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Tongass National Forest

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Greens Creek Mine

Tailings Disposal Facility Expansion

US Army Corps of Engineers

EPA

Draft Environmental Impact Statement

Volume 1

Lead Agency
USDA Forest Service, Tongass National Forest

Cooperating Agencies
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
State of Alaska
The City and Borough of Juneau

Prepared by
Tetra Tech, Inc.
310 K St., Ste. 200,
Anchorage, AK 99501

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Preliminary Draft
Environmental Impact Statement
Juneau, Alaska

Lead Agency:	**USDA Forest Service**
Cooperating Agencies:	**U.S. Army Corps of Engineers** **U.S. Environmental Protection Agency** **State of Alaska, Department of Natural Resources** **City and Borough of Juneau**
Responsible Official:	**Forrest Cole** **648 Mission Street** **Ketchikan, AK 99901**
For Information Contact:	**Sarah Samuelson, Interdisciplinary Team Leader** **Tongass National Forest Minerals Program Leader** **Admiralty Island National Monument** **8510 Mendenhall Loop Road** **Juneau, AK 99801** **(907) 789-6202**

Abstract: The purpose and need for the environmental impact statement includes evaluating the impacts associated with an expansion of the tailings disposal facility associated with an active lead/zinc mine located within the Admiralty Island National Monument (Monument) in Southeast Alaska. The analysis includes four alternatives: the proposed action which calls for a 30 to 50-year expansion of facilities within the Monument; a no action alternative under which an expansion would not be authorized; an alternative that provides an equal amount of waste disposal capacity while reducing the footprint within the Monument; and an alternative that would a allow expansion into the Monument but would avoid direct impacts to Tributary Creek, an anadromous stream in the project area. The scoping process identified water quality, aquatic resources, wetlands, and Monument values as significant issues.

Send Comments to:

By regular mail/ hand delivery:	**Admiralty Island National Monument** **Tongass National Forest** **ATTN: Greens Creek Tailings Expansion** **8510 Mendenhall Loop Road** **Juneau, AK 99801**
By email:	**comments-alaska-tongass-admiralty-national-monument@fs.fed.us** **Please note "Greens Creek Tailings Expansion" in the subject line**
Date Comments Must Be Received:	**June 4, 2012**

The U.S. Army Corps of Engineers is also soliciting comments from the public; federal, state, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. If you wish to provide comments on the proposed activities subject to the jurisdiction of the U.S. Army Corps of Engineers, please provide them to the U.S. Army Corps of Engineers and the Forest Service by the date indicated above. Comments to the U.S. Army Corps of Engineers should be sent to the following address:

U.S. Army Corps of Engineers
Alaska District, Regulatory Division
ATTN: Heidi Firstencel
Juneau Field Office
8800 Glacier Highway, Suite 106
Juneau, AK 99801

or by email at heidi.x.firstencel@usace.army.mil

SUMMARY

This environmental impact statement (EIS) was developed in support of the Tongass National Forest's proposal to modify the existing General Plan of Operations (GPO) for the Greens Creek Mine. The Greens Creek Mine is located on Admiralty Island approximately 18 miles southwest of Juneau, Alaska. The mine has been in operation since 1988 with periods of temporary closure. Major mine facilities include the underground mine, mill, waste rock disposal areas, tailings disposal facility (TDF), a port site and camp, roads and power infrastructure among the mine components. The mine produces lead and zinc concentrates that also contain silver. The Greens Creek Mine is operated by Hecla Greens Creek Mining Company (HGCMC).

HGCMC has proposed a modification to its GPO to expand the TDF so that it can accommodate an additional 30 to 50 years' worth of tailings and waste rock. Tailings are disposed via dry stacking along with co-disposed waste rock. The TDF is currently approved to hold 5.3 million cubic yards of tailings and waste rock and cover approximately 62 acres. At the current mining rate, the TDF will be filled to capacity in 2014. In order to continue operations, HGCMC has requested an expansion of the TDF to hold an additional 9.7 million cubic yards of tailings and waste rock.

Major portions of the mine are located on National Forest System lands and most of the TDF is located in the Admiralty Island National Monument (Monument). The U.S. Department of Agriculture (USDA), Forest Service, Tongass National Forest (Forest Service) developed the first EIS for the Greens Creek Mine in 1983 and approved the original GPO in 1984. As common with large mines, there have been changes to the GPO since mine development. The Forest Service has approved various GPO modifications and developed documents under the National Environmental Policy Act (NEPA), where applicable, for these approvals. The NEPA background is described in Chapter 1 of this EIS.

This EIS focuses on evaluation of the environmental effects associated with expansion of the TDF and alternatives. The Forest Service is the lead agency in preparing this EIS. The cooperating agencies participating in the EIS process include the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency, the State of Alaska (represented by the departments of Natural Resources, Environmental Conservation, and Fish and Game) and the City and Borough of Juneau. These agencies are cooperating agencies because they also need to comply with NEPA, or they are using the NEPA analysis for their own decisions, or they bring special expertise to assist the Forest Service in developing the EIS. Chapter 1 provides information on the permits and approvals required by the cooperating agencies and other agencies for expansion of the TDF.

Purpose and Need and Federal Decisions to be Made

The purpose and need for the federal actions covered by this EIS is to act on HGCMC's proposed modification to the GPO to expand the TDF. Specifically, HGCMC is proposing to extend the footprint of the existing TDF south into the Monument providing capacity for an additional 9.7 million cubic yards of tailings and waste rock (approximately 64 acres beyond the current permitted footprint). In addition to increased disposal TDF capacity and disturbance footprint, the proposed action would include an increase of the HGCMC's existing lease area by 114 acres. Ancillary facilities associated with the TDF, combined with the TDF expansion itself, would result in a total of 143 acres of new disturbance under the proposed action.

The Forest Service will make a decision on HGCMC's GPO modification proposal and will decide whether to select the proposed action or another alternative for implementation. In addition, the Forest Service could add stipulations or require additional mitigation measures.

Expanding the TDF or creation of a new TDF would require the discharge of fill material into waters of the U.S. This activity requires a Clean Water Act (CWA) Section 404 permit. Therefore, the USACE's decision is whether to issue or deny the CWA 404 permit. The USACE could also add stipulations or require additional mitigation measures.

Scoping and Significant Issues

The Notice of Intent (NOI) to prepare the EIS for the Greens Creek Mine TDF Expansion Project was published in the Federal Register on October 5, 2010. The publication of the NOI initiated the scoping process and a public review and comment period required under NEPA. Scoping is a process intended to assist the Forest Service and the cooperating agencies in identifying areas and issues of concern associated with the proposed TDF expansion, and is designed to ensure that all significant issues are fully addressed during the course of the EIS process.

Public scoping meetings were held on October 14, 2010, in Juneau and on October 15, 2010, in Angoon. Oral and written comments were accepted at the public scoping meetings and throughout the scoping process. The Forest Service collected additional comments sent from the public; local, state, and federal agencies; non-governmental organizations; professional and trade organizations; and native corporations and tribal organizations. The formal scoping period ended on November 19, 2010.

Scoping comments were distilled into significant issues that were used to develop alternatives to the proposed action and identify key areas that need to be addressed in the environmental impacts analysis. The following significant issues of public concern were identified by the Forest Service as key issues to be addressed in this EIS.

Issue 1: Water quality may be impacted directly by runoff from acid-generating material or by direct impacts of the expanded facilities or by marine discharges of mine water. The impacts to water quality could adversely impact aquatic life.

Issue 2: Expansion of the mine tailings disposal facility may cause direct and indirect impacts to wetlands. Loss of wetlands can affect migrating and resident birds as well as other wildlife species. Any impacts to wetlands must be mitigated.

Issue 3: Construction of the tailings and waste rock disposal facility, contact water ponds, and roads along or over creeks could negatively impact anadromous and resident salmonids and other fish species.

Issue 4: The Greens Creek Mine and proposed expansion occurs partially within the Admiralty Island National Monument. The Monument was established for the purpose of protecting objects of ecological, cultural, geological, historical, prehistorical, and scientific interests. Any lease of Monument lands for mining must not cause irreparable harm to Monument values.

Other Issues: Other issues were identified during the scoping process as important, but did not influence the development of alternatives. These issues were taken into consideration in the impact analysis and development of mitigation measures. These issues included air quality and dust concerns, adequacy of financial assurance for mine closure and long-term water treatment, and potential impacts to transportation and utility corridors.

Chapter 1 of the EIS describes these issues in more detail and metrics that guided the impact analysis in relation to the issues.

Alternatives

Based on the proposed action and the significant issues, the Forest Service and cooperating agencies developed the following alternatives for analysis in this EIS:

- Alternative A (No Action): Under this alternative, tailings disposal (and therefore mining) would cease in approximately 2014 when the currently approved TDF reaches its full capacity. The TDF would be reclaimed and closed.
- Alternative B (Proposed Action): Under this alternative, the tailings lease area and TDF footprint would be extended south into the Monument providing capacity to dispose of an additional 9.7 million cubic yards of tailings and waste rock. This equates to an additional 30–50 years of mine life.
- Alternative C (TDF located outside the Monument): The existing TDF would be expanded to accommodate an additional 1 million cubic yards of tailings (approximately three additional years of capacity). A new, separate TDF would be built outside the Monument with capacity to accommodate an additional 9 million cubic yards of tailings and waste rock.
- Alternative D (Modified Proposed Action): The existing TDF would be expanded to accommodate an additional 3 million cubic yards of tailings (approximately 10 years of capacity). A new, separate TDF would be built outside the Monument to accommodate an additional 7 million cubic yards of tailings and waste rock disposal corresponding to a total mine life of an additional 30–50 years.

The major difference among the alternatives is the location and configuration of the TDF (or TDFs). The type of tailings disposal (dry stack), TDF construction methods, water management and treatment, and reclamation and closure plans are the same for all alternatives. In addition, mining, milling, and concentrate transport are the same for all alternatives.

Each of the action alternatives (B through D) also includes construction of water treatment ponds, access roads, and laydown areas for storage of reclamation materials. In addition, rock quarries would be needed to obtain materials to construct the TDF extension (or new TDF). Table ES-1 provides the estimated disturbance areas for the alternatives. The alternatives are described in detail in Chapter 2.

Table ES-1. Estimated TDF Disturbance for No Action and Action Alternatives (in Acres).

Project Component	Alternative A	Alternative B	Alternative C	Alternative D
Tailings	—[a]	64.2	101.7	103.1
Reclamation Material Storage	—[a]	17.0	10.3	14.5
Quarry	—[a]	17.6	8.6	16.4
Ponds	—[a]	12.0	7.1	6.7
Roads, including ditches and pipelines	—[a]	19.1	11.5	19.5
Truck Wheel Wash	—[a]	0.1	0.1	0.1
Ancillary Disturbance	—[a]	12.8	17.5	17.6
Total New Disturbance	—[a]	142.8	156.8	177.9
Total Disturbance	65.3[b]	208.1	222.1	243.2

Notes:

a. Component of the existing disturbance associated with tailings disposal.
b. Total disturbance following the 2003 ROD.

Environmentally Preferable and Preferred Alternatives

NEPA requires the lead federal agency to identify both an Environmentally Preferable Alternative and a Preferred Alternative. The Forest Service will identify these alternatives in the final EIS and its Record of Decision (ROD).

Affected Environment and Environmental Consequences

Chapter 3 of the Draft EIS describes the affected environment and environmental consequences for each alternative. Because this EIS is focused on expanding tailings disposal capacity, the project area for the impact assessment includes the areas and watersheds of the proposed TDF expansion. Areas beyond the TDF are also described and consequences evaluated if they could be subject to indirect or cumulative effects for a particular resource.

Chapter 3 is divided into separate sections for each resource considered in the EIS (e.g., air, wetlands, water quality, cultural resources, etc.). Each resource section is further divided into subsections that provide the following information:

Pre-mining environment: An overview of the pre-mining environment is provided based on information in the 1983 EIS. This information is simply summarized since the reader can refer to the 1983 EIS for more detail.

Current (baseline) conditions: The current (baseline) conditions for each resource are described. Since the mine has been in operation for more than 20 years, the baseline conditions include impacts that have occurred as a result of existing operations.

Environmental consequences of each alternative: The environmental consequences sections consider the future impacts that would occur for each of the alternatives based on the current conditions. When the EIS identified potential impacts, mitigation measures were identified to reduce impacts. In addition, monitoring is identified to assess the effectiveness of mitigation measures and allow for adaptive management decisions to revise the measures. In addition, monitoring is identified where there is some uncertainty associated with the impacts analysis.

A summary of the predicted environmental effects for each resource area for the proposed action and alternatives is presented in Table ES-2.

Table ES-2. Summary of Potential Impacts of Each Alternative by Resource.

General	Impact Duration of Mine Life	Alternative A Through 2014	Alternative B 30–50 More Years	Alternative C 30–50 More Years	Alternative D 30–50 More Years
Air Quality	Uncontrolled: $PM_{10-2.5}$ tons per year (tpy)	142	170	229	230
	$PM_{2.5}$ tpy	17	22	30	30
	Controlled: $PM_{10-2.5}$ tpy	77	97	125	129
	$PM_{2.5}$ tpy	9	13	16	16
Water Resources–Surface Water	Percent of watersheds affected by new disturbance	Tributary Creek: 1 Cannery Creek: 0 Fowler Creek: 0	Tributary Creek: 20 Cannery Creek: 0 Fowler Creek: 0	Tributary Creek: 3 Cannery Creek: 0 Fowler Creek: 0	Tributary Creek: 4 Cannery Creek: 0 Fowler Creek: 0
	Reduction in stream flow	Minor reduction of flow in two creeks (Tributary and Cannery)	Minor reduction in flow in two creeks (Tributary and Cannery) but more than Alternative A	Minor reduction in flow in three creeks (Tributary, Cannery, and Fowler)	Similar to Alternative C although effects in Fowler Creek would be delayed by approximately 12–15 years
	Additional water management infrastructure such as diversions, groundwater slurry walls, and water management ponds	Yes as TDF expands to currently approved size	Yes; more water management infrastructure required than Alternative A	Yes; more total infrastructure required than Alternative B; additional water management infrastructure required for new TDF	Similar to Alternative C although additional water management for new TDF would not be put in place until construction began in approximately 12–15 years
	Need for long-term water treatment	Yes	Yes	Yes	Yes
Water Resources–Groundwater	Change in flow or quality	Minimal effect on local hydrogeology; no impacts to groundwater quality	Similar to Alternative A	Similar to Alternative A but new TDF located in additional groundwater area	Similar to Alternative C

Table ES-2. Summary of Potential Impacts of Each Alternative by Resource.

General	Impact Duration of Mine Life		Alternative A Through 2014	Alternative B 30–50 More Years	Alternative C 30–50 More Years	Alternative D 30–50 More Years
Aquatic Resources	Habitat permanently lost (feet)	Class I	Tributary: 0 Fowler: 0	Tributary: 1,646 Fowler: 0	Tributary: 0 Fowler: 34	Tributary: 0 Fowler: 34
		Class II	Tributary: 0 Fowler: 0	Tributary: 2,400 Fowler: 0	Tributary: 0 Fowler: 1,044	Tributary: 0 Fowler: 1,044
	Risk of chemical or mining product spill		Low, due to best management practices (BMPs) and Spill Prevention, Control, and Countermeasure Plan requirements	Similar to Alternative A, although operations would continue over 30 to 50 years, increasing the chance of a spill	Similar to Alternative B except increased risk in Fowler Creek drainage	Similar to Alternative C
Geochemistry	Likelihood of TDF ARD developing		Low due to very low permeability, low availability of oxygen and closure and reclamation of TDF	Same as Alternative A although a pile contains a larger volume of tailings	Same as Alternative B	Same as Alternative B
Geotechnical Stability	Likelihood of TDF failure		Very low probability of TDF failure due to design measures	Same as Alternative A	Same as Alternative A	Same as Alternative A
Soils	New loss in soil productivity (measured in acres disturbed)		0	141	156	169
Vegetation	Acres of disturbance		0	Productive old growth (POG): 109 acres Non-forested: 99 acres	POG: 130 acres Non-forested: 91 acres	POG: 140 acres Non-forested: 95 acres
	Off-site effects		Elevated metals levels in lichens may continue through life of operations; duration of effects would depend on the effectiveness of control measures	Similar to Alternative A; however, off-site effects may continue longer due to longer mine life	Similar to Alternative B	Similar to Alternative B

Table ES-2. Summary of Potential Impacts of Each Alternative by Resource.

	Impact	Alternative A	Alternative B	Alternative C	Alternative D
General	**Duration of Mine Life**	**Through 2014**	**30–50 More Years**	**30–50 More Years**	**30–50 More Years**
Wetlands	Acres and types disturbed	0	Bog: 54.8 Forested: 43.3 Fen: 0.5 Marsh: 0.4 Total: 99	Bog/Bog Woodland: 11.7 Forested: 75.4 Sedge Fen/Fen: 24.9 Marsh: 1.1 Total: 114.2	Bog/Bog Woodland: 13.6 Forested: 76.9 Sedge Fen/Fen: 32.5 Marsh: 1.9 Total: 124.9
Wildlife	New decrease in brown bear buffers (acres)	None	23	<1	1
	Duration of activities that could disturb wildlife and marine mammals	Through 2014	Additional 30–50 years	Additional 30–50 years	Additional 30–50 years
	New removal of POG habitat (acres)	None	109	130	140
	New reduction in deer winter range habitat (acres)	None	109	130	140
	Result in “take” of Endangered Species Act (ESA)-listed species	No	No	No	No
	Number of goshawk nests potentially affected	0	0	1	1
Threatened (FT) and endangered (FE) species / Forest Service Sensitive Species (FSS)	Humpback whale (FE)	Not likely to adversely affect			
	Stellar sea lions (FE)	May affect, but is not likely to adversely affect			
	Yellow-billed loon (candidate and FSS)	May impact individuals but is not likely to cause a trend to federal listing or loss of viability			
	Chinook salmon; sockeye salmon; steelhead (FT or FE, depending on the run)	No effect			
	Queen Charlotte goshawk (FSS)	May impact individuals but is not likely to cause a trend to federal listing or loss of viability			
	Black oystercatcher (FSS)	May impact individuals but is not likely to cause a trend to federal listing or loss of viability			

Table ES-2. Summary of Potential Impacts of Each Alternative by Resource.

General	Impact Duration of Mine Life	Alternative A Through 2014	Alternative B 30–50 More Years	Alternative C 30–50 More Years	Alternative D 30–50 More Years
Land Use	Meet management prescriptions	Yes	Yes	Yes	Yes
Recreation	Duration of operations (when public may be excluded from areas)	Through 2014 plus reclamation period	Additional 30–50 years plus reclamation period	Same duration as Alternative B; disturbance at new TDF initiated in approximately 2–3 years	Disturbance at new TDF not initiated until approximately year 12
Scenic Resources	Compliance with applicable scenic integrity objective (SIO)	Yes	Yes	Yes	Yes
	Duration of visual effects	Around 2014 plus reclamation establishment period	Additional 30–50 years plus reclamation establishment period	Reclamation at existing TDF to begin in approximately 2–3 years; reclamation of new TDF at end of mining activity (30–50 years); reclamation establishment period applies to both facilities	Reclamation at existing TDF to begin in approximately 12 years; additional 30–50 years of mining activity at new TDF; reclamation establishment period applies to both facilities
	Location of TDF	Current location	Expanded at current location	Minimal expansion at current location and new site to the north	Moderate expansion at current location and new site to the north
Subsistence	Duration of mine life	Through 2014	30–50 more years	30–50 more years	30–50 more years
	New reduction in deer winter range habitat (acres)	None	109	130	140
	Location of TDF	Current location	Expanded at current location	Minimal expansion at current location and new site to the north	Moderate expansion at current location and new site to the north
Cultural Resources	Effects on historic properties	Historic properties not adversely affected; Hawk Inlet identified as a sacred place by Angoon affected over the long term.	Same as Alternative A	Same as Alternative A	Same as Alternative A
Socioeconomics	Duration of annual economic and employment benefit from operations	Through 2014	30–50 more years	30–50 more years	30–50 more years

Table ES-2. Summary of Potential Impacts of Each Alternative by Resource.

	Impact	Alternative A	Alternative B	Alternative C	Alternative D
General	**Duration of Mine Life**	**Through 2014**	**30–50 More Years**	**30–50 More Years**	**30–50 More Years**
Monument Values	New disturbance within Monument (acres)	0	109	9	27
	Post mining condition	Near-natural condition following reclamation	Similar to Alternative A	Similar to Alternative A	Similar to Alternative A
Environmental Justice	Disproportionately affect minority or low income populations	No	No	No	No

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Appendix I. Cultural Resources

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List of Acronyms

ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ANILCA	Alaska National Interest Lands Conservation Act
APDES	Alaska Pollutant Discharge Elimination System
ARD	acid rock drainage
BA/BE	biological assessment / biological evaluation
BMP	best management practice
BPT	best practicable control technology
CAA	Clean Air Act
Cannery	cannery facility
CBJ	City and Borough of Juneau
CWA	Clean Water Act
DPS	distinct population segment
EFH	essential fish habitat
EIS	environmental impact statement
ESA	Endangered Species Act
Forest Service	U.S. Department of Agriculture Forest Service, Tongass National Forest
GMU	Game Management Unit
GPO	General Pan of Operations
HGCMC (the proponent)	Hecla Greens Creek Mining Company
KGCMC	Kennecott Greens Creek Mining Company
LUD	Land Use Designation
MBTA	Migratory Bird Treaty Act
MIS	Management Indicator Species
MMPA	Marine Mammal Protection Act

Monument	Admiralty Island National Monument
MOU	Memorandum of Understanding
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSHA	Mine Safety and Health Administration
NAAQS	National Ambient Air Quality Standards
NAWS	non-agricultural wage and salary
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NRHP	National Register of Historic Places
POG	Productive old growth
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
SDM	size-density model
SHPO	State Historic Preservation Officer
SIO	scenic integrity objective
SPCC	spill prevention control and countermeasures
TDF	tailings disposal facility
tpy	tons per year
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VCU	value comparison unit
VPR	Visual Priority Travel Route and Use Area
WAA	Wildlife Analysis Area
WQS	Water Quality Standards
WWTP	wastewater treatment plant

CHAPTER 1. PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 Background

The Greens Creek Mine is an underground metals mine (primarily lead, zinc, and silver) located near Hawk Inlet on northern Admiralty Island. It is located approximately 18 miles southwest of Juneau, Alaska (refer to Figure 1.1-1). The mine access and processing facilities are situated in the Greens Creek watershed while the tailings disposal facility (TDF) is located in portions of the Tributary Creek, South Hawk Inlet, and Cannery Creek watersheds. The mine and portions of the TDF are within the Admiralty Island National Monument (Monument); at its nearest point, the Kootznoowoo Wilderness is less than 2 miles from the mine's mill and mine portal. In 1980, Congress provided for mining within the Monument at the Greens Creek site in Section 503 of the Alaska National Interest Lands Conservation Act (ANILCA). On an annual basis, production from the Greens Creek Mine yields approximately 10 million ounces of silver, 65,000 ounces of gold, and a total of 200,000 tons of zinc, lead, and bulk concentrates.

Before mining operations began, the U.S. Department of Agriculture (USDA), Forest Service, Tongass National Forest (Forest Service), published the Greens Creek Final Environmental Impact Statement (EIS) (USFS 1983) and issued its Record of Decision (ROD) for overall development and operation of the mine. In early 1984, the Forest Service approved a General Plan of Operations (GPO) for Noranda Mining, Inc., the owner and operator at that time.

That original 1984 GPO called for underground mining with ore crushed and concentrated via flotation in a mill near the mine portal. Under the plan, the ore concentrate was to be trucked approximately nine miles to a port on Hawk Inlet at a former cannery facility (Cannery); from there, it was to be shipped to smelters outside Alaska for processing and refining. The *tailings*—the material left after most of the target metal minerals have been removed—were to be piped along the road corridor as a *slurry*, or watery mixture, to a site near the Cannery for disposal. While planning was still going on, ownership of the mine changed, and in early 1986, Amselco assumed control of operations. The new owner changed some aspects of the GPO, particularly the method of tailings disposal. Instead of disposing the tailings as a slurry, Amselco proposed to remove most of the water from the tailings via thickening and filtration and truck the dry tailings to a smaller area at the same site near the Cannery for disposal. In July 1987, the Forest Service determined that this and other proposed changes to the GPO required a review under the National Environmental Policy Act (NEPA). The following year, the Forest Service published the *Environmental Assessment for Proposed Changes to the General Plan of Operations for the Development and Operation of the Greens Creek Mine* (USFS 1988).

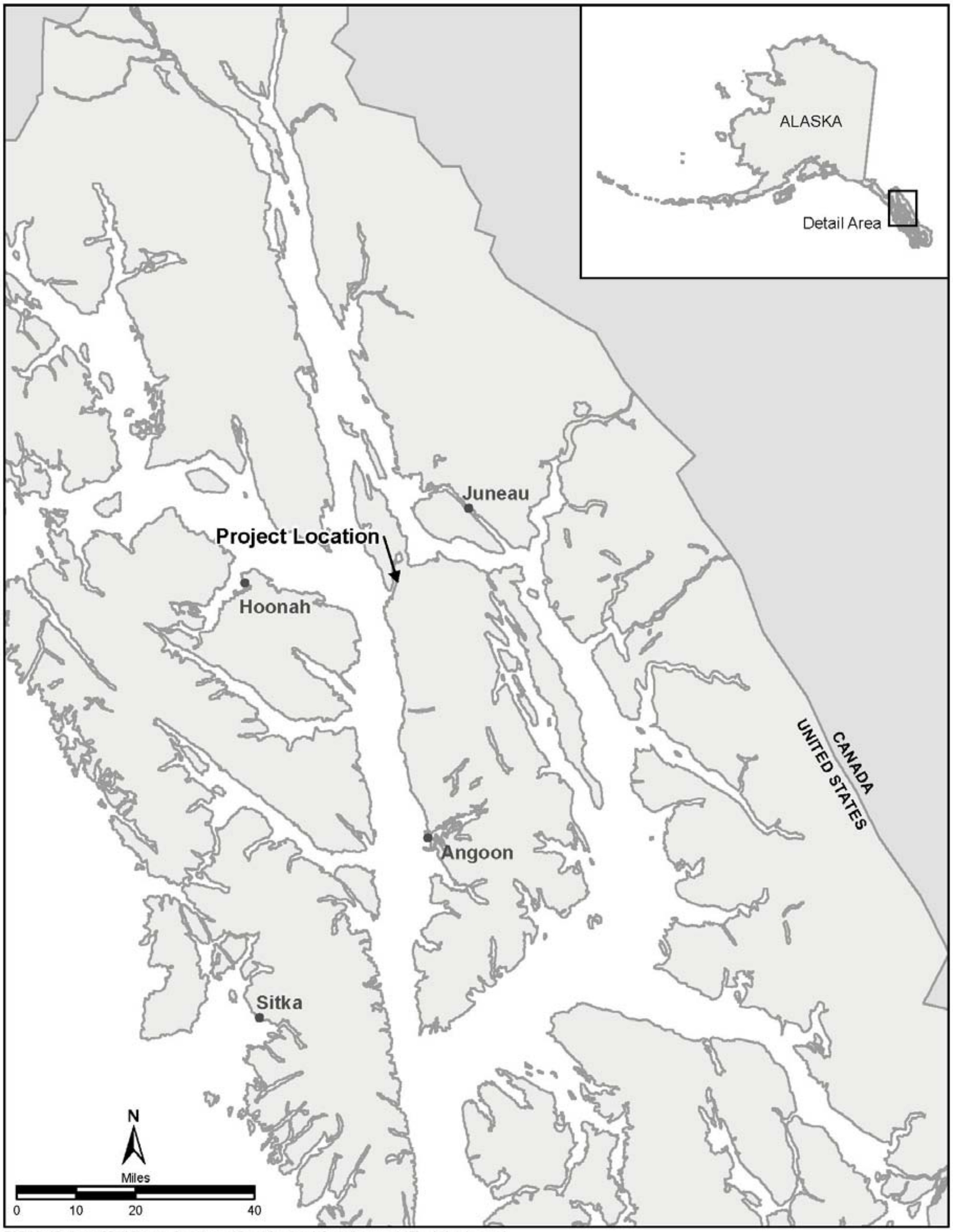

Figure 1.1-1. Greens Creek Project – General Location Map.

Tailings and waste rock conversion:

1.8 tons of tailings = 1 cubic yard

1.7 tons of waste rock = 1 cubic yard

Full-scale development of the mine began in 1987. Workers excavating for the mill site found a large, unanticipated volume of porous soil that had to be removed in order to provide a suitable foundation for the mill. Because this soil was placed in the mine's approved waste rock disposal site, higher volumes of waste rock than anticipated were disposed of at the TDF, which decreased available capacity for tailings. Also, ongoing exploration had identified additional ore reserves. In response to these changed circumstances, in 1990 the project's operator, then Kennecott Greens Creek Mining Company (KGCMC), sought approval for additional waste rock disposal capacity. As a result, in 1991 the Forest Service began a third NEPA review and the following year published the *Environmental Assessment for Additional Waste Rock Disposal Capacity at Greens Creek Mine* (USFS 1992).

In April 1993, KGCMC temporarily suspended mining operations due to depressed metals prices. On April 1, 1996, Congress passed Greens Creek Land Exchange Act, which granted Greens Creek title to the subsurface of 7,500 acres of public land immediately adjacent to their claims. As a result of the implementation of the agreement ratified by the act, the United States acquired 139 acres of private inholdings in the Admiralty Island National Monument and 50 acres of private inholdings in the Misty Fjords National Monument. Upon completion of mining and after reclamation, the exchanged 7,500 acres, as well as all lands currently owned or yet to be acquired by KGCMC on Admiralty Island, will revert to the United States and will be included in the Admiralty Island National Monument, Tongass National Forest. KGCMC reopened the project in July 1996, and in conjunction with the resumption of mining operations, the Forest Service approved an amendment to the GPO. Based on the need for additional surface tailings disposal, in January 2001, KGCMC submitted a proposal to the Forest Service requesting a modification of the existing GPO for expansion of both the area and the disposal capacity of the TDF existing at that time. In November 2003, the Forest Service released the *Greens Creek Tailings Disposal Final Environmental Impact Statement* (USFS 2003). The ROD resulting from the 2003 EIS approved an expansion of the TDF to accommodate an additional 3.3 million cubic yards of tailings storage capacity which was intended to address KGCMC's tailings disposal needs through 2025. Figure 1.1-2 illustrates the general locations of existing facilities at the site, which were previously authorized. Figure 1.1-3 illustrates a detailed aerial view of the existing TDF disturbance.

In April 2008, the Hecla Greens Creek Mining Company (HGCMC) purchased the project from KGCMC and assumed control of the mine's operation. In April 2009, HGCMC submitted a request to the State of Alaska and the Forest Service to co-dispose waste rock that was being stored at "Site E," with tailings at the TDF. The co-disposal request resulted from concerns about the formation of acid rock drainage (ARD) at Site E, which was unlined and without adequate drainage control. Site E contains approximately 365,000 cubic yards of material, of which approximately 270,000 cubic yards is waste rock that had been placed into the facility between 1988 and 1994. The remaining 95,000 cubic yards is glacial till from the original mill site excavation. The proposal involved the removal of waste rock from Site E, disposing of the waste rock at the TDF, and storage of the till material for use in later reclamation. Plans for

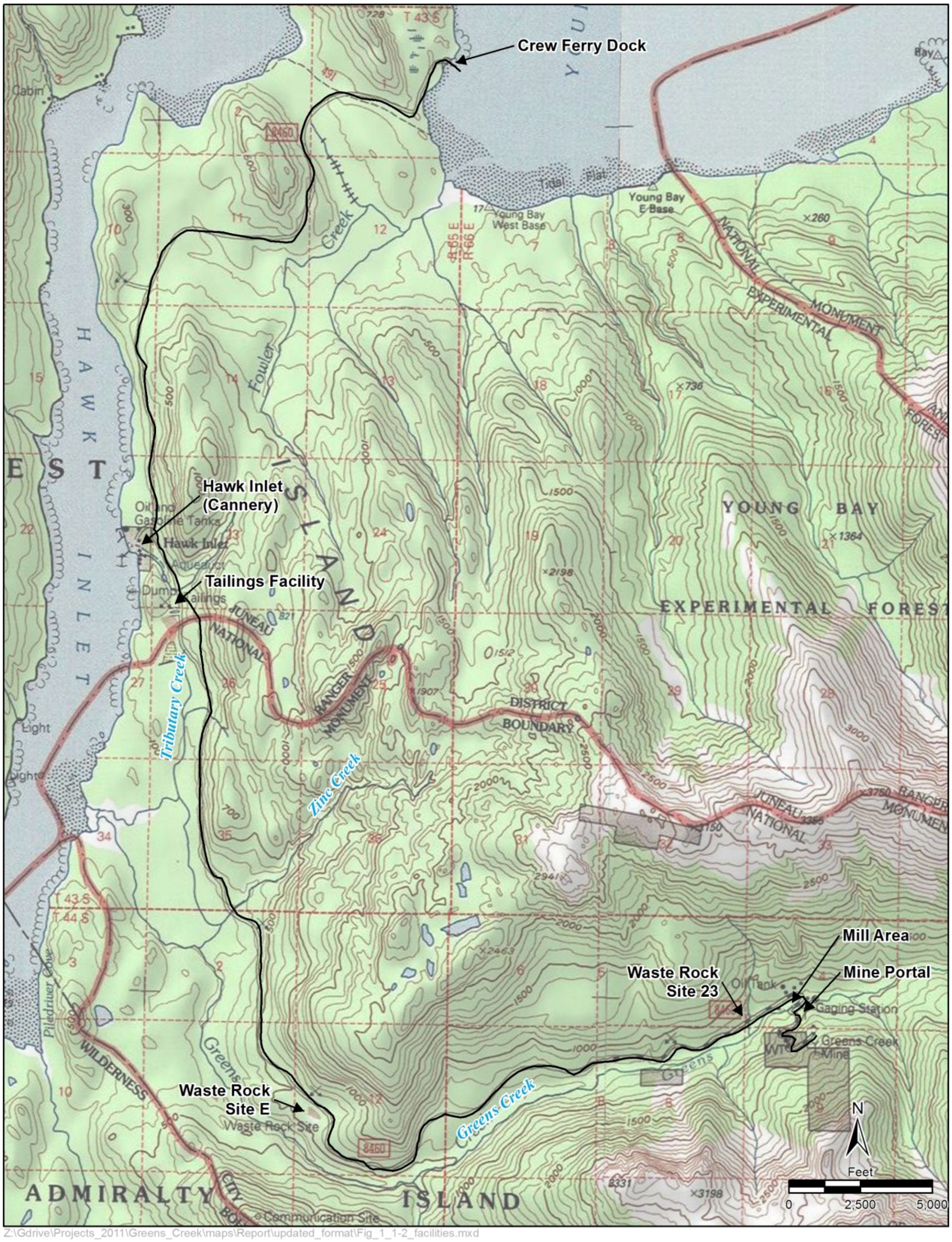

Figure 1.1-2. Greens Creek Project General Location of Existing Facilities.

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Figure 1.1-3. Greens Creek Tailings Facility.

reclamation of Site E require HGCMC to consolidate, hydroseed, and stabilize the till within the existing footprint of Site E, control drainage and recontour slopes.

Ultimate reclamation of the site once the till material is removed will include regrading the site to match, as closely as possible, original contours. HGCMC's submittal included documentation supporting the geotechnical stability of co-disposal of the waste rock within the TDF. The Forest Service conducted a change analysis on the submittal and determined that the modifications did not represent a substantial change requiring a revision or supplement to the 2003 Tailings Expansion FEIS and ROD. The Forest Service approved the modification in June 2009. Additionally, the Alaska Department of Environmental Conservation (ADEC) reviewed the proposal for co-disposal and approved the modification in April 2009. Reclamation of Site E removal will be as described in Hecla's Site E Removal Plan (HGCMC 2009); subject to annual removal plans approved by the USFS and ADEC.

HGCMC has revisited the approved capacity of the TDF. Based on current production levels, HGCMC estimates that the TDF has the capacity to accommodate tailings and waste rock placement through approximately 2014. The apparent "loss" in disposal capacities and volumes anticipated in the 2003 EIS and GPO compared to current calculations results from two sources. The first is a reduction in capacity of the approved TDF. Capacity is reduced because geotechnical conditions (i.e., steep slopes and unstable material) prevented the safe use of some of the areas that had been approved for tailings disposal in 2003. The second reason is an increase in the average annual production of tailings and waste rock being placed into the TDF. While the 2003 EIS volumes reflect a tailings disposal rate of approximately 150,000 cubic yards per year, the metered volume over the last 10 years has been closer to 167,000 cubic yards of tailings plus an additional 30,000 cubic yards of waste rock annually.

With continued discovery of new ore and improved metal prices, HGCMC believes they can extend the life of the mine for another 30 to 50 years. Consequently, to process the known ore reserves, additional disposal capacity of approximately 15 million cubic yards is needed for tailings and waste rock material. Based on that need, in February 2010, HGCMC submitted a letter to the Forest Service requesting a modification of the existing GPO for expansion of both the area and the disposal capacity of the existing TDF. HGCMC's request for the "Stage 3" tailings expansion noted that all other aspects of the operation, including production rates, employment levels, and shipping procedures would remain the same.

The Forest Service reviewed the HGCMC proposal and developed a proposed action to carry forward. The Forest Service determined that an EIS should be prepared. In October 2010, the Forest Service issued a Notice of Intent (NOI) to prepare an EIS to analyze and discuss the effects of proposed changes to the TDF. In the process of preparing the analysis, the Forest Service encouraged public comment through the scoping process (initiated October 5, 2010). Based on the input gathered during scoping, the Forest Service identified *significant issues*—those issues related to the proposed action that cannot be mitigated and are likely to cause impacts to the environment. Through the consideration of these significant issues, the Forest Service formulated alternatives to the proposed action, including a No Action Alternative. This EIS analyzes the proposed action and alternatives to the proposed action and their effects on pertinent physical, biological, and social resources in the area of the proposed expansion.

1.2 Purpose and Need

The purpose of this EIS is for the Forest Service to consider certain changes to the approved HGCMC GPO regarding tailings and waste rock disposal and related infrastructure.

The proposed action, which is the action proposed by HGCMC, is to extend the TDF footprint south into the Monument providing capacity for tailings and waste rock disposal for an additional 30 to 50 years. With continued exploration identifying additional ore, improved metal prices, and ongoing operational efficiencies, there is a need for additional tailings and waste rock disposal capacity and related infrastructure at the Greens Creek Mine to allow for continuous site operations in a safe, environmentally sound, technically feasible, and economically viable manner, while remaining in compliance with regulatory requirements.

This EIS analyzes impacts that could result from expansion of the TDF. Other mine project components (e.g., the underground mine, mine road, waste rock disposal site, Hawk Inlet terminal, etc.) are not addressed because they were analyzed in previous EISs.

1.3 Proposed Action

Annual exploration activity by the Greens Creek Mine has continued to maintain its proven reserves at the 10-year life-of-mine level. Therefore, the mine has operated as a "10-year" mine for the last 20 years with the likelihood that new reserves will continue to be identified well into the future. The combination of new proven reserves and high metal prices has driven the need for additional tailings disposal capacity to allow for the continued operations of the Greens Creek Mine. HGCMC has estimated that pre-tailings construction work would need to begin in 2012 to prepare the site for tailings placement in 2014.

The TDF at the Greens Creek Mine is built and operated using the dry stack tailings disposal technique. This technique allows less ground disturbance than either conventional slurry tailings or paste tailings disposal by reducing the overall volume of waste material. HGCMC proposes to extend the existing TDF in a southward direction for the targeted additional capacity.

Proven, Inferred, and Probable Resources

Proven resources have been defined clearly enough to report to stockholders based on requirements established by the Securities Exchange Commission. Inferred and probable resources are on a less robust level of sampling and reflect either other portions of the ore body or new ore bodies. The request of the expansion is based on these inferred and probable reserves and HGCMC's belief that they will be economical to mine in the future.

The TDF expansion would accommodate an estimated additional 15 million cubic yards of tailings and waste rock. This expansion would include capacity for ongoing operations and project reserves, and provide volume for waste rock co-disposal and an expanded resource base being defined by ongoing on-site exploration activities. Based on these assumptions the expanded TDF could provide enough capacity for the next 30–50 years of mine operations. Waste rock co-disposed could include material generated in the mining process as well as waste rock currently located in existing on-site disposal facilities. The planned expansion would also meet HGCMC management direction to design and permit a "long-term" TDF capable of handling projected operational requirements. HGCMC proposes to use the same tailings disposal techniques, environmental management procedures, and reclamation measures that were analyzed in the 2003 EIS for the site. The expanded TDF proposed by HGCMC would add roughly 60 acres to the TDF, essentially doubling the size of the currently approved facility. Based on preliminary engineering analyses, the tailings expansion would increase the height of the overall facility.

As part of the proposed expansion, HGCMC would incorporate additional supporting infrastructure, including storm water facilities, quarry sites, reclamation material storage areas, new access roads, a new truck wash facility, a new or expanded water treatment plant, and an upgraded water discharge outfall line into Hawk Inlet.

As the TDF expanded, HGCMC would have the ability to initiate interim or concurrent reclamation on sections of the TDF as they reached full design capacity. In addition, HGCMC would continue to use the operational, maintenance, and monitoring techniques for tailings that the operator has employed since the late 1980s, as well as the more recently approved procedures which allow co-disposal of waste rock into the TDF. The company would continue to meet the requirements set forth under the State Waste Management Permit and the Alaska Pollutant Discharge Elimination System (APDES) permit.

1.4 Decisions to Be Made

The Forest Supervisor of the Tongass National Forest is the responsible official for deciding whether to select the proposed action or another alternative for implementation. In addition to increased disposal capacity and disturbance footprint, the proposed action would include an increase of the HGCMC's existing lease area to accommodate additional tailings disposal[1].

The U.S. Army Corps of Engineers (USACE) will decide whether to issue permits under Section 404 of the Clean Water Act (CWA). Section 404 permits are required for some of the activities related to expansion of the TDF. Section 1.8 provides additional information on the USACE's responsibilities; Appendix A presents the USACE's public notice and HGCMC's section 404 permit application. The Alaska District Engineer is the responsible official for the USACE. The USACE is a cooperating agency in developing the EIS.

The Forest Supervisor and Alaska District Engineer will identify any additional mitigation measures and monitoring required for this project. The Forest Supervisor and Alaska District Engineer will document their respective decisions in records of decision, which will include the reasons applicable within their respective authorities for their decision based on the analyses presented in the Final EIS. It should be noted that in the case of this document, the No Action Alternative is not a "no-build" alternative. Selection of the No Action Alternative as a result of the EIS would deny the proposed

[1] The Forest Service issued Lease No. 4050-10 for the Greens Creek Mine in 1988 covering approximately 40 acres for the construction, operations and maintenance of a tailings disposal facility. In 2004, the Forest Service amended the lease to cover a total of 123 acres.

changes to the currently approved GPO but would allow the company to continue mining operations and placement of tailings and waste rock under the terms of the ROD for the 2003 EIS and the approved operating plan. A No Action Alternative that considered the effects of no mining in the project area was evaluated under NEPA in the 1983 FEIS.

1.5 Scoping and Public Involvement

The NOI to prepare the EIS for the Greens Creek Mine Tailings Disposal Facility Expansion was published in the Federal Register on October 5, 2010. The publication of the NOI initiated the scoping process and a public review and comment period required under NEPA at 40 CFR Part 1501.7. The formal scoping period ended on November 19, 2010.

Scoping is a process intended to assist the Forest Service and the cooperating agencies in identifying issues of concern associated with the proposed project, and is designed to ensure that all significant issues are fully addressed during the course of the EIS process. The main objectives of the scoping process are to:

- Provide the public, stakeholders, and regulatory agencies with a basic understanding of the proposed project;
- Provide a framework for the public to ask questions, raise concerns, and identify specific issues with the proposed options; and recommend options other than those currently proposed;
- Ensure that potentially significant issues from the public, tribes, and agencies are identified and fully addressed during the course of the EIS process; and
- Explain where to find additional information about the project.

The scoping document for the Greens Creek Mine Tailings Disposal Facility Expansion EIS was distributed along with the NOI. The scoping document was distributed to a mailing list generated from previously completed similar projects and with input from the cooperating agencies. The scoping document provided a brief background on the Greens Creek Mine; a description of the proposed action, agency involvement, permits and authorizations, and the scoping process; an EIS preparation schedule; and information sources. In addition to the NOI, the Forest Service placed a public notice in the *Ketchikan Daily News* and the *Juneau Empire* on October 8, 2010, which ran for four days, and also used email to advertise public meetings. Public meetings were held in Juneau on October 14, 2010, and in Angoon on October 15, 2010. The purposes of the scoping meetings were to listen to and record the public's comments about the project and to respond to the public's requests for background information needed to fully understand the project description and proposed scope of the EIS.

Throughout the scoping process, the Forest Service collected comments from the public; local, state, and federal agencies; non-governmental organizations; professional and trade organizations; and Native corporations and tribal organizations. Fifteen people signed the attendance sheets at the public meeting in Juneau, and 20 signed in at the Angoon meeting.

The scoping process produced 16 individual comment submittals, which are traditional letters, emails, or written comment forms. Many comment submittals included more than one comment. An interdisciplinary team, consisting of resource experts, reviewed the comment submittals to identify and catalog individual comments. A total of 155 comments were identified. The Forest Service released a Scoping Summary Document[2] that summarized the nature of the scoping comments received during this process and identified in which part of the Draft EIS the comments will be addressed.

1.6 Government-to-Government Consultations

The Forest Service conducts ongoing consultations with Alaska Native groups to comply with Executive Order 13175, which addresses consultation and coordination with Indian tribal governments. The Forest Service conducted government-to-government consultations to solicit comments on the project from the Angoon Community Association and Kootznoowoo Incorporated on October 15, 2010, and held a follow up meeting with Kootznoowoo on November 10, 2010. Additional consultation occurred with the Angoon Community Association on October 13, 2011. The purpose of the meetings was to explain the nature of the project and to solicit comments and concerns. The Sealaska Corporation declined the Forest Service offer to consult on a government-to-government basis. Results of this consultation are discussed in Section 3.21, Environmental Justice.

1.7 Significant Issues

With respect to an EIS, issues are points of discussion, debate, or dispute about the environmental impacts of the proposed action. Issues may be determined to be significant based on the extent, duration, or magnitude of the environmental effect. Significant issues focus the environmental analyses in the EIS on the aspects of the project that are of the greatest concern to the public or regulatory agencies or have the most potential for producing adverse environmental effects. Alternatives to the proposed action or specific mitigation measures are developed in response to significant issues. By associating measures with individual issues, the public and decision-makers are better able to differentiate among different alternatives in terms of environmental impacts. The significant issues summarized below are based on public, tribal, and agency comments made during the scoping process. The measures to be used to assess each of the issues across alternatives are provided at the end of each item.

Issue 1: Water quality may be impacted directly by runoff from acid-generating tailings and waste rock, or by direct impacts of the expanded facilities or by marine discharges of mine water. The impacts to water quality could adversely impact aquatic life.

This issue was identified after considering scoping comments including the following comments:

- Alternative and mitigation measures that minimized adverse impacts to groundwater and surface water should be analyzed, especially in areas that may be hydrologically connected;
- The geochemical stability of the tailings and compliance with Alaska water quality standards should be investigated;
- The EIS should discuss past and current monitoring of the marine habitat and water quality;

[2] The Scoping Summary Document is available online at: http://www.fs.fed.us/r10/tongass/projects/nepa_project.shtml?project=32662.

- Potential impacts to surface waters, even from seepage, should be clearly discussed; and
- Water quality monitoring plans for Tributary Creek, whose headwaters contain portions of the TDF, should include biological components such as fish populations, macrobenthic invertebrates, and periphyton. These organisms are common indicators of water quality. Additionally a suite of toxicology tests should be employed to determine if the biological community is adversely affected by any exceedences of water quality standards.

Assessment Measures:

- Percent of drainage area and flow lost in area streams;
- Ability of effluent and storm water discharges to meet applicable Alaska Water Quality Standards in marine and fresh water;
- Potential for acid rock drainage conditions developing in the TDF;
- Ability to control or prevent discharges of TDF drainage to surface and groundwater; and
- Extent and complexity of water management and treatment infrastructure (e.g., surface and groundwater diversions, water management ponds, pipelines, treatment and wheel wash facilities) required to protect surface and groundwater and manage storm water.

Issue 2: Expansion of the mine tailings disposal facility may cause direct and indirect impacts to wetlands. Loss of wetlands can affect migrating and resident birds as well as other wildlife species. Any impacts to wetlands must be mitigated.

This issue was identified after considering scoping comments including the following specific comments:

- An approved delineation showing all of the proposed activities that may result in impacts to waters of the United States relative to pertinent jurisdictional boundaries (i.e., wetland boundaries). Wetland delineation should clearly depict all proposed impacts in both linear feet and acreage for streams, and acreage for other waters. Both direct and indirect impacts to waters and wetlands should be described in the EIS;
- The loss of wetlands could be mitigated by considering creating shallow water wetlands in reclaimed areas to provide habitat for migrating and resident birds as well as other wildlife species;
- Concern for the temporal loss of wetlands was expressed and it was recommended that mitigation by habitat restoration or fees be considered to offset impacts of the project;
- Design criteria should include reasonable options for a new remote tailings disposal site, predominately an upland site to avoid impacting wetlands; and
- Impacts to anadromous streams and wetlands that support unique plant or animal communities should be avoided and adequate buffers should be established.

Assessment Measures:

- Acres of wetlands affected;
- Type of wetlands affected; and
- Habitat functions of areas affected.

Issue 3: Construction related to expansion of the tailings and waste rock disposal facility, contact water ponds, and roads along or over creeks could negatively impact anadromous and resident salmonids and other fish species.

This issue was identified after considering scoping comments including the following specific comments:

- Potential impacts of situating storm water collection ponds, tailings disposal sites, and a road crossing along/over a tributary to Greens Creek should be considered. Infrastructure may have negative implications for water quality and natural hydrologic function of a tributary, which will impact anadromous and resident salmonids in the tributary and main stem of Greens Creek;
- Impacts to surface water or groundwater could impacts fish or fish habitat in Tributary and Zinc Creek;
- Tributary and Zinc creeks provide habitat for anadromous and resident salmonids as well as other fish species; and
- Given the anadromous fish in Greens Creek, alternative sites not adjacent to a tributary should be used for tailings disposal and infrastructure.

Assessment Measures:

- Length of anadromous (class I) and resident (class II) streams lost, by watershed;
- Area of facilities that could affect groundwater discharge (wetland fills); and
- Potential flow reduction due to basin fill and water capture (percent of watersheds affected by new disturbance).

Issue 4: The Greens Creek Mine and proposed expansion occurs partially within Admiralty Island National Monument. The Monument was established for the purpose of protecting objects of ecological, cultural, geological, historical, prehistorical, and scientific interests. Any lease of Monument lands for mining must not cause irreparable harm to Monument values.

This issue was identified after considering scoping comments including the following specific comments:

- Requests for the feasibility criteria used to determine the relationship of alternative sites and impacts on Monument lands as well as alternative sites not located in Monument lands;
- Requests for baseline conditions for the Monument including the community of Angoon as well as current structure and function; and
- The EIS should disclose any reasonable foreseeable activities that would encroach on the intrinsic and ecological values of the Monument.

Assessment Measures:

- Availability of suitable lands within existing mine claims, HGCMC controlled lands, or off of the Monument;
- The potential for reclamation of impacted areas to pre-project conditions;
- Whether or not surface waters within the Monument will be impacted in the long term; and
- Acres disturbed within the Monument.

Other Issues: Other issues were identified during the scoping process as important, but did not drive the alternatives for this EIS. However these other issues are taken into consideration for the impact analysis and for potential mitigation measures. Other issues include the following:

- Current operation plans used to minimize/restrict air emissions and fugitive dust and how they may be revised upon expansion should be disclosed;
- High levels of contaminants in lichens are a concern in light of expansion plans. Fugitive dusts have a potential to be released over a greater surface area, with a possibility of reaching the Kootznoowoo Wilderness and beyond. Contaminant concentrations in lichens are above Tongass thresholds in all of the locations at the Greens Creek Mine. Many of the contaminants were the highest found in lichens on the Tongass National Forest, including lead, cadmium and sulfur;
- Impacts to seafloor flora and fauna as a result of the marine discharge of treated mine water should be considered. The EIS should disclose all monitoring results of seafloor sediment and biota, as well as contaminated sediments at the loading dock;
- Adequacy of the reclamation and closure bond. Closure bonds should be re-evaluated in context of HGCMC's obligation to protect the environment, including the Monument, from significant damage. Adequate bonding for long term water quality management, monitoring and treatment should be examined; and
- Potential impacts to transportation and utility corridors should be considered. Alternatives should take into consideration impacts on transportation and utility corridors and easements created by Congress and the Angoon Community Association.

1.8 Agency Responsibilities, Approvals, and Compliance

This section describes the primary roles of each agency involved in developing the EIS. The Forest Service is the lead NEPA agency. The USACE, U.S. Environmental Protection Agency (USEPA), State of Alaska, and City and Borough of Juneau (CBJ) are cooperating agencies. The Forest Service coordinated with the cooperating agencies in developing the EIS. The Forest Service consulted with the other agencies identified in this section.

This section also includes a description of the major permits and authorizations required for the project. It addresses how this document or the TDF expansion itself complies with environmental laws as they pertain to each of the responsible agencies.

1.8.1 Applicable Laws, Statutes and Ordinances

The following list presents some of the laws, statutes, and ordinances applicable to operation of the Greens Creek Mine:

- Clean Water Act (CWA);
- Clean Air Act (CAA);
- General Mining Law of 1872;
- Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA);
- National Historic Preservation Act (NHPA);
- National Environmental Policy Act (NEPA);

- Migratory Bird Treaty Act (MBTA);
- Fish and Wildlife Coordination Act;
- Bald and Golden Eagle Protection Act;
- Marine Mammal Protection Act (MMPA);
- Endangered Species Act (ESA);
- Alaska National Interest Lands Conservation Act (ANILCA);
- Greens Creek Land Exchange Act;
- Wilderness Act of 1964;
- Alaska Administrative Code Title 18, Chapters 50, 60, 70, 72, and 97;
- Alaska Administrative Code Title 83;
- Alaska Statute AS 16.05.841, AS 16.05.871, AS 27.19 and 46.17;
- City and Borough of Juneau Exploration and Mining Ordinance (CBJ Title 49, Chapter 49.65, Article I); and
- 2008 City and Borough of Juneau Comprehensive Plan.

1.8.2 Permits and Decisions for Continued Operation of the Greens Creek Mine

The Forest Service, USACE, State of Alaska, and CBJ must all issue permits, authorizations, or approvals for the HGCMC to expand the TDF. These permits and authorizations include the following:

- EIS Record of Decision – Forest Service and USACE;
- Approval of expansion of the lease of National Forest lands – Forest Service;
- Approval of changes to the GPO – Forest Service;
- Readjustment of the Reclamation Bond – Forest Service, ADEC, Alaska Department of Natural Resources (ADNR), and CBJ;
- Section 404 permit for discharge of fill into waters of the United States – USACE;
- Waste Management Permit – ADEC;
- Reclamation and closure plan approval – ADNR; and
- Large Mine Permit – CBJ.

1.8.3 Federal Agencies

1.8.3.1 Forest Service

The Forest Service is responsible for NEPA compliance and issuing a ROD for the Final EIS. The Forest Service is also responsible for the following:

- Approval of 2010 Amended General Plan of Operations (GPO);
- Approval of a lease expansion
- Compliance with Section 106 of the NHPA;
- Compliance with Sections 313 and 319 of the CWA;
- Compliance with Section 7 of the Endangered Species Act;
- Compliance with Section 305 of the MSFCMA, including consultation with the National Marine Fisheries Service (NMFS) on essential fish habitat (EFH);
- Compliance with applicable Executive Orders (specifically 11988, Floodplain Management; 11990, Protection of Wetlands; 12088, Federal Compliance with Pollution Control Standards; 12898, Federal Actions to Address Environmental

Justice in Minority Populations and Low-Income Populations; 12962, Recreational Fisheries; and 13175, Consultation and Coordination with Indian Tribal Governments); and
- Consistency with 2008 Tongass National Forest Land and Resource Management Plan.

The Forest Service is the lead agency in the preparation of the Greens Creek Mine Tailings Disposal Facility Expansion EIS. The Forest Service's authority to require, evaluate, and approve or modify the operator's GPO is based on the Organic Act of 1897 and on the Mining Law of 1872, which is described in 36 CFR Part 228, Subpart A. If another agency cannot meet its regulatory responsibilities, the Forest Service is ultimately responsible for ensuring that federal and state regulations are implemented on National Forest System lands.

All alternatives are consistent with the 2008 *Tongass National Forest Land and Resource Management Plan* (USFS 2008). The site is in an area with the following designated land uses: Non-wilderness National Monument and Semi-remote Recreation. The goals for management in the Non-wilderness National Monument are as follows:

- To manage Admiralty Island National Monument for public access and uses consistent with ANILCA;
- To facilitate the development of significant mineral resources located within portions of Admiralty Island National Monument, as specified by ANILCA;
- To protect objects of ecological, cultural, geological, historical, pre-historical, and scientific interest, as specified by ANILCA, and the GPO, as well as minimize effects on non-mineral resources to the extent feasible. In the long term, when mining is completed, to reclaim areas disturbed by mining to a near-natural condition; and
- To limit mining activities to claims with valid existing rights, and to the land area actually needed to carry out mining operations.

The goals for management of the Semi-remote Recreation areas are as follows:

- To provide predominantly natural or natural-appearing settings for semi-primitive types of recreation and tourism, and occasional enclaves of concentrated recreation and tourism facilities; and
- To provide opportunities for a moderate degree of independence, closeness to nature, and self-reliance in environments requiring challenging motorized or non-motorized forms of transportation.

Forest Plan Objectives

Forest Plan objectives include:

- Ensure that the Plan of Operations for each mineral development specify the activities to be conducted, the location and timing of those activities, and how the environment and resources in each area will be protected through compliance with federal and state requirements. (page 3-26)
- In areas affected by mining, manage activities to maintain the productivity of anadromous fish and other foodfish habitat to the maximum extent feasible. Stress protection of fish habitat to prevent the need for mitigation. (page 3-26)
- In areas affected by mining, manage public recreation use as directed in the Plan of Operations. Outside these areas, manage recreation use and activities to meet the

appropriate levels of social encounters on-site developments, methods of access, and visitor impacts indicated for the adopted or existing Recreation Opportunity Spectrum (ROS), as appropriate. (page 3-26)

- Locate and manage trails to direct the public away from mining operations. (page 3-27)
- Develop reclamation plans prior to project initiation. Include, as needed, rehabilitation of fish and wildlife habitats, soil resources, and the scenery. (page 3-27)

The process of alternatives development described in Chapter 2 took these objectives into account.

Standards and Guidelines for Minerals and Geology

Standards and guidelines are designed so that all activities are integrated to meet land allocation objectives. Standards and guidelines are intended to be used in conjunction with national and regional policies, and direction contained in Forest Service manuals and handbooks. Forest-wide Standards and Guidelines apply to all or most areas of the Forest and provide for the protection and management of forest resources. They are used in conjunction with the additional standards and guidelines given in the management prescriptions for each Land Use Designation (LUD). Forest-wide Standards and Guidelines for Minerals and Geology that applicable to this analysis are provided below (MG2 I, II, III, and VI, USFS 2008).

Minerals and Geology Administration MG2:

I. Forest Lands Withdrawn from Mineral Entry

   A. Claimants with claims located in areas withdrawn from mineral entry retain valid existing rights, if such rights are established prior to the withdrawal date.

   B. Conduct on-the-ground validity examinations by a certified minerals examiner to establish or reject valid existing rights on active mining claims within Wilderness areas and other areas withdrawn from mineral entry.

   C. Permit reasonable access to mining claims in accordance with the provisions of an approved Plan of Operations. Motorized access to sites may be authorized as part of the Plan of Operations. Use of off-highway vehicles may be allowed and must be in accordance with 36 CFR 212, 251, and 261 – Travel Management; Designated Routes and Areas for Motor Vehicle Use.

II. Forest Lands Open to Mineral Entry

   A. Encourage the exploration, development, and extraction of locatable, salable, and leasable minerals and energy resources.

   B. Assure prospectors and claimants their right of ingress and egress granted under the General Mining Law of 1872, ANILCA, and the National Forest Mining Regulations (36 CFR 228).

   C. Permit reasonable access to mining claims and mineral leases in accordance with the provisions of an approved Plan of Operations.

III. Locatable Mineral Operations

A. A Notice of Intent and/or a Plan of Operations is required for locatable operations (Consult FSM 2810 and 36 CFR 228).

1. A Plan of Operations will receive prompt evaluation and action within the time frames established in 36 CFR 228.
2. Conduct an environmental analysis with appropriate documentation for all operating plans.
3. Locatable mineral exploration and/or development situated in areas identified in the Forest Plan for intensive development (minerals overlay) must be consistent with standards and guidelines for mineral development.
4. Following locatable mineral exploration and/or development site rehabilitation and restoration will be designed to return the site to as near as practicable to a condition consistent with the underlying non-mineral LUD.

B. Work with claimants to develop a Plan of Operations that adequately mitigates adverse impacts to LUD objectives. Include mitigation measures for locatable actions that are compatible with the scale of proposed development and commensurate with potential resource impacts.

1. Maintain the habitats, to the maximum extent feasible, of anadromous fish and other foodfish, and maintain the present and continued productivity of such habitats when such habitats are affected by mining activities. Assess the effects on populations of such fish in consultation with appropriate state agencies (consult ANILCA, Section 505(a)).
2. Apply appropriate Transportation Forest-wide Standards and Guidelines to the location and construction of mining roads and facilities.
3. Reclaim disturbed areas in accordance with an approved Plan of Operations. Apply approved seed mixtures as needed (Consult Standards and Guidelines for Plants and FSH 2080).
4. Apply Best Management Practices (BMPs) to maintain water quality for the beneficial uses of water (Consult FSH 2509.22).
5. Periodically inspect minerals activities to determine if the operator is complying with the regulations of 36 CFR 228 and the approved Plan of Operations.

VI. Bonds

A. A bond will be required for locatable, leasable, and salable mineral operations to ensure operator performance and site reclamation are completed (Consult 36 CFR 228).

Pursuant to the Organic Administration Act and 36 CFR 228, Subpart A, the Forest Service requires that mine operators submit a reclamation bond, or financial assurance, prior to approval or modification of the GPO. The purpose of the reclamation bond is to assure reclamation of surface disturbances to prevent or control damage to the environment, to control erosion, landslides, water runoff and toxic materials and to provide for rehabilitation of fish and wildlife habitat.

The State of Alaska requires financial assurance from mines in accordance with Alaska Statutes 27.19 (Reclamation) and 38.05 (Alaska Land Act) and the Alaska Administrative Code, Title II and Chapter 97 (Mining Reclamation). The CBJ also requires financial warranties to be in place for mining operations prior to issuance of the Large Mine Permit (CBJ 49.65.140). For large mine operations, the reclamation bond is usually in the form of a surety or irrevocable letter of credit because of the significant obligation that reclamation typically represents.

Because the Greens Creek Mine already exists, the Forest Service and State of Alaska jointly hold a reclamation bond to assure reclamation of the currently approved operations. At this time, the reclamation bond value is being recalculated as part of its regular review cycle. The current reclamation bond value is over $26 million.

As required by 36 CFR 228.13 (c), if the approved plan of operations is modified, the agencies would review the initial bond for adequacy and, if necessary, would adjust the bond to conform to the operations plan as modified. The modification will only be approved when the required bond is received. After the Forest Service selects an alternative and issues its ROD, HGCMC may, depending on the alternative selected, submit an updated reclamation plan and cost estimate for the first stage of expansion of the TDF to the Forest Service and State of Alaska. Agency engineers and Certified Locatable Mineral Examiners would review the plan and cost estimate to ensure it was adequate. If the Forest Service and State of Alaska conclude that an increase in the bond amount would be necessary, HGCMC must submit the additional bond amount before the approved modifications can be executed. The bond amount is the agencies' estimated cost to complete full reclamation of the site in the event the operator cannot or will not perform the required reclamation. Reclamation is not only defined as surface reclamation; it can also include long-term water management and treatment. The reclamation plan and bond would be developed and reviewed in stages consistent with the staged TDF expansion and commensurate with actual disturbances. HGCMC would not be required to post bond for reclamation of facilities that would not be built for decades.

See Appendix B for additional detailed information on reclamation bond requirements.

National Historic Preservation Act

Prior to approving a revision to the existing GPO, the Forest Service must comply with Section 106 of the NHPA. Compliance with NHPA generally involves the following:

- Identification of historic features that may be affected;
- Assessment of effects to those features;
- Consultation with the State Historic Preservation Officer (SHPO) and interested parties; and
- Consideration of comments by the Advisory Council on Historic Preservation if historic features could be affected.

The Forest Service has initiated consultation with the SHPO and will continue the process through development of the EIS. Review comments provided by the SHPO have been incorporated into this document.

Clean Water Act

Under agreement between the Forest Service and the ADEC, the Forest Service is committed to ensuring that activities on National Forest System lands are consistent with the requirements of the CWA, Sections 319(b)(2)(f); 319(k); 313; and Executive Order 12088. Section 319 addresses nonpoint source pollution, and Section 313 and Executive Order 12088 require the Forest Service to adhere to the goals set forth in state WQS.

Magnuson-Stevens Fishery Conservation and Management Act and Recreational Fisheries Executive Order

The MSFCMA requires the Forest Service to consult with the NMFS regarding the protection of EFH prior to approving the GPO. Executive Order 12962 requires federal agencies to evaluate the potential effects of proposed federal actions on recreational fisheries. This EIS complies with Executive Order 12962 by considering the potential mining and transportation impacts of each alternative on water quality, habitat, and fish populations. An EFH assessment is being prepared for consultation with the NMFS.

Wetlands and Floodplains Executive Orders

Executive Orders 11988 and 11990 address minimizing impacts on the nation's wetlands and/or floodplains are discussed below in Section 1.8.3.2, U.S. Army Corps of Engineers.

Tribal Consultation Executive Order

Executive Order 13175 requires federal agencies to establish a consultation process for interactions with Indian tribes in the development of regulatory policies that have tribal implications. Executive Order 13175 is addressed by ongoing consultation with Alaska Native groups, as discussed in Section 1.6, Government-to-Government Consultations, Section 3.21, Environmental Justice, and Section 4.2, Federal Consultation.

Environmental Justice Executive Order

Executive Order 12898 requires federal agencies to identify and address disproportionately high and adverse human health or environmental effects of proposed activities on minority and low-income populations. This document addresses Executive Order 12898 by considering the potential impacts of each alternative on minority and low-income populations in the discussions of recreation, socioeconomic impacts, and environmental justice.

1.8.3.2 U.S. Army Corps of Engineers

The USACE is responsible for deciding whether to issue the CWA Section 404 permit for the discharge of fill needed to construct the TDF expansion. The USACE is a cooperating agency in developing this EIS since the USACE has an independent requirement to comply with NEPA before making its 404 decision. The USACE's decision will be documented in a ROD. The USACE responsibilities include the following:

- Participation as a NEPA cooperating agency in development of the EIS;

- NEPA compliance for issuance of the Section 404 permit;
- Issuance of a ROD;
- Issuance of a Section 404 Permit: CWA (Dredge and Fill);
- Compliance with all executive orders (specifically 11988, 11990, 12088, 12898, 12962, 13045, and 13175);
- Compliance with Section 106 of the NHPA; and
- Compliance with the MSFCMA.

CWA Section 404 authorizes the USACE to issue permits for discharge of dredged or fill material into waters of the United States. The CWA prohibits such a discharge except pursuant to a Section 404 permit. Various activities undertaken by HGCMC in connection with the proposed action and alternatives have the potential to affect waters of the United States, including expansion of the TDF and construction and operation of access roads, truck wash facility, contact water facilities, quarry sites, disposal areas, a water treatment plant, and a water discharge outfall line into Hawk Inlet. To the extent that these activities would involve the placement of fill in waters of the United States, including jurisdictional wetlands, a Section 404 permit would be required. The USACE is responsible for determining whether an action complies with CWA Section 404(b)(1) guidelines; a Section 404 permit may not be issued without such compliance.

All federal agencies, including the USACE, must comply with Executive Orders 11990 and 11988, which address minimizing impacts on the nation's wetlands and floodplains, respectively. The USACE's regulatory program provides some flexibility when considering the national goal of "no net loss" of wetlands. Because the "no net loss" goal cannot always be achieved on an individual project-by-project basis, the Alaska District of the USACE may consider site-specific conditions and impacts when determining the extent of compensatory mitigation required for wetland losses. Under Executive Order 11988, any bridges proposed under each of the alternatives would need to be constructed to ensure public safety and minimize impacts on the floodplain.

The MSFCMA requires the USACE to consult with NMFS regarding the protection of EFH before a Section 404 permit may be issued. The previous section described the MSFCMA requirements and how this EIS includes the MSFCMA evaluation.

Like the Forest Service, the USACE needs to comply with the NHPA and executive orders requiring tribal consultation and environmental justice considerations. The USACE is relying on this EIS and is cooperating with the Forest Service on these issues.

1.8.3.3 U.S. Environmental Protection Agency

The USEPA has a range of responsibilities related to the proposed TDF expansion at Greens Creek including the following:

- Participation as a NEPA cooperating agency;
- Compliance with the CWA (review of the CWA 404 permit public notice and oversight of the CWA 402 permit developed by ADEC);
- Compliance with the CAA (oversight of the ADEC air permit and review and comment on the EIS); and
- Notification of hazardous waste activity.

The USEPA is a cooperating agency with the Forest Service on this EIS. The USEPA has primary responsibility for implementing CWA Sections 301, 306, 311, and 402. The

USEPA shares responsibility for Section 404 with the USACE. Sections 301 and 306 of the CWA require that USEPA develop wastewater effluent standards for specific industries, including metals mines. These standards are established for both existing sources and new sources.

The USEPA initially issued a National Pollutant Discharge Elimination System permit for the Greens Creek mine in 1987; the permit was re-issued in 1998 and again in 2005. The ADEC is in the process of reissuing the permit for the Greens Creek Mine under the APDES permit program. During the effective period of the new APDES permit, the Permittee will be authorized to discharge pollutants from outfalls 002 and 003 to Hawk Inlet, outfall 004 to wetlands, outfall 005.2 to Zinc Creek, and outfalls 005.3, 005.4, 005.5, 006, 007, 008, and 009 to Greens Creek, within the limits and subject to the conditions set forth in the APDES permit. The APDES permit authorizes the discharge of only those pollutants resulting from facility processes, waste streams, and operations that have been clearly identified in the permit application process.

The USEPA also has authority under CWA Section 404 to review project compliance with Section 404(b)(1) guidelines and Section 404(c) guidelines. Under Section 404(b)(1) the USEPA must ensure that the USACE has selected the least damaging practicable alternative. Under Section 404(c), the USEPA may prohibit or withdraw the specification (permitting) of a site upon determination that use of the site would have an unacceptable adverse effect on municipal water supplies, shellfish beds, fishery areas, or recreational areas.

Section 311 of the CWA establishes requirements related to discharges or spills of oil or hazardous substances. Under 40 CFR Part 112, the USEPA requires each facility that handles substantial quantities of oil to prepare a Spill Prevention, Control and Countermeasures plan. A registered engineer must certify the Spill Prevention, Control and Countermeasures plan. The USEPA Regional Administrator would make a determination regarding whether a Facility Response Plan is required.

The most basic goals of the CAA are to protect public health and welfare. The CAA Section 309 requires the USEPA to review and comment on EISs. In addition, the USEPA approves state implementation plans for air quality and reviews Air Quality Control Permit to Operate applications, including requirements for prevention of significant deterioration.

1.8.3.4 U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is responsible in this process for the following:

- Consultation on the ESA;
- Compliance with the Bald Eagle Protection Act; and
- Coordination under the Fish and Wildlife Coordination Act.

The USFWS administers the ESA, as reauthorized in 1982, the Bald Eagle Protection Act of 1940, as amended, and the Fish and Wildlife Coordination Act. The Forest Service must consult with USFWS regarding any threatened or endangered species that may be impacted by the proposed project. If any impacts are projected, specific design measures must be developed to protect the affected species. The Fish and Wildlife Coordination Act provides a procedural opportunity for the USFWS to coordinate with the Forest

Service and offers means and measures to benefit fish and wildlife resources through mitigation of impacts to water resources and associated fish and wildlife. A combined biological assessment and biological evaluation (BA/BE) is being prepared for consultation with the USFWS and NMFS on Threatened and Endangered Species.

1.8.3.5 National Marine Fisheries Service

The NMFS is responsible in this process for the following:

- Consultation on threatened and endangered species;
- Consultation on EFH;
- Consultation on the MMPA; and
- Consultation on the Research and Sanctuaries Act.

The Forest Service must consult with the NMFS. If any impacts are projected to any threatened or endangered marine species or EFH, specific design measures must be developed to protect the affected species.

1.8.4 State and Local Government

1.8.4.1 State Authorities

The State of Alaska is a cooperating agency. Below, the responsibilities of ADNR, ADEC, and Alaska Department of Fish and Game (ADF&G) are presented.

Alaska Department of Natural Resources

The ADNR has a range of responsibilities in the process of approving the proposed expansion at Greens Creek, including the following:

- Coordination of all State of Alaska agency reviews;
- Water rights authorizations;
- Right-of-way authorization; and
- Reclamation Plan approval, including financial assurance adequacy.

The ADNR is the lead State of Alaska agency involved in permitting mining projects in the State of Alaska. In addition to ADNR, State of Alaska agencies involved in permitting or oversight of the Greens Creek Mine include ADEC, ADF&G, and Alaska Department of Law. The State or Alaska established a large mine project team from these agencies to coordinate permitting activities for the Greens Creek Mine TDF expansion.

The ADNR is responsible for issuing water rights authorizations for the use of surface and subsurface waters of the State of Alaska. These permits require compliance with instream flow requirements. The ADNR Division of Mining, Land and Water is responsible for approval of the reclamation and closure plan.

Alaska Department of Environmental Conservation

The ADEC is responsible for the following decisions related to the TDF expansion:

- Waste Management Permit covering disposal of mine tailings, waste rock, overburden, and solid waste, management of groundwater, storage and containment of hazardous chemicals, facility reclamation and facility closure;

- Air Quality Permit to Operate;
- CWA Section 401 certifications of reasonable assurance for USACE Section 404 permit; and
- Alaska Pollutant Discharge Elimination System Permit (including storm water).

The ADEC is responsible for issuing an integrated waste management permit that includes requirements for solid waste disposal, groundwater protection, mine reclamation and closure, financial assurance, and monitoring.

The ADEC is responsible for issuing the facility's air quality permits for construction activities and operations at the port and the mine. The ADEC will evaluate the changes to emissions sources associated with development of the Greens Creek Mine and, based on the review, require new permits or modification of existing permits as applicable.

The ADEC is responsible for issuance of water quality and air quality permits. Under Section 401 of the CWA, ADEC responsibilities include certification of the USACE Section 404 permit. The ADEC must certify that the requirements of these permits comply with state WQS.

On October 31, 2008, the ADEC assumed initial authority over permitting, compliance, and enforcement of the APDES under Section 402 of the CWA; ADEC's authority over mining APDES permits began on October 31, 2010. APDES permit limits and other requirements are established to ensure compliance with state WQS for both marine water and freshwater. The New Source Performance Standards specifically include effluent limits applicable to discharges of mine drainage; they also prohibit the discharge of process water (including tailings effluent). An exception is provided for excess flows associated with net precipitation where the discharge of such flow is subject to the comparable effluent limits for mine drainage. USEPA is authorized to oversee ADEC's implementation of the program and can intervene on any permit issued, renewed, or modified by the State of Alaska. The Greens Creek Mine's National Pollutant Discharge Elimination System permit was assigned the designation of APDES when it transferred from USEPA to ADEC under Phase III of the National Pollutant Discharge Elimination System transfer of authority program. This permit is in the process of being reissued. The permit establishes water quality based effluent limits and monitoring requirements for treated process water being discharged to Hawk Inlet. It also establishes storm water monitoring requirements at 10 locations throughout the Greens Creek Mine area.

Alaska Department of Fish and Game

The ADF&G's authority to issue permits covers a variety of activities (water removal, instream work, water diversions, etc.) in anadromous water bodies and in resident fish streams. The ADF&G's statutory permitting authority at Alaska Statute 16.05.841 requires fish passage for in-stream activities in resident and uncataloged[3] anadromous fish-bearing waters. Alaska Statute 16.05.871 requires protection of anadromous fish and their habitats for in-stream activities occurring in waters listed in ADF&G's *Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes*.

[3] "Uncataloged" means fish-bearing waters not listed in ADF&G's *Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes.*

1.8.4.2 Local Authorities: City and Borough of Juneau

The Greens Creek Mine is located within the CBJ which is responsible in this process for the following:

- Participation as a cooperating agency in the NEPA/EIS process; and
- Issuance of a Large Mine Permit.

The City and Borough of Juneau Code of Ordinances addresses large mine permitting under land uses addressed in Title 49, Chapter 49.65, establishing requirements for both operations and financial assurance. City and Borough of Juneau Land Use Code also establishes 50-foot no-development setbacks from anadromous streams; 330-foot no-development buffer from eagle nests; building and grading permits; and compliance with the August 2010 City and Borough of Juneau Manual of Storm Water Best Management Practices. The CBJ is participating as a cooperating agency and will use information from the EIS to determine if changes are needed to the Large Mine Permit related to expansion of the TDF.

CHAPTER 2. DESCRIPTION OF PROPOSED ACTION AND OTHER ALTERNATIVES

Tailings Disposal Facility – for simplicity, the text refers to the tailings disposal facility (TDF). However, while the majority of material placed into the TDF is tailings, waste rock, sludge from the wastewater treatment plant, and solid wastes are also placed into the facility.

Chapter 2 describes the proposed action for the Greens Creek Mine Tailings Disposal Facility Expansion and a range of alternatives. The chapter describes how the alternatives were developed as well as the similarities and the differences among them. The alternatives described focus on whether, where, and how to develop additional tailings disposal capacity to accommodate resources identified by Hecla Greens Creek Mining Company (HGCMC or the operator). The comparison of the proposed action with alternatives is a requisite of the National Environmental Policy Act (NEPA).

This chapter begins with a brief overview of mining activities at the Greens Creek Mine that would be similar under all alternatives to provide context as to how each alternative would fit within the existing operation. The subsequent subsections discuss alternatives development within the NEPA process, detailed descriptions of the alternatives themselves, the components of mining operations, alternatives considered but eliminated from further analysis, mitigation and monitoring opportunities and requirements, and summary tables briefly comparing the effects of each alternative across the range of resources areas analyzed in detail in Chapter 3.

2.1 Greens Creek Mine Overview

The Greens Creek Mine is located approximately 18 miles southwest of Juneau, Alaska, on Admiralty Island. The existing operation is shown in Figure 1.1-3. The existing tailings disposal facility (TDF) is located entirely on National Forest System lands, including parts of both the Juneau Ranger District and the Admiralty Island National Monument (Monument). Many aspects of the day-to-day operations of the Greens Creek Mine would remain the same under all alternatives or would need to be maintained in some fashion under each alternative. These components include the mining activity itself, mineral processing, concentrate transport, waste disposal, and water management. This subsection provides a brief overview of these various components of the mining operations.

Underground mining methods are used to remove ore from the mine. Ore is removed from the mine and placed in stockpiles near the mill building. Ore moving through the mill ultimately becomes either concentrate, which is trucked to the port facility and shipped to smelters around the world, or tailings. The mill at the Greens Creek Mine yields a silver/gold product (doré), and zinc, lead, and bulk concentrates.

Waste material produced at the site principally consists of tailings and waste rock. Waste rock is synonymous to non-mineralized material or rock that has mineral values below those that can be economically processed. Waste rock must be removed to gain access to the ore. As part of the mining activity, waste rock and tailings are backfilled into some of the voids created by the mining process to provide structural stability within the mined out areas. Tailings that are not backfilled are trucked to the TDF where they are placed in a series of layers (lifts) within discrete disposal locations (cells).

All water coming in contact with mine-related activities is collected and either recycled back to the mill or discharged into Hawk Inlet as authorized in the Alaska Pollutant Discharge Elimination System (APDES) permit. The flow of water is controlled using a series of ditches, ponds, and sumps located around all the facilities.

The water treatment plant at the mill treats water used in the milling process, mine water, and contact water collected in the immediate vicinity of the mill. Water discharged from this treatment plant can be directed back to the mill for re-use or to a water management pond from which it passes through a second water treatment plant prior to discharge to Hawk Inlet.

No changes to the mining or mineral processing are being considered in this analysis; alternatives focus on tailings disposal.

2.2 Issues and Alternative Development

The proposal to develop additional tailings disposal capacity requires approval from the U.S. Department of Agriculture Forest Service, Tongass National Forest (Forest Service) for a modification in the General Plan of Operations (GPO). The Forest Service's decision regarding whether or not to approve modification of the GPO is a major federal action that requires a NEPA review, including development of an environmental impact statement (EIS). The Forest Service conducted the scoping process to determine the range of issues to be addressed in the EIS. The significant issues (see Chapter 1) derived from the scoping process shaped the development of the alternatives and forms the comparison of the proposed action and alternatives.

The following describes how the significant issues (water quality, wetlands, fish habitat, and Monument values) influenced the alternatives development process:

> **Water Quality**: After assessing the potential benefit of incorporating additives to the tailings to modify the TDF's geochemical behavior as assessed in the 2003 EIS, any alternative would require similar water management and long-term treatment. There are no fundamental differences between the alternatives with respect to water management measures (e.g., clean water diversions, minimizing contact water, controlling runoff) and treatment (long term treatment required) needs. Alternatives C and D, however, would expand tailings disposal into new watersheds, Fowler Creek, and North Hawk Inlet.
>
> **Wetlands**: During alternatives development, an emphasis was placed on avoiding wetlands with the highest priority placed on wetlands located in the headwaters of anadromous streams. Two alternatives (C and D) were developed that would limit impact to Tributary Creek wetlands by creation of a new TDF outside of the Tributary Creek watershed. Alternative C minimizes expansion in the Tributary

Creek wetlands. Alternative D also reduces impacts to Tributary Creek wetlands compared to the proposed action. Development of a new TDF site, however, requires more space and would ultimately affect more wetlands (by acres).

Fish Habitat: During alternatives development, an emphasis was placed on avoiding impacts to fish habitat. The north TDF site (alternatives C and D) was identified early on because, in part, there were no known fish streams (resident fish habitat was later determined to be present at the site). Alternative C minimizes expansion in the Tributary Creek watershed.

Monument Values: Two alternatives (C and D) were developed that limit expansion within the Monument by creation of a new TDF outside of the Monument. Alternative C would allow a smaller expansion footprint within the Monument than Alternative D.

Appendix C provides additional detail on the alternative screening and selection process.

2.3 Alternatives

The proposed action is the basis for conducting the NEPA analysis and for the development of alternatives. In addition to the proposed action three alternatives were developed for detailed analysis in this EIS. NEPA requires the consideration of a No Action Alternative reflecting the outcome should the lead agency chose not to move forward with the action under consideration. Other alternatives developed in response to the significant issues, must meet the purpose and need of the project and present reasonable approaches for implementing the proposal. Another set of alternatives described below are those that were considered in the planning stages but not carried forward for detailed analysis.

Under the No Action Alternative (Alternative A), mining would cease in approximately 2014 when the currently approved TDF reaches its full capacity. The proposed action (Alternative B) would extend the tailings lease area and TDF footprint south into the Monument providing capacity for tailings and waste rock disposal for an additional 30 to 50 years. Alternatives C and D address the need for the same volume of waste disposal (tailings and rock) but would result in a smaller increase in the footprint of the existing TDF within the Monument; however, they would require construction of a new TDF located approximately 3 miles to the north of the existing TDF. Alternatives B through D would be sized to accommodate tailings and waste rock (see Section 2.4.3) generated at current production rates for a period of approximately 30 to 50 years of operation. Alternatives B through D would also allow for disposal of waste rock currently stored at other locations. A detailed description of each alternative is provided below. Under alternatives B through D, the development would be incremental with the Forest Service approving each step or phase in the process of reaching the full build out depicted in the figures (also see Section 2.6.4, Adaptive Management). Appendix D presents figures of each alternative at the end of the first 10 years of operation along with figures of reclaimed facilities at the end of 50 years of operation.

2.3.1 Alternative A: No Action Alternative

Alternative A: No Action Alternative – Mining activities and tailings disposal would continue until 2014 when the existing permitted TDF will reach its tailings capacity.

The 2003 Record of Decision (ROD) for the previous expansion approved an additional disturbance footprint of 65.3 acres, bringing the total approved tailings footprint to 62 acres and 123 total acres in the tailings lease area. The 2003 ROD authorized 3.3 million cubic yards of new tailings disposal capacity increasing the total capacity to 5.3 million cubic yards. Under the No Action Alternative, tailings would continue to be placed in the approved, existing TDF until 2014. Tailings would be generated at a rate of approximately 360,000 cubic yards per year with approximately half (about 180,000 cubic yards per year) used as backfill underground. The remaining tailings would continue to be placed in the existing TDF along with other wastes and waste rock relocated from "Site E" (see Section 2.4.4). No new rock quarries or reclamation material storage areas would be developed under Alternative A. Disposing of tailings at current rates and waste rock disposal from Site E would result in the approved TDF reaching its capacity in 2014 (see Table 2.3-1 and Figure 2.3-1). HGCMC would employ temporary stabilization during operations, allowing them to conduct final reclamation using the best technology available at the time of final closure. As discussed further in Section 2.4.8 below, it is anticipated that drainage from the TDF will require treatment for hundreds of years after closure. While it is not anticipated, in the absence of active water management, the outfall from the TDF would be designed at closure to drain to Hawk Inlet, rather than to Tributary Creek, which supports anadromous fish.

Table 2.3-1. Estimated TDF Disturbance for No Action and Action Alternatives (in Acres).

Project Component	Alternative A	Alternative B	Alternative C	Alternative D
Tailings	— [a]	64.2	101.7	103.1
Reclamation Material Storage	— [a]	17.0	10.3	14.5
Quarry	— [a]	17.6	8.6	16.4
Ponds	— [a]	12.0	7.1	6.7
Roads, including ditches and pipelines	— [a]	19.1	11.5	19.5
Truck Wheel Wash	— [a]	0.1	0.1	0.1
Ancillary Disturbance	— [a]	12.8	17.5	17.6
Total New Disturbance	— [a]	142.8	156.8	177.9
Total Disturbance	65.3 [b]	208.1	222.1	243.2

Notes:

a. Component of the existing disturbance associated with tailings disposal.
b. Total disturbance following the 2003 ROD.

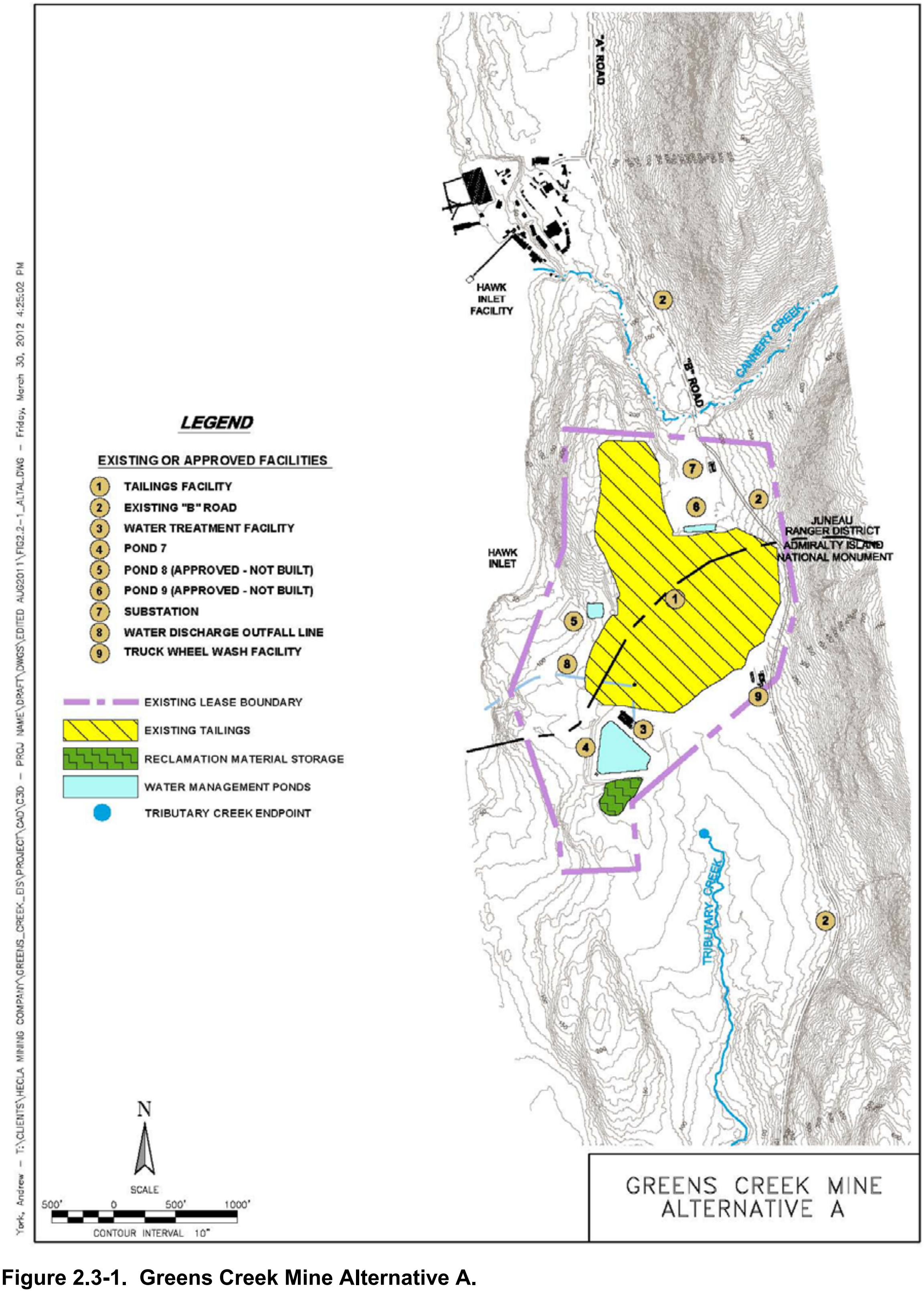

Figure 2.3-1. Greens Creek Mine Alternative A.

2.3.2 Alternative B: Proposed Action

Alternative B: Proposed Action – The existing TDF would be expanded south, farther into the Monument to accommodate an additional 30–50 years of tailings disposal.

The proposed action includes expansion of the existing TDF from its currently permitted capacity of 5.3 million cubic yards of tailings and waste rock to a total capacity of 15 million cubic yards of tailings and waste rock, an increase in capacity of approximately 9.7 million cubic yards. Under this alternative, HGCMC proposed construction for the expansion of the existing TDF beginning in 2012. Figure 2.3-2 illustrates the facility layout at the final stage of expansion. The final TDF expansion would extend the life of the mine for approximately 30 to 50 years at current production and disposal rates. The 30–50 year timeframe reflects the variable nature of production and backfill rate.

During the southward extension of the existing TDF (years 1–30), contact water from disturbed sites would be routed into water management ponds, including new ponds down-gradient of the proposed tailings expansion, and then pumped to the existing Pond 7 where the water would be treated before being discharged to Hawk Inlet. Interim stages of development would require a series of collection ponds that would eventually be covered by tailings. As part of expansion proposed during years 31–50, HGCMC would construct a new water treatment plant and a new water management pond to replace Pond 7 (refer to Figure 2.3-1), although HGCMC plans to maintain the treated water discharge point at the same location in Hawk Inlet.

Maintaining surface water drainage is and would continue to be an ongoing activity that would be adapted as needed as the active tailings placement area moved within the TDF and as the TDF expanded in size. HGCMC would implement sediment control measures to limit tailings erosion. Directing runoff to armored/rocked areas or diversion tubes[1], maintaining road ditches and outside slopes, and cleaning ditches as sediment accumulates are among the techniques that HGCMC uses and would continue to use to control erosion at the site. A new truck wheel wash facility would be constructed at an appropriate location to prevent tracking of tailings and waste materials away from the TDF. A new "West" road would be constructed to the west of the TDF providing access to new reclamation material storage areas and rock quarries. New reclamation material storage areas would be developed around the existing TDF (see Figure 2.3-2). The expansion would occur in stages that would involve the development of a series of quarries, reclamation material storage sites, water management ponds, and diversion ditches. Table 2.3-1 summarizes the final acreage disturbed associated with development of the project. HGCMC would employ temporary stabilization of all ancillary disturbances during operations. Final reclamation would be the same as Alternative A, but over the larger area disturbed under this alternative. Similar to Alternative A, it is anticipated that drainage from the TDF would require treatment for hundreds of years after closure. While it is not anticipated, in the absence of active water management, the outfall from the TDF would be designed at closure to drain to Hawk Inlet, rather than to Tributary Creek, which supports anadromous fish.

[1] Diversion tubes are flexible, water filled tubes used for storm water diversion and erosion control. They are similar in function to the use of sandbags to manage runoff.

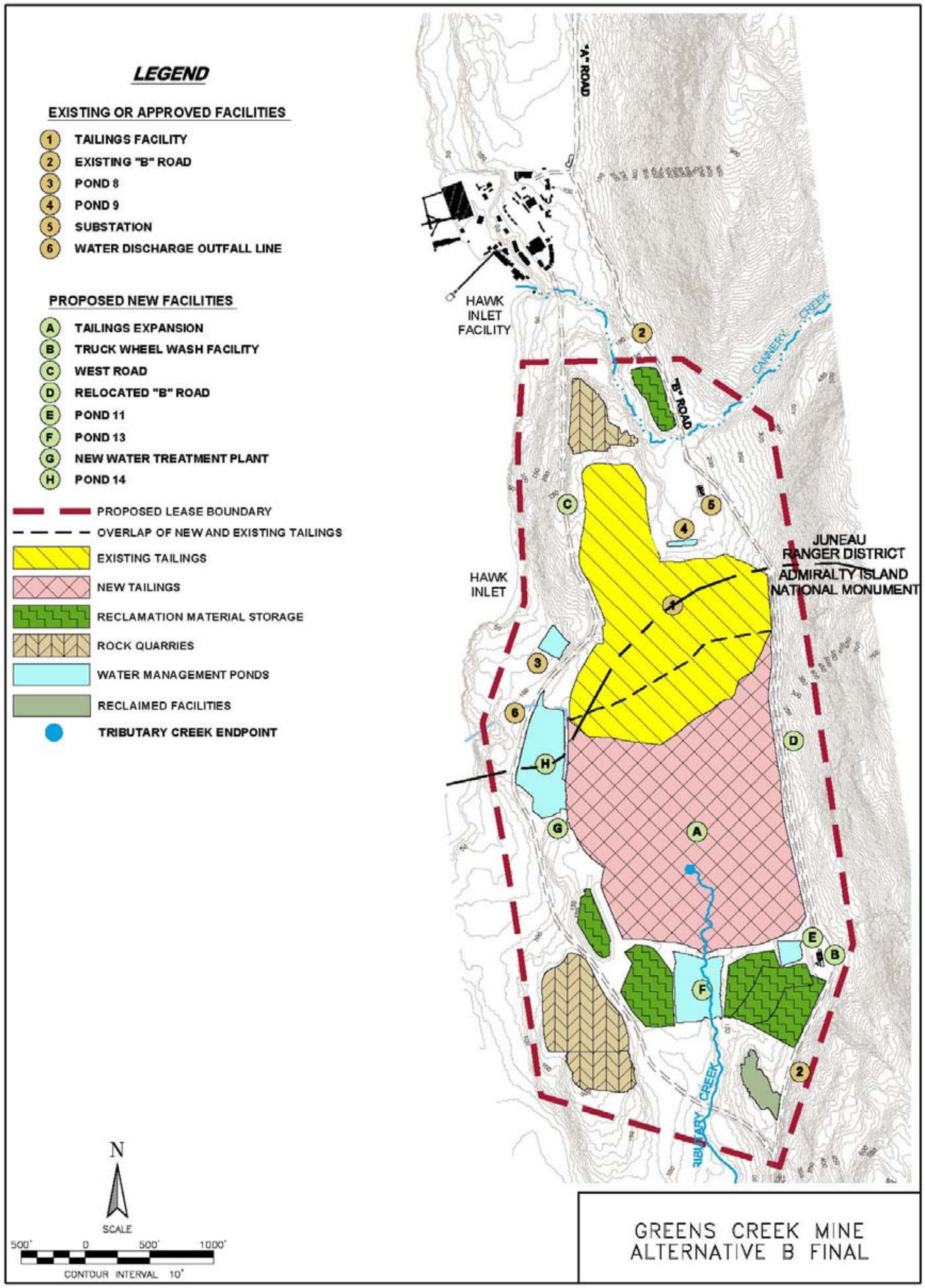

Figure 2.3-2. Greens Creek Mine Alternative B Final.

2.3.3 Alternative C: New TDF Located Outside Monument

Alternative C: New TDF located outside the Monument – The existing TDF would be expanded to accommodate an additional 3 years of tailings disposal. A new TDF would be built to the north to accommodate additional tailings disposal, extending the life of the mine an additional 30–50 years.

Under Alternative C, the capacity of the existing TDF would be expanded by 8.1 acres with the capacity to store approximately 1 million cubic yards, for a total of 6.3 million cubic yards, providing disposal capacity for an additional 3 years. Under this alternative, a new TDF would be developed north of the existing TDF, outside of the Monument (see figures 2.3-3a, 2.3-3b, and 2.3-3c). The new TDF would be developed to accommodate the remaining 8.7 million cubic yards, providing adequate capacity to contain the same amount of tailings and waste rock considered under the proposed action. The development of the new TDF to the north would require 2 to 3 years for site preparation and construction. As with the proposed action, the 30–50 year timeframe reflects the variable nature of production and backfill rate.

Expansion of the existing TDF would occur in a similar manner as proposed under Alternative B except to a lesser extent. Contact water from disturbed sites would be routed into water management ponds, including an expanded Pond 9 (see Figure 2.3-3c), and then pumped to the existing Pond 7, from where it would be pumped to the water treatment plan for treatment before being discharged to Hawk Inlet. An existing reclamation material storage site located near Pond 7 would be expanded. The new TDF would be developed in the same manner as the existing TDF, including the design and construction and operation of the sub-drains, liner, and tailings placement. New finger and blanket drains would be placed to form the facility underdrain system. The underdrains would be built on a pad of unreactive material. The underlying pad would be graded and the underdrain system designed so that, in the absence of active management, contact water from the new TDF would drain toward Hawk Inlet and avoid Fowler Creek, which supports anadromous fish populations. New diversions would also be construction to route non-contact surface water runoff around the facility. Non-contact ground and surface waters diverted around the TDF would be routed to their original drainage basin, Hawk Inlet or Fowler Creek.

All drainage and runoff from within the new TDF would be captured and routed to a new settling pond before being pumped to the existing water treatment plant and discharged through the existing outfall. A pipeline would be constructed following the existing road network to transport contact water from the new TDF to the existing water treatment plant (see figures 2.3-3a and 2.3-3b). The expansion of the existing TDF and the construction of the new TDF would make use of the existing water treatment plant for approximately 30 years, after which a replacement to the water treatment plant would be necessary (due to normal operational lifetime of the water treatment plant).There would be no water treatment plant at the new TDF site.

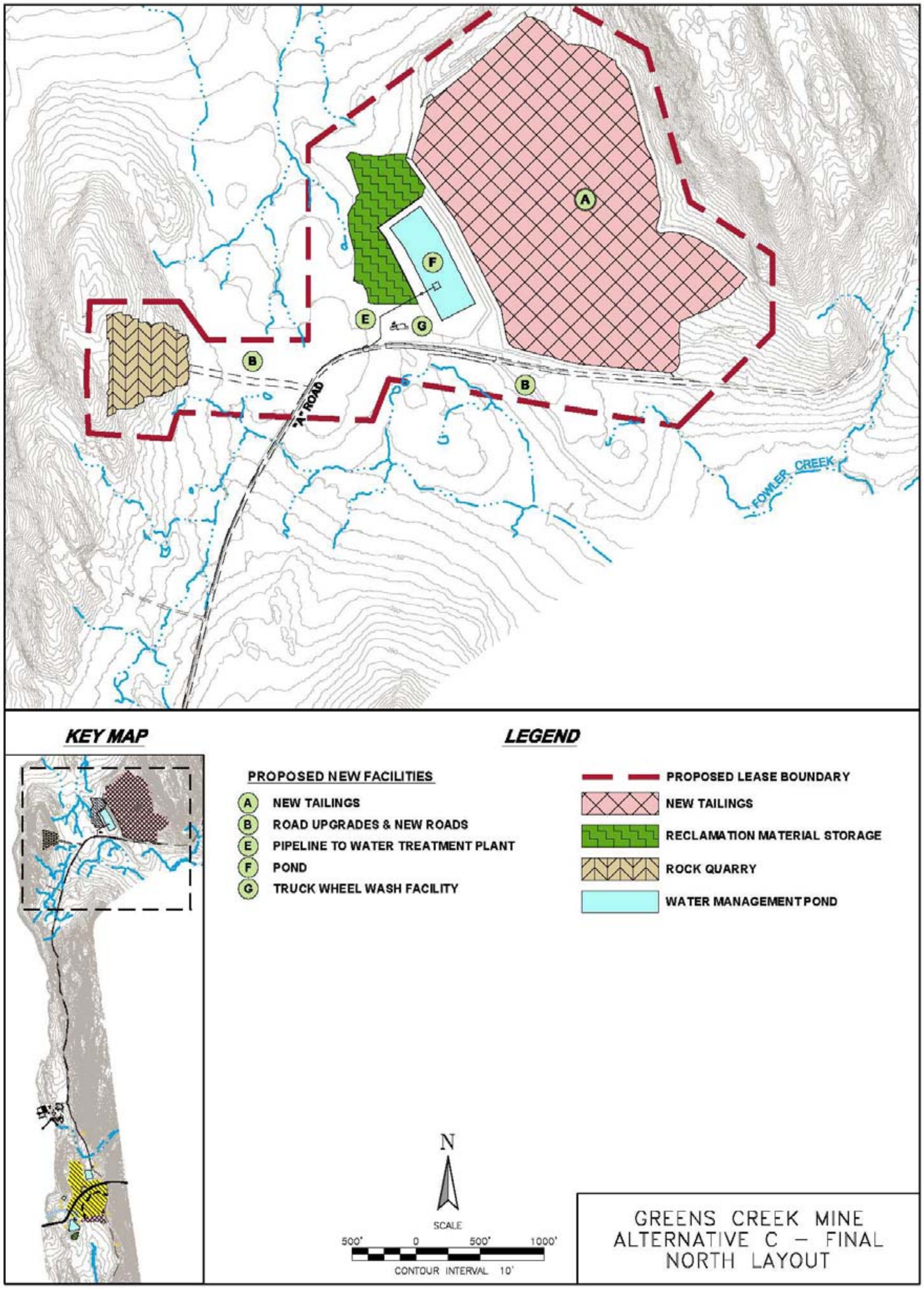

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Figure 2.3-3a. Greens Creek Mine Alternative C – Final North Layout.

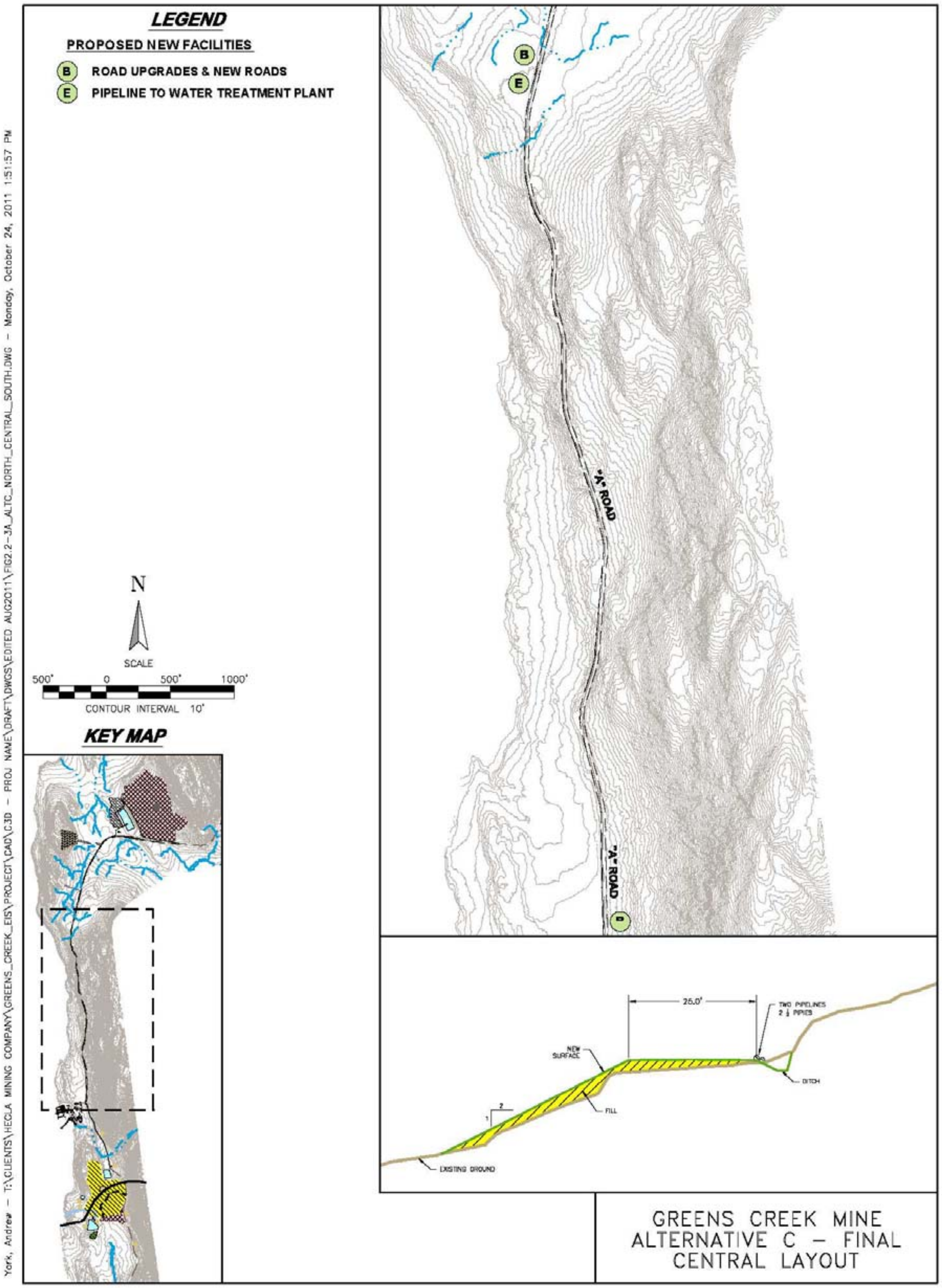

Figure 2.3-3b. Greens Creek Mine Alternative C – Final Central Layout.

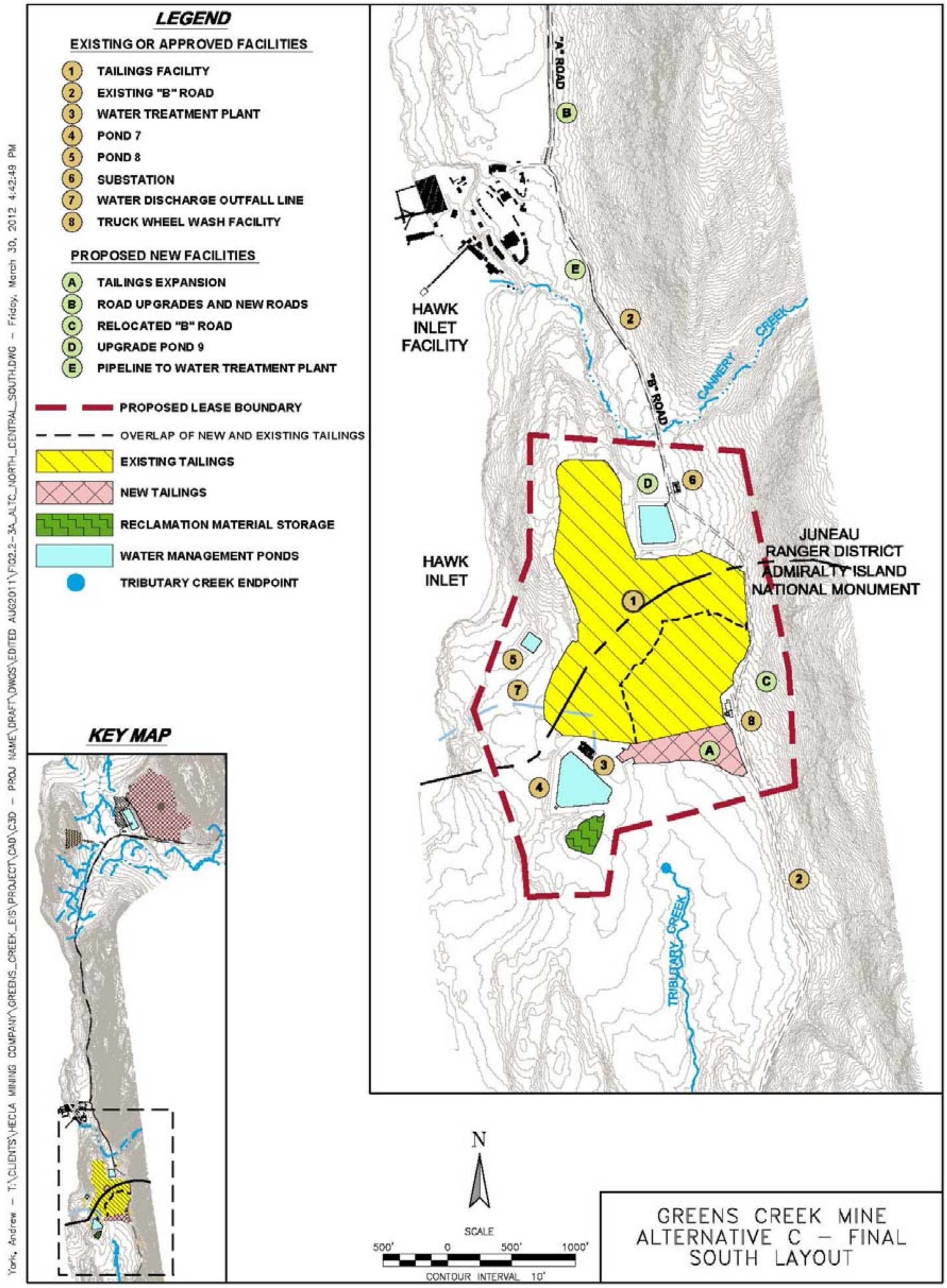

Figure 2.3-3c. Greens Creek Mine Alternative C – Final South Layout.

Construction of the new TDF would also involve developing a reclamation material storage area and two new rock quarries, one of which would ultimately be used for tailings disposal at the new TDF. Rock from the quarries would be used for the construction of internal roads in the new TDF.

A new truck wheel wash facility and associated water collection system would also be constructed at the new TDF to prevent tracking of tailings and waste materials away from the TDF. The A Road would be upgraded to accommodate construction traffic and haul truck use (see figures 2.3-3a and 2.3-3 b).

Maintaining drainage would be an ongoing activity at both TDF sites. HGCMC would implement sediment control measures to limit tailings erosion. Directing runoff to armored/rocked areas or diversion tubes[2], maintaining road ditches and outside slopes, and cleaning ditches as sediment accumulates are among the techniques that HGCMC uses to control erosion at the site. Because the expansion at the existing TDF would be less than under the proposed action, less contact water capacity would be necessary and fewer basins and ponds would be built at the existing TDF.

Alternative C would involve placement of the final cover and revegetation of the existing TDF with closure of the final active disposal areas as soon as possible following tailings placement (beginning in approximately 3 years). Under this alternative, portions of the new TDF would be reclaimed in the interim as conditions allowed, until final reclamation occurred. Final reclamation would be conducted at the end of tailings disposal and would include covering, revegetation, and ongoing water management.

Table 2.3-1 summarizes the additional acreage of disturbance associated with the development and the final footprint of the project.

2.3.4 Alternative D: Modified Proposed Action

Alternative D: Modified Proposed Action – The existing TDF would be expanded to accommodate an additional 10 years of tailings disposal. A new TDF would be built to the north to accommodate additional tailings disposal, extending the life of the mine an additional 30–50 years.

Under Alternative D the capacity of the existing TDF would be expanded by 24.2 acres with the capacity to hold approximately 3 million cubic yards of tailings and waste rock. The expansion would result in an overall capacity of 8.3 million cubic yards of tailings and waste rock in the existing TDF over the 10-year extension in operations. Under this alternative, a new TDF would be developed north of the existing TDF, outside of the Monument at approximately the same location as the new TDF in Alternative C (see figures 2.3-4a, 2.3-4b, and 2.3-4c). The new TDF would be developed to accommodate the remaining 6.7 million cubic yards, providing adequate capacity to contain the same amount of tailings and waste rock considered under the proposed action. As with the proposed action, the 30–50 year timeframe reflects the variable nature of production and backfill rate.

[2] Diversion tubes are flexible, water filled tubes used for storm water diversion and erosion control. They are similar in function to the use of sandbags to manage runoff.

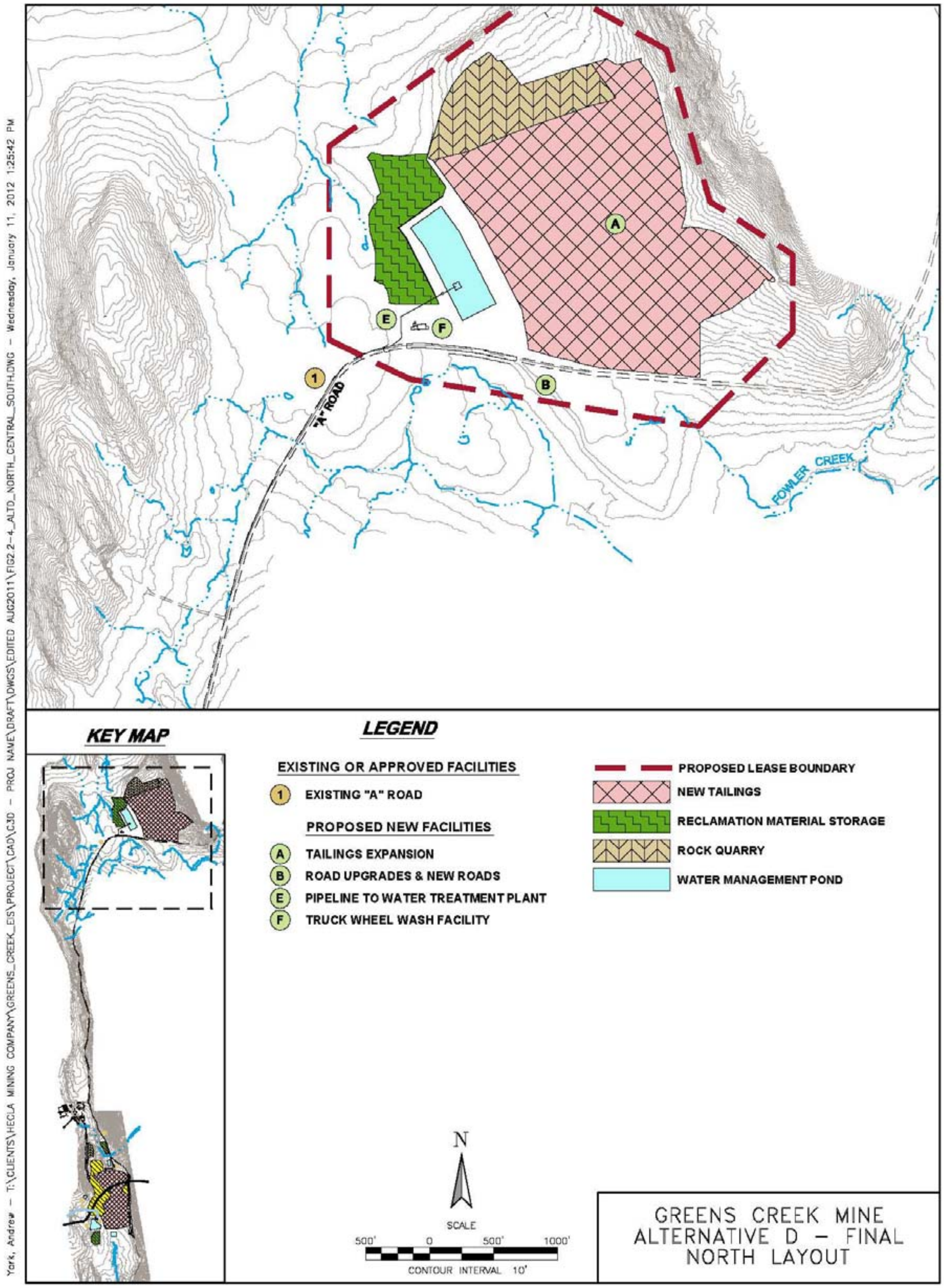

Figure 2.3-4a. Greens Creek Mine Alternative D – Final North Layout.

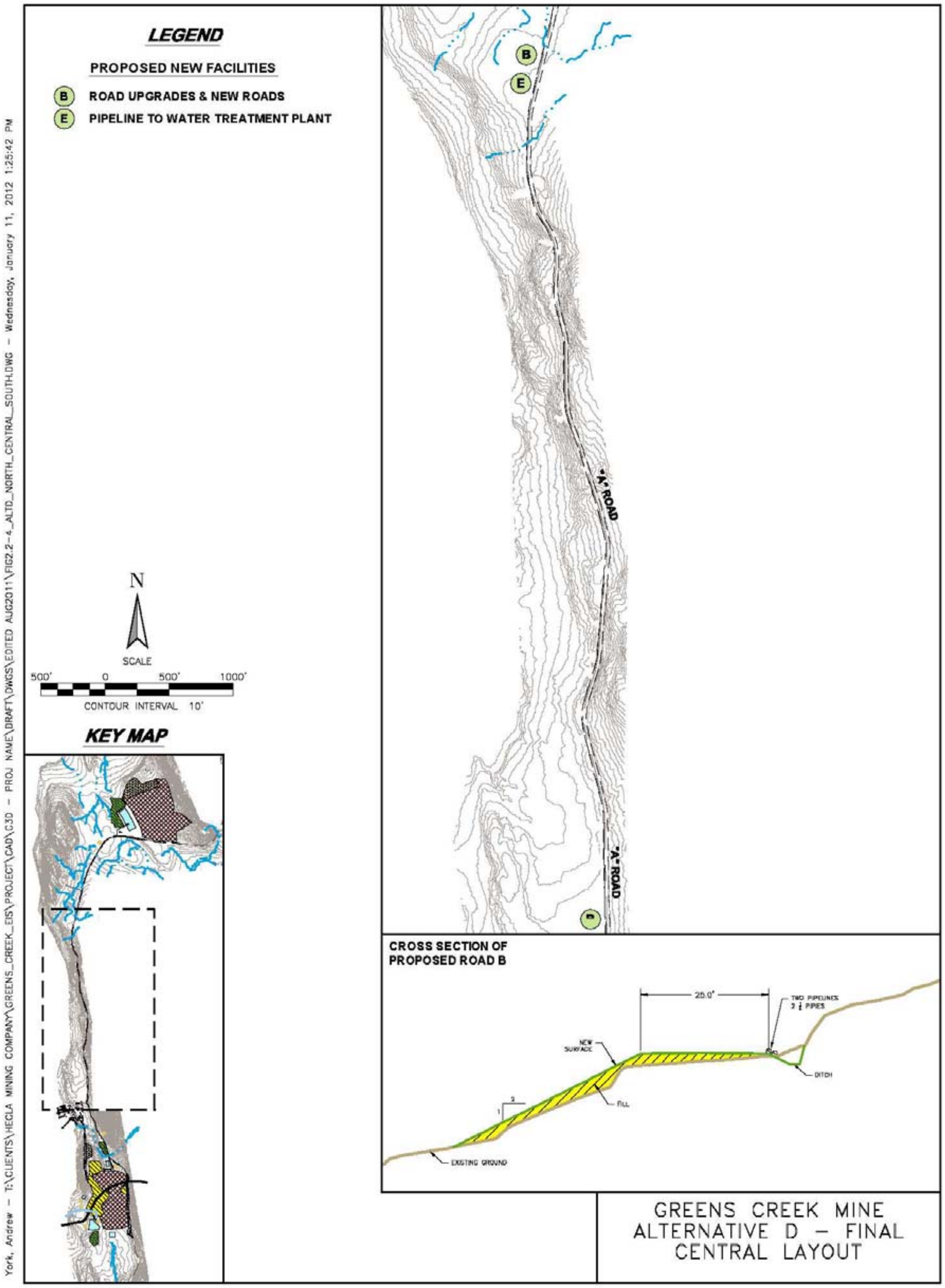

Figure 2.3-4b. Greens Creek Mine Alternative D – Final Central Layout.

