Kenai Hydro, LLC
3977 Lake Street
Homer, AK 99603

March 2, 2010

Secretary Kimberly D. Bose — Filed electronically
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Subject: 2009 Environmental Baseline Study Report, Supplemental Information for the Grant Lake/Falls Creek Project (P-13211 and P-13212)

Dear Secretary Bose,

Enclosed please find additional fish and aquatics and water quality baseline environmental information collected to support the Pre-Application Document filed with FERC on August 6, 2009 for the Grant Lake/Falls Creek Project. The report has been posted on the website (www.kenaihydro.com) as well.

Sincerely,

/Brad Zubeck/

Brad Zubeck
KHL Project Engineer

cc: Service Lists for P-13211 and P-13212

Grant Lake/Falls Creek Hydroelectric Project
(FERC P-13211/13212)

Environmental Baseline Studies, 2009

Kenai Hydro, LLC.
3977 Lake Street
Homer, AK 99603

January 2010

Grant Lake/Falls Creek Hydroelectric Project
(FERC P-13211/13212)

Environmental Baseline Studies, 2009

Final Report

Prepared for:
Kenai Hydro, LLC.
3977 Lake Street
Homer, AK 99603

Prepared by:

HDR Alaska, Inc.
2525 C Street, Suite 305
Anchorage, Alaska 99503

January 2010

Contents

Tables

Figures

Appendices

List of Acronyms

ADF&G	Alaska Department of Fish and Game
ADOT&PF	Alaska Department of Transportation and Public Facilities
AEIDC	Arctic Environmental Information and Data Center (University of Alaska)
AHRS	Alaska Heritage Resources Survey
APA	Alaska Power Authority
ASCI	Alaska Stream Condition Index
AWC	Anadromous Waters Catalog
BLM	Bureau of Land Management
°C	Degrees Celsius
$CaCO_3$	calcium carbonate
cfs	cubic feet per second
cm	centimeter
CPUE	catch per unit effort
°F	Degrees Fahrenheit
DNR	Alaska Department of Natural Resources
DO	dissolved oxygen
EPA	Environmental Protection Agency
EPT	Ephemeroptera/Plecoptera/Trichoptera
FERC	Federal Energy Regulatory Commission
FL	Fork Length
fps	feet per second
ft	feet
G&A	general and administrative
GPS	global positioning system
GWh	gigawatt hours
HBI	Hilsenhoff Biotic Index
HEP	Hydroelectric Evaluation Program
Hg	mercury
IFIM	instream flow incremental methodology
in	inch
KHI	Kenai Hydro Inc.
KHL	Kenai Hydro, LLC
KPB	Kenai Peninsula Borough
kWh	kilowatt hours
LLC	Limited liability company
LWD	large woody debris
m^2	Square meters
$MgCO_3$	magnesium carbonate

mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mi	mile
MIF	minimum instream flow
ml	milliliter
mm	millimeter
MSL	Mean sea level
MW	Megawatt
MWh	Megawatt hours
ng/L	nanograms per Liter
NTU	Nephelometric Turbidity Units
NWI	National Wetlands Inventory
O&M	Operations & maintenance
ORP	Oxidation Reduction Potential
P	phosphorous
Pb	lead
PVC	polyvinyl chloride
RM	river miles
RVDs	Recreation visitor days
STD	standard
TDS	total dissolved solids
TL	total length
TSS	total suspended solids
TWG	technical working group
µg/L	microgram per Liter
µm	micrometer
µS/cm	microSiemens per centimeter
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WSE	water surface elevation
YOY	Young of the year

Executive Summary

Kenai Hydro, LLC (KHL) contracted with HDR Alaska, Inc. to conduct environmental baseline studies in 2009 to support a Federal Energy Regulatory Commission (FERC) license application (FERC P-13211/13212) for a proposed hydroelectric project at Grant Lake near Moose Pass, Alaska. This report describes preliminary environmental baseline information collected from 02 June through 31 October 2009. These preliminary studies were intended to aid in the design of formal study plans that will be needed to specifically address requirements of Exhibit E of the FERC license application process. The following water-related study programs are addressed in this document:

- Fish and Aquatic Resources
- Hydrology
- Water Quality

Project History

Hydroelectric potential at Grant Lake has been evaluated several times as a potential power source for the Seward/Kenai Peninsula area. In 1954, R.W. Beck and Associates (cited by APA 1984) prepared a preliminary investigation and concluded that a project at the site had significant potential. The U.S. Geological Survey (USGS) conducted geologic investigations of proposed power sites at Cooper, Grant, Ptarmigan, and Crescent Lakes in the 1950s (Plafker 1955). In 1980, CH2M Hill (cited by APA 1984) prepared a prefeasibility study for a Grant Lake project and concluded that a project developed at the site would be feasible. The Grant Lake Project was referenced in the 1981 U.S. Army Corps of Engineers (USACE) National Hydroelectric Power Resources Study (USACE 1981). The most extensive study was performed by Ebasco Services, Inc. in 1984 for the Alaska Power Authority (now Alaska Energy Authority; APA 1984). The studies included a detailed examination of water use and quality; fish resources; botanical and wildlife resources; historical and archaeological resources; socioeconomic impacts; geological and soil resources; recreational resources; aesthetic resources; and land use (APA 1984). Two of the alternative project configurations evaluated by Ebasco included the diversion of adjacent Falls Creek into Grant Lake to provide additional water for power generation.

During the 1986-87 period a preliminary application document was filed by Kenai Hydro, Inc. (no relation to the current Kenai Hydro, LLC) for a project at Grant Lake. Support for the application included an instream flow study. Because of competing projects and political considerations the project was never pursued beyond the preliminary application phase.

On August 6, 2009, Kenai Hydro, LLC filed a Pre-Application Document (PAD), along with a Notice of Intent to file an application for an original license for the Grant Lake/Falls Creek project (P-13211/13212) under Part I of the Federal Power Act. On September 15, 2009, FERC approved the use of the Traditional Licensing Process for development of the license application and supporting materials. The PAD summarizes existing information and describes the proposed project facilities, which includes a diversion dam at the outlet to Grant

Lake, and a powerhouse along Grant Creek. The proposal includes diverting water from Falls Creek into Grant Lake in the spring, summer, and fall months to provide additional flow and power generation at the Grant Creek powerhouse.

This report provides results of the preliminary environmental baseline data collected from 02 June through 31 October 2009. These preliminary data will provide information useful in the design of formal study plans needed to specifically address requirements of Exhibit E in support of the FERC license application for the Grant Lake/Falls Creek hydroelectric project. Some data requirements for Exhibit E are met by previous studies in support of earlier feasibility and licensing efforts in the 1980s at Grant Lake. The scope of work was focused on filling data gaps and providing current information regarding fish and aquatic resources, stream hydrology, water quality analyses, as well as providing background information needed for the development of an appropriate instream flow study approach.

Study Area

Grant Creek, Grant Lake, and Falls Creek are located near the community of Moose Pass, Alaska (population 206), approximately 25 miles (mi) north of Seward, Alaska (population 3,016), just east of the Seward Highway (State Route 9) which connects Anchorage (population 279,671) to Seward. The Alaska Railroad parallels the Seward Highway and is adjacent to the study area. Cooper Landing, Alaska is located 24 mi to the northwest and is accessible via the Sterling Highway (State Route 1) which connects to the Seward Highway approximately 10 mi northwest of Moose Pass.

Grant Lake is approximately 1.5 mi southeast of Moose Pass. It is located at an elevation of approximately 709 feet (ft) above mean sea level (MSL), with a maximum depth of nearly 300 ft and surface area of 2.6 square miles (APA 1984). Grant Lake's total drainage area is approximately 44 square miles. Tributaries to Grant lake include Inlet Creek at the east end and numerous other short, steep streams, some of which are glacier-fed. Grant Lake is comprised of two basins separated by a natural constriction and island near the midpoint (Figure 2-1). The lake is ringed by mountains of the Kenai Mountain Range to the east, north, and south, with elevations ranging from 4,500 to 5,500 ft.

Grant Lake's only outlet, Grant Creek, runs west approximately 1 mi from the south end of Grant Lake to drain into the Middle Trail River between Upper and Lower Trail Lake. Lower Trail Lake then flows into Kenai Lake which drains into the Kenai River at its west end near Cooper Landing (APA 1984).

Grant Creek has a mean annual flow of 193 cubic feet per second (cfs), and is 5,180 ft long, with an average gradient of 207 ft/mi. Its substrate includes cobble and boulder alluvial deposits and gravel shoals (APA 1984). The stream is 25 ft wide on average. In its upper half, the stream passes through a rocky gorge with three substantial waterfalls and in its lower half, the stream becomes less turbulent as it passes over gravel shoals and diminishing boulder substrate (APA 1984).

Falls Creek is located approximately one mile south of the south end of Grant Lake; it flows into Trail River just downstream of Lower Trail Lake (approximately 1.8 mi downstream of the mouth of Grant Creek. The Falls Creek watershed is 11.9 square miles in area, draining steep terrain between the Grant Lake and Ptarmigan Lake watersheds. It contains no lakes, and has no major tributaries. Estimated mean annual flow of Falls Creek is 38 cfs. Stream flow during the winter is minimal. Falls Creek is 42,240 ft (approximately 8 mi) long, average stream gradient is 418 ft/mi, and stream width averages 15 ft. Falls Creek substrate includes cobble, boulder deposits, a few gravel bars, and a thin layer of fine silt near the mouth. The lower 1 mi of stream has been extensively channelized and modified by placer mining (APA 1984). Three to four acres adjacent to the active channel in the lower 0.5 mi are covered with tailings, and 100 yards of streambed in this area have been relocated (AEIDC 1983).

Fish and Aquatic Resources

The goals of the 2009 fish and aquatic resources study program were to characterize fish use of aquatic habitats in Grant Lake and Grant Creek, describe anadromous fish habitat in Grant Creek, and characterize aspects of stream and lake biology that may be related to overall productivity. Another goal was to determine fish presence and general habitat characteristics of Falls Creek. Work completed in 2009 built upon the data provided by previous studies in this area (AEIDC 1983, USFWS 1961). Specific study objectives are addressed in Section 3.3.2. The fisheries work completed in 2009 will provide preliminary background information necessary for a FERC environmental assessment.

The results of the 2009 fish and aquatic resources study program were generally consistent with the results of other studies conducted in the Grant Creek watershed with respect to species presence and distribution (see Section 3.2, USFWS 1961, AEIDC 1983, APA 1984, Marcuson 1989).

Grant Lake. Previous studies have indicated that Grant Lake supports resident populations of sculpin (Cottidae) and threespine stickleback (Gasterosteus aculeatus); salmon or other salmonid fish such as Dolly Varden have not been caught in Grant Lake or any of its tributaries during environmental assessments (USFWS 1961, AEIDC 1983, APA 1984). The 2009 study program sampled a variety of habitat types and confirmed the results of the past study efforts. The current study, in combination with past study efforts, provides convincing evidence that no salmonid species are present in Grant Lake or its tributaries.

Zooplankton and phytoplankton were collected in Grant Lake in order to estimate the productivity of the lake, with emphasis on the area of the natural outlet and the proposed project intake. The population density at the sample site furthest from the lake outlet was 3.67 organisms per liter while the sample site closest to the lake outlet had densities nearly three times higher at 10.65 organisms per liter. This difference in population density may be relevant to the availability of fish food organisms in Grant Creek. Contrary to the results of the zooplankton sampling, abundance of phytoplankton (as measured by chlorophyll *a* concentration) was greater at the sample site located further away from the lake outlet.

Grant Creek. Grant Creek is a short, high gradient stream that flows about one mile from Grant Lake to Middle Trail River. Fish habitat quality and availability is largely controlled by accessibility and steepness. A series of waterfalls about 500 ft. downstream from the lake outlet blocks access to fish from downstream. The 2009 studies confirmed the results of past studies that have indicated that salmonid fish from the Kenai River drainage are unable to access Grant Creek above the falls. Fish species present within upper Grant Creek (above the falls) are the same as those in Grant Lake, consisting only of sticklebacks and sculpins.

Downstream from the lower falls, Grant Creek flows through a canyon for about 1800 ft. This reach is characterized by cascades with boulder substrate. Fish habitat is limited by the fast water. Small numbers of adult sockeye and Chinook salmon were observed at the lower end of this reach in 2009. Except for the lower few hundred feet, the reach is inaccessible during the open water season due to dangerous conditions. Information is lacking regarding fish numbers and distribution within this upper stream segment.

The segment of stream between the canyon reach and Grant Creek mouth (2600 ft.) is characterized by relatively fast water and dominant riffle type habitats. Substantial numbers of Chinook and sockeye salmon spawn along the stream margin and within limited gravel pockets. The 2009 studies estimated Chinook salmon escapement to Grant Creek at 235 fish and sockeye salmon at 6300 fish. The number of sockeyes present was higher than observed during prior studies. Six coho salmon were observed during the last survey period (late September, 2009). Later surveys were not conducted; therefore, the extent of coho use was not established. The overall distribution of salmon spawning and the locations of high quality spawning areas were delineated within the accessible portion of Grant Creek.

Stream areas with slower water such as backwaters, side channels, and undercut banks provide rearing habitat and refuge for juvenile Chinook and coho salmon, as well as for juvenile Dolly Varden and rainbow trout. While slow water habitats were limited, the density of juvenile salmonids within some of these areas was high. The locations and physical characteristics of these important microhabitat areas were documented for potential input to an instream flow study program.

Main channel pools and fast water areas are occupied by larger rainbow trout and Dolly Varden. Seventy-two adult and subadult rainbow trout were caught during 91 hours of angling effort. Some trout were present in the stream in early summer and more arrived in late summer coincident with the salmon migration. Spawning by rainbow trout is suspected but has not been confirmed. The presence of trout fry in Grant Creek in mid-summer 2009 provided evidence that spawning had likely occurred in the spring.

Macroinvertebrates and periphyton were collected in Grant Creek in order to characterize the baseline condition of the creek relating to productivity and availability of food for resident fish. Population density estimates indicated that macroinvertebrates were more abundant at the creek outlet than at middle reach locations. Periphyton growth as measured by chlorophyll *a* concentrations was also significantly higher at the creek mouth.

Falls Creek. Falls Creek is a high gradient stream characterized by riffle habitats, a small amount of undercut bank, and a moderate amount of large woody debris. Foot surveys on Falls Creek from the Seward Highway Bridge to the mouth of the creek found no adult anadromous fish in July and August. Due to the high turbidity of Falls Creek, there was a possibility that fish were missed. A larger portion of Falls Creek was sampled with minnow traps from 21 to 22 July 2009. A total of 24 fish were captured, all of which were juvenile Dolly Varden.

Water Resources

The primary goal of the 2009 water quality and hydrology study programs was to begin to characterize the water quality, temperature, and hydrology of Grant Creek, Falls Creek, and Grant Lake in support of the Instream Flow Study to begin in 2010 and the FERC licensing process.

Grant Lake, Grant Creek, and Falls Creek have been studied in the past for hydroelectric feasibility. Previous hydrologic investigations in the project area include:

- Historical Grant Creek stream gage data (USGS 15246000) – 11 years of continuous stream gage data from 1947-1958.
- Grant Lake Hydroelectric Project Detailed Feasibility Analysis, EBASCO, 1987, includes modeled Falls Creek data.
- Historical Falls Creek discharge data limited to several instantaneous discharge measurements made over various years including 1963-70, 1976, and 2007- 2008.

Grant Lake water quality and temperature data were collected between June 10th and October 6th; the 2009 hydrology and stream temperature data were collected between June 9th and October 12th.

Hydrology. Stream gages were installed on Grant Creek and Falls Creek. Continuous stage data was recorded from early June through mid-October 2009. The trends reflected in 2009 were consistent with the mean monthly flow distribution from the USGS data (period of record 1947-1958).

Water Quality. Instantaneous water temperature readings associated with water sampling events at Grant Lake were consistent with seasonal changes. At the outlet of Grant Lake water temperature did not vary widely by depth during the month of June.

The surface temperature at the Grant Lake thermistor string during June was approximately 6 degrees colder than during August. During June the temperature profile showed nearly uniform temperature throughout the depth range except in the immediate vicinity of the surface. During August the temperature was higher at the surface than throughout the rest of the depth profile. However, temperature began to decrease near a depth of 9 m, possibly suggesting thermal stratification. By the end of September the water column was approximately 9°C from the surface to a depth of 14m, where the temperature decreased to closer to 7°C at 19.5 m depth, suggesting a break down in thermal stratification and fall turnover. There appears to be some thermocline formation from late July through early September with the top six meters having relatively uniform temperature.

The stream temperature trends of Grant Creek reflect seasonal air temperature changes and were very similar to temperatures found in the upper 3 meters of Grant Lake.

The conductivity values measured in Grant Creek and Grant Lake during the 2009 sampling season are consistent with the historical data from the 1960s and 1980s (Table 4.2; Appendix E).

Measurements of concentrations of dissolved oxygen (DO) in Grant Creek ranged from 7.31 to 7.34 mg/L in June and from 8.22 to 8.40 mg/L in August. Falls Creek measured DO values were 7.96 and 10.65 mg/L in June and August, respectively. DO measurements in Grant Lake were relatively uniform throughout the entire depth profile during both sampling events. DO values measured in Grant Lake in June 2009 ranged from 7.20 to 7.96 mg/L, while August values were much lower - 5.57 to 6.05 mg/L. These data are lower than what would normally be expected in freshwater systems. This was most likely the result of instrument malfunction in the field, and additional data collection will be needed to verify DO levels.

Grant Creek turbidity readings in 2009 ranged from 10.1 to 11.9 NTU, which are higher than historical turbidity results collected in the 1980's (0.35 to 1.1 NTU). Falls Creek historical readings ranged from 0.37 to 6.0 NTU, while 2009 readings were 8.17 to 17.00 NTU.

Laboratory tests in 2009 indicated that the following analytes were either absent or present at extremely low levels: mercury, lead, nitrates,/nitrites, orthophosphates, and phosphorous. The lack of, or minimal amounts of, nutrients in the samples indicate that the system may be nutrient-limited and possibly oligotrophic.

1 Project History and Overview

Kenai Hydro, LLC (KHL) contracted with HDR Alaska, Inc. to conduct environmental baseline studies in 2009 to support a Federal Energy Regulatory Commission (FERC) license application for a proposed hydroelectric project at Grant Lake (FERC P-13211/13212) near Moose Pass, Alaska. Results for the following studies provided in this report include:

1. Fish Resources and Aquatic Resources
2. Hydrology
3. Water Quality

This report provides a description of study results with the intent of enhancing project planning and providing a basis for discussion of project effects.

1.1 Project History

Hydroelectric potential at Grant Lake has been evaluated several times as a potential power source for the Seward/Kenai Peninsula area. In 1954, R.W. Beck and Associates (cited by APA 1984) prepared a preliminary investigation and concluded that a project at the site had significant potential. The U.S. Geological Survey (USGS) conducted geologic investigations of proposed power sites at Cooper, Grant, Ptarmigan, and Crescent Lakes in the 1950s (Plafker 1955). In 1980, CH2M Hill (cited by APA 1984) prepared a prefeasibility study for a Grant Lake project and concluded that a project developed at the site would be feasible. The Grant Lake Project was referenced in the 1981 U.S. Army Corps of Engineers (USACE) National Hydroelectric Power Resources Study (USACE 1981). The most extensive study was performed by Ebasco Services, Inc. in 1984 for the Alaska Power Authority (now Alaska Energy Authority; APA 1984). The studies included a detailed examination of water use and quality; fish resources; botanical and wildlife resources; historical and archaeological resources; socioeconomic impacts; geological and soil resources; recreational resources; aesthetic resources; and land use (APA 1984). Two of the alternatives evaluated by Ebasco included the diversion of adjacent Falls Creek into Grant Lake to provide additional water for power generation.

During the 1986-87 periods a preliminary application document was filed by Kenai Hydro, Inc. (no relation to the current Kenai Hydro, LLC) for a project at Grant Lake. Support for the application included an instream flow study that examined potential impact to fish resources from altered flow regimes. Minimum instream flows were negotiated with the regulatory agencies. Because of competing projects and political considerations the project was never pursued beyond the preliminary application phase.

On 06 August 2009, Kenai Hydro, LLC filed a Pre-Application Document (PAD), along with a Notice of Intent to file an application for an original license for the Grant Lake/Falls Creek project (P-13211/13212) under Part I of the Federal Power Act. On 15 September 2009, FERC approved the use of the Traditional Licensing Process for development of the license application and supporting materials. The PAD summarizes existing information and describes the proposed project facilities, which includes a diversion dam at the outlet to Grant Lake, and a powerhouse along Grant Creek. The proposal includes diverting water from Falls Creek into Grant Lake in the spring, summer, and fall months to provide additional flows and power generation at the Grant Creek powerhouse.

1.2 Project Overview

This report provides results of the preliminary environmental baseline data collected from 02 June through 31 October 2009. These preliminary data will provide information useful in the design of formal study plans needed to specifically address requirement of Exhibit E of the FERC license application process for the development of small-scale hydroelectric energy generation at Grant Creek. Some data requirements for Exhibit E are met by previous studies in support of earlier feasibility and licensing efforts in the 1980s at Grant Lake. The scope of work was focused on filling data gaps and providing current information regarding fish and aquatic resources, stream hydrology, water quality analyses, and on providing background information needed for the development of an appropriate instream flow study approach.

2 Study Area

Grant Creek, Grant Lake, and Falls Creek are located near the community of Moose Pass, Alaska (population 206), approximately 25 miles (mi) north of Seward, Alaska (population 3,016), just east of the Seward Highway (State Route 9) which connects Anchorage (population 279,671) to Seward. The Alaska Railroad parallels the Seward Highway and is adjacent to the study area. Cooper Landing, Alaska is located 24 mi to the northwest and is accessible via the Sterling Highway (State Route 1) which connects to the Seward Highway approximately 10 mi northwest of Moose Pass.

Grant Lake is approximately 1.5 mi southeast of Moose Pass. It is located at an elevation of approximately 709 feet (ft) above mean sea level (MSL), with a maximum depth of nearly 300 ft and surface area of 2.6 mi (APA 1984). Grant Lake's total drainage area is approximately 44 mi. Tributaries include Inlet Creek at the headwaters and other glacial-fed streams in the watershed. Grant Lake consists of front and back basins, which are separated by a natural constriction and island near the midpoint (Figure 2-1). The lake is ringed by mountains of the Kenai Mountain Range to the east, north, and south, with elevations ranging from 4,500 to 5,500 ft.

Grant Lake's only outlet, Grant Creek, runs west approximately 1 mi from the south end of Grant Lake to drain into Middle Trail River between Upper and Lower Trail Lake. Trail River drains Lower Trail Lake, and then flows into Kenai Lake. Kenai Lake drains to the Kenai River at its west end near Cooper Landing (APA 1984).

Grant Creek has a mean annual flow of 193 cubic feet per second (cfs), and is 5,180 ft long, with an average gradient of 207 ft/mi. Its substrate includes cobbles and boulder alluvial deposits and gravel shoals (APA 1984). The stream is 25 ft wide on average. In its upper half, the stream passes through a rocky gorge with three substantial waterfalls and in its lower half, the stream becomes less turbulent as it passes over gravel shoals and diminishing boulder substrate (APA 1984).

Falls Creek is located approximately one mile south of the south end of Grant Lake; it flows into Trail River just downstream of Lower Trail Lake (approximately 1.8 mi downstream of the mouth of Grant Creek), see Figure 2-1 (Photographs of the study area are provided in Appendix B.). The Falls Creek watershed drains steep terrain between the Grant Lake and Ptarmigan Lake watersheds, is 11.9 mi^2 in area, contains no lakes, and has no major tributaries. Estimated mean annual flow of Falls Creek is 38 cfs. Stream flow during the winter is minimal. Falls Creek is 42,240 ft (approximately 8 mi) long, average stream gradient is 418 ft/mi, and stream width averages 15 ft. Falls Creek substrate includes cobble, boulder deposits, a few gravel bars, and a thin layer of fine silt near the mouth. The lower 1 mi of stream has been extensively channelized and modified by placer mining (APA 1984). Three to four acres adjacent to the active channel in the lower 0.5 mi are covered with tailings, and 100 yards of streambed in this area have been relocated (AEIDC 1983).

3 Fish & Aquatic Resources

3.1 Introduction

Grant Lake and Grant Creek support different assemblages of fish species and possess varying quality and quantity of fish habitat. Only non-anadromous fish have been found in Grant Lake (AEIDC 1983, USFWS 1961, Johnson and Klein 2009), whereas anadromous fish are present in Grant Creek. The following sections describe the 2009 aquatic and water resources baseline study results for fish and aquatic resources associated with the Grant Lake Hydroelectric Project.

Because of its geographic isolation, Grant Lake supports only resident populations of sculpin (Cottidae) and threespine stickleback (*Gasterosteus aculeatus*). Salmon were not observed in Grant Lake or any of its tributaries during environmental assessments (USFWS 1961; AEIDC 1983; APA 1984); and are not included in the Anadromous Waters Catalog (AWC) published by Alaska Department of Fish and Game (ADF&G; Johnson and Klein 2009). Whereas, most of Grant Creek is accessible to anadromous fish from the Kenai River drainage and is included in the AWC due to the presence of spawning Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon and rearing coho salmon (Johnson and Klein 2009).

Other components of the aquatic ecosystem, such as macroinvertebrates and periphyton, often serve as indicators of system productivity or health. Macroinvertebrates and periphyton in Grant Creek are essential as food sources for fish. As the primary food source for juvenile salmonids, macroinvertebrates are potentially a limiting factor in the number of juveniles that survive and remain in Grant Creek. Some fish and many macroinvertebrates depend on periphyton as their primary food source. Changes in water quality can quickly affect periphyton and macroinvertebrate assemblages.

Similarly, zooplankton and phytoplankton in Grant Lake are a primary food source of resident fish populations in Grant Lake. These organisms are also likely washed into Grant Creek through the natural outlet of Grant Lake and may become a food source for juvenile salmonids in the creek. Changes in the water quality in the lake or the flow through the natural outlet may affect zooplankton and phytoplankton availability as a food source.

3.2 Previous Studies

Previous FERC licensing efforts in the 1960s and 1980s for a proposed hydroelectric project at Grant Lake included studies of fish resources in Grant Lake, Grant Creek, and Falls Creek. The Arctic Environmental Information and Data Center (AEIDC 1983) conducted fish sampling from 1981 to 1982 as part of comprehensive environmental baseline study effort and USFWS (1961) conducted limited sampling from 1959 to 1960.

3.2.1 Grant Creek Fish Resources

Both anadromous and resident fish are present in Grant Creek, including salmon, trout and other fish. Spawning Chinook, sockeye, and coho salmon, as well as rainbow trout (*Oncorhynchus mykiss*) and Dolly Varden (*Salvelinus malma*) are found in the lower reaches of Grant Creek (APA 1984, Johnson and Klein 2009). Rearing Chinook, coho and rainbow trout are also present (APA 1984, Johnson and Klein 2009). Round whitefish (*Prosopium cylindraceum*) and Arctic grayling (*Thymallus arcticus*) were caught during angling surveys (APA 1984).

The upper portion of Grant Creek is impassable to salmon 0.5 mi (APA 1984) to 1 mi (Johnson and Klein 2009) upstream of the mouth. The most favorable fish habitat is likely concentrated within the lower portion of stream. Habitat for juvenile fish exists mainly in stream margins, eddies, deep pools and side channels offering reduced velocities (APA 1984). Substrate material is coarse throughout the entire length of the creek due to high water velocity, which tends to wash away smaller gravels (APA 1984). Isolated areas of suitable spawning gravels occur in the lower half of the stream (APA 1984).

Periodic minnow trapping on Grant Creek from July 1959 through January 1961 captured Chinook salmon, coho salmon, Dolly Varden and sculpin (extent of sampling area unknown; USFWS 1961). Minnow trapping and electrofishing in lower reaches of Grant Creek for week-long periods in October 1981 and March, May, June, and August 1982 yielded higher catches of trout, salmon, and Dolly Varden in the fall and summer than in winter and spring (AEIDC 1983). Catches of Dolly Varden were generally the most abundant fish in minnow traps, followed by juvenile Chinook, juvenile rainbow trout, and juvenile coho. Juvenile Chinook were the most commonly caught fish during electrofishing surveys (APA 1984).

APA (1984) estimated that Grant Creek supported 250 Chinook spawners and 1,650 sockeye spawners. These estimates were likely biased low due to the limitations of visual counting methods. The stream was also estimated to support 209 8-inch or larger “trout” (including Dolly Varden and rainbow trout; APA 1984). Spawning coho were not surveyed (APA 1984), but have been recorded as being present at unknown levels in the stream by the AWC (Johnson and Klein 2009). Maximum counts from intermittent stream surveys by ADF&G were 76 Chinook (1963) and 324 (1952) sockeye salmon.[1]

3.2.2 Grant Creek Instream Flow

A limited instream flow study was conducted on Grant Creek in the 1980s by Kenai Hydro, Inc. (KHI; unrelated to Kenai Hydro, LLC). The study related documents include reports and written communications between KHI and State and Federal agencies in 1986 and 1987 relative to a FERC license application for the proposed Grant Lake Hydroelectric Project (FERC No. 7633-002). The documents include draft and final reports of a limited instream flow incremental methodology (IFIM) investigation and negotiated minimum instream flows (MIF) and ramping rates (Envirosphere 1987, KHI 1987a, KHI 1987b). A technical memorandum detailing the results of the previous instream flow study efforts is provided in Appendix A.

[1]Anadromous Waters Catalog Stream Nomination #08-153, http://www.sf.adfg.state.ak.us/SARR/FishDistrib/Nomination/FDDNomHome.cfm

3.2.3 Grant Creek and Falls Creek Macroinvertebrates and Grant Creek Periphyton

A number of previous macroinvertebrate and periphyton studies have taken place in and near the project area.

Surber sampling conducted in Grant Creek and Falls Creek in 1981 and 1982 indicated that benthic macroinvertebrate diversity was low, as is typical of cold, glacial fed streams (APA 1984). The most abundant taxa in Grant Creek were midge species (Chironomidae), followed by mayflies (Ephemeroptera), stoneflies (Plecoptera), and clams. No seasonal variation in macroinvertebrate abundance was observed in Grant Creek. The dominant taxa in Falls Creek were midges and mayflies, although stoneflies, caddisflies, and other species of true flies (Diptera) were present. Densities of all insect taxa, other than mayflies, were low. In Falls Creek, macroinvertebrates were typically most abundant in late summer.

Investigations conducted in 1982 showed that the periphyton community in Grant Creek was dominated by diatoms (APA 1984). Diatoms were most abundant in spring. APA (1984) concluded that input of leaves and other organic matter from along side the stream (allochthonous contribution), along with input of phytoplankton and zooplankton from Grant Lake, was likely more important than periphyton as the basis of productivity in Grant Creek.

3.2.4 Falls Creek Fish Resources

Falls Creek is classified as anadromous in its lower 2,300 ft for the presence of Chinook salmon (Johnson and Klein 2009). Juvenile Chinook salmon and Dolly Varden have been found in its lower section. A series of waterfalls prevents fish passage above the lower 2,300 ft of the stream (USFWS 1961, AEIDC 1982, Johnson and Klein 2009, HDR 2009).

USFWS sampled Falls Creek in 1961 by setting minnow traps in the lower 1 mi of the creek. The results of that sampling effort found juvenile Chinook salmon to be present in the lower 600 ft of the creek. Additional investigations by USFWS in 1959 and 1960 indicated that no adult salmon use the creek and that cold water temperatures may limit its production potential (AIEDC 1983).

Falls Creek was also previously studied by AEIDC (1983). The results of this study determined the lower 1 mi of Falls Creeks to contain limited suitable salmon spawning habitat. Dolly Varden were found below an active mining area located immediately to the east of the rail road bridge in the lower 600 ft of the creek. Six minnow traps were set for a total of 108 hours of trapping effort, and captured 21 Dolly Varden ranging from 45 to 98 mm in length.

In 2008, the ADF&G (Johnson and Klein 2009) placed minnow traps in the lower area of Falls Creek below the rail road and highway bridges and found juvenile Chinook to be present.

3.2.5 Grant Lake Fish Resources

Sampling during 1981-1982 by the Arctic Environmental Information and Data Center (AEIDC) found no fish in any of the tributaries of Grant Lake (AEIDC 1983). Sculpin and threespine stickleback were the only fish found to inhabit Grant Lake. A series of impassable falls[2] near Grant Lake's outlet prevents colonization of the lake by salmonids via Grant Creek (APA 1984). Grant Lake supports a "small" population of slimy sculpin (*Cottus cognatus*) and a "dense" population of threespine stickleback (USFWS 1961). Density of threespine stickleback was ten times higher in the lower basin than the upper basin of Grant Lake (AEIDC 1983).

3.2.6 Grant Lake Zooplankton and Phytoplankton

Zooplankton and phytoplankton samples were collected in Grant Lake in 1981-82 by the ADF&G and the U.S. Forest Service (USFS). Results of those studies indicated that the zooplankton community in Grant Lake was dominated by rotifers and copepods (APA 1984). Non-rotifer zooplankton abundance was highest in August, likely following peak abundance of the phytoplankton upon which they feed. Phytoplankton collection in 1982 showed that the dominant taxa were diatoms with the greatest phytoplankton abundance occurring in August (APA 1984).

In 1983, four limnology sites were established in the upper and lower Grant Lake basins. Water quality and zooplankton samples were collected in eight sampling events during open water seasons from June 1983 - September 1985 (Marcuson 1989). Zooplankton and phytoplankton samples were identified to the lowest practicable taxa in 1981 - 1983 (AEIDC 1983, Marcuson 1989).

3.3 Study Goals and Objectives

3.3.1 Study Goals

The goals of 2009 fish and aquatic resources study program were to characterize fish use of aquatic habitats in Grant Lake and Grant Creek, with an emphasis on anadromous fish habitat and to characterize other components of the aquatic ecosystem that relate to overall productivity and/or system health. Another goal was to determine fish presence and general habitat characteristics of Falls Creek. Work completed in 2009 was designed to compliment but not necessarily duplicate work completed earlier (AEIDC 1983, USFWS 1961; see Section 3.2). Specific study objectives are addressed below. The fisheries work completed in 2009 will provide preliminary background information necessary for input to the design of a more detailed study program required as part of the formal FERC licensing process.

3.3.2 Study Objectives

Objectives of 2009 field efforts were to:

---

[2] 2007 ADFG Stream survey referenced in Anadromous Waters Catalog Stream Nomination #08-153, http://www.sf.adfg.state.ak.us/SARR/FishDistrib/Nomination/FDDNomHome.cfm

1. Characterize resident and rearing fish use of Grant Creek, specifically:
   a) Determine the relative abundance and distribution of juvenile fish in Grant Creek.
   b) Determine relative abundance and distribution of Dolly Varden and rainbow trout present in Grant Creek.
   c) Characterize fish use of microhabitats.
2. Describe the use of Grant Creek by adult migratory fish.
   a) Estimate the abundance and run timing of spawning salmon.
   b) Estimate the abundance and run timing of spawning adult resident fish.
   c) Delineate spawning habitat locations and characteristics.
3. Determine fish presence and distribution in Grant Lake.
4. Develop a Technical Working Group and determine instream flow study methods.
5. Determine fish presence and general distribution in Falls Creek.
6. Collect baseline information on the zooplankton and phytoplankton populations in Grant Lake near the natural outlet to the lake and near the proposed intake.
7. Collect baseline information on the macroinvertebrate and periphyton populations in Grant Creek.
8. Assess chlorophyll *a* concentrations in periphyton and phytoplankton samples as an indicator of primary productivity in Grant Lake and Grant Creek.

3.4 Field Sampling Methods

Multiple sampling methods were used to characterize and enumerate fish presence on Grant Creek, Falls Creek, and Grant Lake. Angling was employed to estimate relative abundance of adult resident fish in Grant Creek. Minnow trapping was used to estimate relative abundance of rearing anadromous and resident freshwater fish in Grant Creek, Falls Creek, and Grant Lake. Electrofishing was used in areas around minnow traps to verify catch results. Gill netting was employed in Grant Lake to document the species in the lake outside of the littoral zone. Foot surveys were employed on Grant Creek and Falls Creek to estimate the escapement of adult anadromous fish.

3.4.1 Establishment of Study reaches on Grant Creek

AEIDC conducted field work in Grant Creek in the early 1980s (AEIDC 1983) and divided the lower half of Grant Creek into four uniform study reaches, each 0.125 mi long. They divided the upper 0.5 mi of Grant Creek into two reaches based on land topography (AEIDC 1983). In June 2009, a total of six study reaches were established on Grant Creek to correspond with historical study reaches. Study reach breaks were marked in the field using surveyor stakes and a handheld global positioning system (Figure 3.4.1-1, see Appendix B for photographs of the study area). Study reach breaks were plotted on an aerial photograph and visually compared to the study reach map established in previous studies, small adjustments were then made to the reach break boundaries as needed to ensure that the historical study reaches were recreated to the best extent possible.

3.4.2 Grant Creek Fish Resources

Rearing Fish Study reaches 1 through 6 were sampled using ¼ in mesh baited minnow traps. Traps were baited with cured salmon eggs. Minnow trapping was conducted on a monthly basis June through September (Figure 3.4.1-1). Study reach 6 was sampled opportunistically in concurrence with two sampling events at Grant Lake in June and August. Minnow traps were set for approximately 24 hours.

All minnow trap sites were marked with a GPS and flagged for future identification (Figure 3.4.1-1). Reach 1 had 10 minnow trapping sites, reach 2 had 10 minnow trapping sites, Reach 3 had 13 minnow trapping sites, Reach 4 had nine minnow trapping sites, Reach 5 had three minnow trapping sites, and Reach 6 had five minnow trapping sites. (Due to the impassible terrain and high water flows in Reach 5 trap sites were limited.) Fish captured were identified to the species level and released near the point of capture. Sculpin were identified to the genus level. A target sample of fish were measured for length to the nearest millimeter (n=20 per sampling event for salmonids and n=10 per sampling event for threespine stickleback); salmonids were measured to fork length (FL) or the tip of snout to the fork in their tail and other fish were sampled for total length (TL) or the tip of snout to the end of their tail.

A subsample of the minnow trapping sites (n=2) were electrofished in order to identify and enumerate fish that may not be readily captured in minnow traps, such as sockeye salmon. Electrofishing, using a Smith-Root Model LR24 backpack electrofisher occurred at two sites per reach, with the exception of Reach 5, which was not electrofished due to high velocity flows and deep water conditions. Electrofishing occurred after the minnow traps were removed from the stream in order to not interfere with trap catch. Fish captured in the minnow traps were retained during the electrofishing effort, so as not to recapture them. Each site was electrofished for approximately one minute. High flows and turbid water conditions in Grant Creek during August made electrofishing impractical. Effort was made to electrofish different sampling sites in each reach during multiple sampling events.

Adult Resident Fish Angling surveys were used to characterize the use of Grant Creek by adult and subadult rainbow trout and Dolly Varden. Four angling stations were established within each study reach, with the exception of Reach 5, which contained two angling stations (Figure 3.4.1-1). Angling did not occur in Reach 6 because of a known fish migration barrier (see Section 3.2.2) and previous study results documenting the absence of adult salmonids in Grant Lake (USFWS 1961, AEIDC 1983, and APA 1984). Study reaches 1 through 4 contained the same number of angling stations (n=4) per river mile (RM) so that the level of effort between reaches could be as uniform as possible. Since only the lower 300 m of Reach 5 were accessible, only two angling stations were contained in Reach 5. Each angling station was fished for 30 minutes using rod and reel methods in accordance with ADF&G Sport Fishing Regulations and Fish Resources Permit SF2009-130. Sampling events occurred approximately every 10 days, except during the last week of July when sampling was not conducted due to flood stage water levels. Lures included spinners, flies, and beads. Bait (e.g. preserved salmon eggs) was used during one sampling event in August then discontinued to ensure that the results of all sampling events were comparable. Captured fish were observed for previous markings. If no previous marks were present, then ¼ in of the upper lobe of the caudal fin was clipped for future identification. If the caudal fin was already marked the fish was noted as a recaptured fish on the field datasheet. All fish caught were identified to the species level, measured, and released near the point of capture. Notes were made as to the spawning condition and sex of the fish.

Catch per unit effort (CPUE) for the resident and rearing fish study was calculated by dividing the total number of fish captured within each study reach by the total amount of sampling effort in each study reach. For the purposes of this study CPUE is defined as fish per hour of sampling effort (angling hour or minnow trap hour) and is used as a measure of relative abundance.

Adult Salmon Foot surveys were conducted every 10 days June through September to estimate the abundance and determine the distribution of spawning anadromous fish in Grant Creek and Falls Creek. One sampling event was missed in late July due to high water. A two person crew started at the mouth of the creek, with one person on each bank. Each person surveyed upstream, counting fish within the nearest one-half of the creek (i.e. mid-stream inward to the streambank). The number of live fish were counted and tallied by species for each survey. Number and location of active redds, areas of concentrated spawning activity, and the numbers of carcasses were also recorded. Due to the high turbidity in the creek (which ranged from 0.66 to 9.38 Nephelometric Turbidity Units; [NTUs]), adult fish may have been missed.

An estimate of total escapement for Chinook and sockeye salmon was calculated based on live fish counts using the area-under-the-curve (AUC) method described by Bue et al. (1998). This method uses a trapezoidal approximation to estimate the number of live fish present in the stream for the days not surveyed. This method has been in use for more than 25 years (Neilson and Geen 1981, English et al. 1992, Bue et al. 1998, Hilborn et al 1999).

The AUC method relies on three critical types of data consisting of live fish counts, an estimate of survey life and an estimate of observer efficiency (Hilborn et al. 1999). Live fish counts are number of fish counted during each foot survey. Survey life is the average number of days a fish was alive in the survey area and observer efficiency represents the proportion of the true number of fish that are present and actually counted by the surveyor.

Survey life can vary between species and within each season. Survey life estimates for sockeye salmon for example, range from 7 to 26.5 days (Shardlow 2004). Survey life for Chinook and sockeye salmon in Grant Creek is not known. An estimate of 14 days for Chinook and 9 days for sockeye salmon was used in the calculations based on observer experience and knowledge of the system.

Observer efficiency can vary spatially, temporally, and between surveyors depending upon factors that affect the surveyor's ability to view an individual fish, such as stream width, depth and water clarity. Observer efficiency values have been obtained through the use of weir counts where the total number of fish in the stream is known and then compared to foot survey counts (Fried et al. 1998). Since there was not a weir on Grant

Creek in 2009 nor have there been previous efforts on Grant Creek to determine observer efficiency, subjective estimates of observer efficiency consisting of 0.30 for Chinook and 0.50 for sockeye were used based on observer estimates. A lower observer efficiency value was used for Chinook because of more turbid water conditions in Grant Creek during the time adult Chinook salmon were present.

The escapement estimate for Grant Creek was calculated by dividing the area-under-the-curve (e.g. fish days) by survey life and then multiplying by an observer efficiency correction factor to adjust for the proportion of fish actually observed. Naturally, if the observer only sees a portion of the fish present, then the estimate will be biased low and the adjustment for observer efficiency corrects this bias. The overall formula is as follows:

$E = (AUC/s)\ v$

where E is escapement, AUC is area under the curve, *s* is stream life, and *v* is observer efficiency

3.4.3 Grant Creek Instream Flow and Microhabitat Preference Study

The purpose of the Grant Creek instream flow study is to determine the potential effects on physical habitat and water temperature in Grant Creek of a range of flow regimes that could result from hydropower development proposed by KHL. The primary goal of the 2009 instream flow study program was to establish a technical working group (TWG) consisting of state and federal resource agency staff, project staff and interested members of the local community. Once established, the TWG met five times during the 2009 study season to review the results of the 2009 aquatic baseline study efforts, discuss alternative methodologies, and determine the need for additional information to support the primary instream flow study effort to occur in 2010.

One outcome of the Instream Flow TWG meetings held in early in 2009 was the identification of a need for site-specific information regarding key habitats and identification of critical suitability factors influencing the use of those habitats that might be altered by project effects. The intent was to use this information to develop a methodology for instream flow analysis that would be tailored to the conditions existing within Grant Creek. Consequently, a study was initiated to address these questions.

Selection of Study Sites Study sites were selected based on the variety of habitats available that were suitable for sampling. Portions of some habitat units were not included in the 2009 surveys due to safety concerns created by swift water conditions. Study site selection also targeted sites that were expected to contain high densities of fish, such as backwater areas; along stream margins; side channels; and portions of the stream associated with large woody debris (LWD). In an effort to include a subset of habitats available in Grant Creek, areas not expected to contain high numbers of rearing fish, such as fast water in the middle of the stream channel was also sampled, where safety conditions allowed. A total of 16 sample sites were established: 11 sites in the main channel and five sites in other channels. The 11 sites in the main channel included five riffles, one backwater pool, one backwater slough, two scour pools, one cascade, and an overflow channel. The other channel sites included two sites in a distributary channel

(Reach 1); two sites in a secondary channel (Reach 3); and one site in a tertiary channel (Reach 3) (Figures 3.4.3-1, 3.4.3-2, 3.4.3-3, 3.4.3-4, and 3.4.3-5).

Description of Micro-habitat Areas Aquatic habitat was described at each sample site by recording macro-, meso-, and micro- habitat characteristics. At the macro-habitat level, the location of the sample site was noted, and described as either fastwater or pool. These broad categories were then broken down into the meso-habitat level, such as glide, riffle, cascade, backwater, scour, or slough (USFS 2001).

Meso-habitats were further broken down into micro-habitats. Micro-habitat sample areas were described and classified based on several criteria including:

1. Location relative to the main channel
2. Depth and flow regime
3. Presence of cover
4. Type of instream cover when present

Fish Use of Micro-habitat Sample Areas Snorkeling was the primary method to document fish presence. Electrofishing was used primarily to confirm species identification and calibrate fish length estimates.

Fish presence was recorded in each discrete microhabitat sample area. This approach was used with the intent to correlate fish presence with the microhabitat characteristics present at location.

Fish were identified to the species level and their fork lengths were estimated (i.e. 20 mm size bins). Dominant and subdominant types of substrate and cover were recorded in the vicinity of each fish observation. The micro-habitat within the sample site was also identified. Depth and velocity measurements were taken at a subset of fish observation locations during snorkeling and also throughout the sample site where fish were not observed nor collected during electrofishing. Qualitative judgments were made regarding which factors were most influential in determining fish use and habitat suitability.

3.4.4 Grant Creek Macroinvertebrates and Periphyton

Macroinvertebrate and periphyton samples were collected once during the 2009 field season, on 06 August. The sampling event was combined with water quality sampling in Grant Lake, Grant Creek, and Falls Creek as well as with zooplankton and phytoplankton sampling in Grant Lake. The event took three days, with one complete day spent collecting macroinvertebrate and periphyton samples in Grant Creek.

Samples were collected at two locations within Grant Creek, GC100 and GC300 (Figure 3.4.4-1). Sampling site selection was based on preliminary project design and natural characteristics of the creek. GC100 is located immediately upstream of the natural split in the creek near the outlet into Middle Trail River. GC300 is located near the proposed powerhouse discharge into Grant Creek.

Macroinvertebrates Benthic macroinvertebrate samples were collected at two sites in Grant Creek; GC100 and GC300. Two sampling methods, the Alaska Stream Condition Index (ASCI) method (Major and Barbour 2001) and the Surber sampler (Eaton et al.

1995), were used to collect macroinvertebrates. The ASCI sampling method was used to begin developing baseline descriptions of macroinvertebrate populations in a range of habitats within the sampling reach. The ASCI method uses a D-frame kick net to sample representative habitats in a 100 meter sampling reach. Twenty subsamples are collected proportionately throughout these habitats. All organisms collected were composited into one sample per site and preserved in 70% isopropyl alcohol. Habitat information, such as riparian vegetation and stream substrate types, was also collected.

In addition to the habitat associated ASCI samples, five samples (pseudo-replicates) of macroinvertebrate populations residing specifically in riffle/cobble areas were collected using a Surber sampler. Surber sampling techniques were used to estimate population densities in riffle/cobble habitat. Each sample was bottled and preserved separately.

All macroinvertebrate samples were returned to the HDR laboratory for sorting and identification. ASCI samples were subsampled until a target of 300 (+/- 10%) organisms were counted. All organisms were sorted from each Surber sample. Identification was completed to genus or the lowest practicable taxon.

Periphyton Periphyton samples were collected at sites GC100 and GC300, concurrent with macroinvertebrate sampling (Figure 3.4.4-1). Periphyton were sampled by removing material from 10 cobbles selected from a riffle/cobble area that had not been disturbed (Eaton et al. 1995). Material was scrubbed from a five centimeter square area on each cobble and rinsed onto a 45-micrometer (μm) glass fiber filter attached to a hand vacuum pump. Water was extracted from the sample and 1-milliliter (ml) saturated magnesium carbonate ($MgCO_3$) solution added to the filter as a preservative. The dry filter was wrapped in a larger filter (to absorb any residual water) and placed in a labeled zipper seal bag with silica gel desiccant. Filters were frozen in a lightproof container for shipment to the laboratory (ADF&G 1998 and pers. comm. Bill Morris, ADNR 2007). Frozen samples were then sent to an Analytica Group laboratory in Juneau for chlorophyll *a* analysis.

Data Analysis Organisms from both ASCI and Surber macroinvertebrate samples were identified to genus or the lowest practicable taxon. Taxonomic data from the ASCI samples was used to calculate several descriptive population metrics: population density, percent Ephemeroptera/Plecoptera/Trichoptera (EPT), taxa diversity, and percent dominant taxa. In addition, Hilsenhoff Biotic Index (HBI) scores, and habitat assessment scores were calculated for ASCI samples. Population density, percent EPT, taxa diversity, and percent dominant taxa also were calculated for Surber samples.

3.4.5 Falls Creek Fish Resources

Falls Creek (Figure 3.4.5-1) was sampled on a reconnaissance level only. It was sampled for juvenile fish using minnow traps in July 2009 to determine the species composition, distribution, and relative abundance. Habitat characteristics such as habitat type, stream gradient, cover, amount of LWD, and substrate type were also recorded.

Foot surveys were conducted from the Seward Highway Bridge to the mouth of the creek to determine if spawning anadromous salmon utilize the creek. A two person field crew walked the banks of the stream from the Seward Highway Bridge to the mouth of Falls

Creek, looking for anadromous salmonids. Foot surveys occurred approximately every 10 days in conjunction with the Grant Creek foot surveys.

3.4.6 Grant Lake Fish Resources

A total of two sampling events were conducted on Grant Lake, one in June and the other in August. Each sampling event occurred over a period of three days. A combination of sampling methods was used including minnow trapping, electrofishing, and gill netting.

Rearing Fish Minnow trapping was used in littoral habitats of Grant Lake and its tributaries during June and August. The 2009 sampling effort targeted locations previously sampled by AEIDC (1983), in addition to new sites (Figure 3.4.6-1). With the exception of the tributary streams during the June event, all minnow traps were set for approximately 24 hours, minnow traps that were placed in the tributaries during June were set for between two and four hours. All fish were identified to species level with the exception of sculpin, TL measured, and released near the point of capture.

Electrofishing occurred in the tributaries of Grant Lake near the east side of the lake in the back basin (Figure 3.4.6-1). Most electrofishing occurred in areas around minnow trapping sites for catch verification; however, some additional sites were electrofished to determine species presence. Time electrofished was approximately one minute at each site. Fish captured were identified to species level, TL measured, and released near the point of capture. Sculpin were identified to the genus level.

Adult Resident Fish Variable mesh gill nets were deployed in approximately the same locations as sampled in 1982 (AEIDC 1983) as well as other locations that appeared to be representative habitats (*n*=9 locations, Figure 3.4.6-1). Two 100 ft long by 6 ft deep gill nets were fished in June with mesh sizes of ¾ in, 1 in, 1.5 in, and 2 in. A third 100 ft long by 8 ft deep variable mesh gill net was added for the August sampling event with mesh sizes from 1 to 5 in. Gill nets were set at a variety of depths, both perpendicular and parallel to the shoreline and fished overnight.

3.4.7 Grant Lake Zooplankton and Phytoplankton

Zooplankton and phytoplankton samples were collected once during the 2009 field season, on 07 August. The sampling event was combined with water quality sampling in Grant Lake, Grant Creek, and Falls Creek as well as with macroinvertebrate and periphyton sampling in Grant Creek. The event took three days, with one complete day spent on Grant Lake.

Sampling occurred at two locations within Grant Lake (Figure 3.4.4-1). Two sampling sites were established to assess conditions in areas of the lake that may be directly impacted by the proposed project. One sampling site was established near the natural outlet of the lake and was named GLOut. The second site was established in the general area of the proposed intake. This site, GLTS, also has a thermistor string installed to record water temperature.

