COOPER CREEK WATERSHED ANALYSIS

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Executive Summary

The Cooper Creek Watershed Analysis was initiated in response to the pending relicensing of the 20.6-megawatt Cooper Lake Hydroelectric Project. The analysis consolidates available information on the watershed for a variety of National Forest resources, and assesses resource trends within the watershed over time. The document is intended as a tool to better understand the functioning of resources within the watershed, the changes that have occurred, and the range of management possibilities for the future.

The Watershed Analysis has four chapters. Chapter 1 explains the process used for developing the analysis. It also provides an overview of the resources and history of Cooper Creek Watershed and of the Cooper Lake Hydroelectric Project.

Chapter 1 summarizes direct and indirect physical and biological changes to the watershed related to the Cooper Lake Hydroelectric Project. Primary among the direct effects are the reductions in flow and water temperature to Cooper Creek, increased water level fluctuation of Cooper Lake, and enhanced public access to Cooper Lake. These direct effects then influence habitat for fish and wildlife, as well as recreation use in the area.

Chapter 2 evaluates historic/social, physical, and biologic resources within the Cooper Creek Watershed in greater detail. This chapter examines both "reference" and "current" resource conditions within the watershed. "Reference" conditions consider both the period before 1890 (when gold miners first entered and began to settle in the area), and period before construction of Cooper Lake Hydroelectric Project (1958 to 1962). "Current" conditions relate to resource conditions and trends after construction of the Cooper Lake Hydroelectric Project.

The Chapter 2 resource evaluations provide a compendium of information and data on the Cooper Creek Watershed gathered from a wide variety of sources. Information sources are referenced at the end of each resource section. Where possible, we have evaluated the quality of the data, and attempted to interpret trends for resource change within the watershed.

Chapter 3 identifies key issues and questions developed over the course of the analysis. These issues and questions relate primarily to the potential effects of Cooper Lake Hydroelectric Project operations on resource values in the Cooper Creek Watershed. Chapter III also highlights resource information gaps identified during the analysis, and possible techniques to obtaining missing information. Changes to fisheries in Cooper Creek and Cooper Lake/Reservoir and possibly Kenai River are issues given particular note in this chapter. Changes in wildlife habitat and recreation potential in the watershed are also examined.

Chapter 4 presents and discusses a number of resource mitigation and enhancement measures suggested during the development of the Cooper Creek Watershed Analysis. The majority of the measures focus on the Cooper Creek and Cooper Lake fisheries.

Proposed measures have been brought forward by a variety of agencies, groups, and individuals. These measures are offered as a starting point for evaluating mitigation and enhancement that could be used to counter habitat and other changes resulting from of the Cooper Lake Hydroelectric Project.

The Cooper Creek Watershed Analysis compiles, synthesizes, and interprets a large volume of information gathered from numerous sources. Additional information, data and concepts have undoubtedly been overlooked and could likely add to and enrich the content of this document. In this context, we hope to maintain this watershed analysis as a “living” document, so that additional relevant information may be incorporated into it through the Cooper Lake Hydroelectric Project relicensing process.

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CHAPTER 1 – INTRODUCTION AND CHARACTERIZATION

I. Overview of Watershed Analysis

Watershed analysis is used to characterize the human, aquatic, riparian, and terrestrial features; and conditions, processes, and interactions within a watershed. It provides a systematic way to understand and organize ecosystem information. In so doing, watershed analysis enhances our ability to estimate direct, indirect, and cumulative effects of our past management activities and guide the general type, location, and sequence of appropriate future management activities within a watershed.

Watershed analysis is essentially ***ecosystem analysis at the watershed scale.*** It provides a watershed context for fish and wildlife protection, restoration, mitigation, and enhancement efforts. Understandings gained through watershed analysis are critical to sustaining the health and productivity of natural resources. Healthy ecological functions are essential to maintain and create current and future social and economic opportunities.

Federal agencies conduct watershed analyses to shift their focus from species and sites to ecosystems. Working at this scale, we can better understand the overall consequences of potential management actions. Use of the watershed scale allows for selection of a well-defined land area with a set of unique features. Watershed boundaries define a system of recurring physical processes, and a collection of dependent plants and animals. Aquatic resources are particularly well suited to evaluation at the watershed scale.

Watershed analysis is not a decision making process. Rather it is a stage setting process. The results of watershed analysis establish the context for subsequent decision-making processes, including planning, project development, and regulatory compliance.

The results of watershed analysis can be used to:

- Assist with future development and evaluation of alternatives in the relicensing process for the Cooper Lake Hydroelectric project.
- Assist in developing ecologically sustainable programs to provide for water, fish and wildlife habitat, recreation, hydropower production, and other commodities.
- Establish a consistent, watershed-wide context for project level National Environmental Policy Act (NEPA) analyses.
- Establish a watershed context for evaluating management activity and project consistency given existing plan objectives.

II. Process and Document Organization

The document is organized around the three primary steps in the process: core topic analysis, answers to key question, and recommendations.

Chapter 2 presents the analysis of core topic areas, as identified in Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis (USDA, USDI 1995). The core topic questions focus the basic analysis on ecological conditions, processes, and interactions at work in the watershed. Current and reference conditions and future trends are examined for each core topic area. The core topics address the major ecological elements that are common to watersheds. This is the basic analysis addressed in all watershed analysis documents. The level of detail for each core topic is based on watershed specific issues.

Chapter 3 identifies key questions and issues for a spectrum of resources and activities within the Cooper Creek Watershed. This chapter identifies information we are lacking in order to make good resource decisions, and where possible, ways of obtaining that information. The chapter includes some recommendations for management within the watershed.

Chapter 4 presents a variety of mitigation and enhancement measures that have arisen and been discussed over the course of developing this watershed analysis. The majority of the measures are focused on the Cooper Creek and Cooper Lake fisheries, which have been repeatedly identified as key issues. The measures are presented mostly as initial ideas and opportunities. All would require further evaluation and design in order to be considered for implementation.

III. Characterization of the Cooper Creek Watershed

A. Introduction

This section summarizes information collected from the Cooper Creek Watershed. Resource changes during the last century are given particular note. Chapter 2 provides a more in-depth evaluation of watershed resource information.

The Cooper Creek Watershed is located on the Kenai Peninsula in Southcentral Alaska, near the community of Cooper Landing. It is a tributary watershed to the Kenai River. ***Figure 1.III.A-1*** displays the location of the Cooper Creek Watershed within Alaska.

This watershed analysis for Cooper Creek was initiated primarily in response to the pending relicensing of the Cooper Lake Hydroelectric Project. The original 50-year license for the project became effective May 1, 1957 and terminates on May 1, 2007. Initiation of the relicensing process must begin at least five years before termination of the original license, by May 1, 2002.

The 1957 Federal Energy Regulatory Commission (FERC) license to Chugach Electric Assn., Inc. (CEA) allowed for construction and operation of a hydroelectric plant on Cooper Lake. Construction of the project began in 1958, with initial power production starting in 1961. Final construction and testing of the facility was completed late in 1962.

Cooper Lake Project's average annual power generation from 1963 to 2000 was 48,300 megawatt-hours. Its peak-generating capacity was 16.6 megawatts ("name plate" peak generating capacity of 15.0 megawatts.) Improved generators installed in 2000-2001 increased the peak-generating capacity to 20.6 megawatts and average annual generation to 53,800 megawatt-hours (CEA, March, 2002.)

The Forest Service is using the watershed analysis process to evaluate past and present conditions within the Cooper Creek Watershed, and to identify key issues and concerns. This information will allow for more informed decisions on management options within the watershed. The watershed analysis synthesizes resource information gathered on the watershed, and identifies data/knowledge "gaps" where more information is needed.

B. Cooper Creek and the Kenai River Watershed

Cooper Creek is a tributary of the Kenai River. It joins the Kenai River three miles downstream from Kenai River's outlet on Kenai Lake. Cooper Creek's 49.0 square mile watershed comprises just over two percent of the 2200 square mile Kenai River Watershed (see ***Figure 1.III.B-1***).

The Kenai River Watershed is largely under federal management. Much of the upper watershed lies within the Chugach National Forest, and mid-portions in the U.S. Fish and Wildlife Service's Kenai National Wildlife Refuge. Kenai, Soldotna, and Sterling are

Figure 1.III.A-1: Kenai River and Cooper Creek Watershed Vicinity Maps)

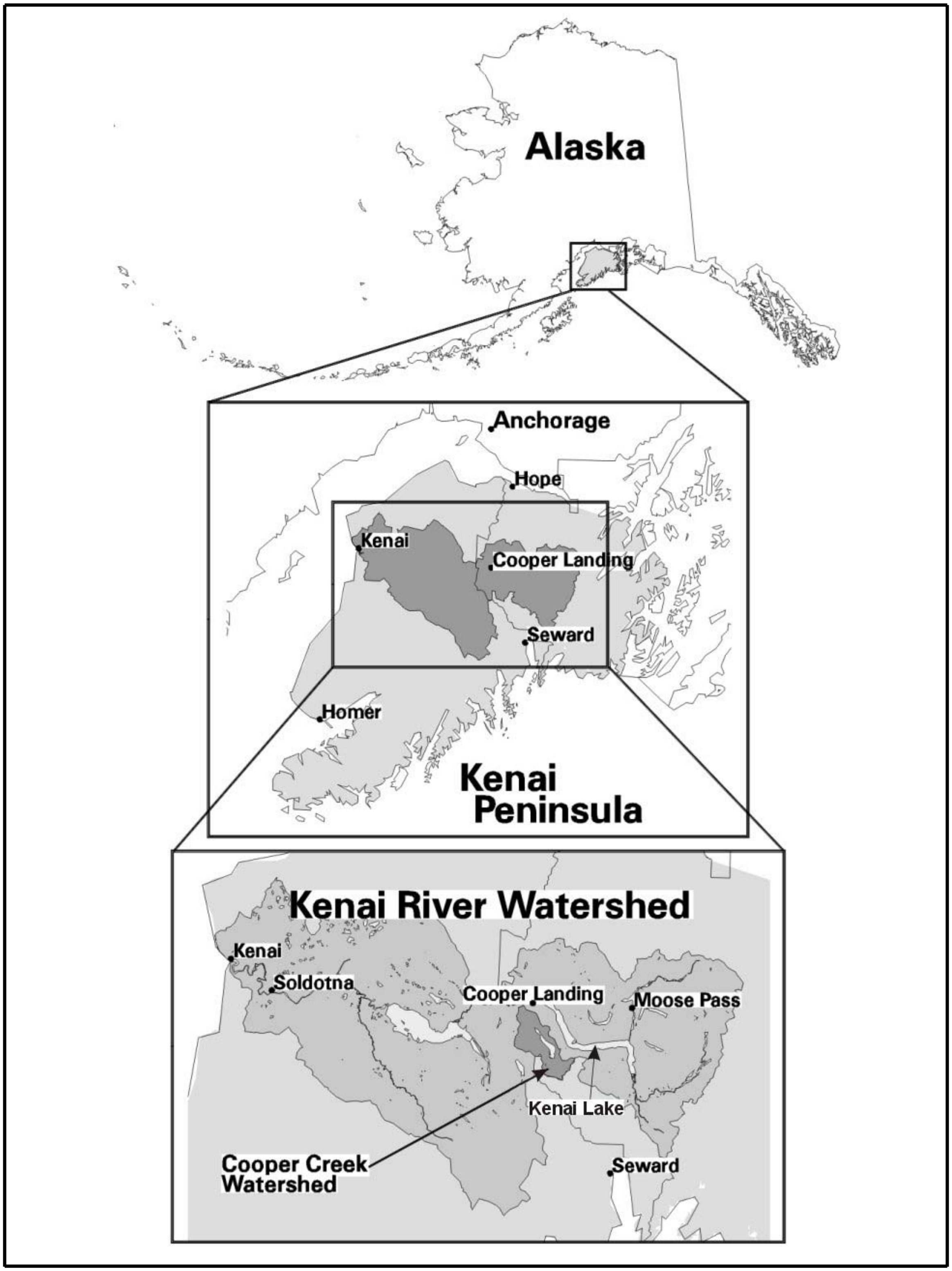
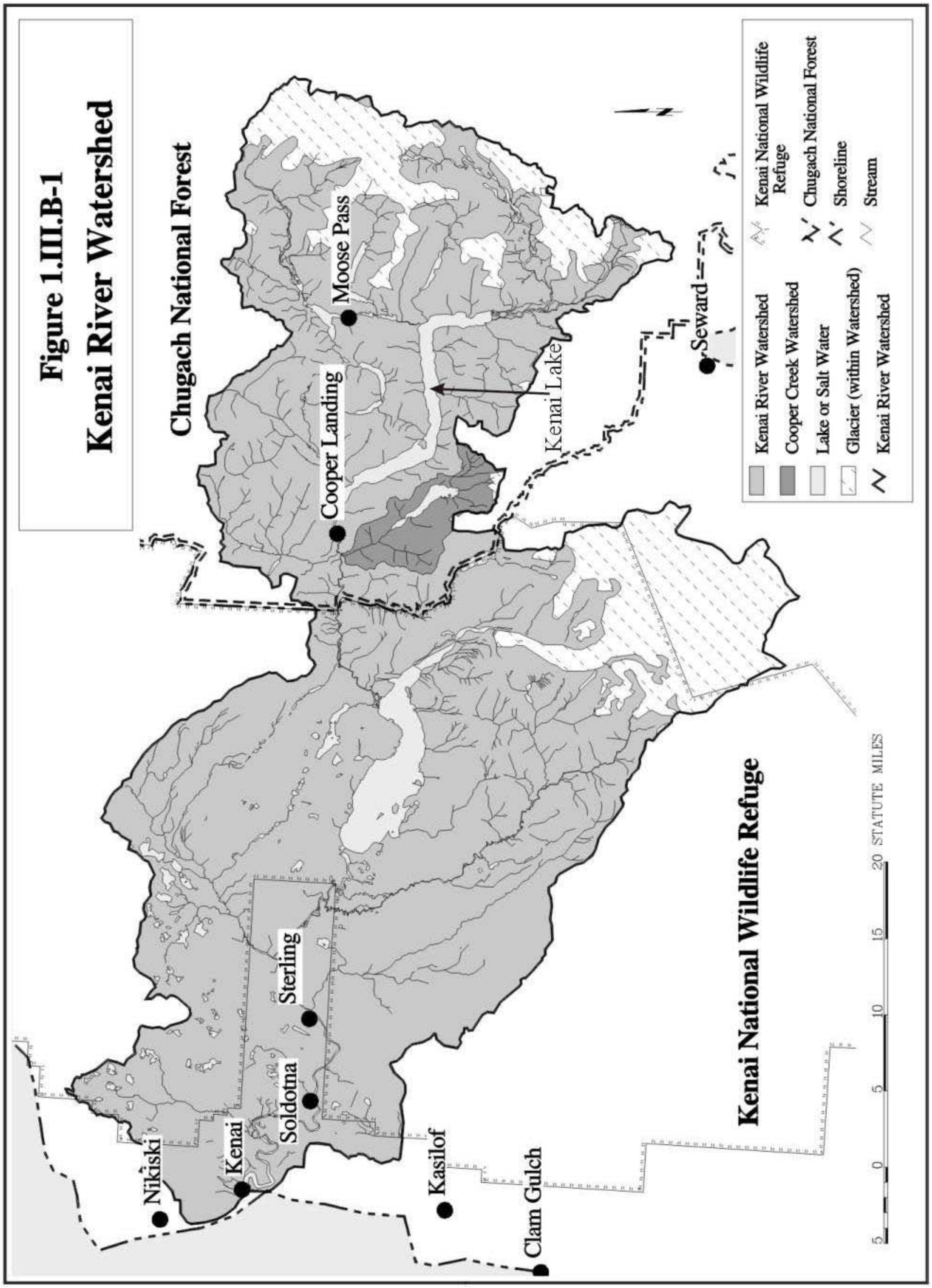


Figure 1.III.B-1: Kenai River Watershed



situated along the lower river, mostly within the Kenai River's watershed boundary. Communities in the River's upper watershed include Cooper Landing and Moose Pass.

The Alaska Department of Natural Resources manages a number of land parcels throughout the Kenai River Watershed, including the Kenai River Special Management Area (KRSMA). KRSMA is managed by the Division of Parks and Outdoor Recreation, and includes the Kenai River corridor from its mouth up through Kenai Lake. The Kenai Peninsula Borough and by two Native Corporations, Cook Inlet Region Inc. (CIRI) and Chugach Alaska Corporation (CAC) own additional land parcels within the Kenai River Watershed.

The Kenai River Watershed is renowned in Alaska for its scenic qualities, its diverse and productive fish and wildlife populations, and its accessible outdoor recreation opportunities.

Two large lakes, Kenai and Skilak, lay along the main Kenai River. Numerous moderate and small-sized lakes are found on tributaries to the Kenai. All these lakes work to moderate Kenai River flood flows, capture stream sediment loads, and diversify fish habitat. Glaciers currently cover over eight percent of the Kenai River Watershed and add significantly to the river's streamflow and sediment load.

Thirty-seven known fish species inhabit the Kenai River Watershed, including all five Pacific salmon species. The Kenai Watershed also supports 21 species of waterfowl, and 30 mammal species.

The river's large, dependable sockeye salmon run is highly important to local commercial fishing interests. Its accessibility and wide variety of angling opportunities have led this river to become the most intensively sport-fished stream in Alaska. In 1997, over 320,000 angler days were logged in the Kenai River Watershed (Howe, 1998). Anglers focus particularly on sockeye, chinook, and coho salmon, as well as rainbow trout and Dolly Varden. Of additional sportfishing interest in the watershed are its hooligan, grayling and lake trout fisheries.

Brown bear populations on the Kenai Peninsula have generated a high level of public interest. Miller (1993) estimates populations on the Peninsula at between 140 and 420 brown bears. Just over a third of the Peninsula's 9,000 square miles are probably used regularly by these bears (Jacobs, 1989).

Preliminary analysis by the Interagency Brown Bear Study Team identifies the Kenai River Watershed as containing the highest densities of feeding and denning brown bears on the Peninsula. Much of this habitat use can be attributed to the large runs of Kenai River salmon. These fish provide the primary food source for brown bears. Within the Kenai River Watershed, brown bear use concentrates along undeveloped reaches of the Kenai River and its primary salmon producing tributaries.

The Kenai River Watershed provides a central travel corridor for brown bears, allowing them access throughout the Peninsula. The watershed has the highest number of human-bear confrontations on the Peninsula, stemming largely from riverside development and angler/bear conflicts over salmon.

C. Cooper Creek Watershed's Physical Character

Cooper Creek Watershed elevations range from 400 feet at the creek's mouth, to 5270 feet atop Cooper Mountain. Mean elevation is about 2200 feet. "Natural" treeline is at about 2000 feet, but is lower on most slopes due to snow avalanche impacts. Much of the watershed is alpine in character, with only 24% forested and 18% in shrub. Several small, remnant glaciers cover about 1.7 square miles (3.5% of the watershed.) ***Figure 1.III.C-1*** displays features within the Cooper Creek Watershed and its surroundings.

Cooper Creek Watershed's annual precipitation averages between 55 to 60 inches. Precipitation generally increases with elevation within the watershed, as does the percent of annual precipitation coming as snow.

Cooper Lake, situated in the middle of the watershed, is six mile long and up to a mile wide. Until 1959, it was a natural lake, with a surface elevation of 1168 feet and depths in excess of 400 feet.

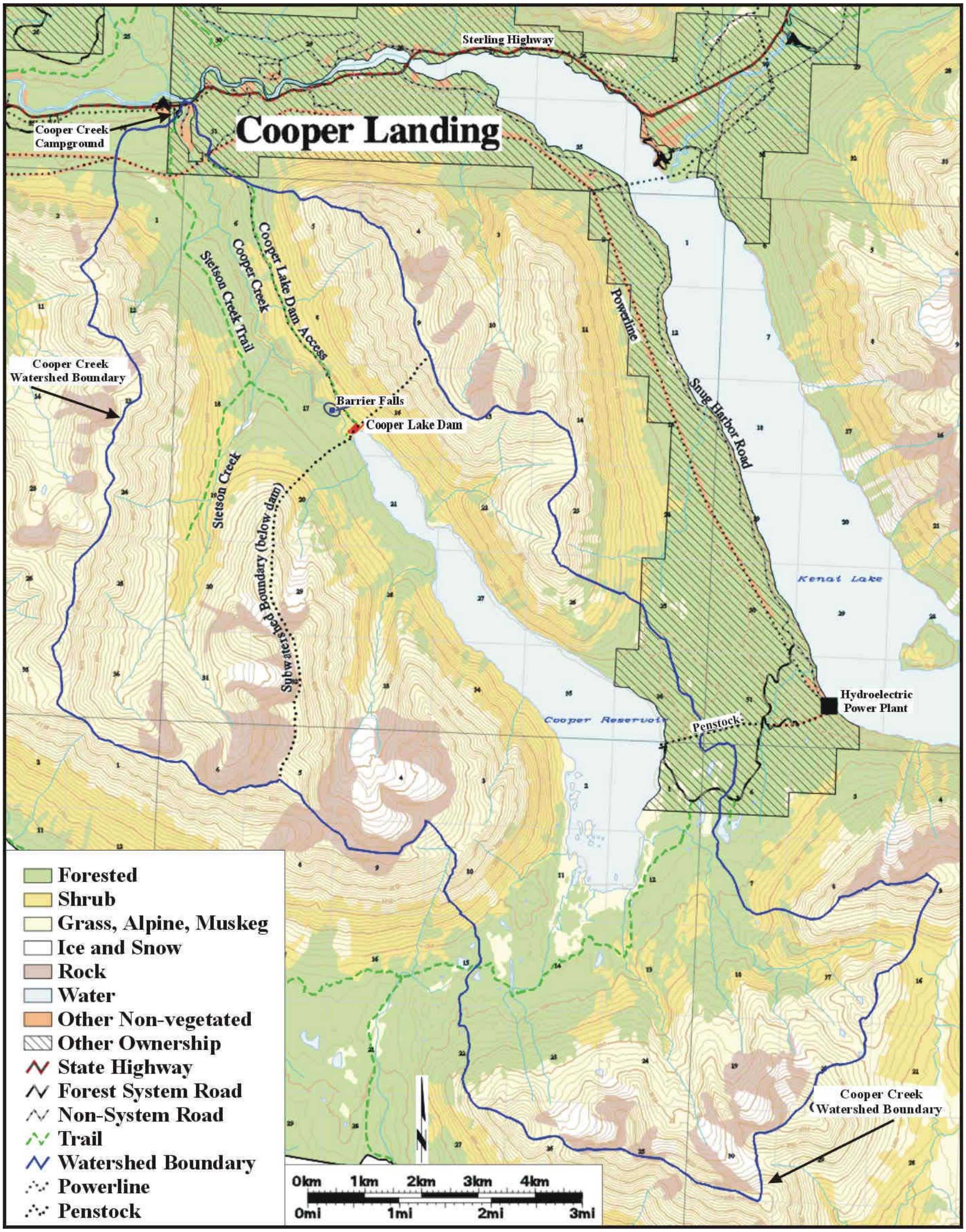
In 1959, the lake was dammed at its outlet for the Cooper Lake Hydroelectric project. Since construction of the dam at the outlet of Cooper Lake in 1959, the reservoir water elevation has varied from a maximum of 1213 feet to a minimum of 1159 feet. Since October 1962, all outflows from Cooper Reservoir have been diverted out of the watershed, to the project power plant on Kenai Lake (see ***Figure 1.III.C-1***.)

This watershed analysis refers to Cooper Lake before construction of the dam in 1959 as "Cooper Lake", and after construction of the dam as "Cooper Reservoir". On many maps and in text, the reservoir is still often referred to as "Cooper Lake". For this report, use of the two names has been helpful for distinguishing times and effects.

Cooper Reservoir and its tributary streams occupy about two thirds (31.7 square miles) of the Cooper Creek Watershed. The remainder of the watershed, below the reservoir, drains 17.3 square miles.

Cooper Creek begins at Cooper Lake/Reservoir and flows 4.7 miles north northwesterly to the Kenai River, dropping 750 feet vertical feet en route. About a third mile below the lake/reservoir, the creek flows into a steep-sided canyon and drops about 160 vertical feet in one-third mile, including over several, 15 to 40 foot falls (impassible to salmon.) Downstream from these falls, the remaining four miles of Cooper Creek drops at an average 2.7% grade, and offers no significant barriers to fish passage.

Figure 1.III.C-1: Cooper Creek Watershed and Surrounding Forest Lands



D. Cultural and Mining History

Salmon runs supported human settlement on the upper Kenai River for over 3,000 years. House pits and cache pits along lower Cooper Creek and its confluence with the Kenai River remain from native settlement. Native use of the Cooper Creek Watershed likely focused most at the mouth of Cooper Creek, where salmon were most accessible. Natives probably used upper parts of the watershed for hunting and possibly fishing.

Russian geologist Peter Doroshin prospected Kenai Peninsula streams between Skilak and Kenai Lakes from 1848 to 1851. In 1884, Joseph Cooper reported finding gold on Cooper Creek, and in 1894 placer claims were staked on the creek. Over the next century, a variety of placer mining operations from small to large have operated on both Cooper Creek and its tributary, Stetson Creek.

E. Cooper Lake Hydroelectric Project

Cooper Lake was first identified for its hydropower potential in a 1915 U.S. Geological Survey Report (Ellsworth and Davenport, 1915). An additional USGS survey in the early 1950's noted Cooper Lake as having significant potential for hydropower development (Plafker, 1955). Desirable hydropower site characteristics at Cooper Lake include:

- An elevation drop of 730 feet between Cooper and Kenai Lakes over just two miles.
- Sizable yearly inflow to Cooper Lake (averaging about 100 cubic feet per second).
- Potential for creating additional storage capacity as well as more hydraulic head and power production capacity by damming the lake at its outlet.

Additional social/economic factors fueling interest in hydropower included:

- Growing size and power demands of Anchorage in the 1950's.
- Completion of the Sterling Highway connecting Kenai/Soldotna to Seward in 1946.
- Completion of the Seward Highway connecting Anchorage to Seward in 1951.

Chugach Electric Association, Inc. (CEA) expressed early interest in developing a hydroelectric power project on Cooper Lake. In December 1953 the Federal Power Commission issued to CEA "Terms and Conditions of License for Unconstructed Major Project Affecting Lands of the United States".

In October 1954, CEA filed a preliminary permit under the Federal Power Act for hydropower development on Cooper Lake. On May 27, 1957 the FPC issued a license to CEA for developing and operating the Cooper Lake Hydropower Project. The Licence's effective date was May 1, 1957. The license included development of a powerline from the Cooper Lake hydropower plant to Anchorage.

Development of the Cooper Lake Project involved construction of four major components:

1) A 50-foot high, 900-foot long earthfill dam near the natural outlet of Cooper Creek at the northwest end of Cooper Lake.

2) A 16.6-megawatt capacity hydropower generating plant on the shore of Kenai Lake.

3) A 10,000-foot tunnel/penstock tapping water at the northeast end of Cooper Reservoir, and diverting it down 750 vertical feet to the powerhouse on Kenai Lake.

4) A high power transmission line between the power plant and Anchorage, with connections to the existing power grid on the Kenai Peninsula.

Cooper Reservoir and the upper portion of its outlet diversion tunnel lie within the Cooper Creek Watershed. The remainder of the tunnel, the penstock, and the power plant all are located outside the watershed. The project diverts all outflow from Cooper Reservoir to Kenai Lake. ***Figure 1.III.C-1*** displays these power facilities.

CEA built two new roads for developing the hydropower facilities, the "Cooper Dam Road and the "Snug Harbor Road". The Cooper Dam Road is a 4.5-mile gravel road up the northeast side of the Cooper Creek valley from the Sterling Highway to the Cooper Dam site. It provided access for dam construction and subsequently for maintenance. All but the first mile of this road lies within the Cooper Creek Watershed.

The Snug Harbor Road along the southwest shore of Kenai Lake allowed access for construction of the power plant and tunnel/penstock. This road starts from the Sterling Highway at the outlet from Kenai Lake and extends 12 miles to Cooper Reservoir. The road follows the shoreline of Kenai Lake for nine miles to the power plant. It then climbs three miles to Cooper Reservoir's northeast end, ending at the tunnel intake (see ***Figure 1.III.C-1***). Only the last mile of the road lies within the Cooper Creek Watershed.

Construction of the Cooper Lake Dam, and filling of Cooper Reservoir began in July 1959. All flow into Cooper Creek ceased for nearly two years as the reservoir filled. In May 1961, the reservoir topped its spillway and water began spilling into Cooper Creek.

Testing of the project's power plant began in February 1961. In May 1961, the Project began transmitting power to the east and south as far as Homer, AK. Initially, the project used only about a quarter of Cooper Reservoir's available inflow for power production, the remainder of the water spilling into Cooper Creek.

Full water use and power production for the Cooper Lake Project started in October 1962 with completion of transmission lines to Anchorage. Since then, all outflow from Cooper Reservoir has been through the tunnel/penstock, with no water spilling to Cooper Creek.

The Cooper Dam's spillway, at 1210 feet in elevation, is 42 feet higher than the former lake level. In 1961, logs built up on the spillway crest raising the reservoir to its highest recorded level of about 1213 feet. In April 1979, CEA drew down the reservoir to its lowest recorded level, 1159 feet, during maintenance operations on the tunnel. Water elevation difference between these maximum and minimum levels is 54 feet.

In November 1998, CEA applied for a license amendment (P-2170-010) to upgrade the existing turbines and generators at the Cooper Lake Project Power Plant. The intent of this amendment was to increase both the efficiency and peak production of the power plant. FERC approved this amendment application in October 1999, and CEA subsequently installed the turbine and generator upgrades during 2000 and 2001. The Cooper Lake Project currently has a peak power production capacity of 19.4 megawatts. This peak power production is reached at an approximate maximum water flow of 380 cubic feet per second through the tunnel/penstocks to the power plant.

F. Direct Physical changes within the Cooper Creek Watershed with development of the Cooper Lake Hydroelectric Project

Construction of the Cooper Lake Hydroelectric Project resulted in a number of direct physical changes to the watershed. Changes include: increased access into the watershed, reduced streamflows and water temperatures on Cooper Creek, altered water levels and shoreline character around Cooper Reservoir, and increased flow out of Kenai Lake.

1. Access

Before initiation of the Cooper Lake Hydroelectric Project, the Sterling Highway was the only major road within the Cooper Creek Watershed. The Sterling crosses Cooper Creek just upstream from its mouth on the Kenai River. An early 1900's mining trail/road was also in place along the west side of Cooper Creek from the Sterling Highway up to Stetson Creek. A hiking trail built in the 1930's connected Kenai Lake to Upper Russian Lake, and crossed the southeast end of the Cooper Creek Watershed (see ***Figure 2.I.A-1***.)

Construction of the Cooper Lake Hydroelectric Project in 1958-1962 opened road access to the dam site at Cooper Lake's northwest end (Cooper Dam Road), and to the tunnel intake at the Lake's northeast end (Snug Harbor Road.) The Cooper Dam Road connects the dam to the Sterling Highway and has been used for dam construction and maintenance. A gate at Mile 1 closes this road to motorized access by the public.

The Snug Harbor Road has been open to public access since construction of the Cooper Lake Project. It provides automobile access to camping, boat launching, fishing and hunting on Cooper Reservoir. In the 1960's, the Forest Service built a half-mile connector trail between the Snug Harbor Road and the Upper Russian Lake Trail. The trailhead is located a half-mile east of Cooper Reservoir on the Snug Harbor Road. The northern three miles of the old trail between Kenai and Cooper Lakes is now abandoned.

2. Cooper Creek Streamflow

Cooper Creek flowed unrestricted from Cooper Lake until July 1959. With the start of dam construction, outflow to Cooper Creek ceased, first temporarily until May 1961, then permanently after October 1962. Cooper Creek's channel immediately below the dam now carries no flow. A short distance downstream, water flow into Cooper Creek begins, as springs and tributary streams enter the main channel. At its mouth on the Kenai River, Cooper Creek now averages about 30 percent of its former flow from before the dam. About two thirds of Cooper Creek's flow is now contributed by Stetson Creek, the primary tributary.

Flood size and duration on Cooper Creek have also diminished greatly. Flood flows are most reduced in Cooper Creek upstream from its junction with Stetson Creek. At the mouth of Cooper Creek, major flood peak flows are now about half their former (pre-dam) size and last for a much shorter period.

3. Cooper Creek Water Temperatures

Cooper Lake/Reservoir surface waters are warmed by solar radiation during the late spring, summer, and early fall. After October 1962, all flow from Cooper Reservoir to Cooper Creek ceased, and water temperatures of Cooper Creek's remaining flow became considerably cooler. Post-dam stream temperature reductions first appear in March/April, and rise to a maximum by mid-summer. We estimate the mid-summer water temperature reductions on Cooper Creek at its mouth are between 6° and 9° F. Stream temperature changes from December to mid-March are likely negligible.

4. Lake Levels

Cooper Lake's surface elevation likely fluctuated less than two feet during an average year, and up to 3 feet (between 1167 and 1170 feet) in an extreme year. Since 1959, Cooper Reservoir has shown a maximum fluctuation of 54 feet (1159 to 1213 feet), and an average annual fluctuation of 11.2 feet. The reservoir usually drops to a minimum level around early May, and climbs to a maximum level from September to November.

During construction of Cooper Lake Dam, woody vegetation around the lake was cleared and burned to the elevation of the spillway, 1210 feet. Since 1970, reservoir levels have rarely exceeded 1195 feet. Fluctuation of the reservoir's water level, combined with wave action, has removed the soil mantle around the shore between elevations 1168 and 1195. Left in place is a gravel/cobble/bedrock shoreline around much of the reservoir. The shoreline between 1195 and 1210 feet in elevation has not been inundated for three decades or more, and vegetation has begun to fill back in.

Most of the denuded shoreline of Cooper Reservoir is relatively steep, and subject to wave action and removal of fine-grained sediments. The southeastern portion of the lake, however, has very low gradient shorelines created by deposited stream sediments. Portions of this southern shoreline receive limited wave action and retain finer-grained substrates along the shore. Grasses and sedges cover these deposits to well below 1195 feet in elevation.

Water level changes on Cooper Reservoir have also inundated the lower portions of all tributaries into the lake and their adjacent riparian zones. Lower gradient streams at the south end of the lake have the greatest length of channel affected by inundation.

Previous to dam construction, several small islands existed in Cooper Lake at its southern end. As water levels increase in Cooper Reservoir, portions of these islands become inundated. Simultaneously, new islands form in the hummocky shoreline at the reservoir's southwestern end. Exposed island area increases markedly at low to mid-range reservoir levels, then drops again higher reservoir levels.

5. Kenai River Streamflows

The Cooper Lake Project diverts about 70 percent of the outflow from the Cooper Creek Watershed into Kenai Lake and then into the Kenai River. In general this diverted water amounts to a very small percentage of the natural Kenai River flows. However, during low flow winters/springs, water diversion from the Cooper Lake Project can supplement the outflow from Kenai Lake, possibly benefiting salmon spawning habitat on the Kenai River.

Immediately downstream from the mouth of Cooper Creek, major rainfall and/or snowmelt floods on the Kenai River may be reduced by 3 to 5 percent by Cooper Dam (due to water retention in Cooper Reservoir.) As additional tributaries enter the Kenai River downstream, this flood reduction effect diminishes, becoming negligible by the time the Kenai River leaves Skilak Lake.

G. Biological changes in the Cooper Creek Watershed from the Cooper Lake Hydroelectric Project

Physical changes on the Cooper Creek Watershed from the development of the hydroelectric project affected a number of biologic changes. Most notable of these include changes in fish habitat on Cooper Creek, changes in fish habitat at Cooper Reservoir, and changes in waterfowl nesting habitat on Cooper Reservoir.

1. Cooper Creek Fisheries

USF&WS (1964) documented runs of sockeye chinook, and coho salmon on lower Cooper Creek previous to the Cooper Lake Project. Spawning rainbow trout and Dolly Varden populations were also noted. Limited survey data from the 1940’s and 50’s suggest small to moderate run sizes for salmon populations, and a moderate sport fishery focusing primarily on rainbows and Dolly Varden.

Early placer mining on Cooper Creek and Stetson Creek likely had adverse impacts on both fish and fish habitat on Cooper Creek. The stream riparian area on lower Cooper Creek was severely disturbed by historic mining. Little is known about the condition of the Cooper Creek fishery before mining, or changes to the fishery as a result of mining. Anadromous and resident fish did continue to use Cooper Creek after the major mining had occurred. Habitat on lower Cooper Creek is still recovering from impacts of early mining operations.

After completion of the Cooper Lake Hydroelectric Project, Cooper Creek showed a progressive loss of its salmon populations as well as its spawning rainbow trout. A population of Kenai River Dolly Varden continues using Cooper Creek for spawning, and a small population of Dollies may reside full-time in the creek. Losses to the Cooper Creek salmon and rainbow fisheries appear to be related primarily to reductions in both streamflows and water temperatures.

2. Cooper Lake/Reservoir Fisheries

Cooper Lake had a native Arctic char population before construction of the Cooper Lake Project. Between 1987 and 1994 ADF&G stocked Cooper Reservoir with rainbow trout. This rainbow population appears to have become self-sustaining, and spawns in inlet streams to Cooper Reservoir. Some competition for feeding habitat within the reservoir likely occurs between the rainbows and the Arctic char. Arctic char are lake spawners, and fluctuating reservoir levels possibly impacts some of their spawning areas.

Fluctuation of Cooper Reservoir water levels has affected rainbow trout spawning habitat on inlet streams to the reservoir in several ways. Vegetation clearing for the reservoir removed all sizable riparian vegetation, and hence, protective cover from these inlet streams between 1168 and 1210 feet in elevation. Inlet stream channels between 1168 and 1195 feet are inundated for varying periods of time depending on reservoir fluctuations. Rainbows spawn in the late spring and early summer, and some spawning habitat in inlet streams is inundated during some years.

3. Waterfowl Nesting Habitat

Some island-nesting habitat existed on (pre-dam) Cooper Lake. Filling of the reservoir increased the amount of island nesting habitat while causing a loss of riparian cover around the reservoir. The new habitat appears to favor nesting gulls and may limit nesting habitat availability for ducks and loons. Gulls probably did not nest on Cooper Lake before the dam. Gulls are now noted to prey on other waterfowl nests. Normal rising of the reservoir level during nesting season (late May through mid-July) can inundate lower elevation nesting sites of gulls and other water birds.

4. Brown Bear Habitat

The Cooper Lake Project has affected the brown bear population primarily by increasing the amount of human use/contact within the Cooper Creek Watershed, and by reducing the salmon runs on Cooper Creek. Increased human contact generally decreases the habitat use by brown bears. Decreases in the salmon populations on Cooper Creek allow less feeding opportunities for bears, and thus poorer habitat quality. However, the probable prime salmon spawning areas on Cooper Creek are in areas with relatively high human use, and thus high probability for human-brown bear interactions.

H. References for Chapter 1

Barry, Mary J., "A History of Mining on the Kenai Peninsula, Alaska", Anchorage, AK, 1997.

Brooks, Alfred H. et. al., "Mineral Resources of Alaska, Report on Progress of Investigations", U.S. Geological Survey Bulletin 520, Washington D.C., Government Printing Office, 1912.

Chugach Electric Association, Inc. “Final Environmental Assessment Amendment of License, FERC Project No. 2170-010”, Federal Energy Regulatory Commission, Office of Hydropower Licensing, Washington, D.C., October 1999.

Chugach Electric Association, Inc. “Public Information Meeting on Relicensing of Cooper Lake FERC Project No. 2170”, Powerpoint Presentation by CEA at WestCoast International Inn, March 19, 2002.

Ellsworth, C.E., and Davenport, R.W. “A Water Reconnaissance in South-Central Alaska”, U.S. Geological Survey Water-Supply Water 372, Washington D.C., Government Printing Office, 1915.

Hoekzema, R.B. and Fechner, S.A., "Placer Gold Sampling in and near the Chugach National Forest, Alaska", Information Circular 9091, USDI, Bureau of Mines, 1986.

Howe, Allen L., et. al., “Harvest, Catch, and Participation in Alaska Sport Fisheries During 1997”. Alaska Dept. of Fish and Game, Fishery Data Series No. 98-25, October 1998.

Jacobs, M.J. 1989. An initial population analysis and management strategy of Kenai Peninsula brown bears. M.S. Thesis, West Virginia Univ., Morgantown. 205pp.

Jansons, U., Hoekzema, R.B., Kurtak, J.M., and Fechner, S.A., "Mineral Occurrences in the Chugach National Forest, Alaska", Open File Report: MLA 5-84, USDI, Bureau of Mines, 1984.

Martin, G.C., Johnson, B.L., and Grant, U.S., "Geology and Mineral Resources of Kenai Peninsula, Alaska", U.S. Geological Survey Bulletin 587, Washington D.C., Government Printing Office, 1915.

Miller, S.D. "Brown bears in Alaska: a statewide management overview", Wildl. Tech. Bull. 11. Alaska Dep. Fish and Game, Juneau. 1993.

Plafker, George, "Geologic Investigations of Proposed Power sites at Cooper, Grant, Ptarmigan and Crescent Lakes, Alaska", U.S. Geological Survey Bulletin 1031-A, Washington D.C., Government Printing Office, 1955.

Sleem, D. H., "Map of Kenai Mining District and Moose Pass Regions" Copyright 1910, Seward Alaska

U.S. Fish &Wildlife Service. "An Initial Follow-up Report for Cooper Lake Hydroelectric Project, FPC. No. 2170, Kenai Peninsula, Alaska", Juneau, AK: July 1964.

USDA-Forest Service, et.al., "Ecosystem Analysis at the Watershed Scale", Revised August 1995, Portland, OR.

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CHAPTER 2 – CURRENT AND REFERENCE CONDITIONS

I. Historic/Social

A. Recreation/Subsistence

1. Before 1880

Salmon runs, abundant game, and a variety of plant life supported human settlement in the upper Kenai River for over three thousand years. House pits and cache pits, along the lower Cooper Creek and the confluence with the Kenai River remain from the Kenaitze Indian settlement of Tasdliht, named after the Kenaitze term for Cooper Creek, Tasdlihtnu, meaning Swift Flowing Water.

Cooper Creek Watershed. has only limited archeological survey work. The age and extent of Cooper Creek native cultural sites, and their context with other Kenai River sites have not been determined. Some cultural sites on lower Cooper Creek may well have been damaged or obliterated during later mining operations. Lower Cooper Creek lies in close proximity to the the Squilantnu Archeological District, and could possibly be considered for inclusion in the District. Upper Cooper Creek, and areas around Cooper Lake remain largely unsurveyed.

Russian explorers in the mid 1800’s left evidence of their presence in the form of Russian period copper artifacts. These artifacts were likely traded to Kenaitze Indians (Painter, 1998). Most the human use of the watershed at this time period came through subsistence activities (hunting, trapping, fishing) and early mining activities.

2. 1880 to 1959 - Mining/Settlement Era

Mining and subsistence activities were the major human uses of the Cooper Creek Watershed during most of this period. The Kenaitze Indians lived in this area until 1920. A 1917 flu epidemic raged through this population, taking a toll on their numbers. In 1920, the remaining Kenaitzes moved to the lower Kenai River area.

Intensive mining started on Cooper Creek in the 1890's. Men who worked these mining claims lived a subsistence life-style, relying on wild game and fish between shipments of supplies from Seward. Charles Chapman worked on the Towle and Stetson Mine in 1898 and 1899. He wrote home to California describing his summers in Cooper Landing. He mentioned eating many grouse, some moose, ptarmigan, and on occasion, bear. He didn't care for porcupines, thinking they looked too much like skunks (Barry, 1997).

During the early part of this period, Resurrection Bay near Seward was the primary starting point for miners coming to Cooper Landing. In the spring, miners used horses to pull sleds with their gear and food from Seward to the south end of Kenai Lake. Crossing the lake ice in the spring was treacherous, with horses and men falling through on occasion. These travelers cached most of their gear along Kenai Lake at Shackleford Mine (one mile east of the lake's outlet) and boated down Kenai River to Cooper Creek with heavy loads. The journey from Seward to Cooper Creek took five to seven days in good conditions. Early Stetson Creek miners may have moved loads from Kenai Lake up to Cooper Lake, across Cooper Lake and down to Stetson Creek.

The 1900 population census for Cooper Creek reported 20 men and one woman living in the area. It did not include the native population. Large-scale hydraulic mining began at the mouth of Cooper Creek in the early 1900's. In 1907 a miner's camp was established on the west side of Cooper Creek, a half mile upstream from the Kenai River. This camp included a bunkhouse, cookhouse, and other buildings to support 20 to 40 men. Later, when the camp was abandoned, its lumber and other materials were used for a new generation of buildings in the area. As more people moved into Cooper Landing, hunting and fishing pressure increased in the Cooper Creek Watershed and surrounding areas.

Guides in the first half of the 1900's hunted the Cooper Creek Watershed extensively. In the November 11, 1915 edition of the Alaska Evening Post, resident Ben Sweazey indicates that many hunters were out looking for sheep and moose in lower Lake District.

In the 1920's and 30's area hunters and trappers established a number of small trapping cabins in the Cooper Creek drainage and the Russian Lakes drainage. One cabin was built at Cooper Lake's south end during this period.

"Cabin on Cooper Lake"

from the album of Maimie Elwell. This picture was probably taken in the 1930's or early 1940's

Photo provided courtesy Mona Painter of Cooper Landing, AK.

Hunting guides, hunters, trappers, and miners were the primarily users of the Cooper Creek Watershed in the 1920's through 40's. Anglers were drawn to the road accessible areas along the Kenai River, Russian River, and lower Cooper Creek to fish for salmon and rainbow trout. Since access to Cooper Lake was still difficult, it received substantially lower use. Access to the lake via floatplane increased in the 1940's and 50's.

A 1929 internal Forest Service memo recommends developing an improved trail location around the Cooper Lake. This memo notes the poor location and condition of existing trail, and the increasing use occurring in the area.

In the 1930's the Forest Service built this trail connecting Kenai Lake (at Snug Harbor) with Upper Russian Lake. The trailhead started very close to the current location of Cooper Lake Project power plant on Kenai Lake. The trail followed a moderate grade up into the Cooper Creek Watershed and around the southeast end of the Cooper Lake, and then on through to upper Russian Lake.

Figure 2.I.A-1 shows human use in the Cooper Creek Watershed around 1940, and displays the Kenai to Russian Lake Trail through the Cooper Creek Watershed. The Forest Service converted the trapper's cabin at the south end of Cooper Lake to a public use cabin after the trail was constructed. Use of the full Kenai Lake to Russian Lake trail continued up until the late 1950's, when construction of the Snug Harbor Road eliminated the need for the trail's first three miles. The cabin location on Cooper Lake was inundated in the 1959 filling of Cooper Reservoir.

Pictures and references about the fishing in Cooper Creek in the 1930's indicate large rainbow trout were the desired catch. King salmon spawning was also noted in Cooper Creek.

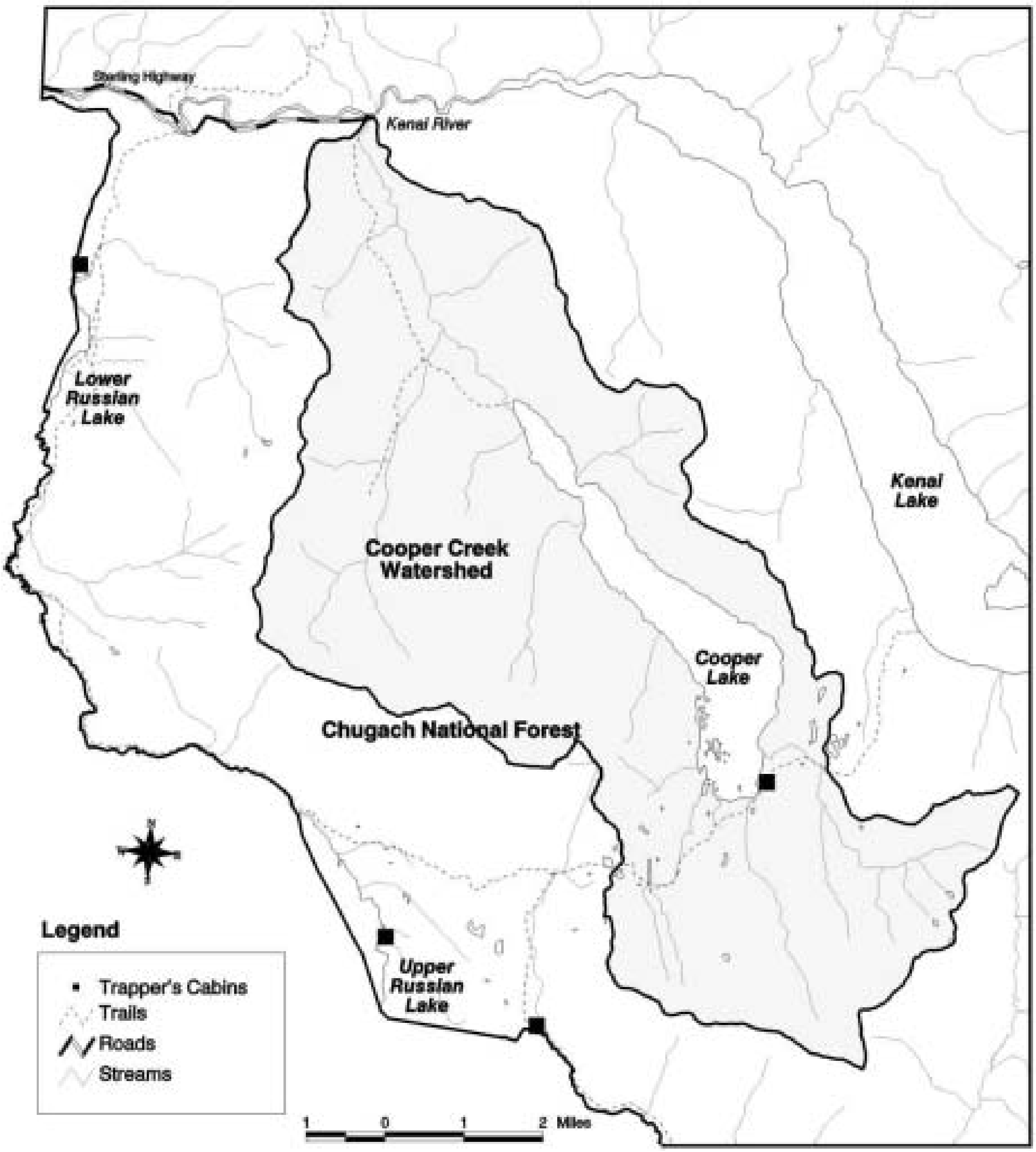
On September 24, 1938, the Seward Daily Gateway reported a large flood had washed out the bridge over Cooper Creek (near it mouth) along with 700 to 1,000 feet of road. During the high water, local residents rowed out to their gardens along Cooper Creek to harvest vegetables from under the water.

The Seward Daily Gateway (9/24/1938) also reports on a Kansas couple hunting in the Cooper Landing area for several weeks with a local guide. The couple bagged two Dall sheep, two moose, and a bear. They ended their Alaskan trip with a fishing outing to Cooper Lake to catch rainbow trout. (Note: This report of rainbow trout in Cooper Lake seems unlikely. Possibly Dolly Varden/Arctic char were caught and referred to as rainbows, or possibly the fishing occurred on Cooper Creek instead of Cooper Lake.)

At the end of World War II, recreation use of National Forests started rising nationwide. The Sterling Highway was constructed in 1946, giving improved access to Cooper Landing from the Kenai/Soldotna area. The Seward Highway was constructed in 1950 giving road access to Cooper Landing from Anchorage. The 1940's Southcentral Alaska population of 15,000 people more than tripled to 50,000 in 1950.

In 1957, Chugach Electric Association (CEA) received a permit for generating hydroelectric power with water from Cooper Lake. In 1958-59, CEA built the Snug Harbor Road and the Cooper Lake Dam road for accessing the tunnel/penstock at the east end of the lake, and the dam site at the northwest end. Construction of these two roads became the most important influence to human use of the watershed from 1959 forward.

Figure 2.I.A-1: Human Use in the Cooper Creek Watershed Around 1940



Note: This map does not meet map or data standards; locations are approximate

3. 1960 to the Present - After Construction of Cooper Lake Dam

a. Recreation Facilities

During the 1960's and 1970's, outdoor recreation expanded exponentially nationwide. Southcentral Alaska's population rose from 50,000 in 1950 to 110,00 in 1970, to 300,000 in 1985. Alaskan residents sought recreation activities in a natural setting, while expanding tourism attracted many more visitors to Alaska. The Forest Service expanded and improved campgrounds, trails, and trailheads on the Seward Ranger District during the 1960's and 70's in response to the increased public demand. ***Figure 2.I.A-2*** displays current recreation use in and around the Cooper Creek Watershed.

(1) Snug Harbor Road Sites

(a) Russian Lakes Trail

The east end of the Russian Lakes Trail now starts from the Snug Harbor Road, a half-mile east of Cooper Reservoir. This 21-mile hiking trail travels around the south end of Cooper Reservoir, then on to Upper and Lower Russian Lakes, and the north trailhead at Russian River Campground.

In 1960, Chugach Electric Association reconstructed a portion of the Russian Lakes Trail flooded by the rising waters of Cooper Reservoir. In a mid-1960's memo the Forest Supervisor of the Chugach National Forest notes the inadequate, wet trail condition between Upper Russian Lake cabin and Cooper Reservoir. He recommends discouraging public use of the trail.

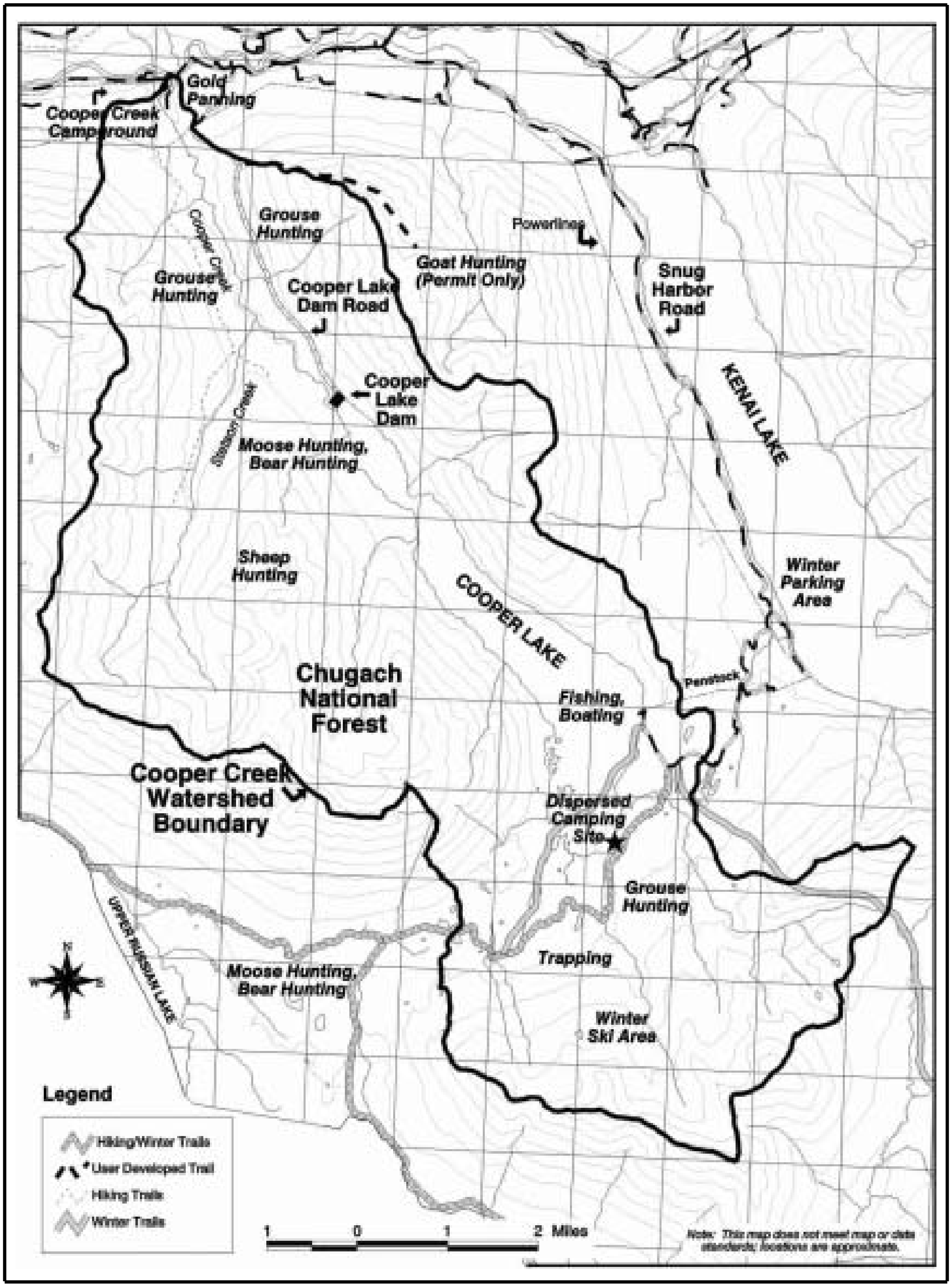
In 1971, the Forest Service improved trail alignment and tread of the Russian Lakes Trail on its south (Cooper Reservoir) end. In 1973, the trailhead on Snug Harbor Road was reconstructed to accommodate more parking. Currently, this Cooper Reservoir Trailhead averages 1500 to 3000 users annually, while the north trailhead at Russian River Campground averages about 12,000 users. Forest Service trail maintenance crews note a significant increase in use at the south end of Russian Lakes Trail the in recent years.