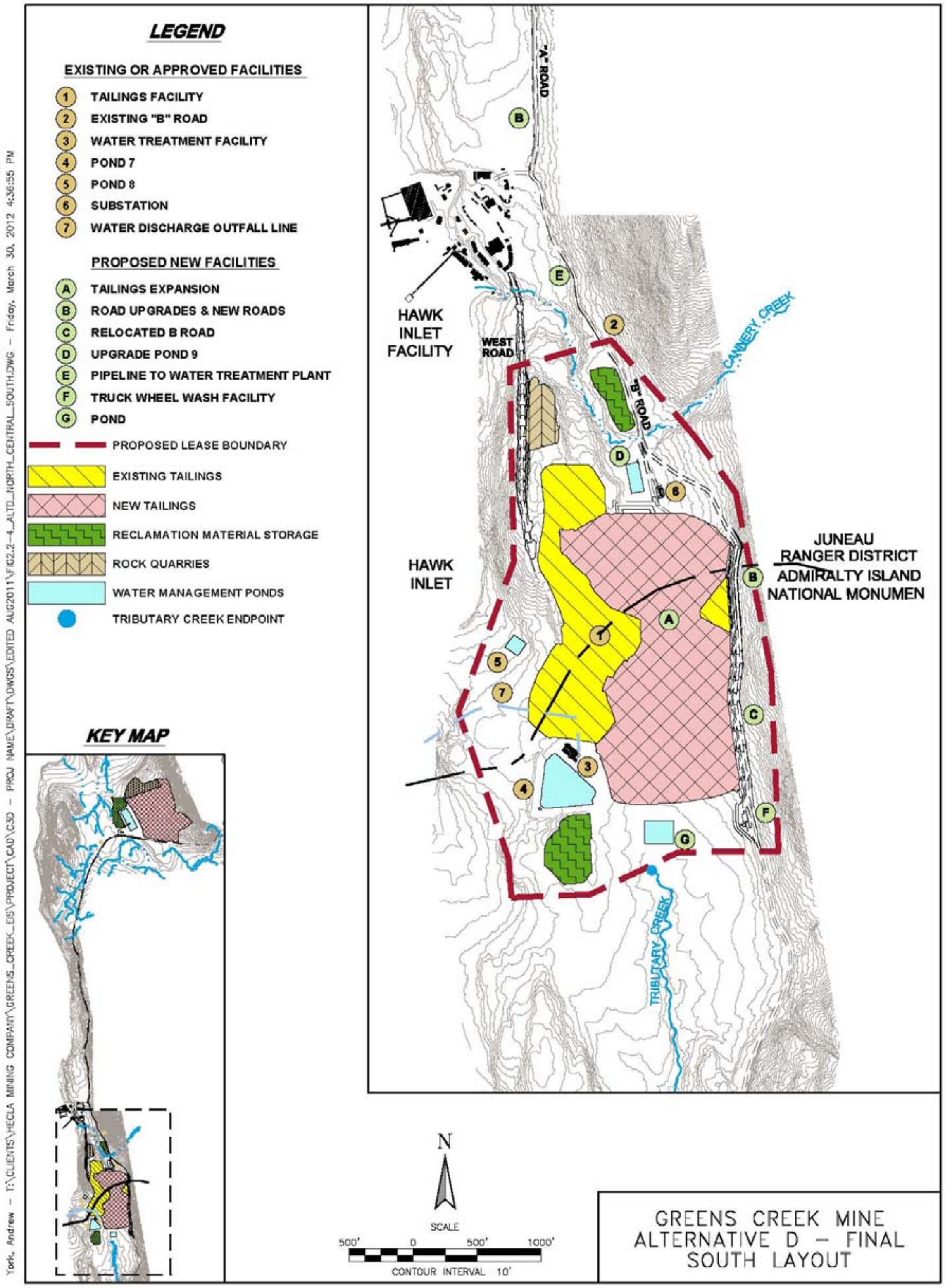

Figure 2.3-4c. Greens Creek Mine Alternative D – Final South Layout.

Expansion of the existing TDF would occur in a similar manner as proposed under alternatives B and C, except the extent of disturbance at the existing location would be less than Alternative B and greater than Alternative C. Contact water from disturbed sites would be routed into water management ponds, including an expanded Pond 9 and a new pond south of the TDF (see Figure 2.3-4c). Contact water would then be pumped to the existing Pond 7 before it would be treated, and then it would be discharged to Hawk Inlet. The existing truck wash would be moved or replaced to make room for tailings placement. Alternative D would require developing a new rock quarry north of the existing TDF, and expanding one and creating a new reclamation material storage area near the existing TDF.

The new TDF would be developed in the same manner as the existing TDF, including the design and implementation, design, construction, and operation of the sub-drains, liner, and tailings placement. The underdrains would be built on a pad of unreactive material graded so that, in the absence of active management, contact water from the new TDF would drain toward Hawk Inlet and avoid Fowler Creek. New diversions would also be required to route non-contact surface water runoff around the facility. Non-contact ground and surface waters diverted around the new TDF would be routed to their original drainage basin, Hawk Inlet or Fowler Creek.

All drainage and runoff from within the new TDF would be captured and routed to a new settling pond before being pumped to the existing water treatment plant and discharged through the existing outfall. A water management pond would be constructed adjacent to the new TDF and a pipeline would be constructed following the existing road network to transport contact water from the new TDF to the existing water treatment plant (see figures 2.3-4a and 2.3-4b). The expansion of the existing TDF and the construction of the new TDF would make use of the existing water treatment plant for approximately 30 years, after which a replacement to the water treatment plant would be necessary (due to normal operational lifetime of the water treatment plant). As with Alternative C, there would be no water treatment plant at the new TDF site.

Construction of the new TDF would involve developing a reclamation material storage area at the new site and a rock quarry in an area that would partially be used for tailings disposal in later stages. Rock from the quarry would be used for the construction of internal roads in the new TDF. A new truck wheel wash facility and associated water collection system would also be constructed at the new TDF. The A Road would be upgraded to accommodate construction traffic and haul truck use (see figures 2.3-4a and 2.3-4 b).

Maintaining drainage would be an ongoing activity at both TDF sites. HGCMC would implement the same sediment control measures to limit tailings erosion as with the other alternatives. Because the expansion at the existing TDF would be less than under the proposed action, less contact water capacity would be necessary and fewer basins and ponds would be built at the site.

Alternative D would involve placement of the final cover and revegetation of the existing TDF as soon as possible following tailings placement (beginning in approximately 10 years). Under this alternative, portions of the new TDF would be reclaimed in the interim as conditions allowed, until final reclamation occurs. Final reclamation would be conducted at the end of tailings disposal and would include covering, revegetation, and ongoing water management.

Table 2.3-1 summarizes the additional acreage of disturbance associated with the development and the final footprint of the project.

2.4 Project Component Details

2.4.1 Mining Activities

Underground mining methods are used to remove ore from the mine. The HGCMC employs a combination of open stope and block mining methods to remove ore and waste rock. As part of the mining process waste rock and tailings are backfilled into some of the voids created by the mining process to provide structural stability within the mined out areas. The waste rock brought to the surface is placed into a disposal facility (Site 23), or, based on need, used in the TDF to build roads that serve as the working surface for tailings placement. No changes to the mining process are being considered in this analysis. Alternatives focus on tailings disposal. Mining activities are guided by the GPO.

2.4.2 Mineral Processing

Ore is removed from the mine and placed in stockpiles near the mill building at a rate of approximately 2,200 tons per day. Ore is fed into the mill where it is crushed and mixed with liquid reagents to form a slurry. The slurry is then pumped into a series of tanks that are used to separate the valuable metals-bearing materials (concentrate) from the non-valuable waste product (tailings). No changes to the mineral processing are being considered in this analysis. Concentrate is trucked to the port facility and shipped to smelters; tailings are either trucked to the TDF or used to make paste backfill and disposed of underground.

2.4.3 Waste Disposal

Waste material consists mainly of tailings and waste rock. As noted above, tailings and waste rock may be either placed back underground or disposed of on the surface. Tailings brought to the surface for disposal may only be placed in the TDF. Waste rock disposed of above ground is primarily placed at the approved disposal facility (Site 23) or used in the TDF for erosion control or to build roads that serve as the working surface for tailings placement. Table 2.4-1 depicts typical disposal options for waste generated at the mine.

Table 2.4-1. Waste Disposal at Greens Creek Mine [a].

Waste	Underground	TDF	Site 23	Off Site
Tailings [b]	X	X		
Waste Rock	X	X [c]	X	
Relocated Site E Waste Rock [d]		X		
Hazardous Materials				X
Other Materials				
Pressed sludge from sewage and water treatment [e]		X		
Incinerator Ash [f]		X		
Sediments removed from settling ponds, ditches, and basins		X		
Tires and miscellaneous refuse [g]	X			

Notes:

a. Per Waste Management Permit and GPO.
b. Approximately half of tailings generated are backfilled underground.
c. Waste rock is permitted in the TDF for co-disposal, including rock used for internal roads and erosion control.
d. Co-disposal of waste rock was authorized by the Forest Service and State of Alaska in 2009. Annually, about 40,000 cubic yards of waste rock from Site E is moved to the TDF (based on 2009 and 2010 records).
e. Respectively, about 50 and 500 cubic yards of sewage and water treatment plant sludge are disposed of at the TDF annually.
f. About 6 cubic yards of incinerator ash is disposed of at the TDF annually.
g. About 5,350 cubic yards of tires and other refuse were disposed of underground in 2010, in accordance with the Waste Management Permit.

2.4.3.1 Tailings

Tailings are the non-valuable waste product of mineral processing. Approximately half of the tailings generated are backfilled into underground voids created by the mining process. The remainder of the tailings (about 180,000 cubic yards annually) are filtered and then transported by covered haul truck to the TDF for permanent disposal. Tailings are placed into the TDF as a series of 1-foot layers (lifts) within discrete disposal locations (cells) to provide for control over compaction, drainage, and pore-pressure dissipation. As part of site reclamation, an engineered soil cover will be placed over the TDF; this is discussed further in sections 2.4.8.2 and 2.4.8.3. Appendix E provides a detailed depiction of the tailings placement within the TDF.

The construction design for the existing TDF is similar to that used for a landfill. Much of the TDF is underlain by naturally occurring low permeability materials or a liner system designed to prevent groundwater from flowing into the facility as well as water leaching from the facility into the local groundwater system. Details on liner construction are provided in Appendix E. Clean surface waters are diverted around the TDF.

2.4.3.2 Waste Rock

Waste rock is rock that has metals concentrations below those that can be economically processed. Waste rock must be removed to gain access to the ore material. Waste rock excavated during underground operations is either directly backfilled underground into areas that have been mined out or hauled from the mine to the surface and stockpiled.

Waste Rock Classification – HGCMC classifies waste rock based on its geochemical reactivity. The material most subject to acid formation and metals leaching is placed back into mined out areas (voids) within the mine without being brought to the surface. Less reactive material is disposed of on the surface. For operational production rock management, visual classification based on geology and periodic sampling and analysis are performed.

Waste rock hauled to the surface from ongoing operations is permitted to be permanently placed at Site 23. From 2008 through 2010, an average of about 17,000 cubic yards of waste rock was placed at Site 23 annually, ranging from about 12,000 cubic yards in 2010 to 24,400 cubic yards in 2008. Waste rock is also placed at the TDF for use as erosion control and internal road material. These roads are known as "dirty roads" and are needed to prevent rutting of tailings material, especially during wet weather (The roads discussed in Section 2.4.7 are considered "clean roads."). HGCMC also uses waste rock or quarry rock to define the disposal cells.

2.4.3.3 Co-Disposal (Tailings and Waste Rock)

Co-disposal refers to the placement of a mixture of waste rock and tailings within the TDF. The primary purpose of co-disposal is to allow potentially acid-generating material at Site E to be moved to the TDF for permanent disposal. Co-disposal would reduce the rates of pyrite oxidation and metal leaching from waste rock by surrounding it with the tailings. The tailings provide a fine-grained bedding material which reduces the amount of waste rock surface area exposed to oxygen. The benefit of co-disposal of waste rock with tailings at the TDF include:

- Lowering oxidation rates in the waste rock and extending its acid neutralization capacity;
- Improving pore water chemistry relative to that of tailings and waste rock disposed of separately;
- Improved drainage quality at sites where waste rock is removed; and,
- Consolidation of waste sites reduces the overall number of sites needing engineered covers at closure.

Waste rock is authorized to be co-disposed of with tailings at the TDF. Sources of waste rock for co-disposal include rock used for erosion control, internal roads, delineating disposal cells and relocated rock from inactive waste rock storage sites. Between 2009 and 2010, about 54,000 cubic yards of waste rock were co-disposed of at the TDF annually.

2.4.3.4 Other Wastes

Other non-hazardous wastes that must be managed include sludge generated in the wastewater treatment process and ash generated in the process of incinerating wastes such as paper and food wastes. Sediments removed from settling ponds, ditches, and basins may also be placed into the TDF. All these materials are placed into the TDF under a waste management permit issued by the Alaska Department of Environmental Conservation (ADEC). Hazardous wastes are collected and shipped off site to an approved facility.

2.4.4 Water Management

All water coming in contact with mine-related activities must be controlled and discharged under the mine's APDES permit. The flow of water is controlled using a series of ditches located around all the facilities. Collection ditches gather water that has come in contact with mining operations and direct it to ponds or sumps where it can be pumped to the appropriate locations for treatment. Diversion ditches around the outside of facilities and disturbances are used to divert clean water away from facilities to minimize the amount of "contact" water. Water from the diversion ditches is directed into the adjacent landscape. Collection and diversion ditches are included as components of all alternatives.

Wastewater treatment is currently accomplished in one of two wastewater treatment plants (WWTPs) located on the site. The WWTP at the mill treats water used in the milling process, mine water, and contact water collected in the immediate vicinity of the mill. Water discharged from this treatment plant can be directed back to the mill for re-use or to Pond 7, which collects water from the TDF. A second WWTP located at Pond 7 treats all runoff from the TDF and any other water directed to Pond 7; the plant discharges to Outfall 002 located in the marine waters of Hawk Inlet.

The APDES permitting program establishes a series of conditions that apply to both storm water and mine water at defined outfalls, including Outfall 002. Storm water outfalls are located at a number of locations throughout the facility. Collected process wastewaters are treated at the Pond 7 WWTP to meet effluent limits identified in the APDES permit prior to discharge through a diffuser outfall located in Hawk Inlet. The Pond 7 process wastewater includes runoff and seepage from the TDF and runoff from mine facility areas. These waters are collected by a series of wastewater management ponds. Seepage through the TDF flows to the TDF underdrain collection system and is collected by a series of wells at the base of the TDF. A conceptual drawing of the TDF and contact water collection system is provided in Figure 2.4-1 in Section 2.4.8.3. After mining is completed, it is expected that seepage from the TDF will not meet Alaska Water Quality Standards (WQS) and therefore water treatment will be needed in order to meet WQS. However, surface water runoff from the engineered final cover would not require treatment and the collection ponds would be reclaimed and runoff would be allowed to go to natural drainages. A more detailed discussion of the APDES permitting requirements and treatment needs is provided in Section 3.5.

The wastewater discharge outfall location and permit requirements would be the same for all of the alternatives. The location of ponds, ditches, and storm water outfalls would change over time and could occur in different locations under each of the alternatives. The WWTP at the existing TDF may need to be relocated at some point in the future depending on the alternative.

Storm water controls include diversion ditches, culverts, storm water detention basins, and storm water collection ponds. Runoff from undisturbed areas is and would continue to be routed around disturbed areas through ditches and culverts.

2.4.5 Rock Quarries

Approximately 20,000 to 30,000 cubic yards of rock material are required annually for the internal roads at the TDF. Several bedrock areas associated with each of the proposed TDF expansion areas have been identified as possible rock quarries (see figures 2.3-2, 2.3-3a, 2.3-4a, and 2.3-4c). These quarries would serve as rock sources for the internal tailings roads. Given the potential for acid generation, none of this rock material would be used external to the TDF. Spur roads, constructed of imported, non-acid forming material, would connect the rock quarries to the A Road, B Road, or West Road (see Section 2.4-7 and Figure 2.3-2 for West Road information) depending on alternative and stage of development.

Rock Quarries – Rock is quarried onsite to develop internal roads within the TDF. Local quarry rock contains pyrite, which can weather to produce acid rock drainage and is therefore restricted to use within the TDF. External roads connecting facilities are built with imported rock.

Materials for the clean roads are imported to the site from off-site quarries. These materials are tested for leachability and acid-generating capacity according to HGCMC's Production Rock Environmental Characterization Standard Operating Procedures prior to their placement. The volume of clean materials imported to the site is approximately 16,000 cubic yards on an annual basis.

2.4.6 Truck Wheel Wash Facility

All vehicles that travel on the TDF are and would continue to be required to pass through a truck wheel wash facility prior to exiting the TDF. The truck wheel wash facility reduces tracking of tailings material onto the clean roads.

2.4.7 Support and Service Roads

Under all alternatives, the existing B Road would be maintained and continue to be the connection from the 920 portal (mine and mill) to the marine terminal area at Hawk Inlet. This road would continue to serve as the route for the transport of tailings and waste rock material from the mill and mine respectively to the TDF. A small portion of the B Road immediately east of the tailings expansion would be relocated to accommodate tailings placement under alternatives B and D.

Under the proposed action, the West Road would be constructed on the west side of the TDF and would serve as access to future rock quarries, reclamation material storage areas, water management ponds, and the existing and future water treatment plant (see Figure 2.3-2). This external road would connect to the Hawk Inlet marine terminal facility and would be used primarily for light vehicle traffic and for trucks hauling reclamation storage material or internal quarry rock. The West Road would be of similar design as the existing B Road. In addition, perimeter service roads would be maintained and installed at the toe of the expanded TDF. These roads would be the same as currently exist, that is, single-lane (minimum top width of 19 feet) all-weather roads, constructed on prepared foundations and surfaced with crushed rock and or gravel obtained from off-island sources. Similar roads would be built under alternatives C and D surrounding the expanded existing TDF as well as the new TDF to the north.

New Roads and Upgrades – Alternative B requires relocating the existing B Road to accommodate the TDF expansion. A new West Road would be built to access future TDF facilities.

Similar roads and upgrades would be needed for alternatives C and D; additionally the A Road would be upgraded up to the new TDF.

Safety berms or barriers (guard rails) would be added as appropriate to all roads to comply with the safety requirements of the Mine Safety and Health Administration (MSHA).

Roads on the TDFs themselves (dirty roads) would be constructed internal to the TDF as discussed in Section 2.4.3.1, Tailings Disposal. These roads would be constructed of waste rock, quarry rock, or off-island rock.

Under alternatives C and D, the A Road would be upgraded from its junction with the B Road to the new TDF site, approximately 3 miles. Upgrades to the A Road would be needed to accommodate TDF construction activities and use by haul trucks as well as the installation of a wastewater pipeline from the facility back to the existing WWTP. Under Alternative C, a short segment of new road would also be needed to access the new rock quarry near the north TDF. These new and upgraded roads are shown in figures 2.3-3a, 2.3-3b, and 2.3-3c and figures 2.3-4a, 2.3-4b, and 2.3-4c. Additionally, Alternative D includes a new road that would be constructed from a new quarry just north of the existing TDF to the Hawk Inlet marine terminal (Figure 2.3-4c). This is similar to the West Road under the proposed action; however it is shorter in length and would not go around the expanded TDF under Alternative D.

Currently tailings are transported from the mill to the TDF in 45-ton capacity covered tractor/trailer trucks. Approximately 20 round trips from the mill to the TDF are made daily, delivering an average of 1,000 tons to the TDF. Round trip travel time for each truck is approximately one hour. Tailings transport is only conducted during the day shift with two to four trucks in use at any given time.

2.4.8 Reclamation and Closure

Reclamation and Closure – The overall goal of reclamation is to stabilize disturbed areas and return vegetated conditions for long-term protection of surrounding land and water resources.

Reclamation and closure techniques would be the same for all the alternatives. This section describes interim and final reclamation and closure planned for the TDF and TDF expansion. Reclamation growth medium material (consisting of soil and peat) would be removed from the areas disturbed by enlargement or construction of any of the TDF structures and placed into stockpiles. This material would be used for reclamation and site closure.

Stockpiles would be protected from erosion; the existing mitigation measures to prevent wind erosion of the TDF and stockpiles include hydro-seeding, the installation of wind breaks, surface water diversions, and armoring of slopes with rip-rap when necessary.

The current land use at and surrounding the existing TDF is primarily for fish and wildlife habitat. The overall purpose of reclamation is to stabilize disturbed areas and return them to vegetated conditions to ensure long-term protection of land and water resources in the area and to obtain near-natural conditions.

HGCMC's current reclamation objectives include the following:

- Reclaim disturbed areas as soon as practical after disturbance;
- Minimize disturbance by maintaining a small footprint;
- Complete final reclamation upon permanent cessation of operations;
- Return the disturbed areas to near-natural conditions to the extent practical;
- Ensure long-term stability;
- Protect water quality;
- Protect employee and public health and safety;
- Minimize or eliminate the need for long-term active management;
- Reclaim for land uses consistent with Monument values and the Forest Plan; and,
- Ensure reclamation is consistent with the approvals and permits from the Forest Service, ADEC, Alaska Department of Natural Resources (ADNR), Alaska Department of Fish and Game (ADF&G), U.S. Army Corps of Engineers (USACE), and other regulatory agencies.

Reclamation practices and technology are ever evolving and improving. Although HGCMC already has an approved reclamation and closure plan, HGCMC will be required to regularly update the reclamation plan to take advantage of future improvements in reclamation technologies and implement improved reclamation measures.

In GPO Appendix 14, Reclamation Plan (included in part as Appendix F here), HGCMC identified the following four stages of reclamation that are applicable to the tailings facility expansion:

- Interim reclamation;
- Temporary cessation;
- Final reclamation; and
- Post-closure care and maintenance.

HGCMC is in the process of updating its current reclamation plan. After an alternative has been selected for implementation and a ROD or decision is issued by the applicable agencies, HGCMC will be required to revise its reclamation plan and financial assurance cost estimate based on the selected alternative and submit these revisions to the agencies. Agency staff will review the revised reclamation plan and cost estimate to ensure that the reclamation and closure requirements of each agency are met. The Forest Service requires submittal of a bond for reclaiming disturbances before approval of a plan of operations and implementation of the action. See Appendix B for additional information.

2.4.8.1 Interim Reclamation

Interim reclamation includes actions taken to stabilize areas that have been disturbed by mine operations. The focus of interim reclamation is twofold:

1. Reduce erosion and sedimentation of waterways; and
2. Protect water quality.

Interim reclamation at the site currently includes placement of growth medium, hydro-seeding, as well as the construction of berms, slope drains, slope armoring, rock check dams, silt fences, jute mats, detention basins, and water management ponds. Under all alternatives, interim reclamation of the TDF(s) would continue to occur throughout their operational life prior to final reclamation which would be initiated upon permanent cessation of tailings disposal.

Facility-wide interim reclamation measures are reported annually to the agencies. For example, potentially reactive berm material (pyritic rock) associated with an inactive waste site was removed and replaced with clean fill in 2010 and waste rock relocation to contained facilities is ongoing. Additional opportunities for interim reclamation are identified on an ongoing basis.

2.4.8.2 Final Reclamation

At the time of permanent cessation of project activities, HGCMC would implement final reclamation on the TDF(s) and associated infrastructure that would involve a number of steps:

- Decommissioning and removal of unnecessary structures and facilities (water treatment facilities and electric power utility lines would remain);
- Establishing surface contours conducive to natural revegetation or consistent with an alternate post-mining land use(s);
- Reclamation within the Monument will be to as near a natural condition as practicable. This would include restoring original surface drainage, removal of all structures, and re-contouring where possible;
- Placement of an engineered soil cover over TDF(s);
- Implementation, maintenance and monitoring of reclamation;
- Revegetation of all disturbed areas; and
- Maintaining wastewater management and treatment as required by permits.

The TDF final contours may be formed to establish natural drainage patterns, with the objective of long-term stability and environmental performance of the covers. Reclaimed facilities would be maintained in a free-draining condition, allowing water to shed from the facility without ponding or causing erosion, to the extent practical.

At permanent cessation of mining operations, seepage from the TDF would continue to be treated and an APDES discharge permit would be required for hundreds of years, perhaps in perpetuity; as long as the TDF seepage does not meet Alaska WQS. During permit review and reissuance cycles, depending on the actual effluent quality, tailings seepage would continue to be treated and discharged to Hawk Inlet (where it would need to meet marine WQS) or to a surface water stream (where it would need to meet fresh WQS).

HGCMC has submitted revisions to its approved reclamation and closure plan to the Forest Service and the State of Alaska. HGCMC assumes that a substantial amount of site-specific reclamation experience and performance data would be available at final closure. At that time, and based on information related to closure gleaned from experience at the site. The Forest Service and the State or Alaska will decide whether to approve the reclamation and closure plan revisions. It is expected that additional revisions will be made to the reclamation and closure plan in the future to take into account performance data based on interim site-specific reclamation experience and to take into account future advances in reclamation and closure technology. The current reclamation and closure plan is included in Appendix F.

As stated above, HGCMC will be required to update its reclamation plan and associated financial assurances to reflect the alternative selected based on this EIS.

2.4.8.3 Engineered Tailings Soil Cover

As required by the 2003 ROD, HGCMC would place an engineered four-layer soil cover over the TDF to minimize the amount of air and water that might enter the tailings after permanent closure. This cover design would be the same for all alternatives. The performance of the engineered four-layer soil test cover at Site 23 (waste rock disposal site near the 920 portal) has been monitored since 2000 and data from the program will be incorporated into the final cover design at mine closure. The components and characteristics of the proposed engineered four-layer soil cover over the tailings are as follows:

Tailings Cover – Upon closure of the mine, the tailings pile will be covered with an engineered four-layer soil cover, to minimize air and water exposure to the tailings and reduce the potential for acid drainage.

Lower Capillary Break: The first layer directly on top of the tailings material would consist of drain rock. Capillary breaks are created by layers of rock through which water can drain from the layers above. The small gaps between the rocks also keep water within the tailings from wicking up through the cover by capillary action. This layer would function as a lower capillary break to drain seepage from above layers and to remove water that might wick up through the tailings. The rock used for this layer would be mine waste rock, quarry rock, or rock imported to the site from an off-island source.

Compacted (Barrier) Layer: The second layer would be composed of a clay soil. This layer would be a compacted, low permeability barrier layer that would minimize water and oxygen infiltration into the tailings pile. This layer is designed to stay 85% saturated to minimize air and water infiltration.

Upper Capillary Break: The third layer would consist of another layer of drain rock. The layer would function as an upper capillary break in a similar fashion as the lower capillary break and drain seepage from the growth layer.

Growth Layer: The fourth or top layer would be composed of reclamation growth material. This material would support vegetation, as well as provide a small amount of recharge water to the underlying compacted (barrier) layer to maintain saturation. This material would support the forest vegetation, such as western hemlock and Sitka spruce that would be allowed to naturally regenerate on the reclaimed tailings. According to HGCMC's Proposed TDF Expansion Stage 3 (Hecla 2011), the plant growth layer would be between 24 and 36 inches. Figure 2.4-1 shows the engineered soil cover.

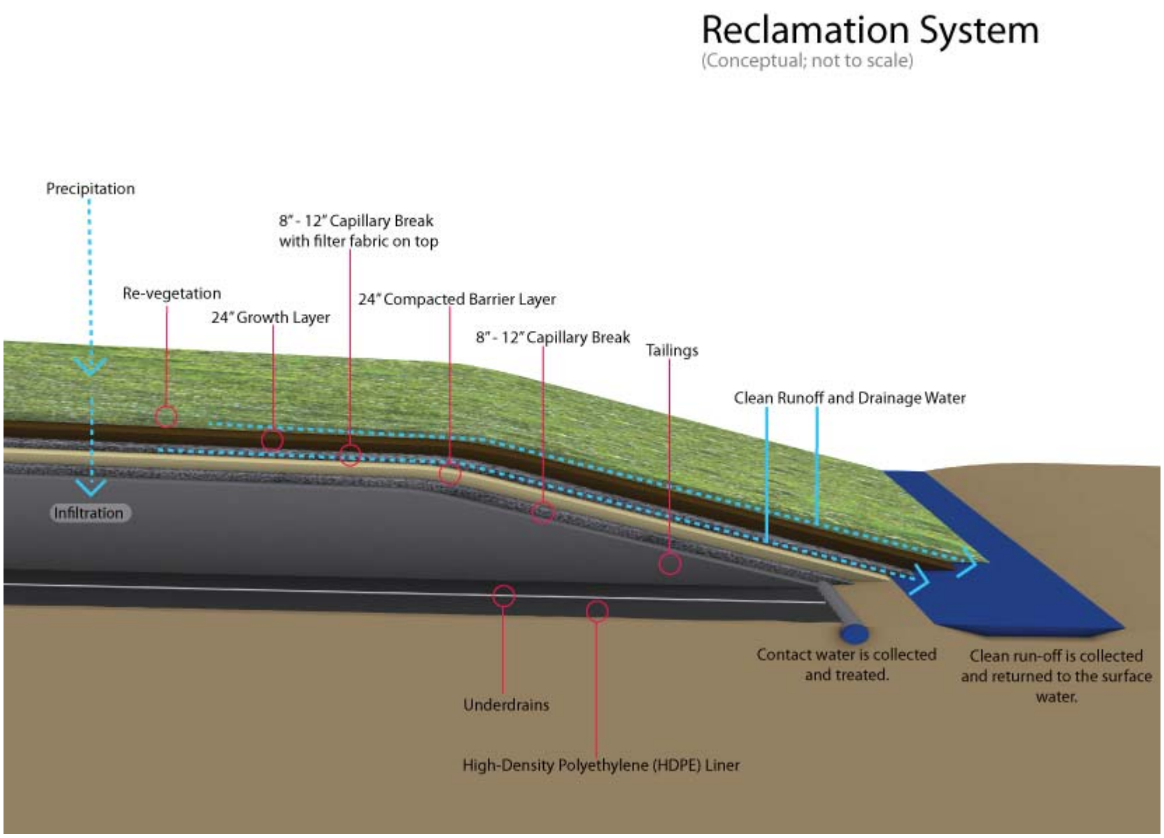

Figure 2.4-1. Conceptual Drawing of TDF at Closure with Typical 4 Layer Engineered Cover for Reclamation Placed on a 3:1 Slope.

Runoff and drainage water from the upper capillary break layer from the surface cap would not be a regulated discharge if it were not allowed to comingle with the tailings contact waters. Once the vegetation on the surface cap matures, these waters would be allowed to flow to surface water or infiltrate to groundwater. A detailed discussion of the management of tailings contact water and non-contact waters after closure is provided in Section 3.5.3.1.

2.4.8.4 Site Revegetation

Disturbed areas would be reclaimed to one of three vegetation types including upland meadows, upland forest, or wetlands. Specific seed mixtures, woody seedling density, and maps showing each vegetation type would be part of a detailed reclamation plan submitted to the Forest Service prior to closure.

Acknowledging that the Greens Creek Mine is located in the temperate coastal rain forests of southeast Alaska, where forest vegetation regenerates quickly and profusely, HGCMC plans to allow natural regeneration to be the primary method of forest re-vegetation (GPO Appendix 14, Reclamation Plan).

2.5 Alternatives Considered but Not Carried Forward

Expansion of the capacity to dispose of tailings and waste rock are the focus of this EIS. Since the Greens Creek Mine is already in operation, a number of aspects of the mining process, including mining methods, processing technologies, production levels, and power supply were not addressed as they are already authorized and currently in place. However, in developing the alternatives evaluated in detail, a number of other alternatives were considered but ultimately not selected to be carried forward. The following subsection describes the rationale for developing these alternatives along with the reasoning for not carrying them forward.

Submarine tailings disposal (in Hawk Inlet or Chatham Straight in this case) has been considered previously for other southeast Alaskan mine projects and would require a change to the National Pollutant Discharge Elimination System regulations under the Clean Water Act (CWA). While the fact that this approach to tailings disposal is not currently allowed under the law does not necessarily eliminate it from further consideration, the permitting pathway could not reasonably be accommodated in the timeframe spelled out within the purpose and need.

Shipping wastes off site was identified during scoping as a potential alternative but was also eliminated because it would have been uneconomical. The following subsections describe the rationale for developing other alternatives along with the reasons for not carrying them forward. Additional discussion is provided in Appendix C.

2.5.1 Alternative Facility Locations

Following the identification of significant issues, the Forest Service hosted a meeting of the cooperating agencies to discuss alternative locations for a TDF that would be located outside the Monument. Locations within the Monument were eliminated from consideration because of the significant issues (minimize effects to Monument values). Screening criteria were developed to provide an initial focus on other potential locations for tailings disposal and included slope steepness, presence of wetlands, and drainages supporting anadromous streams. Hillsides having a slope greater than 30 percent were eliminated from consideration for a tailings facility because of geotechnical stability concerns. The CWA requires that impacts to wetlands and other waters of the United States be avoided or minimized. Further, wetlands and drainages supporting anadromous fish were identified as significant issues in the scoping process, providing additional reason for avoidance or minimization.

The Forest Service and cooperating agency team, including biologists, engineers, and regulators, used a map that highlighted these areas in an effort to identify suitable alternative locations. The topography of the area presented particular challenges in identifying suitable sites since most areas that did not exceed the maximum slope restrictions were wetlands. No sites were identified that would avoid steep slopes, wetlands, and anadromous streams.

The interagency working group eliminated a number of sites from further consideration because of their location within the Fowler Creek drainage. Fowler Creek drains a substantial portion of northeastern Admiralty Island and supports a large anadromous fish population. One location was eliminated because of the difficulties in managing storm water running onto the site since the site straddled the Fowler Creek drainage as well as a number of small, unnamed drainages that eventually discharge to Hawk Inlet. The facility location identified for alternatives C and D reflects a compromise where (1) the portion of drainage within the Fowler Creek drainage could be redirected to the unnamed stream draining to the head of Hawk Inlet (minimizing potential long-term effects on an anadromous stream) and (2) the facility could be constructed maximizing the amount of upland use for the design while minimizing impacts to wetlands and anadromous streams.

2.5.2 Alternative Facility Designs

Disposal of tailings in a slurry form within a tailings impoundment was evaluated in the original EIS finalized in 1989. The technology exists for this approach to tailings disposal although placement opportunities for an impoundment are limited. In addition, a tailings impoundment would result in greater land disturbance and higher volumes of water to be managed in comparison to dry-stack technology. Therefore, construction of a tailings impoundment was not carried forward for detailed analysis. The approach to using submarine tailings disposal (into Hawk Inlet or Chatham Strait) have been considered previously in other southeast Alaskan mine projects and would require a change to the CWA. While the fact that this approach to tailings disposal is not currently allowed under the law does not necessarily eliminate it from further consideration, the permitting pathway could not be accommodated with the time frame spelled out within the purpose and need.

Alternate TDF designs were also considered. Placement of a narrowed and elongated TDF expansion west of the design described under the proposed action could potentially reduce the extent of wetland impacts to Tributary Creek wetlands. This type of design was put forth in the early phases of alternative development. In order to sufficiently shift the TDF to the west out of emergent and scrub-shrub wetlands, a buttress would need to be constructed to ensure stability of the western slope of the tailings pile. While technically feasible, the design would involve the placement of substantial volumes of clean fill (approximately 3.6 million cubic yards) to form a buttress along the slope that leads to Hawk Inlet. Because of the reactive chemical behavior of most of the rock on Admiralty Island, this fill would have to be shipped to the site by barge. Construction of such a buttress would represent substantial costs to the operation. Contributing to the cost factor would be the necessity to construct a new water treatment plant in the immediate future since the staging of this design would require placing tailings into the area currently occupied by the water treatment plant in the immediate (less than 10 years) future, well before its planned service life. In order to develop this design cost effectively, growth material stockpiles would have needed to be placed into wetlands similarly to the proposed action. Ultimately, the costs and logistical complexity of this approach, combined with the wetlands impacts within the Tributary Creek drainage and its presence within the Monument resulted in this alternative being eliminated from further consideration.

2.5.3 Reduction of the Pyrite Concentration in the Tailings

The 2003 EIS identified the reduction of pyrite concentrations within the tailings as an alternative considered but not carried forward. The potential for changes in technology since that time warranted a reevaluation of the 2003 conclusion for this analysis.

The alternative would consist of employing an additional flotation circuit to remove most of the pyrite from the tailings. Pyrite separated from the tailings would require special handling prior to disposal in either specially prepared cells within the TDF or being backfilled into the mine. Existing flotation circuits in the mill could not be used for pyrite flotation without reducing the production rates of lead and zinc concentrates. For this reason, a separate pyrite plant would need to be constructed adjoining the existing mill at the 920 mine site. The pyrite concentration process uses sulfuric acid which would require an additional sulfuric acid storage area. A pyrite concentrate storage facility would also need to be built in order to coordinate disposal to either surface or underground operations.

The 2003 EIS estimated that the pyrite plant would require approximately 1 acre. That analysis also estimated that a sulfuric acid storage and handling facility could require an additional 0.5 acres and a concentrate handling and temporary storage facility could occupy an additional acre. All three facilities would need to be located in the mill site which is a highly congested area with steep topography. The feasibility of locating these facilities in this area is low.

The storage of sulfuric acid would greatly add to the inventory of hazardous materials at the mine, and would require a high level of spill prevention and pollution controls. There would also be increased risk of hazardous material spills during shipping, both by barge to the mine and by truck to the mill. Spills could directly and severely impact water quality, aquatic life, and Monument values.

The pyrite concentrate would be highly reactive with the potential for spontaneous combustion. The 2003 EIS estimated that the pyrite concentrate would have the potential to oxidize within one year. Like the sulfuric acid storage facility, a pyrite storage facility would require a high level of spill prevention, special material handling, and pollution controls.

This alternative was eliminated from further consideration for the following reasons:

- The difficult logistics and operational constraints of placing the required facilities at the current mill site; and
- The unreasonable level of risk to water quality, aquatic life, and Monument values as well as human health that would be associated with the shipping and storage of sulfuric acid, and the handling of pyrite concentrate because of its potential reactivity.

2.6 Mitigation and Monitoring

The descriptions of baseline conditions and impact assessments presented in Chapter 3 identify a number of mitigation measures to address potential impacts and adaptive management and monitoring for areas where there are uncertainties. The following measures have also been included to address mitigation of potential effects.

2.6.1 Alternative B Mitigation

Significant issues identified in the scoping process drove the development of alternatives C and D (see Appendix C, Alternatives Development). Additional mitigation measures, in the form of design modifications, were developed to address the significant issues as they apply to the proposed action. The approach to mitigation includes relocating some of the proposed facilities associated with the TDF expansion outside of high-value wetlands, the Tributary Creek drainage, and the Monument.

Mitigation under Alternative B includes a slight reconfiguring of the TDF and modifying proposed reclamation material storage areas and quarries. The TDF reconfiguration would involve extending tailings placement to the northeast of the existing facility. Approximately 2 million cubic yards of material would be placed in this area with half being placed during the initial expansion phase and half during the final stage. Tailings placement in this area would require the construction of another water management pond. The overall result would be a small reduction in the volume of tailings placed in the Monument and Tributary Creek drainage. As discussed above in Section 2.4.8, it is anticipated that drainage from the TDF will require treatment for hundreds of years after closure. While it is not anticipated, in the absence of active water management, the outfall from the TDF would be designed at closure to drain to Hawk Inlet, rather than to Tributary Creek. While the volume of tailings stored in the Tributary Creek drainage and Monument would be reduced, the tailings footprint would be slightly larger because the geometry of the pile would not support as much height as the proposed action.

The reclamation material storage areas and one of the quarries currently proposed at the southern end of the TDF and inside the Monument would instead be developed to the north of the existing TDF reducing the disturbance within the Monument (see Table 2.6.1 and Figure 2.6-1). Rather than developing a quarry in the southeastern portion of the Tributary Creek drainage, as is currently proposed under Alternative B, the quarry immediately north of the existing TDF would be deepened.

Table 2.6-1. Comparison of Acreage Disturbance within the Monument between the Proposed Action (Alternative B) and Mitigated Alternative B.

Project Component	Alternative B Final (acres)	Mitigated Alternative B (acres)
Tailings	64.2	64.5
Reclamation material storage	17.0	13.6
Quarry	17.6	15.1
Ponds	12.0	14.8
Roads, including ditches and pipelines	19.1	19.1
Truck wheel wash	0.1	0.1
Ancillary Disturbance	12.8	9.1
Total New Disturbance	**142.8**	**136.3**
Total new disturbance within the Monument	109.3	86.2

2.6.2 Contemporaneous Reclamation

Contemporaneous reclamation (also termed concurrent reclamation) would involve placing the final cover on portions of the TDF that have achieved their ultimate height and slope. As currently described, the design of the proposed action and Alternatives C and D would support the placement of the cover in some portions of the TDF without the need to wait until the final stages of tailings placement. In addition to the benefits note above, contemporaneous reclamation could serve as a test facility in which to monitor vegetation establishment and succession, soil building processes and the performance and overall effectiveness of the cover itself.

2.6.3 Mitigation and Monitoring

The severity of impacts associated with any particular alternative depends to some extent on the mitigation that would be implemented. Monitoring can be used to evaluate the effectiveness of a particular mitigation measure or to assess whether impacts may be occurring to a particular resource. Changes in monitoring results outside an expected range can guide adjustments to, or changes in, specific mitigation measures (see Section 2.6.4, Adaptive Management). All of the mitigation measures that require monitoring are expected to have an adaptive management component, whereby the results of monitoring will be used to evaluate the effectiveness of the mitigation measures and make improvements as needed.

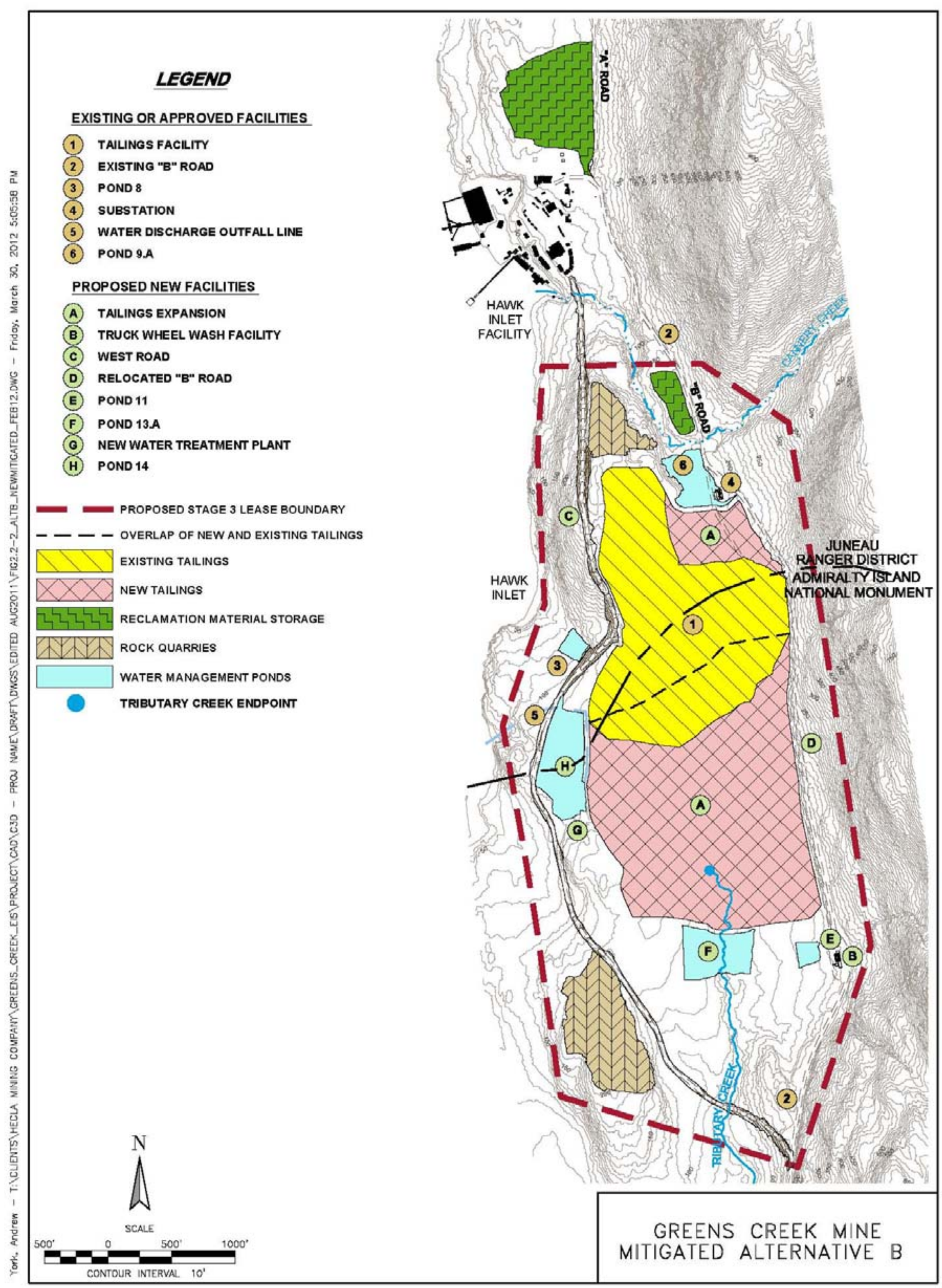

Figure 2.6-1. Facility Locations of Mitigation Options under Alternative B.

2.6.3.1 Mitigation

Table 2.6-2 presents a summary of mitigation measures that were identified for each of the resource areas. The Responsibility column describes which entity would be responsible for overseeing or requiring that the measure was actually implemented. To the extent possible, the cooperating agencies have worked together to incorporate mitigation measures into their permitting requirements. Other measures may be beyond regulatory authority but could be put in place by HGCMC. Table 2.6-2 also includes mitigation measures that are either ongoing or have been implemented according to the GPO (Kennecott 2004), standard operating procedures, or the 2010 Annual Report.

Table 2.6-2. Mitigation Measures by Resource.

Resource	Measure	Section in this EIS	Comment	Responsibility
Air	Ongoing dust abatement and monitoring.	3.2	All alternatives. Interim slopes not being used are covered with rock, outer slopes of the TDF are hydro-seeded, and snow fences and concrete blocks installed on the crest of the TDF to serve as a wind break.	HGCMC
	Total suspended particulates, lead, zinc and PM_{10} monitored per State Quality Assurance Manual. Equipment failing performance audit recalibrated and re-tested prior to being placed back in service.	3.2.3	All alternatives	HGCMC
Air and Water Quality	Inspect trailers hauling tailings/ waste rock; ensure covers are in place and secure and tailgate latched and secured against spillage.	3.2, 3.5	All alternatives	HGCMC
	Spray roads if notable dust observed.	3.2	All alternatives	HGCMC
	Truck wash at Concentrate Storage Building. Vehicles must have the wheels cleaned prior to leaving the Concentrate Storage Building; runoff directed to settling pond for handling.	3.5	All alternatives	HGCMC
	Implement additional fugitive dust control measures.	3.2.3	All alternatives	HGCMC

Table 2.6-2. Mitigation Measures by Resource (continued).

Resource	Measure	Section in this EIS	Comment	Responsibility
Geotechnical Stability	Tailings pile must be constructed with compacted outside side slopes that are no steeper than 3H:1V; slopes during operation may be less than 3:1 if future operation or slope work is planned or approval is obtained.	3.3, 3.5	All alternatives	HGCMC per ADEC Waste Management Permit
Geochemistry	Implement standard operating procedures to evaluate risk of acid rock drainage (ARD) and other geochemical concerns prior to developing quarries.	N/A	All alternatives	HGCMC
Water Resources / Water Quality	Maintain culverts and ditches; inspect facilities twice each year to maintain functionality. Clean culverts when more than 4” of sediment accumulates (6” in ditches).	3.5	All alternatives Additional inspections after significant runoff events	HGCMC
	Install a storm water detention structure or detention pond at the confluence of surface water runoff diversions and natural channels.	3.5	All alternatives	HGCMC
	Water management detention basins and ponds would continue to be operated with low storage volumes to maintain adequate contact water capacity in the pond systems; the maintenance of adequate contact water capacity is required by ADEC.	3.5	All alternatives	HGCMC
	Collect and route direct runoff from tailings facility.	3.5	All alternatives	HGCMC
	Collect and route direct runoff from mill area tailings and storage and transfer facilities.	3.5	All alternatives. Surface water runoff from tailings stored in mill building routed into a settling pond prior to being pumped to tailings facility for treatment. Runoff from the tailings loading area is routed collected and contained. Tailings contact water not allowed directly into Greens Creek or any other water body	HGCMC

Table 2.6-2. Mitigation Measures by Resource.

Resource	Measure	Section in this EIS	Comment	Responsibility
Water Resources / Water Quality (continued)	Prevent contact water runoff into surface water bodies.	3.5	All alternatives	HGCMC
	Truck wash at Concentrate Storage Building. Vehicles exiting the Concentrate Storage Building must have the wheels cleaned; runoff directed to settling pond for handling.	3.5	All alternatives	HGCMC
	Truck wash at mill building concentrate room. Vehicles exiting the mill building concentrate room must have the wheels cleaned; runoff water from the truck wash collects in the sump and is pumped to the bulk thickener; no runoff water from the concentrate loading area leaves the building.	3.5	All alternatives	HGCMC
	Spill response and reporting procedure. Detailed Contingency Plan outlines spill response and reporting procedures in the event of a spill of a hazardous substance.	3.5	All alternatives	HGCMC
	Establish vegetative cover and moderate slopes to manage surface water flows. Most slopes will be constructed with a 3H:1V slope; use straw bales, silt fences, and swales to slow the water and reduce erosion while vegetation becomes established.	3.5	All alternatives	HGCMC
	Straw bales must be certified as weed free.	N/A	All alternatives	HGCMC
	Stabilization of channels and channel banks. Hydroseeding used on channel banks to aid in stabilization; channels will be stabilized with degradable fiber mat to establish vegetation; riprap used to stabilize the constructed channels in areas that are subject to highly erosive stream flows.	3.5	All alternatives	HGCMC

Table 2.6-2. Mitigation Measures by Resource.

Resource	Measure	Section in this EIS	Comment	Responsibility
Water Resources / Water Quality (continued)	Hydroseeding slopes for stability. Monitor road cuts for exposed soils and use hydroseeding as appropriate.	3.5	All alternatives	HGCMC
	During operations, drainage channels designed to handle flows from a 24 hour/25-year storm event. Applies to all drainage channels and diversion structures during reclamation.	3.5	All alternatives	HGCMC
	Ensure that clean water remains clean. Surface runoff is intercepted and diverted around the mill area. Clean water intercept "B" Pond was developed to channel all uncontaminated water, from the diversion ditch, into Greens Creek.	3.5	All alternatives	HGCMC
	Minimize tailings contact with groundwater by installing liners and under drains beneath the tailings; install slurry walls surrounding the facility.	3.6	All alternatives	HGCMC
	Maintain or increase water management infrastructure to contain and treat tailings contact water and manage industrial storm water.	3.5	All alternatives	HGCMC per ADEC APDES Permit
Aquatic Resources	Fisheries Mitigation	3.7	All alternatives. HGCMC has replaced lost fishery habitat through modification of the waterfall barrier on the B Road and through creation of at least five jump pools for salmon passage. Proper functioning of the fish pass is assessed semi-annually. HGCMC will repair and maintain the existing fish pass in Greens Creek.	HGCMC per previous NEPA documents and ADF&G mitigation requirements
Soils	Salvage topsoil in stockpile.	3.8.4	All alternatives	HGCMC per GPO
	Establish test plots to study the optimum depth of the plant growth layer.	3.8.4	All action alternatives	HGCMC

Table 2.6-2. Mitigation Measures by Resource.

Resource	Measure	Section in this EIS	Comment	Responsibility
Vegetation	Establish test plots to verify that vegetative roots would not extend into the barrier layer, and develop an appropriate seed or planting mix.	3.9.3.1	All action alternatives	HGCMC
	Baseline survey for weeds.	3.9.3.1	All action alternatives	Forest Service
	Assure that all vehicles and heavy equipment transported to the project area are free of invasive plant propagules and contaminated soil.	3.9.3.1	All action alternatives	Forest Service
	Use of erosion control materials that are weed seed free.	3.9.3.1	All action alternatives	HGCMC
	Avoidance or removal of existing invasive plant populations in order to reduce the risk of spread.	3.9.3.1	All action alternatives	HGCMC
	Eradication or control of any newly introduced high priority invasive plant populations in the project area for the life of the project.	3.9.3.1	All action alternatives	HGCMC
	Biennial monitoring of the existing and new TDF areas for high priority invasive plant introductions for the life of the project, and for at least 3 years following closure of the sites.	3.9.3.1	All action alternatives	HGCMC
Wetlands	Mitigation for wetlands will be determined by the Section 404 permit.	3.10.4	All action alternatives	HGCMC
Wildlife	HGCMC employees prohibited from hunting.	3.10	All alternatives	HGCMC
	To reduce the potential for impacts to nesting migratory birds, ground disturbing activities and tree clearing should be conducted outside the nesting season in the region (late May through early July).	3.11.4	Alternatives B, C, and D	HGCMC

2.6.3.2 Monitoring

Monitoring programs currently in place provide a means to assess the effectiveness of mitigation measures. Monitoring requirements are established in the GPO, permits, and approvals. Table 2.6-3 summarizes relevant monitoring requirements and authority.

2.6.4 Adaptive Management

Adaptive management provides a mechanism for agencies to determine if and when it is necessary or advisable to require adjustment of operating procedures, mitigation measures, and/or monitoring in response to concerns identified through monitoring. Adaptive management approaches are effective in ensuring that permit and authorization requirements are met while providing sufficient flexibility to take preventative or remedial action if environmental concerns arise.

Adaptive management starts with review and oversight of ongoing activities and evolves as needs or concerns are identified. On a daily basis, HGCMC staff visually observes and responds accordingly to conditions at the TDF, including erosion control measures. Several times a year, Forest Service, State or Alaska, or other agencies inspect the site for compliance with the GPO or permit conditions. The oversight provides frequent opportunity to confirm compliance or identify and respond to concerns.

HGCMC would implement the mitigation measures listed in Table 2.6-2 and monitoring actions and programs listed in Table 2.6-3. If unanticipated adverse conditions are discovered, the Forest Service or another agency would require additional investigations and corrective actions, as appropriate. The ADEC Waste Management Permit includes notification and response requirements should monitoring indicate environmental damage has or is likely to occur. For example, if a statistically significant change in water quality is detected or a water quality standard is exceeded at any surface water point of compliance or down-gradient groundwater monitoring well, the Waste Management Permit requires prompt notification, investigation, and development of an action plan.

HGCMC is required to report the results of its monitoring annually and present the findings at an annual meeting which is open to the public. This provides an opportunity for the agencies and public to review monitoring results, identify issues, and consider corrective actions, including modification of management requirements.

The Waste Management Permit requires that an independent auditor complete a facility-wide environmental audit every 5 years. The purpose of the audit is to determine if both the facility management and regulatory controls and oversight of the facility provide reasonable assurances that the facility and controls are functioning as intended. This audit is an objective, systematic, documented review of the conditions, operations, and practices at the mine. The audit evaluates regulatory compliance, HGCMC's compliance with its own environmental practices, reliability of facility reporting, adequacy of agency oversight, bond adequacy, and other components. The results of this audit assist the agencies in updating plans, procedures, and permit requirements; determining compliance with the GPO and Waste Management Permit; and determining adequacy of the reclamation bond.

If alternatives B, C, or D are selected as a result of this analysis, the Forest Service will require detailed construction plans from the operator for the first phase of development, not to exceed 10 years of development. For future phases, the Forest Service will prepare supplemental information reports to evaluate received phased construction plans in light of existing conditions and information known at the time. Supplemental review may also be required if changing conditions or new information indicates that such a review is necessary.

Table 2.6-3. Monitoring Requirements and Authority.

Resource / Item to be Monitored	Method of Measurement	Frequency of Measurement	Threshold of Variability	Action to be Taken	Authority	Responsible Party
Air Quality	Visual observation of fugitive dust Air quality monitoring at mine site and Hawk Inlet Marine Terminal Facility for total suspended particulates, lead, zinc, and particulate matter less than 10 microns (PM_{10})	Ongoing One 24-hr sample every 6th day	Notable dust levels Assess statistical trends	Watering the roads Report to Air Program Manager	GPO	Operator
Geotechnical Stability	Visual inspections compaction testing, water level measured Inspection of cover during reclamation	Daily visual inspections and recording of volumes by tailings pile operators; visual inspections every two years and following an earthquake, major storms, or over flow for structure by qualified engineer; monthly visual inspection of seepage from the pile and of leachate collection and surface water diversion systems	Structural change or damage to a facility such that environmental damage is likely to occur or any violation of a permit condition is observed	Stop water inflow from all managed sources, notify Forest Service, ADNR, create map of inundation	GPO	Operator

Table 2.6-3. Monitoring Requirements and Authority (continued).

Resource / Item to be Monitored	Method of Measurement	Frequency of Measurement	Threshold of Variability	Action to be Taken	Authority	Responsible Party
Geochemistry	pH, leach testing	Monthly	As stated in Plan of Operation		GPO/ Tailings Internal Environmental Monitoring Program	Operator
	Net neutralization potential and paste pH	Quarterly	As stated in Plan of Operation	An expert in ARD will review the info, and develop a management plan if necessary. Notify Forest Service and ADEC		
	Water in contact with tailings sampled for chemistry, water level measured	Quarterly	No specific compliance levels – looking at trends	Trends reported to Forest Service, ADEC, and ADNR		
Water Resources – Surface Water	Freshwater sampled at various sites for chemistry	Monthly and Quarterly to conduct statistical trend analysis	Compliance with Alaska WQS and APDES permit, and storm water permit.	Compare to up-gradient reference sites, notify Forest Service, ADEC, conduct confirmation sampling, prepare monitoring plan to Forest Service and ADEC	GPO	Operator
	Marine water sampled for chemistry	Quarterly	Compliance with applicable standards of ADEC APDES Permit			
Water Resources – Groundwater	Chemistry	Twice a year	Compliance with Alaska WQS	Compare to up-gradient reference sites, notify Forest Service, ADEC, conduct confirmation sampling, prepare monitoring plan to Forest Service and ADEC	GPO	Operator

Table 2.6-3. Monitoring Requirements and Authority (continued).

Resource / Item to be Monitored	Method of Measurement	Frequency of Measurement	Threshold of Variability	Action to be Taken	Authority	Responsible Party
Aquatic Resources	Juvenile fish sampled for abundance and distribution. Subsamples analyzed for chemistry. Water samples for temp and toxicity texting. Periphyton samples collected for estimates on biomass. Invertebrates sampled for abundance and community structure.	Annually for 5 years, then review	Significant change as compared to baseline or reference site	Increase the number of parameters analyzed in water samples	GPO	Operator
	Inspection of fish ladder to determine it is clear and passable	Annual inspection	Determined not passable	Clear of debris and follow maintenance program		
	Marine sediment and biota for chemistry	Semi-annually	Detect changes in background levels			
Soils	Roads monitored for ruts and accumulations of fines; landslides or washouts	Ongoing	High levels of sediment production	Additional mitigation measures such as carrying lighter loads, reduced air pressure in tires, or enhanced sediment removal and sediment control devises used.	GPO	Operator
Vegetation	Visual inspection of existing and new TDF areas for high priority invasive plant species	Biennial	Existing	Removal	GPO (to be included)	Operator

Table 2.6-3. Monitoring Requirements and Authority (continued).

Resource / Item to be Monitored	Method of Measurement	Frequency of Measurement	Threshold of Variability	Action to be Taken	Authority	Responsible Party
Reclamation/ Post Closure	Visual inspection for subsidence and movement,	Annually	Per Waste Management Permit	Per Waste Management Permit	GPO	Operator
	Visual inspection of infiltration / barrier, root zone layers and establishment of growth and vegetation	Semi-annual for 5 years				
	Groundwater monitoring, surface water seeps and leachate water monitoring, biological monitoring	Semi-annual				
	Net neutralization potential and paste pH	Every 5 years				
	Marine water sampling	Per National Pollutant Discharge Elimination System, if tailings underdrain water is discharged through marine outfall				
Overall Management	Conduct facility wide environmental audit	5 years	Observed environmental harm or operations not in compliance with the GPO or permit conditions	Require corrective actions	GPO, Waste Management Permit	Forest Service, ADEC
	Conduct regular site inspections	Variable (several per year)				

2.7 Comparison of Alternatives

Table 2.7-1. Summary of Potential Impacts of Each Alternative by Resource.

	Impact	Alternative A	Alternative B	Alternative C	Alternative D
General	**Duration of Mine Life**	**Through 2014**	**30–50 More Years**	**30–50 More Years**	**30–50 More Years**
Air Quality	Uncontrolled: $PM_{10\text{-}2.5}$ tons per year (tpy)	142	170	229	230
	$PM_{2.5}$ tpy	17	22	30	30
	Controlled: $PM_{10\text{-}2.5}$ tpy	77	97	125	129
	$PM_{2.5}$ tpy	9	13	16	16
Water Resources–Surface Water	Percent of watersheds affected by new disturbance	Tributary Creek: 1 Cannery Creek: 0 Fowler Creek: 0	Tributary Creek: 20 Cannery Creek: 0 Fowler Creek: 0	Tributary Creek: 3 Cannery Creek: 0 Fowler Creek: 0	Tributary Creek: 4 Cannery Creek: 0 Fowler Creek: 0
	Reduction in stream flow	Minor reduction of flow in two creeks (Tributary and Cannery)	Minor reduction in flow in two creeks (Tributary and Cannery) but more than Alternative A	Minor reduction in flow in three creeks (Tributary, Cannery, and Fowler)	Similar to Alternative C although effects in Fowler Creek would be delayed by approximately 12–15 years
	Additional water management infrastructure such as diversions, groundwater slurry walls, and water management ponds	Yes as TDF expands to currently approved size	Yes; more water management infrastructure required than Alternative A	Yes; more total infrastructure required than Alternative B; additional water management infrastructure required for new TDF	Similar to Alternative C although additional water management for new TDF would not be put in place until construction began in approximately 12–15 years
	Need for long-term water treatment	Yes	Yes	Yes	Yes
Water Resources–Groundwater	Change in flow or quality	Minimal effect on local hydrogeology; no impacts to groundwater quality	Similar to Alternative A	Similar to Alternative A but new TDF located in additional groundwater area	Similar to Alternative C

Table 2.7-1. Summary of Potential Impacts of Each Alternative by Resource (continued).

General	Impact Duration of Mine Life		Alternative A Through 2014	Alternative B 30–50 More Years	Alternative C 30–50 More Years	Alternative D 30–50 More Years
Aquatic Resources	Habitat permanently lost (feet)	Class I	Tributary: 0 Fowler: 0	Tributary: 1,646 Fowler: 0	Tributary: 0 Fowler: 34	Tributary: 0 Fowler: 34
		Class II	Tributary: 0 Fowler: 0	Tributary: 2,400 Fowler: 0	Tributary: 0 Fowler: 1,044	Tributary: 0 Fowler: 1,044
	Risk of chemical or mining product spill		Low, due to best management practices (BMPs) and Spill Prevention, Control, and Countermeasure Plan requirements	Similar to Alternative A, although operations would continue over 30 to 50 years, increasing the chance of a spill	Similar to Alternative B except increased risk in Fowler Creek drainage	Similar to Alternative C
Geochemistry	Likelihood of TDF ARD developing		Low due to very low permeability, low availability of oxygen and closure and reclamation of TDF	Same as Alternative A although a pile contains a larger volume of tailings	Same as Alternative B	Same as Alternative B
Geotechnical Stability	Likelihood of TDF failure		Very low probability of TDF failure due to design measures	Same as Alternative A	Same as Alternative A	Same as Alternative A
Soils	New loss in soil productivity (measured in acres disturbed)		0	141	156	169
Vegetation	Acres of disturbance		0	Productive old growth (POG): 109 acres Non-forested: 99 acres	POG: 130 acres Non-forested: 91 acres	POG: 140 acres Non-forested: 95 acres
	Off-site effects		Elevated metals levels in lichens may continue through life of operations; duration of effects would depend on the effectiveness of control measures	Similar to Alternative A; however, off-site effects may continue longer due to longer mine life	Similar to Alternative B	Similar to Alternative B
Wetlands	Acres and types disturbed		0	Bog: 54.8 Forested: 43.3 Fen: 0.5 Marsh: 0.4 Total: 99	Bog/Bog Woodland: 11.7 Forested: 75.4 Sedge Fen/Fen: 24.9 Marsh: 1.1 Total: 114.2	Bog/Bog Woodland: 13.6 Forested: 76.9 Sedge Fen/Fen: 32.5 Marsh: 1.9 Total: 124.9

General	Impact	Alternative A	Alternative B	Alternative C	Alternative D
	Duration of Mine Life	Through 2014	30–50 More Years	30–50 More Years	30–50 More Years
Wildlife	New decrease in brown bear buffers (acres)	None	23	<1	1
	Duration of activities that could disturb wildlife and marine mammals	Through 2014	Additional 30–50 years	Additional 30–50 years	Additional 30–50 years
	New removal of POG habitat (acres)	None	109	130	140
	New reduction in deer winter range habitat (acres)	None	109	130	140
	Result in "take" of Endangered Species Act (ESA)-listed species	No	No	No	No
	Number of goshawk nests potentially affected	0	0	1	1
Threatened (FT) and endangered (FE) species / Forest Service Sensitive Species (FSS)	Humpback whale (FE)	Not likely to adversely affect			
	Stellar sea lions (FE)	May affect, but is not likely to adversely affect			
	Yellow-billed loon (candidate and FSS)	May impact individuals but is not likely to cause a trend to federal listing or loss of viability			
	Chinook salmon; sockeye salmon; steelhead (FT or FE, depending on the run)	No effect			
	Queen Charlotte goshawk (FSS)	May impact individuals but is not likely to cause a trend to federal listing or loss of viability			
	Black oystercatcher (FSS)	May impact individuals but is not likely to cause a trend to federal listing or loss of viability			
Land Use	Meet management prescriptions	Yes	Yes	Yes	Yes
Recreation	Duration of operations (when public may be excluded from areas)	Through 2014 plus reclamation period	Additional 30–50 years plus reclamation period	Same duration as Alternative B; disturbance at new TDF initiated in approximately 2–3 years	Disturbance at new TDF not initiated until approximately year 12

General	Impact Duration of Mine Life	Alternative A Through 2014	Alternative B 30–50 More Years	Alternative C 30–50 More Years	Alternative D 30–50 More Years
Scenic Resources	Compliance with applicable scenic integrity objective (SIO)	Yes	Yes	Yes	Yes
	Duration of visual effects	Around 2014 plus reclamation establishment period	Additional 30–50 years plus reclamation establishment period	Reclamation at existing TDF to begin in approximately 2–3 years; reclamation of new TDF at end of mining activity (30–50 years); reclamation establishment period applies to both facilities	Reclamation at existing TDF to begin in approximately 12 years; additional 30–50 years of mining activity at new TDF; reclamation establishment period applies to both facilities
	Location of TDF	Current location	Expanded at current location	Minimal expansion at current location and new site to the north	Moderate expansion at current location and new site to the north
Subsistence	Duration of mine life	Through 2014	30–50 more years	30–50 more years	30–50 more years
	New reduction in deer winter range habitat (acres)	None	109	130	140
	Location of TDF	Current location	Expanded at current location	Minimal expansion at current location and new site to the north	Moderate expansion at current location and new site to the north
Cultural Resources	Effects on historic properties	Historic properties not adversely affected; Hawk Inlet identified as a sacred place by Angoon affected over the long term.	Same as Alternative A	Same as Alternative A	Same as Alternative A
Socioeconomics	Duration of annual economic and employment benefit from operations	Through 2014	30–50 more years	30–50 more years	30–50 more years
Monument Values	New disturbance within Monument (acres)	0	109	9	27
	Post mining condition	Near-natural condition following reclamation	Similar to Alternative A	Similar to Alternative A	Similar to Alternative A
Environmental Justice	Disproportionately affect minority or low income populations	No	No	No	No

CHAPTER 3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.1 Introduction

Environmental impact statements (EISs) often separate the discussions of the affected environment (baseline conditions) and environmental consequences into separate chapters. This EIS combines these two chapters because the affected environment has already experienced environmental consequences from previous mining activities.

Chapter 3 describes each resource, beginning with an overview of that resource, a brief summary of pre-mining conditions (based on the 1983 EIS), a description of the current conditions, and finally, a description of the environmental consequences that would result from each tailings disposal facility (TDF) alternative. Current conditions, including effects that have already occurred as a result of mine-related activities, will serve as the baseline conditions against which environmental impacts from the alternatives will be compared. Where applicable, the environmental consequences sections describe effects that are common to all alternatives followed by descriptions of effects that are unique to each alternative. The discussions include descriptions of measures that could be implemented to avoid, minimize, or mitigate impacts.

Analyses conducted under the National Environmental Policy Act (NEPA) focus on assessing effects (positive and adverse) to a suite of resources and consider the frequency, duration, and spatial distribution of those effects. One objective is to identify "significant" effects in an attempt to avoid or minimize them to the extent possible. The Council on Environmental Quality in its NEPA regulations (40 CFR 1508.27) defines significance in terms of both context and intensity. Context refers to the setting of the project and how individual resources may be affected to a local or regional extent. Intensity refers to the severity of the impact and includes considerations of the uniqueness of the resource, whether affects are positive or adverse, whether federal, state, or local laws may be violated, and the degree of risk or uncertainty involved. A project could exhibit extreme intensity to particular individuals (e.g., mortality) while having a low intensity level when considered on the basis of a local population; the significance of an effect would be different if an endangered species was involved compared to a species that occurs commonly. The impact analysis for each resource, therefore, considers the magnitude of the impacts, their frequency, likelihood, extent, duration, and intensity.

The EIS also considers cumulative effects of the proposed action and alternatives when combined with other past, present, and reasonably foreseeable activities. The cumulative effects discussion is provided in Section 3.23.

For this project, the project area is defined as a one-half-mile buffer around the proposed TDF expansion areas and the portions of the A and B Roads extending from the existing lease boundary north to the TDF expansion under alternatives C and D (Figure 3.1-1). The study area for each resource may vary from the project area and in some cases may be much larger. The study area for each resource is described in Table 3.1-1. In some cases, study areas for cumulative effects may extend beyond the study area for direct and indirect effects; these are described in selection criteria identified in Table 3.22-2 in the cumulative effects discussion.

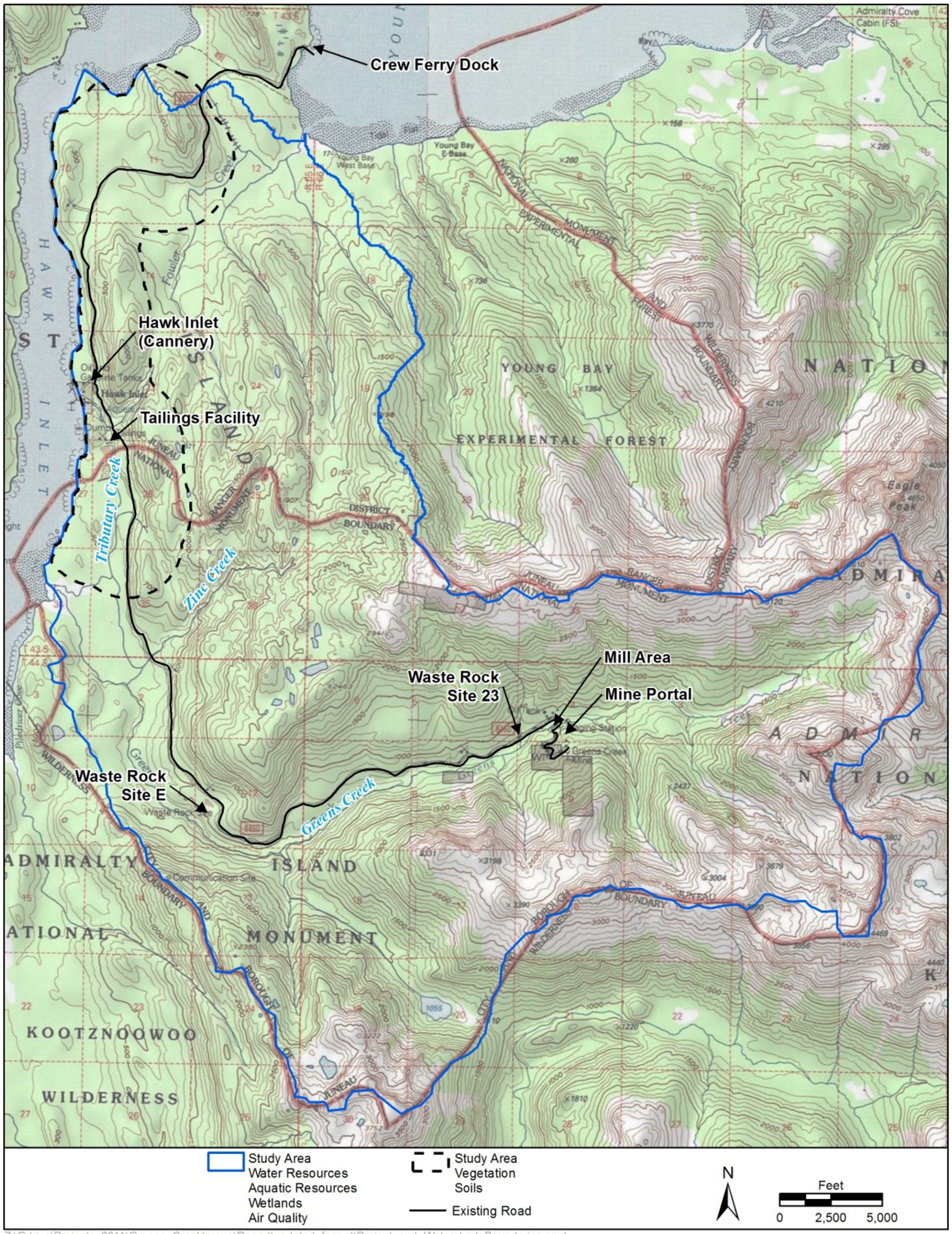

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Figure 3.1-1. Project and Study Areas.

Table 3.1-1. Study Areas for Direct and Indirect Effects.

Resource	Study area for direct and indirect effects
Air Quality	Combined watershed area in Figure 3.1-1
Geotechnical Stability	Direct footprint of the TDF(s)
Geochemistry	Direct footprint of the TDF(s)
Water Resources	Combined watershed area in Figure 3.1-1
Aquatic Resources	Combined watershed area in Figure 3.1-1 and Hawk Inlet
Soils	Project area
Vegetation	Project area
Wetlands	Combined watershed area in 3.1-1
Threatened and Endangered Species	Project area
Land Use	Project area
Scenic Resources	Viewshed from Hawk Inlet (Figure 3.14-4)
Recreation	Project area and Hawk Inlet
Subsistence	Project area and Hawk Inlet
Cultural Resources	Project area
Socioeconomics	City and Borough of Juneau (CBJ)
Monument Values	Admiralty Island National Monument
Environmental Justice	City and Borough of Juneau and Hoonah-Angoon Census Area

3.2 Air Quality

Air quality was not identified as a significant issue during the scoping process. Comments received during the scoping process regarding air quality related to dust generated by mining activities are addressed in this section. Measures of air quality include fugitive dust levels in the project area and metal concentrations in established lichen monitoring plots.

Air quality and permitting for industrial air emission sources is regulated under the federal Clean Air Act (CAA). Industrial air emission sources include stationary (point) sources, fugitive sources, and mobile sources. The U.S. Environmental Protection Agency (USEPA) has approved the Alaska Department of Environmental Conservation (ADEC) Title 1 and Title 5 State Implementation Plan programs. The ADEC administers the air permit program for industrial emission sources in Alaska. To obtain an air permit from ADEC the industrial source must identify all air emissions associated with the operation and demonstrate compliance with ambient air quality standards. National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards which the Greens Creek Mine must comply are listed in Table 3.2-1.

Table 3.2-1. National and Alaska Ambient Air Quality Standards.

Pollutant	Primary Standards		Secondary Standards	
	Level	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8- hour	None	
	35 ppm (40 mg/m^3)	1-hour		
Lead	0.15 µg/m^3	Rolling 3-month average	Same as Primary	
Nitrogen Dioxide	53 ppb	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour	None	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual (Arithmetic Average)	Same as Primary	
	35 µg/m^3	24- hour		
Ozone	0.075 ppm	8-hour	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Average)	0.5 ppm	3-hour
	0.14 ppm	24-hour		
	75 ppb	1-hour	None	

The NAAQS, developed by USEPA and adopted by the State of Alaska, are implemented to protect public human health and welfare. Primary standards are intended to protect public health. Secondary standards are in place to protect public welfare. NAAQS and Alaska Ambient Air Quality Standards have been established for six criteria pollutants which include; sulfur dioxide (SO_2), carbon monoxide (CO), lead, ozone, nitrogen dioxide (NO_2), and particulate matter with a diameter less than 10 microns in size (PM_{10}) and less than 2.5 microns in size ($PM_{2.5}$). For areas that attain the NAAQS, the USEPA has developed Prevention of Significant Deterioration (PSD) regulations. Within the PSD regulations, the PSD increment is defined as the amount of pollution a source is allowed to emit and is based on the specific baseline (ambient) concentration at the time that the first complete PSD permit application affecting the area was submitted. The key purpose of PSD regulations is to protect air quality and keep attainment areas in compliance with the NAAQS. Greens Creek Mine is located in an area classified as PSD Class II, which allows for moderate industrial growth in the area; Greens Creek Mine is considered a major source under PSD regulations, because it has the potential to emit more than 205 tons per year (tpy) of NO_x.

3.2.1 Air Quality – Pre-mining Environment

Before mining, air pollutant concentrations in the vicinity of the Greens Creek Mine are expected to have been well below the NAAQS. Prior to mine development, concentrations of criteria pollutants were not directly measured. Levels of pollutants were expected to be lower than observed in Juneau and similar to levels of surrounding remote areas.

The climate at the Greens Creek Mine is a coastal marine environment. Topography largely influences wind patterns in the area. The terrain at the project site channels the wind, producing a flow from the north-northeast. Based on site data between 2000 and 2010, the wind at the project site was from the north-northeast about 39 percent of the time and from the south about 12 percent of the time. The highest wind speed recorded near the project site between 2000 and 2010 was 72.6 miles per hour (mph). The average wind speed was 6.6 mph. Figure 3.2-1 graphically represents wind direction and speed (in knots) near the project site from January 1, 2000 through December 31, 2010 (1 knot is equal to 1.15 miles per hour).

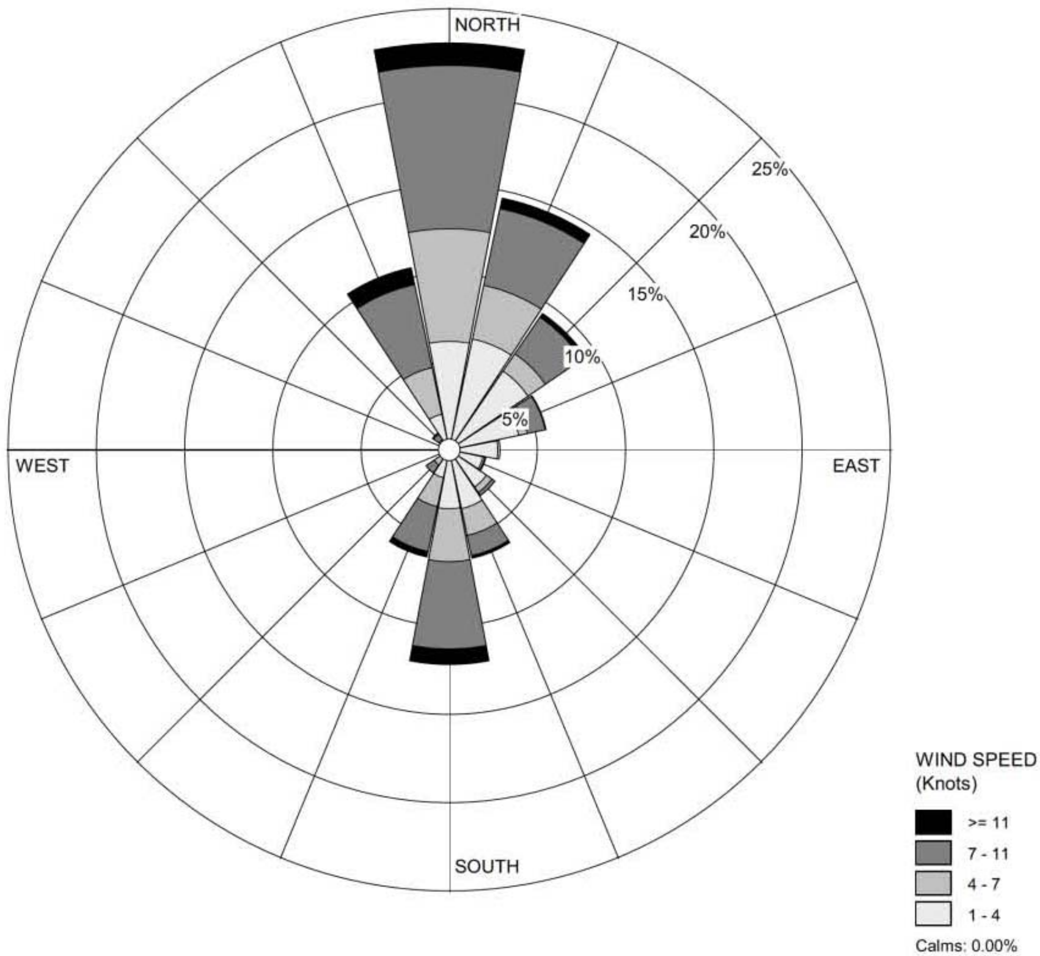


Figure 3.2-1. Annual Prevailing Wind Speed and Direction.

The potential for dispersion of airborne pollutants at the mine site is dependent on several environmental factors: wind speed, precipitation, and the depth of the atmospheric mixing zone. High winds can dilute pollutants in the atmosphere as well as lead to higher fugitive dust emissions. Low wind speeds reduce pollutant dispersion and can increase localized ambient concentrations of pollutants.

3.2.2 Air Quality – Baseline Conditions

Air quality measurements have been conducted for PM_{10} at the mine site and are below NAAQS standards. Concentrations of other commonly monitored air pollutants including nitrogen dioxide, carbon monoxide, and sulfur dioxide have not been directly measured at the mine site.

The ADEC has issued air permits that serve as a framework for the operation of the mine site. Active permits are currently in place to regulate air emissions at the mine site (Title V Operation Permit No. AQ0302TVP02, Owner Request Limit No. AQ0853ORL02 and Minor Permit No. AQ0302MSS01). Operational guidelines and restrictions are identified in the active permits to ensure air quality standards are maintained at the Greens Creek Mine property boundary during ongoing mining activities. The regulations and restrictions put in place by the ADEC are monitored through ongoing reporting requirements and inspections by ADEC personnel (Table 3.2-2).

Table 3.2-2. Alaska Department of Environmental Conservation Air Quality Site Inspections.

Inspection Date	Summary of Inspection Findings
May 22, 2001	▪ Clean Air Act Notice of Violation ▪ Failure to obtain a permit for a generator installed in 1998
December 31, 2007	▪ Facility found to be in compliance with all air quality permits
April 29, 2010	▪ Request air quality monitoring for particulate at the western and southwestern portions of the TDF ▪ Follow-up with ADEC Air Quality Monitoring group to develop this program is recommended

PM_{10} monitoring was conducted at the Greens Creek Mine from April 20, 1995 to March 30, 1996. Two co-located PM_{10} monitors were installed on the slope behind the mill. Concentrations of PM_{10} were well below the ADEC established standard of 150 $\mu g/m^3$. However, the mine was not in operation during this period. Therefore concentrations of PM_{10} were representative of ambient air conditions. No onsite PM_{10} monitoring has been conducted while the mine has been in production.

Fugitive Dust and Deposition

Based on observation, dust is lost from the TDF during dry and windy conditions. These conditions typically occur between mid-December and late February when high pressure systems commonly create strong northern winds and dry, cold conditions. Since 2007, snow samples have been collected prior to spring melt. The samples collected were analyzed to quantify the amount of tailings dust accumulated in the surrounding snow pack. Lead loading was observable up to 1,695 feet from the TDF, with loading concentrations decreasing due to dust mitigation measures put in place by Hecla Greens Creek Mining Company (HGCMC) since initial sampling in 2007 (KGCMC 2009).

The Tongass National Forest and the Alaska Regional Soil, Water, and Air Program of the Forest Service initiated the use of lichens as biomonitors of air pollution in the Tongass National Forest (Geiser et al. 1994). Lichen samples were collected from plots at the mine portal and TDF that are exposed to road dust, vehicle emissions, and other airborne particulates related to mining activities.

Lichens collected at the Greens Creek Mine contained more elements above threshold than any other monitoring site in the Tongass National Forest. Nineteen elements were above natural background levels including sulfur (S), nitrogen (N), aluminum (Al), barium (Ba), cadmium (Cd), copper (Cu), iron (Fe), lead (Pb), vanadium (V), zinc (Zn), cobalt (Co), lithium (Li), and nickel (Ni). The presence of these elevated element counts are suspected to be from fugitive dust or vehicle emissions, and volitization from surface disturbances created during the mining process. This study is discussed in further detail in Section 3.9.3.1, Vegetation.

Dust Control Improvement Methods

In an effort to reduce dust loss from the TDF, HGCMC has employed a variety of voluntary abatement measures. Interim slopes not being used are covered with rock, outer slopes of the TDF are hydro-seeded, and snow fences and concrete blocks were installed on the crest of the TDF to serve as a wind break. Current dust control methodologies are not required under permit terms and conditions, but are expected to achieve NAAQS standards.

3.2.3 Air Quality – Environmental Consequences

This section addresses the expected changes in air quality and emissions associated with the alternatives and the relative differences among alternatives in terms of air emissions. The stationary sources of air emissions included in the proposed action are compared to potential sources of air emissions associated with each alternative. Stationary source emission units will remain virtually the same for all activities associated with mining and mineral processing with only a difference in duration at various sites. Fugitive dust emissions for activities associated with the TDF operations and development will vary by alternative. A summary of emissions units currently permitted at the Greens Creek Mine is listed in Table 3.2-3.

Table 3.2-3. Summary of Emission Units Currently Permitted at the Greens Creek Mine.

	Allowable Tons of Pollutants Emitted Per Year				
Air Emission Source	**NO_x**	**CO**	**PM_{10}**	**SO_2**	**Volatile Organic Compounds**
Ruston Diesel Engine	535.7	100.0	7.2	9.5	27.3
Ruston Diesel Engine					
Ruston Diesel Engine					
CAT 3516B Diesel Engine		15.6	1.0	11.4	15.2
CAT 3516B Diesel Engine					
Diesel Solar Taurus Turbine		1.7	0.8	21.0	8.6
Sullair Air Compressor	36.1	7.8	2.6	0.7	2.9
Volcano Oil Boiler	1.6	0.4	0.1	0.9	0.0
Propane-fired Furnace	0.6	0.2	0.0	0.0	0.0
All Units (Total)	**574.0**	**125.7**	**11.7**	**43.5**	**54.0**

3.2.3.1 Effects Common to All Alternatives

The baseline conditions described previously are the current conditions of the mining operation. Under all identified alternatives, air emissions would continue from mining and support activities already underway. Air emission sources associated with the mine include non-combustion sources such as fuel tanks, fugitive dust-generating sources; other miscellaneous sources; and combustion sources such as mining equipment, heaters, diesel generators, and boilers.

Compliance with all ADEC air quality permits would continue. As noted in Section 3.2.2, elevated concentrations of metals have been observed in lichens adjacent to the TDF. These elevated metals levels are likely to continue into the immediate future under all alternatives and would decrease following closure of the TDF. To the extent that emissions (or deposition) are from TDF operations, the duration of future effects would depend on the effectiveness and implementation schedules of control measures that could be put in place.

Each alternative has the potential for increased fugitive dust emissions due to wind erosion of the TDF and truck hauling on unpaved roads. Emissions generated by wind erosion are dependent upon the frequency and size of disturbances of the erodible surface; each time the surface is disturbed, fresh surface material is exposed to wind.

Stationary source emission units (i.e., generators, boilers, etc.) will not measurably change under all action alternatives. Mobile emissions from vehicle miles traveled and number of vehicles will change by alternative.

Fugitive Dust Emissions

Estimations for the maximum annual uncontrolled and controlled PM_{10} and $PM_{2.5}$ fugitive dust emissions for alternatives A-D are listed in Table 3.2-4. Total maximum emissions incorporate fugitive dust from travel on unpaved roads and wind erosion on the TDF. Fugitive emissions due to travel on unpaved roads were estimated using methods outlined in the Western Regional Air Partnership's fugitive dust handbook. Fugitive emissions due to wind erosion of the surface area of the TDF were estimated using standard methods (Air and Waste Management Association).

Table 3.2-4. Estimated Maximum Fugitive Dust Emissions.

Alternative	Maximum Emissions $PM_{2.5}$ (tpy)	Maximum Emissions PM_{10} (tpy)	Max Tailings Footprint (acres)*	Unpaved Roundtrip Road Length (miles)
A	17	159	49	15.6
B	22	192	64.2	15.6
C	30	259	101.7	21.2
D	30	260	103.1	21.2

* This number represents the footprint of the tailings only.

Unpaved Roads: Fugitive PM_{10} and $PM_{2.5}$ emissions for alternatives A-D from travel on unpaved haul roads are summarized in figures 3.2-2 and 3.2-3. Fugitive PM_{10} dust emissions from unpaved roads were estimated given the number of dry working days per year, length of unpaved road to TDF from the mine, silt content of the road material, and average vehicle weight. Fugitive $PM_{2.5}$ emissions from unpaved roads were estimated using a $PM_{2.5}$:PM_{10} ratio of 0.1. Control efficiencies (44 percent) are based on existing limitations on traffic speeds on haul roads of 25 mph (MRI 2006).

Wind Erosion: Fugitive PM_{10} and $PM_{2.5}$ emissions from wind erosion at the TDF were calculated by establishing an erosion potential of the TDF based on an average peak wind speed observed near the TDF during the period between January 1, 2000 and November 30, 2008. Other variables used to establish the PM_{10} and $PM_{2.5}$ emissions from wind erosion include working dry days per year and the maximum height and surface area of the TDF. The disturbed portion of the TDF was estimated as 50 percent of the total footprint acreage based on existing dust management procedures including re-seeding unused portions of the TDF. Control efficiencies (55 percent) are based on existing dust management procedures, which include watering the TDF as needed. Western Regional Air Partnership guidance indicates a watering frequency of twice per day to obtain this efficiency; however, it was assumed due to the wet conditions of the area that this efficiency is still accurate. The Hawk Inlet Meteorological Station at the Greens Creek Mine indicates an average of 219 wet days per year based on daily precipitation data from 2000 to 2010. Figures 3.2-2 and 3.2-3 summarize the maximum uncontrolled and controlled emissions from the TDF as a result of wind erosion for alternatives A–D.

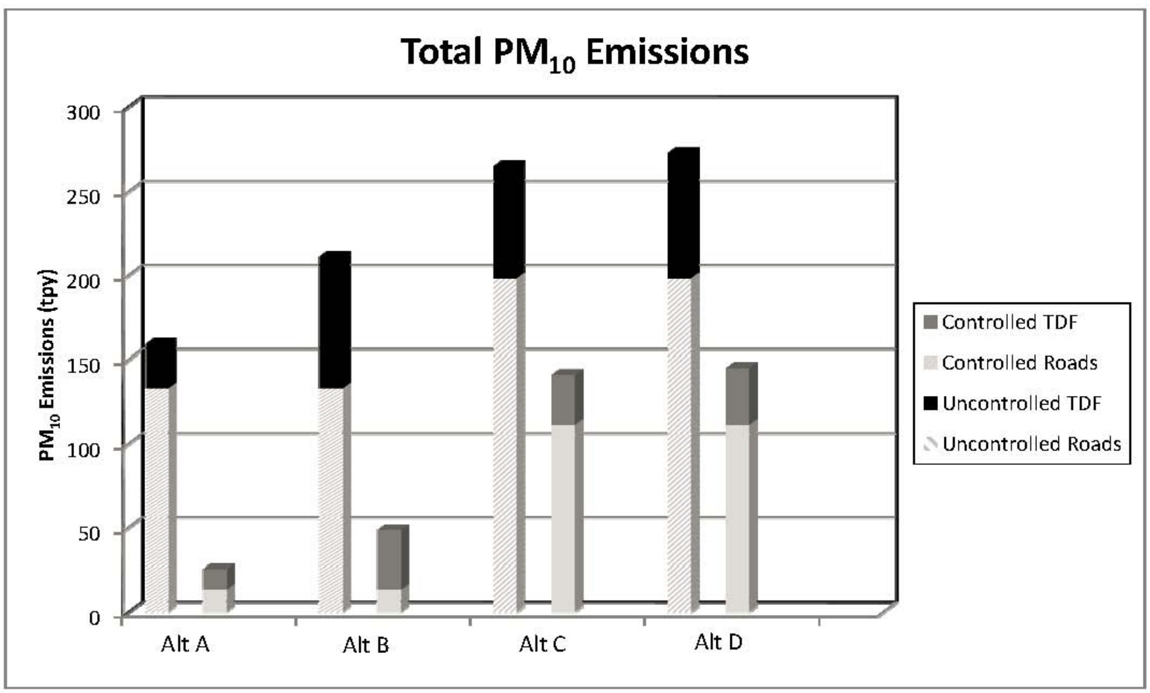


Figure 3.2-2. Maximum Controlled and Uncontrolled PM_{10} Emissions for TDF and Roads.

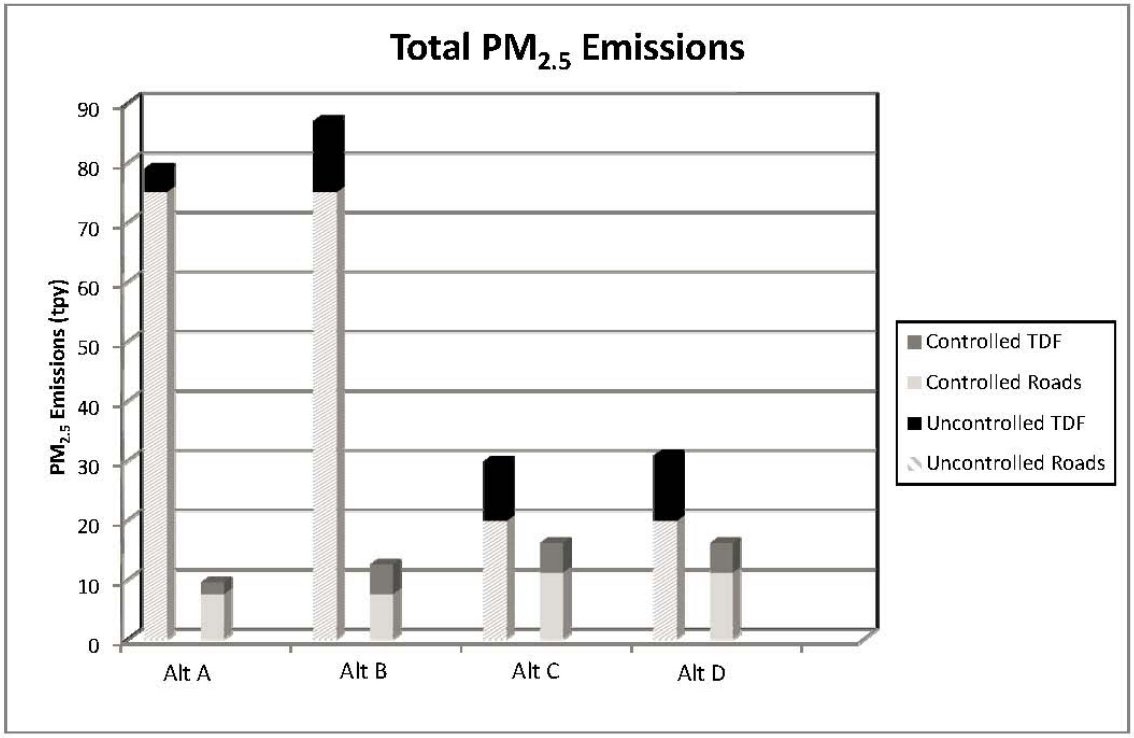


Figure 3.2-3. Maximum Controlled and Uncontrolled $PM_{2.5}$ Emissions for TDF and Roads.

Mitigation and Monitoring

Currently, the existing mitigation measures to prevent wind erosion of the TDF include hydro-seeding on disturbed areas of the TDF, installation of wind breaks, and covering slopes with rock. Additional dust control measures taken for controlling emission sources other than wind erosion are discussed in Section 3.2.3.1 as part of existing conditions.

Sampling has indicated elevated levels of metals in snow and lichen adjacent to the TDF. The extent and source of elevated concentrations of lead, zinc, and other metals would be characterized through a formal monitoring program implemented by HGCMC. In order to address a data gap, the Forest Service will require that additional sampling for fugitive dust in the air specifically is conducted using Federal Reference Methods for dust monitoring devices.

If monitoring indicates that fugitive dust emissions related to TDF activities are the source of elevated concentrations of lead, zinc, and other metals, a mitigation plan would be developed to identify control measures. Such a plan would include an adaptive management approach would allow improvements to trigger more or less future control measures.

Additional control measures included in the mitigation plan should be considered by evaluating the significance of the impact and control efficiencies of control and mitigation measures limit fugitive dust. Acceptable and effective mitigation measures can be found within local and state regulatory standards in dry regions of the continental U.S. and include those as noted in the Western Regional Air Partnership's Fugitive Dust Handbook and are summarized in Table 3.2-5.

Table 3.2-5. Regulatory Formats to Control Fugitive Dust on Unpaved Roads and Open Areas.

Control Measure	Goal	Threshold	Agency
Wind Erosion of Open Sources			
Watering, fencing, paving, graveling, dust suppressant, vegetative cover, restrict vehicular access	Maintain soil moisture content min 12%; or 70% min of optimum soil moisture content; reduce windblown emissions	Construction sites; fences 3 feet – 5 feet, adjacent to roadways/urban areas	Arizona, Maricopa County Rule 310 04/07/2004
Cease ops (wind speed >25 mph); applying dust suppressant two times per hour; watering and fencing (as above); for after work hours: gravel, water three times per day (possibly four times per day)	Reduce amt of windblown dust leaving site; maintain soil moisture content 12%	Wind speed must be >25 mph for 60 minute average; fencing must be 3 feet – 5 feet with <50% porosity; watering for after work, holidays, weekends increase to four times per day during wind event	Arizona, Maricopa County Rule 310 04/07/2004
Use of one of following for dust control on all disturbed soil to maintain in damp condition: soil crusted over by watering or other, or graveling or treated with dust suppressant	Prevent visible fugitive dust from exceeding 20% opacity, and prevent dust plume from extending more than 100 yards	NA	Nevada, Clark County Section 94 Air Quality Regulation 06/22/2000
Requires application of water or chemical stabilizers prior to wind event three times per day (possible increase to four times per day if evidence of wind driven dust), or establish a vegetative cover within 21 days after active operations have ceased to maintain a stabilized surface for six months	NA	For operations that remain inactive for not more than four consecutive days	California, SCAQMD Rule 403 12/11/1998
Unpaved Roads			
Requires annual treatment of unpaved public roads by implementing one of the following: ▪ Paving at least 1 mile with roadway material; ▪ Applying chemical stabilizers to at least 2 miles; ▪ Implementing at least one of the following on at least 3 miles of road surface: Installing signage at 0.25-mile intervals limiting speed to 15 mph; Installing speed control devices every 500 feet; or Maintaining roadway to 15 mph.	NA	Set applicability standard: ▪ unpaved road must be more than 50 feet wide at all points or must not be within 25 feet of property line, or have more than 20 vehicle trips per day ▪ all roads with average daily traffic greater than average of all unpaved roads within its jurisdiction must be treated	California, SCAQMD Rule 1186 9/10/1999

Table 3.2-5. Regulatory Formats to Control Fugitive Dust on Unpaved Roads and Open Areas.

Control Measure	Goal	Threshold	Agency
Pave, apply dust palliative, or other	Complies with stabilization standard: limit visible dust emissions to 20% opacity, limit silt loading to 0.33 ounce per square foot, and limit silt content to 6%	All unpaved roads with vehicular traffic 150 vehicles or more per day	Nevada, Clark County Hydrographic Basins 212, 216, 217 Section 91 Air Quality Regulation 06/22/2000

Year-round monitoring would be implemented to better characterize potential fugitive dust issues and determine the source (i.e., activities at the TDF, mining operations, vehicle emissions, or other). Monitoring programs are put in place to ensure efforts are being made to mitigate fugitive dust onsite. These efforts include record keeping of soil stabilization methods; dates and frequencies of hydro-seeding tailings piles; times and date of watering; and establishment/maintenance of wind breaks. Site inspections and monitoring of the crust strength and erodibility should be documented and scheduled regularly as well. The TDF crust strength can be determined using drop ball tests, as well as observations of operational dust suppressant systems, and inspections of heights and porosities of wind breaks.

3.2.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceased, disturbed sites were reclaimed, and human activity in the area reduced. The TDF would be built to the maximum footprint and height evaluated in the 2003 EIS (USDA 2003). After the TDF is fully constructed in 2014, reclamation would begin as proposed under the currently approved reclamation plan.

The average annual emissions for each decade following the implementation of Alternative A were assessed. The values presented in figures 3.2-4 and 3.2-5 reflect the conservative assumption of full re-vegetation of the TDF by 2020. This conservative assumption predicts zero fugitive dust emissions six years after reclamation begins in 2014.

3.2.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF. The expanded TDF and associated infrastructure would add to fugitive and mobile emission sources during development beyond the impacts of Alternative A. The extended life of the mine would additionally increase the amount of fugitive dust from the TDF, emissions from stationary source emission units would remain the same under this alternative.

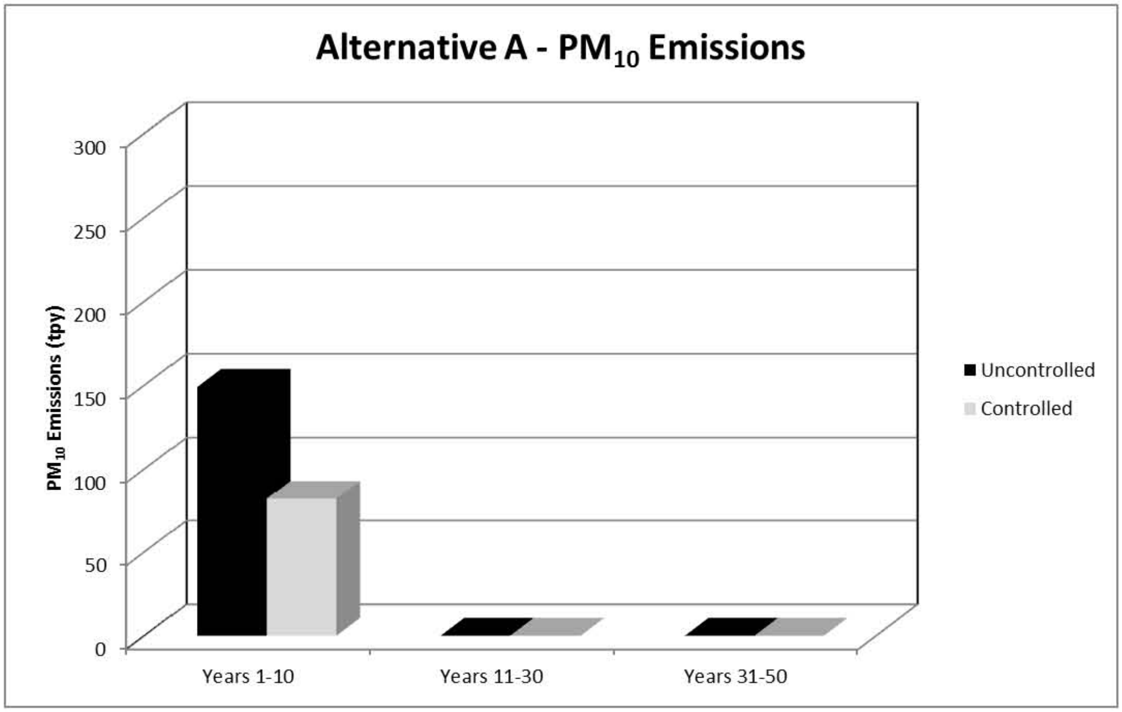


Figure 3.2-4. Average Annual PM_{10} Emissions, Years 1–10.

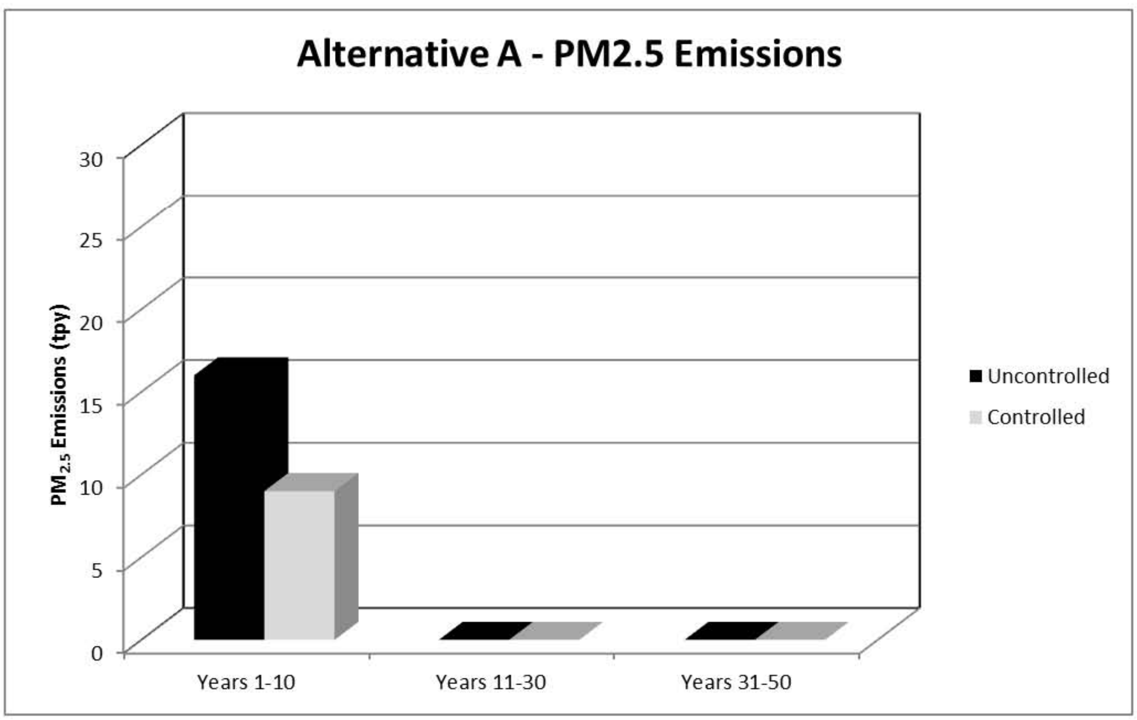


Figure 3.2-5. Average Annual $PM_{2.5}$ Emissions, Years 1–10.

Expansion of the TDF could also potentially result in localized impacts on visibility, vegetation, and soils in the immediate area as a result of fugitive dust. These effects would range from short term (visibility) to long term (soils).

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Admiralty Island National Monument (Monument). The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. Enlarging the quarry rather than developing a new one south of the existing TDF would reduce the areal extent of fugitive dust sources although the activities conducted in the quarry(ies) including blasting, sorting and loading would result in similar overall levels of fugitive dust. Overall, impacts resulting from mitigated Alternative B would be similar to Alternative B although with a slight reduction in deposition within the Monument.

The average annual emissions for each decade following the implementation of Alternative B were assessed. The values presented in figures 3.2-6 and 3.2-7 reflect the conservative assumption that the exposed surface area of the TDF will increase linearly with time over the projected 50-year extended life of the mine.

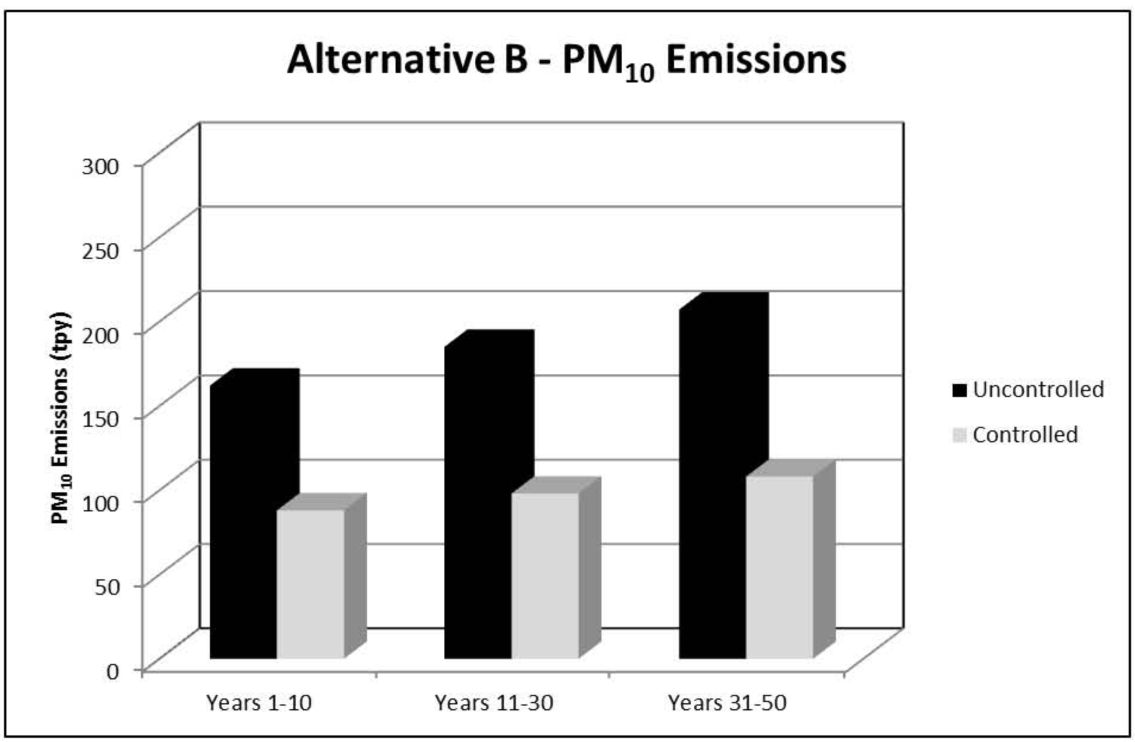


Figure 3.2-6. Average Annual PM_{10} Emissions, Years 1–50.

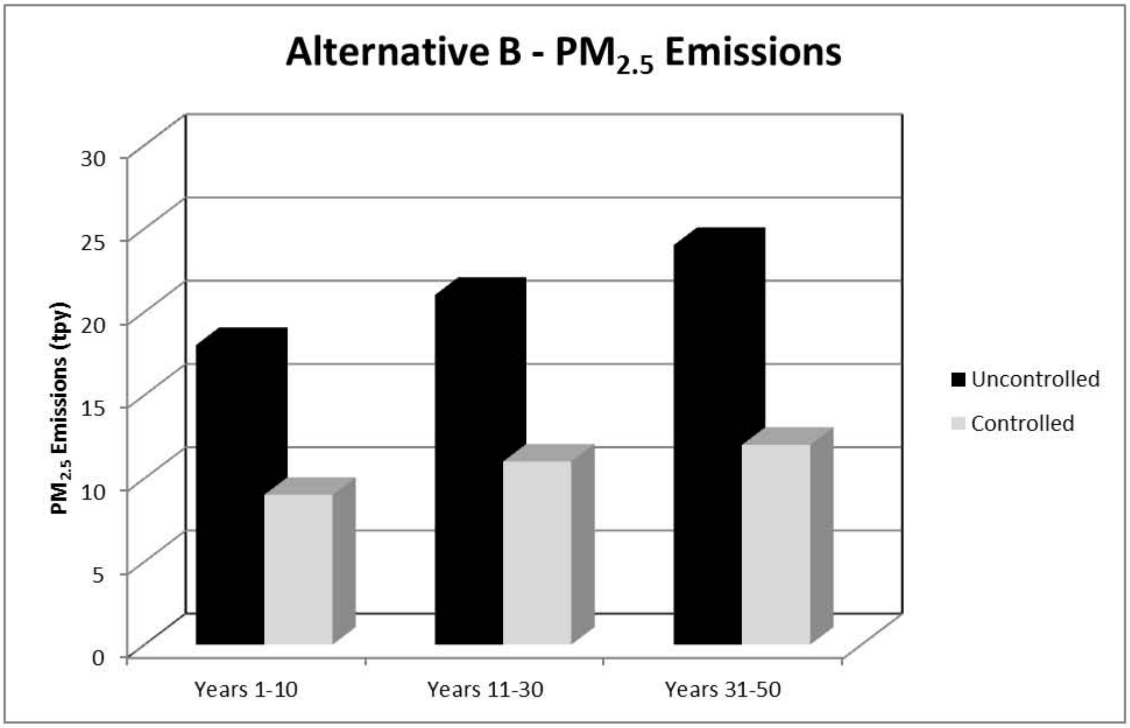


Figure 3.2-7. Average Annual $PM_{2.5}$ Emissions, Years 1–50.

3.2.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve a 3-year expansion of the existing TDF, construction and operation of a new TDF, and upgrading the A Road to handle haul truck traffic to the new TDF. Alternative C would extend the operating period of the mine by 30–50 years. Effects to ambient air quality would be more widely spread than in alternatives A and B due to the development of a new TDF. Development of new facilities would increase mobile, fugitive, and construction air emissions. A quarry would be developed for the construction of the new TDF and road upgrades would add to fugitive and mobile air emissions. An increase in mobile, fugitive, and construction produced air emissions would be expected for the duration of the construction of the new TDF, emissions from stationary source units would remain the same.

The average annual emissions for each decade following the implementation of Alternative C were assessed. The values presented in figures 3.2-8 and 3.2-9 reflect the conservative assumption that the exposed surface area of the TDF will increase linearly with time over the projected 50-year extended life of the mine.

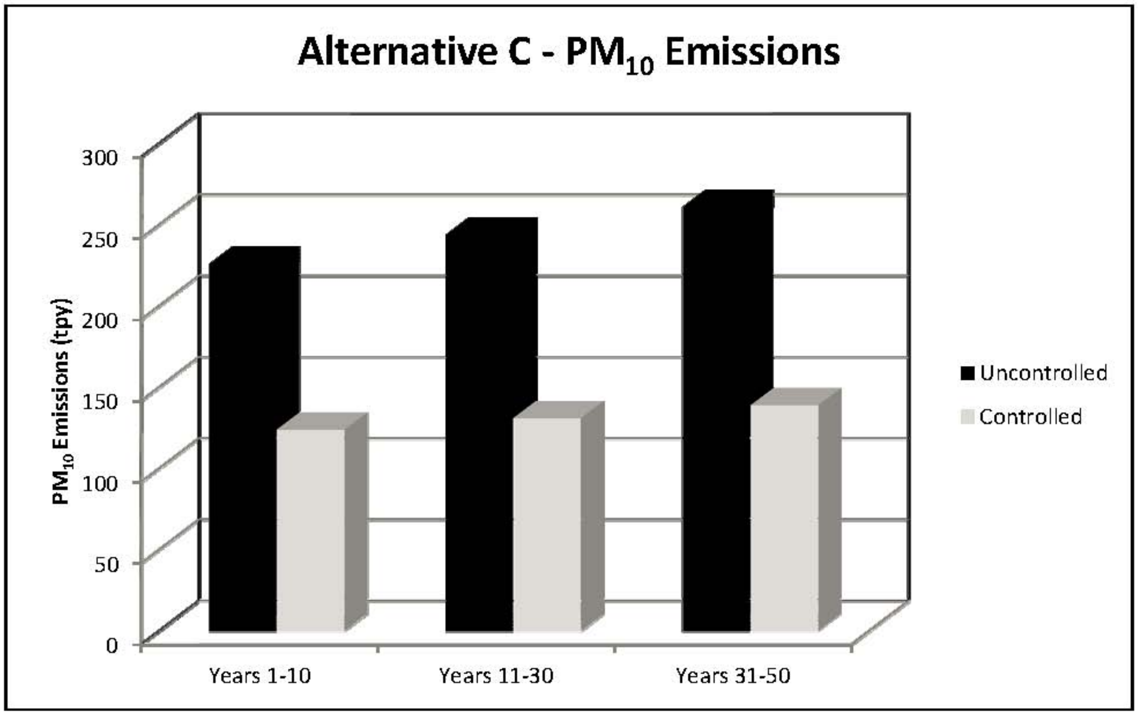


Figure 3.2-8. Average Annual PM_{10} Emissions, Years 1–50.

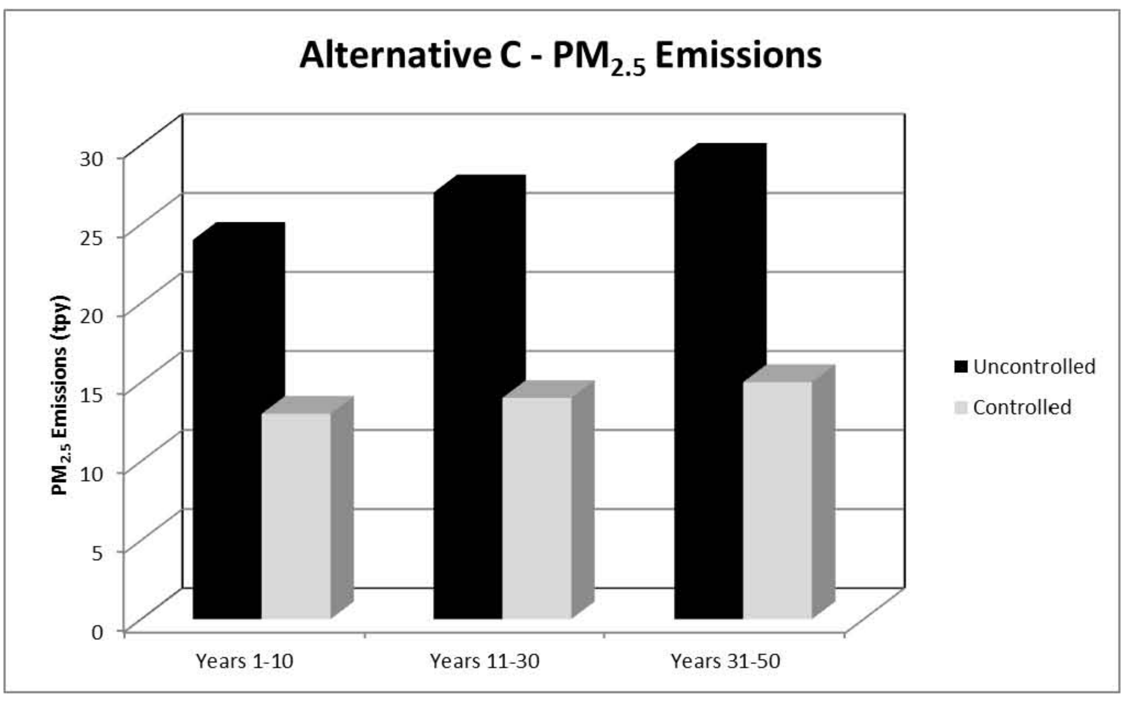


Figure 3.2-9. Average Annual $PM_{2.5}$ Emissions, Years 1–50.

3.2.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve the expansion of the existing TDF and the construction of a new TDF. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than under Alternative B and larger than under Alternative C. Effects to ambient air quality would be similar to Alternative C. The air quality impacts of this alternative would be more widespread than alternatives A and B due to development of a new TDF.

A quarry would be developed for the construction of the new TDF and road upgrade adding to dust and mobile air emissions. An increase in mobile, fugitive, and construction produced air emissions are expected for the duration of the construction of the new TDF, emissions from stationary source units would remain the same under this alternative.

The average annual emissions for each decade following the implementation of Alternative D were assessed. The values presented in figures 3.2-10 and 3.2-11 reflect the conservative assumption that the exposed surface area of the TDF will increase linearly with time over the projected 50-year extended life of the mine.

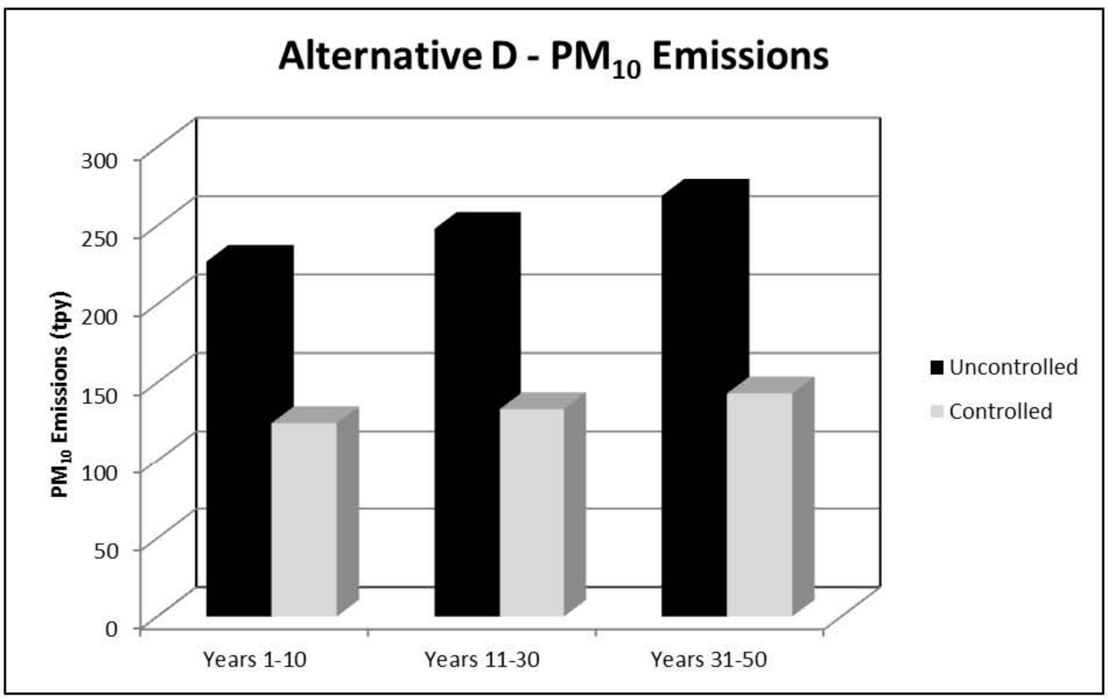


Figure 3.2-10. Average Annual PM_{10} Emissions, Years 1–50.

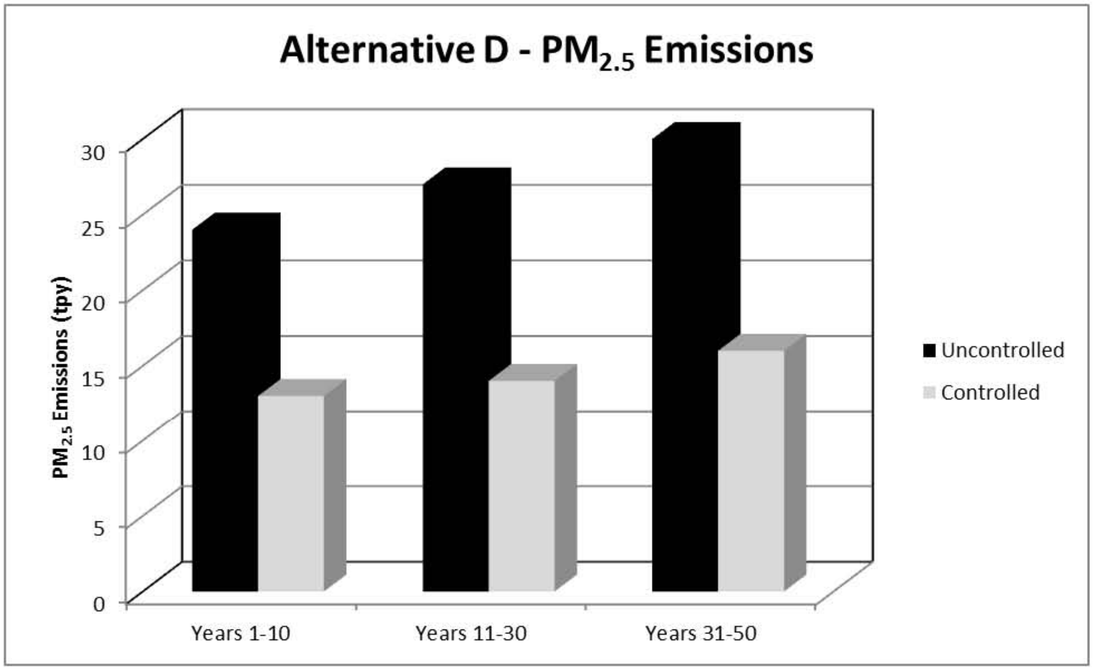


Figure 3.2-11. Average Annual $PM_{2.5}$ Emissions Years, 1–50.