Zooplankton One zooplankton sample was collected at both GLOut and GLTS. Samples were collected using an 18 in diameter 80 µm mesh plankton vertical tow net (Eaton et al. 1995). The net was lowered into the water column using an attached weight to sink it and to keep it from drifting while being towed. The end of the net was capped with a collection bottle into which all zooplankton were trapped. Any organisms attached to the net were rinsed into the collection bottle. The sample was then transferred to a storage bottle and preserved 70% isopropyl alcohol and the sample was returned to the HDR lab for processing. Each sample consisted of one vertical tow.

Rose Bengal solution was added to the sample and allowed to stain the zooplankton for 24 hours before counting and identification. The sample was reduced to 100 mL and 5 mL draws were placed on a counting cell for identification. Draws of 5 mL continued to be withdrawn from the concentrated sample until at least 300 organisms were counted and identified.

Phytoplankton Phytoplankton samples were collected at both GLOut and GLTS. One liter samples were collected using a Niskin bottle sampler (Eaton et al. 1995). The phytoplankton samples were collected at the same time and the same depths as water quality samples. Samples were collected at the surface and at mid-depth at GLOut. Phytoplankton was collected at three depths at GLTS: surface, mid-depth, and a meter above the substrate. The liter of sample was then filtered through a 45-µm glass fiber filter attached to a hand vacuum pump. Filtered samples were preserved with 1-ml saturated $MgCO_3$ solution added to the filter. The dry filter was wrapped in a larger filter (to absorb any residual water) and placed in a labeled zipper seal bag with silica gel desiccant. Filters were frozen in a lightproof container for shipment to the laboratory (ADF&G 1998 and pers. comm. Bill Morris, ADNR 2007). Frozen samples were then sent to an Analytica Group laboratory in Juneau for chlorophyll *a* analysis.

Data Analysis Organisms from the zooplankton samples were identified to order. Zooplankton population density, the number of organisms per liter of water, was calculated by dividing the total number of organisms collected by the total volume of water that passed through the zooplankton net. Percent dominant taxa, the percent of the total number of organisms represented by a taxon, were calculated by dividing the total number of organisms in the sample by the total number of organisms in each individual taxon. Phytoplankton samples were analyzed to determine concentration of chlorophyll *a* as milligram per cubic meter (mg/m^3). Phytoplankton analysis results for each sampling site were averaged.

3.5 Results

The results of the 2009 fish and aquatic resources study program were generally consistent with the results of other studies conducted in the Grant Lake watershed with respect to species presence and distribution (see Section 3.2, USFWS 1961, AEIDC 1983, APA 1984, Marcuson 1989).

3.5.1 Reach Descriptions

Grant Creek consists primarily of fast water habitat. Reaches 1 through 4 are dominated by fast water riffles with a low number of deep main channel scour pools and backwater sloughs; cascade habitat dominates Reach 5. General habitat characteristics and fish use within each reach is described below:

- **Reach 1** is an alluvial reach at the lower end of Grant Creek, where a distributary channel splits from the main channel. Both channels discharge into Middle Trail River. Reach 1 is dominated by riffle habitat with some scour and backwater pools (Figure 3.5-1). One of the more important salmon spawning areas in Grant Creek is just above the distributary split (Figure 3.5-2). The distributary channel provides good rearing habitat conditions during the open water season but may go dry during the winter (Figure 3.5-2). Reach 1 is accessible to foot travel with trails on each side of the creek. The fish species present in Reach 1 are adult and juvenile sockeye, Chinook, and coho salmon, sculpin, rainbow trout, and Dolly Varden.
- **Reach 2** is dominated by riffle habitat with scour and backwater pools (Figure 3.5-1). A remnant channel located on the south bank enters the main channel of Grant Creek in this reach which provides good juvenile fish rearing conditions. Salmon spawning is most abundant on the stream margins (Figure 3.5-2). Reach 2 is accessible via a trail on both banks of the stream. Fish present in Reach 2 are adult and juvenile sockeye, Chinook, and coho salmon, rainbow trout, and Dolly Varden.
- **Reach 3** is dominated by riffle habitat with a larger portion of scour and backwater pools than the previous reaches (Figure 3.5-1). There is a large island complex in Reach 3. Chinook salmon as well as sockeye salmon spawning habitat is present in the main channel area (Figure 3.5-2). The backwater areas as well as the side channel contain good rearing fish habitat (Figure 3.5-1). Reach 3 is accessible via a trail on both sides of the creek, although on the left bank there are two side channel crossings. During high flows, the crossings are impossible. Fish present in Reach 3 are adult sockeye salmon, adult and juvenile Chinook and coho salmon, Dolly Varden, rainbow trout, sculpin, and threespine stickleback.
- **Reach 4** is dominated by riffle habitat with one large scour pool located near the head (Figure 3.5-1). There is an overflow channel on the right bank of Grant Creek in this reach. It provides the primary rearing habitat in this reach (Figure 3.5-2). Both Chinook and sockeye salmon have been documented spawning in this reach (Figure 3.5-2). Reach 4 is accessible via a trail on both sides of the creek. Fish present in Reach 4 are adult sockeye salmon, adult and juvenile Chinook and coho salmon, Dolly Varden, rainbow trout, sculpin, and adult Arctic grayling.
- **Reach 5** is located in a canyon and is mostly inaccessible to foot traffic during the open water season. The lower-most 300 m can be accessed during the summer months because of a shelf on the left bank. Reach 5 is not accessible from the right bank side or further up the left bank side. Reach 5 is dominated by cascade habitat (Figure 3.5-1). Only the first 300 m of Reach 5 were investigated in 2009 due to impassible terrain. No spawning was documented in Reach 5; however, foot surveys indicated that adult salmon were present in Reach 5 (Figure 3.5-2). Fish observed in Reach 5 included adult Chinook and sockeye salmon, adult and juvenile coho salmon, Dolly Varden, and rainbow trout.

- **Reach 6** is located between the outlet of Grant Lake and the lower-most waterfall. It consists of series of falls with backwater, pools, and riffles interspersed between them (Figure 3.5-1). Reach 6 is most easily accessed via the Grant Lake outlet. There is no known spawning or rearing of salmonids in Reach 6 (Figure 3.5-2). The only fish present are sculpin and threespine stickleback.

3.5.2 Grant Creek Fish Resources

Rearing and Adult Resident Fish Overview Resident and rearing fish in Grant Creek were found to consist of juvenile Chinook, coho and sockeye salmon, rainbow trout, Dolly Varden, sculpin, and threespine stickleback (Figure 3.5.2-1). Minnow trapping efforts in Grant Creek consisted of a total of 4,332.42 trap hours. Study Reach 3 received the most effort at 1,147.27 hrs followed by Reach 2 at 990.27 hrs, Reach 1 at 957.57 hrs and Reach 4 at 825.45 hrs. Study Reaches 5 and 6 received considerably less effort due to limited access (Table 3.2).

A total of 2,081 fish were captured during minnow trapping events in June through September (Table 3.3). The most abundant fish in catches were juvenile Dolly Varden (925 fish, Figure 3.5.2-1, Table 3.3). Juvenile coho salmon were the next most abundant species (776), followed by Chinook salmon (191). Eighty-three threespine stickleback, 82 rainbow trout, 22 sculpin, and two sockeye salmon were also caught. Sockeye salmon are rarely attracted to minnow traps.

A total of 167 fish were electrofished at the minnow trapping sites in June through September (Table 3.3). Two sites per reach in Reaches 1 through 4 were electrofished. Coho salmon were the dominant species (59), followed by Dolly Varden (43), Chinook salmon (20), rainbow trout (19), and sculpin (16); six juvenile sockeye salmon were electrofished in June along with four threespine stickleback.

Angling effort at 18 sites in Grant Creek consisted of a total of 90.82 hours (Table 3.1). Reaches 1-4 each had four angling sites with total effort per reach ranging from 19.0 to 20.5 hours. Reach 5 had two angling sites and received 10.65 hours. Total catch for angling from June through August in Reaches 1 through 5 was 72 rainbow trout, 14 Dolly Varden, three sockeye salmon, and one Arctic grayling for a total of 90 fish (Figure 3.5.2-4).

Rearing Fish Spatial Distribution Study Reach 4 had the highest combined CPUE for all reaches across all months, followed by Reaches 1 and 5, then Reaches 3, 2, and 6 (Figure 3.5.2-5). Reach 1 had the highest abundance of juvenile Chinook and juvenile coho salmon. Dolly Varden had the highest CPUE of all fish in all reaches except Reach 6 (Figure 3.5.2-5). The relative abundance of juvenile Chinook steadily decreased moving upstream to Reach 5 where no Chinook were captured. This is consistent with the snorkel survey results (see Section 3.5.4). Juvenile coho abundance decreased slightly upstream although they were relatively abundant in the lower portion of Reach 5. Reach 6 was the only reach in which no salmonids were captured since it is not accessible to salmonids (Figure 3.5.2-5). Excluding Reach 6, the relative abundance of juvenile salmonids was lowest in Reach 2, followed closely by Reach 3, then Reaches 4 and 5, and finally Reach 1.

In Reaches 1, 2, and 4, riffles had the highest CPUE of any habitat type (Figures 3.5.2-6, 3.5.2-7, and 3.5.2-8). However, it should be noted that minnow traps were always set in relatively slow water near the channel margins; consequently, microhabitat characteristics may be more important than the adjacent dominant habitat type. In Reach 3, backwater/pool had the highest CPUE of any habitat type (Figure 3.5.2-9). It should be noted that Chinook salmon were not found in riffle habitat in Reach 3. In Reach 5, cascade had the highest CPUE of any habitat type; however, it was the only habitat type available in Reach 5 and only a small portion of Reach 5 was sampled (Figure 3.5.2-10).

Some inconsistency exists between the minnow trapping results and the snorkel survey results conducted for the instream flow study (see Section 3.5.4). Snorkel survey and minnow trapping results both show a relative decrease in the number of juvenile Chinook moving upstream in Reaches 1 through 4. Snorkel surveys found Chinook to be the most commonly encountered species, followed by coho and Dolly Varden. Minnow traps also captured these species, but Dolly Varden were the most abundant, followed by coho and Chinook salmon. With the exception of backwater pool habitat in Reach 3, minnow traps captured few juvenile salmon in backwater pool habitats, whereas the snorkel surveys found an abundance of fish in these areas.

Rearing Fish Temporal Distribution Between the months of June and September, CPUE was lowest in June (Figure 3.5.2-11). In July, minnow trapping catches showed a marked increase in the relative abundance of Dolly Varden in Reaches 1 through 5 and an increase in CPUE for juvenile coho salmon in Reaches 1 and 2. Minnow trapping catches for August showed a substantial increase in all juvenile fish species captured, although juvenile rainbow trout remained somewhat low across all months sampled. Relative abundance of Chinook salmon appeared to have increased the most between July and August. In the month of September, coho salmon where the most abundant species captured in all reaches, followed by Dolly Varden, rainbow trout, and Chinook salmon.

Rearing Fish Age Class Length frequencies of juvenile coho and Chinook salmon in August and September exhibit a bell shaped distribution (Figure 3.5.2-2 and 3.5.2-3). This suggests that there is one age class predominating for these species, however no age data was collected from scales or otoliths.

Juvenile Chinook salmon studies conducted by ADF&G (Bendock 1995 & 1996) in the Kenai River and at Deep Creek reported mean lengths of age 1 Chinook salmon smolt in May through July ranging from 85.5 mm to 98 mm. Bendock 1995 also reported age 0 Chinook at Deep Creek to have an average length of 70.9 mm in late July. The average length of juvenile Chinook salmon captured in Grant Creek was 67 mm and 76 mm in August and September respectively indicating that young of the year (YOY) appears to be the dominant age class, with a few possible age I fish present.

A juvenile coho salmon study conducted by ADF&G (Carlon 1992) in the Kenai River mainstem and two tributaries reported age 1 coho smolt in May and June to have an average lengths ranging from 76 mm to 122 mm. The average length of juvenile coho salmon captured in Grant Creek was 58 mm in August and September indicating that young of the year (YOY) appears to be the dominant age class, with a few possible age I fish present.

Length frequencies for Dolly Varden in August and September exhibit a bell shaped distribution with a mode of 91-100 mm (Figure 3.5.2-12). Length frequencies for rainbow trout in August and September indicate the presences of YOY fish and the presences of some age I or older juvenile fish (Figure 3.5.2-13).

Adult Resident Fish Adult and sub adult resident fish present in Grant Creek include rainbow trout and Dolly Varden. For purposes of this study, all rainbow trout and Dolly Varden larger than about 180 mm were considered to be "adults" even though many of these fish were likely too small to be sexually mature. Adult rainbow trout likely moved into Grant Creek in the spring with some trout remaining in the creek through the summer and fall. The 2009 study found no direct evidence of spawning. The spawning condition of rainbow trout caught during the month of June could not be determined and there were no evident signs of spawning or spawned out rainbow trout in Grant Creek. However, the presence of YOY rainbow trout fry provides convincing evidence that some spawning may have occurred, possibly prior to initiating angling surveys on 02 June 2009. Additional rainbow trout likely moved into the creek in late summer in response to the presence of salmon eggs.

Dolly Varden were present in Grant Creek in low numbers throughout the study period, but were increasing in number as the salmon returned. Dolly Varden may spawn in Grant Creek in the fall and early winter months, but studies to date have not investigated Dolly Varden spawning.

Adult Resident Fish Spatial Distribution Across all months, Reach 3 had the highest relative abundance for all species, followed by Reaches 5, 4, and 1 with Reach 2 having the lowest relative abundance of adult fish (Figure 3.5.2-14). Rainbow trout were the most abundant in Reach 5, followed by Reaches 3, 4, 1, and Reach 2. The relative abundance of Dolly Varden was the highest in Reach 1 followed by Reaches 3, 2, and 5. Adult Dolly Varden were not caught in Reach 4. A single Arctic grayling was caught in Reach 4.

A total of 72 rainbow trout were captured during angling surveys (Figure 3.5.2-4; Table 3.4). Anecdotal results on rainbow trout recapture indicate nine fish (12.5 %) were recaptured over the course of the sampling season. Recaptures were relatively equal throughout the sampling season, with June 12, having the highest rate at three fish recaptured. As of June 12, only 10 fish had been marked, indicating a 30 % recapture rate.

Adult Resident Fish Temporal Distribution CPUE for rainbow trout was highest in August in Reach 3 when it was approximately 2.5 fish per hour. Reach 1 in June, Reaches 1 and 2 in July, and Reaches 3 and 5 in September had the lowest CPUE with no rainbow trout caught during those months. There is a clear increase in the CPUE in August in all reaches (Figure 3.5.2-15a), which also corresponds with the arrival of Chinook salmon in Grant Creek. In September, Dolly Varden in Reach 3 had the highest relative abundance at 1.0 fish/hour (Figure 3.5.2-15b). In September, a decrease in the relative abundance of rainbow trout across all reaches was apparent. Also in September, an increase in the relative abundance of Dolly Varden was apparent.

Adult Resident Fish Age Class Length frequency data for rainbow trout in June indicate a majority of fish caught were in the size range of 221 mm – 240 mm or 321 mm – 340 mm (Figure 3.5.2-16). Length frequency data for rainbow trout in August indicate the majority of fish caught were in the size range of 181 mm – 220 mm (Figure 3.5.2-17). Length frequency graphs for Dolly Varden in Grant Creek in June and August indicate multiple age classes are present (Figures 3.5.2-18 and 3.5.2-19).

Adult Salmon The 2009 escapement estimate based on foot surveys for Chinook salmon is 231 fish (Figure 3.5.2-20). The highest individual survey count was 62 live fish observed on 23 August 2009. Chinook salmon entered Grant Creek on August 10th, and spawning abundance peaked on approximately August 23rd. By August 31st, adult Chinook salmon began to decline in numbers and by September 11th adult Chinook salmon were no longer present in Grant Creek (Table 3.5).

The 2009 escapement estimate based on foot surveys for sockeye salmon is 6,293 fish (Figure 3.5.2-21). The highest individual survey count was 1,351 fish observed on September 11th. Sockeye salmon were first observed in Grant Creek on August 13th and spawning abundance peaked on September 11th. By September 16th spawning sockeye abundance began to decline and by September 29th spawning sockeye abundance declined to 78 fish (Table 3.5). For the purposes of the escapement estimate it was assumed that no spawning sockeye salmon were present in Grant Creek after October 9th.

A total of six adult coho salmon were observed in Grant Creek, all of which were counted during the final foot survey event on September 29, 2009 (Table 3.5). It is recommended that foot surveys conducted in future years include surveys during the months of October and November to estimate adult coho salmon spawning abundance.

3.5.3 Grant Creek Instream Flow Study

The purpose of the Grant Creek instream flow study is to determine the potential effects on physical habitat and water temperature in Grant Creek of a range of flow regimes that could result from hydropower development proposed by KHL. The development of the Grant Creek instream flow study is a collaborative effort that includes the members of the TWG. The TWG met on several occasions in 2009 to discuss elements of the study design. The following sequence of events occurred in 2009:

- 24 March 2009. TWG presentation in Moose Pass. Included presentation and discussion of draft hydrology, water quality, aquatic biology, and instream flow study plans.
- 21 April 2009. TWG meeting in Kenai. Included presentation of 2009 hydrology and aquatic biology study plans, and discussion of draft instream flow study plan.
- 18 May 2009. Hydrology, water quality, and aquatic biology study plans uploaded to www.kenaihydro.com website.
- 19 May 2009. TWG conference call. Included discussion of modification to 2009 hydrology study plan and applicable instream flow assessment methodologies.
- 10 June 2009. Jason Kent (HDR) sent TWG compilation of documents forwarded by Jason Mouw (ADF&G) regarding instream flow study methodologies.

- 01 July 2009. Jason Kent sent TWG a Technical Memorandum regarding the habitat use (snorkeling) work proposed for the 2009 field season.
- 16 July 2009. TWG conference call. Included presentation of 2009 mid-season results of Grant Creek hydrology, water quality, and aquatic biology studies.
- 27 August 2009. Kenai Hydro, Inc. (KHI) 1984 instream flow study report and associated documents uploaded to www.kenaihydro.com website; Jason Kent sent announcement email to TWG.
- 08 September 2009. Jason Kent sent TWG summary of KHI 1984 instream flow study (attached as Appendix A).
- 22-24 September 2009. TWG meeting in Moose Pass. Included field trip to Grant Creek, presentation of 2009 hydrology, water quality, and aquatic biology studies, and presentation and discussion of proposed instream flow study approach. Also included optional field trip for instream flow study site selection.
- 07 October 2009. Jason Kent sent TWG summary Technical Memorandum describing instream flow study plan – revised based on input from TWG on 22-24 September meeting.

Fish Use of Microhabitats A total of 16 sample sites were established and distributed in the creek as follows: 11 sites in the main channel and five sites in "other" channels. The 11 sample sites in the main channel included five riffles, one backwater pool, one backwater slough, two scour pools, one cascade, and an overflow channel[3]. The "other" channel sites included two sites in a distributary channel (Reach 1); two sites in a secondary channel (Reach 3); and one site in a tertiary channel (Reach 3)(Figures 3.4.3-1, 3.4.3-2, 3.4.3-3, 3.4.3-4, and 3.4.3-5).

The field team identified microhabitat sample areas: faster pools, fastwater riffles, margins with undercut bank, margins without undercut bank, LWD dam, and margin shelf associated with LWD, and backwater pools, sloughs, and pockets, as shown in Table 3.5. The sample sites were lumped into three primary categories for analyses: main channel sites, backwater areas, and other channels, each of which was further subdivided based on microhabitat characteristics (Table 3.6).

Rearing and Adult Resident Fish Juvenile Chinook, coho, and sockeye salmon; juvenile Dolly Varden; juvenile and adult rainbow trout; adult Arctic grayling; and sculpin were observed during the June snorkeling event. Overall, Chinook salmon was the most abundant juvenile fish observed, followed by coho and sockeye salmon (Figure 3.5.3-1). Rainbow trout were the most abundant resident fish species observed, followed closely by Dolly Varden. Two adult Arctic grayling were also observed.

Fish Species by Age Class All coho and sockeye salmon observed in June 2009 appeared to be YOY (<60 mm). A majority (92 %) of Chinook salmon observed appeared to YOY, only 8 % were older (>60 mm; age I) (Figure 3.5.3-2).

[3] The overflow channel was separated from the main channel by a gravel bar.

Rainbow trout were the most abundant resident species observed with multiple size classes present. Nearly 60 % of the rainbow trout were estimated to have fork lengths greater than 200 mm; these fish were considered to be subadults or adults. The remaining 40 % that were less than 200 mm were considered juveniles. The smallest size class of rainbow trout was estimated to be smaller than 40 mm. The majority (89 %) of Dolly Varden were juveniles (<200 mm), with nearly half the fish length less than 100 mm.

Fish Species Spatial Distribution by Reach Juvenile Chinook and coho salmon were observed throughout the lower 4 reaches (Figure 3.5.3-3). Chinook salmon were especially abundant in Reaches 1 and 2, while coho salmon were the more abundant species observed in Reaches 3 and 4. No juvenile coho or Chinook salmon were observed in Reach 5.

Sockeye salmon fry were observed in Reaches 1 – 3, with the highest concentration in the distributary channel in Reach 1. Sockeye salmon were also observed at three main channel sample sites. A deep undercut bank associated with backwater area in Reach 3 (Figure 3.5.3-3) was the farthest upstream sockeye salmon fry observation.

Rainbow trout were observed in all reaches, excluding Reach 2 (Figure 3.5.3-3). Larger (>200mm) rainbow trout dominated the species composition in Reach 4 and Reach 5 and were also observed in deep areas in Reach 3, likely due to the presence of deep pool habitats. Dolly Varden were observed in all reaches with the exception of Reach 4. Dolly Varden and rainbow trout dominated the species composition in Reach 5. Two adult Arctic grayling were observed, both in Reach 5.

Fish Presence by Habitat As expected, juvenile salmon were typically observed more frequently in areas with slower velocities and abundant cover. Based on the three-day sampling event in June 2009, the three microhabitats occupied by juvenile rearing salmon in Grant Creek include backwater areas (i.e., sloughs and pocket water) and stream margins, especially those with undercut banks (Figure 3.5.3-4).

Backwater areas, margin shelves associated with large woody debris, and stream margins with undercut bank appear to be important microhabitats for juvenile Chinook salmon. Similarly, coho salmon occupied backwater areas and margins with undercut banks, some of which were situated along fast stream margins. Sockeye salmon were most commonly observed using backwater areas in the main channel. No juvenile fish were observed along stream margins without undercut bank or large woody debris.

The larger (>60 mm) assumed age I Chinook, along with Dolly Varden, were observed using fast water (i.e., closer to velocity breaks) than the YOY Chinook and coho salmon.

Based on observations from the three-day event, subadult/adult (>200 mm) rainbow trout was the most abundant and commonly observed species occupying deep/fast pools and fastwater riffles.

Typically, the larger (>200 mm) rainbow trout and Dolly Varden were observed using deeper and faster pool habitat in the main channel (Figure 3.5.3-5). For example, nearly 70% of the “subadult/adult” (>200 mm) rainbow trout and 100% of Dolly Varden >200 mm were observed in main channel pools and riffles. Smaller (juvenile <200 mm) rainbow trout and Dolly Varden were observed throughout the various microhabitats, though typically areas with faster velocities compared to that of YOY salmon observations.

YOY Chinook and sockeye salmon dominated the species composition of fish in the distributary channel, while coho salmon, followed by rainbow trout, were the primary fish species that occupied the secondary channel (Figure 3.5.3-6).

Coho salmon were observed using stream margins with undercut bank in the secondary channel; rainbow trout was the only fish species observed using the middle portion of the channel of the secondary channel, similar to the pattern observed in the main channel microhabitats sampled (Figure 3.5.3-6).

3.5.4 Grant Creek Macroinvertebrates and Periphyton

Macroinvertebrates and periphyton were sampled at two locations in Grant Creek on 06 August 2009. All macroinvertebrate samples were identified to genus or the lowest practicable taxon (Table 3.7).

Descriptive metrics calculated for samples collected using ASCI methods included population density, percent EPT, taxa diversity, and percent dominant taxa. HBI scores and habitat assessment scores also were calculated for each sampling site. Population density, percent EPT, taxa diversity, and percent dominant taxa were calculated for samples collected using Surber samplers (Table 3.8).

Grant Creek periphyton samples were analyzed for chlorophyll *a* concentration.

Macroinvertebrate Population Density

Alaska Stream Condition Index (ASCI) ASCI methods required collecting 20 sub-samples in a 100 m stream reach. Organisms were collected from approximately 0.15 square meter of substrate in each sub sample, thus a total of approximately 3.0 square meters (m^2) was sampled. Macroinvertebrate density at GC100 was 5475 organisms in approximately 2.0 m^2 or 274 organisms per 0.1 m^2. At GC300 approximate population density was 1061 organisms per 2.0 m^2 or 53 organisms per 0.1 m^2.

Surber Five samples were collected using Surber samplers at each site. The Surber sampler encloses 0.1 m^2 of substrate. Surber samples were analyzed individually to calculate a range of population densities in the riffle samples. The population density at GC100 ranged from 76 organisms per 0.1 m^2 to 212 organisms per 0.1 m^2. The average Surber sample density at GC100 was 148.4 organisms per 0.1 m^2. GC300 had a range of 41 to 184 organisms per 0.1 m^2. The average population density for Surber samples at GC300 was 98.8 organisms per 0.1 m^2 (Figure 3.5.4-1).

Macroinvertebrate Percent EPT Ephemeroptera, Plecoptera and Trichoptera are three families of macroinvertebrates that are typically regarded as indicators of aquatic habitat quality because of their low tolerance to organic pollution and impaired water quality relative to some other taxa.

Among macroinvertebrates collected using the ASCI method, percent EPT at GC100 was 1.90 % of the total population and at GC300 was 3.59 % of the total population.

The percent EPT of macroinvertebrates collected using Surber samplers ranged from 3.28 % to 16.92 % at GC100 and from 24.49 % to 39.90 % at GC300. The average percent EPT among Surber collected samples at GC100 was 7.72 % and at GC300 was 31.49 % (Figure 3.5.4-2).

Macroinvertebrate Taxa Diversity Taxa diversity is the total number of different taxa found in a sample. Macroinvertebrates in the ASCI sample at GC100 had a taxa diversity of 10 taxa while the taxa diversity at GC300 was 12 taxa.

Surber collected samples at GC100 had a taxa diversity range of 18 to 20 taxa. The average at GC100 was 18.6 taxa. The taxa diversity at GC300 ranged from 11 to 20 taxa. The average at GC300 was 15.2 taxa (Figure 3.5.4-3).

Macroinvertebrate Percent Dominant Taxa The dominant taxon among macroinvertebrates in the ASCI sample at GC100 was Bivalvia, which comprised 83% of the total organisms (Figure 3.5.4-4). The dominant taxon among macroinvertebrates in the ASCI sample at GC300 was also Bivalvia at 78% (Figure 3.5.4-5). Dominant taxon calculations for Surber sample data were averaged to determine overall dominant taxa for the sampling site. The dominant taxa among macroinvertebrates in the Surber samples at GC100 and GC300 was Chironomidae, which comprised 85% and 48% of the total organisms, respectively (Figures 3.5.4-4 and 3.5.4-5).

ASCI HBI and Habitat Assessment Scores Additional metrics that can be calculated using ASCI method collected data include the HBI score and Habitat Assessment scores. HBI values assigned to organisms range from 0-10, where 0 indicates the least tolerant and 10 indicates the most tolerant. These values are translated into a score of from 0-10 indicating average tolerance of taxa present at the site. Habitat scores range from 0-200 with 0 being the most impaired and 200 being the most macroinvertebrate habitat rich environments.

The HBI score for the ASCI sample at GC100 was 7.5 and the habitat assessment score was 200. The HBI score for the ASCI sample at GC300 was 7.1 while the habitat assessment score was 190.

***Periphyton Chlorophyll* a** Chlorophyll *a* concentrations at GC100 ranged from 7.48 mg/m^3 to 82.00 mg/m^3. The average concentration at GC100 was 34.79 mg/m^3. Concentrations at GC300 ranged from 2.94 mg/m^3 to 23.20 mg/m^3. The average concentration at GC300 was 12.70 mg/m^3 (Figure 3.5.4-6).

3.5.5 Falls Creek Fish Resources

Foot surveys took place on Falls Creek from the Seward Highway Bridge to the mouth of the creek. No adult anadromous fish were seen during foot surveys from July – September. Due to the high turbidity of the Falls Creek, there was a possibility that fish were missed. NTUs ranged from 16.6 – 19.3 during August and September; however, they dropped to 2.9 on 29 September.

Falls Creek is a high gradient riffle stream with small amounts of undercut bank and moderate amounts of large woody debris.

A 700 m reach of lower Falls Creek was sampled using minnow traps from 21 to 22 July 2009 (Figure 3.5.5-1). A total of 24 fish were captured, all of which were juvenile Dolly Varden (Figure 3.5.5-1). Fork length ranged from 58 mm to 175 mm (Figure 3.5.5-2). The majority of the fish captured ranged in size from 58 mm – 69 mm, indicating that YOY is the dominant age class of Dolly Varden present in Falls Creek. Dolly Varden in the range from 81 mm – 140 mm likely represent age I fish and those sized 171 – 180 mm may represent age II fish.

3.5.6 Grant Lake Fish Resources

Minnow trapping occurred at 28 sites in June and August (Figure 3.4.6-1). A total of 4,877 fish were minnow trapped. Seventy nine of them were sculpin and 4,798 were threespine stickleback (Table 3.9 and Figure 3.5.6-1). A majority of the threespine stickleback were captured in the front basin of the lake.

Tributaries at the back of Grant Lake were electrofished in June and August at 18 sites (Figure 3.4.6-1). Six threespine stickleback and 18 sculpin were captured (Table 3.9).

Variable mesh gill nets were set in nine locations around Grant Lake in June and August (Figure 3.4.6-1). The gill nets were set at depths from 3 m to 51 m. Four threespine stickleback were capture alive in the gill nets in August (depths ranged from 4 m – 7 m) (Table 3.9). No other species were caught.

3.5.7 Grant Lake Zooplankton and Phytoplankton

Zooplankton and phytoplankton were sampled at two sites in Grant Lake on 07 August 2009. Zooplankton were identified and taxa diversity, population density and percent dominant taxa were calculated for each sample. Phytoplankton samples were analyzed for chlorophyll *a* content.

Zooplankton Taxa Diversity, Population Density, and Percent Dominant Taxa Zooplankton samples were identified to order. GLTS and GLOut both had three identified taxa; rotifers, copepods and protozoans. The zooplankton population density at GLTS was 3.67 organisms per liter. Population density at GLOut was 10.65 organisms per liter.

The dominant taxon at both GLTS and GLOut were rotifers. At GLTS 97 % of the organisms were rotifers and at GLOut 99% of the organisms were rotifers. Other taxa at GLTS and GLOut were copepods and protozoans, with a range of percent dominance of < 0.1 % to approximately 2 %. (Figure 3.5.7-1, Table 3.10).

Phytoplankton Chlorophyll a Chlorophyll *a* concentrations are reported as milligrams per cubic meter (mg/m^3). Concentrations of Chlorophyll *a* ranged from 0.53 mg/m^3 at the lowest depth at the Grant Lake thermistor string site (GLTS) to 1.34 mg/m^3 at the surface. The Chlorophyll *a* concentrations at GLOut were 0.80 mg/m^3 at the middle of the water column and 1.07 mg/m^3 at the surface (Figure 3.5.7-2, Table 3.11).

3.6 Discussion

3.6.1 Grant Creek Fish Resources

Findings from the minnow trap study indicated that Dolly Varden were the most abundant juvenile species in Grant Creek (Figure 3.5.2-1 and Table 3.3). These results are contrary to the snorkeling results, in which few Dolly Varden were observed and Chinook and coho salmon were the dominant juvenile species fish species observed (Figure 3.5.3-1). Daytime snorkeling often is not effective for Dolly Varden observations because of the stream bottom orientation of Dolly Varden and tendency to be inactive during the day. Consequently, the minnow trap results are likely more representative of Dolly Varden abundance. On the other hand, the minnow trap results probably underestimated the abundance of juvenile Chinook and coho salmon. Minnow trap mesh size (¼ in) may have been too large to retain the very small salmon fry, especially in June, or stream velocity may have been too high to allow free movement of the fry into the traps. In August, the numbers of Chinook and coho salmon caught in minnow traps increased as the fork length of the fish increased (Figure 3.5.2-11).

Snorkeling is known to be an effective method of observing Chinook and coho salmon presence because the fish are active during the day and tend to school in mid-channel waters where they are easily visible. The relative abundance of juvenile salmon detected by the snorkeling is likely more representative of stream conditions than indicated by the minnow trapping.

Except for Reach 5, angling effort was fairly uniform throughout all reaches (Table 3.1). Given the uniformity of the sampling effort in the reaches, they can be compared together. Rainbow trout were the dominant species caught (Figure 3.5.2-4) with an increase in relative abundance in August (Figure 3.5.2-15a). This suggests that after spawning occurred fish remained in Grant Creek to recover and feed, then an additional aggregate of fish entered the creek when the spawning salmon arrived. Across all months, Reach 3 had the highest CPUE for angling (Figure 3.5.2-14). This likely indicates that rainbow trout prefer the habitat available in Reach 3.

Salmonids were not caught in Reach 6 (Figure 3.5.2-5). This is most likely due to a series of falls in this reach making it inaccessible to salmonids. As seen in Figure 3.5.2-5, the abundance of juvenile Chinook salmon decreased as distance from the mouth of Grant Creek increased. This is consistent with the snorkeling results.

Length frequency graphs from August and September for coho and Chinook salmon (Figures 3.5.2-2 and 3.5.2-3) indicate the presence of one primary age group with only a few larger fish. This indicates that the dominant age class of Chinook and coho were YOY with few age I fish present in Grant Creek. If this is the case, it is likely that older juvenile Chinook and coho salmon are not overwintering in the creek and few are moving into Grant Creek during the open water period. If Chinook and coho salmon are overwintering in Grant Creek, then based on the length frequency graphs, their survival is low. These results are in concurrence with APA findings (APA 1984).

Moreover, the length frequency graphs from August and September for coho salmon (Figure 3.5.2-2) and rainbow trout (Figure 3.5.2-13) merit some explanation. It is expected that larger fish will be trapped later in the year. However, this is not the case.

In both cases, there was substantial overlap in sizes between months and rainbow trout encompassed a wider range of fish sizes. However as a whole, fish trapped in September were somewhat smaller than fish trapped in August. Given the limited amount of data, it is difficult to determine the actual cause. One likely explanation is lower stream flows in September (Figure 4.5.2-1), may have made the traps more accessible to smaller fish.

When reviewed together, the length frequencies for the minnow trapping and the angling suggest there are multiple age classes for both Dolly Varden and rainbow trout (Figures 3.5.2-13, 3.5.2-16, 3.5.2-17, 3.5.2-12, 3.5.2-18, and 3.5.2-19). This indicates that Dolly Varden and rainbow trout likely use Grant Creek for rearing, spawning and adult feeding. The increase in relative abundance for rainbow trout and Dolly Varden (Figures 3.5.2-15a and 3.5.2-15b) throughout the summer, strongly suggests that adult rainbow trout and Dolly Varden moved into Grant Creek concurrently with the arrival of adult salmon.

Recapture of marked fish through the June12th capture period, indicated that there was a 30 % recapture rate for rainbow trout. This may be indicative of a small spawning population of rainbow trout in Grant Creek. However, the beginning of the study did not coincide with the beginning of the rainbow trout spawning. Therefore, further study needs to be conducted to include the spawning season, to determine the size of the rainbow trout spawning population in Grant Creek.

Findings from this study are similar to the APA (1984) findings. APA determined that Grant Creek supported 250 spawning Chinook salmon, whereas this study estimated an escapement of 231 spawning Chinook salmon (Figure 3.5.2-20). APA estimated that Grant Creek supported 1,650 spawning sockeye salmon. HDR estimated sockeye salmon escapement at 6,293 fish (Figure 3.5.2-21). Both estimates are likely low due to the possible observer inefficiency associated with visual counting methods and the turbidity of the water. The number of Chinook salmon entering, and presumably spawning, in Grant Creek suggests a high density of spawners for such a short stream segment.

In Reaches 1, 2, and 4, riffle margins had the highest relative abundance of fish of any habitat type (Figures 3.5.2-6, 3.5.2-7, and 3.5.2-8). In Reach 3, backwater/pool had the highest CPUE per habitat type (Figure 3.5.2-9). In Reach 5, cascade had the highest CPUE per habitat type but it was the only available habitat (Figure 3.5.2-10). These results are indicative of the type of habitat available and also of the type of habitat that these fish prefer. If more backwater/pools were available, there would most likely be an increase in the number of Chinook and coho salmon.

Rainbow trout and Dolly Varden were the only fish observed during snorkel surveys using fastwater habitat away from the stream margin. Typically, the larger (>200 mm) rainbow trout and Dolly Varden were observed using deeper and faster pool habitat in the main channel. Smaller (juvenile <200 mm) rainbow trout and Dolly Varden were observed throughout the various microhabitats, though typically in areas with faster velocities compared to that of the YOY salmon observations.

Grant Creek is a swift, glacially influenced stream that is somewhat narrow for the amount of flow it supports during the peak flow period in July when high flow conditions can exceed 500 cfs. During winter conditions Grant Creek contains relatively low flow conditions ranging from 15 to 20 cfs. Results from the 2009 juvenile salmon study showed a low number of age I fish present in Grant Creek, which suggests that overwintering of juvenile fish and/or dispersal of juvenile fish into the creek from downstream is limited.

Study Reaches 1-4 supports the greatest abundance of suitable fish habitat in Grant Creek; and while Reach 5 is accessible to anadroumous fish, salmon presence there appears to be somewhat diminished. This is likely due to a bedrock substrate, high flows and a fish passage barrier in the upper end of the reach. Rainbow trout do appear to occupy the lower portion of Reach 5 as indicated by the results of the resident fish study.

Although Study Reach 5 has not been fully characterized, it is evident that the lower reaches of Grant Creek (Reaches 1-4); contain a relative majority of suitable spawning and rearing fish habitats. In spite of high velocity flow conditions in the main channel, the presence of lateral habitats such as backwater areas and stream margins with undercut microhabitats in the main channel and the distributary channel appear to provide important rearing habitats for rearing salmon and resident fish. Study Reaches 1-4 contain all of these critical habitat factors. However, they are not evenly distributed between study reaches. Study efforts in 2010 will focus on identifying and defining the distribution of critical micro habitats, and, in conjunction with the instream flow study, provide an estimate as to how the proposed project could affect micro habitat conditions.

3.6.2 Grant Creek Instream Flow and Microhabitat Preference Study

Collaboratively, the TWG and KHL decided to select an instream flow study methodology based on the knowledge obtained from the summer 2009 aquatic resources and hydrology studies. Data and analysis from these studies were shared with the TWG in July and September. The microhabitat preference study suggested specific habitat types that would be most appropriate for analysis to determine the impact of flow alterations on fish population. A proposed instream flow approach methodology that emphasizes specific high use habitats was presented to the TWG on 23 September. Revisions to this approach were made based on TWG input, and will provide the basis for preparation of a final instream flow study plan.

3.6.3 Grant Creek Macroinvertebrates and Periphyton

Macroinvertebrates and periphyton were collected in Grant Creek to begin to characterize baseline productivity and nutrient and forage availability at GC300 and GC100. The results of analysis of both macroinvertebrate and periphyton data differed between sitesGC100 and GC300. Overall variation in habitat, including gradient and canopy cover, could account for differences in the data between sites.

Macroinvertebrate Population Density Population density estimates indicated that populations of macroinvertebrates at GC100 were greater than at GC300 regardless of sampling method (Figure 3.5.3-1). However, population density also differed between sampling methods, which focus on different habitats. At GC100 population density over a variety habitats, as estimated from data collected by the ASCI methods, was somewhat greater than population density in riffle/cobble habitats, as calculated from Surber sampler data. The reverse occurred at GC300. A large rain event that occurred in late July through early August could have caused differential scouring of organisms from GC300.

Macroinvertebrate Percent EPT The percent of EPT taxa at GC300 was higher than at GC100 (Figure 3.5.3-2). Riffle/cobble habitat, a habitat preferentially colonized by EPT, dominates at GC300. GC100 has a wider variety of habitats available to macroinvertebrates. The difference between sites in percent EPT of macroinvertebrates collected by Surber sampler, which sample only riffle/cobble habitat, is possibly due to other habitat characteristics, such as temperature and volume of winter flows. More data will be needed to better understand this difference.

Macroinvertebrate Taxa Diversity Taxa diversity between the Grant Creek study sites differed slightly, as shown in the data collected by Surber sampler (Figure 3.5.3-3). Taxa diversity at GC100 is somewhat higher than GC300 using Surber collected data. However, when using the ASCI collected data, taxa diversity was higher at GC300. These results are possibly related to storm events or other habitat characteristics such as relative periphyton availability as food source. Studies conducted in Grant Creek in 1981 and 1982 using Surber samplers revealed that benthic macroinvertebrate diversity was low, with the most abundant taxa being Chironomidae, followed by Ephemeroptera, Plecoptera and clams. (APA 1984). Continued sampling at GC100 and GC300, over a variety of conditions, will help to further describe their baseline characteristics.

Macroinvertebrate Percent Dominant Taxa Some differences between GC100 and GC300 were noted especially in samples collected by the Surber sampler method (Figures 3.5.3-4 and 3.5.3-5). The dominant taxon at both sites in samples collected using the ASCI method was Bivalvia. The dominant taxon at both sites collected using the Surber sampler method was Chironomidae, with Bivalvia dominant at two psuedo-replicates at GC300. GC300 had lower percent dominant taxa values which is indicative of conditions that allow successful colonization by a number of taxa, with no single taxa having an advantage.

The rain event described above may have had a greater impact on larger bodied taxa or taxa incapable of clinging to, or burrowing into the substrate. It is possible that Bivalvia were less affected by the rain event for this reason. Another reason could be that the natural emergence timing of some macroinvertebrates in Grant Creek is earlier in the summer. However, previous studies in 1984 showed that no seasonal variation in macroinvertebrate abundance was observed (APA).

ASCI HBI and Habitat Assessment Scores The habitat scores at both sites indicate that habitat availability and quality is high. The creek and riparian area is undeveloped and there are a large variety of habitats for macroinvertebrates. This would indicate the potential exists for a large diversity of organisms with low tolerance to pollution and disturbance. However, the HBI scores are relatively high, greater than seven (on a scale of 1 – 10 where 1 is optimal). This is largely due to the high tolerance value of bivalves and chironomids which were the dominant taxa at both sites. The large rainfall event could have scoured many organisms with low tolerance values. More data is necessary to discover if the results from this year are within the range of typical conditions, or may have been affected by events such as the rainfall in late July and early August.

Periphyton Chlorophyll a Average chlorophyll *a* concentration at GC100 was nearly three times higher than the concentration at GC300, 34.8 mg/m^3 and 12.7 mg/m^3, respectively. The substrate at both sampling sites is similar, however, some features (e.g.

gradient, temperature, and canopy cover) that could affect periphyton growth at these sites do differ. Continued sampling under different conditions will help to further characterize the periphyton growth at these sites.

3.6.4 Falls Creek Fish Resources

As of 29 September 2009, no adult salmon were seen in Falls Creek. The water was turbid and observation conditions were poor; consequently, some fish may have been missed. Falls Creek is listed in the ADF&G AWC as having adult Chinook salmon present

Only Dolly Varden were trapped in the minnow traps (Figure 3.5.4-1). This result differs from 1959-1961 results when juvenile Chinook were trapped in the lower 600 ft of the stream (USFWS 1961 and Johnson and Klein 2009). However, the minnow trapping data is consistent with the AEIDC data (1983) in which investigators only trapped Dolly Varden. There is the possibility that since the juvenile Chinook salmon were trapped within the lower 600 ft of the stream, that they use Falls Creek infrequently.

3.6.5 Grant Lake Fish Resources

Contrary to the findings of AEDIC (1983), fish were present in the Grant Lake tributaries; both sculpin and threespine stickleback were observed. Threespine stickleback were present throughout the lake (Figure 3.5.6-1 and Table 3.9); however, threespine stickleback were much more abundant in the front basin of the lake, which is consistent with previous reports (USFWS 1961, AEIDC 1983, APA 1984).

Minnow traps appear to be the most effective method for capturing fish in Grant Lake (Table 3.9). However, given the conflicting reports as to the presence of rainbow trout and Dolly Varden (Sisson 1984) or absence of rainbow trout and Dolly Varden (USFWS 1961, AEIDC 1983, APA 1984, Marcuson 1989), multiple sampling methods were used. Minnow traps were placed in the littoral zone of the lake, gill nets were placed at varying depths around the lake, and electrofishing was performed in tributaries and around their mouths. Results of the current study, in combination with past study efforts, provide convincing evidence that no salmonid species are currently present in Grant Lake or its tributaries.

3.6.6 Grant Lake Zooplankton and Phytoplankton

Zooplankton and phytoplankton were collected in Grant Lake in order to estimate the productivity of the lake in the area of the natural outlet and the proposed project intake. Zooplankton and phytoplankton in this area of the lake could be contributing to availability of food resources in Grant Creek. The project design could affect how and where these organisms enter the creek system.

Zooplankton There was no difference in the diversity of zooplankton between the Grant Lake sampling sites; there were a total of three orders of zooplankton identified at each site. The two factors that possibly illustrate best the availability of zooplankton as a possible food resource are population density and percent dominant taxa. The population density at the thermistor string site was 3.67 organisms per liter while the natural outlet site is nearly three times higher at 10.65 organisms per liter. This indicates that zooplankton in Grant Lake occur at higher concentrations in the natural outlet area. Rotifers dominate the zooplankton population, which is comprised of 99% and 97% rotifers at GLOut and GLTS sites, respectively.

Studies conducted in Grant Lake in the early 1980s show that rotifers were the dominant taxa found in Grant Lake, but that copepods also were abundant in large numbers (APA 1984). Copepods have been found to be the dominant food found in fish stomachs even when rotifers were the dominant organisms found in the water body (Bailey et al. 1975). Continued sampling in 2010 will help to better characterize zooplankton conditions in Grant Lake.

Phytoplankton Chlorophyll a Phytoplankton are free floating planktonic plants. Like most plants, phytoplankton thrive in areas with greater sunlight. The results of the chlorophyll *a* analysis show that there is greater concentration of these primary producers in the near surface water. Turbidity analysis and Secchi disc readings recorded during the water quality data collection indicate that sunlight does not penetrate much deeper than 7-10 ft. The area of the lake near the proposed intake and natural outlet of Grant Lake is predominantly shallow water. However, contrary to the results of the zooplankton sampling, concentrations of chlorophyll *a* were greater at the thermistor string site as compared the lake outlet site.

4 Water Resources

4.1 Introduction

Water quality and hydrology baseline studies were conducted in the summer of 2009 in support of the FERC permitting process for the proposed hydroelectric developments at Grant Lake. These baseline water resource studies included water quality and temperature studies on Grant Lake, Grant Creek, and Falls Creek, and studies of the hydrology of Grant Creek and Falls Creek. Baseline data collected during the 2009 field season (approximately mid June through mid October) are presented in this report.

4.2 Previous Studies

The hydroelectric potential at Grant Lake (Figure 2-1) has been evaluated several times as a potential power source for the Seward/Kenai Peninsula area. In 1954, R.W. Beck and Associates (cited by APA 1984) prepared a preliminary investigation and concluded that a project was feasible. The U.S. Geological Survey (USGS) conducted geologic investigations of proposed power sites at Cooper, Grant, Ptarmigan, and Crescent Lakes in the 1950s (Plafker 1955). In 1980 CH2M Hill (cited by APA, 1984) prepared a pre-feasibility study for a Grant Lake project and concluded that a project developed at the site would be feasible. The Grant Lake Project was referenced in the 1981 U.S. Army Corps of Engineers (USACE) National Hydroelectric Power Resources Study (USACE 1981). The most extensive study was performed by Ebasco Services, Inc. in 1984 for the Alaska Power Authority (now Alaska Energy Authority; APA 1984). Two of the alternatives evaluated by Ebasco included the diversion of adjacent Falls Creek into Grant Lake to provide additional water for power generation.

4.2.1 Grant Creek Water Quality

The USGS, USFS, USFWS, ADFG, and AEIDC have previously collected water quality data in Grant Creek. Water chemistry and physical data for Grant Creek were collected intermittently from 1950-1960 (Still 1976, 1980; USFWS 1961) and again in 1981-82 (AEIDC 1983). Previous studies show that the water quality in Grant Creek corresponds to that in Grant Lake. Such a correspondence would be expected when there appears to be little additional input to Grant Creek from tributaries.

4.2.2 Grant Lake Water Quality

Previous water quality studies have been conducted by the USGS, USFS, USFWS, ADFG, and AEIDC in Grant Lake. Water quality and temperature profiles were measured in Grant Lake in 1960, and again in 1981-1982 (Figure 4.2.1-1, AEIDC 1983). Four limnology sites were established in the Grant Lake basins (upper and lower) in 1983 and water quality data were collected during eight open water sampling events from June 1983 - September 1985 (Marcuson 1989; Figure 4.2.1-1).

4.2.3 Falls Creek Water Quality

Falls Creek is approximately 8 miles long and drains directly from the surrounding mountains being fed by numerous small tributaries. Previous studies conducted in the area by USFWS, USGS, and AEIDC have included water quality data collection in Falls Creek. The 1981-82 AEIDC study of Falls Creek collected information on water temperature, dissolved oxygen, salinity, trace metals, and pH among other analytes. Falls Creek was found to be generally colder and more turbid than Grant Creek. The source water for Falls Creek is different than that for Grant Creek and thus Falls Creek was found to have several differences in water quality from Grant Creek.

4.2.4 Grant Creek and Falls Creek Hydrology

Grant Lake, Grant Creek, and Falls Creek have been studied in the past for hydroelectric feasibility. Previous hydrologic investigations in the project area included:

- Historical Grant Creek stream gage data (USGS 15246000) – 11 years of continuous stream gage data from 1947-1958.
- Grant Lake Hydroelectric Project Detailed Feasibility Analysis, EBASCO, 1987 includes modeled Falls Creek data.
- Historical Falls Creek discharge data limited to several instantaneous discharge measurements made over various years including 1963-70, 1976, and 2007- 2008.

4.3 Study Goals and Objectives

This baseline report includes two studies: water quality and hydrology. Figure 4.3-1 provides the study area relevant to these two studies.

The primary goal of the 2009 water quality and hydrology study programs was to begin to characterize the water quality, temperature, and hydrology of Grant Creek, Falls Creek, and Grant Lake in support of the Instream Flow Study to begin in 2010 and the FERC licensing process. Goals included increasing the period of record for water quality parameters in these systems, analyzing relationships between and among them, and collecting surface water temperature data to support the Instream Flow Study.

4.3.1 Study Goals

The water quality study goals were:

- To gather data on a combination of water quality parameters in Grant Creek, Falls Creek, and Grant Lake
- To assess potentially limiting nutrient factors in the natural water conditions based on water quality samples
- To collect temperature data in Grant Lake to develop a temperature profile in the proposed intake area of the lake
- To collect temperature data in Grant Creek and Falls Creek to allow development of water temperature models

- To provide input to an Instream Flow Study and background information for Project environmental assessment

The hydrology study goals were:

- To increase the hydrologic period of record on Grant Creek and Falls Creek
- To provide input to an Instream Flow Study and background information for Project environmental assessment

4.3.2 Study Objectives

The water quality study goals were met by completing the following objectives:

- Collected baseline water quality information in Grant Lake near the natural outlet to the lake and near the proposed intake (GLOut and GLTS, respectively).
- Collected baseline water quality information in Grant Creek (GC100, CG200, GC300).
- Collected baseline water quality information in Falls Creek (FC100).
- Collected water temperature information in a vertical transect near the proposed intake in Grant Lake (GLTS).
- Collected continuously recorded surface water temperature data at four locations on Grant Creek to support the Instream Flow Study. Thermistors were located at GC100, GC250, and GC300, and temperature data were also collected at GC200 in conjunction with temperature data from the continually recording surface water elevation data.
- Build upon data collected in previous studies.

The hydrology study goals were met by completing the following objectives:

- Increased hydrologic period of record by collecting continuous stage data with the use of continually recording surface water elevation data loggers and staff gages installed on Grant Creek at the historical USGS location (GC200) and on Falls Creek at FC100.
- Correlate water surface elevation data, or stage data, to discharge through instantaneous measurements taken at the gauging locations.