(b) Rainbow Lake Trail

The Rainbow Lake Trail offers a half-mile hike just outside the Cooper Creek Watershed. This trail starts from the Snug Harbor Road, one mile east of the road's end at Cooper Reservoir. The trail was first "user developed" and then upgraded by the Forest Service in 1973 to improve its alignment. It serves an estimated 1,000 people annually

Char Lake is located on the Snug Harbor Road, 3/4 mile east of Cooper Reservoir. The lake lies within the Cooper Creek Watershed and is visible from the Snug Harbor Road. Char Lake Trail was planned for construction in 1974 by Youth Conservation Corps, but was not built. The proposed trail would have traversed 0.2 miles from the Snug Harbor Road to Char Lake. ADF&G biologists found Arctic char in this lake in 1970.

Figure 2.I.A-2: Current Recreation Use around Cooper Creek Watershed



(2) Cooper Creek Campground

Cooper Creek Campground was built in 1962. The campground lies on the west side of Cooper Creek at its confluence with the Kenai River, and is split into two separate parts by the Sterling Highway. The campground currently has 29 camping units.

Exceptional salmon fishing on the Kenai River system brings hundreds of thousands of anglers to the Cooper Landing area each summer. Camping sites in this area are usually full during the peaks of the two Kenai River sockeye salmon runs in the summer. Cooper Creek Campground serves as an overflow camping area for Russian River Campground, and has an average occupancy of 61% from Memorial Day to Labor Day.

Recreation mining is allowed within the 40-acre mineral withdrawal along the east side of lower Cooper Creek (PLO 1052 – see ***Figure 2.I.C-2***). The Forest Service withdrew these lands in 1955 for campground expansion. By Forest Service regulations, recreation mining must occur within Cooper Creek's "active" (unvegetated) channel. Recreation mining can include: panning, hand sluicing, and suction dredging. Suction dredges may have up to a four-inch intake, and must obtain a permit from ADF&G's, Habitat Division. Due to salmon presence in this section of Cooper Creek, ADF&G allows suction dredging only between May 15 and July 15, when eggs are not in the gravel.

Lands within PLO 1052 on Cooper Creek's east bank have been used for recreation mining, boat launching (into the Kenai River), and dispersed camping, including overflow camping for Russian River Campground during sockeye salmon season. A half-mile long, unpaved road passes through PLO 1052, traveling southward from the Sterling Highway to the mouth of Cooper Creek Canyon. In the summer of 2001, the Seward Ranger District installed a gate on this road at the Sterling Highway, closing it to vehicle access. The District implemented this closure in part due to road drainage problems, and in part because of camping violations along the road.

(3) Stetson Creek Trail

Miners in the late 1800's and early 1900's developed a trail up the west side of Cooper Creek to access their operations on Stetson Creek. The trail now follows a four-mile water ditch first built in 1907 to supply a hydraulic mining operation at the mouth of Cooper Creek. The Forest Service has currently closed this trail to motorized vehicle use, excepting miners with current operating plans. Local residents use the trail for hiking and hunting access. Use figures have not been determined.

(4) Cooper Lake Dam Road

The five-mile Cooper Lake Dam Road starts at mile 49.6 of the Sterling Highway and travels SSE to Cooper Lake Dam. CEA uses the road for dam maintenance. The road is gated one mile off the highway, barring motorized public use of its remaining four miles. Recreation use of the road is largely by local residents for hiking, mountain biking, berry picking, and hunting. For several years in the mid-1990's, an outfitter/guide under Forest Service special use permit offered horseback rides to Cooper Lake Dam.

b. Hunting and Trapping

The Cooper Creek Watershed provides popular hunting and trapping opportunities. Moose and bear are hunted throughout the drainage. Mountain goat hunters have developed a trail from the Cooper Lake Dam Road near the gate eastward up a ridge to Cecil Rhode Mountain. Cooper Mountain, on Cooper Reservoir's west side, supports a healthy Dall sheep population, and receives some hunting pressure in late summer. Spruce grouse are common in forested portions of the watershed, and grouse hunters use all the existing trails and roads for hunting.

Trappers use the Russian Lakes Trail early in the winter to set traps in the south end of the Cooper Creek Watershed. They trap primarily for wolverine and martin. As soon as the ice thickens in late December or early January, trappers cross Cooper Reservoir via snow machines to access the trail to Upper Russian Lake.

c. Summer Use of Cooper Reservoir

Cooper Reservoir receives moderate recreation use during the summer months, with almost all access coming from the Snug Harbor Road. The road accesses a rocky beach on the southeastern side of the reservoir near the penstock. This beach is used for parking vehicles, launching boats, picnicking and camping. The beach accommodates a limited number of users, and varies in greatly in size depending on the reservoir level.

On busy summer weekends, 5 to 10 vehicles may be parked at the beach, and 5 to 7 boats present on the lake. Boats ranging in size from canoes to large powerboats are launched from this beach. Boaters use the reservoir for fishing, sightseeing, and camping in the summer, and also for hunting access in the fall. Anglers catch Arctic char and (starting in the late 1980's) rainbow trout from the reservoir, particularly near the mouths of inlet streams.

Snug Harbor Road's length and condition are likely a prime limiting factors on summer use at Cooper Reservoir. The narrow, 13-mile road has sections of potholes and washboard surface. The Forest Service grades the road once a year from Camp Kustaka at mile 4.5, up to the penstock on Cooper Reservoir.

Cooper Reservoir has no improved recreation or sanitation. Dispersed camping is available on rocky beaches around the entire reservoir. Camp Kustaka (on Snug Harbor Road) often uses a camping site at the reservoir's south end, near the location of the old trapping cabin.

Lands adjacent to the Snug Harbor Road from the Sterling Highway to Cooper Reservoir have been conveyed to State or Borough ownership. All State lands along Snug Harbor Road are proposed for management by Kenai River Special Management Area under

Alaska State Parks (Kenai River Comprehensive Management Plan, December 1997). The parking area and boat launch on Cooper Reservoir at the end of Snug Harbor Road is included in these parcels.

d. Winter Use of Cooper Creek Watershed

Winter use of the Cooper Reservoir area by snowmobilers and skiers has increased rapidly over the past 15 years. Access to the area is primarily via the Snug Harbor Road. Nine miles of the Snug Harbor Road are plowed and kept open through the winter from Cooper Landing to the Cooper Lake Project power plant on Kenai Lake. The last three miles of road to Cooper Reservoir are not plowed, and get snowed-in during the winter.

Winter recreationists generally drive Snug Harbor Road to the power plant turn off, then park, and travel up the road via snowmachine or skis. In the early winter, before Cooper Reservoir freezes, snowmachiners generally use the south end of the Russian Lakes Trails. As the reservoir ice thickens, much of the access occurs across the lake.

Snowmachiners also use the Snug Harbor Road "portal" to access high alpine valleys that open up at the southeast end of the Cooper Lake Watershed. Access to these valleys has become increasingly available as snowmachines have increased in both power and range. These alpine valleys also accessible via the Lost Lake Trail out of Seward, and the Primrose Trail at the southeast end of Kenai Lake. The Snug Harbor Road provides the closest access for residents of the western Kenai Peninsula.

Cooper Reservoir has potential for winter fishing, but very little ice fishing has been observed in recent years. For several winters in the 1980's, a company offered guided backcountry skiing at the south end of Cooper Reservoir (under Forest Service special use permit. They established a camp at a small lake south of Cooper Reservoir and transported people via tracked cat up a nearby slope to ski.

Winter cabin use is popular on the Russian Lakes trail system. These cabins are mostly accessed from Russian River Campground, but also can be reached via Cooper Reservoir.

With winter recreation use rapidly increasing, parking problems have arisen at the power plant junction on the Snug Harbor Road. Due to parking occurring at the intersection, access to CEA's power plant road is occasionally blocked by vehicles and snow machine trailers. CEA had requested the Forest Service to build a parking lot for these vehicles. The road intersection itself is located on State lands.

e. Electronics Sites

Two electronic sites under special use permit are located on the north side of Cecil Rhode Mountain. A Forest Service electronics site is located near Cooper Mountain. These sites need periodic maintenance via helicopter.

4. Future Recreation Use - Potential Recreation Opportunities

a. Cooper Reservoir

Several recreation opportunities have been under consideration within the Cooper Creek Watershed by the Forest Service including a campground, boat launch, and picnic area. In 1967, the Forest Service surveyed and approved an 85-unit campground site on Cooper Reservoir's southeastern shore. This proposed site lies along Cooper Reservoir, one mile south of the penstock/tunnel entrance. Insufficient funding stopped its construction. The site remains on National Forest System Lands and may be considered for future development. Access to the proposed campground would follow the current Russian Lakes Trail, where a road easement across State lands has been retained.

In 1967 the Forest Service also proposed a boat launch and 8-site picnic area located near the Cooper Reservoir penstock. Neither of these facilities was constructed, and the site now is located on lands transferred to the State of Alaska. Alaska State Parks has no immediate plans to build recreational facilities on its land along the southeast side of Cooper Reservoir. Facilities developed on these State lands would be planned and constructed using KRSMA guidelines.

Cooper Reservoir has good potential as a location for a Forest Service public use cabin. A cabin could be located for access primarily by trail, or primarily by boat and float plane. One promising site for boat access is located on the west side of Cooper Reservoir, a mile and a half south of the dam.

A proposal has been submitted to the Forest Service Capital Improvement Project list to upgrade the Rainbow Lake Trail to accessible standards for people with disabilities.

Winter parking problems continue at the powerhouse junction of the Snug Harbor Road. Additional plowed space in needed. CEA, ADNR, and the Forest Service will work to resolve this problem.

b. Cooper Creek

Since the mid-1980's, the Forest Service has considered expanding Cooper Creek Campground to the east side of Cooper Creek. Presently no sanitation facilities are provided for dispersed camping occurring here. Constructing a small camping loop with facilities would reduce sanitation concerns, and would increase yearly maintenance costs.

The town of Cooper Landing has developed a Community Plan to address potential community expansion. Expanding recreation opportunities in and around the Cooper Landing is a priority of the Plan. An example opportunity is to develop a loop trail connecting the Stetson Creek Trail and Cooper Lake Dam Road.

5. References for Recreation/Subsistence

Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, "Kenai River Comprehensive Management Plan", November 1998.

Barry, Mary J., "A History of Mining on the Kenai Peninsula, Alaska", 323 West Harvard Ave., Anchorage, Alaska, Revised Edition, 1997.

Painter, Mona, "Cooper Landing Historic Report", Unpublished Manuscript prepared for the U.S. Forest Service, Cooper Landing, 1998.

Seward Daily Gateway, "Prize Sheep is Capital Trophy Bagged in Hunt", Sept. 24, 1938.

Seward Daily Gateway, "Road Section Cooper Creek Worst Washout", Sept. 24, 1938.

B. Mining in the Cooper Creek Watershed

1. Pre-Settlement Era (prior to 1880)

The first record of gold discovery was in Alaska was by Russian mining engineer Peter Doroshin. In 1848 and 1850, Doroshin prospected in the Kenai River Valley, both on a tributary to Skilak Lake and on two streams flowing into the Kenai River between Kenai and Skilak Lakes (USGS Bulletin 277, 1907). Gold was found in most of the stream gravels examined, but not in commercial quantities, and Doroshin's discoveries were left unexploited by his employer, the Russian-American Company.

Whether Russian mining occurred on Cooper Creek is unclear. Russian period artifacts were discovered near Cooper Creek in the early 1900's (Barry, 1997), but may have been Russian tools traded with local Kenaitze Indians. Evidence of early, Russian-American era mining on lower Cooper Creek would likely have been obscured during intensive mining in the early 1900's (Vinson 1998).

2. Mining/Settlement/Pre-Cooper Dam Era (1880-1959)

a. Early Finds

Gold discovery along the Kenai River was next reported in 1884. In that year, an exploration party lead by Joseph Cooper reported finding gold on a creek later named after him, Cooper Creek. It was not until ten years later, in 1894, that Charles Sickles staked the first placer claim on the "flats" at the mouth of Cooper Creek. His mining method consisted of "shoveling gravel into sluice boxes."

In 1896, James Stetson discovered gold near the mouth of Stetson Creek, a tributary to Cooper Creek. The gold was found in a bank of gravel exposed by a landslide (Barry, 1997). Stetson merged interests with George Towle, and in 1897 they further prospected and developed the gravel bank. In 1898, with a crew of 16 men, they hauled in a hydraulic plant from Resurrection Bay to Stetson Creek. They started mining in September 1898, but soon had to shut down due to lack of supplies.

Mining on Stetson Creek started again in 1899 with a full-scale hydraulic operation that worked two-shifts during the long summer daylight hours (Painter 1998). They found considerable coarse gold, but the quantity of associated gravel made mining unprofitable, and mining ended that summer. Again in the summer of 1900, the Towle family set up a hydraulic outfit on Stetson Creek, but made little more than expenses from the mining (Barry, 1997).

Hand mining with sluices continued on Cooper Creek at the turn of the century. Both the "flats" on the lower half-mile of the creek, and the upstream canyon were mined. Mining in the canyon ceased after 1903, while some mining continued on lower Cooper Creek and to a lesser extent, on Stetson Creek (Barry, 1997).

b. Kenai Milling and Mining Company

In December 1905, the Kenai Mining and Milling Company incorporated with the intent of mining on Cooper Creek. Some 100 acres of placer ground were located on lower Cooper Creek in 1906.

During the summers of 1906 and 1907, the company began preparing for hydraulic mining on the lower flats of Cooper Creek. They constructed a mining camp, built four miles of ditchline to transport water from Stetson Creek to the mine site, installed a hydraulic outfit including 4,000 feet of steel pipe, and constructed a "Ruble elevator" to separate out cobbles and boulders in the sluicing process. Actual mining did not begin until 1908, with two hydraulic plants operating, and another added in 1909 (Barry, 1997).

USGS Bulletin 520 (1912) reports:

> *"The Cooper Creek placers are the property of the Kenai Mining & Milling Co., whose claims extend from Cooper Lake to Kenai River. Hydraulic operations were in progress in 1911 on the stream flat at the lower end of the creek."*, and
>
> *"For several years active operations have been confined to the wide flat at the lower end of Cooper Creek, where the creek gravels, 8 to 10 feet thick, form a uniform layer over a false bedrock of fine sand and sandy clay, with some lenses of pebbly gravel. …. The creek gravels are loose and easily handled. …. Boulders over 3 feet are rare, most of averaging 1 ½ to 2 feet. …. These stream flat gravels are reported to average from 30 to 50 cents gold per cubic yard."*, and
>
> *"Water for hydraulicking is obtained from Stetson, Wildhorse, and Kickinghorse Creeks by an upper ditch 4 miles long, a lower ditch 1 ¾ miles long, and 1,300 feet of flume. Two No.2 Hendy giants with 4-inch nozzles and two No. 4 giants with 5 inch nozzles made by a Portland firm were available, but only one giant with a 5-inch nozzle operating under a 200-foot head was in use in June 1911. The usual mode of operation is to strip the soil down to gravel layer and then wash all the gravel down to the false bedrock, over the elevator."*

The Kenai Milling and Mining Company hydraulic mining operation on Cooper Creek continued until about 1917, with World War I probably putting an end to the mining. The operation is said to have produced $10,000 (Barry, 1997). Current aerial photography indicates the operation may have covered about 50 acres.

c. Hydraulic Mining Operations

Mining within the Cooper Creek drainage during the late 1800's and early 1900's ranged from small scale sluicing and panning to far higher production hydraulic operations. A sluice box processes 1-2 cubic yards of gravel per person per shift. A hydraulic plant can increase production to hundreds of cubic yards per day with a crew of only 2-3 persons. Hydraulic mining was effective in moving large volumes of ground with relatively low operating costs.

In a hydraulic mining operation, gravel is pushed into and through a sluice box using a high-pressure water jet from a water canon, or “hydraulic giant”. To create adequate water pressure, imported water is passed down through a pipeline from a source usually several hundred vertical feet above the mining operation. Miners would tap water from an up valley source and transport it along a low-gradient ditchline and/or flume to gain sufficient elevation above the mining site.

Hydraulic Mining on Cooper Creek by Kenai Milling and Mining Co., circa 1910
(Photo Courtesy Mona Painter)

Kenai Milling and Mining diverted water from Stetson Creek and two other west side tributaries through a four mile long contour ditch and flume along the west side of the Cooper Creek Valley. The lower end of this ditchline was some 600 to 700 vertical feet above the mining area on lower Cooper Creek. Using large volumes of water at high pressure, the hydraulic operation was able to push aside vegetation, soil, gravel, cobbles and boulders. Then the underlying, gold-bearing gravels were directed through a sluice to separate out the gold.

The hydraulic operation was designed for the gold deposit and local topography. "Cutting giants" were used to strip overburden, "driving giants" to move gold-bearing gravels toward the sluice boxes, and “stackers” to push rocks out of the sluice discharge. The stackers created elongated piles of cobbles and boulders. These “tailings” piles are still present in mined areas along lower Cooper Creek.

d. After 1917

Kenai Milling and Mining Company was the last major gold producer on Cooper Creek. U.S.B.M. Circular 9091 (1986) reports a total estimated production of 1,100 ounces of gold from Cooper Creek, and 300 ounces from Stetson Creek by all operations.

Barry (1997) reports some additional mining on Cooper Creek in the 1930's by C.L. Lincke, and on Stetson Creek in 1937 by Bill Knaak and Vern Saxton. Lincke had a relatively small operation, while Knaak used seven men and two hydraulic giants for mining bench deposits above Stetson Creek.

Alluvial deposits near the mouth of Stetson Creek are reported as having been hydraulic mined in the 1950's. Painter (1998) mentions muddy summer flows on Cooper Creek in the 1950's, making fishing difficult.

3. Mining and Dam Construction Activity - 1959 to Present

Construction of the Cooper Lake Hydroelectric Project including roads and infrastructure started in late 1958, with the dam construction beginning in July 1959. The area around the dam site was withdrawn from mineral entry, thus barring future mining claims. The dam itself is earthfill, and used material taken both from the dam site, and from pits along the Cooper Lake Dam Road.

A slate cliff on Cooper Creek’s west bank, about a half-mile south of the Sterling Highway, has been used locally as a building rock source since at least the 1950's (Painter, 1998).

In 1966, Chugach Electric Association undertook a project to face the interior side of the Cooper Dam with riprap due to wave erosion on the dam. A number of areas were tested/mined for riprap during this project. Alluvial deposits from the “dry” channel of Cooper Creek immediately below the dam were processed to separate out larger boulders. About ¼ mile below the dam, where Cooper Creek enters into a canyon, the canyon wall was blasted for a rock source. Both these efforts developed only a limited riprap supply, and other sources were later sought.

Placer mining on Cooper and Stetson Creeks continues to the present, mostly with small-scale operations. Since 1980, modern, portable suction dredges are most frequently used, with additional mining by hand sluice or pan method. ADF&G, Habitat Division requires a permit for suction dredging on the lower two miles (anadromous) of Cooper

Creek. The permit allows dredging between May 15 and July 15 when salmon eggs are not in the stream gravels.

Records at the Bureau of Land Management indicate that since 1985, Fifty-four mining claims have been filed within the Cooper Creek Watershed, primarily on Stetson and Cooper Creeks. In 1998 there were 12 active federal mining claims in the Cooper Creek drainage. Mining plans of operation approved by the Forest Service show suction dredging as the usual mining method. Mining claims are displayed in ***Figure 2.I.B-1***.

In 1955 the U.S. Forest Service withdrew from mineral entry a sliver of land about a half-mile long and about 350 feet wide, mostly along the east side of lower Cooper Creek (PLO. 1052 – see ***Figure 2.I.C-2***). Lands surrounding the withdrawal have since been conveyed out of Forest Service ownership, but the withdrawal remains National Forest land. Cooper Creek, along this withdrawal, is open to public recreation mining, including panning, sluicing, and use of small suction dredges (up to 4" intake.)

A half-mile upstream from its mouth, Cooper Creek traverses onto State lands for about a third of a mile, and then back onto National Forest lands. This one-third mile section of Cooper Creek has four State of Alaska mining claims staked on it. These State Claims have had little mining activity since 1989 when a small "wash" plant, settling pond, and heavy equipment operation was active. In 1998, only hand operations using gold pan and sluice were noted on these claims.

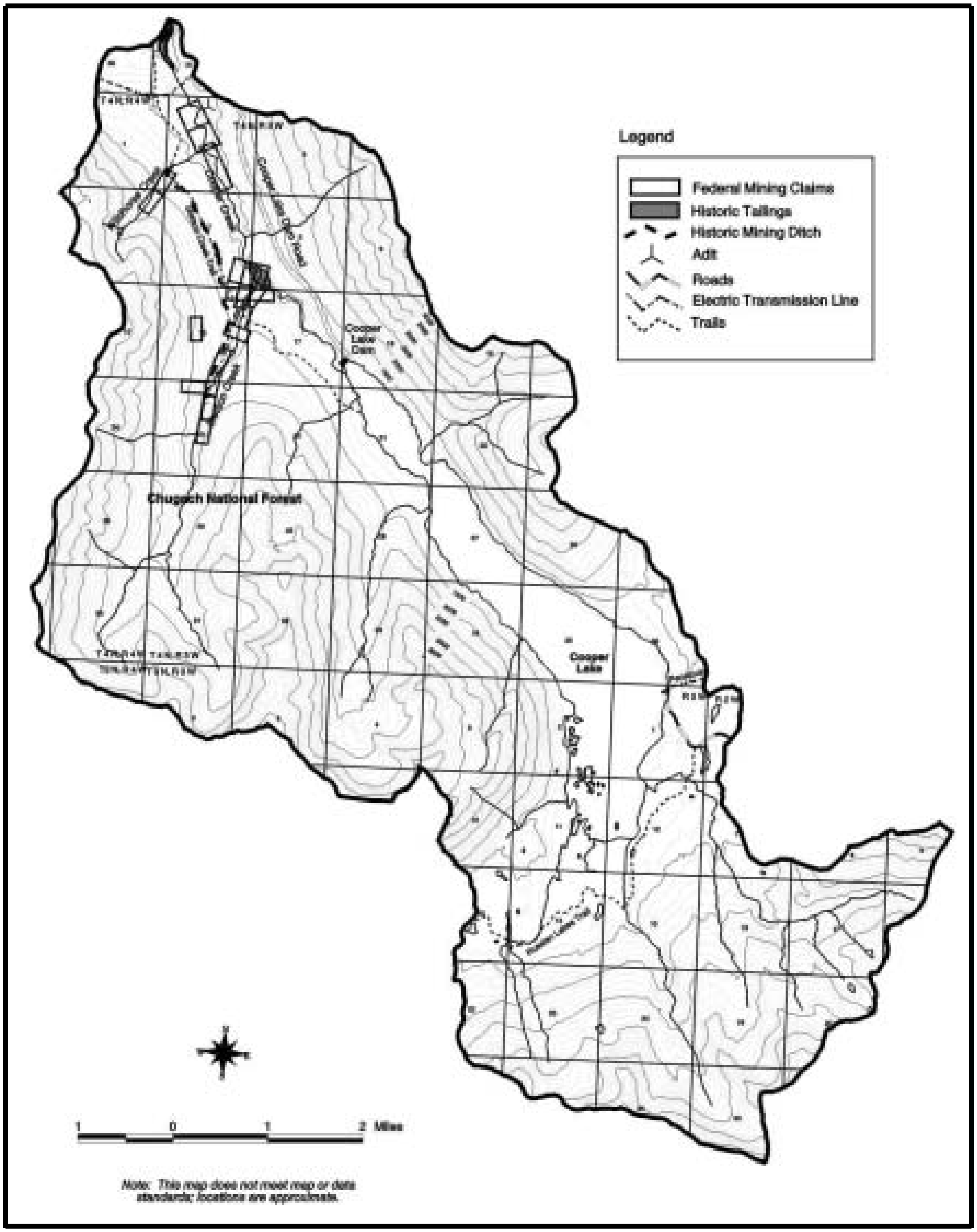
The 70% reduction in water flow on Cooper Creek by the Cooper Lake Hydroelectric Project has been beneficial for mining on Cooper Creek. Plenty of water is still available for sluicing and suction dredging operations, but the hazards associated with high volume flows have been greatly reduced. Despite this, recent mining effort on Cooper Creek has been limited. Some placer mining also continues on the tributary Stetson Creek, where flow conditions remain unaltered by the Cooper Lake Dam.

4. Mining Effects on Cooper Creek

The biggest impacts to Cooper Creek by placer mining were probably the alteration of its channel and riparian habitat, and the increase in fine-grained sediment in the channel. Hydraulic mining by the Kenai Milling and Mining Company on lower Cooper Creek between 1907 and 1917 undoubtedly caused the greatest disturbance along the creek.

Kenai Milling and Mining removed riparian vegetation and soil from about 50 acres along Cooper Creek's lower half-mile, and then processed 8 to 10 feet of underlying gravels. Cooper Creek's channel was likely moved during this operation to process gravels within its channel. Soil organics and fine-grained sediments in the overburden were mostly washed down into the Kenai River.

Figure 2.I.B-1: Mining Use in Cooper Creek Watershed



Mining obliterated numerous fish habitat features along lower Cooper Creek such as large woody debris, pools, and side sloughs. Cooper Creek has been slow to recover from these mining impacts due to the lack of soils and riparian vegetation. Mature riparian vegetation provides a source of large woody debris to the stream, and better root holding strength (hence less erosion) along the streambanks.

The influx of fine-grained sediments into Cooper Creek from mining operations likely settled in part in its downstream gravels, generally lowering fish spawning viability. Hydraulic mining operations processed large volumes of gravel, and likely ran their wash water and fine-grained sediments directly into Cooper Creek. During the 1907 to 1917 hydraulic mining operations on lower Cooper Creek, the lower half-mile of Cooper Creek probably received heavy inputs of fine-grained sediments.

Fine-grained sediments from the Stetson Creek hydraulic mining (1898-1900, 1937, and 1950's) may have influenced the length of the Cooper Creek channel from Stetson Creek to the Kenai River. Fine-grained sediments depositing in Cooper Creek's channel would eventually be transported out of the system, primarily during large flood events. Loss of flooding potential on Cooper Creek from Cooper Dam has significantly limited Cooper Creek's ability to flush out these fine-grained sediments.

Hydraulic mining operations in the Cooper Creek drainage required extensive ditchline and flume systems to transport water to the mining areas. These ditchlines were known to fail, or "blow out" on occasion, sending the full flow of the ditch cascading down the hillslope into Cooper Creek or Stetson Creek. Such blowouts would erode a temporary channel between the ditch and the creek below. These events would also have contributed a large and short-term sediment load to the creek.

Ditchlines and associated small water reservoirs used for hydraulic mining in the Cooper Creek Watershed are still found in place. The ditchlines are now choked with vegetation, and are not effective for water transport, although they do alter downslope runoff patterns along their length.

Current sluice and suction dredge mining on Cooper and Stetson Creeks have some potential for adversely affecting channel riparian habitat and stream sedimentation. However, the gravel quantities processed by these operations are vastly smaller than for historic hydraulic mining operations, and impacts to channel/riparian are far less.

5. Interpreting Mining History

Cooper Creek has a rich mining history that includes the establishment of the town of Cooper Landing. Mary Barry writes at length about Cooper Creek mining in her “A History of Mining on the Kenai Peninsula, Alaska)” (1997).

In July 1979, Doug and Lorena Keating opened the “Hubbard Museum” on the east side of lower Cooper Creek. The museum was named after Charley Hubbard a Kenai Peninsula miner and resident from 1910 to 1969. The museum operated under a Forest

Service special use permit. It displayed mining artifacts from the area, interpreted mining history, and provided gold panning opportunities on Cooper Creek. The museum closed in the summer of 1985 (Painter, 1998.)

6. References for Mining History

Barry, Mary J., "A History of Mining on the Kenai Peninsula, Alaska" 323 West Harvard Ave., Anchorage, Alaska, Revised Edition 1997.

Brooks, A.H., et.al., "Mineral Resources of Alaska, Report on Progress of Investigations, 1911", U.S. Geological Survey Bulletin 520, U. S. Government Printing Office , Washington D.C., 1912.

Hoekzema, R.B., Fechner, S.A., "Placer Gold Sampling in and Near the Chugach National Forest, Alaska", U.S. Bureau of Mines Information Circular 9091, 1986.

Huber, Carol and Blanchet, Dave, "Water Quality Cumulative Effects of Placer Mining on the Chugach National Forest, Kenai Peninsula 1988-1990", Chugach National Forest, 1992.

Huber, Carol and Roe, Chris, "Report on Abandoned and Inactive Mines", Unpublished Manuscript, Chugach National Forest and U.S. Bureau of Mines, 1994.

Lampright, R.L., "Gold Placer Deposits Near Anchorage, Alaska", Iron Fire Publications, 8251 Majestic Drive, Anchorage, Alaska 99504-4702, 1995.

Martin, G.C., Johnson, B.L., Grant, U.S., "Geology and Mineral Resources of the Kenai Peninsula, Alaska", U.S. Geological Survey Bulletin 587, Government Printing Office, Washington, D.C., 1915

Moffit, Fred H., "Mineral Resources of Kenai Peninsula, Alaska", U.S. Geologic Survey Bulletin 277, U.S. Government Printing Office, Washington D.C., 1907.

Painter, Mona, "Cooper Landing Historic Report", Unpublished Manuscript prepared for the U.S. Forest Service, Cooper Landing, 1998

C. Land Status

1. Introduction

The initial order establishing the Chugach National Forest and withdrawing it from the public domain of the Territory of Alaska was signed on February 23, 1907. As of that date, the entire Cooper Creek Watershed was incorporated into the Chugach National Forest. Today, 97.2% of the watershed is National Forest land. Conveyances of approximately 890 acres within the watershed to the State of Alaska (Department of Natural Resources) in the 1980's and 1990's account for the remaining 2.8% of the watershed lands. Several Public Land Orders (PLO), easements, permits, and mining claims are currently in place within the watershed, and are discussed in this section.

2. Land Conveyances to the State in the Cooper Creek Watershed

a. Introduction.

Section 6 of the Alaska Statehood Act states:

> *"for the purposes of furthering the development of, and expansion of communities, the State of Alaska is hereby granted and shall be entitled to select...from lands within the National Forests of Alaska which are vacant and unappropriated at the time of their selection..."*

The State has gone through a process of selecting National Forest Lands, and prioritizing the most desired selections. Land conveyances to the State are tentatively approved (TA) by the BLM, and then patented after a land survey has been completed. Once in State ownership, the State can designate the lands for a wide variety of uses, including State Park designation, and conveyance to the local Borough.

Figure 2.I.C-1 shows land status of areas within and adjacent to the Cooper Creek Watershed. The figure shows a continuous band of lands transferred to the State of Alaska, and the Kenai Peninsula Borough starting from the east side of Cooper Reservoir and stretching north and west along the shore of Kenai Lake to the mouth of Cooper Creek. This band of transferred lands lies within the Cooper Creek Watershed in two locations, one on the east side of Cooper Lake (760 acres), and the other at the mouth of Cooper Creek on the Kenai River (130 acres).

Figure 2.I.C-2 also shows a block of State selected lands (190 acres) on the west side of the mouth of Cooper Creek. These lands are likely to be conveyed to the State in the near future. Additional land selections within the Cooper Creek Watershed by the State of Alaska appear unlikely at this time.

Figure 2.I.C-1: Alaska Department of Natural Resources Map of Land Status Within and adjacent to the Cooper Creek Watershed

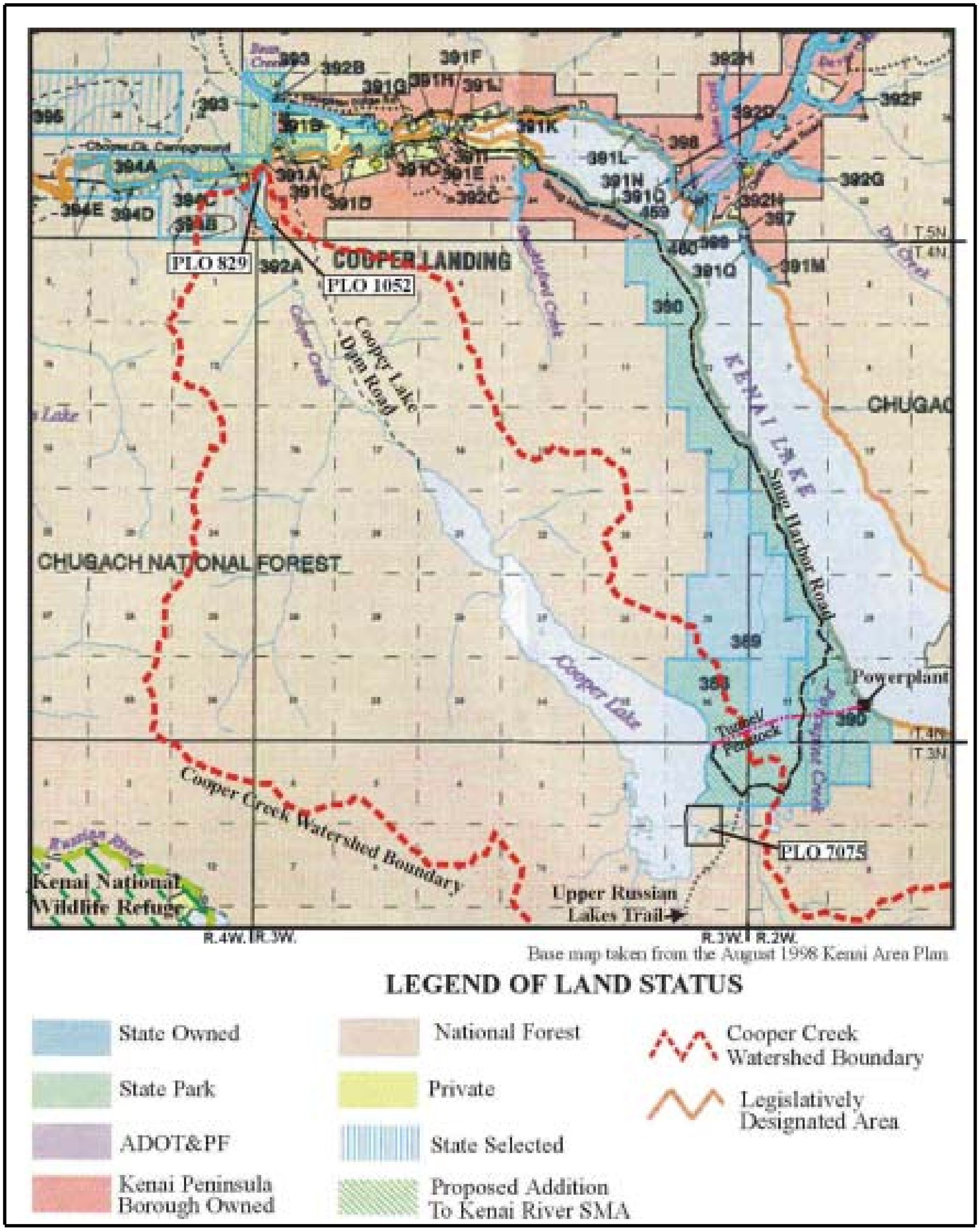
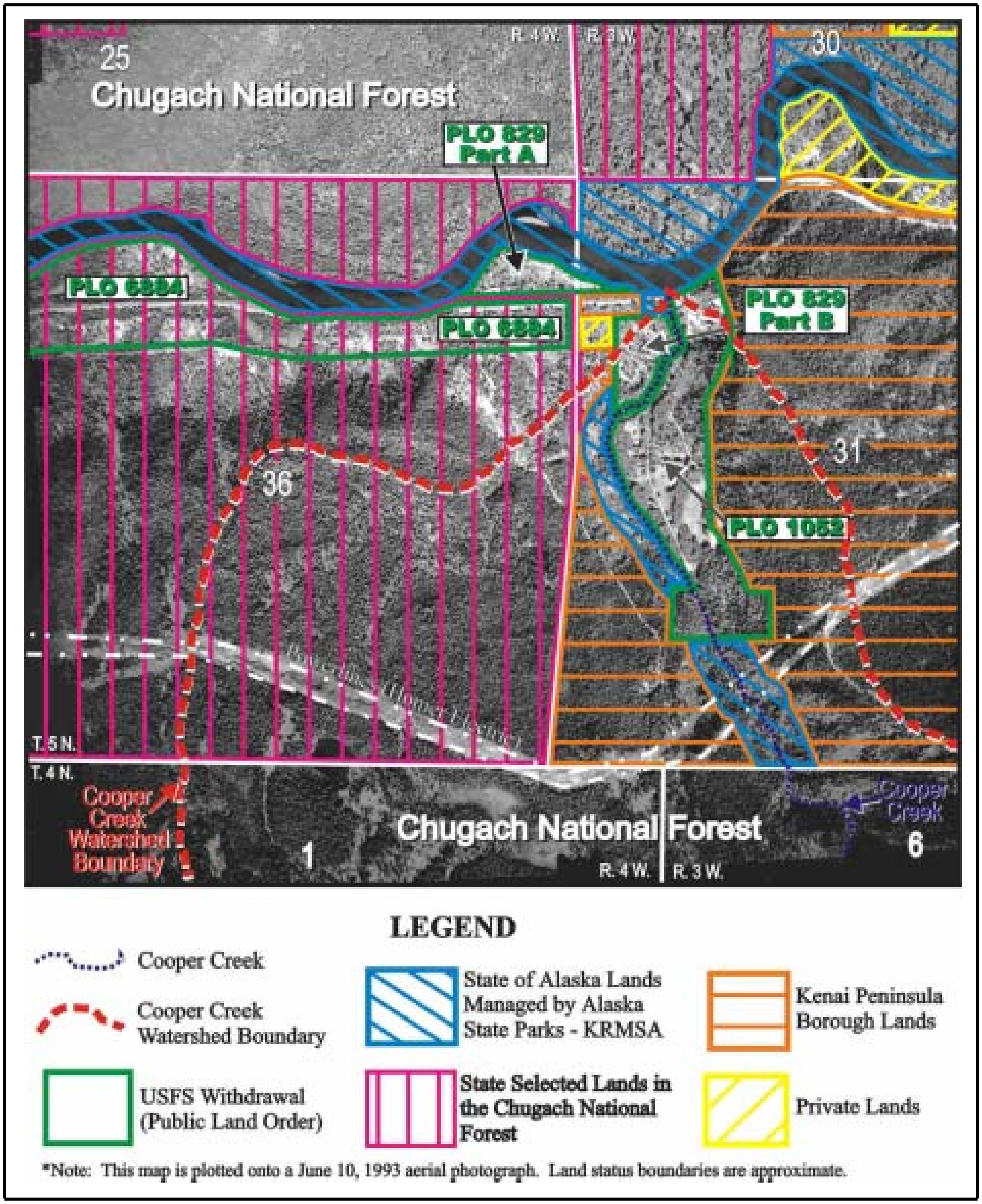


Figure 2.I.C-2: Land Status near the Mouth of Cooper Creek



b. State lands on the east side of the Cooper Creek Watershed

The 760 acres of State Lands along the east side of Cooper Reservoir were selected on September 20, 1989, tentatively approved for conveyance to Alaska Department of Natural Resources (ADNR) on December 4, 1992, and patented to the State on November 7, 1995. State lands within the Cooper Creek Watershed include the last mile of the Snug Harbor Road, the water intake for the Cooper Lake Hydroelectric Project, and the first third mile of its diversion tunnel. These lands are managed by Alaska State Parks – Kenai River Special Management Area (KRSMA) primarily for recreation and habitat purposes.

c. State/Borough lands at the mouth of Cooper Creek

About 130 acres within the Cooper Creek Watershed at the mouth of Cooper Creek (all in Section 31,Township 5N, Range 3W) were selected by and conveyed to the State of Alaska. Most of these 130 acres were selected on July 3, 1978, tentatively approved for conveyance to ADNR on November 15, 1983, and patented to the State on September 27, 1997. A few of the acres (in the northwestern part of Section 31) were State selected earlier, on December 29, 1967, and were patented to ADNR on January 27, 1984.

Most of the State lands within Section 31 at the mouth of Cooper Creek were subsequently conveyed by the State to the Kenai Peninsula Borough for community development (see ***Figure 2.I.C-2***). Although conveyed, these lands will not be fully patented to the Borough until the Borough completes its own survey.

The Kenai Borough's "1996 Cooper Landing Land Use Classification Plan" proposes a variety of uses for the Borough lands within Section 31. Uses include: preservation, recreation, and residential. Maps within this plan designate the proposed land uses by specific area. The Plan was approved by the Kenai Peninsula Borough Planning Commission in July 1996, and adopted by the Borough Assembly in September 1996.

Within Section 31, ADNR has retained a 400-foot wide corridor, 200 feet to either side of Cooper Creek (see ***Figure 2.I.C-2***). A preliminary decision by the Director of Parks and Outdoor Recreation on July 12, 1988 initiated the retention of these lands by the State. These retained lands are managed as part of KRMSA by Alaska State Parks. The Kenai Peninsula Borough appealed the decision and requested a narrower corridor, but the Director of ADNR denied their appeal on May 23, 1990.

Two withdrawals of National Forest land (PLO 829 and 1052) lie within Section 31, along the banks of Cooper Creek. These two withdrawals predate any land selections by the State of Alaska, and were not available to the State for selection. These two withdrawals are further described in the next section on withdrawals.

d. State selected lands at the mouth of Cooper Creek

On February 7, 1989, ADNR selected a block of National Forest lands in Sections 35 and 36 of T. 5 N., R. 4 W. (see ***Figure 2.I.C-1***.) About 190 acres of this selection lie within the Cooper Creek Watershed, on Cooper Creek's west side near its mouth (see ***Figure 2.I.C-2***.) ADNR has a relatively high priority on most these selected lands, and their conveyance to the State appears to be likely. Selected lands close to the Kenai River are intended for inclusion into KRMSA. Lands in the southern approximately two thirds of Section 35, if conveyed to the State, would probably go to either residential use as part of the Borough, or to State lands in habitat protection (per conversation with Bruce Talbot, ADNR Planner, 9/8/99.)

3. Public Land Orders/Withdrawals

National Forest System lands can be withdrawn from operation of the public land laws and reserved for a specified current or future need. The term "withdrawal" in Section 103(j) of the Federal Land Policy Management Act is defined as:

> "*...withholding an area of Federal land from settlement, sale, location, or entry, under some or all of the general land laws, for the purpose of limiting activities under those laws in order to maintain other public values in the area or reserving the area for a particular public purpose or program...*"

Withdrawal usually means that land cannot leave federal ownership by patent, sale, or exchange, although the Forest Service can make a decision to revoke given withdrawals. A withdrawal does not take away existing rights, such as easements or existing mining claims. However, new mining claims cannot be filed on a withdrawal. Because of this, land withdrawals by the Forest Service for administrative sites such as campgrounds are sometimes referred to as "mineral withdrawals" or "withdrawn from mineral entry".

Four current withdrawals are located wholly or in part within the Cooper Creek Watershed. Two of these withdrawals are for potential campground sites, one is for an existing campground, and one is for the Cooper Lake Hydroelectric Project. These withdrawals are discussed below. Also discussed are a recently revoked withdrawal for hydropower development on the Kenai River, and an additional recreation withdrawal just outside the Cooper Creek Watershed.

a. Power Site Classification 409

On June 29, 1950 a power site classification was granted for a half-mile wide strip of land (a quarter mile to either side of the Kenai River) between the outlet of Kenai Lake and the Russian River. This withdrawal extended up a quarter mile into the Cooper Creek Watershed. Subsequent modifications were made to the power withdrawal, then on September 17, 1998, it was completely revoked.

b. Public Land Order 829

This PLO withdraws an area around the Cooper Creek Public Camp and Picnic Ground. It became effective on May 16, 1952, before the campground was built. The withdrawal is in two parts. The first part, (10.25 acres) lies just outside the boundary of the Cooper Creek Watershed, between the Kenai River and the Sterling Highway, immediately west of the mouth of Cooper Creek. The second part of the withdrawal (9.15 acres) lies directly south of the Sterling Highway and directly west of Cooper Creek. This part of the withdrawal lies mostly within the Cooper Creek Watershed. PLO 829 is displayed in ***Figure 2.I.C-1*** and ***Figure 2.I.C-2***.

Lands adjacent to PLO 829 were selected by, and conveyed to, the State of Alaska and subsequently to the Kenai Peninsula Borough. The withdrawal itself, however, remains National Forest land. Subject to valid existing rights, the public lands within PLO 829 are withdrawn from all forms of appropriation under the public land laws, including mining laws, but not mineral leasing laws. The site is reserved for use as administrative sites, recreation areas, or for other public purposes. This withdrawal is "permanent" unless the Forest Service chooses to revoke it, or public land laws are revised.

c. Public Land Order 1052

This PLO is a withdrawal at Cooper Creek's lower end, mostly along its east side. The withdrawal became effective on January 12, 1955 and reserves lands for the possible future expansion of Cooper Creek Campground. The withdrawal (40.35 acres) lies mostly within the Cooper Creek Watershed and is displayed in ***Figures 2.I.C-1*** and ***2.I.C-2***. It is a sliver of land extending from the Kenai River southward along Cooper Creek's east bank for about a half mile. The withdrawal averages about 350 feet wide, becoming wider at its southern end where a portion of the withdrawal crosses over to the west side of Cooper Creek.

PLO 1052 remains as National Forest land. Public lands within PLO 1052 are withdrawn from all forms of appropriation under the public land laws, including mining laws, but not mineral leasing laws. This withdrawal is "permanent" unless the Forest Service chooses to revoke it, or public land laws are revised.

d. Federal Power Project 2170 - Cooper Lake Hydro Project

The FPA permit for developing the Cooper Lake Hydroelectric Project was issued on May 1, 1957 to Chugach Electric Association, and carries a withdrawal for Federal Power Project #2170. The original withdrawal for the project included withdrawals for the dam site on Cooper Reservoir, for the tunnel and penstock including the intake at the reservoir, for the power plant on Kenai Lake and for the power transmission line from the power plant to Anchorage. Land withdrawals for the dam site and powersite were based on the original engineering design plats for the project. The withdrawal for the tunnel/penstock was a 50-foot wide corridor.

This withdrawal reserves lands for the purposes of power production as provided for in Section 24 of the Federal Power Act (FPA). FPA provides:

> *"that any lands of the United States included in an application for power development under that Act shall, from the date of application, be reserved from entry, location or other disposal under the laws of the United States until otherwise directed by the Federal Energy Regulatory Commission (FERC) or by Congress."*

Lands surrounding the tunnel/penstock and the power plant for the Cooper Lake Project were transferred to the State of Alaska on December 4, 1992. The withdrawn lands for the tunnel/penstock and the power plant (about 27 acres) remained under Federal ownership. On December 2, 1992, ADNR petitioned the Bureau of Land Management (BLM) for "vacation and restoration" of these withdrawn lands, subject to the provisions of Section 24 of the Federal Power Act. The BLM issued an order opening these lands to State selection on May 27, 1993. On November 8, 1993 these formerly withdrawn lands were transferred to ADNR, but are still subject to the Federal Power Act.

The dam site on Cooper Lake remains under Federal ownership, and the original withdrawal on the dam is still in place.

e. PLO 7075 - Cooper Lake Recreation Site

This PLO is a withdrawal along the east side of Cooper Reservoir for the purpose of future campground and recreation area development. The withdrawal became effective on August 4, 1994. PLO 7075 covers approximately 160 acres, and lies along the shoreline of Cooper Reservoir immediately south of the State Lands. It is displayed in ***Figure 2.I.C-1***. The original withdrawal application by the Forest Service on May 9, 1977 was for a larger block of land (about 375 acres) that spread further northward along Cooper Reservoir. The Forest Service relinquished the northern portion of the request with the selection of these lands by the State of Alaska.

Public lands within PLO 7075 are withdrawn from all forms of appropriation under the public land laws, including mining laws, but not mineral leasing laws. The withdrawal itself is valid for a 20-year period (until August 4, 2014). To retain the withdrawal past this date, the Forest Service must reapply prior to expiration.

f. PLO 6884 - Kenai River Recreation Site

On June 24, 1970, the Forest Service applied for withdrawal for the Kenai River Recreation Site. ***Figure 2.I.C-2*** displays the eastern end of this withdrawal. The full withdrawal extends westward along the Kenai River to the Forest Boundary near the mouth of the Russian River. The Department of Interior issued a PLO for this withdrawal on October 2, 1991. The PLO expires on October 2, 2011, and the Forest Service must reapply prior to that date to retain the withdrawal.

PLO 6884's eastern end lies close to the Cooper Creek Watershed, but none of the PLO falls within the watershed. State selected lands in Sections 35 and 36, T5N, R4W overlap with PLO 6884. These State selections date to February 7, 1989. If these selected lands are conveyed to the State, the Forest Service might choose to revoke those portions of PLO 6884 that lie within the State selection. Or possibly the BLM might need to adjudicate as to whether the Forest Service or the State holds a priority right to these lands. (As per conversation with Susan Lavin, Resources Officer with the BLM, September 20, 1999.)

4. Easements, and Permits within the Cooper Creek Watershed

Easements or permits are applicable to several roads, trails, and a powerline within the Cooper Creek Watershed.

a. Sterling Highway

The Sterling Highway crosses about 100 yards of the Cooper Creek Watershed, very near the mouth of Cooper Creek on the Kenai River. Part of this section of highway is located on PLO 1052 and is subject to an easement deed between the Forest Service and the Alaska Department of Transportation. This easement deed allows ADOT a 200-foot wide easement for public highway access across National Forest lands.

b. Snug Harbor Road and Upper Russian Lakes Trail

The last mile of the Snug Harbor Road to Cooper Reservoir lies on State lands within the Cooper Creek Watershed. The Upper Russian Lakes Trailhead begins from this last section of the Snug Harbor Road. When these lands were patented to the State (November 7, 1995) a right of way was reserved to the United States for the Snug Harbor Road (66 feet wide), the Upper Russian Lakes Trail (25 feet wide). This right of way allows passage across State lands for users of the National Forest.

c. Cooper Lake Dam Road

The upper three miles of the Cooper Dam Road are located within the Cooper Creek Watershed, and on National Forest lands. This section of the road is operated and maintained by Chugach Electric Association, Inc. under a special use permit to the Forest Service. This section of road is gated by CEA to exclude vehicle access by the public.

d. Power Line Right of Way – Homer Electric Association, Inc.

Two high power electric lines (69KV and 115KV) cross east-west across about a mile of the Cooper Creek Watershed. They are located about ¾ mile south of Cooper Creek's mouth on Kenai River (see ***Figure 2.I.C-2***). About a mile of the powerline corridor is located within the watershed, with about half on State lands, and half on National Forest lands selected by the State. On the selected lands, which are still in National Forest ownership, the powerlines are operated under a special use permit from the Forest Service to Homer Electric Association, Inc. This permit allows a 100-foot right of way for each of the transmission lines.

The original 69KV transmission line across the lower portion of the Cooper Creek Watershed was originally part of the FPA License for the Cooper Lake Hydropower Project (P-2170). On August 28, 1968, the licensee, CEA, applied to eliminate this 69KV transmission line between the Quartz Creek Substation on Kenai Lake and the Kasilof substation from its permit. CEA made this application because the majority of power passing through the transmission line was not from the Cooper Lake Project. On February 3, 1970, the Federal Power Commission issued an order accepting this amendment, and eliminating this segment of transmission line from the license.

5. Mining Claims in the Cooper Creek Watershed

a. Federal Mining Claims

Fifty-four Federal Mining Claims have been filed on streams within the Cooper Creek Watershed since the Bureau of Land Management began keeping computer records in 1985. These claims have been primarily for placer gold, and have been located primarily on Stetson, Cooper, and Wildhorse Creeks. Records from 1999 at the BLM's State Office show 11 active mining claims in the Cooper Creek Watershed. Claim file numbers are as follows: #AA055019, #AA078926, #AA078110, #AA078111, #AA055025, #AA078202, AA078449, #AA078927, AA#078189, AA#055028,and AA#055027. No mining claims within the watershed have been patented.

b. State of Alaska Mining Claims

Four State mining claims are located on State lands at Cooper Creek's lower end. These claims are registered with the Alaska Department of Lands as Mining Claim Locations and are numbered MCL #540137, #540138, #506424, #512347. These claims share a common boundary with PLO 1052 along the east bank of Cooper Creek in its lower reach.

6. References for Land Status

"1996 Cooper Landing Land Use Classification Plan For Borough-Owned and Borough Selected Lands", approved by the KPB Planning Commission on July 1996, and adopted by the KPB Assembly on September 1996.

Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, "Kenai River Comprehensive Management Plan", November 1998.

Alaska Department of Natural Resources, Division of Land Resource and Development, "Kenai Area Plan, Public Review Draft", August 1998.

Bureau Of Land Management Land Title Records, maintained by the Seward Ranger District, and the Supervisor's Office of the Chugach National Forest.

Federal Power Commission, "Order Further Amending License", Chugach Electric Association, Inc., Project No 2170, Issued February 3, 1970.

Land Title Records maintained on the LIS Computer Program by the U.S. Bureau of Land Management, Anchorage, Alaska.

Maley, Terry, "Mineral Title Examination, Mineral Land Publications", Boise, Idaho, 1984.

May 23, 1990 Letter from Gary Gustafson, Director of ADNR to Don Gilman, Mayor or Kenai Peninsula Borough denying the Borough's appeal for limiting the ADNR's land retention along Cooper Creek.

U.S.D.A. Forest Service, "Foundations of Federal Land Management", PRLS 542, George Mason University and USDA Forest Service, 1996.

U.S.D.I. Bureau of Land Management, Public Land Laws of Alaska, no date, circa 1990.

II. Physical Setting

A. Climate

1. Precipitation

Cooper Creek Watershed's average annual precipitation varies from 26 to 100 inches. The watershed spans from a low-elevation, "rain shadowed" region at its northwest end, to a higher elevation, more maritime climate along its southern rim. ***Table 2.II.A-1*** displays average monthly and annual precipitation for four stations located close to the Cooper Creek Watershed. ***Figure 2.II.A-1*** displays the four stations and estimated mean annual precipitation contours. Precipitation increases to the south in the watershed, due to a greater maritime influence. Precipitation generally increases with elevation.