3.2.4 Air Quality – Summary

Under all alternatives, air emissions would continue from mining and support operations until reclamation has been completed. Air emission sources associated with the mine include combustion related emission sources including mobile equipment like trucks and other heavy equipment and non-combustion sources including fugitive dust generated by road traffic and wind. Under Alternative A fugitive dust emissions and mobile source emissions would be minimized after closure in 2014. Using minimal control techniques, the total uncontrolled PM_{10} emissions under Alternative A from fugitive emissions due to the TDF expansion and haul road extensions could reach 159 tpy by 2014 while the uncontrolled $PM_{2.5}$ emissions could reach 17 tpy. Using existing control efforts, the controlled PM_{10} and $PM_{2.5}$ emissions would be 86 and 9 tpy respectively.

Under Alternative B, fugitive dust and mobile emissions would increase over the extended life of the mine. The expanded TDF and associated infrastructure would add to fugitive and mobile emission sources during development beyond the impacts of Alternative A. Using minimal control techniques, the total uncontrolled PM_{10} emissions under Alternative B from fugitive emissions due to the TDF expansion and haul road extensions could reach 212 tpy by 2062 while the uncontrolled $PM_{2.5}$ emissions could reach 25 tpy. Using existing control efforts, the controlled PM_{10} and $PM_{2.5}$ emissions would be 110 and 13 tpy respectively.

Under Alternative C, effects to ambient air quality would be more widespread than in alternatives A and B due to the development of a new TDF to the north. Development of new facilities would increase mobile, fugitive, and construction air emissions. A quarry would be developed for the construction of the new TDF adding to fugitive and mobile air emissions. Using minimal control techniques, the total uncontrolled PM_{10} emissions under Alternative C from fugitive emissions due to the TDF expansion and haul road extensions could reach 265 tpy by 2062 while the uncontrolled $PM_{2.5}$ emissions could reach 30 tpy. Using existing control efforts, the controlled PM_{10} and $PM_{2.5}$ emissions would be 141 and 16 tpy respectively.

Under Alternative D effects to ambient air quality would be similar to Alternative C in that both alternates would create more widespread impacts to air quality as a direct result of the development of the new TDF. The air quality impacts of this alternative would be more widespread than alternatives A and B due to development of a new TDF. Using minimal control techniques, the total uncontrolled PM_{10} emissions under Alternative D from fugitive emissions due to the TDF expansion and haul road extensions could reach 273 tpy by 2062 while the uncontrolled $PM_{2.5}$ emissions could reach 31 tpy. Using existing control efforts, the controlled PM_{10} and $PM_{2.5}$ emissions would be 145 and 16 tpy respectively.

Limited monitoring of snow and lichens has shown metals deposition adjacent and at distance from the TDF. Additional monitoring and development of a mitigation plan will be required to better characterize the source, extent, and nature of the contamination and determine the need for additional mitigation measures. Mitigation measures are listed in Section 3.2.3.1.

3.3 Geotechnical Stability

3.3.1 Geotechnical Stability – Pre-mining Environment

The resource analysis of geotechnical stability does not have any issues directly tied to significant issues. There are no specific measures to address the significant issues; the analysis in this section addresses the long-term geotechnical stability of the TDF.

This section briefly describes the local stratigraphy and seismicity at the mine site to establish a baseline for the geotechnical conditions that may affect stability of the TDF alternatives. The local stratigraphy generally consists of peat followed by various thicknesses and combinations of gravel, sand, silt, and clay. These sediments were deposited as a result of marine, fluvial, and glacial processes. Till and other sedimentary materials are underlain by metamorphic bedrock, typically schist, phyllite, and/or argillite. The depth to bedrock varies greatly in the area. In some places, bedrock is present at or near the ground surface, but in other areas may be covered by more than 100 feet of peat, sand, silt, and till. Depth to bedrock is generally assumed to be quite shallow on steep slopes.

Greens Creek Mine is located in a region of moderate to high seismicity, and is within regional proximity to the active Fairweather-Queen Charlotte Fault, potentially active portions of the Denali Fault, and the Chatham Strait Fault, which is generally not considered active. A site-specific hazard analysis was performed in 1998 by Klohn Crippen. Based on regional active faults and other potential sources zones, this study recommended a maximum design earthquake peak ground acceleration of 0.3 g (gravitational force) and a design basis earthquake peak ground acceleration of 0.15 g for the site to ensure an adequate level of geotechnical stability.

3.3.2 Geotechnical Stability – Baseline Conditions

Overall stability of the TDF was addressed by Klohn Crippen in 2004 and 2005. These analyses were conducted for five critical locations, and addressed the potential for failure in the tailings, foundation soils, and along the liner. Klohn Crippen design criteria required a minimum factor of safety against slope instability of 1.5 for static long-term conditions, and a minimum factor of safety of 1.3 for static short-term conditions.

Stability modeling included the results of Klohn Crippen's 2004/2005 field investigation and laboratory testing program, as well as re-analyzed laboratory data from previous investigations. In addition, Klohn Crippen's laboratory testing program included interface strength testing on the geosynthetics used for the liner materials. Peak and residual strengths for the liner materials were used in the models, as well as water levels established according to piezometer readings from within the tailings and beneath the underdrainage system.

In general, stability analyses through the foundation materials indicated the pile was stable under normal operating conditions. However, the stability analyses performed using residual liner strengths resulted in a minimum factor of safety below 1.5, and inclusion of a small toe berm at the base of the tailings was recommended by Klohn Crippen. A safety factor above 1 is an indication of geotechnical stability and below 1 indicates a potential for instability under certain conditions. Engineers attempt to design facilities with safety factors well above 1 to assure geotechnically stable conditions. Pseudo-static seismic deformation predictions were also shown to be significantly improved by emplacement of a berm at the toe of the pile.

Klohn Crippen performed a sensitivity analysis to determine if higher groundwater levels or a higher phreatic surface (water pressures) would cause instability in the TDF. They determined that the phreatic surface would need to be much higher than the current groundwater levels to reduce the factor of safety from 1.1 to 1.3 or to potentially affect TDF stability.

Ground response analyses conducted by Klohn Crippen Berger, and summarized in their 2007 draft report, indicated liquefaction is not a concern at the facility.

3.3.3 Geotechnical Stability – Environmental Consequences

3.3.3.1 Effects Common to All Alternatives

TDF Stability

Stability analyses of the TDF for all alternatives were conducted using the Slope/W component of GeoStudio 2007. Slope/W was used to conduct limiting equilibrium analyses using the general limit equilibrium method, which satisfies both force and moment equilibrium. The Slope/W program incorporates a search routine to locate those failure surfaces with the least factor of safety within user-defined search limits. Trial failure surfaces were defined with "entry and exit" parameters, resulting in a range of possible locations within which the most critical (lowest factor of safety) potential failure surface may be found.

Preliminary stability analyses for the alternatives were modeled using the material properties and design criteria established by Klohn Crippen in their 2004/2005 reports. These initial analyses indicate that the tailings and foundation materials are likely to be stable, assuming conditions are similar for all alternatives. However, there is the potential for instability on natural slopes of 40 percent (2.5 horizontal units to 1 vertical unit) or steeper, and tailings placed adjacent to these slopes may be impacted by minor quantities of sloughing materials. These stability analyses did not include a study of consolidation in peat layers or soft clays that may be present in the alternative locations, nor did they include pseudo-static analyses.

Stability of TDF Engineered Cover

Maintaining the physical integrity of the barrier layer is the key to maintaining the critical hydrologic functions of the engineered closure cover (OSU 2010). The stability of the engineered cover was modeled independently of the main TDF also using Slope/W. The hydraulic conductivity and relative saturation design criteria for the barrier layer may not be met if inadequate compaction of the barrier layer, slope failure, or tree wind throw were to lead to differential settling, slumping, erosion or exposure of the barrier layer to freeze/thaw or wetting/drying cycles. If fractures develop in the barrier layer, roots could penetrate through the resulting fracture planes. This could lead to increased flux of precipitation and oxygen through the engineered closure cover and into the TDF. The effects of increased flux of water and oxygen in the stability of the TDF would not be sufficient to result in geotechnical concerns; however, the implications of breaching the cover in terms of geochemistry are discussed in Section 3.4.3.

Four scenarios were modeled to evaluate the geotechnical stability of the engineered closure cover under different seismic loading conditions and saturation levels. The Nevada Division of Water Resources recommends the minimum factors of safety shown in Table 3.3-1 for heap leach facilities (which is a comparable design to the TDF).

Table 3.3-1. Minimum Safety Factors for Slope Stability Analyses.

Design Condition	Minimum Factor of Safety
End of Construction; Static Loading (normal conditions)	1.3
End of Construction; Pseudo-Static Loading (earthquake)	1.05

The following slope stability scenarios were evaluated:

1. Static Conditions, Average Pore Pressure Conditions
2. Pseudo-Static Conditions, Average Pore Pressure Conditions
3. Static Conditions, Storm Event Pore Pressure Conditions
4. Static Conditions, Storm Event, Forced Failure Surface at Cover and Tailings Interface

The results of the analyses indicate that the cover is stable under the design conditions, and exceeds the minimum factors of safety recommended by Nevada Division of Water Resources for heap leach facilities. These results indicate that for the conditions modeled the engineered cover is stable as designed. Table 3.3-2 shown the results of the analyses compared to the minimum State of Nevada factor of safety.

Table 3.3-2. Summary of Factors of Safety for TDF Cover Stability.

Seismic Loading Condition	Pore Water Pressure Conditions	Minimum FS	Factor of Safety
Static	Average Climate Year	1.3	3.2
Pseudo-Static	Average Climate Year	1.05	1.7
Static	Storm Event	1.3	3.2
Static	Storm Event	1.3	22.1*

* Failure Surface Forced at Cover and Tailings Interface.

Under all alternatives, a stable dry stack (or stacks) can be built using standard engineering practices. Under these conditions, slope failures are not anticipated.

Monitoring and Mitigation

Changes in predicted water levels and pore pressures within the TDF(s) may change stability parameters over the life of the project. Therefore, the Forest Service and ADEC will require monitoring of the TDF(s) under all alternatives over the life of the project so that any changes to the anticipated conditions within the facilities can be addressed by design modifications necessary to maintain the target factor of safety.

3.3.3.2 Effects of Alternative A, No Action

Under Alternative A, the TDF is stable under current conditions. As discussed in Section 3.3.2, a rise in the phreatic surface within the TDF could result in an unstable condition. Assuming the phreatic levels remain the same, the pile is expected to remain stable. Higher levels are not expected to develop in the future.

3.3.3.3 Effects of Alternative B, Proposed Action

Analyses performed for the proposed action indicate the required factors of safety will continue to be met (Klohn Crippen Berger 2011). However, as discussed in Section 3.3.3.1, natural slopes greater than 2.5H:1V may experience some sloughing, and tailings placed adjacent to these slopes may be slightly impacted.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. No aspects of mitigated Alternative B apply to the geotechnical stability of the existing TDF and the required factors of safety would continue to be met.

3.3.3.4 Effects of Alternative C, New TDF Located Outside Monument

Two sections through the maximum TDF height were analyzed for the new TDF under Alternative C, one from the northwest to the southeast, and one perpendicular to the slope along the north-northeast edge of the alternative pile, oriented northeast-southwest. The analyses assumed a lined pile and similar geology and pore pressure conditions to the existing TDF. The results indicated that Alternative C can be expected to behave similarly to the existing TDF. As with the slopes to the east of the existing TDF, the upper natural slopes to the north-northeast of the site have the potential for minor sloughing. Room to accommodate some sloughed materials between the slope and the TDF is included in the layout, though further analyses would be required at later design stages. If native materials from the upper slopes do accumulate on the TDF edge, some clean up and maintenance may be necessary. However, this potential accumulation is not expected to cause major damage to the TDF or final cover.

3.3.3.5 Effects of Alternative D, Modified Proposed Action

Analyses performed for the proposed action indicate the required factors of safety would continue to be met at both facilities.

3.3.4 Geotechnical Stability – Summary

Slope stability is not expected to pose a credible risk to the current expansion alternatives. While consolidation of peat and/or clay, earthquake induced accelerations, pile pore pressures, and proximity to potentially unstable native slopes are aspects of the expansion that require due consideration and design, they are not insurmountable or substantially different for the alternatives discussed, based on the current analyses. However, it should be noted that these results are preliminary and based on several simplifying assumptions.

3.4 Geochemistry

3.4.1 Geochemistry – Pre-Mining Environment

Surface geochemistry is largely the result of the bedrock geology in an area. The fundamental geology associated with the pre-mining environment is described in detail in the 2003 EIS. The pre-mining environment did not include any appreciable occurrences of sulfide minerals such as pyrite (FeS_2), sphalerite (ZnS), or galena (PbS) that are associated with the Greens Creek ore deposit and tailings as they are unstable at surface conditions and degrade if exposed. Other minerals associated with the deposit may have been present, as they are relatively stable. These minerals would include dolomite and calcite (carbonates) and a host of generally unreactive silicate minerals.

The inferred relative absence of sulfide minerals present at the surface in the pre-mining environment is supported by negligible chemical loading to surface or groundwater. The chemical quality of water in the pre-mining environment would have been controlled more by precipitation interacting with organic material on the forest floor and limited interaction with relatively unreactive bedrock minerals.

3.4.2 Geochemistry – Existing Conditions

Since the 2003 EIS, tailings have been added to the TDF. The overall footprint has increased, as has the total mass of tailings.

The resource analysis of geochemistry is related to Issue 1, water quality and long-term geochemical stability of tailings. Measurements of geochemical impacts include the ability to meet Alaska Water Quality Standards (WQS) by designing the TDF to reduce the rate of geochemical reactions within the tailings pile.

The driving geochemical consideration at the Greens Creek Mine is the water quality associated with tailings. Some of this water is process water entrained in tailings when they leave the mill and some is affected by the result of weathering reactions that occur after placement. Water discharged from the TDF can be described as contact water, which is the result of combining process waters and meteoric precipitation with the products of weathering reactions.

Since the 2003 EIS for the Greens Creek Mine, mineral processing has remained essentially unchanged, the geochemical characteristics of tailings to the present are, therefore, expected to be essentially unchanged. The geochemical characteristics of Greens Creek Mine tailings are thoroughly presented in the 2003 EIS, and are summarized here with more recent information.

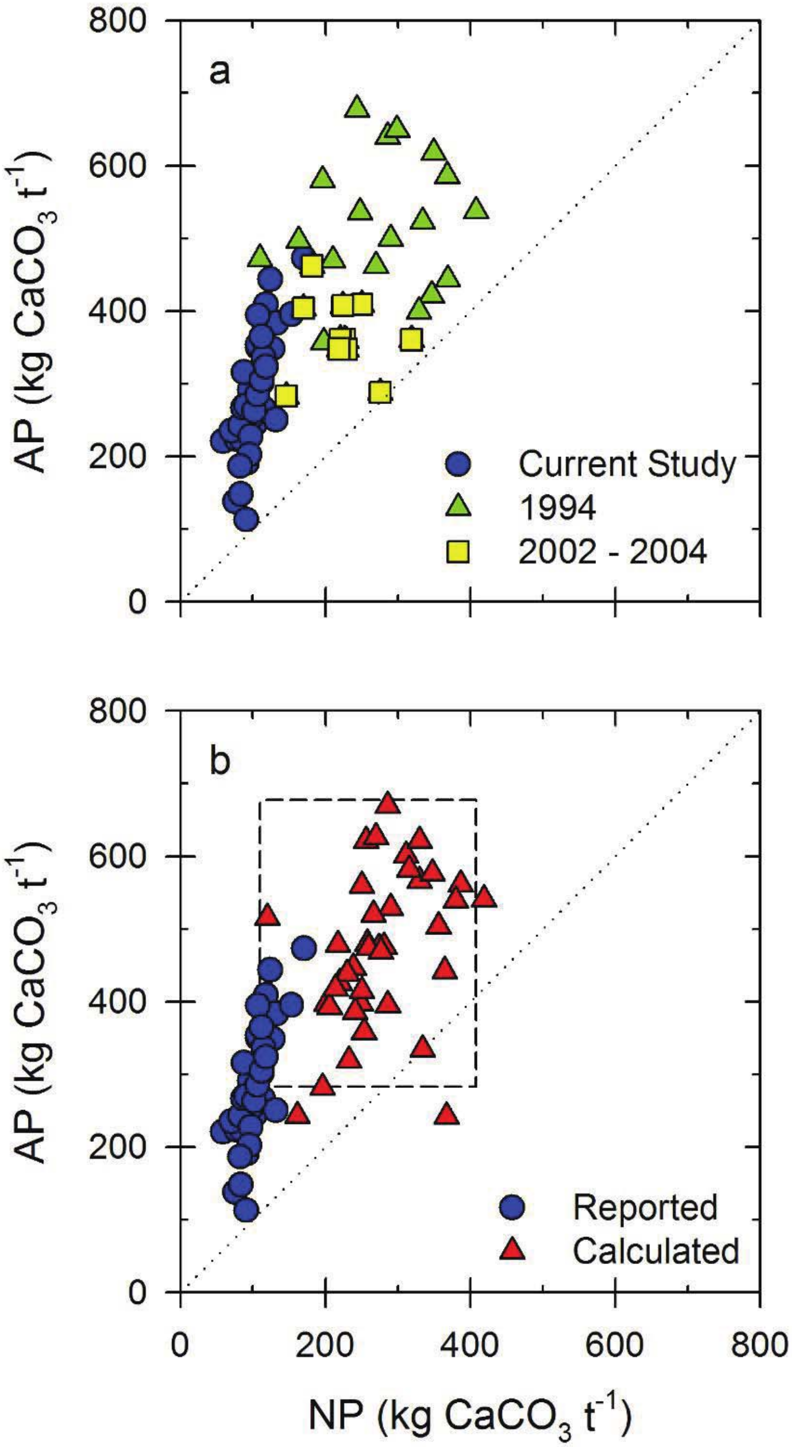
The Greens Creek Mine tailings are silt-sized and composed primarily of pyrite, dolomite, quartz, and barite. Tailings composition was reported by Waterloo (2011) for an average of 14 samples. Ten of these samples were taken from several depths (0.5–2.5 meters) within test cells studied by Lindsay (2009) and are estimated to have been produced in the mid- to late- 1990s. The mineral composition of the tailings by percent weight reported by Lindsay (2009) is listed in Table 3.4-1. The standard deviation for each mineral is relatively small. Within this assortment of minerals the ratio between pyrite and dolomite drive the overall leachate geochemistry and the potential to generate acidic drainage and release chemical constituents of concern.

Table 3.4-1. Tailings Mineral Composition by Weight.

Mineral Type	Chemical Formula	Percent by Weight (%)	Standard Deviation
pyrite	FeS_2	34.3	4.3
dolomite	$CaMg(CO_3)_2$	27.2	3.0
quartz	SiO_2	12.1	3.6
barite	$BaSO_4$	12.3	3.8
muscovite	$KAl_2AlSi_3O_{10}(OH)_2$	3.8.3	2.5
calcite	$CaCO_3$	3.4.3	0.8
sphalerite	Zn,FeS	2.5.3	1.0
cymrite	$BaAl_2Si_2(O,OH)8 \cdot H_2O$	2.1.3	0.6
K-feldspar	$KAlSi_3O_8$	1.5.3	0.6
chlorite	$(Mg,Fe)5Al(Si_3Al)O_{10}(OH)_8$	1.5.3	0.4
hydroxylapatite	$Ca_5(PO_4)_3(OH)$	1.2.3	0.3
galena	PbS	0.7.3	0.2

The tailings associated with the Greens Creek Mine have a net capacity to produce acidic drainage known as acid rock drainage (ARD). That is, the capacity to generate acidity through the oxidation of pyrite exceeds the capacity to neutralize it. ARD is an acidic (low pH) iron sulfate solution containing various trace metals that is produced by the geochemical weathering (oxidation) of sulfide minerals, primarily pyrite. If carbonate minerals (e.g., calcite, dolomite) are present with pyrite, the acidity associated with ARD can be neutralized, and iron, trace metal and sulfate concentrations lowered. But even with neutralization, chemical contaminants can still be released, but far lower than that associated with ARD.

Figure 3.4-1 (Lindsay and Blowes 2011, Figure 5.6) is a graph of the acid generating potential of tailings versus the acid neutralizing potential of tailings. The top graph in Figure 3.4-1 shows acid-base accounting data from 1994-2004 and data initially measured by Lindsay and Blowes (2011) and the lower graph in Figure 3.4-1 shows the raw data of Lindsay and Blowes (2011) shown in (a) as well as recalculated data that more accurately represent the acid potential. The dashed box in (b) corresponds to the range of data in (a) for the years 1994-2004. Data presented in the figure span ages from 1994 to 2008 and provide a representation of the variability of the acid-base balance in Greens Creek tailings. The acid-base accounting data from 1994 (Condon 1995) was obtained from 15 borings within the tailings, distributed to cover the entire pile. Acid-base accounting samples were prepared by compositing over the length of the core obtained, which penetrated the thickness for the pile. The 2008 data were produced from samples taken from four borings transecting the pile east-west and one boring at the southern margin of the pile (Lindsay and Blowes 2011). Together, these samples should be considered representative of the acid-base accounting characteristics of tailings. Although variable, there is no apparent trend in composition over time. Any points that plot above the sloping line that represents an equal balance of acid generating potential and acid neutralizing potential are interpreted as having a net capacity to generate ARD, as acid generating potential exceeds acid neutralizing potential for these data points. All samples that have been taken of Greens Creek Mine tailings are net acid generating. To the extent that waste rock is co-disposed in the tailings pile, the overall acid-base balance of the pile could be altered. This is because waste rock has only 75 percent of the acid neutralizing capacity of tailings. However, the relatively large size of waste rock relative to tailings will mitigate any broad changes in expected acid-base accounting generation because large particles react more slowly than the small tailings particles. Because co-disposed waste rock will be placed within the tailings, where oxygen is restricted, the overall effects on acid-base chemistry of the tailings facility can be anticipated to be negligible.



Source: Lindsay and Blowes 2011.

Figure 3.4-1. Acid-base Accounting of Greens Creek Tailings.

Although tailings are shown to have a net capacity to generate ARD, the rates at which geochemical weathering reactions occur control eventual water quality of tailings pore water and tailings drainage. Pyrite will be oxidized at rates dictated by site conditions. This oxidation will only occur at locations that provide ample water and oxygen. In the pile, only tailings that are located near the outer surface are exposed to abundant oxygen and it is only at these locations that pyrite oxidation is supported. At depth, the tightly packed small tailings grains retard availability of oxygen. Thus, pyrite oxidation can be anticipated to be only a localized occurrence and not widespread throughout the entire pile at any given time. The resulting localized acidity will be neutralized until carbonate minerals are consumed. At that point, acid neutralization is consumed and ARD may form in these localized areas. The key to this sequence is the rate of pyrite oxidation.

The rate at which pyrite oxidizes is related to its grain size (reactive surface area), available oxygen, water, and temperature. Grain size remains essentially constant for Greens Creek Mine tailings and water is present in excess of that required by the oxidation reaction. Pyrite oxidation generates heat. Because there is limited observed pyrite oxidation in the TDF, the internal temperature is expected to stay cool and approximately the annual average temperature of the project site. Currently temperature is not monitored. Ultimately, the rate of oxidation of Greens Creek Mine tailings has been and will continue to be driven by the rate at which oxygen can be supplied to tailings in the pile. Information is available to predict the oxidation of pyrite in Greens Creek Mine tailings from several sources, all with varying degrees of oxygen availability.

The oxidation of Greens Creek Mine tailings:

- has been measured using bench scale laboratory tests
- has been measured in field test plots,
- calculated using empirically determined rate equations, and
- can be estimated for post-closure scenarios.

Laboratory testing of Greens Creek Mine tailings has been conducted using humidity cell testing. This style of testing is conducted in a column where the tailings are exposed to moist oxygenated air for three days, followed by exposure to dry oxygenated air for three days, concluding with a full rinse on the seventh day. The test is then repeated for as many weeks as desired to observe changes in the release of soluble constituents over time. The rate of oxidation is expressed as milligrams (mg) of sulfate (product of pyrite oxidation) released per kilogram (kg) of tailings per week. The humidity cell testing protocol supplies excess water and oxygen to enable the most rapid reaction rates. Other than the pyrite oxidation component, which is well understood within the Greens Creek Mine setting (see below), the specific rate of reaction may be variable, depending upon the geochemical reactions occurring in the test apparatus.

The rate of sulfate release for Greens Creek Mine tailings, for a single random sample taken in 1990 (Vos 1990), through an 18-month study changed from a high of 374 mg/kg/week for the first 6 months to 37 mg/kg/week for the next six months, decreasing to 25 mg/kg/week the final six months (Vos 1990). In the 2003 EIS, the diminishing rate was attributed to a combination of sulfate release caused by the dissolution of gypsum which formed from previous oxidation reactions; and because oxidation of pyrite particles forms a shrinking core over time. A shrinking core can be described as a progressively shrinking unoxidized sulfide mineral core that is surrounded by an ever-growing oxidized rind (layer) that restricts or reduces pyrite oxidation in the center. A second random sample of tailings was submitted for humidity cell testing work in 2009. Although it differed in the beginning and the ultimate measured concentrations, the trend of the sulfate release rate for this sample was similar to that observed for the 1990 sample (see Table 3.4-2).

Table 3.4-2. Pyrite Oxidation Estimates for Greens Creek Tailings.

Source	Early Rate mg/kg/week	Long-Term Rate mg/kg/week
1990 Greens Creek HCT (Vos 1990)	374	25
2009 Greens Creek HCT	529	233
2010 Sulfate Reduction Monitoring Program	No data	9.6
Laboratory Rate	200	200

Note: HCT= humidity cell test.

The rate of pyrite oxidation of tailings in field test plots has also been measured (Lindsay and Blowes 2011). These measurements were made as part of a study to assess the effects of amending tailings with organic material to support biological sulfate reduction as a mechanism to attenuate chemical constituents of concern in tailings pore water. For these field test plots, the pyrite oxidation rate was estimated using measurements of easily leachable iron, which is one product from the oxidation of pyrite. As presented in Condon (2011), easily leachable iron was present at concentrations of approximately 1,500 mg/kg. This mass was accumulated over a four-year time span and correlates to a pyrite oxidation rate of 9.6 mg/kg/week.

Laboratory rate equations have also been established for oxidation of pyrite at the Greens Creek Mine site (Williamson and Rimstidt 1994). These equations incorporate grain size, oxygen dissolved in contact water, and pH and yield an anticipated rate of pyrite oxidation of 200 mg/kg/week. This calculation (assuming general conditions of water saturated with dissolved oxygen, a pH of 7, with an average grain size for Greens Creek tailings and a temperature of 25 degrees centigrade) provides a simple gauge of measured lab rates from humidity cell tests and indicates that the rates observed are consistent with theoretical expectations. Measured rates are slightly higher than the calculated rate and are attributed to variability in grain size as well as the documented variation of sulfide content in tailings. The difference between lab/theoretical estimates of rate and those determined in field test plots is related to limited availability of oxygen at depth in tailings.

The summary of the results of estimates of pyrite oxidation for Greens Creek Mine tailings is presented in Table 3.4-2. The rate of oxidation in humidity cell tests and for the laboratory rate equations, where oxygen is not limited, are comparable, although the 1990 long-term rate is much slower than the 2009 results. This difference may be due to differences in sulfide sulfur content. However, the most significant finding is that the oxidation rate measured in the field test plots is appreciably lower. This is because the ingress of oxygen is limited at depth within the tailings (see Table 3.4-2).

Humidity cell testing in 1993 and 1994 (reported in 2003 EIS) concluded, "Static testing of tailings from the Greens Creek deposit (Figure 3-15) indicates that they have the potential to become acidic. However, owing to the abundance of calcium carbonate and dolomite in the samples (generally ranging from 10 to 60 percent), a long period of weathering, estimated at more than 10 to 33 years in lab tests conducted on siliceous waste rock samples, would have to occur prior to development of acidic conditions." Products of pyrite oxidation have been observed in limited and restricted seeps associated with the tailings immediately before and since the 2003 EIS. This observation is consistent with the projected delay time of 10 to 33 years for the potential onset of ARD in areas where unlimited water and oxygen were available for a substantial period of time.

3.4.2.1 Solutions Associated with Tailings

The fine-grained, silt-sized nature of Greens Creek Mine tailings greatly restricts the infiltration of incident precipitation. Thus, the time required to replace a pore volume of water within the tailings is substantial. Condon (2011) reports an estimated time of 80 years for an average pile thickness of 150 feet. Very slow movement of water in the TDF means that water quality will change very slowly. This time estimate is consistent with earlier estimates made during the 2003 EIS.

Despite the relatively slow rate of infiltration, the tailings contain several aqueous solutions that are discharged ultimately to wet wells associated with the tailings facility (see Section 3.5.2.2). Solutions associated with the tailings include the following:

- Near surface seeps;
- Deeper seated unsaturated portions of the tailings; and
- Saturated tailings.

The near surface seeps are characteristic of water that results from the oxidation of pyrite that is neutralized by carbonate minerals (e.g., dolomite and calcium-magnesium carbonate) and has relatively elevated concentrations of several trace metals. The solution associated with the unsaturated portion of the tailings contains lower concentrations of metals than the surface seeps, but shows a similarity with near-surface solutions. The interpretation is that these neutralized solutions started near the surface and have percolated to lower depths within the pile. In moving deeper into the pile, they experienced attenuation of some constituents in response to the chemically reducing conditions that exist with increasing depth within the pile. The deepest portions of the tailings are saturated. The chemical composition of this zone is consistent with, although not identical to, the zones above it. This lack of interaction is reasonable, as the reactivity (oxidation) of pyrite and other sulfide minerals is negligible because saturated conditions exclude oxygen. A comparison of the chemical composition of solutions associated with the tailings impoundment in presented in Table 3.4-3 (Condon 2012).

Table 3.4-3. Chemical Composition of Solutions Associated with Greens Creek Tailings.

Constituent	Unit	Near Surface Seep		Reduced Unsaturated Zone		Saturated Zone	
		Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Alkalinity	mg/l	209	13	403	68	287	46
Field Conductivity	μS/cm	3150	573	3833	423	4107	601
Field pH	su	6.9	0.17	7.3	0.2	7.9	0.4
Total dissolved solids	mg/l	2943	850	3258	360	3609	655
SO_4	mg/l	2067	371	2230	425	2419	531
Ca	mg/l	532	22	522	56	190	41
Mg	mg/l	241	108	185	62	424	96
Hardness	mg/l	2500	536	2062	299	2331	435
Na	mg/l	22	13	309	122	226	72
K	mg/l	17	12	19	4	45	12
Cl	mg/l	10	4	10	6	28	6
Al	mg/l	*0.025*	NA	No measurements	NA	0.10	0.14
Ag	mg/l	*0.0001*	NA	0.0008	0.0011	*0.002*	NA
As	mg/l	0.0542	0.0761	0.0800	0.0779	0.008	0.007
Ba	mg/l	*0.0071*	NA	0.0062	0.0002	0.0152	0.0061
Cd	mg/l	0.0066	0.0053	0.0015	0.0021	*0.0040*	NA
Cu	mg/l	0.0013	0.0005	0.0074	0.0054	0.0037	0.0018
Cr IIII	mg/l	0.0022	0.0025	0.0047	0.0060	0.0021	0.0021
Fe	mg/l	16.6	18.6	8.1	4.4	*2.2*	NA
Hg	mg/l	*0.00020*	NA	*0.002*	NA	*0.00003*	NA
Mn	mg/l	5.5	4.5	0.21	0.06	0.25	0.19
Mo	mg/l	*0.0028*	NA	0.0086	0.0023	0.134	0.281
Ni	mg/l	0.4490	0.1870	0.0217	0.0041	0.0064	0.0027
Pb	mg/l	0.0100	0.0114	0.0027	0.0022	0.0006	0.0005
Se	mg/l	*0.00827*	NA	0.0053	0.0045	0.043	0.119
Sb	mg/l	*0.0033*	NA	0.0009	0.0005	0.031	0.039
Zn	mg/l	23.6	11.2	1.5	0.8	0.0100	0.0081

Note: For each water type presented, several constituents were either always undetected, or had less than about 10 percent detectable concentrations. For constituents always undetected, the largest reported detection limit value is shown in underlined italics. For constituents with few detections, the highest observed concentration is shown in italics. NA = not applicable; the constituent was undetected.

3.4.2.2 Sulfate Reduction Monitoring Program

The 2003 Greens Creek EIS concluded that there was merit to conducting an investigation into the potential benefit of amending tailings with organic additives to facilitate microbially mediated sulfate reduction. This chemical reduction of sulfate results in the production of sulfide, which forms very low solubility compounds with metals such as zinc. Thus, from 2006 through 2010, Greens Creek conducted a study in conjunction with the University of Waterloo (Ontario, Canada) to prepare and monitor several test plots constructed in the field. Trials evaluated several organic amendments where the geochemical evolution of associated solutions (and solids) was monitored.

As expected, the addition of organic amendments resulted in sulfate reduction, with the attendant decrease in sulfate concentrations as well as a decrease in sulfide mineral forming metals (e.g., zinc). These metals react with the sulfide produced by sulfate reduction to precipitate metal sulfide solids and remove the metal from solution. The decrease in zinc concentration in solution was appreciable, resulting in a representative concentration of 0.2 mg/L compared with 33.5 and 1.52 mg/L in near surface seep solutions and solutions associated with the unsaturated portion of the tailings, respectively (see Table 3.4-3).

However, the addition of organic amendments produced some adverse effects in terms of water quality. Samples collected from trials where previously oxidized waste rock was incorporated in the tailings (co-disposal) showed an increase in arsenic concentrations. The increase in arsenic concentrations was interpreted as being caused by the dissolution of arsenic-containing iron oxyhydroxides in the chemically reducing environment. The iron oxyhydroxides would have formed during the previous weathering of the waste rock. A chemically reducing environment is created when sulfate reducing bacteria consume the organic amendments. Under these conditions, the iron oxyhydroxides dissolve, releasing absorbed arsenic. For this reason, Lindsay and Blowes (2011) conclude that establishing sulfate reduction in combination with co-disposal of waste rock is not recommended at the Greens Creek Mine.

3.4.3 Geochemistry – Environmental Consequences

Water quality changes within the tailings pile and in water seeping or discharging from the tailings pile are the most obvious manifestation of geochemical effects. Since preparation of the 2003 EIS for the Greens Creek Mine (USFS 2003), observations of water quality, water balance, and flow characteristics in the tailings pile have improved the understanding of the relationships among geochemistry, water quality, and fate (chemical changes) and transport in the Greens Creek TDF as discussed above. As a result, the proponent has created a new conceptual and numerical model, which is consistent with these observations and data (Condon 2011). The model estimates the weathering of placed tailings, geochemistry, and effluent quality that could be expected over time. This initial model was created with the intent of continuously updating it and recalibrating it using observed site data obtained in future years. A recommended mitigation measure is to regularly update and recalibrate the model so that predictions of effluent quality and TDF geochemical behavior can be refined and improved as time progresses.

3.4.3.1 Effects Common to All Alternatives

The closure plan for all the TDF alternatives at Greens Creek prescribes an engineered soil cover specifically designed to reduce available oxygen below the cover in the tailings. The cover is primarily designed to prevent diffusion of oxygen in a vapor state into the tailings. The water-saturated layer incorporated into the proposed cover design is intended to limit the flux of oxygen into tailings to that which can be dissolved in water and infiltrated. Ultimately, the rate of water flux through the cover at closure would determine the rate of oxygen ingress to tailings, which in turn would dictate the rate of pyrite oxidation.

Condon (2011) used the designed flux rate of water through the engineered cover with a dissolved oxygen content of 12 mg/L to calculate the rate of pyrite oxidation and carbonate mineral depletion in the TDF. At the conditions of limited oxygen supply, approximately 1,000 years would be required to deliver enough oxygen to oxidize the pyrite contained in a 0.4-inch thick layer of tailings. Approximately 300 years would be required to consume the acid-neutralizing carbonate minerals in the same size layer. These calculated times are a minimum time, as they assume complete and rapid reaction of all oxygen that reports to tailings under the reclamation cover. In reality, the oxidation of pyrite is likely to be slower as the oxidation rate would slow as ferrous iron (Fe^{2+}, released from the oxidation of pyrite) would likely also compete for oxygen to form ferric iron (Fe^{3+}). Further, this ferric iron would precipitate at the neutral pH conditions maintained by the available carbonate minerals and coat existing pyrite. The ferric coating would be expected to further depress the rate of oxidation. Hence, timeframes required to oxidize pyrite, and subsequently consume acid-neutralizing carbonates, are expected to be very long. Because of the sluggish rate of pyrite oxidation, it is unlikely that ARD would form in the entire TDF at any given time. Rather, ARD products are anticipated to only be able to form in thin layers at any given time, depending on the extent of pyrite coating by iron precipitates. These reactive layers would slowly progress deeper within the TDF but leave behind previously reacted acid neutral layers. In this manner only a small volume of the TDF could be producing ARD at any given time. In general, any ARD solutions produced in localized areas are anticipated to become neutralized or diluted by other pore waters as it percolates through the pile.

Condon (2011) constructed a mixing model to calculate the potential water quality in this system associated with discharge from tailings under various discharge scenarios. Unlike the model used in the 2003 Greens Creek EIS, as discussed above, the 2011 model has the benefit of incorporating the geochemical characterization of solids and solutions based on observations conducted over the intervening years. Thus, the 2011 model is based upon actual site data and conditions, whereas the 2003 model required consideration of future effects on a theoretical basis.

The model constructed by Condon (2011) assigned water quality compositions for solutions associated with the tailings as well as associated flows such as surface runoff and background groundwater. These flows were iteratively blended as a calibration exercise to determine the relative proportions required to replicate the existing water quality representative of discharge (wet well data) from the tailings facility. This calibration determined that water reporting to a monitoring wet well from the tailings themselves was comprised of approximately 2 percent shallow surface seep water, 31 percent unsaturated zone solution, 10 percent saturated zone water and 57 percent groundwater. In areas of the TDF that were unlined, groundwater intermingles with tailings effluent in the underdrains of the TDF. These underdrains flow to the wet-wells where it is captured and treated. For comparative purposes, background groundwater quality is provided in Section 3.6.2.3.

Condon (2011) offers a full description of the construction of the water quality model, in terms of characterization of various flows as well as estimates for water quality of tailings solutions post closure. Predictions are produced for the anticipated period of operation, as well as transition time to long-term performance and lastly, long-term estimates. The time domain for the calculations is 2,000 years into the future. Overall, the modeled estimates for future water quality discharging from the tailings impoundment is very similar to the estimates made in 2003. The agreement between model results generated on a theoretical basis (2003) and an empirical, field data basis serves to reinforce confidence in the estimates produced by Condon (2011).

The model results reported by Condon (2011) show very minor differences among alternatives. As shown in Figure 3.4-2 (taken from Condon 2011), numerical differences exist between concentrations of zinc for each alternative, but the differences are inconsequential for comparison purposes. The inherent uncertainty of model predictions for trace metals many years in the future is comparable to, or greater than, the anticipated precision of measurements. In other words, the inherent error of the points associated with each model line overlaps every other line. Thus, there is no statistically significant difference observed among the model results for the various alternatives.

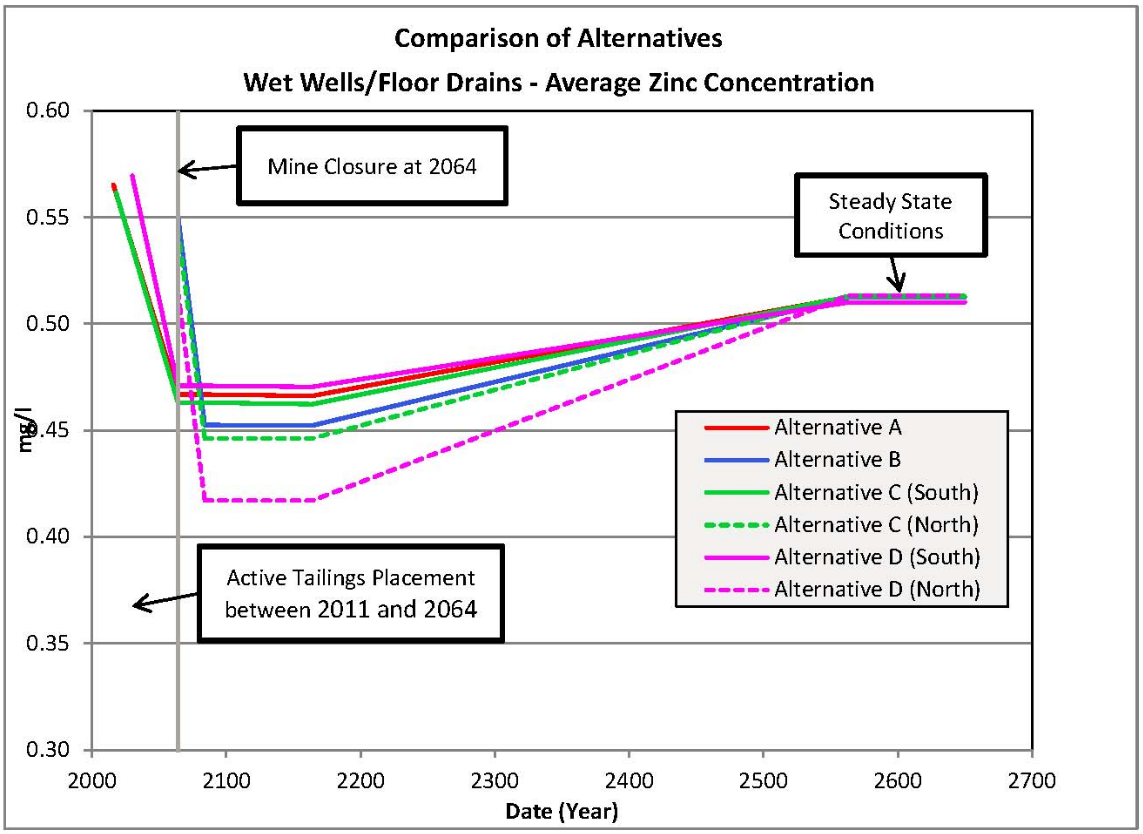


Figure 3.4-2. Model Results for Zinc over Time, for each Alternative.

Although the specific time-dependent concentrations for sulfate differ from those of zinc, the fundamental conclusions are similar. No appreciable difference among alternatives appears to be present. The model results for sulfate are shown in Figure 3.4-3.

The inclusion of organic amendments to establish sulfate reduction results in lower zinc and sulfate concentrations in the relative near term, but does not represent a long-term solution. Although the effect of organic amendment is appreciable, the effect can only be maintained so long as organic material is continually added. Thus, in time, organic materials are consumed through microbial activity and the model results for sulfate reduction become identical to other alternatives.

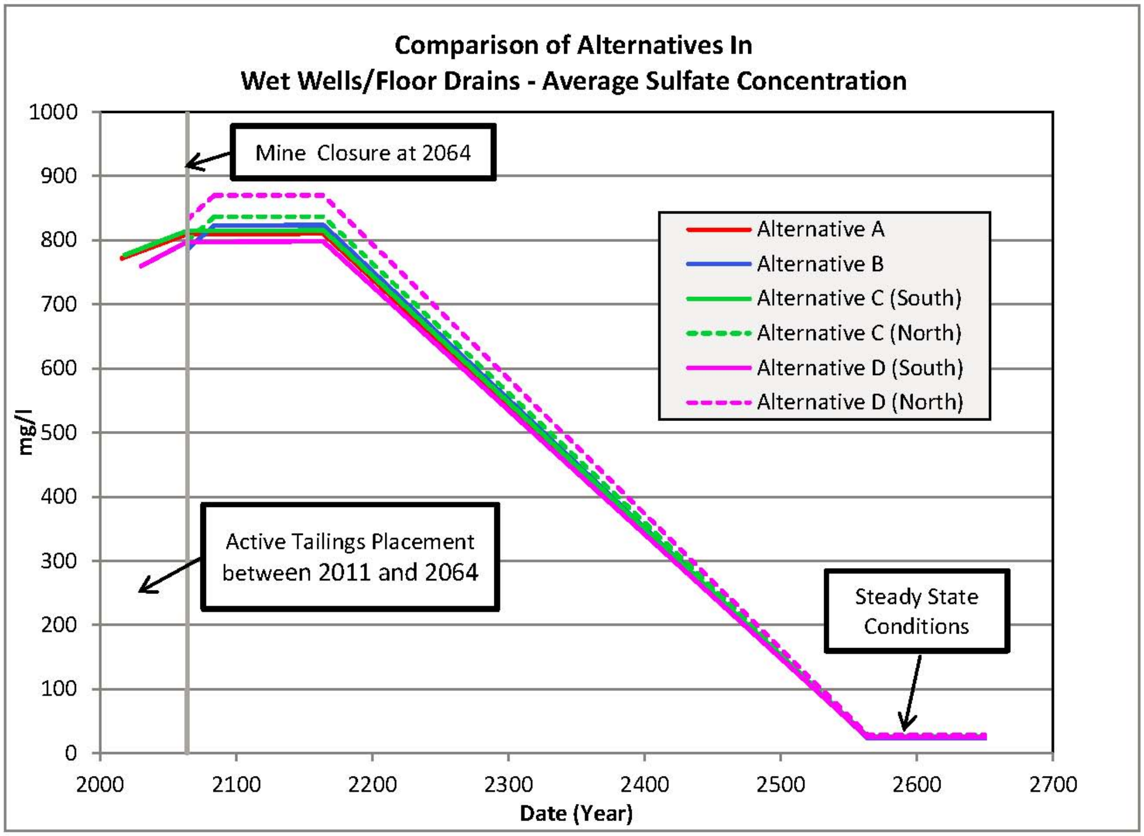


Figure 3.4-3. Model Results for Sulfate over Time, for each Alternative.

Chemical constituents other than zinc and sulfate illustrated previously show similar relative trends, with no appreciable difference among alternatives, save for the application of organic amendments. Results for all constituents are presented by Condon (2011).

3.4.4 Geochemistry – Summary

Weathering (oxidation) is the primary geochemical reaction that would affect the tailings post closure and reclamation. The influx of oxygen and water would be governed by the ingress of oxygen and water through the compacted (barrier) layer of the engineered cover and movement through the tailings themselves. The rates of geochemical reactions would be the same under all TDF alternatives and the low permeability of the tailings would result in the "shrinking core" behavior of the pile, where complete oxidation would require thousands of years. The rate of reaction is unlikely to result in a buildup of ARD although water draining from the TDF under all alternatives would exceed WQS and therefore would require water treatment for at least 100 years after closure and perhaps in perpetuity. The geochemical behavior of the tailings among alternatives would be indistinguishable over the long term. Potential effects on water quality and treatment requirements are discussed in more detail in Section 3.5.3.1.

3.5 Water Resources – Surface Water

Impacts associated with Waters of the United States are evaluated in Section 3.5, Water Resources – Surface Water; Section 3.7, Aquatic Resources; and Section 3.10, Wetlands.

3.5.1 Water Resources – Surface Water – Pre-mining Environment

3.5.1.1 Climate

Between 1997 and 2000, the average annual precipitation at the site was 53.0 inches (USFS 2003). At the TDF, the average annual precipitation from January 2000 through November 2008 was 60.4 inches. This precipitation amount is larger than the average from 1997 through 2000; however, it is consistent with other meteorological measurements in the project area. The meteorological station at Hawk Inlet had an average precipitation of 40.1 inches from 2000 through 2010. The Hawk Inlet station is located less than 1 mile north of the TDF and at approximately sea level. The meteorological station at the mill site had an average precipitation of 66.6 inches from 2000 through 2010. The mill site station is located approximately 5.5 miles southeast of the tailings station and at an elevation of approximately 920 feet. In general, the site is the wettest during the fall and driest during the spring. Table 3.5-1 shows the monthly and annual precipitation for the 11-year period from 2000 through 2010.

From 2000 through 2008, the average annual temperature at the TDF ranged between approximately 30 °F and 56 °F. From 2000 through 2010, the average annual temperature at the Mill site ranged between approximately 28 °F and 54 °F.

From 2000 through 2010, the average annual temperature at the Hawk Inlet site ranged between 31 °F and 55 °F. In general, the site is coldest during the winter and warmest during the summer and the close proximity to the marine environment has a moderating effect on temperature extremes.

3.5.1.2 Surface Water

Water resources are directly connected to significant Issue 1. Water quality concerns raised during scoping are addressed in this section. Measures of water quality include the ability to discharge water that meets Alaska WQS as well as managing pathways of discharged surface water.

Several drainage basins make up the Greens Creek Mine area. The major drainage basins are Cannery Creek, Fowler Creek, Tributary Creek, Zinc Creek, Greens Creek, and several small creeks that drain to Hawk Inlet (Figure 3.5-1). Fowler Creek drains much of the area east of the A Road. An additional small drainage basin north of the Fowler Creek watershed that drains north to Hawk Inlet is referred to as the "North Hawk Inlet watershed."

The Cannery Creek drainage basin is approximately 690 acres located on relatively steep terrain and primarily covered by timber. The creek is a perennial drainage whose upper reaches flow north and northwest and discharges to Hawk Inlet near the cannery buildings. Cannery Creek is also classified as a State Public Water System. The withdrawal point is located immediately east of the B Road crossing near the existing TDF site.

Table 3.5-1. Monthly and Annual Precipitation, 2000–2010.

Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
Tailings Site Monthly Precipitation (inches)												
January	3.02	5.78	3.04	5.07	5.92	12.38	3.85	5.89	4.7	NA	NA	**5.52**
February	0.94	3.27	5.31	2.21	3.87	5.24	1.57	3.58	4.79	NA	NA	**3.42**
March	3.67	2.67	1.11	3.62	6.16	3.87	0.92	29.66	3.9	NA	NA	**6.18**
April	4.32	3.15	0.42	0.72	2.54	2.73	3.45	17.74	4.57	NA	NA	**4.40**
May	2.47	3.65	2.66	3.1	1.14	1.56	3.81	3.34	3.17	NA	NA	**2.77**
June	3.8	1.86	3.2	3.68	1.49	3.68	5.27	1.6	2.82	NA	NA	**3.04**
July	4.02	3.24	4.46	2.45	4.24	6.64	3.45	4.35	5.93	NA	NA	**4.31**
August	4.47	3.08	7.64	4.11	1.89	6.45	7.74	2.17	3.8	NA	NA	**4.59**
September	8.32	7.88	5.06	10.91	7.94	9.62	9.46	6.46	6.6	NA	NA	**8.03**
October	5.98	4.97	7.69	5.74	6.33	7.53	9.99	8.88	9.85	NA	NA	**7.44**
November	4.34	3.16	6.59	4.88	6.71	11.73	2.74	2.67	4.93	NA	NA	**5.31**
December	3.49	3.39	6.27	4.75	10.04	5	10.97	4.3	NA	NA	NA	**6.03**
Total	**48.84**	**46.10**	**53.45**	**51.24**	**58.27**	**76.43**	**63.22**	**90.64**	**55.06**	**NA**	**NA**	**60.36**
Hawk Inlet Site Monthly Precipitation (inches)												
January	2.35	4.30	2.05	3.03	3.71	3.39	2.04	3.85	2.62	4.45	2.60	**3.13**
February	0.76	2.34	3.78	1.46	3.20	3.58	1.18	2.20	1.93	2.24	0.97	**2.15**
March	3.02	2.09	0.73	2.39	4.17	2.84	0.59	2.21	2.36	1.90	3.70	**2.36**
April	3.62	2.48	0.34	0.55	1.98	2.19	3.08	1.90	3.33	0.98	2.01	**2.04**
May	1.92	3.11	2.09	2.60	0.98	1.30	3.47	2.54	2.55	1.43	1.08	**2.10**
June	3.10	1.67	2.69	2.99	1.09	3.22	4.74	1.35	2.12	1.73	3.49	**2.56**
July	3.33	2.67	4.12	1.97	3.27	5.95	3.32	5.69	4.92	0.81	2.56	**3.51**
August	3.21	2.57	5.39	3.04	1.60	6.14	7.08	1.83	2.07	5.49	3.26	**3.79**
September	2.66	7.27	3.98	7.47	6.26	9.35	7.53	5.16	5.22	5.94	5.34	**6.02**
October	2.66	4.28	6.44	3.96	4.75	5.46	7.42	7.46	0.00	4.52	6.33	**4.84**

Table 3.5-1. Monthly and Annual Precipitation, 2000–2010.

Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
November	3.58	2.45	5.24	4.61	5.06	8.80	0.83	1.86	4.58	3.54	4.95	**4.14**
December	2.66	2.34	4.65	3.21	7.33	3.72	5.02	2.95	3.43	2.44	0.06	**3.44**
Total	**32.87**	**37.57**	**41.50**	**37.28**	**43.40**	**55.94**	**46.30**	**39.00**	**35.13**	**35.47**	**36.35**	**40.07**
Mill Site Monthly Precipitation (inches)												
January	4.39	7.82	3.48	5.77	5.53	4.90	3.75	6.15	3.40	6.65	3.57	**5.04**
February	1.08	4.55	5.87	1.63	5.37	4.73	2.60	2.74	3.74	1.96	2.26	**3.32**
March	5.45	4.14	1.63	3.66	7.03	4.82	1.06	11.73	5.15	2.24	6.73	**4.88**
April	4.78	3.39	0.67	1.16	3.88	2.93	4.10	8.24	5.45	1.47	2.81	**3.53**
May	2.51	6.04	2.56	4.09	1.40	1.27	5.10	3.33	3.80	2.10	1.57	**3.07**
June	4.95	2.30	3.07	4.28	1.72	3.54	6.55	2.64	2.45	3.05	4.49	**3.55**
July	6.01	5.19	4.62	2.66	4.29	6.56	4.48	6.58	7.14	1.25	3.25	**4.73**
August	5.47	4.50	9.87	4.97	2.54	6.08	9.07	2.65	4.77	6.94	5.07	**5.63**
September	9.84	11.01	6.20	11.64	9.86	12.66	10.51	9.42	9.99	9.10	7.44	**9.79**
October	8.09	8.07	9.71	5.54	8.26	9.89	11.37	11.76	15.74	6.16	11.61	**9.65**
November	6.47	4.62	8.42	8.09	9.72	15.26	2.52	3.31	5.99	7.66	9.6	**7.42**
December	5.06	3.64	7.60	6.33	13.37	6.79	10.23	4.30	4.02	3.67	0.97	**6.00**
Total	**64.10**	**65.27**	**63.70**	**59.82**	**72.97**	**79.43**	**71.34**	**72.85**	**71.64**	**52.25**	**59.37**	**66.61**

Note: NA = Data not recorded or unavailable.

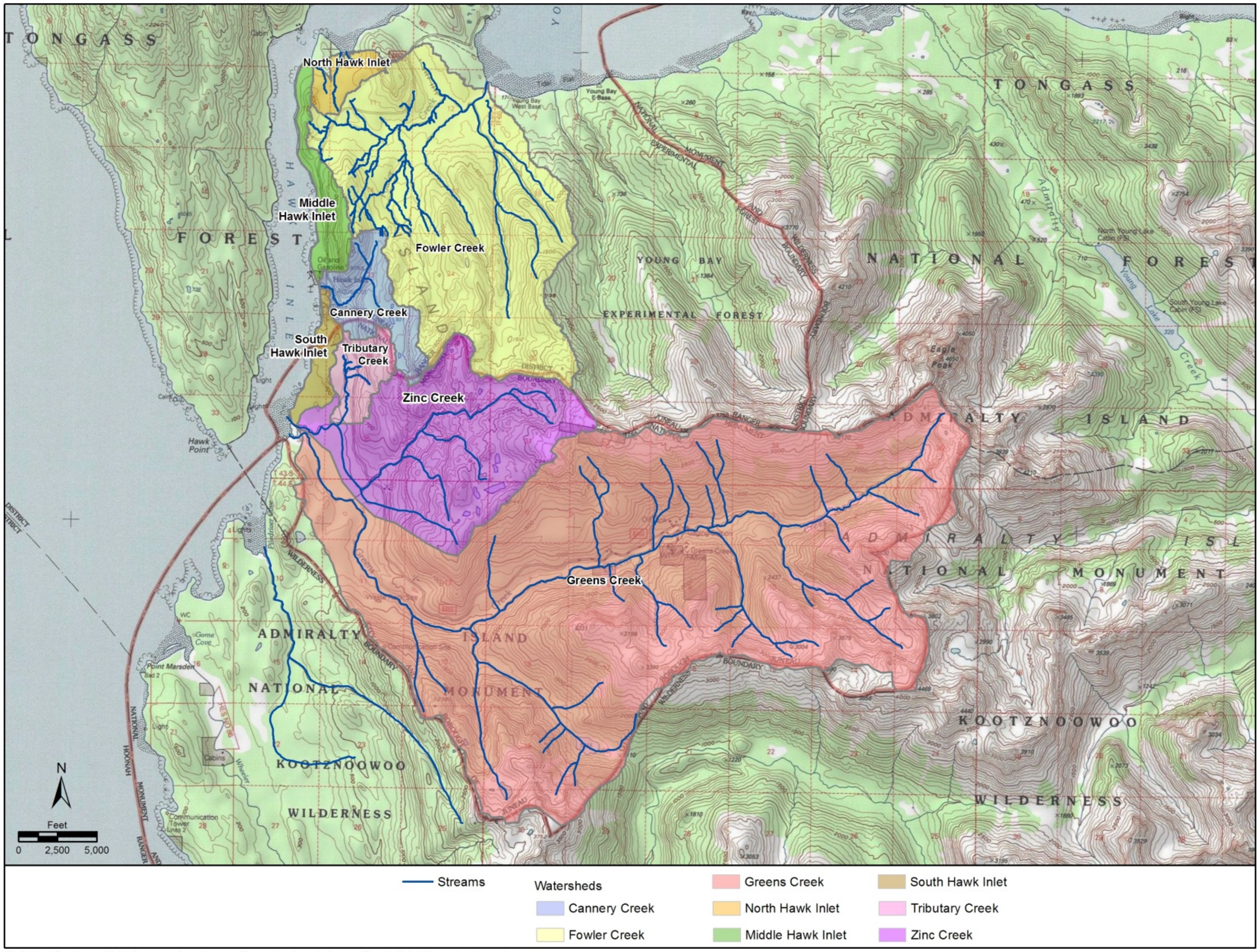


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Figure 3.5-1. Surface Water.

Greens Creek would not be directly affected by the proposed TDF expansion; however, the watershed was included in the study area for surface water due to its proximity to ongoing activities and the potential for indirect effects. Like Cannery Creek, it is a classified as a Public Water System. The withdrawal point is located well upstream of and outside of the project area, upstream of the mill facilities and mine portal.

Prior to mining, the Tributary Creek drainage basin was about 482 acres sloping south towards Zinc Creek and primarily consisting of muskeg vegetation interspersed with stands of timber. The headwaters of Tributary Creek were the slopes east of the TDF and part of the muskeg area where the current TDF is located. Tributary Creek flows to Zinc Creek, which flows into Hawk Inlet near the mouth of Greens Creek.

The South Hawk Inlet drainage basin lies immediately west of the Tributary Creek basin. Several small streams make up this basin, which originally drained approximately 76 acres. The drainage has a northern aspect and is primarily made up of muskeg that occurs on terraces and timber that occurs on steeper slopes. The streams are known as CC Creek, Proffett Creek, and Further Creek. CC Creek and Further Creek drain directly to Hawk Inlet. Proffett Creek flows for a few hundred feet but becomes intermittent and eventually sinks into the underlying strata. Another surface stream occurs about 100 feet down-gradient to where Proffett Creek disappears, and appears (based on similar water chemistry and physiographic position) to be the same water flow. This lower stream is known locally as Franklins Creek, which discharges directly to Hawk Inlet. Water flow in these streams fluctuates seasonally in response to rainfall and snowmelt events. However, all of these drainage features have very low flows, with average flows ranging between less than one gallon per minute (gpm) and approximately 10 gpm. One particular seep of interest is called Further Seep, an intermittent seep with a flow of approximately one gpm.

The Fowler Creek drainage basin is approximately 5,090 acres located on flat to moderately steep terrain and primarily covered by timber and forested wetlands. Fowler Creek has a number of small tributaries and eventually drains to Young Bay. Many northern small tributaries contain beaver dams and drain muskeg and forested wetlands. The central and southern tributaries are relatively low gradient and also contain beaver dams and bog wetlands.

The North Hawk Inlet watershed is approximately 260 acres. The drainage contains two primary unnamed streams that drain muskeg and forested wetlands to Hawk Inlet.

3.5.2 Water Resources – Surface Water - Baseline Conditions

The TDF occupies a gently sloping terrace that straddles the drainage divide between the Tributary Creek drainage basin, the Cannery Creek drainage basin, and the Hawk Inlet drainage area. A steep, timbered mountain slope rises to the east of the TDF, while to the west a muskeg area steepens as it approaches Hawk Inlet. On the northwest side of the TDF, a bedrock knob rises to nearly 300 feet above sea level.

In 1998, a stabilizing berm (known as the West Buttress) was constructed on a prepared foundation on the western edge of the existing TDF site to allow additional height and capacity to the TDF, without a major increase in site surface disturbance. From 2000 to late 2002, tailings were placed in an area known as the East Expansion, taking advantage of the additional room allotted by the construction of the West Buttress.

An additional surface water feature has resulted from mining activities. Duck Blind Drain is a human-induced spring that resulted from construction of the pipeline that discharges treated water into Hawk Inlet. Water that naturally collects within the pipeline trench alignment is allowed to discharge to the surface through a pipe at the location of a pipeline valve vault. This vault contains a flow meter that monitors flow through the pipeline; the discharge pipe is used to keep the vault from becoming flooded. The flow from this source is less than 5 gpm. The streams and seeps in the South Hawk Inlet catchment were sampled during baseline data collection efforts in 2001. Samples were collected in Proffett and Franklin creeks, CC Creek (two sites), Further Creek (four sites), Further Seep, and the Duck Blind Drain.

Water quality and flow samples in area streams, creeks, and other water features have been collected and monitored since 1985. As mining has progressed, the Fresh Water Monitoring Program (FWMP) has expanded to provide monitoring of additional stations and creeks. Figure 3.5-1 depicts the area streams. Under the FWMP, an annual report is produced as a part of the operations plan. This report documents trends in water quality in all project drainage features and creeks. This annual FWMP report is sent to the Forest Service and ADEC for review.

Water quality is usually evaluated in relation to Alaska WQS. Alaska WQS include use classifications, numeric and/or narrative water quality criteria, and an anti-degradation policy. The use classification system designates the beneficial uses that each water body within the State of Alaska (such as Tributary Creek, Greens Creek, and Cannery Creek) is expected to provide. The numeric and/or narrative water quality criteria are the criteria deemed necessary by the State of Alaska to support the beneficial use designation.

Beneficial uses for waters within the Greens Creek area are freshwater industrial water supply use, contact recreation, secondary recreation, water supply for drinking, culinary and food processing, and for the growth and propagation of fish, shellfish, other aquatic life, and wildlife. The most stringent water quality criteria across these designated uses applies to area streams. For most parameters and metals, the most stringent criteria are for the propagation of fish and aquatic life. However, the most stringent water quality criteria for manganese is for the human health consumption of water plus fish, and the most stringent criteria for arsenic and sulfate are for drinking water (ADEC 2009).

Some of the fresh WQS for metals are hardness-based. Hardness is the measure of polyvalent cations (ions with a charge greater than +1) in water. Hardness generally represents the concentration of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in solution, because these are the most common polyvalent cations. Other ions, such as iron (Fe^{2+}) and manganese (Mn^{2+}), may also contribute to the hardness of water, but are generally present in much lower concentrations. Hardness mitigates metals toxicity because polyvalent cations (Ca^{2+} and Mg^{2+}) help keep fish and other aquatic organisms from absorbing metals such as cadmium, copper, and lead into their bloodstream through their gills. The greater the hardness of the water, the harder it is for toxic metals to be absorbed into the gills. For this reason, a higher measured hardness in the receiving water results in a higher (less stringent) WQS for hardness-based metals. A lower measured hardness results in more stringent WQS for hardness-based metals. In this manner, the metals WQS applied to area creeks are based on measured hardness of the receiving water. Table 3.5-2 shows WQS for aquatic life (also see Figure 3.5-2). As an example, standards for the hardness based metals are based on the long-term average hardness of 46 mg/L measured as calcium carbonate (as $CaCO_3$) in lower Tributary Creek.

Table 3.5-2. Applicable Water Quality Standards for Area Streams.

Parameter (in µg/L unless noted otherwise)	WQS Acute	WQS Chronic
Aluminum, Total	750	87
Arsenic	340	10
Cadmium – Dissolved [a]	0.95	0.14
Copper – Dissolved [a]	6.5	4.6
Cyanide [b]	22	5.2
Iron – Total	–	1000
Lead – Dissolved [a]	27	1.07
Manganese [c]	–	50
Mercury – Dissolved [c]	1.4	0.012
Nickel – Dissolved [c]	243	27
Selenium – Total	20	5
Silver – Dissolved [c]	0.91	–
Zinc – Dissolved [c]	61	61
Sulfate (mg/L) [d]	–	250
Total Dissolved Solids (mg/L) [d]	–	500
pH	6.5–8.5	

Notes:

mg/L = milligrams per liter or parts per million; µ/L = micrograms per liter or parts per billion.

a. based on the long-term average hardness of 46 mg/L as $CaCO_3$ in Tributary Creek.
b. the cyanide standard is for free cyanide sampled as weak acid dissociable.
c. based on the human health criteria for consumption of water and fish.
d. based on the drinking water standard.

There are no streams listed as impaired under Section 303(d) of the CWA at the Greens Creek project site. Table 3.5-3 shows cumulative results of the FWMP at major area streams near the TDF. These data show average and maximum concentrations of metals, pH, and other important parameters taken between 1989 when the program was first initiated, and 2010. In general, surface water in Greens Creek, Tributary Creek, and Cannery Creek have near-neutral pH with low levels of metals and sulfate. The water quality generally meets Alaska WQS for aquatic life. Some water quality samples with concentrations above the Alaska WQS for dissolved cadmium, and to a lesser extent copper, mercury and zinc were reported in Tributary Creek in the 1990s. Reported concentrations appear to be anomalous values that were not associated with parallel increases in sulfate, reduced pH, or elevations of non-trace metals, such as iron, calcium, or magnesium. Since 1990, these parameters have returned to low levels that meet the Alaska WQS for aquatic life.

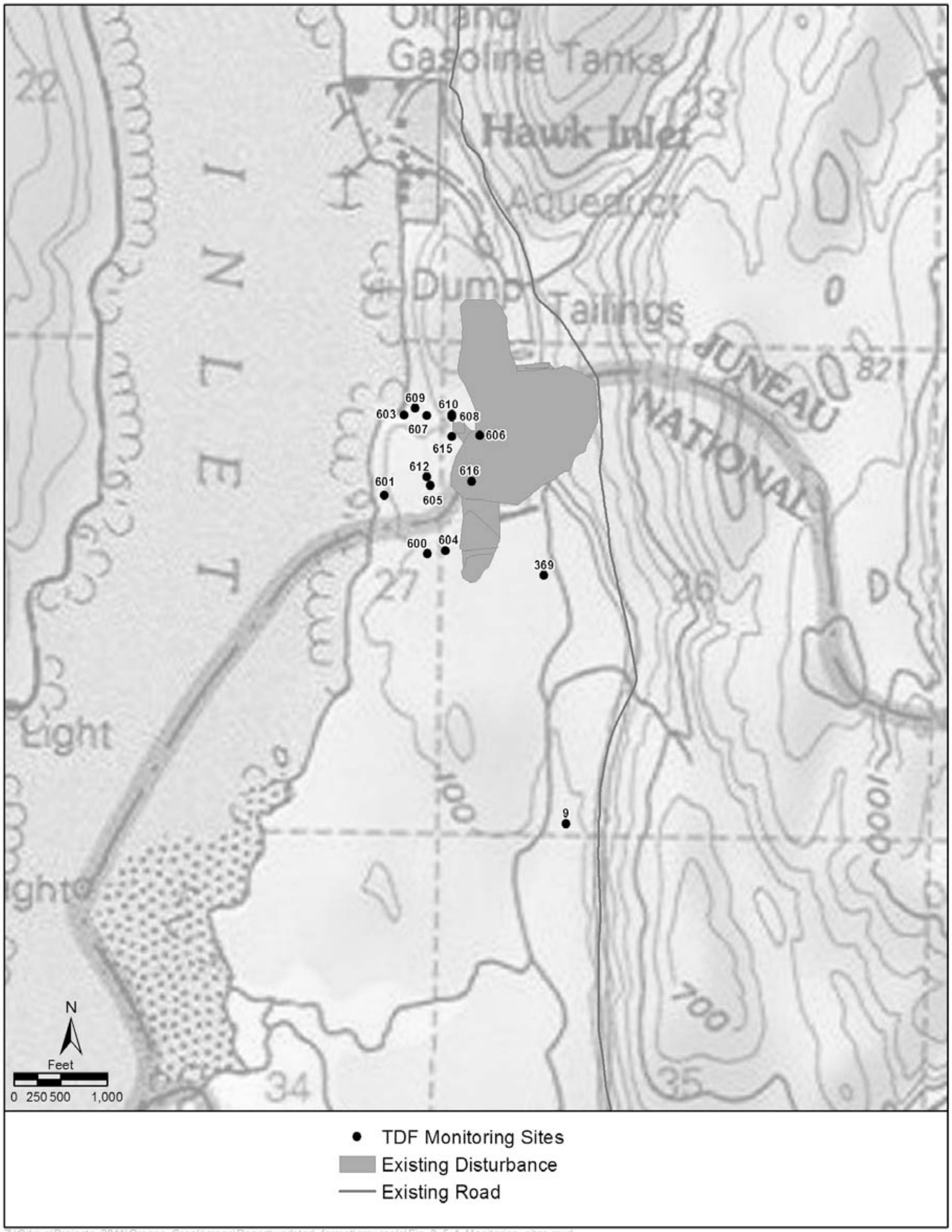

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Figure 3.5-2. Surface Water Quality Monitoring Sites.

Table 3.5-3. Summary of Surface Water Quality Monitoring Stations.

Site Location	Statistic	Flow (gpm)	pH (s.u.)	TDS (mg/L)	TSS (mg/L)	SO4 (mg/L)	Hard-ness (mg/L)	Al (µg/L)	Ag (mg/L)	Cd (µg/L)	Cu (µg/L)	Fe (µg/L)	Hg (µg/L)	Mg (mg/L)	Mn (µg/L)	Ni (µg/L)	Pb (µg/L)	Se (µg/L)	Zn (µg/L)
Althea - Upper	Average	4.95	6.27	174	< 11.8	53.3	118	363	< 0.57	< 0.10	< 1.62	< 539	< 0.10	4.37	11.4	2.37	< 0.49	< 2.02	8.98
	Maximum	30.0	7.82	524	44.0	262	326	na	1.57	na	4.19	900	0.22	18.3	34.0	8.86	1.04	2.80	17.8
	Count	11	9	8	9	9	7	1	7	9	9	9	9	9	9	9	9	7	9
	Count < DL	0	0	0	4	0	0	0	6	9	1	1	4	0	0	0	3	4	0
Althea Creek	Average	7.40	6.38	134	< 3.94	< 51.4	104	509	< 0.22	< 0.40	< 1.51	< 608	< 0.04	5.59	14.2	< 2.19	< 0.29	< 0.98	8.03
	Maximum	30.0	7.77	481	6.40	285	375	594	1.04	0.02	11.8	2,060	0.02	18.3	53.0	6.08	0.95	2.15	48.7
	Count	15	21	12	11	23	20	2	18	26	26	26	19	16	23	21	26	19	26
	Count < DL	0	0	0	10	6	0	0	12	15	1	1	5	0	0	1	7	9	0
CC Creek, lower reach	Average	6.61	5.60	71.8	< 3.92	12.2	44.9	263	< 0.70	< 0.090	< 0.872	568	< 0.0002	1.38	13.2	< 1.03	< 0.37	< 1.62	< 6.37
	Maximum	35.0	6.18	141	2.10	40.8	125	na	2.48	0.09	1.46	1,290	na	2.75	34.2	2.64	0.58	2.19	12.9
	Count	11	12	12	12	12	7	1	6	12	12	12	6	12	12	12	12	6	12
	Count < DL	0	0	0	11	0	0	0	5	11	2	0	6	0	0	2	3	5	1
CC Creek, upper reach	Average	4.99	5.85	70.6	< 3.90	18.5	48.4	129	< 0.56	< 0.090	< 0.984	358	< 0.0002	1.59	7.75	< 0.95	< 0.41	< 1.75	< 5.91
	Maximum	35.0	6.29	143	na	48.1	120	na	1.63	0.10	3.57	516	na	2.96	18.9	2.65	0.62	2.76	13.1
	Count	10	11	10	11	11	6	1	6	11	11	11	6	11	11	11	11	6	11
	Count < DL	0	0	0	11	0	0	0	5	10	3	0	6	0	0	4	3	3	1
Duck Blind[1]	Average	0.80	7.26	407	< 6.73	302	600	11.0	< 0.05	< 0.178	2.37	< 1099	< 0.200	26.9	1,383	18.4	< 0.29	< 2.11	86.2
	Maximum	3.00	7.42	593	9.90	350	na	na	na	0.44	4.04	2,700	na	30.7	2,420	25.6	0.38	3.21	153
	Count	5	3	2	4	4	1	1	1	4	4	4	1	4	4	4	3	2	4
	Count < DL	0	0	0	2	0	0	0	1	3	0	1	1	0	0	0	1	1	0
Franklins Creek #25	Average	10.45	7.15	134	< 3.66	51.7	86.8	90.0	< 0.31	< 0.092	< 0.763	430	< 0.0002	5.13	2.73	< 1.29	< 0.377	< 1.67	< 6.42
	Maximum	50.0	7.90	181	2.00	94.0	144	na	na	0.11	1.73	699	na	8.00	5.82	2.53	1.79	2.51	33.0
	Count	9	11	10	10	11	6	1	6	11	11	11	5	11	11	11	11	6	11
	Count < DL	0	0	0	9	0	0	0	6	10	3	0	5	0	0	1	5	5	2
Further Creek Lower Reach	Average	7.62	5.64	163	< 3.78	82.0	148	132	< 0.31	< 0.10	< 2.82	1,059	< 0.02	7.00	73.0	4.21	< 1.15	< 2.05	54.0
	Maximum	15.9	6.59	305	4.00	182	265	na	na	0.19	9.87	2,010	0.09	12.5	117	9.40	2.82	6.78	147
	Count	10	11	10	10	11	6	1	6	11	11	10	5	11	11	11	11	6	11
	Count < DL	0	0	0	8	0	0	0	6	9	1	0	4	0	0	0	1	4	0
Further Creek North Fork	Average	0.949	6.63	394	< 15.3	219	335	48.0	< 0.29	< 0.11	5.33	367	< 0.0002	18.7	58.0	5.84	< 0.64	5.02	38.5
	Maximum	3.00	7.42	740	42.0	424	585	na	na	0.23	17.7	832	na	32.3	224	12.6	1.45	13.7	71.0
	Count	7	8	9	9	9	5	1	5	9	9	8	5	9	9	9	9	5	9
	Count < DL	0	0	0	1	0	0	0	5	5	0	0	5	0	0	0	3	0	0
Further Creek South Fork #136	Average	2.53	6.08	341	< 2.98	195	283	48.0	< 0.35	< 0.11	< 1.58	354	< 0.0002	15.6	20.1	3.36	< 0.709	< 2.45	106
	Maximum	10.0	6.54	708	na	451	490	na	na	0.20	2.80	840	na	37.8	38.8	8.55	1.32	5.51	214
	Count	8	7	6	6	7	5	1	5	7	7	7	4	7	7	7	7	5	7
	Count < DL	0	0	0	6	0	0	0	5	6	1	0	4	0	0	0	1	3	0

Table 3.5-3. Summary of Surface Water Quality Monitoring Stations.

Site Location	Statistic	Flow (gpm)	pH (s.u.)	TDS (mg/L)	TSS (mg/L)	SO4 (mg/L)	Hard-ness (mg/L)	Al (µg/L)	Ag (mg/L)	Cd (µg/L)	Cu (µg/L)	Fe (µg/L)	Hg (µg/L)	Mg (mg/L)	Mn (µg/L)	Ni (µg/L)	Pb (µg/L)	Se (µg/L)	Zn (µg/L)
Further Creek, NFSS 115 [1]	Average	0.234	6.74	477	< 10.3	295	436		< 0.35	< 1.28	5.35	214	< 0.0002	20.8	21.6	6.26	2.95	< 5.79	369
	Maximum	1.00	7.36	996	31.0	651	735	na	na	3.05	12.6	470	na	42.5	41.1	13.3	5.12	9.92	872
	Count	10	7	7	7	7	4		4	7	7	7	4	7	7	7	7	4	7
	Count < DL	0	0	0	3	0	0		4	1	0	0	4	0	0	0	0	1	0
Further Creek, upper	Average	2.23	5.92	209	< 5.87	115	190	84.0	< 0.31	< 0.12	2.62	887	< 0.0002	9.53	73.6	4.50	< 1.27	< 2.81	76.9
	Maximum	7.00	6.85	432	13.0	270	375	na	na	0.22	10.1	1,600	0.0002	18.9	122	12.3	3.06	9.23	234
	Count	10	11	9	10	11	6	1	6	11	11	10	6	11	11	11	11	6	11
	Count < DL	0	0	0	5	0	0	0	6	6	0	0	5	0	0	0	1	1	0
Further Seep	Average	0.83	3.59	147	< 5.22	98.8	101	1.11	< 0.33	< 0.28	2.46	1,106	< 0.00001	5.75	160	4.92	2.09	< 1.66	94.8
	Maximum	8.00	3.78	187	13.0	120	185	na	na	0.63	3.33	2,040	na	7.50	388	7.67	3.78	na	144
	Count	13	10	10	10	10	5	1	5	10	10	10	5	10	10	10	10	5	10
	Count < DL	0	0	0	6	0	0	0	5	4	0	0	5	0	0	0	0	5	0
Further Seep 2.0	Average	0.25	5.77	156	2	38.5	55.4	37.0	< 0.05	< 0.17	< 1.65	63.9	0.0009	4.70	49.3	< 2.25	< 0.603	0.99	67.3
	Maximum	na	7.59	na	na	93.0	56.0	na	na	0.40	2.80	110	na	6.60	145	5.20	1.70	1.08	193
	Count	1	2	1	1	3	2	1	2	3	2	2	1	2	3	3	3	2	3
	Count < DL	0	0	0	0	0	0	0	2	1	1	0	0	0	0	1	1	0	0
Further Seep, South Fork 115	Average	1.61	5.01	197	< 6.52	109	162	137	< 0.31	< 0.09	< 1.77	440	< 0.0002	9.60	33.8	2.57	< 0.59	< 1.93	50.7
	Maximum	5.00	5.99	519	18.6	312	310	na	na	0.10	4.50	1,060	na	27.1	104	6.05	1.00	3.98	114
	Count	10	11	10	10	11	6	1	6	11	11	11	5	11	11	11	11	6	11
	Count < DL	0	0	0	7	0	0	0	6	10	1	0	5	0	0	0	2	4	0
Gilbert Creek - middle	Average	9.20	8.09	196	< 10.9	53.4	257		< 0.22	< 0.13	< 0.52	< 50	< 0.0002	5.51	< 0.31	< 1.09	< 0.11	< 1.21	< 2.40
	Maximum	30.0	8.3	912	47.1	380	710	na	na	0.47	1.14	na	na	6.20	0.79	1.57	0.07	0.57	6.50
	Count	18	9	9	9	9	4		4	9	9	9	4	9	9	9	9	4	9
	Count < DL	0	0	0	5	0	0		4	8	3	9	3	0	2	1	6	3	4
GR "Golden Road" Creek	Average	14.6	6.87	< 41.1	< 5.05	2.38	15.3		< 0.20	< 0.09	< 1.69	< 136	< 0.20	0.941	16.1	< 1.03	< 0.33	< 0.81	4.87
	Maximum	40.0	7.7	57.6	6.30	3.40	16.1	na	na	na	3.51	250	na	1.20	58.3	1.16	0.66	0.48	6.32
	Count	8	7	7	6	7	5		4	7	7	7	3	7	7	7	7	4	7
	Count < DL	0	0	1	5	0	0		4	7	1	1	3	0	0	1	2	1	0
Herman's Gulch East [2]	Average	36.3	7.12	< 78.0	< 7.33	25.3				< 0.82	2.96	123		3.49	33.3	5.67	< .64		41.1
	Maximum	100	7.24	108	10.0	35.0	na	na	na	0.27	4.70	191	na	4.30	40.7	7.44	0.56	na	58.5
	Count	3	3	3	3	3				3	3	3		3	3	3	3		3
	Count < DL	0	0	1	1	0				2	0	0		0	0	0	1		0
Herman's Gulch South [2]	Average	0.677	6.12	525	18.0	278		386		14.1	70.4	1,173		29.5	1,610	53.5	16.7		2,910
	Maximum	1.14	6.53	682	29.0	292	na	na	na	26.8	142	1,250	na	38.9	2,450	82.5	38.5	na	4,960
	Count	3	4	3	3	3		1		3	3	3		3	3	3	3		3
	Count < DL	0	0	0	0	0		0		0	0	0		0	0	0	0		0

Table 3.5-3. Summary of Surface Water Quality Monitoring Stations.

Site Location	Statistic	Flow (gpm)	pH (s.u.)	TDS (mg/L)	TSS (mg/L)	SO4 (mg/L)	Hard-ness (mg/L)	Al (µg/L)	Ag (mg/L)	Cd (µg/L)	Cu (µg/L)	Fe (µg/L)	Hg (µg/L)	Mg (mg/L)	Mn (µg/L)	Ni (µg/L)	Pb (µg/L)	Se (µg/L)	Zn (µg/L)
Proffett Creek	Average	5.64	7.04	219	< 3.90	89.9	179	15.0	< 0.30	< 0.42	< 0.87	366	< 0.0002	8.51	31.8	2.26	< 0.27	< 1.79	< 6.44
	Maximum	30.0	7.63	335	na	170	236	na	na	0.09	2.60	1,400	na	14.0	147	4.42	0.44	3.16	19.3
	Count	9	11	11	11	11	6	1	6	11	11	11	6	11	11	11	11	6	11
	Count < DL	0	0	0	11	0	0	0	6	10	3	0	6	0	0	0	4	4	1
Tributary - Lower, above Zinc Creek	Average	423	6.67	< 64.7	< 14.9	< 17.6	45.8	< 277	< 8.98	< 5.73	< 9.14	< 682	< 0.70	< 2.09	< 101	< 10.3	< 11.7	< 4.88	< 31.5
	Maximum	2,985	8.00	126	100	52.0	266	700	31.0	195	55.0	6,200	0.70	9.90	620	30.0	64.0	1.5	550
	Count	27	57	43	43	101	37	60	101	108	108	105	78	70	103	80	107	101	107
	Count < DL	0	0	2	8	4	0	14	87	81	52	3	55	2	1	33	74	87	5
Tributary - Upper	Average	3.88	7.03	97.3	< 12.4	31.6	89.0	52.0	< 0.05	< 0.32	2.31	< 104	< 0.03	3.87	23.1	1.59	< 0.85	< 0.10	26.8
	Maximum	10.0	7.27	134	40.0	48.9	na	na	na	0.14	6.24	200	na	5.00	50.7	2.19	3.02	na	34.0
	Count	4	5	6	6	6	1	1	1	6	6	6	1	6	6	6	6	1	6
	Count < DL	0	0	0	4	0	0	0	1	5	0	2	1	0	0	0	1	1	0
Tributary Creek - headwaters at Blue Line	Average	12.4	7.07	164	< 7.16	79.7	119	13.0	< 0.08	< 0.383	1.88	< 683	< 0.115	7.32	120	3.00	< 0.57	< 0.30	32.9
	Maximum	30.0	7.41	214	19.0	169	123	na	na	0.06	6.70	4,090	na	9.75	643	4.32	1.25	na	63.0
	Count	5	7	8	8	8	2	1	2	8	8	8	2	8	8	8	8	2	8
	Count < DL	0	0	0	6	0	0	0	2	7	0	1	2	0	0	0	2	2	0

Notes:
Noted Excursions above WQS for hardness based metals are based on the average hardness for each stream or drainage.
1 Assume 400 mg/L for Total Hardness for calculating Hardness Dependent Metals Criteria.
2 Assume 100 mg/L for Total Hardness for calculating Hardness Dependent Metals Criteria.

Exceeds Dissolved Chronic Criteria

Exceeds Dissolved Acute Criteria

The water quality in the Further Creek, Further Seep, and Duck Blind Drain is generally of lower quality than that of Greens Creek, Tributary Creek, and Cannery Creek. In general these drainages and seeps have elevated sulfate, lower pH, and elevated dissolved zinc as well as some other metals; but are higher in hardness. As a result of these data, an action plan was designed by the operator in 2001 in consultation with the Forest Service and other agencies to conduct a rigorous study of surface water, seeps, and groundwater in the areas near the TDF. As a part of this action plan, an annual report that documents sampling and water quality trend analysis is submitted annually to ADEC and the Forest Service (HGCMC 2009). The action plan sets water quality triggers for these drainage features that require the proponent to notify ADEC and identify mitigation measures if the trigger is exceeded. Results from this action plan has shown that the lower pH and elevated sulfate and metals in these drainage features were not caused by contact with placed tailings but rather were from other pyritic sources such as waste rock or production rock that were outside the slurry walls of the TDF (EDE 2002a and KGCMC 2003).

The elevated levels in Further Seep, including Herman's Gulch was found to be residual effects from an old access road constructed in 1988 that contained pyritic rock. The road was located along the perimeter of the West Buttress and removed during the slurry wall construction in 1996. As a result, the water quality in Further Seep has improved but remains slightly acidic (HGCM 2009). This seep will continue to be monitored under the action plan. Over time it is expected to become less acidic and show decreasing levels of sulfate (HGCM 2009).

Elevated metals levels in the North Fork of Further Creek were reported to be caused by a thin veneer of tailings residue at the toe of the West Buttress that accumulated from the removal of the temporary tailings cover in 1999, and from residual tailings found in the Northwest Diversion Ditch. The Kennecott Greens Creek Mining Company (KGCMC) removed these tailings sources in 2002 which resulted in improved water quality. Elevation of metals was noted in Further Creek as a result of disturbances during the 2007 and 2008 construction seasons. Subsequent monitoring has indicated that Further Creek is returning to pre-construction conditions (HGCMC 2009a).

Slightly elevated metal concentrations in Duck Blind Drain were attributed to pyritic materials used in an access road and trench construction materials that were used for the permitted discharge pipeline. Water quality in this drain has improved since 2008 and continues to be monitored.

3.5.2.1 Wastewater Management

Freshwater intake diversions are located at Greens Creek near the mine portal and at Cannery Creek near the Hawk Inlet camp, shipping dock, and office facilities. These water sources provide water for milling operations, domestic use, equipment wash-down, underground mining activities, and fire suppression.

Non-contact surface runoff from native areas is diverted from contacting disturbance areas or the TDF using upslope ditches. Depending on the location, these ditches direct the runoff to either Cannery Creek or Tributary Creek. The diversion ditches are designed to convey the flow that would occur from the 25-year, 24-hour precipitation event.

Mining activities produce a variety of wastewaters. Wastewaters consist of spent domestic use water (grey water), sanitary wastewater, process water (water used in processing ore), equipment wash-down water, and contact waters, which consist of surface water or groundwater originating within or passing through mining disturbance or the TDF. Contact water includes precipitation and runoff that contacts rock quarries with the potential to develop ARD. Monitoring of these waters is addressed via ambient groundwater monitoring as specified by the FWMP.

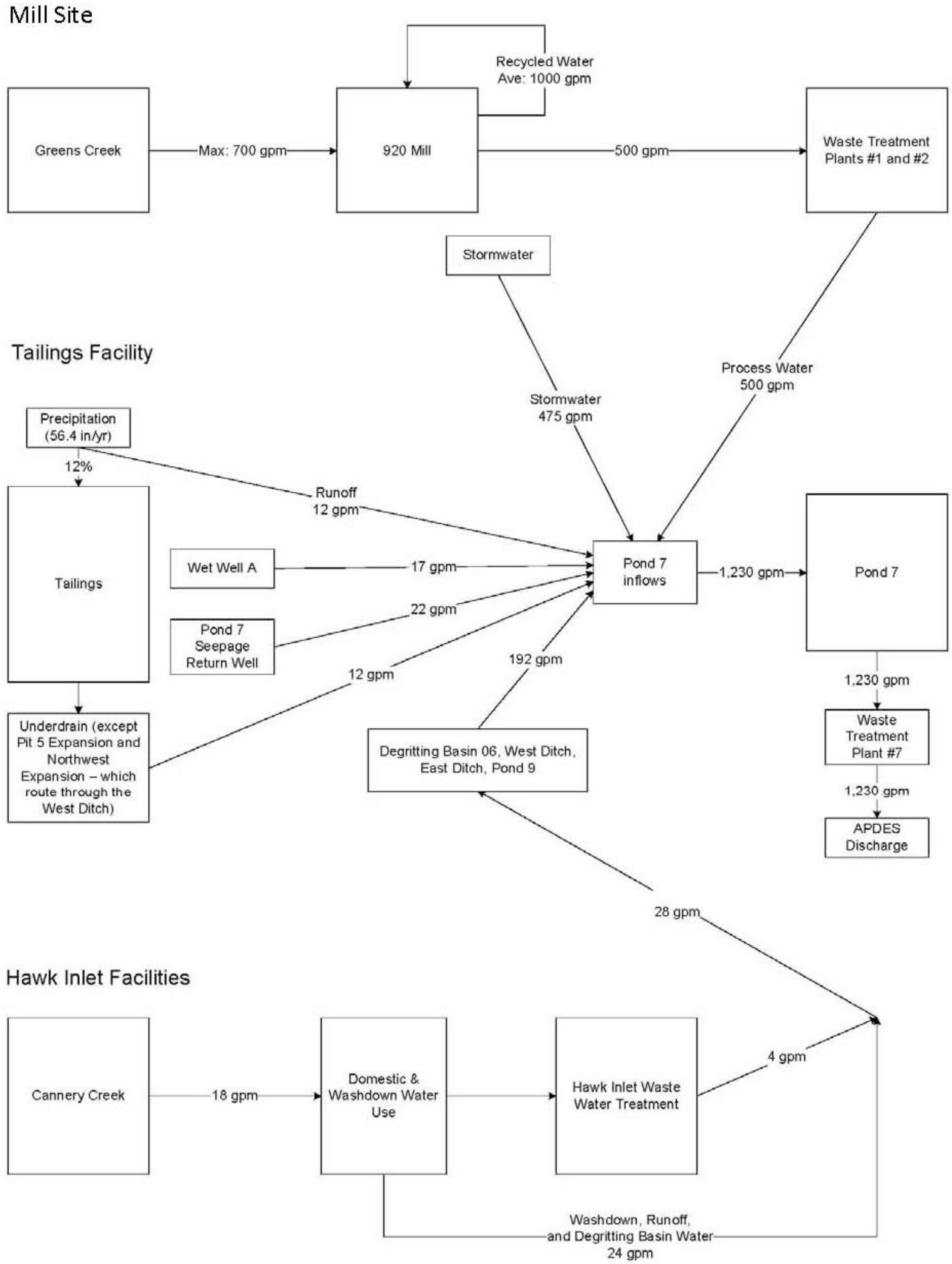
The four primary wastewater management areas at the site are the Hawk Inlet camp/load-out facilities area, the waste rock storage, mine and mill area, (Pond C, Pond D, Area 23, and Area 920), and the tailings facility area, consisting of the TDF, water containment and storage, and the Pond 7 wastewater treatment plant (WWTP). The primary wastewater containment and treatment facilities are located in the southwest corner of the TDF. These facilities consist of Pond 7 and the Pond 7 WWTP. There are two sewage treatment plants located at the site, one at the Hawk Inlet facilities, and one at the mine and mill area. Wastewater discharges, including treated sewage effluent that originates from the Hawk Inlet facilities and the mine and mill area report to Pond 7 and are treated at the Pond 7 WWTP. The WWTP reduces the levels of metals in the wastewater by precipitation with calcium carbonate. Sewage sludge is co-disposed in the TDF. A detailed description of these water management facilities is provided by EDE (2010).

Collected wastewaters are treated at the Pond 7 WWTP to meet effluent limits identified in an Alaska Pollutant Discharge Elimination System (APDES) permit prior to discharge through a diffuser outfall located in Hawk Inlet. The current APDES permit restricts the maximum allowable daily discharge to 4.6 million gallons per day (mgd) [3,190 gpm] and a monthly average discharge of 3.0 mgd (2,080 gpm). The permit limits assure compliance with all Alaska marine WQS. The permit also allows ten non-contact storm water discharge outfalls in Greens Creek, Zinc Creek, and Hawk Inlet. Figure 3.5-3 depicts a flow diagram of the mine water balance for current baseline conditions (EDE 2010).

Surface contact water treated at the Pond 7 WWTP is primarily runoff generated from the TDF or from mine facility areas. Groundwater contact water is a combination of infiltration through the TDF (within containment boundaries) to the underdrain collection system and native groundwater. The majority of native groundwater at the site is intercepted or routed around the TDF by perimeter up-gradient groundwater diversions and barriers. This water does not require containment or treatment.

3.5.2.2 Tailings Contact Water Management

Contact surface runoff is captured via a series of perimeter toe ditches around the TDF. Four primary ditch segments make up the toe ditch network and are designated according to their location around the base of the TDF. The ditches are all designed to convey the runoff that would occur from the 25-year, 24-hour storm event. All runoff water collected by the ditches reports to Pond 7 and is treated by the Pond 7 WWTP.



Source: EDE 2010.

Note: Flow values in the figure are based on average historical flows.

Figure 3.5-3. Water Balance Model – Existing.

Tailings contact groundwater is captured via an underdrain network beneath the TDF. The underdrain network is composed of a combination of French drains, finger drains, high-density polyethylene liner placements, and wet wells. Different phases of the tailings placement expansion have different underdrain configurations based on the order of expansion and the underlying native materials. The wet wells collect water from the underdrain system as collection sumps that direct the water to Pond 7 for surge storage and redistribution for treatment. The TDF currently has three wet wells within the underdrain network. Underdrain discharges are directed to the toe ditches surrounding the tailings pile or directly to Pond 7, depending on their location under the TDF.

3.5.2.3 Hawk Inlet

Hawk Inlet is a marine inlet formed during the late Holocene. The inlet extends seven miles north from Chatham Strait to a tidal mudflat estuary about 0.6 miles in diameter. The narrow channel connecting the Inlet to Chatham Strait, located between the top of the Greens Creek delta and the western shore of Hawk Inlet, has a minimum low tide depth of 35 feet. The mid-channel depth ranges from 35 feet to 250 feet. The Inlet has regular, twice-daily tides, with a maximum tidal variation of 25 feet. On the flood tide, the surface 35-foot layer contains the bulk of the water transport entering the Inlet and is then flushed out on the ebb tide. Flushing describes the rate and extent to which a body of water is replenished by tidal or other currents. Flushing rates are also indicative of the length of time that mining effluent may remain in a water body and become incorporated into the physical and biological ecosystem through ingestion, adsorption, or other means. In 1981, dispersion dye testing in Hawk Inlet determined that over each tidal cycle, an average of 13 billion gallons of water is flushed from the Inlet. At that rate, it is estimated that the Inlet will completely flush at least once every five tidal cycles. Based on the mine output up through 1995, the input of effluent from the mining operations over this flushing period represents approximately 0.009 percent of the total flushing volume (Ridgeway 2003).

Prior to development of the Greens Creek Mine, baseline studies were conducted to document marine life and to characterize existing levels of heavy metals in sediments and marine biota in Hawk Inlet. Currently the APDES permit requires monitoring for water quality, sediment quality, and bio-assays of mussels and worms. The primary objective of the monitoring program is to document the water quality, sediment quality, and metals levels in marine organisms that could be potentially impacted by mining operations. Sea water is sampled quarterly at three locations in Hawk Inlet, and sediment and invertebrate samples are taken at several locations each year in the spring and fall. Figure 3.5-4 shows the location of the APDES outfall and water quality monitoring stations in Hawk Inlet. Table 3.5-4 shows Alaska marine WQS for selected parameters and Table 3.5-5 shows average marine water quality data for selected metals for 2005 through 2009 (HGCMC 2009). The permit requires reporting of any identified impacts, reporting of incidents or spills and descriptions of corrective actions taken, if any were required.

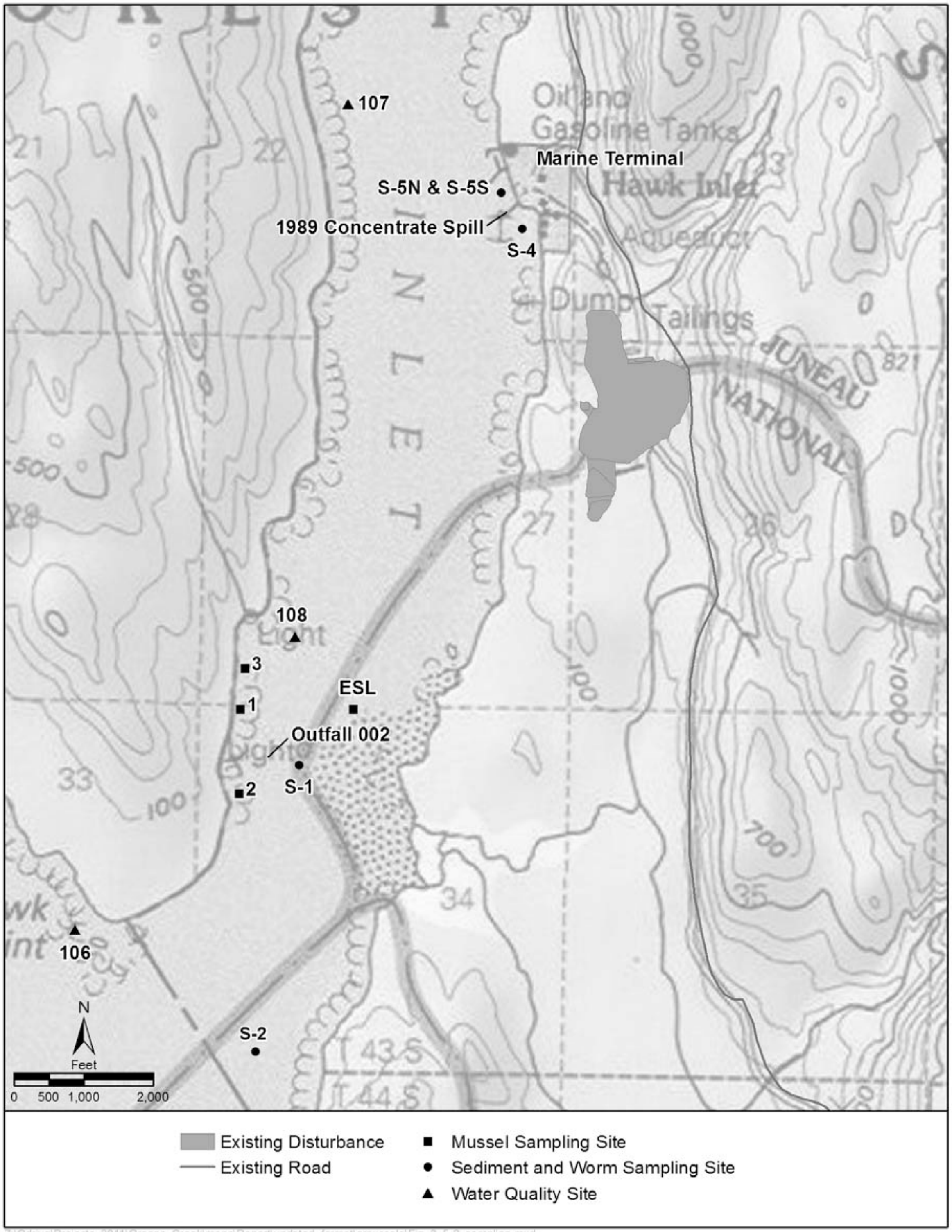


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Figure 3.5-4. Marine Water, Mussel, and Sediment Sampling Sites.

Table 3.5-4. Alaska Marine Water Quality Standards (Adjusted to Total Values).

Parameter	Units	WQS
Total Cadmium	µg/L	8.85
Total Copper	µg/L	3.73
Total Lead	µg/L	8.47
Total Manganese [a]	µg/L	100
Total Mercury	µg/L	1.1
Total Zinc	µg/L	86
pH	s.u.	6.5–8.5

Notes:

s.u. = standard pH units.

a. WQS for manganese is based on the human health consumption standard of aquatic organisms.

Table 3.5-5. Average Marine Water Quality in Hawk Inlet for 2005–2009.

Site	Total Cadmium (µg/L)	Total Copper (µg/L)	Total Lead (µg/L)	Total Mercury (µg/L)	Total Zinc (µg/L)
106 Background Location	0.068	0.42	0.074	0.00056	0.58
107 Near Ore Loading Dock	0.074	0.55	0.13	0.00064	1.08
108 Near Diffuser Outfall	0.070	0.44	0.091	0.00063	0.86

3.5.3 Surface Water – Environmental Consequences

3.5.3.1 Effects Common to All Alternatives

Fugitive Dust

Each alternative has the potential for continued or increased fugitive dust emissions due to wind erosion of the TDF and truck hauling on unpaved roads. Emissions generated by wind erosion are dependent upon the frequency and size of disturbances of the erodible surface; each time the surface is disturbed, fresh surface material is exposed to wind and climatic conditions (e.g., wind, precipitation). The extended life of the mine would increase the amount of fugitive dust from the TDF. Fugitive dust could adversely affect water quality by either direct deposition on streams or accumulated dust on vegetation and soils being carried into stream in runoff. Best management practices (BMPs) are currently employed to minimize fugitive dust from blowing off the TDF. Additional BMPs may be added if monitoring indicates this is necessary. BMPs to reduce fugitive dust are included in Section 3.2.3. HGCMC would continue to implement its FWMP to identify effects to water quality, including effects potentially associated with fugitive dust. After successful reclamation fugitive dust would no longer occur.

Freshwater Sources

Potential indirect impacts to fresh and drinking water sources in Greens Creek and Cannery Creek, respectively, could occur due to continued operation of mine operations. Indirect impacts to water quality could occur from fugitive dust as well as from other non-specific operations. These potential impacts are monitored through the FWMP and trend analyses are conducted annually.

APDES Discharge

Wastewater that comes into contact with the tailings (TDF runoff and seepage) and other industrial wastewater is treated in a WWTP and discharged into Hawk Inlet under the terms and conditions of the APDES permit. The treated effluent is discharged through a diffuser outfall near monitoring location 108. All discharges are required to meet the effluent limits established in the APDES permit. The current permit includes effluent limits for flow, cadmium, copper, lead, mercury, zinc, total suspended solids, and pH. These effluent limits are based on a mixing zone of 79.4 parts receiving water to 1 part effluent. The permit also requires monitoring of cyanide, temperature, biological oxygen demand, and fecal coliform bacteria. The effluent limits established by the APDES permit are provided in Table 3.5-6.

Table 3.5-6. APDES Effluent Limits Established for the Hawk Inlet APDES Outfall.

Parameter	Units	Effluent Limit	
		Daily Maximum	Monthly Average
Flow	mgd	4.6	3
Total Cadmium	µg/L	100	50
Total Copper	µg/L	300	150
Total Lead	µg/L	600	300
Total Mercury	µg/L	2	1
Total Zinc	µg/L	1,000	500
Total Suspended Solids	mg/L	30	20
pH	s.u.	6.0–9.0	

Notes:
mgd = million gallons per day
µg/L = micrograms per liter or parts per billion
mg/L = milligrams per liter or parts per million
s.u. = standard pH units

Under all alternatives, tailings contact water, or any other industrial contact water, would be captured, treated, and discharged under the APDES discharge permit. The APDES permit limit is scheduled to be reissued on a five-year basis. When a permit is reissued, all water quality monitoring data and effluent quality data are reviewed, as is the need for a mixing zone. Changes are made as necessary under provisions established by the Clean Water Act (CWA) and the State of Alaska. An APDES discharge permit would be required as long as the effluent does not meet Alaska WQS. As discussed in the following section, drainage from the TDF is expected to be of poor quality and exceed Alaska WQS for at least the next 100 years and likely much longer. Therefore, active water treatment and an APDES permit to discharge will continue to be needed. Each time the permit is reissued, surface water and effluent monitoring data is reviewed to determine if permit conditions need to be revised to be protective of Alaska WQS. In addition, there could be changes to Alaska WQS in the future. For example, post-closure as TDF discharge volumes decrease, so might the size of the mixing zone, outfall location, etc. This EIS analysis can predict that the TDF discharge will exceed Alaska WQS and require a permit, but it cannot predict the conditions of a permit so far in the future.

Water Quality of Tailings Effluent

Since preparation of the 2003 EIS for the Greens Creek Mine (USFS 2003), observations of water quality, water balance, and flow characteristics in the TDF have improved the understanding of the relationships among geochemistry, water quality, and fate and transport in the Greens Creek TDF. As a result, the operator has created a new conceptual and numerical model, which is consistent with these observations and data (Condon 2011). This initial model was created with the intent of continuously updating it and recalibrating it using observed site data obtained in future years. In this manner predictions of effluent quality and TDF geochemical behavior can be refined and improved as time progresses. The model estimates the weathering of placed tailings, geochemistry, and effluent quality that could be expected over time. A detailed description of the predicted geochemistry of placed tailings and the conceptual and predictive models is provided in detail in Section 3.4, Geochemistry.

The conceptual and predictive models suggest three phases (or time periods) that affect the geochemistry and quality of wastewater from placed tailings:

- An operational period where the tailings are being actively placed;
- A transitional period after closure where oxidation products such as sulfate, calcium, and magnesium, as well as trace metals, such as, cadmium, nickel, manganese, and zinc are flushed through the TDF; and
- A steady-state period.

During the operational period, some oxidation occurs on the surface of the placed tailings because it is temporarily exposed to air. The oxidation of pyrite causes several products to form such as calcium sulfate (gypsum) and some metals to become elevated, such as cadmium, nickel, manganese, and zinc. Acid is also produced, but is neutralized by carbonates that are also present. After a permanent cover is placed on the TDF at closure, these oxidation products begin flushing through the system during the transitional period. Depending on the exact thickness of tailings, the observed hydrologic monitoring data in the existing TDF indicates that it would take between 60 and 140 years for a single pore volume to be replaced by infiltration and drainage. Condon (2011) estimated that the transitional phase would last 350 years, assuming an average tailings thickness of 150 feet. After the oxidation products formed during the operational phase are flushed from the system, a steady-state period will exist with very slow levels of pyrite oxidation, neutralization, and drainage of effluent (Condon 2011). Pyrite oxidation is slow and limited where it occurs within the TDF because the ingress of oxygen is also limited. These processes are discussed in more detail in Section 3.4.

Contact water in the existing TDF comes from three sources, surface runoff, seepage through the TDF, and upwelling groundwater in areas of the TDF that overlay glacial marine deposits. The original permitting of the TDF did not require a liner in these areas.

Upwelling groundwater does not directly contact the tailings; however, it mixes with tailings seepage in the underdrain system prior to collection in the wet wells. The management of contact waters was discussed in Section 3.5.2.2.

Tables 3.5-7 through 3.5-10 show predicted water quality for selected parameters of concern for water reporting at the TDF boundary and at the wet wells. Data are provided for current or initial operation, immediately after closure, and one hundred years following closure (Condon 2011). The applicable Alaska fresh WQS and Alaska marine WQS are also shown for comparative purposes. The predicted concentration at the "facility boundary" represents a relative mixture of runoff water and water collected from the underdrains in the wet wells. During operation and after closure, the volume of runoff water is much higher than the volume of seepage water. Data for the wet wells show predicted water quality in the underdrains only.

Table 3.5-7. Average Predicted Water Quality for Tailings Wastewaters for Alternative A.

Parameter [a]		Alaska Chronic Fresh WQS [b]	Alaska Chronic Marine WQS	Current Condition 2011	2016 Condition at Closure		50 Years After Closure (2064)		100 Years After Closure (2164)	
				Facility Boundary	Wet Wells/ Drains	Facility Boundary	Wet Wells/ Drains	Facility Boundary	Wet Wells/ Drains	Facility Boundary
Cadmium	µg/l	0.12	8.8	24.6	0.2	0.1	0.1	0.1	0.1	0.1
Copper	µg/l	3.8	3.1	9.0	3.0	2.0	3.0	2.0	3.0	2.0
Iron	µg/l	1,000	–	2,500	5,400	3,300	6,100	3,500	2,900	2,300
Lead	µg/l	0.84	8.1	52.2	1.1	0.7	1.2	0.7	1.2	0.7
Manganese [c]	µg/l	50	100	2,400	900	800	800	800	800	800
Mercury	µg/l	0.012	1.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nickel	µg/l	22	8	140	10	10	10	10	10	10
Selenium	µg/l	5	71	3.8	2.8	1.4	3.1	1.5	3.0	1.4
Zinc	µg/l	50	81	8,180	570	220	470	180	470	180
Sulfate [d]	mg/L	250	–	1,455	772	298	810	312	810	312
Total dissolved solids	mg/l	500	–	2,164	1,256	517	1,294	531	1,241	511
pH	s.u.	6.5–8.5	6.5–8.5	7.5	7.3	6.4	7.2	6.4	7.2	6.4

Notes:

The water quality at the wet wells represent drainage collected in the underdrains only

The water quality at the Facility Boundary is a relative mixture of drainage from the underdrains and surface water runoff.

a. All metals are expressed as totals.
b. Based on the long-term average hardness of 37 mg/L as $CaCO_3$. This value is consistent with that used to develop the FWMP.
c. Fresh WQS for manganese is based on the human health consumption standard for water + fish; the marine WQS for manganese is based on the human health consumption standard for consumption of aquatic organisms only.
d. Fresh WQS for sulfate and total dissolved solids are based on the drinking water standard.

Table 3.5-8. Average Predicted Water Quality for Tailings Wastewaters for Alternative B.

Parameter [a]		Alaska Chronic Fresh WQS [b]	Alaska Chronic Marine WQS	Current Condition 2011	Condition at Closure 2064		100 Years After Closure 2164	
				Facility Boundary	Wet Wells/ Drains	Facility Boundary	Wet Wells/ Drains	Facility Boundary
Cadmium	µg/l	0.14	8.8	24.6	0.2	0.1	0.1	0.1
Copper	µg/l	4.6	3.1	10	3.0	2.0	3.0	2.0
Iron	µg/l	1,000	-	2,500	3,800	2,600	2,900	2,300
Lead	µg/l	1.1	8.1	52.2	1.0	0.6	1.1	0.7
Manganese [c]	µg/l	50	100	2,400	1,000	900	900	800
Mercury	µg/l	0.012	1.1	0.01	0.01	0.01	0.01	0.01
Nickel	µg/l	27	8	140	10	10	10	10
Selenium	µg/l	5	71	3.8	2.7	1.3	2.9	1.4
Zinc	µg/l	61	81	8,180	550	210	450	170
Sulfate [d]	mg/L	250	-	1,455	785	303	824	317
Total dissolved solids	mg/l	500	-	2,164	1,239	510	1,251	515
pH	s.u.	6.5 – 8.5	6.5 – 8.5	7.5	7.2	6.4	7.1	6.4

Notes:

The water quality at the wet wells represents drainage collected in the underdrains only.

The water quality at the Facility Boundary is a relative mixture of drainage from the underdrains and surface runoff.

a. All metals are expressed as totals

b. Based on the long-term average hardness of 37 mg/L as $CaCO_3$. This value is consistent with that used to develop the FWMP.

c. Fresh WQS for manganese is based on the human health consumption standard for water + fish; the marine WQS for manganese is based on the human health consumption standard for consumption of aquatic organisms only.

d. Fresh WQS for sulfate and total dissolved solids are based on the drinking water standard.

Table 3.5-9. Average Predicted Water Quality for Tailings Wastewaters for Alternative C – North Stack.

Parameter [a]		Alaska Chronic Fresh WQS [b]	Alaska Chronic Marine WQS	Initial Condition 2024	Condition At Closure 2064		100 Years After Closure 2164	
				Facility Boundary	Wet Wells/ Drains	Facility Boundary	Wet Wells/ Drains	Facility Boundary
Cadmium	µg/l	0.14	8.8	24.6	0.2	0.1	0.1	0.1
Copper	µg/l	4.6	3.1	9	3.0	2.0	3.0	2.0
Iron	µg/l	1,000	-	700	2,100	2,000	2,700	2,200
Lead	µg/l	1.1	8.1	52.2	1.1	0.7	1.2	0.7
Manganese [c]	µg/l	50	100	2,500	900	800	800	800
Mercury	µg/l	0.012	1.1	0.01	0.01	0.01	0.01	0.01
Nickel	µg/l	27	8	140	10	10	10	10
Selenium	µg/l	5	71	3.9	2.9	1.4	3.2	1.5
Zinc	µg/l	61	81	8,160	540	210	450	170
Sulfate [d]	mg/L	250	-	1,482	799	308	837	322
Total dissolved solids	mg/l	500	-	2,163	1,236	509	1,274	523
pH	s.u.	6.5 – 8.5	6.5 – 8.5	7.5	7.3	6.4	7.3	6.4

Notes:

The water quality at the wet wells represents drainage collected in the underdrains only.

The water quality at the Facility Boundary is a relative mixture of drainage from the underdrains and surface runoff.

a. All metals are expressed as totals

b. Based on the long-term average hardness of 37 mg/L as $CaCO_3$. This value is consistent with that used to develop the FWMP.

c. Fresh WQS for manganese is based on the human health consumption standard for water + fish; the marine WQS for manganese is based on the human health consumption standard for consumption of aquatic organisms only.

d. Fresh WQS for sulfate and total dissolved solids are based on the drinking water standard.

Table 3.5-10. Average Predicted Water Quality for Tailings Wastewaters for Alternative D – North Stack.

Parameter [a]		Alaska Chronic Fresh WQS [b]	Alaska Chronic Marine WQS	Initial Condition 2034	Condition at Closure 2064		100 Years After Closure 2164	
				Facility Boundary	Wet Wells/ Drains	Condition At Closure: Facility Boundary	Wet Wells/ Drains	Facility Boundary
Cadmium	µg/l	0.14	8.8	24.6	0.2	0.1	0.1	0.1
Copper	µg/l	4.6	3.1	9	3.0	2.0	3.0	2.0
Iron	µg/l	1,000	-	700	2,000	1,900	2,600	2,200
Lead	µg/l	1.1	8.1	52.2	1.0	0.6	1.1	0.7
Manganese [c]	µg/l	50	100	2,500	1,100	900	1,000	900
Mercury	µg/l	0.012	1.1	0.01	0.01	0.01	0.01	0.01
Nickel	µg/l	27	8	140	10	10	10	10
Selenium	µg/l	5	71	3.9	3.1	1.5	3.4	1.6
Zinc	µg/l	61	81	8,160	520	200	420	160
Sulfate [d]	mg/L	250	-	1,482	832	320	870	335
Total dissolved solids	mg/l	500	-	2,163	1,270	522	1,308	536
pH	s.u.	6.5 – 8.5	6.5 – 8.5	7.5	7.3	6.4	7.2	6.4

Notes:

The water quality at the wet wells represents drainage collected in the underdrains only.

The water quality at the Facility Boundary is a relative mixture of drainage from the underdrains and surface runoff.

a. All metals are expressed as totals
b. Based on the long-term average hardness of 37 mg/L as $CaCO_3$. This value is consistent with that used to develop the FWMP.
c. Fresh WQS for manganese is based on the human health consumption standard for water + fish; the marine WQS for manganese is based on the human health consumption standard for consumption of aquatic organisms only.
d. Fresh WQS for sulfate and total dissolved solids are based on the drinking water standard.

A comparison of these data show there would only be small differences in water quality of the TDF runoff and drainage between all alternatives. For example, predicted zinc concentration at the facility boundary immediately after reclamation and closure ranges between 200 micrograms per liter (µg/L) for the TDF in Alternative D to 220 µg/L in Alternative B. Similarly, predicted sulfate concentration in the wet wells ranges between 810 milligrams per liter (mg/L) for Alternative B and 335 mg/L for the TDF in Alternative D, one hundred years after closure. Condon (2011) attributes these minor differences to build-out acreage, specific tailings depth, and the proportion of co-disposed waste-rock material in the alternatives. However, these differences do not result in an appreciable difference in predicted water quality effects between alternatives.

Further evaluation of these data show that water quality at the facility boundary and in the wet wells would drastically improve after reclamation and final closure. For example, the predicted concentration of zinc at the facility boundary for Alternative A lowers from 8,180 µg/L during operation to 180 µg/L after closure (Table 3.5-7). Similar large reductions in concentration can be noted for other parameters and across all alternatives.

This effect would be caused by placement of the final engineered cover. Runoff water mixing at the TDF boundary would no longer be in contact with tailings. Runoff would now be in contact with reclaimed forest soils and vegetation. The final engineered cover would also affect pH. The pH of the tailings contact water is relatively neutral (7.5 standard pH units [s.u.]). The natural pH of forest soils is acidic (6.4 s.u.), primarily caused by the decomposition of organic matter. Because runoff is the largest component of water at the facility boundary, the pH of the natural soils of the surface cover would dominate pH.

A comparison of the predicted water quality of the tailings wastewater at the TDF boundary and in the wet wells with the Alaska **fresh** WQS indicates that the Alaska fresh WQS would not be met for iron, manganese, zinc, sulfate, and total dissolved solids even several years after closure. It also indicates that the wastewater at the TDF boundary would not meet the Alaska **marine** WQS for manganese and zinc. These data indicate that water treatment would be required at least 100 years after closure of the TDF(s), perhaps in perpetuity. As discussed above, treatment and an APDES discharge permit will be required as long as the effluent does not meet Alaska WQS. If treatment is required after closure, the operator would separate the mixing of surface water runoff from the engineered cover and the seepage water discharging from the underdrains. Runoff from the surface cap would not be a regulated discharge if it is not allowed to comingle with the tailings contact waters in the underdrains. This would drastically reduce the volume of water requiring treatment and would allow clean runoff from the TDF to return to Tributary Creek, Cannery Creek, and other respective drainages in the Middle Hawk Inlet drainage or Further Creek.

3.5.3.2 Effects of Alternative A, No Action

Under Alternative A, the existing TDF would expand to its permitted footprint of 65.3 acres. The existing tailings contact water management and infrastructure would remain in place. Additional infrastructure would be required to divert non-contact surface runoff from undisturbed areas around the tailings facility. The series of toe drains used to collect and route surface runoff on the tailings facility would expand as necessary as the TDF expands. Additional liners, finger and blanket drains beneath the tailings and slurry walls constructed could also be required to divert groundwater around the TDF.

Since construction of the TDF (Figure 2.3-1), the headwaters of Tributary Creek have become small seeps and numerous small channels flowing through bog vegetation. Additionally, surface runoff from east of the TDF is captured and routed in diversions to Cannery Creek and Tributary Creek. The final build out under Alternative A with supporting infrastructure would reduce the total 409-acre watershed area for Tributary Creek an additional one percent over current conditions. The seeps and channels lying south of the TDF are fed from the shallow groundwater regime in the peat and sand substrate (Bosworth 2011). The series of slurry walls installed around the TDF essentially route clean groundwater back to Cannery Creek and Tributary Creek that would normally be stored as shallow groundwater in the bog wetland. As a result of the surface and groundwater diversions and only an additional one percent loss in drainage area, only minor impacts to both base and storm flows in Tributary Creek would be expected. However, because non-contact surface runoff would be routed directly in diversion channels, peak flow velocities could increase in the natural stream channel during large storm events. This could potentially cause erosion of channel substrates and impact channel geomorphology. These potential impacts would be mitigated by a Forest Service requirement to use a storm water detention structure or detention pond at the confluence of the diversions and the natural channels.

3.5.3.3 Effects of Alternative B, Proposed Action

Under Alternative B (Figure 2.3-2), surface runoff from the east side of the TDF will continue to be diverted around the TDF to Tributary Creek. Groundwater flow will also continue to be diverted to Tributary Creek by the slurry walls and drain curtains. The expansion of the TDF footprint under this alternative would reduce the 409-acre watershed by an additional 22 percent (Figure 3.5-5). While some minor impacts to the flow of Tributary Creek could be expected by the loss of drainage area, it is not anticipated that it would result in a 22 percent reduction of flow. This is because the primary area impacted by the expansion is principally wetland with intermittent braided channels. These types of wetlands principally act as storage during precipitation events. Additionally, most of the groundwater that previously fed the wetland would continue to be diverted back to Tributary Creek.

Under Alternative B, the existing TDF would expand from its current footprint. The existing site industrial water and tailings contact water management and infrastructure would remain in place. Additional infrastructure will be required to continue to divert non-contact surface runoff from undisturbed areas around the tailings facility. The series of toe drains used to collect and route surface runoff on the tailings facility would expand as necessary as the TDF expands. Additional liners, finger and blanket drains beneath the tailings and slurry walls constructed could also be required to divert groundwater around the TDF. Infrastructure to manage water would be more than that required for the Alternative A footprint.

Similar to Alternative A, diverting non-contact runoff could increase peak flow velocities in the natural stream channel during large storm events. This could potentially cause erosion of channel substrates and impact channel geomorphology. While it is anticipated that a storm water detention structure would mitigate the effects of the increased flow velocities, the Forest Service and ADEC may require HGCMC to conduct habitat and/or geomorphic surveys in Tributary Creek downstream of the TDF expansion area to detect unanticipated effects, if any. This program would be developed and incorporated into the General Plan of Operations (GPO) as it is updated to reflect the selected alternative.

The current treatment capacity of the Pond 7 WWTP to the outfall in Hawk Inlet is 3.1 mgd, although it is permitted to discharge a maximum daily discharge of 4.6 mgd. Under the full expansion of the TDF, the existing WWTP would be upgraded or a new WWTP would be constructed to accommodate the full 4.6 mgd. The additional treatment capacity is needed in order to accommodate the additional volume of tailings wastewater. To evaluate extreme storm events, EDE (2010) estimated that containment and treatment of two back-to-back 10-year, 24-hour precipitation events would require containment and a treatment capacity of 2.76 mgd over a 30-day period.

