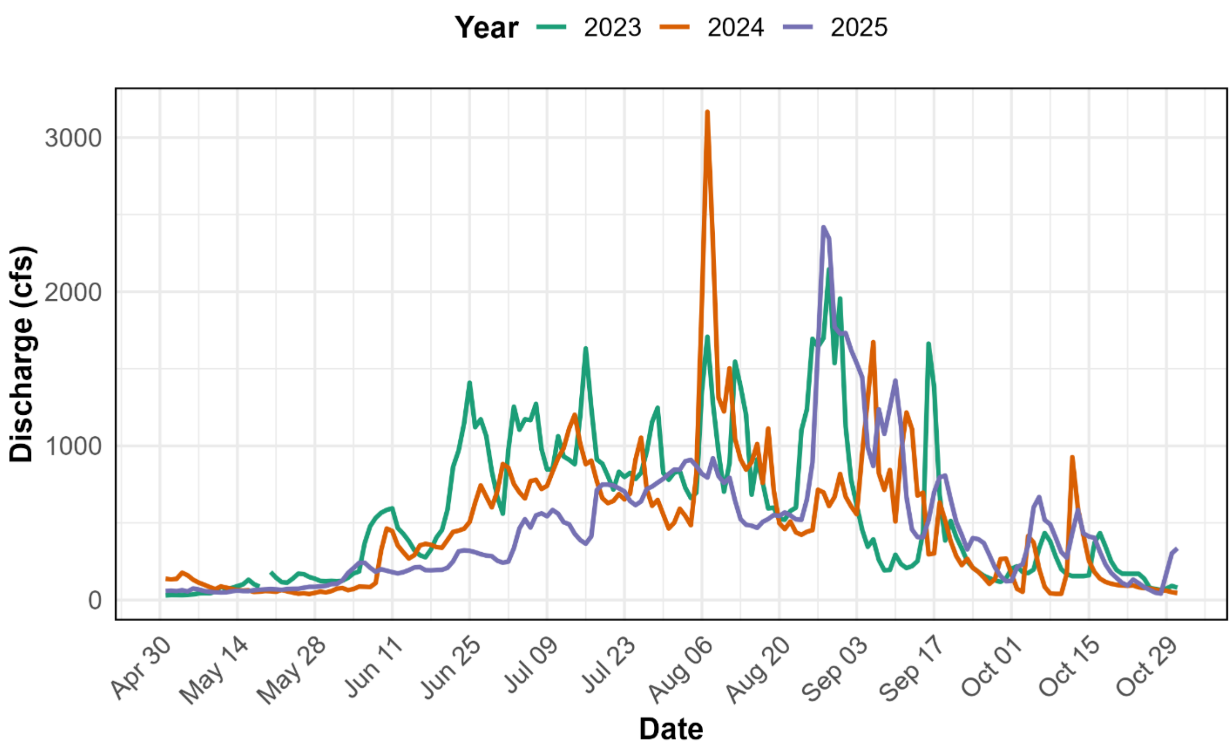

Figure 4.3-2 Average daily discharge at the Martin River PRM 1.9 constriction from May through October 2023–2025.

USGS maintains a gaging station in the EFMR (USGS Gage No. 15238951) that collected discharge data for 2023 and most of 2024, but a 10-year flood in August 2024 changed the channel such that the rating curve was no longer accurate. Since then, only stage height and temperature data are available from the USGS gage site. Historical EFMR flow has been estimated based on records of gaged flow from the Nuka Glacier into the Upper Bradley River (USGS Gage No. 15238990; 1979–2022), adjusted for differences in basin area. That estimated flow and the measured flow in 2023 and 2024 were combined to develop a 45-year hydrograph for the EFMR and were used to generate the metrics and figures in this section (DOWL 2025).

Seasonally, median estimated flows at the EFMR were highest in August (854 cfs) and July (813 cfs), followed by September (408 cfs) and June (225 cfs), and they were relatively low in October (80 cfs) and May (21 cfs). Flows were estimated to be less than 5 cfs approximately 6 percent of the time, typically between November and May. The annual peak flow from Dixon Glacier exceeded 1,000 cfs in 42 of 45 years, 2,000 cfs in 27 of 45 years, and 3,000 cfs in 9 of 45 years (Figure 4.3-3).

The EFMR displays diel fluctuation in flow, typically in July and August, driven by solar radiation resulting in increased glacial melt. Stage height data from the EFMR USGS gage show daily variation of roughly 0.25 to 0.30 foot within a day, with lows occurring between 8 and 10 a.m. and highs between 6 and 8 p.m. The synthetic hydrograph shows an increasing trend in runoff volume, with the total average annual runoff increasing approximately 8 percent every 10 years (Figure 4.3-4), which is consistent with observations in other glacial systems (Milner et al. 2009).

Estimated flow exceedances by month for the proposed Project's timeframe of operation are illustrated in Figure 4.3-5. Table 4.3-2 provides combined monthly flow data from the 43-year synthetic record and 2023–2024 discharge measured at the mouth of the EFMR.

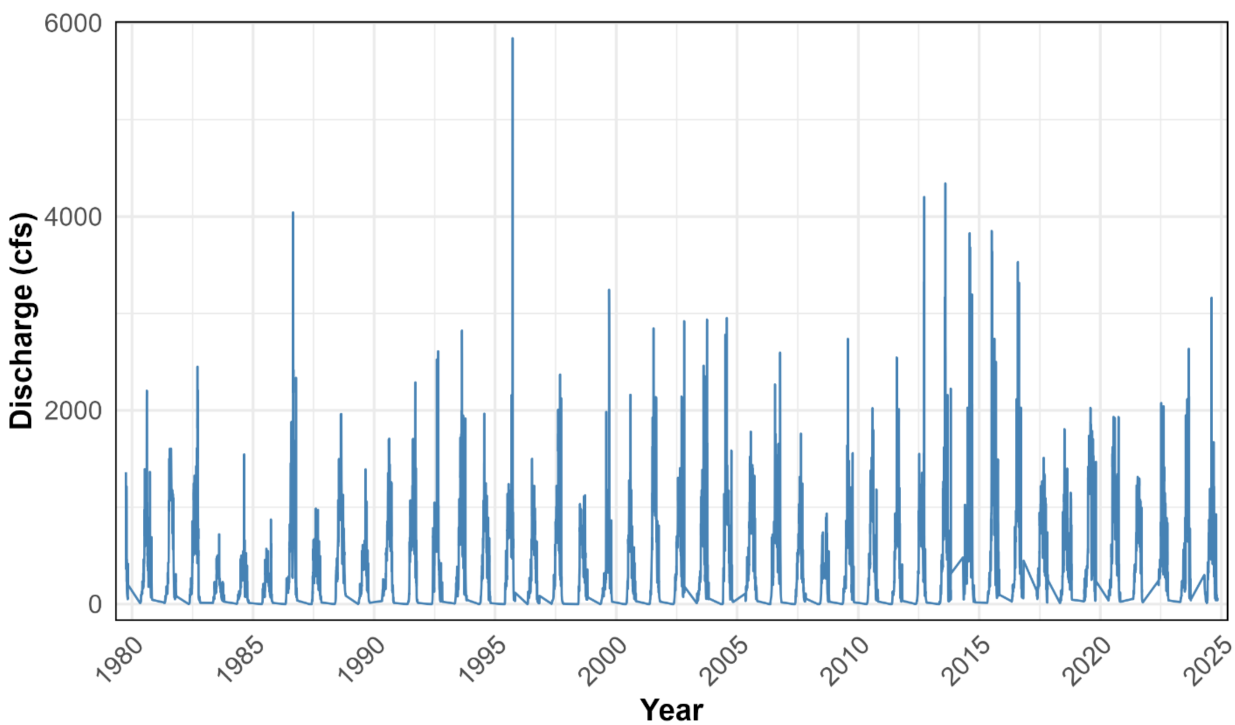

Figure 4.3-3 Daily average flow for the East Fork Martin River, 1979–2024.

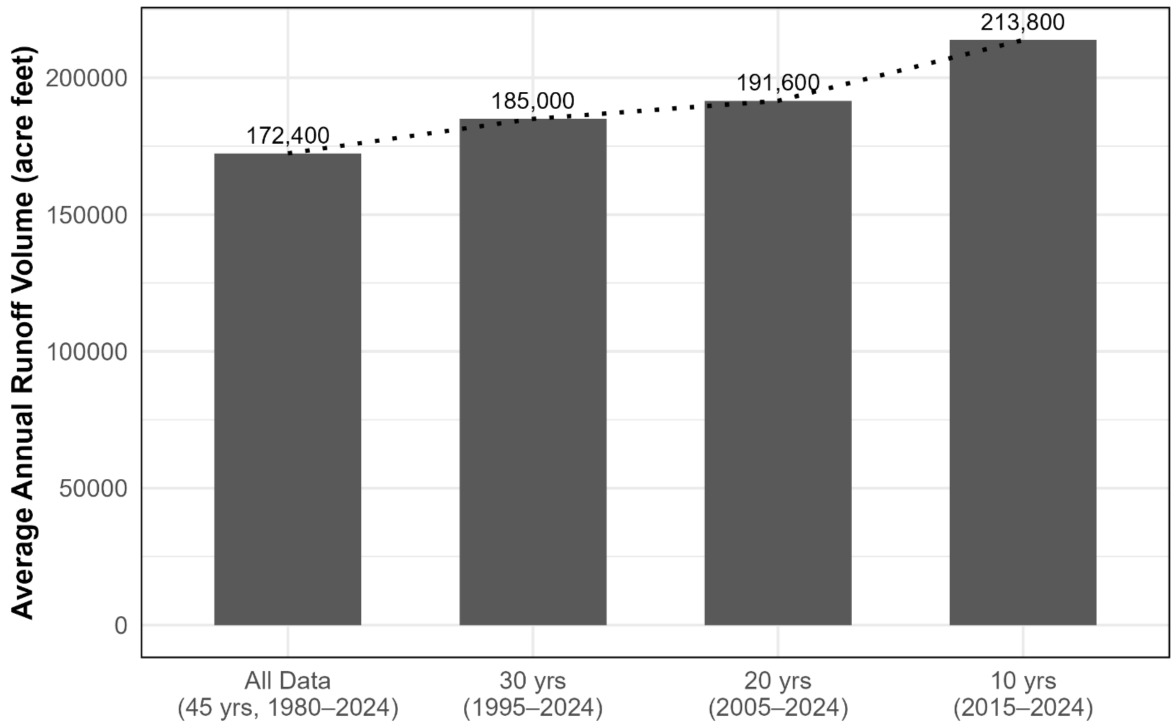

Figure 4.3-4 Average annual runoff volume of the East Fork Martin River at the mouth, 1979–2024.

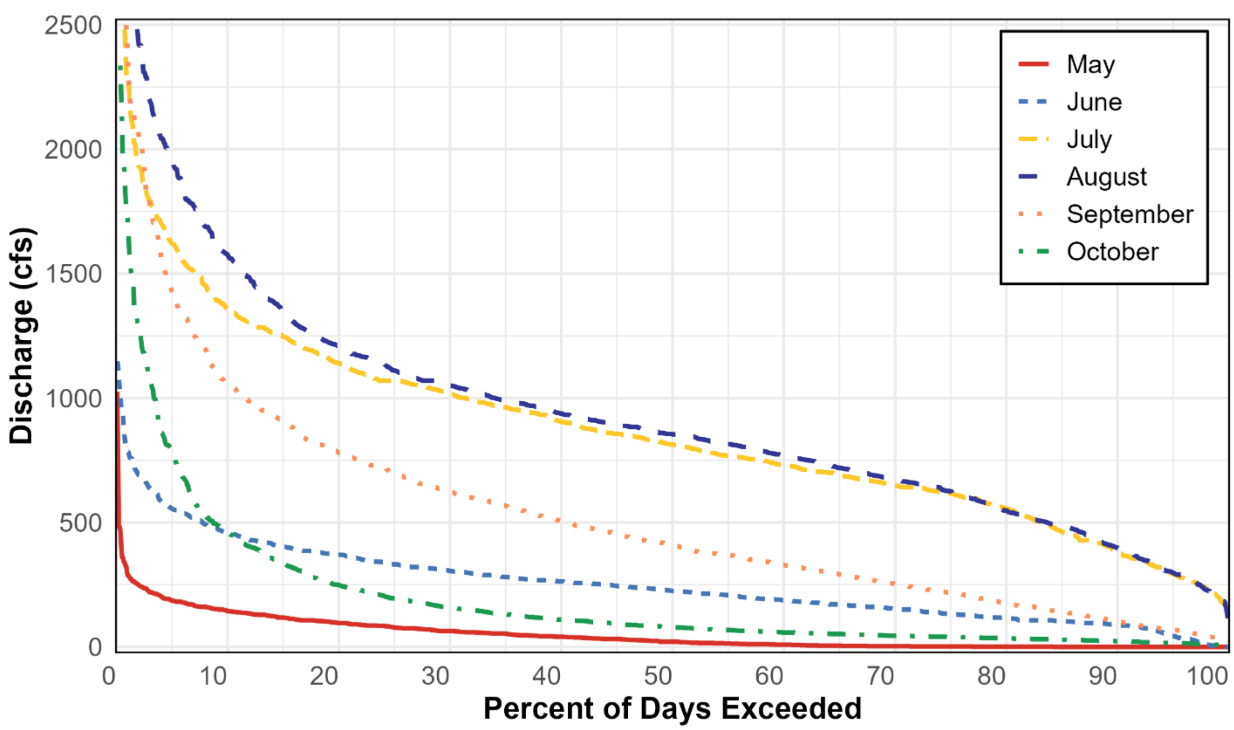

Figure 4.3-5 Estimated flow exceedance for the East Fork Martin River at its mouth, 1979–2024.

Table 4.3-2 Monthly flow data (cfs) for East Fork Martin River at its mouth based on synthetic record (1979–2022) and AEA discharge data measured 2023–2024.

Month	Flows			Exceedance Values				
	Min	Mean	Max	10%	25%	50%	75%	90%
May	0	52	1,026	144	78	21	2	0
June	0	253	1,147	462	332	225	133	88
July	150	871	3,851	1,356	1,070	813	616	384
August	107	940	4,343	1,571	1,110	854	625	399
September	24	538	5,841	1,053	698	408	219	104
October	4	192	2,937	456	195	80	39	23

4.3.1.1.2 Water Quality

None of the Project waters are listed for any impairments by the United States Environmental Protection Agency (USEPA) or ADEC.

Temperature

Continuous temperature monitoring conducted at several sites in 2023–2025 highlighted the distinct water temperature regimes present in the mainstem Martin River and EFMR compared to the off-channel/tributary complexes such as the Swan Lake Outlet, MR1.070, OCH2.8R, OCH3.8L, OCH4.2R, and the Red Lake Outlet (WFMR) (Figure 4.3-1).

Mainstem Martin River and EFMR water temperatures are consistently low from May through October. The EFMR temperatures reach their highest (3°C to 5°C) in late May following snowmelt but prior to glacial melt. As the glacier melts, temperatures drop to about 1°C to 2°C and remain fairly constant through September. As air temperatures cool late September and October, and precipitation events contribute more flow, the EFMR temperatures remain low but exhibit more variation. The Martin River at PRM 1.9 demonstrates a similar pattern with temperatures about 4°C warmer than the EFMR during the spring prior to glacial melt and about 1°C to 2°C warmer during the summer and fall. Water temperatures in the mainstem also exhibit diel fluctuation, with maximum and minimum recorded temperatures in the same day at PRM 1.9 sometimes varying up to 4°C during the summer. There was some variation in these trends from 2023 through 2025, as shown in Figure 4.3-6. The red dotted lines in these plots indicate the 15°C ADEC upper threshold for rearing salmonids.

All other tributaries of OCH to the Martin River are rain, spring, or snowmelt-fed, and some host relatively small (less than 10 acres), shallow lakes (e.g., Red Lake and Swan

Lake) that produce significantly warmer (greater than 12°C) and clearer (less than 5 NTUs) water in the summertime, unless they become inundated with glacial water, as Red Lake and OCH4.2R did in 2024 and Swan Lake did in 2025. OCH4.2R, which is also sourced from a small lake, was monitored in 2023 and 2024 and saw substantial differences between the 2 years due to repeated inundation by glacial waters from mid-July to mid-September in 2024. The tributaries and OCHs without lakes (MR1.070, OCH2.8R, OCH3.8L) tend to host intermediate temperatures, falling somewhere in between the glacial water of the mainstem and the lake-fed tributaries (Figure 4.3-6). Warmer water inputs from off-channel complexes during the summer have little influence on the mainstem Martin River, as their relative flow contribution is low.

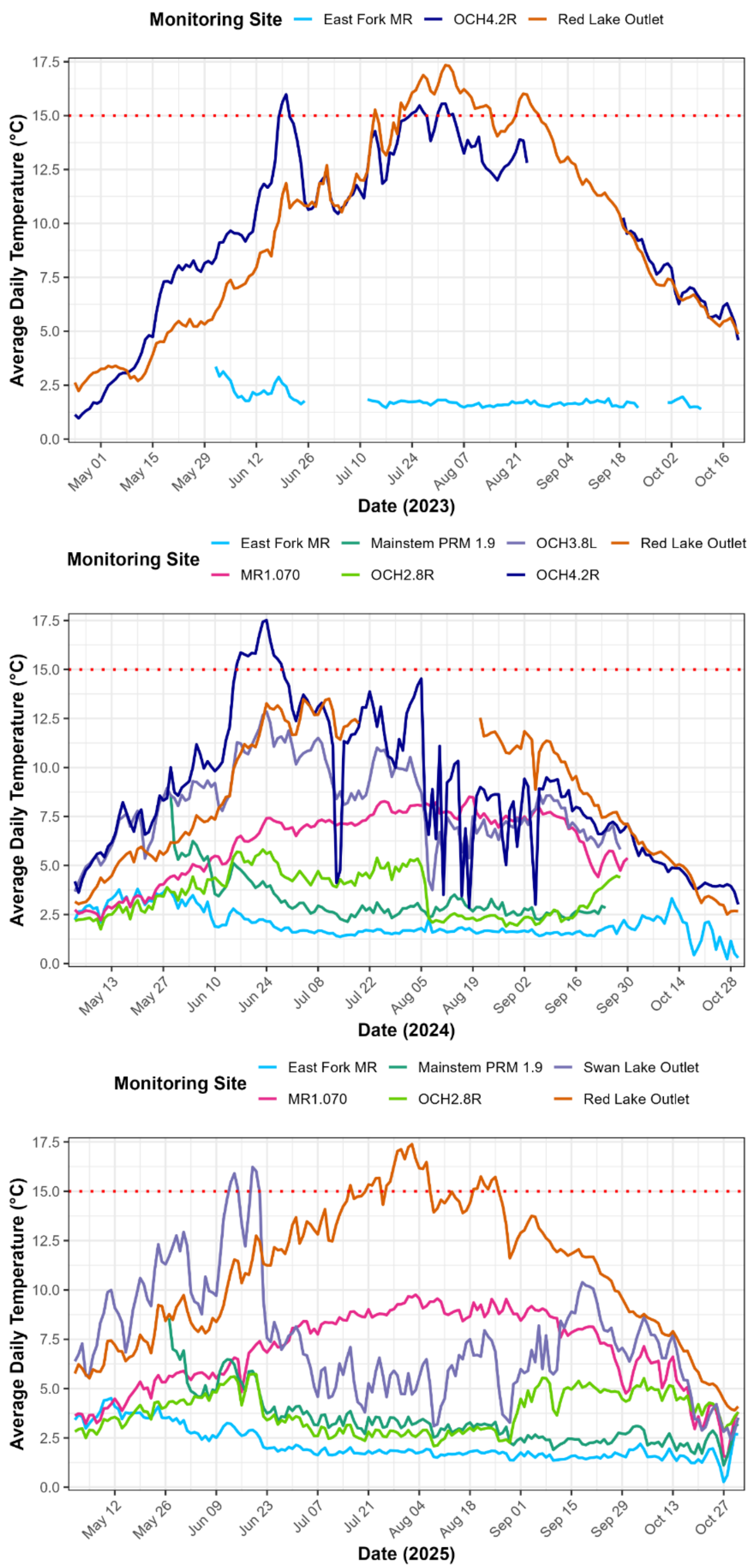

Figure 4.3-6 Average daily water temperatures from the 2023–2025 field seasons in the mainstem Martin River, East Fork Martin River, Red Lake Outlet, and other off-channel and tributary complexes.

Water quality monitoring from 2023–2025 documented multiple exceedances of the ADEC temperature criterion for rearing salmonids (15°C), all of which occurred in OCH4.2 and the outlets of Red Lake and Swan Lake (Table 4.3-3). Swan Lake Outlet was only monitored in 2025, while OCH4.2R was not monitored in 2025. Swan Lake was inundated by glacial water beginning on June 22, 2025, resulting in a subsequent drop in water temperatures (Figure 4.3-6). All exceedances for the Swan Lake Outlet occurred prior to June 22.

Table 4.3-3 Total days with the daily maximum temperature exceeding the 15°C ADEC threshold for rearing salmonids by off-channel habitat.

Off-channel Habitat	Year		
	2023	2024	2025
Swan Lake Outlet	NA	NA	11
OCH4.2R	41	32	NA
Red Lake Outlet (WFMR)	43	1[a]	40

[a] Likely underestimated due to a data gap from mid-July to mid-August.

Turbidity

Turbidity in the mainstem Martin River and EFMR is at its lowest (less than 5 NTUs) during the spring when EFMR flows are low and increases to its summer baseline during glacial melt, typically fluctuating between 60 and 450 NTUs (Kleinschmidt 2025, 2026a). Fall turbidity varies, with dry periods seeing turbidity as low as 5 NTUs and precipitation events pushing turbidity above 240 NTUs (Kleinschmidt 2025, 2026a). For example, following multiple dry, clear days, mainstem turbidity on September 30, 2025, was 13 NTUs but increased to more than 240 NTUs following substantial precipitation on October 4 to 5, 2025 (Kleinschmidt 2026a).

Turbidity is generally lower than 5 NTUs in all non-glacial tributaries during May through October, except when inundated with water from the mainstem Martin River (Kleinschmidt 2025, 2026a). During significant high flow events in August of both 2024 and 2025, floodwaters inundated the floodplain and influenced much of the OCH within and adjacent to the floodplain. These floods created new channels within the floodplain that in summer 2025 resulted in OCH2.8R and Swan Lake being directly connected to the mainstem during flows of about 600 cfs (Photo 4.3-5) and, in fall 2025, OCH 1.7R, OCH3.0L, and portions of OCH 2.8R being directly connected to the mainstem during lower (OCH 1.7R) and higher (OCH1.7R, OCH 3.0L, and OCH 2.8R) fall flows, resulting in high turbidity and low temperatures relative to other OCHs.

Plots of turbidity data collected during 2023 through 2025 field efforts can be found in Kleinschmidt (2025, 2026a).

Photo 4.3-5 Upstream view of Swan Lake and the OCH2.8R complex inundated with turbid mainstem Martin River water. Photo taken August 3, 2025.

Dissolved Oxygen

Dissolved oxygen (DO) is generally high in both the glacial and non-glacial portions of the system throughout May to October and did not appear to change seasonally. Most DO concentration measurements collected from 2023 to 2025 exceeded 10 milligrams per liter (mg/L; some even exceeding 13 mg/L), and few falling just below 9 mg/L. While no DO concentrations measured below the ADEC criterion of 7 mg/L, multiple DO saturation measurements exceeded the 110 percent ADEC threshold, including Red Lake in 2023 (112.9 percent) and 2025 (139.0 percent), and Swan Lake Outlet (116.3 percent) and MR1.120.L1 (115.6 percent) in 2025. Plots of DO data collected during the 2023–2025 field efforts can be found in Kleinschmidt (2025, 2026a).

pH

Measurements of pH were similar between glacial-influenced areas and the clearwater OCHs, with most measurements falling between 7 and 8. Only one measurement from the 2023–2025 field efforts fell outside the ADEC pH lower (6.5) and upper (8.5) thresholds. On October 3, 2025, a pH of 8.72 was recorded in the Red Lake Outlet (WFMR), while both adult and juvenile Dolly Varden and Coho Salmon were present in the tributary (Kleinschmidt 2025, 2026a). Plots of pH data collected during the 2023–2025 field efforts can be found in Kleinschmidt (2025, 2026a).

4.3.1.2 Bradley Lake

4.3.1.2.1 Water Quantity

Bradley Lake was a natural lake created by glacial activity, and the depth and extent of the lake was increased when Bradley Lake Dam was constructed in the early 1990s. Prior to construction, Bradley Lake was a 1,568-acre lake with a water surface elevation of El. 1,080 feet. Currently, the maximum depth of Bradley Lake is about 368 feet. Bradley Lake Dam has an active storage of 280,000 acre-feet between the operating pool elevations of El. 1,080 feet and El. 1,180 feet. At the full normal operating pool elevation of El. 1,180 feet, Bradley Lake has a surface area of 3,802 acres. Bradley Lake can be drawn down to El. 1,060 feet for maintenance and emergencies.

Bradley Lake is primarily fed by glacial runoff from the Nuka Glacier and tributaries north of the lake. The Nuka Glacier feeds the Upper Bradley River, which flows into Bradley Lake from the southeast. Glacially fed Kachemak Creek enters Bradley Lake from east-southeast. Marmot Creek and the Middle Fork Bradley River Diversion enter Bradley Lake from the north. Independent diversions on the EFUBC and WFUBC direct flow to Bradley Lake from the south (Figure 4.1-1). The WFUBC Diversion became operational in July 2020. The average inflow to Bradley Lake (2021–2025) was estimated from the daily reservoir elevations, water surface elevation-storage rating curve, discharge through the turbines, and discharge released through the fishway minimum instream flow valves. Table 4.3-4 provides the average daily inflows (cfs) by month and the average monthly inflows (acre-feet) to Bradley Lake based on generation records and reservoir elevations since the WFUBC Diversion has been in use. Outflows from Bradley Lake include the lower Bradley River through the fishway valves and the Bradley Lake Project power tunnel to the Bradley Lake Project powerhouse, both of which ultimately flow into Kachemak Bay.

Table 4.3-4 Average daily and monthly inflows to Bradley Lake (2021-2025).

Month	Average Bradley Lake Inflow	
	Daily (cfs)	Monthly (ac-ft)
January	91	5,607
February	53	2,955
March	57	3,501
April	100	5,958
May	476	29,256
June	1,433	85,259
July	1,653	101,625
August	1,671	102,743
September	1,059	62,990
October	455	27,974
November	165	3,603
December	155	9,539
Average Monthly	**614**	
Annual Total		**441,009**

Source: Bradley Lake Dam operating records.

4.3.1.2.2 Water Quality

Bradley Lake inflow is dominated by glacial sources and thus is highly turbid and generally cold. USACE conducted water quality studies in 1979 and 1980 in Bradley Lake and at Kachemak Creek and the Upper Bradley River inlets to the lake (Table 4.3-5 and Table 4.3-6). Water temperature profiles indicated that the lake is generally isothermal at 6°C to 7°C in the summer but may partially stratify under the right conditions with temperatures at the surface ranging from 8°C to 10°C and decreasing with depth (FERC 1985). Wintertime temperatures approach 0°C with the formation of surface ice (November through May) and 2°C to 2.5°C in deeper waters (FERC 1985).

Table 4.3-5 Turbidity and suspended solids concentrations in Bradley Lake.

Date	Bradley Lake Inlet Flows		Bradley Lake Center		Bradley Lake Outlet	
	Turbidity (NTU)	Suspended Sediment (mg/L)	Turbidity (NTU)	Suspended Sediment (mg/L)	Turbidity (NTU)	Suspended Sediment (mg/L)
10/18/1979	145	170.0	170	201.0	170	208.0
5/1/1980	-	-	74	50.2	78	46.3
8/3/1980	62	5.8	51	6.5	55	4.8
9/29/1980	61	48.3	55	46.5	50	44.1

Source: AEA (2016).

Table 4.3-6 Water quality data collected in Upper Bradley River and Kachemak Creek.

Date	Turbidity (NTU)	Suspended Sediment (mg/L)	Dissolved Oxygen (mg/L)_	Ammonia Nitrogen (mg/L)	Orthophos phate (mg/L)
Upper Bradley River (Lake Inlet)					
10/18/1979	155.0	508.0	12.33	0.00	0.660
5/1/1980	1.2	0.9		0.01	0.005
8/3/1980	37.0	91.4	8.78	0.08	0.340
9/29/1980	54.0	111.0	9.48	0.02	0.270
Kachemak Creek (Lake Inlet)					
10/18/1979	190.0	2,566.0	12.20	0.00	2.500
5/1/1980	1.5	4.5	9.69	0.01	0.025
8/3/1980	89.0	36.5	9.76	0.08	0.410
9/29/1980	83.0	399.0	9.62	0.02	0.360

Source: AEA (2016).

4.3.1.3 Bradley River

4.3.1.3.1 Water Quantity

Most of the water in Bradley Lake is diverted to the powerhouse and into Kachemak Bay via the tailrace. Water is released to the Bradley River from the dam through the fishway valves to meet MIF requirements. Bradley Lake captures high flow events from glacial sources; thus, the hydrograph for the lower Bradley River between the dam and its confluence with the Middle Fork is consistent with that of rain and snowmelt dominated systems, which see low flows in winter and peak flows in spring and fall (Rickman 1995).

In addition to discharge from the dam, the lower Bradley River receives inflows from the Middle Fork which includes the Middle Fork bypass basin and the North and West forks of the Bradley River.

USGS operates several gages in the Bradley River basin (see Section 4.1.1.1). USGS Gage No. 15239070 Bradley River near Tidewater measures the discharge of the Bradley River downstream of its confluence with the Middle Fork and is the point of compliance for the required Bradley Lake Dam minimum flow releases (USGS 2026). The required Bradley River MIFs as measured at USGS Gage No. 15239070 are: 100 cfs May 12 – September 14; 50 cfs September 24 – October 31; and 40 cfs November 2 – April 30 with ramping rates of 5 cfs per day between seasonal transitions.[8] The MIF requirements are based on the 24-hour rolling average defined as the average flow for a point in time using the proceeding 12-hour period and the succeeding 12-hour period. The minimum, average, and maximum daily discharge measured at the Tidewater gage for the last 20 years is provided by month are presented in Table 4.3-7.

Table 4.3-7 Lower Bradley River mean daily discharge measured at USGS Gage No. 15239070 Bradley River near Tidewater (2006-2025).

Month	Minimum Daily Discharge (cfs)	Mean Daily Discharge (cfs)	Maximum Daily Discharge (cfs)
January	41	85	1,030
February	40	66	256
March	40	60	243
April	40	71	317
May	47	149	384
June	104	163	426
July	100	129	301
August	100	124	211
September	56	177	1,650
October	42	114	1,020
November	26[a]	95	980
December	40	96	2,590
Annual		**111**	

Source: FERC Order Amending Minimum Flows, issued September 8, 2020.

[a] Minimum daily flows were 26 cfs on November 27, 2008 and 31 cfs on November 28, 2008. All other November flows over the period of record were >46 cfs.

[8] Order Amending Minimum Flows (172 FERC 62,132). Issued September 8, 2020.

4.3.1.3.2 Water Quality

The temperature regime in the lower Bradley River is largely influenced by outflow from the lake and flows from the Middle and North forks. Water temperatures range from peaks of 11°C to 14°C in late summer to minimums at 0°C from December through March measured at the USGS Tidewater Gage (Gage No. 15239070). Intragravel water temperature is generally 0.5°C to 1.0°C warmer than surface water during winter months. DO concentrations for the lower Bradley River ranged from 9.5 to 15.0 mg/L with percent saturation ranging from 67 to 103 percent. DO concentrations of intragravel water ranged from 8.2 to 15.3 mg/L (Rickman 1995, 1998). Turbidity follows the trend seen in Bradley Lake, in which suspended sediments and subsequently turbidity is highest in summer and reduces through the wintertime.

4.3.1.4 Kachemak Bay

4.3.1.4.1 Water Quantity

Kachemak Bay currently receives unimpeded flow from the Martin River that typically peaks in late summer with high temperatures driving glacial melt. Flow from the Bradley Lake and river system reach the bay via the river channel or the powerhouse tailrace, with flows from the tailrace highest in early fall and winter to accommodate energy demand and peaking operations, and average daily flows in the Bradley River generally highest in the summer based on data from USGS Gage No. 15239070.

4.3.1.4.2 Water Quality

Input from the Martin River to Kachemak Bay, in conjunction with the nearby mouths of Battle Creek and the Bradley River, create estuarine habitat characterized by gradients in temperature, salinity, and turbidity (Field and Walker 2003; Hartwell et al. 2009). While not extensively studied in Kachemak Bay, glacial freshwater inputs to other marine environments in Alaska transport high loads of suspended sediments and dissolved nutrients, including nitrogen, phosphorus, silica, iron, and labile organic matter, which can subsidize coastal primary production and microbial activity (Hood and Berner 2009; Hopwood et al. 2020). However, glacial input can also stratify surface waters in estuarine and marine environments, sometimes suppressing productivity by reducing light penetration (Meire et al. 2017). Thus, estuaries receiving glacial meltwater often exhibit strong physical and biogeochemical gradients, with glacial inputs acting as both sources of nutrients and modifiers of light and mixing regimes that ultimately shape patterns of estuarine production.

4.3.2 Environmental Analysis

4.3.2.1 Construction

To limit the potential for adverse environmental effects during construction and to ensure compliance with both the CWA and the National Pollutant Discharge Elimination System (NPDES), AEA would require all contractors to implement standard BMPs such as erosion and sediment control, fuel and chemical management, and stormwater management measures. These standard safeguards are consistent with industry practice for construction and are designed to maintain the integrity of water resources. Potential construction impacts from the Proposed Action are described below. There would be no construction-related impacts anticipated to Kachemak Bay, as there would be no operation of equipment or vehicles below the OHW line and no refueling, stockpiling, or staging within 100 feet of Kachemak Bay OHW.

4.3.2.1.1 Dixon Diversion

Martin River

Construction of the Dixon Diversion would disturb approximately 26 acres around the diversion site adjacent to and within the EFMR. This area was recently deglaciated, and there are areas of unconsolidated till and outwash that would be disturbed, which could be destabilized when disturbed. Some areas of bedrock would also be removed for the tunnel and intake facilities. Appropriate BMPs and erosion and sediment control measures would be implemented to minimize movement of disturbed soil and rock into the Martin River. The river naturally carries a very high sediment load, so it is anticipated that erosion of small amounts of material into the river would not result in substantial effects on water quality.

The diversion structure would be built within the existing EFMR channel. This would require temporary measures (e.g., cofferdams) to divert the Martin River around the diversion construction site and dewatering the EFMR downstream of the proposed diversion. Proposed construction sequencing would drill the diversion tunnel prior to constructing the permanent diversion structure, so up to 1,650 cfs could be diverted into the tunnel during construction of the diversion structure. Proper cofferdam sizing would limit this risk of overtopping during a large flood flow. Construction would temporarily change local hydrology and water quantity levels downstream of the proposed diversion structure. The effects on water quantity and flows in the EFMR and Martin River downstream of the proposed diversion site during construction are expected to be limited and short in duration or would be similar to the impacts described under operations in Section 4.3.2.2.1. AEA will consult with ADF&G to develop in-water and water diversion windows to minimize potential impacts and proposes to have an environmental compliance monitor on site.

Bradley Lake

Tunnel muck would be disposed of in a 41-acre area between the tunnel outlet and Bradley Lake. The muck is erodible and could be eroded and transported into Bradley Lake. An ESCMP and containment measures would be implemented to minimize erosion.

Bradley River

Construction-related activity associated with the Dixon Diversion is not anticipated to impact the water quality or quantity reaching the Bradley River. No activities associated with the Dixon Diversion are proposed in the vicinity of the Bradley River downstream of the dam.

4.3.2.1.2 Bradley Lake Pool Raise

Bradley Lake

Construction activity associated with the Bradley Lake Pool Raise includes development or expansion of approximately 66 acres of borrow sites near Bradley Lake, one of which would also be used as a spoils area if needed, and construction on the current dam that impounds the lake. Erosion of borrow material from the borrow sites could enter the lake; implementation of erosion and sediment control measures would limit the likelihood of erosion. The lake would be lowered for construction such that all work would be conducted in the dry.

Bradley River

Construction activity associated with the Bradley Lake Pool Raise includes a potential 1.5-acre borrow site across the Bradley River on the north side of the dam and construction on the current dam. Erosion of unconsolidated material from the borrow site could enter the river; implementation of erosion and sediment control measures would limit the likelihood of erosion and delivery to Bradley River.

4.3.2.2 Operations

Martin River flow and glacial input to the Martin River would be reduced because of Project operations. The diversion tunnel would have a capacity to convey up to 1,650 cfs of water from the EFMR to Bradley Lake. The Project would operate May through November as flows allow after releasing minimum flows of 100 cfs to the EFMR throughout operation. Flows that exceed the capacity of the tunnel conveyance inlet would bypass the diversion and flow into EFMR. To maintain bedload delivery and transport through the system, a channel maintenance flushing flow regime of 1,000 cfs for 12 hours a minimum of 3 years out of each moving 10-year average of Project operation is proposed. In addition, periodic sediment management at the diversion would occur to flush coarse-grained sediment accumulated within the forebay pool, likely on at least an annual basis. The Bradley Lake Pool Raise would increase the normal maximum pool elevation by 16 feet. The below sections discuss the potential effects of these actions on water quantity and quality in the Martin River, Bradley Lake, the Bradley River, and Kachemak Bay.

4.3.2.2.1 Martin River

Water Quantity

The proposed Project would reduce flows in the EFMR and Martin River during operations. The estimated daily (cfs) and monthly (acre-feet) water diverted from the Dixon Diversion at a maximum rate of 1,650 cfs after releasing the proposed EFMR MIF of 100 cfs are provided in Table 4.3-8.

Table 4.3-8 Estimated average daily and monthly inflows diverted from the EFMR to Bradley Lake with the proposed Dixon Diversion.

Month	Average Dixon Diversion[a]	
	Daily (cfs)	Monthly (ac-ft)
January	0	0
February	0	0
March	0	0
April	0	0
May	21	1,301
June	233	13,876
July	873	53,698
August	892	54,832
September	454	26,986
October	166	10,194
November	0	0
December	0	0

Month	Average Dixon Diversion[a]	
	Daily (cfs)	Monthly (ac-ft)
Average Monthly	**220**	
Annual Total		**160,887**

[a] Dixon Diversion flows and volumes are based on the 10-year average comprised of synthetic (2016-2022) and measured (2022-2025) discharge.

Under baseline conditions in May, the proposed MIF of 100 cfs was exceeded 20 percent of days based on the 1979–2024 hydrograph. In October, instream flow of 100 cfs was exceeded 42 percent of days. For these months, most days would not see a change from the baseline condition for flow in the EFMR. From June to September, peak flows and flow variability in the mainstem Martin River would be substantially reduced, with exceedances of 100 cfs under the baseline hydrograph in 86 percent (June), 100 percent (July and August), and 90 percent (September) of days. Over the extent of annual operations, the EFMR would experience the MIF (100 cfs) or less 97.5 percent of the time on average based on the 1979–2024 hydrograph. Therefore, the EFMR would exceed the MIF 2.5 percent of the time during operations, with most of that exceedance likely to occur in August (Figure 4.3-7). Daily average flow by month for baseline conditions and operations as well as estimated exceedance values are shown in Table 4.3-9.

With the Proposed Action, the highest stream flows would occur in the summer months based on snowmelt and runoff similar to existing conditions. While the stream flow in the Martin River would be less during operations, summer and fall storms, flows from the downstream drainage area (14.9 square miles), and the proposed environmental bypass flow of 100 cfs would ensure relatively constant flows in the Martin River. As shown in Figure 4.3-1, runoff volume to the EFMR has been increasing through the extent of the hydrograph and is expected to continue to increase into the near future. Therefore, the exceedances reported above are expected to increase through time.

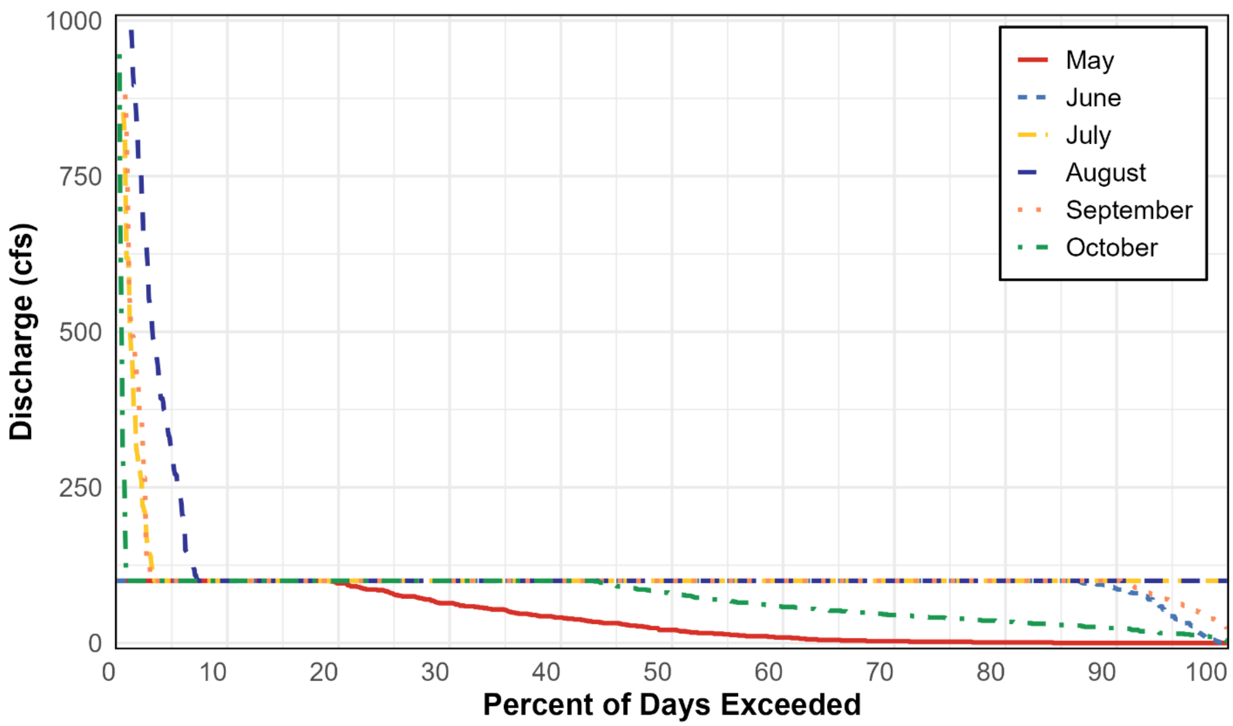

Figure 4.3-7 Estimated flow exceedance for the East Fork Martin River with Dixon Diversion operation at a maximum diversion of 1,650 cfs, based on flows from 1979–2024.

Table 4.3-9 Estimated average daily discharge (cfs) by month into the East Fork Martin River under baseline conditions (1979–2024 hydrograph) and Dixon Diversion operations as well as estimated exceedance flows assuming a 1,650 cfs maximum diversion.

Month	Baseline Discharge (cfs) (mean [range])	Operations Discharge (cfs) (mean [range])	Decrease in Average Flow (%)	Estimated Exceedance Flows				
				10%	25%	50%	75%	90%
May	52 (0-1,026)	38 (0-100)	27	100	78	21	2	0
June	253 (0-1,147)	94 (0-100)	63	100	100	100	100	88
July	871 (150-3,851)	115 (100-2,201)	87	100	100	100	100	100

Month	Baseline Discharge (cfs) (mean [range])	Operations Discharge (cfs) (mean [range])	Decrease in Average Flow (%)	Estimated Exceedance Flows				
				10%	25%	50%	75%	90%
August	940 (107-4,343)	139 (100-2,693)	85	100	100	100	100	100
September	538 (24-5,841)	119 (24-4,191)	78	100	100	100	100	100
October	192 (4-2,937)	74 (4-1,287)	61	100	100	80	39	23

Water Quality

Anticipated direct water quality impacts resulting from reduced mainstem flow downstream of the diversion would include increases in mainstem water temperatures and lower turbidity in the mainstem Martin River. However, these changes would vary temporally within the operation timeframe. For example, only 42 percent of days in October and 20 percent of days in May exceed 100 cfs, so many days in those months would not have flow diverted and, consequently, would reflect baseline water quality conditions. Conversely, 94 percent of days from June to September see flows in exceedance of 100 cfs, so we would expect greater changes to water quality in these months.

The magnitude of these changes will be a function of flow proportion from the EFMR and "warm water" tributaries but also impacted by increased solar radiation impacts due to lower velocities and longer water residency times in the watershed (Kleinschmidt 2026b). However, it is also anticipated that the channel would stabilize and riparian encroachment would shade areas of the river. AEA developed a water temperature model to predict the impact of the proposed Project operations on water temperatures in mainstem Martin River at PRM 1.9 under "worst-case" assumptions, which incorporate the highest recorded tributary input temperatures (18°C) and relatively high solar radiation warming assumptions. This model predicted increases in average daily water temperature from 3.8°C to 5.9°C above baseline conditions, and 7-day average of the daily maximum (7DADM) increases from 4.2°C to 5.4°C above baseline conditions. Most average daily modeled temperatures fell between 6°C and 12°C, and all remained below the ADEC threshold of 15°C (Kleinschmidt 2026b). The capability of water to hold DO is directly related to temperature, with warmer temperatures capable of holding less DO. DO concentrations in the mainstem Martin River under current conditions are high (greater than 12 mg/L) and well above the ADEC lower threshold of 7 mg/L. Even with the increase in temperatures shown in the model, DO is expected to remain well above the 7mg/L threshold (at 15°C, water is saturated at 10.08 mg/L; Kleinschmidt 2026b).

Turbidity is more difficult to predict quantitatively, but in adjacent Battle Creek, turbidity in lower Battle Creek downstream of the WFUBC Diversion was reduced to one third of natural conditions following the diversion operations (AEA 2025).

4.3.2.2.2 Bradley Lake

Water Quantity

Bradley Lake has a current storage capacity of approximately 280,000 acre-feet. The proposed Project would raise the full pool elevation by 16 feet and would increase total storage capacity by approximately 162,000 acre-feet to a total of 342,000 acre-feet. The proposed Dixon Diversion would capture 19.1 square miles of the Martin River drainage area, diverting an average volume of 161,000 acre-feet of water spread out over the normal operating period (Table 4.3-10). The volume of water diverted by the proposed diversion would not exceed the proposed storage capacity that would be available after the dam is modified to raise the normal maximum pool elevation by 16 feet (El. 1,196 feet).

Table 4.3-10 Average daily and monthly inflows to Bradley Lake under current conditions (2021–2025) and with the proposed Dixon Diversion.

Month	Current Average Bradley Lake Inflow[a]		Total Average Inflow with Dixon Diversion[b]	
	Daily (cfs)	Monthly (ac-ft)	Daily (cfs)	Monthly (ac-ft)
January	91	5,607	91	5,607
February	53	2,955	53	2,955
March	57	3,501	57	3,501
April	100	5,958	100	5,958
May	476	29,256	517	30,557
June	1,433	85,259	1,753	99,135
July	1,653	101,625	2,567	155,323
August	1,671	102,743	2,499	157,575
September	1,059	62,990	1,322	89,976
October	455	27,974	455	38,168

Month	Current Average Bradley Lake Inflow[a]		Total Average Inflow with Dixon Diversion[b]	
	Daily (cfs)	Monthly (ac-ft)	Daily (cfs)	Monthly (ac-ft)
November	165	3,603	165	3,603
December	155	9,539	155	9,539
Average Monthly	**614**		**834**	
Annual Total		**441,009**		**601,896**

Source: Bradley Lake Dam operating records and the *Dixon Diversion Conceptual Study Hydrology Report* (DOWL 2023).

[a] Sources of inflow to Bradley Lake include: Middle Fork Bradley River (also known as Middle Fork) Diversion (gaged), Nuka Glacier Diversion (gaged), EFUBC Diversion, WFUBC Diversion (gaged), Kachemak Glacier, and other unnamed tributary drainages.

[b] Dixon Diversion flows and volumes are based on the 10-year average comprised of synthetic (2016-2022) and measured (2022-2025) discharge.

Water Quality

The proposed increase in reservoir elevation will move the location of the high pool shoreline and erosive wave action 16 vertical feet up the sides of the reservoir. The raised pool could result in erosion if the new shoreline encounters new areas of unconsolidated colluvium or till, but based on LiDAR mapping, it does not appear that there are substantial new areas of colluvium or till that would intersect with the new shoreline position. The amount of fine-grained sediment (silt/clay) supplied to Bradley Lake would increase as turbid water from the EFMR is diverted into the lake. As the lake is already turbid from glacial melt and the volume of diverted water is small compared to the total lake volume, it is not anticipated that the sediment would markedly reduce the storage capacity of the lake. Significant impacts to the thermal profile and turbidity of Bradley Lake are not anticipated given the similarity between the EFMR and the current sources of water to Bradley Lake.

4.3.2.2.3 Bradley River

For the Project, AEA does not propose any changes to the existing minimum flow releases into the Bradley River. No impacts to downstream hydrology or water quality are expected in the lower Bradley River.

4.3.2.2.4 Kachemak Bay

Flows from the Martin River into Kachemak Bay during diversion operations should range from 100 cfs to roughly 850 cfs (mean annual peak flow from the 1979–2024 hydrograph minus the diversion capacity) during an average annual high flow event and represent 64 percent of current peak flows. Diversion operations would reduce water reaching Kachemak Bay via the Martin River, with the water that does reach the bay being slightly warmer and less turbid.

The conveyance of water from the EFMR to Bradley Lake and its subsequent use for hydroelectric generation would not change the quantity of water released into Kachemak Bay; however, it could change the timing, duration, or extent of Project discharges at the powerhouse tidal outflow location with corresponding changes in Bradley Lake storage. These changes are not anticipated to substantially impact Kachemak Bay water quality, as the diverted water would follow the existing release pathway through the powerhouse, with no changes to temperature, turbidity, or other key parameters at the discharge point.

4.3.3 Applicant-Proposed Measures

Standard BMPs will be used to minimize construction impacts and to ensure compliance with both the CWA and the NPDES. To reduce the potential for soil erosion and sediment loading to adjacent waters and the potential for fuel and hazardous substance spills, AEA proposes to develop an ESCMP and a Fuel and Hazardous Substance Management Plan. These plans would be process oriented and filed with the FAA. Implementation plans that contain site-specific details of plan activities would be developed based on Project details of the final design and through consultation with resource agencies. These plans would be filed with FERC prior to initiating ground-disturbance activities.

As part of the Proposed Action, AEA would develop a Dixon Diversion Flow Release Management Plan that would include the following:

- EFMR MIFs of 100 cfs, or bypass all available flow if less than 100 cfs, to the EFMR from the Dixon Diversion during all months of operation (May–November).
- Channel maintenance flows to the Martin River by releasing flows of 1,000 cfs a minimum of 3 years out of each moving 10-year average of Project operation.

AEA also proposes to develop an EFMR Flow Measurement Plan to monitor flows diverted to Bradley Lake and bypassed to the EFMR and several monitoring plans to ensure that the proposed flows protect water quality in the Martin River; such plans would support anadromous fish (Water Temperature and Turbidity Monitoring Plan) and provide adequate flow to the Martin River for bedload transport (Martin River Sediment Transport Monitoring Plan) and habitat connectivity in the Martin River between Red Lake and

Kachemak Bay (see Section 2.2.3.2). These plans would be implemented post-construction.

AEA is not proposing any mitigation for protection of water quality in Bradley Lake because the additional water proposed to be diverted from the EFMR is of glacial origin, as is Bradley Lake.

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4.4 Fish and Aquatic Resources

The proposed Project may affect fish and aquatic resources in the Martin River from reduced stream flow during the months of operation. To understand the aquatic resources in the Martin River basin and potential effects of the Project, AEA monitored stream temperature and discharge 2022–2025 (DOWL 2023, 2025); conducted several studies in 2024 and 2025 related to water quality, fish habitat, and fish use of available habitat (Kleinschmidt 2025b, 2026a, 2026b); and funded ADF&G to monitor adult salmon run timing and counts at Red Lake (Otis 2016; Blackmon and Otis 2023, 2024). Detailed study results can be found in the study reports posted to AEA's Project website.[7]

4.4.1 Affected Environment

4.4.1.1 Martin River

4.4.1.1.1 Aquatic Habitat

The Martin River consists of a highly dynamic glacially-dominated mainstem fed by the Dixon Glacier and a network of small tributaries and OCHs, including side channels, sloughs, and connected lakes. In addition to this spatial habitat diversity, the seasonally varying flow patterns between rain/snow-fed tributaries and the glacier-fed EFMR and mainstem channels provide temporal diversity in flow, temperature, and turbidity.

<u>Mainstem Martin River</u>

The Martin River is a braided glacial river with a very high sediment load. Channel gradient is fairly consistent from the mouth to the EFMR canyon, with a slight increase in gradient upstream from PRM 2.5. Streamflow in the Martin River varies from just a few cfs in winter months to 500–1,000 cfs during the glacial melt season (June or July through September or October). Peak flows of several thousand cfs occur during large rainfall events, usually in August or September.