The 2009 Grant Lake water quality and temperature data were collected between 10 June and 06 October; the 2009 hydrology and stream temperature data were collected between 09 June and 12 October.

4.4 Field Sampling Methods

4.4.1 Water Quality and Temperature

Water quality and temperature studies were performed in Grant Creek, Falls Creek, and Grant Lake. To consolidate efforts and to prevent the repetition of data collection these studies were performed in concert with the biological sampling of macroinvertebrates and periphyton in Grant Creek and zooplankton and phytoplankton in Grant Lake. Grant

Creek and Falls Creek temperature data collection efforts were often performed in concert with the hydrology sampling efforts.

Site Selection and Instrumentation Sites for water quality samples in Grant Creek and Falls Creek were selected to be co-located with temperature and hydrology study sites. One site on Falls Creek was established approximately 100 ft upstream of the railroad crossing at FC100, where surface water temperature and water surface elevation data were also collected. Three water quality sites were established on Grant Creek; GC100 is directly upstream of the distributary near the mouth of Grant Creek and is co-located with a temperature logging station, GC200 is located at the old USGS gage station where surface water temperature and water surface elevation data were also collected, and GC300 is located in the approximate location of the proposed powerhouse where temperature data were also being collected. Site GC250 is only a surface water temperature data collection site. Sites GC100, GC250, and GC300 had HOBO Pro V2 temperature data loggers installed to continually record water temperature measurements. Temperature data at FC100 and GC200 were logged with HOBO U20 Water Level Loggers in conjunction with hydrology water surface elevation data recording.

Study sites in Grant Lake were selected to focus on the natural outlet to Grant Creek (GLOut) and the general area of the proposed project intake (GLTS). One water quality site was established in each of these locations. The site near the proposed intake was established in a location in the lake that is approximately 20 meters deep. GLOut, near the natural outlet into Grant Creek, was established in an area where the lake depth is approximately 10 meters. Natural fluctuations in the lake level dictate that the actual lake depths at these two locations will vary slightly throughout each year. A thermistor string was installed and anchored at GLTS. The thermistor string was made up of HOBO Pro V2 temperature data loggers at 0.2 meters, 0.5 meters, 1.5 meters, and 3 meters below the lake surface and every three meters after that to a depth of approximately 20 meters; for a total of 10 data loggers.

Water Quality Sampling Water quality samples at the three Grant Creek and one Falls Creek sites were collected using one of three sampling techniques. Depth and width integrated sampling with a DH-81 sampler was conducted when it was necessary to collect water from multiple locations within the cross section of the creek. The DH-81 bottle collects one liter sub-samples; the bottle slowly fills as it is raised and lowered through the water column, enabling the collection of water from the entire depth of the water column. The sub-samples were mixed into one sampling bucket for a complete integration of water from the entire width and depth of the cross section. In the second technique, integrated grab samples were collected when the width of the stream was wide enough to require multiple subsamples from the cross section, but the flow was not deep enough to warrant depth integration. Integrated grab sampling was done by collecting multiple grab samples from across the creek and mixing them in a sampling bucket for one integrated sample. The third sampling technique, grab sampling, was used when the creek was too narrow and too shallow to warrant integrated sampling, or when the creek is very well mixed. In both cases, grab samples were collected from the most well mixed portion of the stream and transferred directly into the sample bottles.

Water quality samples in Grant Lake were collected using a Niskin bottle which allows collection of water at desired depths within the water column. Niskin samplers are designed to be locked open on both ends and lowered vertically into the water column to the desired depth. A messenger weight is then dropped down a line which triggers the bottle to close. The sampler was raised to the surface and water was transferred from the Niskin bottle to a sample bottle. At GLTS, samples were collected at three depths; surface, mid-depth (or just below the thermocline when present), and at one meter above the substrate. At GLOut, water samples were collected at two depths: surface and mid-depth. Water near the substrate was not collected at GLOut because the outlet of Grant Lake is only a few meters deep and collecting water quality data on the water flowing into Grant Creek was the goal when establishing this site.

Water quality samples collected in the creeks and in the lake were all analyzed at SGS Environmental Services in Anchorage, Alaska for the analytes listed in Table 4.1.

In addition to water quality samples sent to the laboratory for analysis, in-situ parameters were measured using a YSI 556 multi-parameter meter. In-situ parameters measured included: pH, dissolved oxygen, specific and relative conductivity, oxygen reduction potential, and temperature. These measurements were collected at each of the creek and lake water quality sampling sites. A four-meter cable was used to measure these parameters at each creek sampling site. The probe was placed in the flowing section of the stream and measurements were allowed to stabilize before readings were recorded. At the two lake sites a 20 meter cable, clearly marked at one-meter intervals, was used to collect in-situ measurements at one meter intervals in the water column.

Water Temperature Data Collection Water temperature data were collected in two ways in the creeks and in the lake. During each water quality sampling trip measurements of in-situ water quality parameters, including temperature, were collected using a YSI 556 multi-parameter meter. Temperature measurements at the creek sites were collected by placing the probe into the stream flow and allowing the temperature measurement to stabilize before recording. Instrument readings at the two lake sites were collected using a 20 meter cable calibrated at one meter intervals. The measurements were used to create a temperature profile at each lake sampling site.

Water temperatures at GC100, GC250, and GC300 were collected using HOBO Pro V2 temperature data loggers. Surface water temperatures at FC100 and GC200 were collected with HOBO U20 Water Level Loggers in conjunction with the hydrology data collection efforts. Data loggers at FC100, GC100, GC200, and GC250 were installed in June 2009. The thermistor at GC300 was installed in July 2009. Temperature readings were recorded every 15 minutes and data were used to create a temperature model for the creeks.

HOBO Pro V2 temperature data loggers were also used at the proposed intake site on Grant Lake. A thermistor string was installed in this location to a depth of 20 meters. Data loggers were attached to the string at depths of 0.2, 0.5, 1.5, 3, 6, 9, 12, 15, 18 and 19.5 meters. The data loggers were programmed to record every four hours. The thermistor string will remain in place and will continue to record at four hour intervals through the winter and throughout 2010. Temperature measurements from the thermistor string were used to create a temperature profile of the lake.

4.4.2 Hydrology

The 2009 Grant Creek and Falls Creek hydrology studies included measurements of surface water discharge coordinated with continuously recorded stage data on Grant Creek and Falls Creek.

Stream Gage Installation (Continuously Recording Data Logger) A stream gage consists of a staff gage and a continuous stage (CQ) data logger, each anchored individually to posts temporarily driven into the stream bed near the shoreline to avoid catching floating debris. HDR used HOBO U20 Water Level Loggers manufactured by Onset Computer Corporation to continuously record water temperature and pressure. Pressure is related to water surface elevation with post-processing and has an accuracy of 0.015 feet. The data loggers were set to record water depth and temperature at 15 minute intervals. Data loggers were installed in June and were removed in mid-October. The schedule for installation and removal is dependent on individual site conditions (e.g., ice cover and water level).

Each staff gage was 4 in wide by 4 ft long, mounted vertically on a post anchored in the stream bed. The data loggers were housed in a polyvinyl chloride (PVC) sleeve attached to post anchored in the streambed. A prefabricated 1 ft PVC housing was connected to the post at the channel bottom with steel clamps. Holes were drilled in the 1 ft long section of the PVC housing to allow unrestricted water pressure over the sensors. An additional 4 ft section of PVC was installed above the housing and connected to the post with steel clamps. Two data loggers were suspended on a stainless steel cable affixed to a screw cap at the top of the long PVC housing. One data logger was suspended approximately 1 in from the top of the PVC housing to record barometric pressure. The second data logger sat on a bolt passed through the bottom of the 1 ft PVC housing to record water pressure. This bolt was the survey reference point for the data logger elevation.

The staff gage installation and logger installation were placed far enough apart that the minor flow disturbances from one did not affect the other. Figure 4.4.2-1 shows a side view of the staff gage and data logger installation. The anchoring posts were approximately 6 ft long pieces of angle iron. Grant Creek and Falls Creek each had one stream gage at GC200 and FC100 (see Figure 4.4.2-1).

A differential vertical survey was performed for each of the data loggers and associated staff gages following installation and prior to removal in the fall. Cross sections at these locations are typically surveyed once per year. Due to high flows, the Grant Creek cross-section was not surveyed in 2009. Multiple temporary benchmarks at each stream gage location provide differential vertical datum checks for the gage equipment to monitor movement. The Grant Creek stream gage is tied into the elevation of the historical USGS gage. The Falls Creek stream gage is tied into the closest Alaska Department of Transportation and Public Facilities (ADOT&PF) control point because the historical USGS gauging site benchmarks were not relocated.

Data from the data loggers were downloaded periodically after installation until they were removed for the season in October.

Instantaneous Discharge Measurements Instantaneous discharge measurements from Grant Creek and Falls Creek in 2009 were obtained applying the following methods:

- Current meter method -Wading method
- Current meter method - Boat method (for medium flow on Grant Creek)

It was not possible to wade Grant Creek during high and medium summer and fall flows, making wading unfeasible for most of the open water season.

Instantaneous discharge measurements followed field procedures laid out in Rantz et al. (1982).

A Marsh McBirney Flo-Mate 2000 current meter and a top-setting wading rod were used for instantaneous discharge measurements. During high or fast water conditions a boat was employed to obtain one discharge measurement at GC200.

4.5 Results

4.5.1 Water Quality

In situ water quality parameters included temperature (°C), specific and relative conductivity, dissolved oxygen percent (D.O. %), dissolved oxygen (D.O. mg/L), pH, and turbidity. Table 4.1, lists parameters analyzed in samples submitted for laboratory analysis. Table 4.2 shows the results for all parameters.

Temperature In Grant Creek (sites GC100, GC200, and GC300) water temperatures ranged from 7.40°C to 9.44°C during June and from 11.26°C to 12.32°C in August during water quality sampling events. In Falls Creek (FC100) the temperature in June was 5.06°C and 7.31°C in August (Figure 4.5.1-1).

In Grant Lake there were two sites, GLTS and GLOut, where water quality samples were collected. At GLTS the temperatures ranged from 4.34°C at a depth of 20 m to 8.64°C at the surface during the June sampling event (Figure 4.5.1-2). During the August sampling event the temperatures ranged from 5.95°C at a depth of 18 m to 14.66°C at the surface. At GLOut in June the temperatures ranged from 7.09°C at a depth of 8 m to 7.95°C at the surface (Figure 4.5.1-3). In August the temperatures ranged from 8.28°C at a depth of 12 m to 14.87°C at the surface. Water temperatures decreased by early October and ranged from 4.7°C at a depth of 19.5 m to 8.9°C at the surface.

Temperature is recorded continuously at four locations along Grant Creek (GC100, GC200, GC250, and GC300) and at the stream gage on Falls Creek (FC100) (Figure 4.3-1). Temperature was recorded continuously at 10 intervals within the upper 20 meters at GLTS. Figure 4.5.1-4 shows temperature as recorded at each depth interval; Figure 4.5.1-5 shows temperature by depth at eight days evenly spaced throughout the recording period. Stream temperatures are illustrated in Figure 4.5.1-6. Temperature from the upper three meters of Grant Lake was compared to the temperature at stream gage GC200 in Figure 1.5.1-7.

Conductivity Specific conductivity at Grant Creek sampling sites ranged from 84 microSiemens per centimeter (µS/cm) to 89 µS/cm in June and was 87 µS/cm at all locations in August (Figure 4.5.1-8). The relative conductivity ranged from 64 µS/cm to

66 µS/cm in June and 64 µS/cm to 65 µS/cm in August (Figure 4.5.1-9). At GC200 during the June event the conductivity reading was unstable, therefore a measurement could not be recorded.

The Falls Creek specific conductivity was 76 µS/cm in June and 85 µS/cm in August. Relative conductivity was 46 µS/cm in June and 57 µS/cm in August.

At Grant Lake in June, conductivity readings at GLOut were not stable and a reading was not recorded. However, in August the specific conductivity ranged from 82 µS/cm to 140 µS/cm (Figure 4.5.1-10). The relative conductivity at the outlet ranged from 52 µS/cm to 77 µS/cm with the lower concentrations being in the lower depths and the higher concentrations being near the surface (Figure 4.5.1-11). At the thermistor string location on Grant Lake (GLTS) the specific conductivity in June ranged from 90 µS/cm at the surface to 92 µS/cm at depths of 19 and 20 m (Figure 4.5.1-12). In August, specific conductivity ranged from and 65 µS/cm at a depth of 16 m to 210 µS/cm at a depth of 5 m. However, the 210 µS/cm reading was somewhat unstable. During the June sampling event the conductivity reading was unstable at the depth of 2 m to 5 m and was unable to be obtained. Relative conductivity ranged from being 55 µS/cm at depths 16 to 20 m to 63 µS/cm near the surface in June (Figure 4.5.1-13). In August relative conductivity ranged from 41 µS/cm at a depth of 4 m to 156 µS/cm at 5 m. The 5 m depth reading was somewhat unstable.

Dissolved Oxygen Dissolved oxygen measurements recorded in 2009 are listed in Table 4.2. Measurements of concentrations of dissolved oxygen (DO) in Grant Creek ranged from 7.31 to 7.34 mg/L in June and from 8.22 to 8.40 mg/L in August (Table 4.2). Falls Creek measured DO values were 7.96 and 10.65 mg/L in June and August, respectively. Measurements of dissolved oxygen in Grant Lake study sites were relatively uniform throughout the entire depth profile during both sampling events. DO values measured in Grant Lake in June 2009 ranged from 7.20 to 7.96 mg/L, while August values were much lower at 5.57 to 6.05 mg/L. Both sets of data are lower than what would normally be expected in freshwater systems. Considering historical data for Grant Lake and Grant Creek (AEIDC 1983, APA 1984), it appears that the results are anomalous. This was most likely the result of instrument malfunction in the field (see Section 4.6).

pH The pH measurements in Grant Creek during the June sampling event ranged from 7.30 standard (STD) units to 7.66 STD units. In August, Grant Creek pH ranged from 7.39 STD units to 7.72 STD units (Figure 4.5.1-20). In Falls Creek the pH was 7.46 STD units at the sampling site in June and 7.15 STD units in August.

The pH at GLTS during the June sampling event ranged from 7.06 STD units at a depth of 19 m to 7.55 STD units at a depth of 6 m (Figure 4.5.1-21). In August the pH ranged from 7.04 STD units at a depth of 18 m to 7.56 STD units at the surface. At GLOut the pH ranged from 7.26 STD units at 1 m depth to 7.98 STD units at 5 m depth in June (Figure 4.5.1-22). In August the pH ranged from 7.07 STD units at a depth of 12 m to 7.47 STD units at a depth of 8 m.

Turbidity Turbidity in Grant Creek ranged from 0.75 NTU to 0.82 NTU during June (Figure 4.5.1-26). In August turbidity ranged from 10.10 NTU to 11.90 NTU. Falls Creek turbidity measured 8.17 NTU in June and 17.00 NTU in August.

Turbidity in Grant Lake at GLTS during June ranged from 0.55 NTU at 18 m depth to 0.90 NTU at 8 m depth (Figure 4.5.1-27). In August the range was 3.52 NTU at a depth of 8 m to 4.84 NTU at a depth of 17 m. At GLOut turbidity in June was 0.82 NTU at the surface and 0.90 NTU at 5 m depth. In August the turbidity was 4.18 NTU at the surface and 5.20 NTU at a depth of 6 m.

Water Quality Analytes The results of laboratory analysis of water samples from Grant Creek, Falls Creek, and Grant Lake for eight analytes are listed in Table 4.2.

Alkalinity Alkalinity in Grant Creek ranged from 24 to 25 mg/L calcium carbonate ($CaCO_3$) in June (Figure 4.5.1-28). In August it ranged from 23 to 23.5 mg/L $CaCO_3$. The alkalinity in Falls Creek was 37.4 mg/L $CaCO_3$ at the sampling site in June. In August the alkalinity was 21.0 mg/L $CaCO_3$.

Alkalinity concentrations at GLTS on Grant Lake ranged from 23.5 to 24.5 mg/L $CaCO_3$ in June and 24.6 to 25.4 mg/L $CaCO_3$ in August (Figure 4.5.1-29). The concentrations at GLOut in June were 23.2 and 23.8 mg/L $CaCO_3$. In August the concentrations were 24.0 mg/L $CaCO_3$ at both depths (Figure 4.5.1-30).

Total Lead Total lead (Pb) in June was detected in Grant Creek in a range of 0.392 to 3.090 microgram per Liter (µg/L) (Figure 4.5.1-31). In August it was not detected at any of the three Grant Creek sites. Pb was undetected in the Falls Creek sample for June However, in August total Pb was detected at the site at a concentration of 0.252 µg/L.

In Grant Lake total Pb was undetected at GLOut in both June and August. There was one detectable concentration at GLTS in June of 1.100 µg/L at a depth of 8 m, but no detectable total Pb at any other depths in June or at any depths in August (Figure 4.5.1-32).

Mercury Low level mercury (Hg) was not detected at any of the three sites in Grant Creek in June (Figure 4.5.1-33). In August it was detected at GC100 and GC200 with concentrations of 1.48 nanograms per Liter (ng/L) and 1.58 ng/L, respectively. At the Falls Creek location low level Hg was detected in both June and August. In June the concentration was 2.00 ng/L and in August 4.42 ng/L.

Low level Hg was not detected during the June sampling event in Grant Lake. However, during the August sampling event detectable concentrations appeared at both sites, at all depths. At GLTS low level Hg concentrations ranged from 1.15 ng/L to 1.65 ng/L (Figure 4.5.1-34). At GLOut concentrations in August were 1.4 ng/L and 2.05 ng/L (Figure 4.5.1-35).

Nitrate and Nitrite, Total Kjeldahl Nitrogen Nitrite plus nitrate was detected at all locations in June in Grant and Falls Creeks (Figure 4.5.1-36). The Grant Creek locations had concentrations that ranged from 0.416 mg/L to 0.461 mg/L in June. In August the concentrations ranged from 0.292 mg/L to 0.323 mg/L. In Falls Creek the concentration of nitrite plus nitrate was 0.145 mg/L during June sampling but was not detected in August. Total Kjeldahl Nitrogen was not detected at any location during either sampling event.

Nitrite plus nitrate concentrations during the June sampling event ranged from 0.410 mg/L to 0.421 mg/L at the GLTS site on Grant Lake (Figure 4.5.1-37). In August the concentrations ranged from 0.280 mg/L to 0.319 mg/L. In June the concentrations at GLOut were 0.414 mg/L and 0.651 mg/L (Figure 4.5.1-38). Total Kjeldahl Nitrogen was not detected at any sampling location during either sampling events.

Orthophosphate and Total Phosphorous Orthophosphate was not detected at any location during either sampling event. However, total phosphorous (P) was detected in June at GC300 at a concentration of 0.0233 mg/L (Figure 4.5.1-39). In August total P was not detected at any location in Grant Creek. Similarly, in June the total P concentration in Falls Creek was 0.0157 mg/L but was not detected in August.

On Grant Lake the only location that had a concentration of total P was at GLTS during the June sampling event with a concentration of 0.0218 mg/L (Figure 4.5.1-40).

Total Dissolved Solids The concentration of total dissolved solids (TDS) at Grant Creek locations during the June sampling event ranged from 53.8 mg/L to 60.0 mg/L and in August from 43.8 mg/L to 60.0 mg/L (Figure 4.5.1-41). The concentration in Falls Creek was 48.8 mg/L in June and 70.0 mg/L in August.

The concentration of TDS at GLTS on Grant Lake during the June sampling event ranged from 61.3 mg/L to 75.0 mg/L (Figure 4.5.1-42). In August the concentrations ranged from 45.0 mg/L to 48.8 mg/L. The concentrations at GLOut in June were 40.0 mg/L and 51.3 mg/L. In August the concentrations were 32.5 mg/L and 47.5 mg/L (Figure 4.5.1-43).

Total Suspended Solids Concentrations of total suspended solids (TSS) at Grant Creek sites during the June sampling event ranged from 0.700 mg/L to 0.800 mg/L (Figure 4.5.1-44). In August the concentrations ranged from 3.400 mg/L to 2.490 mg/L. In Falls Creek in June the concentration was 8.300 mg/L and 8.240 mg/L in August.

Analysis of samples collected in June showed TSS concentrations of 0.70 mg/L to 1.00 mg/L at the GLTS site on Grant Lake (Figure 4.5.1-45). In August the concentration range increased to 1.90 to 2.83 mg/L. At GLOut in June the concentrations were 0.50 mg/L and 0.60 mg/L (Figure 4.5.1-46). In August the concentrations increased to 1.96 mg/L and 2.77 mg/L.

4.5.2 Hydrology

Stream gages were installed on Falls Creek (FC100) and Grant Creek (GC200) on 09 June and 10 June of 2009, respectively. Continuous stage data was recorded at these locations until 12 October 2009.

The stream gages were surveyed with respect to pre-established vertical elevation datum. GC200 was surveyed with respect to the USGS Gage station 15246000 gage height elevations for comparison with historical data. FC100 gage elevations were surveyed with respect to the closest ADOTP&F reference point (CP #131, in ft MSL 1929 NGVD).

Continuous stage data recorded from 10 June though 12 October at GC200 is presented in Figure 4.5.2-1. The water level recorded as pressure has been converted to ft with respect to the USGS gage height. The actual recorded water surface elevations at 15-minute intervals are displayed in the finer light blue colored line, which generally exhibit the daily fluctuation. The thick, dark blue colored line represents mean daily water surface elevations. The aqua colored circles represent field staff gage observations. Error bars are indicated where a fluctuation in water level was recorded at the time of the staff gage reading. Staff gage readings, without discharge measurements are recorded as an additional point of comparison to the electronic record. Only one discharge measurement was completed during the period displayed. The discharge on 22 June 2009 was measured at 423 cfs by the current meter method, employing a boat as described above. Three instantaneous discharge measurements were obtained in the fall of 2008, which are not accompanied by a continuous record. These measurements are as follows:

- 126 cfs | 04 October 2008
- 108 cfs | 23 October 2008
- 47 cfs | 03 December 2008

Continuous stage data recorded from 09 June though 12 October 2009 at FC100 is presented in Figure 4.5.2-2. The following two discharge measurements were made in the fall of 2008:

- 22 cfs | 05 October 2008
- 14 cfs | 24 October 2008

4.6 Discussion

4.6.1 Water Temperature and Water Quality

Stream temperatures were typical for Alaskan streams and were consistent with seasonal changes; temperatures were lower during the June sampling event compared to the August sampling event (Table 4.2). As expected, temperatures in Grant Creek increased downstream, reflecting gradual warming due to contact with air and sun in the shallow, turbulent stream. The historical data for Grant and Falls Creek do not show continuous temperature data for June in any year. However, in 1958 there was a recorded temperature of 10.5 °C at the USGS gage site (USFWS 1961), which was somewhat lower than that measured in 2009.

The water temperature measurements recorded during water sampling events at Grant Lake also changed seasonally. At the outlet of Grant Lake (GLOut) water temperature did not vary widely by depth during the month of June. The difference between temperatures near the surface and at depth was greater in August (Figure 4.5.1-3).

The surface temperature at the Grant Lake thermistor string during the June sampling event was approximately 6 °C colder than during the August sampling event. During the June event the temperature profile showed fairly uniform temperatures with some increase near the surface. During the August sampling event the temperature was higher at the surface than throughout the rest of the depth profile. However, temperature began to decrease near a depth of 9 m, possibly suggesting thermal stratification. By the end of September the water column was approximately 9 °C from the surface to a depth of 14 m, where the temperature decreased to closer to 7 °C at 19.5 m depth.

The continuous Grant Lake temperature record reflects stratified temperatures. At GLTS there appears to be some thermocline formation from late July through early September with the top 6 m having relatively uniform temperatures (Figure 4.5.1-5). The greatest difference in daily mean temperature across the entire depth profile is in mid-July, as shown in Figure 4.5.1-5. The maximum daily mean temperature observed at 19.5 m depth was 14.76 °C on 19 July. Surficial daily mean temperatures at 0.2 meters depth range from: 7.48 °C on 10 June to 15.59 °C on 08 July. The water surface temperatures decrease by the end of September with signs of lake turnover. The stream temperature trends of Grant Creek are very similar to temperatures found in the upper 3 m of Grant Lake.

The conductivity values measured in Grant Creek and Grant Lake during the 2009 sampling season are consistent with the historical data from the 1960s and 1980s (Table 4.2; USFWS 1961, AEIDC 1983). The conductivity meter readings at GC200 during the June sampling event were unstable and were not recorded. Although meters were calibrated daily, these unstable readings could be due to equipment failure in the field. Conductivity measurements will be monitored closely during future sampling events, and a separate backup meter will be onsite for quality control in the event that measurements are questionable.

Results of the Falls Creek conductivity measurements in 2009 were typical of freshwater streams (APHA 2005) and were found to be similar to the Falls Creek conductivity measurements collected during previous studies (USFWS 1961, AEIDC 1983). In the 1980s the relative conductivity ranged from 45 to 150 µS/cm (AEIDC 1983). The highest reading in 2009 was 57 µS/cm. In 1960 the relative conductivity was measured at 94 µS/cm (USFWS 1961).

Measurements of concentrations of dissolved oxygen (DO) in Grant Creek ranged from 7.31 to 7.34 mg/L in June and from 8.22 to 8.40 mg/L in August (Table 4.2). Falls Creek DO measurements were 7.96 and 10.65 mg/L in June and August, respectively. Measurements of dissolved oxygen in Grant Lake study sites were relatively uniform throughout the entire depth profile during both sampling events. DO values measured in Grant Lake in June 2009 ranged from 7.20 to 7.96 mg/L, while August values were much lower at 5.57 to 6.05 mg/L. Both sets of data are lower than what would normally be expected in freshwater systems. For example, DO at 10 °C is normally expected to be approximately 11.29 mg/L (APHA 2005). The historical DO concentrations were also much higher than any concentrations found during 2009 at Grant Lake locations. In 1981 and 1982 DO concentrations ranged from 9.75 to 14 mg/L (AEIDC 1983). The highest concentration observed in 2009 was 7.96 mg/L. Although meters were calibrated on a daily basis, it is possible that the low DO measurements were the result of equipment malfunction in the field. DO measurements will be monitored closely in the field during future sampling events and will be checked with a backup meter if necessary.

The range of pH at all sampling sites and all depths was between 7.04 and 7.98 STD units, and were well within the neutral range for freshwaters (APHA 2005).

Due to the glacial origins of meltwater in the project area, turbidity results could be expected to be somewhat higher than typical freshwater conditions. Turbidity measured in Grant Lake in 1981 and 1982 ranged from 0.24 to 3.8 NTU (AEIDC 1983); results that are similar to data collected in 2009 (0.55 to 5.20 NTU). Grant Creek turbidity readings in 2009 ranged from 10.1 to 11.9 NTU, which are higher than historical turbidity results from the 1980s (0.35 to 1.1 NTU) (AEIDC 1983). Falls Creek historical readings ranged from 0.37 to 6.0 NTU (USFWS 1961, AEIDC 1983), while 2009 readings were 8.17 to 17.00 NTU. Additional data collected during the course of the baseline studies will be examined to determine trends in turbidity values.

Alkalinity in Falls Creek was found to be 37.4 mg/L CaCO3 in June and 21.0 mg/L CaCO3 in August of 2009, and these results are also similar to the results of the 1960s and the 1980s measurements (USFWS 1961, AEIDC 1983).

The results of the 2009 sampling for TDS in Grant Creek range from 53.8 to 62.5 mg/L (Table 4.3). The historical TDS concentrations at Grant Creek ranged from 31 mg/L in June 1982 to 84 mg/L in March 1982 (AEIDC 1983), indicating that this system can be dynamic and that higher concentrations can occur. Falls Creek historical TDS concentrations ranged from 24 mg/L in June 1982 to 60 mg/L in October 1981 (AEIDC 1983), similar to what was found in 2009 (48 to 70 mg/L).

Grant Lake historical TDS concentrations ranged from 33 mg/L in June 1982 to 87 mg/L in March 1982 (AEIDC 1983). This range is similar to the range of concentrations that were found in 2009 (32.5 to 75 mg.L).

The TSS concentrations in Grant Creek and Grant Lake were relatively low. Grant Creek historical data for TSS concentrations ranged from 0.6 mg/L in October 1981 to 4.3 mg/L in August 1982 (AEIDC 1983). These concentrations are consistent with the concentrations found in 2009 (Table 4.3).

Falls Creek TSS concentrations were higher than the concentrations found in Grant Creek, but were within expectations based on previous studies. The historical data has a very wide range with non-detectable concentrations at the low end of the range and the highest at 86 mg/L (AEIDC 1983). During the 2009 sampling, the concentrations were 8.30 mg/L in June and 8.24 mg/L in August. These concentrations show more of a consistent suspended load than those found in the 1980s.

Results of the following laboratory tests in 2009 were either not detected, or were detected in low levels: low-level mercury, lead, nitrates/nitrites, orthophosphates, and phosphorous. The lack of, or minimal amounts of nutrients in the samples indicate that the system may be nutrient-limited and is oligotrophic (Table 4.3). Future studies will further characterize the water quality conditions of these waterbodies.

4.6.2 Hydrology

The range of the dataset shown in Figure 4.5.2-1 for GC200 indicates two peak flows, one receding in early June driven by spring melt-water and another driven by warm summer temperatures in July. The trends reflected in 2009 are consistent with the mean monthly flow distribution from the USGS data (period of record 1947-1958). The same peaks are shown during the same time period for FC100 (Figure 4.5.2-2). A smaller set of peaks and a low-flow event in September were evident in both creeks and resulted from rain events followed by a cooling trend in air temperatures.

The GC200 and FC100 water surface elevation plots show that the staff gage readings do not always correspond with the logged water surface elevations for many of the staff gage readings. These results suggest that a larger data logger stilling well should be employed in 2010 in order to reduce the data variability, or noise, recorded in 2009 that was likely caused by stream turbulence and high stream velocities.

5 References

Alaska Power Authority (APA). 1984. *Grant Lake Hydroelectric Project Detailed Feasibility Analysis. Volume 2. Environmental Report*. Rep. from Ebasco Services Incorporated, Bellevue, Washington.

American Public Health Association (APHA). 2005. Standard Methods for the Examination of Water and Wastewater. 21st edition.

Arctic Environmental Information and Data Center (AEIDC). 1983 *Summary of environmental knowledge of the proposed Grant Lake hydroelectric project area*. Final Report submitted to Ebasco Services, Inc., Redmond, Washington, University of Alaska, Anchorage, Alaska.

Bendock, T. 1995. *Marking juvenile Chinook salmon in the Kenai River and Deep Creek, Alaska, 1993-1994.* Fishery Data Series No. 95-17. Alaska Dept. Fish and Game, Division of Sport Fish. Anchorage, Alaska.

Bendock, T. 1996. *Marking juvenile Chinook salmon in the Kenai River and Deep Creek, Alaska, 1995.* Fishery Data Series No. 96-33. Alaska Dept. Fish and Game, Division of Sport Fish. Anchorage, Alaska.

Bue, B.G., S.M. Fried, S. Sharr, D.G. Sharp, J.A. Wilcock, and H.J. Geiger. 1998. *Estimating salmon escapement using area-under-the-curve, aerial observer efficiency, and stream-life estimates: the Prince William Sound example*. North Pacific Anadromous Fisheries Commission. Bulletin. No. 1:240-250.

Bailey, J.E., B.L. Wing and C.R. Mattson. 1975. *Zooplankton Abundance and Feeding Habitats of Fry of Pink Salmon,* Oncorhynchus Goruscha, *and Chum Salmon,* Oncorhynchus Keta, *in Traitors Cove, Alaska, With Speculations on the Carrying Capacity of the Area.* National Marine Fisheries Service, NOAA, Auke Bay, Alaska.

Carlon, J. 1992. *Feasibility of capturing and marking juvenile coho salmon for stock assessment in the Kenai River.* Fishery Data Series No. 92-57. Alaska Dept. Fish and Game, Division of Sport Fish. Anchorage, Alaska.

Eaton, A. D., L. S. Clesceri, and A. E. Greenburg. 1995. *Standard Methods for the Examination of Water and Wastewater. 19th ed.* Prepared and jointly published by American Public Health Association, American Water Works Association, Water Environment Federation. American Public Health Association, Washington, D.C.

English, K.K., R.C. Bocking, and J.R. Irvine. 1992. *A robust procedure for estimating salmon escapement based on the area-under-the-curve method*. Canadian Journal of Fisheries and Aquatic Sciences 49:1982-1989.

Envirosphere. 1987. *Instream flow and habitat analysis Grant Lake hydroelectric project*. Prepared for Kenai Hydro, Inc.

Fried, S.M., Bue, B.G., Sharp, D., and Sharr, S. 1998. *Injury to spawning areas and evaluation of spawning escapement of pink salmon in Prince William Sound, Alaska*. Fish /Shellfish NRDA Study Number 1, Restoration Study Number 9, and Restoration Study Number 60B, Exxon Valdez Oil Spill Final Report. Alaska Dept. Fish and Game, Division of Sport Fish. Anchorage, Alaska.

HDR Alaska Inc. 2009. *Falls Creek Proposed Hydroelectric Project Reconnaissance Report Draft*. Prepared for: Kenai Hydro, LLC.

Hilborn, R., Bue, B.G, and Sharr, S. 1998. *Estimating spawning escapement from periodic counts: a comparison of methods*. Can. J. Fish. Aquat. Sci. 56: 888-896 (1999)

Johnson, J. and K. Klein. 2009. *Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southcentral Region, Effective June 1, 2009*. Alaska Department of Fish and Game, Special Publication No. 09-03, Anchorage, AK.

Kenai Hydro, Inc. 1987a. *Grant Lake hydroelectric project additional information*.

Shardlow, T. 2004. *Using time-lapsed video to estimate survey life for area-under-the-curve methods of escapement estimation.* North American Journal of Fisheries Management 24: 1413-1420, 2004.

6 Notes

7 Tables

Table 3.1 Angling effort (hours)

Reach	1	2	3	4	5[b]	Total
June	6.00	6.00	6.33	4.55[a]	3.00	25.88
July	6.00	6.00	6.00	6.00	3.00	27.00
August	6.07	5.95	6.18	6.45	3.65	28.30
September	2.05	1.99	2.03	2.12	1	9.64
Total	20.12	19.94	20.54	19.12	10.65	90.82

[a] One less angling site
[b] Two less angling sites

Table 3.2 Minnow trapping effort (trap hours)

Reach	1	2	3[b]	4[a]	5[c]	6[d]	Total
June	200.95	230.07	190.18	183.48		103.87	908.55
July	295.97	263.53	372.40	219.33	77.20		1,228.43
August	182.00	226.25	271.92	201.60	49.18	105.42	1,036.37
September	278.65	270.42	312.77	221.03	76.2		1159.07
Total	957.57	990.27	1147.27	825.45	202.58	209.28	4,332.42

[a] Reach 4 had one less minnow trap than other reaches.
[b] Reach 3 had three more minnow traps in August.
[c] Reach 5 had three minnow traps.
[d] Reach 6 had five minnow traps.

Table 3.3 Catch table by gear type, Grant Creek

Species	Scientific Name	Number of Fish
Angling		
Rainbow trout	*Oncorhynchus mykiss*	72
Dolly Varden	*Salvelinus malma*	14
Arctic grayling	*Thymallus arcticus*	1
Sockeye salmon	*Oncorhynchus nerka*	3
Total		90
Minnow Trapping		
Chinook salmon	*Oncorhynchus tshawytscha*	191
Coho Salmon	*Oncorhynchus kisutch*	776
Dolly Varden	*Salvelinus malma*	925
Rainbow trout	*Oncorhynchus mykiss*	82
Sockeye Salmon	*Oncorhynchus nerka*	2
Sculpin	*Cottus* spp.	22
Threespine stickleback	*Gasterosteus aculeatus*	83
Total		2,081
Electrofishing		
Chinook Salmon	*Oncorhynchus tshawytscha*	20
Coho Salmon	*Oncorhynchus kisutch*	59
Dolly Varden	*Salvelinus malma*	43
Rainbow Trout	*Oncorhynchus mykiss*	19
Sockeye Salmon	*Oncorhynchus nerka*	6
Sculpin	*Cottus* spp.	16
Threespine Stickleback	*Gasterosteus aculeatus*	4
Total		**167**

Table 3.4 Number of rainbow trout recaptures by survey date and total number of rainbow trout

Survey Date	Total number of rainbow trout marked to date	Number of recaptures
6/2/2009	2	0
6/3/2009	5	0
6/12/2009	10	3
6/22/2009	13	0
7/1/2009	18	1
7/11/2009	18	0
7/21/2009	23	1
8/12/2009	36	2
8/22/2009	52	0
8/29/2009	68	1
9/10/2009	72	1

Table 3.5 Spawning survey results by species and survey date

Survey Date	Species		
	Chinook	Sockeye	Coho
8/1/2009	0	0	0
8/10/2009	4	2	0
8/13/2009	19	1	0
8/23/2009	62	6	0
8/30/2009	31	545	0
9/11/2009	0	1351	0
9/16/2009	0	1188	0
9/29/2009	0	78	6

Table 3.6 General description of microhabitat sample areas surveyed in June 2009

Sample Site Locations	Sample Areas	Typical Characteristics
Main Channel		
	Pool/fastwater	Deep and fast, typically midchannel
	Riffle/fastwater	Fast, typically michannel and margins
	Margin with undercut bank	Stream margin with undercut bank; typically along fastwater in main channel
	Margin without undercut bank	Stream margin with no undercut bank; typically along fastwater in main channel
	LWD dam	LWD creates velocity break (site in Reach 1)
	Margin shelf with LWD	Shallow, wide stream margin with some overhanging vegetation or other instream cover
Backwater/Slough Areas		
	Backwater pool/ slough	Large backwater/low velocity areas, can be located along stream margin near velocity break
	Backwater pocket	Small backwater/low velocity areas, can be located along stream margin near velocity break
Other Channels		
	Distributary channel	Variable microhabitat and depth/flow regimes, all microhabitats present (Reach 1)
	Secondary channel	Typically includes margins with undercut bank, margins without undercut bank, and faster velocity areas in the midchannel. (Reach 3)
	Tertiary channel	Variable microhabitats (Reach 3)

Table 3.7 Benthic Macroinvertebrates – Grant Creek, August 2009					
Site	**Date**	**Sample Type**	**Order**	**Family**	**Genus**
GC100	**8/6/2009**	**Surber**			
			Ephemeroptera	Ameletidae	Ameletus
				Baetidae	Unidentified
					Acentrella
					Baetis
				Ephemerellidae	Drunella
					Ephemerella
				Heptegeniidae	Cinygmula
					Epeorus
			Plecoptera	Chloroperlidae	Unidentified
					Haploperla
					Neaviperla
					Plumiperla
				Nemouridae	Zapada
				Perlodidae	Isoperla
			Trichoptera	Brachycentridae	Brachycentrus
				Glossosomatidae	Glossosoma
				Hydropsychidae	Arctopsyche
				Limnephilidae	Moselyana
			Diptera	Chironomidae	Unidentified
				Empididae	Unidentified
					Chelifera
					Clinocera
				Simuliidae	Simullium
			Bivalvia (Class)	Sphaeriidae	Unidentified
			Gastropoda (class)	Lymnaeidae	Lymnaea
			Arachnida (Class)	Hydracarina (Sub-Order)	Unidentified
			Oligochaeta (Class)	Unidentified	
			Nemotoda (Phylum)	Unidentified	
			Crustacea (Phylum)	Ostracoda (Class)	Unidentified
GC100	**8/6/2009**	**ASCI**			
			Ephemeroptera	Baetidae	Unidentified
				Ephemerellidae	Ephemerella
				Heptageniidae	Cinygmula
					Epeorus
			Plecoptera	Nemouridae	Zapada
				Perlodidae	Isoperla
			Trichoptera	Glossosomatidae	Glossosoma
			Diptera	Chironomidae	Unidentified
			Bivalvia (Class)	Sphaeriidae	Unidentified
			Arachnida (Class)	Hydracarina (Sub-Order)	Unidentified
GC300	**8/6/2009**	**Surber**			
			Ephemeroptera	Baetidae	Acentrella
					Baetis
				Ephemerellidae	Drunella
					Ephemerella

Table 3.7 Benthic Macroinvertebrates – Grant Creek, August 2009					
Site	**Date**	**Sample Type**	**Order**	**Family**	**Genus**
				Heptegeniidae	Cinygmula
					Epeorus
			Plecoptera	Chloroperlidae	Unidentified
					Haploperla
					Neaviperla
					Plumiperla
					Triznaka
					Suwallia
				Nemouridae	Zapada
				Perlodidae	Isoperla
			Trichoptera	Brachycentridae	Brachycentrus
					Microsema
				Glossosomatidae	Glossosoma
				Hydropsychidae	Arctopsyche
				Limnephilidae	Ecclisomyia
				Rhyacophilidae	Rhyacophila
			Diptera	Chironomidae	Unidentified
				Empididae	Chelifera
					Clinocera
				Simuliidae	Simullium
			Bivalvia (Class)	Sphaeriidae	Unidentified
			Gastropoda	Unidentified	
			Arachnida (Class)	Hydracarina (Sub-Order)	Unidentified
			Oligochaeta (Class)	Unidentified	
GC300	**8/6/2009**	**ASCI**			
			Ephemeroptera	Ephemerellidae	Ephemerella
			Plecoptera	Chloroperlidae	Plumiperla
				Perlodidae	Isoperla
			Trichoptera	Brachycentridae	Brachycentrus
			Diptera	Chironomidae	Unidentified
				Empididae	Chelifera
					Clinocera
				Simuliidae	Simullium
			Gastropoda	Lymnaeidae	Lymnaea
				Planorbidae	Unidentified
			Bivalvia (Class)	Sphaeriidae	Unidentified
			Arachnida (Class)	Hydracarina (Sub-Order)	Unidentified

Table 3.8 Benthic Macroinvertebrates Metrics – Grant Creek, 2009

Site	Date	Sample Type	Metric	Result
GC100	8/6/2009	Surber (average of 5 pseudo-replicates)	Population Density	148.4 organisms per 0.1 m^2
			% EPT	7.72%
			Taxa Diversity	18.6
			% Dominant Taxa	85% (chironomidae)
		ASCI	Population Density	274 organisms per 0.1 m^2
			% EPT	1.90%
			Taxa Diversity	10
			% Dominant Taxa	83% (Bivalvia)
			HBI[1]	7.5
			Habitat Assessment[2]	200
GC300	8/6/2009	Surber (average of 5 pseudo-replicates)	Population Density	98.8 organisms per 0.1 m^2
			% EPT	31.49%
			Taxa Diversity	15.2
			% Dominant Taxa	48% (chironomidae)
		ASCI	Population Density	53 organisms per 0.1 m^2
			% EPT	3.59%
			Taxa Diversity	12
			% Dominant Taxa	78% (Bivalvia)
			HBI[1]	7.1
			Habitat Assessment[2]	190

1) HBI = Habitat Biotic Index – scale from 0-10 with 10 indicating highly impaired water bodies

2) Habitat Assessment – scale of 0-200 with 0 being the most impaired macroinvertebrate habitat

Table 3.9 Catch table by gear type, Grant Lake

Species	Scientific Name	Number
Electrofishing		
Sculpin	*Cottus* spp.	18
Threespine stickleback	*Gasterosteus aculeatus*	6
Total		**24**
Gill netting		
Threespine stickleback	*Gasterosteus aculeatus*	4
Total		4
Minnow trapping		
Sculpin	*Cottus* spp.	79
Threespine stickleback	*Gasterosteus aculeatus*	4,798
Total		**4,877**

Table 3.10 Zooplankton, Grant Lake, August 2009

Site	Date	Taxa	# of Organisms	% of Population
GLOut	**8/07/09**			
		Rotifer	1037	98.85
		Copepoda	4	0.38
		Protozoa	8	0.76
GLTS	**8/07/09**			
		Rotifer	553	96.68
		Copepoda	9	1.57
		Protozoa	10	1.75

Table 3.11 Chlorophyll *a* concentrations in Grant Lake and Grant Creek, August 2009

Site	Date	Sample Type	Run Number	Chlorophyll *a* Concentration * mg/M^3
GC100	**8/06/09**	**Periphyton**		
			1	12.50
			2	51.50
			3	16.80
			4	15.00
			5	40.10
			6	19.80
			7	37.60
			8	82.00
			9	7.48
			10	65.10
			Average	**34.79**
GC300	**8/06/09**	**Periphyton**		
			1	19.00
			2	4.54
			3	8.28
			4	10.70
			5	2.94
			6	4.81
			7	5.87
			8	36.00
			9	23.20
			10	11.70
			Average	**12.70**
GLOut	**8/07/09**	**Phytoplankton**		
			1 (surface)	1.07
			2 (mid-depth)	0.80
			Average	**0.94**
GLTS	**8/07/09**	**Phytoplankton**		
			1 (surface)	1.34
			2 (mid-depth)	1.34
			3 (bottom)	0.53
			Average	**1.07**

* Rounded to two decimal places

Table 4.1 Water Quality Parameters

Parameter	Units
Alkalinity (CaCO3)	mg/L
Total dissolved solids (TDS)	mg/L
Total suspended sediment (TSS)	mg/L
Kjeldahl Nitrogen	mg/L
Nitrate/Nitrite	mg/L
Orthophosphate	mg/L
Total phosphorous	mg/L
Lead	µg/L
pH	STD
Temperature	°C
Dissolved oxygen (DO)	mg/L, %
Specific and Relative Conductivity	mS/cm, µS/cm
Oxygen Reduction Potential (ORP)	mV
Turbidity	NTU
Low level mercury	ng/L

Table 4.2 Water Quality Parameters Measured In-Situ at Grant Lake, Grant Creek, and Falls Creek, June and August 2009

Site Name	Date	Depth (m)	Temp (°C)	Specific Conductivity (µS/cm)	Relative Conductivity (µS/cm)	DO* (%)	DO* (mg/L)	pH	Turbidity* (NTU)	Notes
FC100	6/9/2009		5.06	76	46	68.0	7.96	7.46	8.17	
FC100	8/5/2009		7.31	85	57	88.3	10.65	7.15	17.00	
GC100	6/9/2009		9.44	84	57	68.7	7.85	7.39	0.77	
GC100	8/6/2009		12.32	87	66	77.5	8.29	7.40	10.10	
GC200	6/11/2009		7.40			60.9	7.31	7.66	0.75	**
GC200	8/6/2009		11.26	87	64	75.1	8.22	7.39	11.10	
GC300	6/11/2009		7.47	89	64	61.3	7.34	7.30	0.82	**
GC300	8/6/2009		11.49	87	65	77.1	8.40	7.72	11.90	
GLOut	6/11/2009	0	7.95			64.4	7.64	7.27	0.82	**
GLOut	6/11/2009	1	7.90			64.3	7.61	7.26		**
GLOut	6/11/2009	2	7.52			63.8	7.63	7.29		**
GLOut	6/11/2009	3	7.37			63.8	7.67	7.32		**
GLOut	6/11/2009	4	7.27			63.8	7.70	7.37		**
GLOut	6/11/2009	5	7.39			64.1	7.73	7.98	0.90	**
GLOut	6/11/2009	6	7.23			64.0	7.72	7.45		**
GLOut	6/11/2009	7	7.17			63.5	7.67	7.43		**
GLOut	6/11/2009	8	7.09			63.1	7.63	7.41		**
GLOut	8/7/2009	0	14.87	88	71	55.2	5.57	7.24	4.18	
GLOut	8/7/2009	1	13.30	87	67	54.3	5.68	7.24		
GLOut	8/7/2009	2	12.70	140	77	53.9	5.63	7.30		**
GLOut	8/7/2009	3	12.35	89	61	53.1	5.66	7.31		
GLOut	8/7/2009	4	11.99	88	68	52.5	5.65	7.31		
GLOut	8/7/2009	5	11.62	90	67	52.6	5.71	7.25		
GLOut	8/7/2009	6	11.49	91	57	52.3	5.71	7.24	5.20	
GLOut	8/7/2009	7	11.11	82	60	51.9	5.70	7.22		
GLOut	8/7/2009	8	11.02	89	65	51.5	5.69	7.47		
GLOut	8/7/2009	9	10.59	85	62	50.9	5.67	7.38		
GLOut	8/7/2009	10	9.76	85	60	50.1	5.68	7.35		
GLOut	8/7/2009	11	10.01	88	62	50.9	5.75	7.34		
GLOut	8/7/2009	12	8.28	82	52	50.5	5.95	7.07		
GLTS	6/11/2009	0	8.64	90	63	68.4	7.96	7.43	0.64	
GLTS	6/11/2009	1	8.09	90	63	66.2	7.80	7.35		**
GLTS	6/11/2009	2	7.32			65.4	7.86	7.30		**
GLTS	6/11/2009	3	6.93			64.4	7.84	7.30		**
GLTS	6/11/2009	4	6.83			64.3	7.83	7.30		**
GLTS	6/11/2009	5	6.31			63.7	7.86	7.31		**
GLTS	6/11/2009	6	6.04	91	58	63.5	7.89	7.55		
GLTS	6/11/2009	7	5.83	90	57	62.7	7.83	7.49		
GLTS	6/11/2009	8	5.80	91	57	62.3	7.81	7.49	0.90	
GLTS	6/11/2009	9	5.66	91	57	62.0	7.80	7.49		
GLTS	6/11/2009	10	5.41	91	57	61.3	7.74	7.49		
GLTS	6/11/2009	11	5.32	91	57	60.7	7.70	7.47		
GLTS	6/11/2009	12	5.05	91	56	60.1	7.65	7.47		
GLTS	6/11/2009	13	4.87	91	56	59.2	7.58	7.45		
GLTS	6/11/2009	14	4.68	91	56	58.6	7.51	7.42		
GLTS	6/11/2009	15	4.52	91	56	58.0	7.49	7.42		
GLTS	6/11/2009	16	4.43	91	55	57.0	7.37	7.08		
GLTS	6/11/2009	17	4.38	91	55	56.3	7.30	7.41		
GLTS	6/11/2009	18	4.35	91	55	55.8	7.25	7.38	0.55	

Table 4.2 (cont.) Water Quality Parameters Measured In-Situ at Grant Lake, Grant Creek, and Falls Creek, June and August 2009

Site Name	Date	Depth (m)	Temperature (°C)	Specific Conductivity (µS/cm)	Relative Conductivity (µS/cm)	DO* (%)	DO* (mg/L)	pH	Turbidity* (NTU)	Notes
GLTS	6/11/2009	19	4.33	92	55	55.5	7.20	7.06		
GLTS	6/11/2009	20	4.34	92	55	55.6	7.22	7.36		
GLTS	8/7/2009	0	14.66	87	70	56.2	5.63	7.56	3.87	
GLTS	8/7/2009	1	13.07	89	67	54.5	5.72	7.30		
GLTS	8/7/2009	2	12.65	89	69	53.3	5.65	7.35		
GLTS	8/7/2009	3	12.16	87	66	52.9	5.69	7.31		
GLTS	8/7/2009	4	11.95	73	41	53.7	5.80	7.25		
GLTS	8/7/2009	5	11.67	210	156	53.6	5.80	7.26		**
GLTS	8/7/2009	6	11.23	81	63	52.8	5.80	7.21		
GLTS	8/7/2009	7	10.92	86	67	52.4	5.78	7.22		
GLTS	8/7/2009	8	10.71	85	68	52.4	5.81	7.25	3.52	
GLTS	8/7/2009	9	10.37	92	82	52.1	5.82	7.20		
GLTS	8/7/2009	10	9.70	97	67	50.8	5.76	7.16		
GLTS	8/7/2009	11	9.17	87	60	51.9	5.97	7.18		
GLTS	8/7/2009	12	8.71	77	88	51.1	5.94	7.08		
GLTS	8/7/2009	13	8.46	63	43	51.1	5.97	7.13		
GLTS	8/7/2009	14	7.91	89	80	50.6	6.00	7.13		
GLTS	8/7/2009	15	7.00	91	91	49.8	6.05	7.12		
GLTS	8/7/2009	16	6.90	65	89	49.3	5.99	7.07		
GLTS	8/7/2009	17	6.09	96	62	48.4	5.99	7.06	4.84	
GLTS	8/7/2009	18	5.95	87	61	48.0	5.98	7.04		

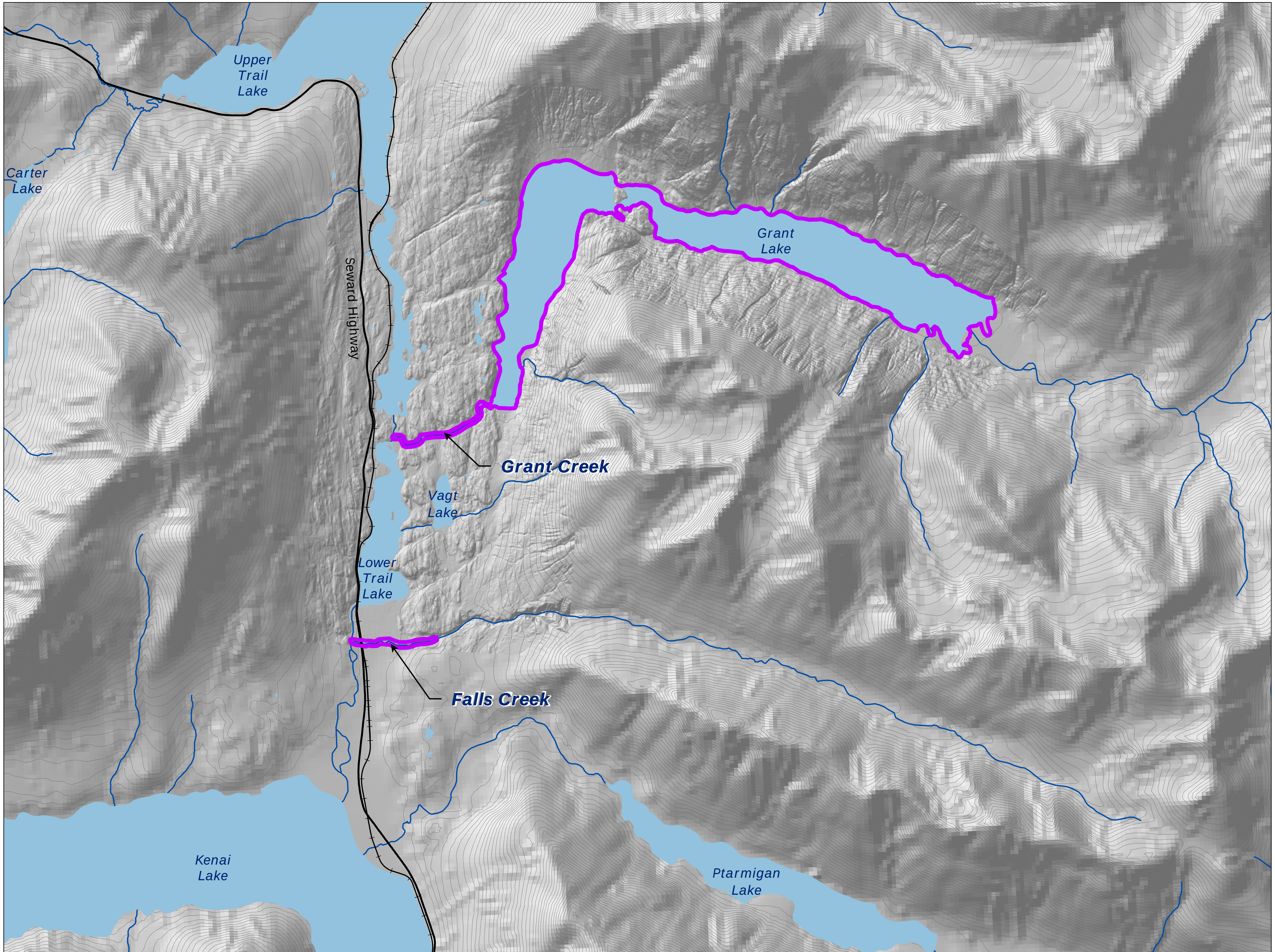
*= Turbidity was only measured at certain depths at the lake sites.