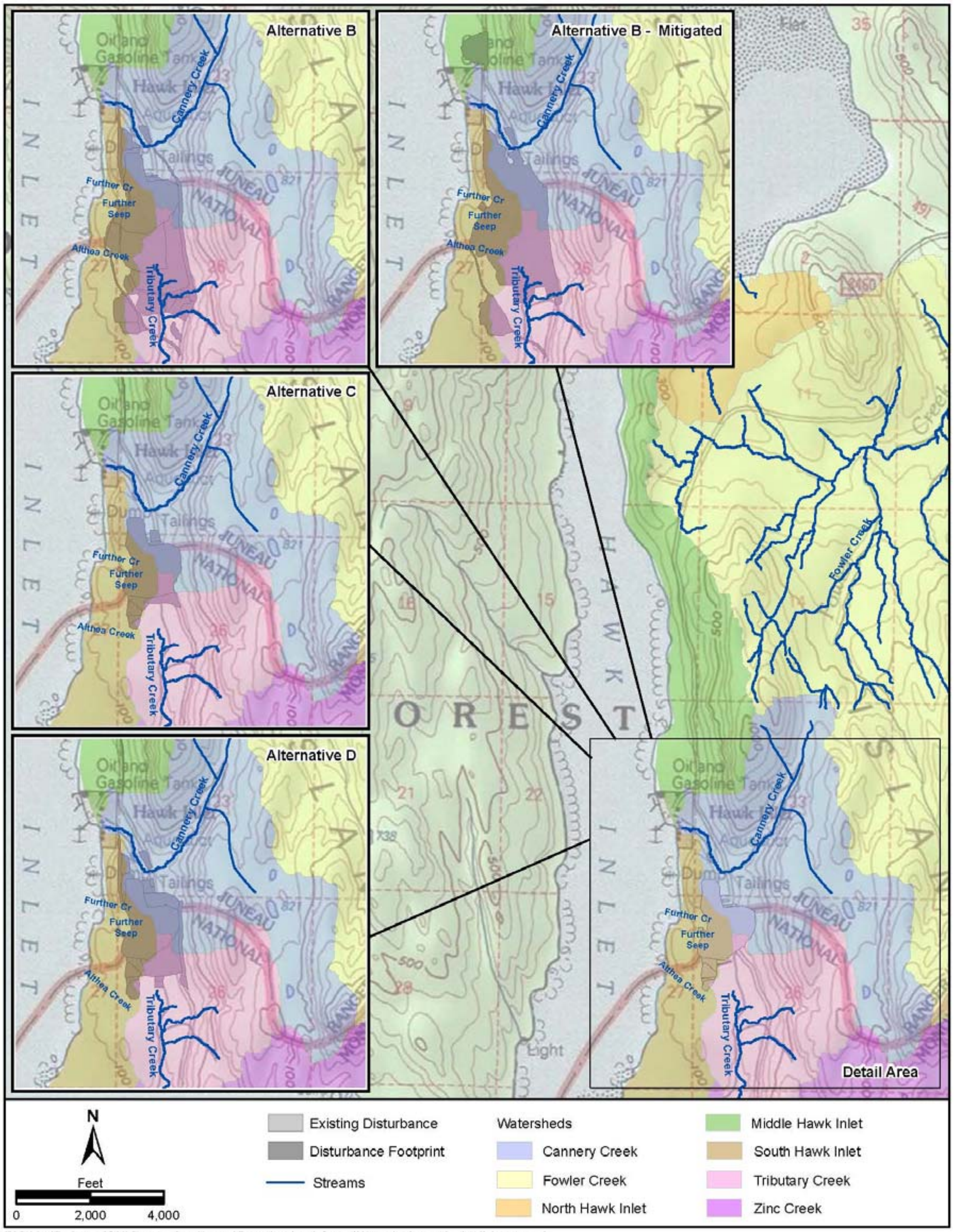


Figure 3.5-5. Impacts to Watersheds and Streams by Alternative (South).

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. Enlarging the quarry rather than developing a new one south of the existing TDF would reduce the footprint within the Monument. Mitigated Alternative B would reduce the acreage impact to the Tributary Creek watershed from 22 percent to 17 percent, when compared with HGCMC's proposed action, Alternative B (Figure 3.5-5). The slight difference in wetlands impacted may produce a very minor improvement in flow attenuation and groundwater discharge to Tributary Creek compared to Alternative B. The relocated reclamation material storage area may have a similar minor adverse effect on flow in the unnamed watershed in its new location.

Potential impacts to stream channel substrates and channel geomorphology would be the same as described for Alternative B. These potential impacts could be mitigated by using a storm water detention structure or detention pond at the confluence of the diversions and the natural channels. While it is anticipated that a storm water detention structure would mitigate the effects of the increased flow velocities, the Forest Service and ADEC may require HGCMC to conduct habitat and/or geomorphic surveys in Tributary Creek downstream of the TDF expansion area to detect unanticipated effects, if any. This program would be developed and incorporated into the GPO as it is updated to reflect the selected alternative.

3.5.3.4 Effects of Alternative C, New TDF Located Outside Monument

The additional expansion of the existing TDF footprint to the south site would reduce the Tributary Creek watershed by an additional 3 percent. Similar to Alternative B, some minor impacts to the flow of Tributary Creek could be expected by the loss of drainage area; however, it is not anticipated that it would result in a 3 percent reduction of flow. Most of the groundwater that previously fed the wetland is being diverted back to Tributary Creek.

Under Alternative C (see figures 2.3-3a, 2.3-3b, and 2.3-3c in Chapter 2), the existing TDF would be slightly larger than the currently permitted footprint. In addition to the expansion of the existing TDF, a new TDF would be constructed to the north of the Monument boundary (see Figure 2.3-3a in Chapter 2).

The expansion of the existing TDF under Alternative C would require construction of water management infrastructure similar to that described for alternatives A and B. At the new TDF, new runoff diversions would be required to divert non-contact surface water runoff from the TDF. New finger and blanket drains, and groundwater curtain and slurry walls would be required to divert groundwater flow around the TDF. Effluent seepage and runoff from the TDF would be collected and pumped to the WWTP for treatment. The amount of water management infrastructure would expand as the new TDF is expanded.

The total footprint of the two TDFs would be larger than the total TDF footprint of Alternative B. The increased requirement for the amount of water management infrastructure required under this alternative would be proportional to the increased acreage and the increased amount of total perimeter of the two facilities. Effects to the mine site water balance should be similar to those presented for Alternative B. However, a larger water treatment capacity could be required because of increased volume of runoff from the two TDFs.

An additional pond to contain surface runoff from the new TDF to the north would need to be designed and built. Additional pumps and a pipe system would be required to pump captured tailings contact water to the existing Pond 7 for treatment and discharge to the Hawk Inlet APDES outfall. Additional storm water controls could also be necessary to control runoff from roads and other required facilities. At closure, captured TDF effluent from the northern TDF would be pumped to the wastewater treatment plant located near the existing TDF.

The new TDF footprint would reduce a portion of the Fowler Creek watershed by approximately 2 percent. The Tributary Creek watershed would be reduced by an additional 2.8 percent and the Cannery Creek watershed by 3.5 percent. Only minor impacts to both the base flow and storm flows of Fowler Creek and the other drainages would be expected, because groundwater and non-contact surface water would also be routed around the new TDF down gradient to Fowler Creek (figures 3.5-5 and 3.5-6).

Potential impacts to stream channel substrates and channel geomorphology from non-contact diversions would be the same as described for alternatives A and B. While it is anticipated that a storm water detention structure would mitigate the effects of the increased flow velocities, the Forest Service and ADEC may require HGCMC to conduct habitat and/or geomorphic surveys in Tributary Creek downstream of the TDF expansion area to detect unanticipated effects, if any. This program would be developed and incorporated into the GPO as it is updated to reflect the selected alternative.

Establishing a new TDF would potentially allow fugitive dust to adversely affect water quality in a new watershed. BMPs would be employed to minimize fugitive dust from blowing off the tailings stack.

3.5.3.5 Effects of Alternative D, Modified Proposed Action

Under Alternative D, the existing TDF would be enlarged to a greater extent than under Alternative C but less than under Alternative B. In addition to the expansion of the existing TDF, a new TDF (see figures 2.3-3a, 2.3-3b, and 2.3-3c and figures 2.3-4a, 2.3-4b, and 2.3-4c in Chapter 2) would be constructed in the same location as under Alternative C.

Additional water management infrastructure at the expansion of the existing TDF would be similar to that described for alternatives A and B. At the new TDF, new runoff diversions would be required to divert non-contact surface water runoff from the facility. New finger and blanket drains, and groundwater curtain and slurry walls would be required to divert groundwater flow around the facility. The amount of water management infrastructure would expand as the TDF expanded. Effects to the mine site water balance would be similar to those presented for Alternative C.

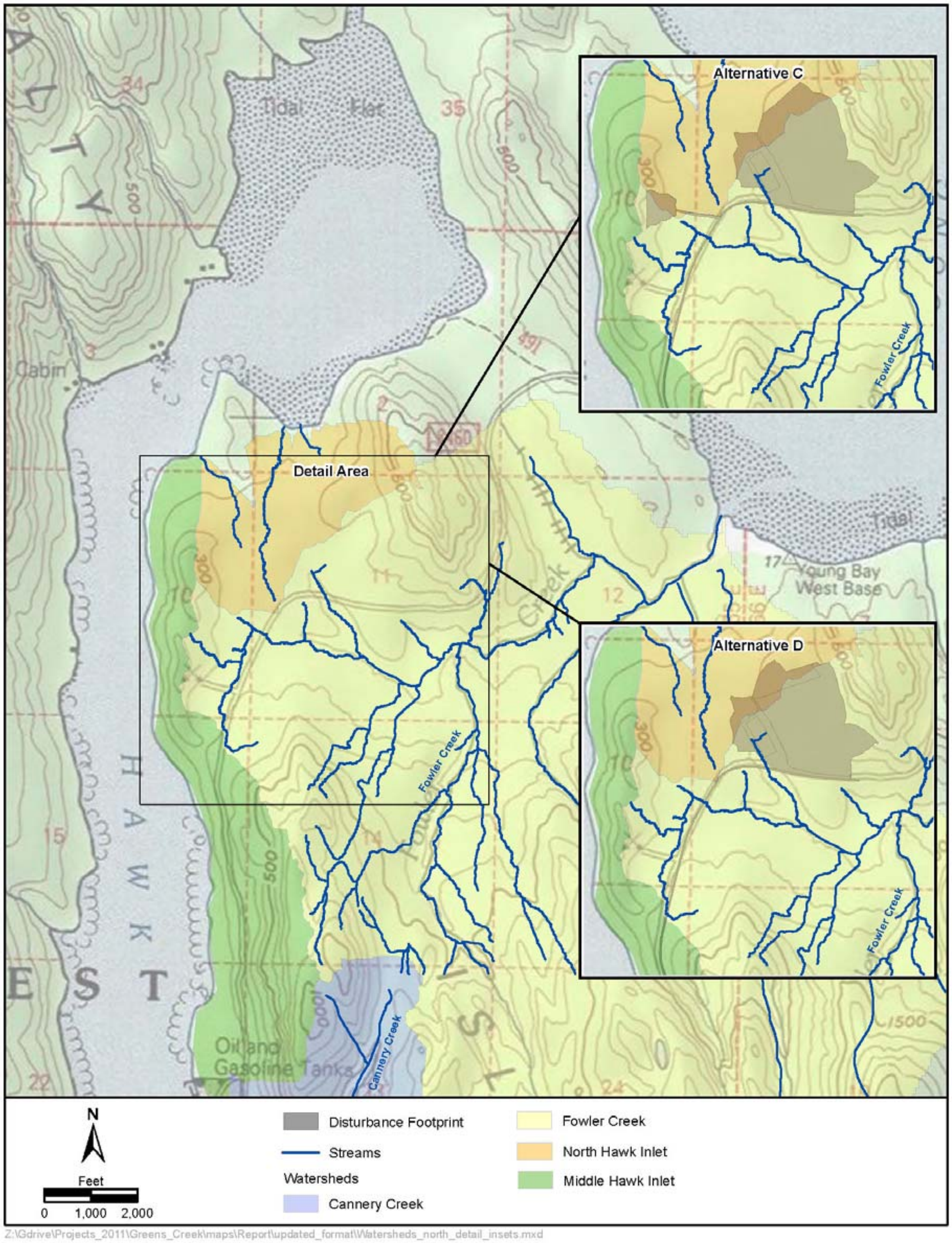


Figure 3.5-6. Impacts to Watersheds and Streams by Alternative (North).

The total footprint of the two TDFs would be larger than the total footprint of Alternative B and slightly larger than the footprint of Alternative C. The increased requirements for the amount of water management infrastructure required under this Alternative would be the same as that described for Alternative C.

The additional expansion of the current TDF footprint at the south site would reduce the 408 acre Tributary Creek watershed by an additional 4 percent. The impacts to the flows in Tributary Creek and to Fowler Creek would be similar to those described for Alternative C (figures 3.5-5 and 3.5-6).

Potential impacts to stream channel substrates and channel geomorphology from non-contact diversions would be the same as described for Alternative C. While it is anticipated that a storm water detention structure would mitigate the effects of the increased flow velocities, the Forest Service and ADEC may require HGCMC to conduct habitat and/or geomorphic surveys in Tributary Creek downstream of the TDF expansion area to detect unanticipated effects, if any. This program would be developed and incorporated into the GPO as it is updated to reflect the selected alternative. As with Alternative B, additional monitoring is being considered to detect unanticipated habitat and/or geomorphic effects.

Establishing a new TDF would potentially allow fugitive dust to adversely affect water quality in a new watershed. BMPs would be employed to minimize fugitive dust from blowing off the tailings stack.

3.5.4 Surface Water – Summary

Geochemical modeling conducted by HGCMC indicates that there is very little difference in the expected water quality of tailings seepage and runoff between alternatives. It also suggests that water treatment may be required for at least 100 years after closure, perhaps in perpetuity.

Some small changes to the flow regime would occur to base flows and storm flows in affected drainages (Tributary Creek under all alternatives; Fowler Creek under alternatives C and D) under all alternatives. However these changes would not be out of the realm of normal fluctuations and would not result in changes to stream geomorphology, sediment loads or fish habitat. Potential impacts to stream geomorphology from non-contact diversions would be mitigated using storm water detention structures or detention ponds.

The requirements for increased water management infrastructure and the complexity associated with maintaining those facilities to contain tailings contact water and manage industrial storm water would be highest for alternatives C and D. For alternatives C and D, captured TDF effluent from the northern facility may be required to be pumped to a central wastewater treatment facility.

3.6 Water Resources – Groundwater

Groundwater in the Greens Creek project area is found in several aquifers. These include: a shallow peat/sand aquifer underlain by a silt confining unit, a till aquifer, and a deeper bedrock aquifer. The following subsections describe these resources and the potential effects that may occur under the various alternatives.

3.6.1 Water Resources - Groundwater – Pre-mining Environment

There is no known regional aquifer system in the project area. However, the aquifer systems in this area are typical of those in the glaciated environment of southeast Alaska. Regionally, the irregular topography and geology make for numerous small-scale aquifers and groundwater flow systems. Groundwater can be found in peat, glacial, marine, fluvial sediments, and fractured bedrock aquifers. Where bedrock is exposed or near the land surface, the sedimentary aquifers and confining materials are absent. The existing tailings facility is located on a beach terrace formed by deposition of marine sediments.

3.6.1.1 Hydrogeologic Units

Hydrogeologic units present at the site occur in layers (or units) and are described below.

Peat: Peat is dense organic matter, often containing root masses and stumps. It was found widely throughout project area prior to development and remains a commonly occurring substrate outside disturbed areas, except on some of the steeper sloping areas. The peat varies in thickness, with a maximum thickness of approximately 20 feet. Peat deposits developed during recent geologic times on gently sloping areas.

Oxidized Sand: Sand occurs as a relatively thin layer across much of the project area directly beneath the peat. The sand is generally coarse and gravelly, with a moderate amount of silt and traces of marine shell fragments. The sand layer resulted from beach or alluvial deposits during periods of higher sea levels. In places, the sand is over 20 feet thick, but in most areas of the project area, it is about 2 to 10 feet thick.

Marine Sand with Silt and Clay: Directly beneath the sand layer that covers most of the site is a relatively continuous layer of marine sand with silt and clay. This layer reaches 50 feet in thickness in places, and it is sometimes inter-layered with the underlying glacio-marine unit. Analyses of this layer indicate that it is made up of approximately 40 percent silt, 30 percent clay, and 30 percent sand.

Glacio-Marine Unit (formerly considered till): This unit, thought to be primarily marine in origin, is characterized by high silt and clay content, glacial dropstones, and reworked glacial sediments or till. Isolated pockets of stratified sand and gravel from glacial activity are also found within this unit. The unit lies beneath the marine sand layer and directly above bedrock; it is present throughout much of the area except where shallow bedrock occurs. The thickness averages about 15 feet, but it is up to 60 feet deep in places.

Bedrock: Bedrock in the area consists of hard, banded schist, phyllite, and argillite. These rocks are metamorphosed from volcanic and marine sedimentary rocks. The bedrock surface is highly irregular—in some places it stands out with minimal soil cover; in others, basins are filled with layers of glacio-marine silt and clay, marine sand and silt, oxidized sand, and peat. The bedrock in the project area is not highly fractured.

3.6.1.2 Groundwater Flow

Groundwater flow is strongly influenced by local geological features and surface water drainages and is driven by local precipitation, snowmelt, and the local terrain. With average annual precipitation at the site of approximately 60 inches, groundwater recharge is large, above 10 percent of average annual precipitation. Flow is generally from the ridge to the east of the existing TDF to Hawk Inlet on the west. The steep ridge to the east is a bedrock recharge area, with Hawk Inlet the major discharge area. More locally, the TDF straddles a three-way divide, with groundwater flow components draining towards Cannery Creek to the north, Tributary Creek to the south, and Hawk Inlet to the west. A minor bedrock recharge area is the bedrock knoll at the northwest corner of the site.

Groundwater is found in several aquifers, listed from top to bottom:

- **Peat/Sand Aquifer**: Peat and sand units are physically adjacent and function as a single aquifer. The peat/sand aquifer is underlain by a silt layer that functions in places as a confining unit between the peat/sand aquifer and the underlying aquifer that occurs within the glacio-marine layer (EDE 2007). Flow in the peat/sand aquifer is unconfined, with a water table close to the land surface. The water table fluctuates seasonally.
- **Glacio-Marine Deposit Aquifer**: This aquifer includes groundwater present in the marine sand and the glacio-marine units. Groundwater in these undifferentiated deposits occurs mainly in isolated small sand and gravel lenses within the deposits. The majorities of the deposits are of relatively low permeability and are intermediate in permeability between sandy units and silt/clay units at the site. On a local scale, the more silty portions of the deposits serve as confining units for sand and gravel units within the aquifer (EDE 2007). Flow in this aquifer is confined and wells exhibit artesian conditions in the discharge areas for Tributary and Cannery creeks.
- **Bedrock Aquifer**: The entire area is underlain by bedrock that contains groundwater in fractures. In areas where bedrock is near the surface, groundwater is considered to be unconfined; in areas where the bedrock is covered by other materials, groundwater is considered to be confined (EDE 2007). Artesian conditions occur in areas where bedrock is overlain by glacial and marine deposits, (e.g., in the discharge areas for Tributary and Cannery Creek).

Groundwater discharges to the surface from the peat/sand aquifer on all sides of the groundwater divide. Groundwater discharge forms a bog near Cannery Creek. The bog and Cannery Creek are a discharge area for groundwater whose sources are the peat and the gravelly sand underlying the peat. The sand source may indirectly discharge to the creek via the peat, as the sand and the peat are in hydraulic communication. As a discharge area for shallow groundwater, Cannery Creek controls groundwater levels in the peat and gravelly sand along the north and northeast side of the groundwater divide (EDE 2002a).

On the south side of the groundwater divide, groundwater feeds Tributary Creek during base flow conditions. Tributary Creek is a perennial stream. Flow/wet conditions are observed in this headwater area during relatively dry periods without visible surface tributaries, which indicates that Tributary Creek is a local groundwater discharge area for the aquifers south of the groundwater divide (EDE 2002a).

On the west side of the groundwater divide, peat discharges into several small intermittent and ephemeral channels, particularly after a recharge event (rainfall or snowmelt) (EDE 2002a).

Groundwater flow within the bedrock appears to follow the topography down-gradient, with a general east to west gradient toward the ocean at Hawk Inlet. The northwest bedrock knob is a local groundwater recharge area, with flows following the topography and not adhering to the principal east to west gradient.

3.6.1.3 Groundwater Quality

Groundwater in and around the project area is exposed to variable geologic materials: decomposition of peat creates acidic muskeg water, while groundwater in contact with marine sediments is more alkaline in nature. Bedrock composition is also variable. A series of wells are completed in various strata in and around the project area. Examination of the field data shows that the specific conductance values of background water are relatively low, ranging from 95 µS/cm (micro Siemens per centimeter) to 258 µS/cm. Specific conductance is a measurement of total dissolved solids and salts and is used as an indicator of sulfate and other salt concentrations. The pH values are generally neutral or lower, ranging from 5.2 to 7.5. The alkalinity ranges from 30 to 160 mg/l as $CaCO_3$. Groundwater in the peat/sand aquifer is at least slightly reducing (as opposed to oxidizing) (EDE 2002b).

Pre-mining groundwater quality for four wells in peat, glacio-marine sediment, and bedrock is shown in tables 3.6-1 and 3.6-2. Water quality for the peat/sand aquifer and glacio-marine aquifers was measured from 1988 to the present and, thus, 1988 data was used as representative pre-mining baseline data. However, no bedrock water quality data exists until 2000; thus, bedrock wells upstream of the tailings facility were selected to represent pre-mining water. Because shallow groundwater supports a majority of base flow in area streams, applicable surface Alaska WQS are shown for comparison to groundwater quality for the peat/sand aquifer and the glacio marine aquifer. Surface Alaska WQS were discussed in Section 3.5.

Table 3.6-1. Pre-mining Groundwater Quality in Peat/Sand Aquifer (Data from 1988).

	MW-1S			MW-2S			MW-3S			MW-4			MW-5			Most Stringent Water Quality Standard
Parameter	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	
Total Alkalinity, mg/l as $CaCo_3$	132.4	102.7	153.9	148.2	119.7	171.0	136.8	119.7	171.0	92.3	85.5	102.6	112.9	85.5	136.8	Not applicable
Specific Conductance (µS/cm @ 25c)	240	140	338	380	165	1801	208	138	252	190	100	458	202	125	310	Not applicable
pH, lab, s.u.	6.46	6.30	6.70	6.29	6.00	6.50	5.99	5.90	6.40	7.47	7.20	7.60	5.78	5.30	5.90	6.5-8.5
Arsenic, dissolved, µg/l	<5	<5	<5	<5	<5	<5	13	8	20	<5	<5	6	8	<5	37	10
Barium, dissolved, µg/l	130	80	190	128	37	260	140	<20	390	45	<20	100	106	40	170	100
Cadmium, dissolved, µg/l	<2	<2	<2	8	<2	58	<2	<2	3	<2	<2	<2	<2	<2	<2	0.09
Copper, dissolved, µg/l	13	5	36	10	<2	22	4	<2	9	5	<2	20	14	<2	49	2.7
Lead, dissolved, µg/l	12.5	<10	30	18	<10	110	<10	<10	<10	<10	<10	<2	<10	<10	<2	0.54
Selenium, dissolved, µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
Silver, dissolved, µg/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	0.32
Sulfate, mg/l	2	1	3	3	2	8	3	1	9	5	4	6	18	10	34	250
Zinc, dissolved, µg/l	74	35	180	438	49	2900	81	55	150	27	9	94	81	<2	130	36

Notes:

Averages are calculated using half detection limit.

In the peat/sand aquifer, pH values regularly fall below the aquatic life standard lower limit of 6.5. Barium, copper, lead, and zinc concentrations also exceed the WQS.

Table 3.6-2. Pre-mining Groundwater Quality in Glacio-Marine Aquifer (Data from 1988).

Parameter	MW-1D			MW-2D			MW-3D			Most Stringent Water Quality Standard
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	
Total Alkalinity, mg/l as $CaCo_3$	329.2	307.8	342	102.6	102.6	102.6	273.6	239.4	307.8	Not applicable
Specific Conductance (µS/cm @ 25c)	616	55	910	197	125	330	448	299	500	Not applicable
pH, lab, s.u.	8.69	8.50	8.80	8.24	8.10	8.40	8.53	8.30	8.80	6.5-8.5
Arsenic, dissolved, µg/l	75	69	81	68	64	71	32	<5	40	10
Barium, dissolved, µg/l	244	70	740	36	<20	90	186	73	720	100
Cadmium, dissolved, µg/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	0.09
Copper, dissolved, µg/l	17	<2	66	<2	<2	4	6	3	10	2.7
Lead, dissolved, µg/l	1	<10	30	<10	<10	10	<10	<10	<10	0.54
Selenium, dissolved, µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
Silver, dissolved, µg/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	0.32
Sulfate, mg/l	26	22	45	10	9	11	3	2	4	250
Zinc, dissolved, µg/l	20	<5	120	8	<2	21	21	<2	92	36

Notes:

Averages are calculated using half detection limit.
In the glacio-marine aquifer, arsenic and barium concentrations commonly exceed WQS. Copper, lead and zinc concentrations also exceed the WQS occasionally.

3.6.2 Water Resources – Groundwater – Baseline Conditions

The initial discovery of the Greens Creek deposit was made in 1975. In 1989, site construction and development work began, and the mine has operated almost continuously since that time. Thus, current conditions include the existing TDF and supporting infrastructure.

3.6.2.1 Hydrogeologic Units

In addition to the hydrogeologic units described in the pre-mining environment section, the existing TDF is also a water bearing unit. In the tailings, depths to water range from about 33 to 102 feet below the top of the tailings. In the northern part of the pile, the tailings water-table surface indicates flow in a generally radial pattern away from the southern part of the existing TDF and towards the perimeter of the pile. A mound in the phreatic surface corresponds generally to the thickest part of the tailings in the oldest part of the TDF. A generally east-to-west flow gradient also appears to exist within the tailings, as in the other hydrogeologic units in the area (EDE 2011).

3.6.2.2 Groundwater Flow

The existing TDF has not altered the principal pre-mining groundwater flow system, but some local changes are apparent.

To ensure groundwater does not mix with water that has been in contact with tailings (contact water), groundwater control structures were put in place around the TDF. These include a bentonite/soil slurry wall and french drain along the eastern margin of the tailings facility to divert up-gradient groundwater to Cannery Creek (north) and Tributary Creek (south). Slurry walls also exist along the northern, western, and southern margins of the facility. Contact water collected by these slurry walls flows into french drains, wet wells, and containment ponds for treatment. Part of the tailings area is lined with polyethylene liners to prevent contact water mixing with groundwater. The original permitted tailings disposal allowed for the facility to be unlined in areas that were overlying a Glacio-Marine Clay formation. It was also not lined in areas overlying bedrock in the northwest corner of the original facility. Since 2003, all new disposal areas are lined. Contact water in the underdrains is a combination of leachate that has drained through the TDF (within the containment boundaries) and groundwater that upwells to the underdrain collection system in areas that were originally unlined. This upwelling occurs because the flow gradient from the Glacio-Marine formation is upward.

It was found that originally unlined bedrock outcrops protruding under the northwest corner of the TDF may have allowed contact water to mix with groundwater. Excavation of materials in the northwest corner of the TDF allowed installation of an underdrain to convey surface and contact water from the northern to the southwestern part of the TDF, in order to reduce flows to a retention pond in the northern portion of the TDF area and facilitate long-term closure drainage. One area in the initial location of tailings placement is underlain directly by bedrock and is still unlined (EDE 2011). A network of blanket drains and finger drains at the base of the tailings collects a mixture of contact water and upwelling groundwater. Water from these underdrains is pumped or flows by gravity to Pond 7 (EDE 2007).

Water flow in the aquifers has changed as follows:

- **Tailings**: Water moves in the tailings as both saturated flow and unsaturated flow. Precipitation in the form of rain and snow enters the tailings. Infiltration occurs even though the TDF is sloped and compacted to promote runoff and minimize infiltration. Infiltrating water percolates through the upper tailings under unsaturated flow conditions, eventually reaching the water table within the tailings. Tailings water eventually exits the TDF via the system of under-drains. The drainage water is then pumped to Pond 7 for treatment. The flow gradient is toward the blanket drains and toward the pumped wet well sumps (EDE 2002).
- **Peat/Sand Aquifer**: Excavation of peat and sand underneath the tailings facility has removed the peat/sand aquifer underneath parts of the TDF (EDE 2011). Where peat was not removed beneath the tailings, it has been compacted and may act as a natural liner and hydraulic barrier (EDE 2011). Bentonite slurry walls partially divert groundwater flow in this aquifer around the tailings facility.
- **Glacio-Marine Deposit Aquifer**: This aquifer is still present in its original extent underneath the TDF, and flow is confined underneath the tailings (EDE 2011).
- **Bedrock Aquifer**: The bedrock aquifer is confined in areas where it is overlain by tailings facility deposits. The tailings act as a confining unit. Recharge to the original bedrock outcrop area in the northwest of the tailings facility is reduced where the tailings facility covers the bedrock, which has lead to a fall in the potentiometric surface in that area.

Groundwater originally surfaced in muskeg areas to form Tributary Creek. A portion of the muskeg area is now covered by the existing tailings facility, and groundwater comes to the surface as small perennial seeps and streams to the south of the tailings contributing to the flow of Tributary Creek.

The groundwater control structures remove and divert groundwater from the underground flow system. An extensive network of monitoring wells and piezometers is in place to observe if groundwater heads (pressures) are falling due to groundwater removal. Several bedrock wells exhibit trends of falling groundwater levels. Bedrock wells located in the Northwest/Pit 5 expansion area of the TDF (MW-T-96-03, MW-T-01-07, MW-T-01-09, MW-T-04-13, MW-T-04-14, MW-T-05-01, and MW-T-05-04) show a drop in heads around 2008, during the time when excavation and lining in the Northwest/Pit 5 occurred. Piezometric water levels appear steady since 2009, and it is likely that a new steady-state flow system with lower heads has been created in the northwest area of the tailings facility. Bedrock well MW-T-02-11 near the center of the TDF shows a similar trend, with a drop in heads occurring in 2007. Heads in bedrock also show a declining trend in the East Ridge expansion area. A bedrock well in the southwest tailings facility area (MW-T-96-02) exhibits a drop in water levels. A trend of declining water levels cannot be confirmed for the southern part of the TDF, partially due to a lack of long term established monitoring wells there. To the northeast of the tailings facility, groundwater control structures seem to divert water from the peat/sand and glacio-marine aquifers into the bedrock aquifer, as evidenced by water levels increasing in bedrock well MW-T-96-04, and declining in peat/sand wells MW-T-95-05B and C, and glacio-marine well MW-T-95-05A.

3.6.2.3 Groundwater Quality

Current groundwater quality is monitored by the operator in accordance with the mine's FWMP for six groundwater monitoring wells surrounding the tailings facility (MW-2S, MW-2D, MW-3S, MW-5S, MW-T-00-01A, and MW-T-001C) (Hecla 2009). Additional groundwater data was collected for the Stage II Tailings Expansion Hydrologic Analysis Update (EDE 2007a).

Four of the wells (MW-2S, MW-3S, MW-5S, and MW-T-001C) monitored in accordance with the FWMP are completed in the shallow peat/sand aquifer, and two (MW-2D and MW-T-00-01A) are completed in the glacio-marine deposit aquifer. None are completed in bedrock.

Tables 3.6-3 and 3.6-4 show groundwater quality measured in 2009 for the FWMP for peat/sand aquifer and the glacio-marine unit.

Table 3.6-3. Groundwater Quality in Peat/Sand Aquifer Wells (after Hecla 2009).

	MW-T-00-01C		MW-2S		MW-3S		MW-5		Average	Most Stringent Water Quality Standard
Sample Date/Parameter	**5/5/2009**	**9/22/2009**	**5/5/2009**	**9/22/2009**	**5/5/2009**	**9/22/2009**	**5/5/2009**	**9/22/2009**	**2009**	
Specific Conductance (µS/cm @ 25c)	61	69	89	127	74	69	65	58	77	Not applicable
pH, lab, s.u.	6.12	6.13	5.61	6.35	5.18	5.29	4.99	5.05	5.59	6.5-8.5
Total Alkalinity, mg/l as $CaCo_3$	21.2	28.2	18.5	26.5	26.4	27	16.7	14.7	22.4	Not applicable
Sulfate, mg/l	1.4	2.6	14.4	35.4	0.3	0.2	0.3	0.3	6.9	250
Hardness (mg/l)	24.6	29.6	28.3	54.4	29.1	30.5	10	10.3	27.1	None
Arsenic, dissolved, µg/l	0.184	0.277	4.29	7.02	11.8	11.7	7.84	5.91	6.13	10
Barium, dissolved, µg/l	11.9	18.1	25.7	46	12.9	12	15.6	17.1	19.9	100
Cadmium, dissolved, µg/l	<0.002	<0.006	0.006	<0.006	0.013	0.014	0.025	0.029	0.012	0.09
Chromium, total, µg/l	1.49	1.17	2.2	1.21	11.4	2.77	11.6	3.43	4.41	100
Copper, dissolved, µg/l	0.069	0.131	0.168	0.212	0.335	0.429	0.748	0.876	0.371	2.7
Lead, dissolved, µg/l	0.0272	0.109	0.224	0.253	0.963	1	1.79	2.63	0.875	0.5
Nickel, dissolved, µg/l	0.425	0.525	1.66	1.65	1.6	1.55	3.77	3.74	1.87	16
Silver, dissolved, µg/l	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.003	<0.003	0.32
Zinc, dissolved, µg/l	2.66	0.71	2.74	2.89	10.1	10.9	12.7	14.4	7.1	36
Selenium, dissolved, µg/l	0.167	0.211	0.14	0.142	0.29	0.19	0.586	0.222	0.244	5
Mercury, dissolved, µg/l	0.000566	0.000774	0.000815	0.00177	0.000446	0.00102	0.000858	0.00172	0.00100	0.012

Table 3.6-4. Groundwater Quality in Glacio-Marine Deposit Aquifer Wells (after Hecla 2009).

Sample Date/Parameter	MW-T-00-01A		MW-2D		Average	Most Stringent Water Quality Standard
	5/5/2009	9/22/2009	5/5/2009	9/22/2009	2009	
Specific Conductance (µS/cm @ 25c)	115	107	213	202	159	Not applicable
pH, lab, s.u.	6.62	6.52	8.18	8.3	7.41	6.5-8.5
Total Alkalinity, mg/l as $CaCo_3$	44.2	42.5	76	75.5	59.6	Not applicable
Sulfate, mg/l	5.4	5.6	11.3		7.4	250
Hardness (mg/l)	51.5	49.5	74.9	77.6	63.4	None
Arsenic, dissolved, µg/l	0.158	0.148	82.3	72.4	38.75	10
Barium, dissolved, µg/l	7.2	7.3	6.5	6.4	6.9	100
Cadmium, dissolved, µg/l	0.016	0.012	0.004	<0.006	0.009	0.09
Chromium, total, µg/l	4.22	4.51	1.21	1.57	2.88	100
Copper, dissolved, µg/l	0.082	0.059	0.083	0.054	0.070	2.7
Lead, dissolved, µg/l	0.0059	0.0166	<0.0030	<0.0030	0.006	0.54
Nickel, dissolved, µg/l	1.11	0.871	0.861	0.559	0.85	16
Silver, dissolved, µg/l	<0.003	<0.003	<0.003	<0.003	<0.003	0.32
Zinc, dissolved, µg/l	0.52	0.54	0.13	0.29	0.4	36
Selenium, dissolved, µg/l	0.418	0.322	0.109	0.138	0.247	5
Mercury, dissolved, µg/l	0.00017	0.000128	0.000103	0.000133	0.00013	0.012

In 2006, groundwater in several bedrock wells had elevated sulfate concentrations and conductivity. These wells are down-gradient and in close proximity to the TDF. Tailings contact water from the old unlined portion of the TDF likely seeped into the bedrock aquifer. This is also shown by the increasing (albeit very slowly) sulfate concentration in MW-2S. MW-2S is located in an area where groundwater has an upward gradient and bedrock water may discharge to the shallow aquifers and surface water. Since then, the northwestern part of the tailings facility was excavated to install a liner, before re-depositing tailings. Currently, sulfate concentrations are still elevated above background levels but are decreasing in all but two wells measured. Sulfate concentrations increased in wells MW-T-04-14 and MW-T-05-04 in the most recent sampling event. It is possible that construction for the liner installation temporarily caused the increases. Trends in groundwater quality data are analyzed according to the FWMP and reported annually to ADEC and the Forest Service.

Both MW-3S and MW-5S have higher than background lead and zinc levels. Fugitive tailings dust may be contributing to the elevated metal levels monitored at these sites (Hecla 2009).

High dissolved arsenic values have been detected in MW-2D since before mining began, and are considered background values.

Specific conductance and sulfate concentrations for bedrock wells as monitored between 2004 and 2010 are listed in Table 3.6-5. All available data for sulfate for 2010 are listed.

Table 3.6-5. Sulfate Concentration and Specific Conductance in Bedrock Aquifer Wells (adapted from EDE 2007).

Site Id	Sample Date	Specific Conductance, Field (µS/cm)	Sulfate, Total (Mg/L)
MW-T-00-02B	4/12/2005	297	19.7
	3/16/2010	266	12.2
MW-T-01-01A	12/7/2005	47.2	1.61
MW-T-01-02A	6/30/2004	858	66.4
	9/28/2010	87.3	27.3
MW-T-01-03A	3/24/2005	604	122
MW-T-01-04	5/13/2004	1332	566
MW-T-01-05	8/26/2004	284	11.8
MW-T-01-06A	3/18/2004	366	40.7
MW-T-01-06B	3/18/2004	426	58.4
MW-T-01-07	2/22/2006	1459	645
	5/26/2010	1142	294
MW-T-01-08	7/2/2004	731	295
MW-T-01-09	2/22/2006	1358	591
	5/26/2010	1320	424
MW-T-01-15A	6/30/2004	118.4	5.97
MW-T-02-07	4/21/2005	799	220
MW-T-02-08	7/22/2004	878	104
MW-T-02-11	4/18/2006	404	25.3
	4/26/2010		9.5
MW-T-04-12	2/23/2006	971	139
MW-T-04-13	2/8/2006	644	148
	5/27/2010	604	64.3
MW-T-04-14	2/8/2006	599	27.6
	5/26/2010	629	98.6
MW-T-05-01	4/18/2006	1739	621
	5/27/2010	907	255
MW-T-05-04	4/18/2006	500	28.7
	6/30/2010	1054	304
MW-T-05-06A	2/8/2006	544	158
MW-T-07-01	5/27/2010	1133	277
MW-T-07-02	5/26/2010	626	50.4
MW-T-96-3	6/6/2005	49.1	9.2
MW-T-96-04	2/8/2006	893	323
	4/25/2010	524	186
MW-T-98-01	6/6/2005	293	22.5
	4/7/2010	103.4	11.9
MW-T-98-4	6/6/2005	74.2	4.3

3.6.3 Water Resources – Groundwater – Environmental Consequences

There are several ways in which the project may affect groundwater.

Changes of groundwater flow patterns could occur from the construction or expansion of tailings disposal facilities and groundwater control structures. Groundwater quality could be affected by mixing of contact water with groundwater, spills from concentrate and tailings haul trucks, or seepage from the tailings pile itself. Additionally, fugitive dust from the tailings may contaminate ground and surface water. Thus, project actions that affect the following factors are of most concern in assessing potential effects to groundwater resources:

- Changes in groundwater flow patterns that cause changes in groundwater discharge to surface waters;
- Water quality changes caused by contact water seeping into groundwater, or fugitive dust contaminating near-surface groundwater.

3.6.3.1 Effects Common to All Alternatives

Under all alternatives mining activities would continue through at least 2014. Groundwater monitoring would continue to be required by the Forest Service and ADEC under all alternatives to monitor groundwater levels and determine if groundwater contamination occurs so that it can be remedied.

3.6.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceased, disturbed sites were reclaimed, and human activity in the area reduced. The existing TDF would continue to be built out to the maximum footprint and height permitted in the 2003 EIS (USDA 2003). After the TDF was fully built out in 2014, reclamation would begin as described in the 2003 EIS (USDA 2003). Impacts to groundwater would be similar to current conditions. The TDF would continue to divert groundwater from the Tributary Creek and Cannery Creek drainages through the groundwater management structures after closure. Heads in bedrock would remain at a lower level, where a new steady-state flow system has established itself, and heads would keep falling in other areas, where a decline is currently occurring until a new steady-state system is achieved. The up-gradient groundwater would continue to be diverted around the existing TDF to Cannery Creek to the north and Tributary Creek to the south.

Decreases of elevated sulfate concentrations in bedrock aquifer monitoring wells would continue to be monitored, and the effectiveness of excavating and relining sections of the originally unlined TDF determined.

BMPs are currently employed to minimize fugitive dust from blowing off the TDF. Additional BMPs may be added if monitoring indicates this is necessary. BMPs to reduce fugitive dust are included in Section 3.2.3. After successful reclamation fugitive dust would no longer occur.

3.6.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF and south into the Tributary Creek drainage.

Groundwater flow would be impacted through the presence of the TDF, which would be much larger than under Alternative A. The TDF expansion would be constructed with a liner and tailings underdrains atop and below the liner. Groundwater collected in the tailings underdrains would also be contained, treated, and discharged under the APDES permit. This includes both groundwater originating from infiltration through the pile and groundwater passing immediately beneath and contacting the placement location as it moves through the local water table. This groundwater would be collected in order to avoid potential groundwater contamination from contact with tailings and to promote the geotechnical stability of the TDF. The required contact groundwater collection volume would increase proportionally to the area of tailings placement, as the TDF was expanded. Condon (2011) estimates a drainage from the TDF to be between 107 and 163 gpm after closure. Additional and increased lowering of groundwater heads in bedrock in the expansion area would likely occur. However, similar to Alternative A, up-gradient groundwater flow would continue to be diverted around the TDF to Cannery Creek and Tributary Creek.

Groundwater quality could be affected by spills or contact water seeping into groundwater. With the extended operating period, the chance of chemical, fuel, or concentrate spills introducing contaminants into groundwater would increase, though it is still expected to be unlikely. Operational procedures and BMPs are intended to reduce the likelihood and severity of a spill so the chance of these effects would be limited. Expanding the TDF with a liner and complete set of groundwater control structures would limit the probability of contact water entering and contaminating groundwater. The groundwater monitoring system will be used to catch unanticipated ground water contamination early enough to allow for it to be mitigated. No pyritic rocks would be used in the construction of roads or other facilities, to avoid sulfate leaching into groundwater.

The longer time period of an active TDF would allow more fugitive dust to escape the tailings stack. Best management methods would be employed to minimize fugitive dust from blowing off the tailings stack. This could reduce the metal concentrations in groundwater potentially contributed by fugitive dust. After reclamation fugitive dust would no longer occur.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. Relocation of these facilities out of wetlands in the area could have a very minor effect on shallow groundwater flows and discharge into Tributary Creek. The relocated reclamation material storage area could produce very minor effects on the shallow groundwater system at its new location.

3.6.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF located approximately three miles north of the existing TDF in a portion of the Fowler Creek drainage. Alternative C would also extend the operating period of the mine by 30–50 years. Effects to surface and groundwater would be more widely spread than in alternatives A and B due to the development of a new TDF and supporting infrastructure.

Disturbances of groundwater from construction and placement of a new TDF would occur in a small portion of the previously undisturbed watershed of Fowler Creek and a small drainage basin that empties in Hawk Inlet. Groundwater control structures including liner and diversion structures similar to the control structures under Alternative B would have to be constructed under the new TDF, resulting in minor changes in groundwater flow patterns in Fowler Creek drainage and potentially in the North Hawk Inlet drainage. Lowering of groundwater heads in bedrock in the expansion area would likely occur. Reduction in groundwater discharge to both drainages could occur.

Expansion of the original TDF in the Tributary Creek watershed would also require additional liner and water control structures. Effects on groundwater flow in the Tributary Creek watershed would be similar to Alternative A.

With the development of a new TDF, groundwater contamination is also possible in this area. However, proper construction techniques and BMPs would reduce the likelihood of impacts on groundwater quality in the Fowler Creek and the North Hawk Inlet drainage.

Establishing a new TDF in a new watershed would potentially allow fugitive dust to contaminate ground and surface water in this area. BMPs would be employed to minimize fugitive dust from blowing off the tailings stack. This would decrease metal concentrations in groundwater caused by fugitive dust. After reclamation fugitive dust would no longer occur. Adverse impacts from fugitive dust near the existing TDF would be smaller.

3.6.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve the expansion of the existing TDF and the construction of the new TDF. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than Alternative B; however, larger than the footprint under Alternative C. Effects to surface and groundwater would be similar to Alternative C. The TDF would be developed similar to alternatives B and C, with a line and underdrain system to capture any contact water and groundwater monitoring surrounding the TDF to ensure that contact water is not escaping the system. Should unanticipated contamination occur, it has the potential to be more widespread than alternatives A and B because the TDF area is greater under this alternative.

Disturbances of groundwater due to construction and placement of a new TDF would occur in the same location as Alternative C. Groundwater control structures including liner and diversion structures similar to the control structures under Alternative C would have to be constructed under the new TDF, potentially resulting in changes in groundwater flow patterns in the Fowler Creek and the North Hawk Inlet drainage. Lowering of groundwater heads in bedrock in the expansion area would likely occur.

With the development of a new area, groundwater contamination is also possible. However, proper construction techniques and BMPs would reduce the likelihood of impacts on groundwater quality in these drainages.

Establishing a new TDF in a new watershed would allow fugitive dust to contaminate ground and surface water in this area. Best management methods should be employed to minimize fugitive dust from blowing off the tailings stack. This would decrease metal concentrations in groundwater that could result from fugitive dust. After reclamation fugitive dust would no longer occur. Adverse impacts from fugitive dust near the original TDF would be smaller.

3.6.4 Groundwater – Summary

The largest impact under all alternatives would be the capture and collection of groundwater through groundwater control structures necessary to protect the groundwater quality. Groundwater would thus be removed from the groundwater flow system and discharged to Hawk Inlet. This ensures that groundwater contamination will not occur, but it also reduces the availability of groundwater to recharge surface waters. Based on groundwater level monitoring and observed changes at the existing TDF, impacts on groundwater hydrology under all alternatives would occur, but would be minimal. The implementation of groundwater control structures would protect the groundwater quality.

3.7 Aquatic Resources

Impacts associated with waters of the United States are evaluated in Section 3.5, Water Resources – Surface Water; Section 3.7, Aquatic Resources; and Section 3.10, Wetlands. Aquatic resources in the project area occur in the freshwater and marine environment. Freshwater aquatic resources are present in the streams surrounding the mine, associated facilities, and project roads. Marine aquatic resources of interest are those found in Hawk Inlet and adjacent Chatham Strait, which may be influenced by treated water discharge as well as concentrate and supply transport.

Aquatic resources are directly connected to significant Issues 1 and 3. Impacts to anadromous and resident fish streams are addressed in this section. Measures of impacts to aquatic resources include length of anadromous and resident fish streams impacted and acres of fish-bearing watersheds impacted.

3.7.1 Aquatic Resources – Pre-mining Environment

The historical conditions are presented separately for the freshwater and marine environment.

3.7.1.1 Pre-mining Aquatic Resources – Freshwater

A total of five major streams or tributaries are present in the project area, including Greens, Zinc, Tributary, Cannery, and Fowler creeks (Figure 3.5-1). A few other streams also enter Hawk Inlet outside of the project area (Table 3.7-1). The length of each stream, by watershed and stream class, is presented in Table 3.7-1. The streams are classified based on the Forest Service stream value class or Aquatic Habitat Management Unit class. The stream class generally relates to fish type and presence and whether the stream can affect the water quality of downstream fish. The classification is based on the Forest Service GIS stream layer, where available. Some additional stream channels were added from high resolution LiDAR data interpretation near potential areas of disturbance. Streams identified by LiDAR interpretation that were within potential areas of disturbance were field verified in the summer of 2011. Streams identified as "Unclassified" have not been field verified and are outside the area of potential disturbance.

Table 3.7-1. Project Area Major Stream and Watershed Characteristics.

Watershed Name	Watershed Acres	Stream Length (ft)					
		Total (ft)	Class I	Class II	Class III	Class IV	Unclassified Area [a]
Greens Creek	14,429	211,340	61,323	60,249	89,768	0	Not mapped
Zinc Creek	3,084	48,849	7,973	32,479	8,397	0	Not mapped
Tributary Creek [b]	409	10,040	5,169	2,991	0	1,880	Not mapped
Cannery Creek	689	12,761	0	7,420	4,721	0	620
Fowler Creek [b]	5,089	132,719	38,388	36,208	12,062	1,486	44,575
North Hawk Inlet [b]	261	7,660	0	4,517	0	703	2,440

Notes:

Class I = Anadromous fish stream, Class II = resident fish stream, Class III = non-fish stream with potential to transport sediment to a fish stream, Class IV = non-fish stream less than 5 feet wide that would not affect downstream fish stream water quality.

a. Mapped from LiDAR data as very small streams; not in Forest Service GIS stream layer.
b. Portions of these watersheds were surveyed in greater detail due to proximity to project area.

Physical characteristics and water quality of the key streams and watersheds in the area are discussed in Section 3.5, Water Resources – Surface Water. Overall, the freshwater aquatic resources in the project area prior to development would be considered typical of Tongass National Forest, containing resident and anadromous fish species common to the region and water quality conditions not markedly different from unaffected stream environments of this region. As discussed in Section 3.5.2, the water quality of area streams generally meets Alaska WQS for aquatic life, exhibiting near neutral pH and low concentrations of metals. Some values exceeded Alaska WQS for dissolved cadmium, and to a lesser extent copper, mercury, and zinc were reported in Tributary Creek in the 1990s. Reported concentrations appear to be anomalous values that were not associated with parallel increases in sulfate, reduced pH, or elevations of non-trace metals, such as iron, calcium, or magnesium. Since 1990, these parameters have returned to levels below Alaska WQS for aquatic life.

Benthic macroinvertebrates were noted as consisting of a diverse population in Zinc, Greens, and Cannery creeks. Common cold mountain stream families of insects were present, dominated by mayflies and stoneflies, followed by less abundant caddisflies and dipterans, and occasionally stream worms (Oligochaetes) were also present (USFS 1983).

As shown in Table 3.7-2, anadromous and resident salmonid species are common in many of the project area streams. Coho (*Oncorhynchus kisutch*), pink (*O. gorbuscha*) and chum (*O. keta*) salmon were widely distributed in these streams prior to development. Greens Creek and Fowler Creek had the largest amount of habitat in stream miles for fish resources in the project area.

Table 3.7-2. Fish Species Found in Streams in or near the Greens Creek Mine Project Area.

Creek	Juveniles / resident adults						Anadromous adults			
	Coho Salmon	Cutthroat Trout	Dolly Varden	Sockeye Salmon	Sculpin	Stickleback	Pink Salmon	Chum	Dolly Varden	Coho Salmon
Greens Creek	++	+	++	0	++	+	++	++	+	+
Zinc Creek	++	+	++	0	++	+	++	++	+	+
Tributary Creek	++	+	++	0	++	0	++	0	+	+
Fowler Creek	++	+	++	0	++	+	++	+	++	+
Lower Fowler Tributary	++	+	++	0	?	0	0	0	?	+
Upper Fowler Tributary	0	0	0	0	0	0	0	0	0	+
Lower Greens Creek Tributary	0	0	0	0	0	0	0	0	0	0
Upper Hawk Tributaries	+	?	+	0	++	++	+	?	?	?
Cannery Creek	0	?	?	0	0	0	0	0	0	0

Note: Abundance indicators: ++ = abundant; + = moderate occurrence or few; 0 = not found; ? = presence strongly suspected but not confirmed. Observations were made in the early 1980s, except recently updated for Tributary Creek juvenile and resident fish.

Chinook salmon (*O. tshawytscha*), which are rare in island streams of southeast Alaska, were also noted to be found in Greens Creek, although its presence may be incidental. Resident cutthroat trout (*O. clarki clarki*) and the more abundant Dolly Varden (*Salvelinus malma*) were also present in most streams, and rarely rainbow trout (*O. mykiss*). Cannery Creek has a large natural fall at the mouth preventing anadromous fish from entering this basin. While it is classified as a Class II stream (non-anadromous fish stream) by the Forest Service, documentation of fish presence within this stream prior to project development had not occurred. Tributary Creek, a relatively small and low-gradient stream that originates near the existing TDF, also contains anadromous fish.

Monitoring of metals in fish was very limited prior to mining, including only juvenile coho salmon in Tributary Creek. Because of limited data and lack of comparability to current studies, results are not reported here.

Management Indicator Species

The use of management indicator species (MIS) is directed by the National Forest Management Act for forest planning. They are used to represent habitat types that occur within the National Forest boundary and/or because they are thought to be sensitive to National Forest System management activities. In the Tongass National Forest MIS fish species include coho and pink salmon, Dolly Varden char, and cutthroat trout. Coho salmon represent anadromous fish that are generally limited in their freshwater life period by rearing areas. Pink salmon serve as an indicator of spawning gravel habitat conditions as this is their limiting habitat condition in freshwater. Dolly Varden char were chosen because of their common distribution in many freshwater systems including high gradient streams. Cutthroat trout were selected because of their dependency on small freshwater streams, areas often affected by development actions.

General Historical Stream Habitat Conditions

The stream conditions prior to mine development were presented in the 1983 EIS. Specific stream data was based on surveys by Buell (1981). The information below is primarily from these documents. However some recent survey results from 2010 and 2011 have been added where relevant.

Greens Creek

Greens Creek is one of the larger streams with a watershed area of 14,429 acres. The total channel length of Greens Creek is about 10 miles, originating from an elevation of over 4,600 feet. The stream empties into Hawk Inlet at a large river delta shared with Zinc Creek. The stream has a set of natural falls approximately 4 and 5 miles up from the mouth that are considered barriers to fish passage including salmon. The channel consists of a Forest Service MMM (medium moderate gradient contained) channel type (Paustian 2010). The area below the falls is considered to contain good to excellent spawning habitat for pink, chum, and coho salmon as well as Dolly Varden char. Rearing habitat is generally fair to good for salmonids in the mainstream, and excellent where the channel is braided.

Zinc Creek

Zinc Creek is just north of Greens Creek where it shares the delta area at its mouth in Hawk Inlet, with a watershed of 3,084 acres. In its lower reaches, its channel meanders in the flat meadows area. The gradient is generally low, less than 2 percent. A natural upstream barrier occurs at about river mile 2.2. Good to excellent spawning habitat occurs in the lower reaches for salmon, Dolly Varden char, and cutthroat trout. Additionally coho salmon, trout, and char rearing habitat is considered good in the lower reaches. The mouth of this stream is a Forest Service FPS channel type which is a small floodplain channel, typical of valley bottom and flat low lands.

Tributary Creek

Tributary Creek is small; about 7,400 feet long with a watershed area of about 409 acres. Its drainage area begins near the existing TDF and flows south before it intersects Zinc Creek at river mile 0.8. The channel has not been characterized by the Forest Service; however, it is likely floodplain (FPS) or palustrine (PA) channel type. The stream is narrow, low gradient (<2 percent), and deeply incised with few pools, typical of valley bottoms or low land flat muskeg regions. Channel widths are up to 7 to 10 feet in its downstream reaches. Flow may be intermittent near its headwaters. The substrate is organic in the upstream portions with gravel and sand in the lower parts. Large woody debris is present in some areas helping to form pools and retain gravel. The downstream portion provides good rearing habitat for coho salmon and Dolly Varden char. The lower 5,600 feet of this stream is accessible to salmon with limited spawning habitat available for coho, chum, and pink salmon as well as cutthroat and rainbow trout.

Cannery Creek

Cannery Creek is a non-anadromous stream that was the historical water source for the local cannery, located just north of the existing TDF. It has a moderate watershed area of about 689 acres. A 15 foot high falls 50 feet from tidewater blocks anadromous fish entry to the system. A reservoir dam is present 0.6 miles upstream from tidewater. Between the falls and the dam, the substrate is primarily cobble with some bedrock. Water depth was measured ranging from about 0.1 to 1 foot with no spawning or good rearing habitat identified for salmonids. Cannery Creek is a Forest Service HCV3 channel type, which is a high gradient upper valley channel (6 to >15 percent slopes). This channel type has deeply incised streams that may supply fish habitat but are often non-fish streams. Anecdotal information suggests resident fish presence in Cannery Creek; however, fish were not detected during limited sampling efforts in August 2011.

Fowler Creek

Fowler Creek enters Young Bay after draining a large area fed by several major tributaries. Fowler Creek watershed area is approximately 5,089 acres. Two palustrine stream channels drain from near the A Road. These are small streams with low gradient (0 to 1 percent) containing beaver ponds (PAB channel types). The other main tributaries of Fowler Creek include low and moderate gradient channel types including floodplain (FPS), and low gradient contained (LCM – medium low gradient contained) channels in the lower portion. Further up the main tributaries moderate gradient channels are present including alluvial fan (AFM – moderate gradient) moderate gradient (MCM – medium moderate gradient Contained), and some smaller high gradient channels (HCV – high gradient upper valley) found further up the drainage. Salmon including pink, chum, and coho salmon, use this system, as well as Dolly Varden char and cutthroat trout. The low-gradient habitat supplies good habitat for rearing coho salmon that use pool areas formed by large woody debris and beaver dams. The upper areas with moderate and higher gradients would be more suitable for resident fish rearing and spawning.

Unnamed Tributary to Fowler Creek and North Hawk Inlet Drainage

The area contains two small unnamed tributaries to Fowler Creek and two additional small unnamed tributaries that drain directly to Hawk Inlet (Figure 3.5-1). One of the small Fowler Creek tributaries drains a very large flat area just west of the A Road in the central western most area of Fowler Creek (Figure 3.5-1). This drainage includes an area of flats with bogs and old and new beaver ponds; the area is heavily vegetated area with poorly defined channels, but near the eastern edge supports a flow rate of approximately one cfs (USFS 2003). The substrate is composed of mud and organic debris. In the eastern region the channel slope increases to 2 to 3 percent. Spot sampling using electrofishing, conducted in July 1981, found no fish. The area was considered suitable for a small number of fish but was absent any spawning habitat in the upper portion of the drainage. This stream does not occur in either the Forest Service or Alaska

Department of Fish and Game (ADF&G) database. The other (northern) Fowler Creek tributary drains an area of muskegs, beaver ponds, and some forests. Recent surveys of these channels found cutthroat trout present above the road. Downstream of the A Road, these unnamed tributaries intersect a Forest Service Class I, palustrine beaver dam/pond channel type (USFS 2010). This channel is considered an anadromous fish stream containing beaver dams and low gradient (typically less than 1 percent). These PAB channels would normally have fine substrate and organic matter bottoms. These channel types are considered good rearing habitat for fish.

Two channels flowing north to Hawk inlet are small and drain muskeg areas. Observations in 2011 found no fish present in these channels, but the sampling effort was limited.

3.7.1.2 Pre-mining Aquatic Resources – Marine

Marine aquatic resources, including habitat and biota, were discussed in both the 1983 and 2003 EISs. A more detailed description of habitat and environment is provided in the Review of Essential Fish Habitat in Hawk Inlet (Oceanus 2003). Information in the following sections is primarily from these documents.

Physical Environment

Hawk Inlet is a long narrow bay located on the northwest portion of Admiralty Island running almost due north and south (Figure 3.5-1) with a narrow inlet opening to Chatham Strait to the west. The inlet is about 7 miles long and ranges from 0.3 to 1.1 miles wide. The midchannel depth ranges from 35 feet at the shallow sill near the mouth to 250 feet. The sill area is near a large stream delta area formed on the eastern side of the inlet by outwash from Greens and Zinc creeks. The head of the inlet opens into a large cove containing large mudflats.

With a tidal range of about 25 feet, large tidal exchange of water and strong currents occur within the inlet, especially near the entrance. Wind and freshwater inflow also influence flows, speed, and vertical mixing, especially near the surface. Currents near the sill, where the existing mine Outfall 002 discharge site is located, are about 2.3 ft/sec maximum on a flood tide and about 1.3 ft/sec on an ebb tide and in other areas of the inlet near the surface (Oceanus 2002). Highest tidal currents occur near the surface and decrease with increasing water depth. Below depths of approximately 100 feet the tidal velocities are less than 10 percent of the surface velocities. However, the velocities and exchange flows are sufficient to provide mixing of the near bottom layers of the inlet and good water exchange between the inlet and Chatham Strait.

Habitat and Biota

A variety of intertidal shoreline, subtidal benthic and demersal, and pelagic habitats and organisms occur within Hawk Inlet and nearby Chatham Strait. Bottom areas are varied, including muddy, sandy, cobble, and bedrock conditions depending on location, depth, and flow within the inlet. Due to currents and wave actions much of the area consists of gravel and cobble. High current areas scour some regions to bedrock. The muddy sand habitat is primarily at the head of the inlet. The bed of the central deep areas consist of muds with high organic matter, whereas submerged rocky areas occur along the banks of the inlet.

Hard bottom organisms included anemones (*Metridium*), large snails (*Polinices, Nucella*), green sea urchins, starfish, sea cucumber, sponges, bryozoans, and variety of attached algae. Soft bottom areas support populations of polychaete worms, clams, and small crustaceans. The soft and hard bottom tidal and subtidal organisms are similar in Young Bay and Chatham Strait but of greater abundance and variety due to greater current velocity. The pre-mine development composition of benthic organisms in Hawk Inlet is shown in Table 3.7-3.

Table 3.7-3. Features of Major Marine Habitat Types in Hawk Inlet, Admiralty Island.

Habitat Type	Area (hectare)	Number of Species	Density Organisms per square meter	Dominant species	Location in Hawk Inlet
Protected (estuarine) intertidal muddy sands	226.4	36	49,480	Gastropods, bivalves, polychaetes	Head of Inlet
Protected subtidal muddy sands	147.3	41	7,596	Bivalves, polychaetes	Head of Inlet
Protected intertidal and subtidal muddy sands	48.8	52	13,776	Polychaetes, foramanifera, bivalves, copepods.	Piledriver Cove
Unprotected intertidal sand	41.3	36	99,900	Foramaniferans (sponges)	Greens Creek Delta
Intertidal and subtidal rocky	66.3	—	—	(samples from Chatham)	Shoreline and mouth of Inlet
Deep subtidal muds	321.8	52	14,061	Polychaetes, bivalves	Basin -- Cannery
Submerged sill of sand-gravel-cobble	187.2	80	30,526	Polychaetes, gastropods, amphipods	Greens Creek Delta/002
Nereocystis kelp beds (sand)	125.4	69	67,352	Polychaetes, amphipods, bivalves	Interspersed
Transition areas	168.5	—	—	—	Interspersed

Source: Holland et al. 1981.

Fish and Shellfish Resources

A variety of commercial and noncommercial, sport, and subsistence species of fish and shellfish resources are present in Hawk Inlet and the surrounding area. Based on surveys conducted prior to mine development known commercial fish resources included halibut (*Hippoglossus stenolepis*), flathead (*Hippoglossoides elassodon*), yellow-fin (*Limanda aspera*) and rock sole (*Lepidopsetta bilineata*), arrowtooth (*Atheresthes stomias*) and starry flounder (*Platichthys stellatus*), and Pacific cod (*Gadus macrocephalus*). Noncommercial fish include whitespotted (*Hexagrammos stelleri*) and masked greenling (*Hexagrammos octogrammus*), shortfin eelpout (*Lycodes brevipes*), snake prickelback (*Lumpenus sagittal*), sturgeon poacher (*Podothecus accipenserinus*), staghorn (*Leptocottus armatus*) and great (*Myoxocephalus polyacanthocephalus*) and spinyhead (*Dasycottus setiger*) sculpins, Pacific sandlance (*Ammodytes hexapterus*), daubed shanny (*Leptoclinus maculatus*), and copper rockfish (*Sebastes caurinus*). Some Pacific herring (*Clupea pallasii*) had been reported spawning near the inlet entrance, but overwinter use was unknown. Young Bay use was likely similar.

Marine-rearing early juvenile and subadult stages of salmon and anadromous stages of trout and Dolly Varden char were also common in Hawk Inlet. Juvenile rearing in the inlet would occur for juvenile chum and pink salmon that spend their early rearing periods (about 40 days) in waters near their stream of origin.

Commercial crab including Dungeness (*Metacarcinus magister*), tanner (*Chionocetes tanneri*), and red king crab (*Paralithodes camtchatica*) would also have been present, as well as noncommercial hermit crabs (*Pagurus spp*.). Extensive beds of clams including littlenecks (*Protothaca staminea*), cockles (*Clinocardium nuttallii*), soft shell (*Mya arenaria*), and horse clams (*Tresus nuttallii*), as well as mussels (*Mytilus trossulus*) were present.

Metals in Sediment in Hawk Inlet

Metals have been monitored in Hawk Inlet sediment and selected marine organisms prior to and during mining operations. Pre-mining sampling was conducted to provide a baseline condition to help determine if metals were potentially causing adverse conditions to native biota and to compare to future conditions once mining operations began. Originally 10 parameters were sampled in sediment and marine organism tissues: silver (Ag), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn). Various studies assessing metals in water, sediment, and organisms were conducted prior to full production beginning in 1989 including (IEC 1980), Holland et al. (1981), and Oceanographic Institute of Oregon (OIO 1984–1988) (all as cited in Oceanus 2003). The OIO studies set the parameters for the monitoring program that would be conducted once the project began; the program identified the metals and biota to be sampled as well as the sample locations. The sampling stations established for this study and carried on through project development and operations are shown in Figure 3.5-2. Some modifications to the sampled parameters and sample locations have occurred over time to adapt to changing conditions and operations (Oceanus 2003; HGCMC 2011).

Oceanus (2003) summarized and compared sediment and tissue data for the 10 monitored metals against a variety of national standards to help compare baseline and operating conditions in Hawk Inlet and assess the level of concern for metals in this environment. For pre-mining condition comparisons, only stations S-1, S-2, and S-3 were consistently monitored prior to mine development. Comparisons of the average metals concentrations in Hawk Inlet sediment prior to mine development indicated that many metals at various locations exceeded the National Status and Trends levels for low level effects to organisms. Average chromium and nickel values were exceeded at all Hawk Inlet sites. The arsenic and copper values were slightly above these guideline levels at station S-3.

3.7.2 Aquatic Resources – Baseline Conditions

Existing conditions for the freshwater and marine environments are summarized below. The characterization is based primarily on monitoring selected streams and Hawk Inlet as part of the mine's monitoring program. The monitoring results for Hawk Inlet are compared between the pre-mining environmental conditions to the conditions following the initiation of mining activities that began in 1989.

3.7.2.1 Baseline Conditions – Aquatic Resources – Freshwater

Greens Creek Mine operations include roads; process, storage, and transport facilities; and instream structures that affect the freshwater environment of the project area. The A and B roads include multiple stream crossings in the Greens, Zinc, Tributary, Cannery, and Fowler Creek watersheds. A total of two Class I, four Class II, and two Class III stream crossings occur along these roads. The existing TDF intercepts some drainage area and flow from the Cannery Creek and Tributary Creek drainages, but has not directly impacted fish bearing stream channels. As discussed in Section 3.5.2.1, non-contact surface runoff from native areas is diverted from contacting disturbed area or the TDF using upslope ditches. Depending on the location, the ditches direct the runoff to either Cannery Creek or Tributary Creek. A weir installed on upper Greens Creek, near the mine and mill facilities, blocks upstream passage of fish including anadromous fish although anadromous fish could not naturally access this area. However, in 1989, the mine operator developed a fish passage facility in a rock chute at river mile 3.6 at a naturally impassible stream segment (Scannell and Paustian 2002). Since the mine has been in operation multiple monitoring activities have been conducted in the affected area including an assessment of water quality conditions (see Section 3.7.1.1, Aquatic Resources – Freshwater) and an aquatic biomonitoring program at several of the site area streams beginning in 2001. Aquatic biomonitoring is conducted annually, including three sites on Greens Creek. The aquatic biomonitoring program includes measurements of stream periphyton, benthic macroinvertebrates, and fish (Scannell and Paustian 2002; Durst and Jacobs 2010, and others). One site on Greens Creek (Site 48) is located upstream of all mine activity and is monitored annually. The second site (Site 6) is downstream of the mine portals and mill facilities but upstream of the waste rock storage area (Site 23); Site 6 is sampled every five years. The third site on Greens Creek (Site 54) is located below all mining activities and waste rock storage and is sampled annually. Tributary Creek (Site 9) is downstream of the TDF and is sampled annually.

Periphyton

The periphyton abundance and trends, based on chlorophyll pigment analysis, was similar among the Greens Creek sites sampled (sites 54 and 48) (Kanouse 2011). Periphyton abundance was lowest during 2001, 2002 and 2008. Peak values occurred from 2003 to 2006 when stream flow was low. Tributary Creek (Site 9) had similar trends with the highest abundance during 2001 to 2005 and lower values during 2006 to 2010. Based on pigment composition, the Tributary Creek site showed more variability than the two Greens Creek sites. The differences in site specific natural environmental conditions relating to flow, stream cover, and morphology correspond to the observed differences in species distributions.

Benthic Macroinvertebrates

Generally high Ephemeroptera, Plecoptera, and Trichoptera levels indicate a relative abundance of taxa intolerant to pollutants.

Benthic monitoring studies have presented data on abundance (as measured by number of insects per net), density (number of insects per cubic meter of water), richness (as measured by the number of taxa represented), and the percentage of Ephemeroptera, Plecoptera, and Trichoptera versus Chironomidae within the project area. The benthic community of the Greens Creek sites was similar being dominated by mayflies (Ephemeroptera) and much fewer stoneflies (Plecoptera) and aquatic true flies (diptera consisting of midge and black fly larvae) (Durst and Jacobs 2010). Overall the Ephemeroptera, Plecoptera, and Trichoptera levels on all three monitoring sites were high, especially at both Greens Creek sites. Tributary Creek was dominated less by mayflies and contained more non-insect taxa than other sites. Densities for all sites were lower statistically in 2005, 2006, 2007, 2008, and 2009 compared to 2003 when all sites showed a peak in overall density. Taxa richness, which can be an indicator of water quality conditions, was also statistically higher in 2003 and 2004 compared to 2009. As with periphyton, the differences among stations likely result from differences in channel morphology, riparian cover, flow rate, and flood frequency. The higher flow peaks in Greens Creek relative to Tributary Creek may contribute to lower taxa richness in the two Greens Creek sites (sites 48 and 6). Overall the high portion of taxa intolerant to pollution present in all streams, well developed complex community structure, and similarity between the control and treatment sites on Greens Creek provide an indication that no marked adverse effects have occurred to stream ecology in these systems.

Fish

As noted previously, historical accounts describe fish presence and relative abundance in local streams. Additionally, streams in the project area have had varied composition and abundance of adult salmon. The current aquatic monitoring program examines fish abundance, composition, and metals concentration in whole body fish tissue.

Anadromous Fish Escapement

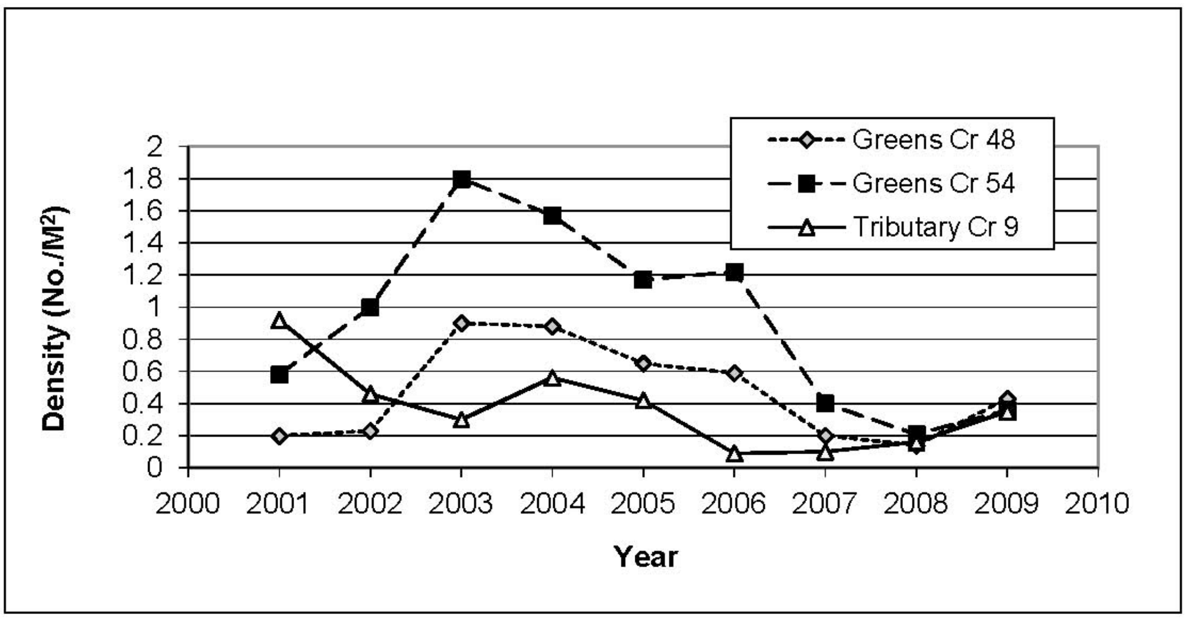
Salmon use of the project area streams is common with an index number of spawning fish, based on observed peak count escapement, ranging from 0 to about 100,000 fish depending on stream and fish species. Peak escapement counts are available for seven of the project area streams, including Greens, Zinc, and Fowler creeks, which could be directly affected by the mine’s activities. Survey records are variable among the streams so complete comparisons among streams are not possible. Greens Creek has been consistently surveyed since 1960, while surveys of other streams were more spotty. Aerial surveys have also been the most consistent method of surveying, although foot surveys are more accurate, especially for species composition.

The purpose of most spawning surveys has been primarily to index pink salmon, so information on chum salmon was secondary (Geiger and McPherson 2004). However, some general conditions are apparent. Overall, escapement peak count for pink salmon in Greens Creek was typically about 7,400 pink salmon and has been as high as 100,000 pink salmon. Other streams in the area have had typical peak escapement counts of about 1,000 to 2,000 pink salmon. Based on a 47-year aerial survey period, the median peak escapement for Greens Creek has been about 1,200 chum salmon with observations ranging as high as 11,500 fish. Chum salmon escapement peak counts are much lower in other area streams. These peak count numbers are much less than the total number of escaped salmon attributed to these systems because they represent a point in time and do not account for missed fish.

Fish Monitoring

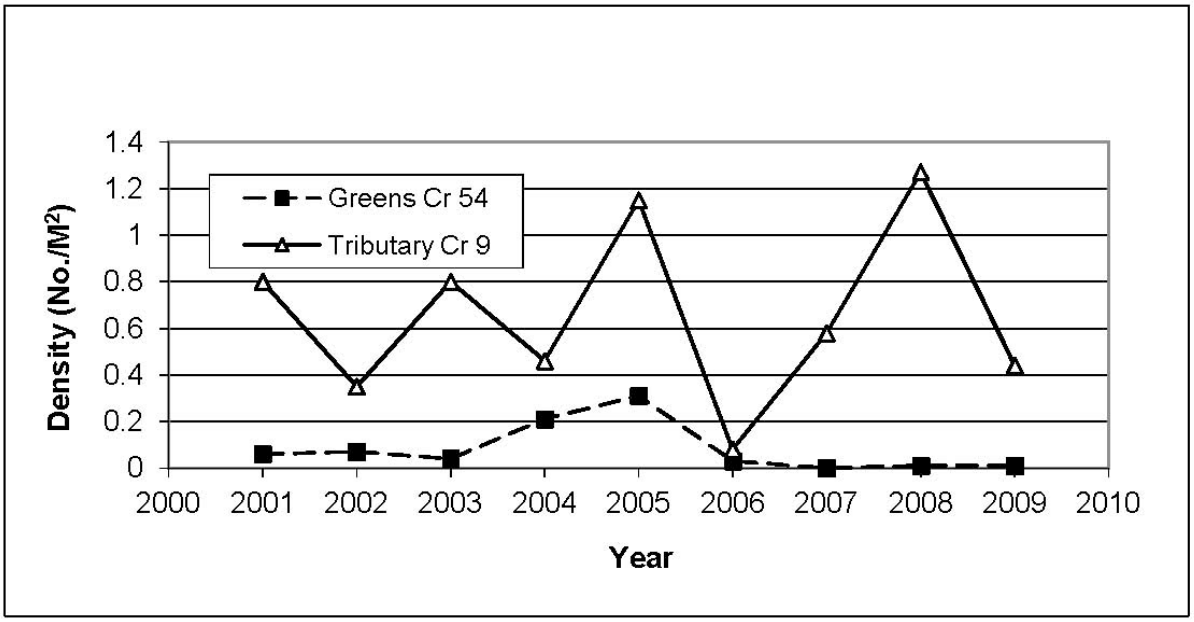
Dolly Varden char density as monitored by minnow traps in the three annual monitoring sites have continued to follow similar abundance patterns over the nine-year sampling period (2001–2009) (Durst and Jacobs 2010) (see Figure 3.7-1). In 2010 Dolly Varden densities were higher at Site 48 than Site 54 for the first time in ten years of monitoring (Kanouse 2011). Based on comparisons with densities of the same channel type in the Tongass National Forest, the 2009 Dolly Varden char density at the upper site was about equal to the average density of Dolly Varden char in the forest, whereas the lower site on Greens Creek was about 20 percent lower than the average forest value. The Tributary Creek Site 9 has been more variable over the years but generally lower in Dolly Varden char density than Greens Creek sites (Figure 3.7-2).

Coho abundance has remained low at Greens Creek Site 54, and has been noticeably lower the last three years (2007–2009) (Figure 3.7-2), remaining low in 2010 (Kanouse 2011). The density at this site was only one-ninth of the forest average for this channel type. Coho salmon density in the Tributary Creek site has been highly variable with no distinct trends, but with values much higher than the Greens Creek site in nearly all years of the study, having highest ever density in 2010 (Kanouse 2011). In 2009, density was greater than 1.5 times the regional average for this channel type.



Source: Durst and Jacobs 2010 et al.

Figure 3.7-1. Dolly Varden Char Density at Biomonitoring Sites on Greens and Tributary Creeks.



Source: Durst and Jacobs 2010 et al.

Figure 3.7-2. Coho Salmon Juvenile Density at Biomonitoring Sites on Greens and Tributary Creeks.

The change in patterns of Dolly Varden char may relate to high flows in 2005 that greatly modified channel conditions in Greens Creek and resulted in continued channel modification of pools, gravel, and large woody debris conditions of this system (Durst and Jacobs 2010). As a result, habitat in local areas may have become less suitable for spawning and rearing Dolly Varden char. The low abundance of coho salmon juveniles at the Greens Creek site may be partly related to these habitat changes. Damage to the fish passage structure sometime around 2005 may have resulted in adult coho salmon having difficulty passing the downstream falls area, as suggested by the low juvenile numbers in the last five years (2006-2010) (Kanouse 2011).

Dolly Varden Metals Concentration

The biomonitoring that began in 2001 has included an assessment of whole body metals concentrations at Site 48 (control – upstream of mining activities) and Site 54 (treatment – downstream of mining activities) noted above. Monitoring of fish tissues metals concentrations is intended as an indicator of whether mining activity may be affecting metals concentrations in stream biota. The tissue metals monitoring was not intended to indicate direct effects to fish but to provide an indicator of how mining operations may influence metal uptake and trends in the biological environment.

Overall, monitoring results of Site 48 and Site 54 on Greens Creek provide an indication that relative metal concentrations in fish are similar above and below the direct mining activity. Comparisons between Site 48 (control) and Site 54 (treatment) indicate that nearly every year no statistically significant difference was apparent between the fish at the two sites for each of the six metals monitored (Durst and Jacobs 2011) (Table 3.7-4).

Table 3.7-4. Number of Years Dolly Varden Char Total Body Metals Concentration Ranked Relative to Indicated Sites (2001-2009).

Greens Creek Site 54 (treatment) Relative to Site 48 (control)						
Relative to	**Silver**	**Cadmium**	**Copper**	**Lead**	**Selenium**	**Zinc**
Higher	0	1	0	1	2	0
Same	9	7	9	7	7	9
Lower	0	1	0	1	0	0
Tributary Creek Site 9 Relative to Greens Creek Sites (54 and or 48)						
Relative to	**Silver**	**Cadmium**	**Copper**	**Lead**	**Selenium**	**Zinc**
Higher	6	1	0	8	2	0
Same	3	6	6	1	6	2
Lower	0	2	3	0	1	7

Source: Durst and Jacobs 2010 et al.

One exception was an increase in lead at the Greens Creek downstream site in 2009 relative to the upstream site, but lead levels observed in fish tissue have been higher in the past at both sites. A dedicated control for the Tributary Creek site was not available but comparison with the Greens Creek sites suggests some differences in metals in the fish. Most often silver and lead concentrations are higher in Tributary Creek Dolly Varden char than in Greens Creek fish, while zinc levels are often lower. The other metals including cadmium, copper, and selenium are usually similar between sample sites at these creeks. The reasons for these trends are not readily apparent but could be caused by metals composition of natural drainage to Tributary Creek or possibly some form of input (groundwater, or surface runoff) from the TDF area. Water quality samples taken from the Greens and Tributary creeks in 2010 tend to mirror these differences with relatively higher lead and silver concentrations in Tributary Creek samples than in Greens Creek (HGCMC 2010; also see Section 3.5, Water Resources – Surface Water). Metals concentrations in Dolly Varden have remained relatively consistent from year to year with little evidence of any trends (increasing or decreasing) over the nine years of sampling.

In summary, the biological conditions at Greens Creek and Tributary Creek have remained fairly robust, as measured by the diversity and productivity during the study period. No trends in reduced ecological function have been observed. However, reduced coho abundance in Greens Creek and reduced benthic abundance in Tributary Creek are conditions that would continue to be monitored by the operator and ADEC.

3.7.2.2 Baseline Conditions – Aquatic Resources – Marine

The general marine physical, habitat and biota conditions, and overall fish and shellfish species noted in the pre-mine conditions in Hawk Inlet area remain unchanged under current conditions. However, past and current harvest of commercial and sport marine species may have changed. Additionally, historic and existing metals concentrations in the marine environment and their uptake by marine organisms may have changed from pre-mining conditions. Local harvest of marine fish and shellfish, and metals concentrations in tissues of these species relative to pre-mine production conditions are discussed in this section.

Commercial and Sport Fish and Shell Fish Harvest

Information on amount of harvest by sport, commercial, and subsistence fishing in the Hawk Inlet area has not been well documented. Some commercial halibut fishing between 1914 and 1976 produced large catches. Apparently between that period and mine opening in 1987, little commercial halibut fishing occurred in the inlet. Also, some commercial crab and shrimp fishing occurred in the inlet. Shrimp and scallop of commercial value have been found in or at the mouth of the inlet.

The Chatham Strait area of southeast Alaska supports substantial harvest of fish and shellfish. Salmon is the largest local harvest. Current harvest in or near Hawk Inlet has also been substantial for some species (Table 3.7-5). Information on harvest within the inlet is limited but it is known to be a popular crabbing area for recreational and commercial fishing.

Table 3.7-5. Commercial Fish and Shellfish Harvest in Hawk Inlet Area, 2001–2010.

	Statistical Area 112-16			Statistical Area 112-65		
	West Mansfield Peninsula (part of Chatham Strait)			Hawk Inlet		
Species	Years	Number	Pounds	Years	Number	Pounds
King Salmon	2001–2010	291	4,264			
Sockeye Salmon	2001–2010	39,163	222,954			
Coho Salmon	2001–2010	25,084	168,410	2001–2010	475	3,158
Pink Salmon	2001–2010	2,452,447	8,640,254			
Chum Salmon	2001–2010	147,278	1,167,476			
Spot Shrimp	2001–2010		Yes	2001–2010		Yes
Sea Cucumber	2002, 2005, 2008		22,718	2002, 2005, 2008		27,483
Dungeness Crab	2001–2010		12,227	2001–2010		15,793
Tanner Crab	2003–2008		Slight	2003–2008		8,547
Golden King Crab	2001–2010		11,215	2001–2010		None
Red/Blue King Crab	3 Years		Slight	3 Years		329

Sources: ADF&G Personal Contacts May 18, 2010: Adam Messmer, David Harris.

Notes:

Salmon pounds are approximate based on average seasonal weights.
All values are yearly average.
Coho Salmon: only troll fishery in Hawk, area 112-16 include troll and seine fishing.
Spot Shrimp: harvest but less than 3 permit holders so no information can be released.
Sea Cucumber: only open these years in last 10 years.
Dungeness Crab: one year had no effort in 112-16 so average for 9 years.
Tanner Crab: no harvest 2001, 2002, 2009, 2010, and limited permit holders using Chatham.
Golden King Crab: Hawk Inlet too shallow for species.
Red/Blue King Crab: only three years in 10 did fishing occur in this area, king crab closed since 2006.

Monitoring for metals was modified when the parameter list was reduced to five based on the EPA National Pollutant Discharge Elimination System permit requirements issued in 2005: cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb), and zinc (Zn). Sediment metal concentrations have been monitored for these five metals allowing levels to be compared at selected sites. Currently only sites S-1 and S-2 are not affected by actions outside of potential mine effects, so only these sites can be compared to pre-mine conditions. A landslide of sediment related to historic mining activities (pre-Greens Creek Mine) located near Site S-3 at the head of Hawk Inlet was thought to potentially affect values at this location. The average and range of values for these five metals for sites S-1 and S-2 are shown in Table 3.7-6. Overall, the average metals concentrations observed during mining operations have been lower than samples from pre-mining. However, some values recorded since mining began are higher than pre-mining years, especially near the Outfall 002 discharge site (HGCMC 2011).

Table 3.7-6. Hawk Inlet Sediment Data: Pre-Production Baseline, Production Period and Current Year Comparison.

	Pre-Production (6/1984-8/1989)			Past Production (9/1989-9/2009)			Current 2010		
Metal	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**
Cd	0.245	0.03	0.87	0.206	0.06	0.89	0.118	0.11	0.13
Cu	18.75	11.9	33	14.8	7.5	39.5	10.2	7.5	13.5
Pb	6.72	2.2	13	5.7	<0.02	23.7	3.94	1.6	6.5
Hg	0.035	0.002	0.094	0.02	0.02	0.14	0.0307	0.02	0.04
Zn	96	52.8	155	74	26.1	185	62.4	33.8	101

Source: HGCMC 2010 Hawk Inlet Monitoring Program Report.

Note: Data are compilation of results from Stations S-1 and S-2.

Two events may have effected metals concentrations at two of the sampling sites, S-4 and S-5 (Figure 3.5-2). Debris from a fire in 1974 at the old cannery affected metals concentrations at sites S-4 and S-5, which were selected to monitor metals near the concentrate loading dock. A concentrate spill occurred in 1989 near Site S-5; although clean-up efforts in 1995 included the use of a suction dredge, pockets of concentrate are still observed throughout the area. Propeller wash from concentrate ships and associated tugboats continues to resuspend these pockets and mix them with natural sediments. Based on sampling results, a rapid increase in metals concentrations occurred after the spill and sample values have been highly varied but remain high relative to metals concentration in other inlet sites. Following attempted cleanup in 1995, Site S-5 was split into two sites: S-5N (at original Site S-5) and S-5S, which now bracket the original spill area (HGCMC 2011). Site S-4 is in the intertidal beach area.

Average concentrations at Site S-4 have increased for all five metals for a time after mining operations began relative to pre-mining concentrations. However, the average concentrations for this station have been decreasing since at least 2002 with the averages for all five parameters in 2009 less than they were in 2002 (Oceanus 2003; HGCMC 2011; Table 3.7-7). Recent average concentrations at the S-5N and S-5S sites were much higher than at S-4 (Table 3.7-7). At Site S-5S, concentrations of cadmium, copper, and lead have remained about the same from 2002 to 2009 while mercury concentrations have increased, and zinc concentrations have decreased.

Table 3.7-7. Average and Standard Deviation Values for Preproduction and Production Sediment Data.

Metal (mg/kg dw)	S-1				S-2			
	Pre-production (9/1984 – 8/1989)		Production (9/1989 – 9/2009)		Pre-production (9/1984 – 8/1989)		Production (9/1989 – 9/2009)	
	avg	stdev	avg	stdev	avg	stdev	avg	stdev
Cd	0.253	0.222	0.248	0.186	0.236	0.119	0.174	0.083
Cu	22.50	5.19	17.9	7.3	15.0	2.68	12.1	4.15
Pb	8.175	2.628	8.80	4.58	5.26	2.16	2.85	1.79
Hg	0.0441	0.0209	0.0317	0.0341	0.0253	0.0150	0.0086	0.0204
Zn	129.18	11.55	102.9	31.3	62.9	6.7	46.4	13.9
Metal (mg/kg dw)	S-4				S-5N		S-5S	
	Pre-production (9/1984 – 8/1989)		Production (9/1989 – 9/2009)		Post spill (9/1989 – 9/2009)		Post spill (6/1995 – 9/2009)	
	avg	stdev	avg	stdev	avg	stdev	avg	stdev
Cd	0.761	1.097	0.933	0.909	13.3	41.4	3.85	3.90
Cu	49.0	19.3	54.4	57.0	260.4	394.8	84.6	43.6
Pb	108.2	136.8	120.3	138.6	1062	2424	260.2	202.8
Hg	0.115	0.083	0.216	0.612	2.09	5.75	0.391	0.311
Zn	179.2	125.5	190.6	189.3	2141	5643	804.1	785.4

Note: Underlined averages are higher than pre-production averages. Pre-production data are not available for sites S-5N and S-5S.

Oceanus (2003) noted that metals concentrations at S-4, S-5N, and S-5S often exceeded the lower ERL (effects range low) guideline levels[1] and occasionally exceeded the higher effects ERM (effects range medium) guidelines through 2002. For station S-4, ERL guidelines for sediment metal concentrations were exceeded during the whole motoring period for all ten parameters and most often for copper, lead, nickel, and zinc. The higher level effects ERM guidelines were exceeded most often for lead and zinc. Exceedences of the sediment concentrations guidance levels occurred both before and after mining began for all of the metals, but with greater frequency and for more parameters from the time mining production began through 2002.

[1] National Status and Trends (non-regulatory) numerical sediment quality guidelines (NOAA 1999) relating to ranges of biologic effects of various metals in sediment:

Effects Range Low (ERL) = Based on the 10th percentile of effects observations – ERL is indicative of concentrations below which adverse effects rarely occur.

Effects Range Median (ERM) = Based on the 50th percentile of effects observations – ERM are representative of concentrations above which effects frequently occur.

The metals levels observed through 2002 could be toxic to bivalves amphipods and burrowing organisms in Hawk Inlet. However the decrease in metals concentrations from 2002 to 2009 is expected to continue.

Metals in Mussels

Mussels were collected at four sample sites (1, 2, 3, and ESL; see Figure 3.5-4) for metal analysis. These sites were selected to monitor the metal accumulation in close proximity to the Outfall 002 discharge location. Oceanus (2003) compared trend data for ten metals compared to Alaska Mussel Watch values at these same four sites. Alaska Mussel Watch values are average values collected from various stations in Alaska and are only used for comparison purposes; values are not indicators of metal effects in mussels. Oceanus noted that average arsenic, chromium, copper, lead, mercury, nickel, and selenium concentrations increased from the pre-mine period to the production period; however, increases were slight except for chromium, copper, and lead. Average concentrations during mine production did not deviate substantially from the Mussel Watch averages; concentrations at the sites overall were markedly higher for cadmium, slightly higher for lead and nickel, and lower for arsenic, copper, mercury, selenium, and zinc though 2002.

Updated data through 2010 show a slightly different trend for the five metals being surveyed in mussels (HGCMC 2011). Average values for cadmium, copper, and zinc are similar to pre-mining averages, and the value for mercury has decreased. However, the average for lead increased and is now about 5 times higher than pre-mining average. Average production-period lead in mussel tissue also exceeded the Mussel Watch value for Alaska reported in 2002. A potential increasing trend of lead throughout Hawk Inlet was suggested by Oceanus (2003). The Oceanus study noted that data from the U.S. Fish and Wildlife Service (USFWS) study showed increases in lead at Hawk Inlet similar to those observed at the outfall sampling area; so these increases may be naturally occurring. Overall, of the five metals currently being monitored, only lead concentrations in mussels appear to have increased since mine production began.

Metals in Polychaete Worms

The polychaete worm (*Nephtsy procera*), which inhabits soft sediment, had been historically sampled at stations S-1, S-2, S-3, and S-4. But as noted for sediment metals, Site S-3 was dropped from sampling after 2004. Oceanus (2003) reported results and trends in metals monitoring in this worm through 2002. The study noted that concentration averages of S-1, S-2 and S-3 increased most noticeably for chromium, lead, and nickel, with other metals remaining unchanged or decreasing from pre-mining levels. Station S-4 showed metal concentrations increases for arsenic, chromium, copper, lead, nickel, and silver, with only lead and silver showing large increases (more than 5 times higher). Data through 2010 show similar trends (HGCMC 2011). During the production period, average values of cadmium and zinc decreased from pre-mining concentrations for worms at stations S-1 and S-2, and increased for copper, lead, and mercury, with the largest relative change for lead (about twice pre-mine values). 2010 results show a marked reduction in the lead values. For Site S-4, near the loading dock, mining period levels remained elevated from pre-mining for cadmium, copper, and lead, but lower for mercury and zinc. Again the most noticeable difference is in lead, which is about three times greater than pre-mining levels. The lead levels in the worm at S-4 increased dramatically from 1990 to 1993 and have been gradually decreasing since 1995 with levels after about 2003 near pre-mining concentrations in worms (HGCMC 2011).

The levels of toxicity of lead or other metals in these or other worms are unknown. However, even shortly after the 1989 spill when concentrations were at their highest, these worms were present near Site S-4. The worms also continue to be present in the area. The level of harm, if any, of the metals being passed into the local food chain is unknown, but benthic polychaetes are a common food source for many marine fish species. Fish species in Hawk Inlet most likely to be present in the project area that would consume polychaetes and many other benthic organisms would include rock sole, yellowfin sole, starry flounder, and arrowtooth flounder. Most individuals, however, undergo local, seasonal (e.g., spawning), and regional movements and migration, so the chance of individual fish feeding specifically on local organisms to a level causing marked bioaccumulation or direct toxicity appears remote.

Overall Marine Conditions

While specific information is not available for Hawk Inlet, the inlet appears to be supplying an abundant and diverse environment for marine sport, non-sport, commercial, and recreational fisheries resources. The common use of this area for harvest of marine resources including crab, shrimp, demersal fish, and salmon; abundant production of salmon in the local streams; and anecdotal observations by fishermen suggest Hawk Inlet has remained productive since mining operations began. Systematic monitoring of biological and sediment resources indicate that there have been increases in some locations in some metal concentrations in sediment and benthic resources. The levels of these metals appear to be influenced heavily by natural conditions in the area; the region is a natural supplier of metals from the surrounding stream basins. However, some increases have occurred since mine production began, which appear to be local such as near the loading dock. There are no distinct indications of direct effects of metals to this environment although some degradation of the overall habitat is possible. Previous whole effluent toxicity tests of mine effluent did not detect levels of adverse effects to tested marine organisms (as a result, the testing was discontinued in 2005) (HGCMC 2011). The level of transfer of metals into the higher levels of the food chain is unknown. Overall, however, monitoring results indicate that the marine system in the vicinity is healthy.

The current project facilities including the dock and transit of concentrate shipping vessels may have some effect on local conditions. The dock facility would affect local habitat (e.g., shading) and possibly local shoreline fish movements. Ship traffic for concentrate transfer can cause local disturbance of fish from boat wakes, movement, and noise.

3.7.3 Aquatic Resources – Environmental Consequences

Factors that affect freshwater and marine resources relative to the TDF expansion alternatives are varied. Project-related habitat alterations and water quantity or quality changes may affect aquatic resources.

Impacts to freshwater resources could occur from loss of habitat resulting from modifications or reductions in flow to those habitats. Water quality could be affected by spills from concentrate and tailings haul trucks. Additionally, land disturbance near streams or from road surface runoff could increase sediment in streams. Construction of roads over fish streams can affect fish passage success, including upstream passage of adult and juvenile fish. Land clearing near streams can influence stream habitat in the short and long term. Thus, project actions that affect the following factors are of most concern in assessing potential effects to freshwater resources:

- Flow reductions to stream systems;
- Water quality changes;
- Sedimentation of stream habitat;
- Fish passage and habitat access;
- Instream habitat modifications; and
- Permanent habitat loss.

Concerns differ from freshwater to the marine environment. Permitted discharges of treated wastewater could potentially affect fish, shellfish, and other organism survival and production. Suspended matter in discharges and actions near piers could affect local area habitat conditions. Transportation activity has the potential to cause harm should a major spill of concentrate or fuels occur. Thus, the following indicators are used to evaluate potential effects to marine resources:

- Water quality modifications that affect resources of concern; and
- Habitat modifications.

3.7.3.1 Effects Common to All Alternatives

The common effects to freshwater and the marine system are those that would occur from ongoing operations, reclamation/closure and ongoing site maintenance following closure of the TDF (e.g., continued operation of the Pond 7 WWTP). While the overall duration and location of TDF operations and the location of subsequent closure and reclamation would vary among alternatives, types of effects and general magnitude would be similar among alternatives. Since mining would continue to some degree before closure began under any alternative, operational-related effects are discussed in the separate alternatives subsections.

Freshwater

The construction of the TDF reclamation cover at closure would include hauling material along the roadway possibly from off-site areas and some additional road work within the lease area. This action poses a slight risk of sediment runoff to freshwater fish streams including Greens, Fowler, Zinc, and Tributary creeks. Sediment increases in streams could affect periphyton and benthic organism production and fish spawning success.

The risk of a fuel and other hazardous substance spill to streams from road transport exists should an accident result in the release of concentrate, fuel, or a hazardous substance near streams. Such hazardous substance spills into streams could cause local mortalities of aquatic resources including fish with some short- and long-term effects depending on magnitude and location of the spill and the effectiveness of the response and clean up. However, past operations including fuel and chemical transport have had a few small (less than 100 gallon) incidents of fuel or other materials entering streams. Greens Creek Mine has a detailed Spill Prevention Control and Countermeasures (SPCC) Plan addressing procedures to be followed to prevent spillage of all hazardous liquids to water systems. With the SPCC Plan in place, including personnel training, the chance of impacts to streams from spills of this type would be limited.

Because seepage and runoff from the tailings is captured, treated, and discharged to Hawk Inlet, it is removed from the system and does not impact freshwater aquatic resources. Treatment of tailings contact water will be required for at least 100 years and likely longer to ensure Alaska WQS are not exceeded. Currently, treated water goes to the marine discharge.

Monitoring of stream biota and water quality similar to the monitoring currently occurring in Greens and Tributary creeks would continue until such time that ADEC is confident that the discharges would meet Alaska WQS and no future impacts would be anticipated. The actual schedule and criteria for termination of monitoring would be determined through agency coordination as set forth in GPO Appendix 14, Reclamation Plan.

Diverting non-contact runoff around the TDF could increase peak flow velocities in the natural stream channel during large storm events. This could potentially cause erosion of channel substrates and impact channel geomorphology. These potential impacts could be mitigated by using a storm water detention structure or detention pond at the confluence of the diversion and the natural channel. While it is anticipated that a storm water detention structure would mitigate the effects of the increased flow velocities, the Forest Service and ADEC may require HGCMC to conduct habitat surveys in Tributary Creek downstream of the TDF expansion area to detect unanticipated effects, if any. This program would be developed and incorporated into the GPO as it is updated to reflect the selected alternative.

Mitigation

During the 1983 EIS process, the mine operator reached agreement with agencies about mitigation for potential lost fish production by creating upstream fish passage on Greens Creek at river mile 3.6. This passage improvement was constructed in 1989 to supply about 6.5 acres of spawning and rearing habitat for anadromous fish. This fish passage facility, however, has not been properly functioning since at least 2005. This facility will be repaired and maintained to again provide adult fish passage (ADF&G October 26, 2011, Draft Fish Habitat Permit FH11-I-0123). The fish passage project was constructed despite the fact that the project that it was considered mitigation for was never developed and therefore can still be mitigation for the lost habitat associated with the proposed action or the either alternative. An estimate of benefit of this passage facility relative to potential coho salmon smolt production can be developed using the Tongass Forest Aquatic Habitat Management Handbook FSH 2090.21 (43 - Exhibit 01). When repaired, the passage facility will allow access of anadromous species to about 18,400 feet of stream. Based on the channel type, this method assumes that 0.10 coho smolts are produced per linear foot of stream length. Applied to the length of anadromous habitat currently available above the fish passage facility, the potential production is estimated to be about 1,840 coho salmon smolts. This benefit would be present for any alternative as long as the fish passage is maintained as required.

However, the Forest Plan (USDA 2008) emphasizes protection of habitat over mitigation. The Forest Plan states “Stress the protection of fish and wildlife resources habitat to prevent or minimize the need for mitigation.” Thus, actions that can be taken to eliminate the need for mitigation are preferred. Due to the ubiquitous nature of fish habitat within the project area and the size of the project (TDF footprint and associated facilities), No Action Alternative completely avoids direct or indirect effects to aquatic habitat. The selection of the north TDF site proposed under alternatives C and D was partly influenced by the fact that no ADF&G or Forest Service streams were mapped at the north site and previous studies (Buell 1981) had not identified fish bearing streams in the area. Ground truthing in 2011, however, identified resident fish in some previously unmapped streams.

Marine Waters

As noted for freshwater, predicted discharge water would not meet Alaska WQS without treatment; thus treatment would be required for hundreds of years, perhaps in perpetuity, in order to meet Alaska WQS. Meeting water quality discharge requirements would ensure the protection of beneficial uses of the waters, including aquatic life. With cessation of concentrate transport, the risk of concentrate spills near the loading facility affecting the marine environment would be eliminated. Other types of marine spill hazards from fuel or other chemical delivery to the marine environment would also be eliminated or substantially reduced compared to current conditions. Overall, the risk and related impacts would not be substantial after closure.

3.7.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceases, disturbed sites are reclaimed, and human activity in the area is reduced. The TDF would continue to be built out to the maximum footprint and height permitted in the 2003 EIS (USFS 2003). After the TDF is fully built out in 2014, reclamation would begin as described in USFS 2003.

Since mining would cease in about two years under this alternative, sources of impact are primarily those related to closure as described in Section 3.7.3.1, Effects Common to All Alternatives.

Freshwater

The potential for higher concentrations of metals such as lead and silver in Tributary Creek Dolly Varden could continue during the remaining two years of operations. These elevated metals levels in fish, though higher than Greens Creek, have not shown any increasing trends over the ten years of monitoring. Thus, they are expected to remain similar over the remaining years of operation. Additionally, adverse effects to periphyton, benthic macroinvertebrates, or fish have not been observed as a result of the higher metals concentrations in fish. Potential changes in some metals levels in Greens Creek, if related to mining, may continue in the short term; however, metals levels have remained relatively consistent in the control and treatment sites, so short-term changes for the remaining operating period appear unlikely. Also, the aquatic environment has not shown effects or changes from the ongoing mining operations that differ noticeably from natural conditions.

As discussed in Section 3.5.3.2, completion of the TDF under Alternative A would reduce the watershed area approximately one percent. Flows in Tributary Creek would only be slightly affected because upper basin surface runoff and up-gradient groundwater is diverted around the TDF back to the creek. Non-contact surface runoff would continue to be routed directly in diversion channels, potentially increasing peak flow velocities in natural stream channels during large storm events. This could potentially cause erosion of channel substrates and impact channel geomorphology and habitat. These potential impacts could be mitigated by using a storm water detention structure or detention pond at the confluence of the diversions and the natural channels. While it is anticipated that a storm water detention structure would mitigate the effects of the increased flow velocities, the Forest Service and ADEC may require HGCMC to conduct habitat and or surveys in Tributary Creek downstream of the TDF expansion area to detect unanticipated effects, if any. This program would be developed and incorporated into the GPO as it is updated to reflect the selected alternative.

Only minor impacts to both anadromous and freshwater fish would be expected from reduced stream flow. These impacts would be similar to current conditions. No direct loss of stream habitat and corresponding potential fisheries production from burial of stream channels would occur with this alternative (Table 3.7-8 shows loss by habitat, Figure 3.5-5).

Table 3.7-8. Stream Habitat and Estimated Coho Salmon Smolt Potential Production lost by Stream Class.

		Estimated Stream Length Lost and Modeled Coho Salmon Smolt Potential Lost						
		Tributary			Fowler			Grand Total
Alternative	Parameter	Class I	Class II	Total	Class I	Class II	Total	
Alt A	Length (ft)	0	0	0	0	0	0	0
	Coho Smolts	0	NA	0	0	NA	0	0
Alt B	Length (ft)	1,646	2,400	4,046	0	0	0	4,046
	Coho Smolts	66	NA	66	0	NA	0	66
Mitigated Alt B	Length (ft)	1,248	1,169	2,416	0	0	0	2,416
	Coho Smolts	66	NA	66	0	NA	0	66
Alt C	Length (ft)	0	0	0	0	1,044	1,044	1,044
	Coho Smolts	0	NA	0	0	NA	0	0
Alt D	Length (ft)	0	0	0	0	1,044	1,044	1,044
	Coho Smolts	0	NA	0	0	NA	0	0

Source: Aquatic Habitat Management Handbook FSH 2090.21 (43 - Exhibit 01), for coho smolt production model.

Class I= anadromous fish streams; Class II=resident fish streams.

Marine Waters

Beyond the expected life of the mine and closure in 2014, effects to marine biota and habitat for this alternative would be the same as described in Section 3.7.3.1, Effects Common to All Alternatives. Operational effects would be similar to those discussed below for Alternative B but for a shorter duration (about 2 years).

3.7.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the existing TDF would be expanded southward. The expanded TDF and associated infrastructure (water management ponds, quarries, and new support roads) would result in impacts to aquatic resources including the filling of portions of Tributary Creek and adjoining wetlands (see Section 3.10, Wetlands).

Freshwater

Monitoring data show that mine operations have not affected aquatic organisms including periphyton, benthic macroinvertebrates, or fish. These conditions would likely remain similar in the future under Alternative B. With continued operations, road runoff near streams may add cumulative sediment to these systems along Greens, Zinc, and Fowler creeks. Sediment increases to Greens Creek based on all mine operations were previously estimated to be about 7 to 12 percent per year above baseline conditions, which was considered to be within annual natural variability of sediment supply (USFS 1983, 1988). Since the amount of roads within the basins is low and traffic volumes are restricted, sediment input should remain below levels that would cause substantial effects and annual peak flow levels are expected to continue to remove fine substrate from these systems.

As discussed in Section 3.5.3.3, the Tributary Creek watershed would be reduced approximately 22 percent under this alternative. However, the flow reduction to Tributary Creek is expected to be less than 22 percent because surface water runoff east of the TDF will be diverted back to the groundwater system through the use of a slurry wall and underground drainage system (see Section 3.5.3.3). The flow reduction has the potential to reduce the quantity of habitat in Tributary Creek even if it is less than the overall portion of the basin area diverted. Slight effects to flows in the lower portion of Zinc Creek could also occur. Flow in Tributary Creek, however, is only 17 percent of the combined flows of the Zinc Creek and Tributary Creek basins so the flow reduction in Tributary Creek would have little or no perceptible change in flow in lower Zinc Creek. Additionally, the change in Tributary Creek headwater flow timing, volume, and pathway could affect stream temperature. However the direction and magnitude of change cannot be estimated as the relative contribution of flow (i.e., surface water, which responds more rapidly to air temperature, compared to groundwater, which has more moderate changes) is not known. Once flows reach the stream they typically equilibrate to local stream temperatures which are the result of shading and air temperatures (Hetrick et al. 1998; Poole et al. 2001), so adverse effects of temperature changes are unlikely. Some loss of food source to the stream may occur from loss of upstream non-fish habitat. While organic fish food sources from non-fish stream segments upstream of fish reaches contribute to downstream areas, this contribution is generally a small portion of total food sources (Wipfli and Baxter 2010). Also, because of the low gradient in this basin, nearly all stream segments affected would be fish bearing. Thus, the loss of non-fish bearing, food supplying, stream segments would be minimal.

Similar to Alternative A, diverting non-contact runoff could increase peak flow velocities in the natural stream channel during large storm events. This could potentially cause erosion of channel substrates and impact channel geomorphology and habitat. These potential impacts could be mitigated by using a storm water detention structure or detention pond at the confluence of the diversion and the natural channel. While it is anticipated that a storm water detention structure would mitigate the effects of the increased flow velocities, the Forest Service and ADEC may require HGCMC to conduct habitat and or surveys in Tributary Creek downstream of the TDF expansion area to detect unanticipated effects, if any. This program would be developed and incorporated into the GPO as it is updated to reflect the selected alternative.

About 4,000 feet of Class I and II streams in the Tributary Creek watershed (Table 3.7-8) would be directly lost to the TDF expansion. This represents about 50 percent of fish habitat in Tributary Creek by length. Fill from past development in the Tributary Creek watershed was limited to non-stream areas. The proposed activities for this alternative would reduce spawning and rearing habitat and ultimately anadromous and resident fish production in these streams. The loss would be primarily of small resident fish stream habitat. Overall, potential production of coho salmon smolts from direct habitat burial loss is estimated to be about 66 smolts for the 1,600 feet of class I stream that would be lost. The maximum loss of this habitat from burial would occur at full build-out with most of the changes occurring gradually over a 30- to 50-year period. The maximum loss would occur at mine closure and would be permanent. Depending on the drainage patterns reestablished at reclamation and the success in meeting Alaska WQS for freshwater, near natural flows could be returned to Tributary Creek sometime after closure. If WQS could not be met and TDF runoff could not be restored to near natural conditions, flows in Tributary Creek would continue to be reduced, continuing habitat reduction in Tributary Creek and, to a lesser extent, Zinc Creek (Figure 3.5-5).

Marine Waters

Several metrics were used to assess likely effects of the existing discharge and loading operations on the marine biotic environment. It is expected that past patterns of metals in the environment and organisms would continue during the operating life of the project under Alternative B and, in the vicinity of Outfall 002, beyond.

With continued operation for another 30 to 50 years, the chance of accidental spills of concentrate during loading or transport would continue. However, since the 1989 spill, no observed spills or leakage of concentrate to the marine environment have been documented. While the monitoring program has indicated some metals have remained elevated near the loading dock, there is no indication of a trend of increasing metals concentrations and such a trend is not anticipated to develop under Alternative B.

Large fuel spills from offloading to the terminal or during transit of the fuel vessel is also a risk that would continue for the duration of operations (30–50 years). Typical fuel barge offloading to a 200,000-gallon storage facility occurs about every 10 days. The largest reported spill to marine waters at the site was 3,000 gallons and occurred in 1989 during an offloading. In the entire project area all other documented spills were less than 100 gallons. The Greens Creek Mine has a detailed SPCC Plan addressing procedures to be followed to prevent spillage of all hazardous liquids to water systems. While the risk of spills at the dock seems remote, effects of a spill near the dock could have substantial short-term adverse effects and some potential long-term effects. The effect would depend on weather, tides, size, location, and material involved in the spill. While there is substantial water exchange locally, Hawk Inlet is a confined bay and the confined nature of this area would aid in retaining much of a spill in the inlet where it could impact shoreline intertidal areas. Depending on the season and where a spill occurred, various resources could be affected. For example, during early spring pink and chum salmon rear in shallow shoreline areas. With the substantial salmon runs into several of the Hawk Inlet tributaries the number of early rearing fish potentially exposed to hydrocarbons could be high. But these fish may actively move away from toxic concentrations thereby reducing effects. There is a substantial intertidal community; especially at the head of the inlet where extensive shallow areas could be affected by a spill. Dissipation and evaporation of oil and fuel would limit effects over time. However, spill control plans and rapid response to spills would be the primary mitigation measures to avoid or minimize adverse spill effects to marine resources. The confined nature of Hawk Inlet aids cleanup and response actions compared to unsheltered waters, potentially retaining much of a spill within a smaller area and reducing effects outside of the inlet. HGCMC maintains marine spill response equipment onsite and fuel barge unloading is closely monitored by trained employees to ensure rapid response in the event of a spill. Additionally, HGCMC maintains an active membership in the Southeast Alaska Petroleum Resource Organization. This membership makes available substantial quantities and types of response equipment and personnel in the event of a petroleum spill as well as training and support.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. The relocation would moderately reduce the amount of fish habitat directly lost from direct burial of Tributary Creek stream channels. Compared to Alternative B without mitigation, this measure would preserve about 1,230 feet of class II resident fish streams in the Tributary Creek watershed (Table 3.7-8). Loss of anadromous fish stream channel would be reduced by 400 feet. Mitigated Alternative B would reduce the acreage impact to the Tributary Creek watershed from 22 percent to 17 percent (Figure 3.5-5). The slight difference in wetlands impacted may produce a very minor improvement in flow attenuation and groundwater discharge to Tributary Creek compared to Alternative B. Relocation of the reclamation material storage area may also provide a small improvement in shallow groundwater discharge to Tributary Creek compared to Alternative B. Other effects would remain similar to Alternative B (Figure 3.5-5).

3.7.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF located adjacent to the Fowler Creek drainage. Additionally, the A Road would be upgraded for about 3 miles and additional facilities would be constructed. Alternative C would also extend the operating period of the mine by 30–50 years. Effects to aquatic resources would be more widely spread than in alternatives A and B due to the development of a new TDF and supporting infrastructure.

Freshwater

Conditions in Greens and Tributary creeks relative to metals, sediment, and flow would remain the same as alternatives A and B for the first few years because tailings disposal would continue in this area while the new TDF site was being developed.

Effects to Tributary and Zinc creeks would be similar to those described for Alternative A, the No Action Alternative. The Tributary Creek watershed would be reduced by an additional 2.8 percent and the Cannery Creek watershed would be reduced by 3.5 percent. The diversion of flows would continue to slightly reduce spawning and rearing habitat and ultimately anadromous fish production in these streams similar to Alternative A. Expansion of the TDF in the Tributary Creek watershed would be completed within about 3 years beyond that of Alternative A. The habitat loss in the Tributary Creek and Zinc Creek watersheds from flow reduction would occur at that time and may be permanent depending on the amount of flow that would continue to be diverted and the duration that contact water would continue to need treatment. No direct stream burial would occur in Tributary Creek with this alternative, so no direct loss of anadromous habitat would occur in these watersheds (Figure 3.5-5).

The north TDF footprint would reduce the area of the Fowler and North Hawk Inlet watersheds. The new TDF footprint would reduce a portion of the Fowler Creek watershed by approximately 2 percent. Only minor effects to both the base flow and storm flows of Fowler Creek would be expected. Up-gradient groundwater would be routed to Fowler Creek. One effect would be the burial of about 1,080 feet of stream channel determined to be resident fish bearing (based on sampling in the summer of 2011 [Tetra Tech 2011]) and a few small beaver ponds (Table 3.7-8). About 1,044 feet of small class II resident fish streams would be lost. This would result in permanent loss of mostly rearing and some spawning habitat of resident fish. Overall, stream channel loss is a small portion of Fowler Creek, which has over 132,000 feet (estimated) of channels in the watershed. Fowler Creek has the potential to support anadromous fish downstream of the north TDF site (see Section 3.7.1.1 for North Hawk Inlet for stream characteristics). Additionally, reduced flow to the downstream channel in Fowler Creek would result in some loss of rearing habitat from minor flow reductions.

The proposed new TDF may slightly reduce flows in two small stream channels that drain north to Hawk Inlet. These channels are not indicated on ADF&G or Forest Service stream databases. No fish were observed during limited surveys in summer 2011 (Tetra Tech 2011); however, one of these streams (furthest west), was determined to potentially provide resident fish habitat. Because of the limited habitat in the area, effects to freshwater aquatic resources in the streams draining north to Hawk Inlet would be minor (Figure 3.5-7).

Potential impacts to stream channel substrates and channel geomorphology from non-contact diversions would be the same as described for alternatives A and B, except that impacts could also occur in the Fowler Creek watershed. These potential impacts could be mitigated by using a storm water detention structure or detention pond at the confluence of the diversions and the natural channels. As with Alternative B, additional monitoring is being considered to detect unanticipated habitat and/or geomorphic effects.

It is expected that the existing Greens Creek fish passage structure, when repaired, will provided adequate mitigation for lost habitat in project area creeks, or other project related activities.

The upgrade of the A Road and additional truck traffic have the potential to increase sediment runoff to streams. Traffic on the A Road would be equivalent to current levels on the B Road. Generally, forest roads with high use have greater sediment discharge to streams than those with light use (Reid and Dunn 1984; Kahklen and Hartsog 1999). The route has few stream crossings with most of the draining area flowing to Young Bay through Fowler Creek. The stream channels near this crossing are small, low-gradient, often having beaver ponds and bottoms consisting of fines and organic matter. The limited road length that would contribute sediment to this area, small size of streams, and the presence of ponds containing fine sediment, would result in the potential increase in sediment to the streams having slight or no effect to the aquatic system and likely no adverse effect to anadromous fish segments of Fowler Creek.

A pipeline would be built to carry runoff from the TDF to the existing water treatment facility. Water from the TDF would contain some elevated metals and possibly other chemicals that could cause adverse effects to aquatic systems. A break in this pipeline could result in spillage entering Hawk Inlet or Fowler Creek resulting in impacts to fishery habitat. With procedures in place to reduce the magnitude of a potential spill and lack of proximity of the pipeline to major stream resources, effects from a pipeline break would likely be short term and not substantial.

Effects of a tailings spill would be similar to Alternative B except there would be the possibility of effects of a tailings truck spill occurring in the Fowler Creek drainage as well either spill type in Zinc or Greens creeks.

Marine Waters

Effects would be the same as Alternative B because all major project actions relative to the marine environment including: location, chemical concentrations and amount of discharge are essentially the same as Alternative B under Alternative C.

3.7.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of a new TDF to the north. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than Alternative B but larger than the footprint under Alternative C. The disturbance footprint of the new TDF would be similar to that of Alternative C. Effects to aquatic resources in the northern drainages, including Fowler Creek, would be similar to Alternative C but would not occur for an additional 10 years. Development of new facilities could further impact aquatic resources. The aquatic impacts of this alternative would be more widespread than alternatives A and B as a result of the development of a new TDF.

Freshwater

Conditions in Tributary Creek relative to metals, sediment, and flow would remain the same as Alternative B for up to 20 years because tailings disposal would continue in this area during the operational life of the water treatment facility.

With the reduction in future tailings disposal the Tributary Creek watershed, compared to Alternative B, effects to Tributary and Zinc creeks would be intermediate between alternatives B and C. This alternative would increase the existing TDF area to 73 acres. The total basin area that would have flow diversion would be 98 acres of Tributary Creek and Zinc Creek basins. However, no length of Tributary Creek would be directly lost due to the tailings pile expansion. The design would also require the placement of tailings as well as the construction of a water management pond within the Cannery Creek drainage. Flow reductions would reduce spawning and rearing habitat and ultimately anadromous fish production in each of these streams. The full loss would be permanent depending on future flow diversions, similar to Alternative C (Figure 3.5-5).

With the movement of a portion of the tailings to the new TDF, effects to the Fowler drainage and small creeks draining north to Hawk Inlet would be similar to Alternative C. The direct loss of fish bearing streams from direct burial would be about 1,044 feet, the same as Alternative C (Table 3.7-8). The main difference is the duration of effects would be shorter because fill would begin 15 years later, reducing the period of effect. The magnitude of effect would be similar to the TDF under Alternative C since the total area disturbed would be similar. Overall, effects from TDF development would be permanent. The effect of flow reduction from flow interception of the tailings pile on fish habitat downstream in Fowler Creek drainage would also be the same as Alternative C, resulting in some loss of rearing habitat from minor flow reductions (Figure 3.5-7).

Potential impacts to stream channel substrates and channel geomorphology from non-contact diversions would be the same as described for Alternative C. These potential impacts could be mitigated by using a storm water detention structure or detention pond at the confluence of the diversions and the natural channels. As with Alternative B, additional monitoring is being considered to detect unanticipated habitat and/or geomorphic effects.

Effects of a tailings spill would be similar to Alternative C. There would be the possibility of a tailings spill occurring in the Fowler Creek drainage as well as either spill type in Zinc or Greens creeks watersheds. The period of time during which a spill could affect the Fowler Creek drainage would be less under Alternative D than under Alternative C because of when the construction of the new TDF would begin.

Marine Waters

Effects would be the same as Alternative B because all major project actions relative to the marine environment including location, chemical concentrations, and amount of discharge are essentially the same as Alternative B.

3.7.4 Aquatic Resources – Summary

Aquatic life conditions in the freshwater streams project area and Hawk Inlet appear to remain healthy and similar to pre-mining conditions. Metals concentrations in stream Dolly Varden char have shown some variability between control and downstream sites but generally, trends of increases resulting from mining activity have not been apparent. Some tissue metals concentrations are higher in areas potentially affected by mine activity. The Forest Service and ADEC require ongoing monitoring of freshwater aquatic resources, including bioassessment and fish tissue monitoring. The ongoing monitoring will be used to assess whether future impacts occur.

Monitoring in Hawk Inlet has shown some increased concentrations of metals near the port site and also near Outfall 002. There may be localized impacts, however, monitoring has not indicated that there has been any adverse effect on the overall marine environment of Hawk Inlet. The TDF wastewater is treated before it is discharged and there is a large amount of flushing and dilution that occurs in Hawk Inlet. Marine organisms (mussels and polychaete worms) have shown increased metals concentrations near the marine loading facility and near the APDES discharge site, with some decrease in metals concentrations in more recent results. Alternative A would continue current conditions though about 2014 when the TDF would become full and mining operations would cease. Alternative B would reduce fish habitat for both freshwater species and anadromous salmon and trout in the Tributary Creek drainage through TDF expansion by about 4,000 feet (stream length), or about 50 percent. Alternatives C and D would be similar in their effect and would include a small loss of stream habitat accessible to anadromous and resident fish in the Fowler Creek drainage. Alternative D would also include a small additional loss of anadromous and resident fish habitat in the Tributary Creek drainage and to a minor extent in the Fowler Creek drainage. Other than Alternative A, which has mining terminated in about 2014, none of the alternatives would change conditions in the marine environment from current operations. Mitigation for all alternatives would include improving anadromous fish passage facilities on Greens Creek. In addition, the Forest Service and ADEC will require that monitoring programs continue in order to identify potential impacts to freshwater and marine resources.

3.8 Soils

Soil productivity is not identified as a significant issue. Measures of soil productivity include acres and types of soils impacted.

Soil characteristics provide the basis for the productivity of plant communities present on a particular site. Microbes function to break down organic matter within the soil and influence chemical and geochemical reactions. Thus soil characteristics have a strong influence on ecosystem structure and function. Soil productivity is related to numerous factors including the nature of the parent material, how the soil layers (horizons) are formed, temperature, and moisture conditions. Disturbances can range from simply removing vegetation from the surface (e.g., wind thrown trees) to complete removal of surficial material above bedrock.

The description of the soils resource also forms the basis for the establishment of reasonable reclamation performance standards and identification of effective mitigation measures, which are designed to prevent, reduce, or eliminate impacts to soils. More detail is provided in Appendix G.

The purpose of this section is to discuss the following:

- Baseline soils conditions as they relate to existing vegetation communities;
- Impact evaluation criteria;
- Soil conditions as they relate to TDF closure and reclamation goals, current closure cover design and existing research.

3.8.1 Soils – Pre-mining Environment

The pre-mining description of the soils resource is extremely limited. The following section is based primarily on the Greens Creek Final Environmental Impact Statement, Admiralty Island National Monument, Alaska (USFS 1984).