During summer, when glacial input is at its maximum, mainstem water temperatures and channel stability are low, and flows are high. These mainstem summer flows result in homogenized channel habitat with little to no wood, few existing pools, and unstable gravel beds. The frequency of channel migrations within one summer can result in bedload movements that fill existing channels while cutting new channels from scour. Substrates consist of boulders and cobble in the upper reaches of the mainstem and transition to cobble and gravels downstream from PRM 4 before grading into finer material in the intertidal reaches.

The mainstem stream bed is highly mobile, experiences high velocities and low temperatures throughout the summer and early fall, and hosts little structural habitat (e.g., large boulders or woody debris). These characteristics significantly limit the suitability of the mainstem Martin River for both fish rearing and spawning. The mainstem Martin River serves primarily as a migration corridor for salmonids moving upstream to spawn in suitable OCHs and tributaries, such as Red Lake and the Swan Lake/OCH2.8R complex, and for juveniles moving downstream to rear in accessible OCH/tributaries or outmigrating to Kachemak Bay (Kleinschmidt 2025b, 2026a). High water velocities in the mainstem during the summer months limit not only adult salmonid spawning, but likely also migration through the mainstem to the OCHs that host suitable spawning habitat. In July and August, flows in the Martin River are typically greater than 500 cfs, and velocities exceed 4.4 feet per second. This timeframe aligns with Pink Salmon and Chum Salmon freshwater migration and spawning; neither species have been observed spawning in the Martin River watershed, but both spawn in the adjacent Bradley River (Morsell et al. 1992), and Pink Salmon spawn in the adjacent Battle Creek (Kleinschmidt 2026a).

Since 2022, AEA has documented substantial changes in the location of both the mainstem and tributary channels across the floodplain due to high flow events that occurred in all years during August (1- to 2-year events) and a 10- to 20-year event that occurred August 6-7, 2024. Multiple high flow events each year resulted in bedload transport and minor to moderate channel change in the densely braided sections of the river, typical of a braided glacial river. The larger events, especially the August 2024 event, redistributed large amounts of sediment in both the mainstem floodplain and OCH, resulting in channel disconnections (dewatering of the OCH1.7R mouth in spring through summer 2025), new connections (OCH4.2R consistently inundated with mainstem flow in 2024 [Figure 4.3-5], mainstem side channel entering and inundating OCH2.8R and Swan Lake during summer flow in both 2024 and 2025 [Figure 4.3-5]; OCH1.7R and OCH3.0L as connected side channels to the mainstem in fall 2025), and changes in sediment composition (deposition of inches to feet of fines across many OCH complexes following the 2025 high flow event and persisting into the fall spawning season; Kleinschmidt 2026a). These high flow events occurring annually underscore the baseline condition of the Martin River watershed as a shifting mosaic of dynamic habitats across the landscape.

<u>Martin River Off-channel Complexes and Tributaries</u>

Unlike the mainstem Martin River, the OCH and tributaries provide a variety of habitat conditions for rearing salmonids and resident fish. The flow regimes and gravel composition in many OCHs are also suitable for spawning salmon. The tributary subbasins are rain or snowmelt systems with higher flows during the spring snowmelt period, low flows during the summer, and intermediate flows during the fall from rain events (Kleinschmidt 2026a). AEA mapped the hydrography of the Martin River watershed using LiDAR and aerial imagery acquired in 2022 and 2024, conducted stream habitat surveys in OCH and the lower reaches of accessible tributaries, and monitored water quality at select locations (Kleinschmidt 2025a, 2026a).

Surveyed habitat in the OCH complexes was largely composed of riffle and glide sequences and scattered pools, with the majority of available wetted habitat surveyed in OCH2.8R (46 percent of total surveyed area), followed by OCH1.7L (19 percent), OCH3.0L (16 percent), Tributary MR1.070 (7 percent), OCH1.7R (5 percent), OCH4.2R (4 percent), and OCH3.8L (3 percent; Figure 4.4-1). However, the proportion of salmonid spawning and rearing habitat varied widely among these OCHs based on habitat type and substrate compositions (Kleinschmidt 2025b).

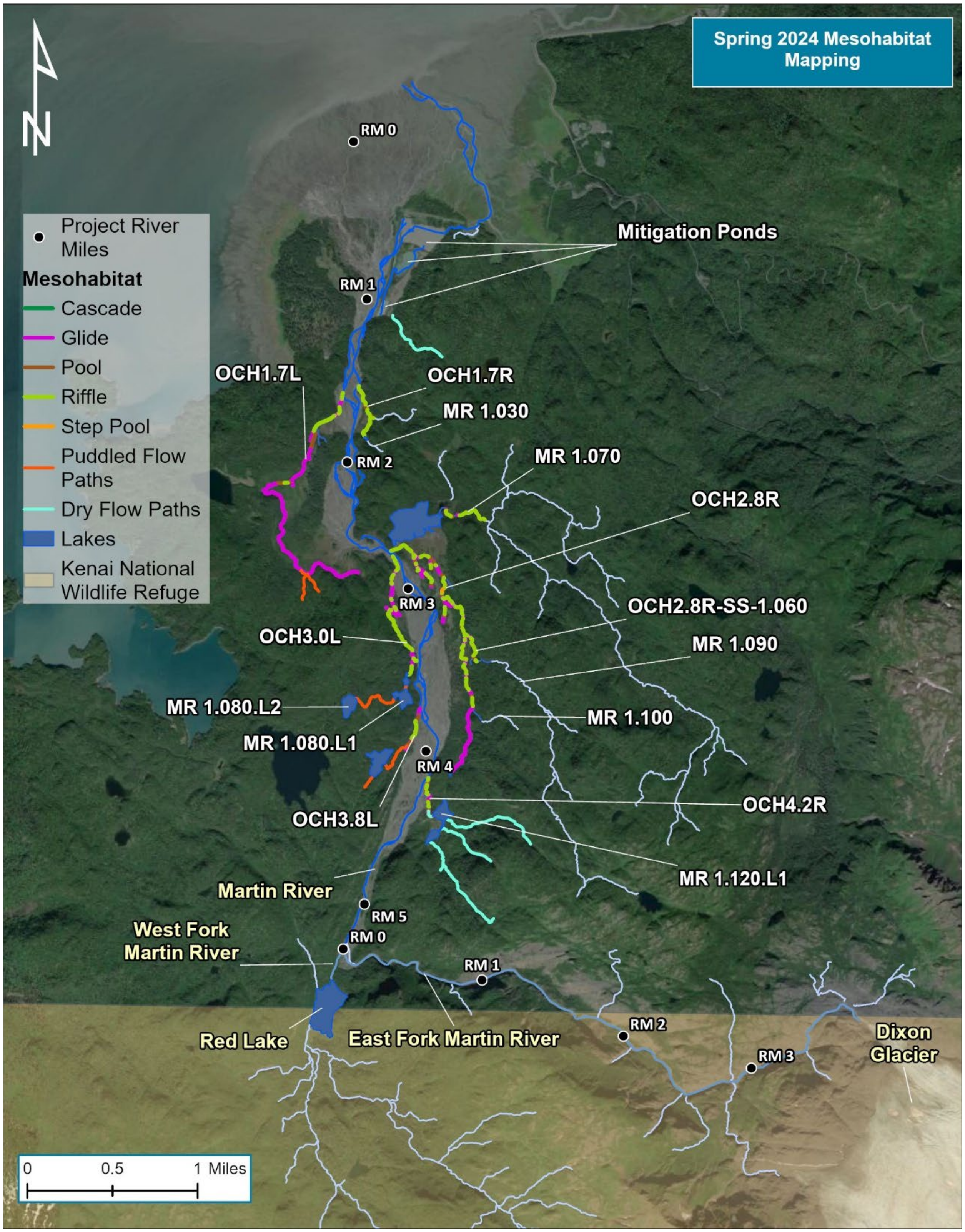

Figure 4.4-1 Martin River stream habitat mapping results, 2024.

Tributary MR1.070 and OCH2.8R hosted most of the system's spawning habitat and subsequently dominated observations of adult salmonids during spawning surveys in both 2024 and 2025. The tributary and the OCH drain into the Swan Lake complex (Upper and Lower Swan Lake), where lentic habitat exists for the rearing of juvenile salmonids, and high densities of juvenile salmonids have been recorded (Kleinschmidt 2025b, 2026a).

Tributary MR1.070 is a single channel system that drains a relatively large watershed compared to many of the OCHs and sees its highest flows in spring as a product of snowmelt, very low flows in summer (less than 1 cfs), and a modest increase in flow in the fall as precipitation events become more common, allowing intermittent access for adult salmon (Kleinschmidt 2026a). Habitat surveys illustrated the dominance of riffles (65 percent), followed by glides (18 percent) and pools (17 percent), and an average wetted width and thalweg depth of 4.7 meters and 0.44 meter, respectively (Kleinschmidt 2025b). The tributary hosts water quality conditions conducive to salmonid rearing and spawning, with all measured DO values greater than 10 mg/L and water temperatures that vary from about 2°C to 9°C from May through October (Kleinschmidt 2025b, 2026a). The channel margins are heavily vegetated, resulting in relatively abundant instream wood, undercut banks, and canopy cover.

OCH2.8R is within the Martin River floodplain; hosts multiple, braiding side slough channels that vary in their contribution to flow in the overall system; and is a much more dynamic OCH when compared to MR1.070 due to its intermittent connection to mainstem Martin River flows during high flow events. For this reason, the adjacent riparian habitat is typically at an earlier successional stage, and the channel has a lower density of woody debris and very little canopy cover. However, the lower gradient nature of the floodplain results in habitat being dominated by glides (56 percent), followed by riffles (31 percent) and pools (13 percent), and an average wetted width and thalweg depth of 6.0 meters and 1.3 meters, respectively (Kleinschmidt 2025b). Because OCH2.8R was inundated with mainstem water during most of the summer of 2025, water quality and quantity varied from being consistent with snowmelt and spring and precipitation-fed OCHs (warmer, clear water) to that of the glacial-dominated flow in the mainstem Martin River (cold, turbid water; Kleinschmidt 2026a).

While OCH1.7L and OCH3.0L comprised 35 percent of total wetted habitat, these areas were dominated by sandy and silty substrates and hosted very little suitable spawning habitat. OCH3.8L and OCH4.2R comprised a small proportion of the total wetted habitat due to their shallow, narrow channels, but both hosted suitable spawning gravels, especially for Dolly Varden, which were observed spawning in OCH3.8L. Shallow riffles at their mouths may restrict adult salmon access to this limited spawning habitat, though adult Coho Salmon were observed at the mouth of OCH4.2R and within OCH3.8L during 2025 surveys, and both yielded catch of juvenile Coho Salmon and Dolly Varden in 2025 (Kleinschmidt 2026a).

Due to their intermittent connection to mainstem waters during high flow events, the Martin River OCHs inherit, albeit to a lesser extent, the habitat instability associated with the mainstem Martin River channel, as described in the previous section. The high flow event in 2025 provided evidence of inundation of all OCH complexes within the floodplain, indicated by new channel configurations, fine sediment deposits, and increased turbidity in multiple lakes (MR1.120.L1, MR1.080.L1, and Lower Swan Lake). This high flow event deposited large quantities of fine sediment across the floodplain and appeared to smother much of the previously suitable spawning areas, especially in OCH2.8R and OCH4.2R. In OCH2.8R, suitable spawning gravel had been re-exposed along higher velocity areas in riffles or constrictions leading to pools, but many pool tail outs, which tend to be favored by salmon for spawning, retained easily visible fine sediment. Additionally, the movement of sediment, especially in OCHs with multiple channels like OCH2.8R, resulted in changes to both the locations of channels as well as their proportional contribution to the total flow transmitted through the OCH (Kleinschmidt 2026a). The level of disturbance (i.e., inundation during a high flow event) in a system is generally inversely proportional to the system’s capacity to support robust salmonid populations (Pitman et al. 2020).

More detailed information on habitat surveying of the individual OCHs is outlined in Kleinschmidt (2025b).

4.4.1.1.2 Fish Species

To document fish use, surveys were conducted over 1-week trips in the spring (May) and fall (September/October) in 2024 and 2025, as well as a summer (July/August) trip in 2025 (Kleinschmidt 2025b, 2026a). In addition, ADF&G conducted AVCT monitoring of the Red Lake Outlet annually from May through October since 2022 to quantify adult salmon escapement into Red Lake (Blackmon and Otis 2023, 2024).

Eight fish species have been documented in the Martin River basin (Table 4.4-1), including four salmonids, two stickleback species, and two sculpin species. Adult salmonid spawning activity was documented in Red Lake Outlet (WFMR), OCH2.8R, MR1.070, OCH3.8L, and OCH3.0L (Figure 4.4-2). The Red Lake escapement was dominated by Sockeye and Coho salmon (Table 4.4-2). Juvenile Coho Salmon and Dolly Varden were relatively widespread in OCH and tributaries, while juvenile Sockeye Salmon were both less abundant and found in fewer locations (Figure 4.4-3).

Table 4.4-1 Fish species and life stage(s) documented in the Martin River watershed.

Common Name	Scientific Name	Life Stage Observed		
		YOY	Juvenile	Adult
Sockeye Salmon	*Oncorhynchus nerka*	X	X	X
Coho Salmon	*O. kisutch*	X	X	X
Pink Salmon	*O. gorbuscha*			X
Dolly Varden	*Salvelinus malma*	X	X	X
Three-spined Stickleback	*Gasterosteus aculeatus*	X	X	X
Ninespine Stickleback	*Pungitius pungitius*	X	X	X
Freshwater Sculpin	*Cottus* spp.		X	X
Pacific Staghorn Sculpin	*Leptocottus armatus*		X	

YOY = young-of-year.

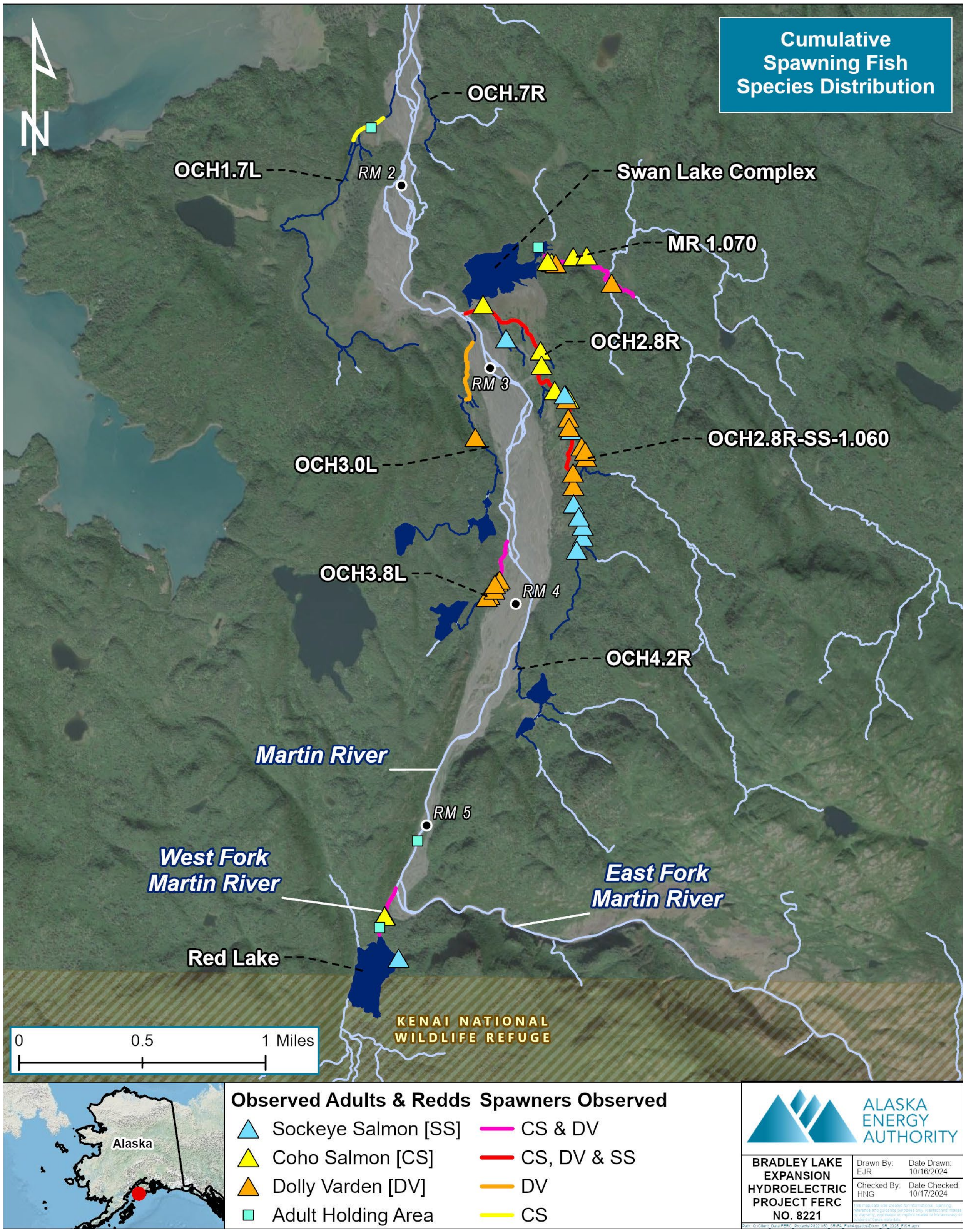

Figure 4.4-2 Distribution of adult salmonids and redds encountered during 2024 and 2025 surveys.

Table 4.4-2 Adult fish counts from ADF&G's monitoring station at the outlet of Red Lake.

Species	Run Year			
	2022[a]	2023[b]	2024	2025
Sockeye Salmon	681	66	1,197	1,500
Coho Salmon	48	205	182	214
Pink Salmon	5	0	0	0
Dolly Varden	53	58	88	855[c]

[a] 2022 does not include night counts.

[b] Multiple recording lapses occurred in 2023.

[c] Dolly Varden counts in 2025 ceased on September 30.

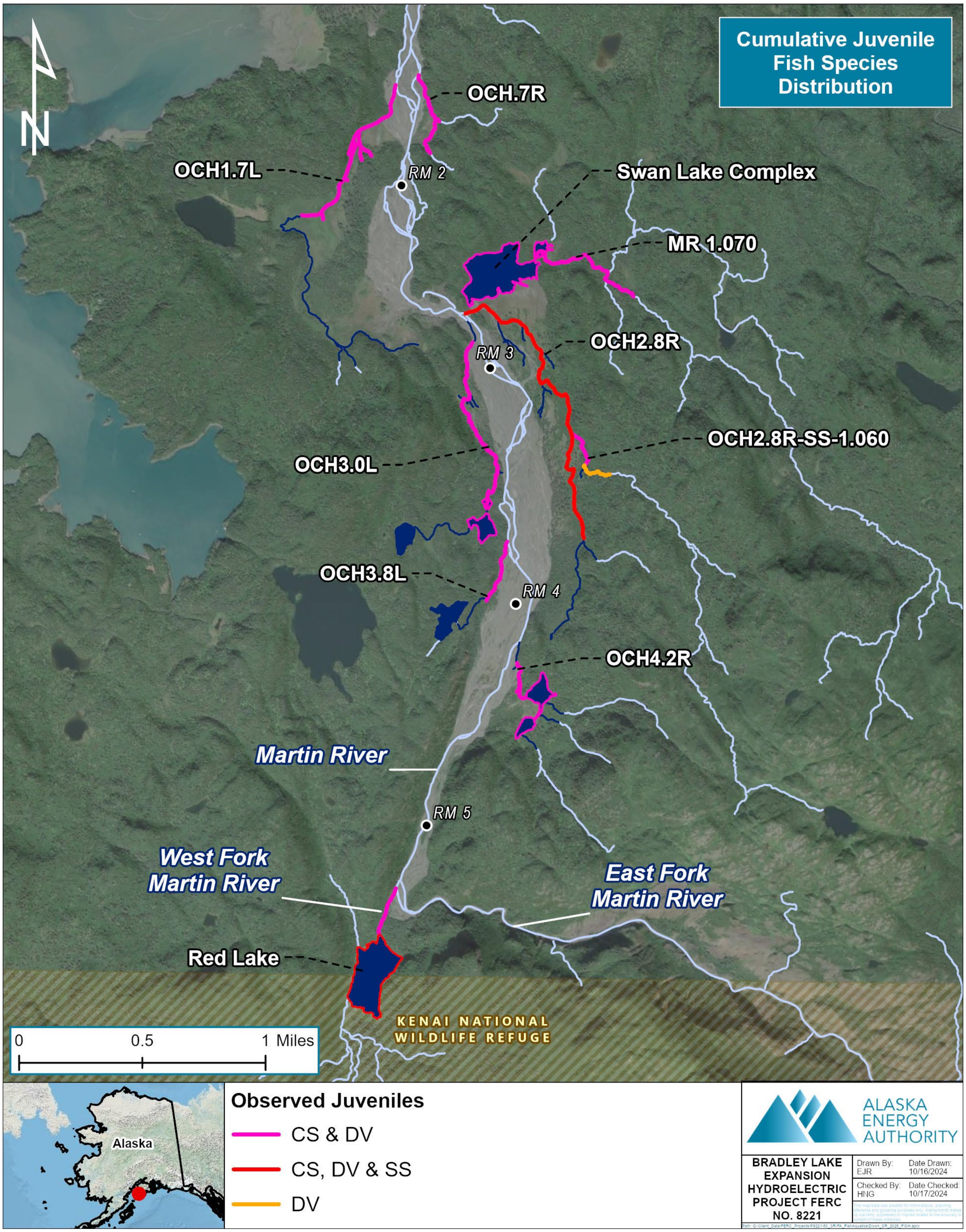

Figure 4.4-3 Distribution of juvenile salmonids documented during 2024 and 2025 surveys.

Sockeye Salmon

During surveys conducted in September/October 2024 and 2025, Sockeye Salmon adults were observed spawning in Red Lake and OCH2.8R (Figure 4.4-2). Sockeye Salmon young-of-year (YOY) were documented in spring and summer of 2025 rearing in Red Lake, OCH2.8R, and estuarine sloughs at the mouth of the Martin River, while age 1+ and age 2+ individuals were observed in Red Lake.

The Red Lake Sockeye Salmon run extends from late May to late June, with the majority of the fish concentrated during a 2- to 3-week period in mid-June; 80 percent of the run passed the AVCT between June 11 and 25, 2024, and June 2 and 21, 2025. The temporal distribution of Sockeye Salmon escapement to Red Lake was visualized only for 2024 and 2025 due to the consistency in data collection in these years (Figure 4.4-1). The shaded rectangles in Figure 4.4-4 represent the timeframe within which 80 percent of each respective run passed the AVCT.

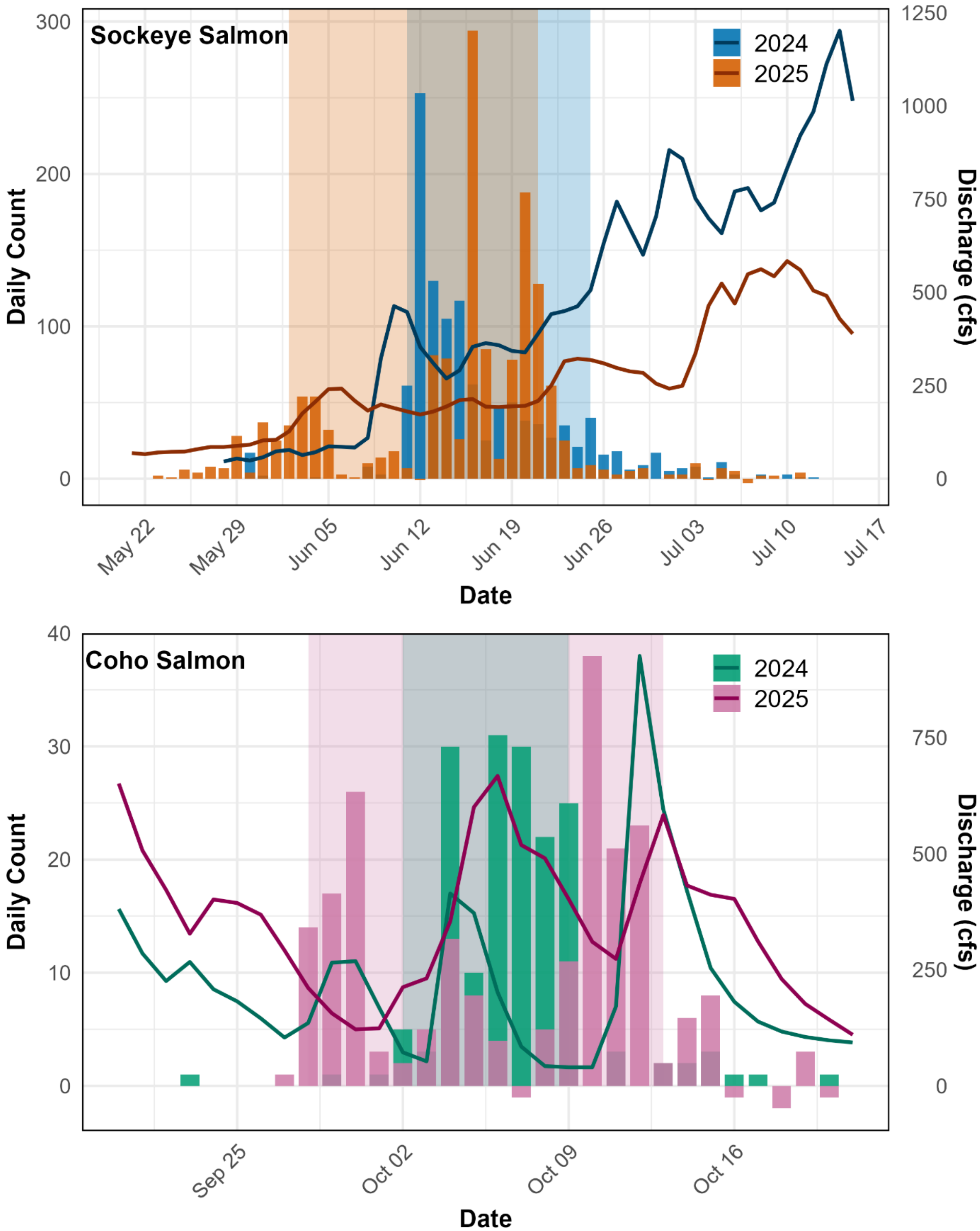

Figure 4.4-4 Temporal distribution of Sockeye Salmon and Coho Salmon escapement to Red Lake in 2024 and 2025.

Coho Salmon

During surveys conducted in September/October 2024 and 2025, Coho Salmon spawning activity was documented in the Red Lake Outlet (WFMR), OCH2.8R, MR1.070, and OCH3.8L. In 2025, a school of Coho Salmon adults were observed holding in OCH1.7L, but no spawning was documented. The Coho Salmon run extends from late September to mid-October; 80 percent of the run passed the Red Lake AVCT between October 2 and 9, 2024, and September 28 and October 13, 2025. The temporal distribution of Coho Salmon escapement to Red Lake 2024 and 2025 is shown in Figure 4.4-4. The shaded rectangles in Figure 4.4-4 represent the timeframe within which 80 percent of the run passed the AVCT.

Juvenile Coho Salmon (YOY, age 1+, age 2+) were documented in most OCHs of the Martin River watershed, and few age 1+ and age 2+ Coho Salmon were captured in the floodplain of the Martin River mouth in spring, summer, and fall 2025. During the inundation of Swan Lake with cold (3.4°C) and turbid (60 NTUs) mainstem water in summer of 2025, overnight sampling of the Swan Lake Outlet yielded 34 juvenile Coho Salmon and 27 juvenile Dolly Varden in a single minnow trap, the highest catch of that trip. This area is characterized by low velocities, relatively deeper depths (greater than 1 meter/1.09 yards), and vegetated margins, and this was the first time it had been sampled while under influence from glacial water. Previous sampling of the same area prior to its inundation with glacial water (2024 and spring 2025), when it was instead characterized by warmer, clearer water provided primarily by MR1.070, also documented relatively high numbers of juvenile Coho Salmon and Dolly Varden. This suggests that water velocity and deeper water habitat may be the primary factors limiting salmonid use of the mainstem, as has been seen in other glacial-fed rivers in Alaska (Murphy et al. 1989), with temperature playing a secondary role. Alternatively, increased turbidity has been attributed to lower predation mortality for juvenile salmonids in glacial systems by limiting the effectiveness of visual predators (Thedinga et al. 1993), so higher turbidity in relatively open lake habitats may encourage more juvenile fish to use these areas.

Pink Salmon

Pink Salmon adults were only observed in the system once during the monitoring period. Five adult Pink Salmon were observed at the Red Lake AVCT, with all observations occurring from early August to mid-September in 2022 (Blackmon and Otis 2023, 2024). Targeted sampling for Pink Salmon spawning in late July to early August of 2025 yielded no observations of this species using the Martin River, despite their observed presence and spawning in nearby Battle Creek and the lower Bradley River.

Dolly Varden

During surveys conducted in September/October 2024 and 2025, Dolly Varden spawning activity was observed in OCH2.8R, MR1.070, OCH3.0L, OCH3.8L, and the WFMR (Figure 4.4-2). Based on the size range of Dolly Varden observed spawning (from about 135 millimeters to more than 400 millimeters) and the lack of observations of larger fish outside of the fall spawning period (Kleinschmidt 2025b, 2026a), there are likely both sea-run and resident Dolly Varden reproducing in the Martin River watershed. For more information on adult fish and redd counts in OCH during these surveys, see Kleinschmidt (2025b, 2026a). Dolly Varden juveniles (YOY, age 1+, age 2+) were observed throughout most OCHs and during limited sampling of the mainstem Martin River and were often the most numerous species encountered during surveys (Kleinschmidt 2025b, 2026a).

Other Species

Three-spined (*Gasterosteus aculeatus*) and Ninespine (*Pungitius pungitius*) stickleback were captured in spring, summer, and fall efforts, and they primarily inhabited slower moving waters of the system, especially in vegetated edges of warm, clear water lake habitat. Both stickleback species were also captured in low numbers in summer 2025 in glacial-dominated water along the vegetated margins of Swan Lake and the inundated marsh grass floodplain near the Martin River mouth. Few freshwater sculpin were captured. Observations of Pacific Staghorn Sculpin (*Leptocottus armatus*) were concentrated at the mouth of the Martin River in sloughs receiving estuarine influence at high tide (Kleinschmidt 2026a). Both freshwater sculpin and Pacific Staghorn Sculpin are generally ubiquitous in coastal systems from Alaska to California (Eschmeyer et al. 1983; Page and Burr 1991).

Targeted efforts to document Eulachon (*Thaleichthys pacificus*) presence and habitat suitability for spawning in May 2025 yielded no observations and discovered likely barriers to passage near the mouth based on velocity measurements and published maximum sustained swimming speeds (Kleinschmidt 2026a).

4.4.1.1.3 Macroinvertebrate Communities

There is limited information on the macroinvertebrate communities specific to the Martin River watershed, but general patterns associated with water quality conditions in glacial-fed, Alaskan river systems can provide insight into likely community composition. In glacial headwater streams, aquatic macroinvertebrate diversity is typically low due to cold water temperatures, unstable substrates, high turbidity, and flow variability. In these environments, macroinvertebrate communities are generally dominated by taxa such as midges in the genus *Diamesa* (Chironomidae) and blackflies (Simuliidae), which are uniquely adapted to persist in highly dynamic, low-productivity systems (Milner and Petts 1994; Milner et al. 2001).

As temperature increases and sediment transport and turbidity decrease with waning glacial influence, macroinvertebrate diversity tends to increase. Transitional zones in these systems often support a wider variety of taxa, including stoneflies (Plecoptera), mayflies (Ephemeroptera), and caddisflies (Trichoptera), especially during spring and early summer when snowmelt flows stabilize and water temperatures increase (Milner and Petts 1994). These seasonal windows allow colonization and emergence of more temperature- and habitat-sensitive species. Additionally, tributary inflows or groundwater-fed sections may host relatively stable microhabitats that act as refugia for more diverse benthic communities (Townsend et al. 1997).

Macroinvertebrate sampling was conducted in 2010 in Battle Creek. While Battle Creek's geologic and hydrologic conditions are distinct from the Martin River and thus not likely to be an accurate representation of Martin River macroinvertebrate communities, the dominant taxon observed were midges (Chironomidae), followed by mayflies (Baetidae), stoneflies (Plecoptera), and caddisflies (Trichoptera; AEA 2015).

4.4.1.2 Bradley Lake

4.4.1.2.1 Aquatic Habitat

Bradley Lake was a natural glacial lake that was impounded by Bradley Lake Dam, raising the maximum lake level by 100 feet. Licensing studies for Original Bradley Lake Project focused on the water quality and quantity of the lake (outlined in section 4.3.2.2) but did not implement any studies to document the aquatic habitat as the lake was recognized to not be accessible to anadromous fishes an non-fish bearing (FERC 1985).

4.4.1.2.2 Fish Species

No fish have been documented in Bradley Lake or the tributaries entering the lake (FERC 1985). The tributaries entering the lake are high-gradient headwater streams or originate at glaciers.

4.4.1.2.3 Macroinvertebrate Communities

There are no published studies on the macroinvertebrate community in Bradley Lake, but, based on studies in other glacial lakes in Alaska, it is likely dominated by cold-tolerant, deposit- and detritus-feeding taxa (notably Chironomidae and oligochaetes). Planktonic assemblages are likely composed of cold-adapted cladocerans and copepods. These species are adapted to lower temperature and nutrient availability and turbid fine-sediment littoral zones characteristic of glacial lakes (Milner and Petts 1994; Milner et al. 2009). Because Bradley Lake is considered fishless, relatively higher macroinvertebrate biomass and a greater representation of large-bodied taxa are expected in littoral habitats than in nearby glacial lakes with fish predators (Schindler et al. 2001). Substrate in glacial lakes is often soft, silt-rich sediment near inflows and coarser material on exposed rocky shores, so benthic assemblages will likely vary spatially with microhabitat (e.g., more oligochaetes and chironomid larvae in fine sediments; more mobile benthic insects and littoral amphipods in coarser substrates) (Milner and Petts 1994).

4.4.1.3 Bradley River

4.4.1.3.1 Aquatic Habitat

The Bradley River is a short, steep, glacially influenced river of which the lower 5.5 river miles are accessible to anadromous fish. Most of this accessible portion of the river is low-gradient and tidally influenced, but the upper 1.5 miles of accessible channel provides spawning habitat for salmonids (Rickman 1998). The greater Bradley River basin supports cold, high-gradient stream conditions with swift flow, coarse substrate, and seasonally variable discharge influenced by snowmelt and glacial runoff (Rickman 1995). The powerhouse tailrace in the tidally-influenced section of the lower river receives variable flows dependent upon energy demand, which may influence temperature, sediment delivery, and seasonal hydrology.

While anadromous fish production within the Bradley River is relatively low compared to adjacent systems, the river and its outlet to Kachemak Bay form part of a larger estuarine mosaic that supports important ecological connectivity for salmonids and estuarine species (Field and Walker 2003; NOAA 2023).

4.4.1.3.2 Fish Species

Five Pacific salmon species have been documented in the lower Bradley River, primarily in the tidally influenced reaches near the confluence with Kachemak Bay (FERC 1985; Morsell et al 1986; Morsell et al. 1992; Otis 2016; ADF&G 2024). Pink Salmon are the most abundant species using the river for spawning, while limited spawning by Chum Salmon, Coho Salmon, and Chinook Salmon (has been assumed to occur based on adult observations in multiple years (Morsell et al. 1992). Sockeye Salmon were observed in relatively large numbers in the powerhouse tailrace during tailrace attraction flow studies in the early 1990s (Morsell et al. 1992), but due to the lack of lacustrine habitat in the Bradley River, they were assumed to be strays from various enhanced fisheries on the Kenai Peninsula or the small populations in the Fox and Martin rivers. Juveniles of these species have been documented using the lower river margins and delta channels while rearing and during outmigration (Otis 2016; ADF&G 2024). Adult Dolly Varden have been captured in the tidal reaches (Morsell et al. 1992), while juveniles dominated catch further upstream in the lower Bradley River during licensing studies (FERC 1985).

Non-salmonid species identified in the lower Bradley River during licensing studies for Bradley Lake in the early 1980s included Eulachon, Longfin Smelt (*Spirinchus thaleichthys*), Bering Cisco (*Coregonus laurettae*), Slimy Sculpin (*Cottus cognatus*), Pacific Staghorn Sculpin, Sharpnose Sculpin (*Clinocottus acuticeps*), Three-spined Stickleback, Ninespine Stickleback, and, in the lower tidal areas, Starry Flounder (*Platichtyus stellatus*; FERC 1985).

4.4.1.3.3 Macroinvertebrate Communities

Licensing studies in the 1980s stated that concentrations of benthic invertebrates were limited in the Bradley River because of the heavy load of glacial flour and its constant deposition. These studies noted higher concentrations of invertebrates in lower river sloughs and tributaries with stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), beetles (Coleoptera), and midges (Diptera) observed (FERC 1985).

4.4.1.4 Kachemak Bay

4.4.1.4.1 Aquatic Habitat

Kachemak Bay hosts a dynamic and productive estuarine system supporting a wide diversity of anadromous, estuarine, and marine species. The Bradley and Fox rivers and Sheep Creek discharge into upper Kachemak Bay, forming braided tidal deltas and estuarine wetlands that provide transitional habitat for juvenile salmonids and other estuarine-dependent fish species (Field and Walker 2003; NOAA 2023; ADF&G 2024).

The estuarine and nearshore habitats of Kachemak Bay are characterized by extensive mudflats, eelgrass beds, and salt marshes, which support detrital food webs and invertebrate prey communities important to fish diets (Field and Walker 2003; NOAA 2023). These habitats are influenced by strong tidal flux, sediment inputs from glacial and upland sources, and freshwater discharge from various rivers. Seasonal variation in river flow, driven by glacial melt, snowmelt, and precipitation, contributes to estuarine mixing, turbidity, and primary productivity (O'Neel et al. 2015).

4.4.1.4.2 Fish Species

The Bradley River and Fox River estuaries serve as important nursery habitat for anadromous species, including five Pacific salmon species, which inhabit the lower river reaches and tidally influenced sloughs during smolt outmigration (FERC 1985; Morsell et al. 1986; Hoem Neher et al. 2014; Otis 2016; ADF&G 2024). Other commonly observed estuarine species include Three-spined Stickleback, Pacific Staghorn Sculpin, and Starry Flounder, which occupy shallow intertidal zones (FERC 1985; Hoem Neher et al. 2014; Beaudreau et al. 2022). In addition to estuarine-dependent fishes, Kachemak Bay supports a diverse marine assemblage, including Pacific Cod (*Gadus macrocephalus*), Walleye Pollock (*Gadus chalcogrammus*), Pacific Halibut (*Hippoglossus stenolepis*), and several rockfish species (*Sebastes* spp.), which use deeper marine habitats within the bay. Eulachon also seasonally enter estuaries to spawn, providing an important forage base for larger predatory fishes, seabirds, and marine mammals (Field and Walker 2003; NOAA 2023).

4.4.1.4.3 Macroinvertebrate Communities

In the estuarine and nearshore areas where the Bradley, Fox, and Martin rivers discharge into Kachemak Bay, macroinvertebrate communities are notably richer than the adjacent freshwater areas and serve as important forage for many aquatic and terrestrial species (Field and Walker 2003). Macroinvertebrates reported in the Bradley River estuary and mud flats include the bivalve *Macoma balthica*, the blue mussel (*Mytilus elegans*), the amphipod *Eogammarus confervicolus*, and the opposum shrimp (*Neomysis mercedis*) (FERC 1985).

4.4.1.5 Essential Fish Habitat

Pursuant to the Magnuson-Stevens Fishery Conservation and Management Act, EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. §1802(10)). The AWC maintained by ADF&G designates EFH for salmonids in Alaska (ADF&G 2024). The waters within and adjacent to the Bradley

Lake Project area, including the Bradley River and Martin River, are designated as EFH for multiple salmonid species (Table 4.4-3).

EFH in both the Martin and Bradley rivers includes freshwater habitats with gravel and cobble substrates, tidal sloughs, emergent marsh, and brackish mixing zones, which provide habitat for multiple salmonid life stages. The glacial-driven hydrology of these systems results in summer glacial melt with flow pulses that often coincide with salmon smolt outmigration and adult returns. Habitat quality in EFH-designated areas may be influenced by flow management, sediment transport, and water temperature (Hoem Neher et al. 2014; NOAA 2023).

Table 4.4-3 Species and respective life stages with designated Essential Fish Habitat in the Martin and Bradley rivers.

Species	Bradley River	Martin River
Chinook Salmon	Spawning; Rearing	N/A
Sockeye Salmon	Spawning; Rearing	Spawning; Rearing
Coho Salmon	Spawning; Rearing	Spawning; Rearing
Chum Salmon	Spawning; Rearing	Presence
Pink Salmon	Spawning; Rearing	N/A
Dolly Varden	N/A	Spawning; Rearing

Source: ADF&G (2024).
N/A = not applicable.

4.4.1.5.1 Martin River

The Martin River watershed (AWC Code 241-14-10600) is designated as EFH for rearing and spawning Dolly Varden, Coho Salmon, and Sockeye Salmon, while tidal flats around the mouth of the Martin River are also recognized as EFH for rearing Chum Salmon (ADF&G 2024). The Martin River contributes to the broader estuarine delta system in upper Kachemak Bay, supporting growth and migratory functions for juvenile salmon and other fishes.

4.4.1.5.2 Bradley Lake

There is no designated EFH in Bradley Lake.

4.4.1.5.1 Bradley River

Designated spawning and rearing EFH for all five Pacific salmon species occurs in the lower Bradley River (AWC Codes 241-14-10625 and 241-14-10625-2010), which includes tidally influenced habitat and distributary channels near its confluence with Kachemak Bay (ADF&G 2024).

4.4.1.5.2 Kachemak Bay

The NOAA EFH mapper designates Kachemak Bay as EFH for a variety of anadromous and marine fish species listed in Table 4.4-4 (NOAA 2025).

Table 4.4-4 Species and respective life stages with designated Essential Fish Habitat in Kachemak Bay.

Species	Life Stage(s)
Chinook Salmon	Marine Juvenile; Marine Maturing Adult
Coho Salmon	Marine Juvenile; Marine Maturing Adult
Chum Salmon	Marine Juvenile; Marine Maturing Adult
Pink Salmon	Marine Juvenile
Sockeye Salmon	Marine Juvenile; Marine Maturing Adult
Southern Rock Sole	Early Juvenile
Northern Rock Sole	Early Juvenile
Yellowfin Sole	Early Juvenile
English Sole	Early Juvenile
Rex Sole	Early Juvenile
Flathead Sole	Early Juvenile
Starry Flounder	Early Juvenile
Arrowtooth Flounder	Early Juvenile
Sablefish	Settled Early Juvenile
Pacific Cod	Settled Early Juvenile
Walleye Pollock	Early Juvenile

Source: NOAA (2025).

4.4.2 Environmental Analysis

This section describes the potential effects of the construction and operation of the proposed modifications to the Bradley Lake Project on fish and aquatic resources in the Project area.

4.4.2.1 Construction

To limit the potential for adverse environmental effects during construction and to ensure compliance with both the CWA and the NPDES, AEA would require all contractors to implement standard BMPs such as erosion and sediment control measures, fuel and chemical management, and stormwater management. These standard safeguards are consistent with industry practice for construction and are designed to maintain the integrity of aquatic resources. AEA would notify ADF&G at least 10 days prior to any complete or partial diversion of streamflow so that staff could be present and ensure the presence of an environmental compliance monitor during any instream construction activity. Potential construction impacts from the Proposed Action are described below. There would be no construction-related impacts anticipated to Kachemak Bay, as there would be no operation of equipment or vehicles below the OHW line and no refueling, stockpiling, or staging within 100 feet of Kachemak Bay OHW.

4.4.2.1.1 Dixon Diversion

Martin River

Construction of the Dixon Diversion would disturb approximately 26 acres around the diversion site adjacent to and within the EFMR. This area was recently deglaciated, and there are areas of unconsolidated till and outwash that would be disturbed, which could be destabilized when disturbed. Some areas of bedrock would also be removed for the tunnel and intake facilities. Appropriate BMPs and erosion and sediment control measures would be implemented to minimize movement of disturbed soil and rock into the Martin River. The river naturally carries a very high sediment load, so it is anticipated that erosion of small amounts of material into the river would not result in substantial effects on fish and aquatic resources.

The diversion structure would be built within the existing EFMR channel. This would require temporary measures (e.g., cofferdams) to divert the EFMR around the diversion construction site and dewatering the EFMR directly downstream of the proposed diversion. Proposed construction sequencing would drill the diversion tunnel prior to constructing the permanent diversion structure, so up to 1,650 cfs could be diverted into the tunnel during construction of the diversion structure. Proper cofferdam sizing would limit this risk of overtopping during a large flood flow. Construction would temporarily change local hydrology and water quantity levels downstream of the proposed diversion structure. Based on the documentation of multiple fish barriers in the EFMR and lack of capture or observations of fishes in the EFMR (Kleinschmidt 2025b, 2026a), no direct impacts from construction are anticipated on fish and aquatic resources. However, reductions in flow and potential increases in turbidity could have indirect impacts on fish and aquatic resources downstream in the Martin River. To mitigate for any potential impacts to adult salmon migrations or juvenile or resident fish habitat, AEA would maintain the proposed EFMR MIF of 100 cfs during any diversion, would consult with ADF&G to develop in-water and water diversion windows, and also proposes to have an environmental compliance monitor on site. For these reasons, impacts on fish and aquatic resources in the EFMR and Martin River downstream of the proposed diversion site during construction are expected to be limited and short in duration.

Bradley Lake

Bradley Lake is a non-fish-bearing glacially fed reservoir. As previously described, standard BMPs to protect water quality would be implemented at all construction sites, staging areas, and spoils deposition areas. Tunnel muck would be disposed of in a 41-acre area between the tunnel outlet and Bradley Lake. The muck is erodible and could be eroded and transported into Bradley Lake. An ESCMP and containment measures would be implemented to minimize erosion. Therefore, construction-related activity associated with the Dixon Diversion is not anticipated to significantly impact aquatic resources in Bradley Lake.

Bradley River

Construction-related activity associated with the Dixon Diversion is not anticipated to impact fish or other aquatic resources in the Bradley River.

4.4.2.1.2 Bradley Lake Pool Raise

Bradley Lake

Bradley Lake is a non-fish-bearing glacially fed reservoir. Standard BMPs to protect water quality and consequently other aquatic resources would be implemented at all construction sites, staging areas, and spoils deposition areas. The lake would be drawn down to allow all construction work on the lake side of the dam to be completed in the dry. Therefore, construction-related activity associated with the Bradley Lake Pool Raise is not anticipated to significantly impact aquatic resources in Bradley Lake.

Bradley River

The Bradley River in the direct vicinity downstream of the current dam is not accessible to fish due to multiple fish passage barriers lower in the system. Therefore, any potential impacts on fish and aquatic resources would be indirect and arise from changes in water quality or quantity. Construction activity associated with the Bradley Lake Pool Raise includes a potential 1.5-acre borrow site near the Bradley River and construction on the current dam across the river. Erosion of borrow material from the borrow site could enter the river; implementation of erosion and sediment control measures would limit the likelihood of erosion. Standard BMPs would be implemented to protect water quality and thus fish and aquatic resources. No equipment refueling would be permitted within 100 feet of the OHW line. Where in-water work is required, the appropriate permits would be obtained, and the work would only occur within the windows as specified by ADF&G. An environmental compliance monitor would be on-site to monitor any in-water work. Therefore, construction-related activity associated with the Dixon Diversion is not anticipated to impact fish or other aquatic resources in the Bradley River.

4.4.2.2 Operations

4.4.2.2.1 Martin River

The Dixon Diversion would reduce the glacial influence on the Martin River, similar to glacial retreat. Glacial retreat and its impact on aquatic systems is relatively well studied. Glacial contribution to flow, and consequently its impact on water quality and channel conditions in the rivers being formed, naturally decreases through time until the glacier is melted and the system relies wholly on snowmelt and rainfall (Pitman et al. 2020). During this transitional period, glacial-born watersheds experience a gradient of channel stability, flow regimes, and water quality conditions across a spatiotemporal scale, resulting in changes to the watershed’s suitability as habitat for Pacific salmon (Milner 1987). Pitman et al. (2020) delineated this timeframe into four sequential phases (Figure 4.4-5):

1. Ice-dominated watersheds
2. Rivers and lakes fed by ice
3. High-elevation glaciers with downstream effects
4. Watersheds without permanent ice

The Martin River watershed falls somewhere between the second and third phase, in which glacial retreat no longer results in the physical creation of additional accessible habitat for salmonids due to fish passage barriers in the EFMR, but glacial-driven high flow events still occur, resulting in sediment transport and low channel stability that limit biotic productivity in mainstem river channels (Brown and Milner 2012). The operation of the proposed Project is likely to push the watershed fully into the third phase by decreasing summer discharge and sediment transport. These changes would likely result in bank and floodplain stabilization that promotes the growth of riparian habitat and increases wood and spawning gravel recruitment, thus improving mainstem habitat suitability for salmon. However, maintaining some contribution to flow by glacial melt is important. For many salmon-bearing systems in Alaska that rely entirely on rain and snowmelt inputs, summertime maximum temperatures are increasingly exceeding thresholds for Pacific salmon (Cline et al. 2020; Jones et al. 2020). Even small glacial-melt inputs, like those that would continue with the MIF in the EFMR, can help mediate climate sensitivity by regulating temperature regimes within the thresholds preferred by Pacific salmon (Kent and Morsell 2004; Huss and Hock 2018).

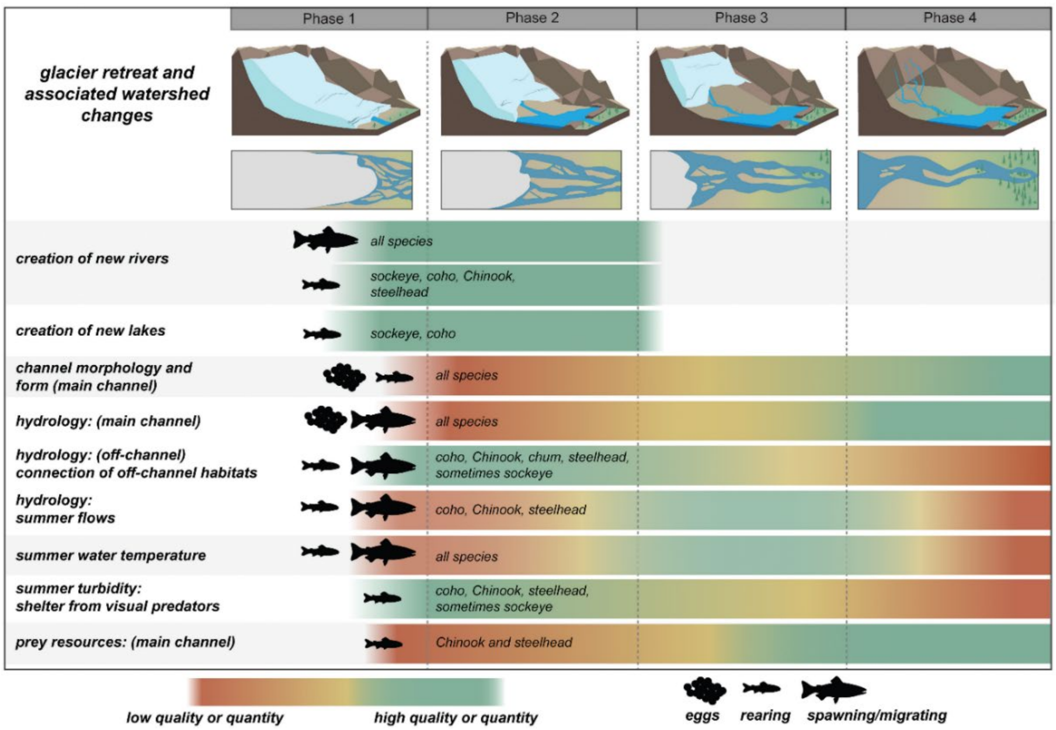

Figure 4.4-5 Phases of glacier retreat and predictions for the effects of associated watershed changes on salmon species and life stages (Pitman et al. 2020).

<u>Habitat Connectivity and Flow</u>

Operation of the Dixon Diversion would affect flow, surface water elevation, sediment load and transport, and water depth in the EFMR and mainstem Martin River downstream from the diversion structure. Flow in the Martin River would be reduced when the Dixon Diversion is in operation (May–November), potentially resulting in flow-related changes at tributary confluences and OCH features affecting fish access.

Aquatic habitat connectivity is important for salmonids and other fish species that rely on multiple habitats during spawning and rearing activities to complete their life cycles. In the Martin River, all the suitable salmonid spawning and year-round rearing habitat occurs in the OCH and tributaries while the mainstem Martin River serves as a migration corridor between these habitats and for anadromous fish to Kachemak Bay.