**= Conductivity reading unstable.

Table 4.3 Water Quality Analysis Results for Grant Lake, Grant Creek, and Falls Creek, June and August, 2009

Site Name	Alk (mg/L $CaCO_3$)		Total Pb (µg/L)		Hg (ng/L)		NO_2+NO_3		PO_4 (mg/L)		TDS (mg/L)		TKN (mg/L)		Total P (mg/L)		TSS (mg/L)	
	Jun	***Aug***	***Jun***	***Aug***	***Jun***	***Aug***	***Jun***	***Aug***	***Jun***	***Aug***	***Jun***	***Aug***	***Jun***	***Aug***	***Jun***	***Aug***	***Jun***	***Aug***
GLTSBOT	24.0	25.4	ND	ND	ND	1.65	0.410	0.319	ND	ND	61.3	45.0	ND	ND	ND	ND	0.80	2.83
GLTSMID	24.5	24.6	1.100	ND	ND	1.64	0.421	0.303	ND	ND	68.8	48.8	ND	ND	0.0218	ND	1.00	2.58
GLTSSUR	23.5	24.8	ND	ND	ND	1.15	0.415	0.280	ND	ND	75.0	46.3	ND	ND	ND	ND	0.70	1.90
GLOUTSUR	23.8	24.0	ND	ND	ND	1.4	0.414	0.268	ND	ND	51.3	32.5	ND	ND	ND	ND	0.60	1.96
GLOUTMID	23.2	24.0	ND	ND	ND	2.05	0.651	0.298	ND	ND	40.0	47.5	ND	ND	ND	ND	0.50	2.77
FC100	37.4	21.0	ND	0.252	2.00	4.42	0.145	ND	ND	ND	48.8	70.0	ND	ND	0.0157	ND	8.30	8.24
GC100	24.0	23.0	0.597	ND	ND	1.48	0.461	0.299	ND	ND	53.8	62.5	ND	ND	ND	ND	0.70	2.49
GC200	25.0	23.5	3.090	ND	ND	1.58	0.455	0.292	ND	ND	60.0	43.8	ND	ND	ND	ND	0.80	3.40
GC300	25.0	23.0	0.392	ND	ND	2.05	0.416	0.323	ND	ND	57.5	60.0	ND	ND	0.0233	ND	0.80	2.93

8 Figures



2009 Fish and Aquatic Resources

Study Area

Legend

- Study Area
- Rail
- Seward Highway
- Lakes
- Rivers
- Contours (10 ft)

NORTH

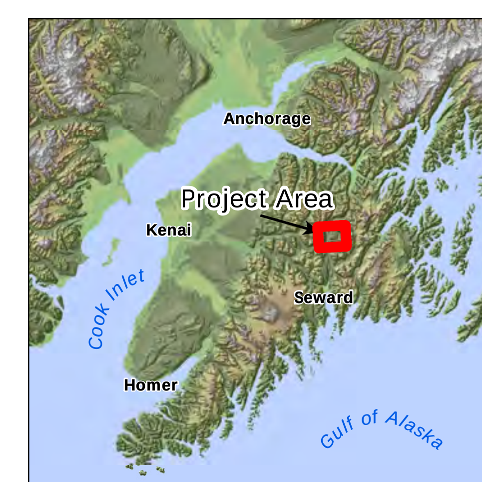
Miles: 0, 0.5, 1

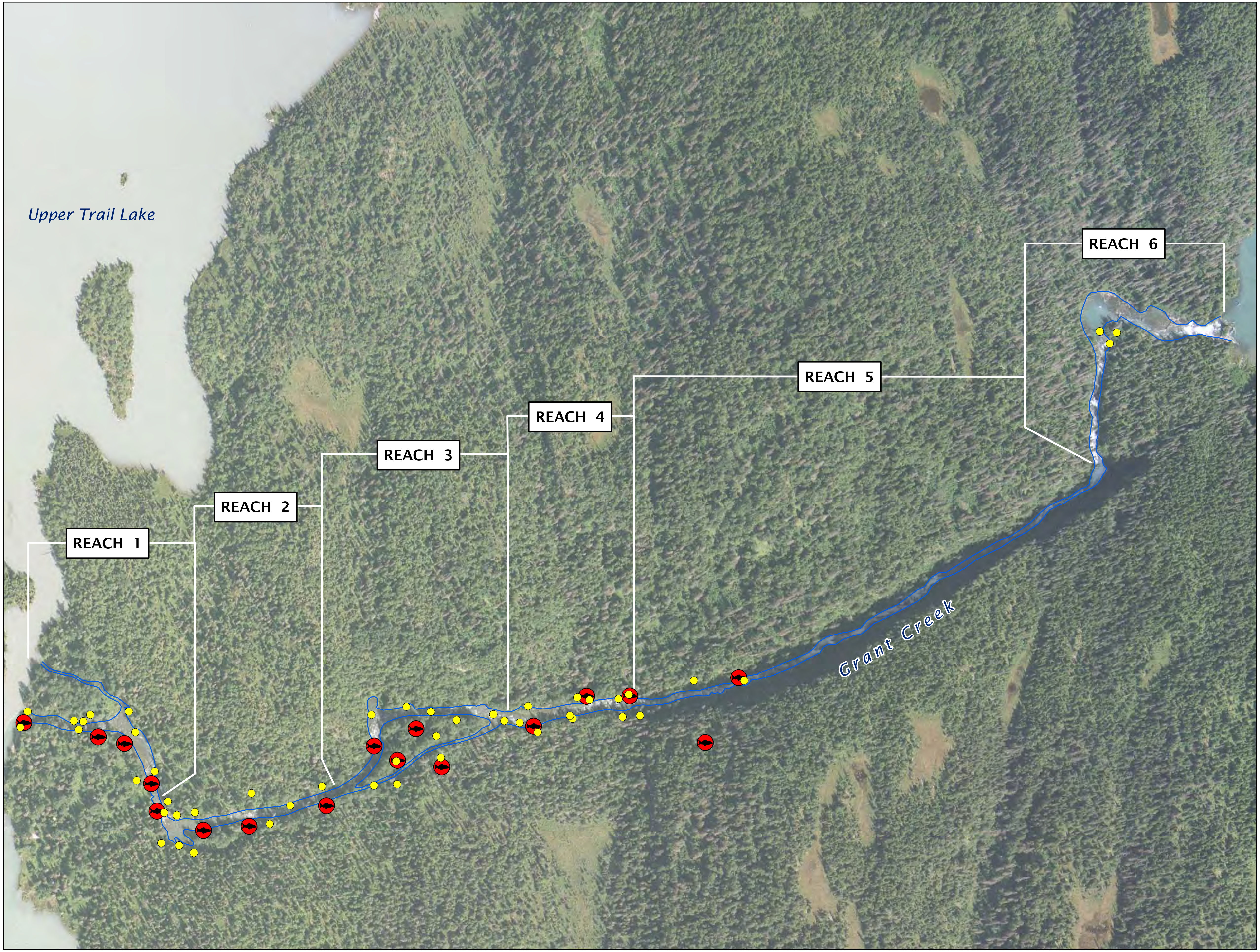
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR, KPB, USFS
Author: HDR Alaska, Inc.
Date: 07 October 2009

This map represents a conceptual level of utility, detail, and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal,
state, public, and private sources.
These maps are for review purposes only.

Kenai Hydro LLC

HDR ALASKA





Fisheries Field Studies

2009 Grant Creek Sampling Sites and Reaches

Legend

- Minnow Trap / Efish Site
- Angling Site
- Grant Creek Wetted Edge

NORTH

Feet
0 250 500

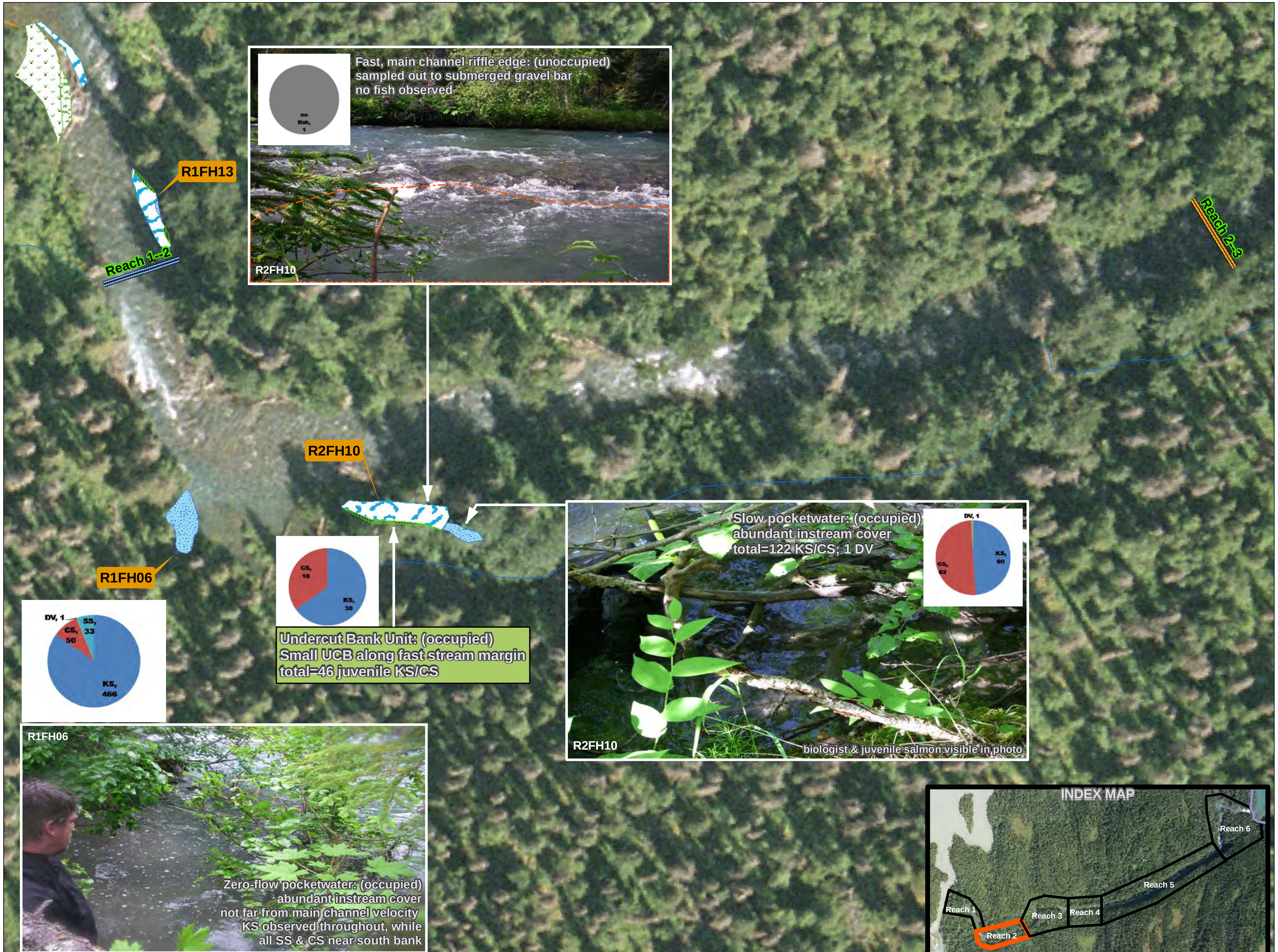
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc., USFS, KPB, USGS, Aerometric
Author: HDR Alaska, Inc.
Date: 05 October 2009

This map represents a conceptual level of utility, detail,and accuracy. The information displayed here is for planning purposes only. Base information shown constitutes data from various federal, state, public, and private sources. These maps are for review purposes only.

Kenai Hydro LLC

HDR ALASKA


INDEX MAP
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Trail Lake
Grant Creek (distributary channel)
Grant Creek (primary channel)
R1FH11
variable microhabitats available and occupied in distributary.
R1FH12
variable microhabitats available and occupied in distributary.
R1FH01
fast riffle no cover no fish observed
SWD instream cover total= 4 KS, 1 RBT, 2 Sc
R1FH05
LWD provides cover & velocity break many juvenile fish
fast riffle primarily KS, RBT & DV
margin shelf w/instream cover many juveniles observed
R1FH13
Fastwater =6 RBT, 2 DV
UCB & slower pockets =141 KS, 31 CS, 2 RBT
Instream Flow
Microhabitat Sample Areas Reach 1, June 2009
Microhabitat Sample Areas
backwater/slow pockets
margin with UCB
margin with no UCB
pool/fastwater
riffle/fastwater
margin shelf w/ instream cover
large woody debris (LWD) dam
side channel: variable
Fish Species Color Key
KS=Chinook salmon
CS=coho salmon
DV=Dolly Varden char
RBT=rainbow trout
SS=sockeye salmon
AG=Arctic grayling
Sc=Sculpin-unspecified
NORTH
Feet
0
50
100
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc.
Author: HDR Alaska, Inc.
Date: October 6, 2009
This map represents a conceptual level of utility, detail,and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal, state, public, and private sources.
These maps are for review purposes only.
Kenai Hydro LLC
HDR ALASKA
Anchorage
Project Area
Kenai
Cook Inlet
Seward
Homer
Gulf of Alaska



Instream Flow

Microhabitat Sample Areas
Reach 2, June 2009

Microhabitat Sample Areas
- backwater/slow pockets
- margin with UCB
- margin with no UCB
- pool/fastwater
- riffle/fastwater
- margin shelf w/ instream cover
- large woody debris (LWD) dam
- side channel: variable

Fish Species Color Key
- KS=Chinook salmon
- CS=coho salmon
- DV=Dolly Varden char
- RBT=rainbow trout
- SS=sockeye salmon
- AG=Arctic grayling
- Sc=Sculpin-unspecified

NORTH

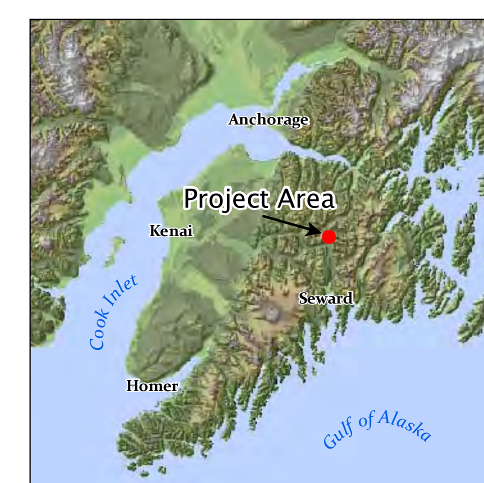
Feet
0 50 100

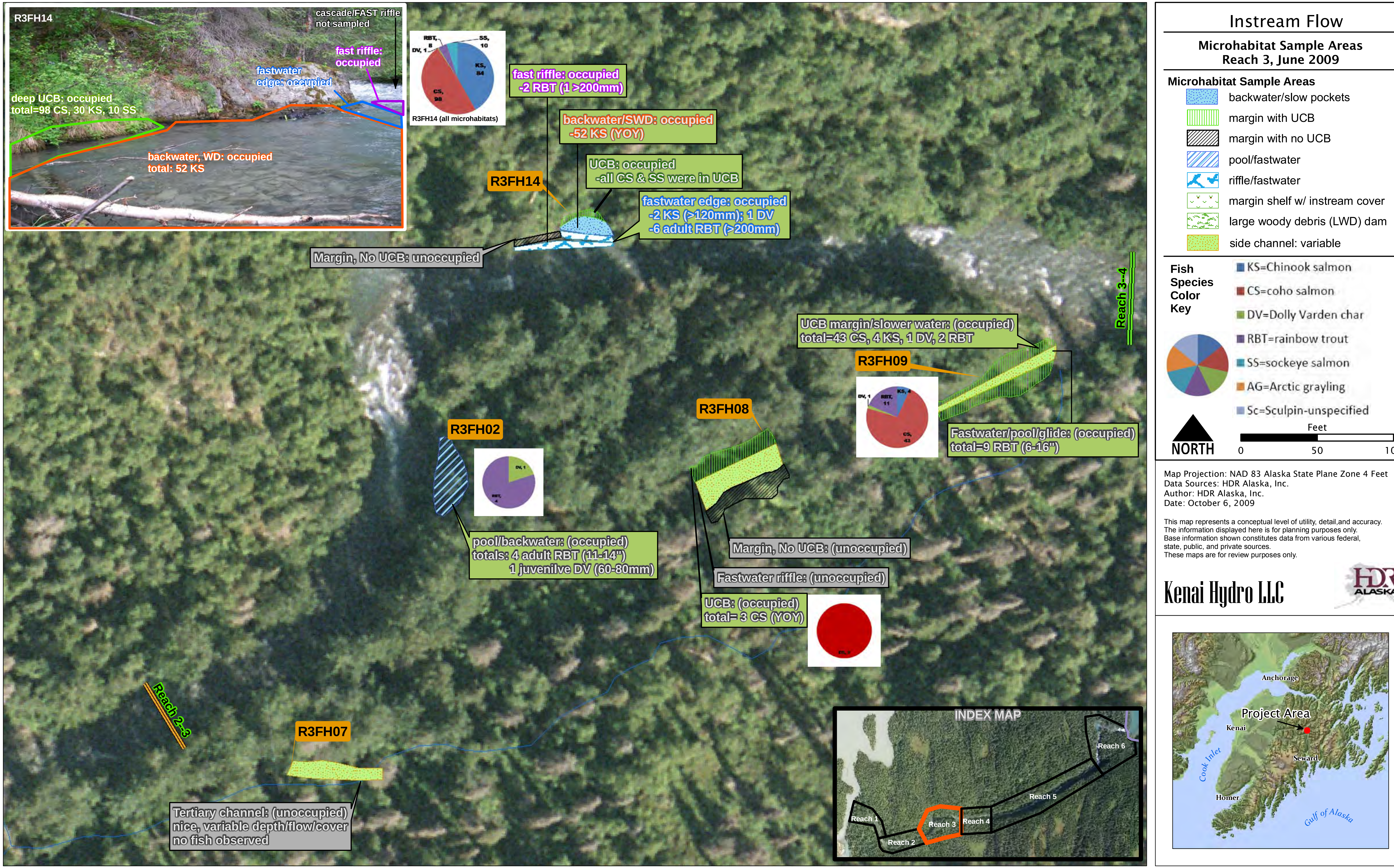
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc.
Author: HDR Alaska, Inc.
Date: October 6, 2009

This map represents a conceptual level of utility, detail,and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal,
state, public, and private sources.
These maps are for review purposes only.

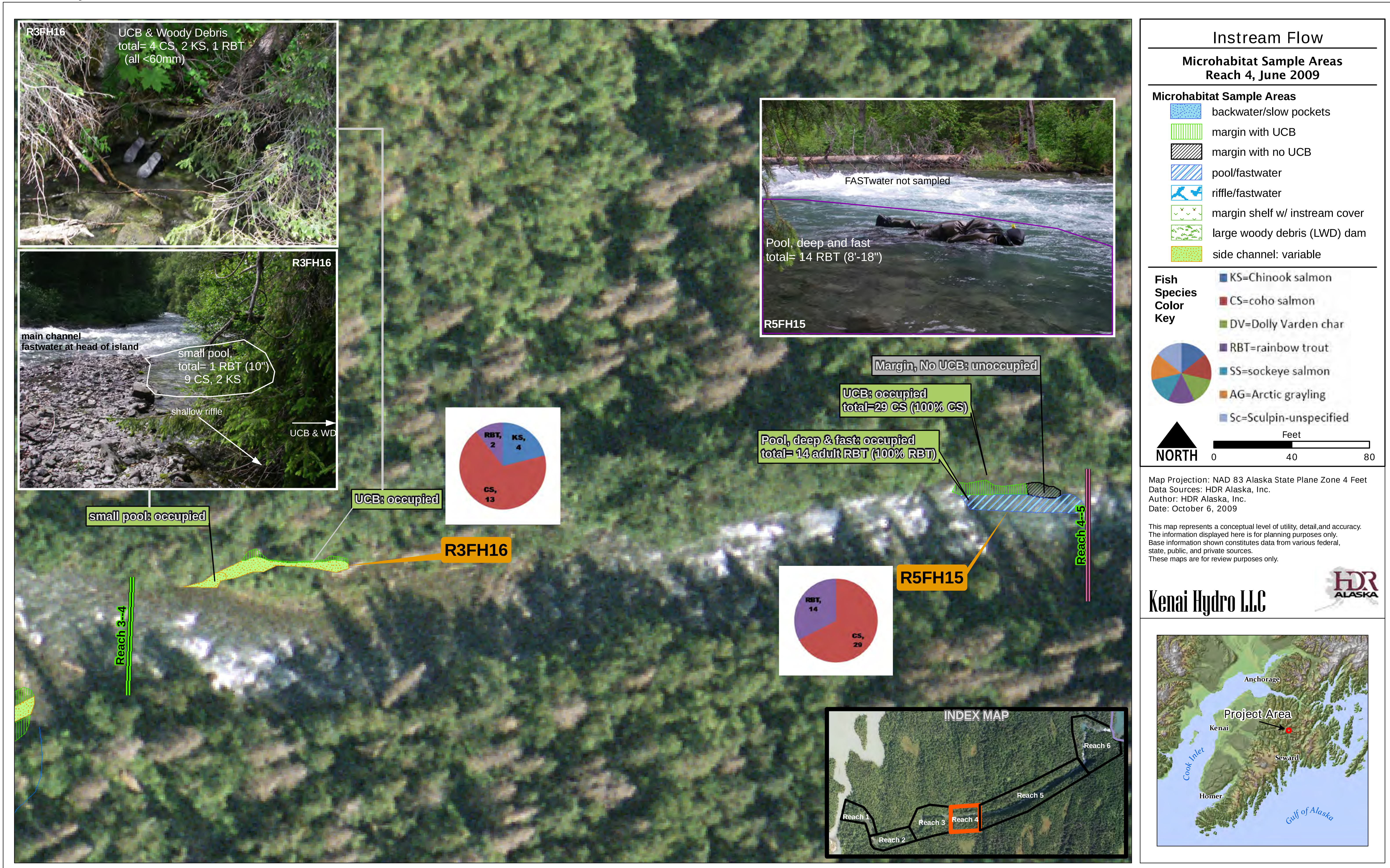
Kenai Hydro LLC

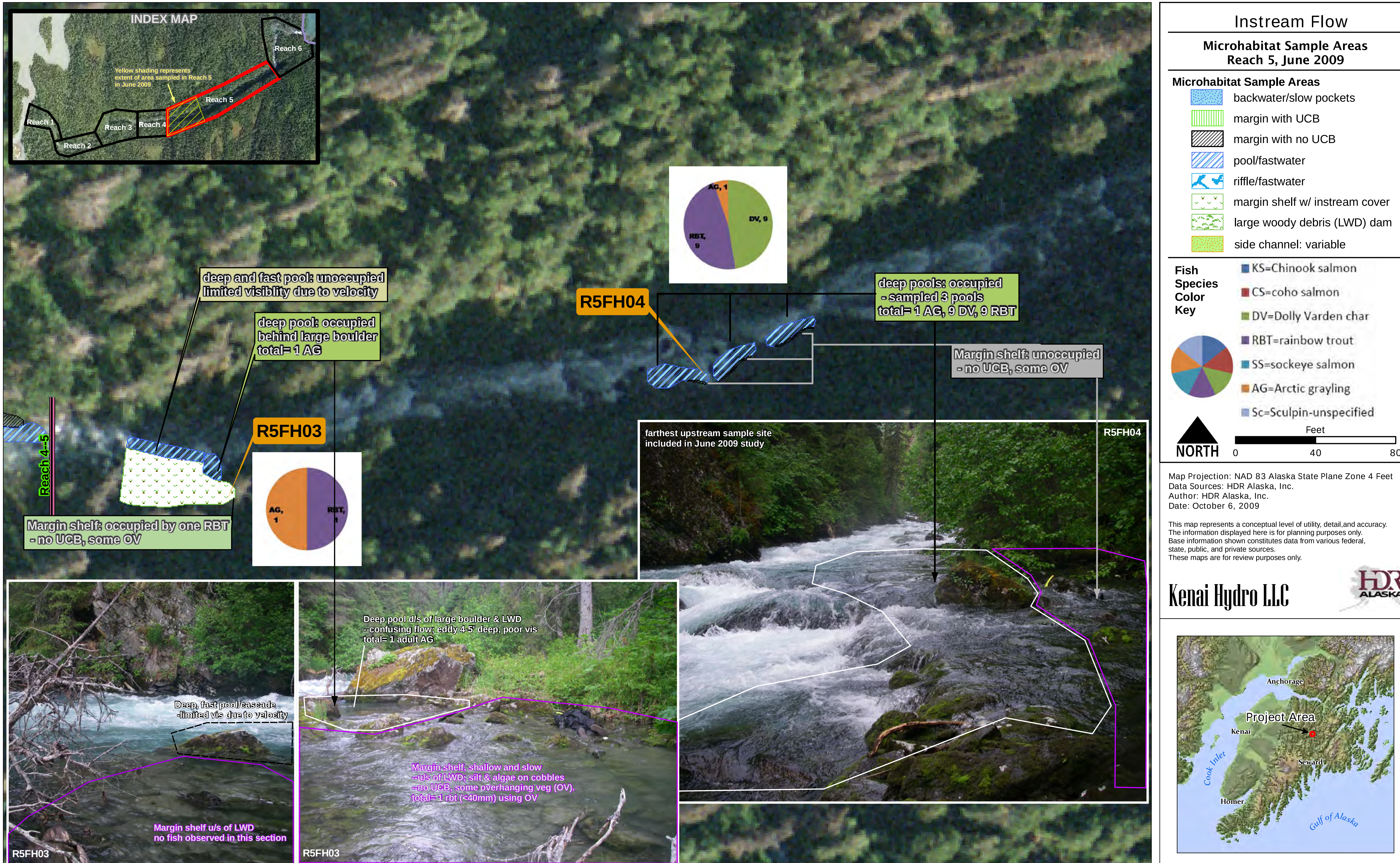
HDR ALASKA

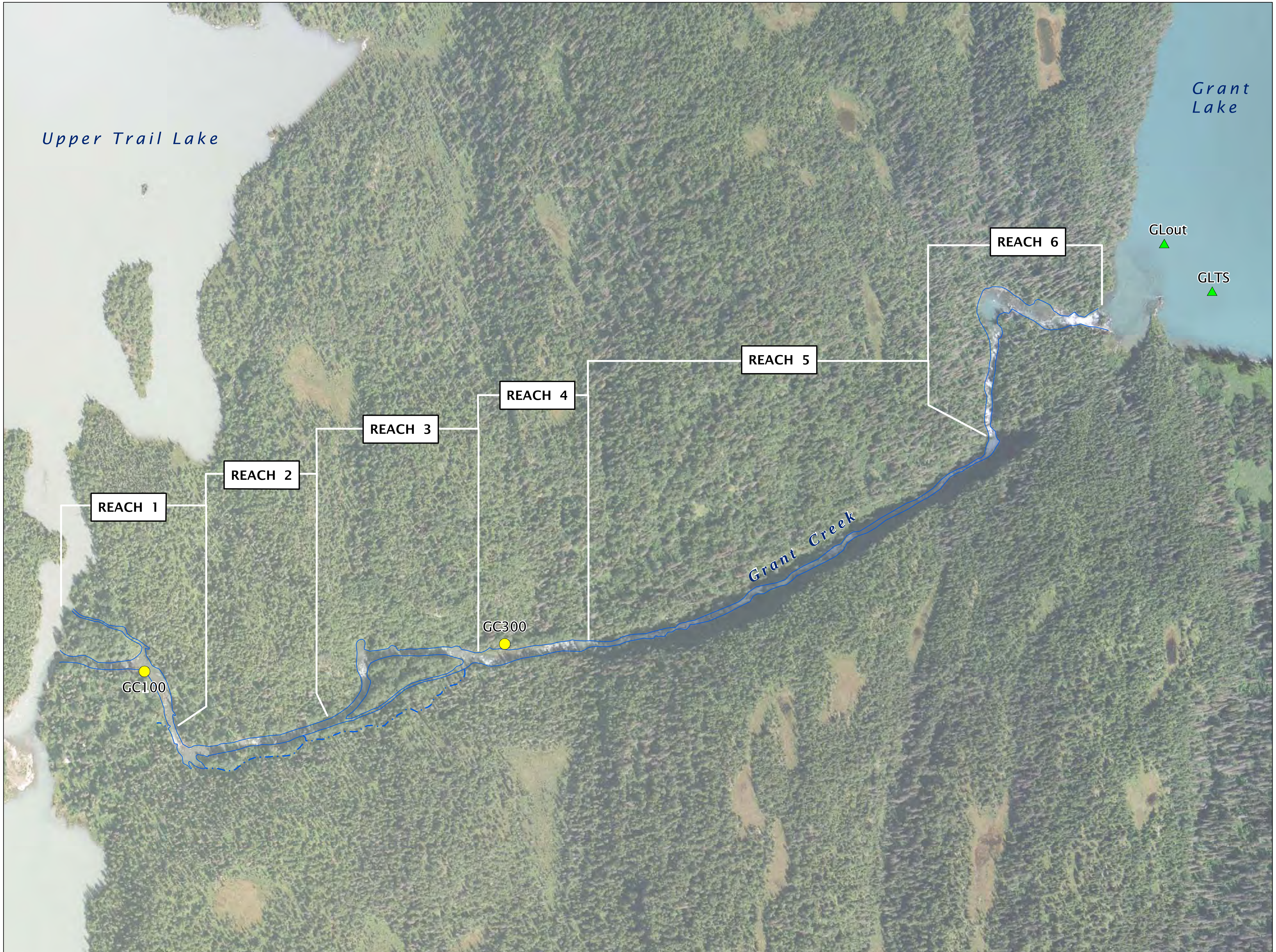




R3FH14
cascade/FAST riffle not sampled
fast riffle: occupied
fastwater edge: occupied
deep UCB: occupied total=98 CS, 30 KS, 10 SS
backwater, WD: occupied total: 52 KS
R3FH14 (all microhabitats)
fast riffle: occupied -2 RBT (1 >200mm)
backwater/SWD: occupied -52 KS (YOY)
UCB: occupied -all CS & SS were in UCB
fastwater edge: occupied -2 KS (>120mm); 1 DV -6 adult RBT (>200mm)
Margin, No UCB: unoccupied
UCB margin/slower water: (occupied) total=43 CS, 4 KS, 1 DV, 2 RBT
R3FH09
Fastwater/pool/glide: (occupied) total=9 RBT (6-16")
R3FH08
R3FH02
pool/backwater: (occupied) totals: 4 adult RBT (11-14") 1 juvenilve DV (60-80mm)
Margin, No UCB: (unoccupied)
Fastwater riffle: (unoccupied)
UCB: (occupied) total= 3 CS (YOY)
Reach 3--4
Reach 2--3
R3FH07
Tertiary channel: (unoccupied) nice, variable depth/flow/cover no fish observed
INDEX MAP
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Instream Flow
Microhabitat Sample Areas Reach 3, June 2009
Microhabitat Sample Areas
backwater/slow pockets
margin with UCB
margin with no UCB
pool/fastwater
riffle/fastwater
margin shelf w/ instream cover
large woody debris (LWD) dam
side channel: variable
Fish Species Color Key
KS=Chinook salmon
CS=coho salmon
DV=Dolly Varden char
RBT=rainbow trout
SS=sockeye salmon
AG=Arctic grayling
Sc=Sculpin-unspecified
NORTH
Feet
0 50 100
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc.
Author: HDR Alaska, Inc.
Date: October 6, 2009
This map represents a conceptual level of utility, detail, and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal, state, public, and private sources.
These maps are for review purposes only.
Kenai Hydro LLC
HDR ALASKA
Anchorage
Project Area
Kenai
Cook Inlet
Seward
Homer
Gulf of Alaska


R3FH16
UCB & Woody Debris
total= 4 CS, 2 KS, 1 RBT
(all <60mm)
R3FH16
main channel
fastwater at head of island
small pool,
total= 1 RBT (10")
9 CS, 2 KS
shallow riffle
UCB & WD
small pool: occupied
UCB: occupied
RBT, 2
KS, 4
CS, 13
R3FH16
Reach 3--4
FASTwater not sampled
Pool, deep and fast
total= 14 RBT (8'-18")
R5FH15
Margin, No UCB: unoccupied
UCB: occupied
total=29 CS (100% CS)
Pool, deep & fast: occupied
total= 14 adult RBT (100% RBT)
Reach 4--5
R5FH15
RBT, 14
CS, 29
INDEX MAP
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Instream Flow
Microhabitat Sample Areas
Reach 4, June 2009
Microhabitat Sample Areas
backwater/slow pockets
margin with UCB
margin with no UCB
pool/fastwater
riffle/fastwater
margin shelf w/ instream cover
large woody debris (LWD) dam
side channel: variable
Fish Species Color Key
KS=Chinook salmon
CS=coho salmon
DV=Dolly Varden char
RBT=rainbow trout
SS=sockeye salmon
AG=Arctic grayling
Sc=Sculpin-unspecified
NORTH
Feet
0
40
80
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc.
Author: HDR Alaska, Inc.
Date: October 6, 2009
This map represents a conceptual level of utility, detail,and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal,
state, public, and private sources.
These maps are for review purposes only.
Kenai Hydro LLC
HDR ALASKA
Anchorage
Project Area
Kenai
Cook Inlet
Seward
Homer
Gulf of Alaska


INDEX MAP
Reach 6
Yellow shading represents extent of area sampled in Reach 5 in June 2009
Reach 5
Reach 1
Reach 3
Reach 4
Reach 2
deep and fast pool: unoccupied limited visiblity due to velocity
deep pool: occupied behind large boulder total= 1 AG
R5FH03
AG, 1
RBT, 1
Reach 4-5
Margin shelf: occupied by one RBT - no UCB, some OV
R5FH04
AG, 1
DV, 9
RBT, 9
deep pools: occupied - sampled 3 pools total= 1 AG, 9 DV, 9 RBT
Margin shelf: unoccupied - no UCB, some OV
farthest upstream sample site included in June 2009 study
R5FH04
Deep pool d/s of large boulder & LWD --confusing flow; eddy 4-5' deep, poor vis total= 1 adult AG
Deep, fast pool/cascade -limited vis due to velocity
Margin shelf u/s of LWD no fish observed in this section
R5FH03
Margin shelf, shallow and slow --u/s of LWD; silt & algae on cobbles --no UCB, some overhanging veg (OV). total= 1 rbt (<40mm) using OV
R5FH03
Instream Flow
Microhabitat Sample Areas Reach 5, June 2009
Microhabitat Sample Areas
backwater/slow pockets
margin with UCB
margin with no UCB
pool/fastwater
riffle/fastwater
margin shelf w/ instream cover
large woody debris (LWD) dam
side channel: variable
Fish Species Color Key
KS=Chinook salmon
CS=coho salmon
DV=Dolly Varden char
RBT=rainbow trout
SS=sockeye salmon
AG=Arctic grayling
Sc=Sculpin-unspecified
NORTH
Feet
0
40
80
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc.
Author: HDR Alaska, Inc.
Date: October 6, 2009
This map represents a conceptual level of utility, detail,and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal, state, public, and private sources.
These maps are for review purposes only.
Kenai Hydro LLC
HDR ALASKA
Anchorage
Project Area
Kenai
Cook Inlet
Seward
Homer
Gulf of Alaska



Aquatic Resources

2009 Grant Creek and Grant Lake Aquatic Invertebrates

Legend

- Macroinvertebrates and Periphyton
- Zooplankton and Phytoplankton
- Grant Creek Wetted Edge
- Side or Overflow Channel

NORTH

Feet
0 250 500

Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc., USFS, KPB, USGS, Aerometric
Author: HDR Alaska, Inc.
Date: 07 October 2009

This map represents a conceptual level of utility, detail,and accuracy. The information displayed here is for planning purposes only. Base information shown constitutes data from various federal, state, public, and private sources. These maps are for review purposes only.

Kenai Hydro LLC

HDR ALASKA

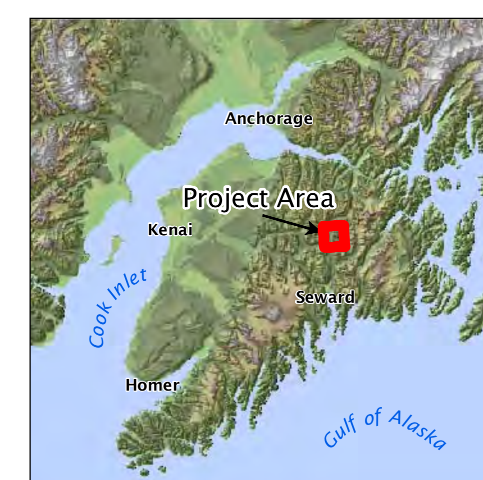


Figure 3.4.5- 1

Fisheries Field Studies

2009 Falls Creek Minnow Trapping

Legend

Minnow Trap Site

NORTH

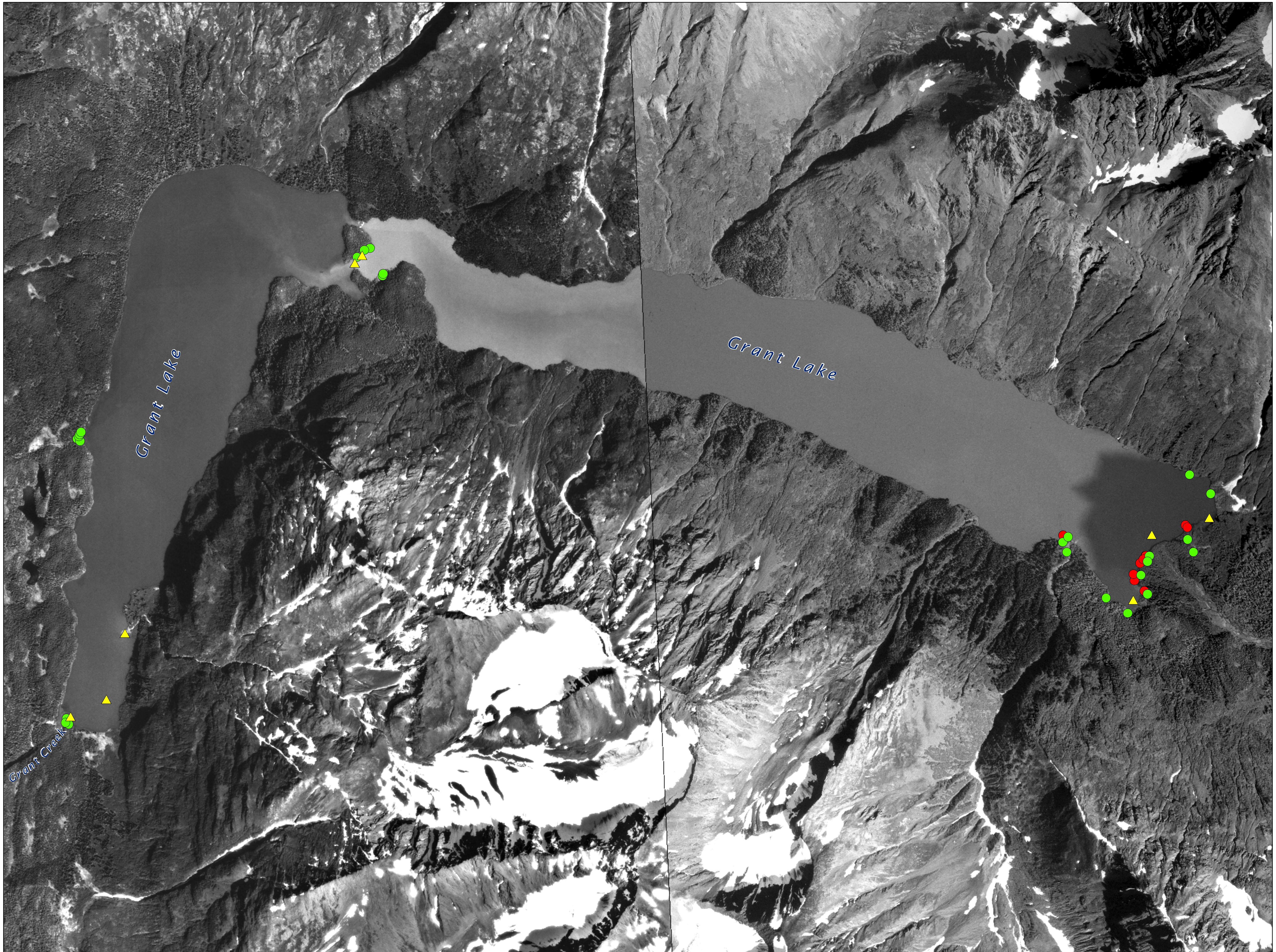
Feet
0 250 500

Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc., USFS, KPB, USGS
Author: HDR Alaska, Inc.
Date: 09 October 2009

This map represents a conceptual level of utility, detail,and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal, state, public, and private sources.
These maps are for review purposes only.

Kenai Hydro LLC

HDR ALASKA



Fisheries Field Studies

2009 Grant Lake Sampling Sites

Legend

- Gill Net Site
- Minnow Trap / Efish Site
- Efish Only Site

NORTH

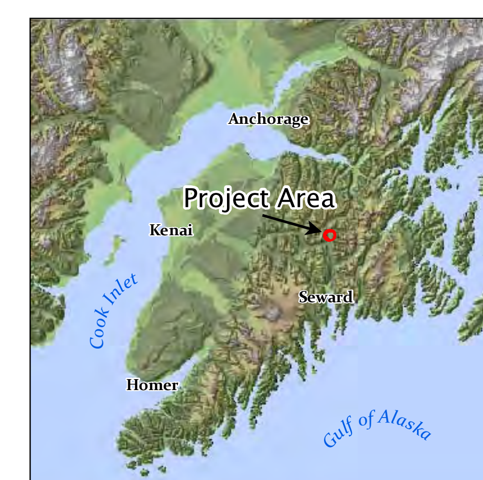
Feet
0 2,000 4,000

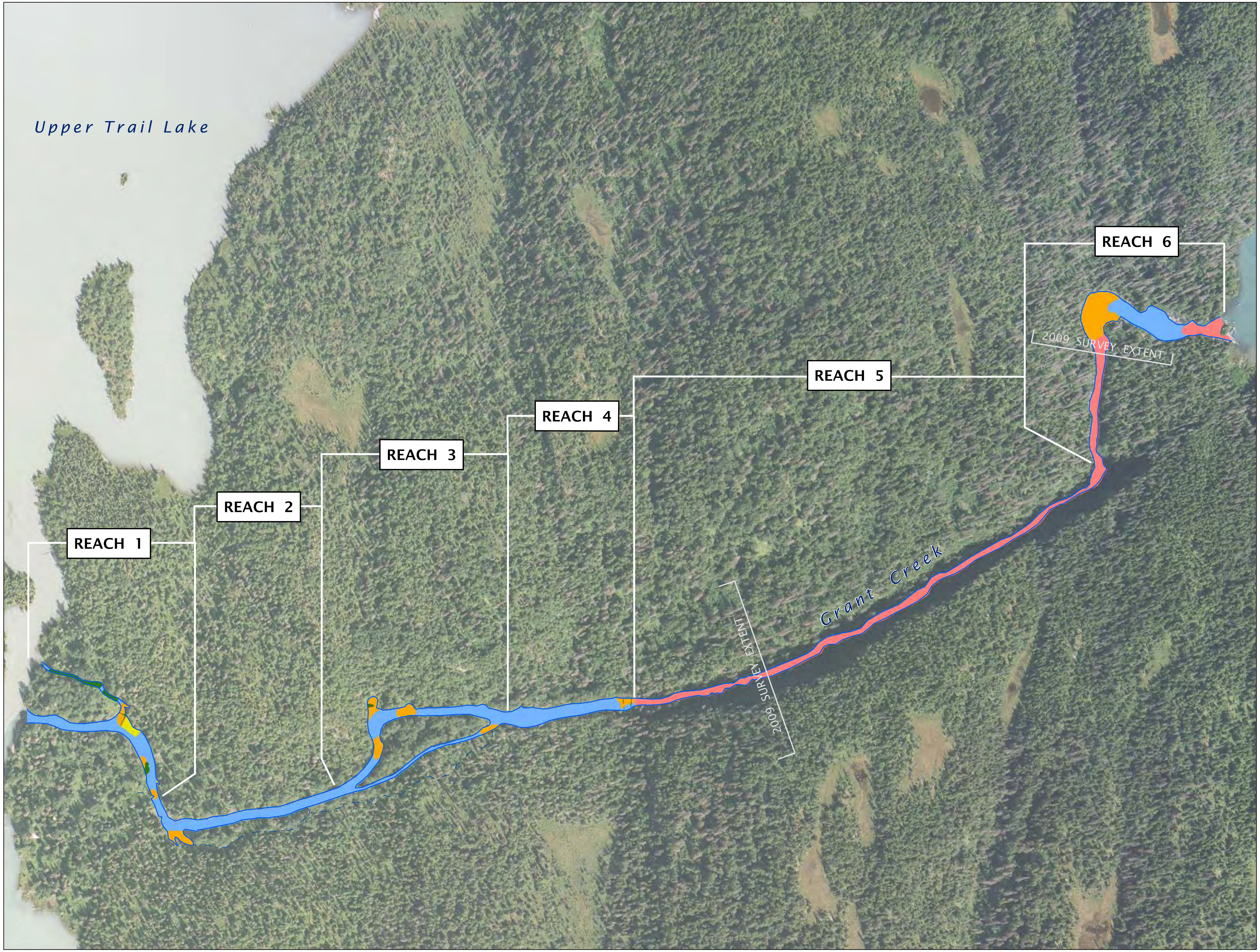
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc., USFS, KPB, USGS
Author: HDR Alaska, Inc.
Date: 09 October 2009

This map represents a conceptual level of utility, detail,and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal,
state, public, and private sources.
These maps are for review purposes only.

Kenai Hydro LLC

HDR ALASKA





Fisheries Field Studies

2009 Grant Creek
Major Habitat Categories

Legend

- Large Woody Debris
- Cascade Dominated Habitat
- Glide Dominated Habitat
- Pool Dominated Habitat
- Riffle Dominated Habitat
- Grant Creek Wetted Edge
- Side / Overflow Channel

NORTH

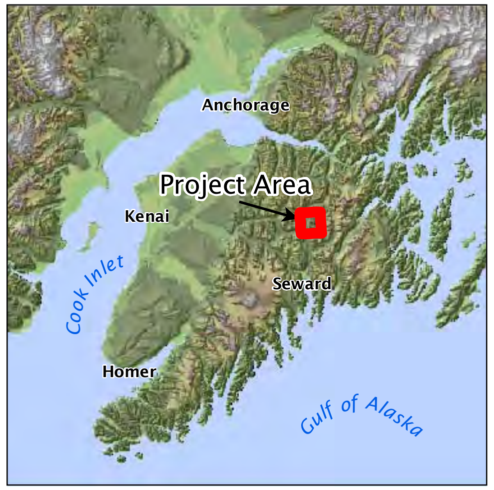
Feet
0 250 500

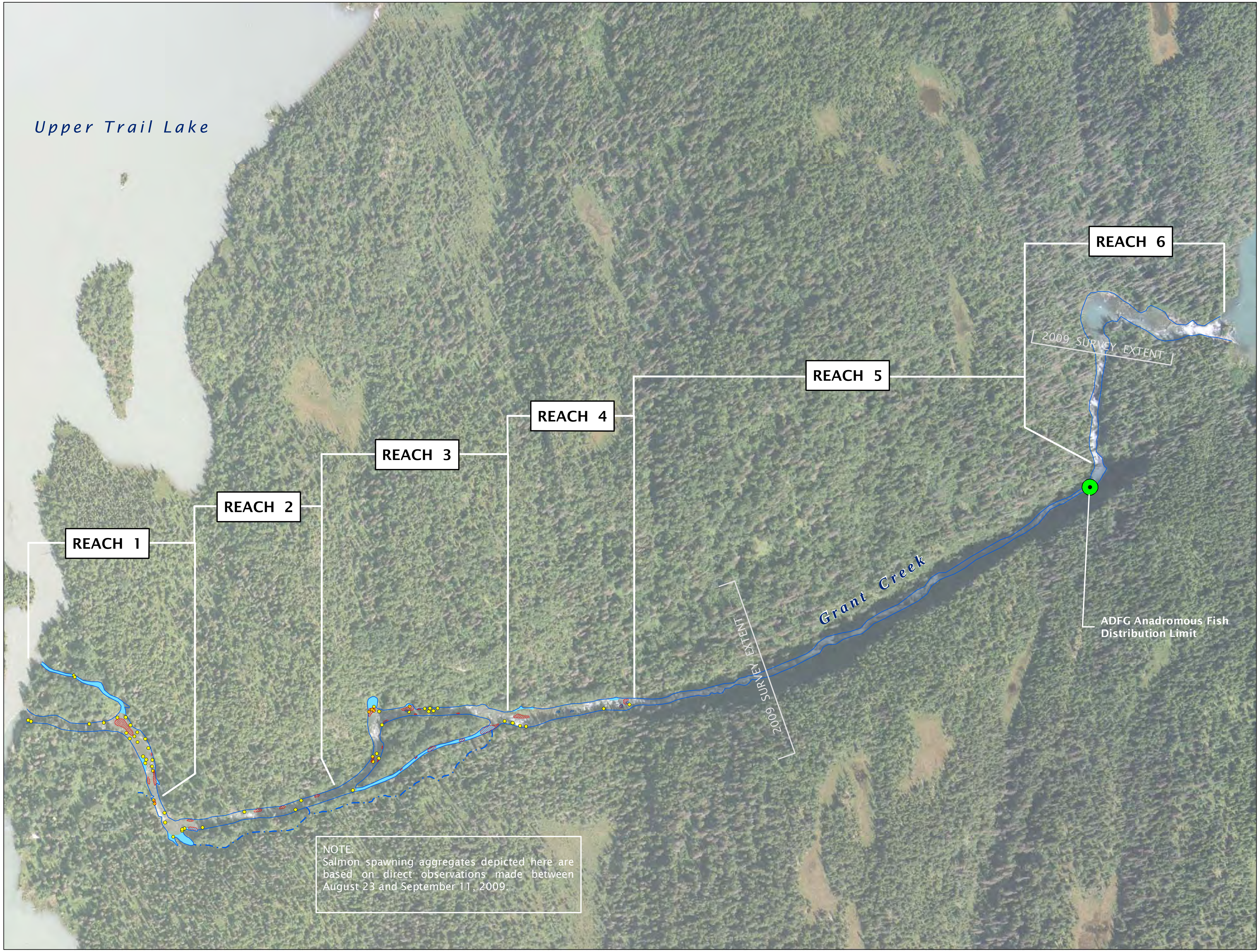
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc., USFS, KPB,
USGS, Aerometric
Author: HDR Alaska, Inc.
Date: 07 October 2009

This map represents a conceptual level of utility, detail,and accuracy.
The information displayed here is for planning purposes only.
Base information shown constitutes data from various federal,
state, public, and private sources.
These maps are for review purposes only.