Table 2.II.A-1: Mean Monthly and Annual Precipitation in Inches at Four Stations near the Cooper Creek Watershed

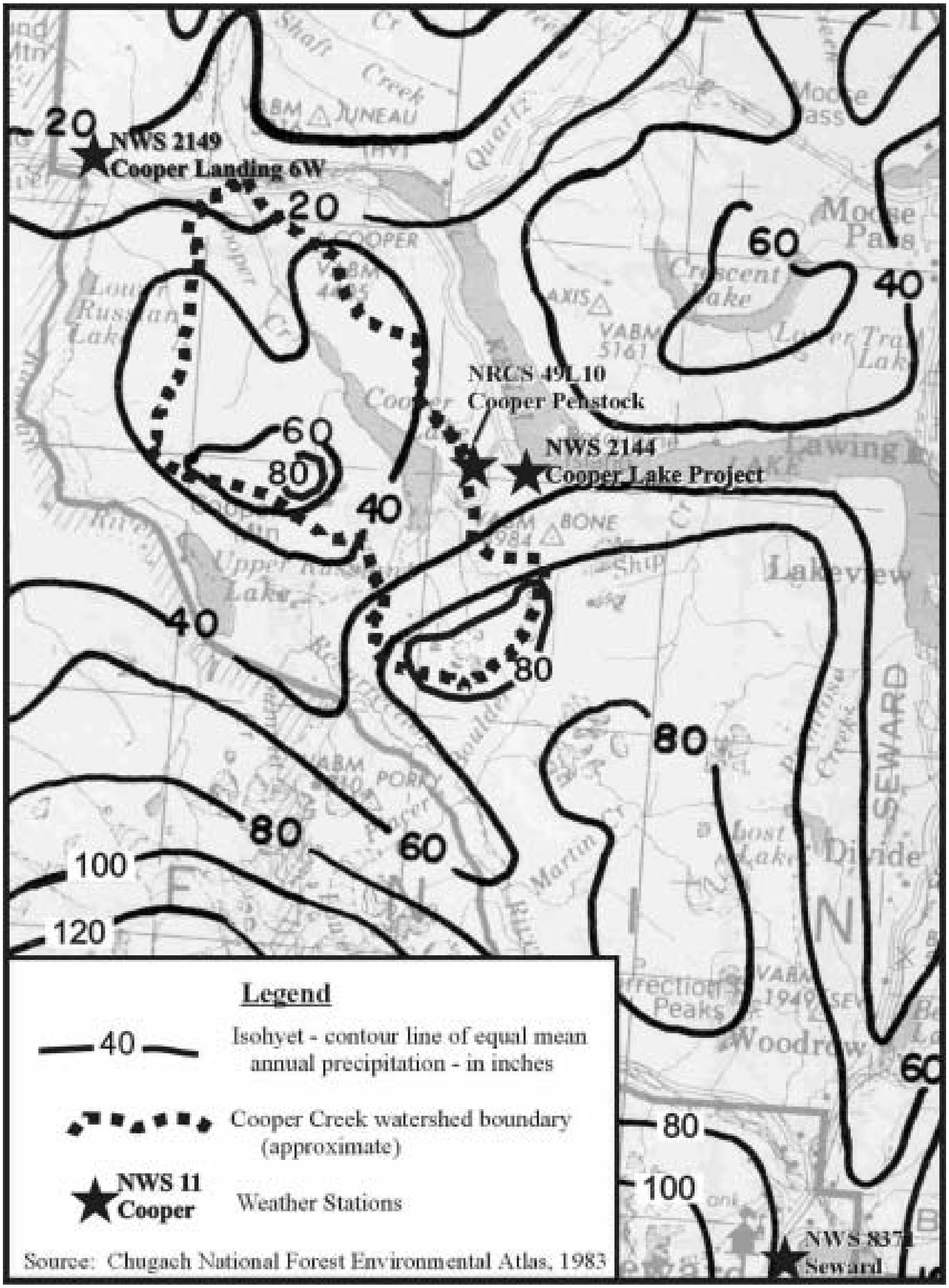
STATION	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Cooper Landing 6W @ 380' elev.	3.0	3.1	0.7	0.9	0.8	1.0	1.8	2.6	3.6	3.3	2.1	3.5	26.3
Cooper Lake Pjt. @ 450' elev.	2.6	2.6	1.3	1.2	1.0	1.2	1.5	3.0	5.6	5.0	3.3	3.8	32.1
Cooper Penstock @ 1200' elev.	4.3	2.8	2.5	2.0	1.5	1.1	1.6	3.7	6.2	5.5	3.7	5.2	39.9
Seward @ 35' elev.	5.7	5.4	3.7	4.2	4.3	2.3	2.5	5.2	10.3	9.4	6.7	7.0	66.7

1. ***Cooper Landing 6W*** *is an NWS observer station located adjacent to the Sterling Highway, 3 miles west of the Cooper Creek Bridge. Record 1975 to 1998.*
2. ***Cooper Lake Project*** *is an NWS observer station located at the Power Plant on Kenai Lake, 8 miles SE of Cooper Landing. Record is 1958 to 1998.*
3. ***Cooper Penstock*** *is an NRCS recording gage located adjacent to the Cooper Lake Penstock at 1200 feet elevation (one mile E of Cooper Lake.) Period of record is 1984 to 1998.*
4. ***Seward*** *is a long term NWS station located 20 miles SSE of Cooper Lake. Record is 1949 to 1998.*

Annual precipitation for the community Cooper Landing averages about 26 inches. A similar amount would be expected at the mouth of Cooper Creek. Precipitation values measured at the penstock indicate the average annual precipitation at Cooper Lake is around 40 inches. The presence of several small remnant glaciers above 3,000 feet in elevation around the southern rim of the watershed indicates a considerably higher localized annual precipitation, perhaps in realm of 100 inches.

Average outflow from Cooper Lake (based on hydropower use records) is about 100 cubic feet per second. This converts an average annual runoff of 43 inches for the watershed above and including Cooper Lake. If all this precipitation runs off during the year, except for approximately 16 inches lost to evapotranspiration, then the average

Figure 2.II.A-1: Average Annual Precipitation, and Climate Station Locations Near Cooper Creek Watershed



annual precipitation for this upper portion of watershed is 59 inches. However, this estimate is likely high by 1 to 4 inches. A portion of the runoff into Cooper Lake is being derived from melting glaciers at the head of the watershed. These glaciers are diminishing in size, and contributing "stored water" to the runoff.

Precipitation is generally highest in September and October (nearly double the monthly average), and lowest in April through June (about half the monthly average). August through February precipitation is generally higher than the yearly mean, and March through July, lower. The heaviest rainfall events on the watershed generally occur in September and October. The two largest storm events recorded in the last 50 years occurred October 10-12, 1986, and September 20-22, 1995.

2. Snowpack

As with total precipitation, snowfall varies by location within the Cooper Creek Watershed, depending largely on elevation and north-south position. At the elevation of Cooper Lake, snow generally starts accumulating in mid to late October, and persists well into May, some years into June.

Within the watershed, the least snow generally falls at the mouth of Cooper Creek, where the winter snowpack has an average maximum depth of about a foot. Here, the maximum pack occurs most often in early March, and snow generally melts away by mid to late April, occasionally persisting into May. At the highest elevations within the Cooper Creek Watershed, first snows generally arrive in September, and portions of the snowpack can persist through much of the summer, particularly on north facing slopes.

The Natural Resources Conservation Service (NRCS) has maintained a snow course near the Cooper Lake Project penstock at 1200 feet elevation (shown on ***Figure 2.II.A-1***). This site is about a quarter mile outside the Cooper Creek Watershed boundary, and is likely representative of snowpacks found around Cooper Lake.

Table 2.II.A-2 displays average first of month snow depth and water content at this site. Snow measurements have been taken from 1982 to the present. Average annual maximum snowpack depth at this site is 50 inches at 32% of water density. The maximum snowpack generally occurs around the beginning of April. The greatest snow depth measured at this site was 82 inches (at 35% density) in early April 1992.

Table 2.II.A-2: Average First of Month Snow Depth and Water Content in Inches at the Cooper Lake Penstock* (Elevation 1200'), 1982 to 1998

January		February		March		April		May	
depth	water	depth	water	depth	water	depth	water	depth	water
37	8.8	40	10.9	47	13.3	47	15.1	33	12.0

**Natural Resource Conservation Service Station No. 49L10, Cooper Lake*

At the mouth of Cooper Creek, on average, about half the annual precipitation comes as snow. Moving up in elevation to the level of Cooper Lake, the percentage of precipitation coming as snow increases to about 55-60%. At the highest elevations in the watershed, percentage precipitation as snow increases to about 60-65%.

3. Temperature

Temperatures within the Cooper Creek Watershed vary depending on elevation, slope exposure, topography, and position in the watershed. ***Table 2.II.A-3*** displays average monthly temperature for three weather stations close to the Cooper Creek Watershed. Station locations are displayed in ***Figure 2.II.A-1***. Of the three stations, Seward shows the greatest maritime effects, and considerably warmer winters. However, Seward is the farthest from the Cooper Creek Watershed and lowest in elevation. Temperature patterns within the Cooper Creek Watershed probably more closely mirror those in Cooper Landing. Temperatures within the watershed generally decrease with elevation.

Table 2.II.A-3: Mean Monthly and Annual Temperature (ºF) at nearby Weather Stations

STATION	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Cooper Landing 6W @ 380' elev.	17.4	18.8	26.6	36.1	45.1	52.7	56.8	54.6	46.4	33.6	21.5	17.7	35.6
Cooper Lake Pjt. @ 450' elev.	19.9	22.1	26.6	35.9	44.6	51.9	56.6	55.3	47.3	36.2	27.7	23.1	37.3
Seward @ 35' elev.	25.2	27.1	31.2	38.1	45.3	51.8	56.0	55.6	49.5	39.4	31.0	26.4	39.7

1. ***Cooper Landing*** *6W is an NWS observer station located adjacent to the Sterling Highway, 3 miles west of the Cooper Creek Bridge. Record 1975 to 1998.*
2. ***Cooper Lake Project*** *is an NWS observer station located at the Power Plant on Kenai Lake, 8 miles SE of Cooper Landing. Record is 1958 to 1998.*
3. ***Seward*** *is a long term NWS station located 20 miles SSE of Cooper Lake. Record is 1949 to 1998.*

The extreme low temperature measured at the Cooper Lake Project power plant on Kenai Lake over 40 years is –25º F and the extreme high is 84º F. At the Cooper Landing 6W station, these same values are –40º F and 90º F over 23 years. Likely Kenai Lake has some moderating effect on temperatures at the power plant site. These same moderating effects may influence the NE portion of the Cooper Creek Watershed. As well, Cooper Lake likely has some temperature moderating effects on its surrounding shores.

4. References for Climate

NWS Precipitation and temperature data were accessed from the Internet at*:* http://www.wrcc.dri.edu/climsum.html

NRCS snow and precipitation data at Cooper Lake was provided by NRCS, Anchorage, AK and can be accessed on the Internet at: http://www.ak.nrcs.usda.gov/

B. Hydrology and Water Quality

1. Channel Character

Cooper Creek extends 4.7 miles and drops 769 feet between its origin at the outlet of Cooper Lake and its mouth on the Kenai River. For most of its length, the stream is sharply incised into its originally U-shaped glacial valley. As characteristic for incised streams, sinuosity (stream length/valley length) is very low, about 1.15.

About ¼ mile downstream from its mouth on Cooper Lake, Cooper Creek passes over several barrier falls. Together the falls total about 160 vertical feet, with the highest fall dropping about 40 feet. These falls provide a solid barrier to fish passage and have kept salmon from migrating to Cooper Lake.

Below the barrier falls, Cooper Creek flows for almost four miles through a highly contained valley with a relatively steady gradient of about 2.7 %. The channel has steady riffle with very few pools. Channel substrate is mostly coarse-grained gravels, cobbles, and boulders. No barriers to fish passage are encountered on the creek's lower four-miles, however, lack of pools appears to be a significant limiting factor for fish habitat.

Cooper Creek's lower half-mile flows out over a broad alluvial fan to the Kenai River. Over many centuries, Cooper Creek has migrated back and forth across this fan; building and extending it with deposited stream sediments. Stream gradient on the fan averages about 1.5%. This channel segment's reduced stream gradient and limited channel containment would seem to allow for better fish habitat. However, pools and side sloughs are currently very limited through this stream section, due in part to past mining disturbances, and possibly to reduced flows.

During the last major glaciation, a large valley glacier flowed through Kenai Lake and westward down the Kenai River Valley, grinding out and widening the valley as it moved. Locally, the upper surface of this glacier sat between 3,000 and 4,000 feet elevation. Glaciers from the Cooper Creek Watershed flowed northwestward, and joined into the Kenai River Glacier as a tributary. These glaciers began receding about 15,000 to 20,000 years ago exposing the land underneath. The lower portion of Cooper Creek Watershed was left as a hanging valley above the Kenai River Valley.

During deglaciation, Cooper Creek likely dropped steeply from its hanging valley at around 800 to 1,000 feet in elevation down to the Kenai River at about 400 feet. Since that time, Cooper Creek has been steadily downcutting into the former valley bottom, and headcutting its way upstream. The Kenai River has also been downcutting, lowering its base level.

On Cooper Creek, the result of the downcutting is the incised stream valley seen today. At its lower end, Cooper Creek has incised down about 500 vertical feet. The amount of incision diminishes moving upstream. The upper extent of this incision and headcutting is the barrier falls just below Cooper Lake. Left unimpeded over many centuries, Cooper Creek would continue headcutting upstream to Cooper Lake, eventually lowering the lake level by 100 to 150 feet. Cessation of Cooper Creek flows by the Cooper Lake Project has essentially stopped further headcutting by the creek.

Cooper Creek's channel for about two and a half miles downstream from Cooper Lake is subject to snow avalanche deposition. These avalanches originate from the creek's northeast valley slope. Avalanches carry sediment and woody debris down into Cooper Creek, and limit the development of riparian vegetation along sections of the creek. Occasionally, wet snow avalanches may cause temporary damming on Cooper Creek, and subsequent outburst flooding of the lake built up behind the snow dam (if the dam fails all at once). Such events, though possible, are like rare on Cooper Creek. Reports of short, intense winter and/or spring flood events on the creek have not been found.

2. Streamflows

Cooper Creek drains a 49.0 square mile watershed. The drainage area into and including Cooper Lake is 31.7 square miles or 64.7% of the full watershed. Five tributary streams enter into Cooper Lake with individual drainage areas of 1.7 to 5.5 square miles (see ***Figure 2.II.B-1***). All other tributary drainages to the Lake are considerably less than a square mile.

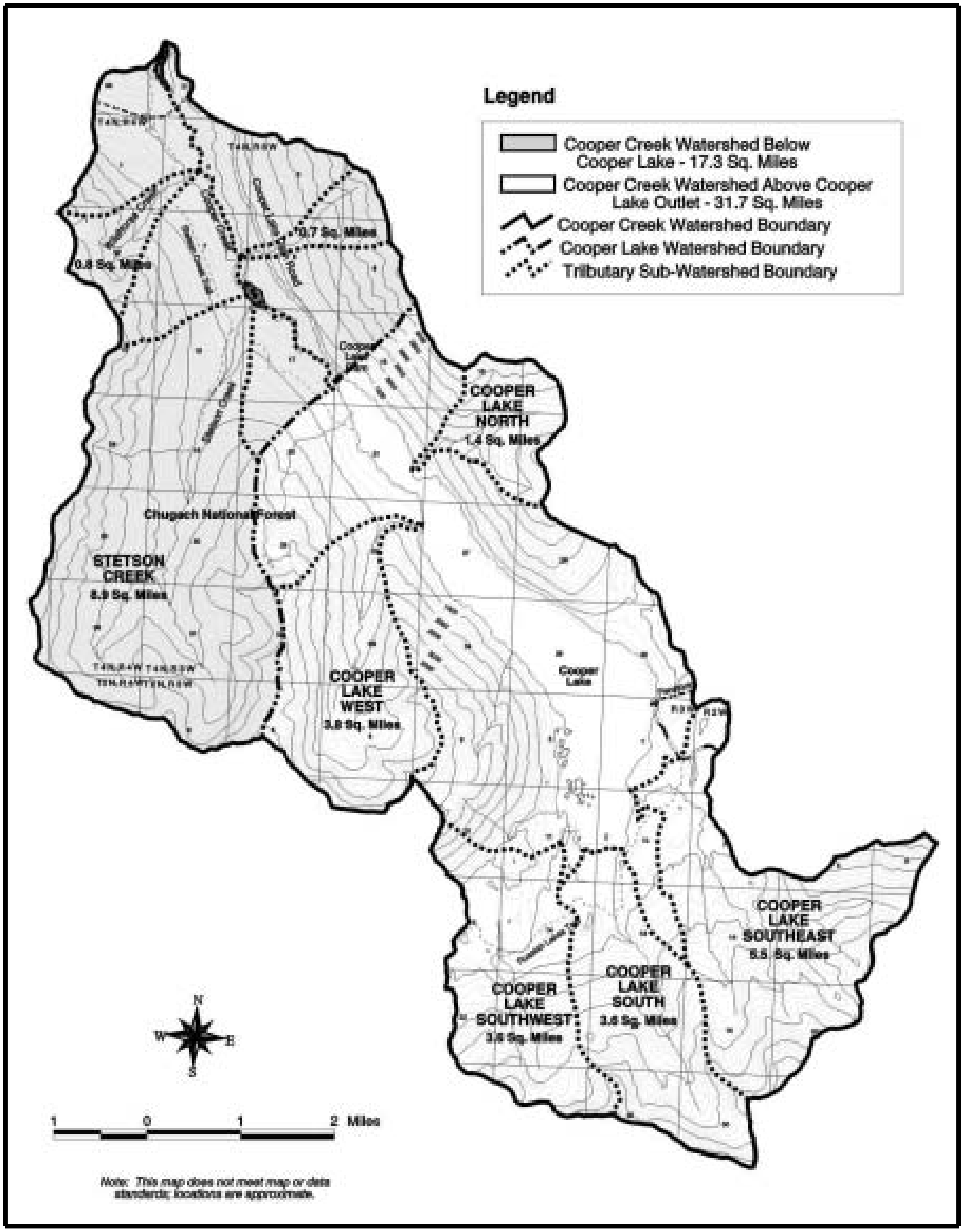
The drainage area of the watershed flowing into Cooper Creek downstream from Cooper Lake is 17.3 square miles, or 35.3% of the full Cooper Creek Watershed. Just over half this lower Cooper Creek Watershed, 8.9 square miles, is occupied by Stetson Creek. All other tributaries in the lower watershed are well under a square mile in drainage area.

a. 1890's to 1960

Alteration of water flows into Cooper Creek first started with placer mining operations on the Creek in the late 1800's and early 1900's. Between 1907 and 1914, during the summer/fall mining season, water was diverted from Stetson Creek and several additional tributaries along the west side of Cooper Creek for use at a hydraulic mining operation located on the lower ½ mile of Cooper Creek. This water was diverted along four miles of ditchline. Flow within the main channel of Cooper Creek between Stetson Creek and lower Cooper Creek would have been reduced during operation of this mining ditchline. Assuming 40 cubic feet per second flowed through the ditchline, this would have reduced Cooper Creek summer flows by 10 to 25 percent.

Water was also diverted from Stetson Creek to a hydraulic mining operation on lower Stetson Creek. Hydraulic operations on Stetson Creek occurred as early as the 1890's and as late as the 1950's. Stetson hydraulic mining operations would have reduced flow within sections of the Stetson Creek channel, but would not have significantly altered flow within the Cooper Creek channel.

Figure 2.II.B-1: Subwatersheds within the Cooper Creek Watershed



b. 1959 to Present

Construction of the 50-foot high Cooper Lake Dam at the outlet of Cooper Lake began in July 1959. All outflow from Cooper Lake into Cooper Creek ceased between July 1959 and May 1961 as water collected behind the dam. By May 1961, Cooper Reservoir had filled and water began flowing over the dam spillway into Cooper Creek. This overspilling continued until October 1962.

Meanwhile, in February 1961 some Cooper Lake water began passing through the tunnel/penstock. This water was used for testing the hydroelectric power plant on Kenai Lake. Partial power production started in May 1961, with an average of about 25% of the outflow from Cooper Lake passing through the penstock (and then into Kenai Lake), and 75% spilling into Cooper Creek.

In October 1962, the Cooper Lake Project power plant moved to full production. All outflow from Cooper Lake since then has been through the tunnel/penstock. Water levels on Cooper Reservoir have since remained well below the height of the spillway.

Termination of stream flows from Cooper Lake caused large changes in flow patterns on all of Cooper Creek. Immediately below the dam (the former lake outlet), Cooper Creek now carries no water, as compared with an average flow of 90 to 100 CFS before the dam. Moving down Cooper Creek's channel from the dam, stream flows gather slowly, as springs and tributary streams enter into the main channel.

About 1.4 miles downstream from the dam, Stetson Creek joins Cooper Creek, and increases Cooper's now meager flows by about 400%. At its mouth on the Kenai River, Cooper Creek now averages about 30 percent of its pre-dam flow.

c. Pre-Dam Flow Conditions on Cooper Creek

The U.S. Geological Survey monitored daily flows on Cooper Creek at its Cooper Lake outlet from August 1949 to July 1959 (before construction of Cooper Lake Dam). They also kept monitored Cooper Creek at its mouth on the Kenai River (10/57-1/65), and Stetson Creek, 0.3 mile upstream from its mouth on Cooper Creek (5/58-9/63).

Figure 2.II.B-2 displays the average annual hydrographs for these three stations during periods when their flows were unaffected by Cooper Lake Dam. Each station has a different period of record, so individual hydrographs are not directly comparable. They are helpful, however, in displaying information about stream flow character.

Figure 2.II.B-3 displays the hydrograph for these same three stream stations for the short period before construction of the Cooper Lake Dam when all three stations operated simultaneously (5/24/58 to 7/20/59). These three hydrographs can be directly compared on a daily basis.

Figure 2.II.B-2: Average Annual Hydrographs for Cooper Creek Watershed Streams before Cessation of Flows from Cooper Lake Dam
(Hydrographs based on USGS daily flow records)

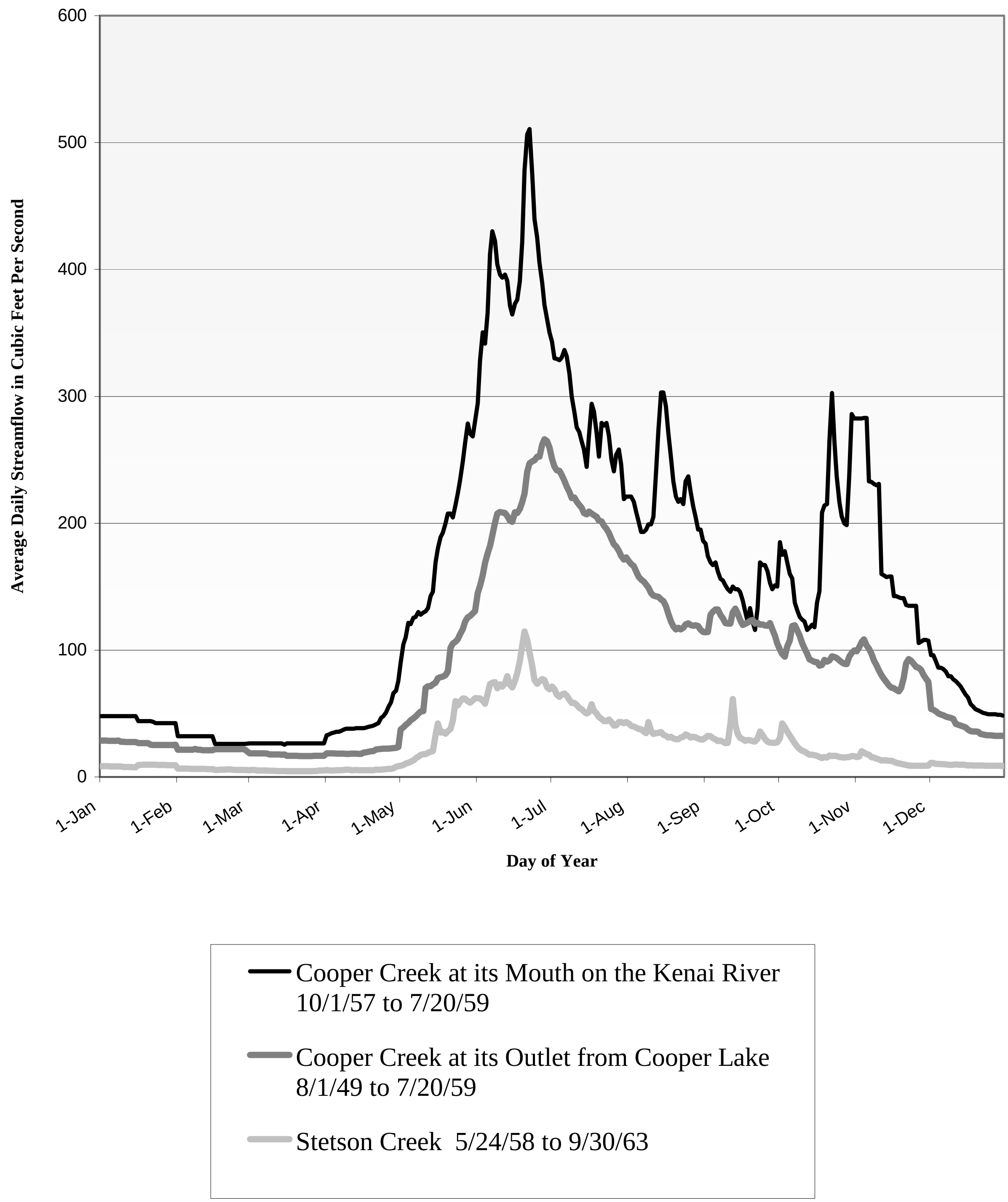
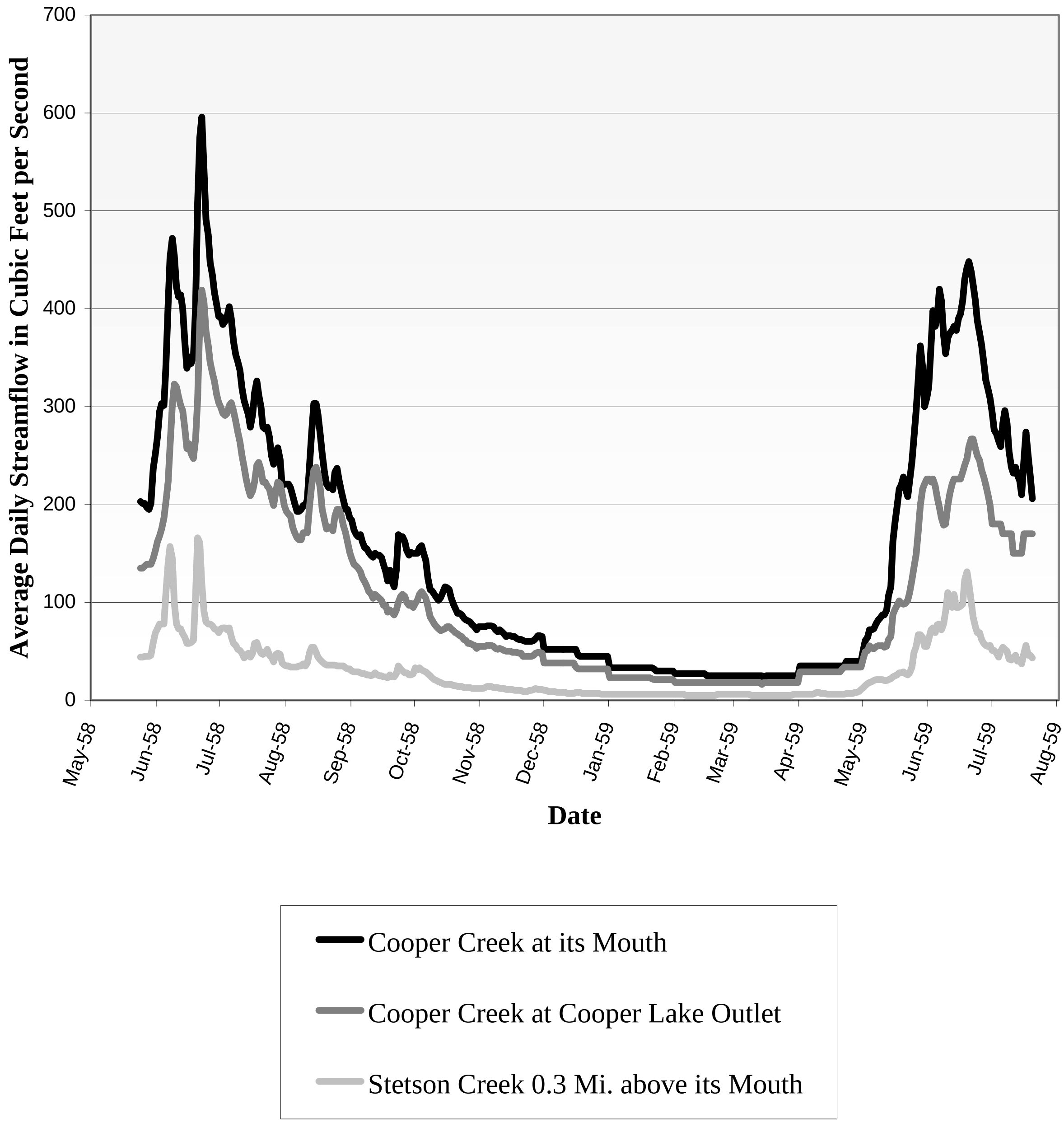


Figure 2.II.B-3: Daily Streamflows for Cooper Creek Stations and Stetson Creek before Cessation of Flows from Cooper Lake Dam – 5/24/58 to 7/20/59
(Hydrographs based on USGS daily flow records)



Listed below are general flow characteristics for Cooper Creek at the outlet of Cooper Lake for its period of record from 8/49 to 7/59.

- Average Cooper Lake outflow 1949 to 1959 was 90.0 cubic feet per second (CFS). Chugach Electric records from 1985 to 1997 indicate an average outflow (through the tunnel/penstock) of 100 CFS.

- Average annual peak flow occurred at the end of June (6/28). This was a snowmelt peak, with an average maximum discharge of 266 CFS. The snowmelt period generally starts in late April and lasts into August. High snowmelt flows generally persisted through all of June and July.

- The largest instantaneous flow during the period of record was a snowmelt peak on 6/29/53 with a flow of 729 CFS.

- The largest flood events on Cooper Creek likely occurred in August, September and October following heavy rainstorms. Such flood events are short in duration, generally lasting 2 to 5 days. During the period of record from 1949 to 1959, no particularly large September/October rainfall events fell on the Cooper Creek Watershed. The largest recorded rainfall peak flow was 316 CFS (9/4/57). However, two very large rainfall events in October 1986 and September 1995 would likely have caused outflows from Cooper Lake significantly in excess of the recorded peak flow (729 CFS) had the dam not been in place.

- Cooper Lake acts to significantly dampen outflow for short-duration flood events to the lake. Inflowing flood events are diminished in size, delayed in time, and lengthened in duration before leaving Cooper Lake.

- Average annual minimum flows at the Lake outlet generally occurred February through late April (32 CFS and below). Lowest of these flows generally occurred in late March and averaged 16.5 CFS.

The USGS stream gaging station on ***Cooper Creek at its Mouth*** has a little less than two years of stream flow record (10/1/57 to 7/20/59) unaffected by Cooper Lake Dam. Stream characteristics for this period of record include:

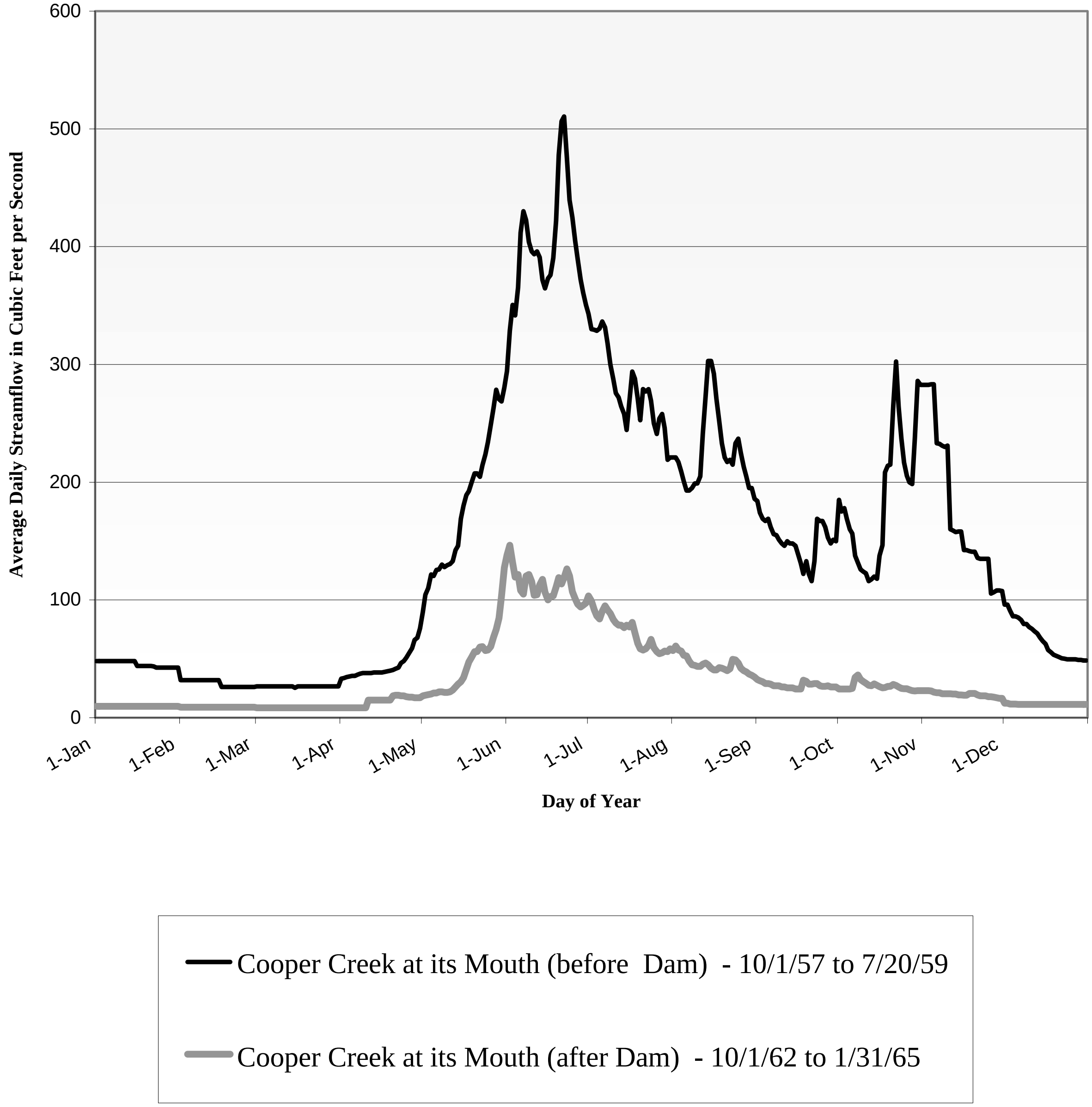
- Cooper Creek at the lake outlet averaged 69% of the flow at its mouth.

- Peak flows on Stetson Creek gathered and dissipated more rapidly than did the same peak flows from Cooper Lake. At the beginning of heavy rainfall events and the initiation of spring snowmelt, contributed flows from Cooper Creek at the Lake outlet dropped to as low as 30 and 40% of the flow at the mouth of Cooper Creek.

- Cooper Creek at its mouth shows its most predominant low flows from mid-February to early April (less than 21 CFS). Average lowest annual flow is 16 CFS.

Figure 2.II.B-4: Average Annual Hydrographs for Cooper Creek at its Mouth before and after Cessation of Flows from Cooper Lake Dam

(Hydrographs based on USGS daily flow records)



USGS monitored daily stream flows on *Stetson Creek 0.3 mile above its Mouth* from 5/24/58 to 9/30/63. For the period 5/24/58 to 7/20/59 the stream gages on Stetson Creek and Cooper Creek at its Mouth operating together, unaffected by Cooper Lake Dam. During this period, Stetson Creek's flow volume averaged 19% of Cooper Creek at its mouth.

In terms of its annual hydrograph, Stetson Creek behaves very much like Cooper Creek at the outlet of Cooper Lake except, with no lake system in its watershed, Stetson Creek is considerably flashier, responding much more rapidly and more intensely to short duration, high intensity rainfall events.

b. Post-Dam Flow Conditions on Cooper Creek at its Mouth

Figure 2.II.B-4 displays average annual hydrographs for Cooper Creek at its mouth 1) before the dam and 2) after flow over the dam spillway ceased. These two hydrographs display average daily stream flows for two different time periods and are not directly comparable. However, the figure is effective in portraying the large reduction in flow on Cooper Creek after completion of the dam.

Based on 10/1/57 to 7/20/59 (before dam) daily flow records, Cooper Lake outflow averaged 69% of the flow of Cooper Creek at its mouth. Put another way, Cooper Creek at it mouth now averages just over 30% of its pre-dam flow. Almost two thirds of the post-dam flow on Cooper Creek at its Mouth comes from Stetson Creek. Construction of Cooper Dam did not altered natural flows from Stetson Creek.

During short duration floods, particularly those associated with heavy rainfall events, the instantaneous flood peak for Cooper Creek at its mouth can now be as much as 50 to 60% of what would have occurred without the dam. However, these post-dam floods are greatly shorter in duration.

Before the dam, the Cooper Lake portion of the watershed took up to three times longer to pass a short duration flood down stream than did the remainder of the watershed below Cooper Lake. Now, no flow (including floods) passes out of Cooper Lake into Cooper Creek. Streamflow on Cooper Creek at its mouth, one to two days after a rainfall flood peak, can now drop to 20 to 25% of the pre-dam amount.

c. Post-Dam Flow Conditions on the Kenai River

Since October 1962, all outflow from Cooper Lake has been directed through the penstocks and powerplant, and then into Kenai Lake. Monthly outflow through the power plant and into Kenai Lake is generally fairly steady, averaging between 70 and 130 CFS per month.

On a daily basis, water use at the power plant varies greatly, from 0 to 330 CFS. However, by the time the power plant's outflow has moved down Kenai Lake to its outlet, these fluctuations have been greatly dampened. In the daily (USGS) flow records for the Kenai River at its outlet from Kenai Lake; fluctuation effects from the powerplant outflows appear to be less than 15 CFS.

The first three miles of the Kenai River from its Kenai Lake outlet down to its junction with Cooper Creek now carries about 100 CFS more water than it did before the Cooper Lake Dam. From the mouth of Cooper Creek onward, the Kenai River now carries more water during winter and spring months (by up to 120 CFS) and less from mid-May to October (by up to 200 CFS in an average snowmelt year).

The U.S. Geological Survey has monitored streamflows on the Kenai River at its outlet from Kenai Lake. ***Figure 2.II.B-5*** displays average annual hydrographs for the Kenai River at its outlet from Kenai Lake, Cooper Creek at its outlet from Cooper Lake (before Cooper Lake Dam), and Cooper Lake penstock outflow (after the dam). The figure shows how greatly flows from the much larger Kenai Lake Watershed exceed those from the Cooper Creek Watershed (both before and after the dam).

Cooper Lake Project flow augmentation to Kenai Lake largely has a near negligible effect on the Kenai River hydrograph. Exceptions occur during 1) winter low flows on the Kenai River, and 2) high intensity rainfall/flood events.

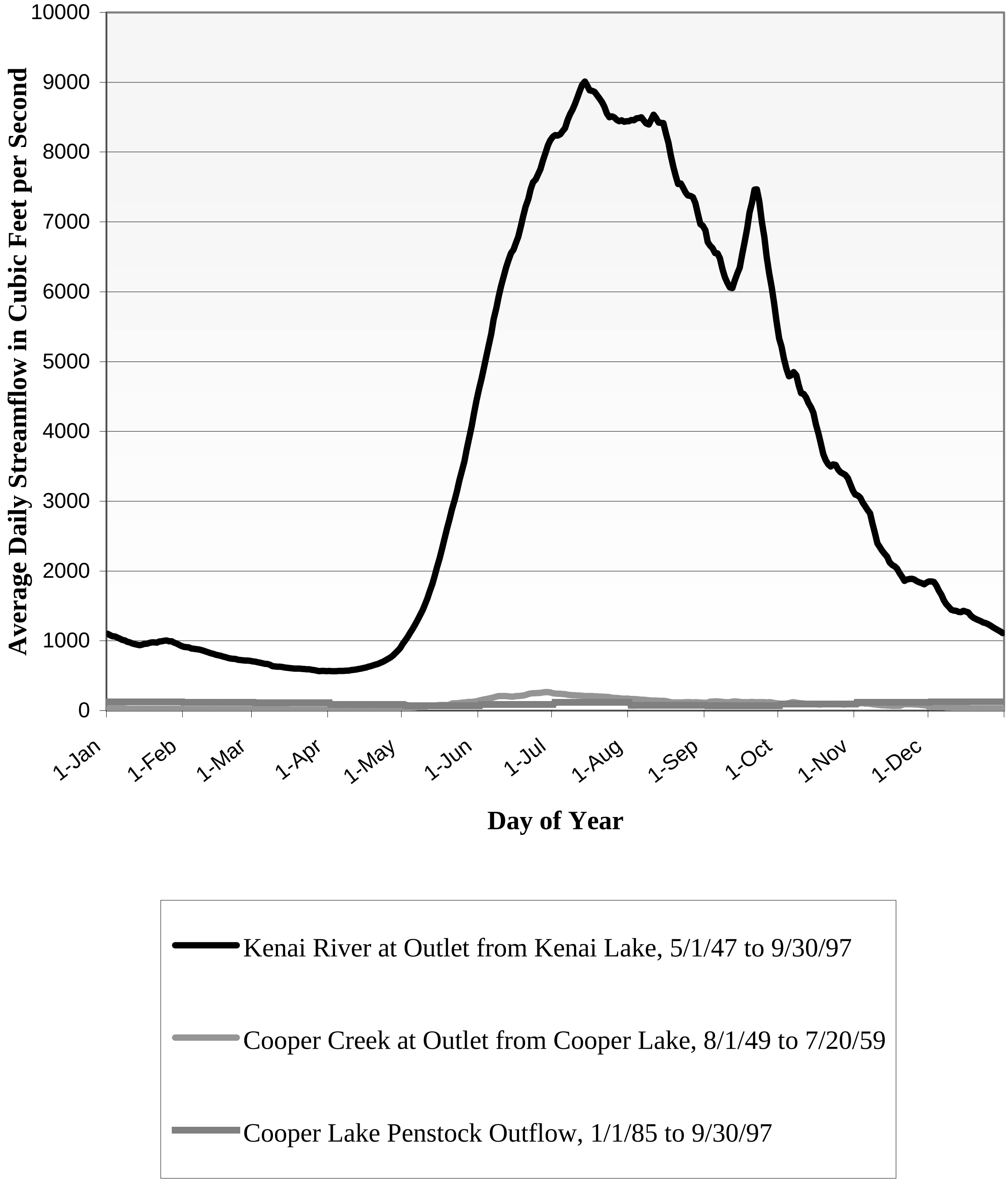
Low flows on the Kenai River at its outlet from Kenai Lake occur in February through April, with the lowest flows generally from late March through mid-April. For the period 1949 to 1958 (before Cooper Lake Dam), the average annual lowest winter flow for the Kenai River was 258 CFS. The lowest winter flow of record for these years was 190 CFS (March 15-24, 1951).

For the years 1963 to 1998 (all with Cooper Lake flow augmentation) average annual lowest winter flow for the Kenai River at the lake outlet was 458 CFS, and the lowest flow recorded was 300 CFS (March 16-April 3, 1996). From the record, it appears that flow augmentation from the Cooper Lake Project increases the lowest winter flows on Kenai River at it outlet from Kenai Lake by an average of about 30%, and in the extreme low flow winters, by up to 50 %.

The Kenai River at Cooper Landing can have major flood events during very heavy, late-summer/early-fall rainfall events. Before the Cooper Lake Dam, Cooper Creek could contribute significantly to the Kenai River during these flood events. Since construction of the dam, Cooper Creek’s influence on Kenai River rainfall floods is much smaller.

An extreme example is the storm of September 20-22, 1995. This storm event resulted in an instantaneous flood peak on Kenai River at its outlet from Kenai Lake of 20,300 CFS (9/23/95). During the flood, no water flowed out of Cooper Reservoir into Cooper Creek. Had the dam not been in place, the Cooper Creek drainage would likely have added more than 1000 CFS to the Kenai River flood peak below Cooper Creek, or approximately a 5% increase in the flood peak.

Figure 2.II.B-5: Average Annual Hydrographs for Kenai River and Cooper Creek at Lake Outlet before Dam, and Cooper Lake Penstock Outflow after Dam
(Hydrographs based on USGS daily flow records)



3. Water Temperatures

Construction of the Cooper Lake Hydroelectric project eliminated flows out of Cooper Lake into Cooper Creek after October 1962. Surface waters of Cooper Lake are warmed by the sun, and during the summer, and portions of the spring and fall, outflow temperatures from the lake were considerably warmer than for the Cooper Creek tributaries downstream from the lake. Elimination of flow from Cooper Lake has significantly reduced temperatures on Cooper Creek.

A July 1964 Report by the U.S. Fish and Wildlife Service entitled, "An Initial Follow-up Report for Cooper Lake Hydroelectric Project", states:

> *"The project has eliminated flows of warm water from the surface of Cooper Lake and water temperatures in Cooper Creek have been reduced by the additional influence of colder waters from Stetson Creek and other tributaries. Water temperatures of lower Cooper Creek prior to project construction were frequently in the mid-fifty degree range during the warm summer months. However, with the project in operation, water temperatures during this same period have been in the high forty degree range and have only rarely reached the low fifties. During October, with the project in operation, temperatures have frequently been near freezing, whereas the warmer Cooper Lake water had maintained the stream in the forty degree range before the project construction."*

Later the same report states:

> *"Temperatures [in lower Cooper Creek] have decreased between 5 and 10 degrees Fahrenheit, …"*

Unfortunately, this report does not provide the stream temperature records kept on Cooper Creek before or after construction of the Cooper Lake Project. While the temperature changes attributed in this report may be reasonable, it is not possible to verify over what range of conditions they may apply.

In 1998 and 1999, ADF&G, Sportfish Division collected hourly stream temperature data on a variety of Kenai Peninsula streams. Include were: Cooper Creek at its mouth, Crescent Creek a half mile above Quartz Creek, Juneau Creek at its mouth, Russian River, Kenai River at Kenai Lake Outlet, and Grant Lake above Trail Lake. All these streams flow from lakes except Cooper Creek.

Figure 2.II.B-6 displays average daily temperatures for these six streams from April into November of 1998. Several of the records are incomplete, but temperatures at many of the sites can be compared during the year. Russian River and Grant Creek show higher (2 to 5º F) water temperatures than either Crescent or Juneau Creeks. The outlet lakes for Russian and Grant are considerably lower in elevation than Crescent or Juneau Lakes, and would be expected to yield warmer summer stream temperatures. Kenai Lake

is lower in elevation, but is much larger in size and volume than any of the other lake systems. Accordingly, Kenai River takes longer to warm up in the summer, and longer to cool down in the fall than the other stream systems.

1998 temperature data for Cooper Creek at its mouth is missing from mid-April through early August. Nonetheless, a notable trend seen in ***Figure 2.II.B-6*** is that Cooper Creek at its mouth has considerably colder summer and early fall stream temperatures than all the other streams. All the other streams have lakes upstream.

Figure 2.II.B-7 displays the same 1998 temperature data as ***Figure 2.II.B-6*** for just Crescent, Juneau, and Cooper Creeks. ***Figure 2.II.B-8*** shows water year 1999 (10/1/98 through 9/30/99) daily water temperatures for the same three creeks.

We hypothesize that water temperatures on Cooper Creek at its mouth, before construction of Cooper Lake Dam, would have been similar to those on Crescent Creek at its mouth and Juneau Creek at its mouth. This comparison seems reasonable due to the similar geomorphic character of the Cooper, Crescent, and Juneau Creek watersheds. All three watersheds are similar in size, regional location, and mean elevation. All have sizable, higher elevation lakes in the center of the watershed, with a 5 to 7 mile stream system from the lake down to the creek's mouth.

Crescent Lake is higher in elevation than Cooper Lake by 286 feet, with about ¾ the surface area of Cooper Lake (before the dam). Both these features might make summer water temperatures slightly colder for Crescent Creek. Juneau Lake is 63 feet higher than Cooper Lake and has only about a sixteenth the surface area (0.2 square miles).

In 1998 and 1999 Juneau Creek shows a very similar temperature pattern to Crescent Creek (see ***Figures 2.II.B-7*** and ***2.II.B-8***). Exceptions include that Juneau Creek warms more quickly in the spring, cools more quickly in the fall, and responds more rapidly to daily/weekly changes in air temperature. These exceptions can be explained largely by the smaller volume and surface area of Juneau Lake.

In 1998 and 1999, both Crescent and Juneau Creeks show significantly higher stream temperatures than Cooper Creek through the late spring, summer, and early fall. We presume that before Cooper Lake Dam, all three creeks would have had very similar temperatures throughout the year.

Comparing Crescent and Cooper Creeks in 1998 shows that Cooper Creek has colder temperatures by 6.3º F in August, 5.0º F in September, and 4.5º F in October. The 1999 data shows that maximum stream temperature differences between these systems occur in July, when the warming effects of air temperatures and solar radiation are highest on lake waters.

In July 1999, stream temperatures on Crescent and Juneau Creek averaged 6.8 and 7.5°F warmer than on Cooper Creek. From mid-November through mid-March, all three

Figure 2.II.B-6 - 1998 Kenai Peninsula Stream Temperatures (4/1/98 to 11/12/98)

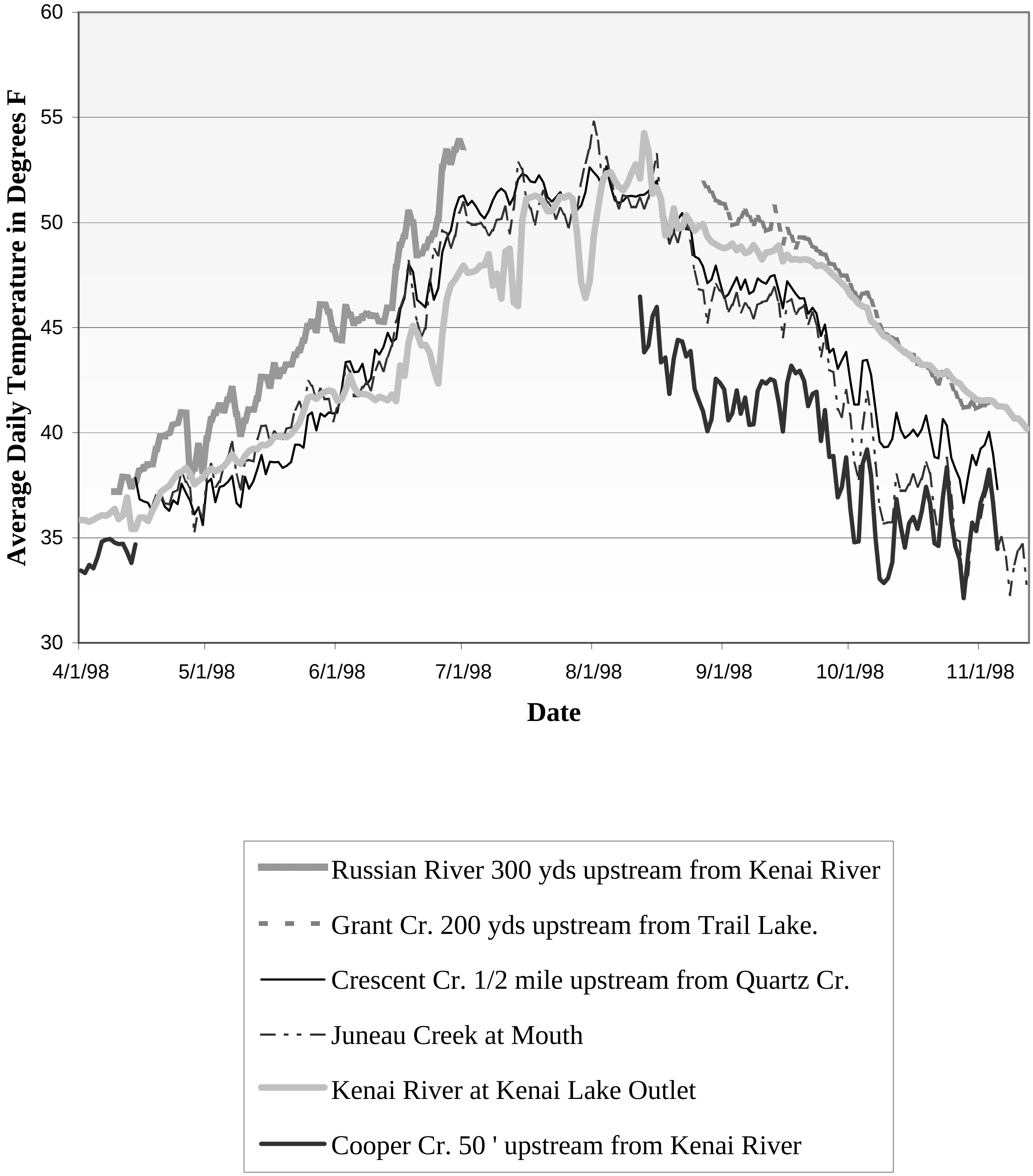


Figure 2.II.B-7: Crescent, Juneau, and Cooper Creek Stream Temperatures (4/1/98 to 11/12/98)
(Individual records are incomplete for the full period)

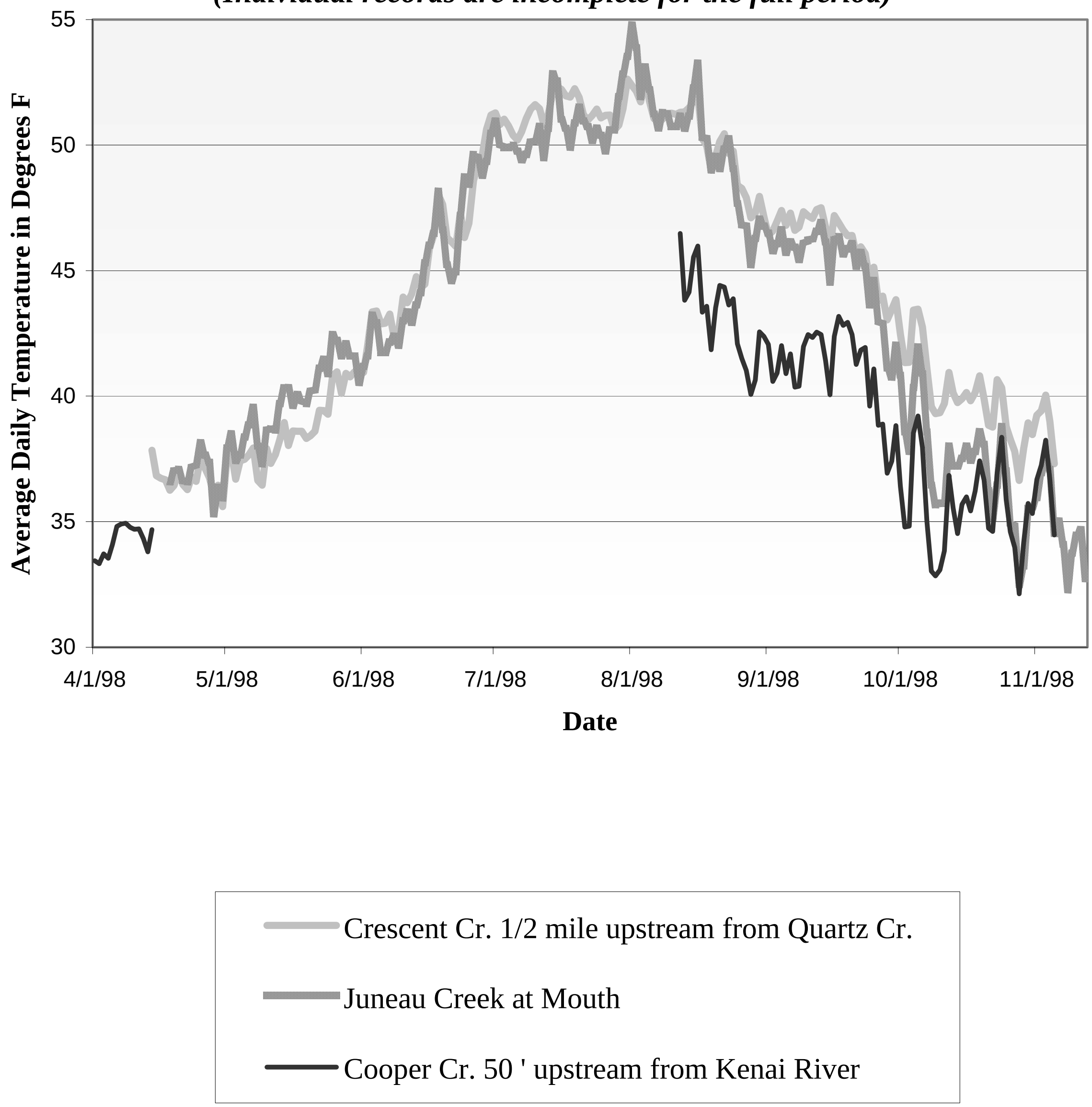
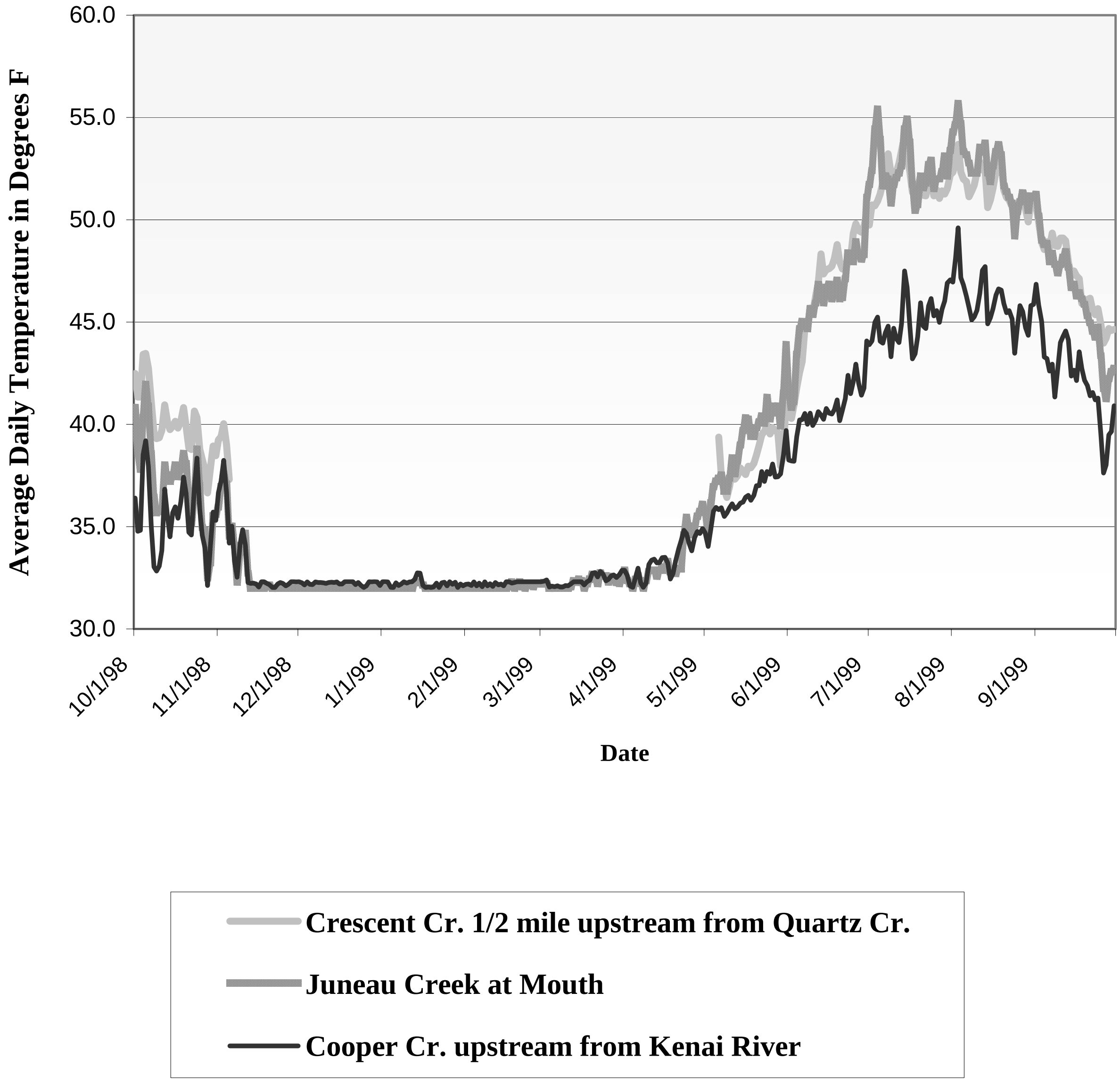


Figure 2.II.B-8: Crescent, Juneau, and Cooper Creek Stream Temperatures (10/1/98 to 9/30/99)

(Crescent Creek records are missing for 11/6/98 to 5/5/99)



streams stay close to freezing (32ºF). In late March, stream temperatures start rising on all three streams, but by early May, temperatures on Crescent and Juneau Creeks started increasing faster than on Cooper Creek.