The 1984 Final EIS described soils as thick, silty, and granular with occasional peat and organic deposits up to 10 feet thick. Soils were described as having low nutrient status and not demonstrating elevated metal or salt concentrations. Soils immediately adjacent to the TDF were subsequently mapped and characterized and likely represent soils that existed prior to initial construction of the TDF (NRCS 2011; Bosworth 2011). The NRCS (2011) described soil pore water pH ranging from 4.0 to 6.0. The observed soil pore water pH of less than 6.0 in these soils is likely the result of organic matter decomposition into compounds including organic acids.

The 1984 Final EIS identified the need to salvage and stockpile existing soils, redistribute soil at the time of final reclamation, and install and maintain erosion and sediment controls.

3.8.2 Soils – Baseline Conditions

This section describes the properties of the dominant soil map units as they relate to the development and structure of existing and possible reclaimed vegetation communities. The soils map unit delineations, descriptions, and engineering properties summarized in this section were derived from the Chatham Area Soils Survey (NRCS 2011).

Based on the data available regarding the type and distribution of soil map units, Table 3.8-1 presents the extent of existing disturbance as a result of existing operations and those activities that have already been approved.

Table 3.8-1. Acres of Disturbance to Soil Map Units based on Existing Operations.

Soil Map Unit ID	Map Unit Name	Disturbance (Acres)
3624E	Foad-Traitors complex, broken, 76 to 140 percent slopes	5.7
4442C	Kaikli-Chuck River complex, smooth hills, 36 to 55 percent slopes	12.7
4454E	Traitors-McGilvery complex, smooth hills, 76 to 120 percent slopes	4.4
5121B	Kupreanof gravelly silt loam, 6 to 35 percent slopes	12.4
5145B	Mitkof loam, footslopes, 6 to 35 percent slopes	8.0
6141B	Kasiana-Kushneahin complex, sloping lowlands, 6 to 35 percent slopes	34.1
6174B	Kina-Kasiana association, sloping lowlands, 6 to 35 percent slopes	17.7
6290A	Kina peat, 0 to 5 percent slopes	7.5
	Total	**102.5**

Of the soil series represented in the project area, bedrock restricts rooting depths in seven of the soils series and glacial till restricts rooting depths in two series. The depths of these root-restricting layers range from eight to 44 inches with an average maximum depth of the root restricting layer of 29 inches. The dominant vegetation on all but one of these soil series is Sitka spruce or western hemlock.

Based on soil series descriptions in the Soil Survey for Chatham Area, Alaska (NRCS 2011) the following may be concluded:

- The growth of Sitka spruce or western hemlock is not inhibited by rooting restricting layers at depths of eight to 44 inches; and
- Sitka spruce-western hemlock vegetation communities proliferate in well-drained to poorly-drained soils (also see Viereck et al. 1992).

3.8.3 Soils – Environmental Consequences

3.8.3.1 Effects Common to All Alternatives

The description of the soils resource provided below forms the basis by which to assess the intensity, duration, and magnitude of soils impacts associated with the proposed action and alternatives. The primary impact to the soils resources associated with all alternatives would be loss in soil productivity in large part caused by stripping the topsoil and organic layers.

Anaerobic conditions within growth media stockpiles are a major cause of soil productivity loss. Soils placed in stockpiles below a depth of approximately three feet for extended periods of time exhibit reduced organic matter cycling, microbial activity and mycorrhizae inoculation potential (Stark and Redente 1987; Gould and Liberta 1981; Rives et al. 1980). The anticipated reduction in soil productivity would be limited to the period between soil salvage and storage and the initial vegetation establishment period at the time of reclamation. Soil erosion potential would increase due to the increased exposure of soil to rain drop impact and concentrated overland flow during the clearing and grubbing of vegetation and soil salvage, stockpiling and redistribution activities.

Common soil management practices could be used to enhance the success of re-establishing native plant communities by improving productivity at closure and minimizing erosion from soil salvage through re-application during reclamation. The practices to mitigate the extent of potential effects under all alternatives include:

- Separate salvage and stockpiling of suitable soils prior to the initiation of tailings disposal activities;
- Build storm water runoff diversions on and around soil stockpiles and reclaimed areas to minimize soil exposure to concentrated overland flow;
- Install and maintain erosion and sediment control BMPs on soil stockpiles and at the time of final reclamation;
- Handling soils during dry periods (to the extent possible) to reduce the potential for soil compaction;
- Construct stable soil stockpiles;
- Eliminate soil stockpiling through soil salvage and direct placement of soils on portions of the TDF that are ready for reclamation;
- Construct stable reclaimed slopes;
- Redistribute salvaged soil at the time of final reclamation; and
- Scarifying compacted soils.

Closure Cover Design

The TDF closure cover design (from bottom to top) according to Hecla's proposed TDF Expansion - Stage 3 (Hecla 2011) is as follows:

- **Lower Capillary Break** – Thickness = 8–12 inches; Material Source = mine waste rock, quarry rock, or rock imported to the site from an off-island source; Material Properties = undefined.
- **Compacted (Barrier) Layer** – Thickness = 24 inches; Material Source = unidentified; Material Properties = capable of compaction to a permeability of 10^{-6} cm/sec.
- **Filter fabric**
- **Upper Capillary Break –** Thickness = 8–12 inches; Material Source = rock imported to the site from an off-island source; Material Properties = non-mineralized.
- **Plant Growth Layer** – Thickness = 24–36 inches; Material Source = stockpiled growth media; Material Properties = undefined.

While not all of the cover materials sources, types, properties, volumes and mass balance have been finalized at this time, the barrier and plant growth layers are currently planned to be supplied from on-site sources which may include reclamation material stockpiles. The materials that will serve as the capillary break are planned to be imported from an off-island source (Kennecott 2008).

To assess the TDF closure cover and reclamation potential in terms of functionality, performance, constructability, design complexity, materials availability, and uncertainties, the impact analysis criteria used for the evaluation of alternatives A through D are as follows:

- Maintain static and pseudo-static geotechnical stability (see Section 3.4.3, Geotechnical Stability)
- Probability of establishing a predominant vegetation of mature Sitka spruce and western hemlock on the surface of the reclaimed TDF (see Section 3.8.3, Vegetation);
- Minimize the penetration (flux) of water and oxygen through the closure cover and into tailings to reduce and manage the generation of acidic/metal-bearing waters in the TDF.

These criteria were developed based in part on reclamation guidance provisions in the Tongass Land and Resource Management Plan (USFS 2008) provided below.

To function as designed, the engineered closure cover must balance percolation of meteoric waters through the cover and into tailings, while providing adequate water storage and nutrient supply capacity to establish the desired vegetation cover. The cover must function to avoiding exposure of tailings due to erosion and slope failure.

Mitigation

Site 23 is currently being used to assess the overall performance of the TDF engineered closure cover and to establish feasible cover design basis and criteria. The growth media depth at Site 23 is 24 inches. Information on the growth layer can be extrapolated from this study site; however, additional test plots should be established on the mine site to specifically evaluate depths up to 36 inches (which reflects the upper bounds documented in the literature) and determine the optimum depth of the plant growth layer for the desired plant communities. This would provide opportunities to evaluate the performance of full-scale implementation of the engineered closure covers and plant growth layer on tailings. Future investigations should be combined with past and ongoing observations at Site 23 to allow the operator to demonstrate the adequacy of the design and performance of the cover and evaluate potential refinements prior to final closure and reclamation of the TDF.

Net Flux of Precipitation and Oxygen through TDF Engineered Closure Cover

The measured average flux of precipitation through the test cover at Site 23 has been approximately 15 to 20 percent of annual precipitation (Hecla 2007 through 2009).

The rate and magnitude of oxygen diffusion through the engineered closure cover and into the underlying TDF is a consideration in the prediction of tailings oxidation rates. Given that oxygen diffusion through water is approximately 10^4 fold slower than in air (Reddy et al. 2000), the diffusion of oxygen through a saturated medium will be substantially less than if the same medium was dry or well below saturation with respect to water. Therefore, the resistance the downward diffusion of atmospheric oxygen, one of the design criteria for the engineered closure cover currently includes the installation and maintenance of the barrier layer at a relative saturation above 85 percent (OSU 2010).

The consumption of oxygen and production CO_2 within the plant growth layer that results from plant and soil microbial respiration should be high due to the relatively high biomass productivity potential of the proposed cover (See discussion below). As plant and microbial respiration doubles, soil oxygen is depleted by approximately 2.5 percent at a depth of one meter (39 inches) (Currie 1962). This should contribute to lowering the rate of oxygen diffusion into the underlying capillary break and barrier layers.

3.8.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceases, disturbed sites are reclaimed, and human activity in the area is reduced. The TDF would continue to be built out to the maximum footprint and height permitted in the 2003 EIS (USDA 2003). After the TDF is fully built out in 2014, reclamation would begin as described in the 2003 EIS (USDA 2003). The soil productivity of existing soil stockpiles would be improved within 4 to 5 years following placement as growth material over the TDF. The plant growth layer under Alternative A would be maximized up to 36 inches where spruce-hemlock forest is to be re-established.

3.8.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF. The expanded TDF and associated infrastructure (water management ponds, quarries, and new support roads) would impact additional acres with an effect to soil productivity of a minimum of 30-50 years since no concurrent reclamation and long-term stockpiling of soil is proposed under this scenario. Alternative B also includes new roads and upgrades to existing roads that would cause further soil disturbance.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. Eliminating the quarry would result in a smaller overall footprint and thus slightly reduce the of soil productivity compared to Alternative B; moving the reclamation material storage area would simply shift disturbance footprint from one location to another. Mitigation recommended under Alternative B, would be the same under mitigated Alternative B.

3.8.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF located approximately three miles north of the existing TDF. Once tailings placement in the existing TDF was completed in approximately 2015, the site would be regraded and the closure cover installed. Final reclamation could occur in approximately 2017 after the final cover was put in place.

Soil disturbance would be more widely spread than in alternatives A and B due to the development of a new TDF and supporting infrastructure. Development of new facilities, including reclamation material storage areas, quarries, water management ponds; linear drain features and pipelines; and truck wheel wash would further impact soil productivity. While final reclamation could occur relatively quickly following the completion of tailings placement on the existing TDF, contemporaneous reclamation of the new TDF may be difficult because of the configuration of the TDF's footprint. The current design and phasing of the TDF may require modification to accommodate development and concurrent reclamation.

3.8.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of the new northern TDF. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than under Alternative B, however the footprint of the new TDF would be similar in size to that built under Alternative C. Overall, the total soil disturbance would be similar to Alternative C; however, the disturbance would be phased to a greater extent since the area associated with the new TDF would not be disturbed until approximately 2030. Development of new facilities, including reclamation material storage areas, quarries, water management ponds; linear drain features and pipelines; and truck wheel wash would further impact soil productivity in disturbed areas.

3.8.4 Soils – Summary

The primary impact to the soils associated with all alternatives would be loss in soil productivity caused by stripping the topsoil and organic layers. The anticipated reduction in soil productivity would be limited to the period of soil salvage and storage and the initial vegetation establishment period at the time of concurrent or final reclamation.

The greatest difference between the action alternatives is the spatial extent of disturbances and the period of time in which mining would continue, and the time until reclamation occurs. Soil disturbance would be more widely spread under alternatives C and D, compared to alternatives A and B, due to the development of a new TDF and supporting infrastructure. Under alternatives A and C, the placement of growth media on the existing TDF would occur in the relative near-term; reclamation of the existing TDF under Alternative D would begin in approximately 10 years, compared to Alternative B which would not include final closure of the existing TDF until 30 to 50 years from the present. Under each alternative, common soil management practices would be used to mitigate the extent of potential effects to soil productivity, as described in Section 3.8.3.1. Additionally, mitigation would be recommended under all action alternatives to establish test plots to determine the optimum depth of the plant growth layer for the desired plant communities.

3.9 Vegetation

This section describes vegetation resources within the vicinity of the mining operation beginning with the pre-mining environment, the baseline conditions that include current mining operations, and the effects of each alternative under consideration. Concerns raised during public scoping include the effects of tree roots on the closure cover, use of native wildflowers during reclamation, and contamination of lichens.

The resource analysis of vegetation is related to Issue 2 impacts to wetlands through removal of wetland vegetation. Measures of affects to vegetation include acres and types of vegetation impacted.

3.9.1 Vegetation – Pre-Mining Environment

Prior to mining, vegetation in the vicinity of the mine was similar to the existing vegetation elsewhere on Admiralty Island. The area consists primarily of upland forests, Sitka spruce-western hemlock interspersed with a mosaic lowland, non-forested plant communities, including peat wetlands, shrub wetlands, and sedge meadows (USFS 2003). The well-drained slopes of the bedrock ridges and mountain slopes are mostly upland vegetation, and the flatter basin and terrace areas, underlain by uplifted marine silts and glacial tills that perch the water table, support wetland vegetation of various types (Bosworth 2010). Pre-mining descriptions of vegetation follow the Viereck et al. (1992) level IV classification system.

Sitka Spruce-Western Hemlock Forest

Sitka spruce (*Picea sitchensis*)-western hemlock (*Tsuga heterphylla*) forests are common in southeast Alaska. They occur mostly at low elevations on alluvial fans, floodplains, footslopes, and uplifted beaches. Sitka spruce-western hemlock forests are at a climax or near-climax successional stage. The spruce provides 35 to 60 percent cover and constitutes most of the overstory. Mature spruces are generally 95 to 145 feet tall and 20 to 40 inches diameter breast height (dbh). Hemlock provides an understory 80 to 125 feet high with 30 to 60 percent cover. Average diameter of mature hemlock is 15 to 25 inches dbh. Other tree species are uncommon.

A well-developed shrub layer 3- to 5-feet tall is usually present and consists of combinations of devil's club (*Oplopanax horridus*), *Vaccinium* spp., and salmonberry (*Rubus spectabilis*). Common ferns and herbs include oak fern (*Gymnocarpium dryopteris*), spiny wood fern (*Dryopteris dilatata*), goldthread (*Coptis aspleniifolia*), dogwood (*Cornus* spp.), trailing raspberry (*Rubus pedatus*), deer berry (*Maianthemum dilatatum*), skunk cabbage (*Lysichiton americanus*), and foamflower (*Tiarella trifoliate*).

No other upland vegetation communities occur in the vicinity of the project area. The various wetland types are discussed in Section 3.10, Wetlands.

3.9.2 Vegetation – Baseline Conditions

The baseline condition for vegetation describes the current condition that has resulted from the construction and operation of the Greens Creek Mine. The construction and operation of the mine has resulted in changes from pre-mining conditions, including direct impacts to vegetation communities. To date, approximately 65 acres of vegetation have been directly disturbed by the existing TDF and associated facilities. The majority of this disturbance occurred within Sitka spruce-western hemlock forests, but a small amount of disturbance occurred within wetland communities (USFS 1983).

Bosworth Botanical Consulting conducted a biological survey for sensitive plant species for Alternative B in July 2010 (Bosworth 2010). The biological survey grouped the vegetation in the area into five communities: Sitka spruce-western hemlock forest (upland); and bogs, fens, forested wetlands, and marshes (wetland) (Figure 3.9-1). The upland vegetation on the slopes of the western bedrock ridges and the hill slopes along the eastern edge of the project area is a Sitka spruce and western hemlock forest with an understory of Early blueberry and Alaska blueberry (*Vaccinium ovalifolium* and *V. alaskaense*), spiny wood fern, and dwarf dogwood (*Cornus canadensis*). A section of steep hillside just east of the B Road has been clear cut. This area was previously a Sitka spruce-western hemlock forest.

3.9.3 Vegetation – Environmental Consequences

Direct effects to vegetation would include primarily long-term impacts. Long-term impacts are defined as those that would last beyond the project lifetime. Short-term impacts are defined as those expected to last less than or as long as the lifetime of the project. An example of a long-term impact would be a vegetative community disturbed for placement of the TDF. This would be considered a long-term impact because the vegetation would not be fully regenerated for a number of years beyond the lifetime of the project.

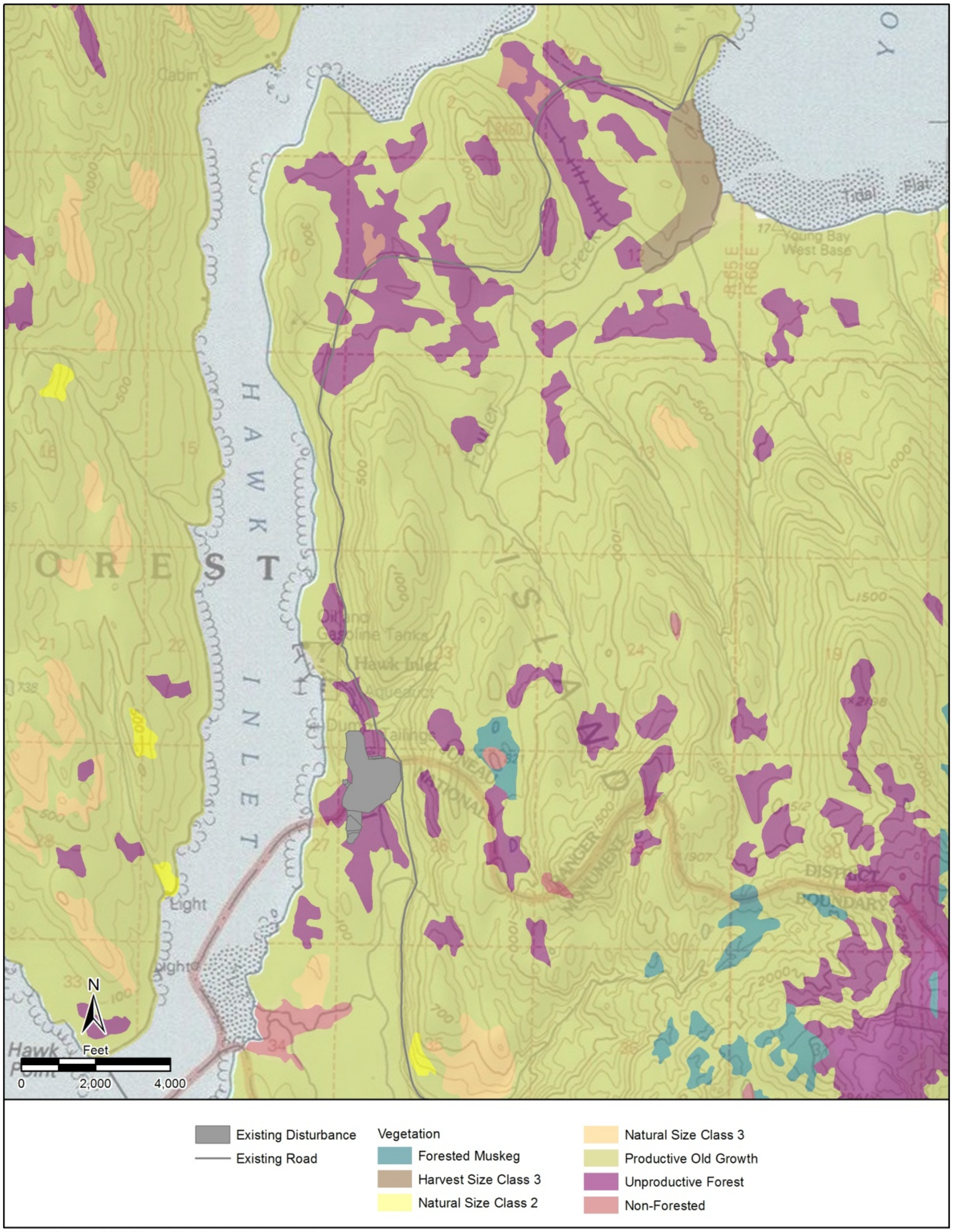


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Figure 3.9-1. Vegetation.

3.9.3.1 Effects Common to All Alternatives

Reclamation

A reclamation plan is currently in place and will be modified under any of the alternatives to accommodate the final configuration of the TDF. The objectives of the reclamation plan include: (1) establish plant communities (where appropriate) that are self-sustaining; (2) assist in protecting water quality by controlling erosion and preventing ARD; and (3) contribute to the proposed land use of the reclaimed site after closure (GPO 2000).

Disturbed areas would be reclaimed to one of three vegetation types including upland meadows, upland forest, or wetlands (GPO 2000). Specific seed mixtures, woody seedling density, and maps showing each vegetation type would be submitted within the detailed reclamation plan. Specific seed mixes would be developed to address the primary issue of erosion control, but would also consider proliferation of native species and diversity. Developing the appropriate seed or planting mixture to produce a plant community that eventually results in the establishment of Sitka spruce and western hemlock forest may need to be determined through test work prior to construction of the final cover.

Succession *is an ecological process whereby the species composition of plant communities shift over time in response to changing environmental conditions. Depending on the size of a disturbance under natural conditions, pioneer species are the first to recolonize a site followed by one or more intermediate communities until a stable, climax community (such as Sitka spruce – western hemlock forest) becomes established. These stages of vegetation succession are typically observed in southeast Alaska following logging of Sitka spruce-western hemlock forests (Alaback 1984). Brief descriptions of these stages of vegetation succession are as follows:*

Pioneer—From 0 to 25 years herbaceous pioneer species such as fireweed, Dryas, horsetail, and graminoid species would likely dominate. There may also be a shrub component of willow and bearberry.

Willow-Alder—From 26 to 50 years the willow-alder stage would likely dominate and the most common species would likely be Sitka alder, Sitka willow, black cottonwood, and Alaska willow.

Hemlock Forest—From 51 to 100 years western hemlock would begin to invade. In bare areas of wind throw or fire, Sitka spruce or red alder would be able to colonize.

Forested areas would be revegetated using a combination of natural regeneration and reseeding or transplanting (GPO 2000). Natural regeneration is preferred over planting as a means of establishing a coniferous overstory in small areas where seed sources are available; because natural regeneration would ensure reestablishment of Admiralty Island genotype species, follow natural successional stages, and provide unique wildlife habitat during stand development. Naturally regenerated plants are also well adapted to local conditions. The coastal forests of southeast Alaska regenerate very quickly and profusely since western hemlock and Sitka spruce grow rapidly in the area. Natural regeneration of these climax species is evident throughout areas previously disturbed by mining activities and in areas without any reclamation preparation.

HGCMC proposes to monitor revegetation success for three years following seedbed preparation, fertilization, seeding, mulching, and temporary erosion control measures.

Growth, ground cover, and species survival would be measured and reported on an annual basis.

Revegetation efforts would be considered successful when the following conditions are met (GPO 2000):

- The total vegetative cover (including live biomass of perennial species, litter, and standing dead) in each revegetated area is equal to or exceeds 80 percent aerial cover, with a 90 percent statistical confidence limit;
- The density of actively growing trees is within 80 percent of target levels contained in the approved reclamation plan with a 90 percent statistical confidence;
- The reclaimed wetland and meadow areas have at least three graminoids present each with relative herbaceous cover value equal to or greater than 5 percent, with no one graminoid comprising more than 70 percent relative cover; and
- The reclaimed upland forest areas have at least two species of trees and one species of shrubs present, with each species comprising no less than 5 percent or no greater than 95 percent of the relative density value.

If vegetation monitoring indicates that, due to natural or other causes, a reclaimed area does not exhibit the potential to achieve the revegetation standards described above, corrective actions may be taken that include reestablishment of topsoil thickness, reseeding, and replanting of trees and shrubs (GPO 2000).

Tailings Cover

Natural regeneration with Sitka spruce and western hemlock is the best strategy for protecting the final tailings cover (described in Section 3.8.3, Soils) from exposure to atmospheric conditions, specifically water and oxygen (OSU 2010). Neither of these species has a tap root which is likely to extend downward into the barrier layer. Western hemlock roots occur in flat mats near the surface and the majority of Sitka spruce roots are found in the top 1 meter (3.3 feet) of soil (OSU 2010). Additionally, the wind throw (uprooting) that is common in spruce/hemlock forested communities in southeast Alaska may actually protect the barrier layer by restoring the productivity and percolation of the soils above the barrier (OSU 2010). Without wind throw, podzolization occurs, leading to less productive vegetation (which eventually diminishes), and an increased chance for widespread erosion.

In southeast Alaska, podzolization occurs primarily in coniferous forests, which have needles high in acid resins. As these decompose, soil acidity increases. Because the climate is cool, decomposition is slow, and a very acidic organic horizon (mor horizon) forms under the surface litter (Brady and Weil 2002; McClellan 1990). Below the mor horizon, an eluviated layer (horizon) develops, from which organic matter, iron, aluminum, and other complexes have been dissolved by the organic acids. These materials are transported downward with water percolating through the soils. The eluviated horizon is often composed entirely of sand-sized particles, without much color, and without much water holding capacity or plant nutrients – a zone not very useful to plant roots (Brady and Weil 2002; Bormann et al. 1995). Below the eluviated horizon, an illuviated horizon forms into which those dissolved mineral and organic complexes settle. Sometimes the illuviated iron-minerals form a placic horizon (or iron pan) that strongly reduces the ability of water to percolate through the layer. This placic horizon, together with the associated dense organic horizon, poses a barrier to moisture percolation and to plant roots seeking nutrients in the illuviated organics, and causes soil saturation (McClellan 1990; Bormann et al. 1995). The productivity of the soil diminishes, due to the unavailability of nutrients and the increase of soil saturation.

Re-establishing a productive and functioning forest community would protect against erosion and subsequent exposure of the barrier layer by keeping the soil genesis and wind throw occurrences as predictable processes within the plant growth layer of the cover to percolate precipitation.

The test plots recommended as a mitigation measure (and described in Section 3.8.3.1) to study the optimum depth of the plant growth layer should also include a study component to verify that tree roots would not extend downward into the barrier layer. The test plots could also be used to develop an appropriate seed or planting mix that would eventually result in the establishment of Sitka spruce-western hemlock forests.

When vegetative cover is removed from an area, there is the potential for invasion of disturbed areas by noxious weeds or other invasive species. Weedy species are primarily a threat to newly cleared soils because the competition from the existing vegetation is reduced. In southeast Alaska, alders and fireweed are the native pioneer species and are often the first to become reestablished in an area. Although these species are indicators of disturbance, their presence is not detrimental to the successional process. However, the introduction of nonnative species might negatively affect the long-term species diversity and success of reclamation. Invasive species have not been as great of a problem in southeast Alaska as they have been in the lower 48, but species like Canada thistle (*Circium arvense*), Japanese knotweed (*Polygonum cuspidatum*), and foxtail barley (*Hordeum jubatum*) are becoming more widespread (Shephard 2002; ADF&G 2002). More than 30 species of invasive species have been identified in the Juneau area, and have the potential to spread to the Greens Creek Mine and Admiralty Island. Two invasive species, reed canary grass and sow thistle were found during project wetland and sensitive plant surveys of the existing and proposed disturbance areas (Bosworth, forthcoming). Previous surveys of the area also found field mustard (*Brassica rapa*) and narrow-leafed hawksbeard (*Crepis tectorum*).

The invasion of weedy species can produce an obvious change in species diversity and adversely impact the ecological integrity of an area. An invasive species risk assessment was completed for the project by the Forest Service in November, 2011 that identified the following mitigation measures to be included as part of a weed management plan:

- A systematic survey of the general Greens Creek mine activity areas and roads to establish a baseline against which any future introductions may be recognized.
- Assurance that all vehicles and heavy equipment transported to the project area are free of invasive plant propagules and contaminated soil. This will only be required of new equipment entering the Greens Creek activity area and will not include haul truck equipment presently located in the area, as these are regularly cleaned after each tailings delivery.
- Use of erosion control materials that are weed seed free. Re-vegetation seed mixtures should be compliant with Tongass National Forest guidelines for re-vegetation (USDA 2007a). Avoid use of hay or straw bales for erosion control. Use weed-free jute matting, synthetic sediment fence or other weed-free materials.

- Avoidance or removal of existing invasive plant populations in order to reduce the risk of spread.
- Use of imported rock material for re-constructing existing roads only, or for use as base material that will be buried under other layers.
- Eradication or control of any newly introduced high priority invasive plant populations in the project area for the life of the project following Forest Service and NEPA guidelines for manual (pull/dig) and mechanical (mowing/weed whacking) treatments. Pesticide use on National Forest will be approved by the Regional Forester (USDA 1994) and follow NEPA guidelines. The District Botanist will receive a copy of the treatment reports as treatment occurs so data may be entered into the FACTS database.
- Biennial monitoring of the existing and new TDF areas for high priority invasive plant introductions for the life of the project, and for at least 3 years following closure of the sites. The District Botanist will receive a copy of each monitoring report for data entry into the FACTS database.

In order to minimize the potential for the introduction and spread of invasive species, a weed management plan should be developed and implemented under all alternatives. The plan should be developed in coordination with the Alaska Association of Conservation Districts and the Natural Resources Conservation Service (NRCS) and should address the priority list of invasive species developed by the Juneau Cooperative Weed Management Area. The plan should include pre-disturbance and annual weed surveys, prevention strategies, control and management techniques for invasive species, and other mitigation measures described above. With the development and implementation of a weed management plan, the overall risk of high priority invasive plant establishment as a result of the project is moderate.

Lichen Contamination

Lichens are strongly affected by atmospheric conditions such as precipitation, gases and particulate matter (Nash and Gries 1991; Herzig et al. 1989). Air pollution is directly tied to forest health and deposition of pollutants can produce effects including altering soil pH, which may in turn damage roots and harm productivity of vegetation (CARB 1989). The airborne deposition of metals or other contaminants can also produce ecosystem changes over time. Lichens' sensitivity to air quality facilitates their use as biomonitors, to evaluate air quality changes in a geographic region over time (Richardson 1988; Garty 1988). The Tongass National Forest and the Alaska Regional Soil, Water, and Air Program of the Forest Service employ a lichens biomonitoring program for air pollution in the Tongass National Forest (Geiser et al. 1994). Lichen sampling at the Greens Creek Mine was initiated in 2005. Sampling plots at the Greens Creek Mine were selected near suspected pollution sources: up-gradient from the mine portal (Plot 511a), across the bridge from the portal on the road (Plot 511b), and near the TDF (Plot 512). Two plot areas (511a and 512) have permanent plot markers. Lichen samples from 511b were collected from trees along the edge of the road leading into the mine which are exposed to road dust and other airborne particulates related to mining activities.

Lichens collected at the Greens Creek Mine portal contained more elements above established baseline levels than any other monitoring site in the Tongass National Forest. Lichens collected from Plot 511a had 12 elements above threshold values, while lichens collected from Plot 511b, 250 feet away from the portal had 7 elements above threshold.

From Plot 512 near the TDF, 19 elements were above threshold including sulfur, nitrogen, aluminum, barium, cadmium, copper, iron, lead, silicon, titanium, vanadium, zinc, cobalt, lithium, and nickel. The presence of these high element concentrations are suspected to be from fugitive dust from mining and road activity. Future development of monitoring sites at a range of distances away from the mining activities are recommended to better identify the sources and determine at what distance contaminant levels in lichens drop below threshold levels (Dillman et al. 2007). Based on results of the additional monitoring, a mitigation plan should be developed to reduce the extent of metals containing fugitive dust escaping mine facilities.

3.9.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceases, disturbed sites are reclaimed, and human activity in the area is reduced. After the TDF is fully built out in 2014, reclamation would begin as described in the 2003 EIS (USDA 2003).

No new impacts to vegetation would occur under this alternative.

3.9.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the existing TDF would be expanded. The expanded TDF and associated infrastructure would impact approximately 28.5 acres of upland vegetation, immediately adjacent to the existing TDF. These areas would undergo long-term changes in species composition and diversity. However, a portion of this area (reclamation material storage area, long-term tailings facility slopes, and road cuts and fills) would be subject to interim reclamation for soil stabilization. These areas would be revegetated in the short term, which would temporarily provide some species diversity. Upland vegetation that would be disturbed under Alternative B consists primarily of Sitka spruce-western hemlock forest (Bosworth 2010). Approximately 208 acres of vegetation would be impacted under Alternative B consisting primarily of productive old growth (POG) (109 acres) and unproductive forest (99 acres). Impacts to wetland vegetation from Alternative B are discussed in Section 3.10.3.3.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. Elimination of the quarry would slightly reduce the extent of vegetation disturbed compared to Alternative B.

3.9.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF. Additionally, the A Road would be upgraded and additional facilities would be constructed, including a tailings water transport pipeline, rock quarry, water management ponds, and internal access roads. Alternative C would also extend the operating period of the mine by 30–50 years, but would allow reclamation to begin in some areas of the existing TDF footprint. Effects to vegetation would be more widely spread than in alternatives A and B resulting from the development of a new TDF and supporting infrastructure; however, they would occur within a condensed period of time (first three years) and then be focused on a single area (the new TDF).

Approximately 222 acres of vegetation would be adversely impacted over the long term, primarily consisting of POG (130 acres) and unproductive forest (91 acres) including impacts to wetlands. Impacts to wetland vegetation from Alternative C are discussed in Section 3.10.3.4.

3.9.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of the new TDF. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than under Alternative B, however the footprint of the new TDF would be similar in size to Alternative C. Effects to vegetation would be similar to or slightly greater than Alternative C, but more widespread than alternatives A and B, primarily resulting from development of a new TDF.

Alternative D would have long-term adverse impacts to approximately 235 acres of vegetation, primarily consisting of POG (140 acres) and unproductive forest (95). Impacts to wetland vegetation from Alternative D are discussed in Section 3.10.3.5.

3.9.4 Vegetation – Summary

Vegetation within the immediate project site is currently dominated by Sitka spruce-western hemlock forests interspersed with a mosaic of wetlands and meadows. No new impacts to vegetation would occur under Alternative A, which would include continuation of mining until 2014 when project closure and reclamation will begin. Under alternatives B, C, and D, impacts to vegetation would extend an additional 30–50 years, and would be similar in type and amount (193, 210, and 236 acres, respectively). Impacts to vegetation would be more widely spread under alternatives C and D, resulting from the development of a new TDF and supporting infrastructure. Closure, including vegetation reestablishment, would begin on the existing TDF in the near future under alternatives A and C. Under Alternative D, closure and vegetation reestablishment of the existing TDF would occur in approximately 10 years (depending on how long cover placement requires) compared to Alternative B, where closure and reclamation would not occur until the end of mining in 30 to 50 years. Monitoring to determine the nature and extent of dust contamination in lichens is recommended in order to develop more effective dust mitigation measures (such as those identified in Section 3.2).

3.10 Wetlands

Impacts to wetlands was identified as significant Issue 3 during the scoping process. Concerns raised during scoping include impacts to the function and values of wetlands, specifically from the alteration of surface and groundwater. Measures of impacts to wetlands include acres and types of wetlands affected as well as associated habitat values.

Wetlands are a subset of aquatic resources that for purposes of this analysis are discussed independently in this section. Other aquatic resources are addressed in Section 3.7, (Aquatic Resources) and Section 3.5, Water Resources – Surface Water). The following section describes wetland resources within the vicinity of the mining operation beginning with the pre-mining environment, the baseline conditions that include current mining operations, and the effects of each alternative under consideration.

Wetlands are transitional areas existing between uplands and open water, commonly considered bogs, swamps, and muskegs. Wetlands provide benefits within the landscape, ranging from providing fish and wildlife habitat to improving water quality. The Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979) provides a basis for characterizing wetlands that can be applied across the United States. This system has been adopted by USFWS for use in its National Wetland Inventory mapping program and is the standard approach used to identify and characterize wetlands. Under the Cowardin/National Wetland Inventory approach, the wetlands occurring in the area are “palustrine” wetlands, which have three classes: scrub-shrub, emergent, and forested. Scrub/shrub wetlands are dominated by shrubs less than 20 feet (6 meters) tall. Emergent wetlands are dominated by herbaceous (non-woody) vegetation, including grasses and sedges, and forested wetlands are dominated by trees. Additional detail on project area wetlands is provided below in Section 3.10.2.

The USACE defines wetlands as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (USACE 1987). The USACE 1987 Manual and the 2007 Alaska regional supplement along with regulations at 33 CFR 328 are the tools by which jurisdictional wetlands are identified in the State of Alaska. Jurisdictional wetlands are subject to Section 404 of the CWA and are defined using soils, vegetation, and hydrologic characteristics. Areas displaying hydric soils with hydrophytic (water loving) vegetation that are saturated or inundated for a defined portion of the growing season and are not isolated from navigable waters of the U.S. are considered jurisdictional wetlands (USACE 1987).

The connectivity of wetlands to navigable waters is a component of jurisdictional wetland determination that has come under closer review in recent years as a result of legal rulings. Tributary Creek is a perennial stream and tributary to Zinc Creek, which empties into Hawk Inlet, a navigable water. Additionally, Cannery Creek empties directly into Hawk Inlet, as do the other small streams that would be impacted by the project, including CC Creek, Franklins Creek, and Further Creek (south and north forks). For purposes of the analysis, wetlands within the project area are adjacent (connected) to these creeks and tributaries and are, therefore, considered jurisdictional.

3.10.1 Wetlands – Pre-Mining Environment

Very little is known about the presence of wetlands prior to mining in the areas that have already been disturbed. The 1983 EIS included only a very brief discussion on wetlands, and stated that muskeg plant communities covered approximately 4 percent of the project area. The dock facilities, TDF, and portions of the road system approved under the 1983 Record of Decision (ROD) occupy former wetland areas. These areas were poorly drained, non-forested areas covered with sphagnum and lichens as well as vascular plants including sedges, ericaceous shrubs, and goldthread. Western hemlock and mountain hemlock also occurred, ranging from small shrubs to stunted trees (USFS 1983). The EIS also identified riparian plant communities characterized by alder (*Alnus* spp.), graminoids, ferns, and *Ribes* spp. The value of the wetlands was primarily its contribution to fisheries and brown bear habitat.

3.10.2 Wetlands – Baseline Conditions

This section describes the current condition that resulted from the construction and operation of the Greens Creek Mine. The construction and operation of the mine has resulted in changes from the pre-mining conditions, including direct impacts to wetlands. As noted, the number of wetlands actually disturbed by construction of the mine and associated facilities cannot be accurately measured because of the lack of detail in pre-mining surveys.

Ecologically, bogs may be considered "isolated" in a regulatory sense if they do not demonstrate a hydrologic connection to adjacent waters or wetlands. For purposes of this analysis, the bog wetlands are assumed to be connected due to their location adjacent to other wetlands.

Bosworth Botanical Consulting conducted a jurisdictional wetland delineation in the area in July and September 2011 and contributed to a functional assessment of wetlands in the area (Bosworth 2011; Adamus 2012). The reports address four types of wetlands (bogs, fens, forested wetlands, and marshes) (Figure 3.10-1), which are discussed in greater detail below followed by a description of the results of the functional assessment.

National Wetland Inventory Classification Descriptions

As noted in the introduction to Section 3.10, the Cowardin/National Wetland Inventory mapping system is used consistently to describe wetland habitats. The following section reflects the Cowardin/National Wetland Inventory descriptions provided by Bosworth Botanical Consulting (Bosworth 2011) for wetland communities occurring within the vicinity of the mine site. National Wetland Inventory identifiers used by wetland scientists are presented in parentheses below following the names of the wetland communities. Table 3.10-1 includes a description of each wetland type (Cowardin et al. 1979; NWWG 1997) and Table 3.10-2 provides the existing acreage for each wetland community.

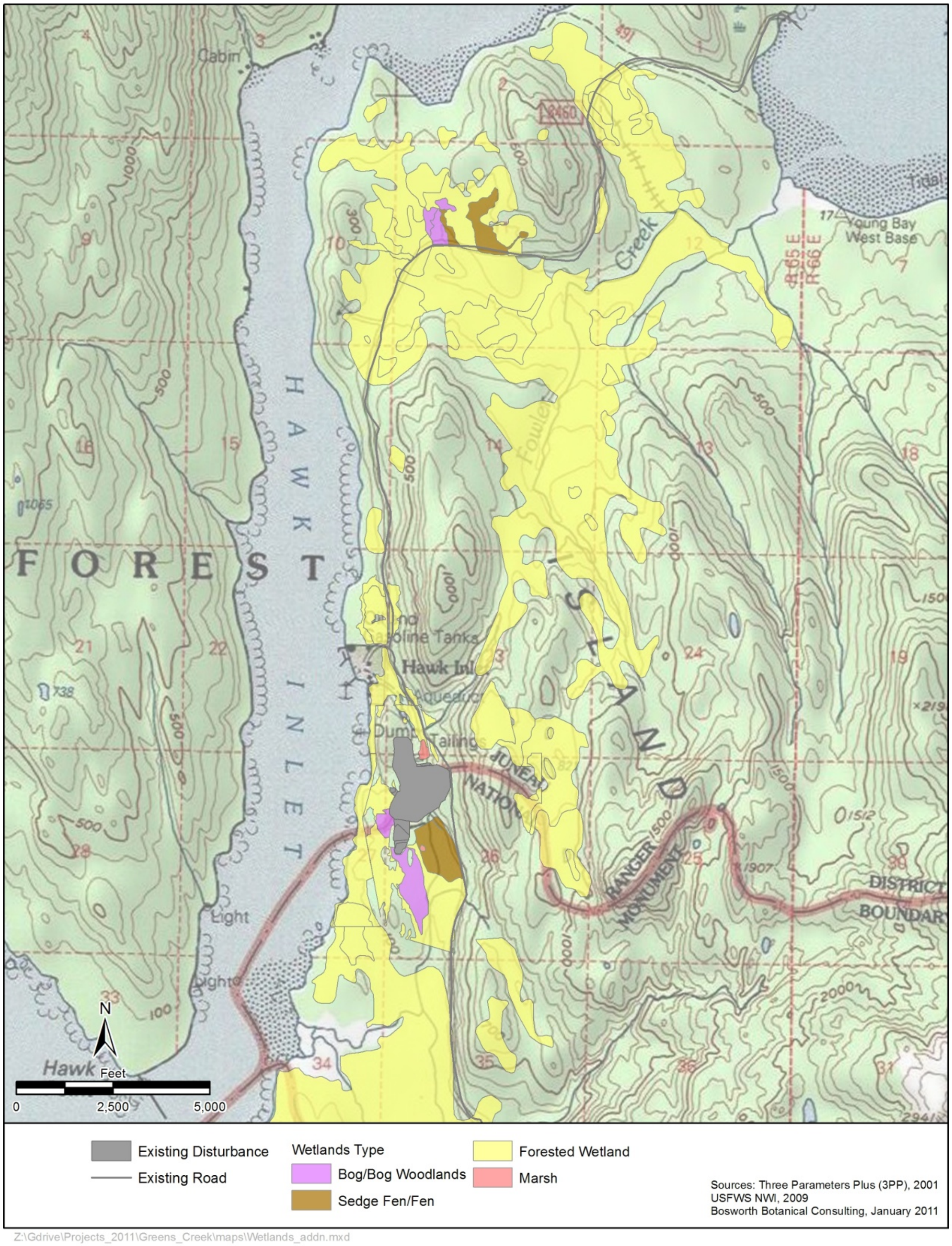

Figure 3.10-1. Wetlands.

Table 3.10-1. Project Area Wetland Type Overview.

Bog/Bog Woodland (emergent scrub-shrub, forested)	A bog is a peat landform where the rooting zone is unaffected by runoff waters or groundwater from the surrounding mineral soils. Precipitation and snowmelt are the primary water sources. Bogs are therefore ombrotrophic ("cloud-fed"). Given that precipitation does not contain dissolved minerals and is mildly acidic, the surface bog waters are consequently low in dissolved minerals and are acidic. Bog water acidity, usually between pH 4.0 and 4.8, is enhanced due to the organic acids that form during decomposition of the peat and the acids present within Sphagnum peat. Generally the water table is at or slightly below the bog surface. As the bog surface is raised by an accumulation of peat, the water table stays at the surface. Most mature bogs in northern southeast Alaska have between 5 and 15 feet of stratified Sphagnum peat and are dominated by a variety of Sphagnum moss species, ericacious sub-shrubs, crowberry (*Empetrum nigrum*), Labrador tea (*Ledum groenlandicum*), bog kalmia (*Kalmia polifolia*) and bog rosemary (*Andromeda polifolia*), sedges (*Carex* spp.) and stunted shore pine (*Pinus contorta*), and mountain hemlock. Bogs in the coastal area are found on a variety of geomorphological landforms but most often on shallowly-sloping to flat areas underlain by bedrock or relatively impermeable glacial till or uplifted glacio-marine sediments.
Sedge Fen/Fen (emergent or scrub-shrub)	A fen is peat landform where groundwater or surface water flow through the rooting zone. These waters are rich in dissolved minerals and are called minerotrophic. Fens in the project area are dominated by shrubs and small deciduous trees (red alder [*Alnus rubra*], crabapple [*Malus fusca*], mountain ash [*Sorbus sitchensis*]), *Sphagnum*, and sedges. Fens are often found at the toe-of-slope where groundwater flowing downslope is forced to the surface by impermeable layers. They are also found as a transition zone between upland areas and bogs.
Forested Wetland (forested)	The forested wetlands in southeast Alaska are almost always minerotrophic or fen-type wetlands with western hemlock trees dominating. They are usually found in shallowly sloping lowland areas with poorly-draining glacial till or glacio-marine sediments underlying shallow (1.5 to 3 feet) mucky peats. They can also be found in riparian situations.
Marsh (emergent)	A marsh is a minerotrophic wetland in which the water table is above the surface and can come from either or both surface water or groundwater flow. Most of the marshes are estuarine or tidal salt marshes dominated by *Carex lyngbyei*. Freshwater marshes in northern southeast Alaska are almost always dominated by Sitka sedge *Carex sitchenisis* and *Scirpus microcarpus*.

Table 3.10-2. Wetlands Occurring within the Study Area.

Community	Dominant Species	Existing Coverage
Bog/Bog Woodland	Lodgepole pine, mountain hemlock, Labrador tea, crowberry, cloudberry, sphagnum.	43.9
Sedge Fen/Fen	Red alder, crabapple, lady fern, skunk cabbage, Sitka sedge, deer cabbage	51.9
Forested wetlands	Western hemlock, Alaska blueberry, false azalea, skunk cabbage	2,555.2
Marsh	Sitka sedge, skunk cabbage	2.7
Wetland*	Not available.	548.8
Wetland with Upland Inclusions*	Not available.	64.7
	Total	**3,267.2**

*Wetlands were mapped by 3 Parameters Plus for the 2003 EIS, and did not categorize wetlands as bog, forested wetlands, sedge fen, or marsh. These wetlands were included in the forested wetlands category for subsequent analyses.

Bog/Bog Woodland (Emergent / Scrub-shrub / Forested)

The open wetlands in the center of the project area, and in the southwest corner of the TDF are bogs that grade from open woodland bog dominated by lodgepole pine (*Pinus contorta*), mountain hemlock, Labrador tea (*Ledum groenlandicum*), crowberry (*Empetrum nigrum*), cloudberry (*Rubus chaemamorus*), and several species of *Sphagnum,* to an open bog dominated by several small *Carex* species, round-leafed sundew (*Drosera rotundifolia*), and several species of sphagnum.

Sedge Fen/Fen (Emergent / Scrub-Shrub)

The toe-of-slope areas just west of the B Road and south of the TDF has a high water table that results in a fen community dominated by red alder, crabapple, lady fern, skunk cabbage, Sitka sedge, and deer cabbage. The water table of the fen supports in part the hydrology of Tributary Creek. The fen transitions to the south into a forested wetland dominated by western hemlock, Sitka spruce, lady fern, and skunk cabbage. Another fen wetland occurs north of the A Road, along and east of Fowler Creek. The wetland supports a similar vegetation community and its hydrology would similarly support some of the flows in Fowler Creek.

Forested Wetland (Forested)

The dominant plant species in forested wetland communities typically include western and mountain hemlock, false azalea (*Menziesia ferruginea*), deer cabbage (*Nephrophyllidium crista-galli*), and skunk cabbage. Much of the forested wetland on the western side of the project area is a western hemlock forest with an understory of early and Alaska blueberry, false azalea and skunk cabbage. The wetlands on the southeast side of the project area (the gently east-west sloping toe of slope and headwaters for Tributary Creek) grades from south to north, from a forested wetland dominated by Sitka spruce-western hemlock, lady fern (*Athyrium felix-femina*), and skunk cabbage to a mixed shrubby fen dominated by red alder, crabapple, false azalea, lady fern, and skunk cabbage. Forested wetlands in the vicinity of the new TDF site proposed under alternatives C and D is an alluvial type forested wetland with an overstory of Sitka spruce and western hemlock and an understory of skunk cabbage.

Marsh (Emergent)

The largest marsh area on the site is located near the northeast corner of the existing TDF and consists of Sitka sedge and skunk cabbage. The marsh contributes to the hydrology of Cannery Creek. A series of inactive beaver dams along Tributary Creek also have small fringing areas of marsh wetlands.

Wetland Functions and Values

The CWA requires that impacts to waters of the U.S. be mitigated on a function and values (or service) basis. “Functions” are the processes or series of processes that a wetland performs under natural conditions. “Values” reflect the importance society places on a particular wetland relative to the functions it provides. A functional assessment entitled Wetland Ecosystem Services Protocol for Alaska – Southeast was used to describe the wetland functions and values for the Greens Creek Mine (Adamus 2012). The assessment found that while some of the wetlands in the project area supported these functions, none of the wetlands evaluated was superior to the reference wetlands in Southeast Alaska with regard to Anadromous Fish Habitat, Resident Fish

Habitat, or Waterbird Nesting Habitat. Half of the wetlands were in better ecological condition than typical non-tidal wetlands in Southeast Alaska and the majority of the wetlands are likely to be more sensitive to impacts than typical Southeast Alaska non-tidal wetlands. Results of the assessment are summarized in Table 3.10-3 below and depicted in figures 3.10-2 (functions) and 3.10-3 (values).

3.10.3 Wetlands – Environmental Consequences

Direct effects to wetlands would generally result in long-term adverse impacts. Long-term impacts are defined as those that would last beyond the lifetime of the project. None of the wetlands directly impacted by the construction of the TDF expansion would be restored after final closure of the mine since the TDF would be covered and reclaimed as an upland. Wetlands that could be restored following mining activities would mostly be those affected by the construction and operation of water management ponds, storm water diversions, and fill placed in the construction of ancillary facilities, such as reclamation storage areas. The amount of time required to restore the wetlands after closure would depend on the wetland type. While facilities like quarries and reclamation material storage areas could be reclaimed as wetlands, restoration of some wetlands would not be conducive on the TDF(s) because of the potential to enhance infiltration and potentially produce geotechnical instability. Mitigation for impacts to wetlands is discussed below.

3.10.3.1 Effects Common to All Alternatives

Wetlands are protected under Executive Order 11990, the "no net loss" policy and the CWA. Executive Order 11990 directs agencies to minimize the "destruction, loss, or degradation" of wetlands in carrying out their responsibilities. The order also directs agencies to avoid undertaking or funding of new construction in wetlands unless there are no practicable alternatives and all practical measures to minimize impacts to wetlands have been included in the proposal. The no net loss policy reinforces the ideas set forth in the executive order, calling for avoidance, minimization of impacts, and mitigation for unavoidable impacts. Section 404 of the CWA establishes requirements, including a permit program, for dredge and fill activities within waters of the U.S., including wetlands. Among other requirements, issuance of Section 404 permits requires compliance with Section 404(b)(1) guidelines. Subpart B of the guidelines requires minimization of impacts to the extent practicable. Ultimately, the guidelines require selection of the "least damaging practicable alternative" identified through the permitting process.

The proponent is currently preparing a Section 404 permit application for the TDF expansion. The public notice for the permit is being released concurrent with the Draft EIS. A draft 404 permit application reflecting the proposed action is included as Appendix A, and includes the details of the proposed compensatory mitigation program which consists primarily of an in-lieu fee program. The Draft EIS also includes a mitigation requirement that the proponent catalog all wetlands disturbances that have occurred onsite to date and determine which sites, if any, could be permanently reclaimed prior to mine closure.

Table 3.10-3. Wetland Functions and Values.

Functions and Values	Forested Bog		Forested Mitigated Alternative B		Forested Alternative C/D		Forested Tributary Creek		Marsh		Fen		Bog		Regional Median	
	F	V	F	V	F	V	F	V	F	V	F	V	F	V	F	V
Surface Water Storage	3.67	2.22	**4.32**	2.22	**4.14**	2.22	3.67	2.22	**4.42**	**5.69**	3.35	2.78	**3.84**	2.22	3.80	2.78
Stream Flow Support	**4.40**	1.22	**6.84**	1.18	**5.97**	**1.29**	**4.40**	**1.25**	**5.18**	**1.42**	**8.29**	**1.75**	3.51	0.79	4.20	1.23
Streamwater Cooling	**2.78**	2.50	**5.37**	2.00	**3.43**	2.75	2.78	3.13	**3.80**	**3.75**	**7.69**	**3.50**	0.00	2.50	2.50	3.23
Streamwater Warming	5.42	**6.08**	**6.83**	3.15	**6.00**	**4.47**	5.42	**5.56**	5.50	3.68	4.25	**4.15**	**5.83**	**6.08**	5.67	3.96
Sediment and Toxicant Retention and Stabilization	3.13	2.36	**5.88**	**3.75**	**4.92**	**4.29**	**3.15**	**3.14**	**5.29**	**4.29**	**3.81**	**3.63**	2.79	2.50	3.14	3.02
Phosphorus Retention	**5.72**	1.47	**5.75**	**2.55**	4.73	**3.68**	**5.55**	**2.02**	**5.09**	**7.32**	**5.71**	**2.66**	**5.30**	1.38	5.05	1.93
Nitrate Removal and Retention	**5.57**	4.21	**6.36**	5.00	4.74	**5.00**	5.28	4.68	**6.21**	**5.24**	**5.98**	4.52	4.58	4.37	5.44	4.68
Carbon Sequestration	5.10		**6.69**		**5.86**		**5.28**		4.93		**5.42**		**7.19**		5.21	
Organic Nutrient Export	**5.26**		**5.34**		**5.66**		4.58		4.25		**4.83**		**5.08**		4.71	
Aquatic Invertebrate Habitat	**4.88**	5.89	4.72	**6.28**	**5.15**	6.18	**5.02**	5.95	**5.70**	6.22	**7.00**	**6.40**	3.15	6.19	4.80	6.27
Anadromous Fish Habitat	0.00	2.64	0.00	**4.88**	0.00	**4.53**	0.00	2.66	0.00	**4.79**	0.00	**5.12**	0.00	**4.45**	0.00	4.38
Resident and Other Fish Habitat	0.00	2.50	0.00	2.12	0.00	3.47	0.00	2.50	0.00	**3.72**	0.00	**3.69**	0.00	3.50	0.00	3.64
Amphibian Habitat	5.42	5.00	**5.58**	5.00	5.15	5.00	**6.15**	5.00	5.06	5.00	**6.57**	**5.12**	5.42	5.00	5.43	5.00
Waterbird Feeding Habitat	0.00	0.00	**4.47**	**5.00**	3.86	**5.00**	0.00	0.00	**4.87**	**5.00**	**4.75**	**5.00**	3.98	0.00	4.10	0.00

Table 3.10-3. Wetland Functions and Values.

Functions and Values	Forested Bog		Forested Mitigated Alternative B		Forested Alternative C/D		Forested Tributary Creek		Marsh		Fen		Bog		Regional Median	
	F	V	F	V	F	V	F	V	F	V	F	V	F	V	F	V
Waterbird Nesting Habitat	0.00	0.00	0.00	**10.00**	0.00	**10.00**	0.00	0.00	0.00	**10.00**	0.00	**10.00**	0.00	0.00	2.53	0.00
Songbird, Raptor, and Mammal Habitat	**5.28**	7.50	**5.28**	7.50	**5.20**	7.50	**5.31**	7.50	4.72	7.50	**5.48**	7.50	**4.92**	7.50	4.85	7.50
Pollinator Habitat	**4.22**	5.00	3.59	0.00	3.97	0.00	**5.11**	5.00	1.63	0.00	**4.34**	0.00	2.07	0.00	4.16	5.00
Native Plant Habitat	**5.12**	**6.54**	**6.66**	4.72	**5.00**	4.79	4.85	**6.50**	**5.94**	5.34	**7.39**	**6.21**	4.73	5.92	4.95	6.00
Public Use and Recognition		4.24		4.82		4.73		5.25		6.18		4.10		4.79	3.80	6.69
Subsistence and Provisioning Services		0.00		0.00		0.00		0.00		0.00		0.00		0.00		5.28
Wetland Sensitivity		**3.15**		**4.16**		**3.94**		**3.84**		2.83		**3.61**		**3.30**		3.06
Wetland Ecological Condition		5.00		**7.08**		**8.33**		2.92		3.33		**5.44**		4.17		5.10
Wetland Stressors		0.60		0.97		**1.77**		0.60		**2.45**		0.60		0.77		1.18

Notes:

Numbers in bold indicate that the wetland was above the regional median for that function or value.

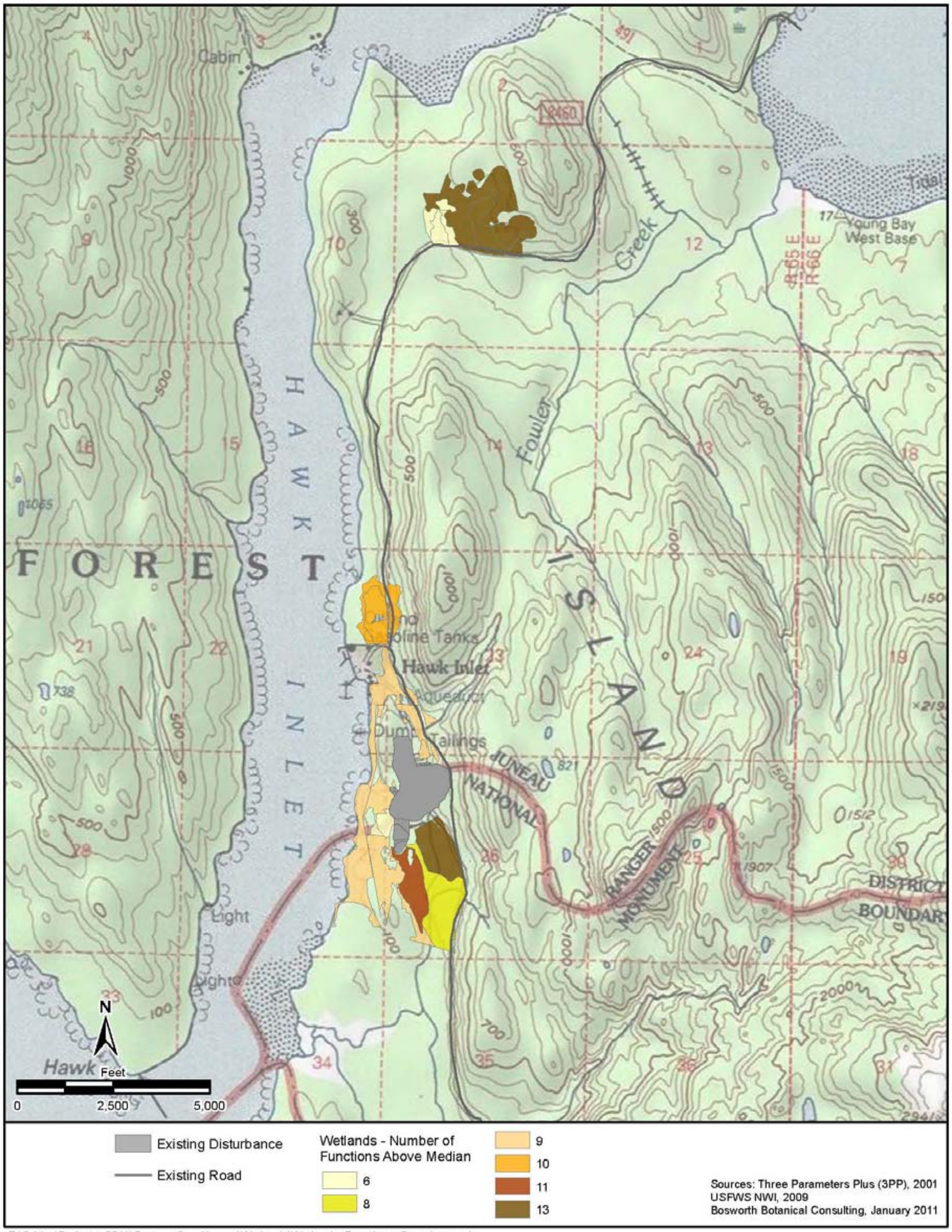

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Figure 3.10-2. Wetland Functions.

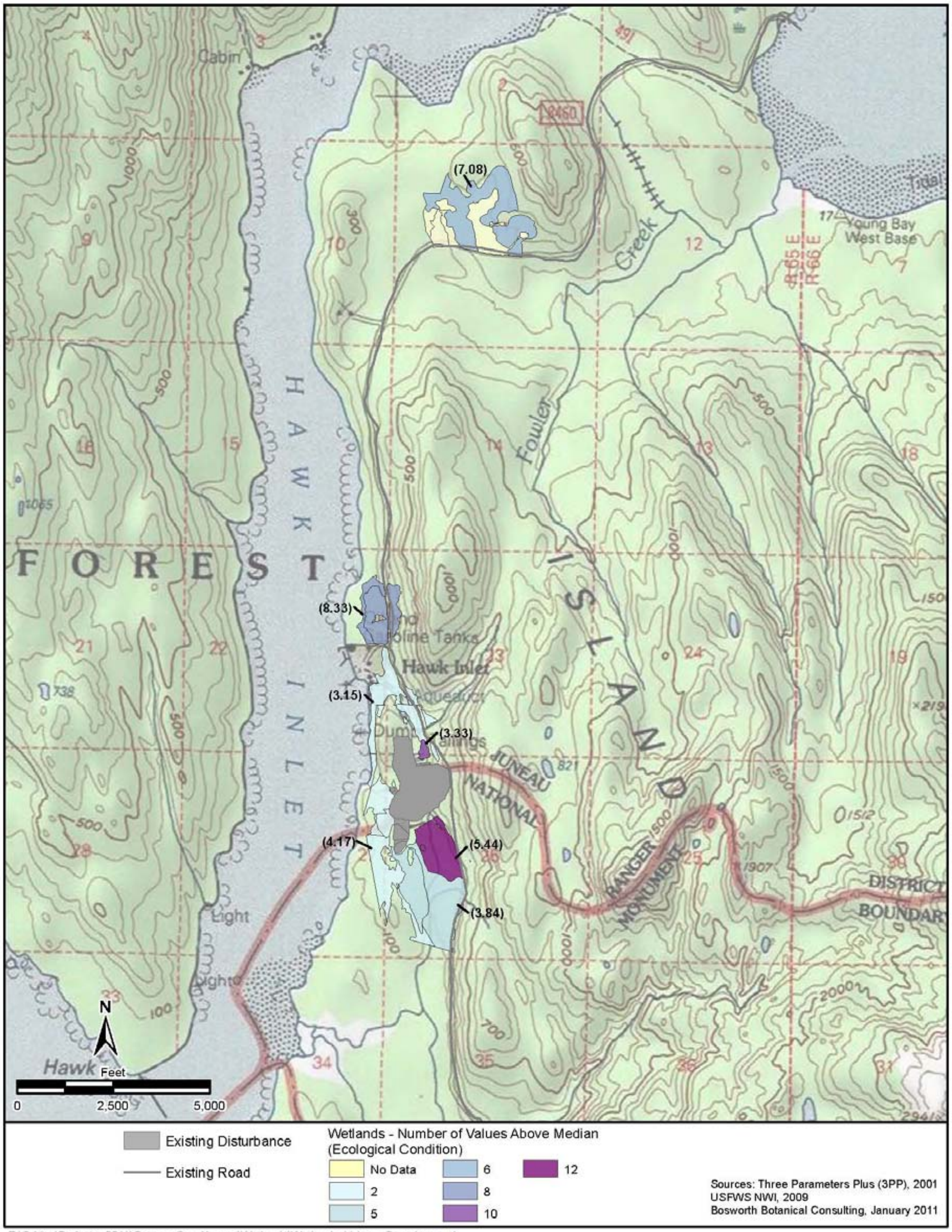

Figure 3.10-3. Wetland Values.

3.10.3.2 Effects of the Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceases, disturbed sites were reclaimed, and human activity in the area was reduced. The TDF would continue to be built out to the maximum footprint and height previously permitted following the 2003 EIS process (USDA 2003) (Figure 3.10-4). After the TDF was fully built out in 2014, reclamation would begin as described in the 2003 EIS (USDA 2003).

Impacts to wetlands from current mining operations would continue at rates as described in the 2003 Final EIS (USFS 2003) and no new dredge and fill activities would be authorized.

3.10.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF.

The TDF expansion would have a long-term adverse impact to approximately 99 acres of wetlands (Table 3.10-4). The majority of the impacts would occur on forested wetlands and fens within the footprint of the TDF. These wetlands would be filled by the liner material, drainage layers, and ultimately, tailings. Wetlands would also be filled by construction of ponds, reclamation material storage areas, and the truck wheel wash facility (Figure 3.10-4).

Table 3.10-4. Wetlands Disturbed by Alternative B.

Wetland Type	Acres of Disturbance
Bog/Bog Woodland	26.2
Sedge Fen/Fen	28.5
Forested Wetland*	43.3
Marsh	0.4
Total	**98.4**

* Includes .5 acre of wetlands not assigned to a specific type in data provided by three parameters plus (2001).

The functions (Figure 3.10-5) and values (Figure 3.10-6) provided by wetlands disturbed under Alternative B would be lost throughout the life of the mine, and in most cases, permanently. All of the fen and most of the bog wetlands within the Tributary Creek drainage would be affected by the operation; roughly half of the forested wetlands with the drainage would also be affected. Table 3.10-5 includes the prominent functions and values of wetlands that would be disturbed under Alternative B. The fen wetland provides the most functions that exceed regional median ratings, including the highest rated level for Stream Flow Support. The associated effects on the hydrologic patterns of the stream and the habitat values for resident and anadromous fish are discussed in sections 3.5.3 and 3.7.3 respectively.

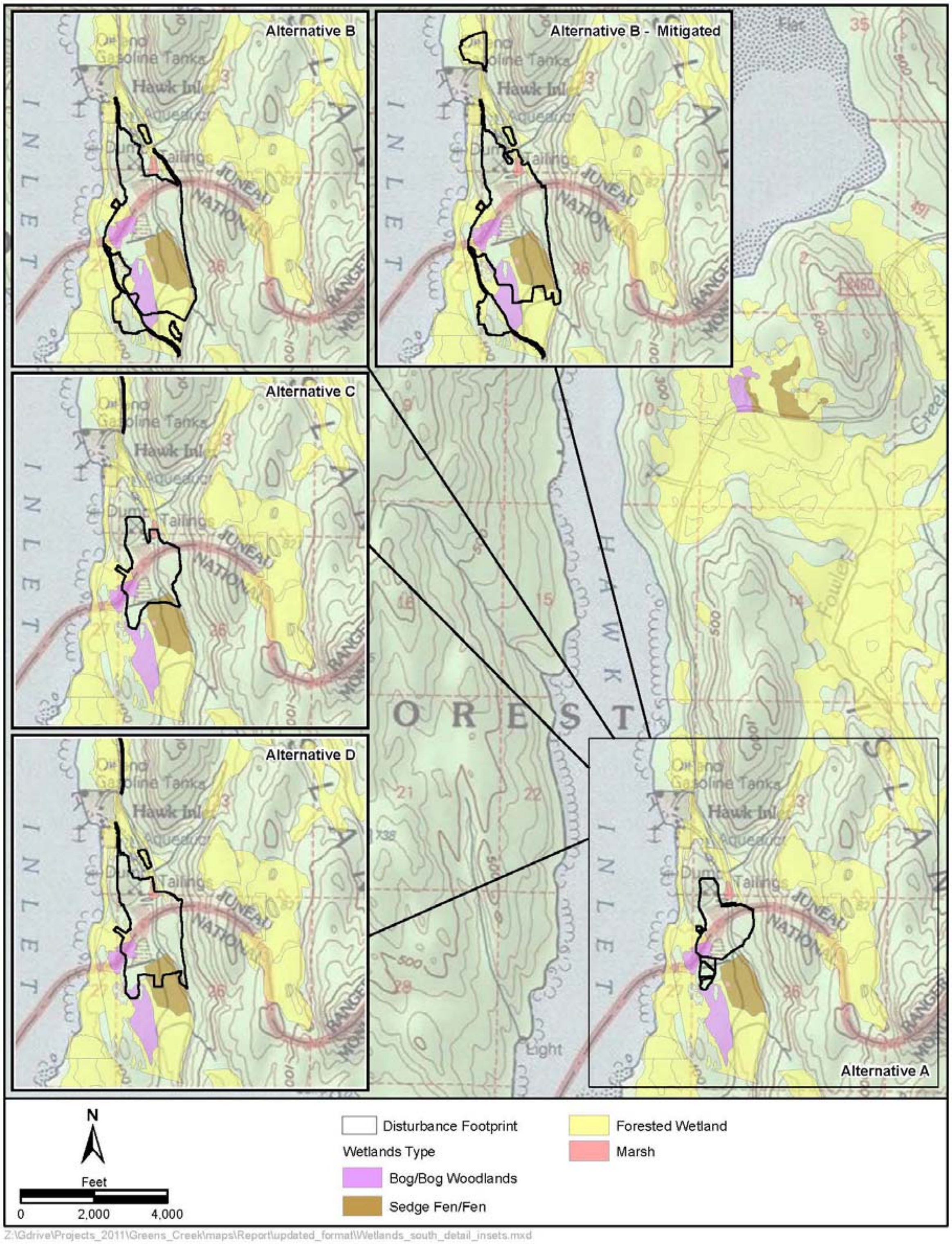

Figure 3.10-4. Impacts to Wetlands by Alternative (South).

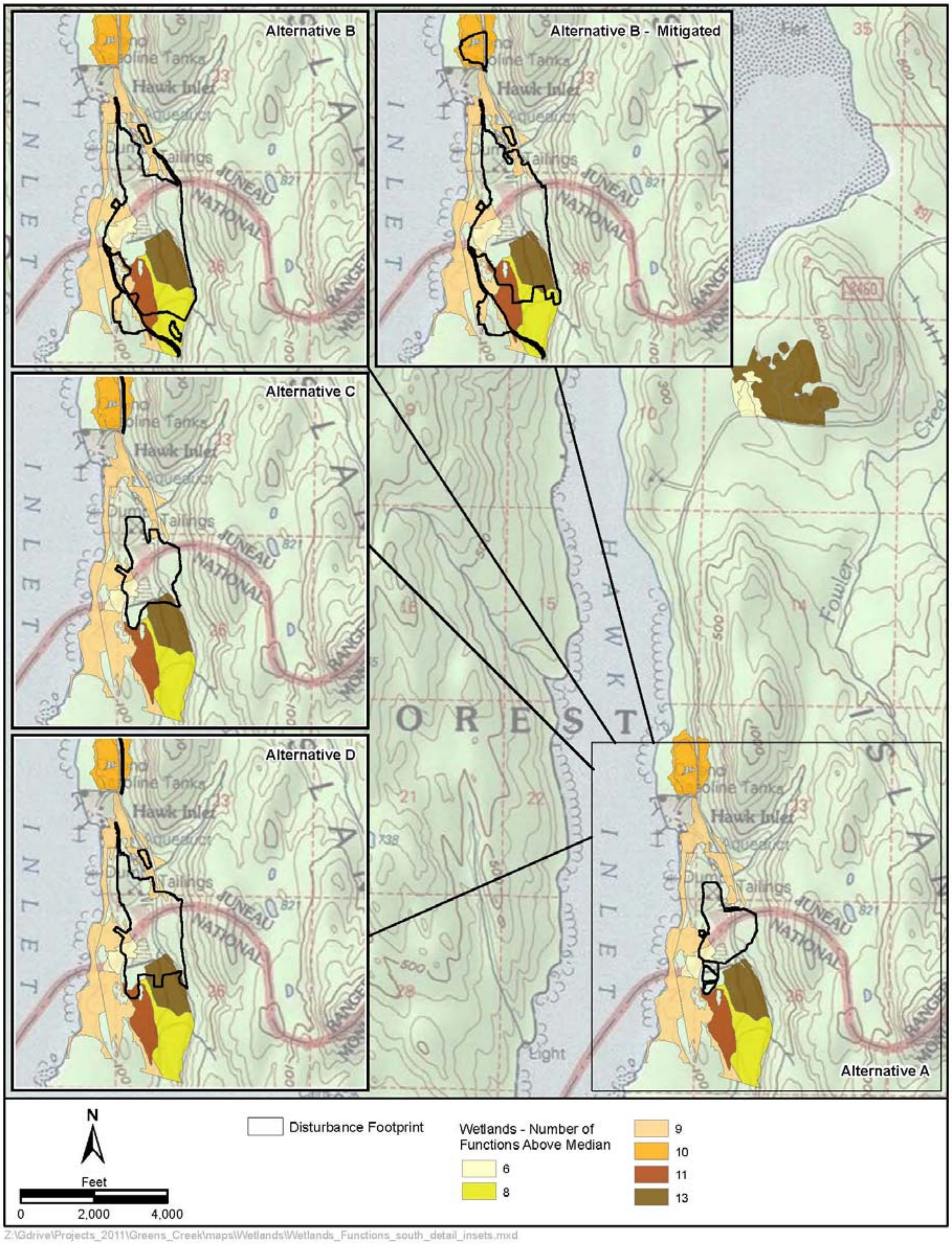

Figure 3.10-5. Impacts to Wetland Functions by Alternative (South).

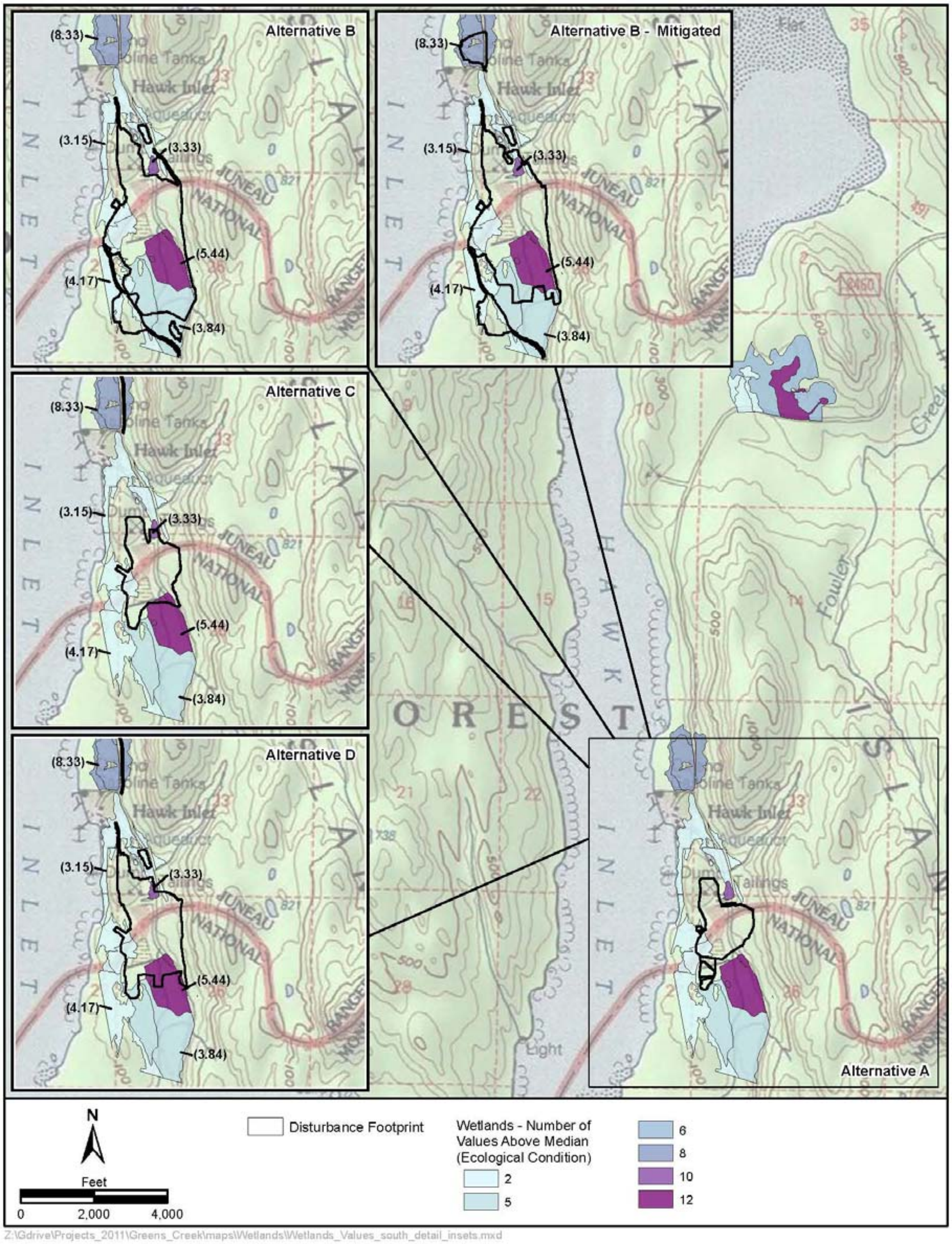

Figure 3.10-6. Impacts to Wetland Values by Alternative (South).

Table 3.10-5. Prominent Wetland Functions and Values under Alternative B.

Wetland	Functions*	Values *
Bog/Bog Woodland	Carbon sequestration	Streamwater warming
Sedge Fen/Fen	Stream flow support, streamwater cooling, aquatic invertebrate habitat, amphibian habitat, native plant habitat	Waterbird nesting habitat
Forested wetlands	Phosphorus retention	Streamwater warming, native plant habitat
Marsh	Sediment and toxicant retention and stabilization, nitrate removal and retention	Phosphorus retention, waterbird nesting habitat

* Table 3.10-3 includes a complete list of functions and values for all wetlands. Functions and values shown here were significantly above the regional median.

Where wetlands were restored in settings such as reclaimed water management ponds or growth media storage piles, some of the functions of the emergent wetlands would return relatively quickly because the structure of vegetation in these wetlands is simple and the plants would grow quickly. Water storage and stream flow functions in emergent wetlands would take longer to develop since they are tied in part to the accumulation of thick organic soils. Functions associated with the forested wetlands would recover more slowly, reflecting the time it would take for trees and shrubs to reestablish. Sites determined to be suitable for wetland restoration would be contoured to ensure the presence of enough water to support the desired environment. To the extent they are available, soils typical of, and suited to, wetlands would be used as appropriate and hydric characteristics would be expected to develop over time.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion; the remaining volume would be placed in the final phase.

The mitigated Alternative B would place the reclamation material storage area in a forested wetland outside the Monument, near the junction of the A and B roads in the Middle Hawk Inlet drainage rather than in a forested wetland in the Tributary Creek drainage. Further, one of the quarries proposed in the Tributary Creek drainage (and inside the Monument) under Alternative B would be eliminated by deepening the quarry located near the north end of the TDF (outside of the Monument). These mitigation activities would slightly reduce the overall amount of disturbance to forested and bog wetlands (by 12 acres) in the Tributary Creek drainage compared to Alternative B (Table 3.10-6). Tailings placement in the area adjacent to the northeast corner of the existing would involve filling all 2.7 acres of marsh wetland within the Cannery Creek drainage. Based on the results of the Wetland Ecosystem Services Protocol for Alaska – Southeast assessment, relocation of the reclamation material storage area would involve moving its proposed location from a forested wetland in the Tributary Creek drainage to another forested wetland (Forested Mitigated Alternative B) in the Middle Hawk Inlet drainage, outside the Monument (see Table 3.10-6 and Figure 3.10-4). The Forested Mitigated Alternative B wetland in the Middle Hawk Inlet drainage exceeds the median for more functions than the Tributary Creek drainage forested wetland, including for wetland sensitivity and ecological condition. The values ratings for both forested wetlands are similar (see Table 3.10-3). While the redesigned TDF under this alternative would shift some of the tailings disposal area to the north end of the existing TDF, impact to the fen in the Tributary Creek drainage could not be avoided; however, the redesign would reduce the extent of impacts to some of the forested wetlands in the Tributary Creek drainage.

Table 3.10-6. Wetlands Disturbed by Mitigated Alternative B.

Wetland Type	Acres of Disturbance
Bog/Bog Woodland	17.5
Sedge Fen/Fen	27.9
Forested wetland *	28.5
Marsh	2.7
Total	**86.4**

* Includes 9.8 acres of wetlands not assigned to a specific type and with upland inclusions, in data provided by Three Parameters Plus (2001).

3.10.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve a short-term expansion of the existing TDF and the concurrent construction of a new TDF in the north drainage to Hawk Inlet, located approximately 3 miles north of the existing TDF. Once infrastructure for the new facility was completed, tailings disposal would shift to the new facility and closure of the existing TDF would begin. The new facility would require an upgrade to the A Road along with the construction of other supporting facilities. Alternative C would also extend the operating period of the mine by 30–50 years, but would allow reclamation to begin in the existing TDF in approximately 3 years.

Effects to wetlands would be more widely spread than in alternatives A and B because of the need to develop a new TDF and supporting infrastructure. Alternative C would affect approximately half of the marsh wetland near the northwest corner of the existing TDF. Forested wetlands in the north drainage to Hawk Inlet (Forested Alternative C/D) that would be impacted by the new TDF are in better ecological condition than the forested wetlands that would be impacted by the expanded TDF under Alternative B (see Table 3.10-3 and figures 3.10-4 through 3.10-9). The number of values for which the Forested Alternative C/D wetland exceeded the regional median (13) was greater than for either of the Forested Tributary Creek (8) or the Forested Mitigated Alternative B wetlands (10). The facility footprints would have less effect on the bog/bog woodland wetlands in the Tributary Creek drainage than under Alternative B or D. No similar comparison can be made for the fen and bog wetlands in the area of the new TDF, as the Wetland Ecosystem Services Protocol for Alaska – Southeast assessment did not evaluate these wetlands separately. Alternative C would only slightly impact the sedge fen wetland in the Tributary Creek drainage, which had the highest number of functions and values above the regional median. However, construction of the new TDF would eliminate a large fen wetland in the Fowler Creek drainage.

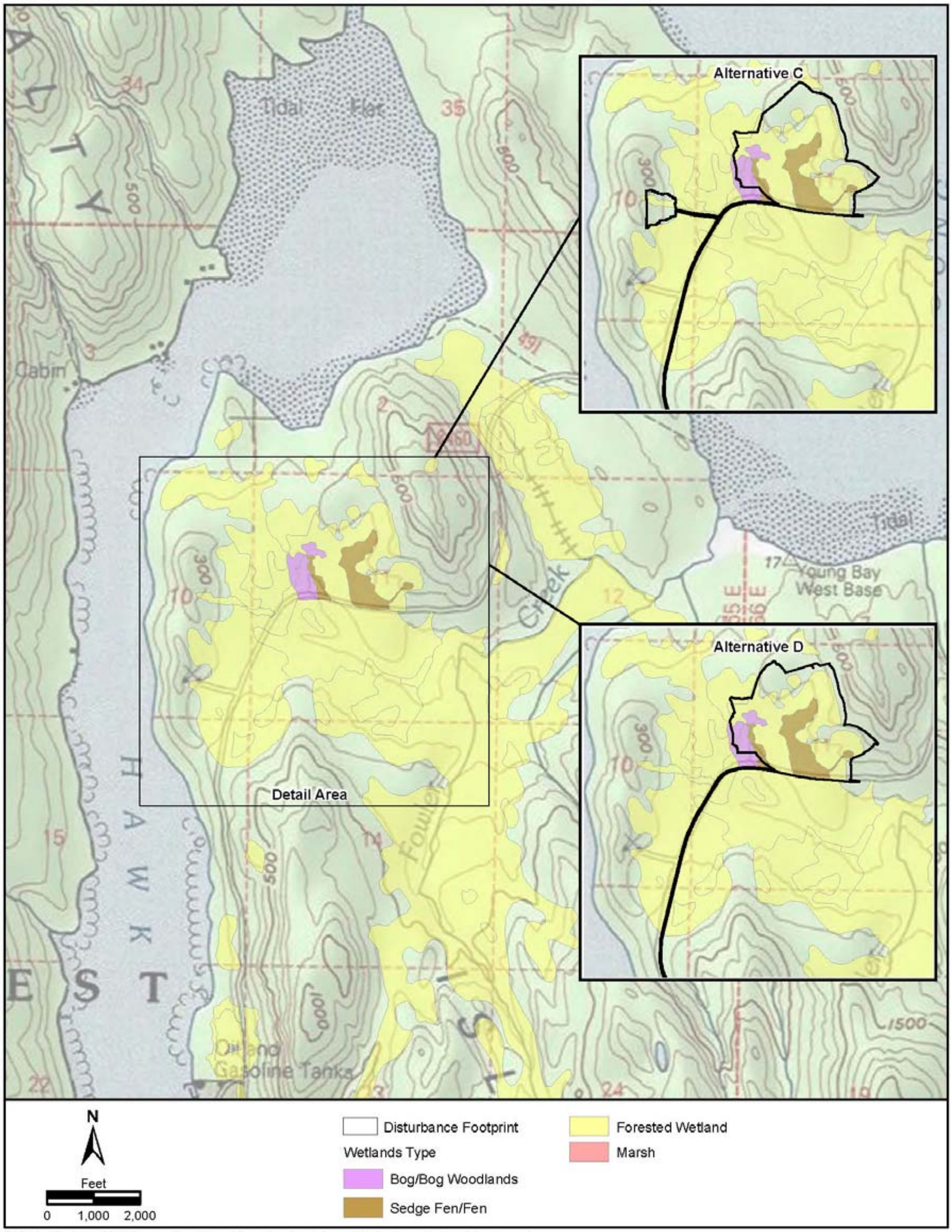

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Figure 3.10-7. Impacts to Wetlands by Alternative (North).

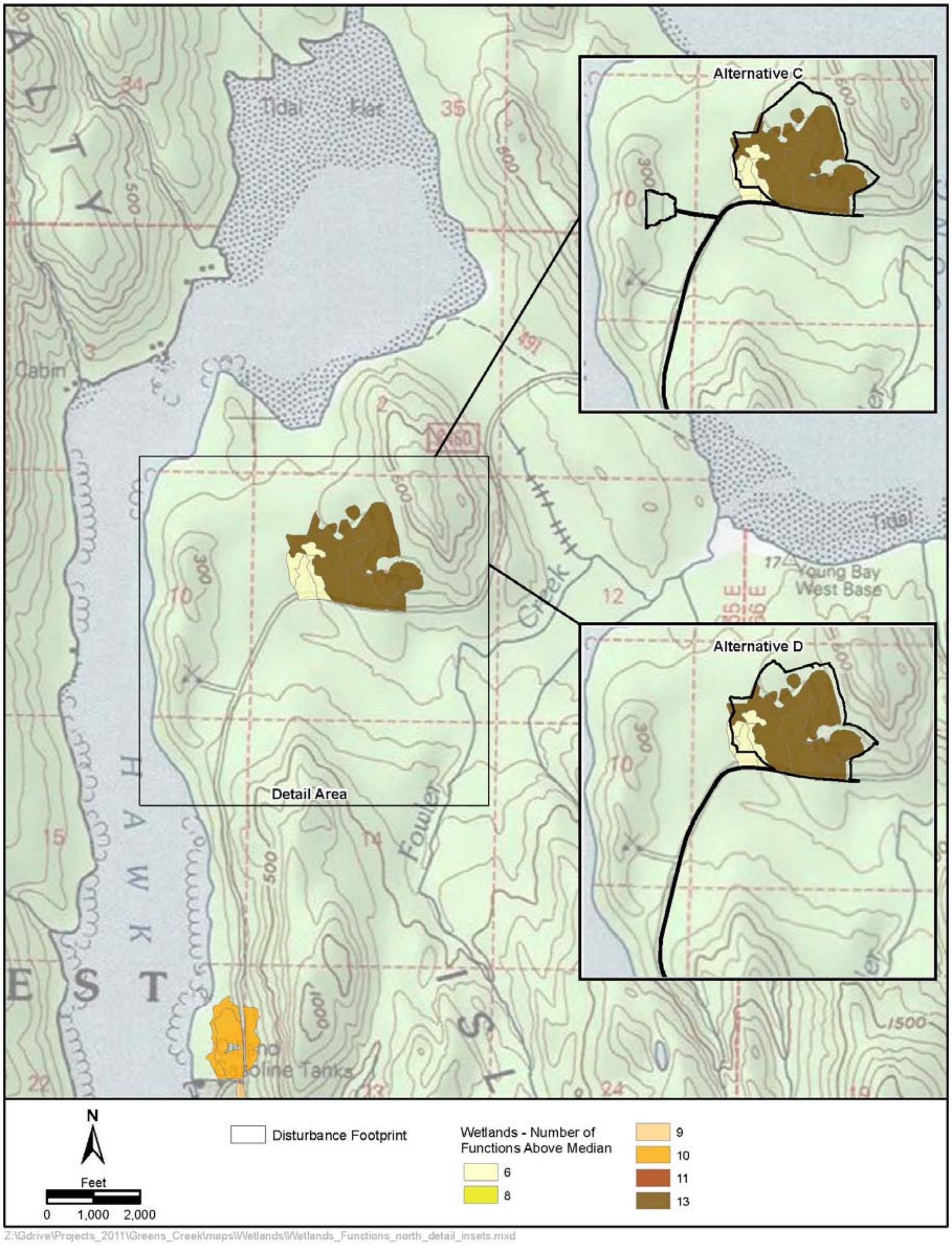


Figure 3.10-8. Impacts to Wetland Functions by Alternative (North).

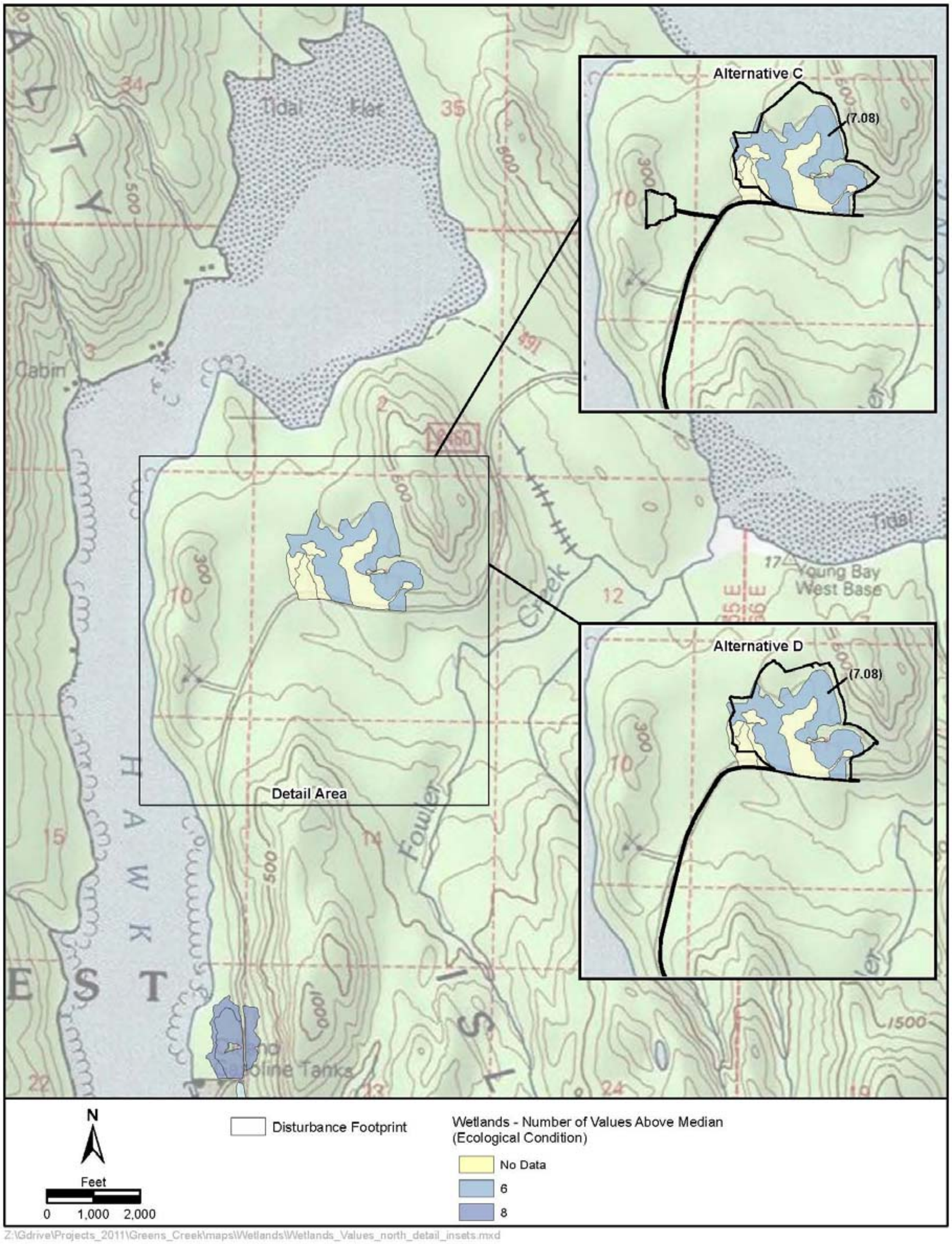


Figure 3.10-9. Impacts to Wetland Values by Alternative (North).

During the initial few years (2012–2015), wetlands would continue to be affected by the expansion of the existing TDF as well as preparation of infrastructure for the new TDF. Effects generated later in the project life would be focused in the north drainage to Hawk Inlet (new TDF) rather than the Tributary Creek drainage. Development of new facilities, including reclamation material storage areas, quarries, water management ponds; linear drain features and pipelines; truck wheel wash; and water treatment plants would further impact wetlands. Alternative C would affect 114.2 acres of wetlands (Table 3.10-7). Figures 3.10-4 through 3.10-9 illustrate the wetland types, number of functions exceeding the regional average, and number of values exceeding the regional average for each alternative.

Table 3.10-7. Wetlands Disturbed by Alternative C.

Wetland Type	Acres of Disturbance
Bog/Bog Woodland	11.7
Sedge Fen/Fen	24.9
Forested Wetland *	76.5
Marsh	1.1
Total	**114.2**

* Includes 1.1 acres of wetlands not assigned to a specific type and with upland inclusions, in data provided by Three Parameters Plus (2001).

The upgrade of the A Road under Alternative C could result in indirect impacts to wetland hydrology by altering flows of surface water and shallow groundwater. The extent to which these impacts would occur is difficult to determine and depends to a large extent on the type of fill material and the effectiveness of the drainage controls along the disturbance. However, studies on roads in wetlands in southeast Alaska indicate that impacts are generally limited to the immediate vicinity of the road and the hydrologic regime recovers relatively quickly within 30 feet down-gradient of the road (Glaser 1999; McGee 2000).

3.10.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of the new TDF. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than Alternative B, however the footprint of the new TDF would be similar in size to Alternative C.

Effects to wetlands would be greater than under any of the other alternatives with effects similar to both alternatives B and C. Under Alternative D, the disturbances to the north would be delayed until approximately 10 years into the life of the project. Under Alternative D, there would be slightly more disturbance to the fen wetland in the Tributary Creek drainage, compared to Alternative C and all of the marsh wetland near the northwest corner of the existing TDF would be filled. Effects to the bog/bog woodland wetlands in the Tributary Creek drainage would be less than under Alternative B. Like Alternative C, the wetland disturbance of this alternative would be more widespread than alternatives A and B due to development of a new TDF. Alternative D would affect 124.9 acres of wetlands (Table 3.10-8). Figures 3.10-4 through 3.10-9 illustrate the wetland types, number of functions exceeding the regional average, and number of values exceeding the regional average for each alternative.

Table 3.10-8. Wetlands Disturbed by Alternative D.

Wetland Type	Acres of Disturbance
Bog/Bog Woodland	13.6
Sedge Fen/Fen	32.5
Forested Wetland *	76.9
Marsh	1.9
Total	**124.9**

* Includes 1.6 acres of wetlands not assigned to a specific type and with upland inclusions, in data provided by Three Parameters Plus (2001).

3.10.4 Wetlands – Summary

Wetland surveys identified approximately 3,267 acres of existing wetlands within the immediate vicinity of the mine, including bogs, fens, forested wetlands, and marshes. Direct effects to wetlands would primarily occur as long-term adverse impacts (placement of fill) and would result in permanent loss of wetlands. Most wetland would not be restored after final closure of the mine, and the amount of time required for wetlands that are restored would depend on the wetland type and the functions they provide. No new impacts to wetlands would occur under Alternative A, which would include continuation of mining until 2014 when project closure and reclamation would begin. Alternative B would have the least amount of impacts to wetlands; compared to other action alternatives, with all impacts confined to the Tributary Creek drainage. The full build-out of Alternative B would result in the total loss of a fen wetland that currently demonstrates 13 functions at levels higher than the median for other wetlands within the region. Mitigated Alternative B would slightly reduce the overall amount of disturbance to wetlands, but would move the impacts from a forested wetland in the Tributary Creek drainage inside the Monument to a more sensitive wetland in better ecological condition outside the Monument. Mitigated Alternative B would also result in the loss of the high functioning fen wetland. Impacts to wetlands would be greater and more widely spread under alternatives C and D, but would occur largely in the north drainage to Hawk Inlet outside the Monument rather than in the Tributary Creek drainage inside the Monument. However, forested wetlands in the north drainage are in better ecological condition than the forested wetlands that would be impacted under Alternative B. Alternative C would impact less of the highly functioning sedge fen wetlands in the Tributary Creek drainage, compared to Alternative D (Table 3.10-9). The Section 404 permit for the least environmentally damaging practicable alternative will require implementation of a mitigation plan.

Table 3.10-9. Summary of Wetland Acreage Impacted by Alternative.

Wetland Type	Acres of Disturbance				
	Alternative A	Alternative B	Mitigated Alternative B	Alternative C	Alternative D
Bog/Bog Woodland	0	26.2	17.5	11.7	13.6
Sedge Fen/Fen	0	28.5	27.9	24.9	32.5
Forested Wetland *	0	43.3	28.5	76.5	76.9
Marsh	0	0.4	2.7	1.1	1.9
Total	**0**	**98.4**	**86.4**	**114.2**	**124.9**

* Includes 1.6 acres of wetlands not assigned to a specific type and with upland inclusions, in data provided by Three Parameters Plus (2001).

3.11 Wildlife

This section addresses the potential effects of the project to wildlife, including MIS, other species of concern, and their habitats. MIS and other species of concern potentially occurring in the project area were identified through consultation with the Forest Service, ADF&G, and USFWS; published literature, unpublished reports, other NEPA documents pertaining to the project area; and field surveys of the project area and other local knowledge. Table 3.11-1 provides a comprehensive list of these species and identifies species carried forward in the analysis based on known occurrences or the presence of suitable habitat in the project area. Species groups discussed in this section include furbearers, waterfowl and shorebirds, endemic mammals, marine mammals and migratory birds. Federally listed species, candidates for federal listing, and Forest Service Alaska Region sensitive species are addressed in Section 3.12, Threatened, Endangered, and Alaska Region Sensitive Species.

MIS are vertebrates or invertebrate species whose response to land management activities can be used to predict the likely response of other species with similar habitat requirements (FSM 2631.3). Forest Service Manual direction requires the assessment of project effects to MIS and that Forest Plan requirements, goals, and objectives for these species are met at the project level (FSM 2621.3, 2621.4 and 2672.4). Thirteen wildlife species were identified as MIS in the Forest Plan (USFS 2008a).

Migratory birds are protected by the Migratory Bird Treaty Act (MBTA) and Landbird Conservation Plan, which require federal agencies to assess project actions that may affect avian species covered by these doctrines and their habitats. The MBTA outlines responsibilities of federal land management agencies relative to landbird conservation and a Memorandum of Understanding (MOU) between the Forest Service and the USFWS provides interim direction on implementation of the MBTA (USFS 2008b). The Forest Service will collaborate with the USFWS, as needed, if project actions produce measurable impacts to avian resources (Executive Order 13186; USFS/USFWS MOU 2001).

Table 3.11-1. Management Indicator Species and Other Species of Concern in the Vicinity of the Greens Creek Mine.

Common Name	Scientific Name	Habitat Association/Range	Potential occurrence in vicinity of Greens Creek Mine [a]	Status [b]
Birds				
bald eagle	*Haliaeetus leucocephalus*	Associated with coastal areas; nests in old-growth trees.	Yes, suitable habitat present.	MIS
Vancouver Canada goose	*Branta canadensis fulva*	Associated with wetlands (both forested and non-forested) in estuary, riparian, and upland areas.	Yes, suitable habitat present.	MIS
red-breasted sapsucker	*Sphyrapicus ruber*	Primary cavity excavators; use a variety of forested habitats but require the presence of snags.	Yes, suitable habitat present. Observed during 2010 wildlife surveys.	MIS
hairy woodpecker	*Picoides villosus*	Primary cavity excavator; use old-growth forest habitats with snags and dying trees for foraging and nesting.	Yes, suitable habitat present.	MIS
brown creeper	*Certhia americana*	Associated with large-diameter old-growth trees.	Yes, suitable habitat present.	MIS
Mammals				
brown bear	*Ursus arctos*	Use areas from sea level to the alpine.	Yes, known to occur in the vicinity of the project	MIS
Alexander Archipelago wolf	*Canis lupus ligoni*	Mainland and the larger islands south of Frederick Sound (MacDonald and Cook 2007) where its densities are closely tied to the population levels of their prey (primarily Sitka black-tailed deer).	No, does not occur on Admiralty Island.	MIS
black bear	*Ursus americanus*	Occurs throughout the mainland and on the islands south of Frederick Sound.	No, does not occur on Admiralty Island.	MIS
Sitka black-tailed deer	*Odocoileus hemionus sitkensis*	Occurs from shoreline to alpine; associated with old-growth forests. This species represents those that use lower elevation (below 800 feet elevation) productive old-growth forest habitats during the winter period.	Yes, common on Admiralty Island and in the vicinity of the mine.	MIS
mountain goat	*Oreamnus americana*	Cliffs, alpine and subalpine habitats.	No, does not occur on admiralty island, though there is suitable habitat.	MIS
marten	*Martes americana*	Coastal habitats, riparian areas, larger-sized old-growth forests.	Yes, suitable habitat present.	MIS
river otter	*Lutra canadensis*	Coastal and freshwater aquatic environments.	Yes, suitable habitat present.	MIS
red squirrel	*Tamiasciurus hudsonicus*	Occupies a wide variety of forest habitat; requires forests with cone-producing trees and cavities in trees and snags for nesting and denning. Likely introduced around 1950 and has successfully colonized Admiralty Island (MacDonald and Cook 2007).	Yes, suitable habitat present; known to occur in vicinity of the project. Two individuals were recorded during deer habitat assessment in 2010.	MIS

Table 3.11-1. Management Indicator Species and Other Species of Concern in the Vicinity of the Greens Creek Mine.

Common Name	Scientific Name	Habitat Association/Range	Potential occurrence in vicinity of Greens Creek Mine [a]	Status [b]
Migratory Birds				
marbled murrelet	*Brachyramphus marmoratus*	Associated with mature/old growth forests.	Yes, suitable habitat present. Observed during 2010 wildlife surveys.	SOC
blue grouse	*Dendragapus obscurus*	Associated with spruce/hemlock/cedar forests of southeast Alaska as a primary or secondary habitat.	Breeding, Winter	Identified as priority breeding landbird species for the southeastern Alaska region. [c]
western screech owl	*Otus kennicottii*		Breeding, Winter	
black swift	*Cypseloides niger (borealis)*		Breeding	
Vaux's swift	*Chaetura vauxi*		Migration Breeding	
rufous hummingbird	*Selashorus rufus*		Migration, Breeding	
red-breasted sapsucker	*Sphyrapicus ruber*		Breeding	
olive-sided flycatcher	*Cantopus cooperi*		Breeding	
western wood-pewee	*Contopus sordidulus*		Breeding	
Hammond's flycatcher	*Empidonax hammondii*		Breeding	
Pacific-slope flycatcher	*Empidonax difficilis*		Breeding	
Steller's jay	*Cyanocitta stelleri*		Breeding, Winter	
northwestern crow	*Corvus caurinus*		Breeding, Winter	
chestnut-backed chickadee	*Poecile rufescens*		Breeding, Winter	
American dipper	*Cinclu mexicanus*		Breeding	
varied thrush	*Ixoreus naevius*		Migration, Breeding, Winter	
Townsend's warbler	*Dendroic townsendi*		Breeding	
blackpole warbler	*Dendroica striata*		Migration	
MacGillivray's warbler	*Oporornis tolmiei*		Breeding	
golden-crowned sparrow	*Zonotrichia atricapilla*		Breeding, Winter	
golden-crowned kinglet	*Regulus satrapa*		Breeding, Winter	

Notes:

a. Source: Boreal Partners in Flight Landbird Conservation Plan for Alaska Biogeographic Regions (BPIF 1999) and BPIF (2011).
b. MIS = Tongass National Forest Management Indicator Species; SOC = other species of concern.
c. Breeding = only has potential to occur during the spring/summer breeding season (dates vary by species); Migration = only has the potential to occur during spring/fall migration; Winter = only has the potential to occur in the project area during winter, outside of the breeding season.

The Bald and Golden Eagle Protection Act of 1940, as amended, prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" eagles, including their parts, nests, or eggs. The definition of take includes disturbance and covers impacts that result from human-induced alterations initiated around an active and previously used nest site during a time when eagles are not present, should disturbance impact eagles or their habitat use upon returning to the nest site.

3.11.1 Wildlife – Pre-mining Environment

The resource analysis of wildlife is related to Issue 2 impacts of wetlands and associated habitat values as well as Issue 3 impacts to fish streams. Wildlife also plays a role in defining Monument Values (Issue 4). Measures of wildlife resources include acres of impacted habitat for selected MIS.

Prior to mining, the wildlife habitats in the vicinity of the mine were much like the existing vegetation elsewhere on Admiralty Island. The predominant vegetation type is hemlock-spruce forest, interspersed with a mosaic of non-forested plant communities, including peat wetlands, shrub wetlands, and sedge meadows (USFS 2003). Coastal and nearshore marine habitats are present in Hawk Inlet and riparian and aquatic habitats occur along Cannery Creek, Greens Creek, Tributary Creek, and several smaller creeks (Further Creek, Franklin Creek, Proffett Creek, Althea Creek and CC Creek). These habitats supported a number of marine mammal, terrestrial mammal, avian, and fish species.

Admiralty Island was designated as a National Monument in 1978 in part for its unique island ecology which included the highest density of nesting bald eagles, large numbers of Alaska brown bear, and the largest unspoiled coastal island ecosystem in North America (16 USC 431 note 43 FR 57009). In his proclamation, the island was described by President Carter as "an outdoor living laboratory for the study of bald eagle and Alaska brown bear." A noted unusual aspect of the island's ecology was that it possessed exceptional distributions of certain wildlife species, but, due to its separation from the mainland, excluded entirely a large number of other species indigenous to the general area.

Prior to construction and operation of the Greens Creek Mine there was an existing level of human activity in the area. The Hawk Inlet marine terminal at the mouth of Cannery Creek previously served as a fish cannery facility. Hawk Inlet and Admiralty Island as a whole have been, and continue to be, used for subsistence activities and recreation including boating, fishing, wildlife viewing, and hunting. Commercial fishing is conducted in Hawk Inlet. A limited amount of mining outside of the Greens Creek watershed has also occurred. In the mid-1970s detailed mining exploration, including surface drilling, began in the Greens Creek area (USFS 1983). In the late 1970s an entirely helicopter-supported exploration program involving extensive underground drilling began. Thus, prior to development of the mine, wildlife in the vicinity were exposed to an existing level of localized disturbance.

3.11.2 Wildlife – Baseline Conditions

This section provides a more detailed description of existing wildlife resources in the vicinity of the mine site and impacts that have occurred to date. The study area for wildlife includes a one-half-mile buffer around the proposed TDF expansion areas and the portion of the B Road extending from the existing lease boundary north to the TDF expansion under alternatives C and D, plus the adjacent waters of Hawk Inlet. This area extends beyond the limit of direct ground disturbance but is adequate to capture farther reaching effects to wildlife such as noise and the introduction and spread of invasive species.

The vegetation of southeast Alaska and the Tongass National Forest is dominated by temperate coastal rain forests at lower elevations (less than about 2,000 feet), with interspersed muskegs, other wetlands, and other nonforest types. At higher elevations, alpine vegetation, rock, glaciers, and snowfields dominate. Although many wildlife species in the Tongass National Forest are associated with more than one habitat type, most inhabit old-growth forests or prey on species that inhabit old-growth forests. Therefore, the following discussion in relation to wildlife focuses on the old-growth ecosystem.

Old-growth forests in the Tongass National Forest can be classified as unproductive and productive. Productive old-growth is generally defined as old-growth capable of producing at least 20 cubic feet of wood fiber per acre per year, or having greater than 8,000 board feet per acre. The Size-Density Model (SDM), which uses a combination of tree sizes and tree densities to classify forest structure (Caouette et al. 2006), is used by Forest Service managers and planners to map POG and assess impacts to wildlife and habitats in the Tongass National Forest.

Table 3.11-2 displays the acres of POG[2], and other habitats within the study area. There are approximately 2,426 acres of POG in the study area, 95 percent of which are 800 feet in elevation. Productive old-growth is discussed based on the SDM, which is described in more detail the 2008 Tongass Forest Plan, but summarized below. The SDM was developed to better describe forest structure, ecosystem diversity, and wildlife habitat, separates POG into seven distinct classes:

- **SD-4H**: Low productive older forest associated with wet, poorly drained land types. Canopy closure is variable and trees are generally small, old, and defective.
- **SD-4N**: Low to moderately productive older upland forest. Canopy characteristics are variable and patchy with moderate canopy closure and relative coarse canopy texture.
- **SD-4S**: Highly productive younger upland forest. Stand volume is moderate but increasing. Canopy characteristics tend to be uniform with high canopy closure and fine texture.
- **SD-5H**: Moderately productive older forest associated with wet, poorly drained land types. Canopy closure, texture, and structure tend to be variable and patchy.
- **SD-5N**: Moderately productive older upland forest. Canopy traits tend to be variable with moderate canopy closure and coarse canopy texture.
- **SD-5S**: Highly productive upland forest. Stand volume is high. Canopy characteristics tend to be uniform with moderate to high canopy closure.

[2] Forest land on the Tongass is defined as productive and unproductive, distinguished in terms of their ability to produce wood. The distinction is primarily used in timber management; however, it is also useful for describing forest cover types for biodiversity and wildlife habitat because these categories describe forest structure (USFS 2008). Productive forest land is defined as land capable of producing at least 20 cubic feet of wood fiber per acre per year or having greater than 8,000 board feet per acre of standing volume. Unproductive forest land is forest land that does not meet these thresholds.

- **SD-6/7**: Highly productive forest associated with riparian areas, alluvial fans, colluvial toe slopes, karst geology, and wind protected uplands. Stand volume is high. Canopy closure is low to moderate and canopy texture is coarse.

Table 3.11-2. Acres of Productive Old-growth Forest by Size-density Model Classes and Other Habitats within the Study Area.

Productive Old Growth by SDM Classes	Acres
Productive Old-Growth	
SD4H	607.4
SD4N	121.4
SD4S	421.0
SD5H	265.1
SD5N	139.3
SD5S	306.7
SD67	565.2
Total Productive Old Growth	2,426.0
Other Habitats	
Unproductive Forest	616.0
Forested Muskeg	14.9
Young-growth	21.5
Non-forested	20.0
Water	1.7
Total Other	674.1
Total	**3,100.1**

A larger spatial scale is used to describe effects for wider ranging species including deer (Wildlife Analysis Area [WAA]) and brown bears (Game Management Unit [GMU]). WAAs are geographical divisions created by the ADF&G to monitor and manage wildlife populations. GMUs are geographical areas defined by the ADF&G to manage wildlife populations. The project is in WAAs 3836 and 3837, and in GMU 4, which includes Admiralty, Baranof, Chichagof, Yakobi, Inian, Lemesurier, and Pleasant islands.

Resources used to derive information on baseline conditions include the following:

- Greens Creek Tailings Final EIS (USFS 2003);
- Greens Creek Mine Final EIS (USFS 1983);
- Peer reviewed research;
- National Marine Fisheries Service (NMFS) stock assessments (Allen and Angliss 2010); and
- Field studies conducted in support of this project (KAI Environmental Consulting 2010a, b).

This section provides relevant life history information for the species potentially occurring in the vicinity of the mine site and highlights new information including information from recent field surveys that form the current project baseline.

Potential effects to wildlife associated with construction and operation of the mine addressed in the 1983 and 2003 EIS included habitat loss, disturbance and/or displacement due to mining activities, attraction of wildlife to mine facilities, and contamination due to contact with water discharged into Hawk Inlet. Effects that have occurred under current operations are summarized in the following discussion.

Direct habitat loss has resulted from development of the Greens Creek Mine and associated processing facilities and infrastructure. Habitat removal has primarily consisted of spruce-hemlock forest with shoreline and muskeg habitats to a lesser extent. The 1983 and 2003 EISs concluded that terrestrial habitat loss would have a negligible impact to terrestrial species due to the availability of these habitats in the surrounding area. To date, most disturbance caused by construction and operation of the mine has been Sitka spruce-western hemlock forest with a smaller amount of disturbance to wetland communities (USFS 1983). Figure 3.9-1 depicts existing vegetation within the study area. Construction of the effluent discharge system disturbed a small amount of offshore habitat which was anticipated to quickly reestablish itself (USFS 1983).

Disturbance from noise and human activity associated with mining operations and the ongoing exploration for additional ore reserves also has likely had an effect to terrestrial species, causing an indirect loss of habitat. Displacement was anticipated to occur in association with human activity in the vicinity of the dock at Young Bay, the Hawk Inlet marine terminal, the mill site, and the TDF, as well as continuous truck transport of concentrate from the mill to the Hawk Inlet marine terminal. The 1983 EIS noted that this loss is difficult, if not impossible, to quantify because species and even individuals differ in their tolerance to noise and human activity.

The 1983 EIS concluded that some species, such as marten, bear, and deer, may permanently avoid the areas immediately adjacent to areas of high human activity, but due to the small footprint of the facility the presence of the mine and associated facilities would not create substantial physical or behavioral barriers to animal movements. Expansion of the TDF addressed in the 2003 EIS was not anticipated to result in additional indirect habitat loss because the expansion was located in the existing lease area. Species such as deer and brown bears are observed frequently in the vicinity of the mine site, therefore, it is apparent that some species have adapted to ongoing operations. Occurrence of wildlife in the vicinity of the mine site is described in more detail under the discussion for each species.

Alternately, mining operations can result in the creation of artificial habitats (i.e., retention ponds) or involve human activities (i.e., garbage) that attract wildlife. These scenarios can be detrimental to wildlife and humans, particularly when species or individual animals become habituated and interactions result in injury or death. To minimize this effect, all food garbage is kept indoors until it is incinerated (daily) and littering or feeding of wildlife is prohibited. Hazing is employed when animals need to be deterred from project facilities. Despite these efforts there have been instances of negative interactions between humans and brown bears (see the discussion under brown bears below for additional information).

The large barges and ships that transport the concentrate from the mine on a regular basis typically operate at low, constant speeds and infrequent intervals. Therefore, vessel traffic is not likely to affect marine mammal distribution in Hawk Inlet or in Chatham Strait, particularly given that there is an existing level of vessel activity in these areas. The 2003 EIS concluded that operation of the port does not constitute harassment or a taking under the Endangered Species Act (ESA) or the Marine Mammal Protection Act (MMPA).

Another issue identified after operation of the mine began was the potential risk of chemical and heavy metal accumulation in Hawk Inlet and resulting bioaccumulation in higher level organisms such as fish, shellfish, mammals, and birds could occur primarily through transfer of metals from prey items. Monitoring data indicate that there has been an increase in some metals in marine sediments at Outfall 002, which could accumulate in benthic organisms (see Section 3.7, Aquatic Resources). However, risks of bioaccumulation to larger organisms such as marine mammals are not likely, due to the transient nature of these species in Hawk Inlet.

Fugitive dusts, resulting from road traffic, concentrate transportation, and diesel emissions from the mining operations at the portal and the TDF are emitted into the air and have the potential to accumulate over time in lichens and possibly other ecosystem components. Dust particles carried by the wind settle in the surrounding area. Subsequently the dust particles, or contaminants metabolized into plant tissues, may then be eaten by animals, which may then be eaten by other animals. Heavy metals can cause acute or chronic neurotoxic, carcinogenic, or reproductive effects to wildlife (AMAP 2002). Some metals can bioaccumulate (concentrations increase within an organism over time as they continue to consume contaminated foods) or biomagnify (concentration increases through the food chain). Typically, heavy metals concentrations are most concentrated near the source, dissipating with distance.

The Forest Service established a biomonitoring program on the Tongass National Forest which uses lichens to monitor air quality (Section 3.2.2, Air Quality – Baseline Conditions). Lichens are commonly used as sensitive receptors for air pollution because they are intimately tied to local conditions and airborne contaminants are absorbed easily and become concentrated in the lichen tissues (Dillman et al. 2007). They are also tied to many ecosystem functions including nutrient cycling, and provide food and nesting material for a variety of vertebrate and invertebrates. Lichen biomonitoring can be used to assess changes in contaminants over time, patterns of contaminant accumulation, and the need for additional monitoring for human health concerns (Dillman et al. 2007). Results of the lichen studies are discussed in sections 3.2.2 and 3.9.2.

3.11.2.1 Management Indicator Species

Brown Bear

Admiralty Island supports one of the highest densities of brown bears in North America. The ADF&G estimates a population of 4,200 bears in GMU 4 (ADF&G 2000), with approximately 1,560 bears inhabiting Admiralty Island (Whitman 2003). Brown bears are the only large omnivore on Admiralty, Baranof, Chichagof, and the smaller adjacent islands. Brown bears are an important species from recreation and tourism, hunting, and cultural perspectives. GMU 4 is one of the most desirable hunting and bear viewing places in the world (ADF&G 2000). Currently for resident and non-resident hunters on Admiralty Island there is a bag limit of one bear every four regulatory years by registration permit only. In regulatory year 2005 (fall 2005 and spring 2006), there were a total of 120 hunter kills and 11 non-hunter kills (defense of life and property, illegal, and other human-caused sources of mortality) (Mooney 2007). The well-known Pack Creek

Bear Viewing Area is located in Stan Price Game Sanctuary in the Seymor Canal on the east side of Admiralty Island.

According to the ADF&G, the major reason the larger islands of GMU 4 can support such dense populations of bears is the presence of salmon streams that provide a readily accessible, efficient way for bears to lay on essential fat reserves. Brown bears are habitat generalists; however during the late summer use is typically concentrated along low elevation valley bottoms and salmon streams, with most use occurring within 500 feet of streams (Schoen and Beier 1990; Titus and Beier 1999). During this time their efforts focus on consuming large quantities of fish in order to rebuild their body condition in preparation for winter. Pre-denning accumulation of energy stores and den site suitability are critical for successful winter denning (Shoen et al. 1987).

Bears also use forests along streams for travel, loafing between fishing sessions, hiding, and escape cover from other bears and humans (Titus and Beier 1999). On Admiralty Island 83 day beds were located an average of 52 meters from streams (Schoen and Beier 1990). Radio-telemetry data from a study on the northeast portion of Chichagof Island indicates that in a given year brown bears do not usually travel to more than one salmon spawning stream and they may visit the same stream section year after year (Titus and Beier 1999).

Given the importance of riparian habitat to brown bears, the primary management issues affecting this species in GMU 4 are loss and alteration of riparian habitat and disturbance associated with human activities near these areas which can displace bears (ADF&G 2000). Flynn et al. (2007) found bears, particularly females, in heavily altered watersheds (i.e., with more road building and timber harvest) tended to occur farther away from salmon streams than bears in watersheds with more intact streamside vegetation suggesting that bears are not making optimal use of available salmon resources in heavily altered landscapes. A study on the Kenai Peninsula reported that female brown bears with cubs tended to avoid areas used by other bears and by humans, apparently in an effort to increase offspring survival, and used less productive salmon spawning areas despite having high nutritional requirements (Suring et al. 2006). Thus even less productive streams may be important to brown bear population productivity (Wielgus and Bunnell 2001). Roads and other human developments can also be detrimental to bears because they increase the opportunity for human-induced mortality of bears through legal hunting, defense of life or property kills, and illegal killing. Additionally, poorly maintained or constructed roads can affect water quality and productivity of salmon streams.

The Forest Plan includes a number of standards and guidelines for brown bears intended to minimize adverse impacts to brown bear habitat and reduce human/bear conflicts. Those that apply to the project include implementing bear-proof garbage disposal methods; locating mineral operational facilities more than one mile from important seasonal bear concentrations; and maintaining 500-foot forested buffers, where available, from Class I anadromous streams (USFS 2008b). Within the study area there are approximately 8,970 acres of forest within 500 feet of Class I streams in WAA 3836 and 10,202 acres of forest within 500 feet of Class I streams in WAA 3837. Greens Creek, Zinc Creek, and the lower stretch of Tributary Creek are important salmon spawning areas. The study area also includes beach fringes and grass meadows where bears concentrate in late spring to forage on grasses, sedges, forbs, carrion, and available marine organisms.

A radio-telemetry study conducted by the ADF&G between 1981 and 1989, which covered the period of mine construction and initial operations, indicated that in general home ranges and seasonal distributions of bears in the vicinity of the mine were not altered by construction. However, within their home ranges bears appeared to temporarily shift away from active construction, denning farther from the mine site after construction and shifting their use of foraging areas along Greens Creek and Zinc Creek to avoid construction (Schoen and Beier 1990). In contrast, some bears appeared to be habituating to helicopter and vehicle traffic near the Greens Creek Delta. The authors noted that the results of the study reflect the short-term effects of mine development and cannot be used to conclude that development of the mine will have minimal impacts to the local brown bear population.

Bears are seen frequently on or near the Greens Creek Mine road system, throughout the Greens Creek drainage, and further north on the peninsula between Hawk Inlet and Young Bay (USFS 2003). Most observations (several per week) occur in May and June. The 2003 EIS reported four bear deaths associated with the mine (late 1970s, 1992, 1993, 1999), two of which involved the shooting of aggressive bears and two were due to vehicle collisions (USFS 2003). Most recently in 2006, a juvenile female brown bear was killed by a larger bear in a work area adjacent to the underground mine.

Bald Eagle

Admiralty Island supports the highest documented density of breeding bald eagles in North America, with the majority of breeding birds remaining resident year-round (Stenhouse 2007). The bald eagle was selected as an MIS to represent species associated with beach, estuary fringe, and riparian habitats. Bald eagles typically nest in large trees in spruce-hemlock forest, and over 90 percent of the nests are within 500 feet of a saltwater beach. Nests are located in beach, estuary fringe, and riparian habitats. An aerial survey covering the shoreline areas in the vicinity of the mine site was conducted in July 2011 (D. Ruddis, USFWS personal communication, 2011; S. Lewis, USFWS, personal communication 2011) which documented eagle nesting activity along the shore in Hawk Inlet and along the coast. There are three bald eagle nests (all inactive in 2011) located within one-half mile of the existing TDF and one nest within one-half mile of the A Road (inactive in 2011). Within the area of the new TDF area proposed under alternatives C and D, there are three nests (two active nests and one inactive nest) located within one-half mile of the proposed location; one of the active nests is approximately 900 feet west of the proposed quarry site.