Kenai Hydro LLC

HDR ALASKA





Fisheries Field Studies

2009 Grant Creek Fish Use Map

Legend

- Chinook Spawning Aggregate
- Sockeye Spawning Aggregate
- Juvenile Rearing
- Historical Spawning (AEIDC, 1983)
- ADFG Anadromous Fish Distribution Limit
- Grant Creek Wetted Edge
- Side or Overflow Channel

NORTH

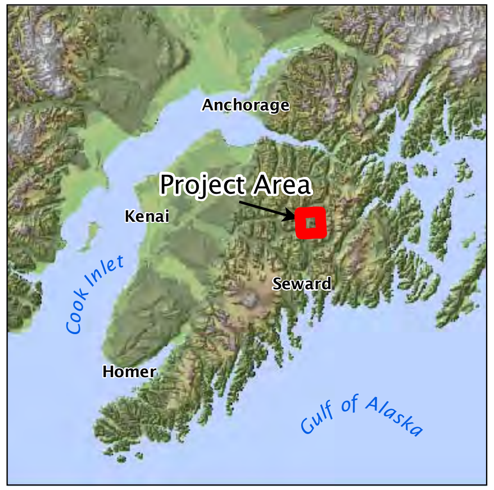
Feet: 0, 250, 500

Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc., USFS, KPB, USGS, Aerometric
Author: HDR Alaska, Inc.
Date: 07 October 2009

This map represents a conceptual level of utility, detail, and accuracy. The information displayed here is for planning purposes only. Base information shown constitutes data from various federal, state, public, and private sources. These maps are for review purposes only.

Kenai Hydro LLC

HDR ALASKA



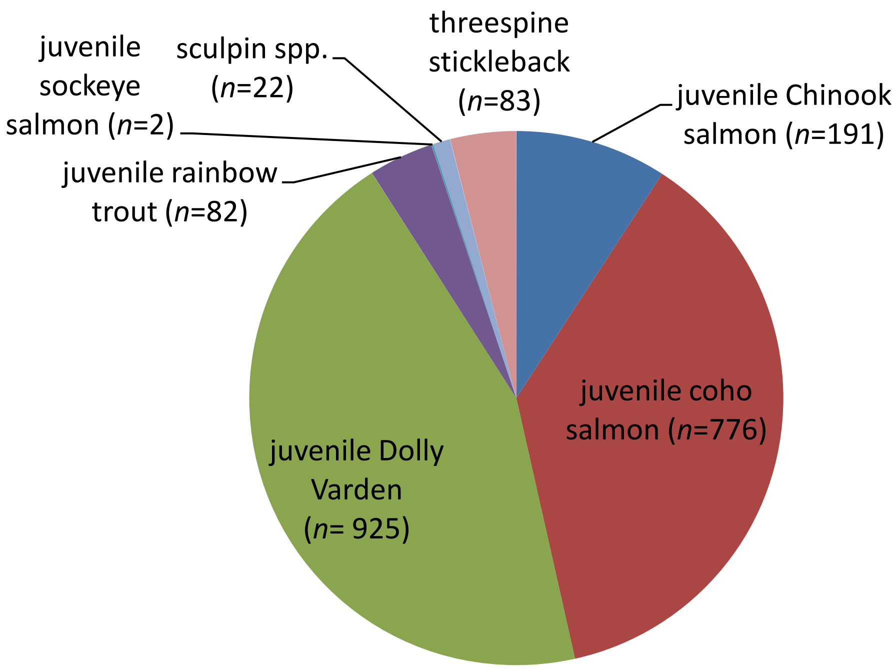


Figure 3.5.2-1 Catch by species in minnow traps in Grant Creek, June – September, 2009

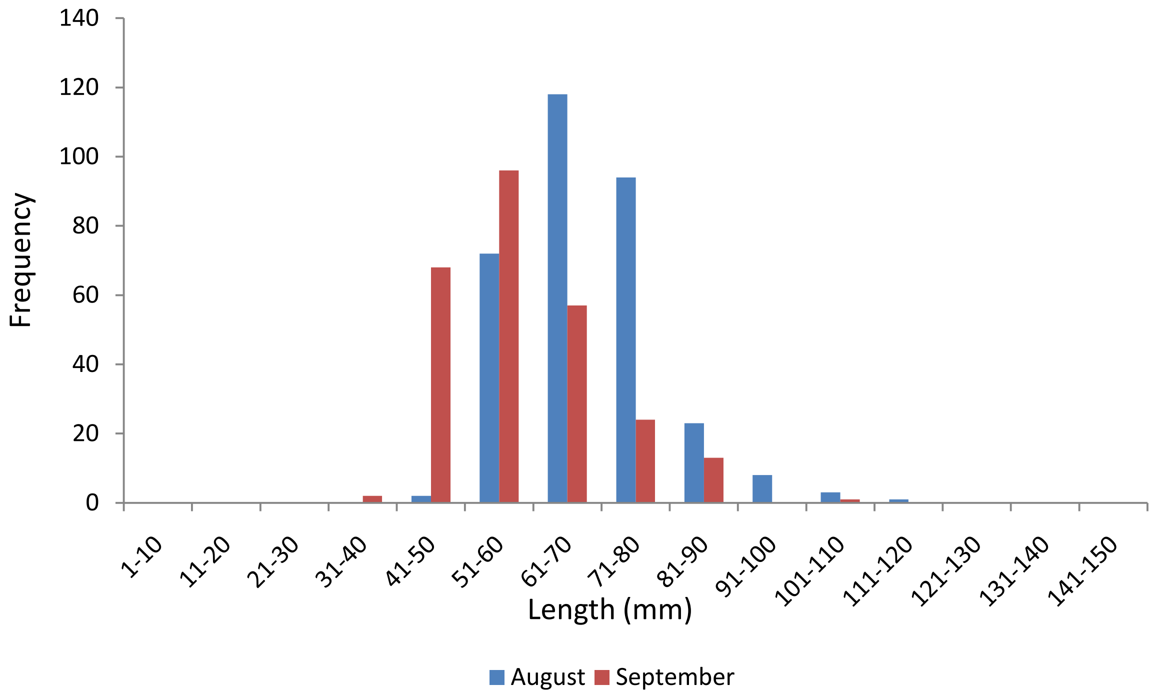


Figure 3.5.2-2 Length frequencies of juvenile coho salmon captured in minnow traps in Grant Creek in August and September, 2009

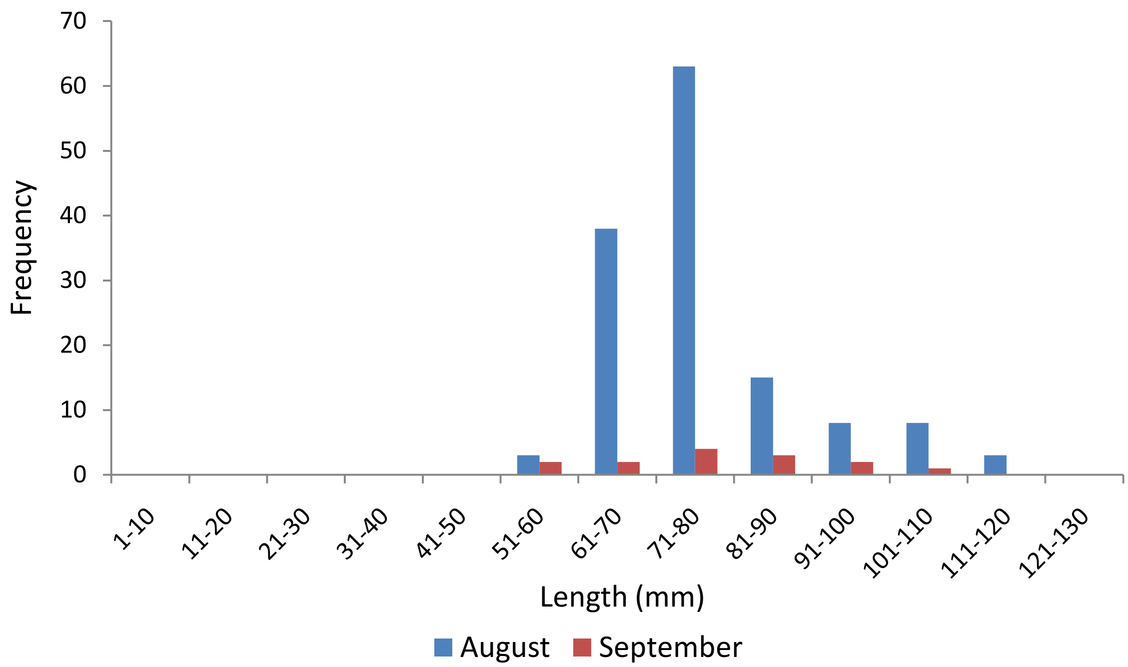


Figure 3.5.2-3 Length frequencies of juvenile Chinook salmon captured in minnow traps in Grant Creek in August and September, 2009

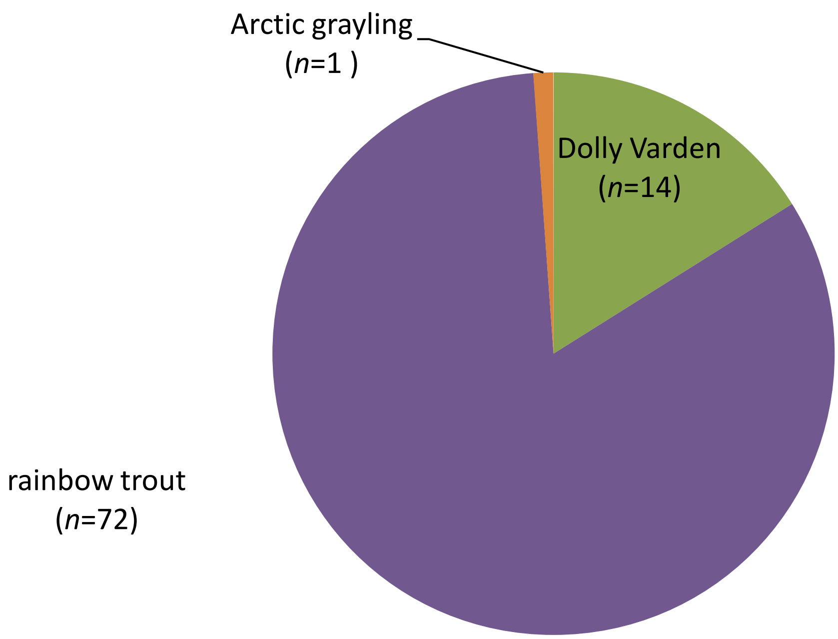


Figure 3.5.2-4 Catch by species for angling surveys in Grant Creek, June – September, 2009

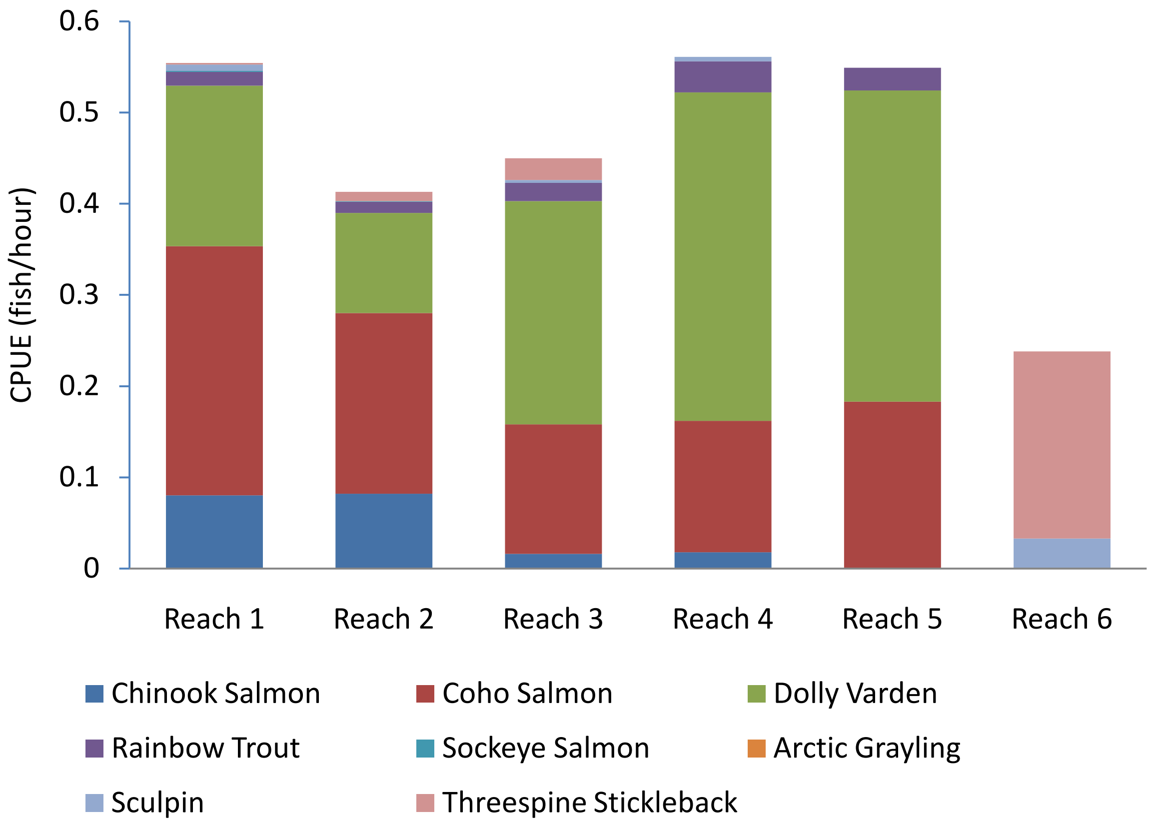


Figure 3.5.2-5 CPUE by reach and species from minnow trapping, Grant Creek, June – September, 2009

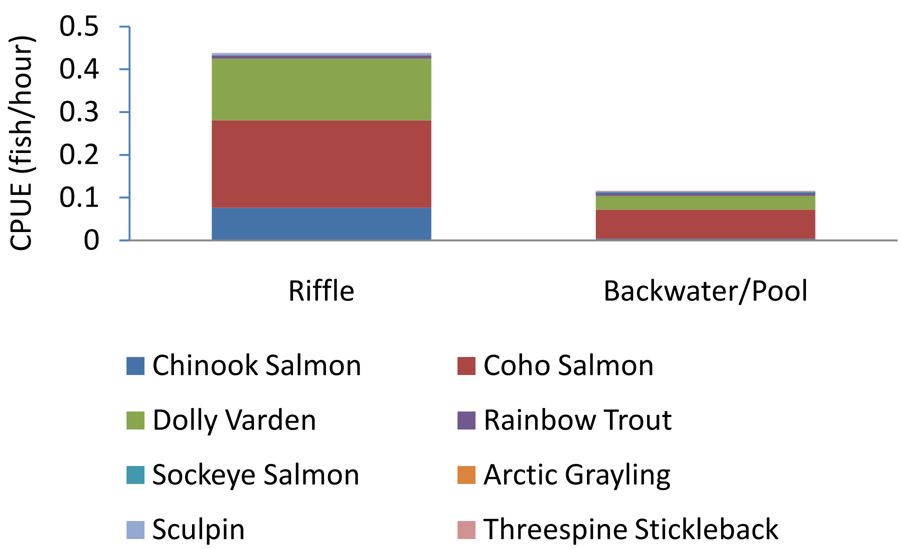


Figure 3.5.2-6 Reach 1, CPUE by habitat, June – September, 2009

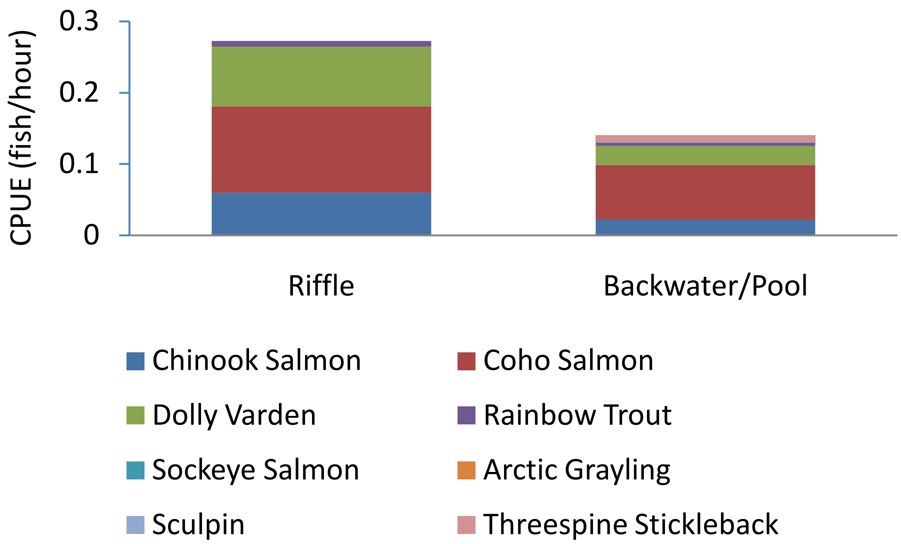


Figure 3.5.2-7 Reach 2, CPUE by habitat, June – September, 2009

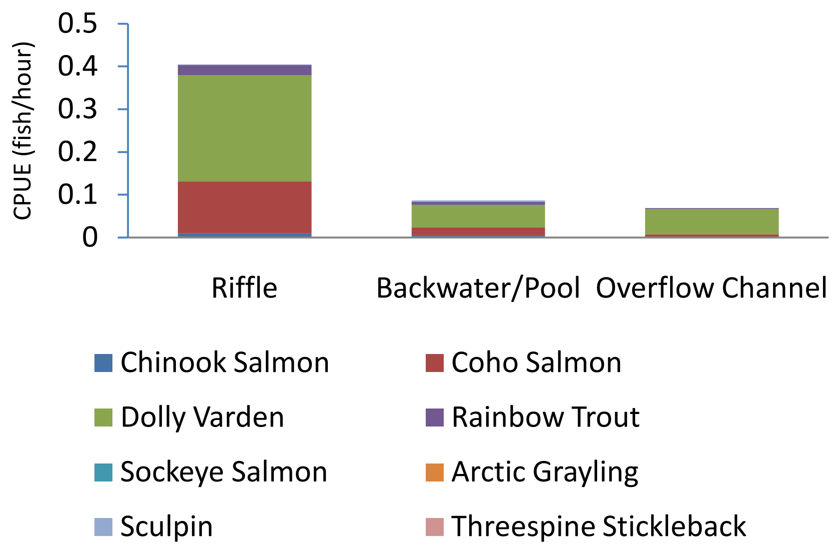


Figure 3.5.2-8 Reach 4, CPUE by habitat, June – September, 2009

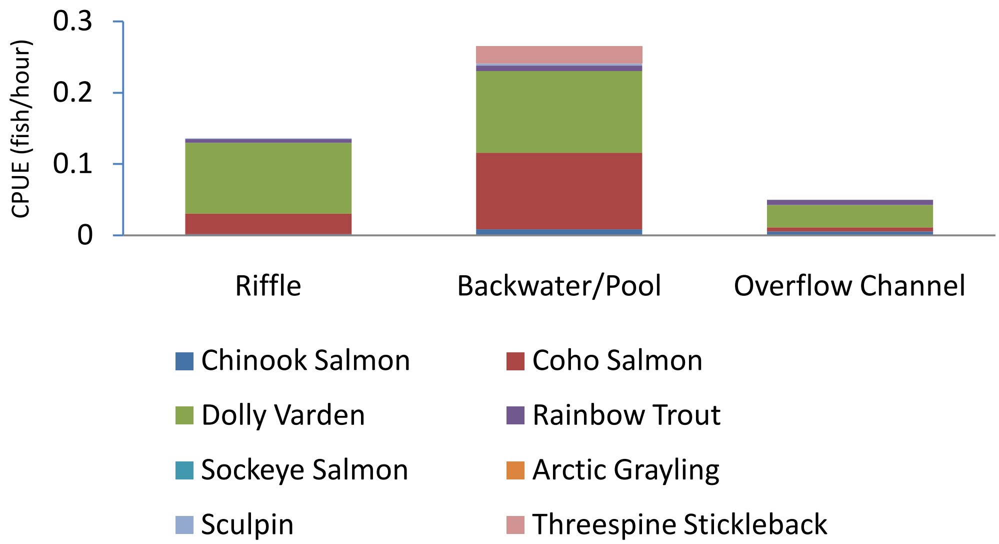


Figure 3.5.2-9 Reach 3, CPUE by habitat, June – September, 2009

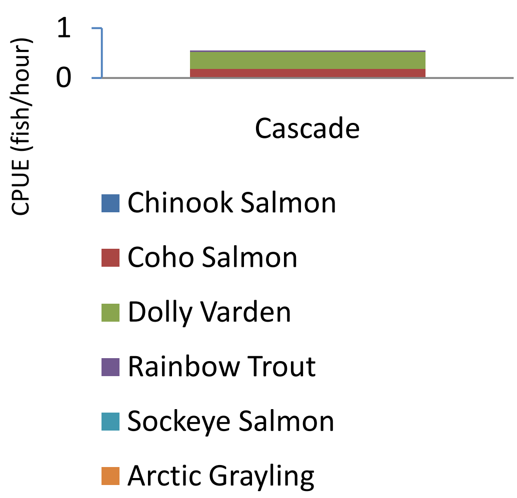


Figure 3.5.2-10 Reach 5, CPUE by habitat, June – September, 2009

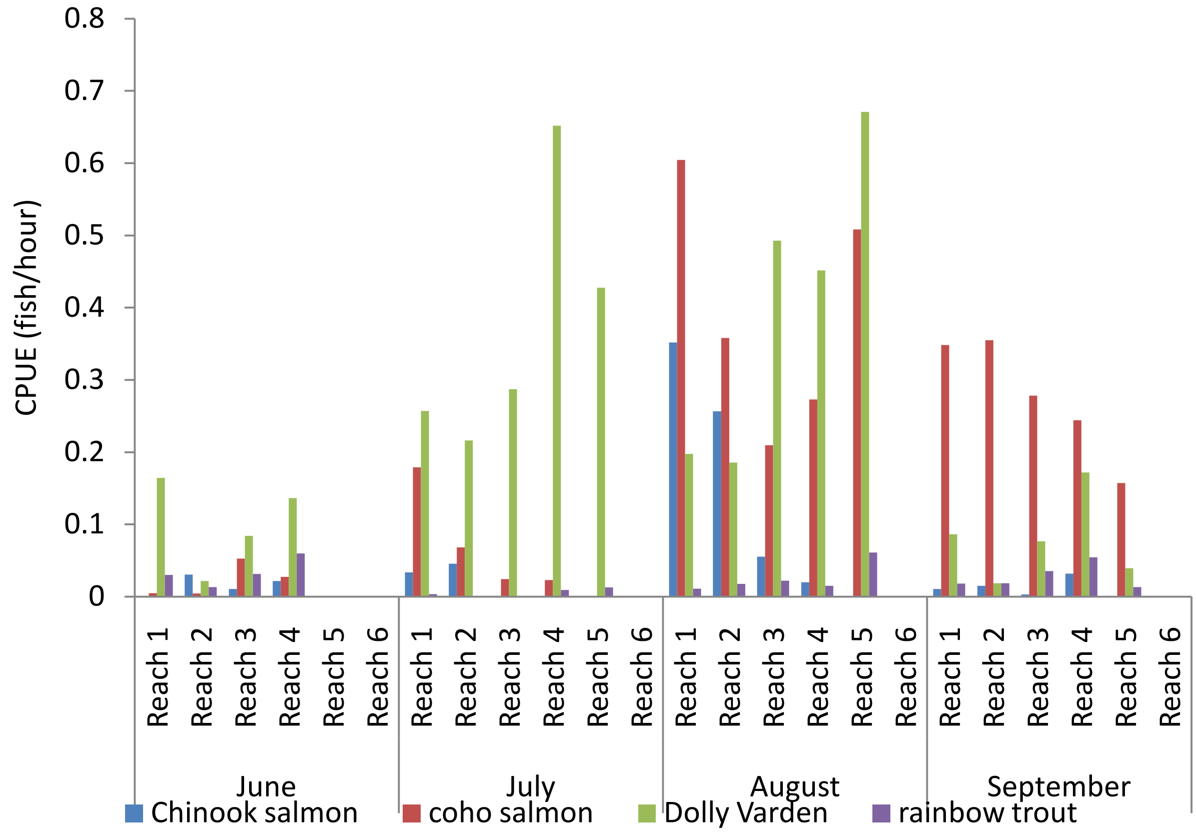


Figure 3.5.2-11 CPUE by reach and species from minnow trapping for selected species, Grant Creek, June – September, 2009

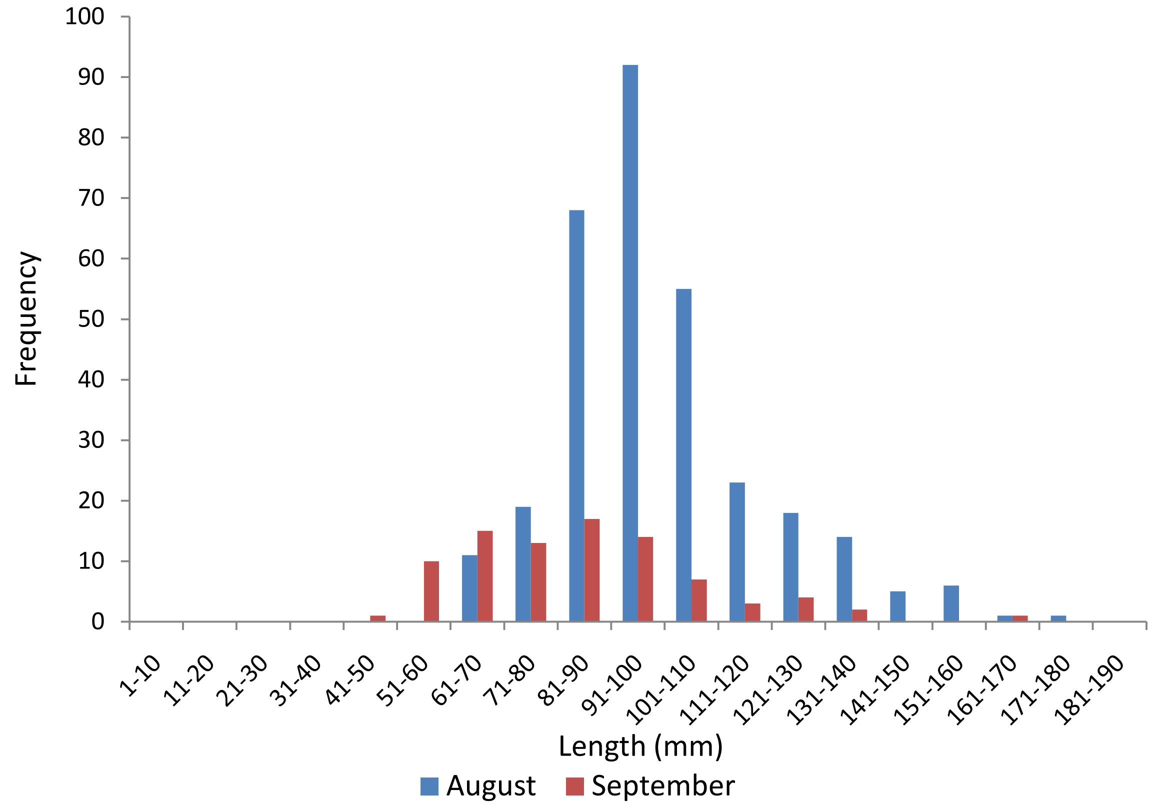


Figure 3.5.2-12 Length frequencies of Dolly Varden captured in minnow traps in Grant Creek in August and September, 2009

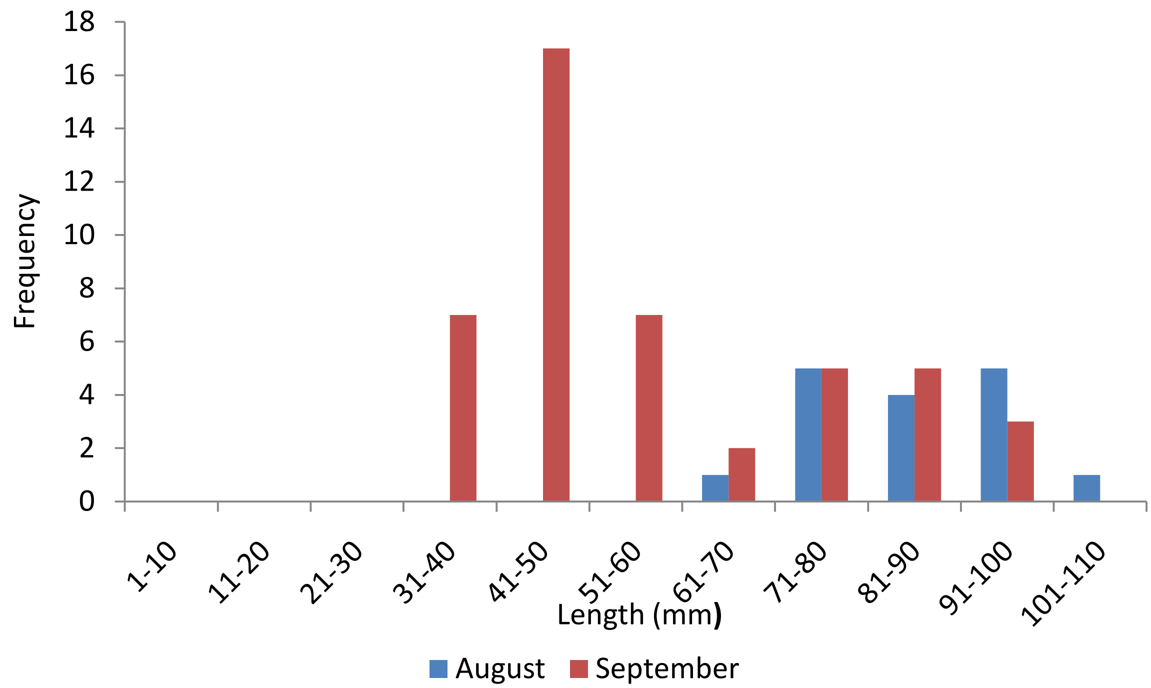


Figure 3.5.2-13 Length frequencies of rainbow trout captured in minnow traps in Grant Creek in August and September, 2009

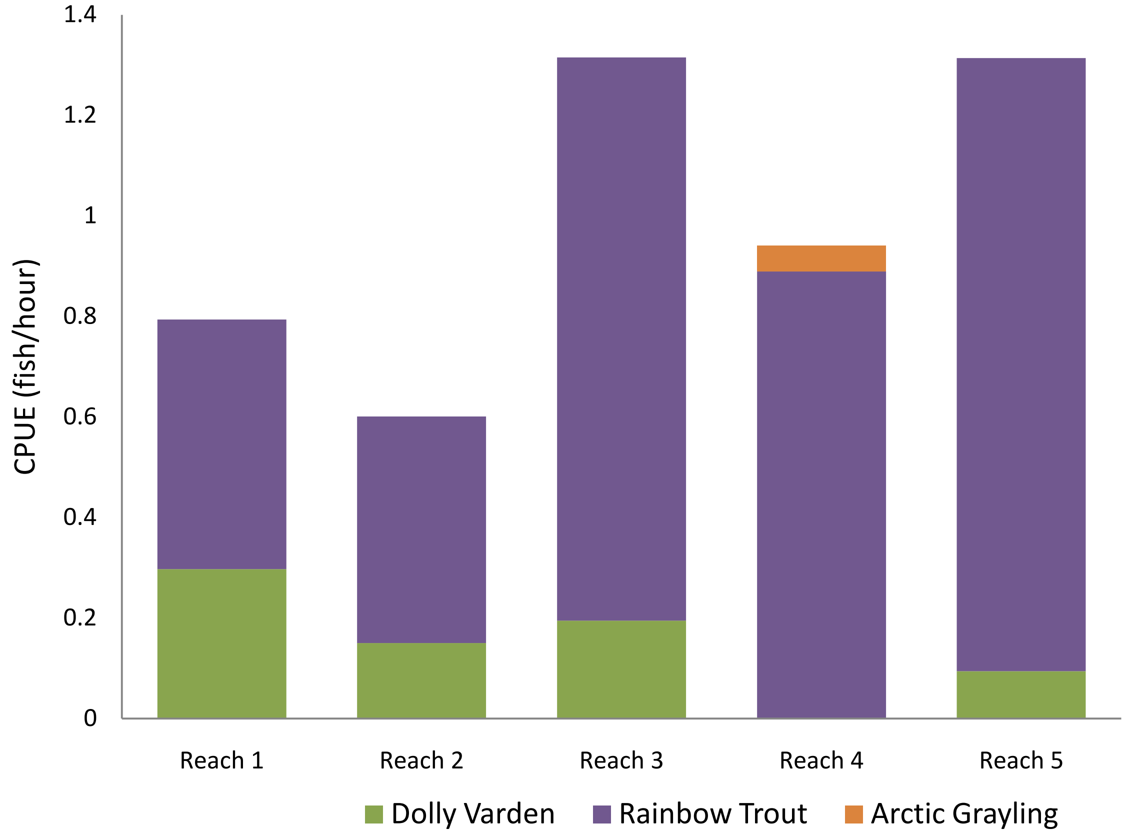
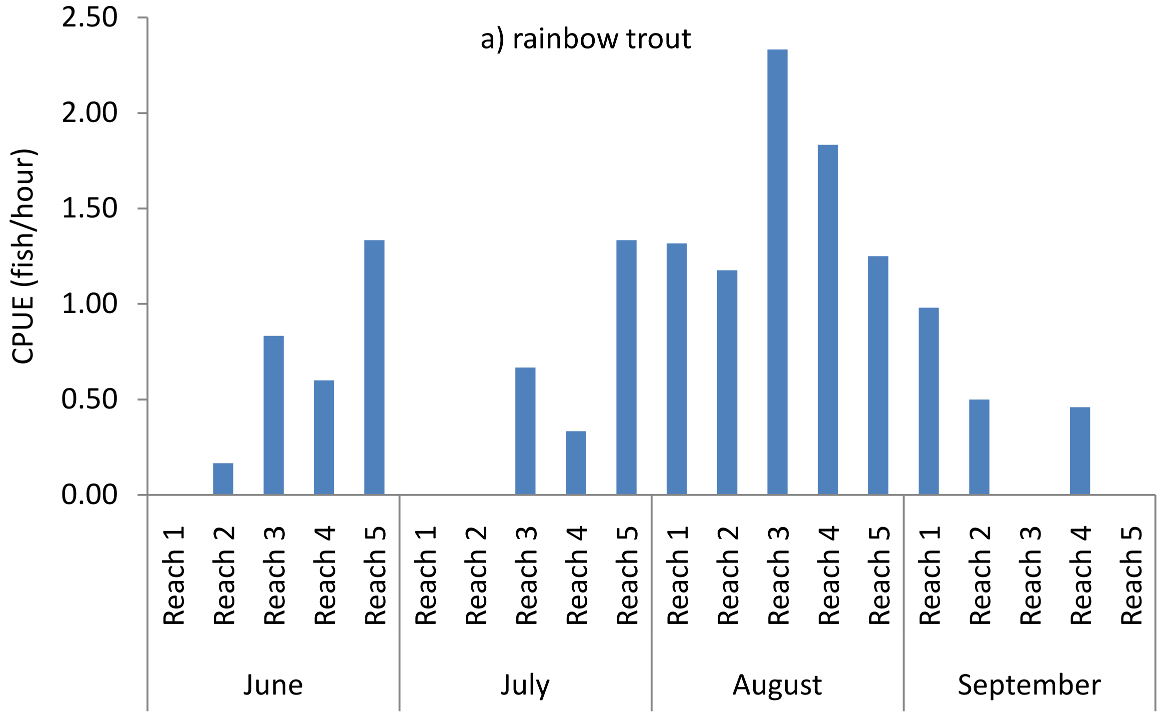


Figure 3.5.2-14 CPUE by reach and species from angling surveys in Grant Creek, June – August, 2009



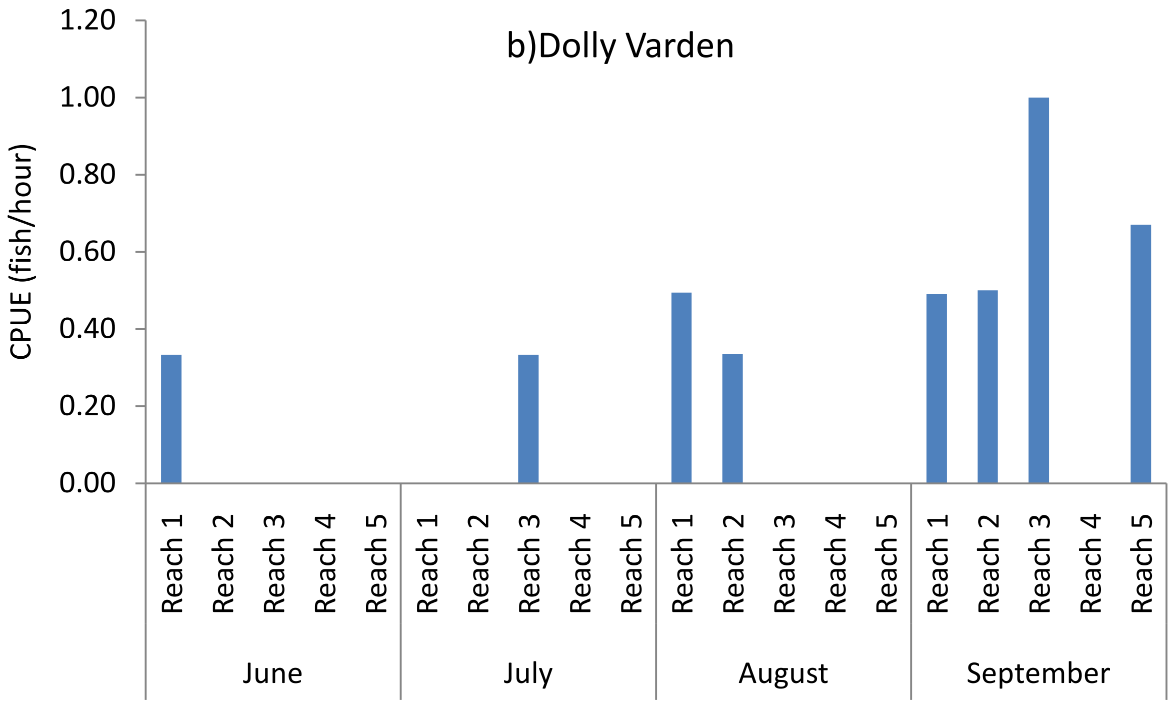


Figure 3.5.2-15 CPUE by month and reach for a) rainbow trout and b) Dolly Varden from angling surveys in Grant Creek, June – September, 2009

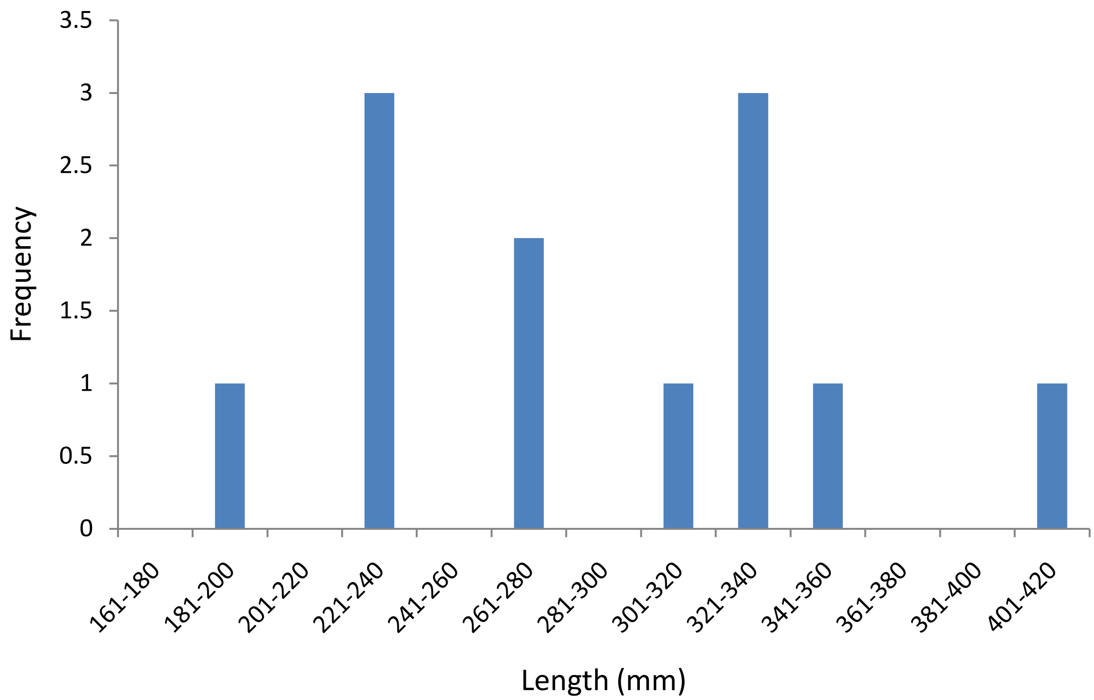


Figure 3.5.2-16 Length frequencies for rainbow trout angled on Grant Creek during June, 2009

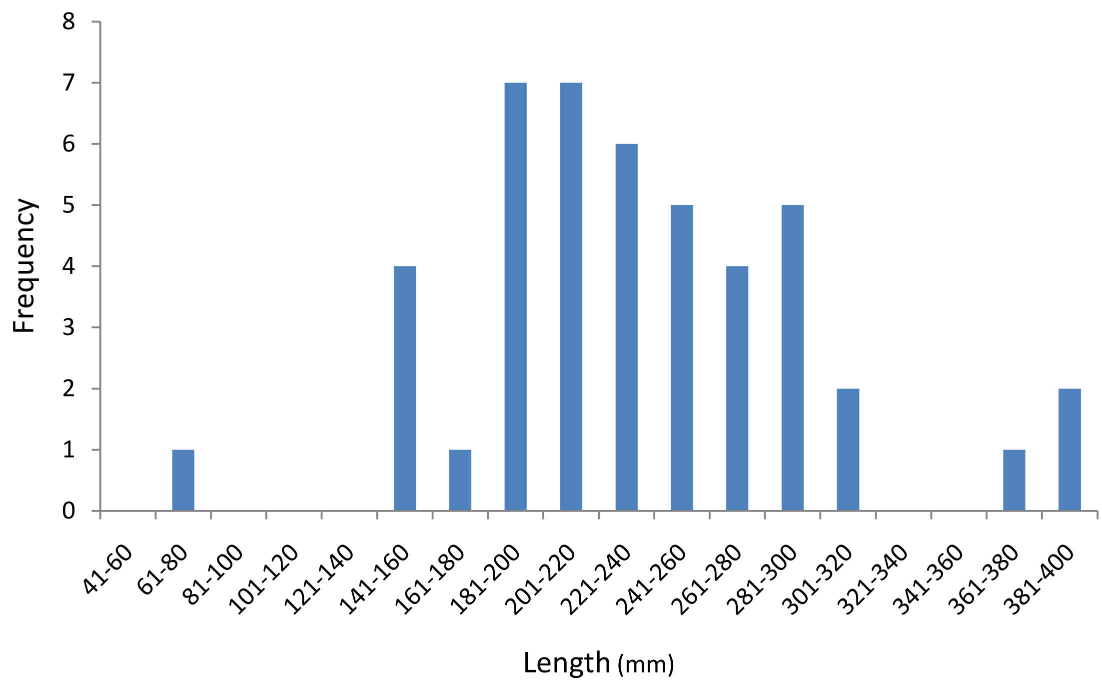


Figure 3.5.2-17 Length frequencies for rainbow trout angled on Grant Creek during August, 2009

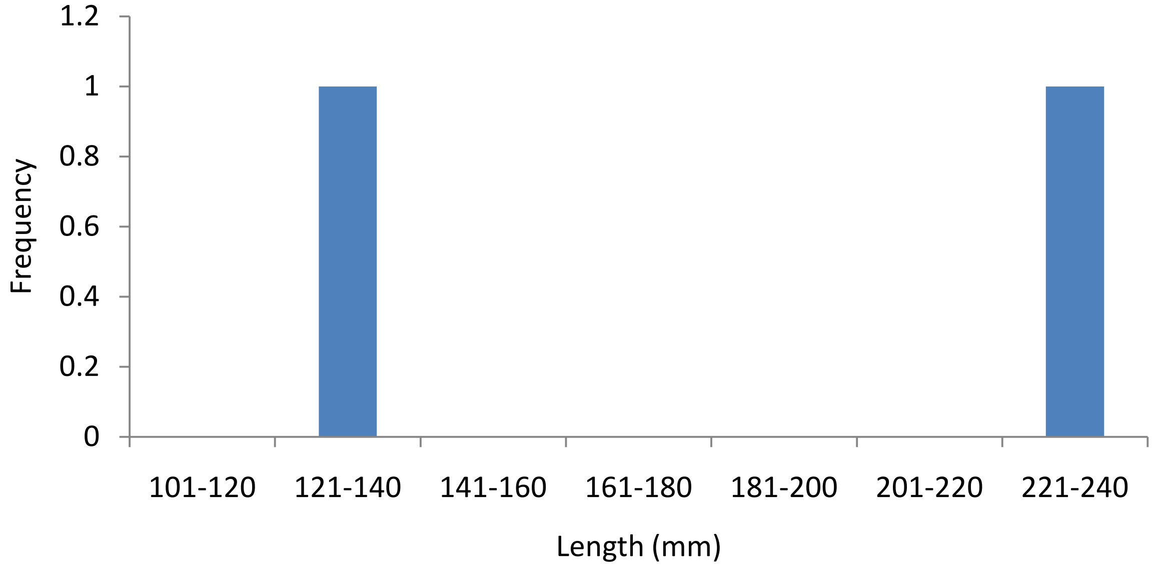


Figure 3.5.2-18 Length frequencies for Dolly Varden angled on Grant Creek during June, 2009

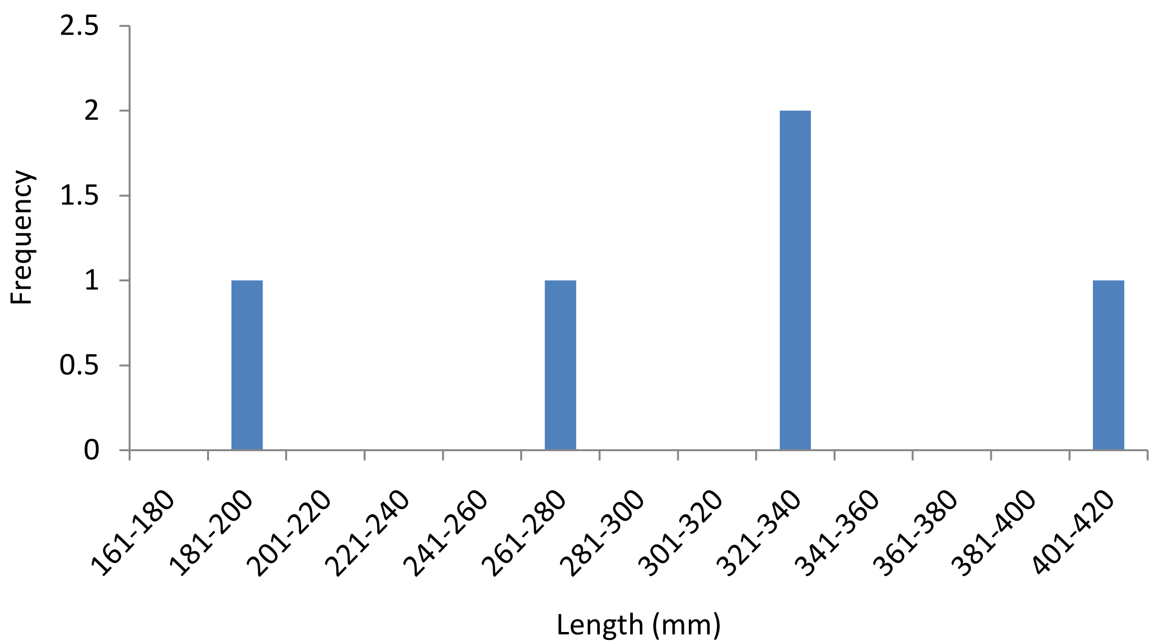


Figure 3.5.2-19 Length frequencies for Dolly Varden angled on Grant Creek during August, 2009

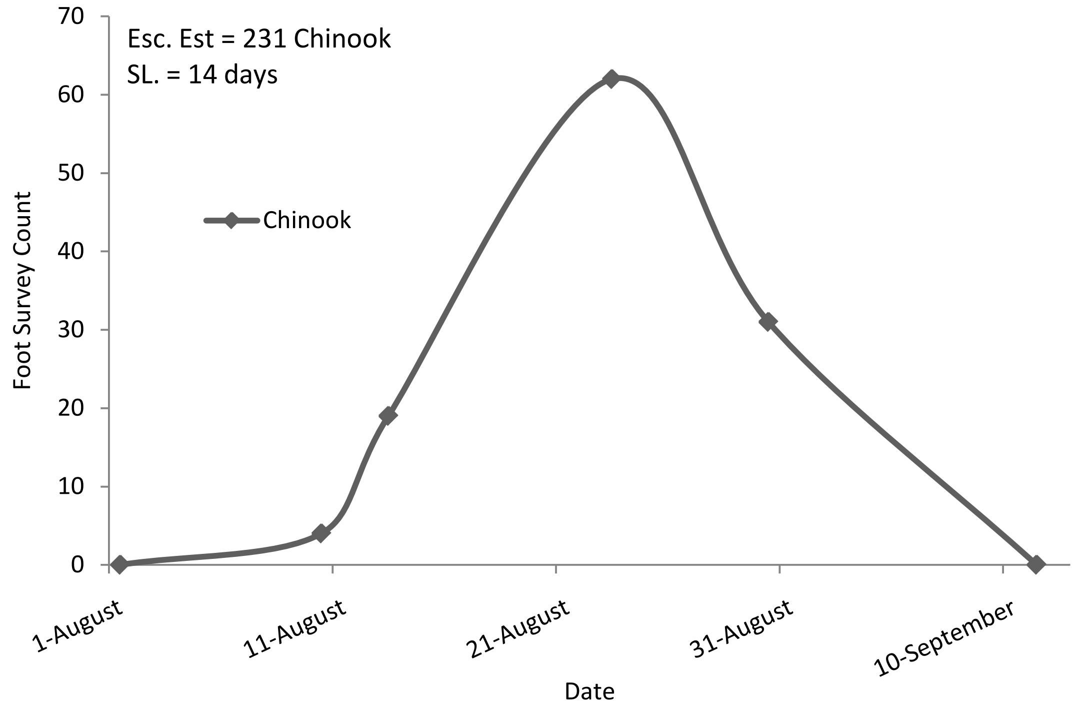


Figure 3.5.2-20 Foot survey counts and estimated escapement for Chinook salmon, June – October, 2009 on Grant Creek