Hydraulic Modeling

Due to the presence of Sockeye and Coho salmon and Dolly Varden in the basin, AEA conducted an aquatic habitat connectivity analysis based on their migration needs (water depth and velocity) and timing and use of OCH to complete their life history. This analysis was used to determine minimum flow requirements to allow fish passage and maintain connectivity between these habitats (Kleinschmidt 2025a).

Although the conditions for successful passage vary by species and size of individual fish, there is a general agreement that upstream movement of adult salmon may be impaired when continuous water depths fall below 0.7 foot (Powers and Orsborn 1985, Bjornn and Reiser 1991, R2 Resource Consultants, Inc. 2008). For resident fish species (Dolly Varden) and juvenile salmon, a minimum water depth of 0.3 foot is generally considered suitable to provide unrestricted access to habitat (Bugert et al. 1991, CDFW 2017, ADF&G 2001).

The 2D hydraulic models can simulate the spatial distribution of depth and velocity in streams or rivers and they are frequently used to assess relationships between discharge and parameters of ecological relevance (Elkins et al. 2007, Clark et al. 2008, Harrison et al. 2011, Grantham 2013). AEA conducted 2D numerical hydraulic modeling to predict the spatial distribution of water depths in the Martin River downstream from the EFMR under three potential EFMR flow scenarios (100 cfs, 150 cfs, and 200 cfs) and applied minimum fish passage criteria for each of the three species and life stages to assess habitat connectivity in relation to discharge. Because Sockeye Salmon are known to migrate to Red Lake in the spring and Coho Salmon migrate in the fall, conservative estimates of total tributary flows of 20.6 cfs and 2.2 cfs, respectively, were added to the three EFMR flow scenarios to model the passage conditions in the Martin River (Kleinschmidt 2025a).

The model was based on channel bathymetry acquired by LiDAR during May 2024, and concurrent surveying, stream discharge, and velocity measurements. Therefore, modeling results represent a snapshot in time of channel morphology in May 2024. As previously described, the Martin River is a highly dynamic system with significant bedload transport and channel movement occurring intra- and interannually. The channel has changed substantially in some locations since spring of 2024 when the input data for the hydraulic model were collected.

Connectivity was also evaluated between the mainstem Martin River and six OCH complexes that had a well-defined hydraulic connection with the Martin River and suitable salmonid habitat or known fish use: OCH1.7L, OCH 2.8R, OCH3.0L, OCH3.8L, OCH4.2R, and the WFMR (Red Lake Outlet). The hydrologic connectivity of off-channel features to the mainstem Martin River is influenced by the channel morphology at the connectivity location and the relationship between discharge in the Martin River and from the OCH complexes. Due to a lack of long-term flow records, a flow of 0.01 cfs was used to estimate the flow contribution from the OCH basins at each connectivity point.

The hydraulic modeling demonstrated that the number and length of potential gaps in mainstem habitat connectivity would decrease with increasing flow releases. However, fish passage conditions (depth and velocity) were met for all three salmonid species and life stages through the mainstem Martin River from the mitigation ponds near the mouth upstream to Red Lake (Kleinschmidt 2025a). The model also estimated that sufficient water depth would be available to provide habitat connectivity under all three minimum flow release scenarios at all OCH/tributary features where adult salmon in 2024 were observed holding (OCH1.7L) or spawning (OCH2.8R, Swan Lake complex/Tributary MR1.070, Red Lake Outlet). No Sockeye Salmon of any life stage and no Coho Salmon adults or observations of spawning activity were documented in 2024 in the other three OCH areas evaluated (OCH3.0L, OCH3.8L, OCH4.2R). Modeled depths were between 0.3 and 0.7 foot at the OCH3.0L connection for the EFMR=100 cfs scenario; Coho Salmon juveniles and Dolly Varden juveniles and adults have been documented using OCH3.0L. Modeled depths were less than 0.3 foot at the OCH3.8L and OCH4.2R connections where juvenile Coho Salmon and Dolly Varden have been observed.

In 2025, three adult Coho Salmon were observed staging in OCH3.8L at the first pool upstream of its confluence with the Martin River (Kleinschmidt 2026a). However, there have been substantial changes to the mouth and confluence of the OCH3.8L and the mainstem Martin River following the major flood events in August of both 2024 and 2025, resulting in changed connectivity conditions compared to those surveyed in May 2024 and used as inputs for the hydraulic model. As similar changes have been observed in both the mainstem channel and OCH complexes since May 2024, it is important to emphasize that the model findings are representative of the system at that snapshot in time, but they may not be directly representative of conditions seen in the 2025 field season, or in coming years following additional high flow events.

Based on the modeling results and observed adult and juvenile salmonid distribution, AEA proposes a MIF release of 100 cfs to the EFMR from the Dixon Diversion dam while it is in operation to maintain connectivity between Kachemak Bay and salmon spawning areas. The point of compliance for the EFMR MIF would be at the Dixon Diversion dam, and therefore 14.9 square miles of drainage in the Martin River below the diversion would contribute to additional flows above the 100 cfs MIF, especially in spring (May/June) and early fall (September/October) when there is substantial contribution to mainstem Martin River flow by snowmelt and rain, respectively.

While the modeled depths at three of the OCH sites that lacked observations of redds or active salmon spawning were 0.3 to 0.7 foot (OCH3.0L) or less than 0.3 foot (OCH3.8L and OCH4.2R), juvenile Coho Salmon and Dolly Varden have been observed in each of these and are relatively widespread in OCH throughout the system, including areas that had no surface connection to the mainstem Martin River at the time of fish observations (Kleinschmidt 2026a). Evidence suggests that some juvenile Coho Salmon and Dolly Varden opportunistically migrate between OCH areas as conditions allow and that some of these rearing areas are only intermittently connected to the mainstem under natural baseline conditions. Additionally, AEA proposes to monitor habitat connectivity under the proposed flow releases to ensure adult salmon passage between Kachemak Bay and Red Lake by monitoring Red Lake escapement for a period of 5 years post-diversion and to monitor connections at key OCH with suitable spawning habitat post-diversion.

Mainstem Habitat Suitability

The current high summer velocities in the mainstem Martin River and the lack of cover limit the use of the mainstem as a migration corridor for juveniles. Reduced summer flows are expected to expand areas within the mainstem Martin River that maintain velocities preferred by juvenile salmonids (less than 1 foot per second), potentially increasing rearing habitat (Katzman et al. 2010; ADF&G 2019). Currently, these areas are limited to backwaters near tributary mouths and bedrock constrictions that form eddys, each of which produced catch of juvenile Dolly Varden and Coho Salmon during fish sampling efforts. While the reduction in flow itself may not immediately expand areas in the mainstem with velocities below 1 foot per second, indirect effects are likely to precipitate in the expansion of areas hosting preferred velocities over time. Increased channel stability, wood recruitment, and riparian growth are anticipated, which are key drivers of habitat complexity, pool formation, and cover for juvenile fish (Buffington et al. 2004).

Current high summer flows may limit adult salmon access to the system, particularly for Pink Salmon, which have been documented in the adjacent Bradley River and Battle Creek and typically spawn from July through August (FERC 1985; Otis 2016). Pink Salmon are limited in their swimming capabilities compared to other Pacific Salmon species, with published maximum sustained speeds of less than 2.5 body lengths per second (roughly 3.75 feet per second assuming the average Pink Salmon size of 18 inches; Williams and Brett 1987; Hinch et al. 2002). Reducing peak summer flows below this velocity threshold are likely to facilitate upstream passage and improve access to spawning habitat. In the adjacent Battle Creek system, Pink Salmon spawning was not documented during targeted surveys of the system in 2010 and 2011 prior to the construction of the diversion structures (AEA 2015). In early August 2025, following multiple years of operation of the WFUBC Diversion and subsequent changes to the hydrology of lower Battle Creek, hundreds of Pink Salmon were observed spawning in lower Battle Creek in 1 day.

Sockeye Salmon and Coho Salmon currently migrate into the Martin River watershed before and after peak summer flow, respectively, with a later-arriving group of Sockeye Salmon being observed in multiple years at both the Red Lake AVCT and during spawning surveys in OCH2.8R (Blackmon and Otis 2023, 2024; Kleinschmidt 2025b, 2026a). This later-arriving group of Sockeye Salmon was typically seen following a drop in flow on the hydrograph in September (EFMR, USGS Gage No. 15238951), indicating that these individuals may stage in Kachemak Bay until flows drop enough to allow passage.

Overall, conditions under the proposed diversion are likely to expand rearing habitat and increase the probability that summer-spawning Pink Salmon would use the Martin River watershed. Monitoring will be essential to ensure connectivity through the mainstem and between the mainstem and OCHs, particularly under changing flow and sediment dynamics.

Temperature

Reduced glacial-melt input and flow from the EFMR are anticipated to result in increased water temperatures in the mainstem Martin River. Temperature monitoring conducted in the basin during 2022 through 2025, found that water temperatures in the EFMR ranged from about 1.5°C to 2.5°C during the summer months when glacial melt dominated flow and reached a high of about 4°C to 5°C in early June following snowmelt (Kleinschmidt 2025b, 2026a). The mainstem Martin River monitored at PRM 1.9 followed a similar pattern, with summer temperatures generally about 3°C to 5°C and early June temperatures of 6°C to 8°C. The summer temperatures in the EFMR and mainstem Martin River are suboptimal for the various life stages of Coho and Sockeye salmon (Table 4.4-5).

A mass balance model based on "worst-case" temperature assumptions (see Kleinschmidt 2026b) estimated temperature increases in the mainstem Martin River of 3.8°C to 5.9°C above baseline conditions, resulting in most daily temperatures in the mainstem Martin River at PRM 1.9 ranging from 6°C to 12°C. These temperatures more closely align with the optimal range of rearing temperatures for juvenile Coho Salmon, Sockeye Salmon, and Dolly Varden (Table 4.4-5). Increasing temperatures into the preferred range for juvenile salmonids is expected to enhance metabolic rates and growth, supporting better survival and condition during rearing (Brett 1979; McCullough et al. 2001). In 2020, AEA completed the WFUBC Diversion in the adjacent basin, which seasonally (May-October) diverts water from Battle Glacier to Bradley Lake. Pre- and post-diversion monitoring in lower Battle Creek found that both summer water temperatures and average size of juvenile Coho Salmon increased post-diversion, and the higher water temperatures were still well within the range of preferred temperatures for the species present (AEA 2025).

Table 4.4-5 Lethal, limiting, and optimal temperatures and accumulated thermal units to emergence for the three salmonids present in the Martin River watershed.

Species and Life Stages		Lower Lethal	Lower Limiting	Optimal	Upper Limiting	Upper Lethal
		Degrees Celsius (°C)				
Dolly Varden	Spawning	0	< 2	3-9	13	25
	Incubation	0	< 2	2-6	13	> 16
	Emergence ATUs	NA	NA	700	NA	NA
	Juvenile Rearing	0	< 2	8-14	16	25
Coho Salmon	Spawning	0	< 3	3-12	14	25.5
	Incubation	0	< 3	3-12	14	> 16
	Emergence ATUs	NA	NA	700-800	NA	NA
	Juvenile Rearing	0	< 2	7-16	18	25
Sockeye Salmon	Spawning	0	< 7.2	10–13	14.5	21
	Incubation	0	< 4	4–13	12	14.5
	Emergence ATUs	NA	NA	900-1,000	NA	NA
	Juvenile Rearing	0	< 4	8–15	16	21

Source: Kraus (1999); Hicks (2002); Kent and Morsell (2004); British Columbia Ministry of Water, Land, and Resource Stewardship (2025).

ATU = accumulated thermal unit; NA = not available.

The frequency and extent of OCH inundation is expected to decrease under Project operations, which is likely to result in higher temperatures in OCH than would be observed under mainstem inundation. Still, inundation of OCH occurs stochastically such that OCH that was connected to mainstem flow during the summer in one year may naturally disconnect the following year, or vice versa.

In the Martin River basin, salmonid spawning and rearing habitat is provided in the OCH and larger tributaries that are rain, spring, or snowmelt-fed. The OCH areas are periodically influenced to varying degrees by the mainstem Martin River at higher flows that occur June through September, significantly decreasing the water temperature and increasing the turbidity within the OCH. Inundation of some OCH areas (e.g., OCH2.8R complex and Swan Lake Outlet) by the mainstem Martin River during the summer resulted in rapid temperature decreases of up to 10°C and continued summer temperatures hovering around 3°C to 6°C until the Mainstem flows dropped in late September (Kleinschmidt 2026a).

4.4.2.2.2 Bradley Lake

As Bradley Lake is a non-fish-bearing waterbody, the proposed lake level increase is not anticipated to affect fish or aquatic resources. As described in Section 4.3.2.2.2, there is limited potential for erosion around the reservoir within the higher pool elevation as areas of unconsolidated material (colluvium or till) do not appear to be present. The amount of fine-grained sediment (silt/clay) supplied to Bradley Lake would increase as turbid water from the EFMR is diverted into the lake. As the lake is already turbid from glacial melt and the volume of diverted water is small compared to the total lake volume, it is not anticipated that the sediment would markedly reduce the storage capacity of the lake. Similarly, significant impacts to the thermal profile of Bradley Lake are not anticipated given the similarity between the EFMR and the current sources of water to Bradley Lake.

4.4.2.2.3 Bradley River

No changes are proposed to the Bradley River MIF regime. Therefore, no effects are anticipated on fish or aquatic resources in the Bradley River below the dam.

4.4.2.2.4 Kachemak Bay

A reduction in flow from the Martin River to Kachemak Bay during Project operation may reduce the area in which the estuarine gradient in temperature, salinity, and turbidity transitions from freshwater to marine conditions and reduce the total transport of sediment and nutrients, which contribute to primary production in estuarine and marine environments. This gradient in conditions is known to serve as an important transition zone for juvenile salmonids undergoing smoltification. However, the Martin River is a relatively small source of freshwater to upper Kachemak Bay in comparison to the Fox and Bradley rivers and Sheep Creek, such that the total estuarine habitat is unlikely to be substantially reduced. Further, the volume of water diverted from the Martin River would eventually end up flowing to Kachemak Bay through the powerhouse.

4.4.3 Applicant-Proposed Measures

Temporary construction-related impacts—such as those associated with intake modification or conveyance structures—would be avoided or minimized through implementation of standard BMPs, the proposed ESCMP, and the Fuel and Hazardous Substances Management Plan. To protect aquatic resources and minimize potential effects of the Project, AEA proposes MIF releases and channel maintenance releases, as described above in Section 2.2.2. Several monitoring plans would be developed through consultation with the regulatory agencies and implemented to evaluate the effects of the proposed flow regime on fish passage and habitat connectivity, water quality, and bedload transport (see Section 2.2.3.2):

- Dixon Diversion Flow Release Management Plan
- EFMR Flow Measurement Plan
- Water Temperature and Turbidity Monitoring Plan
- Martin River Fish and Fish Habitat Monitoring Plan
    - Red Lake AVCT Fish Counts
    - Martin River Habitat Connectivity

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4.5 Wildlife and Botanical Resources

4.5.1 Affected Environment

4.5.1.1 Botanical Resources and Wildlife Habitats

The vegetation and wildlife habitat types occurring in the Bradley Lake Expansion Project area were identified and mapped in the Vegetation and Wildlife Habitat Mapping Study (ABR 2026a). That study included field ground-reference surveys to verify aerial image-signatures and collect field data on vegetation and landscape features that drive the development of vegetation and wildlife habitats in the Project area. It also included digital mapping of vegetation types, to the Level IV of Viereck et al. (1992), as well as the mapping of multi-variate wildlife habitats. The field survey and mapping methods used are described in detail in ABR (2026a).

The primary goals of the Vegetation and Wildlife Habitat Mapping Study were to map current, pre-construction conditions for vegetation and wildlife habitats and compare those data to a map of predicted future conditions after a period of 60 years of Project operations. The wildlife habitat map data were used to then assess the likely changes in suitable habitat availability for wildlife species of concern in the Project area after 60 years (see Section 4.5.1.5 below). A separate, focused mapping effort was conducted to assess habitat availability for disturbance-sensitive mammal and eagle species in areas surrounding locations where construction blasting will be needed. This was done to assess the likelihood that construction blasting could have behavioral displacement impacts on those species (see Section 4.5.2.2.1 below).

The study area for the Vegetation and Wildlife Habitat Mapping Study included a 250-meter (820-foot) buffer surrounding the proposed Project components, including the construction zones and supporting sites for construction of the Dixon Diversion facilities and the raising of Bradley Lake Dam. The mapping buffer also surrounded an elevation contour representing a 28-foot pool raise, which was one of the earlier alternatives that was dismissed (see Section 2.3.3), as well as the entire Martin River floodplain, where reduction of natural stream flow is expected to occur in the summer months. Including each of these project components and the 250-meter (820-foot) buffer surrounding them, the mapping study area represents a total of 11,180 acres (see ABR 2026a). The mapping was based on aerial imagery that was acquired in July 28, 2022 when the Bradley Lake water surface elevation was 1,153.3 feet. Approximately 229 acres of the mapped study area lie between 1,153 feet El. and the current normal maximum pool elevation of 1,180 feet.

The mapping of wildlife habitats in areas where blasting will be needed was conducted within two 2-kilometer (1.2-mile) buffer zones surrounding the Dixon Diversion site in the upper Martin River and in the Bradley Lake Dam area, including associated borrow sites and the tunnel muck spoil placement site near the shore of Bradley Lake. In total, the blasting area mapping encompasses 8,464 acres, though suitable habitats for the focal wildlife species within the mapping buffer zones encompass only 6,989 acres (see ABR 2026a).

4.5.1.1.1 Ecoregions

The Bradley Lake Expansion Project lies within the Coastal Western Hemlock-Sitka Spruce Forests and the Pacific Coastal Mountains ecoregions in Southcentral Alaska (Gallant et al. 1995). These two ecoregions include the glaciated and now vegetated coastline of Kachemak Bay to the rugged mountainous subalpine and alpine terrain of the coastal mountains within the Project area boundaries. Climate near the coast is mild maritime and is influenced by harsher continental conditions at higher elevations. Terrain in both ecoregions is the result of glaciation forming deep and narrow bays, steep valley walls with exposed bedrock, moraine deposits on hills and in valleys, irregular coastlines, braided glacial rivers, and deeply dissected glacial moraine deposits covering the lower slopes of valley walls. Landcover within the Project area ranges generally from coastal mudflats, coastal meadow and marshes, lakes and ponds, rivers and streams, riverine poplar and upland mixed forests, subalpine tall scrub, alpine tundra and rocky barrens, and glaciers.

4.5.1.1.2 Physiographic Zones

The vegetation and wildlife habitat mapping area for the Project spans seven physiographic zones: Alpine, Subalpine, Upland, Lowland, Riverine, Lacustrine, and Coastal as described in the *Vegetation and Wildlife Habitat Mapping Study Report* (ABR 2026a).

Elevation, slope, aspect, available soils, and hydrologic regime largely dictate the plant communities present. The Alpine zone is dominated by dwarf scrub and partially vegetated rocky terrain and only occurs at higher elevations within the construction blasting buffer zones. The Subalpine zone is largely dominated by tall shrub scrub vegetation and ranges between the upper elevation of the coniferous forest tree line and the lower elevation of alpine terrain. Predominant vegetation and landcover types in the Subalpine include extensive tall shrub thickets, dry dwarf shrub tundra, and some scattered patches of barren exposed bedrock and colluvium. The Subalpine zone encompasses Bradley Lake, the proposed diversion structure at the terminus of the Dixon Glacier, and the higher elevations surrounding the Martin River canyon (EFMR). The Upland zone includes the lower forested slopes between the open coastal habitats and the upper elevation of coniferous forests. Upland vegetation and landcover includes mixed Lutz spruce (*Picea x lutzi*) and black cottonwood forests, tall shrub scrub, and some human-modified fill (APA 1984). The Lowland zone is characterized by low-lying, flat or concave surfaces typically associated with lacustrine waterbodies. The Lowland zone is uncommon in the study area and occurs in small, isolated patches in depressional features or valley bottoms. These areas are typically dominated by herbaceous meadow vegetation. The Riverine zone includes riverine-influenced riparian vegetation surrounding the EFMR, the north and south forks of Kachemak Creek, and numerous upper perennial streams flowing into Bradley Lake (APA 1984). The Martin River and Kachemak Creek include low gradient-high flow river channels and a range of successional vegetation types depending on the age of alluvial material deposits. Terrestrial riparian vegetation and landcover in these areas includes gravel barrens, partially vegetated dwarf shrub/forb communities, tall willow and alder, mixed forest, and mature black cottonwood (*Populus trichocarpa*) forest. The Riverine zone along the mainstem Martin River also includes numerous off-channel lakes, ponds, and graminoid marshes formed through channel diversions and overbank flooding. The Lacustrine zone consists of Bradley Lake, Red Lake, and various freshwater ponds formed in depressions in the undulating glacially modified terrain, including the impoundments associated with the Battle Creek outfall area. The Coastal zone encompasses the intertidal zone of the Martin River estuary on Kachemak Bay. The estuary is a large alluvial delta deposit that includes barren mudflats, tidal guts, salt marsh, and saline-influenced meadows.

4.5.1.1.3 Vegetation and Land Cover

A total of 33 Alaska Vegetation Classification Level IV vegetation types (Viereck et al. 1992) and unvegetated land cover classes were identified in the Vegetation and Wildlife Habitat Mapping Study (ABR 2026a; Table 4.5-1, Figure 4.5-1 and Figure 4.5-2). These types fall into the broad categories of Barrens and Water (five types), Herbaceous Meadow (nine types), Dwarf Shrub Tundra (five types), Low and Tall Shrub (eight types), and Mixed and Needleleaf Forest (five types).

Barrens and open water occur commonly throughout the study area, with fresh waterbodies accounting for 31.8 percent of the mapping (most of this is Bradley Lake), and natural and human-disturbed barrens (combined) covering another 18.1 percent of the study area.

Table 4.5-1 Level IV vegetation types (Viereck et al. 1992), land cover classes, and physiographic zones in the mapping study area for the Bradley Lake Expansion Project.

Vegetation and Land Cover Type	Physiographic Zone	Acres	Percent of Study Area
Barrens and Water			
Fresh Water	Subalpine, Lacustrine, Riverine	3558.7	31.8
Marine Water	Coastal	20.1	0.2
Partially Vegetated	Subalpine, Upland, Riverine	99.7	0.9
Ice	Subalpine	4.2	<0.1
Barren	Subalpine, Upland, Lacustrine, Riverine, Coastal	2019.6	18.1
Herbaceous Meadow			
Halophytic Sedge Wet Meadow, brackish	Coastal	65.3	0.6
Halophytic Sedge Marsh	Coastal	107.4	1.0
Halophytic Sedge Wet Meadow, saline	Coastal	4.3	<0.1
Subarctic Lowland Sedge Wet Meadow	Subalpine, Upland, Lowland, Lacustrine	2.4	<0.1
Subarctic Lowland Sedge-Moss Bog Meadow	Subalpine, Lowland, Lacustrine, Riverine	7.8	0.1

Vegetation and Land Cover Type	Physiographic Zone	Acres	Percent of Study Area
Mixed Herbs	Subalpine	53.8	0.5
Bluejoint-Herb	Lacustrine, Riverine	65.3	0.6
Dwarf Shrub			
Dry Dwarf Shrub	Riverine	107.4	1.0
Crowberry Dwarf Shrub Tundra	Subalpine	3.9	<0.1
Ericaceous Dwarf Shrub Lichen Tundra	Subalpine	2.1	<0.1
Mountain Heath Dwarf Shrub Tundra	Subalpine	203.5	1.8
Ericaceous Dwarf Shrub Tundra	Subalpine	47.0	0.4
Low and Tall Shrub			
Closed Low Willow	Riverine	5.0	<0.1
Open Low Willow	Riverine	258.8	2.3
Closed Tall Alder	Subalpine, Upland, Riverine	1856.8	16.6
Closed Tall Willow	Subalpine, Riverine	4.8	<0.1
Open Tall Alder	Subalpine, Upland, Riverine	557.8	5.0
Open Tall Alder Willow	Subalpine	7.7	0.1
Open Tall Scrub, post burn or disturbance	Riverine	150.0	1.3
Complexes	Subalpine	240.6	2.2
Broadleaf, Needleleaf, and Mixed Forest			
Black Cottonwood Woodland	Upland, Riverine	5.8	0.1
Closed Black Cottonwood-Lutz Spruce	Upland, Riverine	118.6	1.1
Open Black Cottonwood-Lutz Spruce	Upland, Riverine	737.8	6.6
Open Lutz Spruce Forest	Upland	408.0	3.7
Lutz Spruce Woodland	Subalpine, Upland	517.7	4.6
	Totals	**11,179.8**	**100.0**

The most common vegetation structure class is low and tall shrub. Closed tall alder communities comprise 16.6 percent of the study area and occur across subalpine, upland,

and riverine physiographic zones. Sitka alder (*Alnus sinuata*) is by far the most abundant shrub in the study area, with willow-dominant communities occurring in more isolated, wetter patches associated with impoundments or seasonally flooded drainages. Various coniferous, deciduous, and mixed forest types combined comprise another 16.0 percent of the study area.

Herbaceous meadows and dwarf shrub communities are the least common vegetation structure classes in the study area. Herbaceous meadows are found across all physiographic zones, with coastal salt marshes encompassing the greatest area (1.6 percent of the study area). Dwarf shrub tundra is found at higher elevations in the subalpine zone, and well drained *Dryas* communities occupy older and very well-drained, abandoned riverine surfaces in the Martin River floodplain (Figure 4.5-1; Figure 4.5-2).

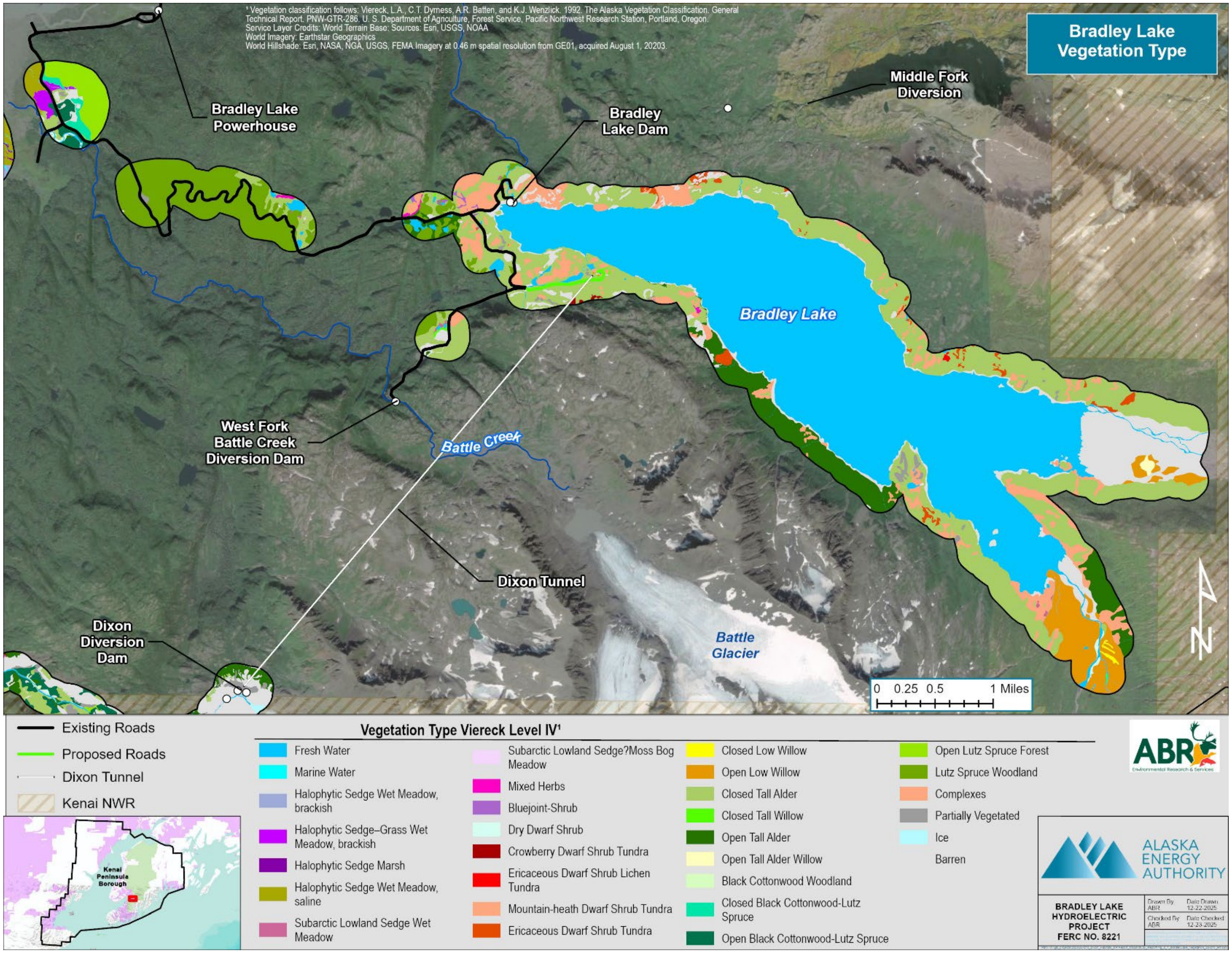

Figure 4.5-1 Level IV (Viereck et al. 1992) vegetation types occurring in the Bradley Lake drainage portion of the mapping study area.

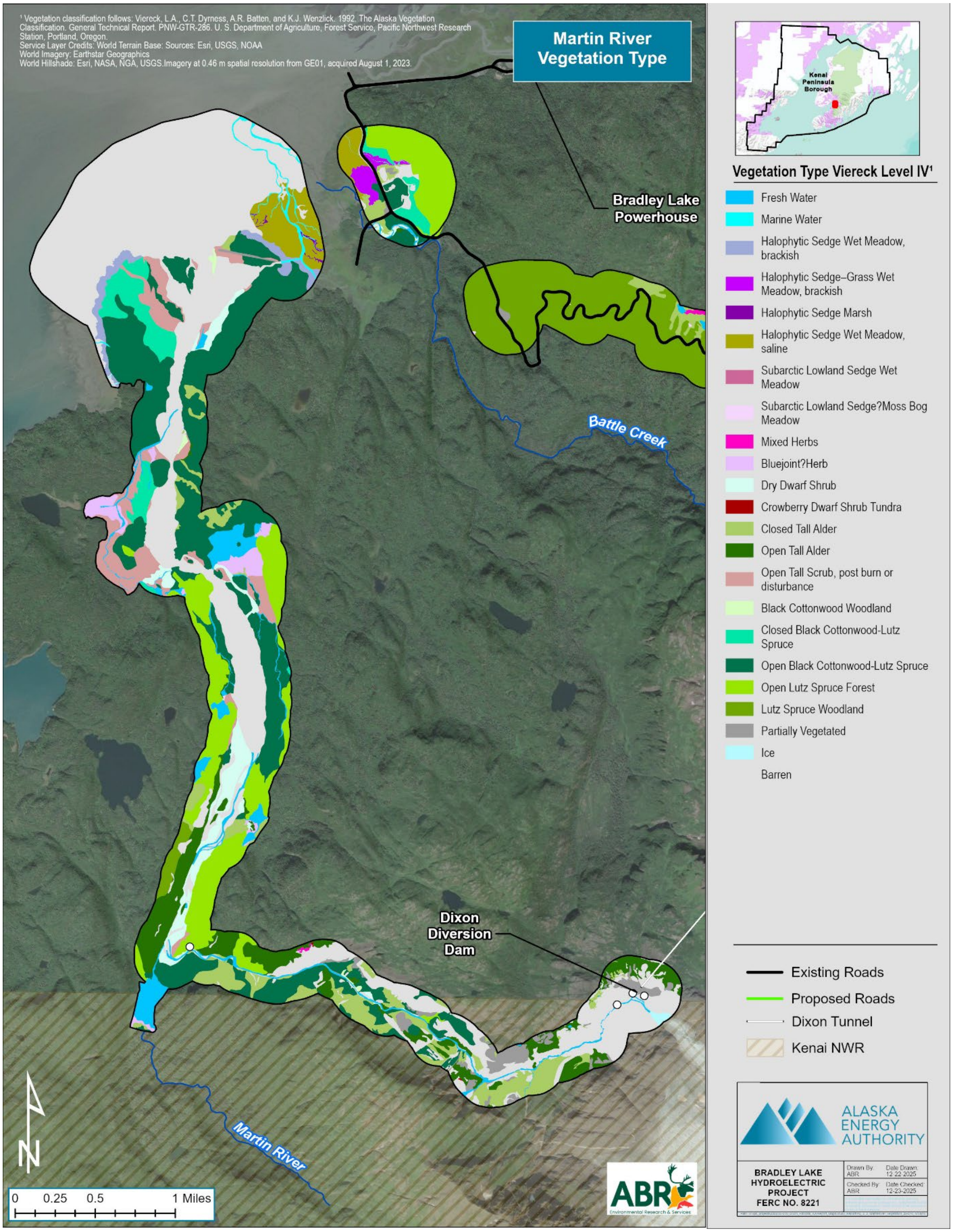

Figure 4.5-2 Level IV (Viereck et al. 1992) vegetation types occurring in the Martin River floodplain portion of the mapping study area.

4.5.1.1.4 Wildlife Habitats

A total of 34 individual wildlife habitats were derived from the aggregation of composite Integrated Terrain Unit (ITU) code combinations (ABR 2026a; Table 4.5-2, Figure 4.5-3 and Figure 4.5-4). These data were then used in the wildlife habitat evaluation (see Section 4.5.1.5 below). The most common habitat types mirror the extent of vegetation and landcover types in the study area where Human Modified Reservoir (Bradley Lake) is the most extensive habitat, covering 29.9 percent of the mapped area. Other freshwater lakes and ponds, Human Modified Ponds, off-channel lacustrine waterbodies, and adjacent fringe marshes combined cover only 1.5 percent of the study area.

Upland and Subalpine Tall Alder Scrub (combining open and closed types) is the most commonly occurring vegetated habitat (21.3 percent of the study area), followed by Upland Mixed Lutz Spruce-Black Cottonwood Forest (12.7 percent). Various riverine forest habitats combined cover another 4.7 percent of the study area, and the riverine dwarf, low, and tall shrub habitats combined cover 3.7 percent. The three rivers and streams types, Riverine Barrens, and Riverine Active Braided Floodplain combined cover 7.7 percent of the study area.

At the coast, Coastal Barren Mudflat and Tidal Gut combined cover 6.6 percent of the study area, whereas coastal and estuarine marsh and meadow habitats combined cover only 1.6 percent of the study area. In the mountains in subalpine and alpine terrain, natural rocky barrens, Rocky Cliffs, and the terminus of the Dixon Glacier combined cover 4.0 percent of the study area. Also in subalpine and alpine areas, dwarf scrub, herbaceous meadow, and bog habitats combined cover 2.5 percent of the study area. Artificial Fill, including cleared and disturbed surfaces, covers only 0.8 percent of the study area.

4.5.1.2 Terrestrial Mammals and Amphibians: Occurrence and Habitat Use

The Bradley Lake Expansion Project area is remote, located approximately 25 miles northeast of Homer, Alaska, on the Kenai Peninsula and accessible only by boat and aircraft. The area encompasses montane and coastal forests, subalpine and alpine areas, shrublands, rocky barrens, glaciers, aquatic lacustrine and riverine habitats, and riparian areas (see Section 4.5.1.1 above). The Project area is located within ADF&G's Game Management Unit (GMU) 15C; directly adjacent to the east on the Kenai Peninsula is GMU 7 (Figure 4.5-5).

Table 4.5-2 Wildlife habitat descriptions and spatial coverage in the mapping study area for the Bradley Lake Expansion Project.

Habitat Type	Description	Acres	Percent Study Area
Tidal Gut	Active channels with marine silt substrates that are flooded twice a day with salt water during each high tide, may have an upstream freshwater connection or not. No rooted vegetation within the channel, banks may be barren marine silts or robust stands of *Carex lyngbyei*.	20.0	0.2
Coastal Barren Mudflat	Barren silt flats occurring in the lowest elevations of the intertidal zone in the Martin River delta.	711.8	6.4
Coastal Saline Wet Sedge Marsh	Typically monotypic stands of *Carex lyngbyei* occurring in narrow fringes on the edges of tidal guts. Most likely flooded with salt water diurnally.	3.2	<0.1
Coastal Saline Wet Sedge Meadow	Wet sedge and forb dominant salt marsh communities in the lower elevations of the intertidal zone, likely receiving marine water input diurnally at each low and high tide. Species include *Carex lyngbyei*, *Potentilla egedii*, *Triglochin maritima*, and *Plantago maritima*. Characterized by low vegetative cover with significant exposed mud. Water input is likely to be primarily saline with very little freshwater influence.	107.4	1.0
Estuarine Brackish Wet Sedge-Forb Meadow	Salt tolerant sedges and forbs in the higher elevations of the intertidal zone. The habitat ranges in species diversity and composition but mostly characterized by regular flooding with saltwater but not with every high tide. Dominant species include; *Calamagrostis canadensis*, *Equisetum arvense*, *Triglochin maritima*, *Lupinus polyphyllus*, and *Poa eminens*.	65.3	0.6
Human Modified Reservoir	Bradley Lake is the only human-modified lacustrine waterbody in the mapping area. A deep >3,000-acre glacial fed lake filling the glacier-carved basin with steep shorelines and borders with little to no emergent or floating vegetation. Bradley Lake does not support fish.	3,343.8[a]	29.9
Human Modified Ponds	Impounded waters in abandoned gravel extraction sites near the mouth of the Martin River floodplain. The two mitigation ponds at the river mouth have largely been displaced and filled with sediment after the levy was breached in 2023, though small portions of one pond remain and another smaller impoundment farther upstream also remains intact. These ponds receive turbid glacial river water through extreme overbank flooding events.	2.8	<0.1

Habitat Type	Description	Acres	Percent Study Area
Lacustrine Freshwater Isolated Off-channel Pond	The Martin River corridor contains one isolated off-channel pond that was formed by an old channel diversion, which was eventually cut off from the river by the deposition of a deep alluvial fan. No seasonal or perennial surface water connection to the river, and if the freshwater ponds contain fish, it would be a resident population. Surrounded by well-developed littoral fringe vegetation and moss bog. The pond also supports floating aquatic vegetation (*Nuphar* and *Potamageton* spp.). The area immediately surrounding the ponds has numerous standing dead alder stems, which suggests that the early successional habitat was a tall alder shrub (*Alnus sinuata*) community that was replaced by a graminoid wetland when the water levels in the pond stabilized.	12.8	0.1
Lacustrine Freshwater Tapped Off-channel Pond	Swan Lake and two smaller impoundments on the Martin River are shallow ponds or small lakes formed during overbank flooding events. They are still connected to the Martin River through continuous surface water channels and support salmonids and resident fish populations. The water is turbid because overbank flooding events through the established channels are frequent. Surrounded by well-developed littoral fringe marshes and wet sedge-grass meadows with significant organic development. Standing dead alder stems and black cottonwood are often present.	33.2	0.3
Lacustrine Fringe Fresh Grass-Sedge Marsh	Flat areas on active glacial outwash deposits typically adjacent to off-channel impoundments. Substrates are less well drained than partially vegetated gravel bars and are composed of finer grained materials. Organic horizon development is limited. Dominant species include *Calamagrostis canadensis*, *Equisetum arvense*, *Carex aquatilis*, *Carex lyngbyei*, and *Juncus triglumis*. Standing dead alder or black cottonwood stems are often present.	47.2	0.4
Freshwater Lakes and Ponds	Shallow ponds and small lakes forming along drainage courses or in glacially carved depressions. In most cases, these are isolated features with intermittent or absent surface water connection to downstream waters; however, Red Lake is included in this habitat class, which has a clear perennial connection to the Martin River. Most waters in this class could support resident fish populations, but Red Lake provides anadromous fish (Sockeye Salmon) spawning and rearing habitat. All waterbodies are clear water with varying degrees	74.3	0.7

Habitat Type	Description	Acres	Percent Study Area
	of emergent and floating aquatic vegetation. At higher elevations, may be associated with moss bog wetland banks.		
Rocky Shore and Cobble Beach	Gently sloping barrens along the shoreline of Bradley Lake. Often occurs where drainageways join the Bradley Lake basin. There is little to no vegetation, and the substrate consists of coarse fragments from gravels to boulders.	102.5	0.9
Rivers and Streams (High Gradient-High Flow)	Permanently flooded channels of freshwater where gradients and flow are relatively high. Sources of water are glacial meltwater, glacial lakes, and surface water runoff. Water levels fluctuate rapidly but experience peak levels during spring melt and rainy periods.	28.7	0.3
Rivers and Streams (Low Gradient-High Flow)	Permanently flooded channels of freshwater where gradients are relatively low but flow remains high. Sources of water are glacial meltwater, glacial lakes, and surface water runoff. Water levels fluctuate rapidly but experience peak levels during spring melt and rain events.	46.7	0.4
Rivers and Streams (Mixed Gradient-Low Flow)	Permanently flooded channels of freshwater where gradients range from low to high and flow is relatively low. Sources of water may be groundwater but dominated by surface water runoff. Water levels fluctuate rapidly but experience peak levels during spring melt and rainy periods.	16.3	0.1
Riverine Barrens	Flat gravel bars in a braided channel system on active glacial outwash deposits. Substrates are extremely well-drained sand and gravels. Vegetation covers <30% and consists of pioneer species including *Epilobium latifolium*, *Oxytropis campestris*, *Latharus japonicus*, *Alnus sinuata*, *Populus trichocarpa* (seedlings), *Salix alaxensis*, and *S. sitchensis*.	395.2	3.5
Riverine Active Braided Floodplain	The width of the active riverine channel in the lower reaches of the Martin River where alluvium is actively being deposited. Consists of fast flowing water and barren gravel bars. The active channels change paths frequently, multiple times through the growing season. Some alluvial deposits may support very limited cover of forbs including *Chamerion latifolium*, *Oxytropis campestris*, and *Populus trichocarpa* seedlings. Standing dead, mature cottonwood trees may also be present in areas with aggradation of sediment from recent channel migrations.	373.9	3.3

Habitat Type	Description	Acres	Percent Study Area
Riverine Dryas Dwarf Shrub	Occurs on older abandoned riverine surfaces that are extremely well-drained gravels and cobbles, typically in isolated stands surrounded by younger aged surfaces, mixed alder shrub, or active riverine deposits. Sparsely vegetated with *Dryas drummondii*, *Oxytropis campestris*, *Lathyrus japonicus*, *Alnus sinuata,* and *Picea x lutzi* and *Populus trichocarpa* (saplings) with the development of some fruticose lichen.	107.4	1.0
Riverine Low and Tall Willow	Located on flat, active glacial outwash. With well-drained substrates composed of silt, sand, and gravels. Limited organic horizon development receiving frequent sediment deposition. Vegetation is dominated by *Salix pulchra* with *Agrostis exarata*, *Equisetum arvense*, and *Calamagrostis canadensis* among the understory components.	265.6	2.4
Riverine Tall Alder	Closed to open stands of alder occurring on some of the older riverine deposits, particularly surrounding waterbodies and next to the coastline. Includes older abandoned riparian surfaces with early successional vegetation development where the surface is less arid. Often monoclonal stands of *Alnus sinuata* and a continuous cover of leaf litter and shallow organic development on the ground surface. Some stands may include several individuals of *Picea lutzi*.	42.4	0.4
Riverine Flooded Black Cottonwood Scrub	Limited to the forest types surrounding the old airstrip next to the delta that have been recently flooded due to the recent channel relocation. These stands were still living in 2025, but significant sediment has been deposited during multiple overbank flooding events and still had flowing water in some areas during the sampling in 2025. These stands are expected to have significant mortality in the coming years.	150.0	1.3
Riverine Mature Black Cottonwood Forest	Occurs on the oldest abandoned riverine surfaces, likely more prevalent toward the coast. Closed to open canopy with large mature black cottonwood trees. The understory is sparse tall alder shrub and devil's club (*Oplopanax horridus*). Leaf litter occupies a significant amount of forest floor cover. Live black cottonwood stands grade into areas of standing dead cottonwood in several places in the Martin River delta.	4.3	<0.1
Riverine Mixed Spruce-Black Cottonwood Forest	Mixed Lutz spruce and black cottonwood in closed to open canopies. Occurs on the flat abandoned riverine terraces typically next to the steep sloping hillsides. Understory species are more diverse than younger riparian surfaces, but the understory is still much less diverse than the adjacent upland mixed forest types.	367.7	3.3

Habitat Type	Description	Acres	Percent Study Area
Upland and Subalpine Herb Meadow	Relatively small clearings in the forest and in protected landscape positions in the subalpine dominated largely by herbaceous plant species. Soils well drained with deep organics. Dominant herb species include *Agrostis exarata*, *Potentilla egedii*, *Carex macrochaeta*, *Leymus mollis*, *Epilobium angustifolium*, and with a significant shrub component including *Rubus arcticus*.	14.4	0.1
Upland and Subalpine Wet Graminoid Moss Bog	Shallow basins along stream-courses within upland forested slopes or in protected subalpine basins, with deep accumulation of organic material. Dominated by Sphagnum moss species with graminoid and forb species assemblages including *Carex saxatilis*, *C. rotundata*, *Eriophorum angustifolium*, *Triglochin maritima*, and *Potentilla palustris*.	6.7	0.1
Upland and Subalpine Tall Alder Scrub	Slopes varying from gentle to steep, occurs throughout the upland and subalpine zones. This type can occur in rocky drainageways, steep slopes, and in protected drainages at higher elevations. Substrates are well drained and range from rocky with very little organic accumulation to deep organic deposits on more moderate slopes and lower elevations. Dominated by shrub species including *Alnus sinuata*, *Rubus spectabilis*, *Betula kenaica*, and *Oplopanax horridus*. Understory species include *Athyrium filix-femina* ssp. *cyclosorum*, *Dryopteris diliatata*, and *Mitella nuda*.	2,380.0	21.3
Upland and Subalpine Tall Willow Scrub	Tall closed willow communities in isolated patches next to open water or within drainage features. Willow species include *Salix pulchra* and *S. barclayi*. Understory species may include *Petasites frigidus*, *Trientalis europaea*, *Sanguisorba officinalis,* and *Carex macrochaeata*.	3.0	<0.1
Upland Mixed Lutz Spruce-Black Cottonwood Forest	Occurs on hillsides throughout the Project area ranging from below treeline to the edge of the intertidal zone. Open to woodland canopy of *Picea x lutzi*, *Populus trichocarpa,* and *Betula neoalaskana*. Lutz spruce is significantly impacted by bark beetle kill, with some stands having 100% mortality of mature individuals. The understory is closed tall shrub consisting of *Alnus species*, *Rubus spectabilis*, *Sambucus racemosa,* and *Oplopanax horridus*.	1,415.9	12.7
Glaciated Subalpine Rock-Shrub Scrub-Meadow Complex	Undulating, complicated terrain with exposed bedrock, dwarf shrub tundra, and alder shrub occurring in close proximity in areas of sharp topographic relief. Dwarf shrub species such as *Empetrum nigrum* and *Vaccinium uliginosum* dominate the higher elevation, exposed areas, while low to tall *Alnus sinuata* shrubs dominate the incised, protected areas.	240.6	2.2

Habitat Type	Description	Acres	Percent Study Area
Subalpine and Alpine Barrens	Barren or partially vegetated areas on extensive exposed bedrock and mineral soil on exposed ridge crests. Soils lack an organic horizon, and substrates range from exposed bedrock to coarse, excessively drained gravels. Vegetation, where present, is <30% of cover and consists of dwarf shrubs such as *Loiseleuria* procumbens, *Empetrum nigrum*, and dwarf *Salix* species.	129.4	1.2
Subalpine and Alpine Dwarf Ericaceous Scrub	Vegetated areas on high, relatively exposed mounds and undulating terrain above Bradley Lake. Moderately thick to thick organic layers over well-drained soils. Vegetated cover is dominated by dwarf shrubs including *Harimanella stelleriana*, *Vaccinium uliginosum*, *Empetrum nigrum*, and *Phyllodoce empetriformis*.	256.5	2.3
Glacier	Toe of the Dixon Glacier. Unvegetated glacier ice with till material on the surface.	4.2	<0.1
Rocky Cliffs	Steep, unvegetated, unweathered parent material generally found along the shoreline of Bradley Lake.	317.4	2.8
Artificial Fill	Fill, or recently modified surfaces that have been modified by human activity and are barren. Areas within the impact assessment area include access roads and the existing dam infrastructure.	89.1	0.8
	Total	**11,179.8**	**100.0**

[a] The area of Human Modified Reservoir (Bradley Lake) is based on the lake area visible on the aerial photography acquired on July 28, 2022 when the lake elevation was El. 1,153 feet (27 feet below the current maximum pool elevation of El. 1,180 feet).

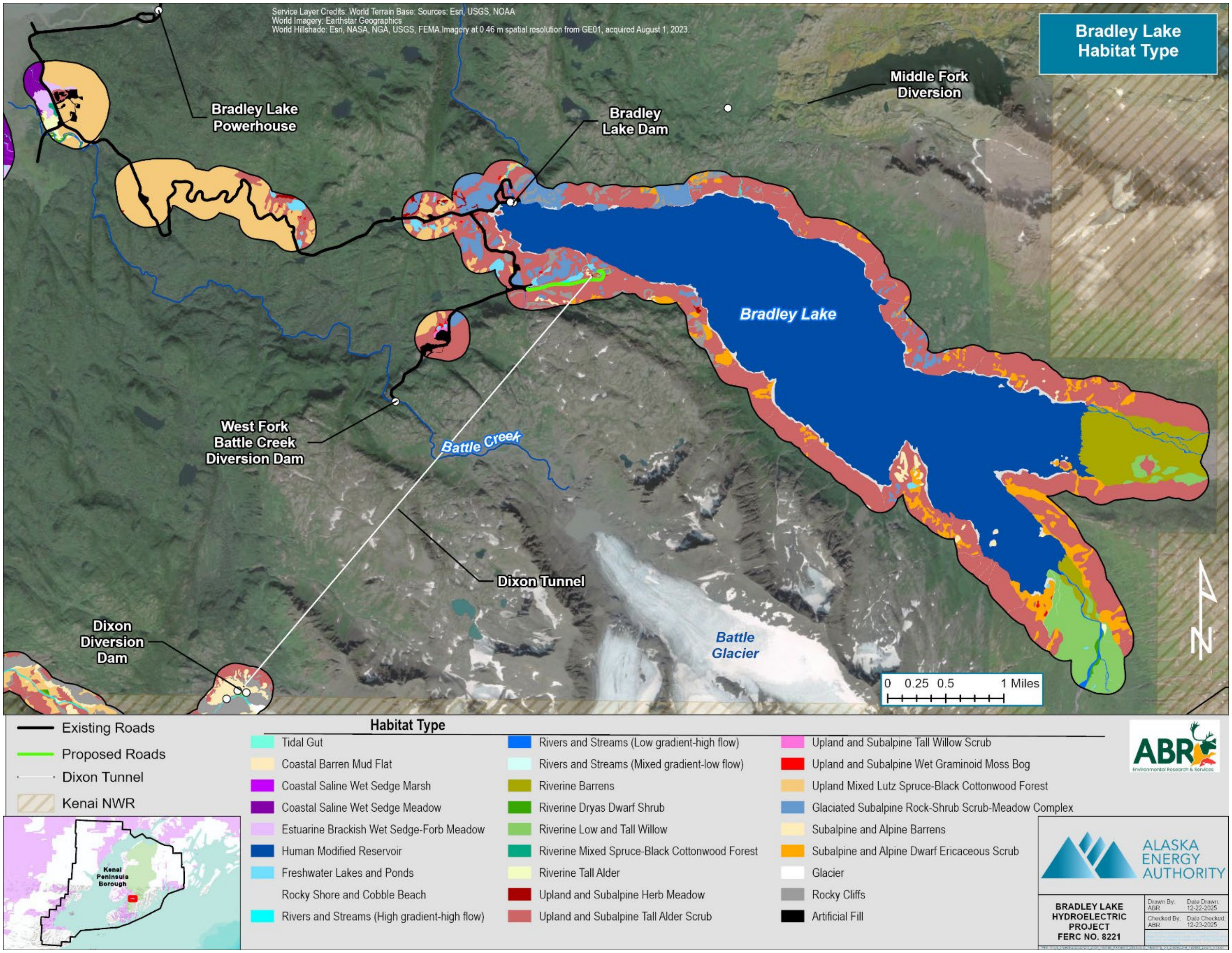

Figure 4.5-3 Wildlife habitat types occurring in the Bradley Lake drainage portion of the mapping study area.