If the hypothesis that Crescent, Juneau, and (pre-dam) Cooper Creek had similar temperature patterns is correct, this implies that Cooper Lake Dam has caused a 6 to 8ºF mid-summer water temperature reduction at the mouth of Cooper Creek. Average monthly temperature differences between Cooper Creek at its mouth and these two other creeks at their mouths are shown in ***Table 2.II.B-1***.

Table 2.II.B-1: Monthly Stream Temperature Difference in Degrees Fahrenheit Between Cooper Creek at it Mouth and Crescent/Juneau Creeks at their Mouths

Month/ Year	**Oct-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**	**Mar-99**	**Apr-99**	**May-99**	**Jun-99**	**Jul-99**	**Aug-99**	**Sep-99**
Crescent & Cooper	4.5º	*	*	*	*	*	*	1.6º	5.8º	6.8º	5.6º	4.8º
Juneau & Cooper	1.7º	-0.1º	-0.3º	-0.2º	-0.2º	-0.1º	0.0º	2.4º	5.4º	7.5º	6.4º	4.0º

* *Crescent Creek temperature data is not available for these months*

4. Sediment Loads

a. Overview

Cooper Lake functions as a settling basin for sediments transported by inflowing streams. Three of the tributary streams entering Cooper Lake currently have small glaciers within their basins, and each carries a sizable sediment load. ***Figure 2.II.B-1*** displays these three tributary streams, Cooper Lake West, Cooper Lake South, and Cooper Lake Southeast.

The fine-grained, suspended sediment load into Cooper Lake from inlet streams is enough to "color" Cooper Lake slightly during peak runoff periods. Much of the sediment load carried by these tributary streams deposits on their lower alluvial fan, or onto their deltas within Cooper Lake/Reservoir. Cooper Reservoir water levels are higher than for the former Cooper Lake. Reservoir levels fluctuate annually an average of 11 feet. Consequently, delta deposits for incoming streams have not only raised in elevation, but also are spread out over a longer section. Delta sediments deposited at high reservoir levels can become exposed and re-eroded at lower reservoir levels.

Cooper Creek at its outlet from Cooper Lake (before the dam) carried virtually no sediment load. However, the alluvial fan on Cooper Creek's lower ½ mile is a strong depositional feature. Presence of the fan indicates that significant amounts of sediment passed down lower Cooper Creek. A portion of the sediments deposited on the fan during flood events, with the remainder passing into the Kenai River.

Cooper Creek's natural sediment load comes in part from several glacial tributaries in the Stetson Creek drainage, in part from the downward movement of sediments on steep, incised sideslopes of Cooper and Stetson Creeks, and in part from the downcutting of these stream channels. Some sediment and woody debris is carried downslope to these streams by snow avalanches.

Much of Cooper and Stetson Creeks' sediment loads move during flood events, whether from snowmelt or large rainfall events. For most of the year, Cooper Creek runs clear, with very low sediment movement (unless impacted by human caused erosion such as mining).

Water at the mouth of Cooper Creek is occasionally clouded by runoff from a natural, 100-foot high bluff on Cooper's east bank near the Kenai River. This exposed bluff "bleeds" fine-grained sediments into Cooper Creek during rainfall events and early snowmelt runoff.

b. Mining Effects on Cooper Creek Stream Sedimentation

The most extreme sedimentation on Cooper Creek from mining likely occurred during 1907 to 1917 when the lower ½ mile of Cooper Creek was hydraulically mined. Stream and streambank sediments were pushed through a sluicebox using high-powered jets of water from hydraulic giants. Up to four giants worked simultaneously.

Some 10 to 20 acres of Cooper Creek's alluvial fan deposit were highly disturbed by hydraulic mining. Overlying vegetation and soil were removed, and the underlying gravels processed down for 8 to 10 feet. Settling ponds were probably not used, meaning much of the fine-grained sediment load from the hydraulic mining would have washed into Cooper Creek and then into the Kenai River. Miners very likely rechanneled sections of Cooper Creek in its lower half-mile as they worked its streambed deposits.

Aerial photographs from 1962 show the lower ¼ mile of Cooper Creek to be wide and braided. Likely in 1962 this channel segment was still in the process of reestablishing a stable channel after the intensive mining impacts some 50 years earlier.

Hydraulic mining also occurred intermittently on Stetson Creek, starting in the 1890's and extending up to the 1950's. Much of this mining was on upland bench deposits. This mining was likely done without settling ponds, meaning the fine-grained sediment loads from mining would have washed into Stetson Creek, Cooper Creek, then down to the Kenai River. Painter (1998) notes observations from the 1950's mentioning Cooper Creek turning brown and muddy during the summer months.

Some additional placer mining has occurred in Cooper Creek Canyon, in a three-mile section between Stetson Creek and the outlet of the canyon onto the lower alluvial fan. As well, some mining has occurred on Stetson Creek. Mining efforts here have mostly concentrated on capturing gold within the stream channels. Early mining in the canyons was done primarily with sluice boxes and shovels.

Placer mining has continued on Cooper and Stetson Creeks through the last two decades, mostly using small, gas-powered suction dredges. Both sluices and suction dredges move fine-grained sediments into suspension down Cooper Creek. However, these sediment loads are very small in comparison to those from former hydraulic mining operations.

The Forest Service initiated a water quality testing program between 1988 and 1991 on several placer-mined streams on the Kenai Peninsula. In this program, Cooper Creek was not formally sampled, but was frequently observed for turbidity. Multiple visits to lower Cooper Creek in the summers of 1988 through 1991 revealed no observable turbidity. (Huber, Blanchet, 1991)

c. Cooper Dam Effects of Cooper Creek Stream Sedimentation

Following Cooper Dam construction, Cooper Creek has experienced large reductions in flood peaks and flood durations. Much less sediment is transported during the diminished flood events. In some locations on Cooper Creek, sediment deposits have built up in the channel or channel banks. This effect is most pronounced for the 1.4 mile portion of the channel from the Dam down to Stetson Creek. Here flood peaks range from 0 to 8% of their pre-dam values. Sediment transport through this stream section is now very low. After Stetson Creek joins Cooper Creek, flood peaks and sediment transport capacity increase very substantially, but are still greatly below pre-dam values.

Diminished sediment transport on Cooper Creek allows less sediment deposition on the creek's lower alluvial fan, and less sediment input into the Kenai River. Since 1962, Cooper Creek has incised into its alluvial fan and developed a stable channel that migrates little. Without a change in the character of flood events, future building of Cooper Creek's fan is unlikely.

Lower flood potential on Cooper Creek also appears to be allowing more deposition of fine-grained sediments within its channel, and increased embeddedness of its channel substrates. Macroinvertebrate sampling on lower Cooper Creek by the Forest Service in 1998 revealed extensive "packing" of the gravel and cobble-sized stream sediments with a fine-grained matrix. The major bedload movement that formerly occurred on Cooper Creek during infrequent, large-scale flooding events worked to "wash" fine-grained sediments from the channel substrate. This bedload movement and cleaning of larger-grained channel substrates may no longer be occurring due to the diminished flooding now occurring on Cooper Creek.

5. Chemical Water Quality

a. Sampling

The U.S. Geological Survey collected data on 17 water quality parameters on Cooper Creek at it outlet from Cooper Lake in 1950, 1952-3, and 1955-6. USGS also collected this data on Cooper Creek at its mouth in 1957-8. ***Table 2.II.B-2*** displays this data. The

Table 2.II.B-2: U.S. Geological Survey Chemical Water Quality Samples Collected on Cooper Creek 1950 to 1958

* Na and K concentrations in ppm are added together rather than being separately noted for five samples

Location	Date	Dis-charge CFS	Silica SiO2 ppm	Iron Fe ppm	Cal-cium Ca ppm	Mag-nesium Mg ppm	Sod-ium Na ppm	Potas-ium K ppm	Bicar-bonate HCO3 ppm	Sul-fate SO4 ppm	Chlor-ide Cl ppm	Fluor-ide F ppm	Nit-rate NO3 ppm	Dis-solved solids ppm	Hardness as CaCaCO3 Ca, Mg ppm	Hardness as CaCaCO3 Non-carbon-ate ppm	Specific conduct-ance mmhos	pH	Color
Cooper Creek at Cooper Lake Outlet	7/9/50	201	4.3	0.01	11	1.4	0.9*		34	3.8	1.5		1.5	41	33	5	69.9	7.7	12
	8/24/50	142	4.5	0.01	11	0.9	3.0*		32	7.6	1.4	0.1	1.6	46	31	5	72.9	7.4	5
	10/6/50	89	6.5	0.03	13	1.2	1.2*		33	9.5	1.5		1.1	50	37	10	67.9	7.0	4
	5/21/52		5.4	0.01	13	1.5	2.5*		38	6.6	2.5	0.0	3.0	53	39	7	83.1	7.1	7
	6/20/52		4.0	0.02	11	1.0	1.5*		32	5.9	1.0	0.0	1.4	42	32	5	64	6.8	5
	7/25/52		4.3	0.01	10	1.4	1.1	0.6	32	7.4	1.0	0.1	1.0	43	32	5	71.3	7.2	3
	1/30/53	37	4.8	0.01	14	1.0	1.6	0.9	44	6.3	1.0	0.0	1.7	53	38	2	80.8	7.3	3
	4/14/53	18	4.6	0.03	12	0.7	1.2	0.7	34	6.7	1.8	0.0	1.4	46	32	4	70.5	6.9	3
	8/6/53	239	3.7	0.01	8	2.1	1.4	0.9	33	4.8	0.2	0.0	0.4	38	29	2	62.4	7.0	4
	1/20/55	40	3.9	0.01	12	0.5	0.7	0.1	36	5.7	1.1	0.0	0.4	42	32	2	72	8.0	
	9/9/55	102	4.9	0.00	11	1.0	1.3	0.6	36	2.5	1.2	0.1	0.8	41	32	2	71	7.2	0
	5/1/56	32	5.0	0.00	14	0.6	1.5	0.8	42	4.1	2.2	0.0	3.6	53	37	3	91	7.4	3
	7/4/56	254	5.5	0.00	11	0.3	1.6	0.4	32	2.7	1.2	0.0	1.1	40	29	2	66	6.5	0
Cooper Creek at its Mouth	10/3/57	200	3.8	0.03	12	1.2	1.1	0.3	38	3.5	1.0	0.0	1.1	43	34	4	73	7.1	5
	11/6/57	390	4.9	0.02	12	0.6	1.7	0.6	36	4.0	1.2	0.0	2.1	45	32	3	77	7.2	0
	12/11/57	99	4.1	0.03	12	0.9	1.4	0.9	40	3.0	1.0	0.1	1.8	45	34	0	77	7.1	5
	1/22/58	55	4.1	0.02	13	1.0	2.5	1.0	41	5.0	1.5	0.0	1.4	50	36	3	81	7.0	0
	2/19/58	27	6.2	0.02	13	2.7	1.6	2.7	43	8.0	2.0	0.0	1.0	56	44	4	90	7.0	0
	5/20/58	187	4.9	0.04	12	2.1	1.2	2.1	35	6.0	2.0	0.0	3.2	49	38	10	72	7.1	5
	7/15/58	279	4.0	0.03	10	2.6	1.2	2.6	34	5.0	2.5	0.2	1.0	44	36	8	71	6.4	0
	8/21/58	217	3.9	0.03	11	1.0	1.0	1.0	36	4.0	1.0	0.1	0.9	41	32	2	74	6.8	0

data shows Cooper Creek to be representative of the unpolluted, clear water streams of the area. The data does not appear to "flag" any water quality problems for Cooper Creek, and shows no discernible difference between the water quality values for Cooper Creek at the Lake outlet, and at its mouth.

On July 29, 1994, a U.S. Forest Service/U.S. Bureau of Mines team gathered water samples from two sites on Cooper Creek to determine concentrations of arsenic, copper, lead, and zinc. These elements can be present in high concentrations in runoff from lode mining operations.

Water samples were taken: 1) 100 yards downstream from Cooper Lake Dam (where Cooper Creek is a mere trickle), and 2) a half mile upstream from the mouth of Cooper Creek. All measured parameters were below detection limits (0.025 mg/l for Cu and Zn, and 0.005 mg/l for As and Pb) at both sampling sites. While these results are only valid where and when taken, they do give a preliminary indication of negligible concentrations of As, Cu, Pb, and Zn on Cooper Creek.

No additional chemical water quality data on Cooper Creek has been found (Framework, 1998). Although construction of Cooper Lake Dam reduced Cooper Creek flow volumes by 70 to 100%, it appears not to have significantly altered the chemical water quality of the remaining flow.

b. Potential Pollutants

Use of mercury for gold amalgamation has been a common practice at placer mines in Alaska throughout the century. Mercury very likely was used in Cooper and Stetson Creek mining operations. A soil sample taken July 25, 1994 at the historic Stetson Creek Cabin was tested for mercury, lead, and arsenic as part of a U.S. Forest Service/U.S Bureau of Mines study. Sample results show mercury at 0.16 mg/Kg, lead at 13 mg/Kg, and arsenic at 24 mg/Kg. These values are within the baseline range for natural soils, and do not indicate elevated levels of mercury, lead, or arsenic.

Beads of liquid mercury from gold processing can persist for many years within stream channels. No known water samples testing for mercury have been collected on Cooper or Stetson Creeks. Mercury is highly insoluble, and would likely not be detected in routine water sampling. However, if consumed, mercury can pose a toxic hazard to aquatic fauna. Sampling of stream sediments, or in some cases, aquatic fauna, would be more effective for detecting if mercury concentrations exist on Cooper or Stetson Creeks.

Present day suction dredging operations on Cooper and Stetson Creeks use petroleum, oil, and lubricants (POL's) in the mining process. These POL's can find their way into the stream system. No water samples have been collected for POL's on these two creeks. With the low level of mining currently occurring, detection of measurable quantities of POL's on Cooper and Stetson Creeks would be unlikely.

6. References for Hydrology and Water Quality

All streamflow data from Cooper and Stetson Creeks and Kenai River were taken from USGS Annual Water Resource Reports for Alaska. This data is available on the Internet at: *http://www-water-ak.usgs.gov/Data/swdata.htm* (go to historic data).

Outflow records from Cooper Reservoir were provided via Excel spreadsheet by CEA. Burke Wick with CEA was helpful in sharing this information with the Forest Service.

Stream temperature data from 1998 was collected by Alaska Department of Fish and Game – Sportfish Division, Soldotna, AK. Data was collected using instream thermographs. Larry Larson with ADF&G kindly shared this data with the Forest Service.

Huber, Carol and Roe, Chris, "Report on Abandoned and Inactive Mines", Unpublished Manuscript, , Chugach National Forest and U.S. Bureau of Mines, 1994.

Painter, Mona, "Cooper Landing Historic Report", Unpublished Manuscript prepared for the U.S. Forest Service, Cooper Landing, 1998

The Nature Conservancy, "Framework For Water Quality Monitoring of the Kenai River", Unpublished Draft, May, 1998.

USGS water quality data was taken from annual water resource reports for Alaska (1950's)

C. Limnology

1. Lake Level Changes on Cooper Lake/Cooper Reservoir

a. Before Cooper Dam

Cooper Lake, with its large size and small drainage area, maintained a relatively stable surface elevation previous to the dam. Based on USGS stream stage records at the Lake outlet, Cooper Lake surface elevation probably fluctuated between one and two feet during an average flow year. The lake may have raised an additional one to two feet during very large flood events. USGS quadrangle maps from 1950 (before the dam) indicate Cooper Lake's elevation at 1168 feet above mean sea level.

Two additional situations that could have resulted in temporarily higher water levels on Cooper Lake were: 1) damming of the lake outlet by woody debris that floated in off the lake, and 2) damming of the outlet by ice pans blown across the lake. It is unlikely either of these potential occurrences would have raised the lake level by more than one to two feet, and in the case of the ice damming would have been short in duration, likely less than a week.

b. After Cooper Dam

Cooper Lake dam was constructed about 200 yards downstream from Cooper Creek's natural outlet from Cooper Lake. ***Figure 2.II.C-1*** shows the reservoir's water surface elevation since the beginning of dam construction. Cooper Reservoir started filling in late July 1959, with Cooper Lake at elevation 1168 feet. By May 1961, the reservoir level reached the spillway at elevation 1210 feet, and water began flowing into Cooper Creek.

During the summer of 1961, woody debris (likely from shoreline clearing) collected on top of the Cooper Dam spillway, raising the reservoir level by about three feet to 1213 feet (from USGS stream gage notes, 1961). The debris was removed in mid-September 1961, and until October 1962, the reservoir level remained near 1210 feet, with water pouring out the spillway.

Reservoir levels dropped below the spillway with initiation of full power production in October 1962 and water levels have not reached the spillway since. The lowest reservoir level reached was 1158.8 feet, in late April 1979, during maintenance on the penstock tunnel. This level was close to the lower limit of reservoir drawdown.

Water levels within Cooper Reservoir fluctuate yearly based on the natural inflow to the lake minus the outflow through the penstock and evaporation and any seepage from the lake. Average monthly outflow through the penstock stays fairly constant between 80 to

Figure 2.II.C-1: Cooper Reservoir Water Elevations
July 1959 through October 2001

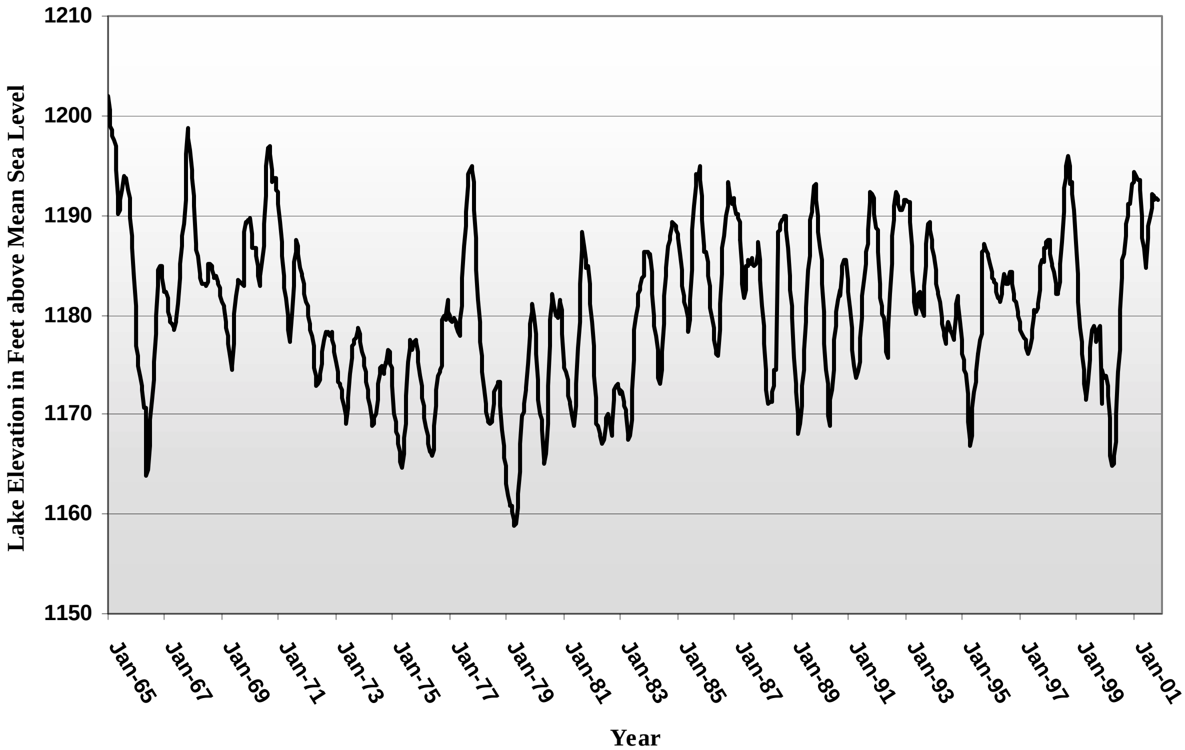


Table 2.II.C-1 shows average monthly and annual reservoir levels over 34 years of operation. Natural inflow to the reservoir is lowest during the winter and early spring, when outflow rates from the reservoir are higher due to power demands. As a result, reservoir levels tend to drop steadily through the winter, reaching a low by early May.

Table 2.II.C-1: Average monthly and Annual Surface Elevation* for Cooper Lake Reservoir 1965 through 1988

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1181.6	1179.2	1177.1	1175.0	1174.5	1177.1	1180.7	1182.9	1184.3	1185.6	1184.7	1183.1	1180.5

**Based on Chugach Electric Association daily elevation records sent to the U.S.G.S.*

In May, snowmelt inflow to the reservoir increases rapidly, while power use decreases slightly. The reservoir level begins to rise, and continues up to its annual peak. The annual peak is reached between August and January, with the average timing being mid to late October. Reservoir levels fluctuate an average of 11.2 feet annually. The greatest annual fluctuation was 25.1 feet in 1989, and the least was 4.5 feet in 1996. Maximum possible reservoir fluctuation is about 53 feet (elevation 1159 to 1212.)

Results of a probable maximum flood study (CH2M Hill, May 1984) led Chugach Electric Assn. to limit the reservoir's upper operating range. Since November 1984, CEA has kept the reservoir's water level at or below 1194 feet (16 feet below the spillway). This operating procedure is a safety precaution to protect against dam failure during an extreme flood event. Two "exceedences" have occurred: once in September 1985 when the reservoir level reached 1195.0 feet, and again in September 1998 when the level reached 1196.0 feet. Based on the full period of operations seem in ***Figure 2.II.C-1***, initiation of the maximum level policy in November 1984 did not markedly change the annual operating pattern from before 1984.

2. Lake/Reservoir Area and Island Area

Figure 2.II.C-2 displays a map of Cooper Lake/Reservoir at three water levels, 1168 feet, 1185 feet, and 1212 feet. ***Table 2.II.C-2*** shows the amount of lake and island area for these same three water levels. The lowest level, 1168 feet, is the profile of Cooper Lake before the dam (Cooper Reservoir can be drawn down about 10 feet below this natural lake level). The 1212-foot elevation represents Cooper Reservoir at near its maximum-recorded level, during the summer of 1961 when water was flowing out the spillway. The 1185-foot elevation was taken from August 1984 aerial photography and represents the level of Cooper Reservoir near its average yearly peak elevation.

Cooper Lake/Reservoir is generally steep-sided except at its southern end, where streams have built out low-gradient alluvial deposits. Where the shoreline is steep, increases in reservoir level create small increases in reservoir area. However, where the shore is low-gradient, significant increases in reservoir area occur, as seen in ***Figure 2.II.C-1***.

Cooper Lake before the dam had several small islands along its southwest shore. As the reservoir water level increases, these islands start to inundate, while other new islands appear in the hummocky terrain along the southwest shore.

Based on aerial photos taken at various water levels, island area increases significantly at reservoir levels between 1170 and 1180 feet. For water elevation 1180 feet up to 1212 feet, island area generally declines. The least island area appears to occur with the natural lake (elevation 1168).

During the "average reservoir year" displayed on ***Table 2.II.C-1***, the most island area is exposed during February through June. Island area then diminishes from July though October as the reservoir level rises and inundates low-lying islands. Due to variations in reservoir fluctuation, the pattern and timing of island exposure and inundation can vary widely from year to year.

Figure 2.II.C-2: Map of Cooper Lake/Reservoir at Varying Water Levels

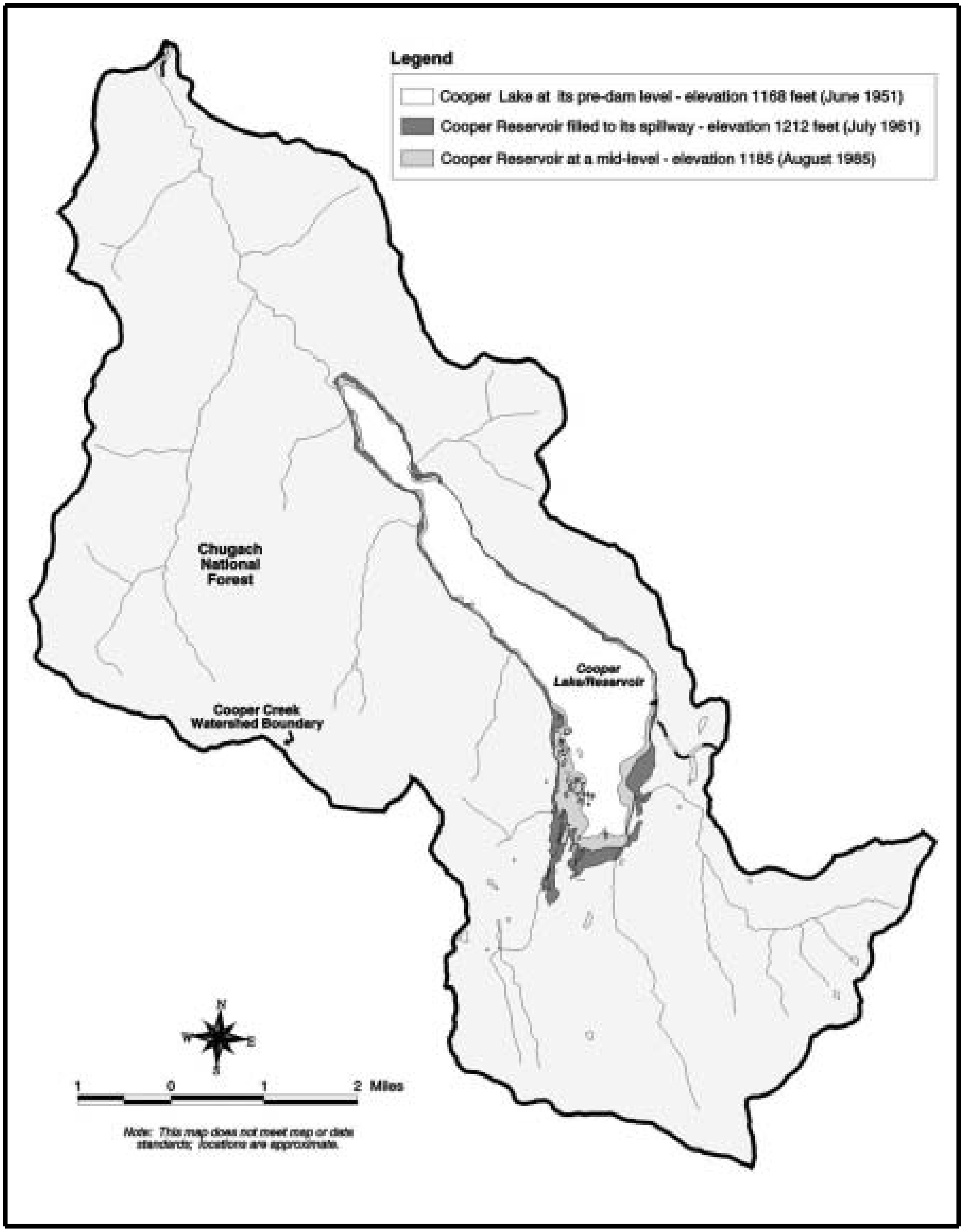


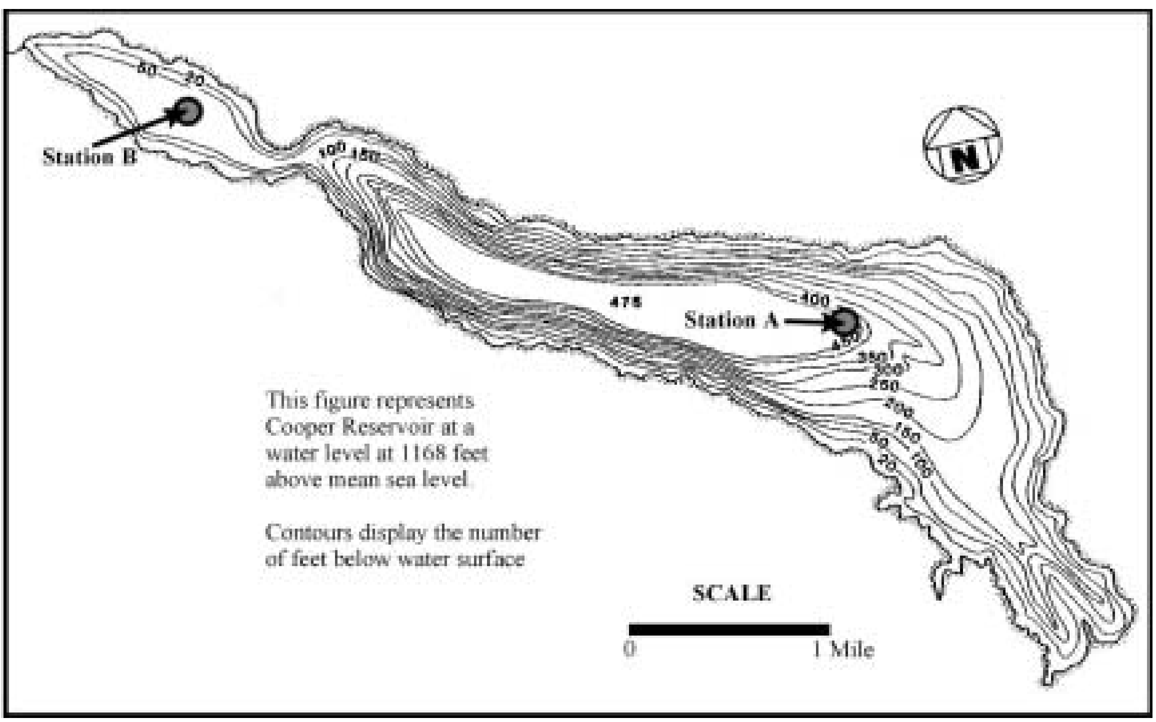
Table 2.II.C-2: Area of Cooper Lake/Reservoir and Islands at Three Water Levels

		Water Elevation	Water Surface Area		Island Area
Name/Condition	**Date**	**Ft. ab. MSL**	**Acres**	**Sq. Mi.**	**Acres**
Cooper Lake Before Dam	06/25/1951	1168	2075	3.2	5
Cooper Reservoir Full	07/14/1961	1212	2825	4.4	10
Cooper Reservoir Mid-Level	08/14/1984	1185	2425	3.8	25

3. ADF&G 1998 Limnologic Study

During the summer of 1998, ADF&G in cooperation with the USFS made a limnological survey on Cooper Reservoir. This survey evaluated temperature, physical and chemical water quality parameters, nutrients, and zooplankton numbers and species. ADF&G Limnologist Jim Edmundson compiled and summarized the sampling results (ADF&G, July 27, 1999).

Figure 2.II.C-3: Cooper Reservoir Limnology Sampling Sites
June-September 1998



ADF&G and the USFS conducted one sampling session a month from June through September 1998. ADF&G selected two sampling sites: Station A located near the center of the Reservoir in its deepest portion; and Station B in the northwestern lobe of the

Reservoir (see ***Figure 2.II.C-3***). Station A has a water depth of about 450 feet, and Station B, about 85 feet. The northwestern lobe is shallower and partially isolated from the rest of the reservoir. It has somewhat different summer temperature characteristics.

(a) Physical and chemical water characteristics.

Table 2.II.C-3 displays water chemistry, nutrient concentrations, and algal pigments measured in Cooper Reservoir at Stations A and B. Summary elements of ADF&G's (1999) Cooper Reservoir evaluation include:

- Cooper Reservoir's mean depth is 57 meters (174 feet) with maximum sampling depth at 145 meters (442 feet).

- Cooper Reservoir has an elongated, irregular shoreline, giving it high potential for littoral development of aquatic communities. Field observations, however, indicate a sparse littoral aquatic community, likely due to fluctuation of the reservoir level and consequent loss of shoreline vegetation.

- Cooper Reservoir is quite clear, with low color and turbidity values. Three glacial streams with fine-grained suspended sediment loads enter Cooper Reservoir. These streams appear to degrade Cooper Reservoir's clarity during the summer and fall runoff season. Reservoir clarity increases over the winter when inflowing suspended sediment loads drop to very low levels.

- Cooper Reservoir's euphotic zone (zone with minimum 1% light penetration) was measured with a maximum depth of between 13 and 23 meters. An estimated 33% of the total reservoir volume is capable of photosynthesis.

- The northwestern lobe or basin (Station B) of Cooper Reservoir is shallower than the main body of the lake. This basin warms up faster in the summer by about a week, and cools faster in the fall.

- Dissolved oxygen measured in August 1998 was slightly over-saturated in the reservoir's upper 50 feet, and slightly under-saturated below this level. These high oxygen levels are likely beneficial for fish.

- Conductivity is a measure of dissolved solids in water. Conductivity is quite low on Cooper Reservoir (71 micromhos/cm), and homogeneous through the water column. This low value implies low nutrient values within the reservoir.

- pH was near neutral, generally a good indicator for fish.

Table 2.II.C-3: Summary of General Water Chemistry, Nutrient Concentrations, and Algal Pigments for Cooper Reservoir, 1998

Date	Sta.	Depth (m)	Conduct-ivity ($\mu S\ cm^{-1}$)	pH (Units)	Alka-Linity ($mg\ L^{-1}$)	Turb-idity (NTU)	Color (Pt-Co)	Ca ($mg\ L^{-1}$)	Mg ($mg\ L^{-1}$)	Iron ($\mu g\ L^{-1}$)
6/9/98	A	1	72	7.2	29.6	0.6	3	10.1	1.1	10
6/9/98	A	50	73	7.3	28.6	0.3	4	10.5	1.0	11
6/9/98	B	1	68	7.3	27.3	1.2	3	10.0	1.1	14
6/9/98	B	20	69	7.3	27.3	0.9	4	9.9	0.8	14
7/7/98	A	1	71	7.4	32.3	1.1	4	11.4	0.8	7
7/7/98	A	50	73	7.4	28.7	0.5	3	11.8	1.1	5
7/7/98	B	1	72	7.5	29.8	0.6	3	12.4	0.8	6
7/7/98	B	27	73	7.5	32.1	0.7	4	11.3	1.0	7
8/6/98	A	1	71	7.4	28.4	0.4	3	11.3	1.0	6
8/6/98	A	50	73	7.3	31.7	0.7	3	11.2	1.1	5
8/6/98	B	1	72	7.5	30.9	0.9	3	11.1	1.1	6
8/6/98	B	25	73	7.3	27.0	0.4	3	11.3	1.1	6
9/2/98	A	1	66	7.3	29.0	1.1	2	11.7	0.8	5
9/2/98	A	50	72	7.3	28.6	1.3	3	11.5	0.9	6
9/2/98	B	1	72	7.5	28.9	2.0	3	11.3	1.1	8
9/2/98	B	25	72	7.3	29.5	1.2	3	11.3	1.3	6

Date	Sta.	Depth (m)	Total-P ($\mu g\ L^{-1}$)	Total Filter-able-P ($\mu g\ L^{-1}$)	Filtrble React-ive-P ($\mu g\ L^{-1}$)	Kjel-dahl N ($\mu g\ L^{-1}$)	Am-monia ($\mu g\ L^{-1}$)	Nitrate + nitrite ($\mu g\ L^{-1}$)	React-ive silicon ($\mu g\ L^{-1}$)	Chloro-phyll *a* ($\mu g\ L^{-1}$)	Phaeo-Phytin ($\mu g\ L^{-1}$)
6/9/98	A	1	1.2	0.4	0.5	35.5	0.5	266.4	1573	0.18	0.17
6/9/98	A	50	1.6	0.8	0.7	57.7	5.5	292.3	1539	0.13	0.17
6/9/98	B	1	2.1	0.6	0.8	63.9	5.5	434.4	1627	0.34	0.30
6/9/98	B	20	2.5	0.6	0.8	53.3	5.5	410.8	1368	0.41	0.37
7/7/98	A	1	2.3	0.6	0.8	52.4	5.5	277.1	1504	0.11	0.11
7/7/98	A	50	2.6	0.7	0.8	56.8	0.5	292.2	1364	0.16	0.23
7/7/98	B	1	2.5	0.8	1.0	129.7	2.1	281.4	1334	0.18	0.23
7/7/98	B	27	3.8	2.0	1.9	64.8	2.1	296.6	1368	0.31	0.42
8/6/98	A	1	2.8	0.9	1.0	71.0	3.0	219.0	1472	0.19	0.14
8/6/98	A	50	1.8	0.9	1.0	54.2	3.0	290.1	1528	0.05	0.03
8/6/98	B	1	2.7	1.1	1.3	93.2	3.8	197.4	1507	0.34	0.12
8/6/98	B	25	2.4	1.4	1.6	71.9	3.0	279.3	1566	0.24	0.11
9/2/98	A	1	4.0	1.0	1.0	77.1	5.5	180.2	1610	0.18	0.13
9/2/98	A	50	2.9	1.1	1.1	77.2	5.5	190.9	1747	0.11	0.07
9/2/98	B	1	5.1	1.4	1.1	117.8	6.3	193.1	1129	0.31	0.19
9/2/98	B	25	2.9	1.3	1.4	81.7	8.8	255.7	1563	0.18	0.21

- Mean hardness was 31 mg/L, indicating water that is quite soft.

- Reactive silicon varied between 1.1 and 1.7 mg/L with no seasonal fluctuation. These concentrations should not limit phytoplankton (diatom) production.

- Inorganic nitrogen, measured as ammonia, was low, as would be expected for the well-oxygenated conditions. Nitrate-nitrite concentrations were nearly 3 times higher than for measured sockeye lakes in Alaska, suggesting that inorganic nitrogen is probably not limiting phytoplankton growth in Cooper Reservoir.

- Total nitrogen and phosphorus concentrations were low, consistent with oligotrophic (nutrient poor) conditions. Filterable reactive phosphorus, the phosphorus readily available for algal uptake, had very low concentrations.

- Chlorophyll *a* is often used as a marker for phytoplankton (algal) stock. Cooper Reservoir has extremely low chlorophyll *a* concentrations (0.05 to 0.41 micrograms/L). Summer chlorophyll concentrations below 3 micrograms/L are generally considered oligotrophic meaning Cooper Reservoir may be "ultra-oligotrophic". Cooper Reservoir fits within a phosphorus-chlorophyll response pattern found by ADF&G on other Alaskan lakes, but ranks among the least productive of the lakes examined.

(b) Macrozooplankton.

ADF&G gathered macrozooplankton samples by pulling a one square meter net up through the water column. ***Table 2.II.C-4*** displays the quantity and taxa collected at the two sample sites on the four monthly sampling runs over the summer.

Table 2.II.C-4: Macrozooplankton Density by Taxon in Cooper Reservoir (number of individuals/meter^2)

Date	Station	Taxon					
		Heterocope	Diaptomus	Cyclops	Bosmina	Daphnia	Total
6/19/98	A	0	8,917	51,592	0	2,124	62,633
6/19/98	B	0	30,361	19,533	425	212	50,531
7/7/98	A	212	44,798	54,990	1,911	3,397	105,308
7/7/98	B	4,671	63,057	89,569	2,335	849	160,481
8/6/98	A	531	134,023	87,174	9,820	1,857	233,405
8/6/98	B	1,699	26,115	17,834	5,520	849	52,017
9/2/98	A	425	109,342	83,350	12,951	2,548	208,616
9/2/98	B	1,062	28,662	13,376	1,699	0	44,799

ADF&G Limnologist Jim Edmundson compiled and summarized these sampling results (ADF&G, July 27, 1999). Summary elements include:

- ADF&G lists zooplankton densities and biomass in Cooper Reservoir as low to moderate. However, the reservoir supports relatively large numbers of calanoid copepods (*Heterocope* and *Diaptomus*) compared to cylopoid copepods (*Cyclops*) and cladocerans (*Bosmina* and *Daphnia*). Calanoids contributed about 70% of the seasonal biomass. ADF&G's lake surveys indicate large-sized calanoids tend to be more prevalent in lakes without fish or with low densities of planktivorus fish.

- Mean body sizes of Cooper Reservoir cladocerans are considerably larger than the 0.4 mm "threshold" associated with intensive fish predation. Predation on Cooper Reservoir zooplankton by rainbow trout and char is probably low.

- Zooplankton probably do not regulate the density of phytoplankton in Cooper Reservoir since their summer peak populations occur at the same time.

- "Cold climate, hard-rock surroundings, morphometric characteristics, and low input of inorganic nutrients impose extreme oligotrophic conditions in Cooper Reservoir".

4. Limnologic Changes in Cooper Reservoir

Pre-dam water quality and other limnologic data on Cooper Lake is not available to compare with current water quality on Cooper Reservoir. Changes in lake characteristics/function after construction of the dam include: 1) increase in both surface area and amount of "shallows", 2) water leaves Cooper Reservoir through the tunnel/penstock, and is drawn at depth where it is considerably cooler than the surface waters, and 3) water is generally drawn out of the reservoir at a relatively steady monthly rate (80 to 130 CFS) as compared to the widely fluctuating annual flows of Cooper Creek before the dam (average 16 to 265 CFS). We do not know whether these functional changes have resulted in any significant water quality changes to the Reservoir since construction of Cooper Dam.

One possible candidate for change would be summer surface water temperature on Cooper Reservoir. The increased surface area of the reservoir, its increased shallows, the reduced summer outflow, and the withdrawal of deeper, colder water, may cause an increased in summer surface water temperatures on the reservoir. Whether such a temperature increase could be large enough to be of significance to water quality is not known. An increase of a few degrees could effect surface water chemistry as well as plankton production on the reservoir.

Water circulation within the reservoir also may have changed following construction of the dam. Factors that might influence change in circulation patterns include the increased reservoir volume/surface area, and potential changes in surface water temperatures.

5. References

Alaska Department of Fish and Game, Div. of Commercial Fisheries. Letter and report from Jim A. Edmundson, Limnologist to USFS biologist, Eric Johansen summarizing data and limnological characteristics of Cooper Reservoir, July 27, 1999.

Ch_2M Hill. "Cooper Lake Probable Maximum Flood Study", prepared for Chugach Electric Association, Inc., May 1984.

Daily reservoir levels at Cooper Reservoir are provided monthly by Chugach Electric Association, Inc. to the U.S. Geological Survey – Water Resources Division, Anchorage Subdistrict Office.

Edmundson, Jim. A., Limnologist, Alaska Department of Fish and Game, Div. Of Commercial Fisheries, phone conversations with Dave Blanchet, USFS, concerning Cooper Reservoir limnology; March 23, 2000.

Lake, Reservoir, and Island areas were calculated from aerial photography of the area from a variety of years. Photography is on file at the Supervisor's Office, Chugach National Forest, Anchorage, AK.

Streamflow data from Cooper Creek were taken from USGS Annual Water Resource Reports for Alaska. This data is available on the Internet at: *http://www-water-ak.usgs.gov/Data/swdata.htm* (go to historic data).

D. Landslide Risk

1. Overview

We evaluated landslide risks in the Cooper Creek Watershed using previously mapped landtypes for the basis. We modeled risks using a standardized hazard assessment procedure developed by Swanston (1997). This procedure evaluates soil properties and topographic conditions. Soil properties include texture, parent material, depth and drainage. Topographic conditions include slope shape and length, gradient, and drainage density. These properties are placed into a weighted formula to model an average landslide failure potential for each landtype.

Landtypes in the Cooper Creek Watershed are displayed in ***Figure 2.II.D-1*. *Figure 2.II.D-2*** shows the average landslide risks associated with the landtypes. Individual map units have inclusions with greater or lesser landslide potential. Landslide risk displayed in ***Figure 2.II.D-2*** is generalized, and may not be valid for specific sites. Field verification should be used for specific sites.

Factors enhancing landslide risk include: high soil moisture, steep slope gradients, slope steepening/alteration (e.g., stream undercutting, road cut-and-fill), and major changes in vegetative cover (e.g., clear cuts, forest fires). Landslide risks displayed in ***Figure 2.II.D-2*** have been divided into four categories:

> ***High to Extreme.*** Natural failures are frequent and large. Road construction and timber harvest can create a high risk of additional slope failure. On-the-ground assessment is necessary to determine needs for mitigating design measures.
>
> ***Moderate.*** Natural failures are small and infrequent, with a moderate risk of induced failure from road construction and timber harvest. Best management practices are usually successful in limiting failures, but on-the-ground investigation is recommended. Mitigation is occasionally needed.
>
> ***Low***. Natural failures are rare and/or small. Risks for management induced failures is low, except on unstable micro-sites such as scarps, V-notches, and stream banks. Standard best management practices that limit surface disturbance and disperse surface water flow are usually highly successful.
>
> ***None.*** No natural failures occur. Risks for management-induced failures are very low. Standard best management practices limiting surface disturbance and dispersing surface water flow are usually highly successful.

Landslide risks are shown in ***Table 2.II.D-1***, as well as the acreage associated with each mapped landtype unit in the Cooper Creek Watershed.

Figure 2.II.D-1: Cooper Creek Watershed Landtypes

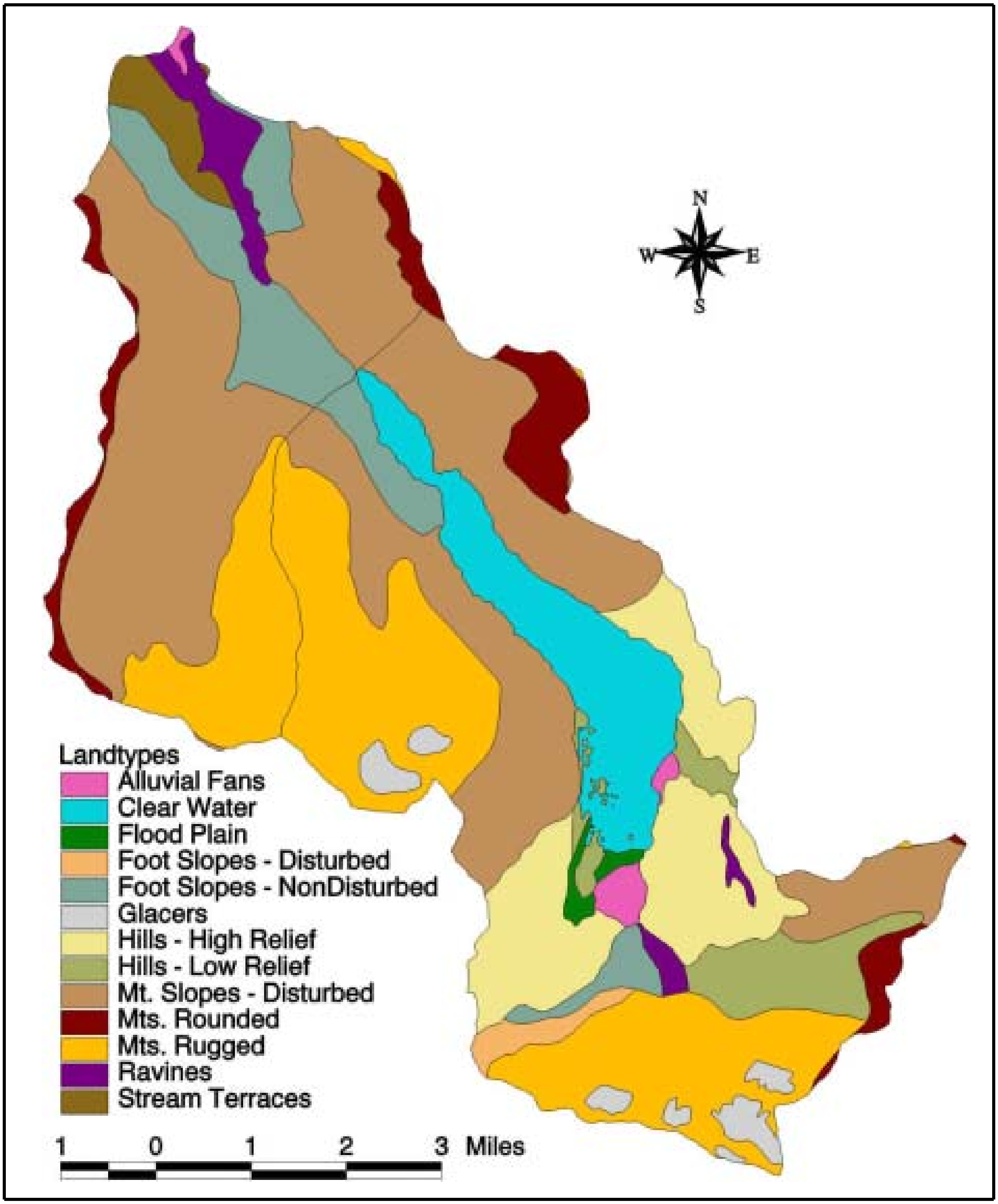


Figure 2.II.D-2: Cooper Creek Watershed Landslide Hazard Potential

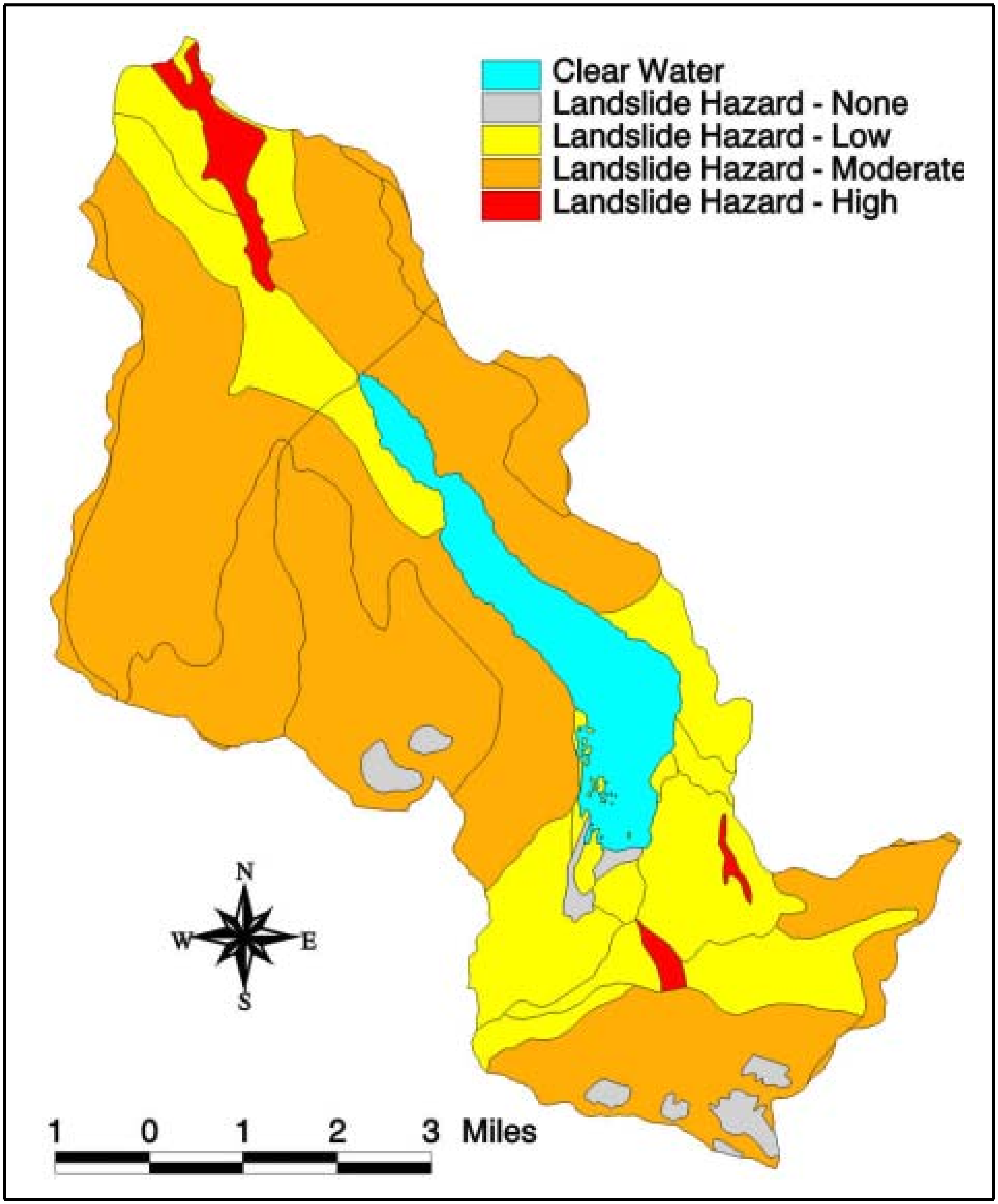


Table 2.II.D-1: Estimated Landslide Risk by Landtype - Cooper Creek Watershed

Landtype Map Units	Landslide Risk	Acreage	Percent of Total Are
Stream cutbanks	Low	248	0.8
Clear water (lake)	None	2,428	7.7
Floodplains	None	145	0.5
Footslopes – disturbed	Low	273	0.9
Footslopes – non-disturbed	Low	2,395	7.6
Glacier	None	551	1.8
Hills – high relief	Low	3,185	10.3
Hills - low relief	Low	1,270	4.1
Mountain slopes	Moderate	11,282	36.1
Rounded Mountains	Moderate	1,417	4.5
Rugged mountains	Moderate	6,974	22.3
Ravines	High	709	2.3
Stream terraces	Low (cut slopes)	468	1.5
TOTAL		**31,345**	**100**

2. Summary of Landslide Risks

This section evaluates high and moderate landslide risk locations within the Cooper Creek Watershed.