Bald eagles are especially sensitive to disturbance early in the breeding season. Activities associated with resource extraction, development, and recreation can result in reproductive failure or cause bald eagles to abandon their nests completely (Fraser et al. 1985). Bald eagles are managed by the USFWS under the National Bald and Golden Eagle Protection Act and through the Bald Eagle Take Permit Program (USFWS 2009). For mining activities, when similar activities occur within 660 feet of a nest, these guidelines recommend a protective management zone 660 feet in diameter surrounding all identified nest trees. Further protection to bald eagles is afforded by Forest-wide standards and guidelines that require the maintenance of a 1,000-foot beach buffer along the shoreline (USFS 2008b).

Bald eagles primarily forage on fish, including herring, flounder, pollock, and salmon. Thus, they are also susceptible to water quality impacts that adversely impact their prey populations.

Sitka Black-tailed Deer

Sitka black-tailed deer, an endemic subspecies of mule deer, are widely distributed throughout coastal southeast Alaska and are common in the study area. They represent species that use lower elevation (below 800 feet elevation) productive old-growth forest habitats during winter, and are an important subsistence and game species. Currently for resident and non-resident hunters on Admiralty Island there is a bag limit of four deer. In regulatory year 2007–2008 the estimated legal harvest from GMU 4 was 1,851 deer; illegal harvest during this period was 463 deer (Mooney 2009). Current federal subsistence regulations allow federally qualified subsistence users to harvest 6 deer in GMU 4.

The quality, quantity, spatial distribution, and arrangement of winter range are considered the most limiting factors for the species in southeast Alaska (USFS 2008). Good-quality winter range for deer includes areas with closed canopy forests, maritime influence, south facing slopes, and low average snow depth (USFS 2008). Optimum winter deer habitat during deep-snow conditions includes forest stands with an overstory capable of intercepting snow to make available for deer an important understory of forage species including bunchberry (*Cornus canadensis*), five leaf bramble (*Rubus pedatus*), and Vaccinium species (Hanley et al. 1989; Kessler 1982).

Based on deer habitat modeling conducted for the 2008 Forest Plan (see pages 3-265 through 3-277 of the 2008 Forest Plan FEIS for details on the model) there are 40,603 acres of deer winter range in WAA 3836 and 41,418 acres of winter range in WAA 3837.

Deer winter habitat surveys were conducted in July 2010 and 2011 in the existing TDF area and the new TDF area to the north of the existing TDF, respectively (Kai Environmental Consulting 2010b, 2011b). The survey areas included abundant forage for black-tailed deer. Understory species including Vaccinium spp., bunchberry, and five leaf bramble were all ubiquitous, with some species more patchily distributed than others. The western and southern portions of the survey area (where a small portion of the TDF expansion would occur, but other facilities are proposed) have the highest quality winter habitat, based on forest cover and forage availability.

Tree clearing may reduce the amount of available winter range for deer. The 2003 EIS concluded that because the current TDF expansion area would be accessible to deer if they crossed through areas of high human activity and because it was not connected to any other forest habitat, it likely was of low value to wintering deer particularly during periods of deep snow when deer movements would be restricted. Further, given the amount of similar surrounding forested lands, the impact of habitat loss was deemed minimal, becoming even less so upon reclamation (USFS 2003).

The 2003 EIS noted that deer are frequently observed near mine facilities, and deer congregate along the Greens Creek road system, feeding on the reclamation grasses during spring, summer, and fall. Deer use of the mine site appears to drop in the winter when snow forces them to seek cover beneath the mature forest canopy. Deer/vehicle collisions along the road system occur approximately 3 to 5 times a year despite an observed speed limit and radio communication between drivers alerting them to animal sightings as traffic moves along the road system (USFS 2003).

Marten

Two distinct types of marten have been documented within the Alexander Archipelago, American marten (*Martes americana*) and coastal marten (*M. caurina*). Coastal marten is endemic to southeast Alaska and indigenous to Admiralty Island (Dawson et al. 2007). Marten are an indicator of species associated with productive old-growth forest. The marten is also an important furbearer in southeast Alaska. Currently in GMU 4 ADF&G permits unlimited trapping of marten. In the 2005–2006 season 2,231 marten were trapped in GMU 4 (Mooney 2007b).

Larger-sized old-growth forests have the highest value for marten because they intercept snow; provide cover and denning sites; and provide habitat for their prey (Flynn et al. 2004). Use of second growth 26–40 years in age has been documented in stands with abundant understory forage and small mammal populations (Flynn et al. 2004). Habitat requirements reflect a strong interaction between food, cover, climate, and predation, with forest cover being particularly important for travel, dens and resting sites, hunting, and avoiding predation and inclement weather (Flynn and Schumacher 1999, 2001). There are approximately 1,011 acres of high-volume productive old-growth in the study area SDM classes SD-5N, SD-5S, and SD-67 (summarized above in Section 3.11.2; see USFS 2008 for more detail). Marten occur year-round in the vicinity of Hawk Inlet, Greens Creek, and Young Bay.

Primary threats to marten include habitat alteration, which could influence the distribution and availability of prey species, and fragmentation which could limit marten dispersal. Marten densities are higher in intact forests with less fragmentation (Hargis et al. 1999; Flynn et al. 2004), indicating that a large, contiguous block of old-growth is important for this species. Additionally, marten populations fluctuate widely in response to prey availability; recent research indicates that the abundance of long-tailed voles is the best predictor of marten abundance (Flynn and Schumacher 2001; Flynn et al. 2004). Marten are considered easy to trap, and local populations can be over-harvested (USFS 2008), therefore development that increases trapper access has the potential to affect the local marten population. Protection for marten is provided for in the Forest Plan through its overall conservation strategy, standards and guidelines for marten, endemic terrestrial mammals, and any legacy forest structure even though the legacy standard does not apply to any value comparison units (VCUs) on Admiralty Island (USFS 2008b).

Vancouver Canada Goose

The Vancouver Canada goose is a primarily a non-migratory waterfowl species that occurs year-round throughout southeast Alaska (Hupp et al. 2010). However geese do move locally between nesting, brood rearing, molting, and wintering grounds. This species nests almost exclusively in forested habitats associated with beach fringe, estuary fringe, and riparian habitats. Hupp et al. (2010) documented nests in forests adjacent to muskegs such as those near to the proposed tailings expansion areas. During winter, marine grasses and salt marsh plants commonly found in intertidal areas are important forage resources, and Vancouver Canada geese exhibit strong fidelity, returning repeatedly to such winter sites (Fox 2008). This species was selected as an MIS because of its association with wetlands (both forested and non-forested) in the estuary, riparian, and upland areas of the forest. There are approximately 3,267 acres of wetlands in the study area, including bogs, fens, forested wetlands, and marshes, which provide potential habitat for the Vancouver Canada goose (Table 3.10-3). Protection under the Forest Plan is provided through standards and guidelines for waterfowl and shorebird habitats, beaches, estuaries, and riparian areas (USFS 2008b).

River Otter

The river otter is an MIS, selected to represent species associated with coastal and freshwater aquatic environments and the immediately adjacent (within 100 to 500 feet) upland habitats. River otter are frequently observed in the drainages of Greens and Zinc creeks and along the shoreline (including nearshore marine areas) of Hawk Inlet and Young Bay and in the vicinity of the cannery (USFS 1983). River otter are also frequently seen near the pond associated with the Cannery Creek dam. Currently on Admiralty Island, ADF&G allows unlimited trapping of these species. Protection under the Forest Plan is provided through standards and guidelines for furbearers, beaches, estuaries, and riparian areas (USFS 2008b).

Red Squirrel

Red squirrels require forests with cone-producing trees and cavities in trees or snags. Spruce trees and mature/old-growth forests are considered to have the highest values for red squirrel habitat (USFS 2008b). Optimum conditions are believed to occur where patches of preferred habitat are greater than 30 acres. Red squirrels are thought to have been introduced to the northern end of Admiralty Island in the late 1940s or early 1950s and appear to have successfully colonized the island (McDonald and Cook 2007). Two individual squirrels were documented in 2010 while conducting deer habitat assessment surveys in the vicinity of the existing TDF. Protection under the Forest Plan is provided through standards and guidelines for furbearers, beaches, estuaries, and riparian areas (USFS 2008b).

Red-breasted Sapsucker, Hairy Woodpecker, Brown Creeper

The red-breasted sapsucker, hairy woodpecker, and brown creeper were selected as MIS to represent old-growth associated and snag dependent species. Hairy woodpeckers and red-breasted sapsuckers are primary cavity excavators that require snags and dying trees for foraging and nesting. The brown creeper requires large diameter old-growth trees. These species are protected under the Forest Plan, overall conservation strategy, and reserve tree and legacy standards and guidelines even though the legacy standard does not apply to any VCUs on Admiralty Island (USFS 2008b).

The red-breasted sapsucker inhabits all of southeast Alaska during spring, summer, and fall but typically winters in the coastal portions of its breeding range. The hairy woodpecker is an uncommon, permanent resident throughout southeast Alaska. Both species have the potential to inhabit old-growth forest in the study area; however, the red-breasted sapsucker is typically associated with low volume POG (SD4H category) whereas the hairy woodpecker is typically associated with high volume old-growth (SD5S, SD5N, and SD67 categories). These species, and in particular the hairy woodpecker, appear to avoid forest edges (Kissling and Garton 2008). There are approximately 607 acres of SD4H, 307 acres of SD5S, 139 acres of SD5N, and 565 acres of SD67 forest in the study area (Table 3.11-2). A red-breasted sapsucker was observed during 2010 wildlife surveys in the existing TDF expansion site (KAI Environmental Consulting 2010).

Brown creepers are considered uncommon, permanent residents throughout southeast Alaska. This species is also associated with high volume productive old-growth (SD5S, SD5N, and SD67 categories). Brown creepers are an interior forest species and have been shown to abandon sites that have been subjected to even light tree clearing (i.e., partial cut timber harvest) if it includes the removal of large, mature trees (Wiggins 2005).

3.11.2.2 Other Species of Concern

Marbled Murrelet

In March 2006, a status review for the marbled murrelet was initiated by the USFWS for the northern part of the species range to support ESA deliberations over the listing of the species as threatened in the southern part of its range (California, Oregon, and Washington; Piatt et al. 2007). Genetic analysis conducted as part of the review identified three distinct population segments (DPSs): one in the central and western Aleutian Islands; one ranging from the eastern Aleutians to northern California; and one in central California. Marbled murrelets are widely distributed across marine waters in southeast Alaska.

Marbled murrelets spend the majority of their lives at sea, but travel inland up to 50 miles to nest in old-growth forest stands (Piatt et al. 2006). While at sea, murrelets remain close to nesting habitat during periods when inland flights are frequent, but otherwise are distributed in relation to prey availability. Marbled murrelets typically nest on mossy-limbed branches of large, mature coniferous trees within stands of structurally complex, coastal old-growth forest (SD5N, SD5S, and SD67 categories; DeGange 1996; Kuletz et al. 1995; Ralph and Miller 1995). However, on some treeless islands in southeast Alaska marbled murrelets will lay eggs on bare talus slopes in mountainous areas (Piatt et al. 2007). Only six nests have been found in southeast Alaska (USFS 2003).

There are approximately 1,011 acres of suitable marbled murrelet nesting habitat in the study area. One marbled murrelet was observed during 2010 wildlife surveys conducted in the existing TDF site (KAI Environmental Consulting 2010). Threats to the marbled murrelet include loss of forested nesting habitat and reductions in water quality which could impact forage species such as herring. Forest Plan standards and guidelines pertaining to marbled murrelets include maintaining a 600-foot radius no-cut buffer zone around identified murrelet nests (USFS 2008b).

Waterfowl/Shorebirds

A variety of waterfowl, seabirds, and wading birds occur in the vicinity of the study area depending on the season. The three primary areas of waterfowl/shorebird habitat include the estuary in upper Hawk Inlet; the mouth of Hawk Inlet, including Piledriver Cove, Hawk Point, and the Greens Creek/Zinc Creek Delta; and the southern portion of Young Bay (USFS 2003). Upper Hawk Inlet is used throughout the summer by many species of diving and dabbling ducks and is an important resting area for dabblers during fall and spring migrations. Shorebirds and gulls also use the estuary and associated mud flats. The mouth of Hawk Inlet provides year-round habitat for waterfowl and other birds. At the southern portion of Young Bay, in the vicinity of the dock for the Greens Creek Mine, is a waterfowl and shorebird migration concentration area. Migrating waterfowl use ponds and beaver impoundments in the study area for feeding, resting, and probably for breeding.

A survey of the distribution and abundance of waterbirds in southeast Alaska conducted between 1997 and 2002 indicated that the most abundant species in nearshore waters during summer were gulls (*Larus* spp.), scoters (*Melanitta* spp.), and harlequin ducks (*Histrionicus histrionicus*) (Hodges et al. 2008). The most abundant species during winter were goldeneyes (*Bucephala islandica* and *B. clangula*), gulls, mallards (*Anas platyrhynchos*), scoters, harlequin ducks, buffleheads (*Bucephala albeola*), and mergansers (*Mergus* spp.). Any of these species may occur in the nearshore waters in the vicinity of the mine. Protection of these species is afforded under the Forest Plan standards and guidelines for waterfowl and shorebird habitats (USFS 2008b).

The 2003 EIS does not specifically address impacts to waterfowl or shorebirds; however, the 1983 EIS concluded that construction and operation of the mine would have no substantial direct or indirect effects to these species (USFS 1983). These species could be impacted if expansion of the mine creates new habitats (i.e., new ponds) that attract them or removes or disturbs existing habitat, particularly during the breeding season.

Marine Mammals

Nine marine mammal species occur in or near Hawk Inlet: Steller sea lion, northern sea otter, harbor seal, killer whale, gray whale, humpback whale, minke whale, harbor porpoise, and Dall's porpoise. Of these the Steller sea lion and humpback whale are listed under the ESA. These species are discussed in Section 3.12.2, Threatened, Endangered, and Alaska Region Sensitive Species – Baseline Conditions.

Harbor seals are the most common marine mammal in the inside waters of southeast Alaska. Small groups frequently haul out at Hawk Point, approximately one mile from the Greens Creek Delta (USFWS 2003b). Harbor seals are also commonly seen foraging inside the inlet when salmon are running in Greens Creek and Zinc Creek; however they also feed on other species including cod, crab, and shrimp. The 2003 EIS concluded that harbor seals are unlikely to be near the Outfall 002 discharge site, with the exception of approximately two hours per day during slack tide. Killer whales are observed in Hawk Inlet and at Hawk Point in the vicinity of the harbor seal haul out (USFWS 2003b). Harbor and Dall's porpoises occur in Chatham Strait and have been observed occasionally in the inlet where they may forage. Gray whales and minke whales occur in Chatham Strait but have not been observed in Hawk Inlet. The shallow sill at the mouth of Greens Creek may preclude larger marine mammals found elsewhere in Chatham Strait and Stephens Passage from using Hawk Inlet (USFS 1983). Threats to these species include entanglements in fishing gear, ship strikes, and coastal habitat pollution. The Forest Plan standards and guidelines for marine mammals provide for the protection and maintenance of harbor seal, Steller sea lion, and sea otter habitats including guidelines for approaching marine mammals and minimizing disturbance in the vicinity of rookeries and haul outs (USFS 2008b).

Endemic Mammals

The federal ESA defines endemic as "a species native and confined to a certain region; having comparatively restricted distribution." Forest Plan standards and guidelines for endemic mammals direct the Forest to "maintain habitat to support viable populations and improve knowledge of habitat relationships of rare or endemic terrestrial mammals that may represent unique populations with restricted ranges." Likewise, the National Forest Management Act directs that management prescriptions "shall preserve and enhance the diversity of plant and animal communities, including endemic(s)."

In the Alexander Archipelago, many species are endemic to an island or a group of islands. The following species are endemic and occur on Admiralty Island (ISLES 2009):

- Admiralty Island beaver (*Castor Canadensis phaeus*): endemic to Admiralty Island; occurs in lakes, rivers, streams, and adjacent riparian habitats;
- Coastal marten (discussed above): endemic to Admiralty and Kuiu islands;
- Admiralty Island meadow vole (*Microtus pennsylvanicus admiraltiae*): endemic to Admiralty Island and meadow habitats;
- Admiralty Island ermine (*Mustela erminea salva*): endemic to Admiralty Island; occurs in a wide range of habitats, but its distribution depends on small mammal abundance;
- Alexander Archipelago mink (*Mustela vison*): endemic to Admiralty Island; associated with coastal marine, nearshore, and freshwater habitats; and
- Insular dusky shrew (*Sorex monticolus elassondon*): restricted to the Alexander Archipelago and Haida Gwaii; forest, shrub, and meadow habitats.

There remain many uncertainties about the extent of endemism in southeast Alaska because research to date has primarily focused on mammals. Due to their restricted ranges, specific habitat requirements, and sensitivity to human activity, endemics are extremely susceptible to extinction (Dawson et al. 2007).

Mink are frequently observed in the drainages of Greens and Zinc creeks and along the shoreline of Hawk Inlet and Young Bay and in the vicinity of the cannery (USFS 1983). Beavers are regularly found on most streams and in some ponds in the vicinity of the Greens Creek facilities, including Greens Creek and along the A Road (USFS 1983). Currently on Admiralty Island, ADF&G allows unlimited trapping of beaver, marten, and mink.

Migratory Birds

Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds) provides for the conservation of migratory birds and their habitats and requires the evaluation of the effects of federal actions on migratory birds, with an emphasis on species of concern. Birds protected under the MBTA include all common songbirds, waterfowl, shorebirds, hawks, owls, eagles, ravens, crows, native doves and pigeons, swifts, martins, swallows, and others, including their body parts (e.g., feathers, plumes), nests, and eggs. Admiralty Island is part of the Southeastern Biogeographic Region of Alaska (BPIF 1999).

Approximately 236 species of birds occur regularly in Southeast Alaska. Roughly 160 species are known or suspected to breed in Southeast Alaska (Armstrong 1995). Migratory birds that occur, but generally only winter in or migrate through Southeast Alaska, include species of seabirds, gulls, and shorebirds. Priority migratory bird species identified in the Partners in Flight Landbird Conservation Plan (BPIF 1999, BPIF 2011) are listed in Table 3.11-1. Of these 20 species, 14 species use hemlock/spruce/cedar forest as primary habitat for known or probable breeding; the remaining 5 use this forest as secondary habitat. Marbled murrelets, bald eagles, and goshawks are also protected by the MBTA but addressed separately above or in Section 3.12.2, Threatened, Endangered, and Alaska Region Sensitive Species – Baseline Conditions.

An MOU was entered into between the Forest Service and the USFWS to strengthen migratory bird conservation (USDA 2008b). The MOU identifies strategies that promote conservation to avoid or minimize adverse impacts on migratory birds through enhanced collaboration between the Forest Service and USFWS and in coordination with State of Alaska, Tribal, and local governments. The MOU requires that the Forest Service, within the NEPA process, evaluate the effects of agency actions on migratory birds, focusing first on species of management concern along with their priority habitat and key risk factors. This includes, to the extent practicable, evaluating and balancing the long-term benefits of projects against short- and long-term adverse effects, pursuing opportunities to restore or enhance habitat, and considering approaches to identify and minimize take.

The main management issue for migratory birds in the southeastern Alaska Biogeographic Region is the harvest of coniferous forests, much of which has been high-volume, low-elevation forest. Timber harvest directly removes habitat and results in habitat fragmentation, which may reduce the suitability of remaining forest for species associated with interior forest conditions. Deciduous riparian forests are also important for many species. This habitat has been altered by road construction, mining, and other human activities. Many migratory bird species are likely to nest in the vicinity of the project area in forested, riparian, and coastal habitats. Protection under the Forest Plan is provided by beach fringe and riparian buffers and standards and guidelines for waterfowl, shorebirds, raptors, and legacy forest structure even though the legacy standard does not apply to any VCUs on Admiralty Island.

3.11.3 Wildlife – Environmental Consequences

Impacts to wildlife are addressed in terms of acres of habitat disturbed, duration of impacts, and proximity of proposed activities in relation to important habitat or areas of concentrated use by various wildlife species.

3.11.3.1 Effects Common to All Alternatives

Under all alternatives, there would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, outfall location, and along the B Road. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing operation and closure of the TDF would continue through the term of the lease. The large barges and ships that are used to haul the concentrate from the mine on a regular basis, as well as the crew shuttle transiting Young Bay are not likely to affect marine mammal distribution in Hawk Inlet, Young Bay, or Chatham Strait. The vessels typically operate at low, constant speeds and infrequent intervals. Therefore, operation of the port under all alternatives does not constitute harassment or a taking under the MMPA.

Under all alternatives, oil or fuel spills could occur from vessels at the marine terminal or at the dock in Young Bay. Spills could adversely impact marine mammal, waterfowl, and shorebird species foraging or moving through the shallow shoreline areas, particularly at the head of the inlet. Spill control plans and rapid response to spills would be the primary mitigation measures to avoid or minimize adverse spill effects to wildlife species in the marine environment.

Surface water runoff from the TDF(s) would continue to be collected, treated, and discharged into Hawk Inlet under all alternatives. As described in more detail in Section 3.7, Aquatic Resources, discharge would continue to be required to meet Alaska WQS under all alternatives, thereby minimizing impacts to wildlife species in the marine environment. However, some heavy metals accumulation in marine sediments is anticipated. Bioaccumulation of these metals in higher trophic level marine mammals or birds has the potential to occur through transfer of metals from prey items though such impacts are unlikely due to the transient nature of these species in Hawk Inlet. The amount of discharge would remain consistent during operation, but at closure, with the suspension of mining activities, the volume of water treated and discharged would appreciably decrease, thereby reducing total metals loading from the discharge to the marine environment. Therefore, while the mine operates, the longer this slight risk exists (USFS 2003).

Under all alternatives the potential effects of fugitive dust produced by TDF operation and closure activities would continue to some extent. Wildlife species can be adversely affected by fugitive dust if they become exposed to the contaminants (heavy metals) within it, which can cause effects ranging from acute to chronic including neurotoxic, carcinogenic, or reproductive effects (AMAP 2002). Dust particles may be transported into the environment by wind and deposited onto various habitats (vegetation, streams, and waterbodies). These particles, present on plants in the form of dust or metabolized into tissue and enter the food chain when eaten by animals. The Tongass National Forest air quality biomonitoring program would continue to provide information about air quality in the vicinity of the mine. Currently, dust abatement measures to prevent wind erosion of the TDF include hydro-seeding on undisturbed areas of the TDF and installation of wind breaks. Section 3.2 describes additional mitigation measures for fugitive dust.

Under all alternatives interim and permanent revegetation measures would be employed in accordance with the mine reclamation plan (Appendix 14 of the GPO). This plan includes interim hydro-seeding to establish an initial grass/forb cover. Upon final cessation of mining activities, disturbed areas would be revegetated to encourage a return to near-natural conditions consistent with Forest Plan standards and to maintain the character of the Monument. Revegetation would include a combination of natural regeneration and reseeding or transplanting. Natural regeneration is favored because it would allow the reestablishment of Admiralty Island genotype species, follow natural successional stages, and thus provide unique wildlife habitat during forest stand development. Monitoring would be conducted to ensure successful reestablishment of native coastal forest vegetation. Once established, vegetation would improve habitat quality for wildlife species using the mine site.

Under all alternatives, some level of potential habitat for migratory birds could be impacted. Direct effects to migratory birds could result from disturbances that adversely affect individuals or young, including removing active bird nests or causing nest abandonment. Since some of these species are year-round residents, mine activities could also disturb and displace birds during the non-breeding season. Indirect effects result from the reduction of perching, foraging, and potential nesting habitat. Most of the migratory bird species would be affected by a reduction in POG. The magnitude of the effects would vary depending on the bird species, the amount of clearing proposed, and the season in which disturbance occurs. Migratory birds would be most susceptible to impacts from disturbance activities occurring in suitable nesting habitat during the nesting/fledging period, which generally begins in mid-April and ends about mid-July, when young birds have fledged. The species most likely to be negatively affected are those that primarily nest in hemlock/Sitka spruce/cedar forests: blue grouse, Western screech-owl, rufous humming bird, red-breasted sapsucker, Pacific-slope flycatcher, Steller’s jay, northwestern crow, chestnut-backed chickadee, golden-crowned kinglet, varied thrush, Townsend's warbler, blackpoll warbler, Northern goshawk, and marbled murrelet. The amount of POG harvest proposed under the alternatives is a measure of the extent of potential effects. Effects to birds can be minimized by altering the season of activity, retaining snags, maintaining the integrity of breeding sites, considering key winter and migration areas, and minimizing pollution or detrimental alteration of habitats. The USFWS recommends time periods to avoid vegetation clearing (USDI 2006).

Although these impacts are common to all alternatives, the duration of effects differs by alternative. Operation of the mine would continue until 2014 under Alternative A. However, expansion of the existing TDF under Alternative B, and the expansion of the existing TDF and construction of a new TDF under alternatives C and D would extend the operating period of the mine for an additional 30 to 50 years. Therefore, reclamation of the mine site and reductions in levels of human activity, water quality impacts, and fugitive dust emissions would occur more quickly under Alternative A than alternatives B, C, and D.

3.11.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceases, disturbed sites are reclaimed, and human activity in the area is reduced. The TDF would continue to be built out to the maximum footprint and height permitted in the 2003 EIS (USDA 2003). Much of this area has already been disturbed by ongoing mine operations, no additional vegetation (habitat) removal would occur that has not already been approved. After the TDF was fully built out in 2014, reclamation would begin as described in the 2003 EIS (USDA 2003).

Management Indicator Species

Brown Bear

Under Alternative A there would be no decrease in brown bear buffers or additional disturbance near Class I salmon streams, because all development under this alternative would occur within the existing lease area. Therefore, Alternative A would not be expected to result in any additional habitat loss for brown bears or displace brown bears from the vicinity of the mine.

Bald Eagle

No bald eagle nests would be directly affected by implementing Alternative A. The project would adhere to the 330-foot management zone around eagle nest sites. Disturbance activities within this zone are restricted during the nesting season (March 1 to May 31 and extending to August 31, if a nest is occupied).

Black-tailed Deer

The 2003 EIS concluded that the existing TDF provides low quality habitat for deer. Under Alternative A there would be no additional impact to black-tailed deer habitat. Indirect impacts to the species' local distribution and use of habitat in the vicinity of the mine may occur as a result of past and ongoing activity but would end once activities in the area cease.

Marten

Marten could occur in the forested areas in the vicinity of the mine and thus could be impacted by the removal of POG. No additional removal of POG would occur under Alternative A. Therefore, habitat loss would be expected to result in only minor local impacts to this species as a result of existing development in areas that have already been disturbed.

Vancouver Canada Goose

A minor amount of wetland habitat has been disturbed in association with previously approved mining activity (USFS 2003). Wetland habitat exists adjacent to the existing TDF; however, no additional wetland impacts would occur under Alternative A. No shoreline or estuary habitat would be impacted by Alternative A. Although continued use of the TDF could disturb geese using the adjacent areas, Alternative A would have no new effects to the Vancouver Canada goose.

River Otter

Potential impacts river otter could occur if any project activities involve removal of old-growth forest along streams or in the beach buffer or adverse effects to water quality. Alternative A would not result in the removal of old-growth forest along streams nor would it increase existing impacts to water quality (see Section 3.7, Aquatic Resources). Therefore, Alternative A would not impact river otters.

Red Squirrel

No additional removal of POG would occur under Alternative A. Therefore, habitat loss would be expected to result in minor local impacts to this species as a result of existing development in areas that have already been disturbed.

Red-breasted Sapsucker, Hairy Woodpecker, and Brown Creeper

The red-breasted sapsucker, hairy woodpecker, and brown creeper could occur in the forested areas in the vicinity of the mine and thus could be impacted by the removal of POG. No additional productive old-growth would be impacted by Alternative A.

Other Species of Concern

Marbled Murrelet

No additional forested habitat would be lost under Alternative A. It is unlikely that marbled murrelets use the area. However, a murrelet was observed flying over the existing TDF during 2010 wildlife surveys.

Waterfowl and Shorebirds

Regional waterbird and shorebird distribution and abundance would not be affected by implementing Alternative A because no new disturbances would be authorized and ongoing mine-related activity would be limited to the vicinity of Tributary Creek. Most waterbird nesting activity in the study area appears to be associated with habitats within Hawk Inlet, with areas of concentrated use in the shallows at the head of the inlet and across the inlet at Hawk Point, away from project activity. Barge and crew shuttle traffic could disrupt flocks of waterbirds congregating in Hawk Inlet though there would be no change in the existing level of vessel activity.

Marine Mammals

Under Alternative A, exposure of marine mammals in Hawk Inlet to disturbance and noise associated with the marine terminal, barge and crew shuttle traffic, and the potential for fuel or oil spills would be unchanged from current operations until mining was completed in 2014. Given that mine operations would cease after two years, these low-potential impacts would not occur over the long term. Marine mammals are transient within Hawk Inlet, therefore, the likelihood for bioaccumulation of metals due to the consumption of contaminated prey would remain extremely low.

Endemic Species

Endemic species occupy restricted ranges and therefore are especially susceptible to activities that result in habitat loss or fragmentation. Alternative A would not result in the authorization of any new disturbance. Additionally, existing beach buffers and riparian buffers in the vicinity of the mine would continue to provide habitat for these species. Therefore, Alternative A would not result in the extirpation of endemic species.

Migratory Birds

There would be no additional impacts to migratory birds beyond those discussed in Section 3.11.3.1, Effects Common to All Alternatives.

3.11.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF.

Alternative B includes previously permitted habitat change that would occur under Alternative A plus the disturbance of approximately 109 acres of productive old-growth, and 99 acres of unproductive forest. The TDF under this alternative would occur adjacent to the previously approved TDF, and would primarily be concentrated within the Tributary Creek area. Alternative B would extend the operating period of the mine by 30–50 years and therefore impacts associated with habitat loss or disturbance would occur over the long term.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. Under mitigated Alternative B, facilities moved to the northern portion of the existing TDF would have similar impacts associated with habitat loss or disturbance; however, overall disturbance would be approximately 7 acres less that Alternative B (approximately 97.6 and 104 acres of productive and unproductive forest impacted, respectively).

Management Indicator Species

Brown Bear

Brown bears foraging along the lower reaches of Tributary Creek could occur in the vicinity of the proposed TDF expansion. Approximately 23 acres of forest within 500 feet of Tributary Creek (the brown bear foraging buffer) would be impacted by Alternative B. Bears in this area would likely be at least temporarily displaced during initial construction of the TDF expansion. The presence of bears at the existing TDF area indicates that bears would be expected to habituate to the disturbance once construction is complete. However, this also means that there is increased potential for human-bear conflicts.

Additionally, Alternative B would result in slight reductions in stream flow to Tributary Creek associated with expansion of the TDF (see sections 3.5.3.3 and 3.7.2 for additional discussion). This area provides rearing habitat for coho, and to a limited extent, spawning habitat for coho, chum, and pink salmon. Thus, reduced stream flow under Alternative B has the potential to reduce anadromous fish production, which provides an important food source for brown bears. It is anticipated that the reduction in anadromous fish production resulting from Alternative B would occur gradually over 30–50 years, and impacts would be long-term. To mitigate for the loss of salmon rearing and spawning habitat, the operator is in discussion with the agencies regarding the suitability of mitigation, in the form of fish passage improvements, for the loss habitat in Tributary Creek. These measures would also mitigate for impacts to brown bears.

Bald Eagle

Bald eagles could be affected by noise associated with the TDF expansion and ongoing operation of the mine. There are three bald eagle nest sites within one-half mile of the existing TDF. However, these nest sites and bald eagles using the general area are already exposed to an existing level of human disturbance. If nests in this area are found to be active prior to construction the project would adhere to National Bald Eagle Management Guidelines, which include maintaining a 330-foot management zone around eagle nest sites (USFWS 2007). Disturbance activities within this zone are restricted during the nesting season (March 1 to May 31 and extending to August 31, if the nest is occupied). Therefore, no adverse impacts to nesting bald eagles would occur under Alternative B.

Black-tailed Deer

Approximately 23 acres of deer winter range in WAA 3836 and 112 acres of deer winter range in WAA 3837 would be removed under Alternative B This equates to 0.1 percent and 0.35 percent of the existing winter range in these WAAs, respectively. Indirect impacts to the species' local distribution and use of habitat in the vicinity of the mine could occur during construction, but given the frequency with which deer are observed in vicinity of the mine it is anticipated that they would return to the area, especially when short-term reclamation activities are implemented that result in new vegetation growth. Because the surrounding area provides winter range for deer and because the reduction in habitat loss would occur gradually over the extended operation period, Alternative B would not preclude deer from wintering in WAA 3836 or 3837.

Marten

Alternative B would result in the removal of 109 acres of productive old-growth (Table 3.11-3). Marten using this area could be displaced to areas where forest cover is maintained, but impacts would be localized. Therefore, no population level impacts would occur under Alternative B.

Table 3.11-3. Existing and Estimated Productive Old Growth that would be Removed under Each Action Alternative within the Study Area.

POG by SDM Class	Existing (acres)	Percent POG	Action Alternatives			
			Alternative B (acres)	Mitigated Alternative B (acres)	Alternative C (acres)	Alternative D (acres)
SD-4H	607.4	25.0%	47.3	39.5	60.4	55.9
SD-4N	121.4	5.0%	9.0	9.0	0.0	0.8
SD-4S	421.0	17.4%	2.7	2.6	0.0	0.7
SD-5H	265.1	10.9%	0.9	2.9	31.7	30.2
SD-5N	139.3	5.7%	0.8	0.8	0.0	0.9
SD-5S	306.7	12.6%	0.6	0.6	6.5	7.4
SD-6/7	565.2	23.3%	47.8	42.2	31.5	44.0
Total POG (Acres)	2,426.0	100%	109.1	97.6	130.1	139.9

Vancouver Canada Goose

Potential impacts from Alternative B on Vancouver Canada geese would be associated primarily with disturbance from daily crew shuttle traffic in Young Bay and periodic barge traffic in Hawk Inlet, which would occur at existing levels but would be extended by 30–50 years. However, geese using these areas are already exposed to vessel activity and therefore would be expected to continue using the inlet during the operating period. Alternative B would remove 99 acres of wetland habitat, located within the Tributary Creek drainage, which could be used for nesting by this species.

River Otter

Alternative B would impact forested habitats within the Tributary Creek drainage. Otters using this area would be displaced from the immediate area of the tailings expansion site over the long term until forests were reestablished following mine closure.

Red Squirrel

Approximately 109 acres of POG spruce/hemlock forest would be cleared under Alternative B. Therefore, habitat loss would be expected to result in minor local impacts to this species, but would not be expected to affect populations given the amount of remaining available habitat.

Red-breasted Sapsucker, Hairy Woodpecker, and Brown Creeper

The additional loss of old-growth habitat from construction activities associated with expansion of the TDF would result in local habitat fragmentation which could potentially disrupt the movements of individual hairy woodpeckers, brown creepers, or red-breasted sapsuckers in the immediate vicinity of Tributary Creek. The disturbance/disruption would not be expected to affect populations of these species in the study area given the remaining available habitat.

Other Species of Concern

Marbled Murrelet

Alternative B would result in the removal of suitable marbled murrelet habitat in addition to that which has already occurred under the approved operation. This would primarily occur along Tributary Creek for the expansion of the TDF. However, no areas of coarse canopy structure (SD67 category) would be removed. Given that a murrelet was observed during 2010 wildlife surveys, it is recommended that dawn watch surveys be conducted prior to the commencement of any disturbance activities to confirm that murrelets are not actively nesting in or adjacent to the proposed tailings expansion area. If nesting murrelets were present at the time of construction, a 600-foot buffer of undisturbed forest would be maintained, where available, in accordance with Forest Plan Standards and Guidelines. Construction activities, if they coincide with this buffer, would be timed to occur outside of the nesting season (May 1 to August 15), to avoid disturbance to nesting murrelets. With mitigation measures in place, Alternative B would have minor effects on the marbled murrelet.

Waterfowl and Shorebirds

Alternative B would not impact any waterfowl or shorebird concentrations areas. The extension of the operating period under Alternative B would extend time during which vessel activity associated with the mine would occur in Hawk Inlet and crew shuttle traffic in Young Bay, and thus that it would be a potential source of disturbance to waterfowl and shorebirds at Hawk Point or in the vicinity of the marine terminal. However, because waterfowl are exposed to an existing level of human activity, extending the operating period of the mine would not be expected to appreciably increase the current level of human activity.

Marine Mammals

Effects to marine mammals would be the same as under Alternative A though for an additional 30–50 years. Given that the operation period is longer than currently permitted, Alternative B would extend the time during which marine mammals could be exposed to metal concentrations in prey due to project-related discharges into Hawk Inlet, oil or fuel spills, and vessel/crew shuttle traffic. However, given the transient nature of these species in Hawk Inlet and Young Bay, Alternative B would result in minor impacts to these species. Additional information is provided for marine mammals listed as threatened or endangered in Section 3.12 and in the draft biological assessment / biological evaluation (BA/BE).

Endemic Species

Alternative B would result in a minor increase in habitat fragmentation resulting from the total disturbance of approximately 208 acres of vegetation adjacent to the existing TDF. Displacement from the project area or alterations in movement patterns resulting from human activity or habitat removal would be anticipated for small endemic mammals with limited movement capabilities in the immediate vicinity of the TDF expansion area under

Alternative B. Existing beach buffers and riparian buffers in the vicinity of the mine would continue to provide habitat for these species. Given the availability of surrounding habitat, Alternative B would not be expected to result in the extirpation of any endemic species.

Migratory Birds

Alternative B would impact approximately 109 acres of productive and 99 acres of unproductive spruce/hemlock forest potentially used by priority migratory bird species. Initial clearing activities at the TDF expansion site have the potential to destroy nests or cause nest abandonment if the activities occur in suitable nesting habitat during the breeding/nesting period. Nesting typically begins in mid-April and ends about mid-July, when young birds have fledged, after which time nesting activities would not be directly affected. To reduce the potential for impacts to nesting migratory birds, ground disturbing activities and tree clearing should be conducted outside the nesting season in the region (late May through early July). Effects would be considered minor due to the amount of overall clearing and low potential for population-level impacts to migratory birds; surrounding habitat would remain functional and could maintain the species.

3.11.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF located in a small drainage leading to Hawk Inlet. Additionally the B Road would be upgraded and additional facilities including a tailings water transport pipeline, rock quarry, water management ponds. Alternative C would also extend the operating period of the mine by 30–50 years. Effects to wildlife would be more widely spread than in alternatives A and B due to the development of a new TDF and supporting infrastructure. Activities associated with expanding the existing TDF would overlap with construction of the new TDF over the short term. After approximately 3 years, reclamation of the existing TDF could begin after which most activity would be focused in the vicinity of the new TDF.

Management Indicator Species

Brown Bear

Brown bears foraging along the lower reaches of Tributary Creek could occur in the vicinity of the proposed TDF expansion. Approximately 0.5 acre of forest within 500 feet of Tributary Creek (the brown bear foraging buffer) would be impacted by Alternative C. Bears in this area would likely be at least temporarily displaced during initial construction of the TDF. The presence of bears at the existing TDF indicates that bears would be expected to habituate to the disturbance once construction is complete. However, this also means that there is increased potential for human-bear conflicts. Even though the TDF to the north proposed under Alternative C does not coincide with a brown bear foraging buffer, the potential for increased human-bear conflicts is likely.

Bald Eagle

Three bald eagle nest sites (all inactive in 2011) occur within one-half mile of the existing TDF area. Within the area of the new TDF area proposed under Alternative C, there are three nests (two active nests and one inactive nest) located within one-half mile of the proposed location; one of the active nests is approximately 900 feet west of the proposed quarry site. Nest sites and bald eagles using the area in the vicinity of the existing TDF are already exposed to an existing level of human disturbance; however those in the vicinity of the new TDF would be exposed to a new source of disturbance. The project would adhere to the 2009 guidelines for the USFWS Bald Eagle Take Permit program, under the Bald and Golden Eagle Protection Act. For mine projects, guidelines include maintaining a 660-foot buffer around eagle nest sites (both active and alternate) that are visible from the location of mine activity (where no similar activities occur within 660 feet of the nest; a smaller buffer is acceptable if similar activities occur within 660 feet). Disturbance activities within this zone are restricted during the nesting season (March 1 to May 31, extending to August 31 if the nest is occupied). One nest (inactive in 2011) is within 660 feet of the A Road, where improvements would occur under Alternative C. All other nests are greater than 660 feet of any proposed activity. Implementation of these guidelines would avoid disturbance to bald eagles. Therefore, no adverse impacts to nesting bald eagles are anticipated under Alternative C.

Black-tailed Deer

Approximately 144 acres of deer winter range in WAA 3836 and 9 acres of deer winter range in WAA 3837 would be removed under Alternative C in association with development of the northern and expansion of the southern tailings expansion areas, respectively. This equates to 0.41 percent and 0.1 percent of the existing winter range in these WAAs, respectively. Indirect impacts to the species' local distribution and use of habitat in the vicinity of the TDF could occur during construction, but given the frequency with which deer are observed in the vicinity of the mining operations it is anticipated that they would return to the area, especially after short-term reclamation activities resulting in new vegetation growth. Because the surrounding area provides winter range for deer and the loss of winter range under Alternative C would occur gradually over the extended operating period, Alternative C would not preclude deer from wintering in WAA 3836 or 3837.

Marten

Alternative C would result in the removal of 130 acres of productive old-growth associated with expansion of the existing TDF and development of the new TDF (Table 3.11-3). Marten using this area would be displaced to areas where forest cover is maintained, but impacts would be localized. Therefore, no population level impacts would occur under Alternative C.

Vancouver Canada Goose

As under Alternative B, potential impacts from Alternative C on Vancouver Canada geese would be associated primarily with disturbance from daily crew shuttle traffic in Young Bay and periodic barge traffic in Hawk Inlet, which would occur at existing levels but would be extended by 30–50 years. However, geese using this area are already exposed to vessel activity and therefore would be expected to continue using the inlet during the operating period. Expansion of the existing TDF under Alternative C would remove a total of 114 acres of wetland habitat, which could be used for nesting by this species.

River Otter

Alternative C would impact a small amount of forested habitats along Tributary Creek in association with the existing TDF expansion area. Otters using this area would be permanently displaced from the immediate area of the tailings expansion site during the life of operations and until a mature forest was re-established.

Red Squirrel

Approximately 130 acres of POG spruce/hemlock forest would be cleared under Alternative C. Therefore, habitat loss and localized habitat fragmentation would be expected to result in minor local impacts to this species, and would not be expected to affect populations given the amount of remaining available habitat.

Red-breasted Sapsucker, Hairy Woodpecker, and Brown Creeper

Under Alternative C approximately 130 acres of old-growth habitat would be removed in association with expansion of the TDF and development of the new TDF. Alternative C would result in local habitat fragmentation which could potentially disrupt the movements of individual hairy woodpeckers, brown creepers, or red-breasted sapsuckers in the immediate vicinity of Tributary Creek and the north-flowing drainage to Hawk Inlet, but would not be expected to affect populations of these species in the study area given the remaining available habitat.

Other Species of Concern

Marbled Murrelet

Alternative C would removal in approximately 130 acres of POG in association with the expansion of the existing TDF and the development of the new TDF. Of that amount, it is estimated that approximately 31 acres of coarse canopy structure (SD67 class) would be removed (Table 3.11-3). Surveys of the new TDF area did not document use by murrelets. One murrelet was observed flying over the existing TDF. Therefore it is recommend that dawn watch surveys be conducted prior to ground disturbing activities to ensure that disturbance to birds using the development areas is minimized. If nesting murrelets were present at the time of construction, a 600-foot buffer of undisturbed forest would be maintained, where available, in accordance with Forest Plan Standards and Guidelines. Construction activities, if they coincide with this buffer, would be timed to occur outside of the nesting season (May 1 to August 15), to avoid disturbance to nesting murrelets. Therefore, Alternative C would have minor impacts to the marbled murrelet.

Waterfowl and Shorebirds

Impacts to waterfowl and shorebirds under Alternative C would be the same as under Alternative B.

Marine Mammals

Effects to marine mammals under Alternative C would be the same as under Alternative B.

Endemic Species

Alternative C would increase habitat fragmentation in the vicinity of the existing and new TDF areas. Displacement from the project area or alterations in movement patterns due to human activity or habitat removal, particularly in a previously undisturbed area, would be anticipated for small endemic mammals with limited movement capabilities in the immediate vicinity of the TDF expansion area and new TDF area under Alternative C. Existing beach buffers and riparian buffers in the vicinity of the mine would continue to provide habitat for these species. Given the availability of surrounding habitat, Alternative C would not be expected to result in the extirpation of any endemic species.

Migratory Birds

Alternative C would impact approximately 130 acres of productive and 91 acres of unproductive spruce/hemlock forest, and approximately 1 acre of non-forested habitat spruce/hemlock forest potentially used by priority migratory bird species. Initial clearing activities at the existing and new TDF areas have the potential to destroy nests or cause nest abandonment if the activities occur in suitable nesting habitat during the breeding/nesting period. Nesting typically begins in mid-April and ends about mid-July, when young birds have fledged, after which time nesting activities would not be directly affected. Effects would be considered low due to the amount of overall clearing and low potential for population-level impacts to migratory birds; surrounding habitat would remain functional and could maintain the species.

3.11.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of a new TDF. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than Alternative B but larger than under Alternative C. The footprint of the new TDF would be similar in size to that build under Alternative C. Effects to wildlife habitat would be similar to Alternative C. Like Alternative C, wildlife impacts of this alternative would be more widespread than alternatives A and B due to development of a new TDF. Construction of the new TDF (and associated effects) would not occur for approximately 10 years.

Management Indicator Species

Brown Bear

Impacts to brown bears under Alternative D would be similar to Alternative C, except that expansion of the southern tailings facility would impact approximately 0.5 more acres of brown bears foraging habitat (forest within 500 feet of the creek) along the lower reaches of Tributary Creek. Bears in this area would likely be at least temporarily displaced during initial construction of the TDF. The presence of bears at the existing TDF indicates that bears would be expected to habituate to the disturbance once construction is complete. However, this also means that there is increased potential for human-bear conflicts.

Additionally, Alternative D would result in a slightly reduced stream flow to a portion of Tributary Creek associated with expansion of the existing TDF (see sections 3.5.3.5 and 3.7.2 for additional discussion). This area provides rearing habitat for coho, and to a limited extent, spawning habitat for coho, chum, and pink salmon. Thus, reduced stream flow under Alternative D has the potential to reduce anadromous fish production by a small amount. Fish provide an important food source for brown bears. It is anticipated that the reduction in anadromous fish production resulting from Alternative D would occur gradually over 30–50 years, and impacts would be long-term. To mitigate for the loss of salmon rearing and spawning habitat, the operator in discussion with the agencies regarding the suitability of mitigation, in the form of fish passage improvements, for the loss habitat in Tributary Creek. These measures would also mitigate for impacts associated with a loss in fish production to brown bears.

Bald Eagle

Impacts to bald eagles under Alternative D would be the same as under Alternative C.

Black-tailed Deer

Impacts to black-tailed deer under Alternative D would be similar to Alternative C. Approximately 142 acres of deer winter range in WAA 3836 and 27 acres of deer winter range in WAA 3837 would be removed under Alternative D in association with development of the existing TDF and new TDF areas, respectively. This equates to 0.41 percent and 0.15 percent of the existing winter range in these WAAs, respectively. Indirect impacts to the species' local distribution and use of habitat in the vicinity of the TDFs could occur during construction, but given the frequency with which deer are observed in the vicinity of the mining operations it is anticipated that they would return to the area, especially following short-term reclamation activities resulting in new vegetation growth. Because the surrounding area provides winter range for deer and because reductions in winter range would occur over the extended operating period, Alternative D would not preclude deer from wintering in WAA 3836 and 3837.

Marten

Alternative D would result in the removal of 140 acres of productive old-growth associated with expansion of the existing TDF and development of the new TDF. Marten using this area would be displaced to areas where forest cover is maintained, but impacts would be localized. Therefore, no population level impacts would occur under Alternative D.

Vancouver Canada Goose

Impacts to Vancouver Canada geese under Alternative D would be similar to Alternative C, except that expansion of the existing TDF and development of the new TDF under Alternative D would remove a total of 125 acres of wetland habitat. This would reduce the amount of potential nesting habitat for this species.

River Otter

Alternative D, like Alternative C, would impact forested habitats along Tributary Creek in association with the existing TDF and along the Unnamed Creek draining to north Hawk Inlet in association with development of the new TDF. Otters using this area would be permanently displaced from the immediate area of the TDF.

Red Squirrel

Approximately 140 acres of POG spruce/hemlock forest would be cleared under Alternative D. Therefore, habitat loss and localized habitat fragmentation would be expected to result in minor local impacts to this species and would not be expected to affect populations given the amount of remaining available habitat.

Red-breasted Sapsucker, Hairy Woodpecker, and Brown Creeper

Under Alternative D approximately 140 acres of old-growth habitat would be removed in association with expansion of the existing TDF development of the new TDF. Alternative D would result in local habitat fragmentation, to a greater extent than the other alternatives, which could potentially disrupt the movements of individual hairy woodpeckers, brown creepers, or red-breasted sapsuckers in the immediate vicinity of Tributary Creek and Fowler Creek, but would not be expected to affect populations of these species in the study area given the remaining available habitat.

Other Species of Concern

Marbled Murrelet

Alternative D would removal in approximately 140 acres of POG in association with the expansion of the existing TDF and development of the new TDF. An estimated 44 acres of coarse canopy structure (SD67 category) would be removed. Surveys of the new TDF area did not document use by murrelets. One murrelet was observed flying over the existing TDF. Therefore it is recommend that dawn watch surveys be conducted prior to ground disturbing activities to ensure that disturbance to birds using the development areas is minimized. If nesting murrelets were present at the time of construction, a 600-foot buffer of undisturbed forest would be maintained, where available, in accordance with Forest Plan Standards and Guidelines. Construction activities, if they coincide with this buffer, would be timed to occur outside of the nesting season (May 1 to August 15), to avoid disturbance to nesting murrelets. Therefore, Alternative D would have minor impacts to marbled murrelets.

Waterfowl and Shorebirds

Effects to waterfowl and shorebirds would be the same as under Alternative B.

Marine Mammals

Effects to marine mammals under Alternative D would be the same as under Alternative B.

Endemic Species

Alternative D would increase habitat fragmentation in the vicinity of the existing and new TDFs. The effect on the area surrounding the proposed new TDF would not occur for approximately 10 years. Local movements by endemic species have the potential to be inhibited by habitat removal; however, given the availability of surrounding habitat, Alternative D would not be expected to result in the extirpation of any endemic species.

Migratory Birds

Alternative D would impact approximately 140 acres of productive and 95 acres of unproductive spruce/hemlock forest, and approximately 1 acre of non-forested habitat potentially used by priority migratory bird species. Effects would be considered low due to the amount of overall clearing and low potential for population-level impacts to migratory birds; surrounding habitat would remain functional to maintain the species. To reduce the potential for impacts to nesting migratory birds, ground disturbing activities and tree clearing should be conducted outside the nesting season in the region (late May through early July).

3.11.4 Wildlife – Summary

MIS, other species of concern, and their habitats would all be somewhat affected under any of the alternatives. Three MIS species are not known to occur on Admiralty Island (wolf, black bear, and mountain goat) even though habitat exists.

Under all alternatives, there would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, and along the access road. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing TDF operations would continue through the term of the lease. The large barges and ships that are used to deliver fuel and equipment and haul the concentrate from the mine, as well as the crew shuttle transiting Young Bay, would continue but are not likely to affect marine mammal distribution in Hawk Inlet, Young Bay, or Chatham Strait. Although these impacts are common to all alternatives, the duration of effects differs by alternative. Operation of the mine would continue until 2014 under Alternative A. However, expansion of the existing TDF under Alternative B and the expansion of the existing TDF and construction of a new TDF under alternatives C and D would extend the operating period of the mine for an additional 30 to 50 years. Therefore, reclamation of the mine site and reductions in levels of human activity, water quality impacts, and fugitive dust emissions would occur more quickly under Alternative A than under alternatives B, C, and D.

Although many wildlife species in the Tongass National Forest are associated with more than one habitat type, most inhabit old growth forests or prey on species that inhabit old growth forests. Therefore the assessment of impacts of wildlife and wildlife habitat focuses on old growth ecosystem. Reduction in productive old-growth is somewhat similar across alternatives ranging from approximately 109 acres under Alternative B to 140 acres under Alternative D. Slightly more high volume/coarse canopy forest SD-5N, SD-5S, and SD-67) would be removed under Alternative D (52 acres) followed by Alternative B (49 acres) and Alternative C (38 acres). The level of reduction would not be expected to affect populations of these species in the study area given the remaining available habitat.

Protection to brown bear, bald eagle, Vancouver Canada goose, waterfowl, shorebirds, and river otter is afforded by Forest-wide standards and guidelines that require the maintenance of a 1,000-foot beach and estuary buffer along the shoreline, stream protection buffers, and maintenance of 500 foot-wide buffers along class I anadromous streams where brown bears forage. Marine mammals are protected under the MMPA and Forest-wide standards and guidelines. Further protection for deer winter habitat, marten, forest-dwelling bird species such as the red breasted sapsucker, hair woodpecker, brown creeper, marbled murrelet, endemics, and various migratory bird species is provided for in the Forest Plan through its overall Conservation Strategy, standards and guidelines for marten, endemic terrestrial mammals, and any legacy forest structure, even though the legacy standard does not apply to any VCUs on Admiralty Island.

3.12 Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species

The resource analysis of threatened and endangered species is related to Issue 2 impacts of wetlands and associated habitat values as well as Issue 3 impacts to fish streams. Measures of impacts to threatened and endangered species include identifying the presence of threatened and endangered species as well as acres of impacted habitat for selected species.

This section addresses the potential effects of the project on federally listed threatened and endangered species, candidates for listing, and Forest Service Alaska Region sensitive species and their habitats. A BA/BE has been prepared for this project (Tetra Tech 2011c) under separate cover, meeting the requirements of Section 7(a)(2) of the federal ESA of 1973, as amended (16 USC 1531 et seq.), and the requirements of the National Forest Management Act (Section 36 CFR 219.19).

The National Forest Management Act requires the Forest Service to manage fish and wildlife habitat to maintain viable populations of existing native and desired nonnative vertebrate species in the planning area and ensures that its actions do not contribute to trends toward federal listing. The Forest Service must evaluate the effects of the project to threatened, endangered, and sensitive wildlife species as directed in Forest Service Manual Chapter 2670.31 through 2672.43.

Section 7 of the ESA requires that "[e]ach Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with affected States, to be critical (16 USC 35 Sections 1531-1544)." Marine mammals are also protected by the MMPA. The USFWS and NMFS share responsibility for implementing the ESA, with terrestrial species falling under the jurisdiction of the USFWS and marine mammals falling under the jurisdiction of NMFS. Candidate species will be discussed in general; however, an effects determination was not established for these species, as they are not currently listed under the ESA and a potential listing is not expected (as may be the case for proposed species).

Threatened, endangered, and candidate species potentially occurring in the vicinity of the Greens Creek Mine were identified through ongoing consultation with the USFWS and the NMFS. Sensitive listed species potentially occurring in the project area were obtained from the most recent Forest Service Alaska Region sensitive species list (USFS 2009). Table 3.12-1 provides a comprehensive list of these species by managing agency, and identifies species carried forward in the analysis based on known occurrences or the presence of suitable habitat. The subsequent discussions of these species are abbreviated for this EIS but are presented in much greater detail in the BA/BE (Tetra Tech 2011c). Additional wildlife species of concern are addressed in Section 3.11, Wildlife. Aquatic resources are discussed in Section 3.7.

3.12.1 Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species – Pre-mining Environment

Prior to mining, the wildlife habitats in the vicinity of the mine were much like the existing vegetation elsewhere on Admiralty Island. They consisted primarily of hemlock-spruce forest, interspersed with a mosaic of non-forested plant communities, including peat wetlands, shrub wetlands, and sedge meadows (USFS 2003). Coastal and nearshore marine habitats are present in Hawk Inlet and riparian and aquatic habitats occur along Cannery Creek, Tributary Creek, and several smaller creeks (Further Creek, Franklin Creek, Proffett Creek, Althea Creek and CC Creek). These habitats support a number of marine mammal, terrestrial mammal, avian, and fish species.

Listed species addressed in the 1983 EIS for the Greens Creek Mine addressed the humpback whale (*Megaptera novaeangliae*) and two subspecies of peregrine falcon (*Falco peregrinus anatum* and *F. p. tundrensis*). Since that time, there have been changes in the ESA listing status of a number of species occurring in Alaska, including the delisting of the peregrine falcon. These changes are summarized below. The Forest Service Region sensitive species list was created in 1991 and therefore, species included on the current list (see Table 3.12-1) were not addressed in the 1983 EIS; however, some of these species were addressed in the 2003 EIS.

Table 3.12-1 also lists the sensitive plant species known or suspected to occur on the Juneau Ranger District and Admiralty Island National Monument of the Tongass National Forest. Only three species, *Cypripedium montanum*, *Cypripedium parviflorum* var. *pubescens*, and *Piperia unalascensis* have the potential to occur in the study area due to the presence of suitable habitat.

3.12.1.1 Species Not Addressed in Detail

Many of the species listed in Table 3.12-1 may occur within the general vicinity of the project area (i.e., within southeast Alaska or in the Tongass National Forest); however, they would not occur in or near the project study area related to the TDF expansion alternatives. This includes all of the marine mammal species listed in Table 3.12-1 except for the humpback whale and Steller sea lion; all of the sea turtle species; and all of the avian species except for the black oystercatcher, Queen Charlotte goshawk, and yellow-billed loon. The remaining species (blue, bowhead, right, fin, sei, and sperm whales; bearded, ringed and spotted seal; polar bear; Pacific walrus; green, leatherback, loggerhead, and olive Ridley sea turtles; Eskimo curlew; Aleutian tern; dusky Canada goose; short-tailed albatross; spectacled eider; Steller's eider; and Kittlitz's murrelet) are discussed in more detail in the BA/BE (Tetra Tech 2011c).

Table 3.12-1. Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species in Alaska and in the Vicinity of the Greens Creek Mine.

Common Name Scientific Name	Habitat Association/Range	Potential Occurrence in Vicinity of Greens Creek Mine	Listing/ Status [a]
Species under USFWS Jurisdiction			
Kittlitz's murrelet *Brachyramphus brevirostris*	Breeds in the vicinity of glaciers and cirques in high elevation alpine areas with little or no vegetative cover; northern Gulf of Alaska and Bering Sea coast (Day et al. 1999).	No, due to lack of suitable habitat.	C; FSS
Eskimo curlew *Numenius borealis*	Arctic tundra.	No, outside of species' range.	FE
Short-tailed albatross *Phoebastria albatrus*	Winters in waters of the Bering Sea, Aleutian Islands, and Gulf of Alaska; breeds in Japan (USFWS 2008).	No, outside of species' range.	FE
Spectacled eider *Somateria fischeri*	Coastal waters in northern and western Alaska (Peterson et al. 2000).	No, outside of species' range.	FT
Steller's eider *Polysticta stelleri*	Occurs in northern Alaska and Aleutian Islands (Fredrickson 2001).	No, outside of species' range.	FT
Yellow-billed loon *Gavia adamsii*	Nests near freshwater lakes in the arctic tundra and winters along the Alaskan coast to the Puget Sound (North 1994).	Possible; not known to nest in the Tongass National Forest but have been documented wintering in the inside waters of southeast AK.	C, FSS
Polar bear *Ursus maritimus*	Sea ice and coastlines of western Alaska and along the North Slope.	No, outside of species' range.	FT
Pacific walrus *Odobenus rosmarus divergens*	Continental shelf waters of Bering and Chukchi Seas.	No. outside of species' range.	C

Table 3.12-1. Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species in Alaska and in the Vicinity of the Greens Creek Mine.

Common Name Scientific Name	Habitat Association/Range	Potential Occurrence in Vicinity of Greens Creek Mine	Listing/ Status [a]
Species under NMFS Jurisdiction			
Blue whale *Balaenoptera musculus*	Off-shore (pelagic) marine waters of the Bering Sea, Chukchi Sea, North Pacific Ocean and/or Gulf of Alaska (ADFG 2008, 73 FR 19000). Critical habitat designated for North Pacific right whales in the Bering Sea and the Gulf of Alaska (73 FR 19000).	No, very rarely observed in southeast Alaska.	FE
Bowhead whale *Blaena mysticetus*			
Fin whale *Balaenoptera physalus*			
Northern Pacific right whale *Eubalaena japonica*			
Sei whale *Balaenoptera borealis*			
Sperm whale *Physeter macrocephalus*			
Humpback whale *Megaptera novaeangliae*	Common in the inside waters of the Alexander Archipelago and are regularly sighted in the Inside Passage and coastal waters of the southeast Alaska panhandle (NMFS 1991).	Yes, occurs in Stephens Passage and documented in the shallow coastal waters of Hawk Inlet.	FE
Bearded seal *Erignathus barbatus*	Sea-ice habitats in Bering Sea, Chukchi Sea, Beaufort Sea (ADFG 2008).	No, outside species' range.	C
Ringed seal *Phoca hispida*			C
Spotted seal *Phoca largha*			C
Northern sea otter, SW Alaska population *Enhydra lutris kenyoni*	Coastal marine habitats.	No, population does not occur in Hawk Inlet.	FT
Steller sea lion – Eastern DPS [b] *Eumetopias jubatus*	Marine and terrestrial areas in southeast Alaska (east of 144° west longitude).	Yes, occurs in Hawk Inlet.	FT
Steller sea lion – Western DPS [b] *Eumetopias jubatus*	Marine and terrestrial areas in southeast Alaska (west of 144° west longitude).	Yes, occurs in Hawk Inlet.	FE

Table 3.12-1. Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species in Alaska and in the Vicinity of the Greens Creek Mine.

Common Name Scientific Name	Habitat Association/Range	Potential Occurrence in Vicinity of Greens Creek Mine	Listing/ Status [a]
Species under NMFS Jurisdiction			
Green sea turtle *Chelonia mydas*	Occur in the Gulf of Alaska and some species are found as far west as the Aleutian Islands.	No, only rarely observed in southeast Alaska.	FT
Loggerhead sea turtle *Caretta caretta*			FT
Olive Ridley sea turtle *Lepidochelys olivacea*			FT
Leatherback sea turtle *Dermochelys coriacea*			FE
Lynn Canal Pacific herring *Clupea pallasi*	Occurs in the marine waters in the Lynn Canal near Juneau.	Yes, occurs in Hawk Inlet.	C
Chinook salmon (Six Runs) *Onchorhynchus tshawytshca*	Originating in freshwater habitats Washington and Oregon; migrate through the Gulf of Alaska.	Possible, primarily occur outside waters of southeast Alaska (USFS 2008). Occurrence in inside southeast Alaska waters has been documented, but infrequently.	FT or FE, depending on run
Sockeye salmon *Onchorhynchus nerka*			
Steelhead (Five Runs) *Onchorhynchus mykiss*			
Species under Forest Service Jurisdiction [c]			
Queen Charlotte goshawk *Accipiter gentilis laingi*	Mature/old growth forests.	Yes, known to occur on Admiralty Island and suitable habitat present. Active nest found in June 2011 north of the existing TDF, within the footprint of the new TDF under alternatives C and D.	FSS
Aleutian Tern *Sterna aleutica*	Nests on islands, shrub-tundra, grass or sedge meadows and freshwater and coastal marshes.	No, no suitable habitat present.	FSS
Black oystercatcher *Haematopus bachmani*	Rocky shorelines along the coast; forages in sheltered areas where low-sloping gravel or rock beaches with abundant prey occur.	Yes, suitable shoreline habitat present.	FSS
Dusky Canada goose *Branta canadensis occidentalis*	Nests primarily on the Copper River Delta of Alaska's south central coast	Yes, habitat is present; not known to nest in the Tongass National Forest although they do occur during migration	FSS

Table 3.12-1. Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species in Alaska and in the Vicinity of the Greens Creek Mine.

Common Name Scientific Name	Habitat Association/Range	Potential Occurrence in Vicinity of Greens Creek Mine	Listing/ Status [a]
Species under Forest Service Jurisdiction [c]			
Moosewort fern *Botrychium tumux*	Sandy beaches.	No, due to lack of suitable habitat.	FSS
Moonwort fern *Botrychium yaaxudakiet*	Occurs among rocks and gravel in alpine habitat, occurs on ridge approximately 1 mile north of Greens Creek Mine.	No, due to lack of suitable habitat.	FSS
Mountain lady's slipper *Cypripedium montanum*	Upper beach meadow/forest ecotone; known to occur north of the mouth of Endicott River, in Haines area, Glacier Bay, the Stikine R., and Etolin Island.	Yes, not documented during 2010 surveys but potential habitat present.	FSS
Large yellow lady's slipper *Cypripedium parviflorum v. pubescens*	Associated with peatlands.	Yes, not documented during 2010 surveys but potential habitat present.	FSS
Calder loveage *Ligusticum calderi*	Subalpine meadows in areas considered to be glacial refugia; also associated with calcareous substrate.	No, due to lack of suitable habitat.	FSS
Alaska rein orchid *Piperia unalascensis*	Dry open sites, under tall shrubs in riparian zones, mesic meadows, and drier areas in coniferous and mixed evergreen forests from low elevation to subalpine.	Yes, not documented during 2010 surveys but suitable habitat present.	FSS
Kruckeberg's swordfern *Polystichum kruckebergii*	Grows in sheltered cracks in the dunite rock of ultramafic outcrops.	No, due to lack of suitable habitat.	FSS
Henderson's checkermallow *Sidalcea hendersonii*	Meadow/forest ecotone of the estuary at the head of Howard Bay.	No, due to lack of suitable habitat.	FSS

Sources: Endangered, Threatened, Proposed, Candidate, and Delisted Species in Alaska (USFWS and NMFS 2011; updated April 21, 2011) and Forest Service Alaska Region Sensitive Species List (USFS 2009).

Notes:

a. FT = federally threatened; FE = federally endangered; P = Proposed for federal listing; C = candidate for federal listing; FSS = Forest Service Sensitive Listed Species.
b. DPS = distinct population segment.
c. The "Species under Forest Service Jurisdiction" portion of this table lists the Forest Service Sensitive species that are not listed under the ESA; however, note that some of the ESA-listed species are also Forest Service Sensitive species.

3.12.2 Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species – Baseline Conditions

This section provides a more detailed description of existing threatened and endangered species in the vicinity of the mine site and impacts that have occurred to date. The study area for threatened and endangered species includes a one-half-mile buffer around the TDF and the portion of the B Road extending from the existing lease boundary north to the new TDF proposed under alternatives C and D, plus the adjacent waters of Hawk Inlet. This area extends beyond the limit of direct ground disturbance but is adequate to capture farther reaching effects such as noise and the introduction and spread of weeds. Resources used to derive information on baseline conditions include the following:

- Greens Creek Tailings Final EIS (USFS 2003);
- Greens Creek Mine Final EIS (USFS 1983);
- Peer-reviewed research (cited below where appropriate);
- NMFS stock assessments (e.g., Allen and Angliss 2010); and
- Field studies conducted in support of this project (e.g., KAI Environmental Consulting 2010a, b; 2011a, b).

As noted above, the peregrine falcon, which was federally listed as endangered during the preparation of the 1983 EIS, has been delisted. Other relevant changes in relation to species status since the inception of mining at Greens Creek have included the listing of the polar bear, Steller sea lion (both western and eastern DPS), short-tailed albatross, northern sea otter (southwest Alaska DPS), Steller's eider, green, leatherback, loggerhead and olive Ridley sea turtles, and spectacled eider; and designation of the Kittlitz's murrelet, Pacific walrus, yellow-billed loon, and Pacific herring as candidates for listing.

Potential effects associated with construction and operation of the mine addressed in the 1983 and 2003 EISs included habitat loss, disturbance and/or displacement due to mining activities and associated marine traffic, attraction of wildlife to mine facilities, and contamination due to contact with water discharged into Hawk Inlet. Effects that have occurred under current operations relative to wildlife, vegetation, and aquatic resources are discussed in more detail in sections 3.11, 3.9, and 3.7, respectively. The 2003 BA/BE for the TDF expansion concluded the continued operation and expansion tailings facilities under the current lease would have no adverse impact to the humpback whale or Steller sea lion. The 2003 BA/BE also concluded that vessel traffic associated with mine operations would not constitute harassment or a taking (defined as harassing or pursuing) under the MMPA.

3.12.2.1 Determinations

A determination was made to assess the effects of the project on threatened, endangered, and candidate species or their critical habitat (50 CFR 402.14, FSM 2671.44), based on the physical and biological requirements of these species and considering the potential effects from implementing any of the action alternatives described in this Draft EIS. Determination calls were also made for Forest Service Sensitive species. Potential impacts to candidate species are summarized in this section and analyzed in detail in the BA/BE. Formal effect determinations were not made for candidate species, since these species are not subject to ESA consultation.

A determination of "***no effect***" is rendered in regard to all threatened and endangered species with the exception of the humpback whale and Steller sea lion where a "***not likely to adversely affect***" call was made. In addition, six species listed as Forest Service Sensitive received a "***may impact individuals but not likely to cause a trend to federal listing or a loss of viability***" and include Queen Charlotte goshawk, black oystercatcher, and yellow-billed loon (also a Federal Candidate), and the three sensitive plant species (*Cypripedium montanum*, *Cypripedium parviflorum* var. *pubescens*, and *Piperia unalascensis*) with the remainder receiving a "***no impact***" determination.

Regardless of the selected alternative, actions are not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat in the project area. All project activities would be conducted in a manner consistent with the ESA and regulations. Table 3.12-2 provides a summary of the effects determination for threatened, endangered, and sensitive species. The effects analysis and discussion for the species listed in Table 3.12-1 may be found in the BA/BE associated with the proposed Greens Creek Mine Expansion project. The BA/BE (Tetra Tech 2011c) is located in the project record.

Table 3.12-2. Summary of Effects Determinations for the Project to Species that Occur in or near the Project Area.

Common Name / Scientific Name	Status	Presence in Study Area [a]		Effects Determination [b]
		Species Present	Species Habitat Present	
Species under USFWS Jurisdiction				
Yellow-billed loon *Gavia adamsii*	ESA Candidate; Forest Service Sensitive	No	Yes	May impact individuals but not likely to cause a trend to federal listing or a loss of viability
Species under NMFS Jurisdiction				
Humpback whale *Megaptera novaeangliae*	Endangered	Yes	Yes	Not likely to adversely affect
Steller sea lion – Eastern DPS / Western DPS *Eumetopias jubatus*	Threatened / Endangered	Yes	Yes	Not likely to adversely affect
Chinook salmon—Puget Sound *Onchorhynchus tshawytscha*	Threatened	No	Yes	No Effect
Chinook salmon—Lower Columbia River *Onchorhynchus tshawytscha*	Threatened	No	Yes	No Effect
Chinook salmon—Upper Willamette River *Onchorhynchus tshawytscha*	Threatened	No	Yes	No Effect
Chinook salmon—Upper Columbia River – spring *Onchorhynchus tshawytscha*	Endangered	No	Yes	No Effect
Chinook salmon—Snake River–spring/summer *Onchorhynchus tshawytscha*	Threatened	No	Yes	No Effect
Chinook salmon—Snake River–fall run *Onchorhynchus tshawytscha*	Threatened	No	Yes	No Effect

Table 3.12-2. Summary of Effects Determinations for the Project to Species that Occur in or near the Project Area.

Common Name / Scientific Name	Status	Presence in Study Area [a]		Effects Determination [b]
		Species Present	Species Habitat Present	
Sockeye salmon—Snake River *Onchorhynchus nerka*	Endangered	No	Yes	No Effect
Steelhead—Upper Columbia River *Onchorhynchus mykiss*	Endangered	No	Yes	No Effect
Steelhead—Middle Columbia River *Onchorhynchus mykiss*	Threatened	No	Yes	No Effect
Steelhead—Lower Columbia River *Onchorhynchus mykiss*	Threatened	No	Yes	No Effect
Steelhead -—Snake River Basin *Onchorhynchus mykiss*	Threatened	No	Yes	No Effect
Steelhead—Upper Willamette River *Onchorhynchus mykiss*	Threatened	No	Yes	No Effect
Lynn Canal Pacific herring *Clupea pallasi*	Candidate	Yes	Yes	Minor Impacts
Species under Forest Service Jurisdiction [c]				
Queen Charlotte goshawk *Accipiter gentilis laingi*	Forest Service Sensitive	Yes	Yes	May impact individuals but not likely to cause a trend to federal listing or a loss of viability
Black oystercatcher *Haematopus bachmani*	Forest Service Sensitive	No	Yes	
Mountain lady's slipper *Cypripedium montanum*	Forest Service Sensitive	No	Yes	
Large yellow lady's slipper *Cypripedium parviflorum* var. *pubescens*	Forest Service Sensitive	No	Yes	
Alaska rein orchid *Piperia unalascensis*	Forest Service Sensitive	No	Yes	

Notes:

a. "Yes" if the species is known or is likely to occur in the study area or in marine waters adjacent to the study area.
"No" if the species has not been documented or is not likely to occur in the study area.

b. Levels of influence are defined in the "Fish and Wildlife Resource Report." Determinations are only required for listed and sensitive species. Determinations for threatened and endangered species include "no effect," "not likely to adversely affect," or "likely to adversely affect." Determinations for sensitive species include "no impacts," "beneficial impacts," "may impact individuals but not likely to cause a trend to federal listing or a loss of viability," or "likely to result in a trend to federal listing or loss of viability" (Bosch 2004).

c. The "Species under Forest Service Jurisdiction" portion of this table lists the Forest Service Sensitive species that are not listed under the ESA; however, note that some of the ESA-listed species are also Forest Service Sensitive species.

3.12.3 Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species – Affected Environment

This section describes the status, distribution, ecology, and potential for occurrence within the project area for Humpback whale, Steller sea lion, Queen Charlotte goshawk, black oystercatcher, yellow-billed loon, and Lynn Canal Pacific Herring are discussed in more detail below. The remainder of the species listed in Table 3.12-1 are assessed in more detail in the BA/BE (Tetra Tech 2011c).

3.12.3.1 Humpback whale (Endangered)

Humpback whales were listed as endangered under the Endangered Species Conservation Act on December 2, 1970 (USFWS 1970) and have been listed under the ESA since its implementation in 1973. Critical habitat for this species has not been designated.

Commercial whaling operations were the primary contributor to the decline in humpback whale populations (NMFS 1991). The primary ongoing threat to humpback whales is entanglement in fishing gear (NMFS 1991), especially drift gill-nets (Carretta et al. 2007). Noise disturbance is also a threat (Carretta et al. 2007). Whales that use low-frequency sounds may be at an increased risk for disturbance from anthropogenic noise. The eastern North Pacific stock is increasing in abundance, with a total annual take of 1.8 per year, based on 2000 to 2004 data (Carretta et al. 2007).

A recovery plan was prepared in 1991 by the humpback whale recovery team for NMFS (NMFS 1991). The goal of the plan is for this species to be "biologically successful," meaning that humpback whales occupy all of their former range in sufficient numbers to buffer their populations against normal environmental fluctuations or anthropogenic environmental catastrophes. The plan states that the best estimator of biological success would be if the species is "numerically successful," meaning that populations grow to levels where their population dynamic responses indicate density-dependent reductions in productivity. The plan defines "political success" as populations being abundant enough that the species can be downlisted or delisted.

The local distribution of humpbacks in southeast Alaska is correlated with the density and seasonal availability of prey species, particularly small schooling fish (herring, capelin, juvenile walleye pollock, and Pacific sandlance) and euphausiids (small crustaceans). With the exception of capelin, all of these prey species occur in Hawk Inlet. Humpback whales occur throughout Chatham Strait and have been observed in Hawk Inlet.

3.12.3.2 Steller sea lion (Eastern DPS-Threatened / Western DPS-Endangered)

The Steller sea lion was emergency-listed as threatened under the ESA in April 1990 by NMFS due to rapid population declines (NMFS 1990a). The final listing for this species as threatened was made in November 1990 (NMFS 1990b). Critical habitat was designated in April 1993. Areas designated included rookeries and major haulouts in state and federal waters off Alaska, Washington, Oregon, and California; and three aquatic foraging habitats: one in the Gulf of Alaska and two in the Bering Sea-Aleutian Islands area (NMFS 1993). In June 1997, USFWS identified two distinct Steller sea lion population segments: one west of 144° W longitude, which was listed as endangered, and one east of 144° W longitude which remained listed as threatened (NMFS 1997). Steller sea lions are designated under the MMPA as depleted (NMFS 2011).

Critical habitat for Steller sea lions has been designated and includes a 3,000-foot distance landward and seaward from major rookery and haul-out sites. It also includes a 3,000-foot-elevation air zone above these terrestrial and aquatic zones. No critical habitat occurs near the project.

The causes of the decline of Steller sea lions are not completely known (62 FR 24345). Decreases in prey availability due to environmental changes of human activity may be a factor. Abandonment of traditional rookeries and haulout sites may be associated with human disturbance. An assessment of incidental take of Steller sea lions during commercial fishing is being undertaken by NMFS. The significance of shark and killer whale predation on Steller sea lion pups is not known. Environmental pollutants and contaminants are also a concern (62 FR 24345).

A recovery plan was released in 1992. The plan called for continuation of research and development of new programs to improve the understanding of sea lion management needs, with an immediate objective of identifying actions that would halt the decline of the Steller sea lion population (NMFS 1992). A revised recovery plan was released in 2008 (NMFS 2008). The goal of the plan is to restore sea lion populations to the point where they can eventually be delisted.

The Eastern DPS is known to occur in Hawk Inlet, although there are areas of overlap documented between the range of the Western and Eastern DPSs of Steller sea lions in Lynn Canal, and intermigration between the populations has been documented (NMFS 2008).

The nearest major haul out, or land site where sea lions rest and take refuge, to the project area is Benjamin Island, located approximately 45 miles north of Greens Creek Mine in Lynn Canal. However, sea lions have been observed hauled out on rock piles just north of the entrance of Hawk Inlet, in Chatham Strait. These rocks are used intermittently by up to two dozen Steller sea lions at a time (USFS 2003). Steller sea lions also gather on well-defined, traditionally used rookeries to pup and breed. The nearest rookery to the Greens Creek Mine is White Sisters, approximately 60 air miles from Sitka, Alaska. Hazy Island and Forester Island rookeries are located on the outer coast, approximately 120 and 150 miles from the mine site, respectively.

3.12.3.3 Queen Charlotte goshawk (Forest Service Sensitive)

The Queen Charlotte goshawk is of special concern to the State of Alaska and is on the Alaska Watch List of vulnerable and declining bird species in Alaska (Kirchhoff and Padula 2010). In 1994 the USFWS was petitioned to list the goshawk under the ESA, but twice found the listing not warranted. However, concern for the species' viability in southeast Alaska remains high due to lack of information regarding goshawk population trends as well as reductions in the amount of mature and old-growth forests due to timber harvest (USFWS 2007). Conservation measures for this species include nest buffer and legacy forest structure standards and guidelines under the Forest Plan (USFS 2008).

The Queen Charlotte goshawk is a subspecies of northern goshawk. The year-round range of this subspecies is the islands and mainland of southeast Alaska, the Queen Charlotte Islands and Vancouver Island of British Columbia, and coastal mainland British

Columbia west of the Coast Range (74 FR 56757). Goshawk habitat in southeast Alaska is generally considered to be mature (old-growth) forest stands. However, recent research in the Southwest and Pacific Northwest indicates that although goshawks prefer to place their nests in mature to old-growth forest types, they are much more adaptable than once thought, and when these habitats are not available they will nest in maturing second-growth with sufficient structure or in smaller patches of trees, and forage in young forest as well as along edges and in openings (Bosakowski et al. 1999; McClaren 2004; Boyce et al. 2006; Reynolds et al. 2006).

Two nest areas were documented on Admiralty Island, one near Green Cove (approximately 15 miles east of the Greens Creek Mine) and one near the Distin Lake Trail (approximately 26 miles south of the Greens Creek Mine). Both nests were active in 2005, the last year they were monitored. Additionally, in 1999 a goshawk was detected across Hawk Inlet from the proposed northern TDF; however, a nest was never discovered. Most recently, an active goshawk nest was discovered in June 2011 within the perimeter of the TDF proposed under alternatives C and D (Kai Environmental Consulting Services 2011).

Surveys for northern goshawks in the proposed expansion of the existing TDF (Alternative B) were conducted in June and July 2010 (Kai Environmental Consulting Services 2010a). No goshawks or their sign were documented.

3.12.3.4 Black oystercatcher (Forest Service Sensitive)

The black oystercatcher was added to the Alaska Region U.S. Forest Service sensitive species list in 2009, and is a priority shorebird species in southeast Alaska due to concerns with population size, breeding and nonbreeding threats, and nonbreeding distribution (Alaska Shorebird Group 2008). It is also a USFWS focal species and Bird of Conservation Concern, and is on the Audubon Society's Watch List (Tessler et al. 2007).

Black oystercatchers are naturally rare, with a small global population; estimates range from 8,500 to 11,000 individuals rangewide (Goldstein et al. 2009). Habitat for black oystercatchers is rocky marine shorelines, where they forage for intertidal marine invertebrates, especially bivalves and other mollusks (Andres and Falxa 1995, Tessler et al. 2007).

Black oystercatchers can be found in the Tongass National Forest (Goldstein et al. 2009). The population estimate for southeastern Alaska is 1,000 to 2,000 (Andres and Falxa 1995). Severe declines of breeding pairs have occurred at Sitka Sound, approximately 80 miles southwest of the project area (Goldstein et al. 2009). Northern southeast Alaska, which includes Admiralty Island, has 93 observations of black oystercatchers recorded between 1972 and 2003 (Tessler et al. 2007).

3.12.3.5 Yellow-billed loon (Forest Service Sensitive / Federal Candidate)

In March 2009, USFWS found that listing of the yellow-billed loon as threatened or endangered was warranted but precluded (74 FR 12932). A species action plan for the yellow-billed loon was released in November 2009 (USFWS 2009). The main threat to this species is illegal harvest, both in the U.S. and in Russia. Other possible, though likely insignificant threats, include commercial and subsistence fishing bycatch, environmental pollutants and contaminants, prey availability on wintering grounds, oil and gas development, and climate change (USFWS 2009). This species is also a Forest Service Sensitive-listed species.

Yellow-billed loons are migratory, breeding in North America in the Arctic in northern Alaska, northern Northwest Territories, and Nunavut, and wintering along the coast of southwest Alaska, British Columbia, and in the Puget Sound. Nesting habitat is low-lying tundra near large lakes, usually near the coast (North 1994). These birds are usually solitary, but they may travel in groups during migration (USFWS 2010).

This species is not common and is distributed sparsely (North 1994; USFWS 2010), but it can be found throughout southeast Alaska during winter (October–March; North 1994, ALGW 2006). During a seabird survey in southeastern Alaska, only eight individuals were seen during winter, and one during summer along 15,600 miles of shoreline surveyed (Hodges et al. 2008). There are some records of this species on Admiralty Island (Dixon 1916). In the project area, this bird could be found in nearshore marine waters and inlets, such as Hawk Inlet (North 1994).

3.12.3.6 Sensitive Plants

Botanical surveys in the study areas proposed for development under alternatives B, C, and D were conducted in July and September 2010 and in July 2011. No sensitive species were found, although there is sphagnum bog, fen, and forested bog vegetation in the study area where these species potentially occur. Based on surveys, and the amount of potential habitat that could be disturbed, it was determined that the project may adversely affect impact individuals, but is not likely to result in a loss of viability in the Planning Area, nor cause a trend toward federal listing. A separate biological evaluation for plants, including a Risk Assessment for Sensitive Plants, was developed and is available in the project record.

3.12.3.7 Lynn Canal Pacific Herring (Candidate)

NMFS received a petition to list the Lynn Canal stock of Pacific Herring as threatened or endangered in 2007. NMFS rejected this petition on the grounds that the Lynn Canal stock was not determined to be a DPS during their review. However, NMFS initiated a status review for Southeast Alaska Pacific herring (a larger DPS of this species, and which also contains the Lynn Canal stock); this review ultimately resulted in this stock being designated as a candidate species under the ESA.

Herring concentrate near the bottom (at 200 to 300 feet) off traditional spawning beaches in Lynn Canal during February and March. They then move into tidal shallows to commence spawning, which typically takes place over a 2- to 3-week period between late April and early May. After spawning, the adult herring return to deep-water areas in Lynn Canal, Stephens Passage, and the western shore of Douglas Island (Carlson 1980). Herring spawning typically takes place over nearshore habitat from mean higher high water to -40 feet, but typically +3 to -7 feet deep.

Herring are one of the more abundant fishes along the coast of Alaska, although this abundance tends to be seasonal and varies tremendously from year to year. Pacific herring occur as juveniles within the marine waters of the study area; however, they are not known to spawn in this area (Monagle 2011). Important spawning areas are located north (e.g., Berners Bay and Auke Bay), as well as east of the project area (e.g., Oliver Inlet).

3.12.4 Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species – Environmental Consequences

3.12.4.1 Effects Common to All Alternatives

Under all alternatives, there would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, and along the A and B roads. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing TDF operations would continue through the term of the lease. The large barges and ships that are used to haul the concentrate from the mine on a regular basis, as well as the crew shuttles, are not likely to affect marine mammal distribution in Young Bay, Hawk Inlet, or in Chatham Strait. The vessels typically operate at low, constants speeds and infrequent intervals. The biological evaluation conducted for the 2003 Greens Creek Tailings EIS concluded that none of the alternatives at that time would constitute harassment or a taking under the ESA or the MMPA. The draft BA/BE prepared for this EIS is summarized here and the following sections and includes adhering to the MMPA, ESA, and Forest Service Standards and Guidelines, NMFS regulations for approaching whales, and following the Alaska Marine Mammal Viewing Guidelines around other marine mammals such as harbor seals, sea lions, dolphins, and porpoise. This includes maintaining a minimum approach distance of 100 yards and traveling at a slow constant speed.

Under all alternatives, oil or fuel spills could occur as a result of vessels at the marine terminal in Hawk Inlet or at the dock in Young Bay. Spills could adversely impact threatened and endangered species foraging or moving through the shallow shoreline areas, particularly at the head of the inlet. Spill control plans and rapid response to spills would be the primary mitigation measures to avoid or minimize adverse spill effects to threatened and endangered species in the marine environment.

Surface water runoff from the operation would continue to be collected, treated, and discharged into Hawk Inlet under all alternatives. As described in more detail in sections 3.5, Water Resources, and 3.7, Aquatic Resources, discharge would be required to meet APDES permit limits based upon Alaska WQS under all alternatives, thereby minimizing impacts to threatened and endangered species in the marine environment. However, some heavy metals accumulation in marine sediments is anticipated. In higher trophic level marine mammals or birds, bioaccumulation of heavy metals has the potential to occur through transfer from prey though such impacts are unlikely due to the transient nature of these species in Hawk Inlet. The amount of discharge would remain consistent during operation, but at closure, with the suspension of mining activities, the volume of water treated and discharged would appreciably decrease, thereby reducing total metals discharge to the marine environment. However, due to the possibility of bioaccumulation, the longer the mine operates, the longer this slight risk exists (USFS 2003). Monitoring in Hawk Inlet will continue to be required by ADEC as long as there is a discharge. These requirements include monitoring of metals concentrations in sediments, water quality, and tissue within the mixing zone of the outfall.

Humpback whale (Endangered)

Impacts to humpback whales from the project could include collisions with watercraft, acoustic disturbance associated with increased boat use in the area, water pollution from spills of hazardous materials, and increased sediment load in waters which could increase the incidents of collisions with boats (NMFS 1991). Exposure of humpback whales in Hawk Inlet to disturbance and noise associated with the marine terminal or the dock at Young Bay (crew shuttles) and the potential for fuel or oil spills would be unchanged from current levels. The project (regardless of the action alternative considered) would extend the time during which humpback whales could be potentially exposed to metal concentrations in prey due to project-related discharges into Hawk Inlet, oil or fuel spills, and vessel traffic. The extended operating period could lead to greater accumulations in the marine environment. However, ADEC's APDES permit (which places restrictions on the types, quantities, and extent of effluent discharges that are allowed to be discharged to waters) would limit the effects of the TDF discharge on water quality. Given the transient nature of this species in Hawk Inlet, the project (regardless of the action alternative considered) may have a minor effect on this species in Hawk Inlet, discharges of treated water under the APDES permit would not be likely to adversely affect the Humpback whale under any alternative.

Steller sea lion (Eastern DPS-Threatened / Western DPS-Endangered)

Impacts from the project to Steller sea lions could include noise and visual disturbance, injury or mortality, decreased fitness of adults if haul-outs are disturbed, decreased habitat quality due to pollutants and turbidity, disturbance to terrestrial haul-outs, and impacts to prey species. The intensity of exposure to disturbance and noise and the potential for fuel or oil spills would be unchanged from current operations; however, implementation of the project (regardless of the action alternative considered) would extend the time during which Steller sea lions are exposed to these impacts. The extended operating period could be exposed to greater metal concentrations in the marine environment. The extended operating period due to TDF expansion alternatives will result in Stellar sea lions having the potential to continue to be exposed to metals in the marine environment. However, ADEC's APDES permit (which places restrictions on the types, quantities, and extent of effluent discharges that are allowed to be discharged to waters) would limit the effects of the project on water quality. Given the transient nature of this species in Hawk Inlet, the project (regardless of the action alternative considered) may have a minor effect on this species.

Queen Charlotte goshawk (Forest Service Sensitive)

An impact to Queen Charlotte goshawks from the project could include noise and visual disturbance. Individuals fleeing from a disturbance would use a greater amount of bodily energy reserves and lose foraging time. Raptors are particularly sensitive to disturbance during nesting and brooding. Incubating adults, when disturbed, could temporarily or permanently abandon nests, exposing eggs or chicks to predators and the elements, possibly resulting in mortality. Disturbance could also disrupt foraging and feeding of young, resulting in decreased chance of reproductive success. Large raptors such as goshawks generally breed later in life and have fewer clutches per season and fewer young per clutch than many other migratory birds; therefore, the loss of an egg, chick, or clutch would have a proportionately greater population-level impact than for other birds.

Black oystercatcher (Forest Service Sensitive)

An impact to this species from the project could include pollutants entering the water and washing up on their beach habitat; black oystercatchers were severely impacted by and are still recovering from the 1989 Exxon Valdez oil spill in Prince William Sound (Goldstein et al. 2009). Another potential impact is noise and visual disturbance, which could flush birds from breeding and nesting grounds and increase energy expenditures. If personnel or vehicles use beaches, foraging habitat and prey populations could be affected, or nests destroyed. However, there are no large concentrations of black oystercatchers known to occur in Hawk Inlet; therefore, few individuals would be exposed to this risk and potential impacts would be minor.

Yellow-billed loon (Forest Service Sensitive / Federal Candidate)

Yellow-billed loons may occur in the nearshore marine environment adjacent to the marine terminal in winter or during migration. Impacts to this species from the project could include:

- noise and visual disturbance, which could cause birds to flush or move to a different area, using energy reserves and potentially causing them to utilize lower quality habitat, with the possible effect of lowering fitness;
- effects on fresh- or salt-water habitats, for example siltation or pollution;
- effects on water quality which could impact prey populations; and
- increase of human presence in the area, which could cause increased illegal harvest, which at present levels is unsustainable and is one of the primary threats to this species (USFWS 2010).

Vessel traffic associated with the operation of the mine would not change in intensity, but would occur for a longer period, for another 30 to 50 years. In the event of a spill, the risk to yellow-billed loons would remain low because the birds typically occur at very low densities in southeast Alaska and therefore, few individuals would be at risk. Therefore, the project (regardless of the action alternative considered) may have a minor effect on this species.

Sensitive Plants

No sensitive plant species were found in the areas that would be impacted by the TDF alternatives, therefore no direct impacts to sensitive plant species would occur. However, moderate indirect impacts to habitats could occur from: invasive species introduction and subsequent competition with native plants for habitat; and alteration in vegetation composition, hydraulic pattern, solar exposure, site characteristics, and organic litter composition. If any previously undiscovered sensitive plants are encountered at any time prior to or during construction and operations of the TDF under any alternative, they would be avoided to the extent possible and the Forest Service would be notified immediately to evaluate the population and recommend avoidance or mitigation measures.

Lynn Canal Pacific Herring (Candidate)

Impacts to Lynn Canal Pacific herring from the TDF alternatives could include impacts due to the APDES discharge and sedimentation into surface waters. These impacts could have both direct effects on herring, as well as indirect effects in the form of impacts to their prey base. Exposure to these risks would be unchanged from current levels;

however, the action alternatives would extend the time frame in which these impacts could occur. Impacts to herring would be more likely than what was analyzed for listed salmon/steelhead and effects could be of a greater level, as herring are known to occur in and around the study area on a regular basis, whereas listed salmon/steelhead presence would be transitory in nature and typically occur in low densities. Herring are not known to spawn in this area, but juveniles would be present (Monagle 2011); therefore, juveniles would be at risk of exposure to project-related water quality and sedimentation impacts. However, ADEC's APDES permit (which places restrictions on the types, quantities, and extent of effluent discharges that are allowed to be discharged to waters) would limit the effects of TDF discharge on water quality. Therefore, impacts to Lynn Canal Pacific herring would be minor.

3.12.4.2 Effects of the Alternative A: No Action

Effects under Alternative A would be the same as described in Section 3.12.6, Effects Common to all Alternatives. There would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, and along the A and B roads. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing mine operations would continue for approximately three additional years.

3.12.4.3 Effects of the Alternative B: Proposed Action

Effects under Alternative B would be the same as described in Section 3.12.6, Effects Common to All Alternatives. There would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, and along the A and B roads. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing mine operations would continue for approximately 30-50 additional years. Queen Charlotte goshawks would be impacted by the removal and degradation of approximately 109 acres of productive old-growth, 49 acres of which are high volume/coarse canopy forest SD-5N, SD-5S, and SD-67 habitat under Alternative B. The level of reduction would not be expected to affect populations of these species in the study area given the remaining available habitat. No nests or sign of nesting activity were documented during the 2010 surveys in the vicinity of the existing mine and proposed expansion area under Alternative B. It is likely that the ongoing noise in the area precludes goshawks from actively nesting or foraging in the immediate vicinity of the mine.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF.

Effects under mitigated Alternative B would be the same as described in Section 3.12.6, Effects Common to All Alternatives. There would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, and along the A and B roads. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing TDF operations would continue for approximately 30-50 additional years. Queen Charlotte goshawks would be impacted by the removal and degradation of approximately 97 acres of productive old-growth, 43 acres of which are high volume/coarse canopy forest SD-5N, SD-5S, and SD-67 habitat under mitigated Alternative B. The level of reduction would not be expected to affect populations of these species in the study area given the remaining available habitat. No nests or sign of nesting activity were documented during the 2010 surveys in the vicinity of the existing mine and proposed expansion area under mitigated Alternative B. It is likely that the ongoing noise in the area precludes goshawks from actively nesting or foraging in the immediate vicinity of the mine.

3.12.4.4 Effects of the Alternative C: TDF Located Outside of Monument

Effects under Alternative C would be the same as described in Section 3.12.6, Effects Common to All Alternatives. There would be some level of continued human activity occurring at the current TDF, mine site, marine facility, and along the A and B roads. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing mine operations would continue for approximately 3 years at the existing TDF and an additional 30-50 years at the new TDF. Queen Charlotte goshawks would be impacted by the removal and degradation of approximately 130 acres of productive old-growth, 38 acres of which are high volume/coarse canopy forest SD-5N, SD-5S, and SD-67 habitat under Alternative C. Expanding operations would increase the scope of this disturbance somewhat. The active nest located in 2011 adjacent to the new TDF proposed under Alternative C may require a non-significant Forest Plan Amendment should that nest remain active at the time of construction (in the next 3 years under Alternative C). Currently, Forest Plan Standards and Guidelines will apply to reduce any disturbance during the nesting season.

3.12.4.5 Effects of the Alternative D: Modified Proposed Action

Effects under Alternative C would be the same as described in Section 3.12.6, Effects Common to All Alternatives. There would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, and along the A and B roads. Thus, the potential for direct mortality and disturbance of wildlife associated with ongoing mine operations would continue for approximately 10 years at the existing TDF and an additional 40 years at the new TDF. Queen Charlotte goshawks would be impacted by the removal and degradation of approximately 140 acres of productive old-growth, 52 acres of which are high volume/coarse canopy forest SD-5N, SD-5S, and SD-67 habitat under Alternative D. Expanding operations would increase the scope of this disturbance somewhat. The active nest located in 2011 adjacent to the new TDF proposed under Alternative D may require a non-significant Forest Plan Amendment should that nest remain active at the time of construction (10 years under Alternative D). Currently, Forest Plan Standards and Guidelines will apply to reduce any disturbance during the nesting season.

3.12.5 Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species – Summary

Under all alternatives, there would be some level of continued human activity occurring at the existing TDF, mine site, marine facility, and along the access road. Thus, the potential for direct mortality and disturbance of marine and terrestrial wildlife and their habitat associated with ongoing mine operations would continue to some extent for all TDF alternatives. The large barges and ships that are used to deliver fuel and equipment and haul the concentrate from the mine, as well as the crew shuttle transiting Young Bay will continue but are not likely to adversely affect marine mammal distribution in Hawk Inlet, Young Bay, or Chatham Strait. Although these impacts are common to all alternatives, the duration of effects differs by alternative. Operation of the mine would continue until 2014 under Alternative A. However, expansion of the existing TDF under Alternative B, and the expansion of the existing TDF and construction of a new TDF under alternatives C and D would extend the operating period of the mine for an additional 30 to 50 years. Therefore, reclamation of the mine site and reductions in levels of human activity, water quality impacts, fugitive dust emissions, and marine traffic would occur more quickly under Alternative A than alternatives B, C, and D.

Under all alternatives, oil or fuel spills could occur as a result of vessels at the marine terminal in Hawk Inlet or at the dock in Young Bay. Spills could adversely impact threatened and endangered species foraging or moving through the shallow shoreline areas, particularly at the head of the inlet. Spill control plans and rapid response to spills would be the primary mitigation measures to avoid or minimize adverse spill effects to threatened and endangered species in the marine environment.

TDF seepage and surface water runoff would continue to be collected, treated, and discharged into Hawk Inlet under all alternatives. Discharge would continue to be required to meet Alaska WQS under all alternatives, thereby minimizing impacts to threatened and endangered species in the marine environment. However, some heavy metals accumulation in marine sediments is anticipated. In higher trophic level marine mammals or birds, bioaccumulation of heavy metals has the potential to occur through transfer from prey though such impacts are unlikely due to the transient nature of these species in Hawk Inlet. The amount of discharge would remain consistent during operation, but at closure, with the suspension of mining activities, the volume of water treated and discharged would appreciably decrease, thereby reducing total metals discharge to the marine environment. Therefore, the longer the mine operates, the longer this slight risk exists (USFS 2003).

Reduction in productive old-growth may affect goshawks and somewhat similar across alternatives ranging from approximately 109 acres under Alternative B to 140 acres under Alternative D. Slightly more high volume/coarse canopy forest SD-5N, SD-5S, and SD-67) would be removed under Alternative D (52 acres) followed by Alternative B (49 acres) and Alternative C (38 acres). The level of reduction would not be expected to affect populations of these species in the study area given the remaining available habitat.

A BA/BE was prepared for this EIS which analyzed potential impacts for all threatened and endangered species that have the potential to occur within or near the project. A determination of "***no effect***" is rendered in regard to all threatened and endangered species with the exception of the humpback whale and Steller sea lion where a "***not likely***

to adversely affect" call was made. In addition, six species listed as Forest Service Sensitive received a "***may impact individuals but not likely to cause a trend to federal listing or a loss of viability***" and include Queen Charlotte goshawk, black oystercatcher, and yellow-billed loon (also a Federal Candidate), and the three sensitive plant species *Cypripedium montanum*, *Cypripedium parviflorum* var. *pubescens*, and *Piperia unalascensis* with the remainder receiving a "***no impact***" determination

All activities proposed will adhere to the MMPA, ESA, and Forest Service Standards and Guidelines, NMFS regulations for approaching whales, and follow the Alaska Marine Mammal Viewing Guidelines around other marine mammals such as harbor seals, sea lions, dolphins, and porpoise, this includes maintaining a minimum approach distance of 100 yards and traveling at a slow constant speed. Best management practices would continue to apply for all activities in marine waters including SPCC and rapid response to spill plans. The Forest Plan provides standards and guidelines to maintain nesting habitat for the Queen Charlotte goshawk.

3.13 Land Use

The Tongass National Forest Land Use Management Plan (USFS 2008) provides direction for managing use of the national forest lands. The plan assigns land use designations (LUDs) to each part of the forest, which give general direction on the types of land uses and activities that can occur in each area, referred to as management prescriptions. The management prescriptions for each LUD list goals, objectives, and the desired condition for each LUD, as well as standards and guidelines for managing specific resources within the LUD. The plan also provides forest-wide standards and guidelines that apply to all LUDs.

Figure 3.13-1 indicates the LUDs assigned to the study area. The northwestern portion of the existing tailings facility, the cannery site, the Young Bay landing dock, the A Road from the dock to the cannery, and a portion of the B Road from the cannery to the existing tailings area all lie within the Semi-Remote Recreation LUD. The remaining mine facilities are located within the Non-Wilderness National Monument LUD. The intent of the Semi-Remote Recreation LUD emphasizes predominantly natural or natural-appearing settings for semi-primitive recreation, but allows for mineral exploration and development as long as it complies with the LUD and forestwide standards and guidelines. The Non-wilderness National Monument LUD also allows for development of mineral resources, as long as effects to non-mineral resources are minimized to the extent feasible and areas disturbed by mining are reclaimed to a near-natural condition. The plan of operations for the mine must specify the activities to be conducted, the location and timing of those activities, and how the environment and resources of the area will be protected through compliance with federal and state requirements.

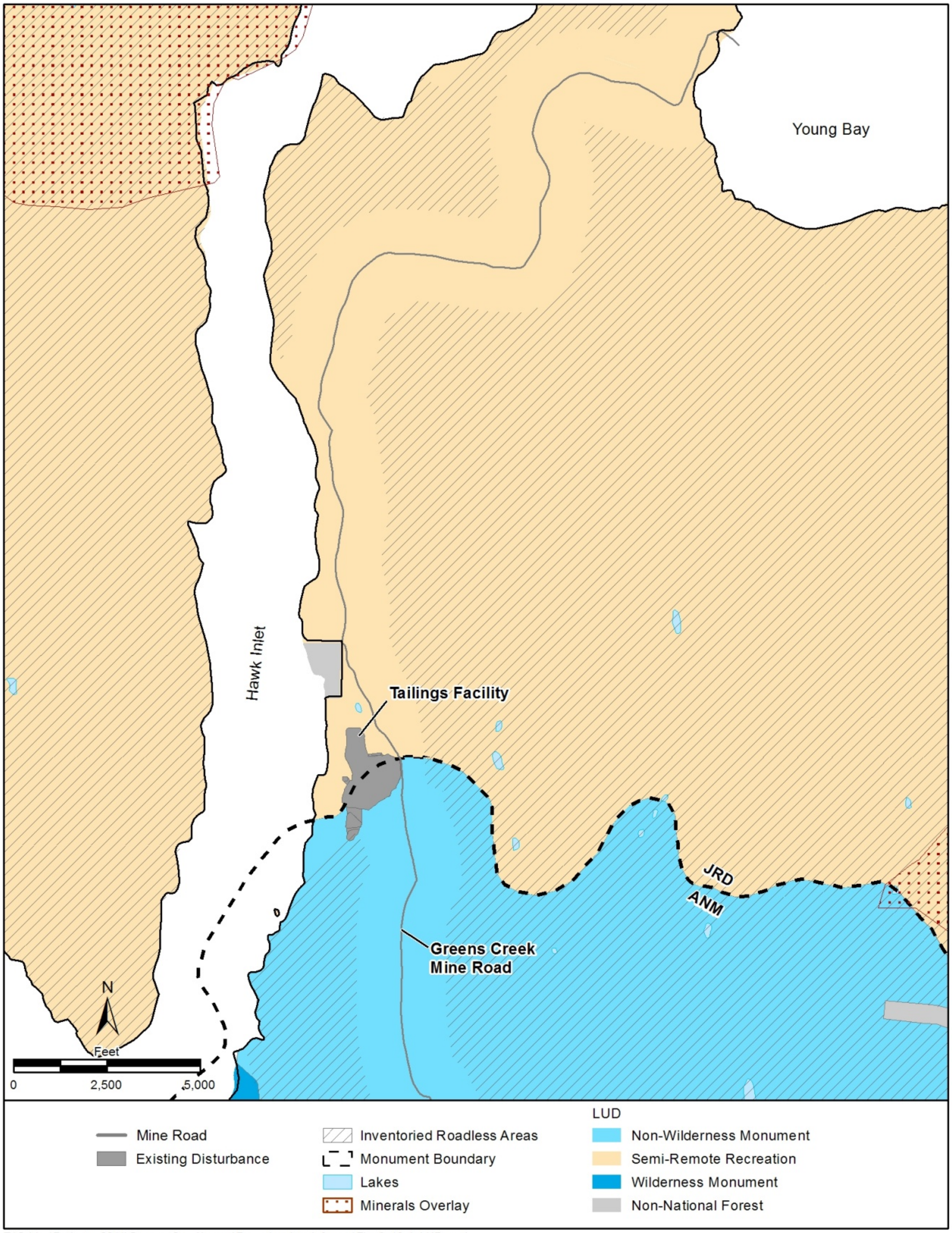


Figure 3.13-1. Land Use Designations.

Figure 3.13-1 also shows the extent of the inventoried roadless areas (IRAs) within the study area. Construction or reconstruction of roads is generally prohibited in IRAs, as is cutting or removal of timber. Paragraph (b)(3) (of the Roadless Rule) permits the construction and reconstruction of a road pursuant to rights granted in statute or treaty, or pursuant to reserved or outstanding rights. Such road construction must be conducted in a manner that minimizes effects on surface resources, prevents unnecessary surface disturbance, and complies with all applicable lease requirements, land and resource management plan direction, regulations, and laws. Mine-related roads must be reclaimed after completion of mining (36 CFR 294). Section 3.20 addresses IRAs in more detail.

3.13.1 Land Use – Pre-mining Environment

The resource analysis of land use is related to Issue 4, Monument related concerns. Measures of impacts to the Monument include acres of disturbance related to the construction and expansion of the TDF.

The Greens Creek Mine is located within the watersheds of Greens, Zinc, Cannery, Tributary, and Fowler creeks on the northern portion of Admiralty Island. The mine lies partially within the Monument. Northern Admiralty Island and Hawk Inlet have historically been used by Tlingit individuals for subsistence activities (Section 3.16, Subsistence and Section 3.17, Cultural Resources). Commercial fishing and recreational activities, including sport fishing, hunting, and boating, have also occurred in the area (Section 3.15, Recreation). The area was first developed for commercial use in 1914 with construction of the Hawk Inlet Fish Cannery. Mining activities at the Greens Creek Mine site began in the mid-1970s when exploration work commenced, with full-scale development initiated in 1989. The mine has operated continuously for all but three of the years since 1989.

3.13.2 Land Use – Baseline Conditions

Land use in the study area is similar to what it was during the pre-mining period, with the exception of the current mine facilities. The area is still used for recreation, commercial fishing, and subsistence activities, although recreational use of Hawk Inlet has increased since the 1980s (Kiesel 2011). There are several recreation cabins along Wheeler Creek and floating cabins in Hawk Inlet, which are described in Section 3.15, Recreation. Most of the recreation use occurs on the waters or shoreline of Hawk Inlet, but deer hunting is also a popular activity throughout the upland areas, except within the mine site. The historic cannery site has been restored and incorporated into the mine facilities, providing a cafeteria, housing, and offices for mine personnel.

The Greens Creek Mine TDF currently occupies 47 acres of land leased from the Forest Service and 15 acres of private land. The private land consists of the former cannery site, including the floatplane dock and concentrate loading facility. The current approved TDF will disturb a total of 65.3 acres at final build-out, of which approximately 33.5 acres lie within the Monument.

3.13.3 Land Use – Environmental Consequences

3.13.3.1 Effects Common to All Alternatives

Potential impacts to land use within the project area would include effects to recreation activities, subsistence uses, and commercial fishing, and disturbance of the immediate project site. Effects to recreation and subsistence activities are discussed in Sections 3.15 and 3.16 respectively. Effects to commercial fishing would be limited to the effects on aquatic resources discussed in Section 3.7.

Adverse impacts to land use under all of the alternatives would be the disturbance of additional acreage for development of the TDF. Table 3.13-1 compares the expected disturbance within and outside the Monument resulting from each alternative. Alterations to the vegetative cover are addressed in Section 3.9, Vegetation. After completion of mining, the water treatment plant and electric lines would remain in place and the slopes of the TDF would remain at a 3:1 (H:V) slope under all of the alternatives. All other facilities would be decommissioned and removed, and surface contours conducive to revegetation or other post-mining use would be established. Disturbed areas will be reclaimed to one of three vegetation types, including upland meadows, upland forest, or wetlands. Natural re-vegetation would be the primary method of forest re-vegetation. The area would be opened to the public for hunting and other public uses. Once natural forest cover was re-established, the LUD management prescriptions would be met under all of the alternatives, since revegetation would allow the project area to return to a near-natural condition.

Table 3.13-1. Disturbances Inside and Outside the Monument by Alternative.

	New Disturbance within/outside Monument	Total Disturbance within/outside Monument (acres)
Alternative A	0 / 0	33.5 / 28.7
Alternative B	109 / 33	142.8 / 65.3
Mitigated Alternative B	86.2 / 33.5	119.7 / 66.3
Alternative C	9 / 114	42.6 / 179.5
Alternative D	27 / 142.8	60.6 / 174.7

3.13.3.2 Effects of Alternative A, No Action

Under Alternative A the existing TDF would reach its currently approved size and configuration by year 2014. Alternative A would not authorize any new disturbances associated with tailings disposal and would result in fewer acres of disturbed land within the Monument than any of the other alternatives. After completion of mining, reclamation would restore the area to a near-natural condition.

3.13.3.3 Effects of Alternative B, Proposed Action

Alternative B would require expanding the TDF, reclamation material storage areas, quarries, water management ponds, roads; truck wheel wash facility; and ultimately relocating of the water treatment plant. The expanded TDF would be developed adjacent to the existing TDF, extending into the undeveloped lands to the south. After completion of mining in 30–50 years, reclamation efforts to restore the site to near-natural vegetative conditions would begin, with the regeneration of native forest cover expected to take an estimated 50 to 100 years.

Material would be placed in the TDF in four phases, which would limit the area of disturbance to areas immediately ahead of tailings placement. Hydro-seeding and other interim reclamation measures in the completed areas would reduce the amount of contrast with the surrounding landscape to the extent practical.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF.

3.13.3.4 Effects of Alternative C, New TDF Located Outside Monument

Under Alternative C a new TDF would be developed north of the A Road outside the Monument as a means to minimize additional disturbance within the Monument. This alternative would have the adverse effect of extending the TDF to a portion of the forest that is currently undisturbed and open for public use. A rock quarry and reclamation materials stockpile would also need to be constructed for the new TDF and the A Road would be improved to accommodate the tailings transport. Tailings generated during the two to three years required for construction of the new TDF would be placed within the existing TDF and increasing the height of the existing TDF by approximately 3 feet. Alternative C would result in 94 percent of the new disturbance to be outside the Monument within the Semi-Remote Recreation LUD. As with the other alternatives, the area would be restored to a near-natural condition after completion of mining.

3.13.3.5 Effects of Alternative D, Modified Proposed Action

The effects of Alternative D would be similar to those of Alternative C in that construction of a new TDF north of the A Road would reduce disturbance of Monument lands, but would introduce tailings and construction activity to a previously undisturbed portion of the forest. The existing TDF would be expanded to allow for an additional 10 years of tailings placement, 17 percent of new disturbance would occur within the Monument. The new TDF to the north would be constructed to accommodate tailings disposal for the remainder of the life of the mine. This alternative would have less adverse impacts to Monument lands than Alternative B and more than Alternative C as shown in Table 3.13-1.

3.13.4 Land Use – Summary

Land use outside the immediate project vicinity consists of recreation, subsistence activities and commercial fishing. Effects on these resources are discussed in sections 3.15, 3.16, and 3.17, respectively. Land use within the immediate project site is currently dominated by the existing mine facilities, which will continue under Alternative A until 2014 when project closure and reclamation will begin. Under alternatives B, C, and D land use of the project vicinity would continue to be dominated by mining until the beginning of reclamation in 30-50 years. Alternatives B, C, and D would increase the extent of disturbed areas both within and outside the Monument. Of the action alternatives, Alternative B would disturb the largest amount of land within the Monument and Alternative C would have the least effect on Monument land. Alternative C would introduce a new land use north of the current mine site by constructing a new TDF to the area north of ‘A’ Road, dispersing the land use effects to a new part of the forest. Under Alternative D tailings would be placed within the existing TDF for the first 10 years of the project, after which it will be placed in the new TDF, and thus would also introduce a new land use in this area. All of the alternatives will meet the management prescriptions for the Semi-Remote Recreation and Non-Wilderness National Monument LUDs as long as the TDF disturbed areas are reclaimed to a near-natural condition. Given current reclamation technologies included in the reclamation plan, it is expected that all the TDF alternatives can be reclaimed to meet this goal.

3.14 Scenic Resources

3.14.1 Scenic Resources – Pre-mining Environment

The analysis of scenic resources was not identified as a significant issue, however it is related to Issue 4, Monument related concerns. Measures of impacts to the Monument include changes to visual integrity.

Prior to mining, the visual condition of the study area was predominantly natural in appearance, except for the presence of the historic cannery facility, which had been gutted by fire and was in disrepair. There were also several floating houses in Hawk Inlet and cabins along Wheeler Creek. The visual variety of the Admiralty Island shoreline and ridgelines was classified as distinctive, whereas much of the remaining landscape was classified as common variety class due to the relatively uniform expanses of coniferous forest. The cannery area was classified as minimal variety class due to the evidence of past human activities (USFS 1983).

3.14.2 Scenic Resources – Baseline Conditions

The following discussion of baseline conditions is based on new methodology and terminology adopted by the Forest Service in 1995, “Landscape Aesthetics, A Handbook for Scenery Management” and incorporated into the Tongass National Forest planning process with adoption of the 2008 Forest Plan. Since the discussion references the 1983 and 2003 EIS documents, which were based on the former methodology, the outdated terminology is listed in parentheses where replaced by new terms.

3.14.2.1 Landscape Character

The Greens Creek Mine is situated within the Pacific Coastal Mountains Ecological Subregion of the United States. The landscape is dominated by rugged glaciated mountains with deep V-shaped and U-shaped valleys. The landscape is known for its meandering shorelines and islands, with numerous bays and coves. A system of seaways separates the many islands and provides a protected waterway for ferries and cruise ships. A relatively uniform canopy of Sitka spruce and western hemlock forest dominates the lower elevations, interrupted by pocket clearings of meadows, muskegs, and lakes. Higher elevations are dominated by low-growing alpine tundra vegetation, with high ridges and steep, rocky cliffs (USFS 1994). Human modifications are not highly visible within much of this subregion, which is predominantly natural in appearance.

The landscape character as seen from Hawk Inlet is dominated by the densely forested ridges and valleys of the Greens Creek drainage and the level plains and foothills along the shoreline. High forested ridges and numerous bodies of water form a repetitive pattern in the landscape surrounding the mine site (USFS 2003). Figure 3.14-1 illustrates the existing conditions as seen from Hawk Inlet looking towards the existing mine facilities. Figure 3.14-2 illustrates the existing character of the study area as seen from the northern portion of Hawk Inlet.

The visual absorption capability is the ability of the landscape to accept human alterations without loss of character or scenic quality. Visual absorption capability is influenced by natural conditions such as soil color, vegetation patterns, and slope. The study area has a relatively low to moderate visual absorption capability. Its light-colored soils and relatively uniform forest cover make openings more apparent than areas with intermittent forest cover, but the area's deep valleys and vegetation density make it easier to screen (or hide) facilities, thus giving the area a low to moderate visual absorption capability.

3.14.2.2 Existing Scenic Integrity (Existing Visual Condition)

The existing scenic integrity describes the degree of human disturbance specific to the study area and is measured on a scale from Very Low to Very High, in which Very High represents areas unaltered by human actions and Very Low represents areas of drastic landscape disturbance. Within the Hawk Inlet viewshed, the existing TDF and cannery site are the most dominant human alterations. Most of the other mine facilities are not visible from the inlet. The existing TDF creates a horizontal line devoid of vegetation, contrasting with the sloping topography. The light color of the soil and tailings material contrasts sharply with the deep green of the surrounding forest. The view from Hawk Inlet would be classified as a moderate Existing Scenic Integrity because the TDF is seen as a major, human-caused deviation in the view, but the TDF's size relative to the surrounding shoreline and ridgelines allow it to remain subordinate to the view as a whole.

Figure 3.14-1. Existing View of Mine Facilities from Hawk Inlet.

Figure 3.14-2. Existing View from Northern Portion of Hawk Inlet.

3.14.2.3 Site Visibility and Concern Level (Sensitivity Level)

For purposes of the Scenic Resource analysis, Hawk Inlet is considered a Visual Priority Travel Route and Use Area (VPR), because the Forest Plan designates the inlet as a small boat route and identifies three small boat anchorages in the inlet (see Section 3.15, Recreation). Hawk Inlet and its shoreline are used by residents and non-residents of Alaska for recreational activities, such as fishing, hunting, boating, and wildlife viewing. There are also six privately-owned floating cabins on the inlet, used by local residents as a base for hunting, fishing, and other recreational activities. Chatham Strait is also considered a VPR due to the Alaska Marine Highway corridor.

The existing TDF is situated within the foreground and middleground view from Hawk Inlet. The only VPR with a background view (over 4 miles) of the project area is from a small portion of Chatham Strait as one looks up the inlet. The region's coniferous vegetation, however, reduces seasonal variation by maintaining the potential for vegetative screening throughout the year.

The Forest Service rates the relative scenic importance of certain views, or the concern level, on a scale of 1 to 3 with 1 having the greatest sensitivity or level of concern. Concern levels are based on the visibility from VPRs, the distance zone of the view from the VPRs (foreground, middleground, or background), and the level of interest people are likely to have for scenery. The existing TDF would be rated as Level 1 (High Level of Concern) because of its location within the foreground and middleground view from the Hawk Inlet VPRs and use of the inlet by recreationists and tourists, many of whom visit the area for its scenic attributes and wildlife viewing.

3.14.2.4 Scenic Attractiveness and Scenic Classes (Variety Class)

The scenic attractiveness rating (Class A, B, or C) is determined by considering the inherent attributes and distinctiveness of the landscape, such as landform patterns and features, water features, vegetation patterns, land use, and cultural features. The Admiralty Island shoreline is considered Class A, or distinctive scenic attractiveness rating, because of the visual variety created by the meandering shoreline. Most of the remaining areas surrounding the mine would be considered Class B, or typical scenic attractiveness rating, because of the large, relatively uniform expanses of coniferous forest (USFS 1983). The existing TDF and cannery facility would be considered Class C because of the extent of human disturbance and the contrasts with natural forms and colors.

The Forest Service classifies portions of the forest in terms of their scenic class as a way to measure the relative value of a particular landscape as scenery. The landscape's scenic attractiveness and level of concern combine to determine its scenic class. The landscape as seen from Hawk Inlet would be considered a Scenic Class of 1 on a scale of 1 to 7 with 1 being the highest, except for the existing TDF and cannery site, which would be a Scenic Class 2. The Class 1 rating is a result of the Class A and B attractiveness ratings combined with its visibility and high level of concern when viewed from t the inlet's VPRs. The Class 2 rating of the existing TDF and cannery site is a result of the Class C attractiveness rating combined with the visibility and high level of concern when viewed from Hawk Inlet.

3.14.3 Scenic Resources – Environmental Consequences

The Forest Service establishes scenic integrity objectives (SIOs), formerly referred to as visual quality objectives, for maintaining scenic resources for each LUD. The SIOs are established relative to their visibility from VPRs, and thus activities that are visible in the foreground from VPRs must often meet a higher standard than activities in the middleground or background distance zones.

Effects of the alternatives on scenic resource are evaluated in terms of their ability to conform to the SIOs for the Semi-Remote Recreation LUD and the Non-Wilderness National Monument LUDs. Lands within the Semi-Remote Recreation LUD are to be managed to meet the Moderate SIO as seen from all distance zones. Under the Moderate SIO, the landscape character may appear slightly altered under the moderate SIO, and resource activities are to be designed to remain visually subordinate to the characteristic landscape. Noticeable deviations to the landscape character are acceptable, but new form, line, color, or texture must remain visually subordinate. Exceptions for small areas of non-conforming developments, such as mining facilities, may be considered in this LUD on a case-by-case basis.

SIOs for the Non-Wilderness National Monument LUDs range from High in remote areas to Very Low for lands developed for mining, provided site specific SIOs and rehabilitation objectives are identified in the mine's Plan of Operations. The Very Low SIO is classified as a "heavily altered" landscape, where activities may strongly dominate the landscape character, but must have visual characteristics similar to those of natural occurrences within the surrounding area. Site-specific SIOs are to be identified in the Plan of Operations for mineral development areas (USFS 2008).

3.14.3.1 Effects Common to All Alternatives

Since Hawk Inlet is a designated VPR, used for boating, fishing and other recreation activities, this section focuses primarily on views of the proposed alternatives from the inlet. Views from inland areas are considered, since dispersed recreation activities (such as deer hunting) occur throughout Admiralty Island. Views from the air are also of concern because hunters, cabin owners, and tourists often access the area by air.

Under all of the alternatives, portions of the TDF would be visible from Hawk Inlet, as well as from the air and from some of the dispersed inland recreation areas. The visibility of the project area from Hawk Inlet and Chatham Strait was determined by preparing viewshed maps from a series of points along Hawk Inlet and one point within Chatham Strait at the mouth of Hawk Inlet. The results of the viewshed analysis indicate that the project area for the proposed expansion of the existing TDF would be visible for a distance of approximately 4.5 miles along the Hawk Inlet Small Boat Route, extending from the mouth of Hawk Inlet to a point approximately 1.7 miles north of the cannery site (Figure 3.14-3). In addition, a boat travelling up the center of Chatham Strait would have a limited view of the site for a distance of approximately 2 miles if one was looking directly up Hawk Inlet. The view from the center of Chatham Strait would be a background view, approximately 6 to 7 miles from the project area. Figure 3.14-2 shows the portions of Hawk Inlet with views of the proposed new TDF, consisting primarily of the head of the inlet and the area immediately to the south.