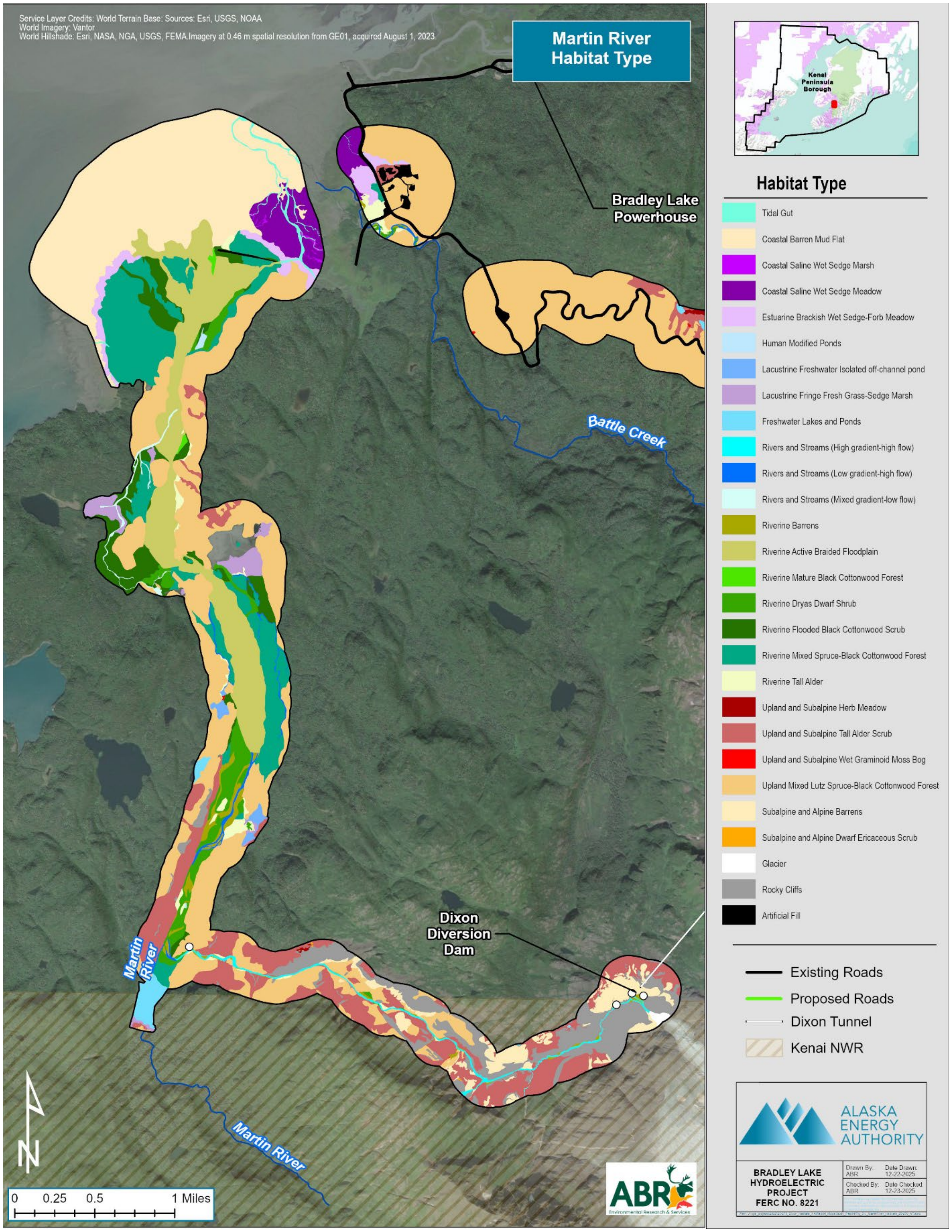

Figure 4.5-4 Wildlife habitat types occurring in the Martin River floodplain portion of the mapping study area.

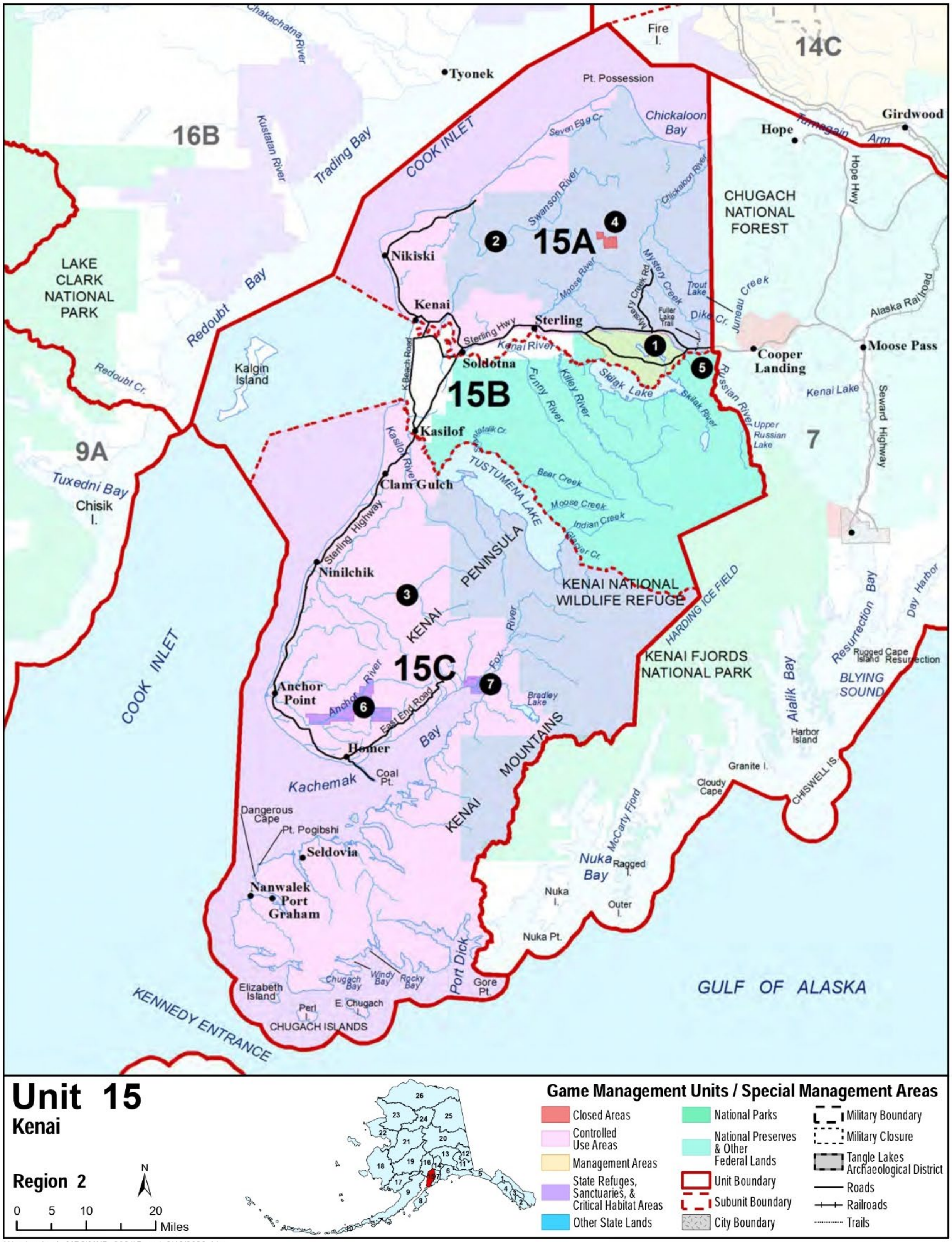

Figure 4.5-5 Game Management Unit 15 (ADF&G 2025a).

A variety of mammal species characteristic of the Kenai Peninsula and the Kenai and Chugach mountain ranges are likely to occur in the vicinity of the Project area (APA 1984; AEA 2015). Based on multiple sources of information including field studies conducted in the early 1980s (APA 1984), ongoing population surveys for large mammals by ADF&G, the mammal list in Exhibit E in the Battle Creek Diversion license amendment for the Bradley Lake Project (AEA 2015), and mammal distribution and habitat-use information in MacDonald and Cook (2009), up to 31 terrestrial mammal species are known or thought likely to occur in available habitats in the Project area. This set of 31 terrestrial mammal species includes large mammals, furbearers, small mammals, and bats (Table 4.5-3).

Of the 31 terrestrial mammal species likely to occur in the Project area, 14 were selected as species of concern based on their conservation status, their ecological or subsistence/recreational hunting importance, and the potential for these species to experience impacts from the Project (ABR 2026b; see Section 4.5.1.5 below). These species warrant specific attention in this license amendment application and are described below, drawing upon information in existing licensing study reports for the Bradley Lake Project and local knowledge of mammal occurrence on the Kenai Peninsula.

Wood frogs (*Lithobates sylvaticus*) are the only amphibians found in Alaska outside of the southeastern panhandle (ADF&G 2025b). They are common in forested wetlands, wet meadows, marshes, and ponds. Their occurrence in the Project area is unknown. Wood frogs were not considered as a species of concern for the Project, and in Alaska no terrestrial reptiles occur north of the southeastern panhandle (ADF&G 2025b).

4.5.1.2.1 Large Mammals

Black bears (*Ursus americanus*) are the most abundant and well distributed of the three bear species in North America (ADF&G 2025b). In Alaska, they are largely associated with forested habitats but range from sea level to alpine regions, depending on the season (ADF&G 2025b). They forage predominantly on berries (e.g., devil's club [*Oplopanax horridus*], blueberry, currents), as well as salmon and herbaceous plant shoots and roots (Schwartz and Franzmann 1991; McLellan 2011). Population estimation surveys have never been conducted on the Kenai Peninsula for black bears (Herreman 2022a), but the species was common in the Bradley Lake Project area during studies in the early 1980s and for the Battle Creek Diversion project around 2012, and black bears continue to be common today (APA 1984; AEA 2015; personal communication between J. Herreman, ADF&G, and Joseph Welch, Senior Scientist, ABR, September 24, 2025). Assuming black bear densities along the southern Kenai Peninsula coast are at least 53 per 100 square miles (Schwartz and Franzmann 1991), ADF&G estimates 3,000–4,000 black bears occur in GMUs 7 and 15, with higher densities along the coast (Selinger 2008), likely due to the availability of salmon and low densities of competing brown bears (*U. arctos*; Selinger 2008).

Table 4.5-3 Avian and mammalian species known to occur (APA 1984; AEA 2015) and likely to occur in the vicinity of the Bradley Lake Expansion Project area.

Species Group	Common Name	Scientific Name
Waterbird	Greater White-fronted Goose	*Anser albifrons*
Waterbird	Brant	*Branta bernicla*
Waterbird	Canada Goose	*Branta canadensis*
Waterbird	Trumpeter Swan	*Cygnus buccinator*
Waterbird	Tundra Swan	*Cygnus columbianus*
Waterbird	Northern Shoveler	*Spatula clypeata*
Waterbird	Gadwall	*Mareca strepera*
Waterbird	American Wigeon	*Mareca americana*
Waterbird	Mallard	*Anas platyrhynchos*
Waterbird	Northern Pintail	*Anas acuta*
Waterbird	Green-winged Teal	*Anas crecca*
Waterbird	Greater Scaup	*Aythya marila*
Waterbird	Steller's Eider	*Polysticta stelleri*
Waterbird	Spectacled Eider	*Somateria fischeri*
Waterbird	Harlequin Duck	*Histrionicus histrionicus*
Waterbird	Surf Scoter	*Melanitta perspicillata*
Waterbird	White-winged Scoter	*Melanitta deglandi*
Waterbird	Black Scoter	*Melanitta americana*
Waterbird	Long-tailed Duck	*Clangula hyemalis*
Waterbird	Bufflehead	*Bucephala albeola*
Waterbird	Common Goldeneye	*Bucephala clangula*
Waterbird	Barrow's Goldeneye	*Bucephala islandica*
Waterbird	Common Merganser	*Mergus merganser*
Waterbird	Red-breasted Merganser	*Mergus serrator*
Waterbird	Horned Grebe	*Podiceps auritus*
Waterbird	Red-necked Grebe	*Podiceps grisegena*
Waterbird	Sandhill Crane	*Antigone canadensis*
Waterbird	Red-throated Loon	*Gavia stellata*
Shorebird	Black-bellied Plover	*Pluvialis squatarola*
Shorebird	Semipalmated Plover	*Charadrius semipalmatus*
Shorebird	Whimbrel	*Numenius phaeopus*
Shorebird	Hudsonian Godwit	*Limosa haemastica*
Shorebird	Dunlin	*Calidris alpina*
Shorebird	Rock Sandpiper	*Calidris ptilocnemis*

Species Group	Common Name	Scientific Name
Shorebird	Least Sandpiper	*Calidris minutilla*
Shorebird	Pectoral Sandpiper	*Calidris melanotos*
Shorebird	Semipalmated Sandpiper	*Calidris pusilla*
Shorebird	Western Sandpiper	*Calidris mauri*
Shorebird	Short-billed Dowitcher	*Limnodromus griseus*
Shorebird	Long-billed Dowitcher	*Limnodromus scolopaceus*
Shorebird	Wilson's Snipe	*Gallinago delicata*
Shorebird	Spotted Sandpiper	*Actitis macularius*
Shorebird	Wandering Tattler	*Tringa incana*
Shorebird	Lesser Yellowlegs	*Tringa flavipes*
Shorebird	Greater Yellowlegs	*Tringa melanoleuca*
Shorebird	Red-necked phalarope	*Phalaropus lobatus*
Seabird	Marbled Murrelet	*Brachyramphus marmoratus*
Seabird	Kittlitz's Murrelet	*Brachyramphus brevirostris*
Seabird	Black-legged Kittiwake	*Rissa tridactyla*
Seabird	Bonaparte's Gull	*Chroicocephalus philadelphia*
Seabird	Short-billed Gull	*Larus brachyrhynchus*
Seabird	American Herring Gull	*Larus smithsonianus*
Seabird	Glaucous-winged Gull	*Larus glaucescens*
Seabird	Arctic Tern	*Sterna paradisaea*
Seabird	Pelagic Cormorant	*Urile pelagicus*
Raptor	Golden Eagle	*Aquila chrysaetos*
Raptor	Northern Harrier	*Circus hudsonius*
Raptor	Sharp-shinned Hawk	*Accipiter striatus*
Raptor	American Goshawk	*Accipiter atricapillus*
Raptor	Bald Eagle	*Haliaeetus leucocephalus*
Raptor	Red-tailed Hawk	*Buteo jamaicensis*
Raptor	Great Horned Owl	*Bubo virginianus*
Raptor	Northern Hawk Owl	*Surnia ulula*
Raptor	Short-eared Owl	*Asio flammeus*
Raptor	Boreal Owl	*Aegolius funereus*
Raptor	Northern Saw-whet Owl	*Aegolius acadicus*
Raptor	Merlin	*Falco columbarius*
Raptor	Peregrine Falcon	*Falco peregrinus*
Landbird	Spruce Grouse	*Canachites canadensis*
Landbird	Willow Ptarmigan	*Lagopus lagopus*
Landbird	Rock Ptarmigan	*Lagopus muta*
Landbird	Rufous Hummingbird	*Selasphorus rufus*
Landbird	Belted Kingfisher	*Megaceryle alcyon*
Landbird	American Three-toed Woodpecker	*Picoides dorsalis*
Landbird	Hairy Woodpecker	*Dryobates villosus*

Species Group	Common Name	Scientific Name
Landbird	Olive-sided Flycatcher	*Contopus cooperi*
Landbird	Alder Flycatcher	*Empidonax alnorum*
Landbird	Canada Jay	*Perisoreus canadensis*
Landbird	Steller's Jay	*Cyanocitta stelleri*
Landbird	Black-billed Magpie	*Pica hudsonia*
Landbird	American Crow	*Corvus brachyrhynchos*
Landbird	Common Raven	*Corvus corax*
Landbird	Black-capped Chickadee	*Poecile atricapillus*
Landbird	Chestnut-backed Chickadee	*Poecile rufescens*
Landbird	Boreal Chickadee	*Poecile hudsonicus*
Landbird	Horned Lark	*Eremophila alpestris*
Landbird	Bank Swallow	*Riparia riparia*
Landbird	Tree Swallow	*Tachycineta bicolor*
Landbird	Violet-green Swallow	*Tachycineta thalassina*
Landbird	Cliff Swallow	*Petrochelidon pyrrhonota*
Landbird	Ruby-crowned Kinglet	*Corthylio calendula*
Landbird	Golden-crowned Kinglet	*Regulus satrapa*
Landbird	Brown Creeper	*Certhia americana*
Landbird	Pacific Wren	*Troglodytes pacificus*
Landbird	American Dipper	*Cinclus mexicanus*
Landbird	Swainson's Thrush	*Catharus ustulatus*
Landbird	Hermit Thrush	*Catharus guttatus*
Landbird	American Robin	*Turdus migratorius*
Landbird	Varied Thrush	*Ixoreus naevius*
Landbird	American Pipit	*Anthus rubescens*
Landbird	Pine Grosbeak	*Pinicola enucleator*
Landbird	Redpoll	*Acanthis flammea*
Landbird	White-winged Crossbill	*Loxia leucoptera*
Landbird	Pine Siskin	*Spinus pinus*
Landbird	Lapland Longspur	*Calcarius lapponicus*
Landbird	Snow Bunting	*Plectrophenax nivalis*
Landbird	Fox Sparrow	*Passerella iliaca*
Landbird	Dark-eyed Junco	*Junco hyemalis*
Landbird	White-crowned Sparrow	*Zonotrichia leucophrys*
Landbird	Golden-crowned Sparrow	*Zonotrichia atricapilla*
Landbird	Savannah Sparrow	*Passerculus sandwichensis*
Landbird	Song Sparrow	*Melospiza melodia*
Landbird	Lincoln's Sparrow	*Melospiza lincolnii*
Landbird	Rusty Blackbird	*Euphagus carolinus*
Landbird	Northern Waterthrush	*Parkesia noveboracensis*
Landbird	Orange-crowned Warbler	*Leiothlypis celata*
Landbird	Northern Yellow Warbler	*Setophaga aestiva*

Species Group	Common Name	Scientific Name
Landbird	Blackpoll Warbler	*Setophaga striata*
Landbird	Townsend's Warbler	*Setophaga townsendi*
Landbird	Wilson's Warbler	*Cardellina pusilla*
Landbird	American red squirrel	*Tamiasciurus hudsonicus*
Large Mammal	Black bear	*Ursus americanus*
Large Mammal	Brown bear	*Ursus arctos*
Large Mammal	Moose	*Alces alces*
Large Mammal	Mountain goat	*Oreamnos americanus*
Furbearer, Aquatic	American beaver	*Castor canadensis*
Furbearer, Aquatic	Muskrat	*Ondatra zibethicus*
Furbearer, Aquatic	River otter	*Lontra canadensis*
Furbearer, Aquatic	Mink	*Neovison vison*
Furbearer, Terrestrial	Hoary marmot	*Marmota caligata*
Furbearer, Terrestrial	Lynx	*Lynx canadensis*
Furbearer, Terrestrial	Coyote	*Canis latrans*
Furbearer, Terrestrial	Wolf	*Canis lupus*
Furbearer, Terrestrial	Red fox	*Vulpes vulpes*
Furbearer, Terrestrial	Wolverine	*Gulo gulo*
Furbearer, Terrestrial	Ermine (short-tailed weasel)	*Mustela erminea*
Furbearer, Terrestrial	Least weasel	*Mustela nivalis*
Small Mammal	American red squirrel	*Tamiasciurus hudsonicus*
Small Mammal	Meadow jumping mouse	*Zapus hudsonius*
Small Mammal	Singing vole	*Microtus miurus*
Small Mammal	Tundra (root) vole	*Microtus oeconomus*
Small Mammal	Meadow vole	*Microtus pennsylvanicus*
Small Mammal	Northern red-backed vole	*Myodes rutilus*
Small Mammal	Northern bog lemming	*Synaptomys borealis*
Small Mammal	Porcupine	*Erethizon dorsatum*
Small Mammal	Snowshoe hare	*Lepus americanus*
Small Mammal	Cinereus shrew	*Sorex cinereus*
Small Mammal	American pygmy shrew	*Sorex hoyi*
Small Mammal	Dusky shrew	*Sorex monticolus*
Small Mammal	Western water shrew	*Sorex navigator*
Bat	Little brown myotis	*Myotis lucifugus*

Note: Species sorted by phylogenetic order within each species group.

Brown bears have a broad diet that includes grasses, sedges, cow parsnip (*Heracleum maximum*), moose calves, salmon, berries, carrion, and roots, with salmon being a particularly important food source for Kenai Peninsula bears (Farley et al. 2001; ADF&G 2025b). They typically den on high-elevation steep slopes (averaging El. 2,120 feet above mean sea level; Goldstein et al. 2010). The brown bear population on the Kenai Peninsula is considered relatively small, and they are only common in certain areas, making the population vulnerable to impacts from development (Schoen 2011; Jackson et al. 2008). On the east side of Kachemak Bay where the Project is located, brown bears are very rare (Selinger 2015). Although tracks were observed near Battle Creek in early May during the 1980s studies (APA 1985), little evidence of brown bears was found during other studies (USACE 1982).

Moose (*Alces alces*) are a very important big game species in GMU 15C (Herreman 2022b). They are most abundant in areas with dense stands of willow, aspen, and/or birch shrubs, which commonly occur in alpine shrub communities and riparian habitats (ADF&G 2025b). Moose browse on birch, aspen, and willow twigs in the fall and winter but diversify their diet in the summer to include the leaves of other trees and shrubs, aquatic vegetation, and herbaceous plants (Risenhoover 1989; Welch et al. 2015; ADF&G 2025b). Moose and signs of moose were common in the Bradley Lake Project area in the early 1980s (APA 1984) and in lower Battle Creek around 2012 (AEA 2015). However, lowland habitat quality in the Kenai Peninsula region may be declining in some locations due to plant succession, spruce bark beetle (*Dendroctonus rufipennis*) infestations, and logging activities (Herreman 2022b). Moose densities in the downstream Bradley River study area in the early 1980s ranged from 1.6 to 1.98 moose per square mile (APA 1985), but the current intensive management goal for all of GMU 15C is 1.0–1.4 moose per square mile (Herreman 2022b). In the Project area, some moose may concentrate at higher latitudes during the rut, but they generally avoid higher elevations during the winter when deep snow restricts movements and covers browse (AEA 2015; Herreman 2022b).

Mountain goats (*Oreamnos americanus*) inhabit rugged, mountainous terrain, typically below El. 5,000 feet (ADF&G 2025b). They spend summers grazing on grasses, sedges, forbs, lichen, moss, and shrubs in high alpine meadows and move to winter ranges at or below the treeline in forested habitats where they predominantly forage on trees, shrubs, and lichen (Fox et al. 1989; White et al. 2012; Westing 2022; ADF&G 2025b). Regardless of season, they are usually not far from rugged cliffs, which provide safety from predators (Fox et al. 1989; White et al. 2012; White and Gregovich 2017). The USFS considers mountain goats a management indicator species in the Chugach National Forest (USFS 2008). Goat populations in coastal Alaska are limited principally by winter severity (mainly snow depth) and the availability of suitable habitat (Fox et al. 1989; White et al. 2012). The Kenai Peninsula is home to a healthy mountain goat population of around 3,300–4,750 animals (ADF&G 2025b). The population had gone through a prior decline in the 1990s and early 2000s, but populations have largely recovered due to adaptive management (Herreman 2025). In the Bradley Lake Goat Management Unit 359, the latest available aerial survey count located 170 goats including 43 kids, indicating the population had recently increased (Herreman 2025). Project staff reported observing numerous mountain goats in cliff habitats adjacent to Bradley Lake and the EFMR during aerial Golden Eagle (*Aquila chrysaetos*) surveys in May just prior to kidding, but very few were observed in the Project area during a July survey (ABR 2025c).

4.5.1.2.2 Furbearers

Wolverines (*Gulo gulo*) have large home ranges and require large expanses of wilderness (ADF&G 2025b). In the Kenai Mountains and other nearby mountains in Southcentral Alaska, the density of wolverines is typically low (4.5 to 5.2 per 1,000 square kilometers; Becker and Gardner 1992; Golden 1996; ADF&G 2025b). They are found in a variety of habitats and elevations but are more common in alpine and subalpine habitats in the summer and often move to lower elevations in the winter where they can also use forest habitats (USFWS 2018). Wolverines are shy and avoid human activity (Gardner et al. 2010). Their diet is opportunistic. They often scavenge in the winter, but throughout the year they also feed on small and medium-sized animals, such as voles, squirrels, snowshoe hares (*Lepus americanus*), and birds, and are known to occasionally kill moose, caribou, sheep, and other large mammals (ADF&G 2025b). Although wolverines are likely present in the area, they are expected to be infrequent due to their wide dispersal and large home ranges.

Hoary marmots (*Marmota caligata*) are the largest members of the squirrel family in North America, weighing up to 10 pounds (ADF&G 2025b). They hibernate during the winter but are active in the summer, especially during the twilight hours (ADF&G 2025b). They build burrows under large rocks in talus slopes, boulder fields, rock outcrops, and cliffs, and they forage on nearby herbs, forbs, berries, roots, mosses, and lichen (ADF&G 2025b). They are common in the Project area (AEA 2015) and were observed numerous times in cliff habitat during aerial Golden Eagle surveys for the current Project (ABR 2025c).

American beavers (*Castor canadensis*), North America's largest rodents, are managed by ADF&G as furbearers and are generally considered common and abundant, especially throughout the forested portions of Alaska (ADF&G 2025b). Beavers usually dam small streams and springs to create deep, stable ponds that stay open in winter; they also use bank dens on fast rivers and build lodges in existing ponds and lakes (ADF&G 2025b).

They are known to occur in the Project area, though aquatic mammals were not commonly observed during the Battle Creek Diversion studies (AEA 2015).

River otters (*Lontra canadensis*) inhabit aquatic and marine shoreline habitats where they primarily consume fish and invertebrates; they also occasionally eat insects, frogs, birds, mammals, and vegetation (Larsen 1983; ADF&G 2025b). While otters use terrestrial habitats for hunting, travel, and denning, they often use habitats in proportion to their availability and within 30.0 meters (32.8 yards) of shore (Larsen 1983; Woolington 1984). Natal dens may be 1.0 kilometer (0.6 mile) inland but are located in close proximity to inland waterbodies for safe access (Woolington 1984). River otters often den in cavities under large stumps in old growth forests or in rock piles (Woolington 1984). They are present in the Project area from the ocean to the alpine (personal communication between J. Herreman, ADF&G, and Joseph Welch, Senior Scientist, ABR, September 24, 2025). Project staff for the Battle Creek Diversion project around 2012 (AEA 2015) noted less frequent sightings of aquatic mammals than in the early 1980s (APA 1984), and that species group would include river otters.

4.5.1.2.3 Small Mammals

Snowshoe hares are distributed throughout most of Alaska and primarily inhabit mixed spruce forests, wooded swamps, shrublands, and riparian communities (Banfield 1974; Wolff 1980; ADF&G 2025b). Their diet includes grasses, buds, twigs, and leaves in the summer, and spruce twigs/needles, bark, and buds of hardwood species like aspen and willow in the winter (ADF&G 2025b). Snowshoe hares are a primary food source for many predators.

The singing vole (*Microtus miurus*) is found throughout much of Alaska, including the Kenai Peninsula (Fuller 1981; ACCS 2018). Singing voles typically inhabit willow thickets, spruce forests, and woody riparian communities in arctic and alpine tundra (Bee and Hall 1956; Manville and Young 1965; Babcock 1984; Douglass 1984; Batzli and Lesieutre 1995). They prefer mesic habitats near or above treeline with ample cover and food sources such as horsetails, palatable forbs, or deciduous shrubs (Batzli and Lesieutre 1995; MacDonald and Cook 2009).

The tundra vole (also known as root vole; *M. oeconomus*) is widely distributed throughout Alaska, including the southern coast (Douglass 1984; Batzli and Henttonen 1990; MacDonald and Cook 2009). They inhabit tundra and taiga biomes at various elevations, preferring mesic herbaceous meadows with abundant cover, especially along the edges of streams and lakes (Bieberich 2007; MacDonald and Cook 2009). Their primary food is sedges (Bieberich 2007). The tundra vole is an important prey species for various carnivores, especially during vole population eruptions (Bieberich 2007).

The dusky shrew (*Sorex monticolus*) is one of the most common species of shrew in North America and occupies a wide range of habitats, including tundra, alpine meadows, forests, and prairies (Forsyth 1985; Banasiak 2001; MacDonald and Cook 2009). They are often found in forest floor litter, typically within 100 meters (109 yards) of streams or rivers, and they prefer moist or wet habitats with dense ground cover, acidic soils, and nearby coniferous forest (Forsyth 1985; Smith and Belk 1996; MacDonald and Cook 2009).

Western water shrews (*S. navigator*) are amphibious, rarely found more than a few meters from the water's edge, and prefer banks offering adequate cover such as thick vegetation or rock crevices (Conaway 1952; Beneski and Stinson 1987; Lehmkuhl et al. 2008; MacDonald and Cook 2009).

4.5.1.2.4 Bats

The only bat likely to inhabit the Project area is the little brown myotis (*Myotis lucifugus*). A single dead specimen of western long-eared bat (*M. evotis*), which was separated taxonomically from Keen’s myotis (*M. keenii*) in Alaska, was reported and collected from the Homer Spit several years ago (personal communication between J. Herreman, ADF&G, and Joseph Welch, Senior Scientist, ABR, September 24, 2025), but no other specimens or acoustic recordings of this species have been identified north of southeast Alaska (personal communication between J. Reimer, University of California-Davis, and Joseph Welch, Senior Scientist, ABR, Inc., September 24, 2025). ADF&G requested that western long-eared bat be considered a species of concern for the Project, but because it is very unlikely to occur in the Project area and population impacts are not possible for out-of-range occurrences, it is not considered further.

The little brown myotis is a small, insectivorous bat found widely throughout most of Alaska, except for the Arctic and the Aleutian Islands (ADF&G 2025b). It has been documented in various habitats, including temperate rainforests and spruce/birch forests and is even known to use coastal, marine-influenced habitats in nearby Kenai Fjords National Park (Mullet et al. 2021; ADF&G 2025b). These bats commonly roost in human-made structures or natural sites like snags of mature trees (Loeb et al. 2014; Tessler and

Snively 2014). They typically feed on insects aerially over water and in riparian areas near forests (Parker et al. 1997; Loeb et al. 2014; Snively et al. 2021). In Alaska, the size and status of the little brown myotis population(s) is unknown, but they appear to be widespread in low numbers (ADF&G 2025b). As with other bats, mortality risk from white nose syndrome (WNS) is a significant global threat to the species (ADF&G 2025b).

4.5.1.3 Marine Mammals

All marine mammals are protected by the MMPA (P.L. 92-522; 16 U.S.C. §§1361-1423h) of 1972. Rare, threatened, and endangered marine mammals are discussed in Section 4.7. Species descriptions and population status, unless otherwise noted, have been summarized from species profiles available on the ADF&G (2025b) website. Marine mammals expected to occur in the shallow waters of upper Kachemak Bay include harbor seals (*Phoca vitulina*), sea lions, sea otters (*Enhydra lutris*) (Southcentral stock), and harbor porpoises (*Phocoena phocoena*; ADF&G 1993). Dall's porpoises (*Phocoenoides dalli*), minke whales (*Balaenoptera acutorostrata*), humpback whales (*Megaptera novaeangliae*), and killer whales (*Orcinus orca*) can occur in Kachemak Bay but prefer the deeper and less turbid waters in the lower bay (see below).

Harbor seals are abundant at the head of Kachemak Bay, are present year-round, and were reported to ascend 6 miles up the Bradley River to the base of the first falls when salmon were present (ADF&G 1993). The tidal flats between the Bradley River and the Fox River are an important haulout area for harbor seals from May to October (ADF&G 1993). Harbor seals are not listed under the ESA or designated as depleted or strategic under the MMPA.

There are two Distinct Population Segments (DPSs) of Steller sea lions (*Eumetopias jubatus*) in Alaska. The western DPS includes animals that occur west of Cape Suckling, Alaska, and therefore includes individuals within Kachemak Bay. The western DPS was listed under the ESA as threatened in 1990, and its continued population decline resulted in a change in listing status to endangered in 1997. Steller sea lions are present in Kachemak Bay year-round, although there are no large traditional haulouts (ADF&G 1993).

The highest densities of sea otters in the lower Cook Inlet are along the north shore of Kachemak Bay and in Port Graham (Gerlach-Miller et al. 2018); these otters are part of the

Southcentral stock which is not listed under the ESA. Sea otters generally occur in nearshore areas and prefer habitats with islets and rocky reefs (ADF&G 2025b).

There are five beluga stocks in Alaska: the Beaufort Sea stock, eastern Chukchi Sea stock, eastern Bering Sea stock, Bristol Bay stock, and Cook Inlet stock (Young et al. 2024). Whales from the Cook Inlet stock (CI beluga) have been present in upper Kachemak Bay and were reported to be present at the mouth of the Bradley River in July through September in the 1990s (ADF&G 1993). All marine waters in Kachemak Bay are designated as Critical Habitat Area 2 for the CI beluga stock (76 Federal Register [FR] 20180). Area 2 critical habitat has a lower concentration of beluga whales in spring and summer but is used by beluga whales in fall and winter. Aerial population surveys have been conducted in June in Kachemak Bay every other year from 1994 through 2025 (NOAA 2025), and belugas were last seen in upper Kachemak Bay in 1994 (NOAA 1995). There have not been any belugas observed during the summer population surveys in Kachemak Bay since 1994 (personal communication between Kim Goetz, NOAA, and Rebecca McGuire, ABR, Inc., January 20, 2026).

There are three stocks of harbor porpoise in Alaska: the Bering Sea stock, the Southeast Alaska stock, and the Gulf of Alaska stock (Young et al. 2024), the latter of which occur in the Project area. Harbor porpoises are not designated as depleted under the MMPA or listed under the ESA but are denoted as "strategic" under the MMPA. Harbor porpoises are common in nearshore waters of Kachemak Bay, generally in waters less than 60 feet deep (ADF&G 1993).

Minke whales are known to occur in Kachemak Bay in the summer where they feed on euphausiids, copepods, and larger schooling fish (ADF&G 1993, 2025b) but generally remain in deeper water (ADF&G 2025b). Killer whales are reported to be occasionally sighted in the outer portions of Kachemak Bay (ADF&G 1993).

Fin whales (*B. physalus*) and humpback whales may be present in Cook Inlet but are not commonly seen in the shallow waters of Kachemak Bay (ADF&G 1993). Similarly, Dall's porpoises are uncommon in Kachemak Bay, generally preferring deeper water (ADF&G 2025b).

4.5.1.4 Avian Species: Occurrence and Habitat Use

The Project area and surrounding region in upper Kachemak Bay include habitat that can be used by multiple bird species, including waterbirds, raptors, seabirds, shorebirds, and landbirds. These species may use the area for breeding and while on migration, and in some cases, they can be year-round residents. Based on the ranges of species, the habitats available (see Section 4.5.1.1 above), the species previously recorded in the Bradley Lake Project area (APA 1984; AEA 2015), and expert opinion based on decades of field experience in Southcentral Alaska, it was determined the Project area and vicinity may be used regularly by at least 120 bird species (Table 4.5-3).

Nearly all of Alaska's bird species, including those that may occupy lands and waters within the Project vicinity, are protected under the provisions of the Migratory Bird Treaty Act (MBTA; 16 U.S.C 703-712). Bald (*Haliaeetus leucocephalus*) and Golden eagles receive additional protection under the Bald and Golden Eagle Protection Act (BGEPA; 16 U.S.C. 668-668d). The BGEPA protects eagles from take at any time of year, including disturbance of nest sites, roosts, and foraging sites (50 CFR 22.6). The MBTA protects migratory birds by prohibiting the take of protected migratory bird species, their eggs, or nests, unless authorized by permit or state-authorized subsistence use.

In general, migratory birds primarily nest in Southcentral Alaska from May 1 through July 15. Seabirds nest from April 15 through September 7, whereas eagles may nest 2 or more months earlier than other birds (March 1 through August 31; USFWS 2017).

4.5.1.4.1 Waterbirds

Waterbirds, which include waterfowl, loons, grebes, and cranes, may use the area during migration and breeding. They require open water and wetlands for feeding and nesting and generally will be found on lakes, marshes, ponds, rivers, wetlands, and coastal estuaries. Most waterbirds frequent rivers, river outlets, and coastal freshwater or brackish wetlands during migration because they are rich in food and because they are the first areas to become ice-free in spring. Waterbirds breed in a variety of aquatic and palustrine wetland habitats. Some species specialize in using primarily one habitat type (e.g., Common [*Gavia immer*] and Pacific [*G. pacifica*] loons prefer large lakes), while other species use many different habitat types (e.g., Mallards [*Anas platyrhynchos*] use lakes, ponds, bogs, rivers, and palustrine wetlands). Stable water levels, irregular shorelines, emergent vegetation, organic content, and water clarity, acidity, and depth are some of the important features that determine whether a waterbody is used during the breeding season by waterfowl for foraging, nesting, and/or brood-rearing (Billerman et al. 2025). Use of meadow and forest habitats for nesting by waterbirds depends on their proximity to a waterbody that serves as foraging and/or brood-rearing habitat. Distance of a nest from water depends on each species' habitat preferences and requirements and can even vary widely within a species. Meadow and forest-edge habitats adjacent to waterbodies are most frequently used for nesting and for protective cover during brood-rearing. In the early 1980s, waterfowl numbers in the Bradley Lake Project area peaked during spring and fall migration, with the greatest numbers recorded in spring (APA 1984).

4.5.1.4.2 Raptors

Raptors, which include eagles, hawks, falcons, and owls, use a wide variety of habitats, and 14 species potentially breed in, or migrate through, the Project area (Table 4.5-3). Many species expected to occur in the study area (Northern Harrier [*Circus hudsonius*], Bald Eagle, Red-tailed Hawk [*Buteo jamaicensis*], Great Horned Owl [*Bubo virginianus*], Short-eared Owl [*Asio flammeus*], Merlin [*Falco columbarius*], and Peregrine Falcon [*Falco peregrinus*]) prefer hunting for fish, small mammals, and/or birds in open habitats (Billerman et al. 2025). These habitats can include open graminoid- and shrub-dominated meadows, riverine and lacustrine areas, and coastal saltmarshes and mudflats. Bald Eagles commonly breed in Kachemak Bay, typically in large Sitka spruce (*Picea sitchensis*) or black cottonwood trees along the coast where fish are present, and they overwinter in congregations where open water with fish and waterbird prey occur (ADF&G 1993). Golden Eagles are generally considered to be rare breeders along the southern Alaska coast, but several active breeding territories were found in suitable cliff habitats in the Project area and surrounding terrain in summer 2025 (ABR 2026c). Raptor numbers in the Bradley Lake Project area peaked during spring and fall migration in the early 1980s (APA 1984).

4.5.1.4.3 Seabirds

Seabirds, which include gulls and terns, are found most commonly in marine and coastal environments and are common in upper Kachemak Bay. They may use the Project area both during breeding and non-breeding time periods.

4.5.1.4.4 Shorebirds

Shorebirds are most commonly found on mudflats, beaches, estuaries, and wetlands, but they may breed in drier areas including upland tundra and forested ecosystems. Breeding shorebirds in Southcentral Alaska generally are adapted to utilize open scrub forests, forest openings in the lowlands (e.g., scrub bogs and graminoid-dominated wetlands), lacustrine waterbodies, gravel river bar and coastal habitats, and dwarf-scrub habitats in upland and alpine areas. Upper Kachemak Bay is used by a variety of migrant shorebird species during spring and fall (APA 1984). Many species are long-distance migrants, and high-quality stopover sites such as productive mudflats can be vital to refueling prior to long flights.

4.5.1.4.5 Landbirds

Landbirds, which include passerines, upland game birds, kingfishers, hummingbirds, and others, are a group of species generally adapted to terrestrial habitats, although they can also use freshwater and brackish water aquatic habitats. Many of the passerines in Alaska are migrants that either breed in the area or pass through on migration, including flycatchers, swallows, thrushes, finches, longspurs, sparrows, and warblers. Most upland game birds (e.g., Willow [*Lagopus lagopus*] and Rock [*L. muta*] ptarmigan and Spruce Grouse [*Canachites canadensis*]) are residents, as are woodpeckers, many finches, chickadees, and corvids (jays, magpies, and crows).

4.5.1.5 Wildlife Habitat Evaluation

To assess the value of habitats in the Project area for wildlife species and to address potential impacts to wildlife species from the proposed Project, a categorical wildlife habitat evaluation was conducted (ABR 2026b). This analysis was conducted using matrix wildlife habitat relationship procedures (Patton 1992; Johnson and O'Neil 2001; Morrison et al. 2006). A list of bird and mammal species of concern that are likely to occur in the vicinity of the Project area and that could potentially experience Project impacts was developed for analysis (Table 4.5-4; ABR 2026b). This species of concern list was prepared in consultation with the resource management agencies in a series of meetings in March and April 2024 and January 2025 and includes 49 bird and 14 mammal species. From the set of 120 bird and 31 mammal species likely to occur in the vicinity of the Project area (see Section 4.5.1.2 above), species of concern were identified for analysis when they met one or more of the following criteria: (1) they are federally listed under the ESA (73 FR 63667-63668) or protected under the BGEPA, (2) they are present on the species of conservation concern lists reviewed for the Project (ASG 2019; ADF&G 2015; Handel et al. 2021; USFWS 2021), (3) they are in a species group experiencing population declines nationwide (bats), or (4) they were specifically requested for inclusion by ADF&G or USFWS personnel (Table 4.5-4).

Table 4.5-4 Avian and mammalian species of concern assessed in the wildlife habitat evaluation for the Bradley Lake Expansion Project and their conservation status.

Common Name	Scientific Name	ESA[a] Listed	SWAP species of concern[b]	Priority shorebird species[c]	BPIF Landbirds of concern[d]	USFWS BCC[e]	Agency request[f]
Landbirds							
Alder Flycatcher	*Empidonax alnorum*		SGCN, AR				
American Pipit	*Anthus rubescens*		SGCN, AR				USFWS
Bank Swallow	*Riparia riparia*						USFWS
Belted Kingfisher	*Megaceryle alcyon*		SGCN, AR				
Blackpoll Warbler	*Setophaga striata*						USFWS
Fox Sparrow	*Passerella iliaca*		SGCN, AR				
Horned Lark	*Eremophila alpestris*						USFWS
Lapland Longspur	*Calcarius lapponicus*						USFWS
Northern Yellow Warbler	*Setophaga aestiva*		SGCN, AR				
Olive-sided Flycatcher	*Contopus cooperi*		SGCN, AR		WL	x	USFWS
Orange-crowned Warbler	*Leiothlypis celata*		SGCN, AR				
Rock Ptarmigan	*Lagopus muta*						
Rufous Hummingbird	*Selasphorus rufus*		SGCN, AR		WL	x	USFWS
Savannah Sparrow	*Passerculus sandwichensis*		SGCN, AR				
Song Sparrow	*Melospiza melodia*		SGCN, AR				
Willow Ptarmigan	*Lagopus lagopus*						
Wilson's Warbler	*Cardellina pusilla*		SGCN, AR		CBSD		
Raptors							
Bald Eagle	*Haliaeetus leucocephalus*		SGCN				
Golden Eagle	*Aquila chrysaetos*		SGCN, AR				
Northern Harrier	*Circus hudsonius*		SGCN, AR				
Peregrine Falcon	*Falco peregrinus*		SGCN				USFWS
Red-tailed Hawk	*Buteo jamaicensis*		SGCN, AR				

Common Name	Scientific Name	ESA[a] Listed	SWAP species of concern[b]	Priority shorebird species[c]	BPIF Landbirds of concern[d]	USFWS BCC[e]	Agency request[f]
Short-eared Owl	*Asio flammeus*		SGCN, AR		CBSD		USFWS
Seabirds							
American Herring Gull	*Larus argentatus*						USFWS
Arctic Tern	*Sterna paradisaea*		SGCN				USFWS
Black-legged Kittiwake	*Rissa tridactyla*						USFWS
Bonaparte's Gull	*Chroicocephalus philadelphia*						USFWS
Kittlitz's Murrelet	*Brachyramphus brevirostris*		SGCN, AR			x	
Marbled Murrelet	*Brachyramphus marmoratus*		SGCN, AR			x	USFWS
Pelagic Cormorant	*Urile pelagicus*						USFWS
Shorebirds							
Greater Yellowlegs	*Tringa melanoleuca*			L			USFWS
Lesser Yellowlegs	*Tringa flavipes*		SGCN, AR	H		x	USFWS
Rock Sandpiper	*Calidris ptilocnemis*		SGCN, AR	H		x	
Semipalmated Plover	*Charadrius semipalmatus*			L			
Semipalmated Sandpiper	*Calidris pusilla*		SGCN, AR	H			USFWS
Short-billed Dowitcher	*Limnodromus griseus*		SGCN, AR	H		x	USFWS
Spotted Sandpiper	*Actitis macularius*		SGCN, AR	L			
Wandering Tattler	*Tringa incana*						USFWS
Western Sandpiper	*Calidris mauri*		SGCN, AR	M			USFWS
Waterbirds							
Barrow's Goldeneye	*Bucephala islandica*						USFWS
Black Scoter	*Melanitta americana*		SGCN, AR				
Common Goldeneye	*Bucephala clangula*						USFWS
Common Merganser	*Mergus merganser*						
Harlequin Duck	*Histrionicus histrionicus*						
Long-tailed Duck	*Clangula hyemalis*		SGCN				USFWS
Northern Pintail	*Anas acuta*						USFWS
Red-breasted Merganser	*Mergus serrator*						

Common Name	Scientific Name	ESA[a] Listed	SWAP species of concern[b]	Priority shorebird species[c]	BPIF Landbirds of concern[d]	USFWS BCC[e]	Agency request[f]
Red-throated Loon	*Gavia stellata*						USFWS
Steller's Eider	*Polysticta stelleri*	x					USFWS
Bats							
Little brown myotis	*Myotis lucifugus*		SGCN				
Furbearer, Aquatic							
American beaver	*Castor canadensis*						
River otter	*Lontra canadensis*						
Furbearer, Terrestrial							
Wolverine	*Gulo gulo*						USFWS,ADF &G
Hoary Marmot	*Marmota caligata*						ADF&G
Large Mammals							
Moose	*Alces alces*						
Mountain goat	*Oreamnos americanus*						
Black bear	*Ursus americanus*						
Brown bear	*Ursus arctos*						
Small Mammals							
Snowshoe hare	*Lepus americanus*		SGCN				
Singing vole	*Microtus miurus*		SGCN				
Tundra (root) vole	*Microtus oeconomus*						USFWS
Dusky shrew	*Sorex monticolus*		SGCN				
Western water shrew	*Sorex navigator*		SGCN				

[a]ESA = Endangered Species Act.

[b]SWAP = State Wildlife Action Plan; species of greatest conservation concern = SGCN; at-risk species = AR. ADF&G (2015).

[c]H =high Concern, M = moderate concern, L = low concern; Alaska Shorebird Group (2019).

[d]WL= Watchlist (SGCN at the continental scale), CBSD= common birds in steep decline; Handel et al. (2021).

[e]2021 USFWS Birds of Conservation Concern = BCC; USFWS (2021).

[f]USFWS= United States Fish and Wildlife Service; ADF&G= Alaska Department of Fish and Game.

None of the 14 mammals included as species of concern are listed under the federal ESA or on two other prominent global conservation listings that include mammals (the International Union for Conservation of Nature Species of Concern and NatureServe Global Concern lists). The ADF&G, however, lists conservation concerns for several small mammals and one bat species in the Project area (Table 4.5-4). Other mammal species were added to the list of species of concern to be evaluated for impacts based on requests from ADF&G and USFWS personnel.

Many of the 120 bird species likely to occur in the vicinity of the Project area (see Section 4.5.1.2 above) are migrants or overwintering species that use tidal mudflats and marine waters in upper Kachemak Bay. Those marine habitats will not be impacted by the Project. Therefore, those additional species were not included in the list of species of concern for analysis. Casual, vagrant, and transient bird species that occur as single individuals or in very low numbers and do not occur annually, and rare species that will not make regular use of habitats in the study area, were not included in the list of species of concern. Of the 49 bird species included for assessments of habitat value, one species, Steller's Eider (*Polysticta stelleri*), is listed as threatened under ESA, though it is likely to occur only rarely in winter in marine habitats in upper Kachemak Bay. Twenty-eight other species are listed as of conservation concern on one or more of the four conservation concern lists assessed for the Project (Table 4.5-4).

In the wildlife habitat evaluation, a matrix of species and habitats was prepared and habitat values for each of the 63 species of concern were assessed for each of the 34 currently available wildlife habitats that were identified and mapped in the study area (see Section 4.5.1.1 above). The specifics of the wildlife habitat evaluation methods are described in the *Wildlife Habitat Evaluation Study Report* (ABR 2026b. In brief, for each cell in the species-by-habitat matrix, a categorical habitat-value ranking (high, moderate, low, or negligible value) was assigned to each species of concern for each mapped wildlife habitat type. Moderate- and high-value habitats combined represent those with a higher probability of species occurrence and represent the set of habitats that wildlife can regularly use (Marcot et al. 2015; Welch et al. 2023). In the discussion that follows, the combination of moderate- and high-value habitats is referred to as suitable habitats for the wildlife species of concern assessed.

4.5.2 Environmental Analysis

4.5.2.1 Effects on Botanical Resources and Wildlife Habitats

4.5.2.1.1 Construction

In total, the footprint for all components of the proposed Project infrastructure and construction support areas in the Martin River and Bradley Lake areas combined encompasses 226.0 acres, and 37.2 acres of that total has been previously filled or disturbed by excavation. This leaves 188.8 acres of undisturbed wildlife habitat that could be permanently lost to the construction of all proposed Project elements. Planned rehabilitation of the tunnel muck spoils at Bradley Lake, however, could result in the rehabilitation of 37.7 acres of wildlife habitat to offset some of the permanent habitat losses (see below).

The Project area is located on the southern shore of Kachemak Bay, bordered by the Kenai Fjords National Park and the Kenai National Wildlife Refuge. The Kachemak Bay area is relatively undisturbed except for Homer, Halibut Cove, Seldovia, a few scattered remote residences along the coast, and the existing Bradley Lake Project facilities. None of the wildlife habitats in the proposed Project footprint is regionally threatened or rare, and efforts have been made to reduce the overall footprint by not building an access road to the Dixon Diversion structure and building the exit portal access road and portal channel at Bradley Lake on tunnel muck spoils. Given the low levels of disturbance overall in the Kachemak Bay area, the additional and limited Project impacts to vegetation and wildlife habitats would not be a significant loss regionally.

<u>Worker Camp</u>
The area for the proposed worker camp at the mouth of Battle Creek encompasses a total of 21.3 acres, of which 10.3 acres is Artificial Fill, including previously cleared and disturbed areas and gravel fill (Table 4.4-5). Wildlife habitats that would be permanently lost due to the placement of new fill for building pads include Upland Mixed Lutz Spruce-Black Cottonwood Forest (6.9 acres) and Upland and Subalpine Tall Alder Scrub (3.8 acres).

Table 4.5-5 Potential wildlife habitat losses in the worker camp footprint for the Bradley Lake Expansion Project.

Wildlife Habitat	Area Lost (acres)
Artificial Fill	10.6
Upland and Subalpine Tall Alder Scrub	3.8
Upland Mixed Lutz Spruce-Black Cottonwood Forest	6.9
Total	**21.3**

Secondary impacts from fugitive dust to the surrounding habitat near the worker camp are expected to be minimal in extent. The wet climate and dense forest and scrub vegetation will preclude extensive propagation of dust particles in terrestrial habitats. Though dust could accumulate in open intertidal habitats, the daily tidal fluctuations would minimize impacts. Control of stormwater through BMPs would ensure that most contaminants do not run off into the adjacent salt marsh and mouth of Battle Creek.

<u>Staging Areas</u>

There are three staging areas proposed to support the Bradley Lake Expansion Project, one along the existing access road, one near Bradley Lake Dam, and a third at an existing pad along the WFUBC Diversion access road. Only existing disturbed and previously filled areas are planned to be used for construction staging activities, which will result in no additional habitat losses. The total area of existing Artificial Fill in the three staging areas combined is 10.1 acres. Fugitive dust escapement is not likely to cause substantial secondary impacts to existing adjacent habitats because the wet climate and dense vegetation will limit the spread of dust.

<u>Dixon Diversion</u>

Martin River

Habitat loss due to direct impacts within the Project footprint in the upper Martin River would be limited to 25.8 acres at the proposed Dixon Diversion site. There are no pre-existing areas of Artificial Fill in this area. Habitat impacts include blasting; placement of fill for construction of the diversion dam, diversion pond, and tunnel inlet; and the staging and storage of heavy equipment. Most of the impacts would affect existing barren wildlife habitats, including Riverine Barrens (1.8 acres), Subalpine and Alpine Barrens (17.5 acres), and Rocky Cliffs (4.3 acres; Table 4.5-6). Permanent impacts to these barren areas would have minimal habitat consequences for most species, with the exception of Golden Eagles (*Aquila chrysaetos*) and mountain goats (*Oreamnos americanus*) that routinely use steep rocky cliff habitats. The proglacial segment of Martin River (Rivers and Streams, 1.4 acres) falls within the direct effects footprint. Portions of the existing channel would be diverted by the dam to the diversion pond and tunnel intake, and the remaining downstream channel would likely remain mostly intact after the diversion infrastructure construction is complete. The only vegetated habitat in the direct impact area is Upland and Subalpine Tall Alder Scrub (0.8 acres), which, at this higher elevation, is a sparsely vegetated early successional habitat that would likely regenerate in 60 years in protected microsites with adequate fines in the substrate.