High Risk. Ravines are the only landtype in the watershed with high landslide risk. Ravines form where streams have cut down through bedrock or deep alluvial and/or colluvial soils, creating steep, exposed slopes. Groundwater seeps and springs are common on these slopes. Stream undercutting of slopes often drives the landsliding process. Slopes are most unstable when water-saturated. Landslide debris often moves directly into stream channels. Cooper Creek Watershed has 709 acres mapped in the Ravine landtype.

Moderate Risk. Three landtypes in the watershed are assessed with moderate landslide risk: 1) Rugged Mountains, 2) Rounded Mountains, and 3) Mountain Slopes. Only part of the 8,391 mapped acres of these three landtypes is susceptible to landslides. Ridges and mountaintops dominate the two Mountain landtypes (rugged and rounded). These two landtypes usually are at a distance from major streams and lakes. Landslide debris often remains in place, and is not transported to stream systems. Sites with steep slopes, wet soils, and loose rock have the greatest potential landslide risk. Earthquakes and heavy rainfall events are common landslide generators on the two Mountain landtypes.

The Mountain Slope landtype shows moderately steep slopes. Areas with poor soil drainage generally have the greatest landslide risk. Landslide debris sometimes remains in place on the slope, and sometimes is transported directly in streams and lakes. Slow, downslope soil creep is common.

3. Summary of Recent History

About 2 percent of the Cooper Creek Watershed has landtypes with high landslide risk, 63 percent with a moderate risk, and 25 percent with a low risk, and 10 percent with no risk. Active landsliding is occurring in the watershed in the ravine landtype, where Cooper Creek or its tributaries are actively cutting at the base of steep ravine slopes.

Historic human disturbances in the Cooper Creek Watershed that are most likely to influence landslide risk include:

- The Stetson Creek diversion ditch and road – built around 1907.
- The Cooper Dam Road – built in 1959.
- The Snug Harbor Road – built 1958-9.

Major landslide activity has not occurred along any of these three routes. The four mile long Stetson Creek diversion ditch is built on lands with low to moderate landslide risk, but the fact that it was used for carrying water and would saturate adjacent soils increases its potential hazard. Outburst/landslide activity possibly occurred along this ditchline during and following mining in the early 1900's.

About three quarters of the Cooper Dam Road is built on the Mountain Slope landtype, with moderate landslide risk. No significant landsliding has occurred along this road. Keeping this road maintained to eliminate concentration of water on the road's surface is important for reducing future landslide risk.

Snug Harbor Road is built on low risk landtypes, and no landslide activity is expected.

The most significant current landslide activity in the Cooper Creek Watershed occurs in the steep, tight ravines of two southern tributary streams to Cooper Lake/Reservoir. These two streams (Cooper Lake South and Cooper Lake Southeast) have cut sharply into erodible bedrock causing active slope failure and landsliding directly into the creeks. Much of this sediment is transported downstream during peak flows and flood events.

The storm event of September 20-22, 1995 caused floods on these two tributaries of unknown magnitude, but possibly in the range of a 100-year event. During the flood, these two streams transported very large sediment loads (thousands of tons). Most of this sediment eventually was deposited on the alluvial fans at the base of the ravines, or on the stream deltas out into Cooper Reservoir.

4. References For Landslide Risk

Swanston, Douglas N. "Controlling Stability Characteristics of Steep Terrain", in: "Assessments of Wildlife Viability, Old-Growth Timber Volume Estimates, Forested Wetlands, and Slope Stability", USDA-Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-392, pp. 44-58. March 1997.

E. Fire History of Cooper Creek Drainage

1. Historic Overview

Fire has been an occasional and important agent of change on the Kenai Peninsula. Over the last century, large fires have occurred on the Peninsula approximately every 12 years. When sustained dry conditions occur in the summer, the fire danger can increase dramatically within a few days. Ignition of fires by lightning is common on the west side of the Kenai Peninsula, but occurs rarely in the Cooper Creek drainage. Recreational use accounts for most of the accidental human caused fires.

USFS records at the Seward Ranger District list 22 fires occurring within the Cooper Creek Watershed since the early 1900's. Sixteen of the fires were size class A (fires of less than .1 acre), four were class B (between .2 and 2.5 acres), and two were class C (27 and 32 acres). The 22 fires were caused by:

Cause	Campfires	Refuse fires	Fireworks	Lighting	Unknown
No. of fires	11	7	2	1	1

Six of the refuse fires were started at a dump located to the west of the Cooper Creek Campground. This dump is now closed. The seventh refuse fire started at Cooper Lake during clearing for the Reservoir. The escaped campfires were scattered along Cooper Creek, in the campground, and along the shoreline of Cooper Reservoir.

Fire starts within the Watershed occurred with the following monthly distribution:

Month	April	May	June	July	August	September
Fire Starts	1	5	3	9	2	2

The concentration of fires in May is typical on the Seward Ranger District. Fire season begins around mid to late April, shortly after the snow melts from the valley bottoms. Late spring weather is usually the driest of the year. These dry conditions, combined with the dead, exposed grasses from the previous year, makes this time of year more susceptible for fire starts and spread. Green up of grasses and shrubs in late May and into June lowers the fire hazard, as does the heavier precipitation as the summer progresses. Occasional extended dry spells in the summer and fall also serve as "fire windows".

The Cooper Landing area including the lower Cooper Creek Watershed averages about 26 inches of precipitation annually. Precipitation within the Cooper Creek Watershed increases with elevation, up to 80 or 100 inches per year. The opportunity for a fire to spread is directly related to the fuel moisture content in the fine fuels, and usually lower elevation areas are more susceptible to fire. Small diameter fuels, especially bluejoint grass (Calamagrostis canadensis), dry quickly in the spring after only a few days of low moisture. Cured grasses allow for rapid fire spread when combined with strong winds.

Weather patterns on the eastern half of the Kenai Peninsula allow only marginal chances for extreme fire behavior conditions to exist. See (1990), in his study of fire behavior and weather in the Cooper Landing area reports less than a 2% chance of having a "bad" fire day during the average 150-day fire season. A "bad" fire day occurs when very low fuel moistures are combined with winds that can rapidly spread a fire. While very infrequent, these catastrophic fires do play a major role in vegetation patterns on the Kenai Peninsula.

The possibility of large wildfires in this area still persists. Large, stand-replacing fires have occurred in the Cooper Landing area with estimated intervals of 250 to 300 years (Potkin 1997).

The largest recent fire in the immediate area occurred in 1959, when about 3,200 acres burned along Kenai Lake's southwestern shore during construction of the Snug Harbor Road to Cooper Lake. Workers burning slash along the roadway started the fire. The fire burned from May 20, 1959 to October 6, 1959, and extended for almost 10miles. It starting near the Cooper Lake Project powerhouse and burned northwest to the Kenai River Bridge at Cooper Landing, burning up to timberline in some areas.

Two additional large fires occurred in the area (not within the Cooper Creek Watershed) in 1969, and 1991. The 1969 fire started on the Lower Russian Lakes Trail and burned westward down the Kenai River Valley consuming about 2,500 acres. The (April) 1991 fire was started by hunters to the west of the Russian River drainage, and burned generally northward to the Kenai River Valley near the upper end of Skilak Lake, consuming almost 9,000 acres.

2. Cooper Lake Project

The Cooper Lake Project brought construction of the Snug Harbor and Cooper Dam Roads, as well as vegetation clearing along the powerline corridors and around the high waterline of the reservoir. The Snug Harbor Road has significantly increased recreation use in the Cooper Creek Watershed.

Increased recreation brings an increased risk for human-caused wildfire. Eleven reported fires have occurred along Cooper Reservoir, or the roads to the reservoir. Only one of these fires was before the Cooper Lake Project, this at the Cooper Lake Cabin in 1953. The other 10 fires can be attributed to the increased access. Increased access to recreation activities and the Upper Russian Lakes Trail has increased the opportunity for fire starts. The trail poses an increased chance of larger fires, since starts along the trail are removed from road access for fire suppression crews. (Potkin, 1997).

3. Area Fire Management

The Forest Service's fire management strategy has generally involved suppressing all detected wildfires, in order to protect private land and timber resources. Although fire starts have increased in recent years, actual number of acres burned has decreased. Increased fire suppression capability, including pumper trucks and helicopters, has allowed for more rapid control and containment of fires.

In the last two decades, the Forest Service has increasing been using prescribed fire for management of forest stands. A stand of beetle-killed spruce to the southeast of Stetson Creek in the Cooper Creek Watershed is currently targeted for prescribed burning.

4. References for Fire

Potkin, Michele. (in draft.) "Fire History Disturbance Study of the Kenai Peninsula mountainous portion of the Chugach National Forest", Internal Report, Chugach National Forest, 1997.

See, John. "Fire Behavior Analysis for the Cooper Landing Spruce Beetle", Alaska Department of Natural Resources, Division of Forestry, 1990.

III. Fauna/Flora

A. Fisheries

1. Pre-settlement – Before 1880

We have not found direct pre-settlement evidence verifying the existence of salmon and trout in Cooper Creek. However, based on historical records of Cooper Creek fisheries, we see no reason to suspect that salmon and trout were not in Cooper Creek for at least the last several centuries. Native house pits and cache pits have been identified along lower Cooper Creek giving a strong indication that the Creek was used for subsistence by native cultures.

2. Mining and Settlement era 1880-1959

a. Fisheries in Cooper Creek

(1) Salmon in Cooper Creek

Limited inventory, as well as newspaper and anecdotal reports indicate that Cooper Creek supported runs of chinook, sockeye, coho and possibly some pink salmon. Populations of both rainbow trout and Dolly Varden char are also indicated in these records. The earliest inventory records found for salmon in Cooper Creek date to the 1930's. These stream surveys (Parker, 1997) mention “a good number of chinooks” in late August of 1931, and “few reds and cohos, fair show of chinooks” in 1936.

Due to a lower gradient and apparent finer substrate, Cooper Creek’s alluvial fan at its lower half mile, may well have provided the creek’s best salmon spawning and rearing habitat. However, the next four upstream miles of Cooper Creek is also accessible to salmon, and likely provided some spawning and rearing habitat. The amount of usable habitat is not well understood.

Spawning and rearing habitats on the lower half-mile of Cooper Creek, including the channel, floodplain, and riparian soils and vegetation, were highly disturbed by the hydraulic placer mining that occurred from approximately 1908 to 1917. We suspect this mining activity may have significantly diminished salmon escapements into Cooper Creek. Aerial photography from the early 1960’s show Cooper Creek to be only moderately recovered from mining activities some 40 to 50 years earlier. Salmon escapements into Cooper Creek in the late 1950’s likely had not reached their potential based on this slow stream recovery.

Table 2.III.A-1 summarizes data from Parker (1997) on Cooper Creek salmon surveys between 1931 and 1959. This survey data is taken primarily from a USF&WS (1953) report, with the data collected by the USF&WS and the Fisheries Research Institute of the University of Washington. The surveys provide a snap shot of the number and kinds of fish present on specific days.

Table 2.III.A-1: Summary of Cooper Creek Salmon Surveys, 1931-1959
(from Parker, 1997)

Date	Salmon Observed	Remarks
1931 late Aug.	Good number of chinooks	
1936 (no date)	Few reds and cohos, fair show of chinooks	Clear
1946 (no date)	20 reds	Mouth of stream
1947 (no date)	Good showing of chinooks	Resident's report
1949 Aug. 9	15 reds	Foot survey, mouth of stream
1950 Aug. 2	300 reds	Air survey at the mouth
1950 Aug. 17	35 chinooks	Foot survey on lower 3/4 mile
1952 Jul. 8	None	Swift water, poor red spawning area
1952 Aug. 29	Few reds, 2 chinooks	Foot survey, mouth of stream
1953 Aug. 18	17 chinooks, 1 chum	Foot survey lower ½ mi., poor red area,
1958 Sept. 3	7 chinooks	Foot survey
1959 (no date)	No salmon	Foot survey

Unfortunately, the surveys were not well controlled and mostly occurred on a single day. Individual surveys may not have been well synchronized with the peak salmon runs. Based on the dates shown, coho salmon runs would have been largely missed.

Nearly all surveys appear to have been limited to the lower ¾ mile of Cooper Creek, and what portion of the lower ¾ mile is generally unclear. Salmon using the next four upstream miles of the Cooper Creek for spawning were not counted.

The surveys indicate the presence of king (chinook), sockeye, and coho salmon spawning in Cooper Creek as well as a single chum (which we suspect was a recording error). In the surveys, salmon in Cooper Creek were generally recorded in numbers from a few to hundreds. Actual escapements into Cooper Creek could be expected to significantly exceed the numbers displayed in the surveys.

A variety of information on Cooper Creek salmon is found in correspondence and reports leading up to and following the construction of the Cooper Lake Hydropower Project. This information is in some cases contradictory, and often lacking in good documentation of the data presented.

The Cooper Lake Hydroelectric Project Report (North Pacific Consultants, 1955) states that, "Cooper Creek's gradient is so steep that salmon can not gain access to the lake but some enter the lower mile of the stream for spawning." We believe that salmon likely used the lower 4 miles of the creek at that time.

In their 1964 "Initial Follow-up Report", USF&WS mentioned a July 1956 memorandum report to the Federal Power Commission (predecessor to FERC), written in response to the May 19, 1955 preliminary permit for the Cooper Lake Project. This memorandum report states that lower Cooper Creek supported an important sport fishery and provided spawning areas for small runs of commercially significant salmon species.

USF&WS states in an attached report to a June 4, 1956 letter, “Cooper Creek has limited value for commercial species of fish. An unknown number (although few) coho salmon and as many as 35 chinook salmon use the lower ¾ mile of the stream for spawning.”

Again USF&WS reports, in an attached report to an October 29, 1958 letter, “The lower portion of this stream [Cooper Creek] sustains a sport fishery of Dolly Varden and rainbow and a limited salmon population of chinooks, and silvers.” And, in a January 12, 1960 memorandum, they state, “The lower portion of this stream [Cooper Creek] sustains a sport fishery of Dolly Varden and rainbow trout as well as a limited salmon population of chinooks, pinks, and cohos.”

In a November 26, 1963 memo, the USFS states, “At the time the original license was issued the anadromous fishery [on Cooper Creek] was valued at approximately $50,000.” The memo does not explain who derived this value, or how they reached it.

An earlier, January 20, 1960 USFS memo reporting on a meeting between the USFS and a variety of fisheries management agencies, reports, “McCrea [Alex McCrea, Sports Fisheries Div., ADF&G] suggested that the power company [CEA] might be induced to support such a program [fish stocking in Cooper Lake] by providing an annual sum equivalent to reasonable interest on $50,000 (the $50,000 in this instance is the amount the company was reportedly willing to spend to rehabilitate lower Cooper Creek).”

(2) Salmon Life Histories

Although we have not found descriptions of run timings and run characteristics in Cooper Creek, we assume that Cooper Creek salmon followed similar patterns to other salmon runs in the Kenai River. A description of these characteristics follows:

(a) Chinooks (kings)

Chinook salmon begin entering the Kenai River from Cook Inlet in late May and early June, but would have been unlikely to start migrating into a spawning tributary like Cooper Creek until late July. The spawning period was likely to extend through August and into early September. Chinooks are particularly well adapted to spawn in coarse channel substrate found in Cooper Creek.

Chinook fry likely emerged from the gravels in May. Due to Cooper Creek’s limited pools, fry would have likely migrated out to the Kenai River system. Some fry may have stayed longer, feeding on macroinvertebrates, salmon eggs, and other salmon fry. Fry would have generally remained in the Kenai River system for one year before outmigrating to the ocean.

Nick Lean, a Cooper Landing resident in the 1920’s and 30’s (born 1921), mentions of Cooper Creek in a 1993 interview (Painter, 1998), “I’d stand there on the bridge as a kid and watch those great big kings swimming up. They were all up and down the creek.”

In a 1999 interview (Larson, 1999), Nick Lean told how kings were abundant in Cooper Creek. One summer (probably early 1930's), he fed and cared for a neighbor's sled dogs, and remembers going to Cooper Creek to snag king salmon for dog food.

Mona Painter (1998) reported seeing king salmon spawning upstream from Cooper Creek Campground during the summer of 1959. That would have been just as the dam construction had commenced on the Cooper Lake Project.

(b) Reds (sockeye)

Red salmon would probably not have entered into Cooper Creek until they were ready to spawn. Fish likely entered Cooper Creek mostly in August. Some data suggests that sockeyes gathered near the mouth of Cooper Creek before moving upstream. This might mean that they spawned primarily at the very lower end of Cooper Creek, or it could mean that they "schooled up" in the Kenai River at the mouth of Cooper Creek before heading upstream to spawn.

Sockeye fry would have emerged from the gravels in May, outmigrated within a fairly short period to the Kenai River, and then mostly migrated to Skilak Lake. They likely resided in the lake for two years before outmigrating to the ocean.

(c) Silvers (coho)

Silver salmon would have been unlikely to enter Cooper Creek until late August, and spawning runs could have continued until at least well into October. Fry would have emerged in May with some remaining in Cooper Creek and some outmigrating to the Kenai River system. Fry likely fed on macroinvertebrates, salmon eggs, and other fry. They would generally reside in the river system for one to two years before outmigrating to the ocean.

(d) Pinks

Pink salmon do not show in Cooper Creek inventories until 1962, after construction of Cooper Dam. Nick Lean (Larson, 1999) mentioned seeing six small, flat-bodied fish resembling pink salmon in the vicinity of the Cooper Creek highway bridge at one time (probably the 1930's or early 40's). A January 12, 1960 USF&WS memorandum mentions pinks in Cooper Creek but does not provide supporting data.

Possibly pre-dam fish surveys simply missed finding pinks. Pinks use the Kenai River primarily in even years, thus lowering the probability of finding them in a survey. Alternatively, changes in Cooper Creek occurring after 1960 (such as flow and temperature) may have opened a window of opportunity for spawning pink salmon.

Post-dam records show pink salmon spawning in Cooper Creek in September, though some fish may have moved into Cooper Creek earlier. Fry likely emerge from the gravels in May and outmigrated directly to the ocean.

(3) Rainbow Trout and Dolly Varden in Cooper Creek

Both rainbows and Dolly Varden in Cooper Creek likely had both resident populations and immigrating spawning populations from the Kenai River system. Resident rainbows and Dollies likely remained stunted in growth due to the limited food supply and habitat on Cooper Creek.

Rainbow spawners from the Kenai River entered Cooper Creek in late April and early May, and outmigrated within a month. Non-spawning rainbows may also have followed spawning salmon into Cooper Creek later in the summer to prey on salmon eggs. Dolly Varden spawners from the Kenai River probably entered Cooper Creek from mid-August to early October, and then outmigrated mostly in October.

Immigrating rainbow and Dolly spawners were large, an obvious target for sport anglers. Cooper Creek's accessibility to Cooper Landing made it a ready source for sport and subsistence fishing.

Mona Painter (1998) located a number of references to rainbows and Dolly Varden in Cooper Creek during the early and mid 1900's. She did not find references describing early Cooper Creek miners fishing on the creek, but it seems likely they might have used the creek for subsistence.

Nick Lean stated in a 1993 interview of his memories of the 1920's and 30's, "…Those things … Dolly or char, I don't know what you call them, … used to go up Cooper Creek to spawn in the fall. Big chars, big Dollies. Cooper Creek was a good fish stream in those days. Big rainbows would go up to spawn in the spring. I've seen 30-inch rainbows up there like you won't believe. …. Cooper Creek was a good trout stream."

Nick Lean is again interviewed in a May 6, 1997 article (Little, 1997). This article mentions, "Sometime after the first quarter of this century, mining subsided and fish returned. It was in those quiet years in the 1920's and 30's that Nick Lean remembers fishing amid the piles of gravel tailings. … Cooper Creek was bigger then, sometimes threatening a small bridge that crossed it near its mouth. … 'The big rainbows went up there to spawn' [Lean] said."

Nick Lean and Laurel Gresham show Cooper Creek rainbow trout caught in 1936 (Photo taken by Beryl Lean, Nick's mother after the anglers returned to the Lean home on the Kenai River. From Anchorage Daily News)

In a 1999 interview (Larson, 1999), Lean tells how the big rainbows would school up at the mouth of Cooper Creek in April or May before running upstream to spawn. These fish were easiest to catch as they schooled at the mouth, and difficult to catch after they had moved upstream and paired up. Lean observed about a dozen rainbows (estimated 24 to 32 inches in length) in a single location in the "canyon" of Cooper Creek at least a mile up from the Kenai River. The largest rainbow he observed in Cooper Creek was approximately 34 inches and weighed 17 pounds.

A September 13, 1933 newspaper story in the Seward Daily Gateway reports Arne Sundby and his wife fishing at Cooper Creek and "having a lot of luck catching rainbows." Though some rainbows were likely present in the stream, it seems possible that Dolly Varden may have been a more likely catch at that time of year.

In a November 6, 1940 memo to the Forest Service's Juneau Regional Forester, Seward District Ranger E. Norgorden writes, "Cooper Creek was heavily fished during April and May. Many fine catches being made, with sizes comparable to those of the Russian River. Placer mining on Stetson Creek ruined the fishing till until late fall." Though not explicitly stated, the "fine catches" clearly appear to relate to rainbow trout.

A May 13, 1941 article in the Seward Daily Gateway reports, "Carl Orlander and Jack Lein [sic]" landing "two nice big rainbows" on Cooper Creek.

Painter (1998) interviewed Cooper Landing cabin owner Bob Williams on January 15, 1998. Williams reported fishing Cooper Creek in 1952, and finding very good rainbow fishing at the mouth of the creek, with a drawback of losing gear in the big rocks there.

Baxter (1956) in an Alaska Game Commission Quarterly Progress Report (p. 48) states:

> "Approximately 340 fishermen are computed to have used this stream [Cooper Creek] during the season. Based on fishing periods I through V, it is computed that about 250 rainbows and 50 Dolly Varden were taken from this water. The rainbows caught were actually taken from the Kenai River by persons fishing at the mouth of Cooper Creek. Cooper Creek itself is known to contain only Dolly Varden, although occasional king salmon and silver salmon have been observed in the stream."

This last sentence from the report is puzzling based on the number of local reports of rainbows in Cooper Creek. On page 54, this same report displays a table showing 10 rainbows and 3 Dolly Varden ranging from 7 to 12 inches being taken from Cooper Creek in 1955. The report also displays a table on page 58 that reports contacting 85 anglers in 1952 who reported catching 28 rainbow trout, average weight 2.2 pounds. Spawning rainbows from the Kenai River would likely have schooled at the mouth of Cooper Creek for a period in the spring before entering. Such schooled fish would have been a good target for sports fishermen.

Painter (1998) tells how in June 1958, Floyd McElveen and his family moved to the Woodring Cabin, just west of Cooper Creek Campground. McElveen wrote a book about his experiences, "The Call of Alaska". McElveen writes (page 42), "Next to our cabin was sparkling Cooper Creek, filled with rainbow trout. … Once while fishing Cooper Creek, I caught a 29-inch trout with a small hook and a single salmon egg." On page 74 he writes, "…when we stopped [working] during the long summer days, I would grab my three boys and rush down to Cooper Creek. Sometimes, I was so tired I couldn't see straight, but a tug on the line by a rainbow trout would rejuvenate me in a hurry. To see the excitement on my boys' faces when they caught their fish was priceless to me."

The USF&WS (July 1964) reports, "A survey of the [Cooper Creek] sport fishery in 1955 indicated that 342 fishermen fished 1,281 days for a total cost, including trips and investments, of $13,947."

An attached report to a June 4, 1956 USF&WS memo adds (page 3):

> "During the 1955 field season, a creel census program carried on by the Office of River Basin Studies and Federal Aid in Fish Restoration, revealed that about $14,000 was spent by sport fishermen angling in this area for Dolly Varden and rainbow trout. In reality, the average 'value' probably exceeds that disclosed in 1955 since construction of a bridge across Cooper Creek resulted in turbid rather than clear waters at the junction during a major portion of the season. It is agreed that this construction resulted in a reduced fishing pressure during 1955 due to the turbidity of the water as well as construction activity which negated the esthetic surroundings."

b. Fisheries in Cooper Lake

The USF&WS conducted a test-netting program in Cooper Lake in the summer of 1955 (USF&WS, 6/4/1956). They report Dolly Varden as the only sport fish captured in the lake. USF&WS (July 1964) reports that, "[Coast Range] Sculpins were apparently uncommon [in Cooper Lake] prior to 1960, but are now very abundant, especially in the shoal areas of the reservoir."

We have found anecdotal reports of other fish species in Cooper Lake, but no substantiating data. Potential for lake trout has been mentioned, but no past or present lake sampling supports this claim. Lazar and Van Hatten (1994) write, "Verbal reports indicate that prior to the construction of the dam, there was a run of rainbow trout into Cooper Lake." However, no rainbows were found in any Cooper Lake sampling until after ADF&G started stocking them in 1987 (see ***Table 2.III.A-5***). A September 24, 1938 article in the Seward Daily Gateway reports a Kansas couple going to Cooper Lake to fish for rainbow trout. We strongly suspect that the couple fished for char, and the paper reported their quarry as rainbows.

Char. In November 1999 and June 2000, USF&WS and ADF&G netted 170 char in Cooper Reservoir. The biologists present identified all these char as Arctic char, and none as Dolly Varden. This data suggests that previous surveys probably misidentified the Cooper Lake/Reservoir char as Dolly Varden. Recent genetic analysis of Cooper Reservoir char (Reist, 6/27/2001) adds a further twist to the char story. The six Cooper Reservoir char tested have characteristics of both Arctic and Taranets char (both lake dwelling char).

Arctic/Taranets char and Dolly Varden are closely related, and difficult to distinguish from one another. Some biologists identify Dolly Varden and Arctic char as a single species, although the two fish have distinct habits, habitats, and morphology. An item of note at Cooper Lake is that Arctic char are known to be lake spawners while Dolly Varden are stream spawners (Dean, 3/23/00). Presence of stream spawning Dolly Varden in Cooper Lake cannot be completely ruled out, but no observations have been made of such spawning.

Arctic/Taranets char are relatively uncommon in Southcentral Alaska, but are found in isolated stocks in a few lakes on the Kenai Peninsula and in the Susitna Valley (Dean, 2000). Presence of Arctic char characteristics in Cooper Lake fish raises the possibility that these fish may have been isolated in Cooper Lake for many hundreds of years. Another possibility is that these char were stocked, although ADF&G has no record of doing so.

One possible scenario for char to have migrated to Cooper Lake involves damming near the outlet of the lake by a small side valley glacier sometime within the last few thousand years. Under this scenario Cooper Lake may have filled to the point where it flowed out from its south end into the Resurrection River drainage, or possibly even the Russian River drainage. This would have created a stream access route to Cooper Lake with fewer barriers than those presented by Cooper Creek.

3. 1960 to the Present – After Construction of Cooper Lake Dam

a. Fisheries in Cooper Creek

(1) Salmon

Limited inventory data is available on salmon populations in Cooper Creek after construction of Cooper Lake Dam. The dam had the effect of terminating flow out of Cooper Lake into Cooper Creek. This reduced annual flow in Cooper Creek at its mouth by about 70 percent and lowered the average July stream temperatures by as much as 6 to 8° F. It also greatly limited the size and duration of peak flood events on Cooper Creek (and hence sediment movement down the creek).

Initiation of dam construction in July 1959 terminated flow out of Cooper Lake. Cooper Reservoir filled to its spillway by April 1961. Reservoir waters then spilled back into Cooper Creek for the next year and a half during completion of the hydropower project. Since October 1962, no water has spilled from the reservoir into Cooper Creek, and all outflow has been through the power turbines and on to Kenai Lake.

Table 2.III.A-2 summarizes Cooper Creek salmon inventory data (Parker, 1997) from 1960 to 1968. We believe USF&WS collected this data, but have not confirmed this. The surveys provide a snap shot of the number and kinds of fish present on a particular day, but are not necessarily indicative of the size to the total run that year. Locations of the surveys are not well documented, and are likely limited to all or portions of Cooper Creek's lower half mile.

Table 2.III.A-2 appears to confirm the indications of ADF&G and USF&WS biologists that Cooper Creek salmon runs have stopped since construction of Cooper Lake Dam. It counters the fisheries prediction by the project consultant (North Pacific Consultants, 12/29/55) that, "Diversion of Cooper Lake and Stetson Creek for power will greatly reduce the flood peaks in Cooper Creek. The area below the dams contribute sufficient run-off to sustain the fish runs and spawning grounds."

(a) Chinooks (kings)

Spawning adult chinook (king) salmon continued to be recorded on Cooper Creek up through 1964 and then cease to appear in the record (chinook fry, possibly spawned in the Kenai River, are identified in Cooper Creek in 1968). USF&WS (1964) suggests that the declining number of spawning chinooks "is probably caused by [altered] water temperatures and reduced flows in this area." On August 5, 1997 ADF&G observed one adult male chinook 3/4 mile upstream from the confluence (Athons, 1998).

Table 2.III.A-2: Summary of Cooper Creek Salmon Surveys, 1960-1968
(from Parker, 1997)

Date	Fish observed	Flow out of Cooper Reservoir *	Cooper Creek Temps.	Cooper Reservoir Temps	Remarks
1960 Jun.-Aug.	No salmon	No	45-49°F	51-59°F	Foot survey
1961 Jul. 18		Yes	53°F	N/A	
1961 Aug. 8	6 chinooks, 7 Dolly Varden (9")	Yes	48°F	N/A	
1961 Sep. 21		Yes	41°F	N/A	
1962 early Aug	20 chinooks	Yes	N/A	N/A	Foot survey,
1962 Sept. 11	196 pinks	Yes	N/A	50°F	1st recorded pinks in creek, foot survey
1963 Oct. 3	no salmon	No	34°F	50°F	No spawning evidence
1964 Jul. 9		No	42°F	54°F	
1964 Jul. 18		No	46°F	56°F	
1964 Aug. 20	2 chinooks	No	43°F	54°F	Foot survey
1964 Sep. 9	55 pink, 2 chinooks	No	39°F	52°F	Foot survey
1965 July 5		No	43°F	N/A	
1965 July 22		No	43°F	54°F	
1965 Sep. 3	no salmon	No	40°F	N/A	Foot survey
1966 Sep. 22	8 pinks	No	38°F	38°F	Foot survey
1967 Oct. 12	no salmon	No	37°F	46°F	Foot survey
1968 Aug. 20	All juveniles fish 10 chinooks (51.6mm); 12 Dolly V. (102.1mm) 1 rainbow (137mm)	No	46°F	N/A	Lower 250 yards of creek with an electro-shocker
1968 Sep. 23	no adult fish	No	38°F	49°F	

** Flow spilled out of Cooper Reservoir into Cooper Creek between April 1961 and Oct. 1962.*

(b) Sockeye (reds)

Sockeye (red) salmon cease to show in the record, and in fact, are last reported in any surveys in 1952. Coho (silver) salmon also cease to show in the record, and are only clearly mentioned in 1936 records, (and possibly in 1953).

(c) Pinks

Pink salmon are inventoried on Cooper Creek in 1962 (196), 1964 (55), 1966 (8), and none in 1968. These are the first recorded inventories of pinks on Cooper Creek (though possibly they were missed in previous inventories). Pinks are generally even-year spawners on the Kenai River, which helps to explain the even-year pattern in the surveys. The number of pinks counted declines in each successive spawning year, which appears to indicate declining spawning habitat conditions. The highest count, in 1962, was made when Cooper Reservoir flows were spilling into Cooper Creek. Whether some characteristic of the reservoir overspill waters could have been an attractant to pink spawners in that year is not known. Reservoir overspill into Cooper Creek ceased in October 1962, and hence was not a factor in the 1964 and 1966 counts.

(d) Recent findings

We have found accounts of salmon in Cooper Creek through the 1970's, 80's, and most of the 90's. We suspect that Cooper Creek has continued to be used for spawning after the dam was built, but only by a very few salmon, that may often have gone unnoticed.

ADF&G's Anadromous Fish Catalogue identifies the lower two miles of Cooper Creek as being used for rearing habitat by coho salmon. The fry trapping data on Cooper Creek from 1968 (see ***Table 2.III.A-2***) and 1997 (Lazar) do not support this ADF&G identification. Possibly coho fry rear in Cooper Creek in the late spring and early summer and outmigrate by mid-summer when the known fry surveys occurred.

ADF&G Weir Study – 1999-2001. ADF&G Sportfish Division has operated a weir seasonally on Cooper Creek for three years. The 1999 weir was operated between August 29 and October 6, 1999. The weir was located about 500 feet upstream from the stream's mouth. ADF&G's counts have focused primarily on Kenai River Dolly Varden migrating into Cooper Creek to spawn. However, during the 1999 operation, they counted one upstream migrating pink salmon (8/29), two cohos that migrated into, then quickly out of Cooper Creek (9/9 and 10/1), and one sockeye that also migrated quickly in and out (9/10 to 11). They also counted five sockeye salmon actively spawning about 200 feet downstream from the weir site (Larry Larson, ADF&G, personal communication, 12/30/99.)

In 2000, ADF&G operated their Cooper Creek weir from July 16 to October 20. This year they counted one sockeye at the upstream weir trap in late July. Then, five sockeye and two coho appeared at the downstream weir trap in mid-October. This implies that the outmigrating sockeye and coho either entered the stream before July 16 when the weir was installed, or somehow got around the weir without being trapped on their way into Cooper Creek.

In 2001, ADF&G operated their Cooper Creek weir from July 18 to October 22. They counted one upstream migrating chinook (8/13), one sockeye pre-spawner that migrated into and quickly out of Cooper Creek (9/7&8), one outmigrating sockeye post-spawner (9/28), and one immigrating coho post-spawner (10/16).

(2) Rainbow Trout and Dolly Varden in Cooper Creek.

(a) Rainbow Trout

Following construction of the Cooper Lake Hydroelectric Project, rainbow trout from the Kenai River system appear to have essentially stopped using Cooper Creek for spawning. This appears to be related primarily to Cooper Creek's reduced spring and summer water temperatures. ***Table 2.III.A-2*** identifies only one rainbow trout (five inches) in an electroshock sampling of 250 yards of Cooper Creek on September 23, 1963. Sport fishing for rainbow trout on Cooper Creek has essentially ceased since construction of the dam.

On July 8, 1997 a USFS fisheries crew set 20 baited minnow traps on Cooper Creek between its mouth and Stetson Creek. They captured 146 Dolly Varden and one rainbow trout, all less than 6 inches (150mm). No fish were caught in the lower 200 yards of Cooper Creek. Although rainbows are present in Cooper Creek and may be resident, this sampling indicates their numbers are very low and the current habitat is marginal for rainbows.

Discussions by fishery management agencies in the 1960's focused on doing enhancement work on lower Cooper Creek to improve its habitat, primarily by increasing deep-water pool habitat. Losses of streamflow and water temperatures were felt to have been detrimental to spawning rainbows.

A February 4, 1969 draft letter from the Secretary of the Interior to the Secretary of the Federal Power Commission states,

"With project operation, all flows from Cooper Lake have been diverted for power production; this diversion has resulted in substantially reduced flows and colder water temperatures in Cooper Creek. These adverse conditions have downgraded the habitat to such an extent that the anadromous fish runs and the sport fishery in lower Cooper Creek have been nearly eliminated."

(b) Dolly Varden

Dolly Varden have continued to use Cooper Creek for spawning and rearing, and appear to have adapted to the flow and temperature changes that have occurred. We are not aware of any reliable pre-dam count of the number of Dolly Varden using Cooper Creek. What changes, if any, the Cooper Creek Dolly Varden population has undergone as a result of the dam has not been examined.

A sport fishery continued on Cooper Creek for several years after construction of the Cooper Lake Project. USF&WS (July 1964) reports "Sport fishing has continued in lower Cooper Creek, especially in the area of its confluence with the Kenai River." They go on to report that Forest Service records from 1963 "estimate that 1,344 persons fished Cooper Creek and adjacent fishing areas." This estimate is apparently based on the number of people staying at Cooper Creek Campground. The number of people actually fishing on Cooper Creek is not spelled out in this report.

Table 2.III.A-2 identifies 12 Dolly Varden (average length four inches) in an electroshock sampling of 250 yards of Cooper Creek on September 23, 1963. A USFS fisheries crew caught 146 Dollies (all under 6 inches) in baited minnow traps on Cooper Creek between its mouth and Stetson Creek (7/8/1997).

Cooper Creek Dolly Varden possibly include both resident fish (that never become very large due to limited food/habitat), and immigrating spawners from the Kenai River system (and their offspring.) Spawning appears to occur primarily from mid-August to mid or late October, and appears to concentrate in the creek's limited pool areas.

Stetson Creek has a barrier falls about 100 feet upstream from its confluence with Cooper Creek. This falls stops any fish migration up Stetson Creek. Dolly spawners can and do continue upstream on Cooper Creek past its confluence with Stetson Creek. Flow in this section of Cooper Creek is minimal, and limits both adult fish migration and availability of potential spawning sites. A series of barrier falls on Cooper Creek a mile upstream from its Stetson Creek confluence prevent further upstream migration. A number of juvenile Dollies rear in the one-mile stream section below the falls.

Trapping studies confirm that juvenile Dolly Varden rear in Cooper Creek. However, it is unclear whether the majority of these fish are resident to Cooper Creek, or if the offspring of the Kenai River system Dollies rear in Cooper Creek for a year or more before outmigrating to the Kenai River.

(c) Recent Findings

Present sport fishing pressure on Cooper Creek has been light, apparently due to the lack of angler success in catching fish. However, recent studies by ADF&G's indicate that several hundred Dolly Varden generally enter Cooper Creek in the late summer and early fall to spawn.

Radio Tagging. In fall of 1997 and 1998 Larry Larson (ADF&G) and Doug Palmer (USF&WS) radio-tagged spawning Dolly Varden in Cooper Creek and then tracked these fish over the course of the following year. ***Table 2.III.A-3*** shows the distribution over the following year of 20 Dolly Varden spawners radio-tagged in Cooper Creek on September 24, 1998 (Palmer, 11/27/2001). These fish were captured and tagged about three and a half miles up Cooper Creek near the mouth of Stetson Creek.

The 20 Dolly Varden radio-tagged in Cooper Creek outmigrated back to the Kenai River in late September through October (except four dead or missing fish.) The remaining 16 fish over-wintered in Skilak or Kenai Lake. In mid-June through July of the following year, almost all these fish moved to the Killey River (tributary to the Kenai River below Skilak Lake) where they apparently feed on salmon fry and eggs. By fall of the following year (1999), most of the fish had returned to Skilak Lake or Kenai Lake, with just two returning to Cooper Creek to spawn again.

ADF&G Weir Studies. From the radio tracking of Cooper Creek Dolly spawners, USF&W and ADF&G biologists speculated that spawning Dollies migrate into Cooper Creek from mid to late August into September, and outmigrate in September and October. ADF&G then initiated a weir study on Cooper Creek to better understand the movements of the Dolly spawners, and other fish, in Cooper Creek.

Table 2.III.A-3: Distribution of 20 Dolly Varden, Radio-Tagged in Cooper Creek on 9/24/1998

Date	Location							Total
	Kenai Lake	Upper Kenai River	Cooper Creek	Skilak Lake	Killey River	Kenai R. Below Skilak L.	Missing or Dead	
09/24/98			20					20
10/01/98		4	13				3	20
10/15/98	4	5	1	4		3	3	20
11/01/98	6			6		4	4	20
11/15/98	6			8		2	4	20
12/01/98	6			9		1	4	20
12/15/98	6			9		1	4	20
01/15/99	6			10			4	20
02/15/99	6			10			4	20
03/15/99	6			10			4	20
04/15/99	6			10			4	20
05/01/99	6			10			4	20
05/15/99	5			10	1		4	20
06/01/99	5			6	5		4	20
06/15/99	1	1		1	13		4	20
07/01/99		2			14		4	20
07/15/99				1	15		4	20
08/01/99		1		1	12	2	4	20
08/15/99			1	2	2	9	6	20
09/01/99		2	2		1	8	7	20
09/15/99		4	2			7	7	20
10/01/99	1	2	2	4	1	3	7	20
10/15/99	2	2		7		2	7	20

ADF&G operated an up and downstream weir seasonally on Cooper Creek in 1999-2001 (8/29-10/6/1999, 7/16-10/20/2000; and 7/18-10/19/2001). The weir was located about 700 feet up Cooper Creek from its mouth.

The weir studies have indicated that while a number of Cooper Creek Dolly spawners do follow the speculated movement pattern, quite a few Dollies are entering Cooper Creek as early as mid-July, possibly even earlier. Some post-spawners start outmigrating in late September and October, but the weir study results suggest others may stay in Cooper Creek longer, possibly even over-winter.

USF&WS fish biologist, Doug Palmer believes over-wintering by the spawning Dollies in Cooper Creek is unlikely, due to the lack of food resources there. He bases this opinion on results from radio tracking studies of Dolly Varden on streams around the Kenai Peninsula (phone conversation, 11/27/01.) If this opinion is correct, it implies that the Cooper Creek weir results may not be complete, and that a number migrating fish have been able to get past the up and downstream weir without being counted.

1999 Weir Study. In their 1999 weir study on Cooper Creek ADF&G counted 327 immigrating Dolly Varden spawners into Cooper Creek between August 30 and October 6, 1999 (Larson, fall 1999). Average length for these Dollies was 17.7 inches (449 mm).

Mark/recapture studies by ADF&G in 1999 on the spawning Dolly Varden population indicate that more than 100 Dollies probably entered Cooper Creek before the weir count started (8/29/99), or passed by the weir uncounted. A few additional Dolly spawners likely entered Cooper Creek after October 6, 1999 as well. In total, Larson estimates 400 to 500 adult Dollies probably entered Cooper Creek during the 1999-spawning season.

Outmigrating Dolly post-spawners were first counted at the ADF&G downstream weir on September 26, 1999. By October 6, 1999 when the weir was removed, 25 outmigrating Dollies had been counted.

Other resident fish captured in the 1999 weir study include:

- Two rainbows in the upstream trap (9/18 and 10/15, av. length 219 mm [8.6”]).

2000 Weir Study. ADF&G’s 2000 Cooper Creek weir study (7/16-10/20/2000) counted 225 individual Dolly Varden (Breakfield, 2000). Of these Dollies, 193 (86%) were 200 mm or greater (average 460 mm.), and 32 were less than 200 mm (average 87 mm.)

All Dollies 200 mm. and greater captured at the weir were tagged, recorded, and passed by the weir, or if they already had a tag, were just recorded and passed. Of these 193 Dollies, 145 Dollies were counted just at the upstream weir, 78 only at the downstream weir, and 15 were counted at both the upstream and downstream weir. Additional Dolly spawners may have entered Cooper Creek before the weir was installed. Some fish likely slipped around the weir without being counted (phone conversation with Jeff Breakfield, ADF&G, 10/30/01.)

Nine Dollies tagged in 2000 at the upstream weir were recaptured in the same upstream trap, meaning they had slipped past the downstream weir without being captured, then headed upstream again. Twelve Dollies tagged in 2000 at the up trap were recaptured later (9/30-10/18) at the down trap. Four Dollies tagged in 2000 at the up trap died and were found washed up on the downstream weir. Sixty-two Dollies with no tags were captured post-spawning at the down trap (and were tagged then). Seven additional untagged Dollies were caught and tagged on upper Cooper Creek near Stetson Creek.

Five fish tagged in 1999 were recaptured at the up trap in 2000, and twelve 1999 tags were recaptured at the down trap including none of the 1999 tags captured in the up trap.) One 1998 tag was captured in the up trap and one 1997 tag in the down trap

The number of fish missed on the up and down stream counts in 2000 is not known, but appears to have been considerable. Many fish were apparently able to pass by the weir without being captured.

Other resident fish captured in the 2000 weir study include:

- Six rainbow trout in the up trap and 2 in the down trap (av. length of all 8 was 318 mm. [12.5"]).
- Two whitefish were caught in the up trap, and one in the down trap (all in early Aug.)

2001 Weir Study. ADF&G's 2001 Cooper Creek weir study (7/18-10/19/2000) counted 473 Dolly Varden (Breakfield, 2001). Of these Dollies, 456 (96%) were 200 mm or greater (average 461 mm.), and 17 were less than 200 mm.

All Dollies 200 mm. and greater captured at the upstream or downstream weir had their tag number recorded, or if they didn't have a tag, were given a new tag. Once recorded, each fish was passed to the other side of the weir. Additional Dollies may have entered Cooper Creek before the weir was installed. ***Table 2.III.A-4*** below gives a breakdown of the 456 Dolly Varden greater than 200 mm.

Table 2.III.A-4: Capture Status of all Dolly Varden 200 mm. and Greater in the 2001 Weir Study on Cooper Creek – 7/18/2001 to 10/19/2001

Weir(s) where fish were captured	Year when captured fish were tagged			
	1999	2000	2001	Total
Number of fish only captured immigrating upstream	10	4	121	**135**
Number of fish captured both immigrating upstream then outmigrating downstream	5	3	129	**137**
Number of fish only captured outmigrating downstream	12	1	85	**98**
Totals	**27**	**8**	**335**	***456***

Additionally, some Dollies likely entered into Cooper Creek before the weir was installed (7/18/2001). Once again, this may mean an "under" count of Dollies entering and leaving Cooper Creek. The number of Dollies recorded in ***Table 2.III.A-4*** are probably an under representation of the actual number. Trends of particular interest in ***Table 2.III.A-4*** include:

- A few Dollies captured and tagged in Cooper Creek in 1999 and 2000 returned to spawn in 2001, but most of the fish (73%) were tagged for the first time in 2001.

- More Dollies appear to return to Cooper Creek to spawn after the two years than after just one year.

- The majority of Dollies past by the weir were just counted once, either going upstream, or coming downstream. This implies that either the Dolly population spends longer spawning in Cooper Creek than the period for which the weir was installed, or that fish are getting past the weir (or both). Counts were stopped at the weir on 10/19/2001 because ice was forming on the creek and weir. However, at the time the counts were stopped, 18 fish a day were being counted leaving the creek. This might mean that a significant portion of the Dolly outmigration occurs past mid-October.

- About a dozen Dollies were captured more than once in the upstream trap with out being captured in the downstream trap, indicating they got past the weir.

Other resident fish captured in the 2001 weir study include:

- Three rainbows in the up trap and 1 in the down trap (av. 289 mm. [11.4”]).
- One grayling (9/3, 10”) in the up trap.

(3) Changes in Fish Habitat Conditions on Cooper Creek

Construction of the Cooper Lake Hydroelectric Project reduced streamflows and stream temperatures on Cooper Creek, and altering sediment movement within the creek. These effects in turn influence the available spawning and rearing habitat within the creek. Generally, the influence on habitat appears to have been negative for Cooper Creek salmon and rainbow trout populations. A sizable Dolly Varden population continues to use Cooper Creek. We do not have sufficient pre-dam data to determine if this Dolly Varden population increased or diminished after project construction.

(a) Temperature effects of the Cooper Creek fishery

Section B.3. (Hydrology/Water Quality) of this chapter discusses apparent temperature changes on Cooper Creek as a result of construction of the Cooper Lake Project. The near freezing stream temperatures found on Cooper Creek from mid-November to late March have changed little since before the dam. However, spring, summer and early fall stream temperatures are lower due to loss of Cooper Lake outflow. Cooper Creek now warms up more slowly in the spring, reaching its peak reduction in average daily temperature by mid-summer (6 to 9°F).

Bjornn and Reiser (1991) note that, “Timing of salmonid spawning has likely evolved in response to water temperatures in each stream before, during, and after spawning, and, in some streams, to the occurrence of flows that allow upstream migration of maturing adults. Salmonids have spawned when water temperatures have ranged from 1.0 to 20°C [2 to 68°F], but the favorable range of temperatures for spawning is much narrower."

Streams can be too cold to attract upstream migration of salmonids. Meehan (1991) notes rainbow trout waiting in the spring for warmer stream temperatures before entering tributaries to spawn.

Kenai River rainbow trout formerly entered Cooper Creek in the spring to spawn. Lowered water temperatures on Cooper Creek as a result of dam construction appear to have ended Cooper Creek's attraction to spawning rainbows. These fish likely pass their spawning prime before Cooper Creek warms enough to attract them.

Cooper Creek appears to still have sufficient physical habitat to support spawning rainbows, but lacks attracting water temperatures. Dolly Varden, who spawn under a different thermal regime than rainbow trout, continue to use Cooper Creek for both spawning and rearing.

Bell (1986) reports the "ideal" temperature range for spawning and successful hatching of chinook salmon eggs as between 5.6° to 13.9°C (42° to 57°F). For coho salmon, the optimum range is 4.4° to 9.4°C (40° to 49°F). Cooper Creek's reduced stream temperatures have likely had an adverse effect on egg-to-fry survival rates for both these salmon species. Combs and Burrows (1957) suggest "salmon produced from eggs deposited in water colder than 4.5°C (40°F) would be less viable than fish produced from eggs spawned in warmer waters."

Post-dam stream temperatures for Cooper Creek at its mouth appear sufficient in August and September to allow for viable spawning by chinook, coho, sockeye, and pink salmon. However, lowered stream temperatures may significantly impact spawning by late season cohos in October and November.

Lowered temperatures on Cooper Creek result in slower growth rates for incubating salmon eggs, and delay the emergence of fry in the late spring. This means that fry emerging from Cooper Creek gravels under the current flow regime would be smaller and would emerge later, possibly at a time of reduced food resources.

(b) Flow effects on the Cooper Creek fishery

Flow volume and velocity are both important determinants for salmon rearing habitat (Bjornn and Reiser, 1991). As flow volume increases, in general so does channel width and available rearing habitat. However, increasing flow velocity in a given stream section generally decreases available rearing habitat. Salmon fry in creeks favor rearing habitats along the stream margin with velocities close to 0 feet per second, with adjacent moderate velocity water where food can be gathered.

Reduced flows on Cooper Creek have reduced both the size of the channel and its water velocity. Cooper Creek's flow volume from its mouth up to its junction with Stetson Creek has been reduced by 70 to 80 percent. Riffles dominate Cooper Creek's channel, and pools are very limited. A wider creek with similar riffle conditions and higher stream velocities likely existed before the dam.

Above its junction with Stetson Creek, Cooper Creek now carries less than 10% of its pre-dam flow. Stream velocities are lower within this upstream segment, but flow is so restricted as to offer only limited habitat, particularly in the winter.

We have not evaluated Cooper Creek's pool habitat changes due to reduced flows. On Cooper Creek's steep, confined channel, some stream segments may have gained pools and others lost as the flow regime changed. A detailed instream flow survey could be used to estimate the amount of pool and riffle habitat at different flow levels.

Cooper Creek's almost continuous riffle character is generally far more limiting to rearing than spawning. The 70%+ streamflow reduction following dam construction has almost undoubtedly reduced available spawning habitat on Cooper Creek. Probably the most limiting effect on salmon populations as relates to flow reductions on Cooper Creek is the very low winter flow (generally in February, March, and early April).

USGS streamflow records indicate that average winter minimum flow at the mouth of Cooper Creek has dropped from 26 cubic feet per second (CFS) before the dam to 8.5 CFS and less after the dam. During these low flows, cold temperatures, potential freezing and desiccation, and disturbance by river ice all work to stress salmon eggs. In addition, slower intergravel flow rates reduce oxygen availability and waste removal for eggs within the stream gravels. Cooper Creek's large flow reduction during winter low flows likely has had a strong adverse impact on salmon egg-to-fry survival rates.

Cooper Creek has a one-mile segment of fish-accessible channel located upstream from its confluence with Stetson Creek, and downstream from the barrier falls below Cooper Lake (See ***Figure I.III.C-1***). This channel segment currently has an average summer flow of around 5 to 10 CFS and winter low flows of less than 2 CFS. During salmon spawning periods in August and September, flows are generally around 3 to 5 CFS. Before construction of the Cooper Lake Project, flow through this same section during spawning averaged about 120 CFS, and winter minimum flows about 18 CFS.

Pre-dam spawning records are not available for this channel segment between Stetson Creek and the barrier falls. Some pre-dam spawning seems probable based on the channel character. Under the present flow regime, winter flows are so low through this segment as to effectively eliminate any salmon spawning success. An instream flow evaluation of this segment would be useful for evaluating available spawning and rearing habitat at different flow levels.

(c) Stream substrate composition

Salmon spawning habitat needs good subsurface flows through the stream gravels to bring oxygen-rich water to fish eggs. These flows not only provide oxygen to the eggs, but also remove harmful metabolic wastes, and regulate egg temperatures. Interstitial spaces within the gravel provide important habitat for newly hatched alevins to move about in prior to emergence.

Optimum inter-gravel flow rates for trout and salmon eggs require “clean” gravels with a low percentage of sand, silt, clay, and organics. Fine-grained substrates limit the subsurface flow. This in turn limits the size and quality of the inter-gravel habitat for eggs and alevins. Substrate composition affects the habitat quality and cover for not only rearing salmon and trout, but also for the benthic invertebrate populations that the rearing fish feed on (Nielsen 1983).

Ideal spawning substrate varies by fish species (Meehan, 1991). For trout and salmon spawning in Cooper Creek, ideal substrate sizes range between 13 to 100 mm (medium gravel to small cobbles). When fine sediments (particles less than 6.35mm) become too abundant, salmon and trout embryos and alevins eventually asphyxiate (Bjornn, 1984). Chinook salmon embryos show the greatest tolerance to increased fines, with fry survival reducing by 50 percent when substrate fines reached 40 percent. For rainbow trout, fry survival rates reduced to 50 percent when fines increased to 30 percent.

Reduced flows and flooding on Cooper Creek have likely limited the stream’s sediment carrying capacity. During macroinvertebrate sampling in June 1998, a Forest Service fishery crew netted much more fine-grained and organic material in their Cooper Creek kick samples than in samples from either Juneau or Crescent Creeks. They noted plumes of fine-grained sands and silts when disturbing Cooper Creek’s streambed. We speculate that over the last four decades, Cooper Creek’s reduced sediment carrying capacity has increased its deposition of finer-grained substrates in the streambed.