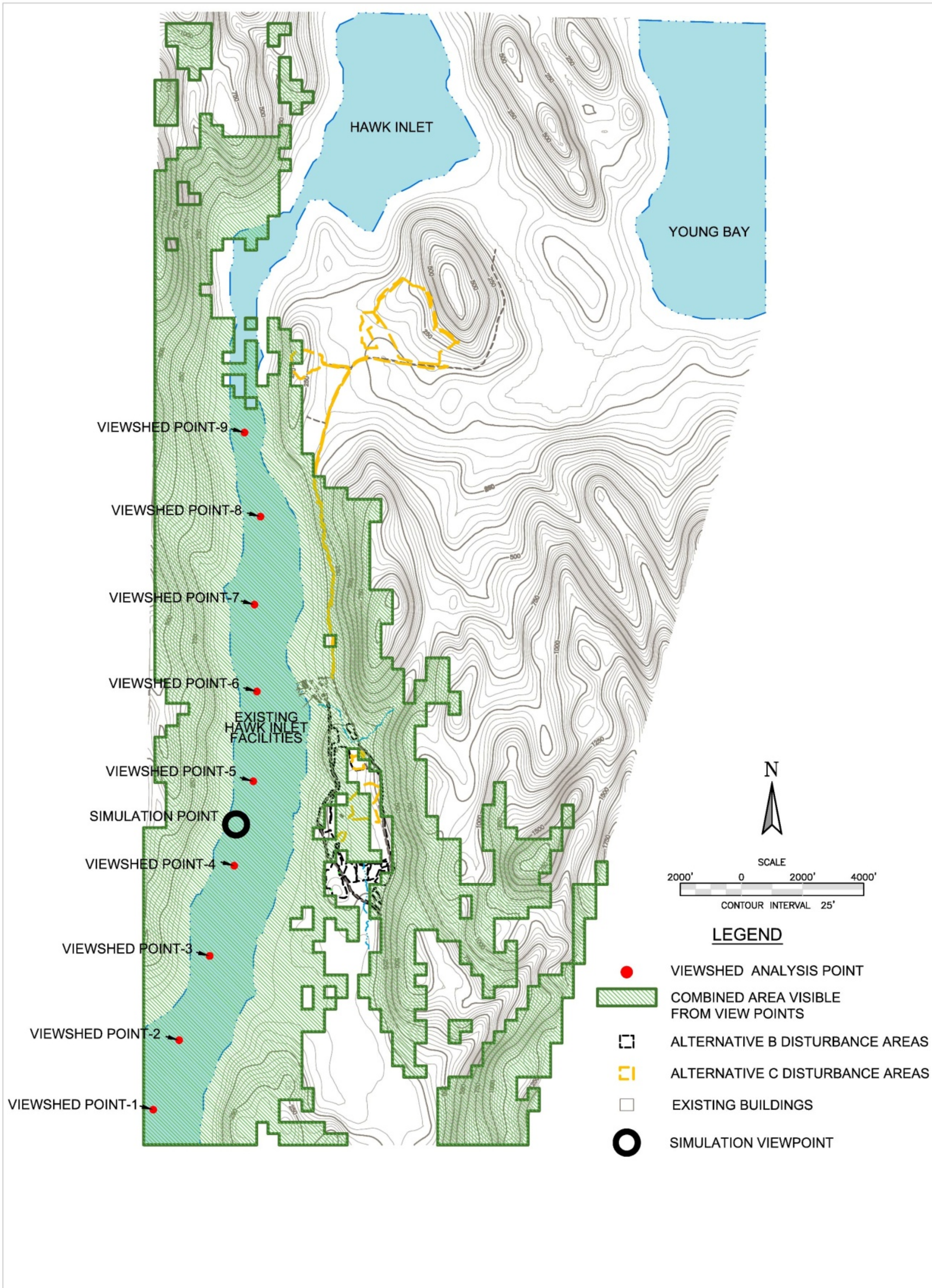


Figure 3.14-3. Viewshed Analysis Points with Views of Proposed Expansion of Existing TDF (Alternatives A–D).

Effects to the view as seen from Hawk Inlet resulting from each alternative were evaluated by selecting key viewpoints from which photo simulations were developed (figures 3.14-3 and 3.14-4). Viewpoints were selected by developing cross sections from a series of points within Hawk Inlet to identify locations with the most expansive view of the tailings facility. The simulations are shown on figures 3.14-5, 3.14-6, and 3.14-7.

Each alternative would create additional contrast with the surrounding landscape by expanding contrasting light grey color, geometric forms, and finer texture of the TDF, as compared to the adjacent forest. The scenic integrity level resulting from all of the alternatives would remain classified as Moderate during operation, because the visual contrasts created by the facility would be visible as human-caused deviations from the surrounding forest, but the contrasts would remain subordinate within the overall view from Hawk Inlet. The scenic attractiveness of the TDF would remain a Class C due to the continued contrasts with natural forms and colors. The Scenic Class 2 would also be maintained under all the alternatives, a result of the Class C scenic attractiveness rating and the high level of concern and visibility from Hawk Inlet.

After completion of the project all project buildings and infrastructure would be removed, except for some access roads, the water treatment facility and pipeline, and power lines. The TDF and associated disturbances would be reclaimed to one of three vegetation types, including upland meadows, upland forest, or wetlands. Natural forest regeneration will be the primary method of forest re-vegetation. The final contours of the TDF would be developed during construction at a slope of 3H:1V. As native species become established over time, the degree of contrast in color would gradually decrease. During the first 5 years after closure, the light green color of the herbaceous plant growth would reduce color contrasts, but the TDF would still be visible against the surrounding forest. Woody plants would be established within the next 10 years, which would further reduce color contrasts. The regeneration of spruce and hemlock during years 15 through 30 would eliminate color contrasts, but the area would still be visible due to the younger age and lower canopy height of the forest cover. After approximately 30 years the revegetated facility would blend in with the surroundings, although the geometric form of the TDF would be visible as a contrast with the adjacent topography (USFS 2003). Once the natural forest cover is established, the scenic integrity of the TDF would be classified as High because the only deviation from the surroundings would be the geometric form of the tailings pile.

The Very Low SIO designated for the Non-Wilderness National Monument LUD would be met during project operation, since this SIO allows the landscape to appear "heavily altered." The Moderate SIO for the Semi-Remote Recreation LUD would also be met during project operation because noticeable deviations to the landscape character are allowed within this LUD, are areas of non-conforming development, such as mines. After project completion, the Moderate SIO within the Semi-Remote Recreation LUD would continue to be met.

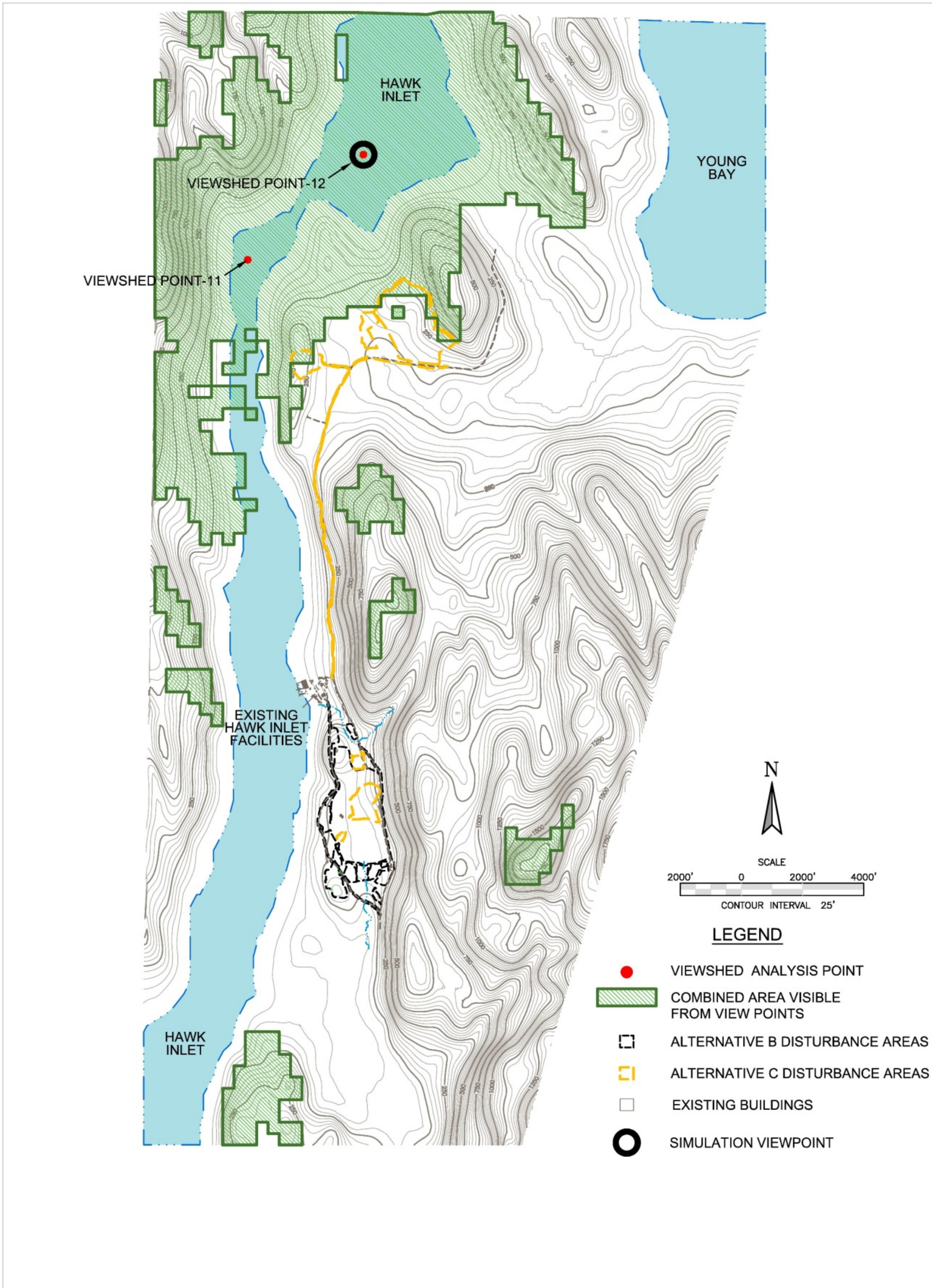


Figure 3.14-4. Viewshed Analysis Points with Views of Proposed New TDF (Alternatives C-D).

Figure 3.14-5. Alternative A: Photo-Simulation from Hawk Inlet showing Approved TDF Expansion at Maximum Height before Revegetation.

Figure 3.14-6. Alternative B: Photo-Simulation from Hawk Inlet showing Alternative B TDF Expansion at Maximum Height before Revegetation.

Figure 3.14-7. Alternative C: Photo-Simulation from Hawk Inlet showing Alternative C New TDF at Maximum Height before Revegetation.

The SIO within the Non-Wilderness National Monument LUD would likely be changed from Very Low to High once mining is completed and reclamation begins. The higher standard would be met after regeneration of native tree species, since the visual characteristics of the TDF would be similar to natural conditions in the surrounding forest.

Mitigation measures required as part of these SIOs include selecting materials and colors that blend with the natural surroundings, designing rock sources to be minimally apparent as seen from VPRs, and keeping vegetation clearing to a minimum and within close proximity to the site. Maintaining vegetative screening between the tailings and ancillary facilities and Hawk Inlet would mitigate adverse scenic impacts. Mitigation measures within Non-Wilderness National Monument LUD call for the use of naturally established form, line, color, and texture. Deviations must be shaped and blended with the natural terrain so that elements such as unnatural edges, roads, landings, and structures do not dominate the composition.

3.14.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceases, disturbed sites are reclaimed, and human activity in the area is reduced. The TDF would continue to be built out to the maximum footprint and height permitted in the 2003 EIS (USDA 2003). After the TDF is fully built out in 2014, reclamation would begin as described in the 2003 EIS (USDA 2003).

The existing TDF would reach its currently approved elevation of 363.7 feet, which would continue to be visible to recreationists in Hawk Inlet (Figure 3.14-5). Under Alternative A, the reclamation and natural revegetation process would begin in the year 2014, earlier than with the other alternatives, with the forest cover reaching its mature height approximately 100 years after mine closure.

3.14.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF.

Alternative B would be visible in the foreground and middleground view from much of Hawk Inlet, extending from the mouth of Hawk Inlet to a point approximately 4.5 miles north of the mouth. The sloping topography and vegetation along the shore would block views from much of the eastern side of Hawk Inlet, thus blocking much of the foreground view of the tailings. This alternative would require construction of a new access road, the West Road, between Hawk Inlet and the existing TDF. Although much of this road would be screened by the ridgeline to the west, portions of it would be visible from Hawk Inlet, particularly the portion between the cannery and the top of the ridge.

The existing TDF under Alternative B would increase to a maximum of 403.8 feet (msl), 40.1 feet higher than the approved TDF. The TDF would expand southward, increasing the width of the TDF as seen from Hawk Inlet by about 80 percent over the approved width. This alternative would maintain the view of disturbance within one location as seen from Hawk Inlet, compared to alternatives C and D.

Figure 3.14-6 illustrates the TDF at its maximum height and width at the end of mine operations in 30–50 years. The TDF under Alternative B would create a strong contrast with the surrounding forest due to its grey color and finer texture. Although its horizontal form is similar to the surrounding ridgelines, the flat horizontal top of the TDF and straight sides would contrast with the rounded forms of the adjacent topography. The phased development and hydro-seeding planned as part of the interim reclamation, however, would partially mitigate the extent of color contrasts shown in Figure 3.14-6. During Phase 1 (Years 1-10) much of the material would be placed within the existing tailings footprint. The height of the TDF would reach its maximum height of 403.8 feet during this phase. During Phase 2 (Years 11-20) and Phase 3 (Years 21-30), the TDF would be expanded to the south and reach the maximum height During Phase 4 (Years 31-50) tailings would be placed at the site of the existing water treatment plant and Pond 7 on previously disturbed land. Tailings placed during previous phases will be revegetated, reducing color contrasts.

A key mitigation measure specific to Alternative B would be to maintain, to the greatest extent possible, existing forest cover between Hawk Inlet and the expanded TDF.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. Under mitigated Alternative B existing forest cover between Hawk Inlet and the expanded TDF would be the same as the proposed action and have similar visual impacts.

3.14.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF located approximately three miles north of the existing TDF. Additionally the A Road would be upgraded and additional facilities including a tailings water transport pipeline, rock quarry, ponds, and additional access road would be constructed. Alternative C would also extend the operating period of the mine by 30–50 years.

Under Alternative C, development of a new TDF north of the A Road would introduce adverse scenery impacts to the northern portion of Hawk Inlet (Figure 3.14-7). The new TDF would be approximately 330 feet in height at the end of mine life, visible from portions of the head of Hawk Inlet and potentially visible from some of the floating cabins. The northern TDF may also be slightly visible from the portion of Hawk Inlet south of the inlet's head, near the abandoned Petrovich Mine cabin. The new TDF would contrast with the surrounding landscape due its grey color, geometric lines, and finer texture. The TDF would have steeply sloping sides, in comparison to the flat profile of the existing TDF, which would be similar to the forms of the adjacent topography. In addition, the upper portion of the north quarry proposed as part of Alternative C may be visible from the southern portions of Hawk Inlet. Alternative C would reduce the amount of disturbance within the Monument as compared to Alternative B (Section 3.13.3.3, Effects of Alternative B, Proposed Action (Land Use)).

Tailings generated during construction of the new TDF would be placed on the southeastern side of the existing TDF to a height of approximately 367 feet above sea level (Figure 3.14-8). These tailings would have minimal additional impact relative to Alternative A, since its maximum height would be only three feet over the approved height and they will be reclaimed as part of the existing TDF reclamation process once the new TDF is constructed. Alternative C would not require a new road west of the tailings as with alternatives B and D. Improvements to the existing A Road would not be visible from Hawk Inlet and thus only be visible to hunters or others recreating in upland areas.

3.14.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of the new TDF to the north. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The scenery effects of Alternative D would be similar to those for Alternative C in that a new area of disturbance would be created, introducing adverse impacts to the northern portion of Hawk Inlet. This alternative would result in less disturbance to the Monument than Alternative B, but more than under Alternative C (Section 3.13.3.4, Effects of Alternative C, New TDF Located Outside Monument (Land Use)). The new TDF to the north would be approximately four feet taller than under Alternative C, but would be smaller overall, with a narrower profile as seen from Hawk Inlet. As under Alternative C, the new rock quarry will be slightly visible from the southern portions of Hawk Inlet (Figure 3.14-9).

Under this alternative the existing TDF would be expanded to the southeast to accommodate tailings for the first 10 years of the expansion project. The existing TDF would be increased in width by approximately 25 percent over the approved configuration and built up to a maximum height of 420.3 feet, 57 feet higher than the approved plan and 17 feet higher than Alternative B (Figure 3.14-10). Alternative D would require construction of a new road located between Hawk Inlet and the existing TDF. Much of this road would be screened by topography and vegetation, except for the portion between the marine terminal and the top of the ridge. As with Alternative B, leaving as much of the existing forest cover in place as possible would help mitigate effects to the view from Hawk Bay.

Figure 3.14-8. Simulation of Alternative C South Tailings Disposal Facility.

Figure 3.14-9. Simulation of Alternative D North Tailings Disposal Facility.

Figure 3.14-10. Simulation of Alternative D South Tailings Disposal Facility.

3.14.4 Scenic Resources – Summary

The TDF would be visible from portions of Hawk Inlet under all of the alternatives and will introduce contrasts with the adjacent forest in terms of form, line, color, and texture. The Forest Service SIOs will be met, however, since approved mining areas are to be managed to a Very Low SIO, or "heavily altered", landscape within the Non-Wilderness National Monument LUD, and non-conforming developments such as mining facilities may be considered within the Semi-Remote Recreation LUD. The existing TDF associated with all of the alternatives would be visible from the southern portion (4.5-mile stretch) of the Hawk Inlet Small Bout Route, primarily as a middleground view, as well as a small portion of Chatham Strait. The new TDF under alternatives C and D would introduce scenery effects to the northern portion of Hawk Inlet, visible primarily from the head of the inlet. Under Alternative D, tailings deposited in the existing TDF would be visible for the initial 20 years, after which it would be reclaimed and tailings deposited in the new TDF. After project completion, all project facilities would be removed and reclaimed under all the alternatives, except for the water treatment plant and power lines. Reclamation would begin in 2014 under Alternative A, compared to year 2064 under the other alternatives.

3.15 Recreation

3.15.1 Recreation – Pre-mining Environment

The resource analysis of recreation was not identified as a significant issue; comments from the scoping process regarding areas used for recreational purposes are addressed in this section.

Hunting, saltwater fishing, and boating were the predominant recreation activities within the study area prior to mine development. Most of the recreation users were residents of Juneau, with a smaller portion from Hoonah and Angoon. During the summer months Hawk Inlet was frequented by sailboats, cabin cruisers, and commercial fishing boats. Wheeled aircraft used the beaches at Hawk Inlet and Young Bay for recreational access. There were also six private cabins each in Hawk Inlet and Wheeler Creek that contributed an estimated 110 to 150 user days to the area per year. An additional 110 to 150 user days were attributed to people using the inlet without direct cabin access, most likely owners of private sport boats or clients of charter boat or guide services. Commercial charter pilots reported 530 user days in the inlet by their clients.

In 1980 there were 695 deer taken by 704 deer hunters over 3,090 hunter days in the area formerly identified by ADF&G as Subunit 4-11, which included Young Bay, Hawk Inlet, Mansfield Peninsula, Seymour Canal, and Glass Peninsula. In the same area and year, eight brown bears were taken. Within the immediate project area there was an average of 3.2 bears taken from 1971 to 1975 and 1.0 bears taken from 1976 to 1980. Deer hunting data in the project area is not available. A limited amount of duck hunting occurred in Hawk Inlet prior to mining (USFS 1983).

Historically, trapping was an important activity in the study area when it included cultural and subsistence trapping by native populations. Trapping gradually developed more of a recreational emphasis in later years, with marten, river otter, and mink comprising the primary species (ADF&G 2006). Most trapping was facilitated by boat access (ADF&G 2006). An estimated 10 river otters were taken annually from the northern portion of Admiralty Island (USFS 1983).

3.15.2 Recreation – Baseline Conditions

There is limited development of recreational facilities in the study area, except for approximately six privately owned, floating cabins in Hawk Inlet and 13 private cabins in the Wheeler Creek drainage, four of which are rented out as guest units. The Hawk Inlet floating cabins are distributed from the south end at Piledrivers Cove to the head of the inlet. Outside the study area there are three Forest Service cabins south of Young Bay (Admiralty Cove, North Young Lake, and South Young Lake). Hawk Inlet has been designated by the Forest Service as a dispersed recreation area and small boat route. There are three designated small boat anchorages in the inlet, one is located at the cannery site with the other two located near the head of the inlet. Young Bay also has a designated small boat anchorage near the existing ferry dock.

Current patterns of recreation use in the study area are similar to those under pre-mining conditions; hunting, fishing, boating, and wildlife viewing are the primary activities and there is a limited amount of recreational trapping. Recreational use is not allowed within the project area and mine employees are prohibited from engaging in recreational activities in the adjacent areas, including Hawk Inlet and Wheeler Creek. Boats are the primary form of transport to the study area for recreational use, although aircraft also land on Hawk Inlet, Young Bay, and Wheeler Creek. Most of the aircraft are commercial pilots transporting hunters or anglers into the inlet for stays ranging from half-day fishing trips to multi-day hunting trips (Wright 2011).

Recreation use within Hawk Inlet is estimated between 950 to 1,200 user days per year (user days are defined as recreational use by one individual at one recreation site during any portion of one 24-hour period). This figure does not include most of the deer hunters because hunting data is only available for the entire GMU. The Hawk Inlet cabins contribute an estimated 600 to 850 user days per year, and the primary air charter service brings approximately 20 deer hunters to the inlet for an estimated 80 user days (Kiesel 2011). An additional 220 days are estimated from charter services and other boats seen in the inlet during the summer, typically one or two on a weekend day. People also occasionally kayak from Juneau to Young Bay and hike across the island to Hawk Inlet. Bear hunting is estimated at 40 user days per year (Johns 2011). According to a long-time cabin owner, recreational use of the inlet has increased substantially since pre-mining days (Kiesel 2011).

In addition, many people visit the northern portion of Admiralty Island outside of Hawk Inlet. The cabins on Wheeler Creek attract people into the area, contributing an estimated 500 user days. Many private sport boats visit the island, particularly those areas within a day trip from Juneau, primarily north of Funter Bay. In 2010 there were six commercial guide services holding permits in subunits 4-10A and 4-10B, which extend from Angoon north to Funter Bay. These services brought a total of 76 groups and 348 clients to the area primarily during the summer for fishing, but some for bear hunting in the spring and fall. The Juneau Youth Services has also conducted a guided kayak trip around Admiralty Island during the past few summers for about 10 young people (Bradey 2011).

Sport fishing is a popular activity in and around Hawk Inlet. Most of the fishing is for salmon, halibut, shrimp, and crab, and occurs primarily during the months of July and August. Approximately 94 percent of the 348 guide clients brought to northern Admiralty Island in 2010 were anglers, and most of those clients fished near the mouth of Hawk Inlet in subunit 4-10A, which extends from a point north of Greens Creek down to Wheeler Creek (King 2011). Private sport fishing boats are also seen in Hawk Inlet.

Deer hunting occurs throughout northern Admiralty Island during the fall and winter months. Data on deer hunting is only available for all of GMU 4, which includes Chichagof, Baranof, Kruzof, and Admiralty islands. There were a total of 2,012 deer hunters in GMU 4 during the 2007–2008 regulatory year due to severe winter conditions (July 2007 through June 2008), numbers were down from an average of 3,434 hunters during the previous 3 years (Table 3.15-1). Average success rate also declined in this period to 45 percent from the 74 to 78 percent seen in previous years. Almost one-half (48 percent) of the hunters in 2007 were from communities within GMU 4, such as Hoonah, Angoon, and Sitka, and another half (49 percent) were Alaska residents from outside GMU 4. A small proportion of deer hunters (3 percent) were from outside the State of Alaska. Most of the deer hunting occurs from August through January, with 49 percent occurring in November. Approximately three quarters of the deer harvest in GMU 4 is transported by boat; most of the remaining harvested deer are transported by air or highway vehicle.

Table 3.15-1. Game Management Unit 4 Deer Hunter Residency and Success, Regulatory Years 2003 through 2007.

Regulatory Year	Successful Hunters				Unsuccessful Hunters				Total Hunters
	Local Resident	Nonlocal Resident	Non-resident	Total	Local Resident	Nonlocal Resident	Non-resident	Total	
2003–2004	1,242	1,535	57	2,834	253	509	41	803	3,637
2004–2005	1,064	1,347	82	2,493	283	544	43	87	3,363
2005–2006	1,124	1,214	102	2,440	291	525	46	862	3,302
2006–2007	1,157	1,151	92	2,400	244	382	50	676	3,076
2007–2008	556	333	9	898	405	648	61	1,114	2,012

Source: ADF&G 2009.

Note: Local residents consist of residents of GMU 4, Nonlocal Residents are Alaska residents from outside GMU 4, and non-residents reside outside of Alaska.

Admiralty Island, particularly Hawk Inlet, is known for its excellent brown bear hunting, which occurs mostly in September and May. Bear hunting data is only available for a subunit of GMU 4 consisting of Admiralty Island. During the regulatory years 2003 to 2007 there were an average 150 bear hunters on Admiralty Island and 669 hunter days per year. The average harvest was 54 bears per year, resulting in a hunting effort of 13 days per bear. Approximately 50 percent of the bear hunters were from outside Alaska, with 10 percent from GMU 4 and the remaining 40 percent from other parts of the State of Alaska (Table 3.15-2). A local bear guide reports that all of their clients are from outside Alaska (Johns 2011). Most of the hunters (92 percent) use boats to transport their harvest and aircraft are the second most common method. An estimated 90 percent of the bear hunting in GMU 4 is “shoreline hunting” presumably because it is the easiest way to hunt.

Table 3.15-2. Admiralty Island Brown Bear Hunting Effort by Residency, Regulatory Years 2003 through 2007.

Regulatory Year	Hunters			Days Hunted			Total Harvest	Effort (Days per bear)
	Non-residents	Residents	Total	Non-residents	Residents	Total		
2003–2004	68	96	164	329	434	763	69	11
2004–2005	97	67	164	370	287	657	58	11
2005–2006	83	62	145	270	340	610	41	15
2006–2007	58	85	143	214	550	764	42	18
2007–2008	70	62	132	266	288	554	58	10

Source: ADF&G 2009

Note: Residents reside within Alaska and Non-residents reside outside of Alaska.

Trapping for mink, marten, and river otter occurs in the Hawk Inlet area for both recreational and subsistence purposes. Trapping activities are minimal in Hawk Inlet compared to hunting and fishing. The most recent data for the otter and marten harvests in Hawk Inlet shows an average per year of six otters trapped from 1981 to 1997 and seven martens trapped between 1984 and 2001 (2003 EIS). Data for all of GMU 4 is available for the years 2001 through 2005, which indicates most (82 percent) of the trapping is by residents of GMU 4, with the remaining trappers coming from other parts of the State of Alaska. December saw the most trapping during these years with the remainder occurring in January and February. Transport of river otter harvest is almost entirely by boat. Marten harvest is transported primarily by boat and highway vehicles are the second most prevalent transportation method (ADF&G 2006).

3.15.3 Recreation – Environmental Consequences

Recreation effects are evaluated based on the compatibility of alternatives with Forest Service management prescriptions for the Semi-Remote Recreation and Non-Wilderness National Monument LUDs. Lands within the Semi-Remote Recreation LUD are to be managed for semi-primitive types of recreation and tourism in predominantly natural or natural-appearing settings. Enclaves of concentrated recreation developments are allowed, as are small-scale rustic recreation facilities such as cabins and docks and development of motorized off-highway vehicle routes.

Standards and guidelines for the Non-Wilderness National Monument LUD call for a spectrum of wildland recreation opportunities that reflect the existing ecological, historical, and sociological conditions found within the Monument. Lands within this LUD should be managed for the established Recreational Opportunity Spectrum, except where closed to public use due to mining operations or other activities. Mineral development is allowed within both of the designated LUDs in the study area as long as effects are minimized to the extent feasible, disturbed areas are reclaimed to a near-natural condition, and forest wide standards and guidelines are implemented. Within the Non-Wilderness National Monument LUD, public recreation use in mining areas is to be managed in accordance with the Plan of Operations. If mining results in a change in the recreation setting after closure, the area is to be managed to the new setting in accordance with the appropriate Recreational Opportunity Spectrum guidelines.

3.15.3.1 Effects Common to All Alternatives

The primary effects of the alternatives would be on recreation and tourism activities within Hawk Inlet, since the inlet experiences the most concentrated use and is a designated VPR. Temporary increases in air and boat traffic within Hawk Inlet or Chatham Strait would occur during the construction process, under all action alternatives.

Indirect effects on hunting and fishing could potentially result from effects on sport fisheries or game species, particularly from the risk of fuel and other hazardous substance spills. Sections 3.7 and 3.11 discuss effects on aquatic resources and wildlife respectively. Indirect effects to recreation from project employees are not expected because there would be no increase in employees under any of the alternatives and employees are prohibited from hunting or fishing while they are working at the mine or staying at the on-site camp. No unauthorized vehicles or firearms are permitted at the mine. These restrictions have been in place since the mine began operations and appear to be effective in preventing increased recreation pressure according to several local cabin owners (Kiesel 2011; Reinwand 2011; Brendt 2011).

The primary adverse impact of all of the alternatives on recreation would be the view of additional tailings to boaters and anglers using Hawk Inlet and to hunters using surrounding upland areas. The facility will not be visible from the Wheeler Creek cabins. Section 3.14, Scenic Resources, describes these effects in greater detail. All of the alternatives meet the standards and guidelines of the Semi-Remote Recreation and Non-Wilderness National Monument LUDs because semi-primitive recreation would be able to continue outside the mine site. In the long term, after project completion, the area's natural-appearing setting would be gradually restored as native vegetation reestablishes itself and the project site is reopened for hunting and other semi-primitive recreation.

3.15.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceases, disturbed sites are reclaimed, and human activity in the area is reduced. The TDF would continue to be built out to the maximum footprint and height permitted in the 2003 EIS (USDA 2003). After the TDF is fully built out in 2014, reclamation would begin as described in the 2003 EIS (USDA 2003).

The only effect to recreation would be the visibility of the facility to people recreating in Hawk Inlet, discussed in Section 3.14, Scenic Resources. After closure of the facility, the area would be reclaimed and reopened for public use.

3.15.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF.

Alternative B would have the least effects to recreation of all of the action alternatives, because the existing TDF facilities would be expanded in an area currently closed to hunting and other recreation. The expanded TDF would be visible from the southern portion of Hawk Inlet small boat route for a distance of approximately 4.5 miles. The TDF will also be visible from a small portion of Chatham Bay, but as a background view. These effects would be phased over the 30-year operational period, with interim reclamation reducing some of the contrast created by the expanded TDF. None of the privately owned cabins in the inlet would have views of the TDF. Most of the new disturbances associated with the TDF (77 percent) would be located within the Monument.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. About 72 percent of the newly disturbed areas would occur within the Monument. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. No aspects of mitigated Alternative B apply to recreation use in the project area.

3.15.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF located approximately three miles north of the existing facility in the Fowler Creek drainage.

To accommodate tailings generated during construction of the new TDF, the existing TDF would be expanded to an elevation of nearly 367 feet above sea level. All new tailings during the construction period would be placed within the existing TDF.

Developing a new TDF north of the A Road would reduce the amount of land available for deer hunting and other dispersed recreation, since this area is currently open to the public. Under this alternative disruption of additional land within the Monument would be minimized as compared to Alternative B.

The new TDF would be visible from the northern portion of Hawk Inlet, including some of the floating cabins. Additional tailings placed at the existing TDF during construction would be visible from the southern portion of the inlet. This alternative would have the effect of distributing the visual impacts as seen by those using Hawk Bay between two locations, compared to one area of disturbance under alternatives A and B.

3.15.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of the new TDF to the north. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years. The expansion of the existing TDF would be substantially smaller than Alternative B, however the footprint of the northern TDF is relative in size to Alternative C.

The effects of Alternative D would be similar to those of Alternative C in that a new TDF north of the A Road would close off an area currently open to the public. Similar to Alternative C, this alternative would have the effect of distributing the visual impacts between two locations and introducing adverse impacts to the northern portion of Hawk Inlet. The new TDF would likely be visible from the floating cabins. Under Alternative D the effects of the new TDF would not occur for another 10 years of production. Tailings would be placed within the existing TDF during the first 10 years of operation, after which the new TDF would begin operation. Compared to the other alternatives, tailings placed in the existing TDF would have a taller profile under Alternative D, reaching a height of nearly 57 feet over the approved height of the existing TDF than the TDF proposed under Alternative B. The new TDF would have a smaller profile, compared to Alternative C, as seen from Hawk Inlet. Alternative D would result in slightly more disturbance to lands within the Monument than Alternative C but would result in less disturbance to the Monument than Alternative B.

3.15.4 Recreation – Summary

All of the alternatives would meet the standards and guidelines of the Semi-Remote Recreation and Non-Wilderness National Monument LUDs because semi-primitive recreation would continue outside the mine site. Within the mine site, the area would be reclaimed and restored to a near-natural condition after project completion and would be re-opened for public recreation. The alternatives differ in terms of their visibility to recreationists in Hawk Inlet (see Section 3.14), as well as the extent and location of new disturbed areas. There would be no additional acres disturbed as a result of Alternative A. Areas of disturbance associated with Alternative B would be located adjacent to the existing TDF, which is currently closed to recreation, whereas alternatives C and D would result in disturbance to the area north of the A Road, which is currently open to public use. Alternative C would affect the least amount of acres within the National Monument, whereas Alternative B would affect the largest number of acres within the Monument.

3.16 Subsistence

The resource analysis of subsistence use was not identified as a significant issue; comments from the scoping process regarding areas used for subsistence purposes are addressed in this section.

The purpose of this section is to describe subsistence uses in the Greens Creek Mine area and to assess potential impacts on subsistence related to the proposed expansion of the TDF at Greens Creek Mine. A more detailed description of subsistence uses and practices is in Appendix H. Subsistence uses are central to the customs and traditions of indigenous cultural groups in Alaska, including the Alaska Natives of Southeast Alaska. Subsistence customs and traditions encompass processing, sharing, redistribution networks, and cooperative and individual hunting, fishing, gathering, and ceremonial activities. Both federal and state regulations define subsistence uses to include the customary and traditional uses of wild renewable resources for food, shelter, fuel, clothing, and other uses (ANILCA, Title VIII, Section 803, and Alaska Statute 16.05.940[33]). The Alaska Federation of Natives not only views subsistence as the traditional hunting, fishing, and gathering of wild resources, but also recognizes the spiritual and cultural importance of subsistence in forming Native peoples' worldview and maintaining ties to their ancient cultures (Alaska Federation of Natives 2005).

Subsistence fishing and hunting are traditional activities that help transmit cultural knowledge between generations, maintain the connection of people to their land and environment, and support healthy diet and nutrition in rural communities in Alaska. The ADF&G estimates that the annual wild food harvest in rural areas of Southeast Alaska is approximately 5 million pounds, or 178 pounds per person per year (Wolfe 2000).

Subsistence harvest levels vary widely from one community to the next. Sharing of subsistence foods is common in rural Alaska and can exceed 80 percent of households giving or receiving resources (ADF&G 2011). The term harvest and its variants – harvesters and harvested – are used as the inclusive term to characterize the broad spectrum of subsistence activities, including hunting, fishing, and gathering.

The combination of subsistence and commercial-wage activities provides the economic basis for the way of life so highly valued in rural communities (Wolfe and Walker 1985). Regarding the importance of the mixed economy to the subsistence lifestyle, George and Bosworth (1988: 35) noted the following on the state of subsistence in the community of Angoon: "Commercial fishing income is, in fact, an important element of the Angoon 'mixed' economy, which greatly depends on a relatively secure cash flow and a productive subsistence resource base."

Subsistence is part of a rural economic system, wherein families invest money into small-scale, efficient technologies to harvest wild foods Fishing and hunting for subsistence resources provide a reliable economic base for rural regions. Subsistence is not oriented toward commercial market production, but is focused toward meeting the self-limiting needs of families and small communities.

While some people earn income from employment, these and other residents rely on subsistence to supplement their diets throughout the year. Furthermore, subsistence activities support a healthy diet and contribute to residents' overall well-being.

Alaska and the federal government regulate subsistence hunting and fishing in the State of Alaska under a dual management system. The federal government recognizes subsistence priorities for rural residents on federal public lands, while Alaska considers all residents to have an equal right to participate in subsistence hunting and fishing when resource abundance and harvestable surpluses are sufficient to meet the demand for all subsistence and other uses.

The Alaska Board of Fisheries and the Alaska Board of Game have adopted regulations enforced by the State of Alaska for subsistence fishing and hunting on all State of Alaska lands and waters, and lands conveyed to Alaska Native Claims Settlement Act groups. State law is based on Alaska Statute 16 and Title 5 of the Alaska Administrative Code (AAC) (05 AAC 01, 02, 85, 92, and 99) and regulates state subsistence uses. Under Alaska law, when there is sufficient harvestable surplus to provide for all subsistence and other uses, all Alaskan residents qualify as eligible subsistence users.

The State of Alaska distinguishes subsistence harvests from personal use, sport, or commercial harvests based on where the harvest occurs, not where the harvester resides (as is the case under federal law). More specifically, state law provides for subsistence hunting and fishing regulations in areas outside the boundaries of "nonsubsistence areas," as defined in state regulations (5 AAC 99.015). According to these regulations, a nonsubsistence area is "an area or community where dependence upon subsistence is not a principal characteristic of the economy, culture, and way of life of the area of community" (5 AAC 99.016).

Activities permitted in these nonsubsistence areas include general hunting and personal use, sport, guided sport, and commercial fishing. There is no subsistence priority in these areas; therefore, no subsistence hunting or fishing regulations manage the harvest of resources. Nonsubsistence areas in Alaska include the areas around Anchorage, Matanuska-Susitna Valley, Kenai, Fairbanks, Juneau, Ketchikan, and Valdez (Wolfe 2000).

3.16.1 Subsistence – Pre-mining Environment

This section addresses the subsistence environment before the development of the Greens Creeks Mine in 1976. Prior to European contact, the study area was inhabited by Tlingit Indians; many of their descendants continue to reside in southeast Alaska communities, including the study communities of Angoon and Hoonah. In 1946, Goldschmidt and Haas (1998) documented the traditional Angoon territory as part of Tlingit and Haida land claims. Angoon residents' traditional territory included the shores of Chatham Strait on Admiralty Island from Point Marsden south to Chapin Bay, and on Chichagof and Baranof islands from Basket Bay south to Gut Bay (Goldschmidt and Haas 1998: 67). Just as they had documented the traditional territory of Angoon, Goldschmidt and Haas (1998) documented the traditional Hoonah territory in 1946 as part of Native land claims. Hoonah's traditional territory included the area along Chatham Strait from Point Howard westward to Cape Fairweather; Chichagof Island from Point Augusta west to Point Urey; and all the islands in Icy Straits and Cross Sound (Goldschmidt and Haas 1998: 53). Later studies, primarily by ADF&G, documented more contemporary subsistence uses of the study area and are described below. The rural communities that participate in subsistence activities in the study area that would likely be most affected by the proposed project include Angoon, Hoonah, and Tenakee Springs.

3.16.2 Subsistence – Baseline Conditions

3.16.2.1 Study Area

The proposed Greens Creek Mine TDF expansion is located within Hawk Inlet on lands managed by the Forest Service and the Monument. Because the project is located within federal lands, federal subsistence regulations apply and only harvests by rural residents in these areas are considered subsistence harvests. Nonrural residents (e.g., Juneau area residents) are not allowed to hunt or fish on these lands under federal subsistence regulations. Nonrural residents may harvest fish and game on these federal lands; however these harvests occur under state regulations. Because the entire project lies in the State of Alaska defined Juneau nonsubsistence area boundary, all harvests of wildlife and fish near the project area by nonrural residents are considered sport or personal use harvests and are not addressed in this section.

Important subsistence resources harvested by residents of Angoon, Hoonah, and Tenakee Springs include deer, salmon, halibut, seal, waterfowl, marine invertebrates, berries, and plants. Due to their island locations and lack of major road development, much of these communities' use areas are accessed using skiffs or boats with some hiking further inland for resources not readily found along the coast. The increased development of logging roads beginning in the early 1980s associated with the passage of the Tongass Land Management Plan and ANILCA has opened access to additional areas. Access to Hawk Inlet is either by boat and skiff or by floatplane.

3.16.2.2 Angoon

Angoon is located on the west coast of Admiralty Island approximately 44 miles to the south of Hawk Inlet and has a population of 459 residents, 76 percent of which are Alaska Native (U.S. Census Bureau 2011a).

Figure 3.16-1 shows the subsistence use areas of Angoon residents for the time periods of pre-1988 (TRUCS 1988) and 1991-1995 (ADF&G 1997). During the most recent study (1991-1995), Angoon residents did not report use areas within Hawk Inlet.

In all study years, fish provide approximately half of the total subsistence harvest, and land mammals account for roughly one quarter to one third of the total harvest, with marine mammals, marine invertebrates, and vegetation accounting for the remaining harvests. Individual resources that contribute a large amount to Angoon's total harvest based on the most representative study year (1996) include salmon (36 percent), deer (23 percent), halibut (18 percent), harbor seal (four percent), chiton (four percent), and butter clams (four percent).

Angoon's seasonal round of harvest activity is based on the research conducted by George and Bosworth (1988) (Figure 3.16-2). At the peak of summer, residents are engaged in fishing activities, particularly for salmon but also other species such as halibut, cod, and other marine fish.

3.16.2.3 Hoonah

Hoonah is located on the northeast shore of Chichagof Island, approximately 28 miles west of Hawk Inlet, and has a population of 760 people, 53 percent of whom are Alaska Natives (U.S. Census Bureau 2011).

Figure 3.16-3 shows the subsistence use areas of Hoonah residents for the time periods of pre-1986 (Schroeder and Kookesh 1990), pre-1988 (TRUCS 1988) and 1991-1995 (ADF&G 1997). Hoonah use areas (pre-1986 and pre-1988) were for the time period community residents had been living in Hoonah. For both studies, their terrestrial subsistence use areas included the northern portion and western coastline of Chichagof Island, Yakobi Island, and northwest coastline of Admiralty Island near Hawk Inlet (Figure 3.16-3). During the most recent study (1991-1995), Hoonah residents reported use areas at the entrance of Hawk Inlet but not within the Inlet.

Individual resources that accounted for the majority of harvests, as recorded during the 1996 study year, included salmon (30 percent), deer (20 percent), a variety of marine invertebrates (16 percent), halibut (eight percent), and harbor seal (six percent). Hoonah residents harvested between 34 and 237 harbor seals annually over a period of 12 study years.

Hoonah's seasonal round of harvest activity is based on the research conducted by Schroeder and Kookesh (1990) (Figure 3.16-4). While some species of fish are available year-round (e.g., halibut, snapper, and king salmon), the majority of fishing begins in June and continues through the summer into fall. During this time, halibut, salmon, and several species of cod are harvested. Residents also harvest plants during the summer months. Although available year-round, the majority of crabs are taken during the summer when they move to shallow waters. Late July and August signal the beginning of berry harvests and deer, seal, black bear, and goat hunting. Late fall harvest activities include waterfowl, spruce grouse, moose, and cranberry harvesting as well as continued fishing and marine invertebrate harvesting. Furbearer harvests occur during the winter. Fishing and marine invertebrate harvesting are also winter activities.

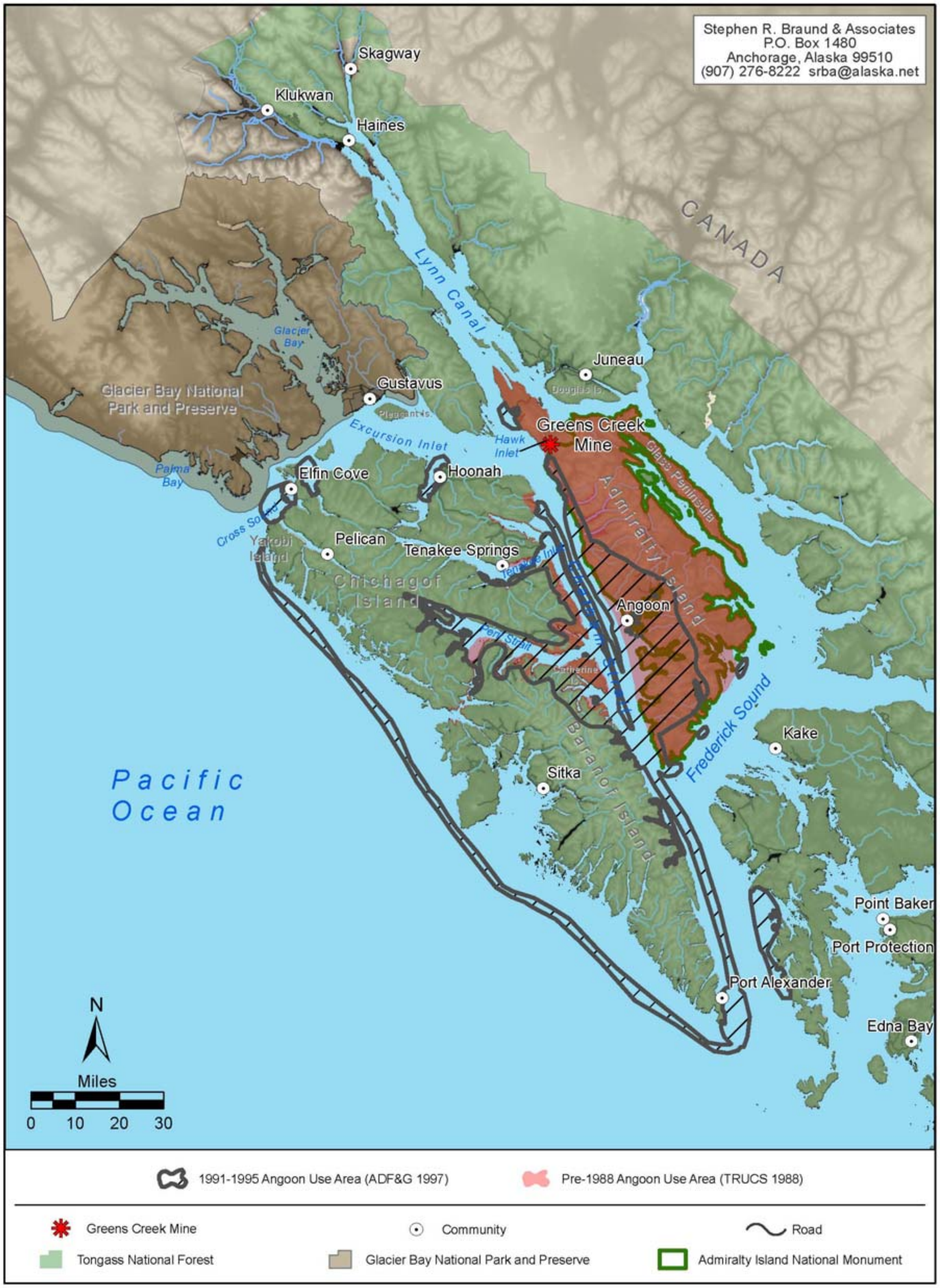
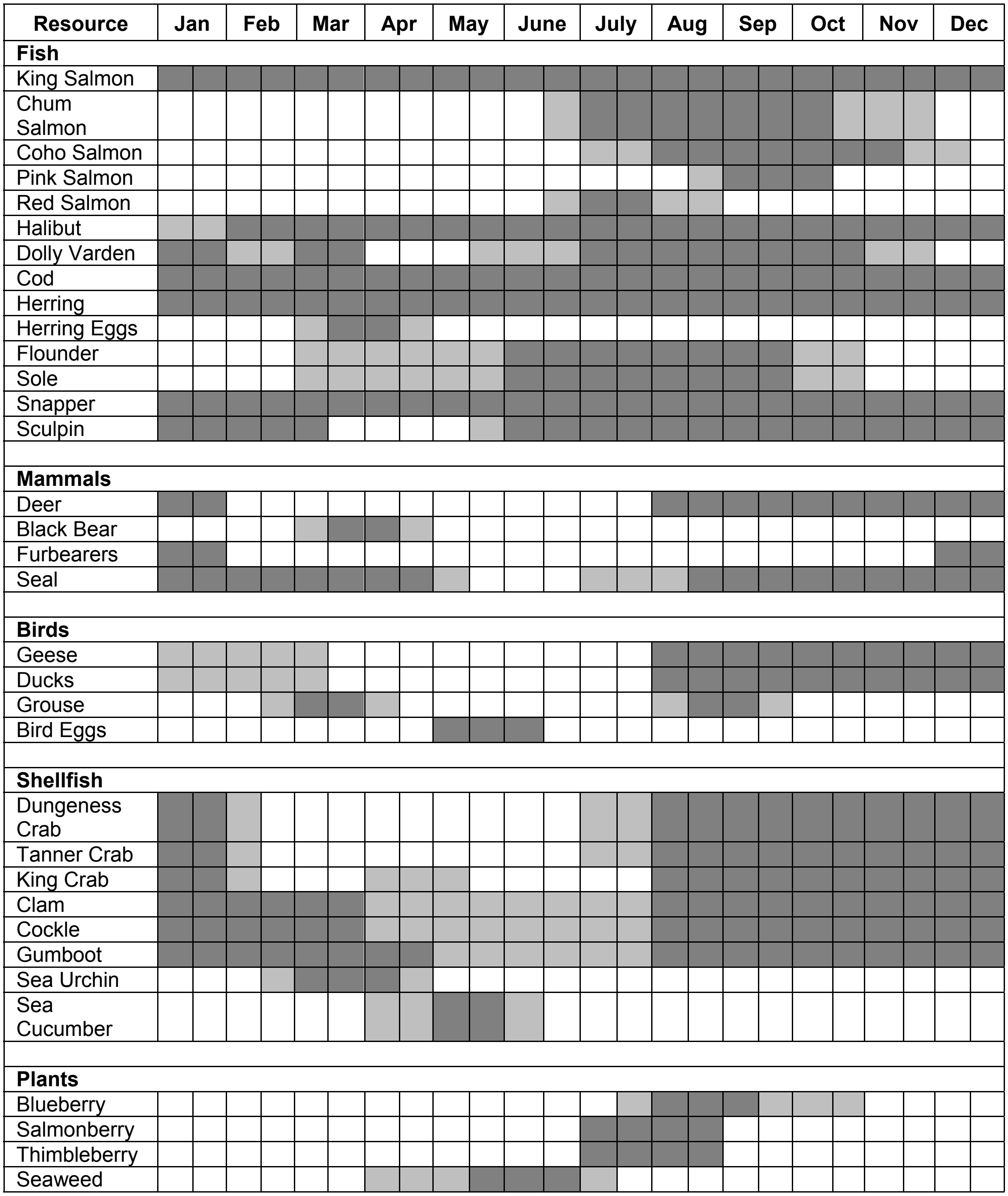


Figure 3.16-1. Angoon Subsistence Use Areas.



Occasional Harvest Effort. Primary Harvest Effort
Source: Adapted from George and Bosworth 1988
Stephen R. Braund & Associates 2011

Figure 3.16-2. Angoon Seasonal Round of Harvest Activities.

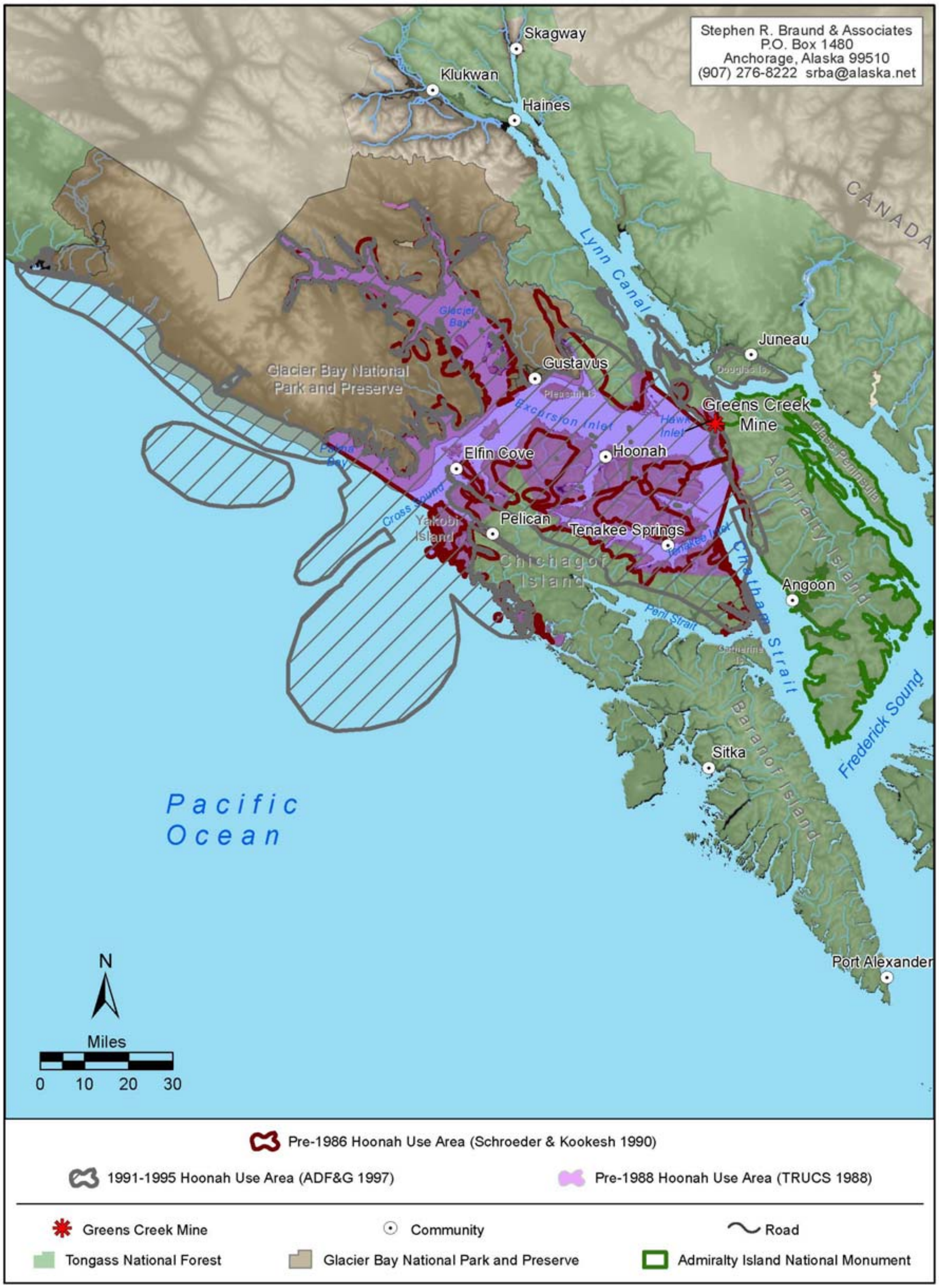
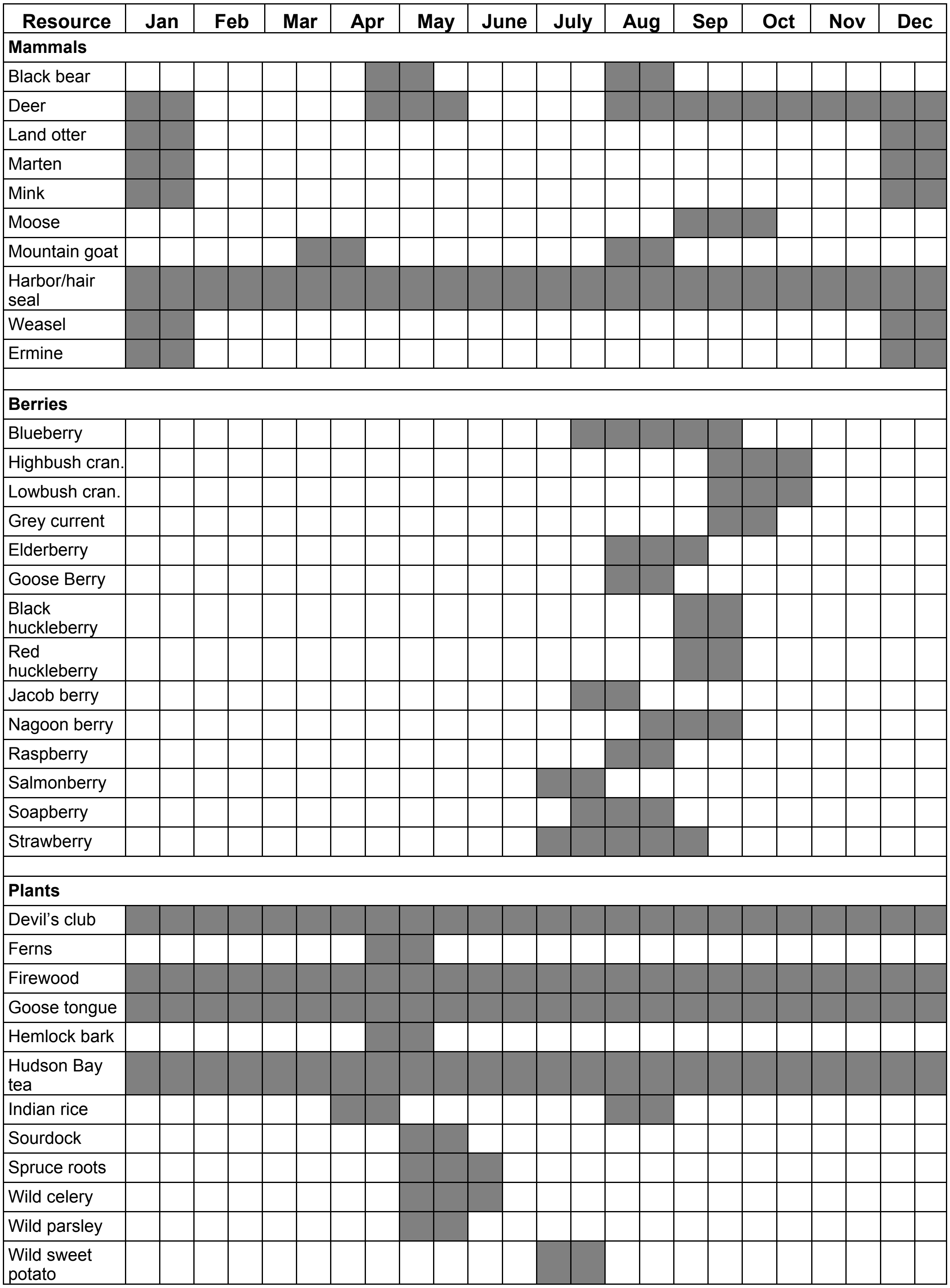


Figure 3.16-3. Hoonah Subsistence Use Areas.

Resource	Jan		Feb		Mar		Apr		May		June		July		Aug		Sep		Oct		Nov		Dec	
Fish																								
Pacific cod	X	X	X	X	X	X																	X	X
Black cod											X	X					X	X						
Ling cod											X	X	X	X	X	X								
Dolly varden						X	X	X	X	X	X	X	X											
Flounder (sole)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Halibut	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Herring eggs								X	X	X														
Pacific herring							X	X	X	X								X						
Hooligan							X	X	X	X	X													
Irish lords					X	X																		
Other rockfish	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Red snapper	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chum salmon													X	X	X	X	X	X	X	X				
Coho salmon												X	X	X	X	X	X	X	X	X				
King salmon	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pink salmon												X	X	X	X	X	X							
Sockeye salmon												X	X	X	X									
Surf smelt						X	X																	
Cutthroat trout						X	X	X	X	X	X	X	X	X										
Steelhead						X	X																	
Birds																								
Sandhill crane																	X	X						
Ducks							X	X	X	X							X	X	X	X	X	X	X	X
Geese											X	X	X	X			X	X	X	X	X	X	X	X
Spruce grouse							X	X	X	X							X	X	X					
Willow ptarm.															X	X								
Seagull eggs									X	X	X													
Waterfowl eggs									X	X														
Intertidal																								
Abalone											X	X	X	X	X	X								
Clams	X	X	X	X	X	X	X	X									X	X	X	X	X	X	X	X
Dungeness crab	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
King crab	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tanner crab	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black gumboot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Red gumboot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Blue mussels							X	X	X															
Octopus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sea cucumber									X	X	X	X	X	X			X	X	X					
Shrimp	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black seaweed								X	X	X	X													
Sea ribbon											X	X												
Garden seaweed							X	X																



Source: Adapted from Schroeder and Kookesh 1990.
Stephen R. Braund & Associates 2011.

Figure 3.16-4. Hoonah Seasonal Round of Harvest Activities.

3.16.2.4 Tenakee Springs

Tenakee Springs is located along the eastern coast of Chichagof Island approximately 28 miles southwest of Hawk Inlet and has a population of 131 residents, one percent of whom are Alaska Native (U.S. Census Bureau 2011). Pre-1988 use areas documented during the TRUCS project show Tenakee Springs residents' subsistence use areas encompassed the entire Tenakee Inlet and surrounding lands, portions of Peril Strait, and coastline areas around Baranof, Pleasant, Douglas, and Admiralty islands (Figure 3.16-5). Tenakee Springs use areas on Admiralty Island are located along much of the island's western and southern coastline including Hawk Inlet; Tenakee Springs residents reported deer hunting along Hawk Inlet's coastline.

ADF&G (2011) considers the 1987 study year data to be the most representative Tenakee Springs study years. During the two study years, fish accounted for between 40 and 45 percent of the total harvest; land mammals between 26 and 41 percent; marine invertebrates between 13 and 24 percent; and the remaining resource categories contributed no more than five percent individually. Based on the most representative study year (1987), individual resources that contribute a large amount to Tenakee Springs' total harvest include deer (41 percent), salmon (15 percent), halibut (14 percent), Dungeness crab (five percent), clams (four percent), and Dolly Varden (four percent).

Tenakee Springs seasonal round of harvest activity was documented by Leghorn and Kookesh (1987) (Figure 3.16-6). Similar to other study communities, several resources are harvested throughout the year with peaks in harvest effort during certain months; fish and marine invertebrates are the primary resources harvested throughout the year.

3.16.3 Environmental Consequences

3.16.3.1 Effects Common to All Alternatives

Based on existing data as described in Section 3.16.2, the communities of Angoon, Hoonah, and Tenakee Springs have documented use of the Hawk Inlet area for subsistence purposes. Subsistence users' access to use areas would not be expected to be impacted except for a potential loss of deer hunting area near the new TDF location at Fowler Creek (see Alternative C and D discussion). Current policy by the applicant prohibits hunting and fishing from mine employees while working at the site and thus extending the duration of the mine would not have an effect on competition for subsistence resources. According to Section 3.7, Aquatic Resources and Section 3.11, Wildlife, effects on certain subsistence resources (e.g., deer, salmon, non-salmon fish, marine invertebrates) could potentially occur due to habitat loss, fuel and other hazardous material spills, heavy metals accumulation, or fugitive dust dispersal. Depending on the magnitude of these potential impacts, subsistence resource abundance, health, and availability for species that are harvested within Hawk Inlet could be affected. Existing mitigation plans such as spill control plans, treatment of surface water runoff, dust abatement measures, and mine reclamation plans, if implemented properly, should minimize these effects. Considering the availability of similar habitat in the area and the practices and measures to reduce to subsistence resources, effects under any alternative would not result in a significant possibility of a significant restriction on subsistence resources or uses under any alternative.

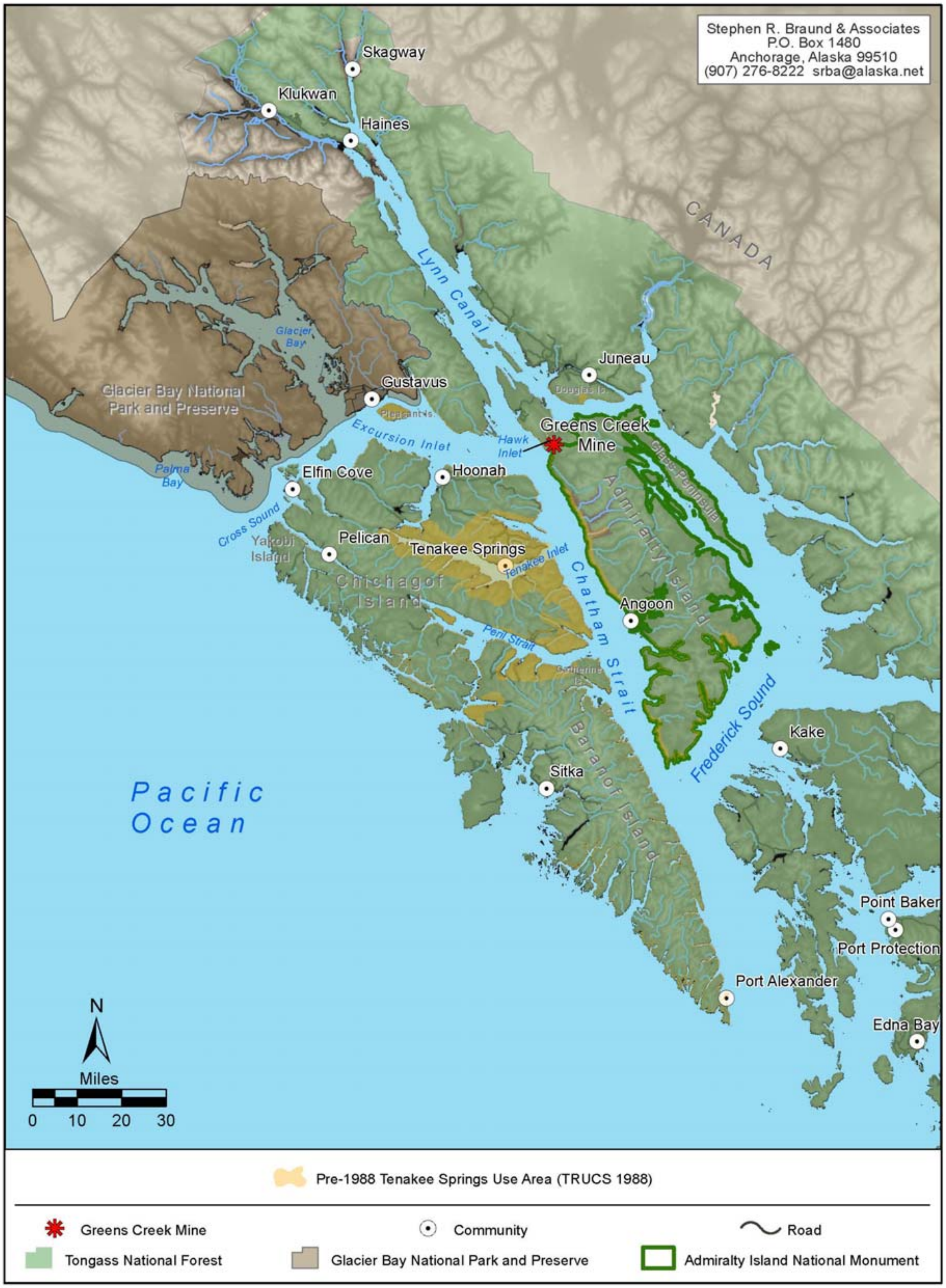


Figure 3.16-5. Tenakee Springs Subsistence Use Area.

Resource	Jan		Feb		Mar		Apr		May		June		July		Aug		Sep		Oct		Nov		Dec	
Mammals																								
Deer																■	■	■	■	■	■	■	■	■
Seal	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Land otter	■	■	■	■	■	■																	■	■
Mink	■	■	■	■	■	■																	■	■
Weasel	■	■	■	■	■	■																	■	■
Marten	■	■	■	■	■	■																	■	■
Intertidal and Other Gathered Resources																								
Clams and cockles	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mussels							■	■	■	■														
Sea urchins									■	■	■	■												
Chiton	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Scallops	■	■	■	■	■	■	■	■	■	■											■	■	■	■
Octopus	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Shrimp	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Herring eggs							■	■	■	■														
Crabs	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Kelp											■	■	■	■										
Sea weed									■	■	■	■												
Berries											■	■	■	■	■	■	■	■						
Wild rhubarb											■	■	■	■	■	■	■	■						
Indian celery											■	■	■	■	■	■	■	■						
Ferns												■	■	■										
Roots											■	■	■	■										
Hudson Bay tea									■	■	■	■												
Goose tongue									■	■	■	■	■	■	■	■								
Beach asparagus									■	■	■	■	■	■										
Mushrooms													■	■	■	■	■	■	■	■	■			
Firewood	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Fish																								
King salmon	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Sockeye salmon											■	■	■	■										
Chum salmon											■	■	■	■	■	■								
Pink salmon													■	■	■	■	■							
Coho salmon											■	■	■	■	■	■	■	■	■	■				
Halibut	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cod							■	■	■	■							■	■	■	■				
Bass	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Dolly varden		■	■	■	■	■	■	■	■	■	■	■	■	■										
Herring							■	■	■	■	■	■	■	■	■	■								
Red snapper	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Birds																								
Ducks																	■	■	■	■	■	■	■	
Canada goose																	■	■	■	■	■	■	■	

Source: Adapted from Leghorn and Kookesh 1987.
Stephen R. Braund & Associates 2011.

Figure 3.16-6. Tenakee Springs Seasonal Round of Harvest Activities.

3.16.3.2 Effects of Alternative A, No Action

Under Alternative A, current mining activities would continue under existing permits until approximately 2014. Subsistence uses would not be affected beyond any potential impacts that may already occur under the No Action Alternative. The 2003 EIS for the project, which also addressed an expanded TDF, identified the impacts of the project as negligible to subsistence uses (USDA 2003: 4-53). Of all alternatives, Alternative A would have the least prolonged impact on subsistence resources as the proposed duration is three years compared to 30-50 years for alternatives B, C, and D.

3.16.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, the existing TDF would be expanded to accommodate an additional 30–50 years of tailings. Alternative B would require expanding the existing TDF southward, increasing the facilities lease area. Alternative B would have minimal impact on subsistence uses of all the action alternatives because any potential impact would occur within an already developed area. The expanded TDF and associated proposed components under Alternative B are co-located nearest to the existing TDF versus the other action alternatives, which include development of a new TDF in previously undisturbed area where subsistence resources, particularly deer, may be taken. Documented uses of Hawk Inlet for deer hunting occurred in pre-1985 (ADF&G 1986) and pre-1988 (TRUCS 1988) time periods, however, the 1991-1995 (ADF&G 1997) data do not show subsistence uses within Hawk Inlet. Effects to aquatic resources, including subsistence resources such as freshwater fish, would also be the least under Alternative B (see Section 3.7). There would not be a significant possibility of a significant restriction on subsistence resources or uses under this alternative.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. No aspects of mitigated Alternative B would impact subsistence use in the project area.

3.16.3.4 Effects of Alternative C, New TDF Located Outside Monument

Under Alternative C, the lifespan of the mine would extend 30-50 years, with a three year expansion of the existing TDF and the construction of a new TDF, approximately three miles north of the existing TDF. Alternative C would have greater impacts on subsistence uses than alternatives A and B due to the new TDF and resulting effects on aquatic resources and removal of approximately 153 acres of deer winter range (potential hunting area) near Fowler Creek. Documented uses of Hawk Inlet for deer hunting occurred in pre-1985 (ADF&G 1986) and pre-1988 (TRUCS 1988) time periods, however, the 1991-1995 (ADF&G 1997) data do not show subsistence uses within Hawk Inlet. There would not be a significant possibility of a significant restriction on subsistence resources or uses under this alternative.

3.16.3.5 Effects of Alternative D, Modified Proposed Action

Similar to Alternative C, Alternative D would extend the lifespan of the mine 30–50 years, with expansion of the existing TDF and construction of a new TDF located in the Fowler Creek area. In this alternative, the existing TDF would be expanded to accommodate for an additional 10 years of use; followed by a new TDF and upgraded haul road three miles north of the existing TDF. Alternative D impacts on subsistence would be the same as Alternative C due to the new TDF and resulting effects on aquatic resources and removal of a deer hunting area near Fowler Creek. Documented uses of Hawk Inlet for deer hunting occurred in pre-1985 (ADF&G 1986) and pre-1988 (TRUCS 1988) time periods, however, the 1991-1995 (ADF&G 1997) data do not show subsistence uses within Hawk Inlet. There would not be a significant possibility of a significant restriction on subsistence resources or uses under this alternative.

3.16.4 Subsistence – Summary

Alternative A would have the least impact on subsistence uses due to the limited new construction and shorter project timeline ending in 2014. Alternative B would have the least impact on subsistence uses of all action alternatives due to the co-location of new project components with existing components. Alternatives C and D would have the same impact on subsistence uses and the impacts would be greater than alternatives A and B due to construction of a new TDF would result in removal of deer hunting area near Fowler Creek and some impacts on fish. The time period of impacts under alternatives C and D would be longer than the other alternatives. Considering the availability of similar habitat in the area and the practices and measures to reduce to subsistence resources, effects under any alternative would not result in a significant possibility of a significant restriction on subsistence resources or uses under any alternative.

3.17 Cultural Resources

The resource analysis of cultural resources was not identified as a significant issue; comments from the scoping process regarding cultural resources are addressed in this section.

The purpose of this section is to describe cultural resources in the area of Greens Creek Mine, describe impacts on cultural resources resulting from mine activities to date, and to assess potential impacts on cultural resources related to the proposed expansion of the TDF at Greens Creek Mine. The following discussion identifies reported cultural resources within the study area and the potential for unknown or undocumented cultural resources that may be affected by the proposed undertaking. More details are included in Appendix I.

The Cultural Resources section includes a discussion of cultural resources that have been, or could be, found in the vicinity of the proposed TDF expansions. Cultural resources include sites and materials of prehistoric Native American, historic Euro-American, and historic Tlingit origin (e.g., traditional cabin sites, camp sites, burial grounds, traditional subsistence harvest sites, middens, and other traditional land use areas, landscapes, and place names). Residents in nearby communities such as Hoonah and Angoon are descendants of the original Tlingit inhabitants and have cultural ties to the sites and the lands in which they are found. A key assumption for the cultural resources analysis is that cultural resources in the study area are assumed to be eligible for the National Register of Historic Places (NRHP) unless otherwise specified.

The cultural resources analysis relies on:

1. Alaska Heritage Resource Survey (AHRS) files located at the Alaska Department of Natural Resources (ADNR), Office of History and Archaeology (ADNR, OHA 2011),
2. An assessment of available literature regarding cultural resources in the proposed project area, and
3. The application of existing laws and regulations regarding the assessment of effects on cultural resources caused by an undertaking.

The relevant regulations for the evaluation of effects to cultural resources are the NEPA and Section 106 of the National Historic Preservation Act (NHPA) and its implementing regulations 36 CFR 800.

3.17.1 Cultural Resources – Pre-mining Environment

3.17.1.1 Prehistoric Environment (Before 12,500 years ago to A.D. 1740)

The earliest human occupation of Southeast Alaska dates to the end of the Pleistocene epoch, about 11,700 years ago. Much of Southeast Alaska was heavily glaciated at that time, and human activity was likely concentrated in the lower elevations and coastal plains that have since been inundated by rising sea levels. For this reason, there are few known archaeological sites from this period in the area.

Regional deglaciation in southeast Alaska was probably complete by 13,900 years ago, creating a relatively stable coastal environment with sea levels several meters lower than they are now (Mann and Streveler 2008). The Paleomarine people in Southeast Alaska at this time relied on a “coastal-marine” economy based on hunting sea mammals and fishing, probably from boats (Davis 1990:197). There is little other evidence to indicate settlement patterns, seasonal rounds, or other elements of culture at the time.

About 6,000 years ago, glaciers in southeast Alaska re-advanced and the relative sea level began to rise (Mann and Streveler 2008). These changes in the environment, called the Neoglacial period for its cooler, wetter weather and glacier growth, correspond with changes in the culture of the people living in southeast Alaska. Starting around 4,500 years ago, the microblades and unifacial tools of the Paleomarine Tradition began to be replaced by ground stone technology. This period of change is referred to as the Transitional stage, indicating that the Paleomarine Tradition was in the process of being replaced by another tradition. Communities formed at favorable locations for shellfish harvests, marked by accumulations of discarded shells called middens. Ground slate tools may be associated with a shift to the harvest of marine mammals such as seal, sea lion, and sea otters. Studies of human skeletons from the period indicate that up to 90 percent of the diet was derived from marine resources (Ames and Maschner 1999). The periodic glacial advances and retreats caused by changes in climate beginning in the Transitional stage may have presented new challenges for people living in coastal Southeast Alaska into historic times. Oral history recounts villages being crushed under the ice of advancing glaciers (Connor, Streveler, Post, Monteith and Howell 2009). However, by about 3,000 years ago, people had adapted to the changing environment and their cultures diversified during the Northwest Coast stage.

The Northwest Coast Stage is characterized by ground stone and bone tools and a subsistence economy that emphasized the near-shore and intertidal resources such as fish and mollusks as evidenced by the occurrence of shell middens. Winter settlements became larger, subsistence camps more specialized, and fortified locations were built as this stage progressed. The Northwest Coast stage consisted of early, middle, and late phases, and ended in historic times with cultural groups like the Eyak and Tlingit (Davis 1990:199-200).

3.17.1.2 Historic Environment (After A.D. 1740)

The historical period for southeast Alaska began with several expeditions on behalf of the Spanish, English, Russians, and French to explore the northern Pacific coast. The first European explorer to reach the region, Alexei Chirikof, sighted the Fairweather Coast in 1741, claiming Alaska to Russia by right of discovery. Subsequent explorations by James Cook starting in 1778 expanded European awareness of Alaskan geography and human populations, and piqued interest in the abundance and profitability of natural resources. European interest first focused on the sea otter populations, whose pelts were a highly sought after commodity in Chinese, European, and Russian markets. Russia, England, Spain, France, and the United States would soon compete for these resources. The Russian American Company's management policies resulted in the near extinction of the sea otter and increased resentment among the Tlingit of Southeast Alaska. Resentment grew and eventually spurred violence, resulting in Tlingit attacks in 1802 which destroyed the Russian post at Old Sitka and in 1805 which destroyed the Russian outpost at Yakutat.

The Russians reoccupied Sitka in 1804, strengthening their hold on Southeast Alaska. Large-scale harvesting of sea otters in Tlingit areas ended in the 1820s, and after 1841, the Russians relied primarily on trade with Tlingit middlemen for land peltry. Tlingit trade networks continued to increase in scope during the early nineteenth century, as did their control of trade to the interior. Russian profits in the fur trade were declining, however, and Russia was concerned about its ability to hold Alaska against the British. To prevent this, Alaska was sold to the United States in 1867.

The Alaska Purchase brought a major influx of Euroamericans to Tlingit territory between 1867 and 1870. Army forts at Sitka, Wrangell, and Tongass brought soldiers, speculators, and camp followers to these trading posts, which became bases for prospectors, miners, and tourists. Fundamental changes to Tlingit culture came as early as the 1870s when commercial fishing, canneries and the tourist industry developed, integrating the Tlingit into the wage-based American economy (de Laguna 1990:224).

Commercial activities in the region at the end of the nineteenth century and beginning of the twentieth century included fishing, whaling, minerals exploration, timber harvest, fur farming, and tourism (Bower, Iwamoto, and McCallum 2003:9). In 1878, profitable salmon canneries were constructed near Klawock and Sitka, marking the onset of the commercial fishing industry that would eventually construct 134 canneries in Southeast Alaska (Bower, Iwamoto, and McCallum 2003:8). The Hawk Inlet Cannery was constructed by the Hawk Fish Company around 1910 as the industry was becoming highly mechanized and dependable markets were being developed, using fish traps as the predominant harvest method. The cannery changed ownership several times, being sold to Peter Pan Seafoods in 1967 and finally to the Dillingham Native Corporation in 1975. In May of 1976 most of the cannery was destroyed in a fire.

Other commercial opportunities including trapping and mining continued to attract homesteaders, migrant workers, and profit seekers to the region during the first half of the twentieth century. Mink, marten, beaver, muskrat, and fox were all harvested for fur (Bower et al. 2003:10). Gold was extracted from the Alaska Empire Mine beginning in 1919 near Hawk Inlet, and in 1926 there were 96 claims in the vicinity, though production slowed steadily until only a crew of five was employed there in 1946. In 1973 the Pan Joint Venture began exploring for base metals in Southeast Alaska, and from 1974 to 1976 geologic studies revealed high base metal deposits on Admiralty Island. Noranda, Inc. assumed responsibilities for field operations in 1976 and began the initial work at Greens Creek (Bower et al. 2003:9).

3.17.2 Cultural Resources – Baseline Conditions

Based on a review of available information in the study area, nine documented cultural resource sites are located in an area bounded by the head of Hawk Inlet to the north, the southwest corner of Young Bay to the east, Chatham Strait to the west, and as far south as the mouth of Hawk Inlet. Site types in the area include mining sites with accompanying built environment resources, early twentieth century homestead claims cabins, prehistoric shell middens, a reported petroglyph/pictograph, and the Hawk Inlet Cannery. Five sites have been evaluated for inclusion on the NRHP; two sites, including the Hawk Inlet Cannery (JUN-00092) and the Young Bay Midden site (JUN-00091), have been determined eligible for the NRHP. Fowler Creek Homestead (JUN-00918), Jacobsen's Cabin (JUN-00236), and the Greens Creek Midden site (JUN-00090) were all determined to be ineligible for inclusion on the NRHP. The Piledriver Cove Pictograph/Petroglyph (JUN-00045), Soldier's Additional Homestead Claim (JUN-00237), Greens Creek Cabin (JUN-00238), and Alaska Empire Mine and Dock Site (JUN-00689) have not been evaluated for eligibility to the NRHP.

Cultural resource investigations of note in the study area include an archaeological impact assessment (Carlson 1981) conducted prior to the development of an Environmental Assessment (USFS 1982) for the Noranda Mining Project at Greens Creek. Two midden sites (JUN-00090 and JUN-00091), three historic cabins (JUN-00236; JUN-00237; JUN-00238), and a historic cannery (JUN-00092) located within the study area were initially recorded by Carlson (1981); the middens were later more fully investigated by Davis (1990). In 1983, the Hawk Inlet Cannery (JUN-00092) was documented and determined to be eligible for the NRHP (Johannsen 1983).

3.17.3 Cultural Resources – Environmental Consequences

3.17.3.1 Effects Common to All Alternatives

An adverse effect to a cultural resource occurs when an undertaking may alter, directly or indirectly, any of the characteristics of a cultural resource that could qualify the property for the inclusion in NRHP in a manner that would diminish the property's integrity (location, design, setting, materials, workmanship, feeling, association) and/or association (i.e., association with an important event or person [Criteria A and B], style of architecture [Criterion C], or information potential [Criterion D]) thus rendering it ineligible for the NRHP. Effects to cultural resources also include those impacts that result from the action later in time or further removed in distance but still reasonably foreseeable such as increased access to and close proximity of project components to culturally sensitive areas.

Examples of direct effects to cultural resources from ongoing or proposed activities could include physical destruction of or damage to all or part of the resource, removal of the resource from its original location, change of the character of the resource's use or of physical features which in the resource's setting that contribute to its historic significance, change in access to traditional use sites by traditional users, or loss of cultural identity with a resource. Indirect effects to cultural resources from the proposed project could include impacts caused by increased access to and close proximity of project components to cultural resources. This could result in a greater vulnerability of cultural resources to damage caused by project personnel and equipment construction and operation. Consultation with the State Historic Preservation Officer has been initiated and will continue through development of the EIS. Review comments provided by the State Historic Preservation Officer have been incorporated into this document.

3.17.3.2 Effects of Alternative A, No Action

Under Alternative A, current mining activities would continue under existing permits. Tailings would continue to be disposed at the existing TDF until 2014 at which point the TDF will have reached capacity. Continued use of the Greens Creek Mine, and TDF until 2014 may result in direct and indirect effects on cultural resources as a result of material spills, fuel spills or discharge of water from the current underground drainage system. Risk of project personnel visiting a site and causing damage or disturbance to its historic context would continue throughout the life of the project. Currently, appropriate identification efforts have already been conducted for the current project, and it is likely that no additional sites will be found in this area; two previously identified sites (Hawk Inlet Cannery and Jacobsen's Cabin) are within 0.5 miles of the existing site although the Jacobsen Cabin has been previously determined ineligible for the NRHP. Alternative A would have the least potential for impacts on cultural resources due to lack of construction activities and shortened project timeline that extends only through 2014.

3.17.3.3 Effects of Alternative B, Proposed Action

Under Alternative B the existing TDF would be expanded to allow for approximately 30-50 years of continued production at the current production rates. Alternative B would require expanding the existing TDF southward, increasing the facilities lease area.

No previously identified sites are located within the proposed footprint of project components under this alternative; however three sites (Hawk Inlet Cannery, Jacobsen's Cabin, and Soldiers' Homestead) are located within 0.5 miles and could experience indirect effects. As discussed above, the Jacobsen's Cabin has been previously determined ineligible for the NRHP. As the total number of acres disturbed increases, the potential for the destruction of unidentified cultural resources increases. Unidentified cultural resources within the proposed TDF expansion and associated structures could be affected due to the expansion of the existing TDF. Additionally, the length of time for uncovering unidentified cultural resources would be extended due to the projected 50 year timeline. Furthermore, cultural resources near these facilities could be contaminated or disturbed in the event of a material spill, fuel spill or discharge of water from the proposed TDF. Risk of project personnel visiting a site and causing damage or disturbance to its historic context would continue throughout the life of the project and be greater than Alternative A because of the expanded TDF area and extended project timeline.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. No aspects of mitigated Alternative B apply to cultural resources in the project area.

3.17.3.4 Effects of Alternative C, New TDF Located Outside Monument

Under Alternative C, a new TDF would be created approximately three miles north of the existing TDF. Since Alternative C requires the construction of a new TDF, a small expansion of the existing TDF would be necessary to accommodate three years' worth of tailings and waste rock disposal during the time necessary to develop the new TDF.

No previously identified sites are located within the proposed new TDF for this alternative; however two sites (Hawk Inlet Cannery and Jacobsen's Cabin [NRHP ineligible]) are located within 0.5 miles and could experience indirect effects. The expansion under Alternative C would pose a greater potential for destroying unidentified cultural resources than alternatives B or A. In addition to increasing the length of time in which cultural materials may be discovered and potentially damaged, unidentified cultural resources within the new TDF could be affected due to construction of as the TDF and associated activity. Furthermore, cultural resources near these facilities could be contaminated or disturbed in the event of a material spill, fuel spill or discharge of water from the new TDF. Risk of project personnel visiting a site and causing damage or disturbance to its historic context would continue throughout the life of the project and be greatest under this alternative because of the upgraded haul road, new TDF, and extended project timeline.

3.17.3.5 Effects of Alternative D, Modified Proposed Action

Under Alternative D, the existing TDF would be expanded to accommodate for an additional 10 years of use. In addition, a new TDF and upgraded haul road would be constructed three miles north of the existing TDF.

Similar to Alternative C, Alternative D proposes constructing a new TDF as well as expand the existing TDF. No previously identified sites are located within the new TDF under this alternative; however two sites (Hawk Inlet Cannery and Jacobsen's Cabin [NRHP ineligible]) are located within 0.5 miles and could experience indirect effects. The expansion under Alternative D would pose a greater potential for destroying unidentified cultural resources than alternatives A, B, and C. In addition to increasing the length of time for uncovering cultural materials by extending the mine's operating capacity, unidentified cultural resources within the new TDF and associated structures could be affected due to construction of this facility as well as associated activity. Furthermore, cultural resources near these facilities could be contaminated or disturbed in the event of a material spill, fuel spill or discharge of water from the new TDF. Risk of project personnel visiting a site and causing damage or disturbance to its historic context would continue throughout the life of the project and be greater than alternatives A and B because of the upgraded haul road, expanded and new TDF, and extended project timeline.

3.17.4 Cultural Resources Summary

Alternative A would have the least potential for impacts on cultural resources due to the least amount of disturbance and shortened project timeline that extends through 2014. Of all the action alternatives, Alternative B would have the least potential for impacts on cultural resources due to the smaller area of disturbance. Alternatives C and D would pose greater risk to impacts on cultural resources due to the larger area of disturbance. In addition, these two alternatives could increase the potential for indirect effects such as increased access to cultural sites due to the upgraded haul road and new TDF. Alternative D would have the greatest potential for impacts on cultural resources due to having the largest area of disturbance and thus the most likely to impact unidentified cultural resources. Consultation with the State Historic Preservation Officer has been initiated and will continue through development of the EIS. Review comments provided by the State Historic Preservation Officer have been incorporated into this document.

3.17.5 Recommended Mitigation

Access related effects could be mitigated through implementation of a Cultural Resources Management Procedure that includes annual training for employees/contractors, posting of cultural resource information including company policy regarding cultural resources, and maintaining confidential records for all sites, with record access limited to designated employees. Continued enforcement of procedures related to cultural resources such as halting operations when cultural resources are found and documenting the site will help mitigate any potential effects in the unlikely event that previously unidentified cultural resources are located in the expansion areas. If material for reclamation of mine components is obtained from areas outside of the existing footprint or from areas not previously surveyed, previously undocumented cultural resources could be affected. These areas should be surveyed carefully prior to ground disturbing activity. If a cultural resource is found, it should be assessed for eligibility for the NRHP and avoided or mitigated in an appropriate manner.

3.18 Socioeconomics

The resource analysis of socioeconomics was not identified as a significant issue; comments from the scoping process regarding socioeconomics are addressed in this section.

The purpose of this section is to describe socioeconomics in the Greens Creek Mine area and to assess potential impacts related to the proposed expansion of the TDF at Greens Creek Mine. The proposed TDF expansion at the Greens Creek Mine would either extend or terminate the life of the Greens Creek Mine and would, therefore, have the potential to affect socioeconomic resources in the CBJ. Local employment and income, population, school enrollment, housing, and local government revenues could be affected.

3.18.1 Socioeconomics – Pre-mining Environment

Mining played an important role in the economy of Southeast Alaska from 1906 through the mid-1950s. Its economic importance declined following closure of the Alaska-Juneau Mine in 1944 and establishment of the pulp mill in Ketchikan in 1954 (USFS 1983). The Greens Creek final EIS (2003) assessed potential socioeconomic impacts to the communities of Juneau, Angoon, and Hoonah.

The CBJ had a total population of 21,080 in 1981 and the local economy was heavily dependent on government employment in 1982, with state and federal jobs accounting for a combined total of 57 percent of total employment. Juneau typically had a higher per capita income and a lower unemployment rate than elsewhere in the State of Alaska in the early 1980s (USFS 1983).

The City of Angoon, located on the west coast of Admiralty Island at the mouth of Kootznoowoo Inlet, about 44 miles southwest of Greens Creek Mine, is a Tlingit Indian community. Angoon had a population of 445 in 1981. Salmon fishing was identified as the main source of employment in the community, with most residents relying heavily on subsistence resources (USFS 1983).

The City of Hoonah, located on Chichagof Island, about 20 miles west of the mine, is another Tlingit community. Hoonah had a population of 800 in the early 1980s. Commercial fishing and government were identified as the main employers in Hoonah, with subsistence continuing to play an important role for many local households, some of whom occasionally visited Hawk Inlet (USFS 1983).

3.18.2 Socioeconomics – Baseline Conditions

The Greens Creek Mine is located on northern Admiralty Island, approximately 18 miles southwest of the city of Juneau. Juneau City and Borough annexed Greens Creek Mine in 1994 and the northern part of Admiralty Island, excluding the Mansfield Peninsula. The Mansfield Peninsula and the Monument south of the Greens Creek Mine area are part of the Hoonah-Angoon Census Area, which, as the name suggests, also includes the communities of Hoonah and Angoon.[3]

[3] Southeast Alaska is divided into six boroughs and two census areas. The six boroughs correspond with the county governments found elsewhere in the United States. Four of these boroughs, Juneau, Sitka, Yakutat, and Wrangell are city/boroughs. The other two, Ketchikan Gateway and Haines, have independent incorporated communities within their boundaries. The remaining unorganized area is allocated to two census areas (CAs). While CAs are only statistical units, they are widely recognized from a data reporting standpoint by federal agencies and most state agencies as county equivalents.

3.18.2.1 Employment and Income

A total of 17,932 non-agricultural wage and salary (NAWS) jobs were identified in the CBJ in 2010, with a total combined payroll of $790 million (Table 3.18-1). These data are compiled from unemployment insurance coverage data and do not include self-employed workers. There were an estimated 1,531 self-employed workers in Juneau in 2008 (Juneau Economic Development Council [JEDC] 2010a).

Table 3.18-1. Annual Employment and Earnings CBJ, 2010.

	Annual Average Employment		Annual Earnings		
Economic Sector	Number of Jobs	Percent of Total	Millions of Dollars	Percent of Total	Average Monthly Earnings ($)
Total Nonfarm	19,912	100	790	100	3,673
Goods Producing	1,564	8	104	13	5,558
Services Providing	10,912	55	287	36	2,681
Natural Resources and Mining	556	3	51	6	7,604
Construction	729	4	44	6	5,001
Manufacturing	279	2	10	1	2,937
Trade/Transportation/Utilities	3,274	18	101	13	2,566
Retail Trade	1,996	11	51	6	2,134
Information	245	1	12	1	3,932
Financial Activities	608	3	29	4	3,975
Professional & Business Services	918	5	37	5	3,399
Educational & Health Services	1,796	10	64	8	2,964
Leisure & Hospitality	1,464	8	25	3	1,424
Other Services	611	3	19	2	2,626
Government	7,436	37	399	50	4,468
Federal Government	840	5	73	9	7,215
State Government	4,276	24	218	28	4,243
Local Government	2,320	13	108	14	3,887

Source: ADOL 2011a.

Notes:

NAWS – Non-agricultural wage and salary.
ADOL – Alaska Department of Labor and Workforce Development.
JEDC – Juneau Economic Development Council.
These data are compiled from unemployment insurance coverage data and exclude self-employed workers because they are not covered by unemployment insurance. In 2008, there were 1,531 self-employed residents in Juneau, which was equivalent to about 8 percent of total NAWS employment in 2008. The top three self-employed occupations were Professional Services, Fishing, and Construction. Note that self-employed workers may also hold jobs counted by ADOL (JEDC 2010a).

The government sector dominates the Juneau economy accounting for 41 percent of total NAWS employment and 50 percent of total annual earnings (Table 3.18-1). These totals include federal, state, and local jobs. State of Alaska government employment alone accounts for almost one-quarter of total NAWS employment and 28 percent of total payroll.

The Natural Resources and Mining sectors employed 556 people in the CBJ in 2010, about 3 percent of total NAWS employment and 6 percent of total payroll (Table 3.18-1).

The government sector dominates the economy in the Hoonah-Angoon CA, accounting for 53 percent of total employment and 62 percent of total earnings in 2010. The majority of this employment, 36 percent of total employment, is in local government. The leisure and hospitality sector is also a major employer, accounting for 18 percent of total employment (ADOL 2011a).

Greens Creek Mine was identified as Juneau's largest private employer in 2009 (and the fourth largest private employer in southeast Alaska), with 333 employees (JEDC 2010a). The mine presently employs nearly 330 people with an annual payroll over $32 million.

The majority of the workers employed at the mine reside in Juneau and commute daily to the mine site via ferry. A smaller component of the labor force is comprised of workers from elsewhere in Alaska and the lower 48 states who reside in dormitory style housing at Hawk Inlet. According to ADOL (2011f), 25.1 percent of the workforce employed by the Hecla Greens Creek Mining Corporation in 2009 was nonresident.

Gold and silver prices continue to be relatively high, with the price of gold (unadjusted for inflation) 28 percent higher in April 2011 than one year earlier (April 2010), and 66 percent higher than it was in April 2009 (World Gold Council 2011). On average, mining workers in Southeast Alaska earned slightly less than $116,000 each in 2010 (wage data are not available for this sector for the CBJ alone), about 2.4 times the average annual wage in Southeast Alaska and 2.6 times the average wage in the CBJ (ADOL 2011a).

Total NAWS employment in the CBJ was approximately 3 percent higher (601 jobs) in 2010 than in 2002. Employment was higher in 2010 in the Natural Resources and Mining, Trade/Transportation/Utilities, Educational & Health Services, and Local Government sectors and lower in the Construction, Leisure & Hospitality, and State Government sectors (ADOL 2011a). In 2002, State Government accounted for 26 percent of total NAWS employment and 30 percent of total payroll compared to 24 percent and 28 percent in 2010, respectively.

The CBJ had an unemployment rate of 5.3 percent in April 2011, compared to a Statewide average rate of 7.7 percent. The unemployment rate in the Hoonah-Angoon CA in April 2011 was 19.5 percent. Annual unemployment rates for Juneau, the Hoonah-Angoon CA, and the State of Alaska as a whole in 2010 were 5.8 percent, 15.4 percent, and 8.0 percent, respectively (ADOL 2011b).

Median household income in Alaska was about one-third higher than the national average in 2009. Median household income in the CBJ was 9 percent higher than the statewide median. In the Hoonah-Angoon CA, median household income was just two-thirds of the statewide median (Table 3.18-2). The percent of the population below the poverty level in Juneau was less than half the national average and slightly more than two-thirds of the state average, 6.6 percent versus 14.3 percent and 9.1 percent, respectively. The percent of the population below the poverty level in the Hoonah-Angoon Census Area was higher than the national average and almost twice the state average (Table 3.18-2).

Table 3.18-2. Income and Poverty, 2009.

Area	Median Household Income		Percent of Population in Poverty (2009) [b]
	Dollars (2009)	Percent of National/ State Median [a]	
City and Borough of Juneau	73,044	109	6.6
Hoonah-Angoon Census Area	41,824	63	17.2
Alaska	66,712	133	9.1
United States	**50,221**	**n/a**	**14.3**

Source: U.S. Census Bureau. 2010.

Notes:

a. Statewide median household income is presented as a percent of the national median; county medians are shown as a percentage of the state median.
b. This represents the percentage of the population of all ages below the poverty level.

3.18.2.2 Population

The CBJ had a total population of 31,275 in 2010 (Table 3.18-3). According to the JEDC (2010a), between 2,700 and 2,900 permanent residents move to and from Juneau each year. From 2000 to 2009, Juneau experienced a net loss of 2,399 people through out-migration, as well as a slight natural decrease (more deaths than births). Population did, however, increase between 2009 and 2010, and the Census identified 564 more residents in Juneau in 2010 than it had a decade earlier in 2000, an increase of 1.8 percent. Population decreased by 1.9 percent in southeast Alaska over this period, while the State of Alaska as a whole experienced a net increase of 13.3 percent (Table 3.18-3). Population in the Hoonah-Angoon Census Area decreased by 13.9 percent between 1990 and 2000, and further decreased 16.5 percent between 2000 and 2010 (Table 3.18-3).

Table 3.18-3. Population 1990 to 2010.

Geographic Area	1990	2000	2010	1990-2000 Change		2000-2010 Change	
				Number	Percent	Number	Percent
Juneau City and Borough	26,751	30,711	31,275	3,960	14.8	564	1.8
Angoon	638	572	459	-66	-10.3	-113	-19.8
Hoonah	795	860	760	65	8.2	-100	-11.6
Hoonah-Angoon CA	2,988	2,574	2,150	-414	-13.9	-424	-16.5
Southeast Alaska	68,989	73,082	71,664	4,093	5.9	-1,418	-1.9
Alaska	**550,043**	**626,932**	**710,231**	**76,889**	**14.0**	**83,299**	**13.3**

Sources: ADOL 2011c, 2011d; USFS 2008a.

The State of Alaska has developed three series of population projections (low, middle, and high) for 2010 through 2034. The middle series of projections for Juneau anticipate that population will stay relatively constant over the next 20 years, with a total population of 30,191 projected for 2034 (ADOL 2011e).

Race and Ethnicity

The majority of the populations of the CBJ and the State of Alaska are White, with White persons making up 70 percent of the population in Juneau and 67 percent statewide (Table 3.18-4). The largest minority group identified in the affected area and statewide in the 2010 census was American Indian and Alaska Native. Alaska Natives accounted for 12 percent of the population in Juneau and 15 percent in Alaska. Alaska Natives comprise 53 percent of the total population in Hoonah and 76 percent of the total population in Angoon, but a smaller share of the total population in the Hoonah-Angoon CA (Table 3.18-4).

Table 3.18-4. Race and Ethnicity, 2010.

Area	Total Population	Percent of Total					
		White	American Indian/ Alaska Native	Asian	Other Race [a]	Two or More Races	Hispanic [b]
Census Tract 6 [c]	5,474	76	11	2	3	8	4
City and Borough of Juneau	31,275	70	12	6	3	9	5
Hoonah	760	33	53	1	1	14	3
Angoon	459	10	76	0	1	12	8
Hoonah-Angoon Census Area	2,150	47	41	1	1	10	4
Alaska	**710,231**	**67**	**15**	**5**	**6**	**7**	**6**

Source: ADOL 2011f.

Notes:

a. The “Other Race” category presented here includes census respondents identifying as “Black or African American,” “Native Hawaiian and Other Pacific Islander,” or “Some Other Race.”
b. The federal government considers race and Hispanic/Latino origin to be two separate and distinct concepts. People identifying Hispanic or Latino origin may be of any race.
c. Census Tract 6 within the CBJ encompasses Douglas Island and the portion of Admiralty Island that includes the Hecla Greens Creek Mine.

The Hecla Greens Creek Mine is located in Census Tract 6 of the CBJ. In addition to the part of Admiralty Island annexed by Juneau, this Census Tract also includes Douglas Island. The population in this Census Tract was predominantly White (76 percent), with Alaska Natives comprising 11 percent, which is less than the State of Alaska average of 15 percent (Table 3.18-4).

3.18.2.3 School Enrollment

A total of 4,953 K-12 students were enrolled in the Juneau School District in 2009/2010. The total number of students enrolled has steadily decreased since the 2001/2002 school year (Table 3.18-5). The number of students enrolled in 2009/2010 was, however, slightly higher than in the preceding year and the JEDC (2010a) anticipates that school enrollment will increase in the future.

Table 3.18-5. Juneau School District K-12 Enrollment.

School Year	Number of Students	Rate of Change
2000/2001	5,463	--
2001/2002	5,540	1.4%
2002/2003	5,506	-0.6%
2003/2004	5,429	-1.4%
2004/2005	5,310	-2.2%
2005/2006	5,218	-1.7%
2006/2007	5,161	-1.1%
2007/2008	5,042	-2.3%
2008/2009	4,930	-2.2%
2009/2010	4,953	0.5%

Source: JEDC 2010a.

3.18.2.4 Housing

According to the Juneau City Assessor, there were a total of 12,974 housing units in Juneau in 2010, with single-family homes making up almost half the total housing stock (Table 3.18-6). Housing surveys conducted by the CBJ in 2001 and again in 2008 found that the number of housing units increased by 704 (6 percent) over this period, with apartment units accounting for the majority (97 percent) of this increase (JEDC 2010a).

Table 3.18-6. Housing, 2010.

Type of Housing	Number of Units	Percent of Total
Single-Family Homes	6,349	49%
Apartments	2,309	18%
Multi-Unit Dwellings	1,745	13%
Mobile Home/Cabin	1,381	11%
Condos and Townhouses	1,190	9%
Total	**12,974**	**100%**

Source: JEDC 2010b.

Juneau has historically had low rental vacancy rates. The 2010 Census identified a rental vacancy rate of 3.6 percent in Juneau in 2010, slightly more than half the State of Alaska average (6.6 percent) (ADOL 2011h).

3.18.2.5 Local Government Revenue

Estimated funding sources for the CBJ are presented for Fiscal Year 2011 in Table 3.18-7. User fees and permits were the largest single source of estimated revenue (and funding) for Fiscal Year 2011, accounting for 37.6 percent of total funding. Taxes, including property tax, sales tax, alcohol tax, tobacco excise tax, and hotel tax, were the second largest source accounting for 25.8 percent of total estimated funding (Table 3.18-7).

Table 3.18-7. Estimated Funding Sources for the City and Borough of Juneau Fiscal Year 2010.

Source	Estimated Revenue	Percent of Total
State Support	$16,694,100	5.1%
Federal Support	$2,767,300	0.9%
Taxes	$83,663,600	25.8%
User Fees and Permits	$122,101,100	37.6%
Penalties and Fines	$925,800	0.3%
Investment Interest and A/R	$4,528,200	1.4%
Property Sales and Rent	$4,430,400	1.4%
Special Assessments	$69,300	0.0%
Other Miscellaneous Revenue	$94,500	0.0%
Total Revenue	**$235,274,300**	**72.5%**
Replacement Reserve Contribution	-$32,600	0.0%
Fund Balance Usage Excluding the General Fund	$6,573,600	2.0%
General Fund Balance Usage	$3,270,300	1.0%
Support from Other Funds	$79,620,000	24.5%
Total Revenue, Fund Balance Usage and Support from Other Funds	**$324,705,600**	**100.0%**

Source: CBJ 2010.

Operation of the Greens Creek Mine presently generates annual property tax revenues. According to the CBJ (2010), which ranked principal property tax payers based on taxable assessed value in 2010, Hecla Greens Creek Mining was ranked first with a taxable assessed value of approximately $166 million and accounted for 4.22 percent of total taxable assessed value in the City and Borough. Alaska Electric Light & Power ranked second, with a taxable assessed value of about $93 million, 2.36 percent of the City and Borough total.

3.18.3 Socioeconomics – Environmental Consequences

3.18.3.1 Effects Common to All Alternatives

A key component in assessing the socioeconomic impacts of the proposed alternatives is the operating life of the mine under each alternative. Other operating criteria are assumed to remain constant. For the purposes of analysis, under Alternative A the mine is expected to close in 2014. The other three alternatives assume that the mine would continue to operate at current levels for 30–50 years. Current annual benefits are summarized in Table 3.18-8. These benefits would be expected to end in 2014 under Alternative A and would continue 30–50 years under alternatives B through D.

Table 3.18-8. Annual Socioeconomic Impacts.

	Direct	Indirect	Total
Employment [a]	333	160	493
Income [a, b]	$38,547,414	$9,636,854	$48,184,268
Population [c]	650	324	974
School Enrollment [d]	130	65	196
Housing [e]	260	130	390

Source: ADOL 2011a, 2011f, 2011g; USFS 2008a.

Notes:

a. Employment and payroll multipliers were developed from the Impact Analysis for Planning (IMPLAN) Model, which resulted in an employment multiplier of 1.48 and a payroll multiplier of 1.25. In this case, the “indirect” category includes both indirect and induced employment and income. Refer to USFS 2008a for more information.
b. Direct payroll is estimated based on the average annual salary for the Alaska mining sector in 2010. Note that this is higher than the recent estimate of about $32 million provided by the mine (HGCMC 2011).
c. Population estimates are based on shares of resident versus nonresident workers and family versus non-family households.
d. School enrollment is based on an average ratio of one school age child for every five residents.
e. Housing estimates are based on an average household size of 2.5 as measured in the 2010 Census.

The following analysis assumes that closure of the mine would result in the loss of 333 direct jobs. The analysis also assumes that the share of the affected labor force that presently resides in Juneau and their families would, as a result, leave Juneau. Assuming that all former employees and their families would relocate following closure of the mine represents a worst case scenario for the purposes of analysis. It is, however, also possible that other residents presently employed in jobs indirectly supported by the mine’s operation would relocate from Juneau if the mine were to close and their jobs were lost.

Closure of the Hecla Greens Creek Mine would also result in a loss of property tax revenue to the CBJ. The mine accounted for 4.22 percent of total taxable assessed value in the CBJ in 2010 (CBJ 2010). If the mine were to close, the value of the mine would be reduced to its salvage value, a fraction of its current value, with a commensurate reduction in property tax revenue. Further, were the mill to permanently close, per the Exchange Act and Agreement, the lands owned and occupied by HGCMC (with the exception of the cannery, which is owned by a third party) would revert to federal ownership and be entirely removed from the local tax base.

3.18.3.2 Effects of Alternative A, No Action

Under Alternative A, mining operations would continue through 2014. Impacts similar to those associated with ongoing mining activities would continue until mining ceased. The TDF would continue to be built out to the maximum footprint and height permitted in the 2003 EIS (USFS 2003). The mine would continue to support the annual direct and indirect employment and associated payroll through 2014 (Table 3.18-8). Following 2014, the mine would close, which would result in an annual loss of most of the 493 direct and indirect jobs and $48 million in direct and indirect payroll (Table 3.18-8). Assuming the workers directly employed by the mine and their families would move from Juneau would result in a net loss of 650 residents or about 2 percent of the total

2010 population of the CBJ (Table 3.18-8). Closure of the mine would also result in a loss of property tax revenues and operating fees that would otherwise be paid to the CBJ.

3.18.3.3 Effects of Alternative B, Proposed Action

Under Alternative B, mining activities would extend an additional 30–50 years, and the TDF would be expanded immediately adjacent to the existing TDF. Viewed in terms of the annual benefits summarized in Table 3.18-6, this would result in the continued direct and indirect employment of an estimated 493 workers, as well as a total of $48 million in direct and indirect payroll based on the estimates presented in Table 3.18-8. The mine would continue to pay property taxes to the CBJ.

Full build-out for development, construction, and reclamation under this alternative would employ a small number of contractors (about 10) for specialized work, like liner installation, but the current mine work force would do most of the work.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF. There are no differences in socioeconomic effects between Alternative B and mitigated Alternative B.

3.18.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would involve the initial short-term expansion of the existing TDF and the construction of a new TDF located approximately three miles north of the existing TDF. Alternative C would also extend the operating period of the mine by 30–50 years. This would result in the same annual and total economic benefits as Alternative B. Construction under Alternative C would be relatively condensed, with the A Road needing to be upgraded, the new TDF built and the existing TDF expanded (land clearing, drain and liner placement) all within the first 3 years and, as a result, this alternative could employ a small additional number of contractors relative to Alternative B, but the difference would be minimal.

3.18.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would involve both the expansion of the existing TDF and the construction of the new TDF to the north. Like alternatives B and C, Alternative D would extend the operating period of the mine by 30–50 years.

This would result in the same annual and total economic benefits as alternatives B and C.

3.18.4 Socioeconomics – Summary

Alternative A would have the largest impact on jobs, income, and tax revenues. Further, assuming the workers presently employed by the mine and their families would move from Juneau; Alternative A would result in a reduction in local population. Mining operations would extend for an additional 30-50 years under the action alternatives and would likely result in continued levels of employment, income, and tax revenues. Full built-out for development, construction, and reclamation under these alternatives would employ a small number of contractors (about 10) for specialized work.

3.19 Monument Values

Impacts related to expanding the TDF further into the Monument is identified as significant Issue 4. Concerns raised during scoping include disclosing any reasonably foreseeable activities that would affect the intrinsic and ecological values of the Monument. Measures of impacts to the Monument include the potential for reclamation of impacted areas to pre-project conditions and acres disturbed in the Monument.

The location of mine facilities, including the proposed TDF expansion, within the Monument was identified as a significant issue during scoping. Although Alaska National Interest Lands Conservation Act (ANILCA) permits the holders of valid mining claims to carry out activities related to the exercise of rights under those claims, any lease of Monument lands for mining must not cause irreparable harm to Monument values.

The 2008 Tongass National Forest Land and Resource Management Plan (Forest Plan) governs Forest Service administered public lands and resources within and surrounding the Greens Creek Mine area. This includes land within both the Tongass National Forest and the Monument. The majority of the proposed TDF expansion area will be located within the Monument; the Forest Plan designation for this area is "Non-Wilderness National Monument," although the Forest Service land use prescription for the area allows HGCMC to "facilitate the development of mineral resources in a manner compatible with National Monument purposes."

As defined in the Forest Plan, the desired future condition for the Monument is "During mining operations, mining activities are localized and limited to the area necessary for their efficient and orderly development. Off-site effects to Monument resources are minimal, and most Monument users are not aware of, or affected by, the mines. After the completion of mining, reclamation of the affected areas is done to minimize the evidence of past mining and, to the maximum extent feasible, seek to return the area to generally natural conditions. Ultimately, the entire Non-wilderness National Monument provides the same natural settings and recreation experiences as the adjacent Wilderness National Monument areas."

Goals identified in the Forest Plan for non-wilderness portions of the Monument include the following:

- Preserving intact a unique coastal island ecosystem to ensure continued opportunities for study of Admiralty Island's ecology and its notable cultural, historical, and wildlife resources, within its relatively unspoiled natural ecosystem;
- Protection and study of Tlingit cultural resources, other historical resources; brown bear and bald eagle populations are specifically directed;
- Facilitate the development of significant mineral resources located within portions of Admiralty Island;
- Protect objects of ecological, cultural, geological, historical, pre-historical, and scientific interest;
- Minimize effects on non-mineral resources to the extent feasible;

- Limit mining activities to claims with valid existing rights, and to the land area actually needed to carry out mining operations; and,
- In the long term, when mining is completed, to reclaim areas disturbed by mining to a near-natural condition.

Objectives identified in the Forest Plan for Non-wilderness National Monument lands include the following:

- Ensure that the Plan of Operations for each mineral development specify the activities to be conducted, the location and timing of those activities, and how the environment and resources in each area will be protected through compliance with federal and state requirements.
- In areas affected by mining, manage activities to maintain the productivity of anadromous fish and other foodfish habitat to the maximum extent feasible. Stress protection of fish habitat to prevent the need for mitigation.
- In areas affected by mining, manage public recreation use as directed in the Plan of Operations.
- Develop reclamation plans prior to project initiation. Include, as needed, rehabilitation of fish and wildlife habitats, soil resources, and the scenery.

In the long term, when mining is completed, areas disturbed by mining are to be returned to a near-natural condition.

3.19.1 Monument Values – Pre-mining Environment

The Monument had not yet been established when, between 1974 and 1976, Pan Sound Joint Venture staked mineral claims in the Greens Creek area. In 1978, Greens Creek claims were put into a development category.

It was also in 1978 when, by Presidential Proclamation (43 Federal Register 57009 dated December 1, 1978), President Carter established the Monument with the goal to "preserve intact the unique scientific and historic objects and sites located there." As noted in the Proclamation, Admiralty Island provided "superlative combination of scientific and historic objects." The island had been inhabited by indigenous people for approximately 10,000 years and provided a "unique combination of archeological and historical resources in a relatively unspoiled natural ecosystem that enhances their value for scientific study." Wildlife were abundant. President Carter specifically noted the abundance of bears and eagles and the opportunity to study these animals.

While the Proclamation withdrew all lands from entry, location, selection, sale, or other disposition, it also expressly made the establishment of the Monument subject to "valid existing rights," such as the mining claims associated with the Greens Creek Mine.

In 1980, ANILCA reinforced that "valid existing rights" included mining rights. While ANILCA designated most of the Monument as Wilderness, portions of the project area, including the mine site, are within the Monument, but are not in the Wilderness Area. In Section 503 of ANILCA, Congress specifically entitled the holders of the Greens Creek claims to a lease and the ability to obtain the necessary permits for the use of Monument lands in support of mining operations on their claims.

ANILCA Section 503(c) provides that the Monument be managed "to protect objects of ecological, cultural, geological, historical, prehistorical, and scientific interest." These objects have been used to describe Monument values, although it is recognized that all the purposes defined in the Proclamation and in ANILCA are valued. In the Admiralty Island National Monument Land Management Act of 1990, Congress further recognized the Monument as an area of unparalleled natural beauty containing multiple values including but not limited to, fish and wildlife, forestry, recreational, subsistence, educational, wilderness, historical, cultural, and scenic values.

3.19.2 Monument Values – Baseline Conditions

The Monument has long been recognized for its local, national, and global value across a broad spectrum of resources. Resource specific baseline conditions relevant to the proposed action have been described in the preceding sections and are not repeated here in detail. Specific values identified through proclamation or legislation applicable to non-wilderness lands are identified in Table 3.19-1. Each of these values is discussed briefly below.

Table 3.19-1. Specific Values Identified in Proclamation or Legislation Applicable to Non-wilderness Areas of the Monument.

Recreation/Public Access [a, b]	Scenic [b]	Educational [b, c]
Forestry [b]	Historical [a, b, c]	Fish and Wildlife (Bears and Eagles) [b, c]
Geological [a]	Subsistence [a, b]	Ecological [a, c]
	Prehistoric [a, c]	Cultural [a, b, c]

Notes:

a. ANILCA 1980.
b. Admiralty Island National Monument Land Management Act 1990.
c. Presidential Proclamation 1978.

Recreation/Public Access

Hawk Inlet and Admiralty Island as a whole, including the Monument have been, and continue to be, used for subsistence activities and recreation including sport fishing, wildlife viewing, and hunting. Notably, the large population of brown bears is important to tourists and hunters. Nearby, the Pack Creek Bear Viewing Area is a popular tourism destination to view bears.

Most of the recreation use occurs on the waters or shoreline of Hawk Inlet, but hunting is also a popular activity throughout the upland areas, except within developed areas of the mine site and associated facilities. Current patterns of recreation use in the study area are similar to those under pre-mining conditions; hunting, fishing, boating, and wildlife viewing are the primary activities and there is a limited amount of recreational trapping. Recreational use is not allowed within the developed areas of the mine site and associated facilities. Mine employees are prohibited from engaging in recreational activities in the adjacent areas.

Trapping for mink, marten, and river otter occurs in the Hawk Inlet area for both recreational and subsistence purposes. Baseline recreation conditions are described in more detail in Section 3.15.

Forestry

The area consists primarily of Sitka spruce-western hemlock forest interspersed with a mosaic of non-forested plant communities, including peat wetlands, shrub wetlands, and sedge meadows. The understory consists of a combinations of devil's club (*Oplopanax horridus*), *Vaccinium* spp., and salmonberry (*Rubus spectabilis*). Common ferns and herbs include oak fern (*Gymnocarpium dryopteris*), spiny wood fern (*Dryopteris dilatata*), goldthread (*Coptis aspleniifolia*), dogwood (*Cornus* spp.), trailing raspberry (*Rubus pedatus*), deer berry (*Maianthemum dilatatum*), skunk cabbage (*Lysichiton americanus*), and foamflower (*Tiarella trifoliate*).

Commercial timber sales and harvesting are prohibited in the Monument. Forested land within the Monument, which includes largely intact Sitka spruce and western hemlock forests, is classified as unsuitable for timber production and withdrawn from the timber base. Baseline vegetation conditions are described in more detail in Section 3.9.

Scenic

Prior to mining, the Monument was predominantly natural in appearance in the vicinity of the project. The landscape is dominated by rugged glaciated mountains with deep V-shaped and U-shaped valleys. The landscape is known for its meandering shorelines and islands, with numerous bays and coves. A relatively uniform canopy of Sitka spruce and western hemlock forest dominated the lower elevations, interrupted by pocket clearings of meadows, muskegs, and lakes. Baseline scenic resource conditions are described in more detail in Section 3.14.

Prehistorical/Historical

In his Proclamation, President Carter noted that Admiralty Island provides a "superlative combination of scientific and historic objects." The island had been inhabited by indigenous people for approximately 10,000 years and provided a "unique combination of archeological and historical resources." Available data indicate that humans have been present in the Southeast Alaska archipelago for at least 10,000 years. Given the length of time humans have lived in the area and the presence of fish and wildlife resources, prehistoric and historic objects may exist in the project area, including lands within the Monument. However, there are no known objects or sites within the immediate area of the proposed TDF expansion. Prehistoric and historical resources are described in more detail in Section 3.17.

Subsistence

Nearby rural subsistence communities include Angoon, 44 miles to the south, Tenakee Springs, 28 miles to the southwest, Hoonah, 28 miles to the west, and Funter Bay, 10 miles to the north. Deer, salmon, waterfowl, plants and berries are important subsistence foods that occur within the Monument. Historically, trapping was an important activity in the area due to cultural and subsistence trapping. Trapping for mink, marten, and river otter continue for both recreational and subsistence purposes. Baseline subsistence uses are described in more detail in Section 3.16.

Educational

In his proclamation, the island was described by President Carter as "an outdoor living laboratory for the study of bald eagle and Alaska brown bear." Other than mine related investigations, there are currently no formal educational activities within the project area.

Elsewhere within the Monument, ongoing fish and wildlife investigations occur, visitors can view wildlife in dedicated areas, and other educational opportunities are implemented.

Fish and Wildlife

Fish and wildlife resources within the Monument have been noted by both Presidential Proclamation and through acts of Congress. President Carter specifically noted the exceptional populations of bears and eagles. As a result of existing mine operations, habitat removal has occurred within the Monument, primarily consisting of spruce-hemlock forests and muskegs. Noise and activity from ongoing operations has likely had an effect on terrestrial species, resulting in a direct and indirect loss of habitat. Although it was expected that some animals would avoid mine activity areas, species such as deer and brown bears are seen frequently in areas with active operations. Within Monument portions of the project area, fish are present in Tributary, Zinc, and Greens Creeks systems. These streams systems contain resident and anadromous fish species common to the region, including cutthroat trout, dolly varden, sculpin, stickleback, and coho, pink and chum salmon. Baseline fisheries and wildlife uses are described in more detail in sections 3.7 and 3.11, respectively.

Ecological

The ecology of the Monument refers to the relation between organisms, such as fish and wildlife species, and their environments. The ecological system involves a complex relationship between biotic (living) and abiotic (nonliving) components. Common measures of ecological health include species composition and richness, nutrient cycling and flow, productivity, and community structure (Cordell et al. 2005).

It is assumed that the ecological value of the Monument is high, as the vast majority of the Monument is preserved as Wilderness and developed portions of the Monument are managed to minimize the adverse effects of authorized actions.

Cultural

The Monument is culturally valuable not only to those that use it, but also to the Nation as a whole. It is valued by many for the unique opportunities for subsistence, recreation, scenic enjoyment and many other aspects. The value inherent in preserving this unique island ecosystem is valuable to many.

3.19.3 Monument Values – Environmental Consequences

ANILCA directs that the Monument be managed to protect objects of ecological, cultural, geological, historical, prehistorical, and scientific interest and that activities must be carried out in accordance with reasonable regulations promulgated by the Secretary to assure that such activities are compatible, to the maximum extent feasible, with the purposes for which the Monuments were established. Any effect to the resources for which the Monument was established to protect would be an effect to Monument values. The magnitude and duration of these effects, as described in the preceding resource discussions, and ultimately the ability to restore areas disturbed by mining to near-natural conditions when mining is completed, determine what level of effect these actions would have on the Monument and its purpose, and whether those effects constitute irreparable harm.

3.19.3.1 Effects Common to All Alternatives

Each of the alternatives, including the No Action Alternative, involves tailings disposal and related development within the Monument, as authorized by existing regulations. The primary differences between each alternative are the spatial extent and location of disturbances within the Monument, the duration of mining activities within the Monument, and the time before reclamation of facilities within the Monument would begin.

HGCMC would implement operational measures similar to those currently used to minimize effects to Monument resources. These measures include, but are not limited to:

- Constructing the TDF to contain contact water (TDF seepage and runoff);
- Diverting clean surface run-off around the TDF;
- Placing tailings and waste rock as described in Section 2.3.3 to promote runoff, reduce the potential for oxygen and water infiltration, and ensure geotechnical stability;
- Constructing the TDF as described in Section 2.3.6 contain tailings contact waters;
- Relocating existing waste rock piles to the TDF to improve containment;
- Covering interim, unused slopes with rock, hydro-seeding outer slopes of the tailings pile, and installing snow fences and concrete blocks to serve as a wind break to limit the spread of dust.
- Minimizing disturbance by maintaining a small footprint;

Under each alternative, disturbed lands within the Monument would be reclaimed at the cessation of mining or earlier if an alternate disposal location is selected. Reclamation would include:

- Decommissioning and removal of unnecessary structures and facilities (water treatment facilities and electric power utility lines would remain as long as necessary);
- Establishing surface contours conducive to natural revegetation or consistent with an alternate post-mining land use(s);
- Reclamation within the Monument will be to as near a natural condition as practicable. This would include sealing mine openings, restoring original surface drainage, removal of all structures, and re-contouring where possible;
- Placement of an engineered soil cover over the TDF;
- Implementation, maintenance and monitoring of reclamation; and
- Revegetation of all disturbed areas as described in Section 2.3.10.7.