Table 4.5-6 Potential wildlife habitat losses in the Dixon Diversion construction footprint in the upper Martin River.

Wildlife Habitat	Area Lost (acres)
Rivers and Streams (High Gradient-High Flow)	1.4
Riverine Barrens	1.8
Upland and Subalpine Tall Alder Scrub	0.8
Subalpine and Alpine Barrens	17.5
Rocky Cliffs	4.3
Total	**25.8**

Secondary impacts due to fugitive dust from blasting and placement of fill at the Dixon Diversion site are expected to be more substantial than in other Project areas because the subalpine and alpine vegetation is mostly low tundra composed of fragile alpine plants and mosses. BMPs for stormwater filtering would reduce effluent to the nearby lotic waters.

Bradley Lake

The development of the Dixon Diversion infrastructure at Bradley Lake would involve the placement of tunnel muck spoils and the construction of three Project components: the tunnel (portal) outlet, portal outlet channel to Bradley Lake, and the tunnel outlet access road. Each of these infrastructure elements would be built entirely on stored tunnel muck so the footprint for the tunnel muck storage site covers all three Project features. The Dixon Diversion tunnel itself would be bored underground in bedrock and would not result in wildlife habitat losses.

The construction footprint for the Dixon Diversion components at Bradley Lake encompasses a total of 40.6 acres, of which Artificial Fill, composed of previously cleared and disturbed areas and gravel fill, covers only 0.2 acres (Table 4.5-7). Habitat impacts in the area would primarily include losses of Upland and Subalpine Tall Alder Scrub (30.6 acres), Glaciated Subalpine Rock-Shrub Scrub-Meadow Complex (4.2 acres), Freshwater Lakes and Ponds (2.1 acres), and Riverine Low and Tall Willow (1.5 acres). Losses to the other five habitat types in the tunnel muck spoils footprint comprise less than 1 acre each.

Table 4.5-7 Potential wildlife habitat losses in the Dixon Diversion construction footprint at Bradley Lake.

Wildlife Habitat	Area Lost (acres)
Artificial Fill	0.2
Human Modified Reservoir	<0.1
Freshwater Lakes and Ponds	2.1
Rocky Shore and Cobble Beach	<0.1
Rivers and Streams (High Gradient-High Flow)	0.5
Riverine Low and Tall Willow	1.5
Upland and Subalpine Tall Alder Scrub	30.6
Upland and Subalpine Wet Graminoid Moss Bog	0.6
Glaciated Subalpine Rock-Shrub Scrub-Meadow Complex	4.2
Subalpine and Alpine Barrens	0.9
Total	**40.6**

The tunnel muck disposal area at Bradley Lake will undergo natural colonization and revegetation, and additional PM&E measures (see Section 4.5.3 below) would involve revegetation efforts to facilitate the development of vegetation cover and minimize erosion. It is expected that alder shrubs will readily colonize the ground bedrock and would be aided by Project revegetation efforts. The revegetated habitats, however, may be patchy depending on local microtopography and drainage, and plant species diversity is likely to be low, which will reduce wildlife habitat quality compared to natural shrub habitats lost during construction.

As noted above, tunnel muck spoils area comprises 40.6 acres. Subtracting the area for the tunnel outlet access road (approximately 2.3 acres) and the tunnel outlet and portal channel to Bradley Lake (approximately 0.6 acres), which would be permanent features built on tunnel muck spoils, results in approximately 37.7 acres of potential shrub wildlife habitat that is likely to regenerate on the deposited tunnel muck. As noted above, these habitats will likely be of lower quality for wildlife compared to natural shrub habitats and they will also be located adjacent to areas of human disturbance in the tunnel outlet area. Nevertheless, over a 60-year Project operations period, up to 37.7 acres of rehabilitated wildlife habitat could become established in the tunnel outlet area to offset approximately 93 percent of the 40.6 acres of habitat lost during construction of the Dixon Diversion components at Bradley Lake.

Bradley River

Construction activity to develop the Dixon Diversion infrastructure is not anticipated to impact wildlife habitats in the Bradley River.

Kachemak Bay

No adverse effects to tidal and intertidal areas in the Martin River delta and Kachemak Bay are expected to occur from construction activity to develop the Dixon Diversion infrastructure.

Bradley Lake Pool Raise

Along with the placement of additional fill around the existing Bradley Lake Dam, the proposed reconstruction to raise the dam would include the establishment of five potential borrow sites (four at Bradley Lake and one adjacent to the worker camp near the mouth of Battle Creek). All proposed borrow sites may not be used. Of the potential total of 128.5 acres impacted, 17.4 acres is currently Artificial Fill (Table 4.5-8). The most common habitats in the Bradley Lake Pool Raise construction footprint are Upland and Subalpine Tall Alder Scrub (37.7 acres), Upland Mixed Lutz Spruce-Black Cottonwood Forest (31.6 acres), and Glaciated Subalpine Rock-Shrub Scrub-Meadow Complex (31.0 acres). Lacustrine and littoral habitats in the footprint at Bradley Lake include Human Modified Reservoir (5.5 acres) and Rocky Shore and Cobble Beach (1.4 acres). The Bradley Lake Pool Raise construction area is entirely within the subalpine physiographic zone and includes several barren habitats, including Rocky Cliffs (1.9 acres) and Subalpine and Alpine Barrens (1.4 acres).

Table 4.5-8 Potential wildlife habitat losses in the Bradley Lake Pool Raise construction footprint.

Wildlife Habitat	Area Lost (acres)
Artificial Fill	17.4
Human Modified Reservoir	5.5
Rocky Shore and Cobble Beach	1.4
Rivers and Streams (Low Gradient-High Flow)	0.6
Rocky Cliffs	1.9

Wildlife Habitat	Area Lost (acres)
Subalpine and Alpine Barrens	1.4
Upland and Subalpine Tall Alder Scrub	37.7
Upland Mixed Lutz Spruce-Black Cottonwood Forest	31.6
Glaciated Subalpine Rock-Shrub Scrub-Meadow Complex	31.0
Total	**128.5**

Bradley River

Construction activity to raise Bradley Lake Dam is not anticipated to impact wildlife habitats downstream in the Bradley River.

Kachemak Bay

No adverse effects to tidal and intertidal areas in the Martin River delta and Kachemak Bay are expected to occur from construction activity to raise Bradley Lake Dam.

4.5.2.1.2 Project Operations

Martin River Basin

During Project operations, the amount of water proposed to be routinely diverted from the Martin River through the Dixon Diversion tunnel and the reduced river flow and overbank flooding during the ice-free seasons are likely to result in the braided sections of the Martin River transitioning to a single-channel system (see the *Geomorphology and Sediment Transport Study Report;* Watershed GeoDynamics 2025). This trend will change the seasonal flooding patterns in the Martin River floodplain and likely contribute to habitat change, particularly in the areas that are currently active braided floodplains. At another hydroelectric project in Southcentral Alaska, some portions of the Eklutna River underwent similar changes over the course of 63 years of dewatering, where sections of the braided channel transitioned to tall closed alder in the active floodplain and mature mixed forest stands on the higher riverine terraces. Along the formerly braided sections of the Eklutna River, very little barren habitat remained after 63 years of active reduction in flow (Davis et al. 2023). Note, however, that river flows were much more reduced and were reduced year-round in the Eklutna River than would be the case in the Martin River. In the Martin River, flows would be reduced only in the ice-free seasons, and EFMR MIF of 100 cfs would be maintained to allow salmon to migrate and spawn in the system (see Section 4.4); all flows in excess of the EFMR MIF and the tunnel capacity (1,650 cfs) would flow to the EFMR and Martin River. In addition, channel maintenance flows of at least 1,000 cfs would be released to the EFMR a minimum of 3 years out of each moving 10-

year average for a duration of 12 hours to transport bedload through the EFMR canyon and the Martin River.

The Martin River has been gradually shifting to a single channel system between PRM 5.3 and 4.3, and observed changes to braided riverine habitats in that area were used to predict the potential changes in riverine habitat throughout the river system during Project operations. Where the Martin River is transitioning to a single channel system, much of the inactive braided floodplain has been colonized by a dwarf shrub-dominated habitat (Riverine Dryas Dwarf Shrub). Because the substrate is extremely well-drained on abandoned alluvial surfaces, the *Dryas*-dominated habitats will likely persist for many years without developing significant shrub or forest cover. In OCHs with finer grained substrates, Riverine Tall Alder may develop first and slowly transition toward Riverine Mixed Spruce-Black Cottonwood Forest.

If most of the active braided riparian areas in the lower Martin River transition to Riverine Dryas Dwarf Shrub, it is expected that habitat would increase by 319.8 acres from the 99.3 acres it currently occupies (Table 4.5-9). Riverine Tall Alder is expected to increase from 26.8 acres currently to 286.9 acres in 60 years. Riverine Mixed Spruce-Black Cottonwood Forest is likely to increase at a more moderate rate from 364.7 acres to 391.5 acres (increase of 26.8 acres). Riverine Active Braided Floodplain, Riverine Barrens, and Riverine Flooded Black Cottonwood Scrub are habitats that are generally sustained by the unpredictable but common overbank and off-channel flood events that maintain the braided river system. In the transition from the current braided channel system to a single-channel system, it is expected that these habitats would disappear in the future.

Table 4.5-9 Habitat losses and gains in riparian wildlife habitats in the Martin River floodplain from operation of the proposed Bradley Lake Expansion Project.

Wildlife Habitat	Current Area (acres)	Future Area (acres)	Acreage Change (acres)
Riverine Barrens	32.6	0	-32.6
Riverine Active Braided Floodplain	373.9	0	-373.9
Riverine Mature Black Cottonwood Forest	4.3	4.3	0
Riverine Dryas Dwarf Shrub	99.3	419.1	319.8
Riverine Flooded Black Cottonwood Scrub	150.0	0	-150.0
Riverine Mixed Spruce-Black Cottonwood Forest	364.7	391.5	26.8
Riverine Tall Alder	26.8	286.9	260.1

In addition to the Project-induced changes in riparian wildlife habitats from river flow reductions, a number of other habitat changes in the Martin River floodplain are expected to occur over a 60-year Project operations period due to recent channel changes and natural plant succession as influenced by climate change. These changes are described in detail in the *Vegetation and Wildlife Habitat Mapping Study Report* (ABR 2026a). The more prominent changes include an expansion of the Coastal Barren Mudflat habitat in the study area due to the Martin River mouth moving to the east in 2023 and the ongoing development of a new alluvial fan in that area. The sediment deposition from the alluvial fan is expected to bury the existing vegetated estuarine and marine-influenced habitats as the area gradually transitions to barren mudflats. Other prominent changes expected over a 60-year period, include a substantial decline in the extent of Upland and Subalpine Tall Alder Scrub as plant succession, accelerated by increased temperatures from climate change, transitions seral shrub habitats to forest types. This is expected to result in a substantial expansion of Upland Mixed Lutz Spruce-Black Cottonwood Forest in the study area (ABR 2026a).

<u>Bradley Lake</u>

Project operations at Bradley Lake would involve an increase in the maximum pool elevation of the reservoir from El. 1,180 feet to El. 1,196 feet. As described in the *Vegetation and Wildlife Habitat Mapping Study Report* (ABR 2026a), based on daily water level monitoring and projections for future seasonal lake level fluctuations (Figure 4.5-6), the future water level fluctuation zone (WLFZ) along the shore of Bradley Lake could span up to 100 feet or more in elevation from early spring to late fall. Habitat mapping was based on aerial imagery acquired on July 28, 2022 when the Bradley Lake surface elevation was 1,153 feet. The area between 1,153 feet El. and the current normal maximum pool elevation of 1,180 feet is referred to as the upper portion of the existing WLFZ for purposes of this analysis; the remainder of the existing WLFZ was inundated. Mapping in the upper portion of the existing WLFZ, indicates that 15 habitats (Table 4.5-10) can persist despite annual inundation from late summer through early winter (Figure 4.5-6). This set of habitats may be representative of those that could also persist in the upper portion of the future WLFZ, up to El. 1,196 feet, which is expected to be annually exposed from early winter and through the early part of the growing season to late summer. This suggests the most likely future scenario is that wildlife habitats, probably in the same locations and proportions that exist now between El. 1,153 feet and El. 1,196 feet (Table 4.5-10), would persist in the upper regions of the future WLFZ. Because of annual inundation, however, these habitats would likely have reduced plant species diversity and reduced vegetation cover and would be of lower quality for wildlife. In contrast, habitats in the lower regions of the future WLFZ would be inundated for a longer period of time each year and likely would transition to partially vegetated habitats dominated by graminoid species that can better survive inundation or barren cobble and rock. When they are inundated, all habitats in the WLFZ would function as seasonally flooded freshwater lacustrine habitats.

Secondary, operational impacts due to dust escapement from use of the proposed Dixon Diversion portal exit and access road and the tunnel muck spoils are expected to occur. Dust impacts may be slightly greater in the more open subalpine areas of the study area, compared to the tall scrub and forest vegetation at lower elevations, but the impacts would likely be limited by the wet climate, the proposed revegetation of the tunnel muck spoils (see Section 4.5.3 below), and the relatively low level of use.

As in the Martin River Basin, there are also expected to be changes in wildlife habitats in the Bradley Lake area over a 60-year Project operations period due to the effects of climate change and natural plant succession. These changes are detailed in ABR (2026a). The prominent changes include the gradual transition of Glaciated Subalpine Rock-Shrub Scrub-Meadow Complex, except for areas of bare rock, to mixed forest woodland habitats, which are included in the Upland Mixed Lutz Spruce-Black Cottonwood Forest type. Similarly, there is expected to be a substantial decline in the extent of Upland and Subalpine Tall Alder Scrub as those areas transition to Upland Mixed Lutz Spruce-Black Cottonwood Forests.

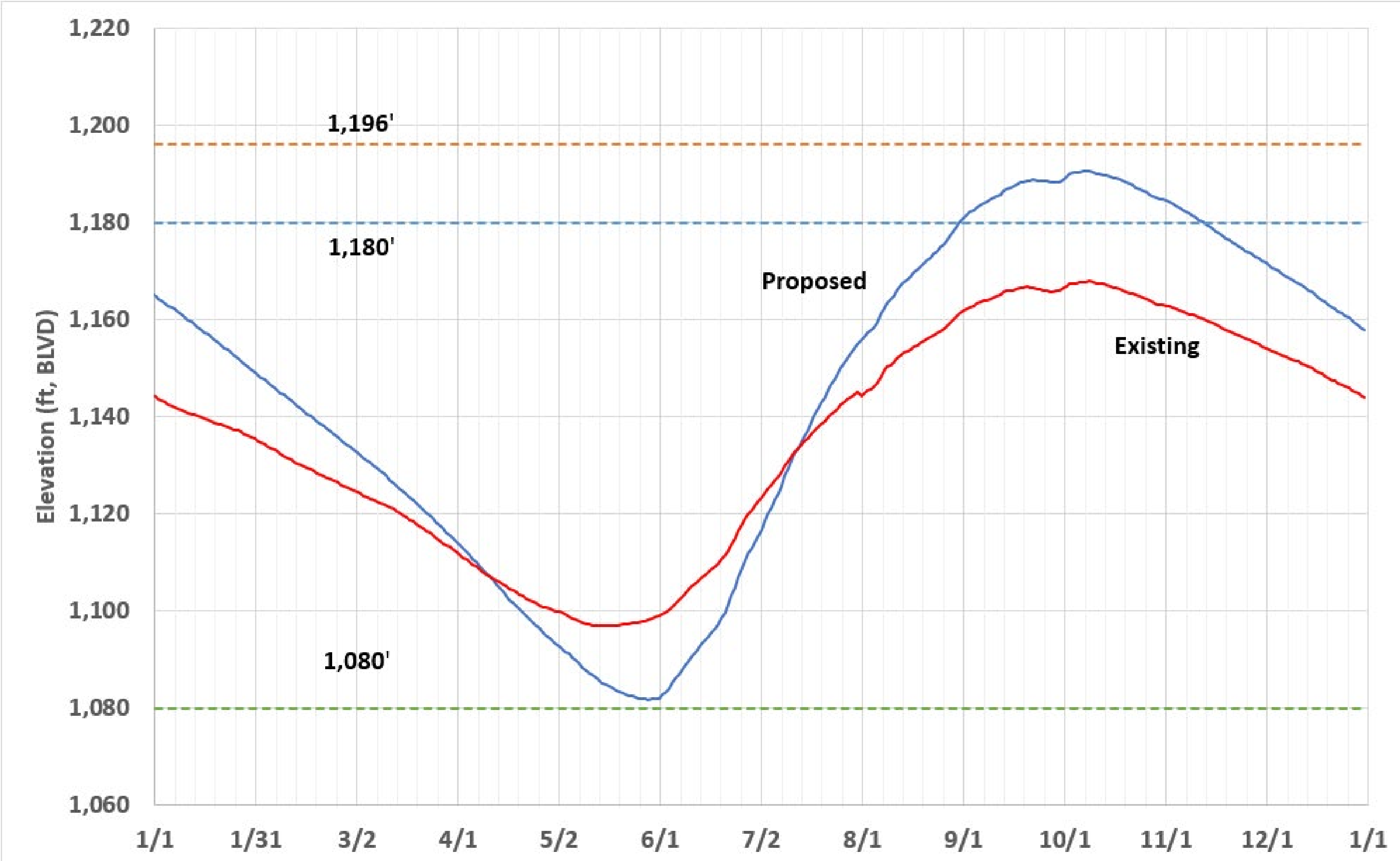

Figure 4.5-6 Average daily Bradley Lake water surface elevation for existing conditions (2020–2025 data, red line) and projected conditions for the proposed Project (blue line), relative to current and future maximum pool elevations of El. 1,180 feet and El. 1,196 feet, respectively.

Table 4.5-10 Wildlife habitats expected to be altered by lake-level rise that would occur within the future water level fluctuation zone at Bradley Lake.

Affected Habitat Type	Acres in WLFZ, El. 1,153 ft to El. 1,180 ft[a]	Acres in WLFZ, El. 1,180 ft to El. 1,196 ft[b]	Total Acres
Freshwater Lakes and Ponds	0.5	0.0	0.5
Rocky Shore and Cobble Beach	93.8	4.8	98.6
Rivers and Streams (High Gradient-High Flow)	0.1	0.1	0.2
Rivers and Streams (Low Gradient-High Flow)	7.4	5.1	12.5
Rivers and Streams (Mixed Gradient-Low Flow)	1.2	0.4	1.6
Riverine Barrens	211.0	59.8	270.8
Riverine Dryas Dwarf Shrub	0.0	2.0	2.0
Riverine Low and Tall Willow	53.4	65.9	119.3
Riverine Tall Alder	0.0	1.8	1.8
Upland and Subalpine Tall Alder Scrub	43.5	69.9	113.4
Upland and Subalpine Wet Graminoid Moss Bog	0.2	1.2	1.4
Glaciated Subalpine Rock-Shrub Scrub-Meadow Complex	1.0	0.7	1.7
Subalpine and Alpine Barrens	2.7	0.1	2.8
Subalpine and Alpine Dwarf Ericaceous Scrub	36.0	16.2	52.2
Rocky Cliffs	0.1	0.3	0.4
Artificial Fill	0.0	1.0	1.0
Totals	**450.9**	**229.3**	**680.2**

[a] Acres of wildlife habitats present in the existing upper water level fluctuation zone (WLFZ) between El. 1,153 feet—the lake level on the aerial photography acquired on July 28, 2022, and used to map habitats in ABR (2026a)—and the current operational maximum pool elevation of El. 1,180 feet.

[b] Acres of wildlife habitats present in the expected upper WLFZ between the current and future operational maximum pool elevations of El. 1,180 feet and El. 1,196 feet.

Bradley River

No significant adverse effects to vegetation and wildlife habitats are expected along the Bradley River downstream of Bradley Lake Dam due to the proposed lake-level rise at Bradley Lake during Project operations.

Kachemak Bay

No adverse Project-induced effects to the tidal and intertidal areas in the Martin River delta are expected to occur. Significant loss of salt marsh habitat in the delta is expected to continue to occur because of the relocation of the Martin River mouth to the east, resulting in the rapid deposition of alluvial material in existing salt marsh habitats. However, this ongoing habitat change is due to natural overbank flooding and river rerouting, not Project operations.

4.5.2.2 Effects on Terrestrial Wildlife Resources

4.5.2.2.1 Construction

Construction of the proposed Project infrastructure would result in direct impacts to terrestrial wildlife resources with the loss or alteration of suitable habitats for some of the wildlife species of concern assessed in the wildlife habitat evaluation (see Section 4.5.1.5 above). Construction could also have direct behavioral impacts involving the displacement of disturbance-sensitive wildlife species from noise and vibration effects during blasting activities (see Potential Construction Blasting Impacts below). Additional, but unlikely, temporary behavioral displacement impacts to marine wildlife species are possible from the limited barging activities in Kachemak Bay needed to support the construction work (see Section 4.5.2.3 below). BMPs and PM&E measures designed to minimize the Project impacts to terrestrial and marine wildlife species are discussed below in Section 4.5.3.

Direct loss of suitable habitats for wildlife species of concern would occur from development of the various Project components including the planned worker camp. The loss of suitable habitats for the more aquatic-oriented avian species of concern would be minor for the worker camp, located near the mouth of Battle Creek and Kachemak Bay shoreline. At the worker camp, the loss of suitable habitat for all waterbird species would be 1.4 acres (Table 4.5-11). The habitat losses for all shorebird and seabird species would be 1.2 and 1.4 acres, respectively. The suitable habitat losses for the more terrestrial avian species would be substantially greater. For all raptor species, 41.2 acres of suitable habitat would be lost, and for all landbirds, 45.5 acres would be lost. The raptor habitat losses would be accounted for largely by losses in forest habitats for two species, Bald Eagle and

Red-tailed Hawk (Table 4.5-11; ABR 2026b). Similarly, for landbirds, the habitat losses would primarily be accounted for by several forest breeding passerine species and Rufous Hummingbird (*Selasphorus rufus)*. The acres of suitable habitats that would be lost for mammal species of concern are similar to the terrestrial-oriented birds. For all large mammals, furbearers, small mammals, and bats, the acres of suitable habitat that would be lost within each species group from development of the worker camp are 45.5, 44.3, 45.3, and 41.0, respectively. As with the terrestrial-oriented bird species, the overall amount of suitable mammal habitat lost would be accounted for largely by losses for those species that are known to regularly use forest habitats, such as black bear, moose, wolverine, and various small mammals (Table 4.5-11; ABR 2026b).

Table 4.5-11 Acres of wildlife habitat lost in the Bradley Lake Expansion Project footprint for avian and mammalian species of concern.

Species	Worker Camp/Borrow Site	Dixon Diversion, Martin River[a]	Dixon Diversion, Bradley Lake[b]	Bradley Lake Dam/Spillway Raise	Bradley Lake Dam Borrow Site[c]	Total Acres
Northern Pintail	0.0	0.0	2.1	0.0	0.0	2.1
Steller's Eider	0.0	0.0	0.0	0.0	0.0	0.0
Harlequin Duck	0.0	3.2	1.9	0.6	0.0	5.7
Black Scoter	0.0	0.0	0.0	0.0	0.0	0.0
Long-tailed Duck	0.0	0.0	0.0	0.0	0.0	0.0
Common Goldeneye	0.0	0.0	2.1	5.5	0.0	7.6
Barrow's Goldeneye	0.0	0.0	2.1	5.5	0.0	7.6
Common Merganser	0.0	1.4	2.5	0.6	0.0	4.5
Red-breasted Merganser	0.0	0.0	2.1	0.0	0.0	2.1
Red-throated Loon	0.0	0.0	0.0	0.0	0.0	0.0
All Waterbirds	**0.0**	**3.2**	**4.0**	**6.1**	**0.0**	**13.3**
Golden Eagle	0.0	21.9	5.1	2.8	31.5	61.2
Northern Harrier	0.0	17.5	5.1	2.3	30.0	55.0
Bald Eagle	39.8	0.0	0.0	0.2	0.2	40.2
Red-tailed Hawk	39.8	0.0	0.0	0.2	0.2	40.2
Short-eared Owl	0.0	0.0	0.0	0.0	0.0	0.0
Peregrine Falcon	0.0	4.3	4.2	2.8	30.1	41.4
All Raptors	**39.8**	**21.9**	**5.1**	**2.9**	**31.7**	**101.4**
Marbled Murrelet	0.0	0.0	0.0	0.0	0.0	0.0
Kittlitz's Murrelet	0.0	0.0	0.0	0.0	0.0	0.0
Black-legged Kittiwake	0.0	0.0	0.0	0.0	0.0	0.0
Bonaparte's Gull	0.0	0.0	2.1	0.0	0.0	2.1
American Herring Gull	0.0	0.0	0.0	0.0	0.0	0.0
Arctic Tern	0.0	0.0	2.1	0.0	0.0	2.1

Species	Worker Camp/Borrow Site	Dixon Diversion, Martin River[a]	Dixon Diversion, Bradley Lake[b]	Bradley Lake Dam/Spillway Raise	Bradley Lake Dam Borrow Site[c]	Total Acres
Pelagic Cormorant	0.0	0.0	0.0	0.0	0.0	0.0
All Seabirds	**0.0**	**0.0**	**2.1**	**0.0**	**0.0**	**2.1**
Semipalmated Plover	0.0	1.8	0.0	0.0	0.0	1.8
Rock Sandpiper	0.0	0.0	0.0	0.0	0.0	0.0
Semipalmated Sandpiper	0.0	0.0	0.0	0.0	0.0	0.0
Western Sandpiper	0.0	0.0	0.0	0.0	0.0	0.0
Short-billed Dowitcher	0.0	0.0	0.0	0.0	0.0	0.0
Spotted Sandpiper	0.0	1.8	3.6	2.1	0.0	7.5
Wandering Tattler	0.0	3.2	2.0	2.1	0.0	7.2
Lesser Yellowlegs	0.0	0.0	0.0	0.0	0.0	0.0
Greater Yellowlegs	0.0	0.0	0.0	0.0	0.0	0.0
All Shorebirds	**0.0**	**3.2**	**4.0**	**2.1**	**0.0**	**9.3**
Willow Ptarmigan	4.3	0.8	36.3	9.5	59.2	110.1
Rock Ptarmigan	0.0	21.9	0.9	0.4	2.8	26.0
Rufous Hummingbird	39.8	0.0	0.0	0.2	0.2	41.5
Belted Kingfisher	0.0	0.0	2.1	0.6	0.0	2.7
Olive-sided Flycatcher	39.8	0.0	0.6	0.2	0.2	40.2
Alder Flycatcher	44.1	0.8	32.1	7.4	30.8	115.1
Horned Lark	0.0	17.5	0.9	0.0	1.4	19.8
Bank Swallow	0.0	0.0	2.1	0.6	0.0	2.7
American Pipit	0.0	17.5	0.9	0.0	1.4	19.8
Lapland Longspur	0.0	17.5	0.9	0.0	1.4	19.8
Fox Sparrow	4.3	0.8	32.1	7.2	30.6	75.0
Savannah Sparrow	4.3	18.3	36.3	9.5	60.6	129.0
Song Sparrow	0.0	0.0	0.0	0.0	0.0	0.0
Orange-crowned Warbler	44.1	0.8	32.1	7.4	30.8	115.2

Species	Worker Camp/Borrow Site	Dixon Diversion, Martin River[a]	Dixon Diversion, Bradley Lake[b]	Bradley Lake Dam/Spillway Raise	Bradley Lake Dam Borrow Site[c]	Total Acres
Northern Yellow Warbler	44.1	0.8	32.1	7.4	30.8	115.2
Blackpoll Warbler	0.0	0.0	1.5	0.0	0.0	1.5
Wilson's Warbler	4.3	0.8	32.1	7.2	30.6	74.9
All Landbirds	**44.1**	**22.6**	**39.9**	**10.8**	**62.2**	**152.3**
Black bear	44.1	0.8	38.4	9.7	59.4	152.4
Brown bear	4.3	0.8	38.4	9.5	59.2	112.2
Moose	44.1	0.8	34.2	7.4	30.8	117.1
Mountain goat	39.8	21.9	5.1	2.9	10.14	69.7
All Large Mammals	**44.1**	**22.6**	**39.3**	**10.1**	**62.2**	**178.3**
American beaver	0.0	0.0	3.5	0.0	0.0	3.6
River otter	0.0	3.2	4.0	0.6	0.0	7.8
Hoary Marmot	0.0	21.9	5.1	2.8	31.5	61.2
Wolverine	44.1	0.8	34.9	9.7	59.4	148.9
All Furbearers	**44.1**	**25.8**	**39.7**	**10.8**	**62.2**	**182.5**
Snowshoe hare	44.1	0.8	32.1	7.4	30.8	115.1
Singing vole	4.3	0.8	34.9	9.5	59.2	108.6
Tundra (root) vole	44.1	0.8	33.4	7.4	30.8	116.3
Dusky shrew	44.1	0.8	32.1	7.4	30.8	115.1
Western water shrew	0.0	0.0	2.7	6.1	0.0	8.8
All Small Mammals	**44.1**	**0.8**	**39.0**	**15.8**	**59.4**	**159.1**
Little brown myotis	39.8	5.7	4.6	1.2	1.6	53.0
All Bats	**39.8**	**5.7**	**4.6**	**1.2**	**1.6**	**53.0**

[a] Dixon Diversion site in the Martin River floodplain includes the diversion dam and pool and the diversion tunnel inlet.

[b] Dixon Diversion infrastructure at Bradley Lake includes the tunnel exit access road, tunnel exit, and the exit portal channel to Bradley Lake, all constructed on tunnel muck spoils.

[c] Includes the four proposed borrow sites at Bradley Lake.

Dixon Diversion

Martin River

In the Martin River drainage, habitat impacts from construction of the Dixon Diversion dam and associated infrastructure would be limited to the higher elevation subalpine and alpine habitats that occur in the headwaters of the EFMR. The wildlife habitats within the construction footprint in this area, encompassing the proposed diversion dam, diversion pool, and the diversion tunnel intake, primarily consist of barren rock, cliffs, and high-gradient streams (ABR 2026b). In this area, all waterbirds, seabirds, and shorebirds would be expected to lose small amounts of suitable riverine habitat; the acres lost would be 3.2, 0.0, and 3.2, for the three species groups, respectively (Table 4.5-11). As with the worker camp at the coast, the acreage of suitable habitat expected to be lost for the more terrestrial avian species is greater. If the full Dixon Diversion footprint area is developed, the acres of suitable habitat lost for all raptors and landbirds would be 21.9 and 22.6, respectively (Table 4.5-11). For raptors, the greatest amount of habitat lost by far would occur for Golden Eagles and Northern Harriers, both species that breed and regularly hunt in open subalpine and alpine habitats in the study area (Table 4.5-11). For landbirds, the overall amount of habitat lost would be accounted for primarily by losses for several species that breed in subalpine and alpine habitats, such as Rock Ptarmigan, Horned Lark (*Eremophila alpestris)*, American Pipit (*Anthus rubescens)*, Lapland Longspur (*Calcarius lapponicus)*, and Savannah Sparrow (*Passerculus sandwichensis)*. The amount of suitable habitat that would be lost for all large mammals and furbearers (22.6 and 25.8 acres, respectively) is similar to that for raptors and landbirds. Substantially smaller amounts of suitable habitat would be lost for bats (5.7 acres) and small mammals (0.8 acre). For mammals, the expected habitat losses in the upper Martin River are accounted for largely by losses for species that prefer open higher elevation habitats, such as mountain goat and hoary marmot.

Bradley Lake

At the terminus of the Dixon Diversion tunnel in the Bradley Lake drainage, infrastructure development would result in wildlife habitat losses from the storage of tunnel muck spoils and construction of three Project components: the tunnel (portal) outlet, portal channel, and tunnel outlet access road. The Project infrastructure in this area would be built entirely on stored tunnel muck near Bradley Lake so the footprint for the tunnel muck storage site covers all three Project features. The Dixon Diversion tunnel itself would be bored underground in bedrock and would not result in wildlife habitat losses.

Wildlife habitats at the tunnel outlet area at Bradley Lake are strongly dominated by tall alder scrub with smaller amounts of barren rock, meadow, and aquatic habitats (ABR 2026b). As in the headwaters of the Martin River, only small amounts of suitable habitat would be lost for all waterbirds, seabirds, and shorebirds from construction of the Dixon Diversion infrastructure; for the three species groups, the acres lost would be 4.0, 2.1, and 4.0, respectively (Table 4.5-11). A similarly small amount of suitable habitat (5.1 acres) would be lost for all raptors, which, as a group, do not regularly use the extensive tall scrub habitats in the diversion footprint area at Bradley Lake (Table 4.5-11; ABR 2026b). In contrast, a much greater amount of suitable habitat (39.9 acres) would be lost for all landbirds (Table 4.5-11). Habitat losses for species that rely on tall scrub habitats, such as Willow Ptarmigan, Alder Flycatcher (*Empidonax alnorum*), Fox Sparrow (*Passerella iliaca*), Savannah Sparrow, Orange-crowned Warbler (*Leiothlypis celata*), Northern Yellow Warbler (*Setophaga aestiva*), and Wilson's Warbler (*Cardellina pusilla*) account for the majority of the acreage that would be lost for landbirds. In general, for the mammal species, the losses of suitable habitat would be similar to those for landbirds. The acres that would be lost for all large mammals, furbearers, and small mammals would be 39.3, 39.7, and 39.0, respectively. The exception is bats, which are expected to lose only 4.6 acres of suitable habitat. Habitat losses for mammal species that can regularly use tall alder scrub, such as black bear, brown bear, moose, wolverine, and various small mammals, account for the majority of the suitable habitats that would be lost for mammals.

Bradley River

Construction activity to develop the Dixon Diversion infrastructure is not anticipated to impact wildlife habitats in the Bradley River.

Kachemak Bay

No impacts to terrestrial wildlife resources are expected from barging activities in Kachemak Bay to support the construction of the Dixon Diversion infrastructure. The potential impacts to marine mammals and birds from construction barging activity in Kachemak Bay are discussed below in Section 4.5.2.3.

Bradley Lake Pool Raise

Bradley Lake

Accommodating the additional water from the Martin River and raising the pool elevation in Bradley Lake by 16 feet necessitates reconstruction of the Bradley Lake Dam and spillway as well as development and use of borrow and spoil sites.

The wildlife habitats within the construction footprint for the Bradley Lake Dam and spillway modifications encompass a relatively small area and are dominated largely by tall alder scrub with smaller amounts of existing lake waters, barren rock, and meadows (ABR 2026b). Accordingly, small amounts of suitable habitat would be lost for all waterbirds, seabirds, shorebirds, and raptors from construction activities in this area; for the four species groups, the acres lost would be 6.1, 0.0, 2.1, and 2.9, respectively (Table 4.5-11). The 6.1 acres expected to be lost for waterbirds is largely accounted for by losses of existing lake waters for Common (*Bucephala clangula*) and Barrow's (*B. islandica*) goldeneye (ABR 2026b), which would be replaced by an overall increase in the area of Bradley Lake waters during Project operations. All landbirds would see greater losses of suitable habitat (10.8 acres) than the other bird species groups. This result is largely due to the expected habitat losses for species that regularly use tall scrub habitats, such as Willow Ptarmigan, Alder Flycatcher, Fox Sparrow, Savannah Sparrow, Orange-crowned Warbler, Northern Yellow Warbler, and Wilson's Warbler (ABR 2026b). Three of the mammal species groups are expected to see similar amounts of suitable habitat loss as landbirds, with losses of 10.1 acres for all large mammals, 10.8 acres for furbearers, and 15.8 acres for small mammals (Table 4.5-11). Bats are the exception, as little brown myotis is expected to only lose 1.2 acres of suitable habitat (Table 4.5-11). As with the Bradley Lake area impacts expected for the Dixon Diversion construction, the habitat losses for those mammal species that can regularly use tall alder scrub on the shoreline of Bradley Lake, such as black bear, brown bear, moose, wolverine, and various small mammals, would account for the majority of the suitable mammal habitat lost from modifications to the Bradley Lake Dam and spillway (Table 4.5-11; ABR 2026b).

A substantially larger amount of suitable wildlife habitat occurs within the combined construction footprints for the planned borrow/spoil sites in the Bradley Lake drainage. Habitats in these areas include only well-drained terrestrial types dominated strongly by barren rock, meadows, and tall alder scrub; no freshwater aquatic habitats are present (ABR 2026b). In the borrow/spoil footprint areas, there are no suitable habitats for any waterbird, seabird, or shorebird species of concern (Table 4.5-11). For all raptors and landbirds, the acres of suitable habitat expected to be lost are 31.7 and 62.2, respectively. For raptors, the overall amount of suitable habitat lost would be accounted for primarily by losses for species such as Golden Eagle, Northern Harrier, and Peregrine Falcon, which can hunt in higher elevation open meadow and partially vegetated habitats (Table 4.5-11; ABR 2026b). For landbirds, habitat losses for species that rely on tall scrub and/or open meadow habitats, such as Willow Ptarmigan, Alder Flycatcher, Fox Sparrow, Savannah Sparrow, Orange-crowned Warbler, Northern Yellow Warbler, and Wilson's Warbler, would account for most of the overall loss of suitable landbird habitat. Habitat losses for most of the mammal species groups would be similar to the losses for landbirds. The acres of suitable habitat that are expected to be lost for all large mammals, furbearers, and small mammals are 62.2, 62.2, and 59.4, respectively. As in the construction footprint for the Bradley Lake Dam and spillway, bats are the exception, as little brown myotis is expected to only lose 1.6 acres of suitable habitat. The overall amount of suitable habitat lost for mammals would be accounted for primarily by losses for species that can regularly use tall scrub, barren rock and cliffs, and/or open meadow habitats, such as black bear, brown bear, moose, mountain goat, hoary marmot, wolverine, and various small mammals.

The direct inundation effects on wildlife habitats from raising the water level in Bradley Lake will be discussed when considering Project operations in Section 4.5.2.2.2 below, as wildlife habitats would only be altered by inundation after Martin River water is diverted to Bradley Lake during operations.

Bradley River

Construction activity to raise the level of Bradley Lake Dam is not anticipated to impact wildlife habitats in the Bradley River.

Kachemak Bay

No impacts to terrestrial wildlife resources are expected from barging activities in Kachemak Bay to support raising the level of Bradley Lake Dam. The potential impacts to marine mammals and birds from construction barging activity in Kachemak Bay are discussed below in Section 4.5.2.3.

<u>Potential Construction Blasting Impacts</u>

In addition to direct impacts to wildlife habitats, there could be temporary behavioral disturbance to wildlife species if they are displaced by construction activities. Six disturbance-sensitive species (black bear, brown bear, Golden Eagle, moose, mountain goat, and wolverine) were assessed for their possible occurrence within 2-kilometer (1.2-mile) buffer zones surrounding the two areas where blasting is planned during construction (Figure 4.5-7). Suitable habitat for all six species is present in the blasting area buffer zones (ABR 2026b), and if these species occur in those areas during blasting activities, displacement from noise and vibration effects could occur. In summer 2025, an active Golden Eagle nest was found within the blasting area buffer zone surrounding Bradley Lake Dam (0.8 mile from the dam), and an unoccupied nest and a nest of unknown occupancy were located approximately 0.3 mile and 0.2 mile, respectively, from the outer boundary of the buffer zone surrounding the Dixon Diversion site (ABR 2026c). To minimize possible behavioral impacts to Golden Eagles and sensitive mammal species, a set of PM&E measures was developed, which largely involve conducting blasting outside the important life-history stages for these species to the extent practicable (see Section 4.5.3 below).

4.5.2.2.2 Project Operations

<u>Martin River Basin</u>

Over a 60-year Project operations period in the Martin River floodplain, aquatic and riverine-influenced wildlife habitats in the Martin River floodplain are expected to decline in extent, and more well-drained habitats are expected to increase as river flows, overbank flooding, and channel braiding is reduced (Watershed GeoDynamics 2025) and climate-change driven plant succession results in the expansion of terrestrial scrub and forest habitats (Section 4.5.2.1.2). Along with Project-induced impacts, natural plant succession is also expected to result in substantial declines in Upland and Subalpine Tall Alder Scrub as those areas transition to Upland Mixed Lutz Spruce-Black Cottonwood Forest (ABR 2026a). The Project-induced changes in river flow cannot be entirely separated from changes expected due to natural plant succession, but much of the landscape change, especially in currently open, barren riverine habitats in the braided-channel floodplain, would be stimulated by the planned seasonal reductions in flow in the Martin River. The changes in the predicted future availability of suitable habitats in the Martin River floodplain for the bird and mammal species of concern discussed below reflect these overall expected changes in the extents of wildlife habitats. Because of differences in species habitat preferences, there is substantial variability in the predicted increases and decreases in availability of suitable habitats within and among the wildlife species groups assessed.

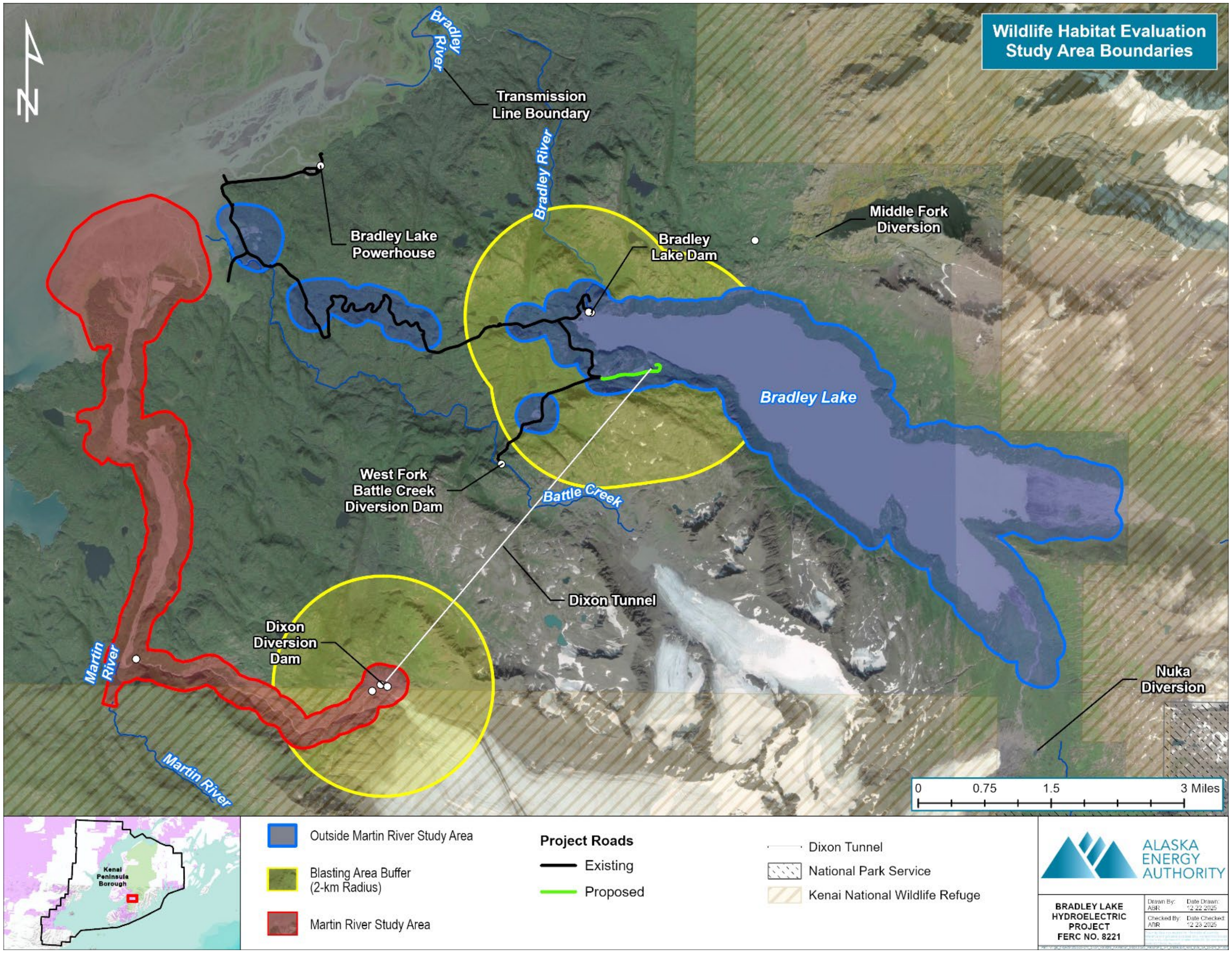

Figure 4.5-7 Buffer zones (yellow shading) surrounding areas where blasting will be needed during Project construction.

For all large mammals, there is expected to be an overall net increase in the extent of suitable habitat available in the Martin River floodplain over a 60-year Project operations period, but the predicted increase is relatively small (+27.1 acres; Table 4.5-12). However, with the expected increases in the extent of more well-drained habitats in the Martin River floodplain (Section 4.5.2.1.2), some individual large mammal species would see substantial increases in the availability of suitable habitats (+288.0 acres for moose and +396.8 acres for black bear; Table 4.5-12). In contrast, although the species is very rare on the east side of Kachemak Bay (Section 4.5.1.2.1), a substantial decline in suitable habitat availability for brown bear (-389.3 acres) is expected (Table 4.5-12), driven largely by large reductions in riverine braided floodplain and upland tall shrub habitats (ABR 2026b).

For all furbearers, an overall net increase in the availability of suitable habitats (+149.4 acres) is expected under future conditions in the Martin River floodplain; this change is driven primarily by a large increase in suitable habitat for beavers (+134.2 acres) as Riverine Tall Alder colonizes currently barren river bars and flooded scrub habitats that are expected to die off and be recolonized (Table 4.5-12; ABR 2026b). The loss of those same flooded scrub habitats near the coast (Riverine Flooded Black Cottonwood Scrub) largely accounts for the expected decrease in availability of suitable habitat for river otters (-138.9 acres; Table 4.5-12; ABR 2026b).

With the overall transition to more well-drained, terrestrial habitats in the Martin River floodplain (Section 4.5.2.1.2), all small mammals and little brown myotis are expected to see overall net increases in the availability of suitable habitat under future conditions (+320.9 acres for small mammals and +417.0 acres for bats; Table 4.5-12; ABR 2026b). More aquatic-adapted small mammal species (e.g., western water shrew), however, would see a decline in suitable habitat availability (-136.0 acres; Table 4.5-12).

For waterbirds, under future conditions there is predicted to be an overall net loss in the availability of suitable habitat in the Martin River floodplain with the transition to more well-drained, terrestrial habitats (-532.8 acres; Table 4.5-12; ABR 2026b). A substantial loss of suitable active braided floodplain habitat for Harlequin Ducks (-362.9 acres; *Histrionicus histrionicus*) is expected, and losses of potential nesting habitat in Riverine Flooded Black Cottonwood Scrub is expected for Common and Barrow’s goldeneyes (-125.9 acres for both species; Table 4.5-12; ABR 2026b). For the other two bird species groups that also have strong associations with aquatic and riverine habitats, seabirds and shorebirds, there are also expected to be overall net losses in suitable habitat availability (-167.1 and -456.8

acres, respectively; Table 4.5-12; ABR 2026b). Substantial losses of suitable active braided floodplain habitat for three shorebird species (Semipalmated Plover [*Charadrius semipalmatus*], Spotted Sandpiper [*Actitis macularius*], and Wandering Tattler [*Tringa incana*]; -453.2, -363.1, and -362.9, respectively; Table 4.5-12) are predicted under future conditions (ABR 2026b).

Table 4.5-12 Predicted acres of habitat change (loss or gain) for avian and mammalian species of concern due to river flow reductions, climate change, natural plant succession in the Martin River floodplain.

Species of Concern	Total Acres of Change
Northern Pintail	-46.7
Steller's Eider	0.0
Harlequin Duck	-362.9
Black Scoter	0.0
Long-tailed Duck	0.0
Common Goldeneye	-125.9
Barrow's Goldeneye	-125.9
Common Merganser	-82.3
Red-breasted Merganser	-43.9
Red-throated Loon	0.0
All Waterbirds	**-532.8**
Golden Eagle	4.2
Northern Harrier	-87.0
Bald Eagle	345.1
Red-tailed Hawk	411.2
Short-eared Owl	-43.9
Peregrine Falcon	-46.7
All Raptors	**171.5**
Marbled Murrelet	0.0
Kittlitz's Murrelet	0.0
Black-legged Kittiwake	0.0
Bonaparte's Gull	-167.1
American Herring Gull	-43.9
Arctic Tern	-43.9
Pelagic Cormorant	0.0
All Seabirds	**-167.1**
Semipalmated Plover	-453.2
Rock Sandpiper	85.6
Semipalmated Sandpiper	-43.9

Species of Concern	Total Acres of Change
Western Sandpiper	-43.9
Short-billed Dowitcher	-43.9
Spotted Sandpiper	-363.1
Wandering Tattler	-362.9
Lesser Yellowlegs	-58.0
Greater Yellowlegs	-10.7
All Shorebirds	**-456.8**
Willow Ptarmigan	-384.3
Rock Ptarmigan	4.2
Rufous Hummingbird	522.4
Belted Kingfisher	-82.3
Olive-sided Flycatcher	261.3
Alder Flycatcher	138.0
Horned Lark	4.2
Bank Swallow	-3.1
American Pipit	-39.7
Lapland Longspur	-39.7
Fox Sparrow	-124.3
Savannah Sparrow	-152.5
Song Sparrow	137.0
Orange-crowned Warbler	138.0
Northern Yellow Warbler	138.0
Blackpoll Warbler	286.9
Wilson's Warbler	-124.3
All Landbirds	**410.7**
Black bear	396.8
Brown bear	-389.3
Moose	288.0
Mountain goat	388.6
All Large Mammals	**28.1**
American beaver	134.2
River otter	-138.9
Hoary Marmot	4.2
Wolverine	0.0
All Furbearers	150.4
Snowshoe hare	288.0
Singing vole	-385.4
Tundra (root) vole	194.0

Species of Concern	Total Acres of Change
Dusky shrew	239.7
Western water shrew	-136.0
All Small Mammals	**320.9**
Little brown myotis	417.0
All Bats	**417.0**

In contrast, for the two bird species groups that rely more on terrestrial habitats, raptors and landbirds, there are predicted to be overall net increases in the availability of suitable habitat (+171.5 and +410.7 acres, respectively; Table 4.5-12 ; ABR 2026b). Much of the increase in habitat availability for raptors is expected to be driven by increases in suitable habitat for Bald Eagles and Red-tailed Hawks (+345.1 and +411.2 acres, respectively; Table 4.5-12; ABR 2026b) as natural plant succession transitions extensive areas of tall scrub to Upland Mixed Lutz Spruce-Black Cottonwood Forest (ABR 2026b). Within the diverse group of landbirds, there is extensive variability in the predicted habitat changes, with notable declines in suitable habitat availability predicted for some species (Willow Ptarmigan, Fox Sparrow, and Wilson's Warbler; -384.3, -124.3, and -124.3 acres, respectively), due largely to natural plant succession transitioning tall scrub habitats to forests (ABR 2026b). In contrast, Olive-sided Flycatcher (*Contopus cooperi*) is expected to benefit from the natural expansion of forest habitats (+261.3 acres), and other species (Alder Flycatcher, Orange-crowned Warbler, and Northern Yellow Warbler) are expected to benefit both from the natural expansion of forest habitats and the Project-induced increases in Riverine Tall Alder (+138.0 acres for all three species). Belted Kingfisher (*Megaceryle alcyon)* is expected to see a decline in suitable habitat availability (-82.3 acres) from a reduction in the extents of aquatic habitats and the transition to more terrestrial habitats.

<u>Bradley Lake</u>

During Project operations at Bradley Lake, habitats would be altered in the water level fluctuation zone (WLFZ). The future WLFZ at Bradley Lake is expected to span 100 feet or more in elevation, ranging approximately from El. 1,080 feet to El. 1,196 feet and 15 existing habitats were found to occur and were mapped in the upper portions of this range between El. 1,153 feet and El. 1,180 feet and between El. 1,180 feet and El. 1,196 feet (see Section 4.5.2.1.2 above and ABR 2026a). In the future WLFZ, these habitats would be exposed annually from early winter and through the early part of the growing season to late summer. These habitats are expected to persist in the upper parts of the future

WLFZ. However, because they are inundated annually, these habitats would likely have reduced plant species diversity and reduced vegetation cover and would be of lower value for wildlife (ABR 2026a). In contrast, habitats in the lower regions of the future WLFZ likely would transition to partially vegetated habitats dominated by graminoid species that can better survive inundation, or barren cobble and rock (ABR 2026a).