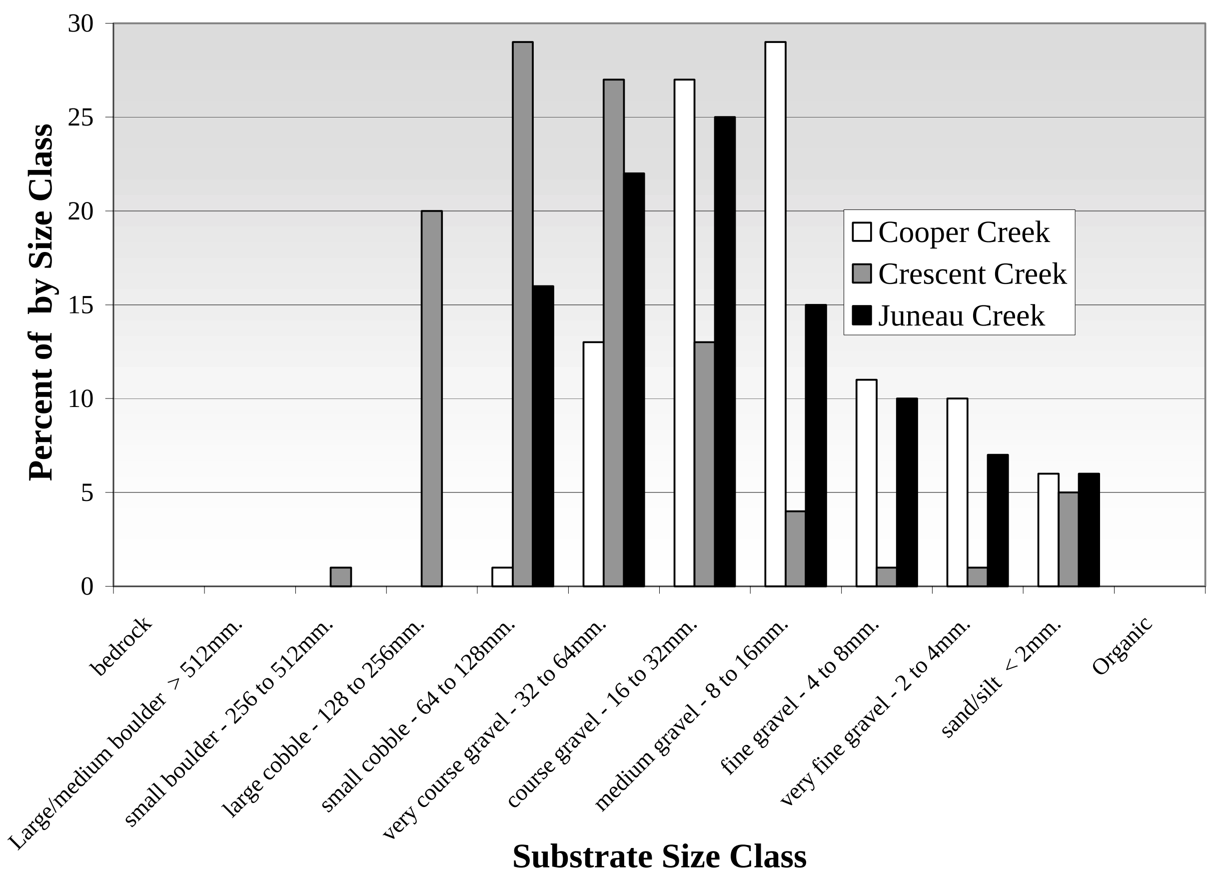
During major flooding on Cooper Creek before the Cooper Lake Project, a sizable portion of the channel substrates likely went into motion downstream. Gravel and cobbles would bounce and roll along the channel bed, while sands, silts, clays, and organics would be carried away in suspension. These flood events likely provided periodic “cleaning” of the stream gravels.

Reduced flood sizes and durations following construction of the Cooper Lake Project have limited Cooper Creek’s ability to “purge” finer-grained sediments. Higher concentrations of fine-grained sediments appear to have accumulated within the stream gravels, leading to increased gravel embeddedness. This observation implies the creek now has diminished inter-gravel flow rates, causing reduced egg-to-fry survival. Although spawning adult salmon do stir up and clean gravels within their spawning redds, they eliminate only a portion of the fine-grained sediments.

In the summer of 1998 a USFS fisheries crew made a single sample evaluation of channel substrates on the alluvial fans of Cooper, Juneau, and Crescent Creeks using the Wolmann pebble-count technique (USFS, 1998). Channel substrate size distributions are displayed in ***Figure 2.III.A-1***. The figure shows a generally bell-shaped substrate distribution curve for all three streams, but with a significant size shift between streams. Crescent Creek shows the coarsest overall substrate distribution curve, and Cooper Creek the finest. Cooper Creek's finer-grained shift could be a result of flow regulation on the creek since 1962. However, the small sample size limits the reliability of this interpretation.

Other techniques that could be used for measuring the fine-grained sediment component within channel substrates include: 1) collecting and sieving freeze-core samples from a set depth into the streambeds, and 2) measuring air permeability within the stream gravels. Neither of these techniques has been used on Cooper, Juneau, or Crescent Creeks. Each could be helpful for both evaluating spawning viabilities of channel substrates, and differentiating the substrate characteristics of the three streams.

Figure 2.III.A-1: Substrate Composition on the Lower Alluvial Fan Sections of Cooper, Juneau, and Crescent Creeks



(d) Other factors.

Dolly Varden predation may be an additional impact on emerging salmon fry in Cooper Creek. Dollies have been successful in adapting to the new flow and temperature conditions on Cooper Creek. Predation on salmon fry is likely high due to the sparse available cover on Cooper Creek.

Cooper Creek's low woody debris content and limited overhanging cover are due in part to: mining impacts, narrowing of the stream channel (due to reduced flow), avalanches, and floods within the canyon. Streamside vegetation along numerous channel segments has not had time to grow enough to contribute significantly as large wood and cover.

Reduction in salmon runs on Cooper Creek means some loss of nutrient supply to the creek provided by decaying salmon carcasses. This loss of nutrient supply can in turn limit the production of stream macroinvertebrates. Comparative data is not available to test whether Cooper Creek stream macroinvertebrates populations changed after the dam was built. Macroinvertebrate species diversity in Cooper Creek as tested by the USFS and ADF&G in 1998 does not appear to be adversely affected.

Macroinvertebrate productivity is far more critical to rearing salmon and trout than to spawners. Since Cooper Creek appears to be quite limited in rearing habitat, possible changes in macroinvertebrate productivity might have only effects. Most likely to be impacted would be any resident trout populations.

(4) Aquatic Stream Habitat Survey

The USFS Seward District fishery crew conducted aquatic stream habitat surveys on the lower main stems of Cooper, Juneau, and Crescent Creeks in August 1998 (USFS, FSH2090, 1998). They identified "reaches" on each stream. Reaches are stream segments with consistent physical attributes including: channel gradient, channel pattern, stream bank incision, channel containment, and riparian plant community.

Cooper, Juneau, and Crescent Creeks all have an alluvial fan reach at their lower ends. On the surveys, USFS biologist Eric Johansen noted far less large wood and pools on Cooper Creek's alluvial fan reach than for the other two systems. Large wood and pools generally correlate well with high quality trout and salmon habitat. Lower Juneau Creek showed the greatest channel complexity with numerous pools and multiple side channels. Cooper Creek may have lost considerable complexity due to both past mining effects and flood flow reduction.

Cooper Creek's main stem channel provides accessible habitat for salmon and trout for four miles upstream from its mouth to the barrier falls below Cooper Reservoir. The lowest half-mile on the alluvial fan probably has the best potential for spawning and rearing habitat because of its more moderate gradient (about 1.5%), and better woody debris recruitment.

On Cooper Creek's next three and a half miles within an incised canyon, habitat potential is primarily limited by gradient (average 2.7%), stream velocity, lack of large woody debris, and lack of pools. For the mile of Cooper Creek upstream from its confluence with Stetson, lack of flow (particularly in the winter) now presents the major adverse impact to fish habitat.

Tributary streams into the lower four miles of Cooper Creek are steep and provide almost no fish habitat. One exception is the lower 100 feet of Stetson Creek from its confluence with Cooper Creek up to its barrier fall. This short channel segment provides similar habitat to the incised channel of Cooper Creek.

A series of barrier falls four miles up Cooper Creek prohibit further upstream migration of salmon and trout. Above these barrier falls the creek continues an additional one-third mile before reaching Cooper Reservoir. This channel segment is now primarily dewatered, and cannot be accessed by fish from downstream or upstream.

Before Cooper Lake Project, Cooper Creek's upper one-third mile was directly accessible to Cooper Lake char. A pre-dam ground survey (North Pacific Consultants, 1955) indicates this stream segment had an average 1.5% gradient, and no barriers to fish. The 500-foot segment of this channel immediately downstream from Cooper Lake had the least gradient, and probably the highest potential for woody debris recruitment (primarily floating in from Cooper Lake). It likely had considerable of pool habitat based on historic aerial photography.

The 1/3-mile channel segment at the outlet of Cooper Lake was accessible to char and sculpins. Although this channel may have offered good spawning and rearing habitat, Cooper Lake char may not have used it if they are primarily lake dwellers. Cessation of flow to Cooper Creek terminated any fish use of this channel segment.

(5) Flow effects on the Kenai River fishery

Section 2.II.B.2 in this chapter (Hydrology/Streamflows) discusses how diversion of Cooper Reservoir waters into Kenai Lake changes flow rates on the Kenai River. Throughout most of the year, outflow from the Cooper Lake Project to Kenai Lake makes up only a small percentage of the Kenai River's flow from Kenai Lake. In general, these diverted waters have a negligible effect on Kenai River flow patterns and associated habitat. Two occasions when Cooper Reservoir water diversion can significantly effect the Kenai River flows are during extreme winter low flow periods, and during peak rainfall-generated floods.

(a) Winter Low Flows

The Cooper Lake project augments Kenai River flow at the outlet of Kenai Lake by generally between 70 and 130 cubic feet per second (CFS). During March and April, the Kenai River's lowest flow period, Cooper Lake Project's average flow augmentation to the Kenai River is about 100 CFS. The Kenai River's lowest recorded outflow from

Kenai Lake was 190 CFS on March 15-24, 1951 (before the Cooper Lake Project). Since augmentation of Cooper Reservoir flow to Kenai Lake began (10/62), the Kenai River's lowest outflow has been 300 CFS on March 16 - April 3, 1996.

For Kenai River's most extreme low flow events, Cooper Reservoir flow augmentation can increase flow in the Kenai River at its Kenai Lake outlet by as much as 50 percent. During the "average winter", the Kenai River at its outlet from Kenai Lake has a minimum (unaugmented) low flow is about 335 CFS. A 100 CFS flow augmentation by the Cooper Lake Project increases this minimum annual low flow by about 30 percent.

Cooper Reservoir flow augmentation has the greatest effect on the Kenai River flows at the outlet of Kenai Lake. Augmentation effects are diluted downstream, as incoming tributaries provide additional flow to the Kenai River. By the time the Kenai River reaches Soldotna, Cooper Lake Project flow augmentation increases the river's average minimum winter low flows by about 6 to 8 percent.

Sockeye, chinook, coho, and pink salmon, as well as Dolly Varden and whitefish spawn in the main stem Kenai River downstream from Kenai Lake. Egg-to-fry survival rates for these various fish species can be strongly impacted by winter low flow levels. Impacts include exposure, desiccation, freezing, and low intra-gravel flow rates. Flow augmentation to the Kenai River likely has a beneficial effect on the survival of over-wintering fish eggs. Increasing egg-to-fry survival rates likely helps to increase fish populations in the Kenai River. Actual fish population increases probably vary depending on the fish species and availability of viable rearing habitat.

Benefits to Kenai River egg-to-fry survival rates from Cooper Reservoir flow augmentation have not been quantified. Determining the location of Kenai River spawning redds in relation to various winter low water levels would be an important step for making such quantification. If fish are spawning in channel locations that could be exposed during low water levels, then flow augmentation may play an important role in effecting the productivity of the system.

(b) Peak Rainfall Flood Events

Although the Cooper Lake Project was not built for flood control, it does have the effect of reducing Kenai River flood levels downstream from Cooper Creek. An extreme example of this effect is the flood of September 21-23, 1995, which had an instantaneous peak flow of 20,300 CFS at the outlet of Kenai Lake. Without the Cooper Lake Project, Cooper Creek would have added an additional 1,000 to 1,500 CFS to this Kenai River flood, a 5 to 7 percent increase in the Kenai's flood volume. However, all flood inflows to Cooper Reservoir were stored within the reservoir. The only contribution by the Cooper Reservoir watershed to the Kenai River flood peak was the flow through the penstock, about 100 CFS (less than half a percent of the Kenai River peak).

The September 23, 1995 flood peak occurred after many of the fish using the main stem Kenai River had already spawned. This flood likely damaged spawning redds within the

Kenai River. Greater damage would likely have occurred downstream from Cooper Creek had Cooper's full natural flows been added to the Kenai River.

Cooper Lake Project's flood reduction "benefit" to the Kenai River decreases moving downstream from Cooper Creek, because downstream tributaries continue to increase the Kenai's flow. Flood reduction essentially ceases by the time the Kenai River enters Skilak Lake.

We suspect that the Kenai River flood damage reduction afforded by Cooper Reservoir is limited to a few very large rainfall-generated floods. The Kenai River also has floods caused by glacial outburst events on the Snow River. These floods are among the largest recorded for the upper Kenai River. In general, they are little influenced by Cooper Creek flow alterations.

b. Fisheries in Cooper Reservoir (post-dam)

(1) Dolly Varden /Arctic/Taranets char and sculpin

Dolly Varden/char and Coast Range sculpin were identified in Cooper Lake by the USF&WS prior to construction of the Cooper Lake Project (USF&WS, 6/4/1956). After construction of the Cooper Lake Project, char continued to be found and identified in Cooper Lake up into the 1990's (see ***Table 2.III.A-5***).

Recent sampling by the USF&WS and ADF&G (November 1999 and June 2000) identifies all Cooper Reservoir char as Arctic char, and none as Dolly Varden. Retired USF&WS fish biologist Jack Dean believes Cooper Reservoir may in fact support two or three morphological forms of Arctic char, including a dwarf Arctic char (personal communication, 3/23/00).

In the fall of 2000, Jack Dean and others sent a number of Alaskan char, including six Cooper Lake char for genetic typing to Dr. James D. Reist with the Arctic Fish Ecology and Assessment Research Section of Fisheries and Oceans Canada, in Winnipeg, Manitoba, Canada. Dr. Reist initially identified the six Cooper Lake fish as Taranets char (Salvelinus taranetzi). Genetically, all six fish exhibited haplotype 57, characteristic of both S. alpinus (Arctic char) and S. taranetzi (Reist, 6/27/2001). Dr Reist also identified char with haplotype 57 from Char Lake (adjacent to Cooper Reservoir), and Ice and Wolf Lakes on the Kenai National Wildlife Refuge. Whether Cooper Reservoir char are Arctic char, Taranets char, or a hybrid was not determined.

In this report we have continued to identify char as "Dolly Varden" where that name was used in past Cooper Lake/Reservoir survey and sampling notes. The most recent surveys suggest that Cooper Lake Arctic/Taranets char were probably misidentified as Dolly Varden in past surveys.

Cooper Lake/Reservoir sculpin also may have been misidentified in early reports as Coast Range sculpin. Coast range sculpin (Coltus aleuticus) generally live in free flowing water, while slimy sculpin (Coltus cognatus) are associated with ponded water. Sculpins within Cooper Reservoir are likely slimy sculpins.

Table 2.III.A-5: Fish Sampling in Cooper Reservoir, 1962-1999

Date	Source	Species	Gear	No. Caught	Capture Per Unit Effort	Mean Length (mm.)	Length Range (mm.)
1962	USF&WS	Dolly Varden*	Creel census	190	-	-	167-419
08/29/73	ADF&G	Dolly Varden	Gill net (#1) diver	8	0.31/hr	150.6	115-235
08/29/73	ADF&G	Dolly Varden	Gill net (#2) floater	44	1.91/hr	225.0	125-365
08/29/73	ADF&G	Dolly Varden	Gill net (#3) floater	63	2.74/hr	236.2	160-325
06/21/83	ADF&G	Dolly Varden	Gill net (set 1)	42	2.13/hr	293.9	155-410
06/21/83	ADF&G	Dolly Varden	Gill net (set 2)	14	0.71/hr	296.3	250-385
06/21/83	ADF&G	Dolly Varden	Gill net (set 3)	30	1.52/hr	286.3	235-378
06/21/83	ADF&G	Dolly Varden	Gill net (set 4)	40	2.19/hr	216.3	135-405
06/21/83	ADF&G	Dolly Varden	Gill net (set 5)	13	0.67/hr	195.2	150-300
06/21/84	ADF&G	Dolly Varden	Gill net (set 1)	32	1.94/hr	236.0	132-415
06/21/84	ADF&G	Dolly Varden	Gill net (set 2)	73	3.65/hr	274.0	143-363
06/21/84	ADF&G	Dolly Varden	Gill net (set 3)	42	2.90/hr	246.2	128-344
06/27/85	ADF&G	Chinook	Angling	5	2.50/hr	147.4	145-149
07/24/85	ADF&G	Chinook	Gill net	4	0.05/hr	154.7	148-158
07/24/85	ADF&G	Chinook	Angling	2	1.00/hr	158	158-158
08/01/85	ADF&G	Chinook	Angling	4	0.57/hr	170.5	167-173
08/02/90	USFS	Dolly Varden	Vexar trap box	2	0.09/hr	167.5	110-225
08/02/90	USFS	Dolly Varden	Gill net	2	0.09/hr	67.0	49-85
08/02/90	USFS	Rainbow trout	Vexar trap box	5	0.21/hr	50.2	43-65
09/25/90	ADF&G	Dolly Varden	Gill net (∑3 sets)	243	2.23/hr	196.0	120-292
09/25/90	ADF&G	Rainbow trout	Gill net (∑3 sets)	4	0.05/hr	154.0	130-195
07/10/91	USFS	Dolly Varden	Gill net	51	0.84/hr	244.8	130-412
07/10/91	USFS	Dolly Varden	Minnow trap	6	-	155.7	141-176
07/10/91	USFS	Rainbow trout	Minnow trap	2	-	94.0	85-103
07/10/92	USFS	Dolly Varden	Gill net	24	0.55/hr	325.1	210-473
07/10/92	USFS	Rainbow trout	Gill net	4	0.09/hr	325.3	295-385
07/10/92	USFS	Dolly Varden	Minnow trap	1	0.04/hr	128	128
07/10/92	USFS	Rainbow trout	Minnow trap	2	0.09/hr	126.5	125-128
08/18/94	USFS	Dolly Varden	Gill net	1	-	129	129
08/18/94	USFS	Rainbow trout	Gill net	29	-	299.8	124-389
08/17/94	USFS	Rainbow trout	Hoop net	3	0.14/hr	146.7	145-150
08/18/94	USFS	Rainbow trout	Minnow trap	14	-	87.6	56-154
08/18/94	USFS	Dolly Varden	Minnow trap	1	-	54	54
11/22/99	USF&WS	Arctic char	Gill nets (3 sets)	6	2.0/hr	336.7	217-424
11/22/99	USF&WS	Rainbow trout	Gill nets (3 sets)	6	2.0	?	?
06/08/00	USF&WS	Arctic char	Gill nets (3 sets)	164	2.4/hr	297.7	190-504
06/08/00	USF&WS	Rainbow trout	Gill nets (3 sets)	34	.51/hr	304.6	243-383
10/08/01	ADF&G	Arctic char	Gill net -90' depth	17	~0.24/hr	N/A	N/A
10/08/01	ADF&G	Rainbow trout	Gill net -90' depth	5	~0.07/hr	N/A	N/A
10/08/01	ADF&G	Arctic char	Gill net -150' depth	2	~0.03/hr	N/A	N/A
10/08/01	ADF&G	Arctic char	Gill net -200' depth	1	~0.015/hr	N/A	N/A

**Note: All listed Dolly Varden catches are probably Arctic/Taranets char, misidentified as Dolly Varden.*

(2) Char 1959 to 1984 (before stocking Cooper Reservoir)

Dolly Varden/char and coast range sculpin are the only two fish identified in Cooper Reservoir sampling surveys from before 1984. The USF&WS (1964) reported an increased sculpin population after construction of Cooper Reservoir, but did not provide any data to support this conclusion. They also reported sampling 190 Dolly Varden from Cooper Reservoir in 1962. Age distribution and lengths from this 1962 sampling are as follows:

Age (Year)	0	1	2	3	4	5	6	7
Length Range (mm)	none	none	167-190	205-250	245-325	312-380	373-380	419

In their 1964 report, USF&WS suggests the existing Dolly Varden/char population in Cooper Reservoir was "perhaps in better condition than before project development". They indicated this might have been due to the surge of nutrient rich material around the shores of Cooper Reservoir as the water level rose.

The 1964 report questions whether Dolly Varden/char were still spawning viably in Cooper Reservoir. Subsequent surveys confirm that these fish have maintained a viable population. No studies have been conducted to evaluate the effects of the dam construction on the char population size and dynamics in Cooper Reservoir.

Construction of the Snug Harbor Road in 1958-9 allowed road access to fishing at Cooper Reservoir. USF&WS (1964) reported "substantial gains in fishing pressure" at Cooper Reservoir. A one-month creel census taken in the summer of 1962 identified 826 anglers catching 3,665 Dolly Varden from Cooper Reservoir.

Food Resources. ADF&G limnologist Jim Edmundson (3/23/00) noted several studies indicating a nutrient surge into the waters of new reservoirs as they filled and shorelines were inundated. In the case of Cooper Reservoir, nutrient loading would have started in July 1959 as the reservoir began to fill above its former lake level. Inundation of new shoreline continued up until April 1961. Nutrient loading and submerged vegetation and soils likely benefited both food and cover resources for resident char and sculpins in the reservoir.

Over a period of several years, the nutrient surge to Cooper Reservoir and its benefit to fish likely abated. Nutrient-rich waters flowed out of the reservoir as nutrient-deficient waters flowed in. Similarly, submerged vegetation and organics deteriorated, leaving a stony littoral zone.

Fluctuation of reservoir levels along with loss of shoreline vegetation reduces productivity in the reservoir's littoral zone over time (Edmundson, 3/23/00). The littoral zone is made up of the shallow waters around the reservoir's shore that photosynthesize chlorophyll and create the highest nutrient productivity in the reservoir. Fluctuation of water levels within Cooper Reservoir has likely had the long-term effect of lowering shoreline productivity and food resources.

ADF&G sampled stomach contents of 44 gill netted Dolly Varden/char on August 30, 1973. These fish ranged in length from 125 to 365 mm. Stomach contents were listed as: snails, insects, and invertebrates. Invertebrates only showed in smaller fish and we suspect were zooplankton. One 228-mm. male had eggs in its stomach contents, implying that some fish were spawning by this date.

ADF&G again sampled stomach contents of 43 char captured from Cooper Reservoir on June 21-22, 1983. These fish ranged in length from 135 to 405mm and in weight from 21 to 567 g. Snails showed up fairly consistently in the stomachs of larger fish, and zooplankton were common in the smaller fish. Other stomach contents included: midges, sculpin, dipterans, mayflies, beetles, ants, caddis flies, leeches, and chara algae.

(3) Char Lake

This 10-acre lake is located immediately south of the Snug Harbor Road, 1/2 mile east of Cooper Reservoir. Char Lake flows to Cooper Lake Southeast Creek via a short outlet stream, and then about a half mile to Cooper Reservoir. Char Lake's maximum depth is 22 feet. ADF&G biologists netted 24 Arctic char from this lake in 1970 (Dean, 2000). Seven of the fish were over 14 inches in length.

Dean (June, 2000) noted two rainbow trout in spawning color in the inlet stream to Char Lake in mid-June, 2000. On June 29-30, 2000, a Forest Service fisheries crew set a gill net in the lake for 24 hours and caught eight Arctic char and two rainbow trout (Johansen, 2000). The Arctic char ranged in length from 37 to 47.5 cm. (14.6 to 18.7 inches), and in weight from 310 to 1075 g. (0.7 to 2.4 lbs.) The two rainbow trout were not measured.

(4) Chinook Salmon Stocking

In June of 1984, ADF&G, Sportfish Division stocked over 125,000 chinook (king) salmon fry into Cooper Reservoir (see ***Table 2.III.A-6***). ADF&G monitored this chinook population during the summers of 1984 and 1985 (see ***Table 2.III.A-5***). Between stocking on June 12, 1984, and sampling on August 1, 1985, chinook fry grew on average from 2.3 grams to 55.2 grams, reaching an average length of 170.5 mm. These chinooks were clearly successful at feeding within Cooper Reservoir.

Cooper Reservoir fish were next sampled in 1990. Chinook salmon were not captured in 1990 or in any subsequent sampling. Correspondences from ADF&G and USFS biologists around 1985-86 indicate that some chinook fry in Cooper Reservoir were lost to predation by Dolly Varden and water birds. However, many, and perhaps most of these chinooks outmigrated from the reservoir via the only available outlet, the tunnel/penstock. All outmigrating fish likely died as they passed through the power turbines (Chugach Electric, 1984, and ADF&G, 1986).

Any remaining chinooks in Cooper Reservoir probably died by the late 1980's, having reached the end of their expected 4-year lifespan (personal communication, Larry Larson, ADF&G-Sportfish, 1999). ADF&G deemed chinook stocking in Cooper Reservoir unsuccessful and terminated the effort.

Table 2.III.A-6: ADF&G Stocking Records for Cooper Reservoir

Trip Date	Species	Number Released	Hatchery	Stock	Brood year	Age	Weight (grams)
6/12/84	chinook	125586	Trail Lake	Quartz Cr.	1983	fingerling	2.3
6/23/87	rainbow tr.	421700	Ft Richardson	Swanson R.	1987	fed fry	0.15
6/23/87	rainbow tr	84200	Ft Richardson	Big Lake	1987	fed fry	0.15
6/23/89	rainbow tr	275569	Ft Richardson	Swanson R.	1989	fed fry	0.17
8/02/90	rainbow tr	50000	Ft Richardson	Swanson R.	1990	fingerling	1.3
6/12/91	rainbow tr	250000	Ft Richardson	Swanson R.	1991	fed fry	0.1
6/25/92	rainbow tr	259848	Ft Richardson	Swanson R.	1992	emerging fry	0.25
6/10/93	rainbow tr	97251	Ft Richardson	Swanson R.	1993	emerging fry	0.2
6/10/93	rainbow tr	161700	Ft Richardson	Big Lake	1993	emerging fry	0.2
7/22/94	rainbow tr	24728	Ft Richardson	Swanson R.	1994	fingerling	1.29
7/22/94	rainbow tr	15023	Ft Richardson	Swanson R.	1994	fingerling	2.5

Records provided by ADF&G

(5) Rainbow Trout Stocking

ADF&G stocked rainbow trout into Cooper Reservoir on seven occasions between 1987 and 1994. ***Table 2.III.A-6*** displays the size, date, and characteristics of the stocking releases. Cooper Reservoir received a total of 1,640,019 rainbows of varying size ranges and stocks over this period.

Table 2.III.A-5 displays data from a variety of Cooper Reservoir fish sampling studies from 1962 to 2001. Rainbow trout first appear in these studies in 1988, in an ADF&G creel census (Mills, 1989). Gill net surveys from 1990, 1992, and 1994 show the rainbow trout becoming both progressively larger, and a larger percentage of the captured fish population. The largest rainbow trout measured in surveys (8/18/94) was 389 mm (15.3 in.) Significantly larger fish may be present.

We have not determined to what degree Cooper Reservoir rainbow trout compete with resident chars for food and habitat. Rainbows are more effective filter feeders than char, and may be more effective at exploiting zooplankton in Cooper Reservoir. Stomach contents of Cooper Reservoir rainbows have not been evaluated to date. Rainbows and char adults likely prey on the eggs and fry of both species, as well as on sculpin.

During the summer, rainbows are attracted to warmer water and would likely be found in the upper 40 feet of the reservoir. On 10/8/2001, ADF&G netted five rainbows at 90 feet in depth in Cooper Reservoir indicating rainbow use down to at least that level (phone conversation with Rob Massengill, ADF&G, 12/7/2001). No rainbows were captured in deeper nets (150 and 200 feet).

(6) Rainbow Trout Spawning

Dave Blanchet (USFS) observed 45 rainbow trout spawning in Cooper Lake Southwest Creek (for stream location, see ***Figure 2.II.B-1***) on June 9, 2000. USF&WS gillnet sampling in Cooper Reservoir one day before (6/8/00) yielded a number of sexually mature rainbows that and had not yet moved into spawning streams. More spawning rainbows likely move up into Cooper Lake Southwest Creek throughout June.

Cooper Lake Southwest Creek appears to have the most and best potential spawning habitat for rainbows of all the inlet streams to Cooper Reservoir. Some spawning likely occurs in other inlet streams. The three other largest inlet streams are turbid from glacial runoff, have colder water temperatures, and for the most part, higher stream velocities. These factors are less desirable for spawning rainbows. Jack Dean observed two rainbow spawners in June 2000 at the inlet to Char Lake, and two more rainbows were netted in Char Lake on June 30, 2000 (Johansen, 2000). Rainbow trout would have had to access Char Lake via Cooper Lake Southeast Creek.

Cooper Reservoir rainbow spawners likely enter into inlet streams from late May through June. After spawning, most adult fish return to the reservoir. Fry likely emerge from stream gravels in one to two months, and migrate back to Cooper Reservoir before freeze-up. Spawning by Cooper Reservoir char probably conflicts minimally if at all with rainbow trout spawning, particularly if all char spawn within the reservoir.

Cooper Reservoir's rainbow trout population appears to be self-sustaining, although it may not yet have reached equilibrium. The fact that macrozooplankton in Cooper Reservoir have not been more fully exploited (ADF&G, 1999) suggests that the resident rainbow population may either not be fully developed, or may be spawning limited.

Cooper Reservoir rainbow trout start spawning in inlet streams as water levels are rising on the reservoir. The reservoir level raises an average 7 feet in the two-month period from mid-June to mid August. Active spawning redds located closest to the reservoir can be inundated by the reservoir's rising waters in some years. Inundation of redds likely decreases egg-to-fry survival rates, and in some cases may cause complete mortality at individual redds. Clearly however, rainbow trout have a viable population in Cooper Reservoir and are spawning successfully, despite Cooper Reservoir's annual fluctuations.

(7) Dolly Varden /Arctic/Taranets char - 1984 to present

(a) Competition with Introduced Species

Since 1984, the native char in Cooper Reservoir have had to coexist with introduced populations of chinook salmon and/or rainbow trout. Chinook were present in the reservoir only for a few years, and competition between them and the char appears to have been limited.

The chinook fry may have provided a food resource for larger adult char, although stomach samples from adult char taken by ADF&G in 1985 did not reveal any fry. The chinook fry may have preyed on char eggs in the fall. Within two years, most chinooks had likely left the reservoir, via the penstock.

Rainbow trout were stocked in Cooper Reservoir between 1987 and 1994, and appear to be maintaining their population successfully. This rainbow population likely competes to an extent with the native char for food resources. Overlap of rainbow and char spawning areas and timing appears very limited, particularly if all the char are lake spawners.

Little is known about long-term effects of rainbow trout on the Cooper Lake char population. Compression of the Arctic/Taranets char population into deeper, cooler waters during the summer is a likely result of rainbows occupying the warmer upper waters of the lake (Dean, 3/27,00).

Cooper Lake/Reservoir has a maximum depth of around 480 feet, and well over half is greater than 200 feet deep (see ***Figure 2.II.C-3***.) On October 5, 2001 ADF&G biologists set three variable mesh nets at depths of 90 feet, 150 feet and 200 feet to test for the presence of fish at these deeper levels (Dean, 11/2/2001). The nets "soaked" for three days and were retrieved on October 8, 2001. The 90-foot net held 17 Arctic char and 2 rainbow trout. The 150-foot net had two arctic char, and the 200-foot net, one Arctic char, confirming the use of lake habitat down to at least this depth.

(b) Spawning

Spawning behavior of Cooper Reservoir char and sculpin is poorly understood. Dolly Varden, if present in Cooper Reservoir, would likely spawn in inlet streams to the reservoir between August and October. We are not aware of observations or data collected on Dolly Varden spawning in Cooper Reservoir inlet streams.

Arctic char are lake spawners. Little is known about their selection of spawning areas within a lake. Recent USF&WS/ADF&G sampling (11/23/99 and 6/8/00) indicates that possibly all char in Cooper Reservoir are Arctic char. If this is the case, then likely all char spawning occurs within Cooper Reservoir, and not in the inlet streams.

Spawning by Cooper reservoir Arctic char likely occurs between September and December, with the fry emerging the following spring or summer. Dean (2000) has observed Arctic char spawning in other Kenai Peninsula lakes around freeze-up in October/November. While gill netting on 11/23/99, the USF&WS/ADF&G crew captured one mature male Arctic char that was likely spawning at the time (in approximately 15 to 20 feet of water).

The September-November spawning period for Arctic char in Cooper Reservoir occurs when the annual reservoir levels are at or near their peak. During the time the eggs are incubating, the reservoir drops to its lowest annual level (changing an average of 12.5 feet between high and low water levels). Arctic char eggs spawned in shallow reservoir waters may be subject to exposure and mortality as the reservoir level drops in the winter and spring. However, many char are spawning successfully, as evidenced by their viable population in Cooper Reservoir.

(8) Sportfishing in Cooper Reservoir

Representative angler use and fishing success figures have not been collected on Cooper Reservoir. Use is moderate throughout the summer, with a good chance of finding one or more fishing parties on any one day. Anglers fish from shore and from boats. Virtually all access to the Reservoir for fishing is via the Snug Harbor Road.

ADF&G, Sportfish Division annually surveys a sampling of Alaskan fishing license holders, and compiles the data in their "Alaska statewide sport fisheries harvest report". Cooper Reservoir catches can be found within the raw data for these reports, but the number of Cooper Reservoir responses are low, and generally provide a poor basis for extrapolating total use at the Reservoir. Cooper Reservoir catches do not appear in the publication itself, and are included in a grouping called "other Kenai Peninsula lakes".

(9) Changes in Fish Habitat Conditions in Cooper Reservoir

A number of changes to fish habitat appear to have occurred when Cooper Lake converted to a reservoir in 1959. Changes to habitat occur mostly around the shoreline, within the reservoir's zone of fluctuation. Some changes in water quality and nutrient cycling may have occurred within the reservoir but have not been quantified.

(a) Shoreline/Littoral effects.

Cooper Reservoir fluctuates an average of about 11 feet annually, compared to about 1 to 2 feet for the former Cooper Lake. Historic water levels on Cooper Reservoir have ranged between 1159 and 1213 feet in elevation. Since 1970, reservoir elevations have remained below 1196 feet (see ***Figure 2.II.C-1***).

Cooper Reservoir's fluctuation causes a near complete loss of overhanging vegetation at the shoreline. On the former Cooper Lake, overhanging vegetation provided both cover and a nutrient supply for fish. Cooper Lake generally had steep shores that received considerable wave action. However, pre-dam photography shows good vegetative cover around the lake's shoreline (North Pacific Consultants, 1955; also ***Figure 2.III.C-1***).

In 1959 construction crews cut and burned woody vegetation around Cooper Lake up to elevation 1210 feet. All vegetation taller than six feet or greater than 2 inches in diameter was removed. By 1961, rising reservoir levels had inundated the shoreline up to about 1213 feet in elevation. This inundation of vegetation and soil supplied a large pulse of nutrients into reservoir waters. Cooke (1992) observed similar nutrient surges in other new reservoirs.

Cooper Reservoir's increased nutrient supply likely had beneficial effects for feeding fish for several years after 1959. Increased cover from inundated shrubs also persisted in the reservoir's littoral zone for a period of years, and likely benefited fish. This cover was eventually lost through wave action and decay.

Inflowing waters to the new Cooper Reservoir likely diluted away the nutrient pulse over a period of several years. Shorelines and littoral zones have changed primarily to bedrock, cobble and gravel. This has meant a reduction in the productivity of the littoral zone, and a limiting of nutrient supply to Cooper Reservoir. Littoral zone productivity in Cooper Lake was likely low and has been further reduced by the reservoir.

(b) Inlet Stream Habitat

As a result of clearing and inundation in 1959 through 1962, Cooper Reservoir inlet streams lost the majority of their woody riparian vegetation between elevations 1168 and 1210. This vegetation formerly provided cover, large woody debris, and beaver forage for Cooper Lake's inlet streams. The vegetation loss reduced the quantity and quality of the available fish and beaver habitat on these streams (see ***Figure 2.III.C-1***.) Over the last 35 years, some vegetative recovery has occurred around the reservoir above elevation 1195, where little or no inundation has occurred.

Cooper Reservoir's inlet streams below elevation 1195 are subject to periodic inundation. Such inundation can have adverse effects on egg-to-fry survival of fish spawned in the creeks. Adverse effects include damage to spawning beds by wave action, and reductions in flow and oxygen supply to the eggs. The extent of such impacts would depend on the timing, duration, and location of the inundation. Rainbow trout appear to be the most likely species to be adversely affected.

(c) Lake Spawning

Arctic char likely spawn in the mid to late fall in Cooper Reservoir. This is when reservoir levels are usually at their annual high and just starting to drop. Eggs then incubate in the reservoir through winter and spring. During this incubation, the reservoir drops to its lowest seasonal level, usually by early May. If eggs were originally deposited in shallow water, they could be subject to freezing and/or desiccation as reservoir levels drop over the winter and spring.

In a year of "average" reservoir fluctuation, falling water levels may adversely affect Arctic char eggs originally deposited in less than about 15 feet of water. Spawning sites within the reservoir below about 1155 feet in elevation are likely not impacted by reservoir fluctuations.

(d) Water Temperature

Cooper Reservoir has greater surface area, and less and colder summer outflow than did Cooper Lake. As a result, Cooper Reservoir may have slightly higher summer water temperatures than did the former Cooper Lake. Such a temperature increase is likely small (if present at all), but may allow some increase in summer plankton productivity. Any such increase in reservoir's plankton population would generally be beneficial for char and rainbow trout as an additional food resource.

4. References For Fisheries

Alaska Department of Fish and Game. Memo from FRED Division Regional Engineer, Fred Harding to FRED Division Regional Biologist Bill Hauser concerning fish mortality through Cooper Lake Project turbines, February 26, 1986.

Alaska Department of Fish and Game. "On the Water", ADF&G Newsletter of Kenai Peninsula Research and Management, vol. 96-1, Feb 1996.

Athons, David. ADF&G - Sportfish Division, One page fishery handout for Cooper Creek Watershed Public Meeting held on January 23, 1998 in Cooper Landing.

Baxter, Ray. "Quarterly Progress Report – Surveys and Investigations as required by Federal Aid in Fish Restoration", Alaska Game Commission (Territory of Alaska), June 30, 1956.

Bell, Milo C. "Fisheries Handbook of Engineering Requirements and Biological Criteria", U.S. Army Corps of Engineers, Office of the Chief Engineers, Fish Passage Development and Evaluation Program, Portland, Oregon, 1986.

Bjornn, T. C. and Reiser D. W. "Influences of forest and rangeland management on salmonid fishes and their habitats", American Fisheries Society Special Publication 19:83-138, 1991.

Breakfield, Jeff, AK Dept of Fish & Game, Sportfish Division. "Weir count of upstream and downstream migrating fish in Cooper Creek, July 16 to October 20, 2000", unpublished data table, Soldotna, AK; fall 2000.

Breakfield, Jeff, AK Dept of Fish & Game, Sportfish Division. "Weir count of upstream and downstream migrating fish in Cooper Creek, July 18 to October 22, 2001", unpublished data table, Soldotna, AK; fall 2001.

Chapman D.W. "Food and space as regulators of salmonid populations in streams." American Naturalist, 100:345-357, 1966.

Chugach Electric Association. Letter from CEA Mechanical Engineer, John Spence to Chugach National Forest Engineer, Randy Schrank concerning Cooper Lake Project operations, April 12, 1984.

Cooke, Dennis G. "Restoration and Management of Lakes and Reservoirs, Second Edition", CRC Press Inc., Boca Raton Florida; 1992.

Dean, Jack. Letter to Fred DeCicco, ADF&G, Sport Fish Division, Fairbanks, Concerning Arctic char in Southcentral Alaska Lakes; March 9, 2000.

Dean, Jack, Retired USF&WS fisheries biologist. Phone conversations with Dave Blanchet, USFS, concerning Arctic char in Cooper Reservoir and their characteristics; March 23 and 27, 2000.

Dean, Jack, retired USF&WS fisheries biologist. "Arctic Char in Southcentral Alaska", unpublished monograph; May 2000.

Dean, Jack, retired USF&WS fisheries biologist. "Cooper Lake Deep Water Test Netting", unpublished report; 11/2/2001.

Johansen, Eric, USFS fisheries biologist, Seward Ranger District. Survey notes from Char Lake gill net survey conducted 6/29-30/2000, Seward, AK, August 1, 2000.

Larson, Larry, AK Dept of Fish & Game, Sportfish Division. "Cooper Creek History from an Interview with Nick Lean"; September 30, 1999.

Larson, Larry, AK Dept of Fish & Game, Sportfish Division. "Weir count of upstream and downstream migrating fish in Cooper Creek, August 29 to October 6, 1999", unpublished data table, Soldotna, AK; fall 1999.

Lazar, Jim, USFS, USFS, Seward Ranger District. "Cooper Creek Stream Walk", unpublished report of observations and fry trapping on Cooper Creek on July 8, 1997 and observations on 7/9/97, 8/6/97, and 8/17/97.

Lazar, Jim, and Van Hatten, Gareth, USFS, Seward Ranger District. "Cooper Lake Survey. August 16-18, 1994", unpublished report on Cooper Lake trapping and stocking efforts, Seward, AK; 1994.

Lean, Nick. Interviewed at his Cooper Landing residence on Kenai River Mile 48.5 Sterling Highway. Video taped interview by Gary and Chris Titus; summer, 1993.

Little, Jon. "This time, fish may hold sway. Fight brews over dam permit", Anchorage Daily News, page A-1; May 6, 1997.

Major, E.B., and Barbour M.T. "Alaska Stream Condition Index: a modification of the U.S. EPA rapid bioassessment protocols", Environmental and Natural Resources Institute, University of Alaska, Anchorage, 1997.

McElveen, Floyd C. "The Call of Alaska", Copyright by Floyd C. McElveen 0-933497-38-7.

Meehan, W. R., Editor. "Influences of forest and rangeland management of on salmonid fishes and their habitats", American Fisheries Society Special Publication 19; 1991.

Mills, Michael J. "Annual performance report for Alaska statewide sportfish harvest studies, 1988 data", Juneau, AK: Alaska Dept. of Fish and Game, Division of Sportfish; 1989.

Nielsen, Larry A. and Johnson D. L. "Fisheries Techniques", American Fisheries Society, Southern Printing Company, Inc., Blacksburg, Virginia; 1983.

North Pacific Consultants. "Definite Project Report on Cooper Lake Hydroelectric Project, Kenai Peninsula, Alaska", prepared for Central Alaska Power Assn., Inc., Anchorage, AK/Portland, OR.; December 29, 1955

Harrelson, Cheryl C., Rawlings, C.L., and Potyondy, John P. "Stream Channel Reference Sites: An Illustrated Guide to Field Technique", Gen. Tech. Report RM-245, Fort Collins, CO: U.S.D.A., Forest Service, Rocky Mountain Forest and Range Experimental Station; 1994.

Painter, Mona. "Cooper Landing Historic Report", Unpublished Manuscript prepared for the U.S. Forest Service, Cooper Landing; 1998

Palmer Doug, USF&WS fisheries biologist. Phone conversations with Dave Blanchet, USFS regarding characteristics of Cooper Creek Dolly Varden; 1998 and 2001.

Palmer Doug, USF&WS fisheries biologist. Unpublished spreadsheet of location distribution of Dolly Varden radio tagged in Cooper Creek on 9/24/98. Received electronically on 11/28/2001.

Palmer Doug, USF&WS fisheries biologist. Unpublished fisheries data on three Cooper Reservoir gillnet sets, June 7 and 8, 2000.

Parker, Jeff, Member - Anchorage Fish and Game Advisory Committee. Letter to Steve Nachtman and Joe Taddeucci, Stone & Webster Engineering Corp. RE: "Cooper Lake/Creek Hydroelectric Project - Planned License Amendment by Chugach Electric", Feb. 6, 1997.

Reist, Dr. James D., Research Scientist and Head of Arctic Fish Ecology and Assessment Research Section, Fisheries and Oceans Canada, Winnipeg, Manitoba, Canada. E-mail to Jack Dean in Sterling Alaska with genetic haplotype results from numerous char samples from Alaska sent for evaluation. June 27, 2001

Seward Daily Gateway. "Detective Sundby Solves Mystery of Cooper Creek Fish", September 13, 1933.

Seward Daily Gateway. "Prize Sheep is Capital Trophy Bagged in Hunt", September 24, 1938.

Seward Daily Gateway. "Sportsmen Lure Rainbows With Melodious Song", May 13, 1941.

U.S. Fish & Wildlife Service and Fisheries Research Institute. "Cook Inlet Lake and Stream Records, 1927-1952, with Accompanying Descriptive Material"; May 29, 1953. A copy of this document is located at ARLISS Resource Library in Anchorage, AK.

U.S. Fish & Wildlife Service and Fisheries Research Institute. "Cook Inlet Stream and Lake Surveys, 1953"; 1953 or 1954. A copy of this document is located at ARLISS Resource Library in Anchorage, AK.

U.S. Fish & Wildlife Service. Letter from Donald L. McKernan, Administrator, Alaska Commercial Fisheries to USFS Alaska Regional Forester; June 4, 1956. Letter encloses a 6-page, undated report entitled: "Supporting Narrative for Memorandum Draft, Cooper Lake FPC # 2170, (License)".

U.S. Fish & Wildlife. Letter from John T. Gharrett, Regional Director Bureau of Commercial Fisheries to USFS Alaska Regional Forester; October 29, 1958. Letter encloses a 6-page, undated report entitled: "F.P.C. No. 2170, Cooper Lake Hydroelectric Project"

U.S. Fish & Wildlife Service. "An Initial Follow-up Report for Cooper Lake Hydroelectric Project, FPC. No. 2170, Kenai Peninsula, Alaska", Juneau, AK.; July 1964.

U.S. Fish & Wildlife Service. Letter from Ann G. Rappoport, Field Supervisor for Ecological Services to David P. Boergers, Secretary of the Federal Energy Commission, January 24, 2000. Re: Cooper Lake Project, FEREC No. 2170-010, New Biological Information: Arctic Char in Cooper Lake.

U.S. Forest Service. Memo from Chugach National Forest, Kenai Division Ranger, E. Norgorden to Juneau Regional Forester, Heintzleman concerning fish catches on Kenai Peninsula streams; Nov. 6, 1940.

U.S. Forest Service. Memo to files from J.E. Schwartz, Forester, Wildlife Management, File No. 2610, Cooperation, ADF&G and USF&WS; January 21, 1960.

U.S. Forest Service. Memo from J.F. Grant, Forest Supervisor, Chugach National Forest to Alaska Regional Forester, File No. 2750, Easements/Licenses (CEA, FPC 2170); November 26, 1963.

U.S. Forest Service. "Channel Type user guide, Tongass National Forest, Southeast Alaska", Alaska Region R10-TP26, 1992

U.S. Forest Service. “FSH 2090- Aquatic Ecosystem Management Handbook”, R10 Amendment 2090-98-1, DRAFT Chapter 20- Fish and Aquatic Stream Habitat Survey, Juneau, AK; 1998.

Winter, Larry and Williams, Mark. USFS, Seward Ranger District. “Cooper Lake Survey. July 9/10, 1992”, unpublished report on Cooper Lake trapping and stocking efforts, Seward, AK, 1992.

Wolman, M. Gordon. “A Method of Sampling Coarse River-Bed Material”, Transactions, American Geophysical Union, Vol. 35, No. 6; December 1954.

B. Wildlife

1. Introduction

The Cooper Creek Watershed provides habitat for a wide variety of wildlife species. However, this watershed is relatively small and predominantly above timberline, and does not provide an abundance of high quality habitat for any one species. In this analysis we focus on wildlife species that have experienced substantial changes in habitat, or that are of special concern to the Alaska Department of Fish and Game (ADF&G).

Before 1960, agencies collected very limited information on Cooper Creek's wildlife. Even after 1960 the data compiled is mostly limited to sporadic surveys and anecdotal accounts. Lacking good survey data, we developed a habitat capability index (HCI), estimating the condition and trend of wildlife habitat over the last 150 years. Index values range from 1.0 for optimum habitat capability to 0.0 for no habitat capability. HCI rates habitat conditions at the watershed level (unless otherwise specified). The ratings relate to habitat conditions found across the Kenai Peninsula. The HCI ratings are based on: 1) assumptions about the limiting factors for each species, 2) existing quality and quantity of habitat, and 3) historic changes to the habitat.

This wildlife section evaluates habitat capability for moose, bald eagles, brown bear, water birds, furbearers, and harlequin ducks. Four broad time periods are considered:

- Pre-settlement, prior to 1880
- Mining and settlement from 1880 to 1959
- Dam construction and community development from 1959 to the present;
- Future over the next 50 years.

Wildfires, human development, and the spruce bark beetle infestation are the three largest sources of wildlife habitat alteration in the watershed in the last 150 years.

Prior to European settlement, wildfire was likely the primary change agent for wildlife habitat. A fire history analysis conducted on the Seward Ranger District indicates that the Cooper Creek drainage may experience an approximate 300-year fire return interval (personal communication, M.Potkin, USFS). A summary of journal entries and articles by early explorers indicates wildfires (primarily human-caused) were widespread and pervasive on the Kenai Peninsula from the 1830's through the 1890's (Lutz 1960).

Mining and settlement of the Cooper Creek area led to changes in the vegetation, especially along Stetson and Cooper Creeks (Painter 1998). Human caused fires were extensive in the Cooper Landing area. Habitat disturbances have continued as a result of powerline clearing, road and dam construction, Cooper Reservoir shoreline inundation, community expansion, and recreation. The current spruce bark beetle infestation has caused loss of mature spruce trees and rapid changes in the understory plant community. These changes in turn affect the structure and function of wildlife habitat.

Table 2.III.B-1 at the end of this section summarizes changes in estimated habitat capability for six wildlife species and groups over time. The percentage *change* in HCI over time generally provides a more meaningful measure of impacts to habitat than the absolute HCI value itself.

2. Moose

Moose depend on early successional vegetation, and feed primarily on hardwood shrubs. Winter range (defined as hardwood forage below 1000 feet elevation) is the primary limiting factor for moose populations in the Cooper Creek Watershed. Without fire, moose winter range becomes limited to permanent shrub fields along flood plains, avalanche chutes, and riparian zones. Assuming that all riparian areas below 1000 feet elevation provide some winter range, the Cooper Creek Watershed currently provides around 1,430 acres of permanent winter range.

Pre-settlement. If pre-settlement vegetation patterns were similar to those found today, then the limited winter range would result in a pre-settlement HCI estimate of 0.1. If we assume that all timbered land below 1000 feet elevation could burn and regenerate to hardwoods, then a maximum of 1700 acres of winter range might have been available at some point in the past. Due to the limited burnable area, and the ephemeral benefits of fire, we estimate the HCI for moose would only increase to 0.3 following a major fire. This rating might persist for up to 50 years.

Mining/settlement. Mining and settlement of the watershed likely had both harmful and beneficial affects on the HCI for moose. Mining and its associated settlement had a negative, localized impacts on the HCI through loss of riparian vegetation and human disturbance. Settlement related wildfires, however, improved moose winter range conditions. Abandoned placer claims typically revegetate to a mix of alder and hardwoods. Increased human disturbance and hunting pressure brought about by increased access have lowered the HCI on a short term and local basis. We estimated HCI increased to 0.2 as a direct result of fire.

Dam to present. Moose habitat in the Cooper Landing area rates at low to moderate quality, supporting less than two moose/square mile (personal communication Ted Spraker, ADF&G). Aerial trend and composition surveys flown in the Cooper Creek Watershed by ADF&G show 0.2 to 0.5 moose/square miles. By contrast the East Juneau Creek/Bean Creek survey area (north of Cooper Creek) has a higher quality and quantity of moose browse, and shows from 0.7 to 3.9 moose per square mile.

Beneficial effects from turn-of-the-century fires in the watershed have now dissipated, and current moose winter range is limited to approximately 1430 acres of heavily used, permanent shrub fields. Dam construction and shore inundation did not seriously impact the amount of moose winter range available at the south end of Cooper Reservoir.

Increased winter recreation may have both positive and negative effects on moose populations. Snowmobiles cause moose to expend energy in escape, but at the same time provide moose a packed trail that reduces energy expenditure for feeding.

The ongoing spruce bark beetle infestation in the watershed will ultimately have a positive effect on browse production as the forest canopy opens up. While current forage conditions in the watershed may rate slightly better than historic levels, human disturbance has reduced the HCI to 0.1.

Future. Available winter moose range in the Cooper Creek Watershed can be increased through prescribed burning. Over 450 acres of beetle-killed spruce forest south of Stetson Creek are slated for burning in 2000. The forested area north of Stetson Creek is infested, and could be burned.

In 1988, the Forest Service cut back about half of a 150-acre Scouler willow stand adjacent to the Cooper Dam Road to enhance its growth. Additional thinning at this site would further benefit moose browse.

Cooper Reservoir's southwest end has vegetation and topography suitable for mechanical treatments such as hydroaxe or roller-crusher. Without treatment or wildfire, this area's moose winter habitat capability will remain low. Increases in summer recreation at the reservoir would have very limited effects on moose habitat capability.

3. Bald Eagles

Bald eagle numbers in Southcentral Alaska are primarily limited by the availability of suitable nest trees with abundant food nearby. Bald eagle nests on the Chugach National Forest's Seward District are found mostly (82%) in mature cottonwoods, averaging 31 inches in trunk diameter. The Kenai River is the only stream corridor on the Seward District with enough nesting and feeding habitat to merit a high HCI.

Pre-settlement. Before 1880, mature cottonwoods suitable for eagle nesting were probably present at: the mouth of Cooper Creek; stream inlets on the south end of Cooper Lake, and possibly at Cooper Lake's outlet. At Cooper Creek mouth, good access was available to plentiful salmon and trout stocks in Cooper Creek and the Kenai River. Eagles also likely fed on winter moose carrion in the lower watershed. The Cooper Lake char fishery would have provided a very limited food resource for eagles.

Based on number and location of eagle nests in neighboring drainages, the Cooper Creek Watershed probably supported one to two eagle territories, with one to three nests in each territory. The mouth of Cooper Creek probably provided high quality eagle habitat. The north and south ends of Cooper Lake likely provided low to moderate quality eagle habitat with limited food supply and nest trees. Our estimate of the pre-settlement HCI for Cooper Creek Watershed is 0.2.

Mining/settlement. Twenty-two people lived at the mouth of Cooper Creek in 1900 (Painter 1998). Most mining activity took place between Stetson Creek and the mouth of Cooper Creek. From 1907 to 1917, some 50 acres of alluvial fan/cottonwood forest near the mouth of Cooper Creek were highly disturbed by large-scale hydraulic mining. Habitat capability for bald eagle nesting at Cooper Creek's mouth was probably lost due to human habitation, and cottonwood clearing for mining and cabin sites. Eagle habitat around Cooper Lake was little disturbed by mining. The watershed provided a low HCI of 0.1.

Dam to present. Cooper Lake Dam virtually eliminated salmon and rainbow trout runs on Cooper Creek, thus limiting available food resources for eagles. Human disturbances at Cooper Creek's mouth are currently increasing. These disturbances include camping, recreational mining, highway traffic, and powerline access. Nest and roost trees are available, and food is abundant, but no eagles have nested at the mouth of Cooper Creek for the last 10 years.

Dam construction removed all mature cottonwoods from the outlet of Cooper Lake. This, combined with loss of productive fisheries on Cooper Creek, led to a complete loss of eagle habitat capability at the former lake outlet (northwest end of the reservoir.)