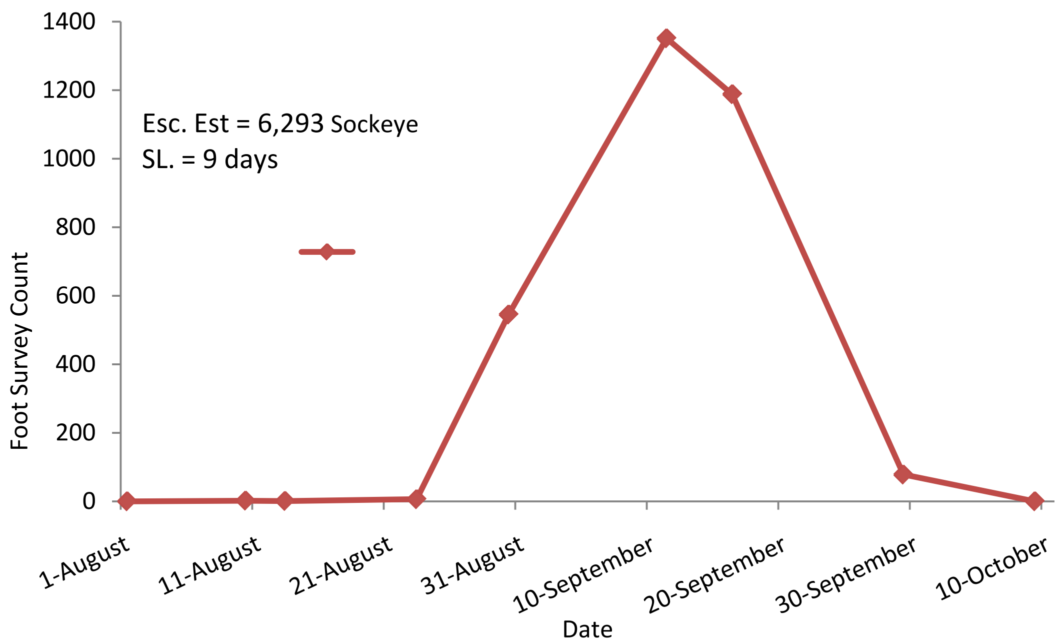


Figure 3.5.2-21 Foot survey counts and escapement estimates for sockeye salmon, June – October, 2009 on Grant Creek

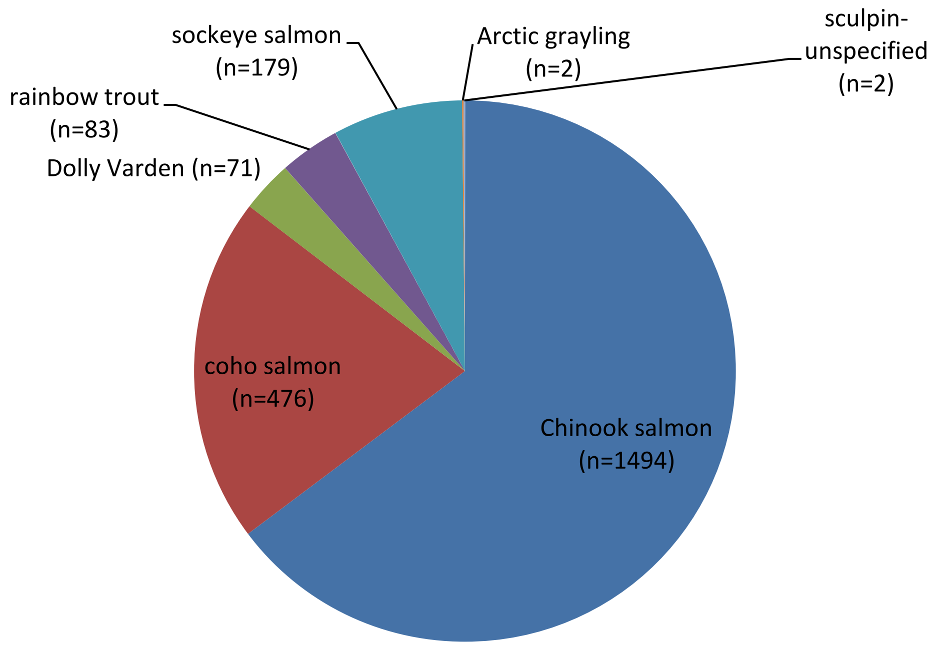


Figure 3.5.3-1 Composition and relative abundance of fish species observed, June, 2009

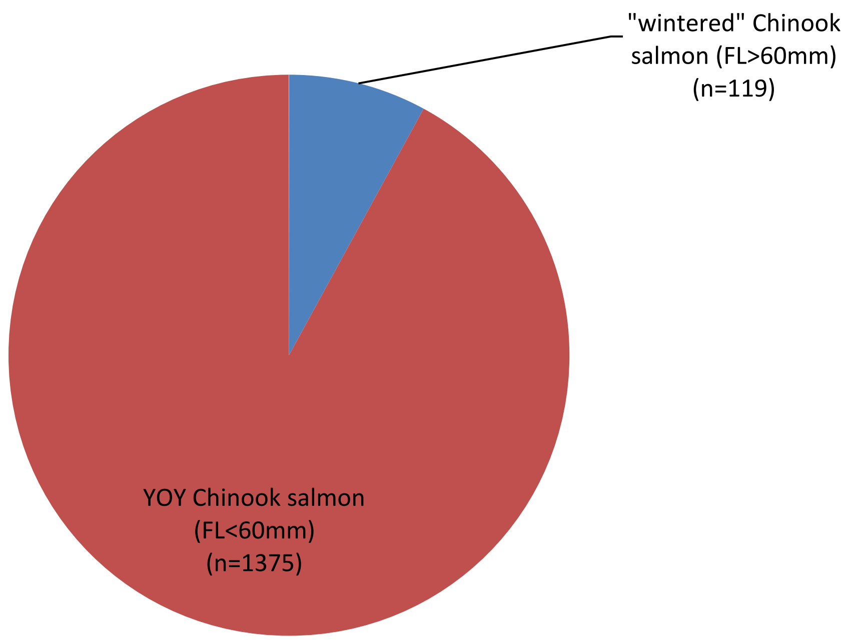


Figure 3.5.3-2 Juvenile Chinook salmon ages observed: June, 2009

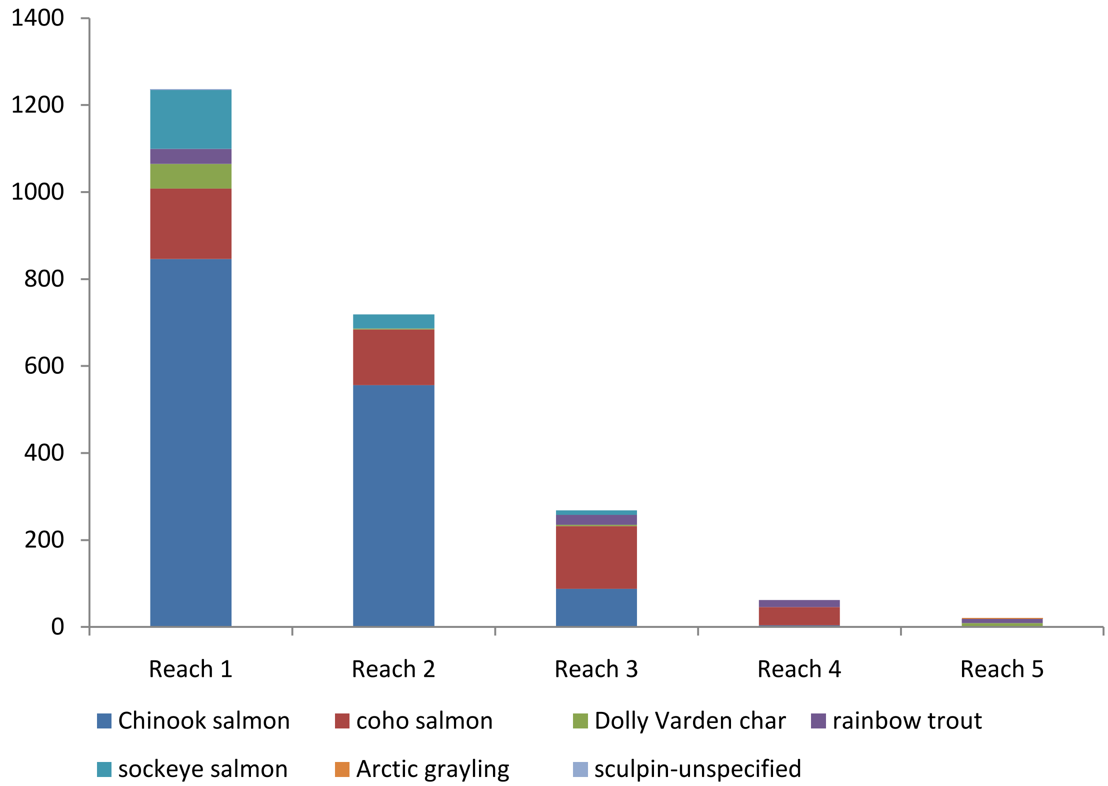


Figure 3.5.3-3 Relative abundance of fish species observed by reach, June, 200

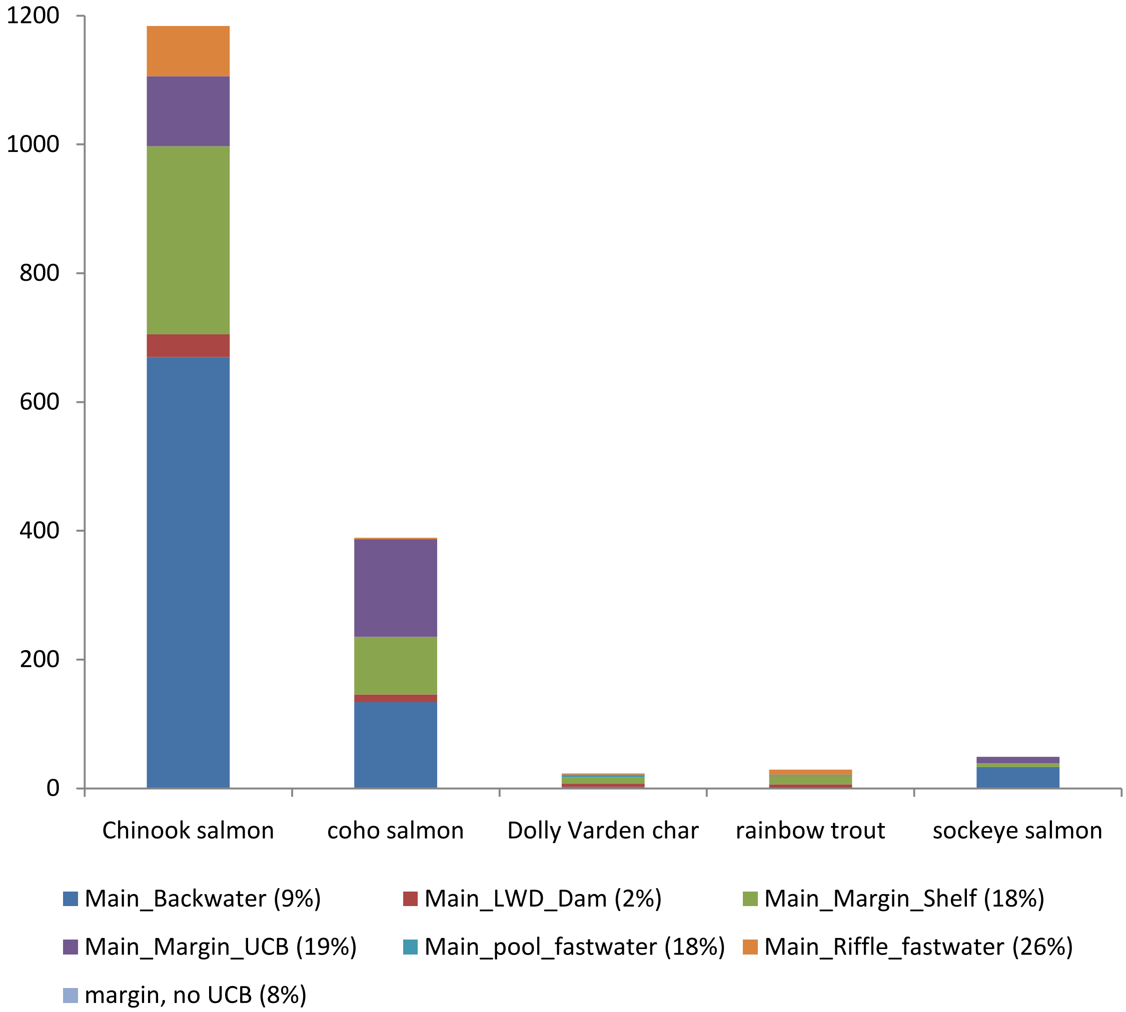


Figure 3.5.3-4 Relative abundance rearing salmon and juvenile resident fish species observed in microhabitat units, June, 2009

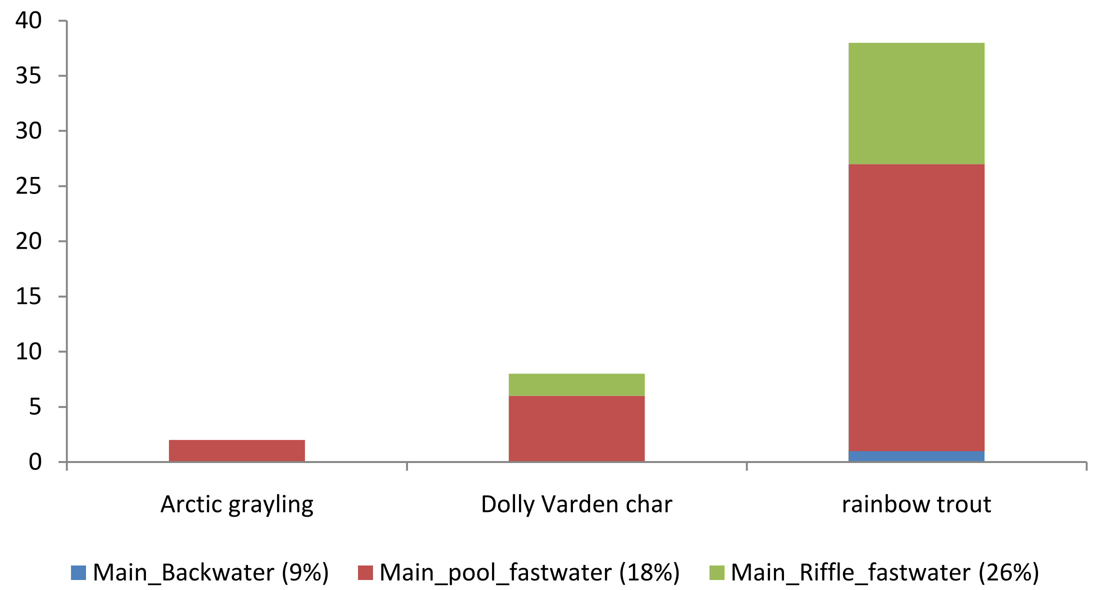


Figure 3.5.3-5 Relative abundance of resident fish (>200 mm) observed in microhabitat units, June, 2009

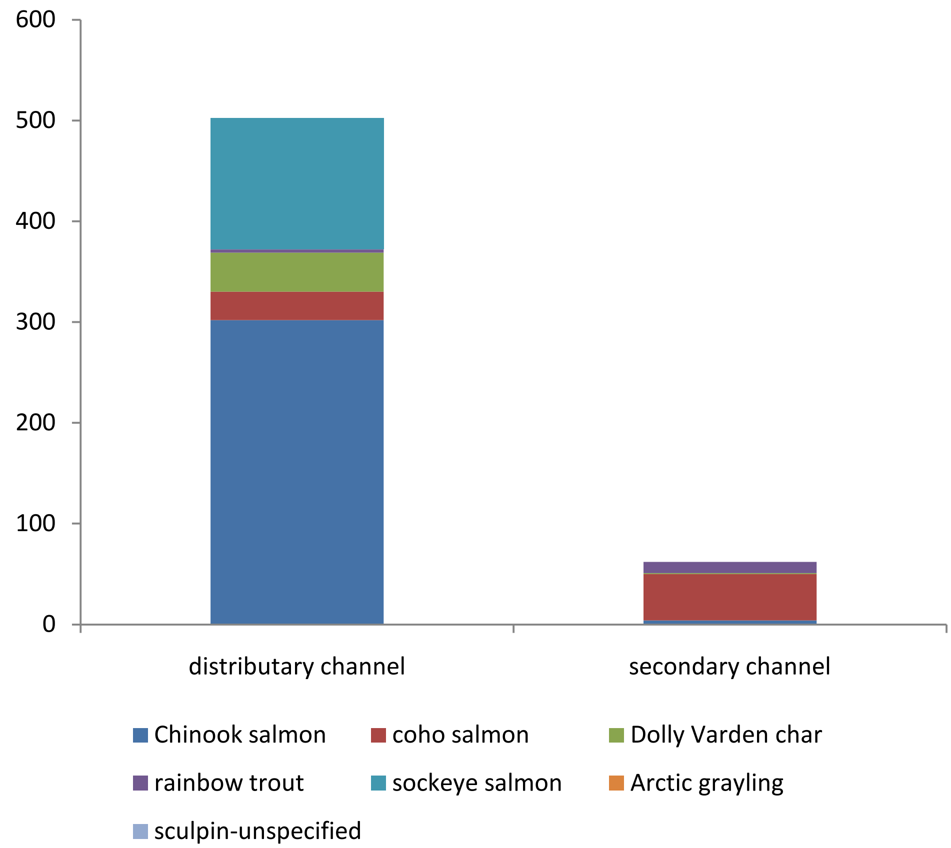


Figure 3.5.3-6 Relative abundance of rearing and resident fish observed in the distributary channel (Reach 1) and secondary channel (Reach 3), June, 2009

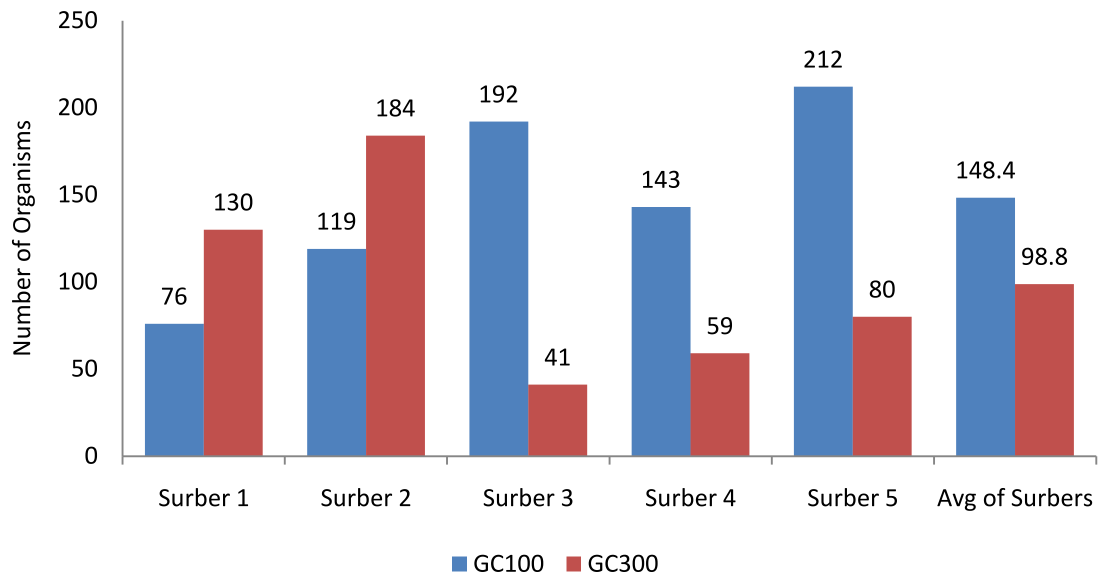


Figure 3.5.4-1 Population Densities at GC100 and GC300 from five pseudo-replicate macroinvertebrate surber samples (per 0.1 M^3), August 2009 – Grant Creek

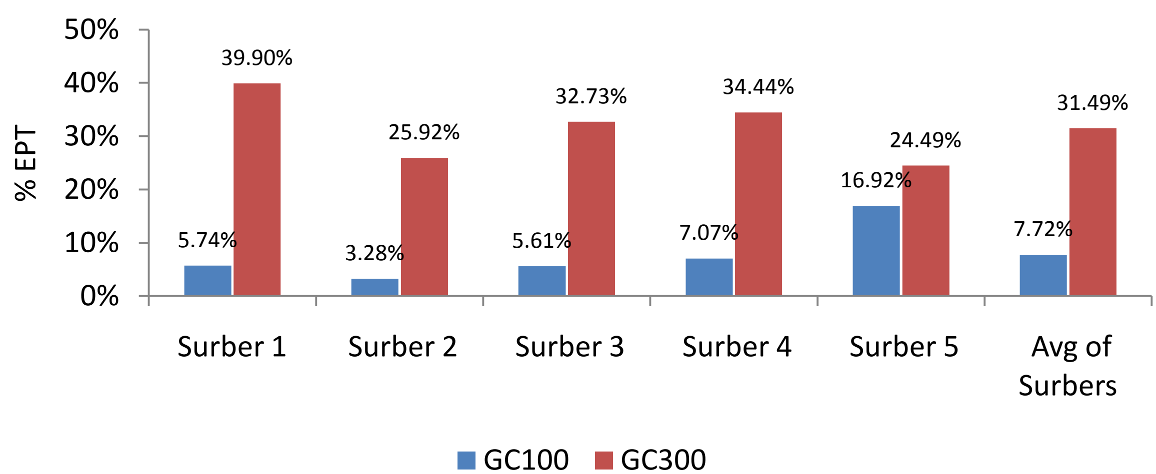


Figure 3.5.4-2 Percent EPT at GC100 and GC300 from five pseudo-replicate macroinvertebrate surber samples (per 0.1 M^3), August 2009 – Grant Creek

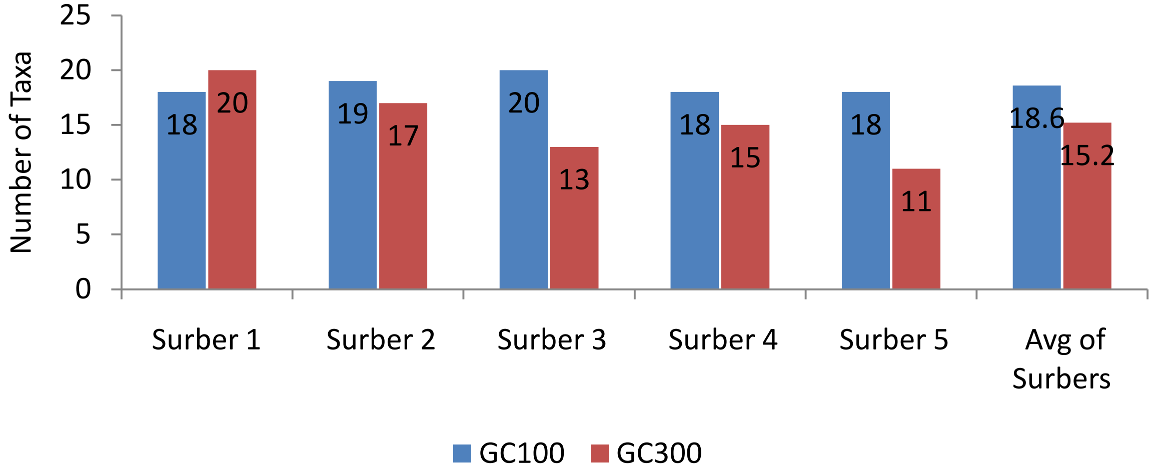


Figure 3.5.4-3 Taxa Diversity at GC100 and GC300 from five pseudo-replicate macroinvertebrate surber samples (per 0.1 M^3), August 2009 – Grant Creek

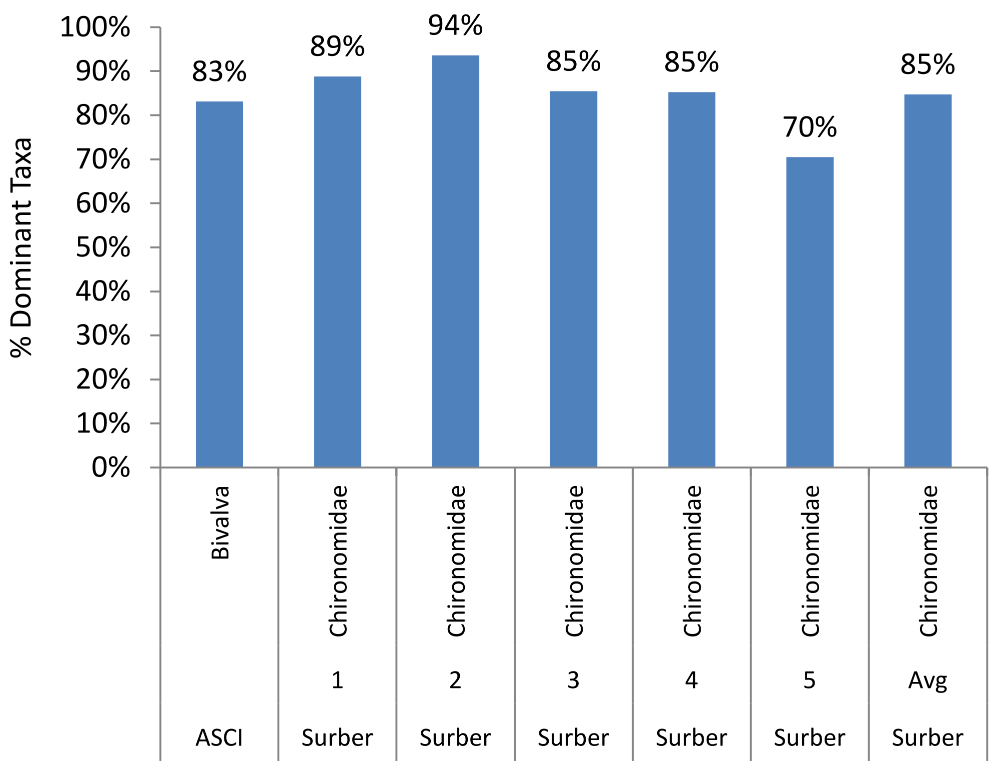


Figure 3.5.4-4 Percent Dominant Taxa in macroinvertebrate samples collected at GC100 on Grant Creek, using ASCI and five pseudo-replicate Surber samples, August 2009

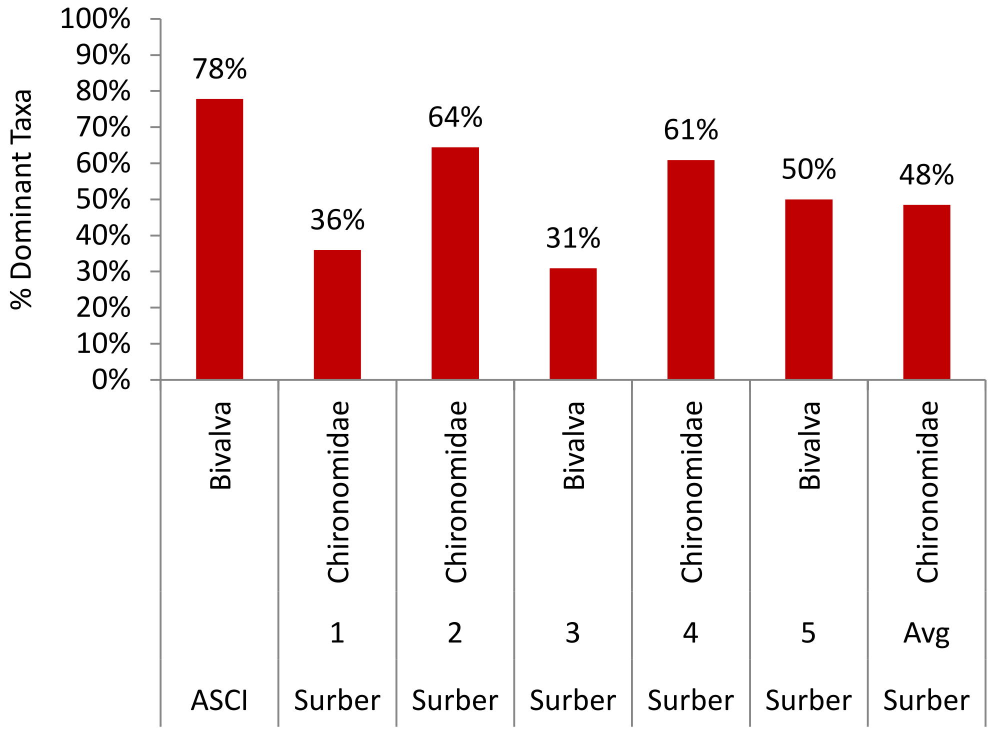


Figure 3.5.4-5 Percent Dominant Taxa in macroinvertebrate samples collected at GC300 on Grant Creek, using ASCI and five pseudo-replicate Surber samples, August 2009

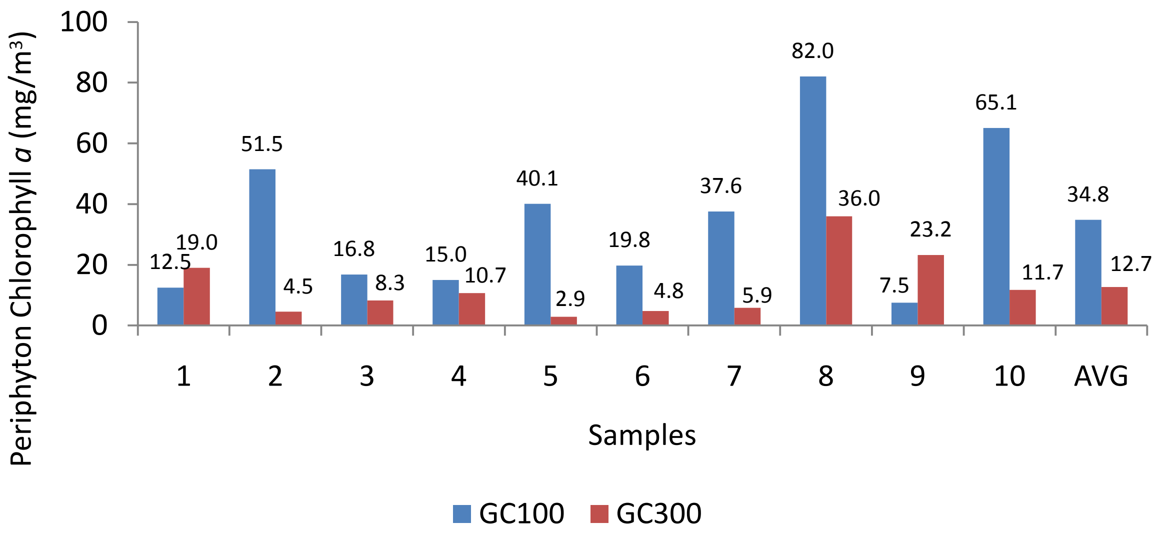


Figure 3.5.4-6 Periphyton Chlorophyll *a* concentrations (mg/m^3) at GC100 and GC300 from ten pseudo-replicate samples, August 2009 – Grant Creek

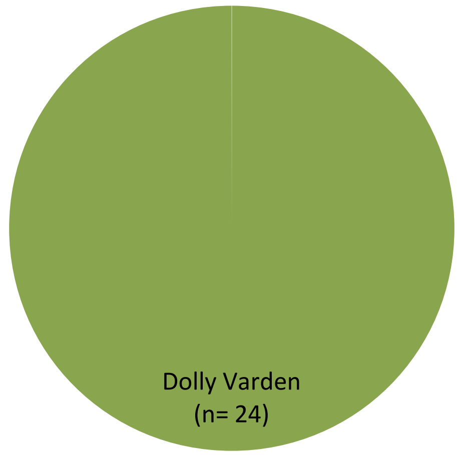


Figure 3.5.5-1 Total catch minnow trapping on Falls Creek, July, 2009

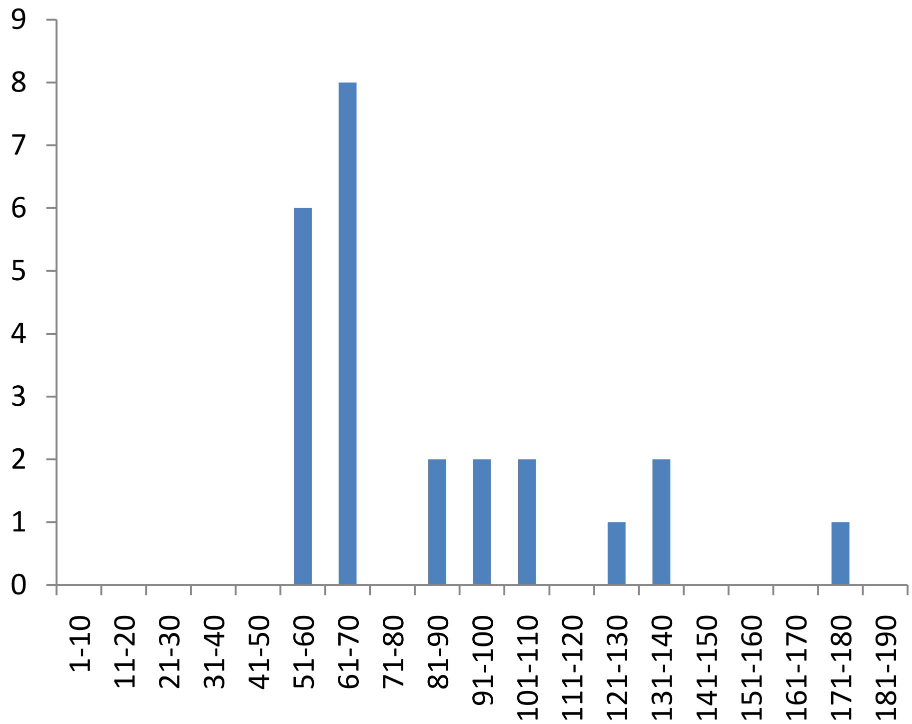


Figure 3.5.5-2 Length frequencies for Dolly Varden minnow trapped in Falls Creek, July, 2009

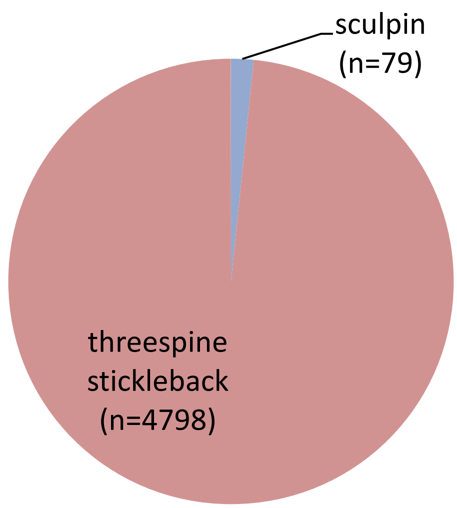


Figure 3.5.6-1 Total catch by minnow traps in Grant Lake, June and August, 2009

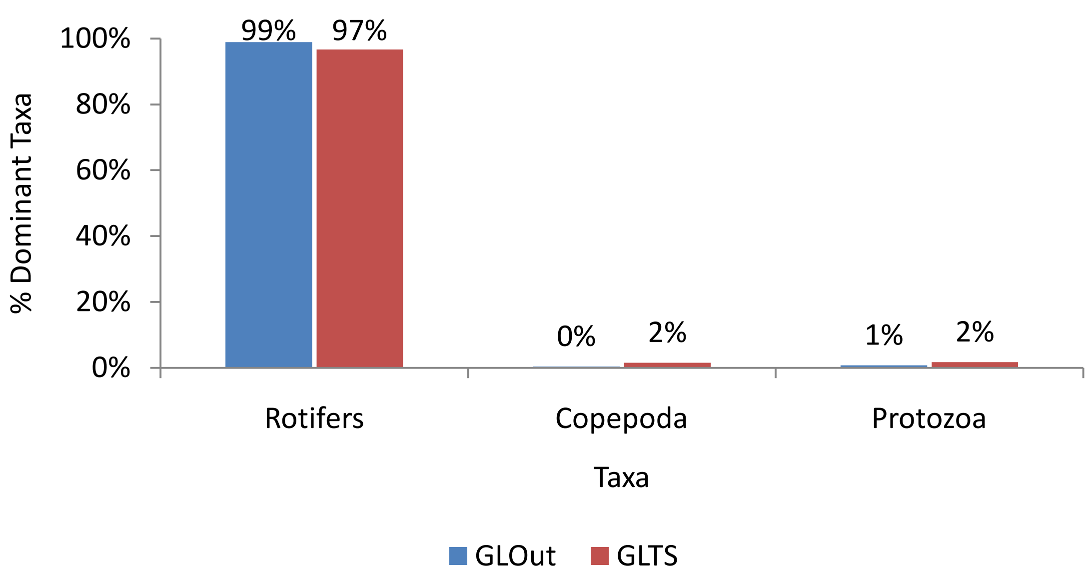


Figure 3.5.7-1 Percent Dominant Taxa in zooplankton samples at GLOut and GLTS, August 2009 – Grant Lake

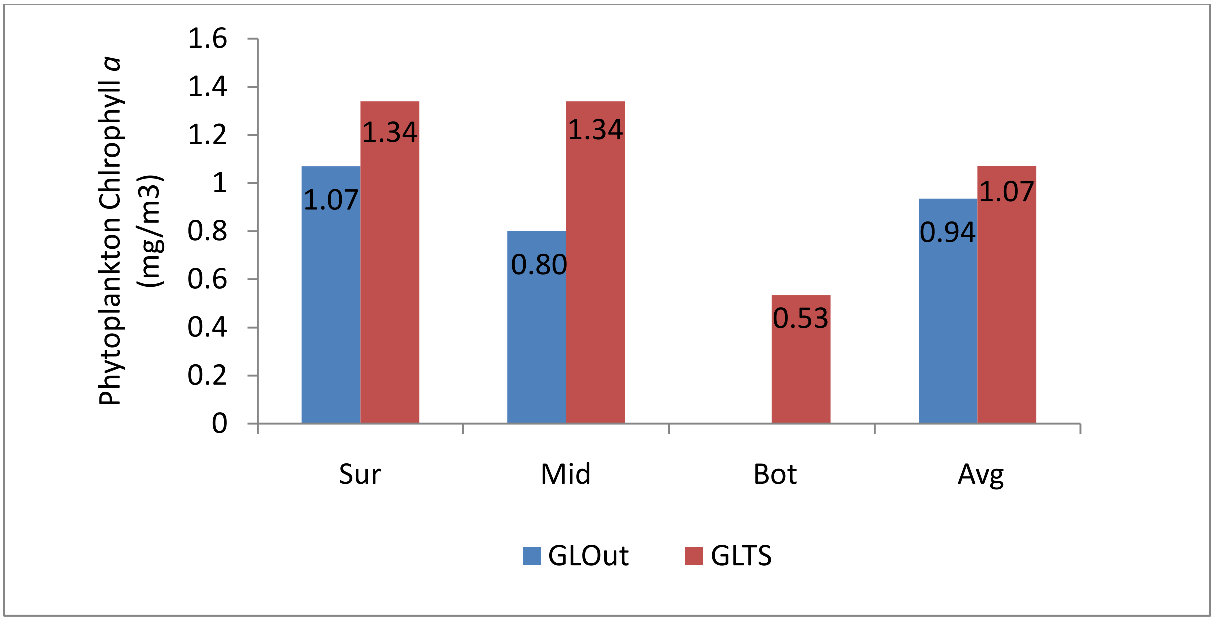


Figure 3.5.7-2 Chlorophyll *a* concentrations (mg/m^3) in phytoplankton samples at GLOut and GLTS, August 2009 – Grant Lake

Figure 4.2.1-1. Sites sampled and types of samples collected at Grant Lake in 1981 – 1982 (AEIDC 1983).

Numbers represent sampling sites; 1= variable mesh gill net sampling sites, 2= minnow trap sites, 3= plankton and water quality sampling sites, 4= benthos sampling sites.

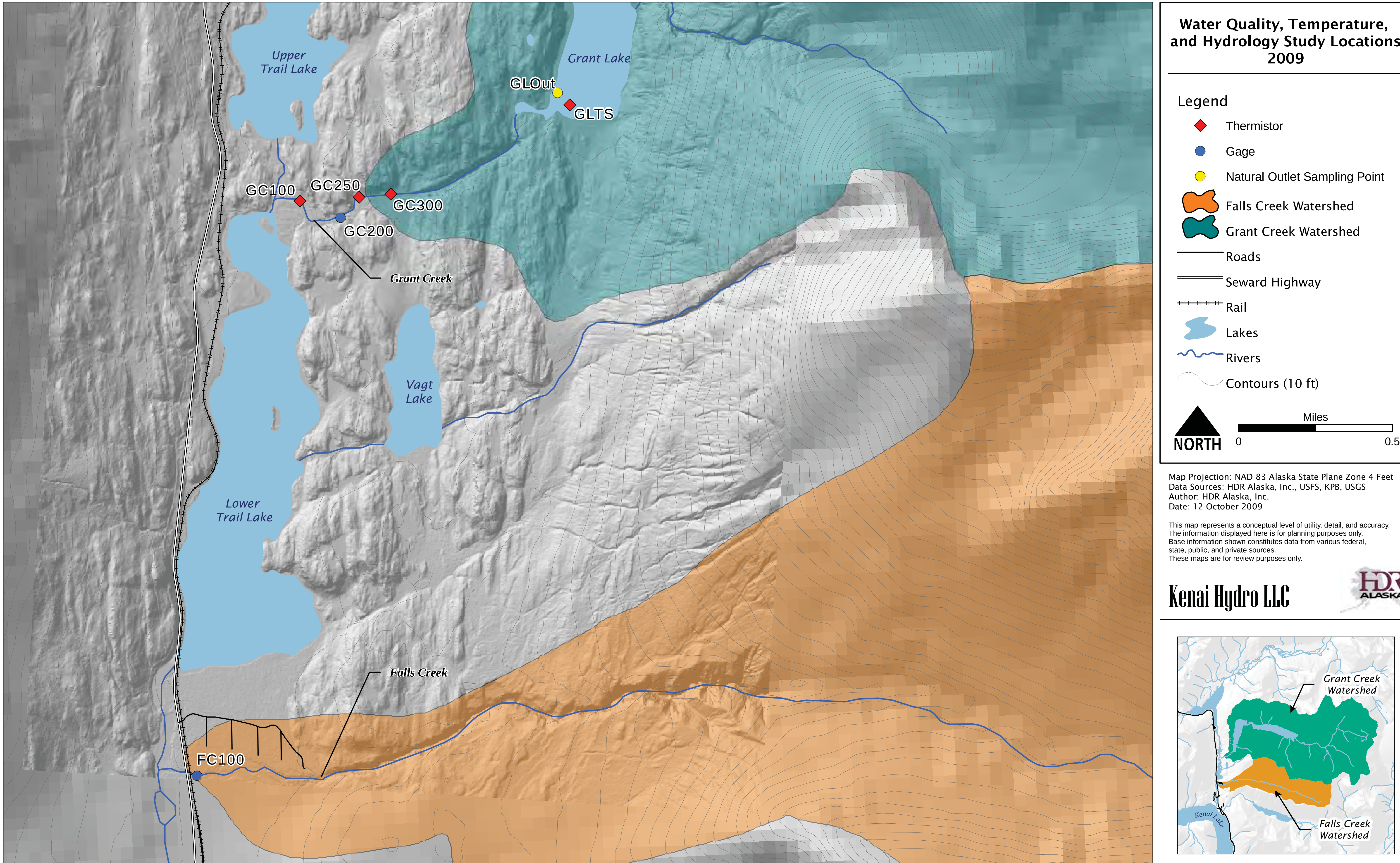

Upper Trail Lake
Grant Lake
GLOut
GLTS
GC100
GC250
GC300
GC200
Grant Creek
Vagt Lake
Lower Trail Lake
Falls Creek
FC100
Water Quality, Temperature, and Hydrology Study Locations 2009
Legend
Thermistor
Gage
Natural Outlet Sampling Point
Falls Creek Watershed
Grant Creek Watershed
Roads
Seward Highway
Rail
Lakes
Rivers
Contours (10 ft)
NORTH
Miles
0
0.5
Map Projection: NAD 83 Alaska State Plane Zone 4 Feet
Data Sources: HDR Alaska, Inc., USFS, KPB, USGS
Author: HDR Alaska, Inc.
Date: 12 October 2009
This map represents a conceptual level of utility, detail, and accuracy. The information displayed here is for planning purposes only. Base information shown constitutes data from various federal, state, public, and private sources. These maps are for review purposes only.
Kenai Hydro LLC
HDR ALASKA
Grant Creek Watershed
Kenai Lake
Falls Creek Watershed

Figure 4.4.2-1. Example staff gauge and data logger installation

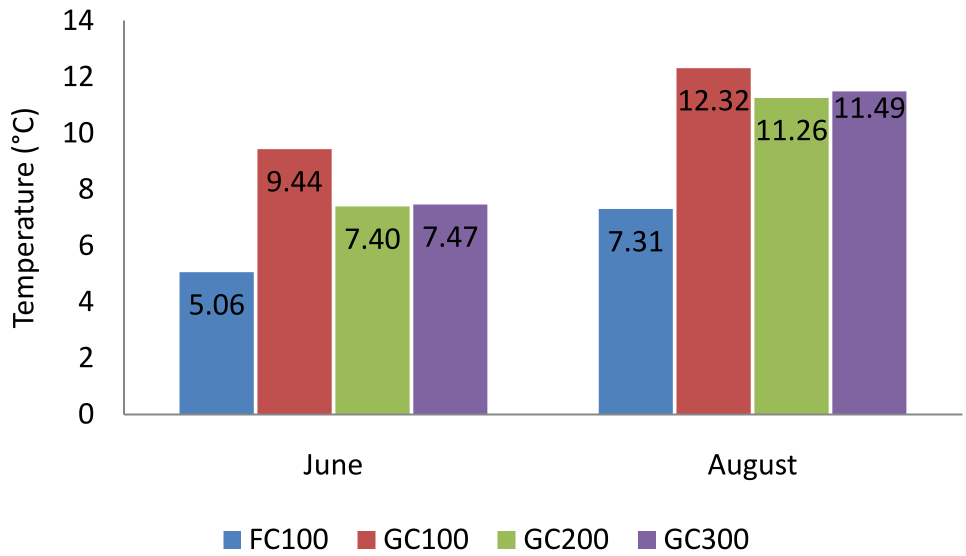


Figure 4.5.1-1. Temperature at Grant and Falls Creek during water quality sampling.

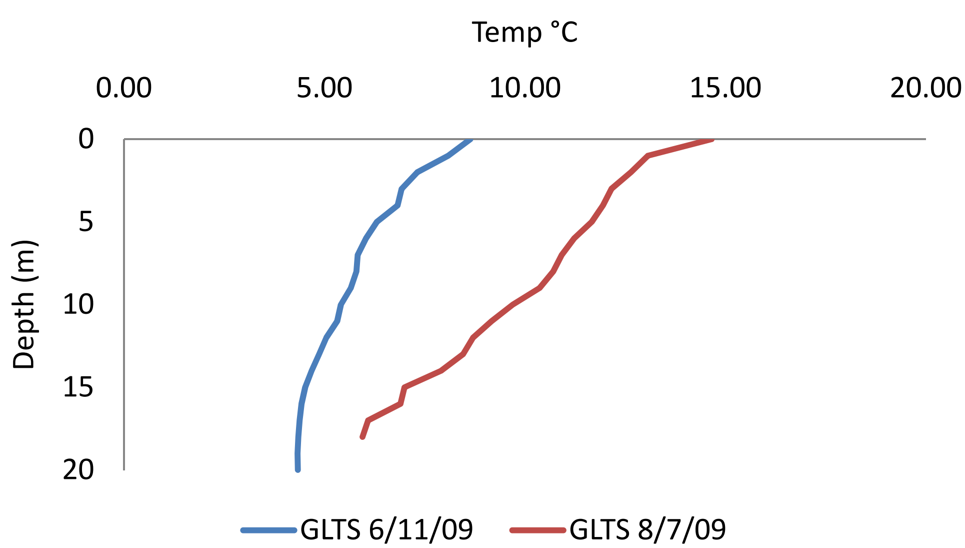


Figure 4.5.1-2. Temperature at Grant Lake Thermistor String location taken during water quality sampling.

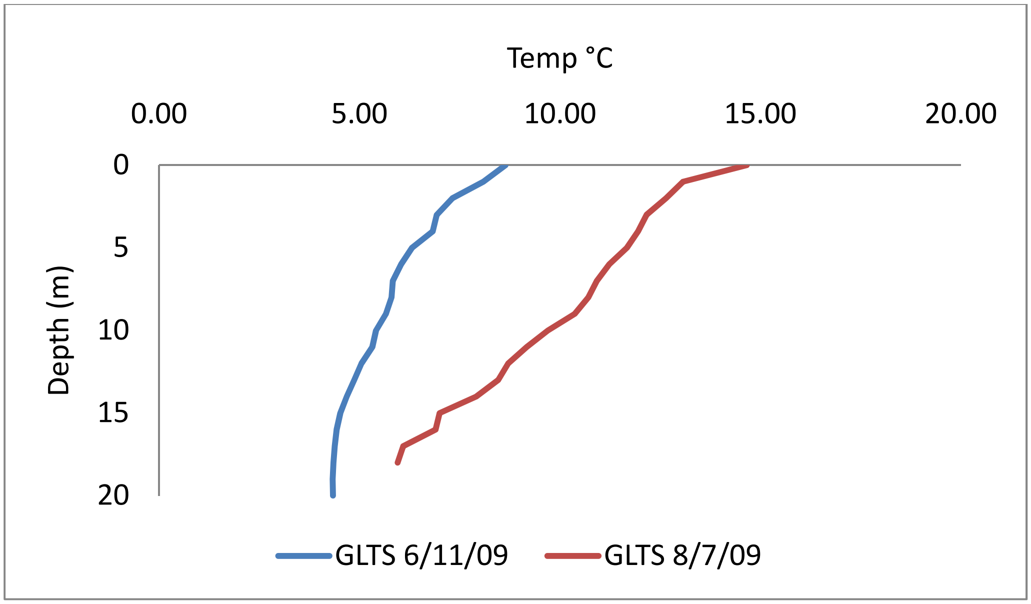


Figure 4.5.1-3. Temperature at Grant Lake Outlet location taken during water quality sampling.

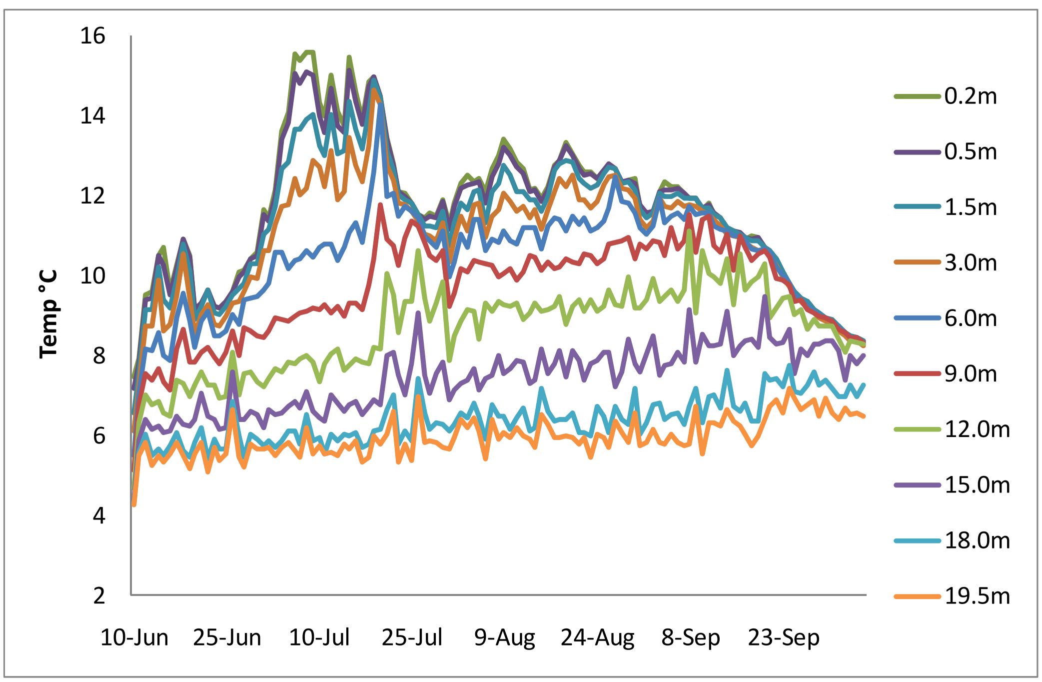


Figure 4.5.1-4. Continuous temperature for all depth intervals in Grant Lake as daily mean values.