Among the mammal species groups, the area of suitable habitat potentially altered by water level fluctuations in the future WLFZ at Bradley Lake would be greatest for furbearers (577.2 acres; Table 4.5-13). Most of that furbearer habitat acreage, based on habitat values alone, would be accounted for by Riverine Barrens and Riverine Low and Tall Willow habitats for river otters in the upper lake area (ABR 2026b). However, there are no fish in Bradley Lake, so the likelihood that river otters occur regularly there is low. If the unique suitable habitats for river otters are removed from the calculations, the overall altered habitat acreage for furbearers drops to 293.7 acres, which is similar to the other mammal species groups, except for bats. Lake-level rise impacts would be very similar for large and small mammals (294.1 and 306.4 acres, respectively), and little brown myotis would see substantially less suitable habitat altered (139.7 acres) than the other mammal species groups (Table 4.5-13).

For the bird species groups, there is a wide range in the acres of suitable habitat expected to be affected by lake-level rise effects at Bradley Lake. Shorebirds, which focus much of their foraging in littoral zones in the margins of lacustrine and riverine habitats, are expected to see the greatest amount of suitable habitat area potentially altered in the future WLFZ at Bradley Lake (501.9 acres; Table 4.5-13). This overall acreage would be primarily accounted for by Riverine Barrens, Riverine Low and Tall Willow, and Rocky Shore and Cobble Beach habitats which are used by Spotted Sandpipers and Wandering Tattlers (ABR 2026b). Waterbirds would see less suitable habitat altered (404.9 acres), and nearly all of it would be accounted for by riverine habitats used by Harlequin Ducks. Landbirds are expected to have 308.0 acres of suitable habitat altered, and most of that acreage would be accounted for by low and tall shrub habitats used by species such as Willow Ptarmigan, Alder Flycatcher, Fox Sparrow, Orange-crowned Warbler, Northern Yellow Warbler, and Wilson’s Warbler (ABR 2026b). Raptors and seabirds would see substantially less suitable habitat altered in the future WLFZ (57.1 and 0.5 acres, respectively).

Table 4.5-13 Acres of suitable habitat for avian and mammalian species of concern expected to be affected by water level fluctuations and pool rise impacts at Bradley Lake.

Species	Water Level Fluctuation Zone Impacts, El. 1,180 to 1,196 feet (acres)[a]	Water Level Fluctuation Zone Impacts, El. 1,153 to 1,180 feet (acres)[b]	Total Acres
Northern Pintail	0	0.5	0.5
Steller's Eider	0	0	0
Harlequin Duck	131.3	273.1	404.4
Black Scoter	0	0	0
Long-tailed Duck	0	0	0
Common Goldeneye	0	0.5	0.5
Barrow's Goldeneye	0	0.5	0.5
Common Merganser	5.2	8	13.2
Red-breasted Merganser	0	0.5	0.5
Red-throated Loon	0	0	0
All Waterbirds	**131.3**	**273.6**	**404.9**
Golden Eagle	17.3	39.8	57.1
Northern Harrier	17	39.7	56.7
Bald Eagle	0	0	0
Red-tailed Hawk	0	0	0
Short-eared Owl	0	0	0
Peregrine Falcon	1	1.1	2.1
All Raptors	**17.3**	**39.8**	**57.1**
Marbled Murrelet	0	0	0
Kittlitz's Murrelet	0	0	0
Black-legged Kittiwake	0	0	0
Bonaparte's Gull	0	0.5	0.5
American Herring Gull	0	0	0
Arctic Tern	0	0.5	0.5
Pelagic Cormorant	0	0	0
All Seabirds	**0**	**0.5**	**0.5**
Semipalmated Plover	59.8	211	270.8
Rock Sandpiper	0	0	0
Semipalmated Sandpiper	0	0	0
Western Sandpiper	0	0	0
Short-billed Dowitcher	0	0	0
Spotted Sandpiper	135.6	366.1	501.7

Species	Water Level Fluctuation Zone Impacts, El. 1,180 to 1,196 feet (acres)[a]	Water Level Fluctuation Zone Impacts, El. 1,153 to 1,180 feet (acres)[b]	Total Acres
Wandering Tattler	135.7	365.7	501.4
Lesser Yellowlegs	0	0	0
Greater Yellowlegs	0	0	0
All Shorebirds	**135.7**	**366.2**	**501.9**
Willow Ptarmigan	136.5	97.9	234.4
Rock Ptarmigan	16.6	38.8	55.4
Rufous Hummingbird	1.8	0	1.8
Belted Kingfisher	5.1	7.9	13.0
Olive-sided Flycatcher	1.2	0.2	1.4
Alder Flycatcher	137.6	96.9	234.5
Horned Lark	16.3	38.7	55.0
Bank Swallow	5.1	7.9	13.0
American Pipit	16.3	38.7	55.0
Lapland Longspur	16.3	38.7	55.0
Fox Sparrow	135.8	96.9	232.7
Savannah Sparrow	88.9	83.2	172.1
Song Sparrow	1.8	0	1.8
Orange-crowned Warbler	137.6	96.9	234.5
Northern Yellow Warbler	137.6	96.9	234.5
Blackpoll Warbler	67.7	53.4	121.1
Wilson's Warbler	137.6	96.9	234.5
All Landbirds	**163.2**	**144.8**	**308.0**
Black bear	140.3	98.4	238.7
Brown bear	156.5	134.4	290.9
Moose	137.6	97.4	235.0
Mountain goat	17.3	39.8	57.1
All Large Mammals	**156.9**	**137.2**	**294.1**
American beaver	68.1	55.1	123.2
River otter	131.3	273.6	404.9
Hoary Marmot	1.1	3.8	4.9
Wolverine	86.8	80.5	167.3
All Furbearers	**220.3**	**356.9**	**577.2**
Snowshoe hare	137.6	96.9	234.5
Singing vole	86.8	80.5	167.3

Species	Water Level Fluctuation Zone Impacts, El. 1,180 to 1,196 feet (acres)[a]	Water Level Fluctuation Zone Impacts, El. 1,153 to 1,180 feet (acres)[b]	Total Acres
Tundra (root) vole	91.1	80.2	171.3
Dusky shrew	137.6	96.9	234.5
Western water shrew	6.7	9.3	16.0
All Small Mammals	**163.2**	**143.2**	**306.4**
Little brown myotis	76.8	62.9	139.7
All Bats	**76.8**	**62.9**	**139.7**

[a] Acres of wildlife habitats present in the expected upper water level fluctuation zone between the current and future operational maximum pool elevations of El. 1,180 and 1,196 feet.

[b] Acres of wildlife habitats present in the existing upper water level fluctuation zone between El. 1,153 feet—the lake level on the imagery used to map habitats in ABR (2026a)—and the current operational maximum pool elevation of El. 1,180 feet.

Bradley River

Project operations affecting the Martin River floodplain and the shoreline of Bradley Lake are not anticipated to impact wildlife habitats in the Bradley River.

Kachemak Bay

The barge movements in Kachemak Bay to deliver construction supplies for the proposed Project are expected to cease once construction is complete and operations begin. Therefore, marine mammals and birds should not be impacted during Project operations (see Section 4.5.2.3 below).

4.5.2.3 Effects on Marine Mammals and Birds

4.5.2.3.1 Construction

The additional barge movements in Kachemak Bay between Homer and the Bradley Lake Project dock and potentially in Cook Inlet between Anchorage and Homer and the Bradley Lake Project dock to deliver construction equipment and supplies during the three to four years of construction are not anticipated to significantly impact marine mammals or birds. Travel between Anchorage and Homer would occur within the designated shipping lanes. Barge movement across Kachemak Bay would be concentrated during mobilization and demobilization activities and would occur on the days of the month with extreme high tides.

There are no significant Steller sea lion haul outs or rookeries within Kachemak Bay or upper Cook Inlet although they feed in the area year-round (ADF&G 1993). In the event that sea lions are present and a slow-moving barge is encountered, individuals should easily be able to move away and avoid harm.

Construction-related barging should not impact Fin, Minke, and humpback whales, Dall's porpoise, and killer whales; these species may be present in Cook Inlet but they are not commonly seen in the shallow waters of Kachemak Bay (ADF&G 1993).

If barging activity includes trips to the Port of Alaska in Anchorage before transiting to Homer, Project-related barge traffic may occur in the vicinity of northern sea otter (Southwest Alaska DSP) critical habitat, which includes the western coastal waters of lower Cook Inlet. However, barge traffic in Cook Inlet would occur in the designated shipping lanes in deeper water away from the shoreline and nearshore waters, making it unlikely that barges would come into contact with northern sea otters outside of Kachemak Bay. Sea otters normally feed in waters less than 200 feet deep or less, and prefer shallow, rocky-bottom habitat broken by reefs and islets (ADF&G 1993). When barges transit the shallow waters of upper Kachemak Bay to approach the Project dock, sea otters should easily be able to avoid harm and move away from a slow-moving barge.

Harbor seals are the most abundant marine mammal in upper Kachemak Bay and the tidal flats between the Bradley River and the Fox River are an important haulout area (ADF&G 1993). Although the timing of use (summer) overlaps with construction barging, barge traffic would occur in the deeper waters away from the flats, and harbor seals are unlikely to be impacted. Harbor porpoises are common in nearshore waters of Kachemak Bay, generally in waters less than 60 ft deep (ADF&G 1993). As with sea otters, except when approaching the Project dock, barge traffic will be in deeper water away from the shoreline and nearshore waters, making it unlikely that barges would come into contact with harbor porpoises. Additionally, if a slow-moving barge is encountered, individuals should easily be able to move away and avoid harm.

Kachemak Bay and the upper and western portions of Cook Inlet are designated Cook Inlet beluga whale critical habitat (76 FR 20180). In the warmer, ice-free months when Project-related barge traffic would occur, beluga whales are most likely to be found in shallower, coastal waters, and near the mouths of salmon streams in upper Cook Inlet (see Section 4.7.2.1). Except when approaching docking areas, barge traffic would occur in the deeper water of designated shipping lanes in Cook Inlet and in deeper water in Kachemak

Bay, away from the mouths of salmon streams. Beluga whales have not been recorded in Kachemak Bay during the summer since 1994 (See Section 4.5.1.3 above and Section 4.7.2.1). Because Project barging would occur in the ice-free season (April through Oct) and because the limited number of barge trips (up to ten total trips) could only occur on the 3–4 days per month of extreme high tide cycles, the possibility of barges encountering CI beluga would be low.

Construction barging for the Project would occur between April and October but only during extreme high tides that occur about 3–4 days per month. This timeframe overlaps with the presence of migratory birds, some of which will use Kachemak Bay marine waters and associated mud flats. Eight species of sea ducks or seabirds could use Coastal Barren Mud Flats for foraging (ABR 2025c), but likely only during high water conditions, which is also when barging would occur. Although the ranges of these species overlap with marine waters in the vicinity of the Project, they are generally found in more productive waters to the south in Kachemak Bay than in the turbid and strongly glacially influenced waters in the upper bay. This mirrors the pattern in Cook Inlet where sea duck and seabird species occur much more commonly in southern inlet waters than in the turbid waters of upper Cook Inlet. It is important to note as well that the entirety of upper Kachemak Bay is exposed mudflat at low tide, which is unsuitable habitat for diving sea ducks and seabirds, so only portions of each day would provide habitat for these species. In the event that seabirds, waterbirds, or shorebirds are present and a slow-moving barge is encountered, the birds should easily be able to move away and avoid harm.

4.5.2.3.2 Operations

The modification of river flows from the Dixon Glacier and Martin River and the Bradley River are not expected to affect marine mammals or birds. The Dixon Diversion will divert water from the Dixon Glacier to the Bradley Lake Reservoir from May through October, and the Bradley Lake normal maximum pool elevation will be raised by 16 feet. The increased water level is not expected to affect marine mammals or marine birds, which do not occur in Bradley Lake; impacts on terrestrial birds are discussed in Section 4.5.2.2.2. The additional barge movements in Kachemak Bay and potentially Cook Inlet to deliver construction supplies for the proposed Project are generally expected to cease once construction is complete and operations begin, with the possible exception of construction work for infrastructure repairs or alterations. The Project barging impacts to marine mammals and birds are expected to be minor during construction (Section 4.5.2.3.1) and will likely be negligible during operations. Although harbor seals are known to ascend 6 miles up the Bradley River (ADF&G 1993), they are not expected to be impacted by changes to the Bradley River due to dam elevation increase and lake-level rise, as no significant adverse effects to vegetation and wildlife habitats, including riverine habitats, are expected along the Bradley River (Section 4.5.2.1.2).

4.5.3 Applicant-Proposed Measures

The PM&E measures proposed below are provisionary for this draft Exhibit E as discussion of the efficacy and feasibility of implementing these measures with the agency licensing participants has not yet occurred. Those discussions for terrestrial resources will occur in early March 2026 and the final set of PM&E measures agreed upon for the Project will be included in the final version of Exhibit E.

The proposed draft PM&E measures for botanical resources include the following:

- Use stormwater pollution prevention strategies as part of the ESCMP to reduce contaminants and sediments larger than naturally occurring suspended glacial silt from entering waterbodies and associated aquatic vegetation types.
- Propose to segregate and stockpile surface organic material from the borrow sites for use in reclamation efforts after construction is completed. Given that much of the vegetation to be impacted in the borrow sites is Sitka alder shrub (*Alnus sinuata*), regrowth after placement of organic material could be considerable with a high density of alder propagules in the overburden and the propensity of the species to establish on disturbed surfaces.
- Propose to use the reserved organic material to help revegetate the tunnel muck spoils at Bradley Lake, upon which the exit portal access road and the outlet channel to the lake would be constructed. This measure should also serve to minimize the spread of fugitive dust from the tunnel muck spoils after construction.
- Require all construction equipment to be cleaned of debris prior to being onsite to ensure invasive and/or non-native species are not introduced.

The proposed draft PM&E measures for wildlife resources include the following:

- Meet with USFWS personnel to discuss and settle on a blasting-specific disturbance buffer distance and potential avoidance window to be used to minimize disturbance to nesting Golden Eagles from blasting activities at the Dixon Diversion site and Bradley Lake Dam and associated borrow sites. Golden

Eagles are more sensitive than Bald Eagles, for which the USFWS guidelines use a 0.5-mile buffer to avoid blasting disturbance.

- Conduct aerial Golden Eagle nesting surveys twice each spring during all construction years to determine nest occupancy. These should be conducted in April and/or early May, prior to mountain goat parturition to avoid helicopter disturbances to goats. Surveys should be conducted twice per year because it is challenging to detect all eagle nests in a single survey. Because blasting may need to occur during low-water conditions in May at the Dixon Diversion site, these spring surveys will provide the information needed to assess the presence or absence of nesting Golden Eagles within the agreed-upon disturbance buffer distance prior to blasting activities.
- Establish an avoidance window and distance buffer for mountain goats in consultation with ADF&G. Currently, the agency has recommended an avoidance buffer of 2 kilometers (1.2 miles) for five sensitive mammal species based on observations of abandonment of bear dens and disturbance to goats within that distance. The list of sensitive mammal species developed by ADF&G for the Project includes mountain goat, black bear, brown bear, moose, and wolverine.
- For helicopter overflights, maintain a minimum altitude of 1,500 feet above ground level (agl) and avoid flying over cliffs and rugged terrain to minimize potential disturbance of Golden Eagles and mountain goats. Additionally, all wildlife will be avoided by 1,500 vertical feet whenever possible.
- Conduct vegetation clearing before or after the migratory bird nesting window (May 1–July 15 for Southcentral Alaska). USFWS does not recommend nest searches to identify active nests because of the difficulty of confirming that no active nests are present in any given search area.

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4.6 Wetland Resources

4.6.1 Affected Environment

The discharge of pollutants into waters of the United States (WOTUS) is regulated under the CWA (33 U.S.C. 1251 et seq. USEPA 1972), and WOTUS are currently defined as "relatively permanent, standing or continuously flowing bodies of water [such as] 'streams, oceans, rivers, and lakes'" and "wetlands that are 'indistinguishable' from those bodies of water due to a continuous surface connection" (Sackett v. USEPA 2022). Wetlands are areas with water inundation at or near the surface of the soil all year or for varying periods during the year, including the growing season, that would support hydrophytic vegetation and promote development of wetland hydric soils (USEPA 2025).

Existing USFWS National Wetlands Inventory wetland mapping and data (USFWS 2024) are available for the Project area that describe the extent and type of wetlands and WOTUS within the buffered Project footprint (scale 1:24,000). In 2024 and 2025, wetland delineation surveys were conducted to identify wetlands and WOTUS within a 734-acre study area that included the proposed Project footprint, potential construction impact areas, and additional areas outside of the direct footprint (DOWL 2024, DOWL 2026). The study area lies within portions of the Martin River, Bradley Lake/River, and Battle Creek watersheds.

Within the study area, a total of 83.9 acres of wetlands and waters occurred within the pool raise and 14.8 acres of wetlands and waters occurred within the remaining study area. Approximately 635.3 acres (86.6 percent) were determined to be upland habitat (Table 4.6-1 and Figure 4.6-1). The wetlands in the study area are classified as depressional, riverine, and slope hydrogeomorphic classes (Brinson 1993). Depressional wetlands include kettles, potholes, and vernal pools. They typically receive hydrology from precipitation. Riverine wetlands and surface water form linear strips in the landscape and receive hydrology from streams. Slope wetlands include surface water slope and groundwater slope that receive hydrology in the form of precipitation, overland flow, throughflow, or groundwater.

Most wetlands and surface water within the study area are connected by a surface connection through several small, high-gradient streams flowing into Bradley Lake and into the Bradley River. The Martin River and Bradley River both flow to Kachemak Bay, a traditional navigable water. Several small, isolated alpine and sub-alpine depressional ponds and swales present in the study area lack a surface connection. At lower elevations, palustrine riverine wetlands are situated above estuarine and marine habitat associated with Kachemak Bay. This area has been distinguished from estuarine habitat since Bradley Lake Road was developed, and facilities were completed in 1991.

Table 4.6-1 Wetlands and waters mapped in the study area.

Cowardin Code	Cowardin Classification Description	Pool Raise (acres)	Remaining Study Area (acres)
Waters			
L1UBH	Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded	0.0	0.2
L2UBH	Lacustrine Littoral Unconsolidated Bottom Permanently Flooded	0.0	5.4
PUB1C	Palustrine Unconsolidated Bottom Cobble-Gravel Seasonally Flooded	0.0	0.0

Cowardin Code	Cowardin Classification Description	Pool Raise (acres)	Remaining Study Area (acres)
PUBH	Palustrine Unconsolidated Bottom Permanently Flooded	0.0	3.4
R2UBH	Riverine Lower Perennial Unconsolidated Bottom Permanently Flooded	0.0	0.1
R3UBC	Riverine Upper Perennial Unconsolidated Bottom Seasonally Flooded	15.2	0.4
R3UBH	Riverine Upper Perennial Unconsolidated Bottom Permanently Flooded	66.8	2.6
R3UBJ	Riverine Upper Perennial Unconsolidated Bottom Intermittently Flooded	0.0	0.0
R3USC	Riverine Upper Perennial Unconsolidated Shore Seasonally Flooded	0.0	0.0
R4SBC	Riverine Intermittent Streambed Seasonally Flooded	0.4	0.3
R5UBH	Riverine Unknown Perennial Unconsolidated Bottom Permanently Flooded	0.0	0.0
	Waters Total	**82.4**	**12.4**
Wetlands			
E2EM1P	Estuarine Intertidal Emergent Persistent Irregularly Flooded	0	0
PEM1B	Palustrine Emergent Persistent Saturated	0.0	1.0
PEM1C	Palustrine Emergent Persistent Seasonally Flooded	0.1	0.2
PEM1E	Palustrine Emergent Persistent Seasonally Flooded/Saturated	0.0	0.1
PSS1A	Palustrine Scrub-Shrub Broad-Leaved Deciduous Temporarily Flooded	0.0	0.0
PSS1/EM1C	Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Seasonally Flooded	0.7	0.0
PSS1B	Palustrine Scrub-Shrub Broad-leaved Deciduous Saturated	0.6	0.2
PSS1C	Palustrine Scrub-Shrub Broad-leaved Deciduous Seasonally Flooded	0.1	1.0
	Wetlands Total	**1.5**	**2.5**
	Uplands Total	**635.3**	
	Total Study Area	**734.0**	

Source: DOWL (2026).

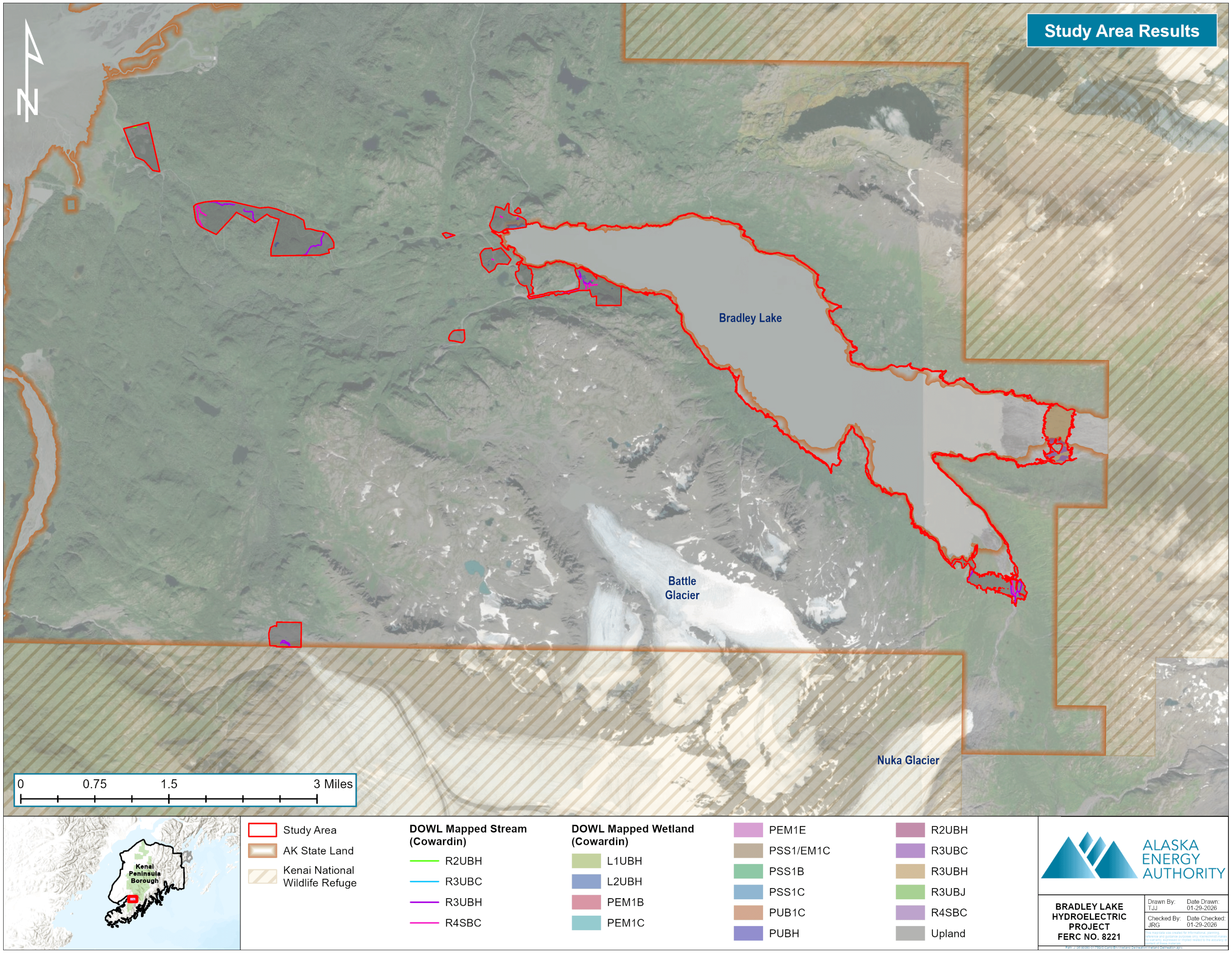

Figure 4.6-1 Wetlands mapped within the Study Area, 2024 and 2025.

4.6.1.1 Wetlands

Wetlands within the study area consisted of the following dominant vegetation: speckled alder (*Alnus incana),* Sitka alder (*A. viridis),* bluejoint (*Calamagrostis canadensis),* leafy tussock sedge (*Carex aquatilis),* Alaska long-awn sedge (*C. macrochaeta),* alpine-tundra sedge (*C. macrochaeta),* alpine blueberry (*Vaccinium uliginosum),* balsam poplar (*Populus balsamifera),* Bigelow's sedge (*Carex bigeloeii),* narrow-leaf fireweed (*Chamaenerion angustifolium),* black crowberry (*Empetrum nigrum),* marsh horsetail (*Equisetum palustre),* marsh willowherb (*Epilobium palustre),* tall cotton-grass (*Eriophorum angustifolium),* tussock cotton-grass (*E. vaginatum),* strawberry-leaf raspberry (*Rubus pedatus),* felt-leaf willow (*Salix alaxensis),* diamond-leaf willow (*S. pulchra),* Sitka willow (*S. barclayi),* oval-leaf willow (*Salix ovalifolia),* salmonberry (Rubus spectabilis), Canadian burnet (*Sanguisorba canadensis),* Arctic starflower (*Trientalis europaea),* alpine blueberry (*Vaccinium uliginosum),* and alpine-marsh violet (*Viola palustris).*

Hydrologic indicators consisted of a high water table, soil saturation, a dry season water table, algal mat, inundation visible on aerial imagery, water-stained leaves, drainage patterns, presence of reduced iron, geomorphic position, microtopographic relief, and passing the "Facultative" (FAC)-neutral test. The most common primary indicators were a high water table and soil saturation.

In general, wetland soils had a thick organic layer and met the criteria for Histosol or Histic Epipedon. Soils without a thick organic layer were considered problematic hydric soils based on the USACE (2007) Alaska Regional Supplement (Section 5.0).

4.6.1.2 Streams

Both the Bradley River and Martin River flow to Kachemak Bay, a traditional navigable water. Nearly all of the water from Bradley Lake is diverted through the powerhouse and into Kachemak Bay. Wetlands that flow to Kachemak Bay within the study area include palustrine emergent and scrub shrub wetlands and ponds with hydrologic inputs from nearby streams.

4.6.1.2.1 Martin River

Meltwater flows to the EFMR from the Dixon Glacier terminus near the proposed Dixon diversion tunnel intake. The Martin River is a perennial, high-gradient river with two channels at the intake structure and evidence of stream channel migration. Where the glacier has receded, rock and bedrock remain with no hydrophytic vegetation, hydric soils formation, or hydrology indicators. The remainder of the Project area flows to Bradley Lake and the Bradley River.

4.6.1.2.2 Bradley Lake

Wetlands above Bradley Lake include ponds, scrub shrub, and emergent wetlands that are fed by nearby streams, alpine swales with precipitation inputs, and palustrine emergent and scrub shrub wetlands with precipitation and shallow groundwater hydrologic inputs.

Two major tributary streams, the Upper Bradley River and Kachemak Creek, discharge into the eastern extent of Bradley Lake. Along the steep slopes of the Bradley Lake shoreline, several small, high-gradient streams flow to Bradley Lake. In addition to naturally occurring tributaries, Bradley Lake sees input from the Battle Creek Diversion project on the southern shore near its western terminus (i.e., the dam) and the Middle Fork Bradley diversion through Marmot Creek along its north shore. The West Fork Upper Battle Creek diversion surfaces approximately 0.5 miles south from the shoreline of Bradley Lake and joins the diverted East Fork Battle Creek within a naturally constricted channel before flowing into Bradley Lake. Ponds have formed in shallow sloped areas with small deltas-braided sections that are visible during low flow.

The glacially-fed Upper Bradley River and Kachemak Creek form braided streams where they enter Bradley Lake with multi-threaded channels consisting of vegetated or non-vegetated areas that seasonally flood during high water and have dynamic channels with large sediment movement. In braided streams, the outer channel banks and everything in between are considered the extent of the Riverine System (Federal Geographic Data Committee 2013). The ordinary high water (OHW) of the outermost channels in the braided streams were considered the base elevation for stream classification. One of the braided tributaries feeding Bradley Lake contained two islands with elevations above the OHW. Any vegetated areas below the OHW elevation within the stream braids were considered stream channel and not wetlands.

4.6.1.2.3 Bradley River

No wetlands are located adjacent to the Bradley River or downstream of the existing Bradley Lake Dam within the study area. The Bradley River at the outfall is a perennial, low-gradient stream with variable flows. Most of the water from Bradley Lake is diverted to the powerhouse. The Bradley Lake Project releases MIFs to the Bradley River through the Bradley Dam diversion tunnel.

4.6.2 Environmental Analysis

4.6.2.1 Construction

The potential Project impacts described below are based on the preliminary design of the proposed Project. As the design is finalized and geotechnical investigations are completed at the potential borrow sites, the Project footprint would be refined and wetlands avoided to the maximum extent practicable. Thus, the potential impacts are anticipated to be less than those described below. Table 4.6-2 identifies wetlands and water types that may be impacted by construction of the proposed Project.

Table 4.6-2 Potential impacts to wetlands and waters from construction of the Bradley Lake Expansion Project.

Project Impact	Cowardin Types	Acres
Dixon Diversion dam, tunnel intake and appurtenant facilities	0.03-acre isolated pond (PUBH) and 1,673 linear feet (2.21 acres) of the East Fork Martin River (R3UBC, R3UBH, and R4SBC)	2.24
1-mile-long new access road	PEM1C, R4SBC	0.08
Dixon Diversion tunnel outlet and tunnel discharge channel	L2UBH, PUBH, R3UBH, PSS1B, PSS1C	3.50
Bradley Lake Dam (Bradley Lake)	L1UBH, L2UBH	5.47
Bradley Lake Dam (Bradley River downstream of existing dam)	R3UBH	0.67
Material sites (Borrow sites and spoils areas)	L1UBH, PEM1B, PEM1C, PEM1E, PSS1B, PUBH, R2UBH, R3UBH, R3UBJ	0.35
Staging areas (other than the one on WFUBC Rd)	N/A	0
Total Potential Wetland Impact		**10.07**
Total Potential Waters Impact		**2.21**

4.6.2.1.1 Martin River Watershed

The Dixon diversion structure, tunnel intake, and appurtenant facilities would lie within the Martin River watershed near the Dixon Glacier terminus at the headwaters of the EFMR. A 0.03-acre isolated pond (PUBH) would be filled, and 1,673 linear feet (2.21 acres) of the EFMR (R3UBC, R3UBH, and R4SBC) would have a structure and fill material placed across the two channels. Associated material sites (borrow sites, staging areas, and/or spoils area) would also be located in this area within the Project footprint. Access to the site would be via helicopter.

4.6.2.1.2 Bradley Lake and River Watershed

The potential impact area within the Bradley Lake and River watershed consists of placing fill material in wetlands and waters to construct the following:

- 1-mile-long new access road
- Dixon Diversion tunnel outlet and discharge channel to Bradley Lake
- Bradley Lake Dam and spillway modifications
- Material sites (potential borrow sites and spoils areas)
- Existing staging sites

A 1-mile-long new access road would be constructed from the existing road to the tunnel outlet. Approximately 0.08 acres of wetlands would be filled during construction of the access road. Culverts would be placed at streams and drainageways to maintain hydrologic connectivity. Portions of the access road would be constructed on top of spoils from the tunnel and other areas.

The tunnel outlet and discharge channel to Bradley Lake would be constructed on top of spoils from the tunnel and other areas. Approximately 3.5 acres of wetlands would be filled during construction of the tunnel and discharge channel.

To support modifications to the Bradley Lake Dam and spillway, riprap and other fill material would be placed in approximately 5.47 acres of Bradley Lake and in approximately 460 linear feet of the Bradley River.

Material sites would be developed to construct the access road and dam raise. The material sites are predominantly in uplands. Approximately 0.35 acres of wetlands would be excavated through material site development.

Existing developed sites would be used for staging areas for equipment and infrastructure. The staging areas would not be expanded into wetlands, avoiding all wetlands adjacent to the existing staging areas.

Fugitive dust would have an indirect effect on wetlands during construction with construction traffic along the existing road, blasting, and other construction activities. Construction equipment and vehicles driving up the access road during construction of the tunnel outlet, dam and spillway modifications, material sites, and staging areas would create dust that has the potential to coat wetland vegetation, decrease wetland water quality, and increase sedimentation.

4.6.2.1.3 Battle Creek Watershed

The proposed Lower Battle Creek (LBC) construction camp pad area and one of the borrow sites lie within the Battle Creek watershed adjacent to the existing road between the powerhouse and Bradley Lake Dam. This area was previously used as a construction camp site and borrow area for construction of the original Bradley Lake Project and the WFUBC Diversion. Approximately 1.27 acres of wetlands (PEM1B, PEM1C, PEM1E, PSS1B) and waters (R2UBH) were identified along the northern border of this area (DOWL 2026) all of which would be avoided during construction. An existing developed staging area along the WFUBC Diversion road (Staging Area 3) may be used for temporary staging during construction if needed. The 0.07 acres of wetlands (PSS1/EMC1) and waters (PUBC) identified within this potential staging area during surveys (DOWL 2026) would be avoided and not impacted by the proposed Project.

4.6.2.2 Operations

Potential impacts by fill placement in wetlands and waters during construction would be permanent. Final stabilization would be reached once construction is complete. No sedimentation or disturbance to wetlands is anticipated to occur after construction.

4.6.2.2.1 Martin River

The diversion structure would be operated from approximately mid-May through October or November, diverting up to the tunnel capacity of 1,650 cfs to Bradley Lake while maintaining minimum stream flows of 100 cfs to the EFMR. Excess flow greater than the 1,650-cfs capacity of the tunnel would spill over the diversion dam to the EFMR canyon. Depending on operations and flows, the diversion dam could potentially store up to 37 acre-feet of water covering a surface area of 3.5 acres during operations.

AEA also proposes to release channel forming flows to the EFMR of 1,000 cfs for a duration of 12 hours a minimum of 3 years out of each moving 10-year average period. It is also anticipated that sediment management release flows to the Martin River would be required as needed to flush any accumulated bedload buildup from behind the diversion dam. The forebay pool would need to be flushed of sediment on at least an annual basis, possibly multiple times per year. Proposed sediment flush operations are to quickly drop one or more of the crest gates at the diversion dam for 1 hour, then raise the gate(s) and visually assess the success of the flush. These channel forming flows and Dixon Diversion sediment management flows would periodically deliver accumulated sediment and bedload to the Martin River.

As a result of Project operations, the total volume of coarse-grained sediment supplied to the Martin River would be similar to current conditions, but the timing of sediment supply would be altered (Section 4.2 Geology). Martin River flow and bedload transport potential would be reduced because of Project operations. Due to uncertainty around the exact amount and timing of sediment flushes and exact flows to transport bed material through the Martin River, it is recommended to monitor sediment accumulations and grain size in the Martin River to assess the actual effects of the proposed flow regime and the ability to maintain a passage corridor for aquatic species.

4.6.2.2.2 Bradley Lake

In addition, to the increased volume of water diverted to Bradley Lake, modifications at the dam would raise the normal maximum pool elevation by 16 feet. Currently, Bradley Lake water surface elevations fluctuate from 1,080 feet El. to 1,180 feet El. With the proposed Project, the maximum normal pool would be 1,196 feet El. Lake levels would fluctuate seasonally similarly to current conditions. Reservoir elevations would continue to be highest during the fall months and lowest during the spring months prior to snow and glacier melt. There are approximately 83.9 acres of wetlands and waters around Bradley Lake between elevations 1,180 and 1,196 feet. Existing wetlands and waters in this inundation zone would be flooded, altering hydrologic regimes and creating wetter conditions. Complete inundation of this area would result in the creation of 142.96 acres of WOTUS and a change in Cowardin classification of the 83.9 acres of existing wetlands to waters. The created waters would be in the Upper Bradley River and Kachemak Creek drainages as well as along the steep shoreline of Bradley Lake.

4.6.2.2.3 Bradley River

There are no proposed changes to the current Bradley River MIFs or operations related to spill. Bradley River instream flow would fluctuate seasonally similarly to current conditions.

4.6.3 Applicant-Proposed Measures

BMPs will be used to minimize construction impacts and to ensure compliance with both the CWA and the National Pollutant Discharge Elimination System. BMPs will be outlined in a Storm Water Pollution and Prevention Plan implemented by the construction contractor. USACE Individual Permit stipulations would be identified during the Section 404 Permitting process but may include the following:

1. The permittee shall install erosion control measures along the perimeter of all work areas to prevent the displacement of fill material outside the authorized work area. The erosion control measures shall remain in place and be maintained until all authorized work is completed and the work areas are stabilized. Immediately after completion of the final grading of the land surface, all slopes, land surfaces, and filled areas shall be stabilized using sod, degradable mats, barriers, or a combination of similar stabilizing materials to prevent erosion.
2. The permittee shall use only clean fill material for this project. The fill material shall be free from items such as trash, debris, automotive parts, asphalt, construction materials, concrete blocks with exposed reinforcement bars, and soils contaminated with any toxic substance, in toxic amounts in accordance with Section 307 of the CWA.
3. No stockpiling of fill materials shall occur in wetlands or other WOTUS that do not have USACE authorization.
4. Natural drainage patterns shall be maintained using appropriate ditching, culverts, storm drain systems, and other measures to ensure hydrology is not altered.

4.6.4 References

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4.7 Rare, Threatened, and Endangered Species

4.7.1 Affected Environment

4.7.1.1 Federally Listed Species

The ESA (73 FR 63667 63667-63668) provides a program for the conservation of threatened and endangered plants and animals and their habitats. USFWS and NMFS are the lead federal agencies that implement the ESA. The law requires federal agencies, in consultation with USFWS (terrestrial and freshwater species) or NMFS (marine and anadromous species) to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law also prohibits any action that causes "taking" of any listed species of endangered fish or wildlife. Additionally, marine mammals are protected under the MMPA, which prohibits the hunting, capture, killing, or harassing of marine mammals, with limited exceptions.

For purposes of evaluating potential effects of the proposed Project on ESA-listed species, AEA considered the Project area, Kachemak Bay and Cook Inlet between Homer and Anchorage. Three ESA-listed species managed by USFWS could occur within this area: the northern sea otter (*Enhydra lutris kenyoni*; Southwest Alaska DPS), Short-tailed Albatross (*Phoebastria albatrus*), and Steller's Eider (*Polysticta stelleri*) (Table 4.7-1; USFWS 2025a). Five ESA-listed species and/or DPSs managed by NMFS also could occur within this area: the beluga whale (*Delphinapterus leucas*; Cook Inlet DPS), the fin whale (*Balaenoptera physalus*), the humpback whale (*Megaptera novaeangliae*; Mexico DPS), the leatherback sea turtle (*Dermochelys coriacea*), and the Steller sea lion (*Eumetopias jubatus*) (Table 4.7-1; NOAA 2025a).

Table 4.7-1 ESA-listed species that may occur within the Project vicinity, including Cook Inlet.

Common Name	Species Name	Federal Protection Status	Year of Listing
Fin whale	*Balaenoptera physalus*	E	1970
Beluga whale (Cook Inlet DPS)	*Delphinapterus leucas*	E	2008
Leatherback sea turtle	*Dermochelys coriacea*	E	1970
Northern sea otter (Southwest Alaska DPS)	*Enhydra lutris kenyoni*	T	2005
Steller sea lion (Western DPS)	*Eumetopias jubatus*	E	1990
Humpback whale (Mexico DPS)	*Megaptera novaeangliae*	E	1970
Short-tailed Albatross[a]	*Phoebastria albatrus*	E	2000
Steller's Eider	*Polysticta stelleri*	T	1997

Source: ADF&G (2025a); NOAA (2025a); USFWS (2025a).
E=Endangered; T=Threatened
[a] Alaska State Endangered Species

4.7.1.1.1 Beluga Whale (Cook Inlet DPS)

The Cook Inlet beluga whale was listed as endangered under the ESA in 2008 (50 CFR Part 224; 73 FR 62919, October 31, 2008). There are five beluga whale (beluga) stocks found in Alaska. The Cook Inlet beluga stock[9] is geographically isolated from the other Alaskan stocks. It is also the smallest of the five stocks and the only stock listed under the ESA. Cook Inlet stock belugas (CI belugas) generally occupy the upper portion of Cook Inlet during ice-free months. During these warmer months, they are more often found in shallow coastal waters and gather in areas near river mouths where there are ample supplies of fish (NOAA 2025b, 2025c). This is also the period when breeding and calving occurs. Starting in late fall, when ice begins to form in the upper inlet and when anadromous fish runs end, CI belugas begin to separate into smaller groups; during this time, some groups of CI belugas migrate south into the deeper waters of the mid and lower portions of the waters of Cook Inlet (NOAA 2025b). The CI belugas that migrate into the mid and lower portions of the inlet will generally remain there all winter until the ice melts in the upper portion of the inlet. While the timing of their migrations within the inlet varies, migrations appear to be dependent on environmental factors such as ice formation and the timing of fish runs (NOAA 2025b).

Critical habitat was designated in 2011 (76 FR 20180, April 8, 2011) and encompasses waters in Cook Inlet, Kachemak Bay, and portions of associated tributaries and inlets (NOAA 2022a). Kachemak Bay is designated as Critical Habitat Area 2 for CI beluga whales. Area 2 critical habitat has a lower concentration of beluga whales in spring and summer but is used by beluga whales in fall and winter. However, Kachemak Bay is surveyed every other year during NOAA's beluga population surveys in June, and CI belugas have not been observed in Kachemak Bay since 1994 (personal communication between Kim Goetz, NOAA, and Rebecca McGuire, ABR, January 20, 2026).

Threats to beluga whales, in general, include pollution (from chemicals and trash), shipping, offshore development, commercial fishing, extreme weather events, strandings, predation from killer whales and polar bears, ocean noise, and subsistence harvest (NOAA 2025c). For the CI beluga whale population, many of the human-induced threats such as shipping and ocean noise are exacerbated due to their proximity to Anchorage, which is the most densely populated area of Alaska (NOAA 2025b).

[9] Classified under the ESA as the "Cook Inlet DPS."

4.7.1.1.2 Fin Whale

The fin whale was decimated by commercial whaling in the 1800s and early 1900s. It was listed as an endangered species under the Endangered Species Conservation Act (ESCA) in 1970 (35 FR 8491, June 2, 1970, baleen whales listing; and 35 FR 18319, December 2, 1970, fin whale listing) and continues to be listed as endangered species following passage of the ESA. Critical habitat has not been designated for fin whales. There are no reliable estimates of current and historical abundances for fin whales, and there continue to be uncertainties in their population structure (Muto et al. 2021).

Fin whales are found in polar, temperate, and subtropical waters worldwide. Within U.S. waters in the Pacific, they are found seasonally off the coast of North America and Hawaii and in the Bering Sea during the summer (ADF&G 2008). The population structure is not well understood for fin whales in the North Pacific, but for management purposes they have been divided into three stocks: Alaska (North Pacific), California/Oregon/Washington, and Hawaii. In Alaska, fin whales are found as far north as the western Chukchi Sea, the Bering Sea, and throughout the Gulf of Alaska (ADF&G 2008). Fin whales are migratory. In general, the spring and early summer are spent in cold, high latitude feeding waters. In the fall, populations tend to return to low latitudes for the winter breeding season; however, they may remain in residence in their high latitude ranges if food resources remain plentiful. In the eastern Pacific, fin whales typically spend the winter off the central California coast and into the Gulf of Alaska. In summer, they migrate as far north as the Chukchi Sea to their summer feeding grounds in the Gulf of Alaska, Prince William Sound along the Aleutian Islands, and west of Kodiak Island (ADF&G 2008). The major threats to fin whales are vessel strikes, entanglement in fishing gear, ocean noise, and the impacts of climate change (NOAA 2024).

4.7.1.1.3 Humpback Whale (Mexico DPS)

The humpback whale was listed as endangered under the ESA in 1970 (35 FR 8491, June 2, 1970, baleen whales listing and 35 FR 18319, December 2, 1970, humpback whale listing), and humpback whales continued to be listed as endangered under the ESA (1973). NMFS conducted a global status review that led to changing the status of humpback whales under the ESA and dividing the species into 14 DPSs (81 FR 62259, September 8, 2016). Of these 14 DPSs, NMFS listed four as endangered and one as threatened, and NMFS delisted the remaining nine. Three humpback whale DPSs occur in waters of Alaska:

the Western North Pacific DPS is listed as endangered; the Mexico DPS is listed as threatened; and the Hawaii DPS is not listed (81 FR 62259, September 8, 2016).

The humpback whale is a migratory species, spending its summers in temperate and subpolar waters but mating and calving in tropical and subtropical waters closer to the equator. The threatened Mexico DPS is the only ESA-listed DPS that could be encountered off the coast of Southcentral Alaska (NMFS 2021). These whales winter off the coast of Mexico and the Revillagigedo Archipelago and summer primarily in Alaska waters, from Southeast Alaska and the Gulf of Alaska to the Aleutian Islands and Bering Sea (Young et al. 2023).

Humpbacks may be seen at any time of year in Alaska, but most animals winter in temperate or tropical waters near Mexico, Hawaii, and in the western Pacific near Japan (ADF&G 2015). In the spring, the animals migrate back to Alaska where food is abundant and tend to concentrate in several areas including Southeast Alaska, Prince William Sound, Kodiak, the Barren Islands at the mouth of Cook Inlet, and along the Aleutian Islands. The major threats to humpback whales include vessel strikes and vessel-based harassment, the impacts of climate change, and entanglement in fishing gear (IWC 2025).

4.7.1.1.4 Northern Sea Otter (Southwest Alaska DPS)

There are three stocks of sea otters identified in Alaska, two of which occur within the Cook Inlet area: Southcentral and Southwest. The Southwest Alaska stock of northern sea otter was listed as threatened under the ESA in 2005 (70 FR 46367, August 9, 2005). In addition to protection under the ESA, northern sea otters also receive protection under the MMPA. The Southwest Alaska stock inhabits coastal areas from the western edge of Cook Inlet out to the Aleutian Islands. Although northern sea otters breed throughout the year, most pups in Alaska are born in late spring. Sea otters spend most of their lives in water but occasionally go on land to rest. Sea otters reside in mostly coastal waters, which they use for foraging; however, they have been known to dive to depths up to 250 feet (ADF&G 2025b). Critical habitat was designated for the Southwest Alaska DPS in 2009 (74 FR 51988, October 8, 2009) and includes the western coast of Cook Inlet and the coastal areas around Kodiak Island, which is within the vicinity of the Project impact area (USFWS 2025c). Major threats to northern sea otters include predation, overharvest, fishery interactions, disease, and oil spills (ADF&G 2025b).

4.7.1.1.5 Leatherback Sea Turtle

Leatherback sea turtles were listed as endangered in 1970 (35 FR 5961, June 2, 1970). Leatherbacks are the most wide-ranging sea turtle species, found throughout temperate to tropical waters worldwide. They can tolerate much colder temperatures than other species due to counter-current exchange, high oil content, and large body size. Leatherback sea turtles are a highly pelagic species; they spend most of their time in the open ocean, but they are known to forage in coastal waters. Females come ashore every 2-3 years to nest on tropical beaches, preferring beaches backed by vegetation near deep water and rough seas. Leatherbacks rarely occur within Alaska, where their range extends along the southern coast of Alaska, including Cook Inlet and Kachemak Bay. Nineteen leatherbacks have been reported in Alaska between 1960 and 2007 (ADF&G 2025c). NMFS revised and expanded the designated critical habitat to provide protection for endangered leatherback sea turtles along the U.S. West Coast in 2012 (77 FR 4170, January 26, 2012); however, there is no designated critical habitat in Alaska (NOAA 2022b). Ongoing long-term harvest and bycatch are the greatest threat to the species. Other threats include vessel strikes, loss of habitat, and pollution (ADF&G 2025c).

4.7.1.1.6 Short-tailed Albatross

The Short-tailed Albatross was listed as endangered in 2000 (65 FR 46643, 31 July 2000). It is a large, long-lived fish- and squid-eating seabird that travels widely across the North Pacific and spends most of its time over the open ocean. In Alaska, Short-tailed Albatross are most often found in association with the Bering Sea and Gulf of Alaska continental shelf edge (Piatt et al. 2006) but could potentially occur in the Project area (USFWS 2025a). This species is widely distributed across its historical range, with an estimated population of 1,200 birds, 600 of which are of breeding age. Currently, most of the world’s breeding nests are on Torishima Island, Japan. Nesting sites are typically on steep sites on soils with loose volcanic ash, usually with grasses that stabilize the soils and provide nesting materials. Short-tailed Albatross breed on remote islands of the Pacific, and the only known nesting in the U.S. is on Midway Atoll in Hawaii (USFWS 2025b). However, the marine range of Short-tailed Albatross extends into the open ocean of the Gulf of Alaska, Aleutian Islands, and the North Pacific Ocean (Carboneras 2020), where they feed along the shelf, from 0 to 200 meters (0 to 219 yards) in depth, and in shelf break areas (USFWS 2008). Juveniles and younger sub-adults (up to 2 years old) use the wider geographic range that encompasses Alaska compared to adults (O’Connor et al. 2013). Major threats to the Short-tailed Albatross are habitat loss, entanglement in fishing gear, and pollution (USFWS 2025b).

4.7.1.1.7 Steller's Eider

The Alaska-breeding population of Steller's Eider was listed as threatened under the ESA in 1997 (62 FR 31748, June 11, 1997). It is the least abundant eider in Alaska. Critical habitat for the Alaska breeding population of Steller's Eider was designated in 2001 (66 FR 8850, February 2, 2001) and is divided into the following five units in the marine waters of southwestern Alaska and on the north side of the Alaska Peninsula: Yukon-Kuskokwim Delta (historical breeding area); Kuskokwim Shoal (molting and staging area); Seal Islands (molting and staging area); Nelson Lagoon (molting, wintering, and staging area); and Izembek Lagoon (molting, wintering, and staging area). None of these critical habitat units occur in the Project area (USFWS 2025d).

Virtually all Steller's Eiders nest in northeastern Siberia, while a very small portion of the population (less than 1 percent) breeds in North America. Within Alaska, Steller's Eiders are known to breed along the Arctic Coastal Plain of northern Alaska and along the Yukon-Kuskokwim Delta in western Alaska. Breeding occurs generally in the summer months from May to September. Their preferred nesting areas are on islands or peninsulas, as well as tundra lakes and ponds near the coast. Around September, Steller's Eiders will migrate into wintering areas in the eastern Aleutian Islands, along the Alaska Peninsula, and in Cook Inlet, Kachemak Bay, and Kodiak Island (ADF&G 2025d). Threats to Steller's Eider include predation, lead poisoning, exposure to contaminants, and long-term or cyclical changes in their marine habitat (ADF&G 2025d).

4.7.1.1.8 Steller Sea Lion (Western DPS)

Steller sea lions were listed as threatened in 1990 (55 FR 29792, April 5, 1990). In 1997, NOAA fisheries recognized two distinct DPSs, and the western DPS was elevated to endangered (62 FR 24345, May 5, 1997). The western DPS includes all Steller sea lions originating from rookeries west of Cape Suckling, which includes the Project area. Steller sea lions utilize aquatic and terrestrial habitats. They are generalist marine predators, and their foraging trips are usually within a few tens of miles from the shore (although they have been observed foraging as far as 550 miles from the shore). They mate and give birth on land at traditional rookery sites, with certain individuals returning to the same rookeries annually. Sea lions also use beach habitat for "haulouts", which are non-breeding terrestrial spots where seals exit from the water to rest (ADF&G 2025e). NMFS has mapped locations of monitored rookery and haulout sites in Alaska. These locations include haulout sites on the eastern and western shores of the southern portion of Cook Inlet (NOAA 2022c). Original critical habitat was designated in 1993 (58 FR 45268, August 27, 1993) and later revised in 2010 (75 FR 13127, March 22, 2010), and it includes portions of the southern Cook Inlet as well as portions of inlets within southern Kachemak Bay (NOAA 2025d). Possible threats to Steller sea lions include the "top-down" sources such as predation, disturbance, and intentional killing and entanglements, and "bottom-up" sources, such as reduced prey quality or abundance and long-term shifts in their environment (ADF&G 2025e).

4.7.1.2 State Listed Species

ADF&G is responsible for determining and maintaining a list of endangered species in Alaska under AS 16.20.190. A species or subspecies of fish or wildlife is considered endangered when the Commissioner of ADF&G determines that its numbers have decreased to such an extent as to indicate that its continued existence is threatened. Of the five current state-listed species, only one, the Short-tailed Albatross, may occur within the areas potentially affected by the construction of the Dixon Diversion (ADF&G 2025a).

4.7.2 Environmental Analysis

4.7.2.1 Construction

All the ESA-listed species potentially occurring in the Project vicinity use marine habitats and do not occur in the area of the proposed construction footprint. The limited number of additional barge trips to transport equipment and supplies during construction are not anticipated to have any effect on these species, and changes in operations associated with the proposed amendment would not affect these species.

During the anticipated 3-4 years of construction, there would be additional barge movements in Kachemak Bay between Homer and the Bradley Lake Project dock and potentially in Cook Inlet between Anchorage and Homer and the Bradley Lake Project dock to deliver construction equipment and supplies for the proposed facilities. Additional barge movement across Kachemak Bay would occur between April and October during extreme high tides that occur about 3–4 days per month. It is anticipated that there would be ten or less barge trips during mobilization and demobilization annually.