At Cooper Lake's south end, about 164 acres of mature cottonwood-Lutz spruce were cut in 1959 for the reservoir. Although no eagle nests have been found near Cooper Reservoir in the last 10 years, 222 acres of mature, mixed cottonwood-spruce remain in place at the reservoir's south end. Some remaining trees at Cooper Reservoir's south end may be structurally capable of supporting eagle nests. Stocking of rainbow trout into Cooper Reservoir in 1987-94 possibly increased the (very limited) availability of reservoir trout/char to eagles.

We estimate a current HCI of 0.1 for the Cooper Creek Watershed, showing that some nesting capability may still remain.

Future. The mouth of Cooper Creek might support nesting eagles again in spite of the level of human intrusion. Closing Cooper Creek Campground and the road and campsites along the east side of lower Cooper Creek would reduce disturbance levels and improve nesting success. Thinning young cottonwoods stands along lower Cooper Creek would also help to improve future nesting habitat.

Habitat conditions at the Cooper Reservoir's north end could be improved by planting and maintaining a cottonwood stand, and by re-establishing salmon and trout fisheries on Cooper Creek. An opportunity also exits for long-term habitat management at the south end of Cooper Reservoir through thinning and burning. Raising the water levels in the reservoir above the current maximum 1194 feet would reduce potential nesting habitat at the south end of the lake. Increasing recreation within the cottonwood community type around the reservoir would further reduce the eagle HCI.

4. Brown Bear

Brown bears are wilderness species with large home range requirements and an intolerance of human disruption and development. The primary limiting factor for brown bears on the Kenai Peninsula is spring and summer feeding habitat. South facing slopes and avalanche chutes that green up early, big game winter range (for scavenging winter mortality), and salmon streams provide forage needed by bears.

Pre-settlement. The lower four miles of Cooper Creek up to barrier falls would have provided a low to moderate quality salmon fishery for bears. Small populations of mountain goats, Dall sheep, and moose within the watershed provide only a limited source of carrion. The proximity of adjacent, high quality habitats such as Russian River and Kenai River increases the HCI for the Cooper Creek Watershed. We estimate the pre-settlement HCI at 0.4.

Mining/settlement. Active mining on anadromous portions of Cooper Creek, as well as settlement at the creek mouth, likely reduced salmon production of the creek significantly, and limited fish access within the creek. The influx of humans in the watershed would have resulted in displacement and unregulated bear harvest, causing an estimated decline in the HCI to 0.2.

Dam to present. A suite of factors have contributed to the decline in brown bear habitat capability in the Cooper Creek Watershed including:

- Construction of the Snug Harbor and Cooper Lake Dam roads
- Upgrading and improved access to the Upper Russian Lakes hiking trail
- Development along the Sterling Highway corridor and Kenai River
- Decline of the Cooper Creek salmon and trout fisheries.
- Increase in backcountry recreation and hunting use.

We used Suring's 1998 Kenai Peninsula brown bear cumulative effects model to determine the current HCI for the Cooper Creek Watershed. Current spring feeding yielded an HCI of 0.1, and summer feeding, an HCI of 0.09. This 75% reduction in brown bear habitat potential since pre-settlement is due primarily to increased human access sparked by dam construction. Loss of the Cooper Creek salmon run has also worked to reduce habitat capability in the watershed.

Future. Increasing access and recreation use in the Cooper Creek Watershed during spring and summer months would further decrease the brown bear HCI. Restoring Cooper Creek's salmon fishery would provide additional food for brown bears, but would also increase human/bear interactions. Temporal or spatial fishing closures could be used to reduce conflicts. Limiting access into the watershed could be used as a tool to increase habitat capability. Constructing a campground and recreational cabin on Cooper Reservoir would reduce the HCI an additional 6 percent.

5. Water Birds

Nesting water birds in the Cooper Creek Watershed using lake habitat include mallards, greater scaups, least sandpipers, common loons, mew gulls, arctic terns, Barrow's goldeneyes and green-winged teal. Lack of nesting habitat likely limits the abundance and diversity of water birds in the watershed. Palustrine wetlands at the south end of Cooper Lake provide most of the available nesting habitat. Nesting areas on Cooper Lake/Reservoir are often not available until mid- to late May, when the ice goes out.

Pre-settlement. An estimated 760 acres of palustrine wetlands were present at Cooper Lake's south end during pre-settlement (D. Blanchet, per. comm.) Common loons may have historically nested along the shore of Cooper Lake. Puddle ducks, such as mallards and teal, would have nested near shallow feeding habitat at lake's south end and in adjacent small lakes. Mew gulls probably did not nest on the lake in pre-settlement days due to their preference for barren ground. The low HCI (0.2) for the watershed reflects the limited availability of nesting habitat.

Mining/settlement. The HCI for water birds was likely unaffected by mining or settlement, unless egg collection or spring hunting took place.

Dam to present. Cooper Reservoir inundates hummocky shoreline at it southwest end, creating 10 to 15 small islands where most water bird nesting occurs. A search of the reservoir's south shore and two largest islands on June 23, 1997 (water elevation 1179 feet) located a total of 46 mew gull nests, five unidentified duck nests, and one arctic tern nest. A search of the south shore and islands on June 16-17 and 24, 1998 (water elevations 1185 and 1186 feet) yielded a total of 77 mew gull nests, six mallard nests, three greater scaup nests, four least sandpiper nests, and one common loon nest. These numbers likely indicate a significant increase in nesting density from pre-dam conditions.

Cooper Reservoir shows an average 4.3-foot increase in the water level during the probable nesting season, May 15 to July 1. In 1998, the increase was 4.9 feet. We observed approximately 30 (horizontal) feet of inundation along the south shore between the June 17 and June 24, 1998 visits. Some known nest sites had flooded, and a duck egg was seen floating. Most nests located on the June 16-17, 1998 visit were less than 10 feet above the water level. Number flooded nests and the hatch success rates for individual nests were not determined.

We have not reached a clear understanding of Cooper Reservoir's overall effect on nesting water birds. Negatives impacts include an estimated loss of 50 to 150 wetland acres through inundation. Nesting opportunities may have been lost along the shoreline due to loss of adjacent vegetative cover. Inundation at the reservoir's south end has created more island/edge habitat, which nesting birds seem to favor. Mew gulls, however, dominate the current nesting population, and prey on the eggs and chicks of other water birds. The rising reservoir levels may flood out a significant portion of water bird nests during some years. The overall impact of the dam on habitat capability remains speculative. We estimate the HCI at 0.2.

Future. Raising the average water level of Cooper Reservoir would reduce the amount of island and shoreline habitat available for nesting. Absolute water level, however, is likely less influential on nesting success than is the change in water level during nesting. Maintaining a steady water level during the nesting season would increase nesting success. Maximum island habitat is attained at reservoir elevations around 1175 feet. Inundation impacts around the reservoir could be mitigated in part through construction of pothole lakes at the reservoir's south end, and near Rainbow Lake.

Common loons are of special concern to the Forest Service due to their small population size and sensitivity to human disturbance. Physical limitations prevent the bird from nesting more than a few inches from the water's edge, especially when the shoreline is steep. Rapid increases in water level during nesting can jeopardize or prevent successful fledging of loon chicks. Stabilizing the Reservoir level during nesting would eliminate nest flooding, but do little to improve shoreline cover. An artificial nesting platform installed in Cooper Reservoir in 1994 has not been used, and needs further evaluation. The resident loon nest on the reservoir should be located and monitored for nest success. Use of artificial nest islands should be considered.

6. Beaver/River Otter/Mink

The Cooper Creek Watershed provides limited habitat for stream and wetland associated furbearers (personal communication, Ted Spraker, ADF&G). The primary limiting factors for these species is the availability of an adequate water source with an associated food supply.

Pre-settlement. Beavers were likely present in the small lakes and inlet streams at the south end of Cooper Lake, possibly in the lake itself, and at the mouth of Cooper Creek. River otter were probably restricted to Cooper Creek and Lake where fish were available. Mink could have been found anywhere along Cooper Creek, Cooper Lake or any of the smaller tributaries and lakes.

The lower section of Cooper Creek probably provided the best otter and mink habitat, while the south end of Cooper Lake provided the best beaver habitat. Likely none of these species were abundant. The low HCI (0.3) reflects the limited amount and relatively low quality of aquatic furbearer habitat.

Mining/settlement. Mining related stream disturbance and sedimentation likely damaged the salmon and trout fisheries on Cooper Creek. This in turn would have reduced the habitat capability for mink and otter (Linscombe et al 1987, Toweill and Tabor 1987).

Increased human activity and trapping along the lower stream also likely had a negative impact on furbearers. Overharvest of furbearers on the Kenai Peninsula and poisoning by fox farmers may have led to local extirpation. Together these changes probably caused Cooper Creek to be largely abandoned by mink and otter, and possibly beaver, at the turn of the century. Populations were low enough to prompt suggestions of harvest moratoriums (Bangs et al 1982). A September 13, 1933 story in the Seward Gateway does reports on a Cooper Creek fisherman having his rainbow trout stolen by a mink (Painter, 1998).

Very few changes in beaver habitat appear to have occurred during this period, with the exception of cottonwood clearing and stream channelization near the mouth of Cooper Creek. The residual HCI of 0.1 reflects the lack of human disturbance to beaver habitat.

Dam to present. We have only found anecdotal information on furbearer status in the Cooper Creek Watershed. Ted Spraker, ADF&G Area Game Biologist, believes the watershed supports a very small furbearer population. The primary limiting factor is probably the winter food source.

Low water flows and lack of flooding on Cooper Creek immediately below Cooper Dam have allowed beavers to colonize a ¼ mile section of former stream channel. In Cooper Reservoir, the fluctuating water level has eliminated potential for beaver habitat along the shore. Some good quality beaver habitat on inlet streams at the south end of Cooper Reservoir has been lost through both inundation and loss of vegetation.

Adverse impacts to Cooper Creek fisheries from dam construction have significantly reduced the creek's food supply for river otter and mink. Some recreational trapping currently occurs around Cooper Reservoir, with access via snowmobile from the Snug Harbor Road. The HCI remains lower than historic levels due to loss of the Cooper Creek fishery, reductions in the Cooper Lake fishery, increased human access, and trapping.

Future. Re-establishing a fishery in Cooper Creek would improve mink and otter habitat. Successful re-establishment could return the furbearer HCI for Cooper Creek to near pre-settlement levels. If winter access and trapping were to increase, the HCI would decrease. Access and harvest levels could, however, be regulated.

Construction of additional recreation facilities on Cooper Reservoir should not further impact furbearer populations. Furbearer population status should be determined to provide a baseline for comparison with future changes in the watershed. Winter track surveys, remote camera stations, and aerial beaver dam surveys could be used to monitor population changes.

7. Harlequin Ducks

Harlequin ducks nest inland along the rapids of mountain streams. Females nest near the waterline, adjacent to stream rapids. They rear their broods in nearby shallow, quiet pools. Females and broods feed primarily on the larvae of aquatic insects found in highly oxygenated streams (Bellrose 1976).

Harlequin duck nesting habitat is remote and rugged. Little is known about potential densities or limiting factors. Rosenberg et. al. (1994) report that the availability of food in Alaskan nesting and rearing areas appears to be the primary limiting factor to the population. Harlequin territories are very small, sometimes limited to the area around the nesting female.

Pre-settlement. We have no information as to whether Cooper Creek historically supported harlequin ducks. Although the stream currently supports at least 1 breeding pair, the overall HCI for the watershed is low (0.2) based on the restricted amount of nesting and rearing habitat. This estimate is subjective since we have not surveyed broods or habitat within Cooper Creek or adjacent watersheds.

Mining/settlement. Sedimentation from past hydraulic mining on Stetson and Cooper Creeks may have had a negative impact on aquatic insect production. Increased human presence along the stream may have displaced individual birds. The HCI for Cooper Creek would have been reduced to 0 during active mining.

Dam to present. We have not determined how the sharp flow reductions on Cooper Creek associated with dam construction have affected harlequin habitat. Aquatic insect production may have declined. However, more pool-rearing habitat may have become available as a result of the reduced flows (personal communication D. Blanchet USFS hydrologist). Two adults with chicks were observed on Cooper Creek in 1998, verifying that the stream offers some nesting habitat. The low HCI (0.1 to 0.2) reflects the small amount of habitat available at the watershed level.

Future. Increasing Cooper Creek's aquatic insect production would improve nesting and rearing habitat for harlequin ducks. Some increase could likely be achieved by increasing Cooper Creek's flow and water temperature. A habitat survey is needed to better quantify the stream's existing habitat quality.

Table 2.III.B-1: Estimated Historic, Current, and Future Habitat Capability Indices* For Six Species and Groups of Wildlife in the Cooper Creek Watershed

Species	Pre-settlement (pre-1880)	Mining – Settlement (1880 to 1959)	Dam to Present (1959 to 1999)	Future (2000 to 2050)
Moose	0.1	0.2 (+100%)	0.1 (0%)	0.1 - 0.3
Bald eagle	0.2	0.1 (-50%)	0.1 (-50%)	0.1 - 0.2
Brown bear	0.4 spring 0.4 summer	0.2 spring (-50%) 0.2 summer (-50%)	0.1 spring (-75%) 0.09 summer (-78%)	0.07 spring (-83%) 0.06 summer (-85%)
Waterbirds	0.2	0.2 (0%)	0.3 (+33%)	0.1 - 0.3
Furbearers	0.3	0.1 (-67%)	0.2 (-33%)	0.1 - 0.3
Harlequin duck	0.2	0 (-100%)	0.1 (-50%)	0.1 - 0.2

* Habitat capability index (*HCI) values range from 0.0 for no capability to 1.0 for optimum capability. HCI's are based on the range of conditions found across the Kenai Peninsula.*

8. References for Wildlife

Bangs, E.E., T.H. Spraker, T.N. Bailey and V.D. Berns. 1982. "Effects of increased human populations on wildlife resources of the Kenai Peninsula, Alaska", Forty-seventh North American Wildlife Conference. Pages 605-616.

Bellrose, F.C. 1976. "Ducks, Geese and Swans of North America", Stackpole Books, Harrisburg, PA. Pages. 380-384.

Linscombe, G., N.Kinler and R.J.Aulerick. 1987. "Mink", Pages 629-643 in J.A.Chapman and G.A.Feldmamer, eds. "Wild mammals of North America", Johns Hopkins University Press, Baltimore and London.

Lutz, H.J. 1960. "History and early occurrence of moose on the Kenai Peninsula and in other sections of Alaska", USDA Forest Service. Misc. publ. No. 1. Juneau, AK. 25pp.

Painter, M. 1998. "History of Cooper Landing", USDA Forest Service Unpubl. Rpt., Seward, AK.

Rosenberg, R., S.Patton and T.Rothe. 1994. "Harlequin Duck, Alaska Wildlife Notebook Series", Alaska Department of Fish and Game, Anchorage, AK., 2pp.

Suring L.H., K.R. Barber, C.C. Schwartz, T.N. Bailey, W.C. Shuster, and M.D. Tetreau. 1998. "Anlaysis of cumulative effects on brown bears on the Kenai Peninsula, southcentral Alaska", Ursus 10:107-117.

Toweill, D.E. and J.E.Tabor. 1987. "River Otter" Pages 688-703 in J.A.Chapman and G.A.Feldhamer, eds. "Wild mammals of North America", Johns Hopkins University Press, Baltimore and London.

C. Vegetation Change

1. Vegetation Change At Cooper Lake

a. Overview.

Before Cooper Lake Dam, Cooper Lake had a water level 1168 feet above sea level. Aerial photographs from 1950 show the lake and vegetation cover before any effects of the dam. Dam construction started in 1959. Cooper Reservoir filled to its spillway (elevation 1210 feet) by April 1961. The Reservoir kept it water level at near 1210 feet until October 1962. Since then, the water level has generally been maintained at below 1195 feet. U.S. Forest Service aerial photography taken in the summer of 1961 and 1962 show the reservoir filled to its spillway.

This section of the report analyzes vegetation types found around Cooper Lake and on Cooper Creek, as well as changes to those vegetation types over time. The analysis uses vegetation patterns mapped on five sets of aerial photography, as follows:

- ***1950-51***, black and white (1:40,000), representing pre-dam lake level at 1168 feet
- ***1961*** and ***1962***, black and white (1:16,000), representing highest reservoir water level at 1210 to 1213 feet
- ***1974***, color (1:16,000), used for representing current conditions at reservoir level 1174.6 feet
- ***1993***, color (1:32,000), used for representing current conditions at reservoir level 1181.2 feet
- ***1993***, color infrared (1:12,000), representing current conditions for the alluvial fan on lower Cooper Creek.

The vegetation analysis describes changes in vegetation associated with construction and filling of Cooper Reservoir.

Vegetative disturbance around Cooper Lake before the dam included: 1) stream bank disturbance from erosion and channel shifting during floods on inlet streams, and 2) small fluctuations in lake level combined with wind-driven wave action/erosion. These localized disturbances are set within the context of larger forest disturbances, including periodic fires, bark beetle outbreaks, avalanches, and blow downs.

In 1959, Cooper Lake's shoreline vegetation between 1168 and 1210 feet was cut and burned in preparation for reservoir filling. All vegetation more than six feet high and two inches in diameter was cut. By summer of 1961, some 750 acres of Cooper Lake shoreline had been inundated.

Cooper Reservoir water levels fluctuate an average of 12 feet annually, with 25 feet marking the greatest annual fluctuation. Changing water levels have created new vegetation patterns in the zone between low and high water around Cooper Reservoir. Besides just inundation of vegetation, on windy days waves pound the shore, removing both soil and vegetation. The steepest shorelines are most susceptible to wave erosion. The zone of inundation around the former Cooper Lake now shows a sharp increase in bare ground and early successional vegetation.

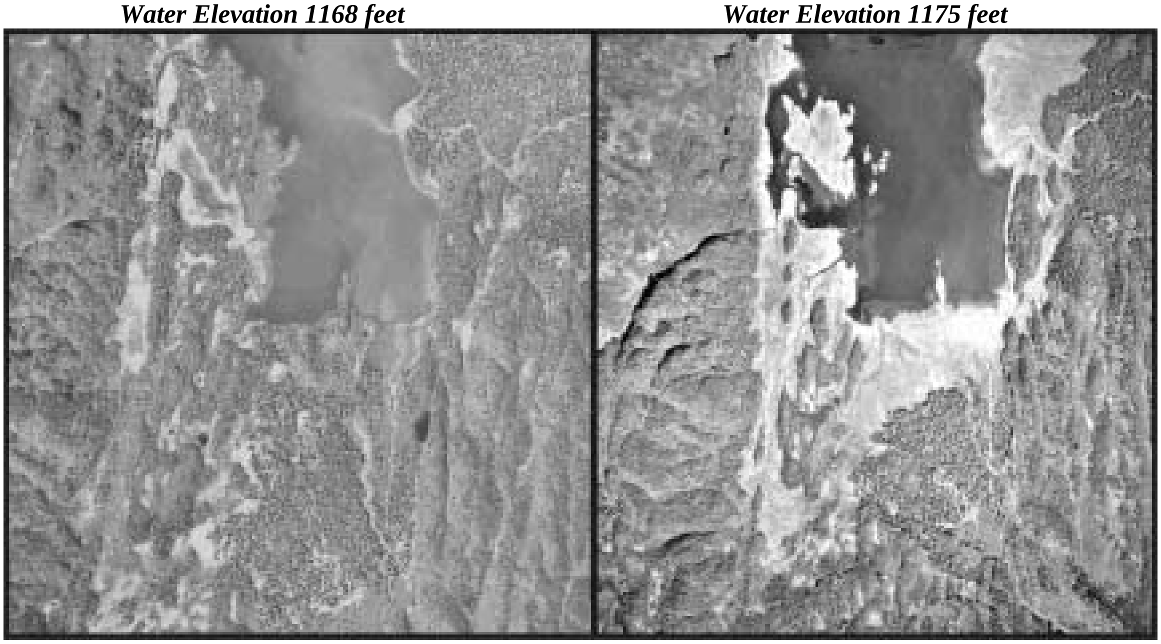
b. South End Cooper Reservoir

Due to its low gradient, the shoreline at Cooper Reservoir's south end receives much more extensive inundation than does the remaining steeper shoreline. Currently, the low-gradient alluvial fans along the south and southeast sides of Cooper Reservoir support early successional cottonwood/alder-willow stands on the higher elevations (1180 to 1210 feet). At lower elevations (1170 to 1185 feet) these fans support willow/ bluejoint-horsetail or willow/ bluejoint-mixed forb (with inclusions of sedge bog). During the "average" year of reservoir operation, the water level drops to a low of 1174 feet in April/May, then rises to a high of 1186 feet by late summer to fall.

Figure 2.III.C-1: Vegetation Change at the South End of Cooper Lake/Reservoir

1951 - before the Cooper Lake Project
Water Elevation 1168 feet

1974 – after dam construction
Water Elevation 1175 feet



Vegetation on the low elevation rock islands and knobs along the south and southwest shores of Cooper Reservoir has also changed. At pre-dam water levels, these rock knobs were part of the shoreline, forested with spruce and cottonwood/birch. At peak reservoir levels in 1961-2, some knobs were mostly inundated and became islands. Currently these knobs support low, early-successional shrubs and alder vegetation types.

Each annual inundation on Cooper Reservoir resets shoreline vegetation communities to an earlier successional stage. The zone between 1168 and 1175 is frequently inundated, creating a non-vegetated or sparsely vegetated band around the reservoir. The annual range, timing, and speed of reservoir fluctuation all influence the degree of disruption to lakeside vegetation, nesting habitat, and spawning habitat along inlet streams.

Filling Cooper Reservoir to its maximum level (1210 feet) currently would result in inundation and loss of 340 acres of low-lying vegetation at the reservoir's south end. Vegetation types lost would include: sparsely vegetated, grass-forb, low shrub, willow, alder, and cottonwood/alder-willow (see legend for type descriptions).

c. North End Cooper Reservoir

Loss of the overhanging vegetation around the edge of Cooper Reservoir has been a major vegetative/habitat impact of the dam. Between elevations 1168 and 1194 feet, most of the steeper shorelines are now gravel/cobble, or bedrock, with little or no vegetation. Lower gradient shorelines, particularly those above 1185 feet, currently show denser vegetation (due to less wave action and less inundation.)

Loss of shoreline vegetation has reduced cover and habitat for reservoir fish, and cover for waterfowl and aquatic mammals. This same vegetation loss has provided an open travel corridor for animals traveling around the reservoir.

d. Roads and Power Lines

Road and power line construction associated with the Cooper Lake Project has required removing or greatly reducing vegetation along these corridors. Within the Cooper Creek Watershed, vegetation was cleared along three miles of the Cooper Dam Road, one mile of the Snug Harbor Road, and one mile of power line right-of-way. The power line runs east-west across the north end of the watershed. Together the roads and power line corridor amount to about 25 acres of vegetation disturbance/removal.

e. Cooper Lake/Reservoir Map Legend Description.

Figure 2.III.C-2 displays vegetation around Cooper Lake before dam construction (1950-51), and ***Figure 2.III.C-3*** shows vegetation after dam construction. ***Figure 2.III.C-3***, the current status map, combines information taken from several different aerial photograph years after construction of the dam. Vegetation around the reservoir can change over time depending on the range of reservoir water elevations in the immediately preceding years. The following list provides legend descriptions of the vegetation types displayed in ***Figure 2.III.C-2*** and ***2.III.C-3***:

sparse: early successional vegetation in the frequently flooded zone around Cooper Reservoir. These areas are probably maintained in a sparsely vegetated condition due to intermittent inundation. Exposed rock, gravel, and cobble are common. This type was not observed on pre-dam air photos.

Figure 2.III.C-2: Pre-Dam Vegetation Around Cooper Lake between Elevations 1168 and 1212 feet
(Based on 1950 and 1951 Aerial Photography)

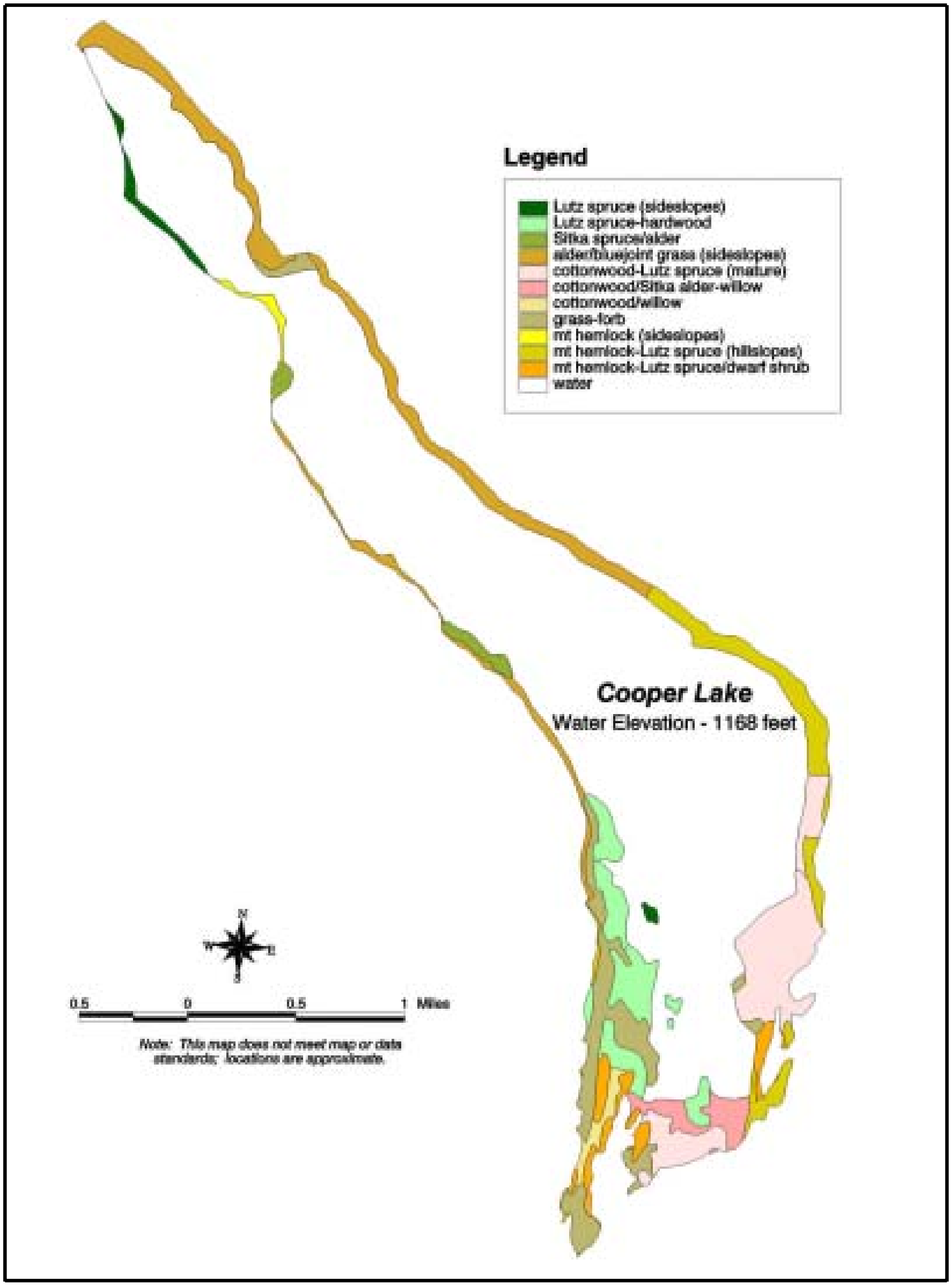
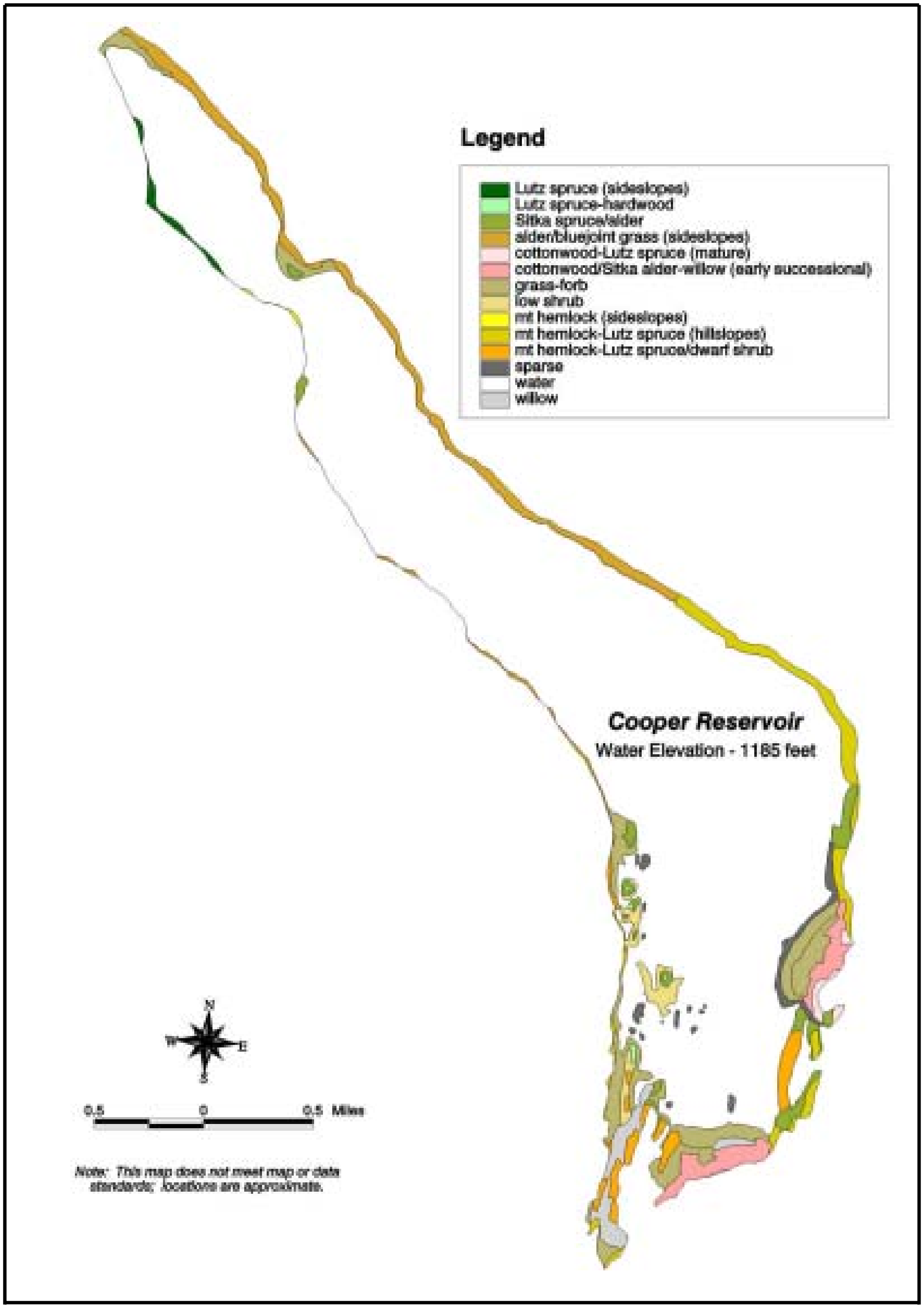


Figure 2.III.C-3: Current Vegetation Around Cooper Reservoir Elevations 1185 and 1212 feet



grass-forb: grass and forb dominated communities include: bluejoint, bluejoint-mixed forb, bluejoint-horsetail, sedge bog, and “willow”/ bluejoint-mixed forb. The sedge bog type is found in low-lying areas mostly away from the water’s margin on both the pre-dam and current vegetation map. The “willow”/bluejoint-mixed forb type is an early succession stage occurring on the upland portion of the floodplain on the current vegetation map. Large portions of the area around Cooper Reservoir currently identified in the grass-forb vegetation type were formerly forested community types (i.e., cottonwood-Lutz spruce, cottonwood/Sitka alder-willow, or Lutz spruce-hardwood) before the dam.

low shrub: early-successional, shrub-dominated communities occur on rocky knobs on the current vegetation map. Prior to inundation in 1961-62, these areas likely supported Lutz spruce-mountain hemlock/dwarf shrub and Lutz spruce-hardwood community types. Vegetation was cleared from these knobs in 1959-60 up to elevation 1210 feet.

willow: early-successional willow communities occur on the current vegetation map. Before the dam, this type apparently supported a cottonwood/willow community type.

Sitka alder: Sitka alder dominated community types occur most commonly on the current vegetation map around the reservoir between elevations 1194 and 1210 feet (above current and recent inundation levels.) This type can also be dominant within other disturbed sites including avalanche zones and along roadways.

cottonwood/willow: a pre-dam vegetation type featuring mature open cottonwood forest with willow understory. This type generally converted to the willow type when large vegetation was removed during dam clearing.

cottonwood/Sitka alder-willow: An early successional type occurring on both the pre-dam and current vegetation maps. On the current vegetation map, it occurs on the floodplain and alluvial fan just below high water. Prior to inundation this area likely supported cottonwood (mature)-Lutz spruce communities. On the pre-dam map, this type occurs on the floodplain adjacent to an inlet stream, and along the floodplain/lake margin.

cottonwood (mature)-Lutz spruce: mature cottonwood forest with spruce in the understory or as a codominant. This type occurs on both the pre-dam and current vegetation maps. On the current vegetation map, it is limited to areas above 1210 feet.

Lutz spruce-hardwood*:* a pre-dam forest type occurring on the forested knobs adjacent to Cooper Lake. Vegetation was cleared from these areas in 1959-60, and they now support various early successional types (sparse, grass-forb, alder, and low shrub).

mountain hemlock-Lutz spruce/dwarf shrub: A pre-dam forest type occurring on forested knobs adjacent to Cooper Lake. These forests generally occur on slightly drier, more upland sites than Lutz spruce-hardwood types. Areas above 1210 feet remain unchanged before and after the dam.

roads: No roads to Cooper Lake existed prior to dam construction (although a hiking trail was present passing by the south end of the lake.) Access to Cooper Lake was developed in 1959 with construction of the Cooper Lake Dam and Snug Harbor Roads.

Sideslope and hillslope types: were included on the map to provide context. These types include Sitka alder/bluejoint (sideslopes), Lutz spruce (sideslopes), mountain hemlock-Lutz spruce (hillslopes), mountain hemlock (sideslopes), and alpine and subalpine types. Change/reduction in these types before and after the dam has not been addressed.

Table 2.III.C-1: Changes in Cooper Lake/Reservoir Shoreline Vegetation Between Elevations 1168 and 1212 Feet

Cover Type*	Pre-Dam Vegetation (water level 1168')	Current Vegetation (water level 1185')	Change In Acres
Lutz spruce (sideslopes)	19.8	9.1	-10.7
Lutz spruce-hardwood	109.3	2.1	-107.2
Sitka spruce/alder	20.2	41.2	21.0
alder/bluejoint grass (sideslopes)	182.6	97.7	-84.9
cottonwood-Lutz spruce (mature)	170.3	8.9	-161.4
cottonwood/Sitka alder-willow (early successional)	39.4	48.7	9.3
cottonwood/willow	17.4	0.0	-17.4
grass-forb	127.8	135.5	7.7
low shrub	0.0	28.0	28.0
mt. hemlock (sideslopes)	8.5	1.2	-7.3
mt. hemlock-Lutz spruce (hillslopes)	98.7	67.0	-31.8
mt. hemlock-Lutz spruce/dwarf shrub	43.4	36.1	-7.3
sparse	0.0	25.2	25.2
willow	0.0	33.2	33.2
Total Acres	837.4	533.9	-303.7†

** Plant scientific names are displayed at the end of Table 2.III.C-3*
† Negative total acres (-303.4) are acres inundated by Cooper Reservoir

The vegetative changes around Cooper Lake/Reservoir displayed in ***Figure 2.III.C-2*** and ***2.III.C-3*** are quantified in ***Table 2.III.C-1***. This table quantifies vegetation types within the band of land around Cooper Lake/Reservoir between 1168 and 1212 feet in elevation. Total "pre-dam acres" exceed "current acres" by 303.7 acres. These are acres inundated by the reservoir.

2. Vegetation Change on Cooper Creek Alluvial Fan

a. Overview of the Disturbance Regime

Cooper Creek's lower half-mile flows across an alluvial fan before it joins the Kenai River. This alluvial fan has formed where Cooper Creek leaves its confined canyon and spills out onto the Kenai River valley bottom. As Cooper Creek drops onto the fan, its gradient, degree of containment, and sediment carrying capacity are all reduced. Portions of the stream's sediment load have dropped in place, building into a broad delta (fan) that the stream has migrated back and forth across over time.

Alluvial fans grow broader, thicker, and steeper over time as more and more sediment accumulates. The confined channel leading down to the alluvial fan is generally an erosional feature, with the channel cutting down into bedrock or sediments over time. The greater the sediment load carried by the stream, the more rapid the deposition on the alluvial fan, and the more rapid the migration of the channel across the surface of the fan. Most of the sediment deposition on the alluvial fan occurs during flood events.

Cooper Creek undoubtedly carried much larger sediment loads in the past when glaciers within the Stetson Creek drainage were larger and more active. This was likely the case as little as 150 to 200 years ago ("the Little Ice Age"). Sediment contributions from Cooper Creek as it leaves Cooper Lake on the other hand, have been minimal. Cooper Lake settles out virtually all inflowing sediment loads from its inlet streams.

Recession glaciers in the Stetson Creek basin, and subsequent stabilization of the valley sideslopes with vegetation, have resulted in a steady reduction in Stetson Creek's sediment load. These reduced sediment loads have resulted in reduced sediment deposition on Cooper Creek's alluvial fan. In the last 200 years, the fan has become steadily more stable, with less and less channel migration across it.

Sediment loads into Cooper Creek were likely increased by mining operations on Stetson Creek, and within the Cooper Creek canyon over the last century. However, these mining sediment loads were likely considerably smaller than the long-term sediment supply from natural erosion of the drainage basin. Mining related stream sedimentation may not have significantly increased deposition on Cooper Creek's alluvial fan.

Dam construction has reduced the average flow of Cooper Creek at its mouth to about 30 percent of the pre-dam values. Peak flows for large flood events at Cooper Creek's mouth are now about 60 percent of what they were before the dam. Floods are now far shorter in duration than those before the dam. As a result, Cooper Creek's sediment carrying capacity has been greatly reduced, and deposition of sediments onto the alluvial fan has been greatly diminished. Channel migration across the fan has been largely eliminated. Cooper Creek appears currently to be degrading (eroding down) into the fan, rather than depositing sediment and further building the fan.

At least three major stream terrace formations are visible on Cooper Creek's alluvial fan. The most recent terrace is seen on both sides of the current (and pre-dam) stream channel. This terrace supports stands of mature cottonwood. Extensive hydraulic mining occurred on this terrace in the early 1900's, and seems to relate closely to the terrace surface in some locations.

Two other stream terraces occur on the west side of the fan. Both support spruce-hardwood forests with trees over 150 years old. These forests may even be older than first generation. Clearly, hydraulic mining did not occurred on these older terraces.

The lower of the two terraces is dominated by spruce-cottonwood-birch forest, with an understory of bluejoint grass and fireweed. The higher, older terrace supports spruce-birch forest with an understory of crowberry, lowbush cranberry and other low shrubs (dwarf birch, twinflower, rose, and willow). All three terraces can be identified in ***Figure 2.III.C-4*** and ***2.III.C-5*****,** which display vegetation types on the fan both before and after construction of Cooper Dam.

Major flood events have probably provided the most important process for developing Cooper Creek's alluvial fan. In addition to flood events, several other natural and development-related disturbances have influenced vegetation patterns and succession on the alluvial fan. These disturbances include: mining, gravel pits, homesteading, highway and spur roads, power lines, spruce bark beetle, logging, and recreation campgrounds.

b. Impact of Cooper Dam on Cooper Creek's Alluvial Fan

Cooper Creek's dam-related reductions in flood flows and sediment loads have caused the creek to develop a narrower channel across the alluvial fan. Reduced flooding along the creek should allow for the growth of successional forest types along the stream (like those found on the fan's upper terraces.) In 1962, Cooper Creek's channel on the alluvial fan was up to 80 feet wide, and braided in places. Now the channel is 15 to 20 feet wide and vegetated along its banks by young cottonwood and alder. In the absence of major flood events, early successional communities will be limited to a narrow strip along the shore of the current stream channel.

Cooper Creek's alluvial fan was stabilizing and becoming more static before construction of Cooper Lake Dam. Since the dam, stabilization has accelerated significantly. Flood related vegetation disturbance on the fan is unlikely in the future under the current flow regime. Without flood disturbance, the fan's vegetation is likely to progress to a greater Lutz spruce component. Other disturbance factors such as fire, beetle infestations, timber harvest, and land clearing can all work to set back this successional process.

c. Cooper Creek Alluvial Fan Map Legend Description

Figure 2.III.C-4 and ***2.III.C-5*** display vegetation and disturbance types on the Cooper Creek alluvial fan both before and after dam construction. ***Figure 2.III.C-4***, the current condition map was developed primarily from low level, 1993, color infrared

photography. ***Figure 2.III.C-5***, the pre-dam map was developed primarily from 1962 black and white aerial photography. Significant changes between the two maps include: vegetating of the former Cooper Creek braided channel after dam construction, and development of a campground and gravel pit on the fan. Listed below are descriptions for the vegetation and disturbance types displayed in the legends of ***Figure 2.III.C-4*** and ***2.III.C-5***:

tailings: mining tailings. Extensive tailings piles occur on both the pre-dam and current vegetation map. These tailings piles result from hydraulic mining in 1908-1917.

gravel: gravel pits. Present on the current vegetation map only.

slide area: An erosional cut appears in the escarpment above the alluvial fan at its NE corner. This slide has apparently been eroding naturally since before the turn of the century. Fine-grained sands and silts erode off the face of the slide during snowmelt and rainfall events, and deposit on top of the alluvial fan. Young cottonwood and some willow grow sparsely on this deposit.

pasture: This is a homestead pasture and is present on both the pre-dam and current vegetation maps. A mixed-forb community including several introduced species such as clover, timothy, and common plantain dominates this unit.

cottonwood/Sitka alder (early successional): young stands invading the historic stream channel. Present on the current vegetation map.

cottonwood (mature): mature cottonwood stands occur on the lowest of three terraces on the fan. On the western boundary, a small stand occurs on an upper terrace at the point where a side stream meets the valley bottom. On the current vegetation map, there may be minor inclusions of young cottonwood within this type, particularly near the stream channel and around the mining tailings.

cottonwood-paper birch-Lutz spruce/bluejoint grass: occurs on a terrace adjacent to, and slightly higher than, the *cottonwood (mature) type.*

Lutz spruce-paper birch/bluejoint grass: occurs on a terrace adjacent to, and slightly higher than, the *cottonwood-paper birch-Lutz spruce/bluejoint grass* type.

Lutz spruce-paper birch/dwarf shrub: similar to adjacent sideslope forest types.

braided stream channel: occurs only on the pre-dam vegetation map. On the current vegetation map it is replaced by the **cottonwood/Sitka alder (early successional)** type.

roads: Cooper Creek campground was constructed in 1962. The current vegetation map shows the campground, as well as the Sterling Highway, and a spur road along the east side of Cooper Creek.

Figure 2.III.C-4: Pre-Dam Vegetation on Cooper Creek's Alluvial Fan
(Based on July 1962 Aerial Photography)

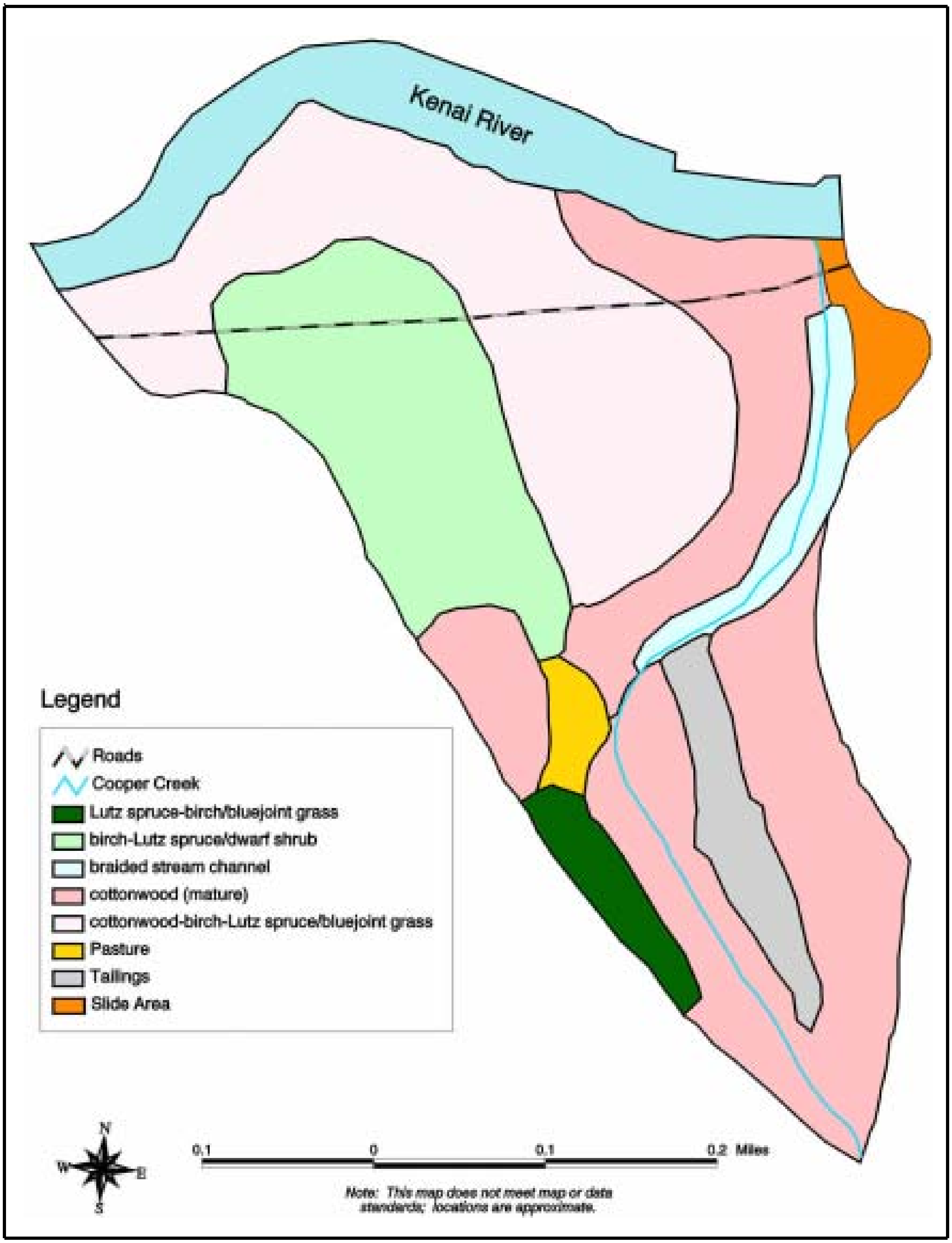


Figure 2.III.C-5: Current Vegetation on Cooper Creek's Alluvial Fan
(Based on June 1993 Aerial Photography)

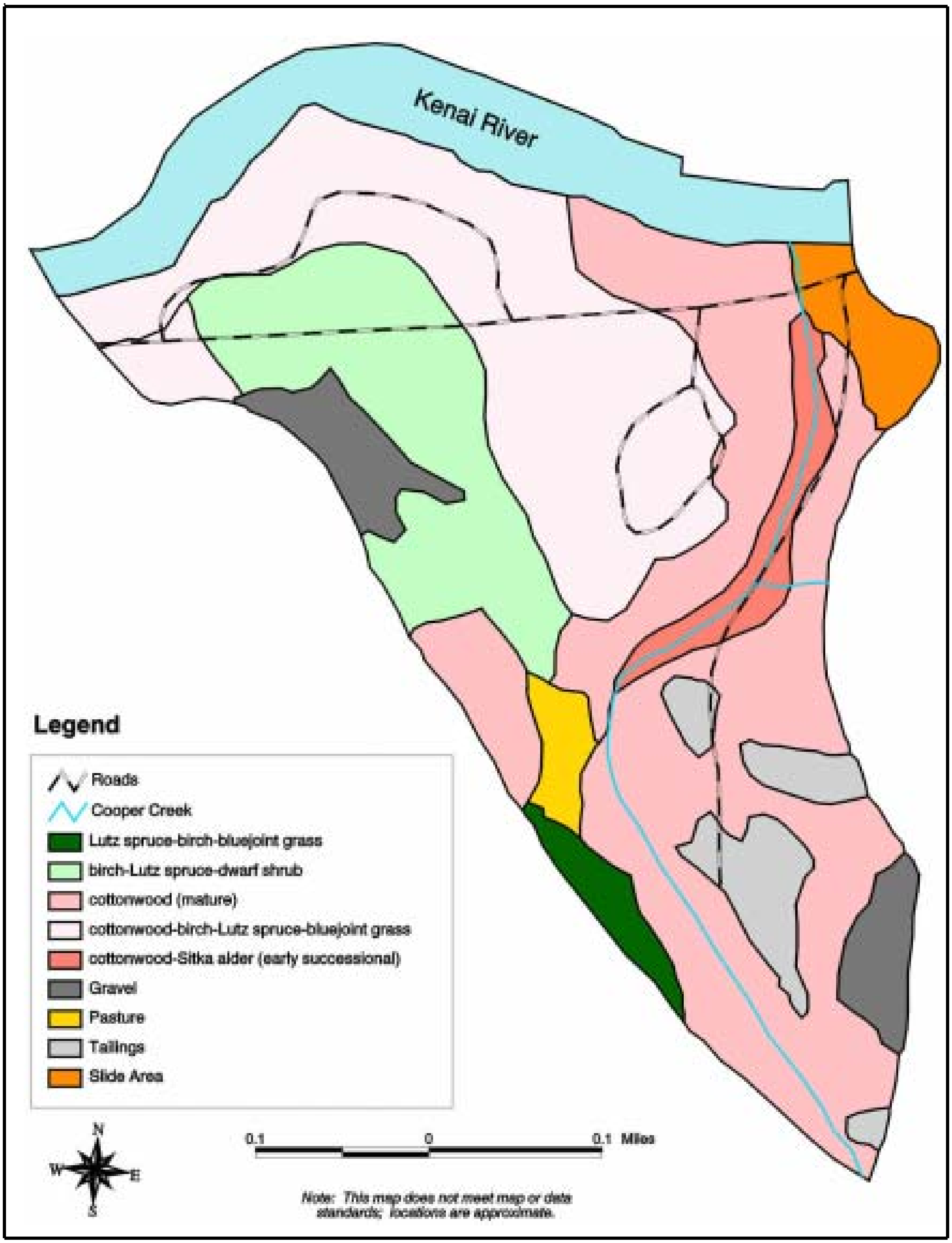


Table 2.III.C-2 quantifies the vegetative changes on Cooper Creek's alluvial fan before and after construction of Cooper Lake Dam. Significant changes displayed on this table include a 3.4 acre increase in early successional cottonwood/alder within the former braided channel of Cooper Creek, and 4.9 acres of clearing for a gravel pit on the east side of Cooper Creek.

Table 2.III.C-2: Vegetation Change on Cooper Creek's Alluvial Fan

Vegetation type	Current (Acres)	Pre-Dam (Acres)	Change (Acres)
gravel	4.9	0	+4.9**
slide area	2.8	2.1	+0.7
pasture	1.5	1.4	+0.1
tailings	4.6	4.4	+0.2
cottonwood/alder (early successional)	3.4	0	+3.4*
cottonwood (mature)	32.9	33.4	-0.5
cottonwood-birch-Lutz spruce/bluejoint	25.6	26.5	-0.9
Lutz spruce-birch/bluejoint	1.7	2.6	-0.9
Lutz spruce-birch/dwarf shrub	13.8	17.2	-3.4**
braided stream channel	0	3.7	-3.7*

* *Changes directly linked to reduced flow in Cooper Creek due to dam installation.*
** *Changes associated with gravel extraction.*

Table 2.III.C-3: Common and Scientific Names for Plants in the Watershed

Common Name	Scientific Name
Lutz spruce	Picea lutzii
cottonwood	Populus balsamifera spp. trichocarpa
Sitka alder	Alnus crispa spp.
horsetail	Equisetum spp.
bluejoint	Calamagrostis canadensis
sedge	Carex spp.
birch	Betula papyrifera
mountain hemlock	Tsuga mertensiana
fireweed	Epilobium spp.
lowbush cranberry	Vaccinium vitus-idaea
clover	Trifloium spp.
timothy	Phleum pratense
common plantain	Plantago major

D. Wetlands

1. Wetlands Definition

Wetlands are defined in the 1987 Corps of Engineers Wetlands Delineation Manual as:

> "Those areas that are inundated or saturated by surface or ground water 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. Wetlands generally include swamps, marshes, bogs, and similar areas."

Figure 2.III.D-1 and ***2.III.D-***2 show the mapped wetlands within the Cooper Creek Watershed. The U.S. Fish and Wildlife Service, using the National Wetlands Inventory (NWI) procedure,. Wetlands are divided into five major wetland "systems". Three of these major systems occur in the Cooper Creek Watershed, namely: palustine, lacustrine, and riverine. These wetland systems, as well as their associated sub-systems, classes, and sub-classes are defined in detail in the 1992 USF&WS publication, "Classification of Wetlands and Deepwater Habitats of the United States".

Wetlands displayed in ***Figure 2.III.D-1*** and ***2.III.D-2*** were inventoried primarily from 1:60,000, color infrared photography taken in August 1978 by NASA,. Accuracy of this wetlands delineation process is about 75%. Not well represented on the map are wetlands less than an acre in size, particularly forested wetlands. The watershed has a number of these small wetlands that are not displayed in the figure.

Palustrine wetlands are non-tidal wetlands dominated by trees, shrubs, and emergent vegetation including mosses and lichens. ***Figure 2.III.D-1*** identifies 760 acres of palustrine wetland in the Cooper Creek Watershed. The great majority of these wetlands are located on the low-lying ground at the south end of Cooper Lake/Reservoir. Other palustrine wetlands in the watershed are small in size, sparsely distributed, and situated primarily in low gradient areas.

Cooper Lake appears to have had a higher water level in the past, possibly due to glacial damming near the lake's north west end. If this damming occurred, the lake would have inundated lands at its south end. Fine-grained lake sediments likely deposited in these shallow flats. Such fine-grained, poorly drained sediments provide an ideal substrate for subsequent development of palustrine wetlands.

Lacustrine wetlands are defined as lakes greater than 2 meters in depth or 20 acres in size. ***Figure 2.III.D-1*** identifies 2240 acres of lacustrine wetland within the Cooper Creek Watershed. Cooper Reservoir accounts for almost all these acres, with one pond to the south of the Reservoir contributing additional acres. Cooper Reservoir, as displayed in ***Figure 2.III.D-1***, was mapped when the water was at an elevation of 1172 feet. The surface area of the reservoir, and hence the acreage of lacustrine wetlands, varies considerably depending on the reservoir's water level.