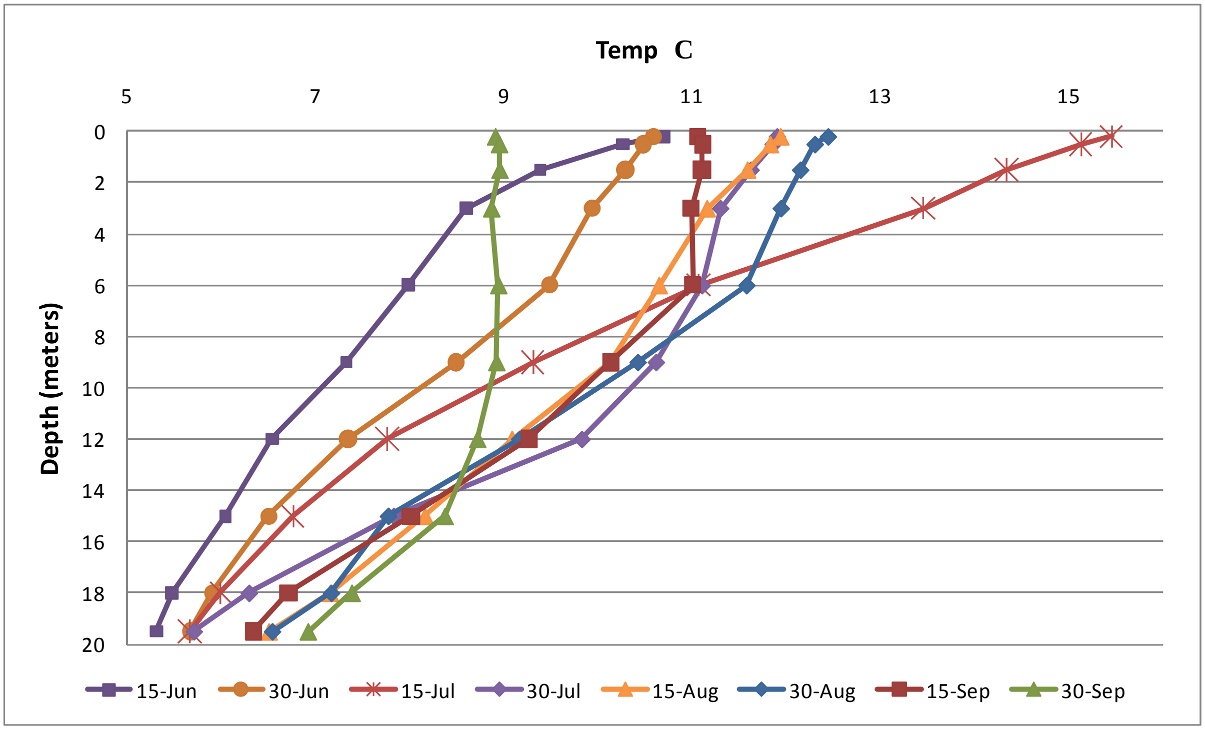


Figure 4.5.1-5. Continuous temperature in Grant Lake as daily mean values.

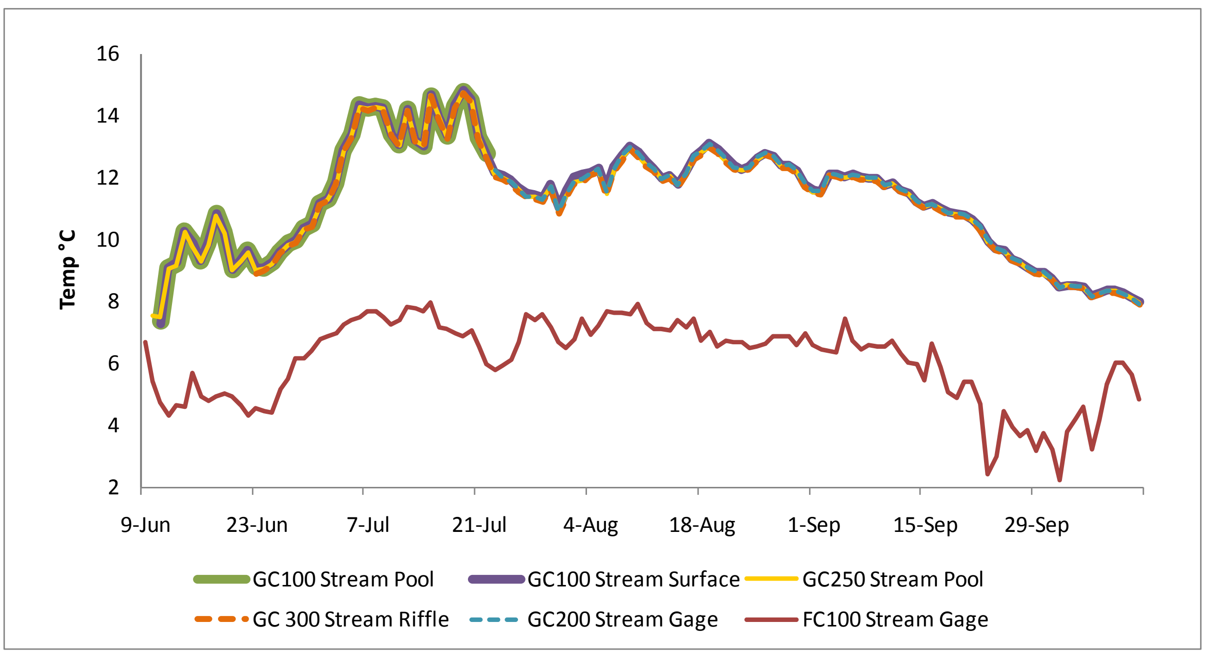


Figure 4.5.1-6. Continuous temperature at stream stations as daily mean values.

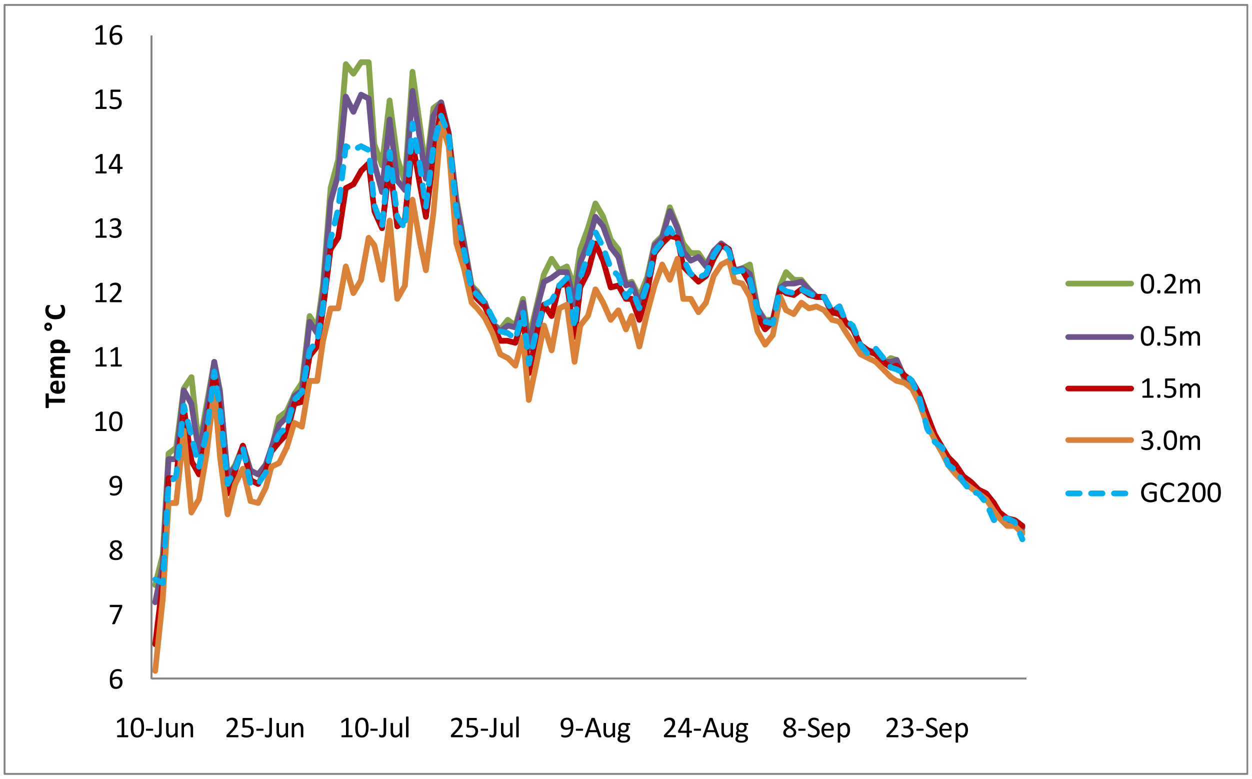


Figure 4.5.1-7. Continuous temperature at shallow depths in Grant Lake and Grant Creek stream gage as daily mean values.

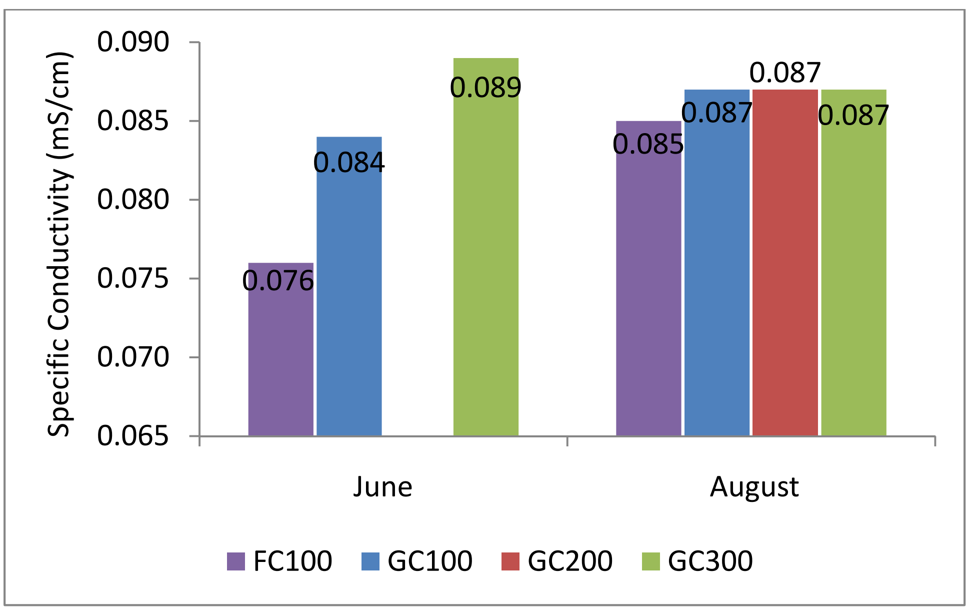


Figure 4.5.1-8. Specific Conductivity at stream sampling locations.

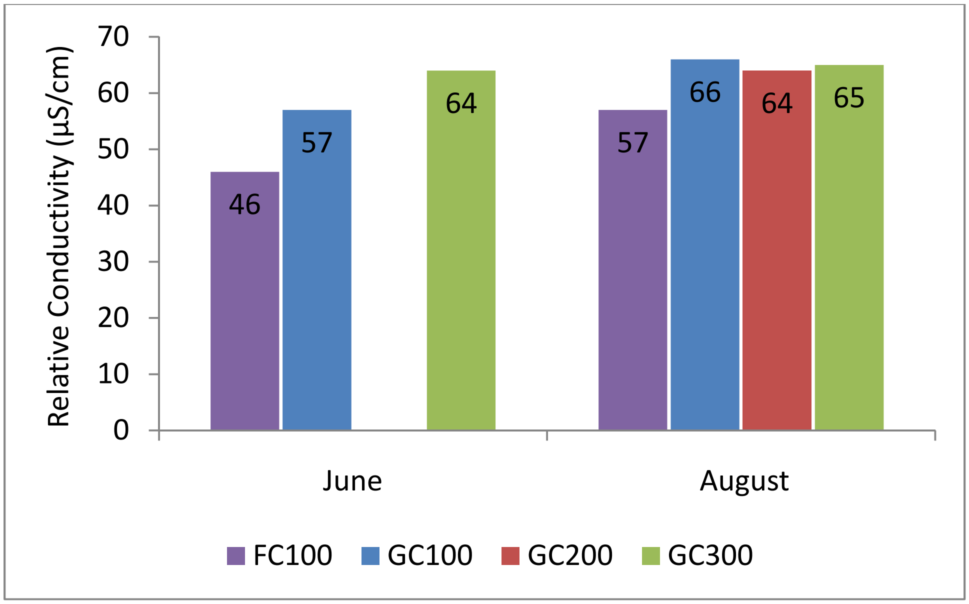


Figure 4.5.1-9. Relative Conductivity at stream sampling locations.

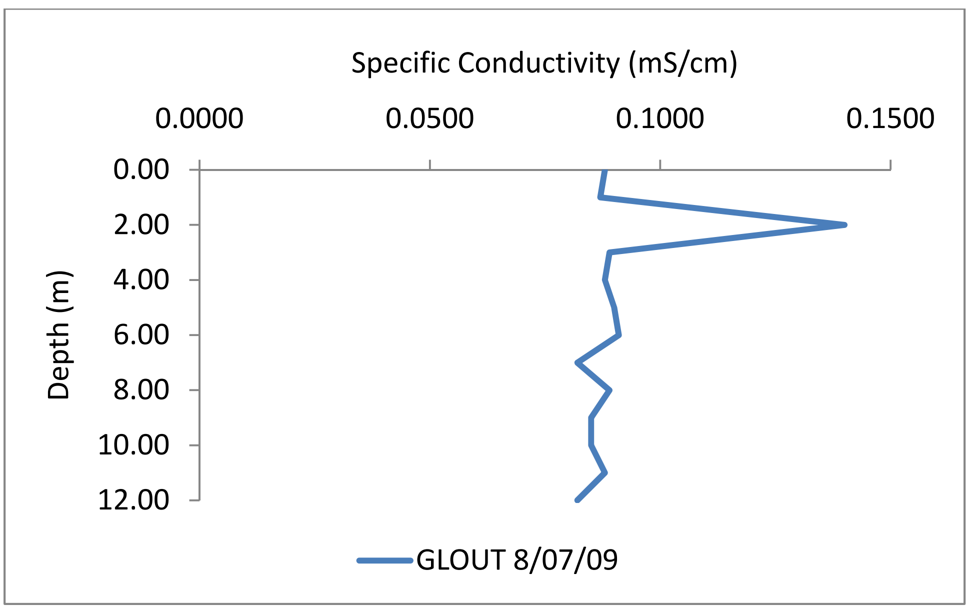


Figure 4.5.1-10. Specific Conductivity at Grant Lake Outlet.

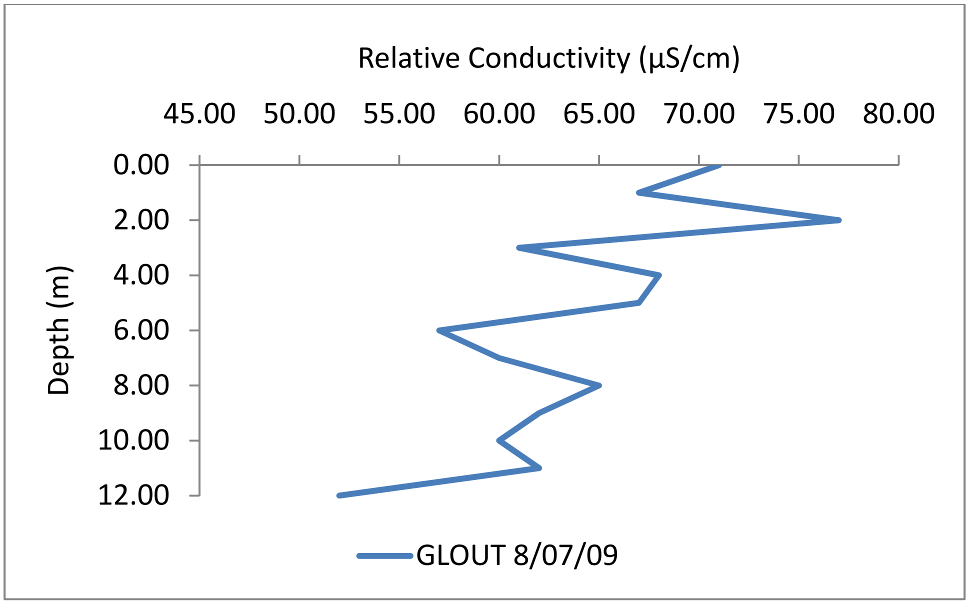


Figure 4.5.1-11. Relative Conductivity at Grant Lake Outlet.

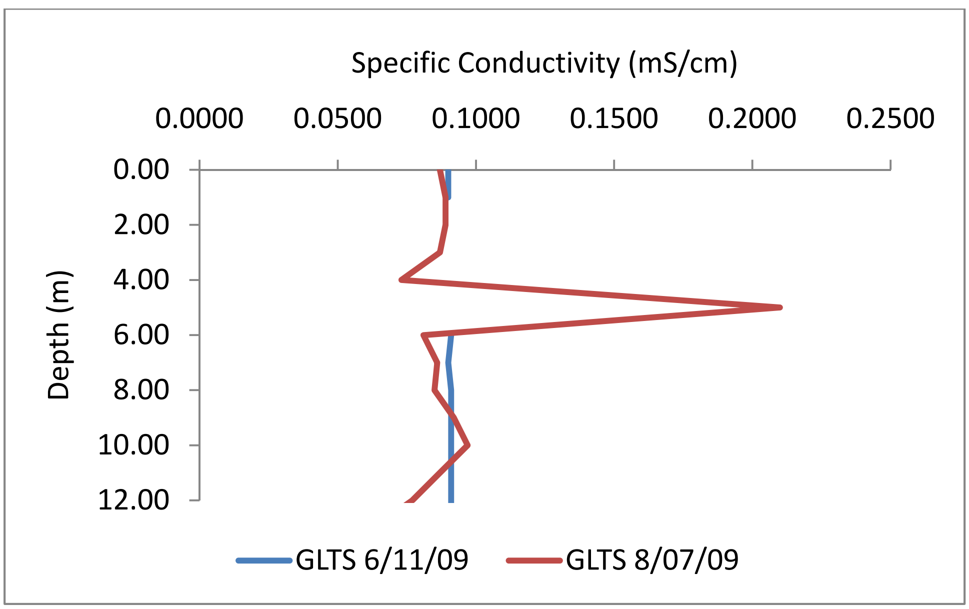


Figure 4.5.1-12. Specific Conductivity at Grant Lake Thermistor String Location.

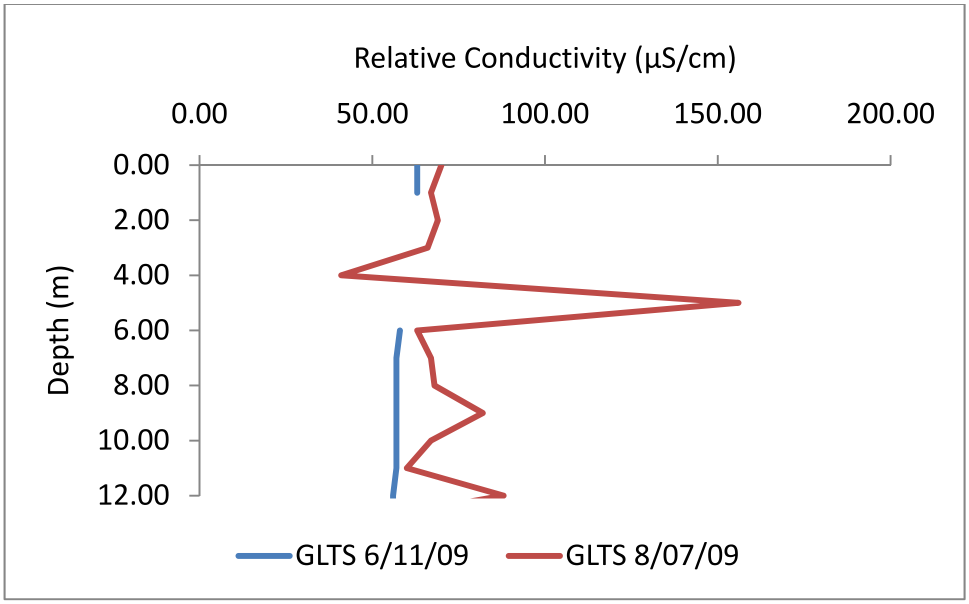


Figure 4.5.1-13. Relative Conductivity at Grant Lake Thermistor String Location.

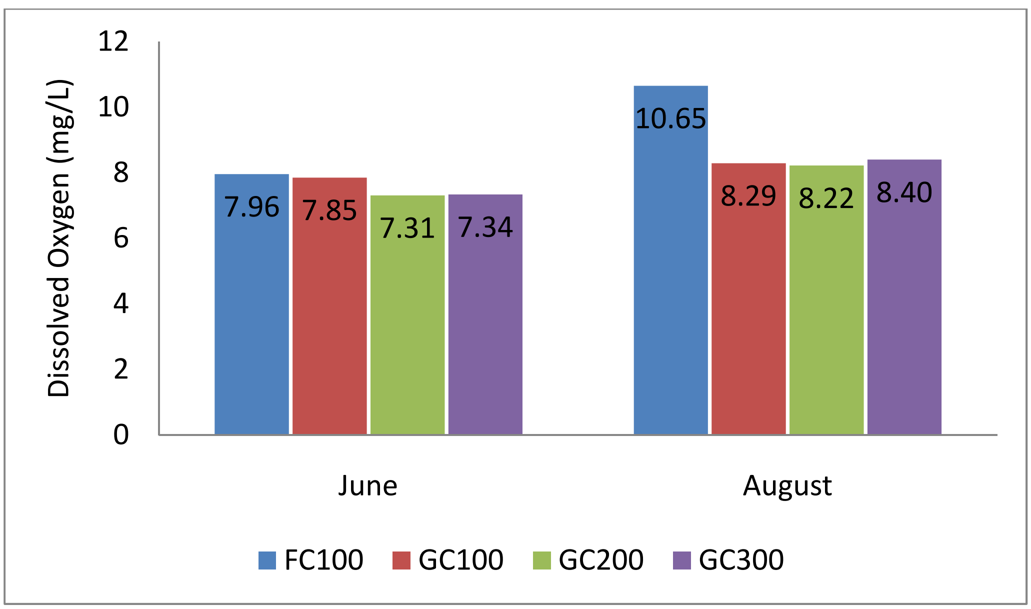


Figure 4.5.1-14. Dissolved Oxygen Concentration at Grant and Falls Creek.

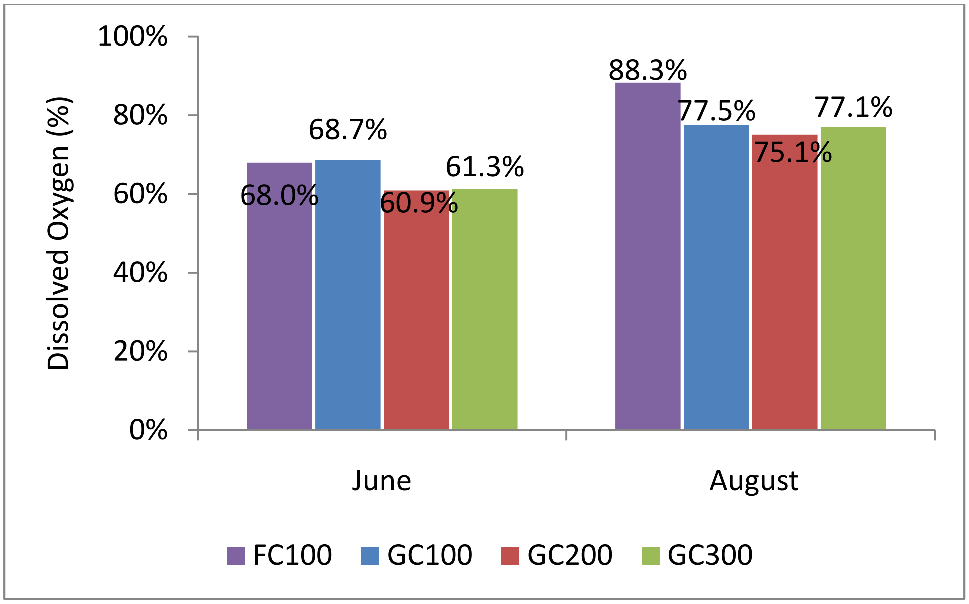


Figure 4.5.1-15. Dissolved Oxygen Saturation at Grant and Falls Creek.

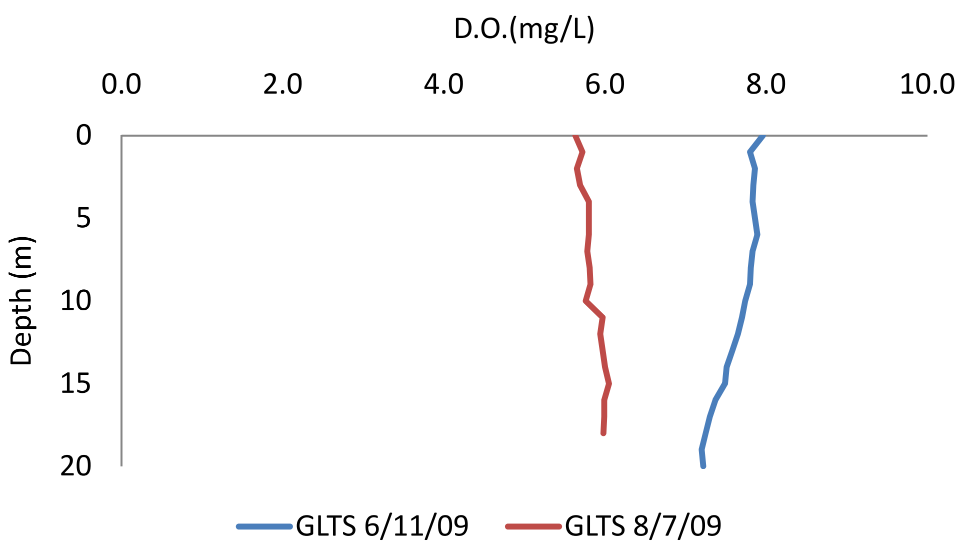


Figure 4.5.1-16. Dissolved Oxygen Concentration at Grant Lake Thermistor String Location.

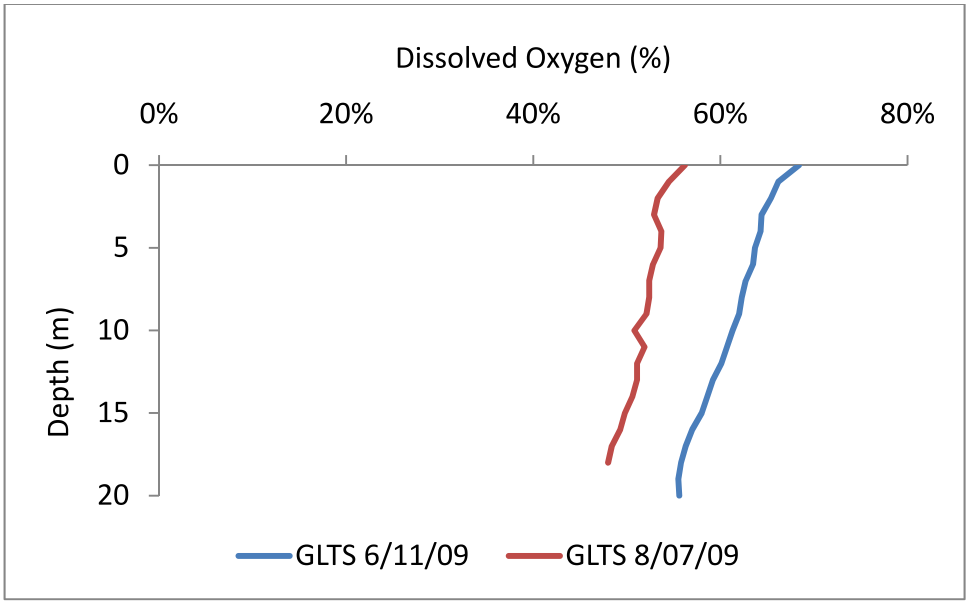


Figure 4.5.1-17. Dissolved Oxygen Saturation at Grant Lake Thermistor String Location

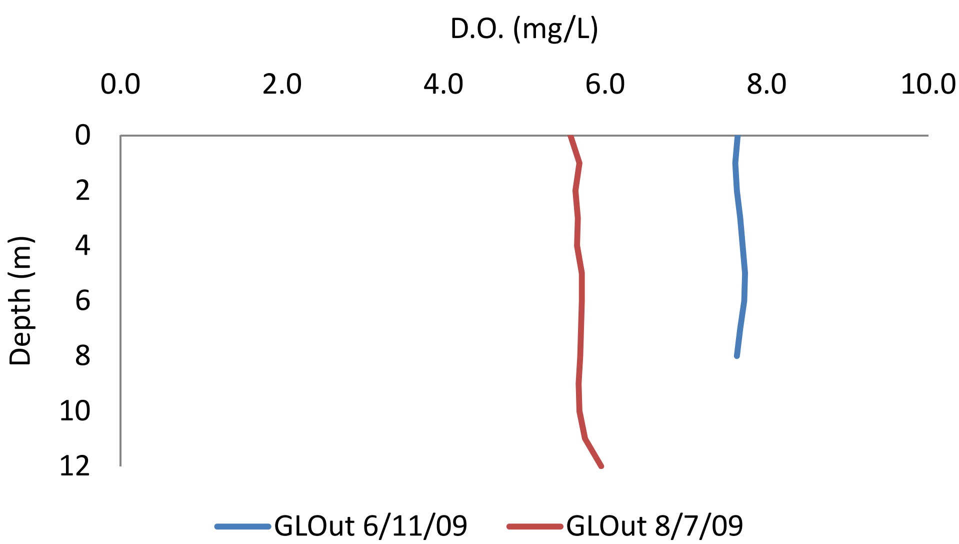


Figure 4.5.1-18. Dissolved Oxygen Concentration at Grant Lake Outlet.

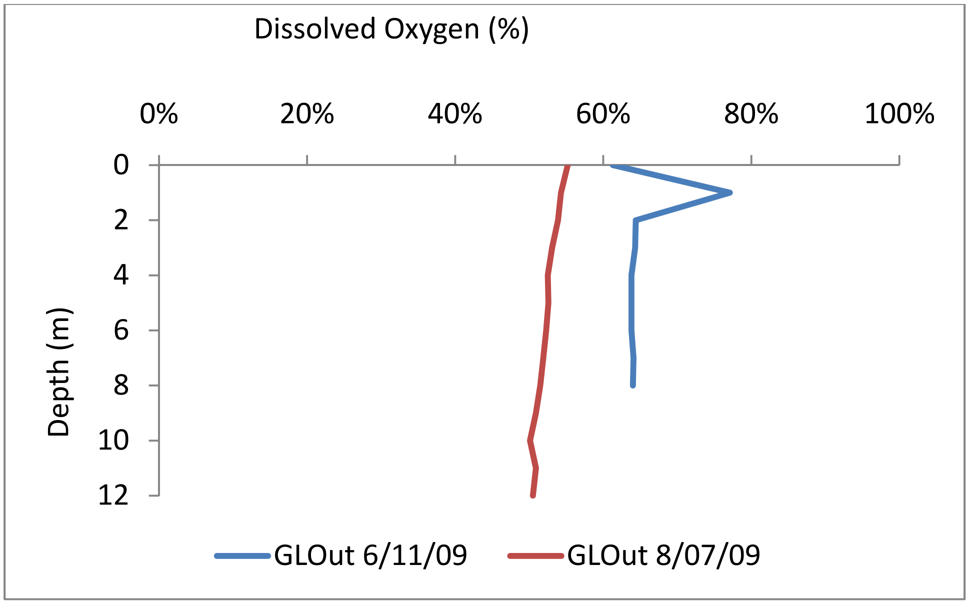


Figure 4.5.1-19. Dissolved Oxygen Saturation at Grant Lake Outlet.

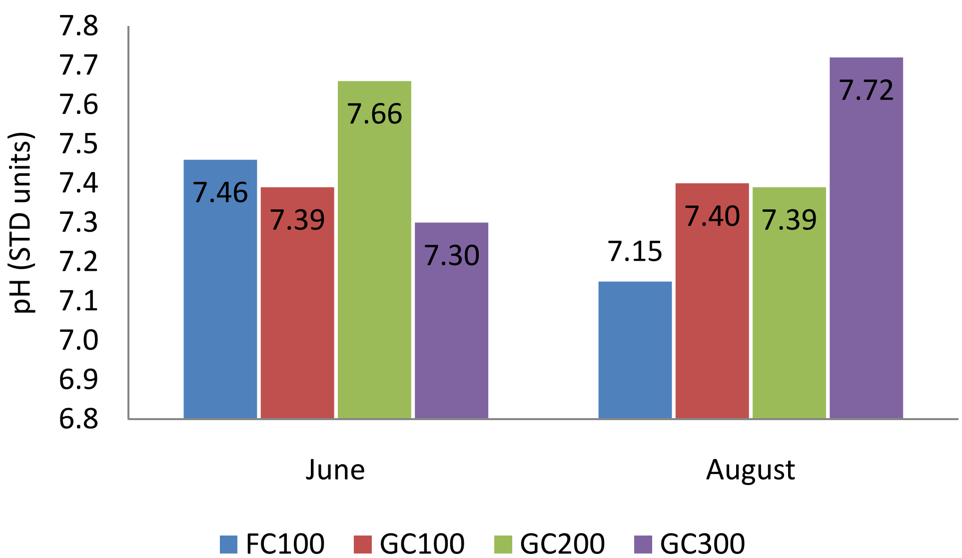


Figure 4.5.1-20. pH Concentrations at all Stream Locations.

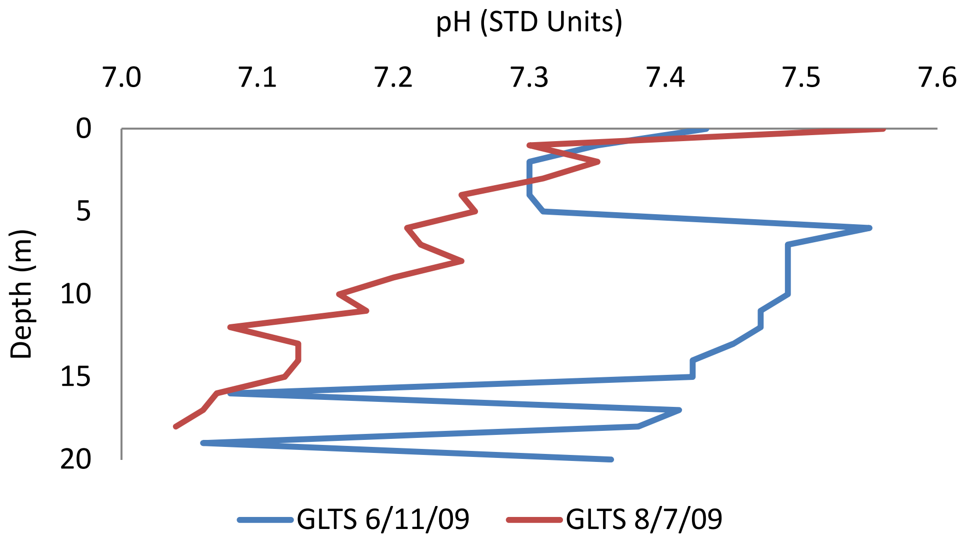


Figure 4.5.1-21. pH Concentrations at Grant Lake Thermistor String Location.

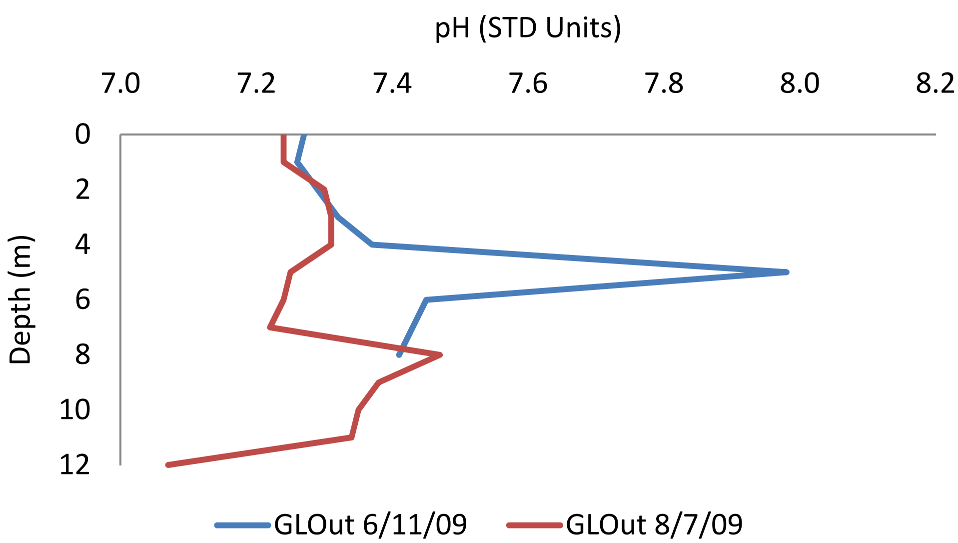


Figure 4.5.1-22. pH Concentrations at Grant Lake Outlet.

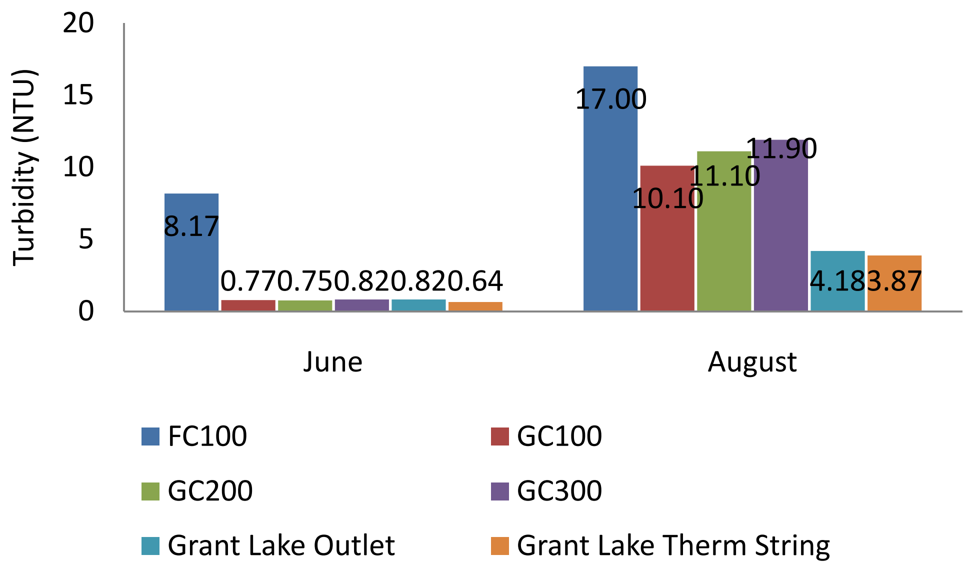


Figure 4.5.1-23. Turbidity at all Grant and Falls Creek Locations with included Turbidity of Surface of Grant Lake.

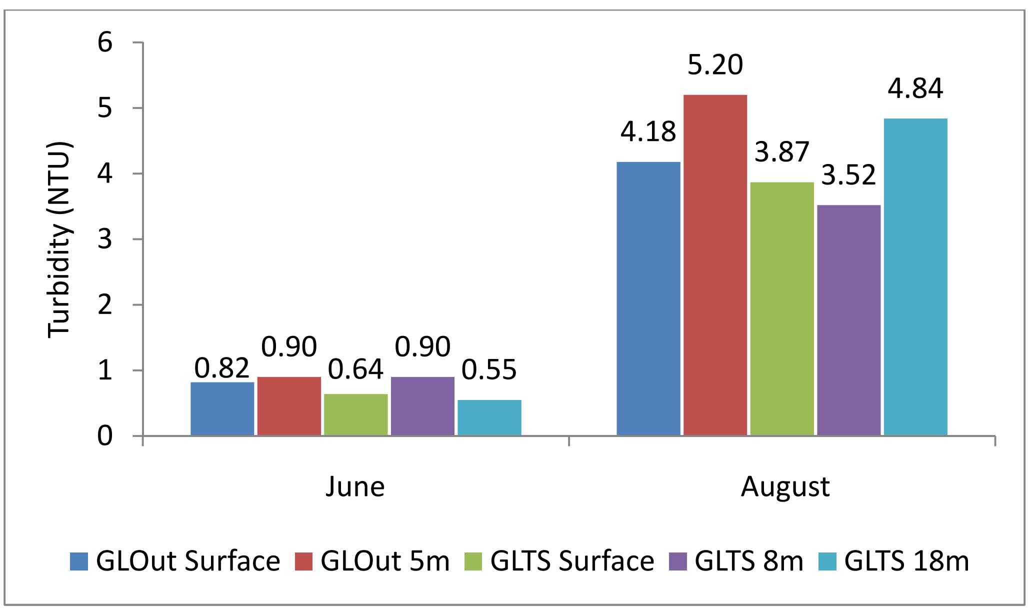


Figure 4.5.1-24. Turbidity at all Grant Lake Locations and Depths.

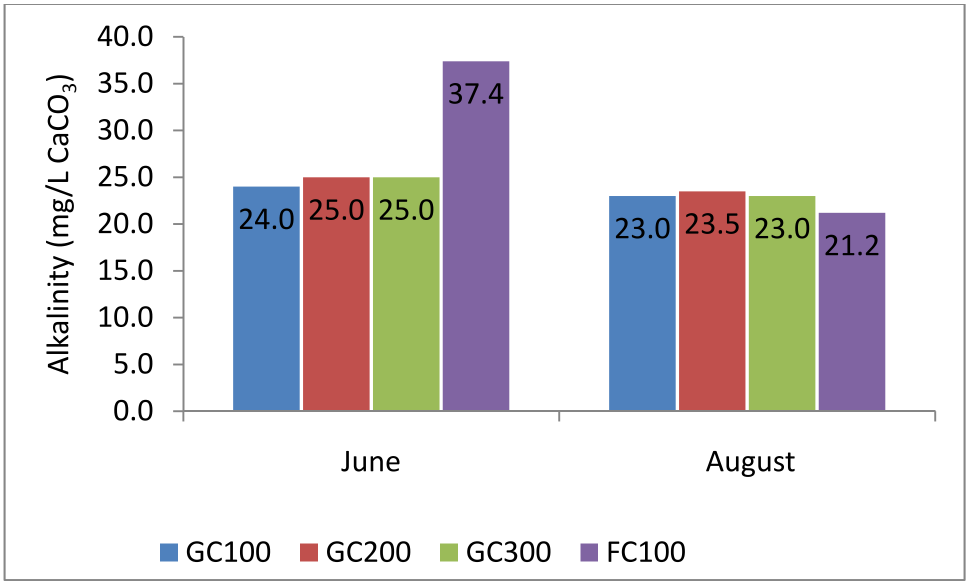


Figure 4.5.1-25. Alkalinity at all Grant and Falls Creek Locations.

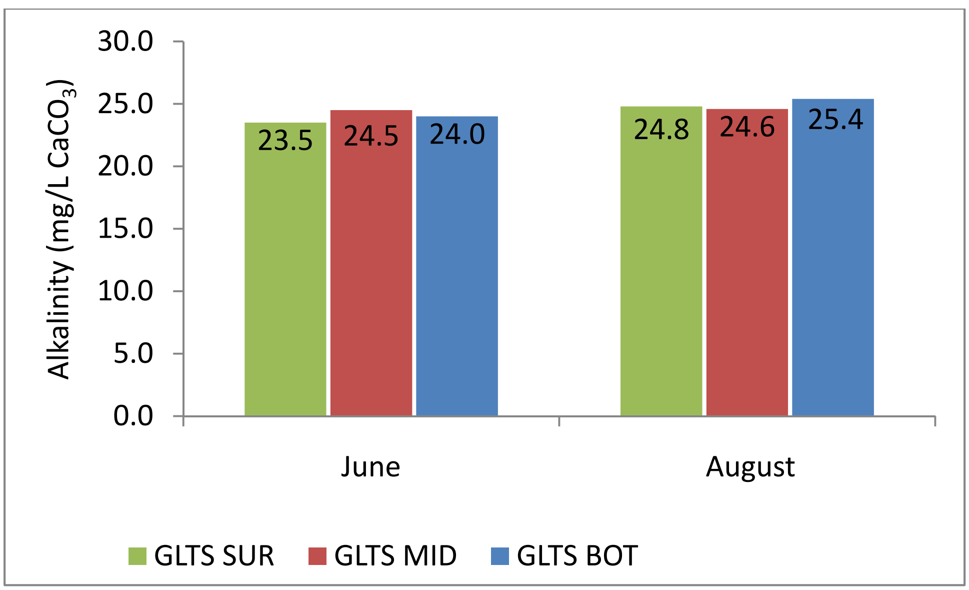


Figure 4.5.1-26. Alkalinity Concentrations at Grant Lake Thermistor String Location.

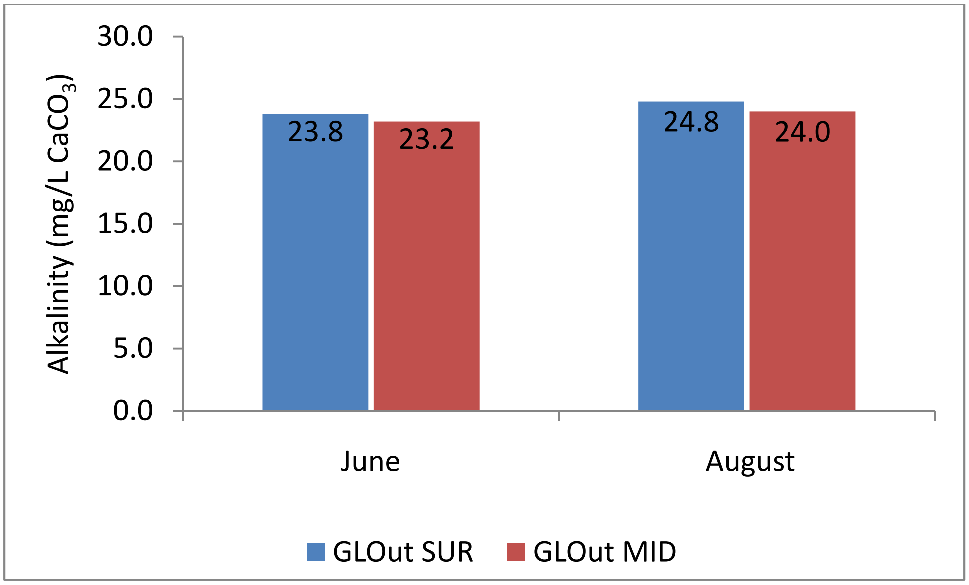


Figure 4.5.1-27. Alkalinity Concentrations at Grant Lake Outlet by Depth.

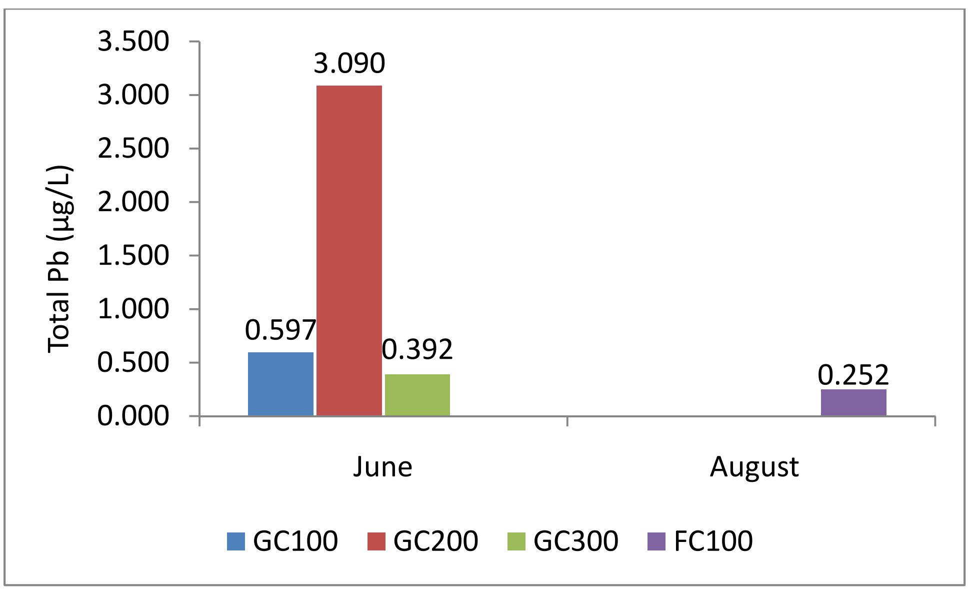


Figure 4.5.1-28. Total Lead Concentrations in Grant and Falls Creek.

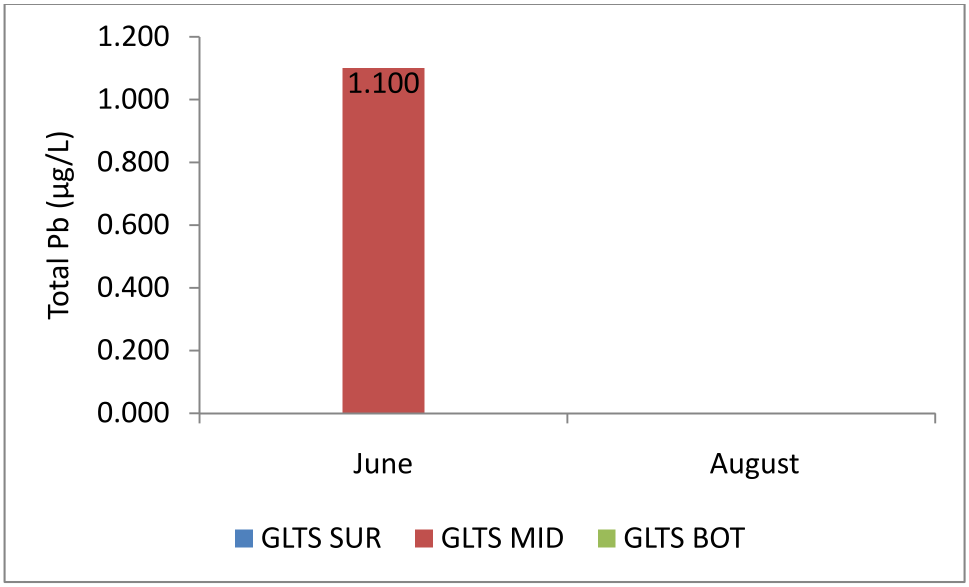


Figure 4.5.1-29. Total Lead Concentrations at the Grant Lake Thermistor String Location.

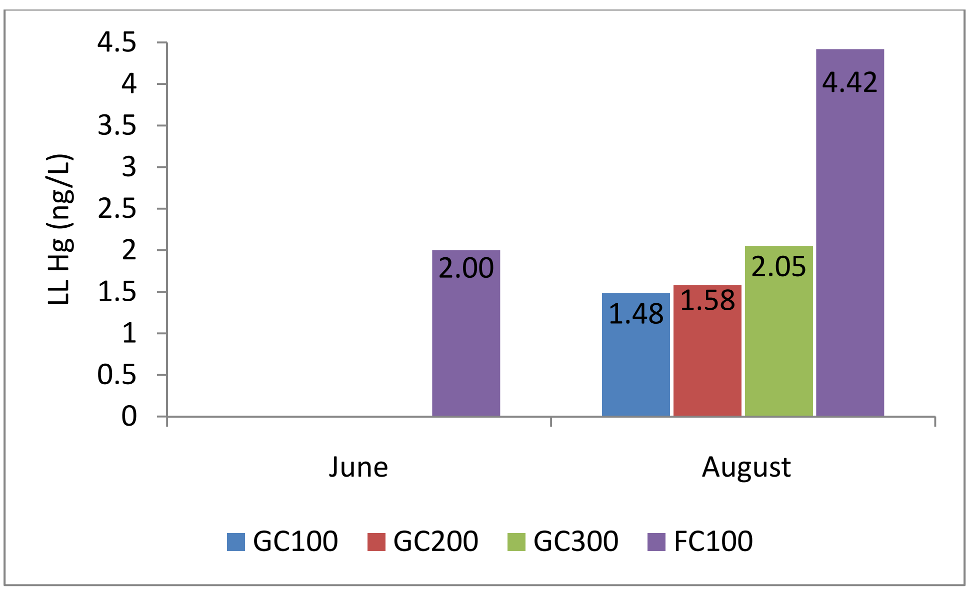


Figure 4.5.1-30. Low Level Mercury Concentrations at Grant and Falls Creek.