It is unlikely that the Short-tailed Albatross, Steller's Eider, or any of the ESA-listed marine mammal species would be impacted by the increased barge traffic in Kachemak Bay during construction. The Short-tailed Albatross is unlikely to occur within the Project area because it spends a vast majority of its time in offshore marine environments (ADF&G 2025f) and is currently known to nest only on islands in the tropical Pacific Ocean (Carboneras 2020, USFWS 2025b). Steller's Eiders occur in nearshore waters in western Cook Inlet during the wintering/nonbreeding season (typically late November through mid-April) and almost exclusively in the lower inlet (PLP 2011). The species also occurs in winter in lower Kachemak Bay (Erickson and West 1992, ADF&G 1993) but is unlikely to regularly use the shallow, turbid marine waters in the upper bay. For these reasons, Steller's Eiders are unlikely to occur in the vicinity of the Project during the construction phase of the Project from April to October.

There are no significant haulouts or rookeries within Kachemak Bay or in upper Cook Inlet used by Steller sea lions. Leatherback sea turtles are very rare, and it is unlikely that one would be present in Kachemak Bay during barge delivery of materials. Fin whales and humpback whales may be present in Cook Inlet but are not commonly seen in the shallow waters of Kachemak Bay.

If Project-related barge traffic moves through Cook Inlet to the Port of Alaska in Anchorage before transiting to Homer, barges may occur in the vicinity of northern sea otter critical habitat. Northern sea otter critical habitat includes the western coastal waters of Cook Inlet (USFWS 2025c). However, barge traffic in Cook Inlet would occur in designated shipping lanes in deeper waters away from the shoreline and nearshore waters where sea otters are most common, making it unlikely that barges would come into contact with northern sea otters in Cook Inlet. Sea otters normally feed in waters less than 200 feet deep, and prefer shallow, rocky-bottom habitat broken by reefs and islets (ADF&G 1993). If sea otters are present when barges transit the shallow waters of upper Kachemak Bay to approach the Project dock, they should easily be able to avoid harm and move away from a slow-moving barge.

Kachemak Bay and the upper and western portions of Cook Inlet are designated CI beluga critical habitat (76 FR 20180). Kachemak Bay is included within the designated Critical Habitat Area 2 for CI beluga whales. Area 2 critical habitat has a lower concentration of beluga whales in spring and summer but is used by beluga whales in fall and winter. In the warmer, ice-free months, when Project-related barge traffic would occur, CI belugas are most likely to be found in upper Cook Inlet in shallow coastal waters and near the mouths of salmon streams, and not in Kachemak Bay (NOAA 1995, NOAA 2025e). CI belugas have not been observed in Kachemak Bay during bi-annual NOAA surveys conducted during June since 1994 (personal communication between Kim Goetz, NOAA, and Rebecca McGuire, ABR, January 20, 2026). Additionally, except when approaching docking areas, barge traffic would occur in the deeper water of designated shipping lanes in Cook Inlet and in deeper water in Kachemak Bay, away from the mouths of salmon streams. For these reasons and because the number of anticipated Project barge trips (up to ten during mobilization and demobilization) would be limited to the 3–4 day extreme high tide period during the construction season (April through October), the possibility of barges encountering CI beluga would be low.

4.7.2.2 Operations

The modification of flows from the Dixon Glacier, Martin River, Bradley River, and Bradley Lake is not expected to affect any of the ESA-listed species. The Dixon Diversion would divert water from the Dixon Glacier to the Bradley Lake reservoir May through November as flows allow after meeting EDFMR MIF requirements. The increased water level as a result of the Bradley Lake Pool Raise is not expected to affect any of these species. During the anticipated 3-4 years of construction, there would be additional barge movement in Kachemak Bay and Cook Inlet to deliver construction supplies for the proposed diversion. The barge movements would occur between April and October and are generally expected to cease once construction is complete and operations begin. Infrequent barge trips to the project already occur to support normal operations and are not expected to change in frequency post-construction.

4.7.3 Applicant-Proposed Measures

AEA has concluded that the Project would have no effect on federally-listed threatened and endangered species. As such, no environmental measures are proposed that specifically address species listed under the ESA.

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4.8 Recreation, Land Use, and Aesthetics

4.8.1 Affected Environment

4.8.1.1 Recreation

The recreation sites associated with the Bradley Lake Project consist of six scattered campsites located along the road from near the barge basin dock up to Bradley Lake (Figure 4.8-1); these sites are only accessible by boat or air and are managed by Bradley

Lake Project personnel. Heavy recreational use within the area is not common due to the remote location and rugged terrain of the Bradley Lake Expansion Project vicinity, as well as the extensive recreational opportunities that are available in closer proximity to nearby population centers. Due to the limited potential for recreational opportunities in the Bradley Lake Project area, FERC exempted AEA from Form 80 recreation use reporting on January 27, 2004.[10] AEA annually requests a FERC exemption from preparing an Emergency Action Plan (EAP) due to little public use downstream of the Bradley Lake Project. In AEA's EAP exemption request letters, the visitor log from the tidewater dock is included.

As this location is the primary visitor access point for the Bradley Lake Project area,[11] the visitor log provides insights into the frequency and types of recreation activities occurring near the Project area. There were 12 recreational groups of varying sizes recorded as having visited in 2022 and 2024, which were the highest recorded recreation years in the past 6 years (Table 4.8-1). The other years ranged from two to four recreational groups per year. Most recreational visits occurred between June and October, with some visits documented as early as April and as late as early November. Group sizes ranged from one to six people, and activities included camping, biking, fishing, kayaking, and hunting for goats and bears (Table 4.8-1). While this visitor log provides insights into recreation in the general area, recreation is not anticipated to occur near the Dixion Diversion dam. The surrounding steep and rugged terrain would make access very difficult on foot and aircraft is prohibited from landing in the nearby Kenai National Wildlife Area.

[10] Accession Number 20040130-0022
[11] Accession Number 20241211-5265

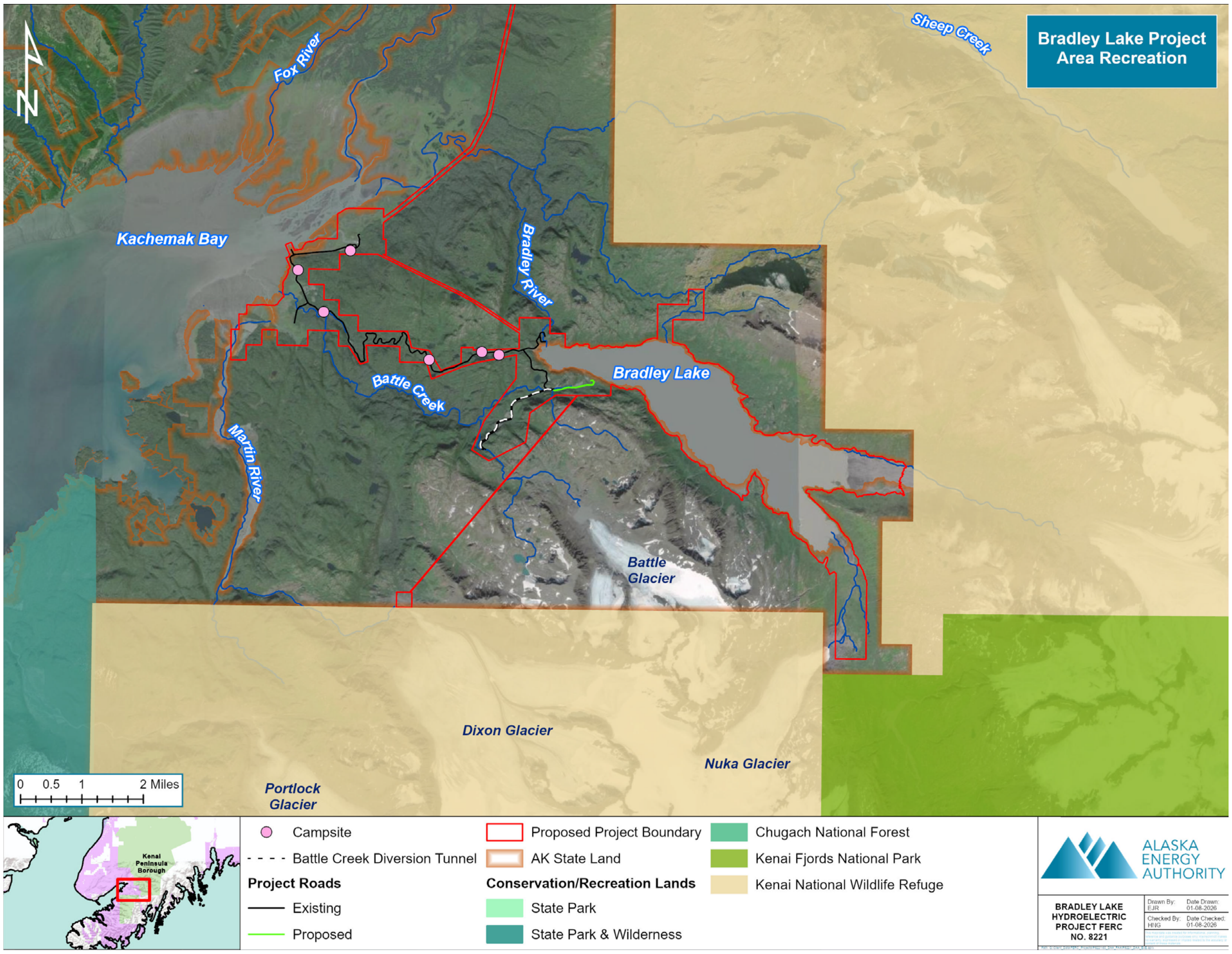

Figure 4.8-1 Recreation access at and near the Bradley Lake Project.

Table 4.8-1 Visitor log details from 2018 to 2024.

Date	No. of Recreationalists[a]	Noted Activity[a]
6/12/2018	1	Unknown
9/26/2018	1	Unknown
10/12/2018	1	Unknown
10/13/2018	1	Unknown
7/8/2019	1	Kayaking and camping
9/22/2019	1	Unknown
9/30/2019	1	Unknown
11/2/2021	2	Bear hunt
6/10/2022	2	Bike trip and camp
6/21/2022	1	Unknown
6/24/2022	2	2-day bear hunt
6/28/2022	2	2-day bike and camping trip

Date	No. of Recreationalists[a]	Noted Activity[a]
9/10/2022	3	Bike and fish
9/11/2022	Unknown	Ducks
9/11/2022	2	5-day goat hunt
9/12/2022	1	Hunting
9/21/2022	3	5-day camping trip
9/24/2022	2	Weeklong goat hunt and biking with dog
10/8/2022	2	Goat hunting
10/23/2022	2	Bike trip
9/3/2023	2	Hunting
9/11/2023	Unknown	Ducks
4/13/2024	2	Unknown
5/16/2024	2	Unknown
July 2024[b]	1	Unknown
7/18/2024	2	Camping trip
8/13/2024	6	Unknown
8/31/2024	1	5-day camping trip
9/17/2024	2	Weeklong camping trip
10/1/2024	4	Biking, noted the goats and bears
10/5/2024	1	2-day bear hunt
10/9/2024	2	Unknown
10/10/2024	2	Unknown
10/10/2024	2	Bradley Lake for goats and bears

Note: On September 11, 2024, three members of ADF&G were on site with a focus on goats; this is not noted in the table because it is not a true recreational visit.

[a] "Unknown" either means the number of individuals in the party were not specified, or the purposes for the trip were not noted or illegible.

[b] No exact date was provided for the trip

4.8.1.2 Land Use

The Bradley Lake Project is located on state-owned lands on the Kenai Peninsula within the Kenai Peninsula Borough. Land use within this area is managed according to the Kenai Area Plan (ADNR 2000). The Bradley Lake Expansion Project is located within Region 8 of the Kenai Area, which encompasses the upper Kachemak Bay and the drainages flowing into it, including the Bradley and Martin rivers (ADNR 2000). Region 8 is further divided into four distinct areas: 1) the Fox River Flats; 2) mostly state lands surrounding Caribou Lake and the Fox Creek drainage; 3) the Bradley Lake Project; and 4) tidelands. The region is enveloped by the Kenai National Wildlife Refuge on the north, east, and south. The Kenai Fjords National Park lies to the east of the refuge, and Kachemak Bay State Park is on the southwest (Figure 4.8-2). A portion of the Kachemak Bay Critical Habitat Area (CHA) and all the Fox River Flats CHA are contained within Region 8 and Kachemak Bay is also a National Estuarine Research Reserve (NERR) (ADNR 2000).

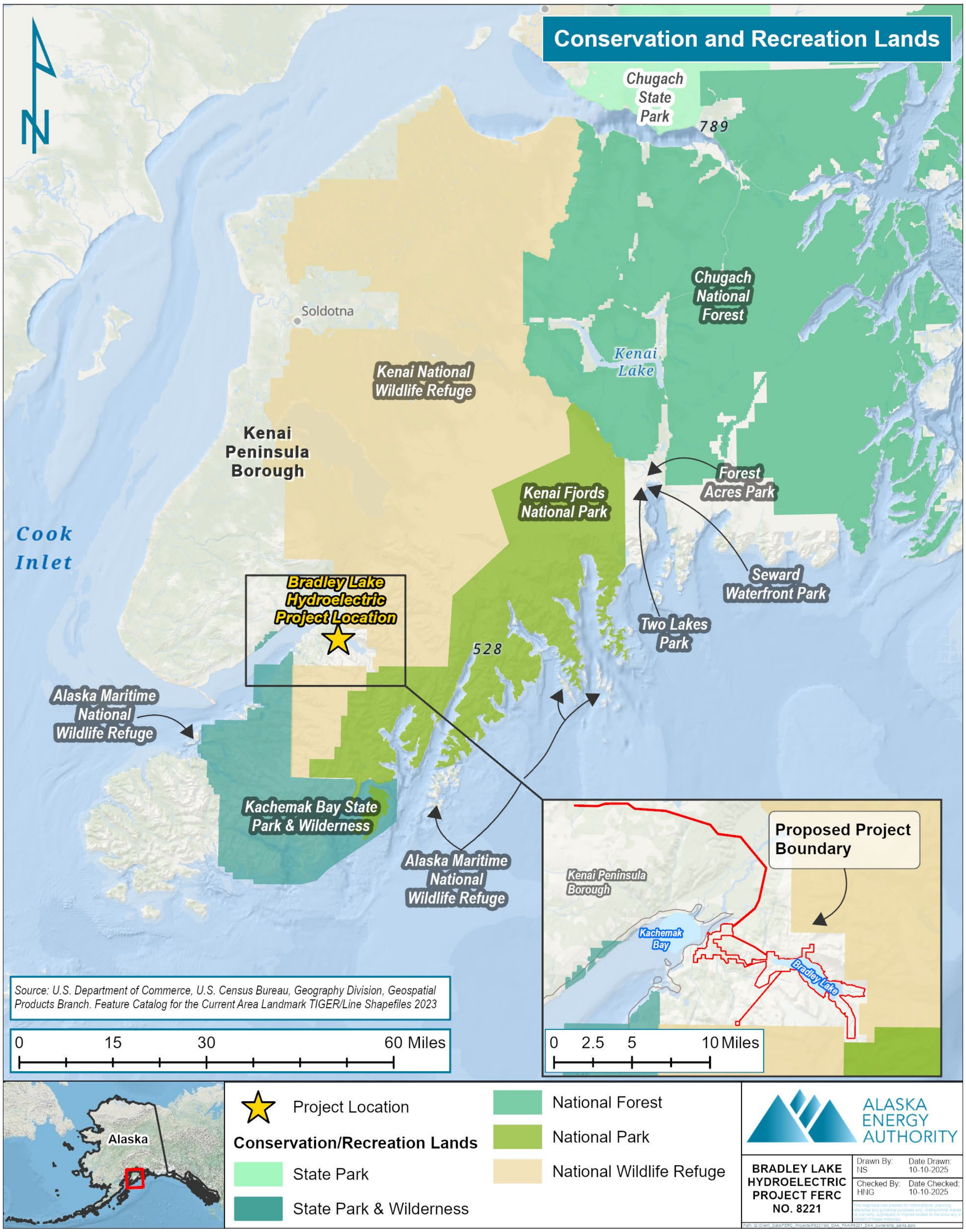

Figure 4.8-2 Land use near the Bradley Lake Project.

The CHAs of Alaska are managed through their Critical Habitat Area Management Plan, which has the goal of protecting habitats particularly crucial to the continuation of fish and wildlife, and to restrict all other uses not consistent with this purpose (ADF&G 1993). A Special Area Permit is required from the ADF&G to conduct certain activities within the CHAs, including any action likely to have a significant effect on vegetation, drainage, water quality, soil stability, fish, wildlife, or their habitats (ADF&G 1993).

The Kachemak Bay NERR boundaries encompass the Kachemak Bay and Fox River Flats CHAs. Additionally, the Kachemak Bay NERR includes the waters of Kachemak Bay east of the line connecting Bluff Point in the north with Point Pugibshi in the south, the Fox River Flats, a large portion of Kachemak Bay State Park, the Beluga Slough property in public ownership, and city-owned tidelands and marshlands along the Homer Spit. The NERR system was put into place as part of the CZMA and is managed by NOAA (Field and Walker 2003).

The Kenai National Wildlife Refuge was established in 1941 and is managed by USFWS and was previously established as the Kenai National Moose Range following moose population decline in the region due to commercial guided hunts. The mission of the Kenai National Wildlife Refuge and the National Wildlife Refuge System overall is to administer a network of lands for the conservation, management and, where appropriate, restoration of fish, wildlife, and plant resources and their habitats for future generations. In 1980, 1.35 million acres of the 1.92-million-acre Kenai National Wildlife Refuge were designated as federal wilderness under the Alaska National Interest Lands Conservation Act. The areas are managed to protect wilderness values such as healthy watersheds for spawning salmon and habitat for sensitive species (USFWS 2019). A multitude of recreational opportunities are available on the Kenai National Wildlife Refuge including camping, canoeing/kayaking, fishing, hiking, hunting and trapping, photography, and wildlife viewing. Notable attractions within the Kenai Wildlife Refuge include the Skilak Wildlife Recreation Area, Swan Lake Canoe Route, and Swanson River Canoe Route (USFWS 2012).

The Kenai Fjords National Park and Kachemak Bay State Park are both in the vicinity of the Bradley Lake Expansion Project and offer high-quality outdoor recreational access. Recreational activities within the Kenai Fjords National Park include boating, fishing, paddling, climbing, hiking, camping, and wildlife viewing (NPS 2025). The main visitor center for the park is located in the Seward small boat harbor, which is approximately 55 miles northeast of Bradley Lake. The Exit Glacier Campground has 12 walk-in tent camping areas that are used from July to August. The campground is approximately 52 miles northeast of the Bradley Lake Project (NPS 2025). The Kachemak Bay State Park is the first state park of Alaska and the only wildness park. It contains about 400,000 acres of mountains, glaciers, forest, and ocean. It is considered high-quality recreation for fishing, boating, kayaking, hiking, camping, mountain sports, and wildlife viewing. There are four trails provided in this part: the Alpine Ridge Trail, China Poot Peak Trail, Goat Rope Spur Trail, and Lagoon Trail. All trails are located southwest of the Project area. Access to this park is by boat or plane only, as there are no roads available (ADNR 2025).

The Bradley Lake Project and surrounding lands are managed as a separate unit through the Kenai Area Plan (ADNR 2000). The area surrounding the Bradley Lake Project is owned by the state as of 1962, and approximately 38,066 acres have been managed as a power-producing site consistent with FERC license requirements in addition to accommodating recreation and public access where safely feasible. The area is also managed for wildlife habitat and harvest. The Martin River and lands to the west are undeveloped. A gravel pit was developed at the mouth of the Martin River during construction of the Bradley Lake Project (ADNR 2000). No areas within the vicinity of the Bradley Lake Expansion Project are included in the National Wild and Scenic Rivers System or the National Trails System, and none have been designated for an inclusion study.

4.8.1.3 Aesthetic Resources

The most valuable aesthetic resource in the Project vicinity and area is the landscape itself. Rugged mountain terrain, glaciers, and unique coastal habitat occupy the entire Project vicinity and area. Even Bradley Lake offers aesthetic views of the waterbody with a mountainous backdrop. Photo 4.8-1 through Photo 4.8-8 display the aesthetic nature of the landscape within the Project area and vicinity.

Photo 4.8-1 View of upper Kachemak Bay.

Photo 4.8-2 Aerial view of Bradley Lake and dam.

Photo (a)

Photo (b)

Photo (c)

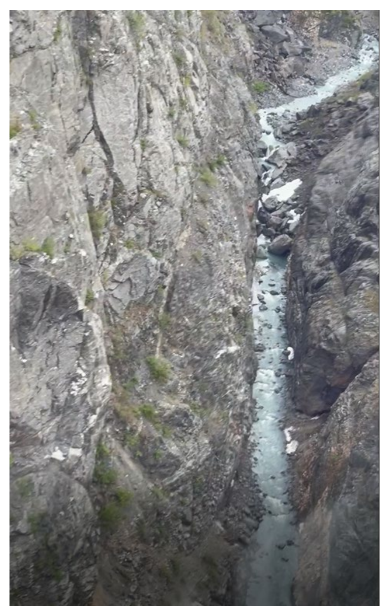

Photo (d)

Photo 4.8-3 Aerial view of the Dixon Glacier and its terminus (a and b) and the East Fork Martin River canyon (c) and (d).

Photo 4.8-4 East Fork Martin River at its mouth.

Photo 4.8-5 West Fork Martin River (Red Lake outlet) flowing north into the Martin River at its confluence with the East Fork Martin River.

Photo 4.8-6 Mainstem Martin River flowing north towards Kachemak Bay.

Photo (a)

Photo (b)

Photo (c)

Photo (d)

Photo 4.8-7 Mainstem Martin River near the its mouth at the mitigation ponds during high flows (a and b) and at the levee breach on April 19, 2024 (c) and on August 7, 2024 (d).

Photo 4.8-8 View of a side channel entering the mainstem of the Martin River.

4.8.2 Environmental Analysis

4.8.2.1 Construction

4.8.2.1.1 Recreation

Overall, there are few opportunities for recreation within the Project area, and few people visit the Project area annually; construction is not expected to have a significant impact on recreational opportunities, and any impacts would be temporary in nature. Additionally, there are numerous other locations in the region for recreationists to access if they would like to avoid the construction activities of the Bradley Lake Expansion Project. Certain areas, including the Bradley Lake road, would be off limits for public safety and construction sounds, blasting, equipment operations, and increased traffic in the area could be a temporary disturbance to an otherwise quiet and remote area. The proposed construction activities are not expected to have any long-term impacts on regional recreation.

Equipment and supplies would be transported to the Bradley Lake Project dock from Homer via barge, and construction contractors and supplies would also be transported to and from the site via aircraft. Due to the shallow nature of upper Kachemak Bay, barges would only travel and dock during extreme high tides, which occur about 3-4 days per month. The proposed Project may entail up to ten barges during the construction period (April through October), occurring during mobilization at the beginning of construction and demobilization as construction is completed. Recreationists who are kayaking and boating within Kachemak Bay or adjacent waters may interact with construction-related barge traffic, but it is unlikely to be noticeable beyond the current baseline levels of use of the area. If a barge were to observe a recreational watercraft, safety measures would be taken to ensure safe passage for the barge and recreationists.

4.8.2.1.2 Land Use

The major land use in the Project area is the Bradley Lake Project, and the land is owned by the state. AEA has consulted with the ADNR to extend the area of its current lease with the state for the Bradley Lake Project and developed the proposed FERC Project boundary to encompass the proposed Project lands. AEA would obtain the authorization to occupy and use for hydropower all lands necessary to operate the Dixon Diversion prior to construction and would construct access roads to meet the current standards set by the Bradley Lake Project licensing for roads.

With the exception of the Dixon Diversion, much of the proposed construction is located on or adjacent to lands already developed as part of the existing Bradley Lake Project. The construction camp would be located in the same area as the camp that was developed for construction of the original project and used again for the WFUBC Diversion. Existing developed areas adjacent to the existing road and dam would be used for staging. Material sites would be located along the existing roads or near Bradley Lake Dam. Portions of the proposed new access road would be built on top of spoils from construction activities. Construction of the Dixon Diversion dam and tunnel inlet would convert some land from undeveloped to developed (approximately 25.9 acres). Considering the amount of undeveloped land around the Project area, the Proposed Action is expected to have a negligible permanent impact on land use.

4.8.2.1.3 Aesthetics

As the Project is remote and the public does not often visit, aesthetic resources are not likely to be impacted. The new Project facilities would be constructed in a remote and undeveloped area. Although the proposed Dixon Diversion would add new features to the landscape, these features would be located in a remote area that is infrequently visited by the public.

4.8.2.2 Operations

The Bradley Lake Expansion Project operations would not have major impacts on recreational uses or current land management practices, and it would not substantially alter the aesthetic character of the surrounding lands. At full pool (El. 1,196 feet), the Bradley Lake Pool Raise would inundate approximately 231 additional acres of undeveloped land compared to the current normal maximum pool elevation of 1,180 feet. The impacts of increased water in the pool would either be negligible or have a positive impact on aesthetics because there would be fewer time periods of low water. The Bradley Lake Project would still pass the same amount of water as previous operations, but would be able operate at those levels for a longer period of time due to additional inflows into Bradley Lake. Additionally, public visitors to Bradley Lake are rare, and therefore impacts would be negligible.

4.8.3 Applicant-Proposed Measures

AEA is not proposing any environmental measures that specifically address recreation, land use, or aesthetic resources.

4.8.4 References

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4.9 Cultural and Tribal Resources

Information from federal, state, and local agencies, consultants, and academia were compiled to summarize cultural and historic resources within 1 mile of the proposed Project area. Previous cultural resource investigations and previously recorded cultural resources information are included in this summary.

4.9.1 Affected Environment

4.9.1.1 Cultural Context

The region of Kachemak Bay has a rich history of Indigenous and historic activities. Kachemak Bay is a part of the homelands of the Alutiq/Sugpiaq people. Indigenous people have continuously lived in the area dating back to 5,000 years before present, with sites such as the Sylva Site and the Island Creek Site radiocarbon dated to around 4,600 years ago (Kopperl 2012; Workman 1998). The Alutiq/Sugpiaq people continue to live in several communities along Kachemak Bay. Traditional practices, still practiced today, are evidenced by shell middens, tools, house floors, and other items recorded at archaeological sites in the region. Approximately 200 years ago, European explorers began directly interacting with Indigenous people in Kachemak Bay and Cook Inlet (Cook and Norris 1998). Russian traders built Fort Alexandrovsk at Nanwalek, on English Bay, in 1786, establishing a colonial presence in the region. A Russian Orthodox chapel was built, along with the founding of Fort Alexandrovsk, but the religion became fully established in the region with the founding of the mission at Kenai in 1842 (Cook and Norris 1998). With the establishment of the mission in Kenai, Russian Orthodox priests began making more regular visits to the villages on Kachemak Bay.

Coal mining in the region began in 1848 when Russian entrepreneurs established Coal Village, near Port Graham. However, the operation was completely abandoned by 1868 (Cook and Norris 1998). Coal mining in the region was revived on the north side of Kachemak Bay in later decades. The beginnings of Euro-American settlement in the city of Homer area began in the 1890s due in part to coal mining on the north side of Kachemak Bay (Klein 1996).

Gold strikes on the outer Kenai Peninsula, at Nuka Bay, encouraged both miners and traders to stake claims and establish trading posts (Hall 2008). Mineral exploration around Kachemak Bay and on the outer coast of the Kenai Peninsula began as early as 1909 (Cook and Norris 1998; Hall 2008). The first major discovery of gold was in 1918, in Nuka Bay, and by 1924, multiple outfits and companies were working in Nuka Bay. Work continued at five mines in the Kachemak Bay area until 1941, when a combination of limited returns and the beginning of World War II halted work. In the 1950s, mining resumed at a smaller scale than prior to World War II, but by 1972 most of the work had significantly decreased and mining completely ceased in Nuka Bay by 1979 (Cook and Norris 1998; Hall 2008).

During the 1970s, the benefits were evident for a hydroelectric dam on the Kenai Peninsula to provide additional power to various communities in the region. Construction of the Bradley Lake Project began in the early 1980s, and it was completed in 1986 (HEA 2024). The power plant on Kachemak Bay began producing electricity in 1991, providing power to nearby Homer and as far north as Fairbanks (HEA 2024). In 2020, the output of the Bradley Lake Project was increased by diverting the Upper West Fork of Battle Creek to add water to the lake. Bradley Lake Dam is the largest hydroelectric dam in the state of Alaska (HEA 2024).

4.9.1.2 Previous Surveys

Technical reports, memorandums, and letters generated by past cultural resources investigations and held as digital files at the AOHA through the Alaska Heritage Resources

Survey (AHRS) Portal, Document Repository and AHRS References modules were reviewed. According to the AHRS database, eight previous cultural resource investigations have been conducted within 1 mile of the Project area (Table 4.9-1). Each of the previous cultural resources field investigations were conducted in association with the existing Bradley Lake Project, five of which were conducted for the Bradley Lake Project's initial development (APA 1984; Steele 1979, 1982; Woodward-Clyde Consultants 1984; Redding-Gubitosa 1992), one for a subsequent license amendment to support the development of the Battle Creek Diversion project (HDR 2013), and two for the subsequent license amendment to support the development of the Dixon Diversion and the Bradley Lake Expansion Project (DOWL 2024, 2025).

Table 4.9-1 AHRS reported investigations within 1 mile for the Project area.

Year	Title	Results	Author
1979	Field Survey in Support of the Bradley Lake Hydroelectric Project	Negative within Bradley Lake Expansion APE	Steele
1982	Field Survey in Support of the Bradley Lake Hydroelectric Project	Negative within Bradley Lake Expansion APE	Steele
1983	Helicopter Reconnaissance in Support of the Bradley Lake Hydroelectric Project	Negative within Bradley Lake Expansion APE	APA
1983	Field Survey in Support of the Bradley Lake Hydroelectric Project	Negative within Bradley Lake Expansion APE	Woodward-Clyde
1992	United States Bureau of Land Management Examination for Cultural Resources, of Revoking Lands Withdrawn in the Bradley Lake/Upper Kachemak Bay Area	Negative within Bradley Lake Expansion APE	Redding-Gubitosa
2013	Cultural Resource Survey of the Battle Creek to Bradley Lake Diversion	Negative within Bradley Lake Expansion APE	HDR
2024	Amendment to Bradley Lake Hydroelectric Project (FERC No. 8221), Dixson Diversion Project: Cultural Resources Study Report	Negative within Bradley Lake Expansion APE	DOWL

Year	Title	Results	Author
2025	Amendment to Bradley Lake Hydroelectric Project (FERC No. 8221), Bradley Lake Expansion Project: 2025 Addendum Cultural Resources Study Report	Negative within Bradley Lake Expansion APE	DOWL

APE = Area of Potential Effect

Review of the AHRS database confirmed that there were no recorded AHRS sites within the survey area, nor were there any recorded sites within 1 mile of the survey area. The closest AHRS site was approximately 4 miles from the Area of Potential Effect (APE; Table 4.9-2). Other identified AHRS sites were 4.5 to 6 miles from the APE.

Table 4.9-2 Previously reported cultural and historic resources within 4 miles of the Project area.

AHRS Number	Site Name	Site Description	Resource Type	NRHP Status
SEL-00126	Olsen Fox Farm / Bradley Lake Fox Farm	Remains of the fox farm of Hilmer (Hjelmer) Olsen, which was in operation between 1922 and 1932	Site	Eligible

4.9.1.3 Area of Potential Effect

Consistent with 36 CFR 800.4(a)(1), AEA defined the following APE for the proposed Project: direct effects (direct APE) and indirect effects (indirect APE). The expanded 2025 APE is illustrated in Figure 4.9-1. The direct APE consists of a 50-foot buffer around the disturbance footprint of the construction area (worker camp, potential material sites, staging areas), Dixon Diversion dam and diversion tunnel inlet near the terminus of Dixon Glacier, tunnel outlet channel to Bradley Lake, 1 mile of new access road extending from the existing Upper Battle Creek diversion access road to the tunnel outlet, and the ground surface between El. 1,180 feet and 1,196 feet that would become inundated under the proposed Bradley Lake Pool Raise. To account for potential indirect effects, AEA included an indirect APE buffer of 0.25-mile from all direct APE components.

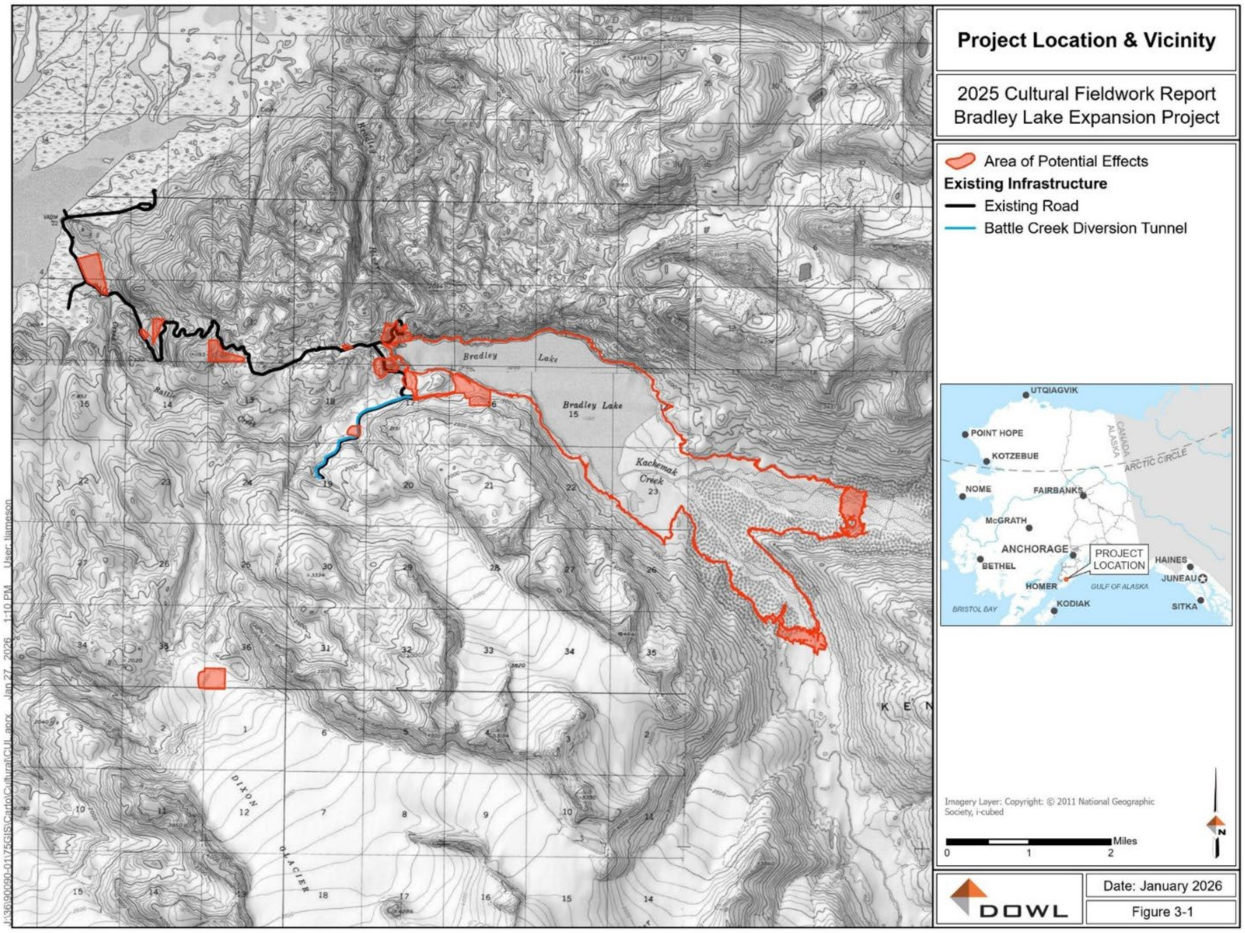

Figure 4.9-1 Project location and Area of Potential Effect.

4.9.1.4 2024 and 2025 Surveys

A pedestrian survey was completed in July and August 2024 at a spacing of approximately 33 feet (10 meters) between transects in denser vegetation areas and up to 50 feet (15 meters) between transects in areas of high visibility. Researchers identified surface artifacts, features, or landforms likely to contain or possibly containing buried cultural materials that could be investigated via the excavation of subsurface tests. The pedestrian survey area included 118.9 acres (48.1 hectares). Areas unlikely to contain cultural features or artifacts such as steep grade, deep water, or dense wetlands were avoided to focus on areas with the highest potential to hold cultural material such as knolls, level ground, and well-drained areas which are consistent with land use and cultural activity. The proposed Dixon Diversion intake portal at the foot of Dixon Glacier was not pedestrian surveyed as the area is not likely to contain cultural artifacts; as previously described, the area has been deglaciated for less than a decade. Subsurface testing methods consisted of the excavation of 50-centimeter x 50-centimeter wide subsurface test pit. The pits were excavated with hand tools on landforms identified as likely or possibly contain buried cultural deposits. All excavated sediment was screened through one-eighth-inch hardware mesh onto a tarp, and subsurface tests were excavated to bedrock, gravel, or glacial till.

Much of the APE is in steep terrain with slope grades of 60 to 90 percent, wetland areas, glacial meltwater drainages, and exposed bedrock. The only observed evidence of human use within the APE were structures associated with the Bradley Lake Project and management of Bradley Lake. A total of 12 subsurface tests were excavated across 6 testing areas in the APE, and all were negative for cultural material or features.

The same survey methods were conducted in 2025 of an additional 59.56 acres (48.1 hectares). The only observed evidence of human use within the APE was the road, staging areas, and materials sources associated with the Bradley Lake Project and management of Bradley Lake. These features are all 40 years old or younger. Four of the six proposed materials sites are in locations previously used for material procurement. The undisturbed materials sites are large rock outcrops with exposed bedrock. A total of four subsurface tests were excavated in the additional 2025 APE, and all were negative for cultural material or features.

No identified or suspected archaeological or historic materials have been identified within the proposed Project APE as indicated through desktop review of previous surveys and the pedestrian surveys in 2024 and 2025. The Project, as proposed, has been determined to result in no historic properties being affected.

4.9.2 SHPO and Tribal Consultation

AEA presented the proposed Project APE in April 2024 to the AOHA, relevant Tribes, Alaska Native Claims Settlement Act (ANCSA) corporations, and local governments, and held a follow-up meeting in June 2024 with AOHA. Table 4.9-3 includes a list of the consultation parties that are distributed information. AEA hosted a meeting for each of the consulting parties on January 30, 2025, to present the results of a cultural resources field survey completed in July and August of 2024 (further details provided in Section 4.9.4; see DOWL 2024). The Alaska SHPO responded by letter dated February 21, 2025, concurring with the defined APE – direct and indirect. Later in 2025, additional areas that may be subject to ground disturbance as part of the Project were identified, and a survey was conducted with the aim of identifying any cultural resources that could be affected in these additional areas. A report was developed that describes the 2025 survey effort and is an addendum to the original Cultural Resources Study Report (see DOWL 2025). The 2024 report and 2025 addendum were provided to AOHA and relevant Tribes and stakeholders, upon request, for a 30-day review and comment period. Additional consultation is to be discussed in the FAA.

Table 4.9-3 List of consulting parties.

Consulted Party Name	Consulting Party Type
Kenaitze Indian Tribe	Indian Tribe
Native Village of Nanwalek	Indian Tribe
Native Village of Port Graham	Indian Tribe
Ninilchik Village Tribe	Indian Tribe
Seldovia Village Tribe	Indian Tribe
Village of Salamatof	Indian Tribe
Chugach Alaska Corporation	ANCSA Regional Corporation
Cook Inlet Regional, Incorporated	ANCSA Regional Corporation
Kenai Natives Association, Incorporated	ANCSA Regional Corporation
Salamatof, Incorporated	ANCSA Regional Corporation
Chugachmiut	ANCSA Regional Non-profit
Seldovia Native Association	ANCSA Village Corporation
The English Bay Corporation	ANCSA Village Corporation
The Port Graham Corporation	ANCSA Village Corporation
State Historic Preservation Officer, Alaska Office of History and Archaeology	Regulatory Agency
City of Homer	Local Government
City of Seldovia	Local Government
Kenai Peninsula Borough	Local Government
Chugach Regional Resources Commission	Other Stakeholder
Pratt Museum and Homer Society of Natural History, Incorporated	Interested Party
Water Policy Consulting, LLC	Interested Party

4.9.3 Environmental Analysis

4.9.3.1 Construction

No historic or known potentially historic properties have been identified within 3 miles of the Project APE and much of the affected area has a low potential for the occurrence of historic properties. Should any unrecorded cultural resources be discovered during construction, AEA would consult with a qualified archaeologist and the Alaska SHPO on how to proceed.

4.9.3.2 Operations

No historic properties have been identified within 3 miles of the Project APE, and no historic properties or cultural or Tribal resources would be adversely affected by proposed operations.

4.9.4 Applicant-Proposed Measures

Article 38 of the existing license requires AEA to implement its CRMP to avoid impacts on the historic Hilmar Olsen Fox Farm site and the Jansen-Zanitowski Fox Farm site, as described in the mitigation plan filed with the Commission on November 22, 1985. Article 38 also required AEA to consult with a qualified archaeologist and the Alaska SHPO if any previously unrecorded archaeological historical sites were discovered during construction. As part of the Proposed Action, AEA would continue to implement the CRMP, including requiring the contractor to stop work and notify AEA immediately if any archeologically significant materials or sites are discovered during the work to implement the Dixon Diversion and Bradley Lake Pool Raise and to consult with a qualified archeologist and the Alaska SHPO as necessary.

4.9.5 References

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4.10 Socioeconomics

4.10.1 Affected Environment

This section provides a general description of the socioeconomic conditions per 18 CFR §5.6(d)(3)(xi) within two of the largest population centers of the Railbelt region (Anchorage and Fairbanks, Alaska), as well as the closest city to the Project (Homer, Alaska), due to a lack of development within the immediate Project vicinity.

4.10.1.1 General Land Use Patterns

The Bradley Lake Project is situated in a remote location on the Kenai Peninsula, at the northeast end of Kachemak Bay. The Bradley Lake Project provides power to the Railbelt region of Alaska, from Homer in the south to the northern city of Fairbanks, which encompasses approximately 75 percent of the state's population. There are no residences, businesses, or other development within the immediate vicinity of the Bradley Lake Project. The nearest population center to the Bradley Lake Project is Homer, Alaska, located 27 miles southwest.

Homer, Anchorage, and Fairbanks all have significantly higher population densities than the state of Alaska. Fairbanks has the highest population density, at 1,015.6 people per square mile, while Homer and Anchorage have 417.1 and 167.6 people per square mile, respectively. Though the state of Alaska covers more than 570,000 square miles, the population density averages just 1.3 people per square mile (Table 4.10-1) (Census Reporter 2023a, 2023b, 2023c, 2023d).

Table 4.10-1 Population density and housing units in Homer, Anchorage, and Fairbanks, Alaska.

	Homer	Anchorage	Fairbanks	State of Alaska
Land area (square miles)	13.8	1,707.0	31.7	571,051.6
Persons per square mile	417.1	167.6	1,015.6	1.3
Housing units (2023)	2,984	120,956	13,924	329,681

Source: Census Reporter (2023a, 2023b, 2023c, 2023d).

4.10.1.2 Population Patterns

As of 2023, the population of the city of Anchorage was 289,069, reflecting a decrease in population of 1.0 percent since 2020 (United States Census Bureau [U.S. Census] 2023a). The city of Homer had a population of 5,750, Fairbanks had a total population of 32,242, and the state of Alaska had a population of 733,971. Between 2020 and 2023, the city of Homer and the state of Alaska decreased in population by 1.4 and 0.4 percent, respectively, while Fairbanks' population grew by 2.6 percent (Table 4.10-2) (U.S. Census 2023a).

Table 4.10-2 summarizes population estimates for the cities of Homer, Anchorage, and Fairbanks and the state of Alaska, based on data from the 2010 and 2020 censuses, as well as 2023 population estimates provided by the U.S. Census.

Table 4.10-2 Population totals in Homer, Anchorage, and Fairbanks, Alaska.

City / Census Area / State	2010 Population	2020 Population	Change 2010 – 2020 (%)	2023 Population Estimates	Change 2020 – 2023 (%)
Homer	4,969	5,830	17.3	5,750	-1.4
Anchorage	284,267	292,090	2.8	289,069	-1.0
Fairbanks	31,178	31,427	0.8	32,242	2.6
State of Alaska	691,189	736,990	6.6	733,971	-0.4

Source: U.S. Census (2023a).

Table 4.10-3 presents the racial composition in the cities of Homer, Anchorage, and Fairbanks and the state of Alaska. In the city of Homer, approximately 78.9 percent of residents identify as White alone, not Hispanic or Latino; 0.3 percent as Black or African American; 6.5 percent as American Indian and Alaska Native; 1.9 percent as Asian; and 0.8 percent as Native Hawaiian and Other Pacific Islander. Additionally, 10.2 percent identify as being of two or more races; 5.9 percent as Hispanic or Latino of any race; and 1.3 percent as a race not included among the surveyed categories (U.S. Census 2023b).

In Anchorage, the racial composition is as follows: 58.3 percent identify as White alone, not Hispanic or Latino; 5.3 percent as Black or African American; 6.5 percent as American Indian and Alaska Native; 9.8 percent as Asian; and 3.1 percent as Native Hawaiian and Other Pacific Islander. Additionally, 13.1 percent identify as being of two or more races; 9.3 percent as Hispanic or Latino of any race; and 3.1 percent as a race not included among the surveyed categories (U.S. Census 2023b).

The city of Fairbanks and the state of Alaska both include a 60.7 percent White alone population, but differ as follows: in Fairbanks, 7.4 percent of the population identifies as Black or African American; 7.8 percent as American Indian and Alaska Native; 4.0 percent as Asian; and 0.7 percent as Native Hawaiian and Other Pacific Islander. Additionally, 16.1 percent identify as being of two or more races; 10.6 percent as Hispanic or Latino of any race; and 3.3 percent as a race not included among the surveyed categories (U.S. Census 2023b). In Alaska, 3.1 percent of the population identifies as Black or African American; 13.8 percent as American Indian and Alaska Native; 6.4 percent as Asian; and 1.6 percent as Native Hawaiian and Other Pacific Islander. Additionally, 12.2 percent identify as being of two or more races; 7.1 percent as Hispanic or Latino of any race; and 2.2 percent as a race not included among the surveyed categories (U.S. Census 2023b).

Overall, the racial composition of the cities of Homer, Anchorage, and Fairbanks is comparable, apart from a much lower African American population in Homer, and higher Asian and Native Hawaiian and Other Pacific Islander populations in Anchorage. Additionally, Fairbanks has a higher population of individuals identifying as two or more races, as well as Hispanic or Latino. In contrast, the state of Alaska has notably higher proportions of American Indian and Alaska Native populations (13.8 percent) compared to the three cities (U.S. Census 2023b).

Table 4.10-3 Racial composition in Homer, Anchorage, and Fairbanks, Alaska.

Race	Homer	Anchorage	Fairbanks	State of Alaska
White alone, not Hispanic or Latino	78.9%	58.3%	60.7%	60.7%
African American	0.3%	5.3%	7.4%	3.1%
American Indian and Alaska Native	6.5%	7.3%	7.8%	13.8%
Asian	1.9%	9.8%	4.0%	6.4%
Native Hawaiian and Other Pacific Islander	0.8%	3.1%	0.7%	1.6%
Two or More Races	10.2%	13.1%	16.1%	12.2%
Hispanic or Latino	5.9%	9.3%	10.6%	7.1%
Other	1.3%	3.1%	3.3%	2.2%

Source: U.S. Census (2023b).

4.10.1.3 Household/Family Distribution and Income

Household statistics for 2023, including income and poverty levels, are presented in Table 4.10-4. As shown, average household sizes within the geographic scope do not vary significantly. The average household size in the city of Homer is 2.3 persons per household, while Fairbanks averages 2.4 persons per household, and the city of

Anchorage and the state of Alaska both average 2.6 persons per household (U.S. Census 2023c).

Median and per capita household incomes in the city of Anchorage are higher than those of the cities of Homer and Fairbanks and the state of Alaska. The median household income in Anchorage is $98,152, with a per capita income of $49,338 (Table 4.10-4). In contrast, the median income for the city of Homer is $73,723, with a per capita income of $44,386. The median household income in Fairbanks is $72,077, with a per capita income of $36,392, and in the state of Alaska the median household income is $89,336, with a per capita income of $44,928 (Table 4.10-4; U.S. Census 2023d).

Table 4.10-4 Household and income statistics.

	Homer	Anchorage	Fairbanks	State of Alaska
Total Households	2,393	107,868	12,203	267,865
Average Household Size	2.3	2.6	2.4	2.6
Median Household Income	$73,723	$98,152	$72,077	$89,336
Per Capita Income	$44,386	$49,338	$36,392	$44,928
Poverty Status All People	6.9%	5.8%	5.2%	6.8%

Source: U.S. Census (2023c, 2023d).

4.10.1.4 Employment Resources in the Vicinity of the Project

Unemployment rates and labor force statistics for the cities of Homer, Fairbanks, and Anchorage and the state of Alaska are presented in Table 4.10-5. The unemployment rates for the cities of Anchorage and Fairbanks and the state of Alaska are relatively similar at 3.8 percent for each city (State of Alaska, Department of Labor and Workforce Development [ADLWD] 2025; YCharts 2025), and 4.5 percent for the state of Alaska (ADLWD 2025). The unemployment rate for the city of Homer is notably higher, at 8.8 percent (U.S. Census 2023d). The borough where Homer is located, however, has a similar unemployment rate to Anchorage, Fairbanks, and the state of Alaska at 4.8 percent (ADLWD 2025; Table 4.10-5).

Table 4.10-5 Labor force and unemployment in Homer, Anchorage, and Fairbanks, Alaska.

	Homer	Anchorage	Fairbanks	State of Alaska
Labor Force (Count)	2,863	158,566	17,601	380,935
Labor Force (%)	60.3	69.8	70.8	66.4
Unemployment Rate (%)	8.8[a]	3.8	3.8	4.5

Source: U.S. Census (2023d); YCharts (2025); ADLWD (2025).

[a] The most recent unemployment data for Homer, Alaska, is from 2023. Homer is located in the Kenai Peninsula Borough, which has an unemployment rate of 4.8 percent as of July 2025.

Occupational and industry distributions in the cities of Homer, Anchorage, and Fairbanks and the state of Alaska are presented in Table 4.10-6. The percentage of the workforce in each occupational category is similar across all three cities and the state. In all locations, the most common occupational category is management, business, science, and arts, comprising 39.8 percent of the workforce in the city of Homer, 42.7 percent in Anchorage, 33.7 percent in Fairbanks, and 39.3 percent overall in the state of Alaska (U.S. Census 2023d).

The second most common occupational categories across all geographies are sales and office, followed by service occupations, accounting for a similar percentage of the workforce in each location, and ranging from 17.5 percent to 22.7 percent (Table 4.10-6). Production, transportation, and material moving occupations account for between 11.3 and 13.2 percent of the workforce in each location, and the least common occupational category is natural resources, construction, and maintenance, accounting for 10.7 percent of the workforce in Homer, 8.3 percent in Anchorage, 8.7 percent in Fairbanks, and 11.5 percent statewide (U.S. Census 2023d).

Industry distribution is also generally consistent across the four geographies, except for a slightly higher percentage of agriculture, forestry, fishing, hunting, and mining in the city of Homer. The most common industry is educational services, and healthcare and social assistance, employing 27.3 percent of the workforce in Homer, 24.5 and 28.8 percent respectively in Anchorage and Fairbanks, and 24.3 percent of the workforce statewide (Table 4.10-6; U.S. Census 2023d).

The second most common industry across the four geographies is generally retail trade, although in Anchorage professional, scientific, and management, administrative, and waste management industries are slightly more common than retail trade. Public administration is more common statewide and in the city of Anchorage than in Homer or Fairbanks, and information and wholesale trade are generally the least common industries, accounting for between 1.5 and 2.0 percent of the workforce in any location (Table 4.10-6; U.S. Census 2023d).

Table 4.10-6 Occupations and industries in Homer, Anchorage, and Fairbanks, Alaska.

	Homer	Anchorage	Fairbanks	State of Alaska
Occupation				
Management, business, science, and arts	39.8%	42.7%	33.7%	39.3%
Service	18.4%	17.2%	21.8%	17.5%
Sales and office	18.7%	20.4%	22.7%	19.2%
Natural resources, construction, and maintenance	10.7%	8.3%	8.7%	11.5%
Production, transportation, and material moving	12.4%	11.3%	13.2%	12.6%
Industry				
Agriculture, forestry, fishing and hunting, and mining	6.8%	2.6%	3.6%	5.1%
Construction	6.6%	5.8%	4.9%	7.3%
Manufacturing	3.9%	2.5%	1.5%	4.0%
Wholesale trade	1.7%	1.8%	1.6%	1.7%
Retail trade	12.6%	10.5%	13.5%	10.1%
Transportation and warehousing, and utilities	8.9%	10.3%	9.4%	9.1%
Information	1.5%	2.0%	1.7%	1.6%
Finance and insurance, and real estate and rental and leasing	3.0%	5.0%	5.5%	4.1%
Professional, scientific, and management, and administrative, and waste management	7.0%	10.7%	6.3%	8.5%
Educational services, and healthcare and social assistance	27.3%	24.5%	28.8%	24.3%
Arts, entertainment, and recreation, and accommodation and food services	10.2%	9.5%	10.8%	8.5%

	Homer	Anchorage	Fairbanks	State of Alaska
Other services, except public administration	4.9%	4.6%	4.5%	4.5%
Public administration	5.5%	10.1%	7.8%	11.4%

Source: U.S. Census (2023d).