Figure 2.III.D-1: Wetlands within the Cooper Creek Watershed
(by Wetland System)

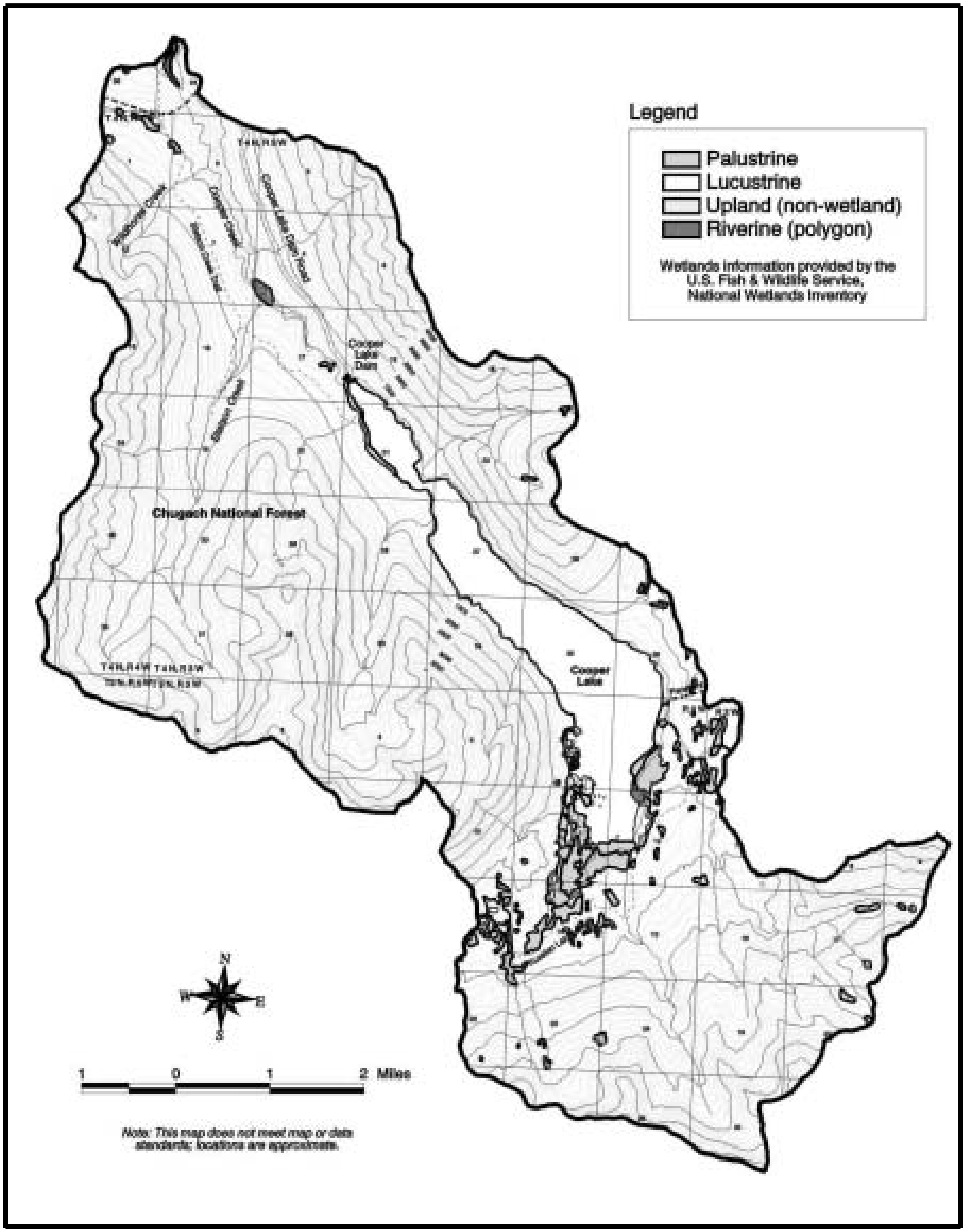
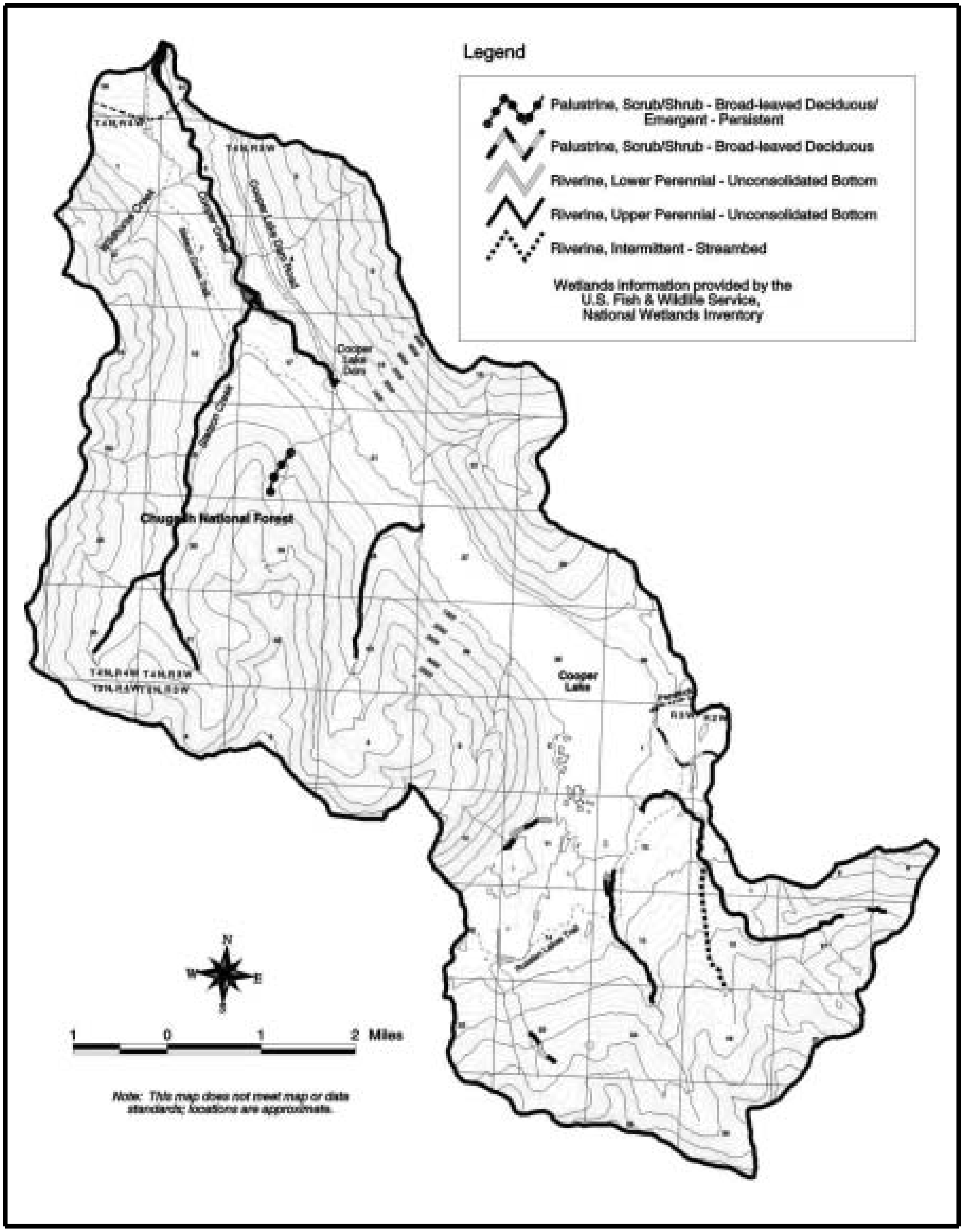


Figure 2.III.D-2: Riverine Wetlands within the Cooper Creek Watershed



The riverine system includes wetlands and deepwater habitats within stream channels. Mostly these wetlands are mapped as linear features (without area) along stream corridors as seen in ***Figure 2.III.D-2***. This figure displays nearly 31 kilometers (19 miles) of riverine wetlands along stream corridors within the Cooper Creek Watershed. ***Figure 2.III.D-1*** identifies a few riparian wetland polygons totaling 12 acres.

2. Wetland Changes.

Changes in both wetland acres and type have occurred due to disturbances within the Cooper Creek Watershed. Initial changes were related to early mining activity, and later changes occurred with construction of Cooper Dam.

Wetlands - 1890 to 1958. Early mining efforts in the Cooper Creek Watershed had some impact on wetlands. Primary impacts to palustrine wetlands were likely from ditchlines and roads/trails. The ditchline and road along the west side of Cooper Creek from its mouth up to Stetson Creek likely had the largest impact.

Hydraulic mining on the lower Cooper Creek fan and on Stetson Creek caused significant land disturbance, but occurred mostly on well-drained alluvial deposits that were likely not wetlands. Channel disturbances from mining on both Cooper and Stetson Creeks impacted several miles of riverine wetlands on these two streams.

Construction of the Upper Russian Lake Trail in the 1930's around the southeastern end of the Cooper Creek Watershed involved crossing though a number of small wetlands. Impacts to the wetlands were limited.

Wetlands – after 1958. Construction of the Cooper Lake Project involved building roads into the watershed to both the dam and the tunnel/penstock intake at the east end of the lake. The roads, the dam, and the penstock all involved construction efforts that displaced palustrine wetlands, likely between 1 and 5 acres

The greatest displacement of palustrine wetlands occurred around the perimeter of Cooper Reservoir, particularly at its south end. At the reservoir's south end, the rising water inundated broad areas of scattered wetlands. Inundation of muskegs/peat bogs caused floating and/or eventual removal of the thick organic mat from the underlying soil.

Fluctuating water levels allows waves to impact Cooper Reservoir's shoreline between elevations 1168 and 1195. In many cases, wave erosion has removed the soil and underlying fine-grained substrates from the shoreline. Most of the reservoir's shoreline is currently gravel/cobble or bedrock. A few areas of shoreline along the reservoir's southwest side are protected from wave action and retain their fine-grained substrates. In some cases these shorelines are vegetated with grasses/sedges able to withstand intermittent inundation. Wetland displacement/conversion caused by reservoir inundation has not been well determined, but is likely on the order of 50 to 150 acres.

3. References for Wetlands

Dept. of Army Environmental Laboratory, "Corps of Engineers Wetlands Delineation Manual", Army Corps of Engineers Technical Report Y-87-1, Washington, DC, January 1987.

Cowardin, L.M., Carter, V., Golet, F.C., and LaRoe, E.T., "Classification of Wetlands and Deepwater Habitats of the United States", U.S. Fish and Wildlife Service, FWS/OBS-79/31, USDI, Washington, DC., December 1979, reprinted 1992.

USF&WS National Wetland Inventory map of the Cooper Creek Watershed. Mapped on USGS quad sheet Seward B-8, 1988.

Table of Contents – Chapter 3

CHAPTER 3– KEY QUESTIONS AND ISSUES

This chapter presents key questions, issues, and opportunities that have come to light through the Cooper Creek Watershed analysis process. Many of the issues identified tie directly or indirectly to the Cooper Lake Hydroelectric Project and its upcoming relicensing.

This watershed analysis attempts to identify important information we know about the watershed. It also focuses on key data gaps, where information is not currently available, and may be needed to respond to future management of the watershed. We used Forest Service staff, and other agencies, groups, and individuals to helping us define future needs for the Cooper Creek Watershed. Chapter 3 presents issues, concerns, and opportunities that may help us better consider designing the future for the Cooper Creek Watershed. It also serves as a source of recommendations for future studies and activities to be considered in and adjacent to the watershed.

I. Historic/Social

A. Subsistence/Recreation

Cultural Resources. Survey of native cultural sites in the Cooper Creek Watershed has been limited, and known sites are relatively few. However, Cooper Creek's close proximity and possible connection to the Sqilantnu Archeological District may lend importance to existing sites and those yet undiscovered. Reduced streamflows and reduced flooding on Cooper Creek as a result of the Cooper Lake Hydroelectric Project have likely had a positive effect on the longevity of house and cache pit sites along the creek.

Cultural resources issues and concerns in relation to areas affected by the Cooper Lake Hydroelectric Project relicensing include:

- ***Are there additional cultural resources that have not yet been surveyed?***
- ***Are prehistoric and historic cultural resources in the area eligible for the National Register of Historic Places?***
- ***How do the prehistoric and early historic cultural resources present in the Cooper Creek Watershed relate to the Squlantnu Archeological District, and should any of these resources be included in the District?***

Recreation. Construction of the Snug Harbor Road for the Cooper Lake Project in 1958 and 1959 provided public access to Cooper Reservoir and its surrounding lands. With this access came greatly increased public recreation use of the area. Recreation uses include camping, boating, and fishing/hunting on and around Cooper Lake, and hiking on the Russian Lakes Trail and Rainbow Lake Trail. Winter use has grown rapidly in the last decade. The last three miles of the Snug Harbor Road receive heavy recreation use as a winter access route for snowmachines and skiers/snowshoers. The Cooper Dam Road constructed in 1959 provides additional summer and fall recreation access into the watershed for hikers and mountain bikers.

Recreation use raises a series of questions as to how area recreation needs are being met. Questions include:

- ***Are boating, camping, parking, and day-use recreation needs being adequately met at Cooper Reservoir?***

- ***Are trails and trail conditions meeting public needs on the Russian Lakes Trail, Rainbow Lake Trail, and Cooper Dam Road?***

- ***Are parking, information, and winter access needs being adequately met for winter recreationists on the Snug Harbor Road?***

- ***What dispersed camping use and impacts are occurring on the east side of Lower Creek's lower half mile? Could this camping be better accommodated with a developed recreation site?***

- ***Is adequate interpretation of prehistoric and historic cultural sites on lower Cooper Creek being provided for recreation users of the area?***

Potential opportunities for recreation development in and adjacent to the Cooper Creek Watershed are further discussed in Chapter 4, Section E (Recreation Facilities Opportunities).

B. Minerals

Mining activity on lower Cooper Creek in the early 1900's likely had extensive adverse impacts on spawning and rearing habitat for both salmon and trout. Channel alteration, soil loss, and removal of mature riparian vegetation are mining related factors that are particularly damaging to fish habitat.

Hydraulic mining along lower Cooper Creek between 1908 and 1917 appears to have caused long-term alteration of the stream channel. At the time of construction of the Cooper Lake Project in the late 1950's and early 1960's, lower Cooper Creek's channel was still showing marked instability and lack of adjacent mature riparian vegetation communities (and woody debris in the channel).

Natural recovery of the mining impacted stream habitat on Cooper Creek likely would have taken well over a century under natural flow conditions. During recovery, salmon and trout spawning and rearing habitat would likely steadily improve due to increases in large woody debris, cover, and pools on the stream channel.

Construction of the Cooper Lake project altered flow and stream temperatures on Cooper Creek. Ongoing recovery of Cooper Creek fish habitat from mining impacts appears to be overshadowed by the current adverse flow and temperature effects.

Present day mining activities. Placer mining operations continue on Cooper Creek to the present day. Current operations are primarily small suction dredges and hand sluicing. Mining operations have generally benefited from the reduced flows, which allow easier access to the stream bottom. Any potential future flow alterations or channel enhancements on Cooper Creek should be coordinated with management of the current recreational and commercial gold mining activities on the creek.

Recreation mining. Lower Cooper Creek lies within a mineral withdrawal, but the “active” stream channel remains open to recreation mining, including: panning, sluicing, and suction dredging (May 15 to July 15 only for suction dredging.) If proposals were made for stream and/or riparian zone restoration along Cooper Creek, such measures should consider potential impacts to the restoration work by recreation mining.

C. Land Status/Special Use Permits

Land status issues include:

- ***Coordination of land owners/managers.*** Lower Cooper Creek has a mix of land ownerships including the Forest Service, Alaska Department of Natural Resources, and the Kenai Peninsula Borough. The Borough proposes to sell some of its Cooper Creek lands for private residential lots. Any future channel enhancements, or flow alterations on lower Cooper Creek would likely need to be coordinated between the various land owners/managers.

- ***State Lands on Cooper Reservoir.*** The water intakes for the Cooper Lake Project at the east end of Cooper Reservoir, as well as the upper Snug Harbor Road, are located on State of Alaska (DNR) lands. Potential developments on Cooper Reservoir such as a boat launch, restroom facilities, and picnic area would logically be situated on these State lands. Boating launching facilities would provide improved access to National Forest Lands on Cooper Reservoir.

- ***KRSMA.*** Cooper Reservoir and Cooper Creek are managed as part of the Kenai River Special Management Area (Alaska State Parks). Development activities along the shores of these two waterbodies are subject to certain recommended regulations and restrictions under KRSMA.

- ***Road maintenance on Snug Harbor Road.*** The Forest Service holds a right-of-way for the Snug Harbor Road where it crosses State lands. The Forest Service pays annual road maintenance costs on this road. The road was built specifically for construction and servicing of the powerplant and penstock/tunnel for the Cooper Lake Project. An opportunity exists to transfer maintenance costs to Chugach Electric Association.

- ***Road maintenance on Cooper Dam Road.*** A number of drainage problems are currently noted on the Cooper Dam Road, including failed culverts and non-functioning drainage ditches. Without correction, road surface damage, road erosion, and stream sedimentation are likely to occur.

II. Physical Setting

A. Climate

This report presents a variety of available climate data. Adding climate stations and collecting more data at existing stations could improve climate characterization for the watershed. However, issues have been raised to date pointing to the specific needs for improved climate information.

B. Hydrology and Water Quality

USGS monitored streamflows at Cooper Lake's outlet for the 10 years (1949-1959) before construction of the Cooper Lake Dam. Since then, average annual values for inflows into Cooper Reservoir can be estimated using known reservoir levels and calculated outflows through the tunnel/penstock to the powerplant.

USGS monitored daily streamflows near Cooper Creek's mouth at the Kenai River both before and after dam construction, from October 1957 to January 1965. USGS restarted a station on lower Cooper Creek on August 13,1998, collecting daily streamflow and daily mean, maximum, and minimum stream temperatures.

Stetson Creek daily streamflows were monitored from May 1958 through September 1963. Streamflow values on Stetson Creek have been unaffected by construction of the Cooper Lake Project.

Available streamflow data is very helpful in characterizing flow conditions within the Cooper Creek Watershed. Specific issues demanding additional flow data have not been raised to date. Hydrology and water quality issues that have been noted include:

- ***How have flood flows on Cooper Creek changed in size and duration since construction of the Cooper Lake Project?***

  This question is answered in Chapter II using existing flow records. During the periods when daily streamflow records were kept on Cooper Creek, no large flood events occurred. A better understanding of large floods in this drainage would require either modeling and/or a longer period of data record.

- ***What stream temperature changes have occurred on Cooper Creek as a result of construction of the Cooper Lake Project?***

  ADF&G stream temperature data from Cooper, Crescent, and Juneau Creeks in 1998 and 1999, point to a probable 6 to 8°F depression in daily summer stream temperatures on Cooper Creek. Temperature records for additional years would be desirable on these three streams. Another approach would be to model undammed temperatures for Cooper Creek using surface water temperatures from Cooper Reservoir and the estimated natural outflow volumes without the hydropower project.

- ***What effects did the construction of Cooper Lake Project have on sediment movement down Cooper Creek, and substrate embeddedness in the channel?***

  Flood size and duration has been greatly reduced on Cooper Creek since construction of the Cooper Lake Project. This has resulted in a narrowing of the channel and alterations in the movement of movement of stream sediments within the channel. The significance of changes in sediment loads and sediment movement within Cooper Creek on the character of in-channel, and riparian habitat has not been determined. Comparing substrate sizes and embeddedness on Cooper Creek with similar undammed streams such as Juneau and Crescent Creeks would aid in understanding the size of changes that may have occurred on Cooper Creek.

C. Limnology

Water temperature and quality, circulation patterns, and other limnologic parameters may have changed within Cooper Reservoir as a result of dam construction. However, little or no pre-dam data is available to compare against present conditions. Changes after dam construction may be subtle due to the large size of the lake, and the relatively small change in surface area after damming. Noted limnology issues include:

- ***Has the conversion of Cooper Lake from a natural lake to a fluctuating reservoir affected physical or biologic processes within this waterbody?***

  Possible avenues for evaluating if limnologic changes have occurred at Cooper Reservoir include: comparing the reservoir with similar, undammed lake systems, and modeling of pre-dam conditions. Within the nearby area, Crescent Lake then upper Russian Lake are probably the most similar to Cooper in terms of size, elevation, drainage area, and water clarity.

Potential change in Cooper Reservoir's primary biologic productivity is probably the issue of greatest public concern. Addressing this issue involves determining if the reservoir's macroinvertebrate population has changed significantly in quantity, species distribution, or aerial distribution within the reservoir. If the primary productivity were determined to have changed in some significant way, then evaluation of potential influencing factors should be considered. Such factors might include: nutrient supply, predation, water temperature, circulation patterns, and effects of fluctuating shorelines.

D. Land Stability

Land stability has not been identified as a key issue for management within the Cooper Creek Watershed. The watershed does have several unstable areas subject to natural erosion. Land stability issues within the Cooper Creek Watershed associated with the Cooper Lake Project are limited primarily to the Cooper Dam Road, which contours along a steep hillside in Cooper Creek Valley. No known mass failures have occurred on this road since its construction in 1959. Improving existing side and cross drainage on the Cooper Dam Road is an identified watershed improvement issue.

A naturally eroding bluff on the east side of Cooper Creek's mouth has carried fine sediment into Cooper Creek for a number of decades. Sediment moves off the bluff in a slurry during heavy rains and spring snowmelt. Some sediment reaches Cooper Creek, and then the Kenai River. In 2000 and 2001, the Forest Service stopped virtually all sediment flow into Cooper Creek at this site by installing a silt fence around the base of the eroding slope. Crews planted grasses and shrubs between the silt fence and Cooper Creek to provide additional buffering. The silt fence has been very effective in capturing sediment flowing off the hillside. The Forest Service plans to continue using silt fence at this site for a number of years until a wide riparian buffer has had a chance to develop.

Stability concerns at Cooper Dam are very low under its current management scheme. Cooper Reservoir is operated so that its maximum water level does not reach above elevation 1194 feet. This maximum reservoir level, 16 feet below the dam spillway, and 26 feet below the crest of the dam, minimizes any possibility of a catastrophic failure of the Cooper Lake Dam.

E. Fire

Wildfire and proposed controlled burns have not been identified as major issues in relation to relicensing for the Cooper Lake Hydropower Project. Increased access to the watershed as a result of the hydropower project has increased access for fire control, while at the same time increasing the potential for fire starts. Proposed control burns within the watershed are not projected to alter existing runoff rates or sediment loads to Cooper Creek.

III. Fauna/Flora

A. Fisheries

1. Salmon in Cooper Creek

Cooper Creek salmon escapement data is sparse, both before and after construction of the Cooper Lake Hydroelectric Project. Pre-dam data indicates Cooper Creek had runs of chinook, sockeye, and coho salmon. Some pink salmon may also have been present. Pre-dam salmon counts were infrequent, and usually made on a single day, during the spawning season. Counts were mostly visual estimates. Run size estimates were generally between tens and hundreds of salmon on the day censuses were taken.

Whether the pre-dam counts were made when most of the salmon were "in" is not clear. Due to the infrequency of the surveys, a significant portion of the fishery possibly went uncounted. What portion(s) of the creek the surveyors evaluated is generally not clear. Based on the available pre-dam escapement data, as well as anecdotal information, we believe salmon used Cooper Creek for spawning, and the escapements may well have been of moderate size. The available pre-dam data, however, is too sporadic and poorly documented to provide a reasonable estimate of former salmon populations on Cooper Creek.

We have gleaned very little information on what, if any, chinook, sockeye, or coho salmon fry rearing occurred on Cooper Creek before construction of the dam. Based on the low number of pools in the system, many of the fry may have outmigrated to the Kenai River fairly quickly after emergence from the stream gravels.

Sporadic salmon escapement data has been collected on Cooper Creek since 1960 (and the construction of the Cooper Lake Dam.) The chinook salmon run apparently petered out over several years (***Table 2.III.A-2***) after the dam was completed. Coho and sockeye salmon do not appear in any of the monitoring done between 1960 and 1968. ADF&G has considered Cooper Creek to be primarily devoid of salmon in recent years.

ADF&G Sportfish Division operated a weir on Cooper Creek in 1999 to 2001 to track the migration of spawning Dolly Varden. They operated the weir from late August to early October in 1999, and from mid-July to mid-October in 2000 and 2001. During the three years of monitoring, ADF&G captured just a few sockeye and coho, and one chinook salmon at the weir. A number of these salmon were clearly straying into and out of Cooper Creek. A few may have spawned in Cooper Creek, but were not observed doing so upstream from the weir. In 1999, five sockeyes were observed spawning in the lower reach of the stream below the weir (Larry Larson, personal communication.)

Important information needs for understanding salmon use in Cooper Creek include:

- ***What are the current salmon escapements into Cooper Creek? What are the migration patterns/timing of the salmon using Cooper Creek?***

  The 1999-2001 weir data indicate that only a very few salmon frequent Cooper Creek, a number of which are strays. The accuracy of this data could be improved by operating the Cooper Creek weir over a wider timing window, and by taking more vigilant steps to make the weir "fish tight" so that all migrating fish are counted. Ideally the weir could be operated from ice out in April to ice up in October so that a wider window of fish migration could be observed.

- ***What were the sizes of pre-project salmon runs on Cooper Creek?***

  Pre-project escapement data collected on Cooper Creek is of questionable quality. This data provides only a limited understanding of salmon usage on Cooper Creek. Two approaches available for evaluating pre-project salmon escapements are: 1) an instream flow evaluation, and 2) an evaluation of salmon runs on nearby streams with characteristics similar to Cooper Creek.

  An instream flow evaluation for Cooper Creek should consider how flow alterations, diminished summer stream temperatures, and altered sediment movement all work together to affect available spawning and rearing habitat on Cooper Creek. Instream flow modeling can be used to evaluate habitat potential over a wide range of flow and temperature conditions.

  Another approach for estimating pre-project escapements is to evaluate habitat values and salmon escapements on streams similar in character to Cooper Creek. Two potential candidates are Juneau Creek (directly across the Kenai River from Cooper Creek) and Crescent Creek (flowing into Quartz Creek and then Kenai Lake). Juneau and Crescent Creeks share many similarities with Cooper Creek in terms of flow, and basin size and morphology.

  As an example, a comparative study might conduct escapement surveys along spawning-accessible segments of both Cooper and Juneau Creeks over the course of the season. Escapements could be compared for the two physically similar watersheds, one dammed, and the other not. This comparative technique would not give a precise indication of the former salmon escapements on Cooper Creek, but it could provide a range for evaluating Cooper Creek's potential.

2. Resident Fish in Cooper Creek

Information on rainbow trout and Dolly Varden populations in Cooper Creek before construction of the Cooper Lake project is limited to a creel census and a variety of anecdotal information. Nick Lean, a former Cooper Landing Resident, indicates that large rainbow trout used both Cooper Creek and its outlet on the Kenai River. A fishable run of Dolly Varden was also reported in the stream.

Based on patterns in adjacent Kenai River tributaries, we surmise that the large rainbows reported in Cooper Creek (before the dam) were probably spawning adults. These Kenai River fish generally enter tributaries in April and May to spawn. After spawning, they return to the Kenai River system, over-wintering mostly in Kenai and Skilak Lakes. The extent to which Cooper Creek may have been used for rearing by rainbow trout is not known, but was likely limited due to the stream's very limited pool habitat.

Large Dolly Varden reported in Cooper Creek before construction of the dam were also likely spawners entering from the Kenai River system. These fish probably immigrated into Cooper Creek to spawn in July through September, and then returned to the Kenai River in late September through November. Emerging Dolly Varden fry reared for an unknown amount of time in Cooper Creek, then out-migrated to the Kenai River.

Information on Cooper Creek rainbow trout remains sparse after construction of the Cooper Lake Project. Available information does appear to indicate that rainbow trout spawning in Cooper Creek essentially stopped after construction of the dam. Recently, only occasional stray rainbows have been found in Cooper Creek. This end to rainbow trout use is mentioned extensively in past correspondence between the Forest Service, ADF&G, and USF&WS. Biologists generally attribute Cooper Creek's rainbow population decline to the lowering of the creek's spring and summer water temperatures after construction of Cooper Dam. Several ADF&G biologists have reported that stream temperatures are presently too cold to attract spawning adults into Cooper Creek.

In contrast to rainbow trout, Dolly Varden spawners from the Kenai River system currently appear to be thriving in Cooper Creek. ADF&G weir studies in 1999 – 2001 show several hundred adult Dolly Varden entering Cooper Creek each July through September to spawn. A Forest Service trapping study in August 1997 found juvenile Dolly Varden in Cooper Creek up to and past its junction with Stetson Creek. Some of these juvenile fish may remain in Cooper Creek for a year or more. When they reach a size where available food or other habitat characteristics become limiting, they likely outmigrate to the Kenai River system.

Important information needs for understanding resident fish in Cooper Creek include:

- ***What is the size and character of current resident fish runs on Cooper Creek?***

  ADF&G operated a fish weir on Cooper Creek from August 28 to October 6, 1999; July 16 to October 20, 2000; and July 19 to October 19, 2001. The weir had both up and downstream traps so that fish could be counted moving both in and out of Cooper Creek. From this weir data, ADF&G has evaluated migration patterns for spawning Kenai River Dolly Varden during 1999-2001. The data also offers insights into the limited use of Cooper Creek by several salmon species, rainbow trout, whitefish and even one grayling. Additional important information on the full Dolly Varden run as well as determination of use by rainbow trout could be obtained by operating a weir on lower Cooper Creek between ice-out and freeze-up (generally late April to late October.)

Weir data from all three years (particularly 2000) indicate that some fish passed the weir uncounted. If this is the case, then the actual fish counts are low. What percent of fish were able to get past the weir without being counted has not been determined. Any additional weir studies should focus on making the weir "fish tight" so that fish are unable to pass the weir uncounted. Mark/recapture studies could also be used to evaluate the percent of fish are passing the weir uncounted.

- ***What was the size and character of pre-project resident fish runs on Cooper Creek?***

  As with salmon, pre-project rainbow trout and Dolly Varden populations could be estimated using an instream flow methodology. Instream flow modeling would allow comparisons Cooper Creek habitat before and after construction of the Cooper Lake Project.

  Useful information could also be obtained by evaluating resident fish runs on similar, undammed systems such as Juneau Creek and Crescent Creek. Installing a fish weir from ice-out to freeze-up (April to October) on one or more of these similar systems could provide valuable information about the patterns of fish use that may have occurred on Cooper Creek before construction of the dam.

- ***What changes in instream rearing habitat for resident fish have occurred on Cooper Creek as a result of dam construction?***

  Running synchronous trapping surveys for juvenile fish on both Cooper Creek and a paired, undammed system would provide a useful comparison to understand the rearing characteristics of both systems. It could provide insight into whether significant rearing habitat changes may or may not have occurred on Cooper Creek. The issue of potential change in rearing habitat on Cooper Creek could also be evaluated using instream flow methodology.

3. Resident Fish in Cooper Lake

Limited information is available on the resident fish in Cooper Lake/Reservoir and their population dynamics both before and after construction of Cooper Lake Dam. USF&WS test netted Cooper Lake in 1955 and reported char as the only sport fish captured. We know of no pre-dam data evaluating the Lake's char population size, or its spawning, rearing, and feeding habits. We have found no hard data identifying rainbow trout and/or lake trout in Cooper Lake before the dam.

Cooper Reservoir currently supports populations of Arctic char and rainbow trout. The rainbow population originated from an ADF&G stocking program implemented between 1987 and 1994. This rainbow population has become self-sustaining, with adult spawning occurring in several inlet streams to Cooper Reservoir. No other sport fish populations are known in the Reservoir. Slimy sculpin are the only other known fish population in the lake.

Important information needs for understanding resident fish use in Cooper Lake/Reservoir include:

- ***What are the sizes of current Cooper Reservoir Arctic char, rainbow trout, and Coast Range sculpin populations?***

  A variety of population censing techniques could be used. Mark/recapture studies might be a logical approach for Cooper Reservoir trout and char.

- ***Do any other fish populations exist in Cooper Reservoir?***

  Numerous studies by the USF&WS, ADF&G, and the USFS have involved fish capture in Cooper Lake/Reservoir. At present, Arctic char and rainbow trout are the only known sportfish. Chinook salmon fry were stocked in the reservoir in 1984. Some of these fry were recaptured in minnow traps the following year (1985), but no chinooks have been discovered in any subsequent studies.

  A 1994 Forest Service report mentions an undocumented report of lake trout in Cooper Reservoir. No lake trout, however, have been identified in any of the numerous netting and trapping studies on the Reservoir, and their presence in seems doubtful. Future population studies on Cooper Reservoir char and trout might use traps or nets, and should logically identify any additional fish species captured.

- ***Are Cooper Reservoir Arctic char genetically distinct from other Arctic char populations?***

  Cooper Lake Arctic char may have been isolated in the lake for several hundred or even several thousand years. A possibility exists that these char are a distinct genetic strain, different from other char populations on the Kenai Peninsula and in Southcentral Alaska.

  Recent genetic evaluations of ten Cooper Reservoir char, however, suggest these fish are not genetically distinct from Arctic char in three other Kenai Peninsula lakes. Wider sampling and genetic evaluation of Cooper Reservoir char would be desirable.

- ***What are the spawning, rearing, and feeding patterns for fish within Cooper Reservoir by species? Where and when does spawning occur by species?***

Current spawning and rearing patterns for the known species in Cooper Lake, Arctic char, rainbow trout, and sculpin are not well understood. Rainbow trout spawning occurs in several inlet streams to Cooper Lake in the late spring/early summer, but their spawning patterns are not well understood. Arctic char likely spawn within Cooper Reservoir in the fall, but where and when spawning occurs has not been verified. Spawning studies would involve observing adult fish during spawning, and evaluating the success of their spawning redds.

Use of Cooper Reservoir by rainbows, char, and sculpins is not well understood. Initial studies indicate that rainbows inhabit shallower waters in the Reservoir, while char tend to be in deeper. Evaluation of rearing habitat for Cooper Reservoir would involve determining the spatial and temporal distribution of fish within the reservoir, likely through netting of rainbows and char, and trapping of sculpin. Determining feeding patterns might include evaluating stomach contents (by species and size).

- ***What changes have occurred in spawning and rearing habitat for rainbow trout and Arctic char as a result of the Cooper Lake Project and its associated reservoir level fluctuation and alterations to stream and lake side vegetation?***

  Overhanging vegetation has been lost on Cooper Reservoir, and on lower reaches of its inlet streams due to the fluctuation of reservoir levels. As well, char spawning habitat within the reservoir may go dry in some winters, and trout spawning habitat in inlet streams may get inundated in some summers. The extent of such effects, if any, is not known. Use of lakeside habitat by trout and char on Cooper Reservoir could be compared with nearby unregulated lake systems like Rainbow, Char, Crescent, and Juneau Lakes to identify if significant differences exist in patterns of use.

- ***How does reservoir level fluctuation affect rainbow trout spawning success in inlet streams?***

  Rainbow trout spawning in lower reaches of Cooper Reservoir inlet streams can be adversely impacted by both lack of vegetative cover, and by inundation of the eggs by rising reservoir levels. By mapping the locations of rainbow trout spawning redds, and determining the time needed for eggs to hatch, the susceptibility of individual redds to inundation could be determined. Survival rates of inundated redds could be measured in the field or modeled.

  The primary impact of streamside vegetation loss in spawning areas is likely to be increased predation. Quantifying this impact may be difficult. One approach would be to compare predation rates during spawning on denuded bank segments versus predation rates on vegetated bank segments.

If spawning either within Cooper Reservoir or its inlet streams were adversely impacted by inundation, a possible mitigation measure could be to regulate how and when reservoir levels are altered.

B. Wildlife

Key questions and issues with wildlife in the Cooper Creek Watershed revolve primarily around the question of how have habitats have been affected by various activities.

In this watershed analysis we have attempted to respond to habitat issues for a variety of species and groupings of species (see ***section 2.III.B***). The model used to estimate habitat condition under a variety of scenarios was simplistic. No accurate censusing of any wildlife populations within the watershed is currently known or available.

Wildlife species that have drawn particular attention in the course of this Watershed Analysis include: nesting waterfowl, eagles, and brown bears. Gaining an improved understanding of both the populations of these species and their patterns of use within the Cooper Creek Watershed would be useful for estimating how these species may respond to changes in habitat.

Important information needs for understanding wildlife use in the Cooper Creek Watershed include:

- ***How has waterfowl nesting/rearing habitat been affected at Cooper Reservoir by to water level fluctuations and losses of cover along the shore?***

  Waterfowl nesting concentrations on Cooper Reservoir could be compared to concentrations on similar, nearby, undammed lakes (e.g. Upper Russian Lake, Crescent Lake) to evaluate if any significant differences existed. Nesting success of Cooper Reservoir waterfowl could also be compared with that of waterfowl on other nearby lakes to evaluate if reservoir fluctuation affects waterfowl production.

- ***How has brown bear feeding on Cooper Creek been altered by changes in salmon use of the creek after construction of the dam?***

  Little censusing data exists for brown bear use on Cooper Creek either before or after construction of the Cooper Lake Project. Evaluating how brown bear used the creek before the Cooper Lake Project requires an improved understanding of the size and timing of salmon runs on the creek. Juneau Creek, just across the Kenai River from Cooper Creek is quite similar to Cooper Creek in size, character, and location, and is unaltered by land disturbance or flow regulation. Evaluation of brown bear use on Juneau Creek during spawning (July through September) could provide an approximation of brown bear use on Cooper Creek before mining and flow regulation.

- ***How has bald eagle nesting habitat on the lower half mile of Cooper Creek been altered by changes in both the vegetation and in the salmon use of the creek? Do options exist to restore lost nesting habitat?***

  Removal of mature cottonwood forests on the Cooper Creek's lower half mile during placer mining operations likely eliminated a number of suitable eagle nesting sites. Loss of the salmon fishery in Cooper Creek likely further reduced the quality of the nesting habitat. Evaluating eagle nesting on Juneau Creek's alluvial fan (which is unaffected by mining or flow regulation) could give a good sense of Cooper Creek's potential nesting habitat.

  The potential for bald eagle nesting on Cooper Creek could be improved by actively managing Cooper Creek's alluvial fan for mature cottonwoods, or by building enhanced (potential) nest sites in existing trees. Even with good nesting sites, however, the lack of salmon in Cooper Creek would work against the quality of the nesting habitat.

C. Vegetation Change

- ***What changes in vegetation have occurred as a result of management activities, and what are the effects of those changes.***

  The primary vegetation changes identified are those from placer mining at the mouth of Cooper Creek in the early 1900's, and from construction of the Cooper Lake Project. As relates to key questions in this watershed analysis, changes in vegetation are probably most important in relation to their effects on wildlife and fish habitats. These changes are most prominent along Cooper Creek's lower half mile, and around the margin of Cooper Reservoir in the zone of water fluctuation.

D. Wetlands

- ***What changes in wetlands have occurred within the Cooper Creek Watershed and what has been the effect of those changes?***

  The largest single change in wetlands identified in this analysis has been around Cooper Reservoir (particularly its south end) due to inundation of the shoreline by the Cooper Lake Project. Additional smaller changes to wetlands have resulted from mining, ditchlines, roads and powerlines into the watershed. Changes in wetlands provided in this analysis are quantified only as rough estimates. Improved estimates could be gained using a more detailed analysis of aerial photography from various years. Changes to wetlands are again of concern/interest in the Cooper Creek Watershed primarily as they affect fish and wildlife habitat.

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CHAPTER 4 – MITIGATION AND ENHANCEMENT

During the development this watershed analysis, a variety of mitigation and enhancement measures have been suggested both within the Forest Service, and externally, through other agencies, groups and individuals. The measures pertain largely to the Cooper Creek fishery, to changes at Cooper Reservoir, and to recreation facilities in the watershed. This chapter attempts to capture these mitigation and enhancement measures, and present them in summary.

The measures presented here are truly "from the drawing board", and none has been fully designed or evaluated. They are presented here to capture their essence and to stimulate thought on mitigation and enhancement opportunities at the Cooper Creek Watershed. The list presented is not exhaustive, and certainly could be expanded as more ideas surface.

A. Fisheries Mitigation and Enhancement on Cooper Creek

This section presents a variety of fisheries mitigation and/or enhancement measures that could be considered on Cooper Creek. Some of these measures involve diverting water from Cooper Reservoir into Cooper Creek, and others do not. The measures are presented in no particular order or priority. Additional measures can be created by combining one or more of the measures presented here.

1. Channel enhancement on lower Cooper Creek. Because of its greatly reduced flood flows, Cooper Creek has considerable potential for enhancement of pool habitat. Opportunities for altering the position and gradient of Cooper Creek's channel are limited mostly to its lower half mile across the alluvial fan. Channel enhancements could include lowering the stream gradient by creating stream meanders, and strategically placing large wood within the channel. Increasing pool habitat in this lower half mile could possibly benefit all salmon and trout species in Cooper Creek. However, without increasing stream temperatures and/or winter flows, primary benefit would likely accrue just to the creek's Dolly Varden populations on this lower half mile of stream.

2. Channel enhancement in Cooper Creek Canyon. Additional pool habitat could be created in Cooper Creek Canyon. Work could be done on approximately three miles of channel, from the mouth of the canyon (1/2 mile upstream from the mouth) up to Stetson Creek. Pool habitat could be created using weir structures that create a pool-drop channel pattern. Weirs can be constructed using boulders and or logs. Weirs would need to be designed in steps, so that fish passage is allowed. Life of the weir structures would be greatly enhanced by the current reduced flood flows on Cooper Creek. Unless water temperatures and/or winter flows are enhanced on Cooper Creek, the benefit of increased pool habitat would likely be primarily just for Dolly Varden.

3. Return some winter flow to Cooper Creek from Cooper Reservoir. This mitigation measure would require maintaining a minimum flow of about 20 CFS flow in Cooper Creek through the winter. It would involve siphoning, tunneling, or otherwise passing reservoir water over and/or through the Cooper Dam and into Cooper Creek. Current streamflow would need to be augmented by water from Cooper Reservoir during low flow periods (usually occurring in January to April) to improve spawning habitat availability and survival rates.

The primary benefit of this measure would likely be increased egg-to-fry survival for Dolly Varden. Salmon spawning success could improve to some extent as well. Benefits would apply to 3 ½ miles of Cooper Creek, from its mouth up to Stetson Creek.

To improve spawning habitat on Cooper Creek in the ¾ mile of stream above Stetson Creek up to the barrier falls, would require tapping reservoir water from July through May, so that more waters would be available for spawning and egg incubation.

4. Return warmer streamflow to Cooper Creek from Cooper Reservoir during rainbow trout spawning. This measure would involve siphoning, tunneling, or otherwise passing reservoir surface water over and/or through the Cooper Dam and into Cooper Creek. This measure would target improving spawning habitat for rainbow trout.

The enhanced water temperature flows could logically be continued through the egg incubation period, late April through July. In order to reach pre-dam temperature levels in Cooper Creek, water extraction from the reservoir would need to approximate the pre-dam outflow hydrograph from Cooper Lake (varying from 50 to 250 cubic feet per second). Less water could be used, but would result in less warming of Cooper Creek.

This measure would targets rainbow trout specifically, and would likely have negligible benefits to salmon or Dolly Varden. Benefits of the measure would apply to the entire reach (over 4 miles) of Cooper Creek below the barrier falls.

A variation on this measure would be providing enhanced Cooper Reservoir surface flows from July through September to (possibly) encourage more salmon to enter Cooper Creek and spawn.

5. Divert Stetson Creek flows into Cooper Reservoir and optimize outflow from the reservoir into Cooper Creek. This measure would involve constructing a canal or other conveyance system to divert Stetson Creek at its lower end into Cooper Reservoir. Water from Cooper Reservoir would then be siphoned, tunneled, or otherwise passed through Cooper Dam into Cooper Creek. The outflow from Cooper Reservoir into Cooper Creek would then be optimized for ideal flow levels by season. From April to November, water could be taken at the reservoir surface to provide higher water temperatures on Cooper Creek.

This measure would benefit spawning and egg survival of both salmon and rainbow trout. Flows and temperatures could likely be adjusted to benefit one fish species more than other. Effects to Dolly Varden are less clear. Increased competition for spawning sites would likely occur. This measure would benefit the entire reach (over 4 miles) of Cooper Creek below the barrier falls. It would also create a 1/3 mile section of stream below Cooper Dam and above the barrier falls that could be used by rainbow trout or Dolly Varden.

6. Provide flushing flood flows down Cooper Creek to reduce the retention of fine sediments in the stream channel. This measure would involve siphoning, tunneling, or otherwise passing reservoir water over and/or through the Cooper Dam and into Cooper Creek in short, intense bursts. The size of flood, duration, timing, and frequency would need to be calibrated. Some pre-flood channel clearing would likely be needed in order to avoid damaging downstream effects.

This measure is intended to reduce the embeddedness of channel substrates in Cooper Creek. It would benefit the quality of spawning habitat and egg to fry survival for any salmon or trout species on Cooper Creek. Benefits of the measure would apply to the entire reach (over 4 miles) of Cooper Creek below the barrier falls.

7. Pump Kenai River water into lower Cooper Creek. The intent of this measure would be to increase both flow and water temperature on lower Cooper Creek in order to improve spawning habit for salmon and trout. The amount of water pumped would be varied based existing flows in Cooper Creek and target fish species needs for flow and water temperature.

This measure would benefit spawning habitat for salmon and rainbow trout. Benefits of the measure would only apply to the reach of lower Cooper Creek that the water was pumped to.

8. Move the Cooper Lake Hydroelectric Project powerplant to lower Cooper Creek. This measure would increase flow on Cooper Creek downstream from the new power plant location. Cooper Creek flows upstream from the new powerplant location would remain unchanged from the current condition. The measure would require installation of a new penstock down Cooper Creek Valley to the new powerplant location. Depending on the power plant location, power producing potential of the project could be reduced a little or a lot.

A deep-water intake at Cooper Reservoir such as currently used would yield very cold flows at the tailrace of the new powerplant. These cold flows could be detrimental to spawning habitat for salmon and rainbow trout downstream from the powerplant. To benefit fish spawning habitat downstream from the powerplant, a surface water intake on Cooper Reservoir would likely be needed so as to provide warmer spring, summer, and fall flows at the powerplant tailrace.

Under its present operation, the Cooper Lake Hydroelectric Project may fluctuate its water draw through the penstock widely (from 0 to 390 cubic feet per second) during the course of any day. At a powerplant site on Cooper Creek, such large swings in flow would likely to be detrimental to salmon and trout spawning habitat. Application of this measure would likely need to be coordinated with a requirement to optimize flows through the penstock throughout the year. Rapid changes in flow through the penstock would probably need to be kept to a minimum. Flow through the penstock would also need to remain relatively constant, and stoppages of flow could have the potential of being very detrimental to spawning habitat.

In summary, to effectively improve spawning habitat for salmon and rainbow trout, this measure would likely require careful control and monitoring of water temperature and flow through the penstock. Assuming flow and water temperature could be effectively optimized, the measure could enhance salmon and rainbow trout spawning habitat for the section of Cooper Creek from the new powerplant tailrace down to the Kenai River. The amount of power produced, and the timing of power use could be changed very significantly.

9. Decommission the Cooper Lake Dam. This measure would involve removing the Cooper Lake Dam and returning flow to Cooper Creek. It implies a termination of the Cooper Lake Hydroelectric Project. The measure would return streamflows and water temperatures on all of Cooper Creek to their pre-dam status, as well as lake levels and water level fluctuation on Cooper Lake/Reservoir. In theory this measure would return all fish habitat on Cooper Creek and Cooper Lake to pre-dam conditions. However, a time lag might well occur in returning to pre-dam salmon and trout escapement levels. Cooper Creek itself would need to readjust to the new flow conditions, and it would likely take salmon and trout runs a number of years to reestablish themselves on Cooper Creek.

A variation on this measure would be to decommission the dam and install a "run of the river" hydroelectric plant on Cooper Creek. Such a system would require installing an intake on Cooper Creek just downstream from Cooper Lake, and a penstock from the intake to a powerplant lower down on Cooper Creek. This measure would provide relatively unaltered streamflow and water temperature conditions downstream from the powerplant location.

Between the intake and the powerplant Cooper Creek would be partially dewatered. This measure would significantly reduce the amount of power produced by the project, and would greatly alter when and how the power could be used. Habitat for salmon and trout could return to pre-dam conditions downstream from the power plant, and would be somewhat enhanced from current conditions upstream from the powerplant.

B. Fish and Wildlife Mitigation on Cooper Reservoir

1. Stabilize reservoir levels during rainbow trout spawning and waterfowl nesting. Rainbow trout spawning habitat and waterfowl nesting habitat may be adversely affected by fluctuating reservoir water levels during spawning and nesting seasons. Fluctuating reservoir levels could be stabilized by altering power plant operations during the spawning/nesting seasons in late May through July.

2. Year round stabilization of Cooper Reservoir water levels. A further step to providing natural habitat on Cooper Reservoir would be to operate the powerplant so as to maintain a constant or near constant water level on the reservoir. This would not alter annual power production of the Cooper Lake Project, but would greatly alter the distribution of the power produced over a year. Around the reservoir and along its inlet streams within the current zone of water fluctuation, this measure would allow vegetation to encroach to the water's edge. This vegetation would provide additional cover to spawning and rearing rainbow trout, and to nesting waterfowl. The measure would likely have adverse effects on mew gull populations currently nesting on the reservoir.

3. Reservoir Fertilization. Evaluations by ADF&G limnologists indicate that Cooper Reservoir is quite nutrient poor. Fertilization and other nutrient enhancing techniques could be considered on Cooper Reservoir to increase the productivity of its macroinvertebrate populations. This would in turn increase the growth rates and productivity of Cooper Reservoir Arctic char and rainbow trout.

4. Stocking. Sportfishing opportunities on Cooper Reservoir could be enhanced to some extent by stocking additional trout, or salmon (kokanee or coho). Cooper Reservoir is large, and stocked fish can disperse widely. This means fairly high numbers of stocked fish might need to be supplied in order to enhance the sportfishery.

C. Offsite Fisheries Mitigation and Enhancement

As well as trying to benefit fisheries directly on Cooper Creek and Cooper Reservoir, offsite measures could be considered as mitigation for impacts within in the Cooper Creek Watershed. When considering offsite measures, the door opens to an almost infinite array of possibilities. Three somewhat wild measures are presented here. Each of these measures would be expensive and would affect substantial amounts of habitat.

1. Artificial Channel on Kenai Lake. This measure would involve pumping Kenai Lake water uphill (maybe 50 vertical feet) into an artificial channel that flowed back into Kenai Lake. The channel would be designed to maximize beneficial habitat features. Channel character, and flow into the channel could be designed to most benefit specific salmon or trout species. A potential channel site exists along the Snug Harbor road, close to the Quartz Creek Substation. Water pumping would likely need to be continued year-round, but for some species might only be needed for a portion of the year.

2. Crescent Creek Fish Ladder. This measure would involve constructing a series of fish ladders over several barrier falls on lower Crescent Creek. These ladders would provide access to upstream habitat for salmon. Habitat on Crescent Creek is similar to the habitat lost on Cooper Creek upstream from its alluvial fan. Benefits most likely to improve the productivity of chinook, sockeye, and coho salmon, and possibly rainbow trout. The measure could possibly increase spawning and rearing habitat competition for resident grayling. Barrier falls on Crescent Creek are very difficult to access with heavy equipment.

3. Juneau Creek Fish Ladder. This measure would involve constructing a series of fish ladders, or an alternate channel around the major barrier falls (Juneau Falls) on lower Juneau Creek. This measure would provide access to upstream spawning and rearing habitat for salmon in Juneau Creek, Juneau Lake and its tributaries, and possibly Trout Lake. This measure could benefit productivity of chinook, sockeye, and coho salmon. The measure might also increase spawning and rearing habitat competition between salmon and a variety of resident fish species in Juneau and Trout Lakes.

4. Grant Creek Fish Ladder. This measure would involve constructing a series of fish ladders, or an alternate channel around a series of barrier falls on Grant Creek. This measure would provide access for chinook, sockeye and coho salmon into Grant Lake and inlet tributaries to Grant Lake. This measure would increase available spawning and rearing habitat for salmon, and would benefit salmon productivity for this drainage. The measure might increase spawning and rearing habitat competition between salmon and resident fish species in Grant Lake and its tributaries.

5. Ptarmigan Creek Fish Ladder. This measure would involve constructing a series of fish ladders, or an alternate channel around several barrier falls on Ptarmigan Creek just downstream from Ptarmigan Lake. This measure would provide access for chinook, sockeye, coho, pink and chum salmon into Ptarmigan Lake and inlet tributaries to Ptarmigan Lake. This measure would increase available spawning and rearing habitat for salmon, and would benefit salmon productivity for this drainage. The measure might increase spawning and rearing habitat competition between salmon and resident fish species in Ptarmigan Lake and its tributaries.

D. Fisheries Mitigation on the Kenai River

1. Kenai River minimum flow requirements at the outlet of Kenai Lake. The Cooper Lake Project may benefit the Kenai River salmon fishery, by increasing streamflow during stressful winter low flow periods. If we are able to determine that this enhanced flow does benefit egg-to-fry survival on the Kenai River, then it may be beneficial to operate the Cooper Lake Project so that minimum flows on the Kenai River at its outlet from Kenai Lake never falls below a set value (say 500 cubic feet per second). This requirement would only affect power production from the Cooper Lake Project during extreme winter low flow periods, which are generally fairly short in duration. During these periods, increased water flow, and hence power production, would be needed in order to maintain the minimum flow level.

E. Recreation Facilities Opportunities

Potential opportunities to meet existing recreation needs near Cooper Reservoir include:

- ***A boat launch and picnic site at the end of Snug Harbor Road***. Construction of a boat launch and picnic facility would serve an existing recreation use at the end of Snug Harbor Road. The boat launch and picnic area sites are on Alaska Department of Natural Resources Lands. Alaska State Parks does not have present plans to build recreational facilities on these lands at the southeast corner of Cooper Reservoir.

- ***Development of a campground on Cooper Reservoir***. The Forest Service has long considered a campground on Cooper Reservoir about one mile south from the end of the Snug Harbor Road. Such a campground could serve existing camping use at Cooper Reservoir. The potential campground site is on National Forest System lands. Development of a campground would require construction of about a mile of new road. The road route would likely follow the current Russian Lakes Trail.

- ***Development of improved winter parking on the Snug Harbor Road.*** CEA plows Snug Harbor Road to the powerhouse during the winter. No winter maintenance occurs beyond the powerhouse junction up to Cooper Reservoir. Rapidly increasing popularity of this road as an access point for winter recreationists has created parking problems at the powerhouse junction. Limited parking is causing congestion/traffic problems on the Snug Harbor road during the snow season. Development of a plowed parking area/winter trailhead near the Powerhouse junction on the Snug Harbor Road could alleviate the traffic/congestion problems.

  The Snug Harbor Road at the powerhouse junction was built by CEA, is located on ADNR lands. The US Forest Service holds the road easement. Developing and maintaining winter parking at this location would require combined efforts by these three entities.

- ***Upgrading Rainbow Lake Trail to accessible standards for users with disabilities.*** Current trail conditions on the half-mile long Rainbow Lake Trail are difficult for users with disabilities. The trail could be made accessible by upgrading the trail surface, drainage and routing.

- ***Construction of a Forest Service public use cabin*** on the shores of Cooper Reservoir. Such a cabin would be available for nightly rental to the public, and could be located for primarily boat and float plane access, or for both float and hike-in access. In the case of a hike-in cabin, trail access would need to be constructed from the Snug Harbor Road. The Forest Service has identified one promising cabin site on the Reservoir’s west side, a mile and a half southeast of the dam.

Potential new opportunities along Cooper Creek include:

- ***Expansion of Cooper Creek Campground to the east side of Cooper Creek.*** Presently no sanitation facilities are provided for the dispersed camping occurring along the lower half mile of Cooper Creek's east side. Constructing a small camping loop with facilities would increase developed camping capacity and reduce sanitation concerns.

- ***Development of a Stetson Creek Trail/Cooper Lake Dam Road loop trail.*** This proposal would establish a hiking trail about nine miles in length traveling up one side of Cooper Creek Valley to Cooper Reservoir, and returning down the opposite side of the valley. Development of the route would involve about a mile of new trail construction from Stetson Creek up to Cooper Reservoir. Some trail hardening and drainage work would be needed on the existing Stetson Creek Trail.

- ***Protection/interpretation of native pit sites on lower Cooper Creek.*** Several cache pit sites have been identified near the mouth of Cooper Creek. These sites require protection from ground disturbance and offer a good opportunity for interpretation of native cultural sites near Cooper Creek Campground.

- ***Interpretation on early 1900's mining activities on lower Cooper Creek.*** Cooper Creek has a rich mining history over the last century and a half. Mining provided the original basis for establishing the town of Cooper Landing. On lower Cooper Creek where the greatest portion of the mining occurred, a number of tailings piles and other mining-related ground disturbances are still present. Mining camp structures from the early 1900's have mostly disappeared.

  The "Charley Hubbard Mining Museum" operated on Cooper Creek from 1979 to 1985 under a Forest Service special use permit. The museum displayed mining artifacts, interpreted the local mining history, and offered gold panning opportunities. Opportunities continue to exist for mining interpretation, either on site or elsewhere in Cooper Landing.