The current understanding of the predicted water balance and chemistry post closure is that discharge water would not meet Alaska water quality standards and treatment would be required for hundreds of years, perhaps in perpetuity, under any alternative. Water quality within the Monument will be protected by requiring HGCMC to treat all contact water until Alaska WQS can be achieved. Only treated water that meets Alaska WQS will be discharged inside or outside the Monument. See Section 3.5, Water Resources – Surface Water, for a more detailed discussion of water quality effects and Section 3.7, Aquatic Resources, for more detail on effects to freshwater streams within the Monument.

Following successful reclamation of the TDF and associated facilities and closure of the mine, recreational and subsistence users could return to the area. Vegetation similar to the surrounding hillsides would be allowed to regenerate on top of the engineered soil cover, providing habitat, food, and cover for wildlife. The topography and vegetation would look similar to surrounding areas. Mining activity would cease and wildlife that may have been displaced would return. Anadromous and resident fish will continue to use streams within the Monument. The cycle of vegetation generation and decay would promote soil genesis on top of the cover. In the long term, when mining is completed, the mine and TDF would be reclaimed to a near-natural condition. It is acknowledged, however, that water treatment systems may be maintained over the long term and could be present on the Monument long after the reclamation of other facilities. Effects to the specific values identified in Table 3.19-1 are described below.

Recreation/Public Access

All of the alternatives would meet the standards and guidelines of Non-Wilderness National Monument LUDs because public recreation use within Monument area would be managed in accordance with direction contained in the GPO. Following closure and reclamation, Monument lands affected by the mine would be reclaimed and restored to a near-natural condition and re-opened for public recreation when safe to do so. Access restriction may remain around facilities maintained for long-term water treatment. The alternatives differ in terms of their extent and location of new disturbed areas within the Monument. These effects are discussed in detail in Section 3.15, Recreation.

Compared to the size of the entire Monument (nearly 895,000 acres), the expansion of the existing tailings pile, under any alternative, would represent about 1/100th of 1 percent of the Monument. Because HGCMC is required to restore lands to near-natural conditions, the relatively small size of disturbance and recreational access restrictions, and the fact that most restored areas would be made accessible to Monument visitors following reclamation, there would be negligible effects to recreation and public access within of the Monument as a whole.

Forestry

Under all alternatives, commercial timber sales and harvesting would continue to be prohibited in the Monument. The alternatives differ in terms of their extent of forest removal within the Monument. These effects are described in detail in Section 3.9, Vegetation.

There would be no additional forest clearing within the Monument as a result of Alternative A. Clearing of vegetation associated with Alternative B would be located adjacent to the existing TDF, whereas alternatives C and D would result in vegetation to the area north of the A Road, which is outside of the Monument. Alternative C would affect the least amount of forests within the National Monument, whereas Alternative B would affect the largest number of acres within the Monument. Table 3.19-2 provides the acres of POG within the Monument that would be lost by each alternative. Compared to the size of the entire Monument, the expansion of the existing tailings pile, under any alternative, would represent about 1/100th of 1 percent of the Monument. Thus, there would be negligible effects to Monument forests as a whole.

Table 3.19-2. New Acres of Productive Old Growth Removal within the Monument

	Alternative A	Alternative B	Mitigated Alternative B	Alternative C	Alternative D
Acres of POG removed (558,350 acres total in Monument)	None	88.2	70.7	26.0	34.8

Scenic

Under all alternatives, the TDF would be visible within the Monument; however disturbed lands would be returned to near natural condition following closure and reclamation of the mine. Some facilities needed for access and water treatment would remain until no longer needed. The Forest Service SIOs would be met, however, since approved mining areas are to be managed to a very low SIO, or “heavily altered,” landscape within the Non-Wilderness National Monument LUD. These effects are described in detail in Section 3.14, Scenic Resources. Visual simulations of the TDF, prior to reclamation and revegetation are also provided in Section 3.14.

Compared to the size of the entire Monument, the expansion of the existing tailings pile, under any alternative, would represent about 1/100th of 1 percent of the Monument. While the TDF would continue to be visible within the Monument locally, most Monument visitors would be unable to see it. Because of the relatively small portion of the Monument affected and the fact that the most of the site would be revegetated during reclamation, there would be negligible effects to scenic resources within the Monument as a whole. Locally, scenic affects from ongoing and future operations would continue during operations, the duration of which varies by alternative. Access and water treatment infrastructure would remain for at least 100 years, potentially in perpetuity, under each alternative. The visual effect of these facilities on the Monument, however, would be very localized.

Prehistorical/Historical

Given the length of time humans have lived in the area and the presence of fish and wildlife resources, prehistoric and historic objects may exist in the project area, including lands within the Monument. However, there are no known objects or sites within the immediate area of the TDF. The alternatives differ in terms of their extent and location of new disturbed areas within the Monument. These effects are discussed in detail in Section 3.17, Cultural Resources.

Considering that the area that would be affected by the action alternatives is unlikely to contain prehistorical and historical objects and that the area affected would be about 1/100th of 1 percent of the total Monument area, effects to these Monument resources would be minimal. The alternatives differ in their potential to affect unidentified prehistorical or historical resources within the Monument. This risk is directly related to the physical extent of disturbance within the Monument. Alternative A would disturb the least acres within the Monument and Alternative B would disturb the most acres within the Monument (see Table 3.19-3).

Subsistence

Existing development has had negligible effect on subsistence uses within the Monument. There would be no new

effect on subsistence under Alternative A. Each of alternatives B, C, and D would require expanding the existing southward into the Monument, increasing the facilities lease area, and delaying reclamation of the new TDF for 30 to 50 years. While, of the action alternatives, Alternative B would have the least effect on subsistence within the project area, Alternative B would result in the greatest expansion within the Monument. Of the action alternatives, Alternative C would have the least effect on subsistence uses within the Monument. These effects are discussed in detail in Section 3.16, Subsistence, and Appendix H.

Compared to the size of the entire Monument, the expansion of the existing TDF, under any alternative, would represent about 1/100th of 1 percent of the Monument. Thus, there would be negligible effects to subsistence uses within the Monument as a whole. There would be localized effects. Alternative A would have the least impact on subsistence uses within the Monument due to the limited new construction and shorter project timeline ending in 2014. Alternative B would have the greatest impact on subsistence uses within the Monument because it would affect the most Monument acres (Table 3.19-3). This differs from the finding in Section 3.16 that alternatives C and D would have a greater affect to subsistence uses overall, because only Monument uses and effects are considered here.

Educational

There would be negligible effects to educational opportunities under each of the alternatives. Education opportunities provided in the Monument well outside of the project area would not be affected.

Fish and Wildlife

Except for Alternative A, each alternative would result in some further development into the Monument (Table 3.19-3), potentially affecting fish and wildlife resources. Effects to subsistence resources are discussed above. Compared to the size of the Monument as a whole, the expansion of the existing tailings pile, under any alternative, would represent a very small percentage of available fish and wildlife habitat within the Monument. Alternative A would have the least affect to fish and wildlife resources within the Monument because of the limited extent of disturbance the operations. Effects to aquatic and wildlife resources within the Monument would be greatest with Alternative B because this alternative would disturb the most acres of fish and wildlife habitat within the Monument, including burial of portions of Tributary Creek. While alternatives C and D would limit disturbance within the Monument compared to Alternative B, mining operations and associated effects to fish and wildlife habitat and species would continue for an additional 30 to 50 years under all action alternatives. Effects to fish and wildlife resources are described in more detail in sections 3.7 and 3.11, respectively.

Compared to the size of the entire Monument, the expansion of the existing tailings pile, under any alternative, would represent about 1/100th of 1 percent of the Monument. Thus, there would be negligible effects to fish, wildlife, and their habitats on the scale of the Monument as a whole.

Ecological

Locally, within the TDF area, biotic (wildlife, aquatic species, plant, etc.) and abiotic (soils, hydrology, etc.) have been affected by mine related activities, habitat removal and alteration,

changes in topography and hydrology and similar alterations. Alternative A would result in no additional changes to the local ecological system. Alternatives B, C, and D would each result in some new disturbance within the Monument that would increase local impacts to ecological systems. Disturbance within the Monument because of these alternatives is presented in Table 3.19-3. Compared to the size of the entire Monument, the expansion of the existing tailings pile, under any alternative, would represent about 1/100th of 1 percent of the Monument. Thus, there would be negligible effects to ecological systems of the Monument as a whole. BMPs and mitigation measures would continue to be implemented to reduce the effects of the project under all alternatives. Monitoring and adaptive management will continue, providing opportunity for operational and management response to ecological effects as they are identified.

Cultural

Except for Alternative A, each alternative would result in some further development into the Monument, potentially affecting objects of cultural interest. Effects to prehistoric/historic objects are discussed above. The alternatives differ in their potential to affect unidentified cultural objects within the Monument. This risk is directly related to the physical extent of disturbance within the Monument. Alternative A would disturb the least acres within the Monument and Alternative B would disturb the most acres within the Monument (see Table 3.19-3). Compared to the size of the entire Monument, the expansion of the existing TDF, under any alternative, would represent about 1/100th of 1 percent of the Monument. Thus, there would be negligible effects to cultural objects of interest within the Monument as a whole.

3.19.3.2 Effects of Alternative A, No Action

Alternative A would have the least impact on the Monument. No further expansion of the TDF would be authorized in the Monument and reclamation would begin following a predicted closure around 2014. About 33.5 acres of disturbance would occur within the Monument.

3.19.3.3 Effects of Alternative B, Proposed Action

Alternative B would affect the largest area within the Monument and therefore have the largest effect. At the completion of mining, activities would have disturbed a total of approximately 142 acres within the Monument; 33.5 acres of that were analyzed in previous NEPA documents and authorized in the current GPO. Under Alternative B, full reclamation of the TDF would not occur for 30 to 50 years.

Mitigated Alternative B

Under mitigated Alternative B, the expansion of the TDF would result in about 2 million cubic yards of tailings and waste rock being placed in the northeast corner of the existing TDF, outside of the Monument. Approximately half of the material would be placed in the initial phase of the expansion with the remaining volume being placed in the final phase. In addition, the reclamation material storage area and quarry to the south of the

TDF would be relocated out of the Monument. The result would be a new reclamation material storage area located near the junction of the A and B roads; moving the quarry out of the Monument would require deepening the quarry at the north end of the existing TDF, which is also outside the Monument. At the completion of mining, activities would have disturbed a total of approximately 119.7 acres within the Monument; 33.5 acres of that disturbance were previously approved.

3.19.3.4 Effects of Alternative C, New TDF Located Outside Monument

Alternative C would reduce effects to the Monument compared to the proposed action by relocating most of the additional tailings storage capacity outside of the Monument at a new site. At the completion of mining, activities would have disturbed a total of approximately 42.6 acres within the Monument; 33.5 acres of that disturbance were previously approved. Reclamation of the TDF within the Monument would begin in approximately 3 years. Mine operations and associated activity that currently occur within the Monument would continue for 30 to 50 years while the mine continued to operate and place tailings at the alternative site.

3.19.3.5 Effects of Alternative D, Modified Proposed Action

Alternative D would reduce effects to the Monument compared to the proposed action by relocating some of the additional tailings storage capacity outside of the Monument at a new site. At the completion of mining, activities would have disturbed a total of approximately 60.6 acres within the Monument; 33.5 acres of that disturbance were previously approved. Reclamation of the TDF within the Monument would begin in approximately 10 years. Mine operations and associated activity that currently occur within the Monument would continue for 30 to 50 years while the mine continued to operate and place tailings at the new TDF.

3.19.4 Monument Values – Summary

Each of the alternatives would have some local effect on the Monument values. Because the tailings pile is already existing on Monument lands, many of the effects to resources described throughout this EIS have already occurred and will require reclamation to restore the land to near-natural conditions. Based on current water chemistry data, study results and the modeling that was undertaken for this analysis, long term water treatment, perhaps in perpetuity, is anticipated regardless of which alternative is developed, including the No Action Alternative.

The greatest difference between the alternatives is the spatial extent of disturbances within the Monument the period of time in which mining will continue within the Monument, and the time until reclamation occurs. Under each alternative, operational measures would be implemented to reduce effects to the Monument and reclamation would restore lands to near-natural conditions after closure.

Table 3.19-3 presents the spatial extent of disturbance within the Monument, duration of continued mining, and approximate time before reclamation of the TDF within the Monument. While local effects to values and objects of the Monument would occur from any expansion, this new disturbance is about 1/100th of 1 percent of the total Monument area (about 895,000 acres).

Table 3.19-3. Comparison of Alternatives with Respect to Monument Disturbances.

	Total Tailings-related disturbance within the Monument * (acres)	Estimated Time Before Mine Closure (years)	Estimated Time Before Existing TDF Reclamation Begins (years)
Alternative A	33.5	2–3	2–3
Alternative B	142.8	30–50	30–50
Mitigated Alternative B	119.7	30–50	30–50
Alternative C	42.6	30–50	3
Alternative D	60.6	30–50	10

* 33.5 acres of disturbance within the Monument were evaluated in previous NEPA actions are authorized in the current GPO.

3.20 Inventoried Roadless Areas

3.20.1 Background

Inventoried roadless areas are defined as undeveloped areas typically exceeding 5,000 acres that meet the minimum criteria for wilderness consideration under the Wilderness Act

This project-level analysis does not evaluate roadless areas for wilderness recommendation. However, roadless characteristics are used in this EIS to analyze and describe potential changes to roadless areas by alternative, and are discussed further in the individual resource analysis sections. Effects to roadless characteristics are summarized at the end of this section. Table 3.20-1 summarizes the roadless characteristics considered and the section in this chapter where potential effects are discussed.

Table 3.20-1. Roadless Characteristics and Discussion Section.

2000 Roadless Characteristics *	Chapter 3 Section
Soil, Water, Air	Soils; Water Resources - Surface Water; Water Resources-Groundwater; Air Quality
Sources of public drinking water	Water Resources-Surface Water
Diversity of plant and animal communities	Vegetation; Wetlands, Wildlife; Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species; Aquatic Resources
Habitat for threatened, endangered, proposed, candidate, and sensitive species and for those species dependent on large, undisturbed areas of land	Threatened, Endangered, Candidate, and Forest Service Alaska Region Sensitive Species
Primitive, Semi-Primitive Non-Motorized, and Semi-Primitive Motorized classes of recreation opportunities	Recreation
Reference landscapes	Scenic Resources
Landscape character and scenic integrity	Scenic Resources
Traditional cultural properties and sacred sites	Cultural Resources; Subsistence
Other locally identified unique characteristics	Monument Values

* November 2000 Forest Service Roadless Area Conservation FEIS (USDA 2000, Volume 1, pp. 3-3 to 3-7).

Effects are measured by acres of development and feet of road construction within roadless area boundaries, as well as total acres affected by proposed activities, including “zones of influence” that include a 600-foot buffer around the TDF and a 1,200-foot buffer placed around roads. The analysis focuses on the potential impacts to the unique or outstanding biological, physical, or social values of the IRAs. Roadless characteristics (i.e., values or features that make the area appropriate and valuable for wilderness) are described in the November 2000 Forest Service Roadless Area Conservation FEIS (FEIS Vol. 1, pp. 3-3 to 3-7). The 2001 dataset has been used to analyze the effects of proposed alternatives on the roadless characteristics of the Greens Creek (307) and Mansfield Peninsula (306) IRAs.

Inventoried roadless areas are defined as undeveloped areas typically exceeding 5,000 acres that meet the minimum criteria for wilderness consideration under the Wilderness Act and were inventoried during the Forest Service’s Roadless Area Review and Evaluation (RARE II) process, with subsequent assessments and forest planning analyses. Including Wilderness, the Tongass National Forest is currently more than 90 percent roadless.

3.20.2 Inventoried Roadless Areas – Baseline Conditions

The Forest Plan Revision SEIS (USDA 2003) outlines all the values used to evaluate the wilderness potential of the Greens Creek (307) and Mansfield Peninsula (306) IRAs (Figure 3.20-1). Both IRAs represent the typical qualities of many IRAs in southeast Alaska. Descriptions of existing conditions are used to help facilitate an understanding of the potential change to the roadless characteristics that could occur as a result of the Greens Creek Mine Tailings Disposal Facility Expansion EIS Decision. The following discussion focuses on the unique or outstanding qualities of these IRAs.

Greens Creek IRA

The Greens Creek (307) IRA is located on the north end of Admiralty Island. The southern portion of the IRA contains the Greens Creek Mine and the Monument. The Non-wilderness National Monument LUD facilitates the development of mineral resources in portions of the IRA. To the south and east of the area is the Admiralty Island National Monument-Kootznoowoo Wilderness. Greens Creek Mine and Young Bay access roads border the northern portion of the area and separate it from the Mansfield Peninsula Roadless (306) IRA. The Greens Creek Mine access road also borders the western portion of the area and provides access to the National Monument. The city of Juneau is located approximately 18 miles northeast of the area.

The Greens Creek (307) IRA is accessed primarily by private boat or chartered aircraft. Regular transportation by boat has been provided to Greens Creek Mine employees since 1987. There is no area suitable for landing wheeled airplanes. There is no public transportation in the roadless area. The Hawk Inlet trail is located north of the area, and access into the interior portion of the roadless area is by foot or helicopter (USDA 2003).

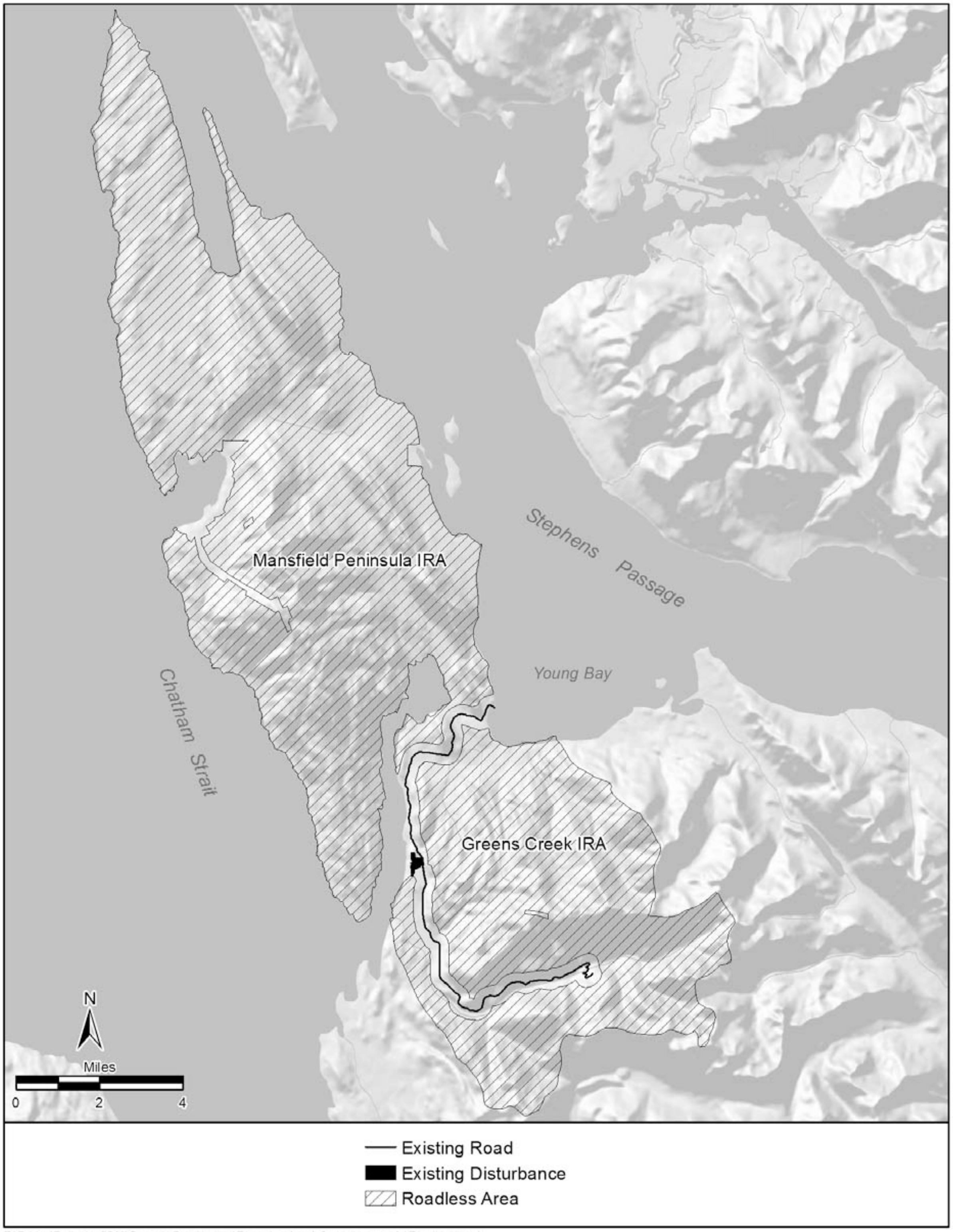


Figure 3.20-1. Inventoried Roadless Areas.

The topography of the area ranges from blocky and hummocky landforms to complex terrain with sharply defined crests and angular profiles. The main geologic features are rock outcrops and craggy peaks, and prominent escarpments dominate the view. Level plains and foothills along Young Bay include pocket clearings of muskegs, lakes, and meadows. There are 3 miles of saltwater shoreline in the area. Approximately 1,552 acres are inventoried as alpine and 715 acres are identified as rock; there are no ice or snow features (USDA 2003).

Biological Values

There are no unique ecologic values in the area. The federally listed threatened and endangered species likely to occur within or adjacent to the IRA are the humpback whale (endangered) and the Steller sea lion (threatened). Listed Chinook salmon, sockeye salmon, and steelhead occur infrequently in the inside waters of southeast Alaska.

Two Forest Service Region 10 Sensitive Species are suspected or known to occur within the area: Queen Charlotte goshawk and black oystercatcher. As inhabitants of late seral forests, Queen Charlotte goshawks are closely associated with POG and are known to nest within the roadless area. Black oystercatchers inhabit the rocky marine shorelines. Both the yellow-billed loon and dusky Canada goose may occur during migration. In addition, eight sensitive plant species are known or suspected to occur in the Juneau Ranger District.

Other important wildlife populations in the Greens Creek (307) IRA include brown bear, bald eagle, Sitka black-tailed deer, waterfowl/shorebirds, and furbearers such as marten, river otter, beaver, and mink. Black bears are not present on Admiralty Island, and moose and mountain goats have not been reported in this area.

Admiralty Island streams within the area provide habitat for pink, coho, and chum salmon. The Tongass Fish and Wildlife Resource Assessment identified all three VCUs in the area as secondary salmon producers and no VCUs as primary sport fish producers (ADF&G 1998). Fisheries resources in the project area are discussed in more detail in Section 3.7.

Physical Values

There is a very small area of high vulnerability karst in the southwest section of this roadless area adjacent to the border of the Monument. The mapped karst resources encompass 127 acres, which is less than one percent of the roadless area. Approximately 30 percent of the karst is mapped as having high vulnerability. There are no known glaciers or unique geologic features in the area.

Portions of the IRA within the project area have been affected since the inventories were conducted for the 2001 Roadless Rule. Limited geotechnical and mineral exploration drilling has been authorized.

Human modifications are not highly visible within much of this area, which is predominantly natural in appearance. The landscape character as seen from Hawk Inlet is dominated by the densely forested ridges and valleys of the Greens Creek drainage and the level plains and foothills along the shoreline. High forested ridges and numerous bodies of water form a repetitive pattern in the landscape surrounding the mine site. Within the Hawk Inlet viewshed, the existing TDF and cannery site are the most dominant human alterations. Most of the other mine facilities are not visible from the inlet.

Social Values

There are no unique scientific or educational values identified in the area. The Greens Creek (307) IRA is bordered to the east and south by wilderness. The area is bordered to the west by the Greens Creek Mine access road and an area allocated to the Transportation and Utility System LUD. The 2008 Tongass Land Management Plan Revision identifies the existing road and transportation line corridor from Young Bay to the Hawk Inlet cannery, and continuing up to the mill site. A potential transmission line corridor continues west from the Hawk Inlet cannery site outside of the roadless area. Adjacent land to the north is allocated to the Semi-remote Recreation LUD. Recreational use in the area occurs mainly along the shoreline. Areas south and east of the area are used more intensively for recreational activities. The 1998 Tongass Fish and Wildlife Resource Assessment indicated that subsistence use in the VCUs that comprise this area are not sensitive to disturbance. None of the VCUs in this area were included among the highest value community use areas (ADF&G 1998).

Evidence of prehistoric and historic use of this roadless area is documented. Historically, Tlingit clans used the area as a seasonal subsistence area. Trapper cabins have been found in the area, along with evidence of hunting and fishing camps.

Greens Creek Mine, located in the south portion of the area, employs approximately 330 workers.

Mansfield Peninsula (306) IRA

The Mansfield Peninsula IRA encompasses the northernmost portion of Admiralty Island. The area is bordered by saltwater to the north, east, west, and part of the south. Lynn Canal, Chatham Strait, and Funter Bay State Marine Park border the western portion of the area. Stephens Passage and Saginaw Channel border the area to the east. The southern portion of the area is bordered by Hawk Inlet and the Greens Creek Mine access road, which separates the area from the adjacent Greens Creek (307) IRA. It is approximately 3 miles from the eastern shore of the peninsula to the west side of Douglas Island and approximately 10 miles to Auke Bay.

The area is accessed primarily by private boats, float planes and helicopters. There is no area suitable for landing wheeled airplanes. There is no public transportation in the area. Several anchorages are found adjacent to the peninsula, including Funter Bay, Barlow Cove, and Hawk Inlet. Access into the interior is by foot or helicopter. There are several trails used to access 11 isolated privately owned hunter, recreation, and residence cabins located within the area. The area also includes Bear Creek Trail and part of the old Hawk Inlet Road, which is now used as a trail.

Biological Values

There are no unique ecologic values in the area. Like the Greens Creek (307) IRA, the federally listed threatened and endangered species likely to occur within or adjacent to the IRA are the humpback whale (endangered) and the Steller sea lion (threatened). Listed Chinook salmon, sockeye salmon, and steelhead occur infrequently in the inside waters of southeast Alaska.

Two Forest Service Region 10 Sensitive Species are suspected or known to occur within the area: Queen Charlotte goshawk and black oystercatcher. As inhabitants of late seral forests, Queen Charlotte goshawks are closely associated with POG and are known to nest within the roadless area. Black oystercatchers inhabit the rocky marine shorelines. Additionally, both the yellow-billed loon and dusky Canada goose may occur during migration. In addition eight sensitive plant species are known or suspected to occur in the Juneau Ranger District.

The Mansfield Peninsula supports a large population of brown bear as well as Sitka black-tailed deer. Wolves may be present (MacDonald and Cook 1999), as well as furbearers such as marten, mink, and beaver. Black bears are not present on Admiralty Island, and moose and mountain goats have not been reported in this area.

Physical Values

There are no known karst or cave resources in this roadless area. There are no glaciers or known unique geological features.

The visual condition of the area is predominantly natural. The area appears natural when viewed from Lynn Canal, Saginaw Canal, Funter Bay State Marine Park, Barlow Cove, and the hiking trails within the area. Viewed from Hawk Inlet, the roadless area itself appears unmodified, but the Greens Creek Mine access road, which partially borders the area to the south, affects the perceived naturalness of the landscape.

Social Values

There are no unique scientific or educational values identified in the area. The area is located approximately 10 miles southwest of Juneau and is reasonably accessible. Approximately 11 isolated hunter or recreation residence cabins are under special use permit in this area, and most are accessed from the eastern shoreline which is closest to Juneau. Hunting is the primary activity in the area. There are no public recreation cabins, but there are several trails used to access recreation residences as well as Bear Creek Trail and part of the Hawk Inlet Trail. Subsistence use occurs in the area (USDA 2003). The Tongass Fish and Wildlife Resource Assessment (ADF&G 1998) identified two of the VCUs in this area (VCUs 125 at the northern tip and VCU 128 along Hawk Inlet) as subsistence use areas with a high sensitivity to disturbance. None of the VCUs in this area were included among the highest, second, or third group for community use values (ADF&G 1998).

The Mansfield Peninsula has had a long history of use. Native use of the area focused on fishing and hunting. Goldschmidt and Haas (1946) identified commercial fish traps along the west shore of the peninsula. They also identified hunting or trapping, a former camp, and a former village in the area. More recent history reveals the importance of mining in the area. Much of the peninsula contains evidence of active or historic mining claims (USDA 2003).

3.20.3 Inventoried Roadless Areas – Environmental Consequences

3.20.3.1 Effects Common to All Alternatives

Under all action alternatives, portions of the IRAs would be affected by TDF expansion. Most IRA acres affected would occur within the zones of influence as a result of the 600-foot buffer around roads and 1,200-foot buffer around facilities. In all alternatives, the Greens Creek (307) and Mansfield Peninsula (306) IRAs would remain greater than 5,000 acres in size. Mining activities would continue through 2014 under Alternative A and for an additional 30 to 50 years under the action alternatives. For each alternative, Table 3.20-2 displays the length of new road, acres of development, acres that would be affected within the zone of influence or roads and facilities, and total acres affected within each IRA. As a result of each alternative, some roadless characteristics (e.g., ecologic values, natural integrity and appearance, scenic values, and semi-primitive and primitive recreation opportunities) may be reduced within the project area, although this would only occur within a small percentage of either IRA. These effects would diminish to some degree following mine closure and reclamation. Figure 3.20-2 shows IRAs along with the disturbance footprint of each alternative at the existing TDF site. Figure 3.20-3 shows the same at the north site.

Table 3.20-2. Acres of IRA Affected by each Alternative.

	Alternative A	Alternative B	Mitigated Alternative B	Alternative C	Alternative D
Length of New Road (feet)					
Greens Creek (307)	0	1,400	1,400	0	0
Mansfield Peninsula (306)	0	0	0	163	120
Acres of Development					
Greens Creek (307)	1	26	18.8	1	3
Mansfield Peninsula (306)	0	0	0	51	46
Acres Effected in Zone of Influence					
Greens Creek (307)	12	78	85	21	26
Mansfield Peninsula (306)	0	0	0	112	74
Total acres affected					
Greens Creek (307)	13	104	105	22	29
Mansfield Peninsula (306)	0	0	0	163	120
Percent of IRA affected					
Greens Creek (307)	0.05	0.38	0.39	0.08	0.11
Mansfield Peninsula (306)	0.00	0.00	0.00	0.30	0.22

For both IRAs, the roadless characteristics would be modified locally. No unique attributes would be affected. The biological value of old-growth forest would be reduced proportionately by the amount of old growth removed in each roadless area. The scenic condition of the IRAs would only be slightly changed compared to the existing condition.

3.20.3.2 Effects of Alternative A – No Action

Under Alternative A, the No Action Alternative, the mine would continue to operate until 2014. No new roads would be constructed within either IRA. About 1 acre of facilities would be constructed within the Greens Creek IRA at full build-out in 2014. Approximately 12 acres would be affected within the zone of influence facilities and roads. This would result in about 13 acres, less than 0.1 percent of the Greens Creek (307) IRA, being affected.

3.20.3.3 Effects of Alternative B

Under Alternative B, the mine would continue to operate for an additional 30 to 50 years. Approximately 1,400 feet of new road would be constructed within the Greens Creek (307) IRA. Alternative B would affect the greatest amount of acres within the Greens Creek (307) IRA, totaling approximately 104 acres, or about 0.4 percent of the IRA. There would be no new impacts to the Mansfield Peninsula (306) IRA, although operations in Hawk Inlet would be viewable from the Mansfield Peninsula and would continue for decades.

Figure 3.20-2 shows each action alternative footprint in relation to IRAs at the existing TDF site.

Mitigated Alternative B

Under mitigated Alternative B, the mine would continue to operate for an additional 30 to 50 years. Approximately 1,400 feet of new road would be constructed within the Greens Creek (307) IRA. Mitigated Alternative B would affect 105 acres within the Greens Creek (307) IRA. There would be no new impacts to the Mansfield Peninsula (306) IRA, although operations in Hawk Inlet would be viewable from the Mansfield Peninsula and would continue for decades.

3.20.3.4 Effects of Alternative C

As with Alternative B, Alternative C would extend the mine life an additional 30 to 50 years. However, there would be no new road construction in either IRA and less effect on the Greens Creek (307) IRA. Tailings disposal would continue at the existing TDF for approximately 3 years while a new TDF would be constructed to the north, partially within the Mansfield Peninsula (306) IRA. While Alternative C would result in less acres of effect within the Greens Creek IRA compared to Alternative B, the total effect on any IRA would be increased. Alternative C would result in about 22 acres (less than 0.1 percent) of effects within the Greens Creek (307) IRA and 163 acres (about 0.3 percent) within the Mansfield Peninsula (306) IRA, totaling approximately 185 acres the most of any alternative.

Figure 3.20-3 shows the footprints of alternatives C and D in relation to IRAs at the north site.

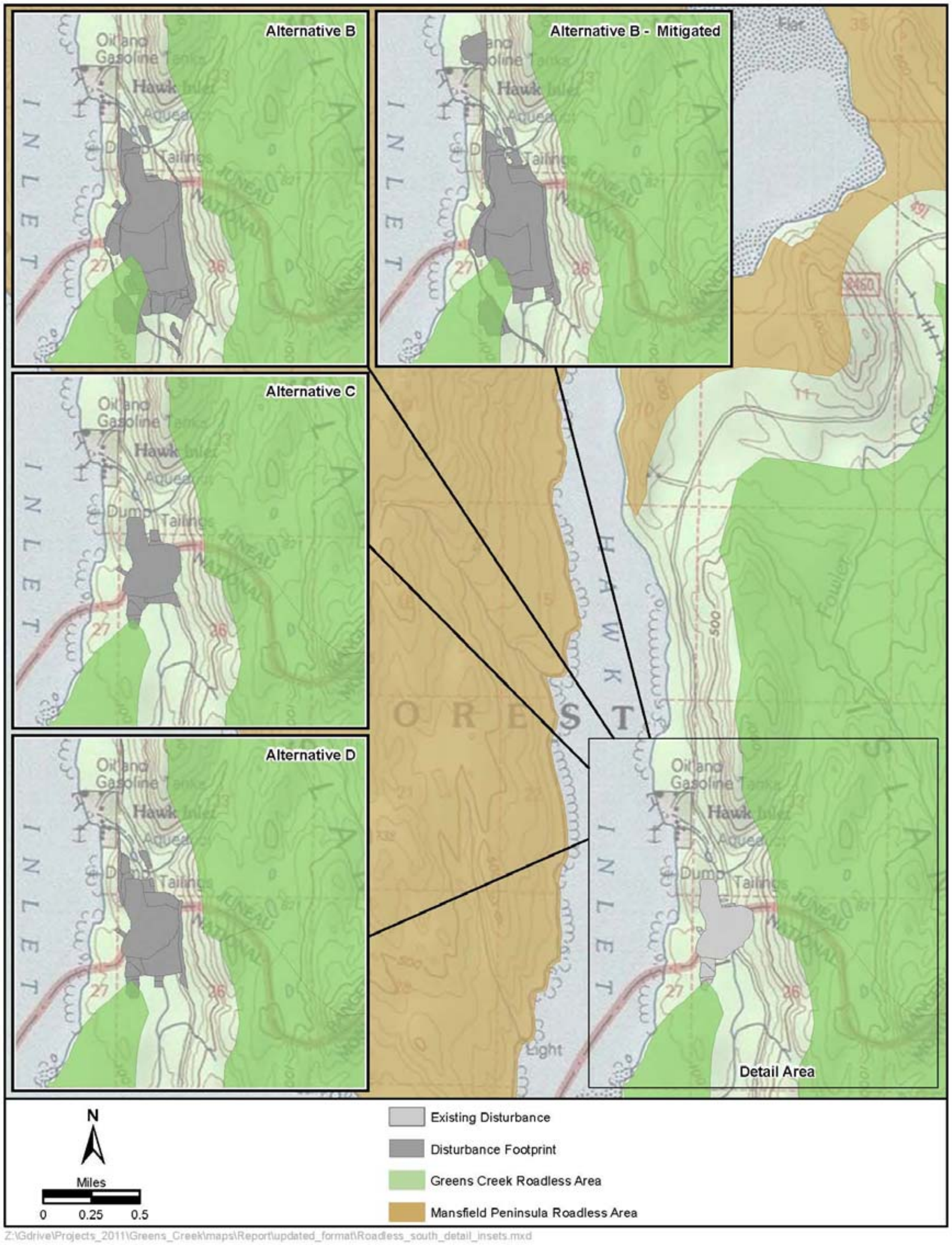


Figure 3.20-2. Alternative Footprints – South.

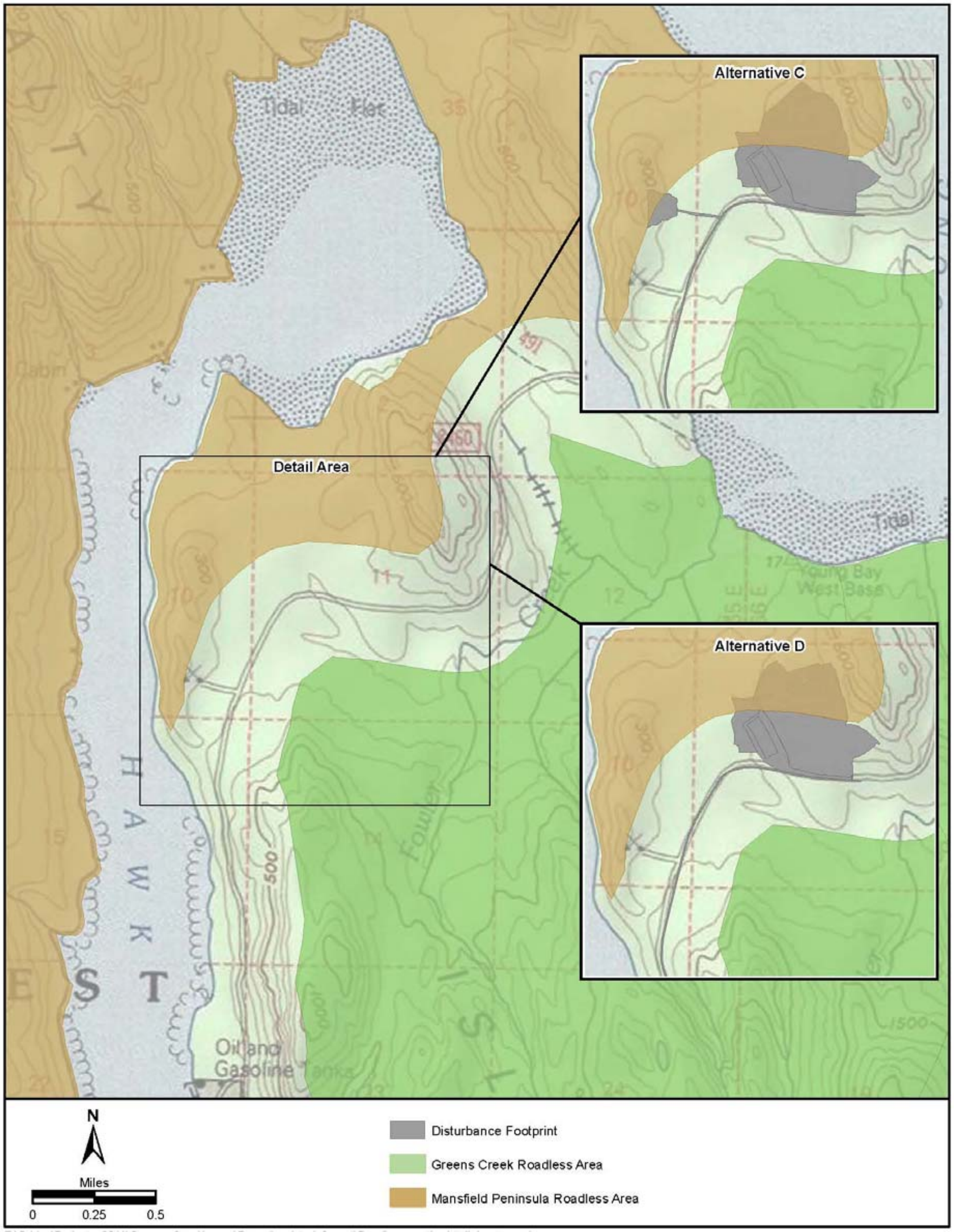


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Figure 3.20-3. Alternative Footprints (C and D) – North Site.

3.20.3.5 Effects of Alternative D

The effects of Alternative D are similar to those of Alternative C. The mine would continue to operate for an additional 30 to 50 years. No new road construction in either IRA would occur. While tailings disposal continues at the existing TDF for about 10 years, a new TDF would be constructed to the north, partially within the Mansfield Peninsula (306) IRA. Alternative D would also reduce effects within the Greens Creek (307) IRA compared to Alternative B while adding effects to the Mansfield Peninsula (306) IRA. Alternative D would result in about 29 acres (about 0.1 percent) of effects within the Greens Creek IRA and 120 acres (about 0.2 percent) within the Mansfield Peninsula (306) IRA, totaling approximately 149 acres. Alternative D would result in fewer IRA acres affected than Alternative C due, in part, to the elimination of a quarry along the A road.

3.20.4 Roadless Areas – Summary

The activities currently proposed are not likely to significantly affect the roadless characteristics of the Greens Creek and Mansfield Peninsula IRAs. No unique attributes would be affected. In all alternatives, the Greens Creek Mansfield Peninsula IRAs would remain greater than 5,000 acres in size. When considering the potential change to the roadless characteristics of the IRAs, Alternative C would affect the most acres within the two IRAs but does not include new road construction with IRAs. Facility development (all action alternatives) and road construction (Alternative B only) at the south TDF site would occur adjacent to existing facilities. Only alternatives C and D would result in a new affect to the Mansfield Peninsula (306) IRA. No alternative would result in more than 0.4 percent of either IRA being affected. The individually identified roadless values would either remain unchanged or be minimally influenced by any alternative activities. Effects to either of these IRAs would diminish to some degree following mine closure and reclamation.

3.21 Environmental Justice

3.21.1 Background

The resource analysis of environmental justice was not identified as a significant issue; comments from the scoping process regarding environmental justice are addressed in this section.

This section addresses environmental justice and is formatted differently than other resource sections in this EIS. The analysis presents a brief description of the policies and guidance related to environmental justice, an assessment of how environmental justice applies in the region, and the effect the project may have in terms of environmental justice.

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires each federal agency to make the achievement of environmental justice part of its mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. The Order further stipulates that the agencies conduct their programs and activities in a manner that does not have the effect of excluding persons from participation in them, denying persons the benefits of them, or subjecting persons to discrimination because of their race, color, or national origin.

Evaluating whether a proposed action has the potential to have disproportionately high and adverse impacts on minority and/or low income populations typically involves: (1) identifying any potential high and adverse environmental or human health impacts,(2) identifying any minority or low income communities within the potential high and adverse impact areas, and (3) examining the spatial distribution of any minority or low income communities to determine if they would be disproportionately affected by these impacts.

Guidelines provided by the Council on Environmental Quality (CEQ) (1997) and USEPA (USEPA 1998) indicate that a minority community may be defined where either: (1) the minority population comprises more than 50 percent of the total population, or (2) the minority population of the affected area is meaningfully greater than the minority population in the general population of an appropriate benchmark region used for comparison. Minority communities may consist of a group of individuals living in geographic proximity to one another, or a geographically dispersed set of individuals who experience common conditions of environmental effect. Further, a minority population exists if there is “more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds” (CEQ 1997, page 26).

The CEQ and USEPA guidelines indicate that low income populations should be identified based on the annual statistical poverty thresholds established by the U.S. Census Bureau. Like minority populations, low income communities may consist of individuals living in geographic proximity to one another, or a geographically dispersed set of individuals who would be similarly affected by the proposed action or program. The U.S. Census Bureau defines a poverty area as a census tract or other area where at least 20 percent of residents are below the poverty level (U.S. Census Bureau 2011b).

Communication and Outreach

Government-to-Government Consultation

As discussed in this section, the community of Angoon is considered an environmental justice community. From the beginning of the NEPA process, the Forest Service has worked to ensure that Angoon has been sufficiently involved in the decision-making process, and that the analysis has considered the potential for disproportionately high adverse effects to the local population.

The Forest Service conducted consultations with Alaska Native groups on October 15, 2010, to comply with Executive Order 13175, which addresses consultation and coordination with Indian tribal governments. The purpose of the meetings was to explain the nature of the project and to solicit comments and concerns. The Forest Service conducted government-to-government consultations to solicit comments on the project from the Angoon Community Association and Kootznoowoo Incorporated on October 15, 2010, and held a follow up meeting with Kootznoowoo on November 10, 2010. Additional consultation occurred with the Angoon Community Association on October 13, 2011. The Sealaska Corporation declined the Forest Service offer to consult on a government-to-government basis.

During consultations with the Forest Service, the Angoon Community Association expressed concern about the effects on fish and wildlife and indicated that Hawk Inlet, along with all of Admiralty Island, is considered a Sacred Place. The Angoon Community Association has indicated that Hawk Inlet is a traditional migration and trade route between Chatham Straight and Stephens Passage; an important source of food, both from freshwater streams and the marine environment; and the inlet is important to elders, as many of them grew up and learned their traditions in that area.

Scoping

Public scoping for this EIS was initiated with publication of a Notice of Intent (NOI) to prepare an EIS in the Federal Register on October 5, 2010. The Forest Service also mailed a scoping document to a mailing list developed by the Forest Service.

The scoping process was intended to provide information about the proposed project and solicit comments from local, state, and federal agencies; tribes; non-governmental organizations; and the public. In addition to the NOI, the Forest Service placed a public notice in the Ketchikan Daily News and the Juneau Empire on October 8, 2010 (each running 4 days), and used email to advertise public meetings. The Forest Service held public meetings in Juneau on October 14, 2010, and in Angoon on October 15, 2010. The purposes of the scoping meetings were to provide project information to the public, solicit comments from the public, and inform the public on how to participate in the process.

Attendance at the public meetings consisted of representatives from the Forest Service and cooperating agencies, the proponent, Non-Governmental Organizations, and individuals. Fifteen people signed the attendance sheets at the public meeting in Juneau, and 20 signed in at the Angoon meeting.

This scoping process is documented in the Scoping Summary Report prepared for the project (Tetra Tech 2011b). This report summarizes the scoping process, presents the concerns and issues that were identified during the scoping process, and describes how the scoping comments will be addressed in the EIS.

3.21.2 Environmental Justice – Baseline Conditions

Geographic Communities

Census data that may be used to identify the presence of minority and low income populations in the vicinity of the proposed project are presented in Section 3.19, Socioeconomics. Data on race and ethnicity were compiled as part of the 2010 Census. As noted in the Socioeconomics section, the CBJ annexed the mine in 1994. The surrounding areas are part of the Hoonah-Angoon CA, an unincorporated area that is considered equivalent to a Borough in Alaska (or a County in the lower 48 states) for data compilation purposes.

Data on median household income and poverty compiled by the Census Bureau for 2009 are summarized in Table 3.18-2 in the Socioeconomics section. Data are presented for Juneau, the Hoonah-Angoon CA, and the State of Alaska. Data are not available in this series at the place or census tract level.

Review of these data suggests that the communities of Angoon and Hoonah and the population of the entire Hoonah-Angoon CA may be considered minority communities because the combined minority population comprises more than 50 percent of the total population in these areas. The majority of the populations in the CBJ and the census tract that encompasses the mine site are White, with 70 percent and 76 percent of their respective populations identifying as White in the 2010 Census (Table 3.18-4).

The data on median household income and poverty summarized in Table 3.18-2 suggest that the Hoonah-Angoon CA could be considered a low income community. Although less than 20 percent of the population was identified as below the poverty level in 2009, median household income in this area was just 63 percent of the State of Alaska median, which suggests the area may be considered low income. Median household income was 9 percent higher than the State of Alaska average in the CBJ in 2009, and the percent of the population below the poverty level was lower than the State of Alaska average (Table 3.18-2).

Communities of Shared Interest

The term community of shared interest is used here to refer to geographically dispersed individuals who could experience common conditions of environmental effect. Potential impacts to subsistence use are addressed in Section 3.16, Subsistence. Communities of shared interest in the vicinity of the mine include subsistence users.

3.21.3 Environmental Justice – Environmental Consequences

3.21.3.1 Effects Common to All Alternatives

Potential high and adverse environmental impacts are addressed by affected resource elsewhere in this EIS. There are no communities located near the mine site. There are recreational cabins located at Wheeler Creek, approximately 5 miles from the mine site, and Funter Bay is located approximately 10 miles from the mine and proposed project. Although the mine site is part of the CBJ, it is located approximately 15 miles from the closest populated parts. The nearest minority communities are Hoonah (28 miles) and Angoon (44 miles). None of these communities are expected to be affected by the action alternatives (alternatives B, C, and D).

Impacts to subsistence use are addressed in Section 3.16, Subsistence. Hawk Inlet is not in the Customary and Traditional Use Area for any rural communities, but the area has long been used for subsistence hunting, fishing, and gathering. However, the reliance on subsistence resources harvested in this area is minor and the impacts of the action alternatives on fish and wildlife resources are expected to be negligible. As a result, the potential impacts of the action alternatives on the subsistence use of wildlife, fish, or other resources are expected to be very low and would not disproportionately affect minority or low income populations.

3.21.3.2 Effects of Alternative A – No Action

Under Alternative A, the No Action Alternative, the mine would continue to operate until 2014 and continue to support the annual direct and indirect employment and associated payroll. Following 2014, the mine would close, which would result in an annual loss of 493 direct and indirect jobs and $48 million in direct and indirect payroll. These reductions in employment and payroll would primarily affect the CBJ and would not be expected to disproportionately affect minority or low income populations.

3.21.3.1 Effects of Alternatives B, C, and D

As discussed in the Effects Common to All Alternatives section, none of the proposed action alternatives are expected to disproportionately affect minority or low income populations.

3.21.4 Environmental Justice – Summary

Under Alternative A, reductions in payroll and income would primarily affect the CBJ and would not be expected to disproportionately affect minority or low income populations. The proposed action alternatives (alternatives B, C, and D) are not expected to affect the closest minority communities—Hoonah and Angoon—and the reliance on subsistence resources harvested in the affected areas are minor and the impacts of the action alternatives on fish and wildlife resources are expected to be negligible. The Forest Service has made a concerted effort to involve the environmental justice communities in the NEPA process, including encouraging comments during scoping and holding government-to-government consultation meetings.

3.22 Cumulative Effects

Cumulative effects are defined in the CEQ regulations as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).

This section considers the cumulative effects by judging whether the direct and indirect effects of the proposal are significant when coupled with the effects from other past, present, and reasonably foreseeable future actions. Cumulative actions are defined as "actions, which when viewed with other proposed actions, have cumulatively significant impacts and should therefore be discussed in the same impact statement" (40 CFR 1508.25).

This section presents a discussion of the potential cumulative effects associated with the proposed project and is presented in three sections: Section 3.22.1, Basis for Assessment, addresses the basis of the evaluation including the regulatory framework, scope, and lists the past, present, and reasonably foreseeable future actions. Section 3.22.2, Descriptions of Selected Relevant Actions, describes relevant actions addressed. Section 3.22.3, Cumulative Effects by Resource, addresses the potential cumulative effects associated with the proposed project when considered together with the relevant past, present, and reasonably foreseeable actions.

3.22.1 Basis for Assessment

3.22.1.1 Scope of the Analysis

The Greens Creek Mine and its TDF already exist. Alternative A considered in this document represents a continuation of the existing mining operation through 2014. All action alternatives represent an extension of mining operations of 30 to 50 years based on the current knowledge of the mineral resources, the positive forecast for the metals market, the historic success in replacing reserves over two decades, and the possibility of identifying and defining additional economic resources at the site through continuing exploration activities. Proper final closure would include reclamation of the TDF in a stabilized and re-vegetated condition. Consequently all analyses of impacts throughout this chapter consider the impact of the mine operation in the past, combined with the anticipated impacts of future operations.

The scope for the analysis of cumulative impacts used in this EIS includes the following:

- Identify potential effects of the expansion of the TDF and attendant extended life of the Greens Creek Mine that may occur on the natural resources and human environment;
- Analyze other past, present, and reasonably foreseeable future projects that reasonably could affect the natural resources in the vicinity of the Greens Creek Mine;
- Attempt to quantify effects by estimating the extent of changes to existing environment; and
- Consider the guiding principles from existing standards, criteria, and policies that control the management of the natural resources of concern.

To keep the cumulative effects analysis useful, manageable, and concentrated on the effects that are meaningful, greater weight has been given to activities that are more certain and geographically close to the project with a focus on issues of greatest concern.

The analysis of impacts to different resources has involved the use of different spatial boundaries. For example, in analyzing the impacts to scenic resources, it makes sense to analyze impacts within visual range of the project or other portions of the mine. In analyzing socioeconomic impacts, the boundaries of the analysis are expanded to the effect of the continued life of the mine on the economy of the CBJ.

Likewise, the analysis of impacts to different resources involved the use of different temporal boundaries. Direct impacts to wildlife from the activities associated with the operation of the mine or reclamation can be measured in a shorter timeframe than the potential effects of the TDF on water quality and secondary impacts to fish, wildlife, and vegetation, which can be longer term.

3.22.1.2 Alternatives Chosen for Evaluation

Overall, there would be very small differences between any of the action alternatives in terms of cumulative effects. These small differences are greatly overshadowed by the inherent uncertainty in making estimates of past, present, and reasonably foreseeable cumulative effects. Therefore, one analysis is presented for all three action alternatives.

3.22.1.3 Selection of Relevant Past, Present and Reasonably Foreseeable Actions

Based on a review of published material and available information about the Tongass National Forest and Admiralty Island on various agency websites and the scoping process, an initial list of existing, proposed, and reasonably foreseeable actions in the region was compiled to be assessed for inclusion in this cumulative effects evaluation. Resources drawn from include the Forest Service Schedule of Proposed Actions report April 2011 through June 2011 (USFS 2011a), October 2011 through December 2011 (USFS 2011b), January 2012 through March 2012 (USFS 2012), the Alaska Department of Transportation and Public Facilities Project Information as of April 2011, the results of the scoping process, and agency comments.

Some general criteria were developed to help assess the relevance of each past, present, and reasonable foreseeable actions. The relationships of the general criteria to the environmental resources evaluated in this EIS are summarized in Table 3.22-1. The basis and resources listed in Table 3.22-2 identifies potential effects of each action. The evaluation of applicable effects that contribute to cumulative effects is discussed under each resource below.

The long list of potentially relevant past, present, and reasonably foreseeable actions was reviewed to assess the actions for relevance in this evaluation of cumulative effects and circulated to key stakeholder agencies to enlist their help in assessing the actions for relevance in this evaluation of cumulative effects (Table 3.22-2).

This cumulative effects analysis does not attempt to quantify the effects of past human actions by adding up all prior actions on an action-by-action basis. The only major past action in the proposed project area is the operation of the mine. By looking at current conditions, residual effects of past human actions and natural events are captured, regardless of which particular action or event contributed those effects. In addition, the Council on Environmental Quality issued an interpretive memorandum on June 24, 2005 regarding analysis of past actions, which states, "agencies can conduct an adequate cumulative effects analysis by focusing on the current aggregate effects of past actions without delving into the historical details of individual past actions." For these reasons, the analysis of past actions in this section is based on current environmental conditions as described in the previous sections (sections 3.2 through 3.22) and summarized below by resource.

3.22.2 Descriptions of Selected Relevant Actions

Angoon Airport Project

According to the 2007 Angoon Airport Master Plan prepared by the Alaska Department of Transportation and Public Facilities, the proposed airport would be designed around a single 3,300-foot runway with a full length parallel taxiway system. This runway would accommodate all small aircraft that are forecast to use the airport. Planned ancillary developments would include an aircraft parking apron, aircraft maintenance and storage facilities, and various support facilities, all of which would be situated to interface with the proposed taxiway system. A terminal building and associated parking lot is also anticipated to provide arriving and departing passengers shelter during inclement weather (FAA 2011). The Final EIS is expected to be completed in early 2013 (USFS 2011b).

Table 3.22-1. Relationship of Selection Criteria to Environmental Resources.

Resource	Selection Criteria	
General	1	Actions are planned (beyond speculation), are located in the same spatial scale (within proximity of the proposed action on Admiralty Island), and are able to be implemented within the same temporal scale (operating life of 30–50 years) of the proposed action.
General	2	Actions have international or global importance (e.g., climate change).
Air Quality	3	Actions are within the same general air shed as the proposed action.
Geotechnical Stability	4	Actions are within the same watersheds as the proposed action.
Geochemistry	5	Actions are within the same watersheds or aquifer as the proposed action.
Water Resources	6	Actions are within the same watersheds or aquifer as the proposed action.
Aquatic Resources	7	Actions occur within the same watersheds as the proposed action and Hawk Inlet.
Soils	8	Actions involve a disturbance area that overlaps with the proposed action (project area).
Vegetation	9	Actions involve vegetative zones and geographic distribution of plant communities that overlap with the study area for the proposed action (project area).
Wetlands	10	Actions are within the same watersheds as the proposed action.
Wildlife	11	Actions occur within wildlife habitats, ranges, or migratory corridors that overlap with the study area for the proposed action (Admiralty Island and surrounding waters).
Threatened and Endangered Species	12	Actions occur within wildlife habitats, ranges, or migratory corridors that overlap with the study area for the proposed action (Admiralty Island and surrounding waters).
Land Use	13	Actions occur within geographic areas that overlap with the study area for the proposed action (Admiralty Island).
Scenic Resources	14	Actions occur within the same viewshed as the proposed action
Recreation	15	Actions occur within geographic areas that overlap with the study area for the proposed action (project area).
Subsistence	16	Actions involve locations, habitats, ranges, or migratory corridors of subsistence resources that overlap with the study area for the proposed action.
Cultural Resources	17	Actions occur within geographic areas that overlap with the study area for the proposed action.
Socioeconomics	18	Actions occur within the CBJ and on Admiralty Island that could affect the area in terms of economics, commerce, or culture.
Monument Values	19	Actions occur within the geographic boundaries of the Monument and overlap with the study area for the proposed action.
Inventoried Roadless Areas	20	Actions occur within the Greens Creek or Mansfield Peninsula IRAs
Environmental Justice	21	Actions occur within geographic areas that overlap with the study area for the proposed action.

Table 3.22-2. General Criteria Applied in Selecting Relevant Actions for this Evaluation.

Action	Relevant	Basis	Resources
Tongass National Forest, Admiralty National Monument			
Angoon Airport Project (facility and road management, City of Angoon)	Y	Construction of a new commercial airport near the village of Angoon. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 11, 12, 18, 19.	Wildlife, Threatened and Endangered Species, Socioeconomics, Monument Values
Hecla Greens Creek Mine (exploration drilling)	Y	Continuation of surface exploration program; provide safe helicopter landings and drill pads. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20.	Air Quality, Geotechnical Stability, Water Resources, Geochemistry, Aquatic Resources, Soils, Vegetation, Wetlands, Wildlife, Threatened and Endangered Species, Land Use, Scenic Resources, Recreation, Subsistence, Cultural Resources, Socioeconomics, Monument Values, IRAs
Hecla Greens Creek Mine (geotechnical drilling)	Y	Mineral exploration and drilling. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20.	Air Quality, Geotechnical Stability, Water Resources, Geochemistry, Aquatic Resources, Soils, Vegetation, Wetlands, Wildlife, Threatened and Endangered Species, Land Use, Scenic Resources, Recreation, Subsistence, Cultural Resources, Socioeconomics, Monument Values, IRAs
Kanalku Creek Barrier Modification (modify partial barrier falls for improved migration of sockeye, southeast corner of Mitchell Bay)	Y	Modification of barrier falls. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 11, 12, 19,	Wildlife, Threatened and Endangered Species, Monument Values
Pack Creek Zoological Area Outfitter/Guide Permitting (recreation and special use management in Park Creek Zoological Area, Skagway-Hoonah-Angoon Boroughs)	Y	Nature based viewing outfitting and guiding activities. Applicable selection criteria include 1, 11, 12, 19.	Wildlife, Threatened and Endangered Species, Monument Values
Angoon Thayer Creek Hydroelectric Project	Y	Construction of a hydroelectric facility on Thayer Creek. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 11, 12, 18, 19	Wildlife, Threatened and Endangered Species, Socioeconomics, Monument Values

Table 3.22-2. General Criteria Applied in Selecting Relevant Actions for this Evaluation.

Action	Relevant	Basis	Resources
Admiralty Cove Trail Project: completion of trails	Y	Completion of trails near Admiralty Cove. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 11, 12, 15, 19	Wildlife, Recreation, Threatened and Endangered Species, Monument Values
Whitewater Bay Nonnative Invasive Plant Control	Y	Control of NNIP in Whitewater Bay. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 9, 11, 19	Wildlife, Threatened and Endangered Species, Monument Values
Isolated or recreational residence cabins	Y	Permitted cabins on Mansfield Peninsula. Applicable selection criteria include 1, 11, 12, 15, 20.	Wildlife, Threatened and Endangered Species, Recreation, IRAs.
Mt. Robert Barron Communication Site	Y	Permitted communication site on the Mansfield Peninsula. Applicable selection criteria include 1, 11, 12, 20.	Wildlife, Threatened and Endangered Species, IRAs.
Alaska Department of Transportation and Public Facilities			
Angoon Ferry Terminal Passenger Facility (in preconstruction phase)	Y	Construct ferry terminal building/shelter with utilities and facilities for ferry passengers which may include parking and staging area improvements. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 11, 12.	Threatened and Endangered Species
Angoon Ferry Terminal Improvement (in construction phase)	Y	Upgrades to existing bridge, float, dolphins, and structures to accommodate the fast ferry and LeConte class vessels to provide more options for ferry service to Angoon. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 11, 12.	Threatened and Endangered Species
Other			

Table 3.22-2. General Criteria Applied in Selecting Relevant Actions for this Evaluation.

Action	Relevant	Basis	Resources
Indian Reservation Road Route 0025	N	Not selected for evaluation. Planned action is the development of a roadway. Although this action could take place within the operating life of the proposed action, it is considered too speculative to contribute to an evaluation of potential cumulative effects.	N/A
Shee Atika ongoing timber harvest on private lands south of the mine	Y	Timber harvest on private lands. Selected for this cumulative effects evaluation. Applicable selection criteria include 1, 11, 12, 18.	Wildlife, Threatened and Endangered Species, Socioeconomics

Hecla Greens Creek Mine (Exploration Drilling)

The HGCMC plans to continue its surface exploration program in 2012 and proposes limited or minimal tree cutting in the Greens Creek IRA to provide safe helicopter landings and drill pads (USFS 2011a). Similar exploration programs are anticipated throughout mine operations (up to 50 years if the expansion is approved).

Hecla Greens Creek Mine (Geotechnical Drilling)

Geotechnical and hydrologic drilling were conducted in the project area in summer and fall 2011. No more than three sites were located within the Greens Creek IRA, with less than 1.75 acres total ground disturbance. No roads were constructed (USFS 2011b).

Angoon Ferry Terminal Passenger Facility

Construct ferry terminal building/shelter with utilities and facilities for ferry passengers. Parking and staging area improvements may also be constructed. It is currently in the preliminary design and scoping stage as of April 2011.

Angoon Ferry Terminal Improvement

Angoon Ferry Terminal is in the construction stage to replace conventional mono-hulled service to Angoon with service by Alaska Marine Highway System Fast Vehicle Ferries Fairweather or Chenega when transiting between Sitka and Juneau. This will increase the frequency of service to Angoon and increase opportunities for the residents to go to Sitka and Juneau by stopping in Angoon once in one direction on each round trip between Juneau and Sitka. This federally funded project consists of removing the existing ferry terminal and constructing new ferry terminal structures. Work includes furnishing and installing a new steel transfer bridge; steel float system and associated pile restraints, fenders and intermediate ramp and apron systems; six-pile supported mooring and breasting dolphin structures, and other miscellaneous work (State of Alaska 2010).

Kanalku Creek Barrier Modification

The Forest Service proposes to improve sockeye salmon passage over a partial fish passage barrier falls on the outlet stream from Kanalku Lake. The project area is located nearly 8 air miles from the community of Angoon, Alaska on Admiralty Island and is within the Kootznoowoo Wilderness Area, which is part of the Monument. The decision to implement this action was made in February 2012.

Angoon Thayer Creek Hydroelectric Project

The development of a hydroelectric facility on Thayer Creek to supplement the use of diesel generators by the City of Angoon was authorized in May 2009. The facility is a 1 megawatt run of river hydroelectric facility located approximately 6 miles north of Angoon that includes a diversion dam, penstock, powerhouse, transmission lines and access roads. An application for a special use permit from the Forest Service was submitted in summer 2011 for installation of a stream gauge on Thayer Creek, locating and brushing the proposed access road center line and exploratory drilling for quality of quantity of rock quarries (USFS 2011c).

Shee Atika Timber Harvest

Timber harvesting has occurred and could occur in the future on private lands on Admiralty Island south of the mine.

Admiralty Cove Trail Project

This proposal involves the completion of trails from Admiralty Cove Cabin to Young Lake trail, with potential trail to Mole Harbor trail and Mitchell Bay trail. This is an American Recovery and Reinvestment Act (ARRA) project in agreement with SAGA (USFS 2011d).

Whitewater Bay Nonnative Invasive Plant (NNIP) Control

To control invasive plants, this project uses volunteers to hand-pull species hidden in the beach rye grass in Whitewater Bay, Kootznoowoo Wilderness Area. The existing project has been ongoing for three plus years with significant progress in controlling the spread of black bindweed. Additional work proposed includes one week long trips in the next two years (USFS 2011e).

Isolated and Recreational Residence Cabins

The Forest Service permits approximately 11 cabins on the Mansfield Peninsula. Most of these cabins are located on the eastern shore of the Mansfield Peninsula or in Barlow Cove, closest to Juneau.

Mt. Robert Barron Communication Site

Continued operation of communication site(s) located on Mt. Robert Barron on the Mansfield Peninsula.

3.22.3 Cumulative Effects by Resource

The above-described actions are reasonably foreseeable to occur in or affect resources in the general vicinity of the proposed action and therefore are included in the cumulative effects evaluation. The actions comprise primarily two types of activities: (1) drilling

(Hecla Greens Creek Mine exploration and geotechnical drilling) and (2) construction and operation of expanded or new facilities and infrastructure (Angoon Airport, Angoon Ferry Terminal Passenger Facility, and Terminal Improvement). The main source of cumulative impacts for the proposed action is the continued operation of the mine and its associated facilities such as the mill, roads, offices, Young Bay dock, and Hawk Inlet seaplane, and barge loading docks. The potential cumulative effects of the proposed action when considered together with these relevant actions are discussed below by resource.

Climate Change

Climate change refers to the large scale, global changes in precipitation patterns and temperatures over time, resulting from human activity and natural variability. Climate change has been included in this document because it is an ongoing condition that must be taken into consideration when evaluating the cumulative effects of the proposed action alternatives.

Ongoing climate change research has been summarized in reports by the United Nations Intergovernmental Panel on Climate Change. The reports conclude that greenhouse gas emissions are the main source of accelerated climate change. Impacts of projected climate change include sea level rise, increase in air temperature, as well as changes in climate and weather patterns (Climate Change Considerations in project-level NEPA Analysis 2009). Combustion of fossil fuel produces emission byproducts that include greenhouse gas emissions. It is expected that the each alternative would result in greenhouse gas emissions which may have an indirect effect to global concentrations of greenhouse gasses that affect climate change.

The magnitude of total greenhouse gas emissions associated with any one of the action alternatives has not been measured. Emission standards for primary pollutants including greenhouse gas for any action alternative would be set by air permits issued by the ADEC based on Alaska Ambient Air Quality Standards. On a global scale, the emissions from the alternatives are at such a minor scale and fairly dispersed that the direct effects of the project’s greenhouse gas emissions on climate change cannot be quantified. There are no quantifiable differences in carbon storage and greenhouse gas emissions between the action alternatives. No adaptive capacity of ecosystems is needed to mitigate climate change effects on the projects surrounding ecosystem. Likewise the proposed action and action alternatives are not sensitive to projected climate change impacts outlined by the United Nations Intergovernmental Panel on Climate Change. Changes in precipitation magnitude and intensity could affect the amount of contact water that must be treated. Ongoing monitoring of precipitation would continue to be used by HGCMC to predict water treatment capacity needs.

Air Quality

Current baseline conditions resulting from past and present actions (mainly, the construction and operation of the mine) are described in detail in Section 3.2. In summary, air quality measurements for PM_{10} at the mine site are below NAAQS standards set to protect human health and the environment.

Short-term cumulative adverse effects on air quality could result from construction of exploration drill pads and roads, transportation and stockpiling of mining products, and during construction associated with relevant actions. Effects from emissions, including greenhouse gases, could occur from stationary and mobile combustion engines. Fugitive dust would be generated during construction of facilities, as well as during project operations as part of the proposed action.

Most mobile sources of emissions (e.g., pad construction) associated with exploration would be of limited duration, although emissions from drilling operations may occur intermittently throughout the year. In these cases, the emission sources would be limited to a small number of engines at each location. While the additional dust generated would be of a cumulative nature, the mine's air permits would continue to require that all emissions levels meet NAAQS at the mine's industrial boundary.

Construction activities associated with the Angoon airport, the Angoon Ferry Terminal Passenger Facility, and the Angoon Ferry Terminal Improvement may overlap in time with the proposed action, although individual projects may not overlap with each other; however, measureable effects to air quality are not expected to overlap spatially.

Mining and construction activities would be regulated under air permits issued by ADEC and all other stationary and mobile emissions would be regulated according to Alaska and federal regulations. Existing air quality in the air shed associated with these past, present, and reasonably foreseeable projects is expected to remain within NAAQS. Therefore, it is anticipated that potential cumulative effects on air quality, based on the incremental effects of the existing and relevant projects considered in this cumulative effects evaluation, would be less than significant.

Geotechnical Stability

Current baseline conditions resulting from past and present actions (mainly, the construction and operation of the mine) are described in detail in Section 3.3. In summary, the TDF has been constructed in compliance with the Plan of Operations, waste management permit, and design measures established to ensure stability of the pile.

Potential cumulative effects on geotechnical stability would be limited to the proposed action and drilling activities. The relevant construction actions are not expected to affect geotechnical stability within the area of the proposed action. The proposed facilities are expected to remain stable or will require mitigation for some alternatives. Relevant action drilling activities will not likely have a significant effect to stability of the existing and proposed facilities.

Geochemistry

Among the relevant actions being evaluated, it is anticipated that potential geochemical effects would be limited to those relevant actions involving mining. Measurable environmental effects are not expected to result from exploration drilling or any other of the relevant actions. The proposed action already accounts for continued success in identifying additional reserves and continued mining activities for 30 to 50 years, there are no other relevant actions that would contribute cumulatively to the geochemical effects of the proposed action.

Water Resources

Current baseline conditions resulting from past and present actions (mainly, the construction and operation of the mine) are described in detail in sections 3.5 and 3.6 for surface water and groundwater, respectively. Water resources have been managed by past and present actions to reduce or eliminate significant effects. Fresh surface water within the Greens Creek area is monitored and protected using water quality criteria for all designated beneficial uses, including aquatic life. Collected wastewaters are treated to meet effluent limits identified in an APDES permit prior to discharge through a diffuser outfall located in Hawk Inlet. The majority of native groundwater at the site is intercepted or routed around the TDF by perimeter up-gradient groundwater diversions and barriers, and this water does not require containment or treatment.

Exploration drilling and the proposed action would all occur within the same watershed and aquifer, and effects of each could overlap in time. Thus, these projects could potentially produce adverse cumulative effects on water resources. Exploration drilling is unlikely to have any effect on marine waters, nor any significant effect on freshwater. Cumulative adverse effects on marine water could occur as a result of the Angoon Airport and Ferry construction, and cumulative adverse effects to surface waters in a separate watershed could occur from sediment and runoff from the construction; however, these effects would not overlap in space with the proposed action and are therefore not considered. The other relevant actions are not located within the same watersheds as the proposed action, therefore will not contribute to cumulative effects to surface water.

The planned drilling activities would involve a relatively low level of activity that would have minimal effect on fresh surface water quality. Because wastewater from the mining operations would be treated, and the discharge quality would be governed by applicable permits, the potential cumulative effects on water quality are anticipated to be less than significant. Most of the effects to water resources, including interbasin water transfer, would be due to the proposed action, and therefore cumulative effects are likely to be insignificant.

Aquatic Resources

The relevant actions within the aquatic habitats and migratory corridors include the drilling and construction actions. Potential adverse cumulative effects on freshwater aquatic resources (fish and benthic invertebrates) could occur within freshwater streams from drilling activities in combination with the proposed action. Short-term effects on aquatic resources could include increased turbidity, increased sediment generated, temporary physical disruption of habitats during construction, and possible spills of contaminants from the relevant actions. The ongoing and future drilling activities would involve a relatively low level of activity with corresponding limited opportunity to contribute sediments or other discharges to the local drainages. Therefore, they would be expected to have minimal incremental effect on aquatic resources. The combined proposed action and relevant construction actions may have greater potential to create adverse cumulative effects on the aquatic resources in the respective drainages through increased sediment loading and wastewater discharges. Long-term effects would include a loss of habitat from changes to water quality or physical changes such as sedimentation in spawning gravels. Sediment would be controlled with BMPs identified within the storm water management plan (part of the discharge permit requirements). Wastewater from mining operations would be treated, discharged to Hawk Inlet, and the discharge quality controlled by applicable permits. Therefore the potential cumulative effects on freshwater aquatic resources are expected to be less than significant in the drainages associated with the proposed action.

Cumulative aquatic resources effects associated with construction of the ferry and airport and other actions would occur within a different watershed and not overlap within the freshwater drainages of the proposed action. The effects would be localized and at a location well removed from the proposed action and therefore contributions to effects to freshwater resources would not be considered cumulatively significant.

Cumulative adverse effects on marine aquatic resources could occur from relevant actions related to the proposed action, and operation and construction of the ferry passenger terminal and improvements due to marine wastewater discharge and the risk of concentrate or fuel spills. Cumulative effects would primarily occur as short-term increases in sediments and turbidity during construction activities. BMPs (e.g., sediment control) required through Section 10 permits would limit construction effects. Any marine discharge of wastewater would need to meet permit limits, therefore limiting the area affected by the outfall. Spills either from supply unloading, fuel transfers, or concentrate loading or transport could cause significant localized effects to marine aquatic resources over the short term until the spill is cleaned up. Overall, cumulative effects are not anticipated to produce significant adverse impacts to aquatic resources.

Soils

The past and present construction and operation of the mine has resulted in direct impacts to soils (soil disturbance) as described in detail in Section 3.8. The relevant actions within the soil disturbance area of the proposed action include the drilling actions and not the construction actions in Angoon or other projects located in the Monument. Effects to soil resources from relevant drilling actions are expected to be minimal. Most of the effects to soil resources would be due to the proposed action, and therefore cumulative effects are likely to be insignificant.

Vegetation

The past and present construction and operation of the mine has resulted in direct impacts to vegetation as described in Section 3.9. Changes to vegetation include direct impacts to vegetation communities, mostly Sitka spruce-western hemlock forests. The relevant actions within the vegetative zones and geographic distribution of plant communities that overlap with those affected by the proposed action include the drilling actions and not the construction actions in Angoon or other projects located in the Monument. Minimal tree cutting would occur for exploration drilling and less than 2 acres of ground disturbance would occur for the geotechnical drilling. Relative to the proposed action, the effects on vegetation from drilling actions are minimal; therefore cumulative effects are likely to be insignificant as most of the impacts to vegetation would be from the proposed action. There would be a continued risk of introduction or spread of noxious weeds or invasive plant species; however, with the development and implementation of a weed management plan, impacts from noxious weeds and invasive species are expected to be minimal. This plan would apply to all operations at the mine, and thus the cumulative impact from noxious or invasive plants would also be minimal.

Wetlands

The past and present construction and operation of the mine has resulted in direct impacts to wetlands as described in Section 3.10. The acres of wetlands affected by the original tailings pile are not well defined; existing dock facilities, portions of the road system, and the original TDF occupy former wetland areas. In 2003, the USACE issued a permit to the operator to discharge fill material into approximately 60 acres of waters of the United States, consisting mainly of Palustrine Forested Wetlands, to facilitate the expansion of the TDF and related infrastructure. The relevant actions within the wetland zones and geographic distribution of wetlands that overlap with those affected by the proposed action include the drilling actions and not the construction actions in Angoon or other projects located in the Monument. Minimal filling of wetlands, if any, would occur for drilling actions. Minimal clearing is expected that would directly impact wetlands. Relative to the proposed action, which would result in the filling of about 98 acres of wetlands, the effects on wetlands from drilling actions are minimal; therefore cumulative effects are likely to be insignificant as most of the effects to wetlands would be from the proposed action.

Wildlife

Current baseline conditions resulting from past and present actions (mainly, the construction and operation of the mine) are described in detail in Section 3.11. Potential effects to wildlife associated with construction and operation of the mine included habitat loss, disturbance and/or displacement due to mining activities, attraction of wildlife to mine facilities, and contamination due to contact with water discharged into Hawk Inlet.

Relevant actions that would affect wildlife include the drilling actions within Greens Creek Mine and construction actions in Angoon and are therefore evaluated in cumulative effects. Human activity, direct habitat loss, and exposure to contaminants may affect wildlife.

Disturbance to species may occur from human activity associated with mining operations, drilling actions, construction and operation of the Angoon airport, and construction and operation of the Angoon ferry terminal facility and improvement, causing an indirect loss of habitat and displacement of species in the vicinity of the ongoing and proposed actions. Construction activities could be postponed or relocated to avoid significant adverse effects to nest sites of species such as bald eagles and marbled murrelet, however ongoing operation of the proposed action and airport would continue to have cumulative effects for the duration of the actions.

Oil or fuel spills could occur from vessels at the marine terminal or at the dock in Young Bay as well as the Angoon ferry terminal. Spills could adversely impact marine mammal, waterfowl, and shorebird species foraging or moving through the shallow shoreline areas. Spill control plans and rapid response to spills would be the primary mitigation measures to avoid or minimize adverse spill effects to wildlife species in the marine environment.

The proposed action and relevant drilling and construction and operation of relevant actions would extend the duration of direct habitat loss such as old growth forest and wetlands used for foraging and breeding. Cumulative loss of habitat acreages associated with the proposed action as well as construction of the Angoon airport and ferry terminal facility, hydroelectric facility, and timber harvest could affect some species of wildlife.

Specific acreages of habitat lost due to construction and operation of related facilities is not known at this time.

The proposed action and ferry terminal facility and improvements could increase marine mammal exposure to metal concentrations in prey due to project-related discharges, oil or fuel spills, and vessel/crew shuttle traffic. However, as documented in the 2003 BA/BE for marine mammals, given the transient nature of these species in Hawk Inlet, the proposed action would not result in “take” as defined under the MMPA. It is undetermined at this time if the ferry terminal and Angoon airport construction and operation would also not result in a “take.”

Threatened and Endangered Species

Current baseline conditions resulting from past and present actions (mainly, the construction and operation of the mine) are described in detail in Section 3.12. Potential effects to wildlife associated with construction and operation of the mine included habitat loss, disturbance and/or displacement due to mining activities and associated marine traffic, attraction of wildlife to mine facilities, and contamination due to contact with water discharged into Hawk Inlet. Operation of the port does not constitute harassment or a “take” under the ESA or the MMPA according to the 2003 BA/BE for marine mammals.

Operation of the proposed Angoon ferry terminals would result in additional marine traffic and an increased risk of spills in the marine environment, and thus have the potential to disturb marine mammals, birds, and fish using Chatham Strait or result in their exposure to toxics. Therefore, these projects have the potential to impact individuals of these species that could also occur in the vicinity of the Hawk Inlet Marine Terminal. According to the 2003 BA/BE, the proposed action and relevant actions are not likely to adversely affect the humpback whale or Steller sea lion because of the transient nature of these species would reduce the exposure to metals concentrations in prey, oil and fuel spills, or vessel traffic. Yellow-billed loons do not occur in large concentrations in southeast Alaska, therefore few individuals would be at risk of exposure to fuel or oil spills from vessels. Herring are not known to spawn in this area, but juveniles would be present (Monagle 2011); therefore, juveniles would be at risk of exposure to project related water quality and sedimentation impacts. However, the ADEC APDES permit would limit the effects of the project on water quality. Therefore, impacts to Lynn Canal Pacific herring would be minor. In addition, it is assumed that these projects would operate in compliance with the ESA and the MMPA. Therefore, the proposed project when taken together with these foreseeable projects would not result in significant cumulative impacts on the humpback whale, Steller sea lion, yellow-billed loon, and pacific herring.

The relevant actions occurring in Angoon (ferry terminal and airport) would not overlap in space and time with the proposed action in terms of impacts on goshawks, therefore are not included in the cumulative impacts analysis. No nesting goshawks were documented within the existing lease area in 2010, though suitable nesting habitat was documented in the vicinity of the TDF proposed action. Future exploration drilling has the potential to disturb nesting goshawks if drilling were proposed near an active nest site. However, it is assumed that goshawk nest surveys would be conducted in suitable habitat in the vicinity of the drill sites prior to ground disturbance. If an active nest were documented, the Forest Service Standards and Guidelines for goshawks would be implemented to minimize impacts to this species. Therefore, the proposed action, when taken together with the foreseeable actions, would result in negligible cumulative impacts on this species.

The proposed action would result in potential for exposure of black oystercatchers to oil or fuel spills at the Hawk Inlet marine terminal. Ongoing marine traffic in Hawke Inlet has the potential to contribute to this effect. However, because there are no large concentrations of black oystercatchers known to occur in Hawk Inlet and likely few individuals to occur in the vicinity of the marine terminal, and because the risk of spills is also low, the likelihood of cumulative effects to the black oystercatcher population associated with the proposed action in combination with existing marine traffic is very low.

The relevant actions occurring in Angoon (ferry terminal and airport) would not overlap in space and time with the proposed action in terms of impacts on sensitive plants, therefore are not included in the cumulative impacts analysis. No sensitive plants were found in the currently permitted tailings lease area, Surveys for sensitive plants would likely be conducted prior to drilling, and sensitive plants would be avoided, therefore the proposed action in combination with future mine drilling activities would have negligible cumulative impacts on sensitive plants.

Land Use

The past and present construction and operation of the mine has resulted in changes to land use from forest land and a cannery as described in Section 3.13. Relevant drilling actions would occur within the existing site of the proposed action, therefore would not result in a change of land use and would not have significant cumulative effects. The relevant actions located in Angoon would change the land use in that part of Admiralty Island. Cumulatively, the change in land use is not considered a significant adverse impact on land use overall on Admiralty Island.

Scenic Resources

The past and present construction and operation of the mine has resulted in changes to scenic resources from predominantly natural in appearance, except for the presence of the historic cannery facility, as described in Section 3.14. The relevant actions occurring in Angoon (ferry terminal and airport) would not overlap in space and time with the proposed action in terms of impacts on scenic resources, therefore are not included in the cumulative impacts analysis. The relevant drilling actions may be visible from Hawk Inlet, and therefore may overlap in space and time with the proposed action. However, effects of the drilling activities are temporary and of limited extent, and therefore impacts on scenic resources would primarily be from the proposed action, and therefore cumulative impacts would be negligible.

Recreation

The past and present construction and operation of the mine has not resulted in significant changes to recreation except within the project area, as described in Section 3.15. Increased boat traffic during the construction phase of the proposed action and relevant actions in Angoon (ferry terminal and airport) may overlap in time and space. However, the indirect effects on recreation, including hunting and fishing are not likely to significantly adversely affect recreation. Views to boaters and anglers using Hawk Inlet would be not significantly changed as a result of drilling activities, and relevant actions in Angoon would not be within views of boaters and anglers in the vicinity of the proposed action, and therefore would not contribute to a cumulative effect.

Subsistence

The past and present construction and operation of the mine has not resulted in significant changes to subsistence as described in Section 3.16. There are no communities located in the vicinity of the mine, however the community of Angoon may be considered within the study area for subsistence. The proposed action, drilling activities, and construction and operation of the Angoon airport and ferry facilities are considered for the cumulative effects analysis on subsistence resources due to the proximity to Hawk inlet and Chatham Strait. Hawk Inlet is not in the Customary and Traditional Use Area for any rural communities, but the area has long been used for subsistence hunting, fishing, and gathering. However, the reliance on subsistence resources harvested in this area is minor and the impacts of the action alternatives on fish and wildlife resources are expected to be negligible. As a result, the cumulative effects of the proposed action and relevant actions on the subsistence use of wildlife, fish, or other resources are expected to be very low.

Cultural Resources

The past and present construction and operation of the mine has not resulted in significant changes to cultural resources as described in Section 3.17. The proposed action, drilling activities, construction of the Angoon Ferry terminal facilities and construction of the Angoon airport would require ground disturbance, and thus could have the potential to affect cultural resources. Each activity would be subject to investigation and consultation procedures prescribed under the Section 106 process of the NHPA. Prior to any planned disturbance at these project sites, the areas would be surveyed to determine the presence or absence of archaeological and historic evidence, and sites containing such evidence would be evaluated for listing on the NRHP. Eligible sites would either be avoided or would undergo data recovery and documentation under strict protocols.

The cumulative nature of the effects of these projects would be regional rather than local. Because projects would need to follow the Section 106 guidelines regarding the presence of cultural resources, effects from the development of any of the relevant projects under consideration would be minimized. Therefore, it is expected that potential cumulative effects on cultural resources would not be significant.

Socioeconomics

Greens Creek Mine was identified as Juneau's largest private employer in 2009, it generates approximately $1 million in annual property tax revenues, and the mine pays $5 million per year for a license. The relevant actions occurring in Angoon (ferry terminal and airport) would not overlap with the study area of the proposed action, as the proposed action is in the CBJ, and the relevant actions in Angoon are part of the Hoonah-Angoon Census area, and therefore are not included in the cumulative effects analysis. The relevant drilling activities overlap in space and time with the proposed action, and are therefore included in the cumulative effects analysis. In comparison to the proposed action, drilling activities are expected to be short-term in nature, employ relatively few people, generate relatively little income, generate little to no income for the CBJ, and not change the population significantly. Therefore, cumulative socioeconomic effects are expected to be less than significant.

Monument Values

The past and present construction and operation of the mine has affected Monument values as described in Section 3.21. The location of the proposed action is in and adjacent to the Monument. Relevant actions that may occur in this vicinity include drilling activities on the mine site, Angoon airport and ferry terminal, Kanalku Creek Barrier Modification, Pack Creek Outfitter, Thayer Creek Hydroelectric Project, Admiralty Cove trails, and Whitewater Bay NNIP control. The effects of drilling activities on Monument values are relatively low. The Angoon airport and ferry terminal are adjacent to the Monument, and therefore have indirect effects to wildlife and habitat over the long-term operation of each facility. The effects of the Kanalku Creek Barrier Modification improve fish habitat by improving passage for sockeye salmon. The effects of the Pack Creek Outfitter include minor effects to wildlife with the increased usage of the Monument by people. The Thayer Creek Hydroelectric Project will affect the scenic landscape in the vicinity of the creek, the natural ecology of Thayer Creek for the 1-mile span, and alter fish passage in the creek. The Admiralty Cove trail completion project will encourage hikers to the area, thus affect wildlife resources. The Whitewater Bay NNIP control will enhance wildlife habitat on the shores of Whitewater Bay by controlling the spread of invasive species. Each of these relevant actions has localized effects: some adverse and some positive enhancements. However, they do not overlap with the area of the proposed action. Therefore, due to the spatial distribution throughout the Monument, from a cumulative effects standpoint, the overall effects to Monument Values are relatively low.

Inventoried Roadless Areas

The Greens Creek (307) and Mansfield Peninsula (306) IRAs surround the project area. Other actions that occur within or affect these IRAs could incrementally contribute to cumulative effects on the roadless characteristics of the IRAs. Other relevant actions or activities that occur within these IRAs include exploration and geotechnical drilling activities on and around the mine site (within the Greens Creek IRA) and the continued presence of communication sites and several cabins within the Mansfield Peninsula IRA. The effects of these activities on the biological, physical, and social values of the IRAs are relatively low and well dispersed. Besides the continued presence and operation of the mine, no other projects have been identified that would measurably affect roadless characteristics within these IRAs. Relative to the proposed action, the effects on IRAs from other relevant actions are minimal; therefore cumulative effects are likely to be insignificant as most of the impacts to IRAs would be from the proposed action.

Environmental Justice

The past and present construction and operation of the mine has not affected environmental justice as described in Section 3.21. There are no communities located in the vicinity of the proposed action. The nearest minority communities are Hoonah (28 miles) and Angoon (44 miles). None of these communities are expected to be significantly affected by the proposed action; therefore no cumulative effects are expected.

3.23 Irretrievable and Irreversible Commitment of Resources

An irreversible commitment of resources applies primarily to the loss of non-renewable resources (e.g., minerals or cultural resources) and resources that are renewable only over a long period of time (e.g., soil productivity). Irretrievable commitments apply to loss of production or use of renewable resources. These opportunities are forgone for the period of the proposed action, during which the resource cannot be used. These decisions are reversible, but the utilization opportunities forgone are irretrievable. Table 3.23-1 presents the irreversible and irretrievable resource commitments associated with the Greens Creek Mine TDF expansion. Note that because this mine is already in operation irretrievable and irreversible commitment of resources has already occurred for most resources and was evaluated in past EISs.

Table 3.23-1. Irreversible and Irretrievable Resource Commitments.

Resource	Alternative A	Alternative B	Alternative C	Alternative D
Air quality	No foreseeable or predicted irreversible or irretrievable commitments beyond those previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Geochemistry/ Geology	Loss of 360,000 cubic yards of tailings and waste rock per year until 2014	Loss of 360,000 cubic yards of tailings and waste rock per year for 30-50 years	Same as Alternative B	Same as Alternative B
Surface water hydrology	No foreseeable or predicted irreversible or irretrievable commitments beyond those previously evaluated.	Irretrievable stream flow reduction by 3 percent in Tributary Creek Drainage during operation	Irretrievable stream flow reduction by 3 percent in Tributary Creek Drainage during operation	Irretrievable stream flow reduction by 4 percent in Tributary Creek Drainage during operation
Surface Water Quality	No foreseeable or predicted irreversible or irretrievable commitments beyond those previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.

Table 3.23-1. Irreversible and Irretrievable Resource Commitments.

Resource	Alternative A	Alternative B	Alternative C	Alternative D
Groundwater	Additional and increased lowering of groundwater heads in bedrock in the expansion area would likely occur.	Additional and increased lowering of groundwater heads in bedrock in the expansion area would likely occur. Additional and increased lowering of groundwater heads in bedrock in the TDF expansion area would likely occur.	Additional and increased lowering of groundwater heads in bedrock in the expansion area would likely occur. Reduction in groundwater discharge to Fowler Creek and tributaries could occur.	Same as Alternative C.
Aquatic Resources	Reduced stream flow to Tributary and Zinc creeks from water interception in the TDF, resulting in reduction of spawning and rearing habitat.	Reduced stream flow to Tributary and Zinc creeks from water interception in the TDF would increase from Alternative A, resulting in reduction of spawning and rearing habitat. Direct habitat loss of about 4,000 linear feet of streams (Class I and II combined) by burial.	Reduced stream flow to Fowler, Tributary and Zinc creeks from water interception in the TDF, and resulting in reduction of spawning and rearing habitat.	Same as Alternative C.
Soils	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Vegetation and Wetlands	Some additional irreversible change in vegetative species composition likely due to fugitive dust deposition from road and TDF. 65.3 acres of vegetation irretrievably impacted by the existing TDF Some areas revegetated through reclamation after closure. Permanent loss of 5 acres of wetlands at the TDF	Some additional irreversible change in vegetative species composition likely due to fugitive dust deposition from road and TDF. 208 acres of vegetation irretrievably impacted by the existing TDF Some areas revegetated through reclamation after closure. Permanent loss of 99 acres of wetlands at the TDF	Some additional irreversible change in vegetative species composition likely due to fugitive dust deposition from road and TDF. 222 acres of vegetation irretrievably impacted by the existing TDF Some areas revegetated through reclamation after closure. Permanent loss of 114 acres of wetlands at the TDF	Some additional irreversible change in vegetative species composition likely due to fugitive dust deposition from road and TDF. 235 acres of vegetation irretrievably impacted by the existing TDF Some areas revegetated through reclamation after closure. Permanent loss of 124 acres of wetlands at the TDF

Table 3.23-1. Irreversible and Irretrievable Resource Commitments.

Resource	Alternative A	Alternative B	Alternative C	Alternative D
Wildlife and Threatened and Endangered Species	Irreversible commitment of wildlife habitat associated with the TDF (65.3 acres total).	Irreversible commitment of wildlife habitat associated with the TDF (208 acres total).	Irreversible commitment of wildlife habitat associated with the TDF (222 total).	Irreversible commitment of wildlife habitat associated with the TDF (235 acres total).
Land Use and Recreation	Irreversible commitment of 33.5 acres within the Monument.	Irreversible commitment of an additional 109 acres within the Monument.	Irreversible commitment of an additional 9 acres within the Monument.	Irreversible commitment of an additional 27 acres within the Monument.
Scenic Resources	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Subsistence and Cultural Resources	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Socioeconomics	Closure of the mine in 2014 would result in a net loss of $48 million associated direct and indirect payroll.	Extending the life of the mine 30-50 years would result in a continued direct and indirect payroll of $48 million.	Same as Alternative B.	Same as Alternative B.

CHAPTER 4. LIST OF PREPARERS

Tetra Tech Team

Preparer	Degree/Years of Experience	Project Role
Gene Weglinski	M.S., Horticulture B.S., Botany Years of experience: 20	Project Manager
Dave Cox	B.S. Geology Years of experience: 10	Deputy Project Manager
Katie Goodwin	M.S., Environmental Sciences B.S., Natural Resources Years of experience: 4	Project Assistant Air Quality
Susan Bautts	M.S., Civil Engineering B.S. Environmental Engineering Years of experience: 6	Air Quality
Mike Henderson, P.E.	M.S., Geotechnical and Water Resources Engineering B.S., Civil Engineering Years of experience: 30	Geotechnical Stability
Diana Cook, EIT	Ph.D, Colorado School of Mines M.S., University of Illinois Urbana Champaign B.S., New Mexico State University Years of experience: 4	Geotechnical Stability
Mark Williamson	Ph.D., Geochemistry M.S., Geochemistry B.S., Chemistry Years of experience: 25	Geochemistry
Tim Reeves	M.S., Range Management / Water Resources B.S., Range Management Years of experience: 25	Water Resources
Joe Frank	M.S., Geology\Hydrogeology B.S., Geology Years of experience: 35	Groundwater Hydrology
John Knutzen	M.S., Fisheries B.S., Biology Years of experience: 31	Fisheries
Henry Sauer	B.S., Range Management Years of experience: 18	Soils
Selina Koler	M.S., Restoration Ecology B.S., Natural Resource Management Years of experience: 8	Vegetation, Wetlands
Steve Negri	M.S., Wildlife Ecology B.S., Business-Finance Years of experience: 16	Wildlife
Brita Woeck	M.S., Wildlife Ecology and Management B.S. Wildlife Science Years of experience: 9	Wildlife
Susan Ernst Corser	M.U.P., Urban Planning M.A., Landscape Design B.A., Geography/Environmental Studies Years of experience: 25	Land Use and Recreation
Stephen Braund	M.A., Anthropology B.A., Northern Studies/English Years of experience: 33	Subsistence, Traditional Knowledge, and Cultural Resources
Erik Hilsinger	M.A., Anthropology Years of experience: 16	Cultural Resources

Preparer	Degree/Years of Experience	Project Role
Paul Lawrence	B.A., Anthropology Years of experience: 8	Subsistence, Cultural Resources
Raena Schraer	B.A., Geography/Spanish Years of experience: 7	Subsistence, GIS
Matt Dadswell	M.A., Economic Geography, 1990 B.A., Economics and Geography, 1988 Years of experience: 16	Socioeconomics, Environmental Justice
Jennifer Hawkins	B.S., Environmental Science and Biology Years of experience: 15	Cumulative Effects
MaryJo Watson	B.S., Business Administration - Computer Information Systems Years of experience: 20	GIS Lead
Sierra Marrs	B.S., Environmental Geology Years of experience: 5	GIS
Juanita Barboa	B.S., Technical Communication Years of experience: 21	Formatting and Editing

Lead Agency Reviewers

USDA Forest Service

Sarah Samuelson, Project Manager
Chad Hood, Deputy Project Manager
Karen Iwamoto, Land Management Planner
Steve Paustian, Hydrology

Cooperating Agency Reviewers

U.S. Environmental Protection Agency

Lynne McWhorter, Project Lead/NEPA Compliance
Cindi Godsey, NPDES Permits and Water Resources
Lorraine Edmond, Water Resources, Groundwater, Hydrogeology, Geochemistry
Phil North, Wetlands

U.S. Army Corps of Engineers

Heidi Firstencel, Project Lead

State of Alaska

Sharmon Stambaugh, Alaska Department of Natural Resources
Kenwyn George, Alaska Department of Environmental Conservation
Ed Emsweiler, Alaska Department of Environmental Conservation
Steve McGroarty, Alaska Department of Natural Resources
Rick Fredericksen, Alaska Department of Natural Resources
Kate Kanouse, Alaska Department of Fish and Game

City and Borough of Juneau

Teri Camery, Community Development Department

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CHAPTER 6. GLOSSARY

100-year flood	A stream discharge that occurs on the average of once every 100 years.
Acid-base accounting	A test method to predict acid mine drainage. The "static" test compares a waste rock's maximum potential acidity with its maximum neutralization potential.
Acid-generating potential	The long-term potential of a material or waste to generate acid, as related to acid mine drainage.
Acid mine (rock) drainage	Drainage of water from areas that have been mined for mineral ores. The water has a low pH because of its contact with sulfur-bearing material. Dissolved metals, including heavy metals, might be present. Acid mine drainage might be harmful to aquatic organisms and to drinking water supplies.
Acre-foot (ac-ft)	The amount of water that covers an acre of land to a depth of 1 foot; equal to 325,827 gallons.
Adsorb	To take up and hold by the physical or chemical forces of molecules.
Airshed	An area of land over which the pattern of air movement is influenced by major topographic features.
Alkaline	Having the qualities of a base; basic (pH greater than 7.0).
Alkaline chlorination	A treatment method by chemical reaction used to break down by chlorination the toxic cyanide radical (NC) into nontoxic sodium bicarbonate, nitrogen, sodium chloride, and water. This method can be used to treat mill effluent and tailings.
Alkalinity	A measure of the alkali content of a sample occasionally expressed as the number of milliequivalents of hydrogen ion that can be neutralized.
Alluvium	Material, including clay, silt, sand, gravel, and mud, deposited by flowing water.
Alternatives	For National Environmental Policy Act purposes, alternatives to the proposed action examined in an environmental impact statement or environmental assessment. The discussion of alternatives must "sharply [define] the issues and [provide] a clear basis for choice…by the decision maker and the public" (40 CFR 1502.14).
Ameliorate	To influence or alter conditions so as to cause improvement.
Anadromous	Describes fish that migrate upstream from salt water to fresh water to spawn (breed), such as salmon, some trout and char species, and shad. Also describes the fishery or habitat used for spawning by these species.
Aquatic	Growing, living, frequenting, or taking place in water. In this EIS, used to indicate habitat, vegetation, and wildlife in fresh water.

Aquifer	A zone, stratum, or group of strata acting as a hydraulic unit that stores or transmits water in sufficient quantities for beneficial use.
Aspect	The direction toward which a slope faces.
Attainment area	A geographic region within which National Ambient Air Quality Standards (NAAQS) are met. Three categories of attainment— Class I, Class II, and Class III—are defined by the level of degradation of air quality which may be permitted.
Base drain	A drain for water at the bottom of an impoundment or a storm runoff catchment.
Base flow	A sustained or fair-weather flow of a stream.
Baseline data	Data gathered prior to the Proposed Action to characterize predevelopment site conditions.
Bathymetry	The measurement of depths of water in an ocean, lake, or sea.
Benthic	All underwater bottom terrain from the shoreline to the greatest deeps.
Berm	An earthen embankment; dike.
Best available control technology	Pollution control as defined by EPA for a specific emission or pollutant stream and required for meeting pollution control regulations.
Bioaccumulation	Pertaining to concentration of a compound, usually potentially toxic, in the tissues of an organism.
Bioassay	The study of living organisms to measure the effect of a substance, factor, or condition by comparing before-and-after exposure or other data.
Biodegradable	Capable of being broken down by the action of living organisms such as microorganisms.
Biomass	The amount (weight or mass) of living material.
Biomonitoring	The use of living organisms to test the suitability of effluents for discharge into receiving waters and to test the quality of such waters downstream from the discharge.
Biota	All living material in a given area; often refers to vegetation.
Bond	An agreed-to sum of money which, under contract, one party pays another party under the condition that when certain obligations or acts are met, the money will be returned; an example is mining reclamation. See Reclamation guarantee.
Borough	An area incorporated for the purpose of self-government; a municipal corporation.
Borrow area	Source area for earthen construction material, such as sand and gravel, till, or topsoil used in construction or reclamation; a quarry.

Cadmium	A tin-white, malleable, ductile, toxic, bivalent metallic element used in electroplating of iron and steel and in the manufacture of
Carbon monoxide	A colorless, odorless, very toxic gas formed as a product of incomplete combustion of carbon.
Catchment area	The drainage area or basin drained by a river, stream, or system of streams.
Change analysis	An interdisciplinary review conducted to determine if a proposed modification to an action constitutes a substantial change relevant to environmental concerns (40 CFR 1502.9(c) (1) (i)) or if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts (40 CFR 1502.9(c) (1) (ii)).
Char	Fish that is closely related to trout. The char genus (*Salvelinus*) comprises Dolly Varden present in the project area.
Climax plant community	The stabilized plant community on a particular site. The relative composition of species does not change so long as the environment remains the same.
Closure	The final stage of mining, which involves closing all mine openings, regrading, and reclaiming.
Colluvial	Describes soil material that has moved downhill and has accumulated on lower slopes and at the bottom of a hill, consisting of alluvium in part and also containing angular fragments of the original rocks; i.e., cliff and avalanche debris.
Concentrate	The ore that contains the mineral sought following the concentration process (e.g., flotation, gravity).
Conductivity (electrical)	An electrical measurement to determine the amount of salinity or total dissolved solids in soils, surface water, and groundwater.
Cone of depression	The geometry or shape of an inverted cone on the water table or artesian pressure surface caused by pumping of a well. The cone of depression disappears over time after well pumping ceases.
Copper	A red, ductile, malleable native metal found in hydrothermal deposits, cavities of basic igneous rocks, and zones of oxidization of copper veins.
Council on Environmental Quality (CEQ)	A body established by the National Environmental Protection Act (NEPA) to draft regulations for implementing and monitoring NEPA. CEQ regulations are presented in 40 CFR 1500–1508.
Cover	Living or nonliving material (e.g., vegetation) used by fish and wildlife for protection from predators and to ameliorate conditions of weather.
Criteria	Standards on which a judgment or decision can be based. Water quality criteria can be based on various standards, including aquatic life or human health.

Cubic feet per second (cfs)	One cubic foot per second (cfs) equals 448.33 gallons per mile.
Cumulative impacts	Combined impacts of past, present, and reasonable foreseeably future actions. For example, the impacts of a proposed timber sale and the development of a mine together result in cumulative impacts.
Demography	A statistical study of the characteristics of human populations with reference to size, density, growth, distribution, migration, and effect on social and economic conditions.
Depletion	Use of water in a manner that makes it no longer available to other users in the same system.
Deposit	A natural accumulation, such as precious metals, minerals, coal, gas, oil, and dust, that may be pursued for its intrinsic value; gold deposit.
Development	The work of driving openings to and into a proven ore body to prepare it for mining and transporting the ore.
Dewatering	The reduction of aquatic habitats by diversion of stream flow; removal of water from underground mine workings.
Dilution	The act of mixing or thinning and thereby decreasing a certain strength or concentration.
Direct impacts	Impacts that are caused by the action and occur at the same time and place (40 CFR 1508.7). Synonymous with direct effects.
Discharge	The volume of water flowing past a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, or cubic meters per second.
Dispersion	The act of distributing or separating into lower concentrations or less dense units.
Diversion	Removing water from its natural course of location, or controlling water in its natural course of location, by means of a ditch, canal, flume, reservoir, bypass, pipeline, conduit, well, pump, or other structure or device.
Earthquake	Sudden movement of the earth resulting from faulting, volcanism, or other mechanisms within the earth.
Effluent discharge	Disposal of water previously used, as in a milling process.
Endangered species	Any species that is in danger of extinction throughout all or a significant portion of its range.
Environmental Impact Statement (EIS)	A detailed written statement of the potential environmental effects resulting from a action proposed by a federal agency required by section 102(2)(c) of the National Environmental Policy Act (40 CFR 1508.11).
Ephemeral stream	A stream channel that is normally dry; stream flow occurs for short periods of time in response to storm events.

Erosion	The wearing away of the land surface by running water, wind, ice, or other agents.
Estuarine	Of, relating to, or formed in a place where an ocean tide meets the current of a freshwater stream.
Exploration	The search for economic deposits of minerals, ore, gas, oil, or coal through the practices of geology, geochemistry, geophysics, drilling, shaft sinking, and/or mapping.
Fault	A displacement of rock along a shear surface.
Fines	Fine particulate matter; specifically, particles less than 0.4 mm in diameter.
Fishery	All activities related to human harvest of a fisheries resource.
Flocculation	The addition of an agent to a settling pond that causes suspended particles to aggregate and settle out more rapidly than they would under natural conditions.
Flotation	An ore concentration process that separates ground ore from waste in a mixture of ore, water, and chemicals. When air is forced through the ore/water mixture, the chemicals cause certain minerals to adhere to the air bubbles and float to the top in a froth, thus effecting a separation.
Flotation circuit	The portion of the milling process where the flotation process occurs. See Flotation.
Flotation concentrate	The layer of mineral-laden foam built up at the surface of a flotation cell.
Fry	A recently hatched fish.
Fugitive dust	Dust particles suspended randomly in the air from road travel, excavation, or rock-loading operations.
Fugitive emissions	Emissions not caught by a capture system.
Geomorphic	Pertaining to the form of the surface of the earth.
Geotechnical	Related to branch of engineering that is essentially concerned with the engineering design aspects of slope stability, settlement, earth pressures, bearing capacity, seepage control, and erosion.
Geotextile	A synthetic fabric used in the construction of earthen structures, such as embankments, landfills, and roads.
Grade	The content of precious metals per volume of rock (expressed in ounces per ton).
Gradient	The inclination or the rate of regular or graded ascent or descent (as of a slope, roadway, or pipeline).

Gypsum	A naturally hydrated calcium sulfate, $CaSO_4 \cdot 2H_2O$, white or colorless, sometimes tinted grayish, reddish, yellowish, bluish, or brownish. Insoluble in water; soluble in ammonium salts, acids, and sodium chlorides.
Habitat	The natural environment of a plant or animal, including all biotic, climatic, and soil conditions, or other environmental influences affecting living conditions.
Hardness	Quality of water that prevents lathering because of the presence of calcium and magnesium salts, which form insoluble soaps.
Hazardous waste	By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special EPA lists.
Heavy metals	A group of elements, usually acquired by organisms in trace amounts, that are often toxic in higher concentrations. Heavy metals include copper, lead, mercury, molybdenum, nickel, cobalt, chromium, iron, silver, and others.
Herbaceous	Lacking woody tissue; used to describe vegetation.
Heterogeneous	Not uniform in structure or composition.
Hydraulic barrier	An abrupt change in geology or soil type that inhibits the flow of water.
Hydraulic conductivity	A measure of the ability of soil to permit the flow of groundwater under a pressure gradient; permeability.
Hydrogen sulfide	A colorless, flammable, poisonous gas.
Hydrologic system	All physical factors, such as precipitation, stream flow, snowmelt, and groundwater, that affect the hydrology of a specific area.
Hydrophytic	Pertaining to aquatic plants that require an abundance of water for growth.
Impermeable	Having a texture that does not permit the passage of fluids through its mass.
Impoundment	The accumulation of any form of water in a reservoir or other storage area.
Incised	Cut into.
Increment	The amount of change from an existing concentration or amount, such as air pollutant concentrations.
Indigenous	Originating, developing, or produced naturally in a particular land, region, or environment; native.
Indirect impacts	Effects that are caused by the action and occur later in time farther removed in distance but are still reasonably foreseeable (40 CFR 1508.8). Synonymous with indirect effects.

Infauna	Aquatic animals living in and on soft bottom substrates.
Infiltration	The movement of water or some other fluid into the soil through pores or other openings.
Jurisdictional wetland	A wetland area delineated or identified by specific technical criteria, field indicators, and other information for purposes of public agency jurisdiction. The public agencies that administer jurisdictional wetlands are the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, EPA, and the USDA Natural Resources Conservation Service.
Lime	Calcium oxide. Sometimes used as an abbreviated name for any rock consisting predominantly of calcium carbonate.
Long-term impacts	Impacts that result in permanent changes to the environment. An example is a topographic change resulting from tailings disposal in a creek drainage.
Marine discharge	Disposal of mine water, treated sewage, and/or stormwater bypass.
Marine outfall	The mouth or outlet of a river, stream, or pipeline where it enters the sea.
Median	The value of the middle number of a data set such that half of the data values are greater than the median and half of the data values are less than the median.
Microclimate	The local climate of a given area or habitat characterized by uniformity over the site.
Migratory	Moving from place to place, daily or seasonally.
Milling	The act or process of grinding, extraction, or mineral processing.
Mine drainage	Gravity flow of water from a mine to a point remote from the mining operations.
Mine Safety and Health Administration (MSHA)	A federal agency under the Department of Labor that regulates worker health and safety in mining operations.
Minimum stream flow requirement	A set amount of water to be maintained in a watercourse for the purpose of reasonably maintaining the environment.
Mining plan	*See Operating plan.*
Mitigation measure	A step planned or taken to lessen the effects of an action.
Mixing zone	An area between an effluent discharge point and the associated water quality compliance monitoring station.
Monitoring	Continued testing of specific environmental parameters and of project waste streams for purposes of comparing with permit stipulations, pollution control regulations, mitigation plan goals, and so forth.

National Environmental Policy Act of 1969 (NEPA)	National charter for protection of the environment. It establishes policy, sets goals, and provides means for carrying out the policy. The regulations for implementing the act are at 40 CFR 1500–1508.
National Pollutant Discharge Elimination System (NPDES)	A program authorized by sections 318, 402, and 405 of the Clean Water Act, and implemented by regulations at 40 CFR 122. The NPDES program requires permits for the discharge of pollutants from any point source into waters of the United States.
National Register of Historic Places (NRHP)	A list, maintained by the National Park Service, of areas that have been designated as being of historical significance.
NEPA process	All measures necessary to comply with the requirements of section 2 and Title I of NEPA.
New Source Performance Standards	Standards set by EPA defining the allowable pollutant discharge (air and water) and applicable pollution control for new facilities by industrial category (Clean Air Act and Clean Water Act).
Nonpoint pollution	Pollution caused by sources that are nonstationary. In mining, nonpoint air pollution results from such activities as blasting and hauling minerals over roads, as well as dust from mineral stockpiles, tailings, and waste dumps prior to mulching and/or revegetation.
Oligotrophic	Having a deficiency in plant nutrients that is usually accompanied by an abundance of dissolved oxygen.
Operating plan	Plan submitted by the mining operator that outlines the steps the mining company will take to mine and reclaim the site. The operating plan is submitted prior to starting mining operations. Synonymous with the term mining plan (36 CFR 228).
Ore	Any deposit of rock from which a valuable mineral can be economically extracted.
Ore body	Generally, a solid and fairly continuous mass of ore, which might include low-grade ore and waste as well as pay ore, but is individualized by form or character from adjoining rock.
Ore reserve	Ore of which the grade and tonnage have been established with reasonable assurance by drilling and other means.
Organic matter	Matter composed of once-living organisms (carbon compounds).
Organism	A living individual of any plant or animal species.
Orographic effects	Pertaining to relief factors such as hills, mountains, plateaus, valleys, and slopes; usually used to describe weather patterns.
Outfall	A structure (pipeline) extending into a body of water for the purpose of discharging a waste stream, storm runoff, or water.
Oxide	A compound of oxygen with one or more elements or radicals.

Ozone	Form of oxygen (O_3) found largely in the stratosphere; a product of reaction between ultraviolet light and oxygen, or formed during combustion of hydrocarbon fuels.
Palustrine	Of, or relating to, shallow ponds, marshes, or swamps.
Palustrine forested	A forested wetland dominated by woody vegetation more than 20 feet tall.
Palustrine scrub-shrub	A wetland area dominated by woody vegetation less than 20 feet tall.
Peak flow	Highest flow; can be quantified as daily or instantaneous.
Permeability	The capacity of a material for transmitting a fluid. Degree of permeability depends on the size and shape of the pores, their interconnections, and the extent of the latter.
pH	Symbol for the negative common logarithm of the hydrogen ion concentration (acidity) of a solution. The pH scale runs from 0 to 14, with a pH of 7 considered neutral. A pH number below 7 indicates acidity, and a pH value above 7 indicates alkalinity or a base.
Physiography	A science that deals with the features and phenomena of nature; physical geography.
Piezometer	A device for measuring moderate pressures of liquids.
Piezometric head	The level to which a liquid rises in a piezometer, representing the static pressure of a waterbody.
Piezometric surface	Any imaginary surface coinciding with the hydraulic pressure level of water in a confined aquifer, or the surface representing the static head of groundwater and defined by the level to which water will rise in a well. A water table is a particular piezometric surface.
Plan of Operations	*See Operating plan.*
Plate filter	A filter used to remove gold precipitate from solution.
Point source	Stationary sources of potential pollutants. In terms of mining, some examples of point sources are crushing and screening equipment, conveyors, and pond outlet pipes.
Pollution	Human-caused or natural alteration of the physical, biological, and radiological integrity of water, air, or other aspects of the environment producing undesired effects.
Polychaete	Any of a class of mostly marine, annelid worms, having on most segments a pair of fleshy, leg-like appendages bearing numerous bristles.
Portal	The entrance to a tunnel or underground mine.
Potable water	Suitable, safe, or prepared for drinking.
Potentiometric surface	Surface to which water in an aquifer would rise by hydrostatic pressure.

Precipitation	The process of removing solid or liquid particles from a gas or smoke; the process of forming a precipitate from a solution (flocculation); rain, mist, snow, and the like.
Prehistoric	Relating to the times just preceding the period of recorded history.
Prevention of Significant Deterioration (PSD)	Under the provisions of the federal Clean Air Act, a proposed new source of air pollution may be required to apply for a PSD permit if certain emission limits are expected to be exceeded.
Pristine	Pertaining to pure, original, uncontaminated conditions.
Probable maximum flood (PMF)	A flood calculated to be the largest probable under any circumstances.
Probable maximum precipitation (PMP)	The theoretical physical maximum amount of precipitation that could occur at a given point or location.
Process area	The area that encompasses the adit, mill, and processing facilities.
Process water	Water required for use within the mill system.
Project area	The area within which all surface disturbance and development activity would occur.
Public scoping	An early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action (40 CFR 1501.7).
Pyrite	A common mineral consisting of iron disulfide (FeS_2) with a pale brass-yellow color and brilliant metallic luster. It is burned to make sulfur dioxide and sulfuric acid.
Pyritic	Relating to or resembling pyrite, a common mineral; iron disulfide.
Receiving waters	A river, lake, ocean, stream, or other watercourse into which wastewater or treated effluent is discharged.
Reclamation	Returning an area to a productive land use by regrading and reseeding areas disturbed during mining activity.
Record of Decision (ROD)	A document that discloses the decision on an environmental impact statement and the reasons why the decision was made; it is signed by the official responsible for implementing the identified action. The environmental consequences disclosed in an EIS are considered by the responsible official in reaching a decision (40 CFR 1505.2).
Redox	A chemical reaction in which one component loses electrons (is oxidized) and another gains electrons (is reduced).
Residence time	The amount of time a receptor organism or object is in contact with a source.
Resident	A species that is found in a particular habitat for a particular time period (e.g., winter, summer, year-round) as opposed to species found only when passing through during migration.

Richter Scale	A numerical (logarithmic) measure of earthquake magnitude.
Riparian	A type of ecological community that occurs adjacent to streams and rivers. It is characterized by certain types of vegetation, soils, hydrology, and fauna that are suited to conditions more moist than those normally found in the area.
Riprap	A layer of large rocks placed together to prevent erosion of embankments, causeways, or other surfaces.
Riverine	Of or relating to rivers, creeks, and streams.
Runoff	Precipitation that is not retained on the site where it falls and not absorbed by the soil; natural drainage away from an area.
Salinity	A measure of the dissolved salts in sea water.
Salmonids	Fish species (salmon, trout, and char) that belong to the same family; salmonidae.
Saturation	The extent or degree to which the voids in a material contain oil, gas, or water. Usually expressed in percent related to total void pore space.
Section 10 Permit	A permit issued under section 10 of the Rivers and Harbors Act of 1899. Section 10 requires a permit for any structure or work that might obstruct traditionally navigable waters. This permit is issued by the U.S. Army Corps of Engineers.
Section 404 Permit	A permit issued under Section 404 of the Clean Water Act. Section 404 specifies that anyone wishing to place dredged or fill materials into the waters of the United States and adjacent jurisdictional wetlands must apply to the U.S. Army Corps of Engineers for approval.
Sedentary	Not migratory; staying in one place; stationary.
Sediment	Material suspended in liquid or air; also, the same material once it has been deposited by water.
Sediment basin	A pond, depression, or other device used to trap and hold sediment.
Sediment loading	The mass of solid erosion products deposited by or carried in water or air.
Sediment pond	Structure constructed by excavation or by building an embankment whose purpose is to retain water and allow for settlement of fines (suspended solids) and reduction in turbidity.
Seepage	The slow movement of gravitational water through the soil.
Selenium	A nonmetallic, toxic element related to sulfur and tellurium; a by-product of the electrolytic refining of copper.
Semiautogenous	Produced or created without external help or influence.
Sensitive species	A plant or animal listed by a state or federal agency as being of environmental concern; includes threatened and endangered species.

Settling ponds	*See Sediment pond.*
Short-term impacts	Impacts occurring during project construction and operation, and ceasing upon project closure and reclamation.
Significant issues	Of the issues raised during the scoping process for an environmental impact statement, certain issues are determined to be "significant' by the lead public agency. Determining which issues are significant, and thus meriting detailed study in the EIS, is the final step of the scoping process and varies with each project and each location. Significant issues are used to develop alternatives.
Slurry	A watery mixture or suspension of insoluble matter, such as mud or lime.
Sodium hydroxide	A common laboratory reagent that is strongly alkaline when in solution with water.
Solid waste	Garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities.
Spawn	To produce or deposit eggs or sperm; the eggs or sperm product (fish reproduction).
Spill Prevention, Containment, and Countermeasure (SPCC) Plan	A plan that USEPA requires of facilities storing more than a given threshold of fuel or hazardous material. It is a contingency plan for avoidance of, containment of, and response to hazardous materials spills or leaks.
Stockpiling	Storage of soils or rock material.
Stormwater	Overland flow generated as the result of a storm event.
Strata	A tabular mass or thin sheet of earth of one kind formed by natural causes usually in a series of layers of varying makeup; sedimentary units.
Stream channel geometry	The cross section of a stream channel (end view).
Stream flow	The discharge (flow of water) in a natural channel.
Stream gradient	The rate of fall or loss of elevation over the physical length of a segment or total stream usually expressed in feet change per feet in distance (%).
Study area	The zone around the project area within which most potential direct and indirect effects on a specific resource would occur.
Subaqueous	Living, formed, or found under water.
Subsidence	A local lowering of land surface caused by the collapse of rock and soil into an underground void or by the removal of groundwater; it can result in stability failures such as landslides and mine roof cave-ins.

Subsistence use	Section 803 of the Alaska National Interest Lands Conservation Act defines subsistence use as follows: "The customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of the non-edible by-products of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade."
Substrate	An underlayer of earth or rock.
Succession	Changes in the plant communities composing an ecosystem as the ecosystem evolves from one type to another; e.g., wetland becoming grassy meadows.
Sulfide	A compound of sulfur with more than one element. Except for the sulfides of the alkali metals, the metallic sulfides are usually insoluble in water and occur in many cases as minerals.
Sump	In the case of an underground mine, an excavation made underground to collect water, from which water is pumped to the surface or to another sump nearer the surface.
Surficial	Characteristic of, relating to, formed on, situated at, or occurring on the earth's surface; especially, consisting of unconsolidated residual, alluvial, or glacial deposits lying on the bedrock.
Synchronous	Recurring or operating at exactly the same periods.
Tailings	The noneconomic constituents of the ground ore material that remain after the valuable minerals have been removed from raw materials.
Taxa (taxon)	Any group of organisms, populations, or the like considered to be sufficiently distinct from other such groups to be treated as a separate unit.
Terrestrial	Of or relating to the earth, soil, or land; an inhabitant of the earth or land.
Thermistor	A resistor made of semiconductors having resistance that varies rapidly and predictably with temperature.
Threatened species	A plant or wildlife species that is officially designated by the U.S. Fish and Wildlife Service as having its existence threatened and is protected by the federal Threatened and Endangered Species Act.
Tideland	Land that is overflowed by the tide but exposed during times of low water.
Topography	The physical configuration of a land surface.
Toxicity tests	Laboratory analyses generally used to determine the degree of danger posed by a substance to animal or plant life.
Trace metals	Metals present in minor amounts in the earth's crust (trace elements).

Transmissivity (coefficient of)	A measure of the ability of an aquifer to transmit water.
Turbidity	Reduced water clarity resulting from the presence of suspended matter.
Understory	A foliage layer lying beneath and shaded by the main canopy of a forest.
Visual resources	The visual quality of the landscape. The Forest Service manages viewsheds as a resource, establishing specific management objectives for different areas of Forest Service land.
Waste rock	Also known as development rock, waste rock is the non-ore rock extracted to gain access into the ore zone. It contains no gold or gold below the economic cutoff level.
Water balance	A measure of continuity of water flow in a fixed or open system.
Watershed	The entire land area that contributes water to a particular drainage system or stream.
Waters of the United States	All waters that are currently or could have been used in interstate or foreign commerce, including waters that are subject to the ebb and flow of the tide; wetlands; and lakes, rivers, streams, mudflats, sandflats, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds.
Weathering	The process whereby larger particles of soils and rock are reduced to finer particles by wind, water, temperature changes, plant and bacteria action, and chemical reaction.
Wetlands	Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.
Wilderness	Land designated by Congress as a component of the National Wilderness Preservation System.
Xanthates	A class of chemicals known as "collector" chemicals that attach to floating minerals, making them normally incapable of adhering to the froth in a flotation circuit.

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