4.10.2 Environmental Analysis

4.10.2.1 Construction

The construction associated with the Bradley Lake Expansion Project would not adversely affect socioeconomics of the local area; no towns, government facilities, or services exist in the vicinity, and no residences or business will be displaced or affected. Construction would require two consecutive summer seasons, and personnel would reside on-site in temporary housing during the work seasons. In the 2 years of construction, up to 2,120 direct jobs may be produced (Northern Economics 2025). Following construction, no additional jobs above existing positions are expected.

4.10.2.2 Operations

The first region-wide transmission load forecast for the Railbelt was completed in 2023 and predicts an increase in energy demand for the region due to the increased adoption of heat pumps, electric vehicles, and behind-the-meter solar (Cicilio et al. 2023). An increase of up to 80 percent in demand during normal energy usage and up to 113 percent during peak load could occur under the assumption of a moderate adoption of electric technologies, and significantly more than that under an aggressive adoption scenario (Cicilio et al. 2023).

The additional renewable energy supplied to the Railbelt region by the increased production at the Bradley Lake Project would lower energy costs for residents during anticipated higher demand periods and help to meet goals of increasing renewable energy availability in Alaska. At present, the Bradley Lake Project provides the lowest cost energy available to the Railbelt grid (Anchorage 2019). Between 1995 and 2020, energy produced by the Bradley Lake Project sold for an average of $0.04 per kilowatt-hour, providing lower cost energy to the Railbelt, and reducing energy costs in rural communities by participating in the Power Cost Equalization Program[12] (AEA 2025a). The power generated at the Bradley Lake Project costs significantly less than the cost of fossil fuel sources and provides renewable energy that can continue to generate long into the future (Homer Electric Association, Inc. 2025).

The monetary value of the energy displaced by the Bradley Lake Project does not reflect its true value to the participating utilities. During the winter when there is a high demand for heating, the risk of low natural gas pressure, which can cause blackouts, increases. Bradley Lake Project generation reduces the demand for natural gas during peak energy, thereby increasing stability of the system for the partner utilities, reducing the risk for blackouts, and it enables the utilities to avoid costly start/stops of thermal units. These benefits will reduce the energy costs of the Railbelt consumers in the future, provide more energy security, and reduce greenhouse gas emissions.

The Bradley Lake Expansion Project is anticipated to produce an average of 165,000 MWh of energy annually, helping to mitigate stress on the transmission system from increased demand. The additional hydroelectric energy would displace energy from natural gas used by utilities in the Railbelt region, power conservatively worth 20.1 million dollars (USEIA 2026). With the Bradley Lake Expansion Project expected to be operational by 2031, the annual energy production of Bradley Lake would increase by 38 percent from the long-term average, thereby displacing over 1.5 billion cubic feet of natural gas consumption on the Railbelt annually (AEA 2025a).

4.10.3 Applicant-Proposed Measures

There are no measures proposed by the applicant related to socioeconomics.

4.10.4 References

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[12] The Power Cost Equalization Program lowers electric costs for rural communities where rates would typically be three to five times higher than in urban communities. This reduces the rates down to a cost similar to what urban areas, such as Anchorage, Fairbanks, and Juneau, would pay (AEA 2025b).

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Census Reporter. 2023b. Anchorage, AK. Available online at https://censusreporter.org/profiles/16000US0203000-anchorage-ak/. Accessed September 3, 2025.

Census Reporter. 2023c. Fairbanks, AK. Available online at https://censusreporter.org/profiles/16000US0224230-fairbanks-ak/. Accessed September 3, 2025.

Census Reporter. 2023d. Homer, AK. Available online at https://censusreporter.org/profiles/16000US0233140-homer-ak/#housing-occupancy. Accessed September 3, 2025.

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United States Energy Information Administration. 2026. Natural Gas | Alaska Price of Natural Gas Delivered to Residential Consumers. Available online at https://www.eia.gov/dnav/ng/hist/n3010ak3m.htm. Accessed February 9, 2026.

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5.0 DEVELOPMENTAL ANALYSIS

5.1 Power and Economic Benefits of the Project

The long-term benefit of the Proposed Action is that it would increase the average annual generation of the Bradley Lake Project by 165,000 MWh from the increased storage capacity and diverted water. This would allow the Railbelt utilities to better manage peak loads and offset the need for natural gas to meet current energy demand for the region.

Power generated at the Bradley Lake Project is provided to the Alaska Railbelt region, which spans 700 miles from Fairbanks to Homer (Cicilio et al. 2023). The Railbelt serves approximately 75 percent of Alaska's population and is currently facing an imminent energy crisis due to declining gas reserves in Cook Inlet (Department of Energy 2024). Currently, the Railbelt receives 70 percent of its electricity from natural gas, and shortfalls are expected to begin in 2027. The Bradley Lake Expansion Project is part of the solution to the upcoming energy crisis and was identified in the Railbelt Decarbonization Study conducted by the University of Alaska and Telos Energy (Cicilio et al. 2023) directly tied to the goals of decarbonizing Alaska.

5.1.1 Proposed Action

The Alaska Railbelt region would derive economic benefit from expanding the Bradley Lake Project to add renewable generating capacity that would otherwise have come from fossil-driven sources. An annual increase in generation of 165,000 MWh is predicted, although actual production would depend on the water year and demand.

The total Project cost including all license amendment, permitting, engineering, and construction costs is forecasted to be $401,000,000. When annual cost of capital and operations and maintenance costs are combined, the annual cost of the Project is approximately $25,000,000, depending on final financing rates. The total annual cost is anticipated to increase by about $500,000 for the operation and maintenance of the new diversion dam and underground conveyance tunnel.

This additional hydropower generation is anticipated to replace 1.5 billion cubic feet of natural gas that would otherwise be needed to meet demand. At an expected cost of approximately $13.90 per thousand cubic feet (USEIA 2026), this represents a savings of $20,850,000 in natural gas costs.

5.1.2 No Action Alternative

Under the No Action Alternative, the proposed diversion dam and underground conveyance tunnel would not be built and would therefore not provide additional water for energy generation at the Bradley Lake Project. Under the No Action Alternative, the current and projected increase in energy demand in the Railbelt would be met by importing high volumes of natural gas from outside the region, contributing to increased cost for power over the long term.

5.2 Cost of Environmental Measures

This section will be completed in the FAA.

5.3 References

Cicilio, P., J. VanderMeer, S. Colt, A. Francisco, E. S. Hernandez, C. Morelli, M. Wilber, C. Pike, D. Stenclik, M. Richwine, C. Cox, I. Anselmo and K. Ciemny. 2023. Alaska's Railbelt Electric System: Decarbonization Scenarios for 2050. Alaska Center for Energy and Power, University of Alaska, Fairbanks.

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6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Comparison of Alternatives

This section will summarize the effects on the developmental and non-developmental resources for the Proposed Action and No Action/alternatives; this information will be completed for the FAA. Developmental values include the impacts associated with operating the Project, while non-developmental values include the impacts on fish and wildlife, recreational opportunities, and other environmental aspects.

6.2 Comprehensive Development and Recommended Alternative

FERC is required to consider all uses of the waterway on which the Project is located according to Sections 4(e) and 10(a)(1) of the FPA. This includes fish and wildlife, recreational, and other non-developmental resources. All resources are considered equally with a hydroelectric project's electric energy or other developmental values. FERC must weigh various economic and environmental considerations involved in approving or rejecting the Proposed Action.

The following sections provide AEA's summary and rationale for recommendations to FERC for the approval of this Project.

6.2.1 Recommended Alternative

Based on the review and evaluation of the Proposed Action and the No Action Alternative, AEA selected the Proposed Action as the preferred and recommended alternative.

The Proposed Action was selected because it is likely the most cost-effective alternative for meeting the growing energy demand in Alaska and provides a reliable source of generation with long-term stable rates. As discussed in Section 2.0, the Proposed Action would consist of building an approximately 25-foot-high, 135-foot-long diversion dam, a 4.6-mile-long underground diversion tunnel, a 1,100-foot-long channel to convey the diverted flows into Bradley Lake, construction of a new access road to the tunnel exit, and raising the Bradley Lake pool by 16 feet through modifications to the existing Bradley Lake Dam. The pool raise would result in increased storage capacity to 342,000 acre-feet and that when combined with the additional diverted water would increase the generation by 165,000 MWh or 38 percent. The proposed Project would necessitate a Bradley Lake Project boundary modification to include the new facilities, including a 25-foot buffer along the underground tunnel alignment, and the land surrounding Bradley Lake up to El. 2,010 feet.

6.3 Unavoidable Adverse Effects

Effects to resources from construction activities would be temporary and would be avoided or minimized through implementation of BMPs and resource-specific monitoring plans, discussed above. The construction of the entirety of the Bradley Lake Expansion Project could permanently remove approximately 12.3 acres of wetland and waters and 151.5 acres of wildlife habitat following the rehabilitation of 37.7 acres. However, as discussed in Section 4.5.2.2.2, the loss of suitable habitat is species-dependent as the currently open, barren riverine habitats in the braided-channel floodplain of the Martin River, would be stimulated by the planned seasonal reductions in flow, introducing more suitable habitat for some species.

Detailed descriptions of impacts to each resource from operations and proposed PM&E measures to minimize and monitor potential effects are available in Section 4.0 of this exhibit.

6.4 Agency Recommendations

This section will be completed in the FAA.

6.5 Consistency with Comprehensive Plans

Section 10(a)(2)(A) of the FPA, 16 U.S.C. § 803(a)(2)(A), requires the Commission to consider the extent to which a project is consistent with federal or state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by the project. The following list names the comprehensive plans that are applicable to the Project (FERC 2025). No inconsistencies were found.

ADF&G. Kachemak Bay/Fox River Flats Critical Habitat Areas, December 1993. Juneau, AK.

ADF&G. 2000. Kenai Peninsula Brown Bear Conservation Strategy. Juneau, AK. June 2000.

ADF&G. 2006. Cook Inlet Regional Salmon Enhancement Planning - Phase II (2006-2025). Soldotna, AK. 2006.

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6.6 References

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7.0 FINDING OF NO SIGNIFICANT IMPACT

AEA will complete this section as part of the FAA.

APPENDIX E1

COMMENT MATRIX

Comment No.	Entity	Document	Section	Comment
1	USFWS	DSP	**3.0 Summary of 2022 Field Season Studies**, 3.1 Topographic Survey (p. 3-1 and A-21)	The Service requested the geology around the Dixon Glacier be characterized and mapped, and controlling features for the glacial outflow identified. The response to our request was that the geology would be characterized based on existing geologic mapping and aerial photographs. We continue to believe a study to determine the underlying glacier bed elevations is needed to predict potential changes in the glacial outflow path and assess the viability of the project as proposed. Existing geologic mapping and aerial photography alone will be insufficient for providing this information.
2	USFWS	DSP	**3.0 Summary of 2022 Field Season Studies**, 3.2 Streamflow Gaging (p. 3-1 and A-19)	We believe measuring flow coming from the lower East Fork Martin River is still important for quantifying the amount of flow coming from the smaller glacial outflow channel, as well as addressing a separate study request that seeks to quantify how much water in the smaller glacial outflow channel is glacial versus snowmelt with isotopic analysis. We request either a gage station on the East Fork Martin River before it joins with the outflow of Red Lake, a gage station installed later to avoid bedload movement and equipment damage (but would still provide volume information for the remainder of the time), or alternate methods discussed in section 4.1 be used at this location.
3	USFWS	DSP	**4.1 Streamflow Gaging**, 4.1.1 Goals and Objectives (pp. 4-1 and A-22), glacial versus snowmelt in small outflow channel	While gaging at the tributary south of the diversion site might be too challenging, the measurement of glacial versus snowmelt would require two to three water samples take over a 1-year period and use isotopic analysis to determine old versus new water. While accessing the site is challenging, there are qualified individuals who could do this and do it safely. This isotopic analysis combined with requested flow information for the lower East Fork Martin River and the existing gage station near the proposed intake location should provide a quantitative measurement of flow coming from the tributary and would show how much glacial melt is passing through this tributary. This is preferable to a reliance on photographs to attempt to quantify this flow.
4	USFWS	DSP	**4.1 Streamflow Gaging**, 4.1.1 Goals and Objectives (pp. 4-1 and 4-5), continuous gaging and alternate methods	The DSP proposes gaging sites but states that safety concerns may prevent continuous gaging of the Martin River and its tributaries, and alternate methods would be implemented should that occur. What are the limitations with the alternate methods? Should continuous gaging be feasible, we recommend also employing the alternate methods so the datasets are comparable and estimates from alternative methods are calibrated to this system should continuous gaging discontinue.

Comment No.	Entity	Document	Section	Comment
5	USFWS	DSP	**4.1 Streamflow Gaging**, 4.1.5 Methodology (pp. 4-3 -- 4-4)	The DSP states that gage installation will occur in May and removal will occur in October each year. However, section 4.1.3 Background and Existing Information states that the highest peak flow in the Kachemak Bay watershed occurs from late August through November. An effective streamflow study should capture the annual hydrograph, especially the primary peaks, as well as the periodic freshets from heavy rain that are important for channel maintenance. We recommend gage installation be timed to capture the highest peak flow periods.
6	USFWS	DSP	**4.2 Water Quality Monitoring**, 5.2.5 Methodology, Schedule (p. 4-10)	The DSP states that water quality monitoring will occur from May through October, aligning with the period of the proposed diversion. However, project operations may have year-round impacts. A year-round water quality monitoring study is important for informing baseline conditions that could be impacted. Year-round water quality monitoring could also inform locations of groundwater inflows along the mainstem, which are known to provide clearwater habitat during turbid flows.
7	USFWS	DSP	**4.2 Water Quality Monitoring**, 5.2.5 Methodology, Analytical Methods (pp. 4-9, 4-11 -- 4-12)	The DSP provides a table of state water quality criteria (Table 4.2-1 in DSP) and states the data will be evaluated with respect to these criteria. However, Alaska has several salmon runs in turbid glacial systems, especially where ground water-surface water interactions create clearwater zones. For context, please also include examples of productive salmon runs in turbid glacial systems.
8	USFWS	DSP	**4.3 Aquatic Habitat Characterization**, 4.3.5 Methodology, Remote Line Mapping (pp. 4-17 -- 4.18)	The DSP states that a linear stream network will be created in a Geographic Information System (GIS) framework by drawing segments along the stream channel center line as viewed using aerial imagery or Light Detection and Ranging (LiDAR), and that any tributaries or sloughs will be delineated in aerial up to 0.5 miles from the centerline of the main channel or off-channel confluence. Please delineate the full extend of tributaries or sloughs that could be fish bearing. Slough and pond boundaries can be interpreted with aerial imagery, and flow accumulation tools in GIS can be used to generate streamlines from LiDAR data. Mapped streams and sloughs should be verified in the field, and fishing bearing streams should be mapped until a permanent barrier is reached. Because fish access to existing habitat may be affected by the project, it is important to quantify that upstream habitat.

Comment No.	Entity	Document	Section	Comment
9	USFWS	DSP	**4.3 Aquatic Habitat Characterization**, 4.3.5 Methodology, Ground Mapping (pp. 4-17 and 4-20)	Are there known groundwater inflow points within the main channel? The DSP states that Martin River imagery from 2022 shows complex glacial outwash channels along with several off-channel habitats that contained clear water during the low flow conditions. The DSP proposes habitat data collection in off-channel clearwater habitats, focusing survey work during low flow conditions. The DSP further states that no winter surveys are proposed as the project would not operate during the winter and would therefore not impact existing winter conditions. However, groundwater inflow points within the main channel should be identified since they could be providing important clearwater habitat and refugia from turbid flows, and potential project-induced changes in stream bed elevation could have year-round impacts to groundwater-surface water interaction points.
10	USFWS	DSP	**4.4 Martin River Fish Use**, 4.4.5 Methodology (p. 4-27)	The DSP states that sampling will focus on fish use of habitats from May through October aligning with the period of the proposed diversion. Furthermore, the Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation Study will evaluate the potential project-induced changes in stream bed elevation and habitat connectivity, which are year-round impacts from project operations. Since the project could have year-round impacts, it is important to understand the year-round baseline distribution and abundance of fish that could be affected by the project.
11	USFWS	DSP	**4.4 Martin River Fish Use**, 4.4.5 Methodology, Objective 2. Run Timing of Sockeye and Coho Salmon into Red Lake (p. 4-30)	The DSP acknowledges it was too dark to see fish in the autonomous video counting tower (AVCT) from approximately 00:00 to 04:00 each night. Sockeye Salmon (*Oncorhynchus nerka*) often migrate at night, with one project documenting 95 percent of the counted fish migrating through a video weir between 23:00 and 06:00 (Van Alen and Mahara 2011). Short of pairing the AVCT with a full escapement study to calibrate an index estimate, the AVCT totals represent minimum count but will be valuable for informing run timing and annual variability in run strength.
12	USFWS	DSP	**4.4 Martin River Fish Use**, 4.4.5 Methodology, Objective 2. Run Timing of Sockeye and Coho Salmon into Red Lake (p. 4-30)	During the Study Plan meeting on November 17, 2022, Alaska Department of Fish and Game stated that they intent to set up the AVCT project earlier since it appeared the run had already started by June 8. The DSP also states that the project will continue through the third week of October to look for Coho Salmon (*Oncorhynchus kisutch*) before significant ice formation occurs. We support efforts to extend the length of the AVCT project and capture salmon run timing into Red Lake.

Comment No.	Entity	Document	Section	Comment
13	USFWS	DSP	**4.4 Martin River Fish Use**, 4.4.5 Methodology, Objective 3. Document adult Coho Salmon Sockeye Salmon, and Eulachon (pp. 4-31 -- 4-33)	Clearwater habitats and the mixing zones with turbid mainstem Martin River are the proposed focus for adult surveys. The DSP states that evidence of Sockeye Salmon and Coho Salmon spawning may be documented using visual observations of spawners, spawning activity, and established redds; carcass surveys along two off channel habitat reaches; seining in select side-channel habitats where suitable substrate and upwelling occur; or with evidence of spawning success from the presence of young-of-year or emergent fry life history stages of those species. However, spawning activity may occur in the mainstem Martin River in times of lower flow and could provide opportunities to observe activity in the mainstem. Additionally, the timing of adult salmonid use likely extends beyond the operation period for the proposed diversion (May through October). A pre-project understanding of adult distribution and timing is important for estimating potential impacts and minimum flow requirements.
14	USFWS	DSP	**4.5 Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation**, 4.5.4 Project Nexus (p. 4-40)	The DSP in this section states that potential changes to river flow and stage could affect connectivity to off-channel habitats, which could affect fish populations. *It is important for the Martin River Fish Use Study to capture the year-round distribution and abundance of fish so that the magnitude of effects to fish populations can estimated. However, the DSP focuses studies to the timing of proposed project operations.*
15	USFWS	DSP	**4.5 Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation**, 4.5.5 Methodology, Geomorphology and Sediment Transport Analysis (pp. 4-44 -- 4-45)	The methods described in the DSP will use historical aerial photography, LiDAR data, current information on substrate size, and outputs from the two-dimensional (2D) hydraulic model to analyze potential future sediment transport and accumulation trends from the project. One of the listed tasks includes coordinating with team members assessing riparian and aquatic habitat conditions and connectivity to help develop a multi-disciplinary analysis of the effects of changes in flow regimes. Will the information provided by this study be sufficient for the team to also estimate the size and frequency of flows necessary for channel maintenance and habitat diversity?

Comment No.	Entity	Document	Section	Comment
16	USFWS	DSP	**4.5 Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation**, 4.5.5 Methodology, Aquatic Habitat Connectivity Evaluation, Identify Fish Species and Periodicity (p. 4-46)	Table 4.5-1 identifies species that are reported to use the Martin River and lists the species and life stages that are proposed to be included in the Aquatic Habitat Connectivity Evaluation. Migration should be included for Sockeye Salmon and outmigration should be included for both Coho and Sockeye Salmon since water depth could impact those life stages.
17	USFWS	DSP	**4.5 Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation**, 4.5.5 Methodology, Aquatic Habitat Connectivity Evaluation, Aquatic Habitat Connectivity Analysis (p. 4-48)	The Aquatic Habitat Connectivity Analysis will include an evaluation of the frequency and duration of minimum water depth to ensure habitat connectivity, and that the 2D hydraulic modeling approach will provide a valuable tool for aquatic habitat connectivity-flow relationships and evaluating alternative flow regimes. Will these models also consider the amount of flow necessary to saturate the substrate before surface flow occurs, and how that might change if the stream bed is elevated?
18	USFWS	DSP	**4.7 Vegetation and Wildlife Habitat Mapping**, 4.7.5 Methodology, Study Area (p. 4-62)	The DSP states that the Wetland Delineation study area (DSP Section 4.6) will be the base for developing the Vegetation and Wildlife Habitat Mapping study area, with additional buffer sizes around project elements depending on the focal wildlife species list (DSP Section 4.8) and consultation with agency stakeholders. We look forward to future coordination on the buffer zones sizes for wildlife in the area (DSP Section 4.7 and 4.8, p-70).

Comment No.	Entity	Document	Section	Comment
19	USFWS	DSP	**4.8 Wildlife Habitat Evaluation**, 4.8.5 Methodology (p. 4-69 -- 4-71)	…the habitat ranking procedure will be developed with input from State and Federal resource agencies. This ranking should be more quantitative to determine which species are using the areas and for what life stages. Habitat used for feeding, breeding, resting, staging, and migration should all be considered. Quantifying the amount of habitat by life stage for each species of concern will be important for informing the direct and indirect effects analysis, as well as the cumulative effects analysis when past, present, and reasonably foreseeable actions are also considered. Acres of disturbance by species and habitat will also be necessary when analyzing protection, mitigation, and enhancement measures (PM&Es); alternatives; and potential compensatory mitigation.
20	USFWS	DSP	**4.9 Raptor Nesting and Migration**, 4.9.1 Goals and Objectives (p. 4-74)	We recommend revising this section to "Raptors and Migratory Birds" to provide data for evaluating and mitigating the potential effects of the project on all migratory birds, not limited to only nesting raptors and their migration. While migratory birds are also considered in section 4.8, that study is focused on providing quantitative estimates of habitat change. This section focuses on determining collision and/or electrocution risk, important nesting areas, and work timing windows for raptors and other migratory birds so impacts and alternatives can be analyzed and PM&Es may be considered.
21	ADF&G	DSP	*Section 2.1 Summary of Comments and Proposed Studies Received*	ADF&G is appreciative of the inclusion of a future Mountain Goat Monitoring study in the Summary of Study Requests and Proposed Studies (Table 2.1-2). The proposed Dixon Diversion occurs within important mountain goat habitat, including overwintering areas and kidding habitats. Any construction activities will impact these populations by causing disruptions in their behavior, alterations in movement patterns, and by the reduction of their current habitat. while disturbance from construction activities related to this project are expected, the changes in habitat use and/or changes in population demographics are hard to forecast and cannot be realized until after the project has started. Therefore, we would to reiterate the importance of conducting a monitoring project that starts pre-construction and ends multiple years after construction is completed to better understand current mountain got habitat use and monitor for changes that may occur due to this project.

Comment No.	Entity	Document	Section	Comment
22	ADF&G	DSP	*Proposed Study 4.1 Streamflow Gaging*	First, ADF&G requests to amend the objectives to include capturing spring break-up timing when monitoring streamflow in the Martin River watershed. Capturing the timing of spring break-up is important to help identify when diversion water becomes available and when smolt outmigration may be occurring. AEA states that they would plan to begin diverting water in mid-to-late May, in which case it will be necessary to understand when additional water becomes available. Given the relatively low cost of pressure transducers and the value of the data, we highly recommend that the transducers remain operational over the winter to capture spring break-up timing. Since the proposed project will not be operating in the winter, collecting winter discharge measurements is not necessary. However, a pressure transducer that is operated throughout the winter will record critical spring break-up timing and volume data during this biologically important period.
23	ADF&G	DSP	*Proposed Study 4.1 Streamflow Gaging*	Second, we understand the complexity of the Martin River and recognize the limitations in streamgaging this system. We suggest installing the Red Lake tributary streamgage within the lake itself, near the outlet stream. The lake would seem to provide an ideal site for the transducer with a stable control and a pool with sufficient depth at extreme low flows. Additionally, the transducer should remain in place throughout the winter and during break-up.
24	ADF&G	DSP	*Proposed Study 4.1 Streamflow Gaging*	Lastly, we would like to highlight the importance of a continuous streamgage located on the mainstem Martin River. The proposed location identified in the draft study plan does appear to be the most ideal place for this streamgage, as there is a distinct constriction of the river channel (Table 4.1-1). A continuous streamflow record of the mainstem Martin River throughout the entire open water season will be imperative when deciding future instream flow needs for fish.

Comment No.	Entity	Document	Section	Comment
25	ADF&G	DSP	*Proposed Study 4.4 Martin River Fish Use*	The fish distribution study plan as currently described should adequately account for fish species that utilize clearwater habitats for spawning and/or rearing between mid-to-late May into October (e.g., coho and sockeye salmon and Dolly Varden). The methods presented for sampling clearwater habitats (minnow trapping, backpack electrofishing, seining, and the autonomous video counting tower) are suitable for this purpose. However, ADF&G has concerns about under sampling the main channel and initiating sampling after spring break-up, as this creates both temporal and spatial data gaps. By focusing fisheries studies primarily in clearwater and off-channel habitats, fish species that use mainstem and/or turbid side channel habitats could be missed or under-represented. The presence of some species (e.g., chum and pink salmon) could potentially go undetected by the current sampling design. For instance, chum salmon often favor spawning sites where upwelling occurs; upwelling often occurs where surface water flows through porous substrates separating adjacent stream channels. Such habitats are likely common in the highly braided but turbid Martin River, however, they would not be sampled under the current study design. Additionally, outmigrating chum and pink salmon smolt will likely be overlooked if sampling begins after spring break-up. ADF&G requests that study Objective 1 be amended to include sampling turbid mainstem and braided side channel habitats of the Martin River and that study Objective 3 be amended to include chum and pink salmon.
26	ADF&G	DSP	*Proposed Study 4.4 Martin River Fish Use*	ADF&G recommends the following methods to achieve comprehensive fish sampling of the mainstem and all salmon species present. During periods and areas of low flow, beach seining can be employed in the mainstem. At times and areas where seining is ineffective, hook and line sampling may be an especially effective fish capture method, particularly for sampling adult pink salmon in the more turbid summer months. We would expect adult chum salmon to be present in the Martin River between the months of July and September. Adult pink salmon are expected to be present in greater abundance during August and September. Their spawning activity may be visible in the margins of the stream, even if flows are high and turbid.

Comment No.	Entity	Document	Section	Comment
27	ADF&G	DSP	*Proposed Study 4.4 Martin River Fish Use*	Similar to our comments regarding streamflow gaging, it is important to understand when smolt outmigration is occurring in order to inform when diversion operations can begin after spring break-up. We recommend conducting smolt outmigration studies to capture the timing of smolt leaving the system. Without either knowing when spring break-up occurs or when smolt outmigration occurs, we cannot recommend when water diversions can begin. Page 4–32 of the draft study plan states that “emergent fry and young age-class Coho and Sockeye salmon juveniles may be encountered during sampling under Objective 1…” However, these methods will likely be unsuccessful at capturing young-of-year pink and chum salmon, since they do not rear in freshwater and, therefore, will leave the Martin River system in late winter/early spring.
28	ADF&G	DSP	*Proposed Study 4.4 Martin River Fish Use*	We also encourage employing environmental DNA (eDNA) sampling techniques if traditional fish capture methods prove difficult. eDNA sampling can serve as a viable tool for at least establishing presence/absence of a species that may be using only turbid main channel habitats.
29	ADF&G	DSP	*Proposed Study 4.4 Martin River Fish Use*	Finally, we would like to see the autonomous video counting tower project extended for at least two more seasons (2023 and 2024) and preferably longer after the initial field studies have been conducted. It is standard practice for stock assessment projects to span at least one full generation for the target species in order to capture some of the inter-annual variability (e.g., run timing and magnitude) that occurs with many fish populations, especially salmon. Ideally, that would be 4 or 6 years of assessment for coho and sockeye salmon, respectively.
30	ADF&G	DSP	*Proposed Study 4.5 Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation*	ADF&G recommended an instream flow study to assess mainstem instream flow protection needs for riverine resources and values. We recommended an Instream Flow Incremental Methodology (IFIM) with a flow-habitat component to assess mainstem channel instream flow needs. The draft study plan states that the dynamic nature of the Martin River downstream of the confluence with the East Fork Martin River creates an unstable stream channel and thus would limit the effectiveness of a flow-habitat modeling technique such as the Physical Habitat Simulation (PHABSIM) model for this system.
31	ADF&G	DSP	*Proposed Study 4.5 Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation*	We believe a mainstem instream flow assessment is important and needed. ADF&G’s Anadromous Waters Catalog documents fish usage in the Martin River that includes chum, coho and sockeye salmon, as well as Dolly Varden. Pink salmon have also been observed by the autonomous video counting tower below the outlet of Red Lake.

Comment No.	Entity	Document	Section	Comment
32	ADF&G	DSP	*Proposed Study 4.5 Hydraulic Modeling, Geomorphology, and Aquatic Habitat Connectivity Evaluation*	An objective of the draft study plan is to develop a two-dimensional (2D) hydraulic model to predict the magnitude and trends of Martin River channel response to proposed project operations. Can the 2D hydraulic model be used to assess mainstem instream flow needs for identified fish resources? If not, then based on field results from the 2023 season, we may again request an instream flow assessment that includes field data collection in the 2024 field season.
33	WPC	DSP	**I. Consultation with Tribal Governments**	As the non-federal representative for the purposes of initiating informal consultation In relation to the license amendment process including the Study Plan, AEA is required to consult with the Native Villages of Nanwalek and Port Graham and the Seldovia Village Tribe in addition to the named resource agencies. The Study plan must therefore, include a description of any efforts the agency has made to initiating informal consultation with Alaska Native Tribal entities for purposes of consultation under Section 7 of the Endangered Species Act with, requesting that such tribes participate the in the study plan and what efforts it will make to ensure the and the remaining licensing amendment process.
34	WPC	DSP	**II. Additional Minimum Stream Flows Studies, a. Bradly River Minimum Flows**	The Study Plan should therefore, include an analysis of what caused the above deviation [August-September, 2020] from required minimum stream flows and how this can be avoided in relation to the proposed license amendment.
35	WPC	DSP	**II. Additional Minimum Stream Flows Studies, b. Battle Creek Minimum Flows**	The Study Plan should, therefore, analyze what happened to the Battle Creek minimum flows during 2021 and provide strategies for avoiding the same incidents from happening in relations to Dixon Creek, the Martin River and other tributaries related to the proposed license amendment.
36	WPC	DSP	**II. Additional Minimum Stream Flows Studies, c. Climate Change and Minimum Stream flows**	The onset of climate change, has resulted in increasing temperatures and decreasing snowpack, causing declines in stream flows for a significant number of a streams throughout the Kenai Peninsula, some of which are already experiencing summer temperatures that cause potentially lethal stress to salmon. The Study Plan, therefore, should include an analysist of whether removing stream flows out of Dixen Creek that could help offset increasing temperatures within the Watershed. The Study plan should take advantage of stream temperature and other data being collected around the Kenai Peninsula.

Comment No.	Entity	Document	Section	Comment
37	WPC	DSP	**II. Additional Minimum Stream Flows Studies, c. Climate Change and Minimum Stream flows**	The Study Plan should also protect salmon habitat in the Martin River by including federal fish and wildlife agency recommendations for minimum flows necessary to adequately maintain viable spawning and rearing habitat. Such recommendations could be developed in accordance with a Diversion Flow Release Management Plan and a stream gaging plan, which could be developed in coordination with the resource agencies oversight.
38	WPC	DSP	**III. Extended Stream Gaging**	According to the study plan stream gaging will be conducted from May -- October. using Telemetry gaging as the primary method due to the difficulty of accessing the site and the safety hazards of manually taking discharge measurements. See Study plan p. 3.4 - 3.5. However, because the main peak flows happen in August to November, this gaging schedule will leave out such flows. Peak flows are essential for setting-up a rating curve and it usually takes at least 3 years of peak flow data to obtain an accurate rating curve. Therefore, the stream flow gaging should be extended through November in order to capture these flows.
39	WPC	DSP	**IV. Climate/Stream flow & Temperature Forecasting/Modeling**	Although, FERC, currently, does not require climate change analysis related to hydropower licensing studies, this policy seems completely inapplicable to the impacts that climate change has on rivers and streams. This is especially true in the present case when the project will effect flows directly affected by a rapidly retreating glacier. We believe that for the above reasons, climate forecasting, modeling and "Future Flows Study" should be a major part of the licensing amendment process and are encouraged by AEA's commitment to conduct river forecasting on it's own initiative. To this end, we support the Future Flows Study Request being proposed by the National Marine Fisheries Service. As the climate changes so will the mass balance and discharge of the receding Dixon Glacier.
40	WPC	DSP	**IV. Climate/Stream flow & Temperature Forecasting/Modeling**	Any climate analysis should also include climate, precipitation and temperature forecasting. Researchers, for example are, currently, studying stream temperature increases, how watersheds off-set such increases and how these phenomena relate to protecting fish and wildlife habitat. There are also ongoing Salmon Surveys in the Fox River Flats and Bradly Creek estuaries to see how Bradley Hydro Project including the Battle Creek Diversion may impact salmon populations in those systems. This data should be include in the Study Plan in order to help predict how the licensing amendment will impact water temperature and flows and fish and wildlife habitat.

Comment No.	Entity	Document	Section	Comment
41	WPC	DSP	**IV. Climate/Stream flow & Temperature Forecasting/Modeling**	Similarly, the natural regime and project operations section of the Study Plan should analyze whether outflow from the south glacier and draining partially down main channel will change as the glacier pulls back.
42	WPC	DSP	**IV. Climate/Stream flow & Temperature Forecasting/Modeling**	Understanding projections for future climate and water levels will be important for developing effective protection, mitigation, and enhancement measures.
43	WPC	DSP	**IV. Habitat Mapping**	Fish should be sampled using the appropriate methods for the habitat, season, and life stage (juveniles: electrofishing, snorkeling, minnow trapping, seining; adults: weirs, foot surveys, aerial surveys, mark recapture), and environmental DNA (commonly known as eDNA) should be used to validate sampling efforts. Passive integrated transponder (commonly known as PIT) tags and antenna arrays should be used to determine seasonal habitat utilization and movements, and radio tags could be used to track fish. The surveys should be timed so that they can inform year round fish distribution and habitat use. This study should occur over a recommended minimum of 5 years to cover as much habitat as possible and to adequately characterize fish assemblages under a variety of natural flow conditions. Information to be collected should include species, size, age, sex, and condition, as well as movement patterns and habitat utilization. Standard water quality data (e.g., water temperature, dissolved oxygen, pH, etc.) should be collected in conjunction with these surveys.
44	WPC	DSP	**IV. Habitat Mapping**	Because of the physically dynamic glacial environment of this system coupled with its valuable fisheries resources, the study plan should include a characterize the relationship between the hydrograph and fish habitat under both. Therefore, instead of the maximum -- 1/2 mile geographical range of distribution cited in the the study plan, there, the plan needs to include year round distribution the full extend of tribs or at least up to barriers.
45	WPC	DSP	**IV. Habitat Mapping**	Similarly, the plan should include an analysis of the seasonal distribution, relative abundance (as determined by catch per unit effort, fish density, and counts), and fish habitat associations of anadromous and resident fish species in Martin River, Red Lake, associated tributaries and off channel ponds, and East Fork Martin River up to identified fish barriers.

Comment No.	Entity	Document	Section	Comment
46	WPC	DSP	**VI. Ground Water**	In order to ensure clean water and healthy salmon in the region we must protect streams and groundwater. Gravel pits -- if not designed thoughtfully and developed carefully -- can pose a serious risk to salmon streams, especially baby salmon. The study plan therefore, should include Martin River and Dixon Creek tributaries, side channels & ponds in groundwater studies.
47	ADF&G	DSP2		ADF&G recommends the following species to be added (+) or removed (-) from the impacted species list for analysis: [SOME TEXT EXCLUDED] +Brown bear; +Black bear; +Wolverine; +Hoary marmot; -Alaskan marmot; +Keen's myotis
48	ADF&G	DSP2		The extent of the overall study area should be expanded to encompass the entire area that will be affected by disturbance due to project activity. This includes drilling activity, blasting activity, temporary workforce housing, transiting to work sites, and any other associated activities. If disturbances cause wildlife to abandon an area, this is a change in wildlife habitat as that habitat is no longer available for use. Changing wildlife habitat studies must include soundscape and visual disturbances as well as physical changes to the vegetation and landscape. Bears and other hibernators are sensitive to human activities during this critical life stage and have been documented to abandon den sites when activity is up to 2-km away, depending on the extent and intensity of the activity. The study area should include all areas over which human activity such as drilling, blasting, or other work would be detectable by hibernators. Mountain goats are highly sensitive to helicopter traffic, mining activity, and other human disturbance particularly during critical life stages such as winter and kidding. Mountain goats require a 2-km buffer area in regions of elevated human activity to completely avoid harassment. Displacement from important wintering and kidding habitat could lead to population level effects that would take years to recover from due to low reproductive rates. Wildlife habitat change studies must include the entire area from which animals could be displaced due to development activities. For these reasons and based upon recommendations from relevant literature, ADF&G proposes a study area buffer zone of: 1) 2-km around Project design elements and primary flight paths for mountain goat, black bear, brown bear, moose, and wolverine; and 2) 250-m around Project design elements and primary flight paths for all other wildlife species on the list.

Comment No.	Entity	Document	Section	Comment
49	USFWS	DSP2		USFWS Suggestions: [SOME TEXT EXCLUDED] Rufous Hummingbird, Olive-sided Flycatcher, Bank Swallow, Blackpoil Warbler, Steller's Eider, Common Goldeneye, Barrow's Goldeneye, Rock Sandpiper, Western Sandpiper, Semipalmated Sandpiper, Herring Gull, Arctic tern, Long-tailed Duck, Wandering Tattler, Marbled Murrelet, Short-eared Owl, American Pipit, Horned Lark, Lapland Longspur, Northern Pintail, Black Scoter, Red-throated Loon, Lesser Yellowlegs, Greater Yellowlegs, Short-billed Dowitcher, Bonaparte's Gull, Black-legged Kittiwake, Pelagic Cormorant, Peregrine Falcon, Red-tailed hawk, Peregrine Falcon, Tundra Vole, Wolverine.
50	WPC	2024 Study Reports		[SOME TEXT EXCLUDED] The [Hydrology and Aquatic Resources] Reports, therefore should include the recommendations included in the [2024 Project Report for the Alaska Stream Temperature Action Plan] Progress Report including: *[the] purpose of the Plan is to identify the highest priority actions for the next 5-10 years that would lead to greater protection of Alaska's wild salmon habitat as thermal change continues. By implementing these priority actions in data collection, protection, and research in the Cook Inlet watershed and across Alaska and through collaboration and coordinated discussions, we hoped to achieve the following goals: 1. improve our understanding of current thermal regimes in Alaska's salmon streams; 2. refine data collection for fisheries management and modeling applications; 3. target cold water habitat protection efforts; 4. fill stream network data gaps; and 5. direct relevant fisheries and habitat research.*
51	WPC	2024 Study Reports		[SOME TEXT EXCLUDED] Similarly, the [Hydrology and Aquatic Resources] the Reports should utilize the new AK TEMP Data Visualization Tool developed in partnership with the USGS Eastern Ecological Science Center and Walker Environmental Research, pulls data from the AKTEMP Water Temperature database NPS's Aquarius database, the USGS's Water Data for the Nation, and Daymet to explore temperature data across the state. There is a need to connect with the authors of these data bases to ensure the Studies are included in the data sets.

Comment No.	Entity	Document	Section	Comment
52	ADF&G	2024 Study Re	**Hydrology Report/ Hydrology Memo**	Understanding the streamflow regime of Martin River is a crucial study component that will help to inform future project operations. ADF&G appreciates the efforts to utilize the historic streamflow records from the Upper Bradley River to aid in calculating synthetic streamflow data for sections of the Martin River and to better understand the impacts from projected increasing annual precipitation trends. ADF&G requests this long-term synthetic flow analyses be used to develop mean/minimum/maximum annual and monthly flow summaries as well as provide monthly exceedances (in graphic and tabular formats) for the Martin River at the Constriction streamgage site.
53	ADF&G	2024 Study Re	**Hydraulic Modeling and Habitat Connectivity Study Report**, 4.2 fish Passage/Habitat Connectivity Assessment	Please provide justification for why the 7-day low flow method was selected for comparison with instream flow assessments. This method is traditionally used in the water quality community to estimate extreme low flow events pertaining to water chemistry issues but are not appropriate for instream flow/fish passage assessments. Fish habitat suitability criteria, based on fish species- and site-specific hydraulic information (i.e. depth criteria), are commonly used for fish passage assessments.
54	ADF&G	2024 Study Re	**Geomorphology Study Report**, 4.5.2 Comparison of Future Sediment Input and Transport Potential	We look forward to additional information on flows needed to initiate channel maintenance processes and those necessary to continue to move sediment pulses. Further refining the sediment transport analysis will help develop the PM&E's.
55	ADF&G	2024 Study Re	**Aquatic Studies Report**, 3.5.4 Temperature and Water Quality Monitoring	For a few representative off-channel and tributary habitat sites that are suitable for spawning and where thermal data was also collected, it would be useful to overlay coho, sockeye, and Dolly Varden preferred/optimal spawning temperature ranges (as opposed to ADEC spawning max) over the temperature data series. See Table 7 and Figure 10 of Cooper Creek (P-2170 Instream Flow Study Report for reference.
56	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Page 4-9*	The Red Lake video system was installed on May 28, 2024. The report states the system was installed "by June 15th" but prudent to provide the refined date since it is available.
57	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Page 4-9*	The Report states there were ~4hrs of darkness each night when it was too dark to see fish without supplemental light in June/July giving the impression in this section of the report that fish were not counted at night. However, as correctly mentioned later in the results, the underwater lights were installed in 2023 and 2024 to document nocturnal migration. We suggest modifying methods to clarify that lighting was used to assess nocturnal migration.

Comment No.	Entity	Document	Section	Comment
58	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Juvenile Sockeye Salmon*	In various locations throughout the report it states that no juvenile sockeye salmon were documented in the drainage, despite observing adult spawning at multiple locations, most notably Red Lake. This is attributed to either a) Martin River sockeye are of the sea-type ecotype, which emigrate to estuaries soon after emergence, or b) sampling gear or timing was not appropriate for catching juvenile sockeye in 2024.
59	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Juvenile Sockeye Salmon*	It appears the sampling of Red Lake consisted of setting 6 minnow traps for 24 hours during October 2-3, 2024. Minnow traps are not the most appropriate gear for capturing juvenile sockeye salmon, especially young-of-year fish. If Red Lake sockeye are sea-type, no juveniles would be present in the lake in September/October, the fish would have emigrated the previous spring.
60	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Juvenile Sockeye Salmon*	We suggest increased sampling of Red Lake in 2025 to include setting a fyke net/holding box in the outlet creek to capture juveniles emigrating from Red Lake in the spring to determine if they are all age-0, or if there are age-1 or age-2 fish also present. This would establish if sockeye salmon utilize Red Lake for rearing, or only for spawning/incubation. Fyke net operations should occur at night as sockeye salmon fry emigration typically peaks at night. Timing for this work is difficult to predict for this stock, but the emigration timing for other sea-type sockeye populations in Alaska generally occurs from late-April into July, with a peak usually sometime in May.
61	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Juvenile Sockeye Salmon*	Another easier but less definitive way to assess whether Red Lake (and Martin River Off Channel Habitat (OCH)) sockeye are sea-type is to sample otoliths from spawned out fish and determine if they have any freshwater annuli. If they don't, they're determined to be sea-type. Otoliths, rather than scales, are preferred for this exercise as scales are reabsorbed and degrade when adult salmon return to freshwater to spawn, erasing some of the life history details otherwise present in scales. It's possible early life history (e.g., freshwater annuli) might still exist in scales of spawned out fish, but the whole scale may be reabsorbed by that point; therefore, otoliths are the preferred structure for this exercise. This method is less definitive than the age structure of outmigrating fry as there is no guarantee that the adults sampled derive from the Martin River/Red Lake as some could be strays from other populations. Thus, it's preferred to sample outmigrating fry to assess which ecotype Red Lake/Martin River sockeye are.

Comment No.	Entity	Document	Section	Comment
62	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Evidence of Distinct Sockeye Salmon*	The first paragraph states "Spawning sockeye salmon were observed in OCHs beginning on September 24, 2024 when four post spawned adults were documented in OCH2.8R-SS-1". Again on page 4-64 (last paragraph) the author notes observing sockeye spawning in OCH2.8R-SS-1 in early October. It's possible there are two distinct runs of sockeye into the Martin River, one that spawns in Red Lake (run timing in early June, as documented by ADF&G video project) and another that spawns in OCHs, possibly with a later run timing. It's also possible the adults observed spawning in OCHs in September/October may have entered the system in June, but didn't spawn until much later.
63	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Evidence of Distinct Sockeye Salmon*	The ADF&G video system documented post-spawn adult sockeye drifting back down-stream from Red Lake in September and even October, but virtually all those fish migrated into Red Lake in June. The "bright red fish" the report stated were observed in the inlet to Red Lake on September 24 were very likely spawning or post-spawning sockeye salmon. It's not unusual for lake spawning sockeye, even those that enter the lake in early summer, to live until early fall after spawning in August/September.
64	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Evidence of Distinct Sockeye Salmon*	Further evidence can be derived from photo 4-7 (page 4-59). The top image shows a clearly spawned out male sockeye salmon that was caught at Red Lake on September 30. The bottom image shows a female sockeye salmon caught on September 24 at OCH2.8R-SS-1. It does not appear that the latter (female) has spawned, as evidenced by the condition of the tail, which should be well frayed from nest digging. Were eggs extruded from this female? Or was any other note made regarding the spawning status of this fish? This may be evidence that there are two distinct runs of sockeye into the Martin River, with the OCH spawning component having later run timing than the Red Lake spawners.
65	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Evidence of Distinct Sockeye Salmon*	It is suggested to add mid-summer fish sampling trips to the 2025 schedule to assess the run timing of OCH spawning sockeye salmon. Limiting Martin River/OCH fish surveys to only Spring (May) and Fall (September/October) leaves a large gap that potentially limits understanding the run timing for all species that may be utilizing the Martin River drainage for spawning.
66	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Coho Spawning*	Page 4-57: The ADF&G video system documented active coho spawning directly in front of the camera in October each year the video was operated. Figure 4-38 should include the location of coho spawning redds in the Red Lake outlet stream.

Comment No.	Entity	Document	Section	Comment
67	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Additional Adult Fish Sampling*	Mainstem and OCH fish sampling should occur across a broader time frame. This report indicates there were just two multi-day sampling events, one in Spring (May) and one in fall (September/October). The spring event may be conducive for documenting juvenile rearing (and sockeye fry emigrating from Red Lake, if this gets added that to the 2025 plan), but it is insufficient to determine if chum or pink salmon spawn in the Martin River. These species are known to spawn in glacial systems and ADF&G staff observed five pink salmon at the video site in 2022, so it is known they are (at least sometimes) in the system.
68	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Additional Adult Fish Sampling*	ADF&G encourages the study team to beach seine areas of potential spawning riffles/runs in the main and off channels (especially turbid habitats where visual observations cannot be made) in July and August when chum and pink salmon typically spawn. If there are known areas where groundwater or hyporheic upwelling occurs in the Martin River, efforts should focus in these areas as chum salmon in particular are well known to prefer upwelling areas for spawning. Given the abundance of braided channels and porous substrates, there are likely many side channels in the Martin River with hyporheic upwelling.
69	ADF&G	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Additional Adult Fish Sampling*	As pink and chum salmon emigrate to the ocean soon after emerging, the study team will not find juveniles rearing in the areas they're sampling. If adult sampling does not occur, the fish studies may not be documenting all the species that could be using this system for spawning.
70	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *3.4 Methods - "No winter surveys were proposed as the Dixon Diversion Project would not operate during winter and Bradley Lake Project operations would not impact existing winter conditions"*	This statement is incorrect as worded. The project could change the geomorphology of the river, resulting year-round impacts to fish, habitat, and access to overwintering sites. If the intention is to say that winter surveys were not necessary because other studies would capture potential changes to overwintering habitat and habitat access, then please modify this statement to make that point.

Comment No.	Entity	Document	Section	Comment
71	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *4.6.3 Document Adult Coho and Sockeye Salmon Spawning Behavior*	We appreciate that the study expanded to document adult spawning in the off-channel riverine habitats. The mapped results were informative and helpful.
72	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *4.6.4 - Eulachon*	This section is brief. Is there more discussion on how the conditions influenced the Eulachon study?
73	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Appendix A - Mesohabitat Surveying for Martin River Clearwater Habitats*	The tables have two "Average Wetted Width (m)" columns. Is one supposed to be "Average Bankful Width (m)"?
74	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Appendix A - Mesohabitat Surveying for Martin River Clearwater Habitats*	Why does MR 1.070 have wetted width values that are higher than the corresponding bankful width values?
75	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Survey Limitations*	The Aquatic Habitat Characterization study noted that many sites were identified as tributaries by the GIS habitat mapping, but that ground sampling revealed no connectivity or water, and did not contain fish habitat (page 3-67).

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76	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Survey Limitations*	Tributary MR1.090 was identified during GIS habitat mapping, but the conclusion from ground sampling was that it was dry with no defined channel, and was unlikely to be connected to the mainstem at higher flow (page 3-47). The LiDAR-derived mapping product likely picked up this tributary because it accumulates enough water to provide surface flow at certain times, but when observed during dry periods the value for fish may be difficult to determine and could ultimately depend on its proximity to other habitat features, including habitat further upstream. The value of seasonal connection was shown in MR1.080.L1 where fish were sampled despite the lack of a permanent connection to the mainstem slough.
77	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Survey Limitations*	Habitat surveys during low flows were beneficial for maximizing the extent of clearwater habitats and surveyor access, but could have made habitat assessments and sampling challenging, especially without the use of electrofishing. Ephemeral and intermittent water bodies still have habitat value, especially where they are groundwater fed or provide connectivity to other habitats. Using bankfull width indicators during low flow conditions can help surveyors visualize what the habitat looks like in better conditions. For the smaller tributaries, fish sampling is more successful when flows are closer to bankfull, which might have influenced some of the habitat calls. Electrofishing would have been helpful for determining the end of habitat where the tributaries are small and depths are shallow. This sampling method has risks for larger-bodied and spawning fish, but those risks are usually less in these upper reaches.

Comment No.	Entity	Document	Section	Comment
78	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Survey Limitations*	Similarly, there is still habitat value for streams above the 12% gradient that was used to end habitat calls. The U.S. Forest Service (USFS) Aquatic Habitat Surveys Protocol provides an adult salmonid blockage table (22.6, Exhibit 01) with criteria for identifying fish passage barriers. Notably, for Dolly Varden char the gradient could be as high as 30% before habitat stops being suitable. For falls, there is no minimum pool depth required for passage if the jump is less than 1.2m for coho, and 0.6m other anadromous fish species. Also, USFS stream surveyors are instructed to make end-of-habitat calls based on gradient and bedrock barriers, but not on temporary (downed wood) or man-made obstructions (culverts). The Martin River Aquatic Studies Report describes an upper side slough draining OCH1.7R-SS-1 that had a 0.5m drop, channel gradient beyond 20 percent, and step pools over large wood pieces to explain the absence of fish habitat above the drop (page 3-41). While the value of habitat decreases in higher gradients and the end of habitat was likely in the vicinity of the drop, it is difficult to know how far away the call might have been without sampling in higher flows.
79	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Survey Limitations*	How many of the tributaries surveyed had end of habitat calls that could have been influenced by low flow conditions (observers using wetted width instead of bankful indicators, and too shallow for sampling) or channel gradient? Please include a statement that acknowledges additional habitat may exist in some of the channels surveyed that were ephemeral or where the gradient was beyond 12%.
80	USFWS	2024 Study Re	**Aquatic Studies Report**, 4.0 Martin River Fish Use Study, *Survey Limitations*	Ultimately, these study results will facilitate an effects analysis, and comparisons for future conditions and can be made as long as any future surveys follow the same methodologies. The study successfully documented habitat value and fish use throughout the study area.