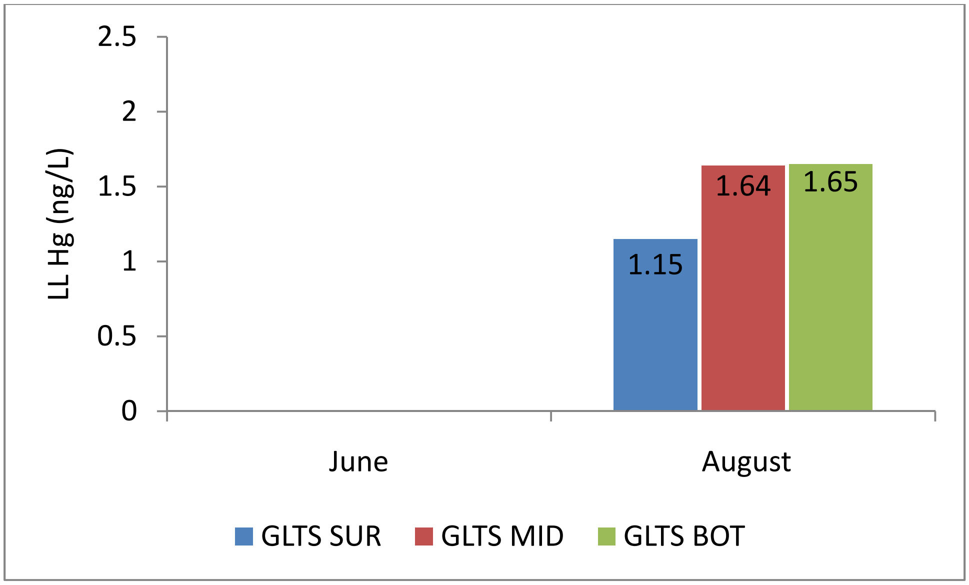


Figure 4.5.1-31. Low Level Mercury Concentrations at Grant Lake Thermistor String Location.

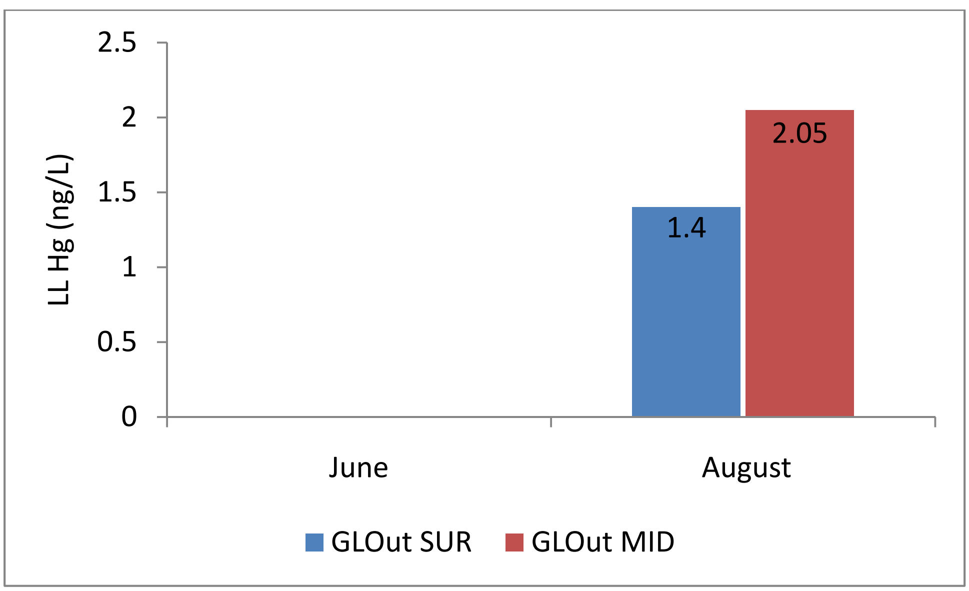


Figure 4.5.1-32. Low Level Mercury Concentrations at Grant Lake Outlet.

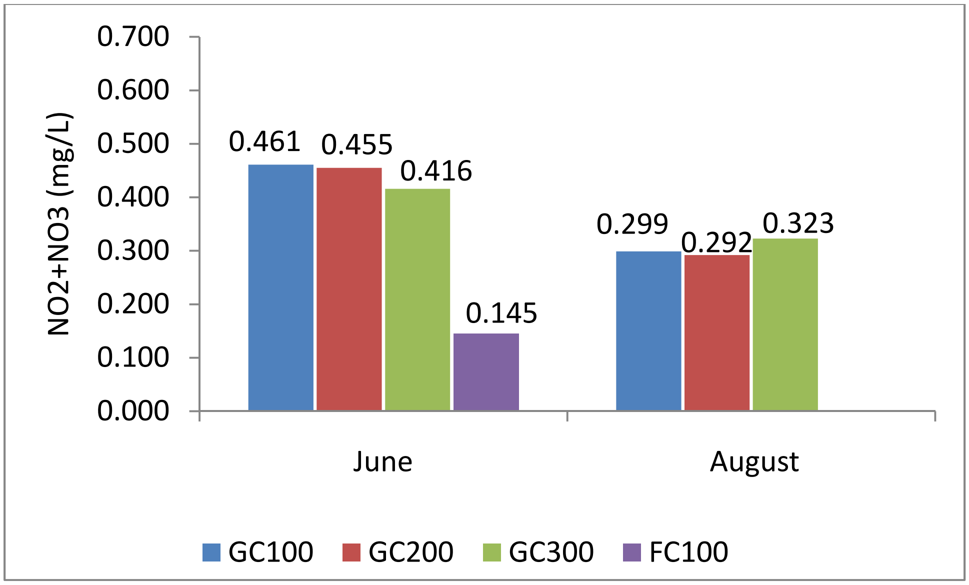


Figure 4.5.1-33. Nitrate and Nitrite Concentrations at all Grant and Falls Creek.

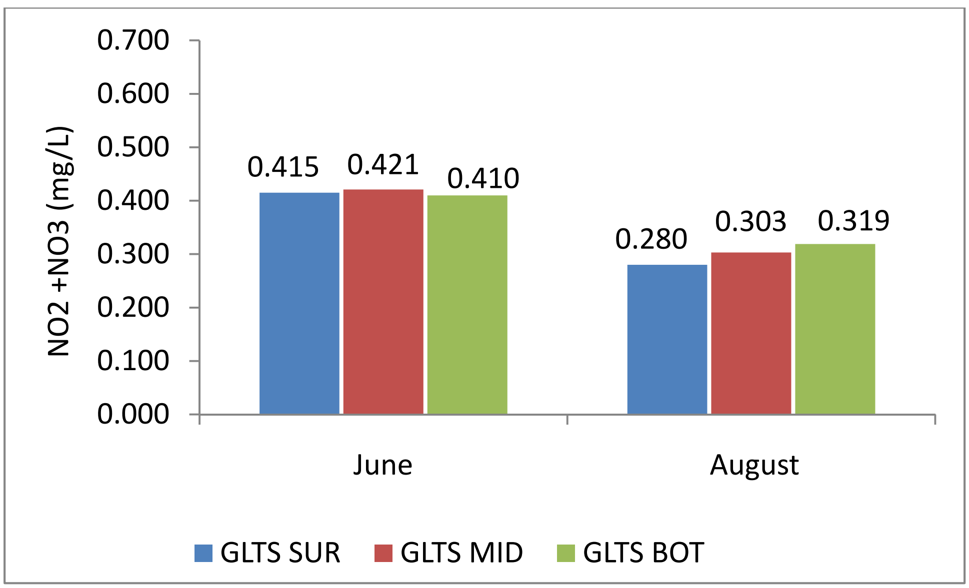


Figure 4.5.1-34. Nitrate and Nitrite Concentrations at Grant Lake Thermistor String Location.

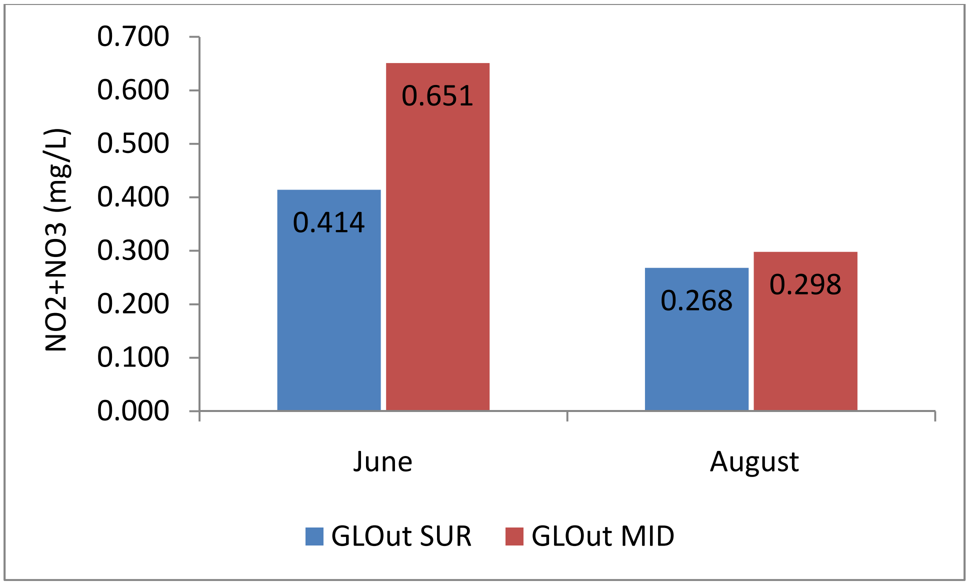


Figure 4.5.1-35. Nitrate and Nitrite Concentrations at Grant Lake Outlet.

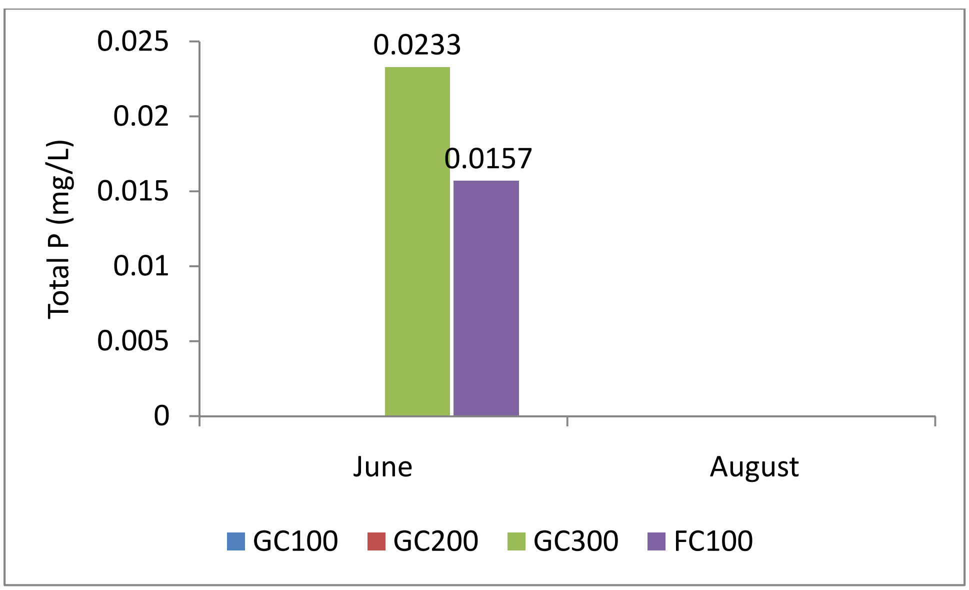


Figure 4.5.1-36. Total Phosphorous Concentrations at all Grant and Falls Creek Locations.

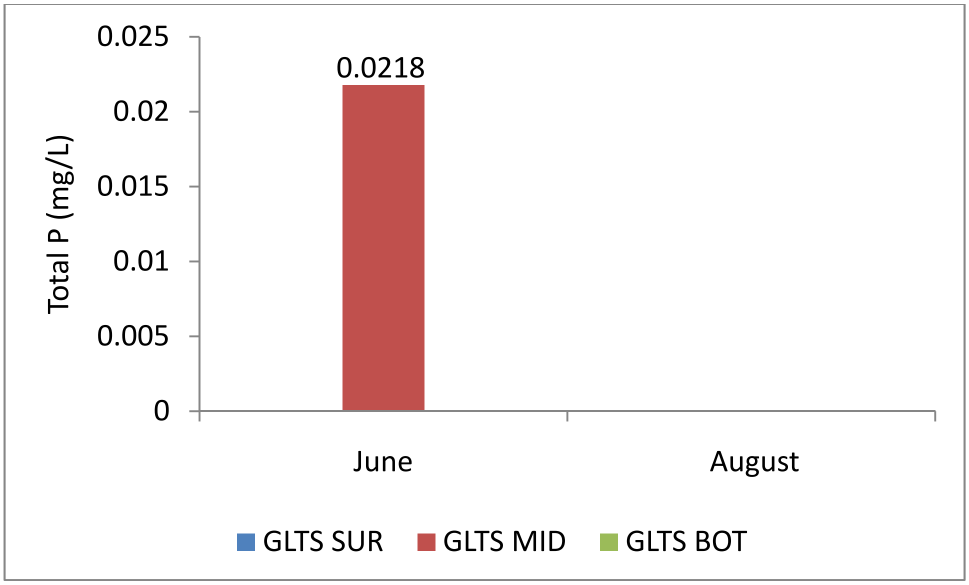


Figure 4.5.1-37. Total Phosphorous Concentrations at Grant Lake Thermistor String Location.

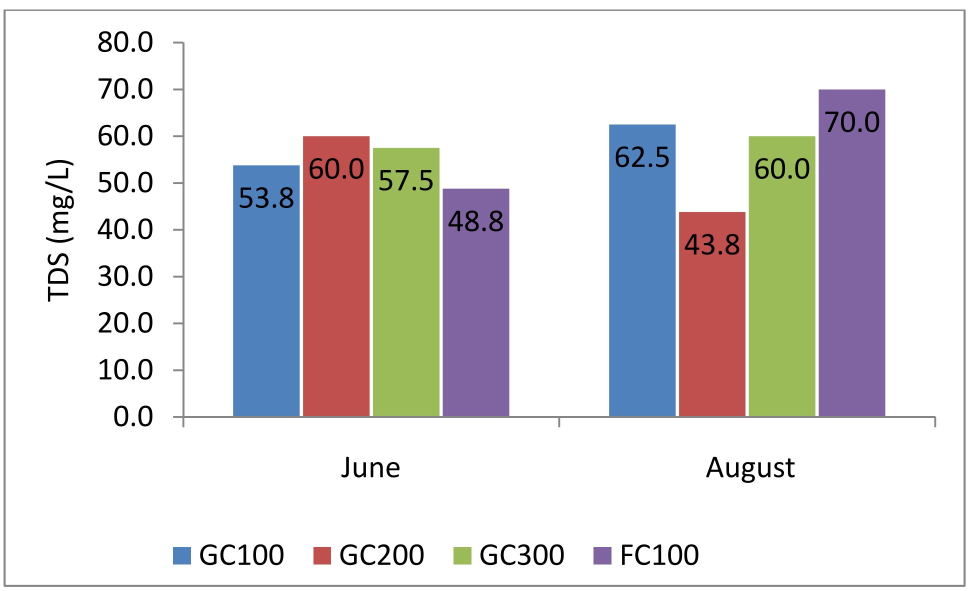


Figure 4.5.1-38. Total Dissolved Solid Concentrations at all Grant and Falls Creek Locations.

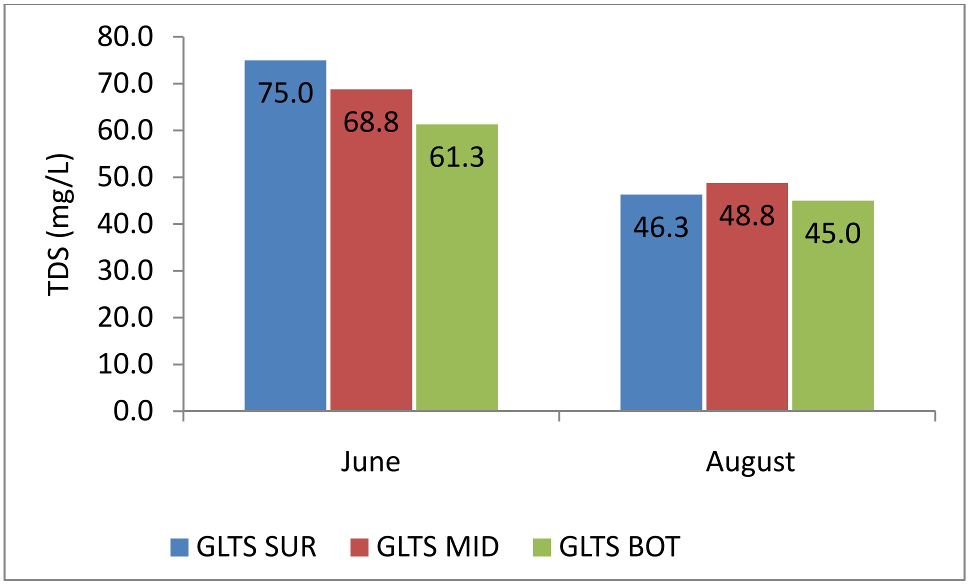


Figure 4.5.1-39. Total Dissolved Solid Concentrations at Grant Lake Thermistor String Location.

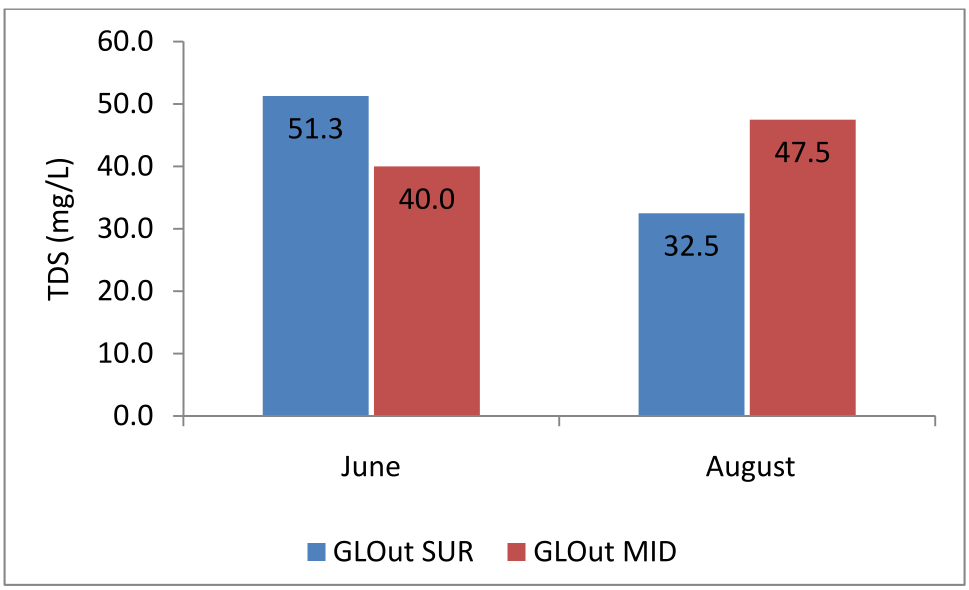


Figure 4.5.1-40. Total Dissolved Solid Concentrations at Grant Creek Outlet Location.

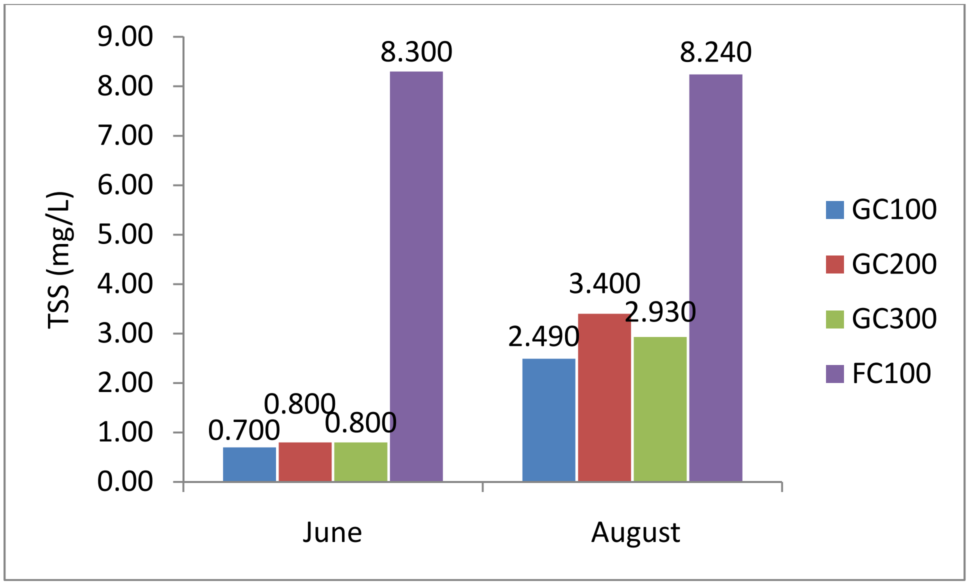


Figure 4.5.1-41. Total Suspended Solid Concentrations at all Grant and Falls Creek Locations.

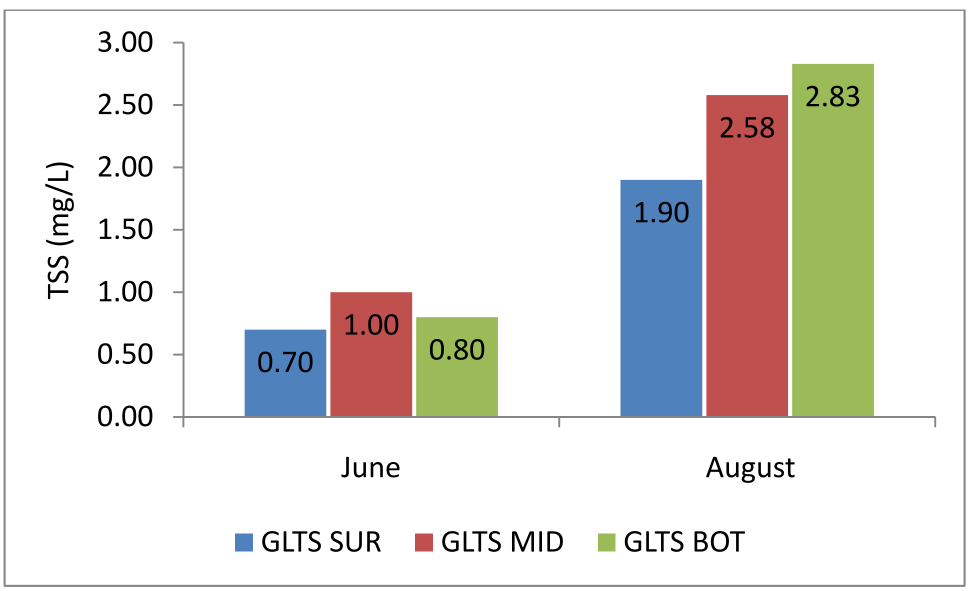


Figure 4.5.1-42. Total Suspended Solid Concentrations at Grant Lake Thermistor String Location.

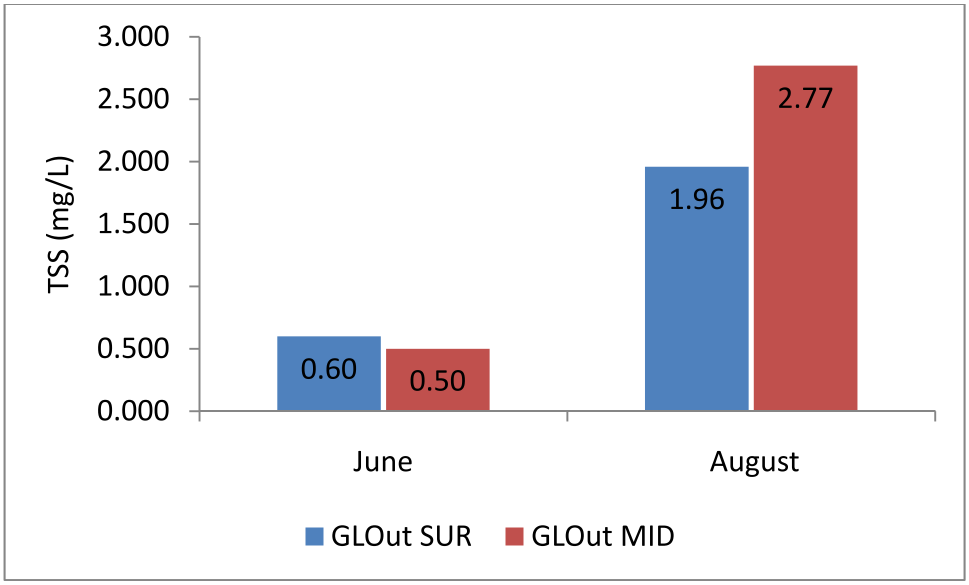


Figure 4.5.1-43. Total Suspended Solid Concentrations at Grant Lake Outlet Location.

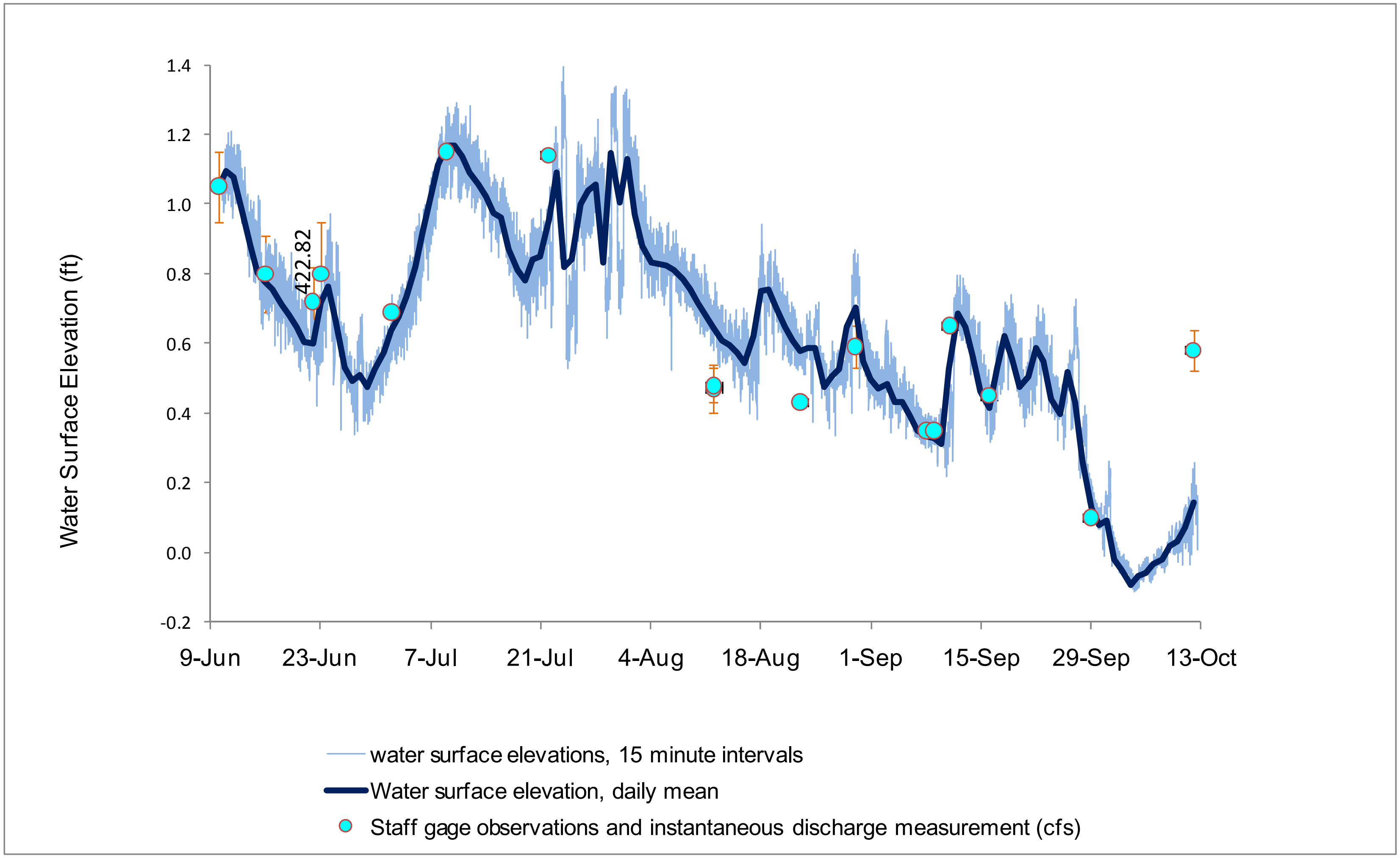


Figure 4.5.2-1. Continuous and observed water surface elevation at GC200

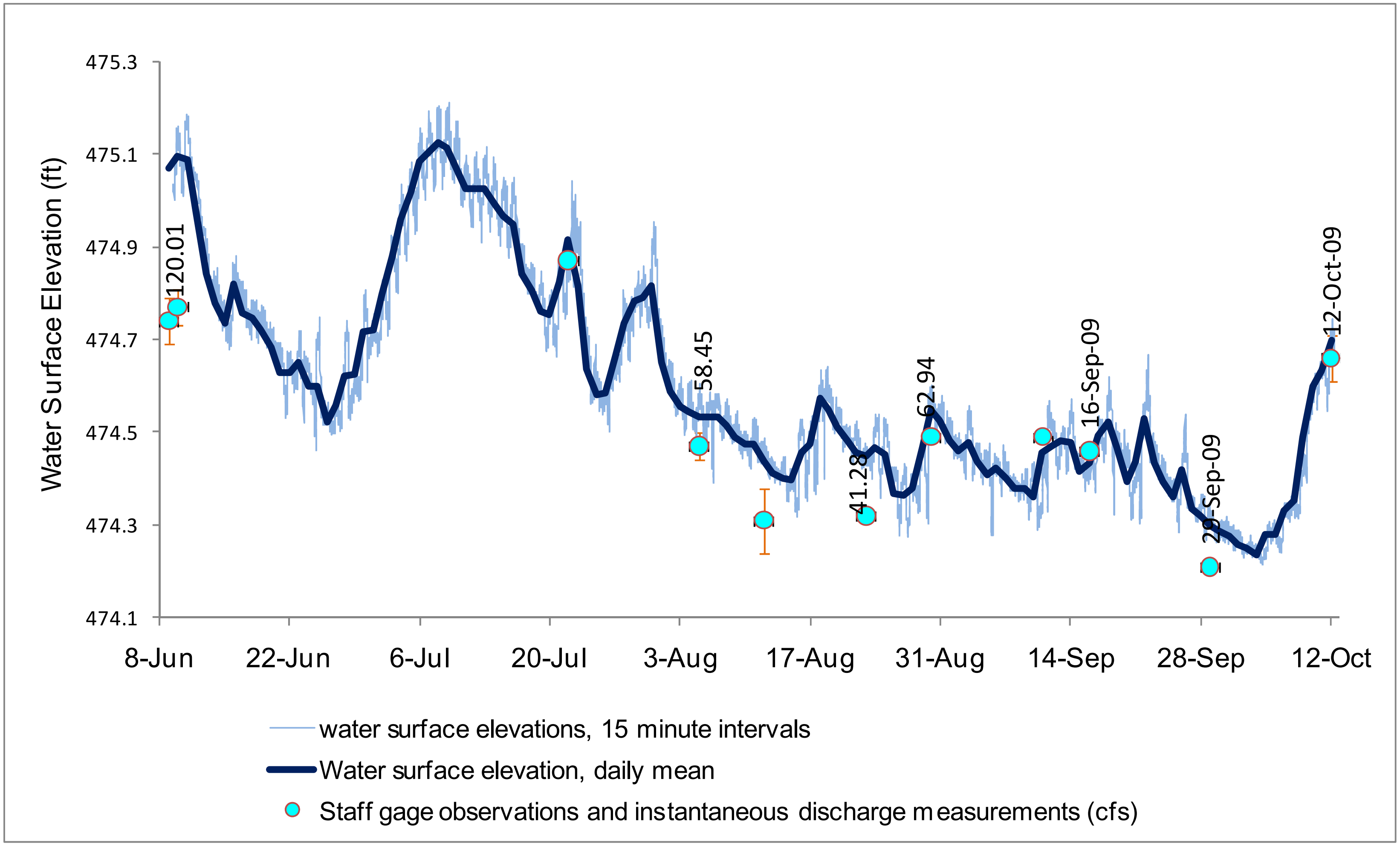


Figure 4.5.2-2. **Continuous and observed water surface elevation at FC100**

9 Appendices

Appendix A

HDR | ONE COMPANY *Many Solutions*℠

Memo

To:	Grant Lake/Falls Creek Hydroelectric TWG		
From:	Jason Kent	Project:	*Grant Lake/Falls Creek Hydroelectric*
Copy:	Brad Zubeck, Kenai Hydro LLC		
Date:	September 9, 2009	Job No:	*91437*
Re:	***Review of 1986-1987 Grant Lake FERC Application Documents for Instream Flow Considerations***		

Introduction

During drafting of the Pre-Application Document (PAD), Kenai Hydro, LLC conducted due diligence contacts to agencies and Tribes to collect existing information. During this information gathering effort, some additional instream flow and environmental analysis conducted in the 1980s by Kenai Hydro, Inc. (unrelated to Kenai Hydro, LLC) in support of a license application for hydropower development on Grant Creek was provided to KHL.

The documents are an assemblage of reports and written communications between Kenai Hydro Inc. (KHI) and state and federal agencies in 1986 and 1987 relative to a Federal Energy Regulatory Commission (FERC) license application for the proposed Grant Lake Hydroelectric Project (FERC No. 7633-002). The documents include draft and final reports of a limited but complete IFIM investigation and negotiated minimum instream flows (MIF) and ramping rates.

Summary of Kenai Hydro Inc. Documents

Originally, KHI's proposal was to route flow from Grant Lake to a powerhouse off Grant Creek, effectively removing a large portion of the flow from the creek. An initial license application included an instream flow proposal that was based on a Tennant Method book analysis and negotiated with the agencies in 1982. The proposal was based on Tennant's classification system and the assumption that "base flows of 40-60% would be outstanding and the optimum range would be 60-100% of average flow."

After two years of negotiations with the agencies, Kenai Hydro Inc. determined that the resulting loss of habitat would be considered unacceptable by the agencies and went forward with a new alternative that returned water to the creek at the downstream end of the "canyon reach." This new alternative was investigated in the 1987 instream flow study, and is similar to the approach being proposed by Kenai Hydro LLC today.

KHI suggested the following proposed MIF regime:

October – May	50 cfs
May - October	100 cfs

The agencies (led by USFWS) countered with a proposal favorable to both parties that featured a step increase with the purpose of limiting potential stranding.

November 1 – April 30	50 cfs
May 1-31	75 cfs
June 1 – October 15	100 cfs
October 16-31	75 cfs

The KHI proposal included load following as an important component. To offset the potential impacts of load following on redd dewatering and stranding of fish, the USFWS suggested the following ramping rate:

Increasing flow	• Not to exceed 100 cfs/hr
Decreasing flow	• 10%/hr at flows above 100 cfs • 10 cfs/hr at flows below 100 cfs

KHI anticipated that the project would impart a temperature effect on Grant Creek. The maximum expected change would be -1℃ in the summer and +2℃ in the winter. The USFWS stated that this change in temperature regime would impact fisheries by increasing the time to button-up stage for Chinook fry. To mitigate these impacts, USFWS asked KHI to construct a a multi-level intake structure in Grant Lake and operate the structure to draw water from the uppermost levels of the lake.

In addition, USFWS recommended monitoring of post-operation thermal regime in Grant Creek and evaluation of the changes from the pre-project conditions for a minimum of 6 years after commencement of project operations. NMFS requested a verification study of the instream flow study that included a weekly census of adult Chinook and sockeye salmon in August and September during construction and for a ten-year period thereafter.

Report Details

Document 1. Kenai_Hydro_Inc_Grant_Lake_Hydro_Project_Addtl_Info_2-15-1987.pdf

The revised project, with the powerhouse at the bottom of the canyon reach and flows diverted from Grant Lake, is discussed in this document. Proposed project flows are presented in Figure 1.

On October 21-23, 1986, a meeting and site visit was held at the USFWS office in which an alternate analysis method was selected. The discussion was centered on results of a stream survey conducted by Kenai Hydro Inc. (KHI) on June 26, 1986 (Figure 2). The work group determined the “most critical reach of the stream” that contained the highest amount of spawning activity was near the mouth of Grant Creek between stations 4-8 as shown on Figure 2. The work group selected a method that included the collection of 3 transects at stations 5 and 6 (Figure 3), and analysis using the computer model WSP/IFG-2, a precursor to the PHABSIM suite of models that is used today. Later that month, a consulting firm collected the stream surveys. The work group attendees included:

KHI – Dick Poole, Jonathan Hanson

ADFG – Don McKay, Christopher Estes

USFWS – Lenny Corin, Steven Lyons, George Elliott

NMFS – Brad Smith

The work group determined that “spawning is the most critical factor since rearing occurs mainly in the associated lakes.” This assumption led to a study design that included one transect flow measurement at three transects. KHI determined that one set of measurements was justified because “conflicts are low and the stream is a simple stable channel.” KHI characterized Grant Creek as “a simple stream with steep gradients, minimal side channels, few pools, and a rough bottom with a minimum of spawning gravel.” The selected study area where spawning was determined to occur the most, stations 4-8, was considered the “the most sensitive to changes in stream flow due to the elevated gravel bar and riffles that are present.” Typical PHABSIM-style transect measurements were taken during the field work conducted on October 24, 1986 (Figure 3).

KHI provides the following information regarding icing and winter flows:

“On a month by month basis, flows are lowest in the months of January, February, March and April. During this period minimum daily flows of 11 cfs occur with the stream icing up. Flows across the ice affecting stage-discharge relationships are recorded indicating anchor ice and solid freezing are occurring.

“During this period egg incubation is occurring and for the four month period the eggs are essentially in a holding phase due to the low temperatures which limit development. Stream flow is restricted to the bottom of the channel and eggs which have been spawned on the upper gravel bars freeze or depend on the availability of ground water for survival. Juvenile rearing would be restricted to the channel and limited pools during winter. Ice cover may or may not occur to protect the exposed eggs. Dewatering of alevins would of course cause 100 percent mortality.”

The original KHI proposal included reservoir management regimes (reservoir filling in off-peak months for use during the peak energy demand months of November through February) and proposed ramping rates. KHI reports daily changes of 185 cfs/day were observed during the period of record. KHI proposed a 100 cfs/hr rate of change for Grant Creek.

Figure 4 presents the projected project temperature discharges in Grant Creek. The project was projected to slightly flatten the temperature curve, warming the discharged water in the winter and cooling it in the summer. The reason for this difference is that the water intake in Grant Lake is below the surface, and the natural discharge is surface water that is exposed to ambient air temperatures. Due to this impact, USFWS asked KHI to include a multi-level intake structure in Grant Lake (this is discussed in the details of Document 3).

<u>Details of Envirosphere’s February 1987 Instream Flow Study Report</u>

The objectives of Envirosphere’s instream flow study were to quantify the relationship between habitat and flow for trout and salmon, to identify the physical habitat type that is limiting production in Grant Creek, and to determine how daily flow fluctuations from load following may potentially strand juvenile fish.

The report included a summary of existing data including fish resources of Grant Creek. Summary of that summary:

- Chinook
  - Adults
    - spawn in August and September.
    - Based on surveys (ADFG 1952-1981 and APA 1984), average peak salmon spawning ground count was 19 fish. Weir counts by Cook Inlet Aquaculture Association indicated that this number may be somewhat larger but generally less than 50 returning adults each year.
  - Juveniles
    - Age 1+ observed year round (APA 1984), but low numbers observed during March, May & June suggest they are either inactive or migrated elsewhere.
    - Natural emergence may be later than June because no observation in minnow traps until August (APA 1984). Some were observed during electrofishing in May, but may have been stimulated from the gravel.
- Sockeye
  - Adults
    - Spawn in August and September.

        - Based on surveys (ADFG 1952-1981 and APA 1984), average peak salmon spawning ground count was 61 fish. Weir counts by Cook Inlet Aquaculture Association show higher numbers – 400 in 1985 and 675 in 1986.
    - Juveniles
        - Likely rear in the downstream lake system and not in Grant Creek.
- Coho
    - Adults
        - No observations (ADFG 1952-1981 and APA 1984). However, very small (<40 mm) coho fry were trapped in August 1984 (APA 1984), indicating some natural spawning.
        - Returns were observed in 1985 and 1986 by CIAA weir counts; these fish were returns from the coho introduction program in Grant Lake that has since been discontinued.
    - Juveniles
        - Previous studies (APA 1984) show some coho rear in the lower reaches of Grant Creek but were less abundant and not as widely distributed as juvenile Chinook.
- Rainbow Trout
    - Spawning
        - No spawning adults were observed, but small juveniles (45-50 mm) were observed in October 1982, indicating some natural spawning (APA 1984).
    - Rearing
        - RBT are evenly distributed in Grant Creek, and are found in most habitat types. RBT captured in 1982 ranged in length from 43-106 mm (APA 1984).
- Dolly Varden
    - Spawning
        - No spawning adults were observed (APA 1984).
    - Rearing
        - Larger fish may move into Grant Creek during the late summer to feed and avoid the high turbidity of the Trail Lakes.
        - DV observed ranged in length from 55-300 mm.

Envirosphere analyzed the data and determined that "as a result of the similarities among the salmonid species present in Grant Creek…an analysis of Chinook and sockeye salmon will provide a relatively good indicator of the habitat relationships for coho, rainbow trout, and Dolly Varden char...therefore the stranding analysis in this study can be broadly applied, even though it is targeted on Chinook." They selected as the evaluation species for the instream flow study the spawning and rearing lifestages of Chinook and the spawning lifestage of sockeye.

Suitability curves "were developed from information found in the literature. This was believed to be a reasonable approach because a considerable amount of information is available in Alaska on suitability and some is directly available from the Kenai River system (e.g., Burger et al. 1982)." The HSC used for this study are presented in Figures 5 through 7. Details on the studies used to develop these criteria are given on pages 10-16 of the Envirosphere report.

Timing of life history phases for Chinook and sockeye are presented in Table 1. Envirosphere characterizes the incubation phase as “somewhat more difficult; however, inferences have been made from observations of the appearance of small juveniles (less than 50 mm) in the summer.”

Table 1. Life history phases of Chinook and sockeye salmon in Grant Creek.

Stage	When Present
Chinook	
Adults	August-September
Egg incubation and early intragravel	August-May/June
Juveniles	All year
Sockeye	
Adults	August-September
Egg incubation and early intragravel	August-May/June
Juveniles	Move downstream and rear elsewhere

Field data were collected on October 24, 1986 by KHI. Information collected on three transects included depth, velocity, and substrate. Vertical intervals were 2-4 feet, and velocities were measured at 0.2, 0.6, and 0.8 * depth. The calibration flow was approximately 246 cfs.

The model was calibrated and flow simulations were run for 50-450 cfs using WSP (Bovee and Milhous 1978). Stranding potential was examined using the methodology described by Prewitt and Whitmus (1986). This methodology uses information on cross slope, substrate, and discharge to determine stranding potential.

Results of Weighted Usable Area (WUA) are presented in Figures 8 through 11. In general, flows greater than 100 cfs cover a majority of the stream bed. Chinook spawning area peaks around 350 cfs, with about 70% of maximum spawning area available at 150 cfs. Sockeye spawning area peaks between 50 and 175 cfs and drops off sharply at flows greater than 175 cfs.

Chinook <50mm fry rearing peaks around 150 cfs, and for Chinook 50-100mm fry the peak habitat is somewhat steady between 100 and 350 cfs. For both sizes of Chinook juveniles, habitat drops sharply at flows less than 100 cfs.

The change in rate of stranding is relatively steady throughout the simulated flow range of 50-450 cfs with the exception of the range 50-120 cfs; in this flow range, stranding area rate was very high. Incremental changes in flow greater than 350 cfs impart a large increase in stranding area; the effect is lower for increments smaller than 350 cfs.

Document 2.

Kenai_Hydro_Inc_Grant_Lake_Hydro_Project_FERC_No_7633-002_Instream_Flow_Study_5-4-1987.pdf

This document includes the final instream flow report and comments from the resource agencies (USFWS, ADFG, NMFS) on the draft report.

Three agencies – ADFG, USFWS, and NMFS, provided KHI technical comments and concerns with the instream flow study. These comments are summarized below relative to the limitations of the study.

- The model (WSP) assumes steady flow during data collection. Flow measurements show that the flow rate dropped 51.5 cfs (21%) during the field study.
- USFWS applied a rule of thumb that flow simulations should not be applied to flows less than 40% of the lowest calibration flow. In this case, 40% of 246 cfs is 98 cfs.
- The study would be more credible if data had been collected at flows between 100-125 cfs.
- The model cannot be extrapolated upwards if the end of the cross sections were at the water's edge.
- Habitat suitability criteria are questionable (multiple concerns – see original letter).
- Stranding analysis is unclear because the method used is unpublished and unknown.
- The Tennant Method was presented improperly and it is unclear how it fits into the report.

Document 3.

Kenai_Hydro_Inc_Grant_Lake_Hydro_Project_Addtl_Info_Final_Report_with_Agency_T_Cs_9-4-1987.pdf

This document includes the communication between KHI and the agencies regarding negotiated minimum instream flows and ramping rates. The key documents are letters to KHI Vice President Richard Poole dated July 14, 1987 from USFWS and July 1, 1987 from NMFS. The letters suggest modifications to KHI's proposed minimum instream flows, thermal impacts, and ramping rates.

Instream Flows

USFWS determined the instream flow study "inadequate for the purpose of evaluating the fishery habitat currently available in Grant Creek, and the impacts (both positive and negative) which would result from the current proposal. The basic and most important concern with the study is poor data." USFWS interpreted the raw velocity data for transect T1 as having errors of greater than 20% for 8 of 16 verticals. Considering this error, they questioned the ability of the model to extrapolate to 100 cfs and beyond.

USFWS and NMFS suggested the following MIF regime:

November 1 – April 30	50 cfs
May 1-31	75 cfs
June 1 – October 15	100 cfs
October 16-31	75 cfs

USFW also suggested installing a continuous flow recording gage at or downstream of the tailrace.

Ramping Rates

Although the USFWS doubted the validity of the instream flow model, they acknowledged the increased potential for stranding at flows below 100 cfs. To address this concern, they recommended the following ramping rates:

Increasing flow	• Not to exceed 100 cfs/hr
Decreasing flow	• 10%/hr at flows above 100 cfs • 10 cfs/hr at flows below 100 cfs

Temperature

KHI anticipated that the project would impart a temperature effect on Grant Creek. The maximum expected change would be -1°C in the summer and +2°C in the winter (Figure 4). USFWS voiced concern that the change in the project temperature regime would affect the time for Chinook fry to reach the button-up stage. "In consideration of temperature-related concerns, Kenai Hydro, Inc., has agreed to utilize a multi-level intake structure. To minimize adverse impacts to the fishery resources we recommend that the intake structure be operated to draw water from the uppermost levels of Grant Lake."

Monitoring

USFWS also recommended monitoring of post-operation thermal regime in Grant Creek and evaluation of the changes from the pre-project conditions for a minimum of 6 years after commencement of project operations.

NMFS requested a verification study of the instream flow study that included a weekly census of adult Chinook and sockeye salmon in August and September during construction and for a ten-year period thereafter.

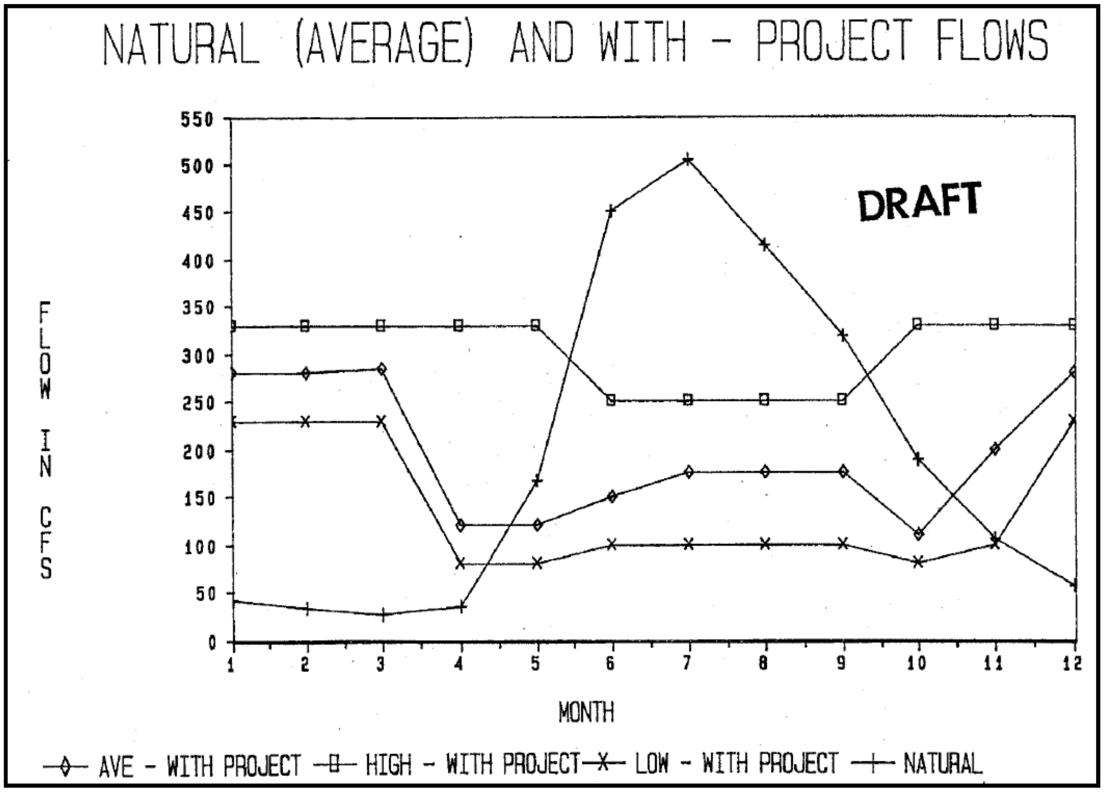


Figure 1. Proposed project flows in Grant Creek

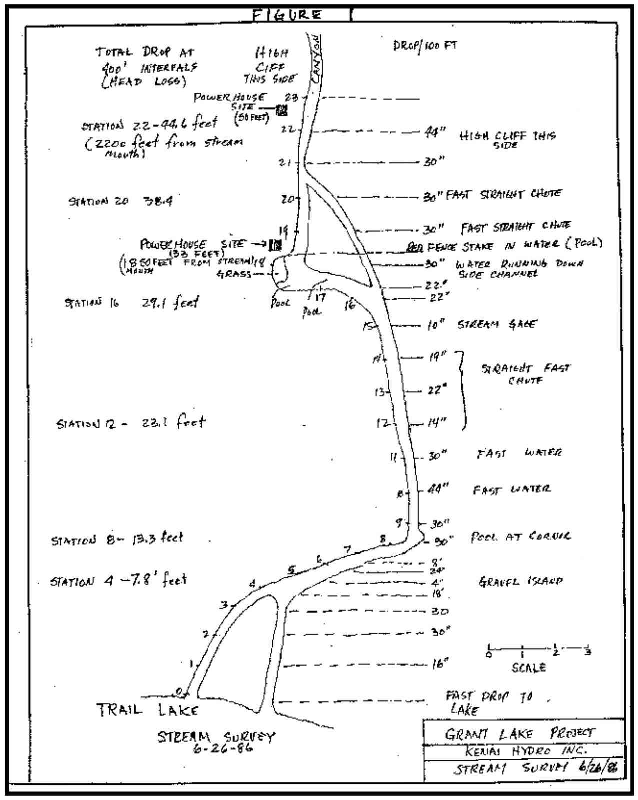


Figure 2. KHI stream survey June 26, 1986

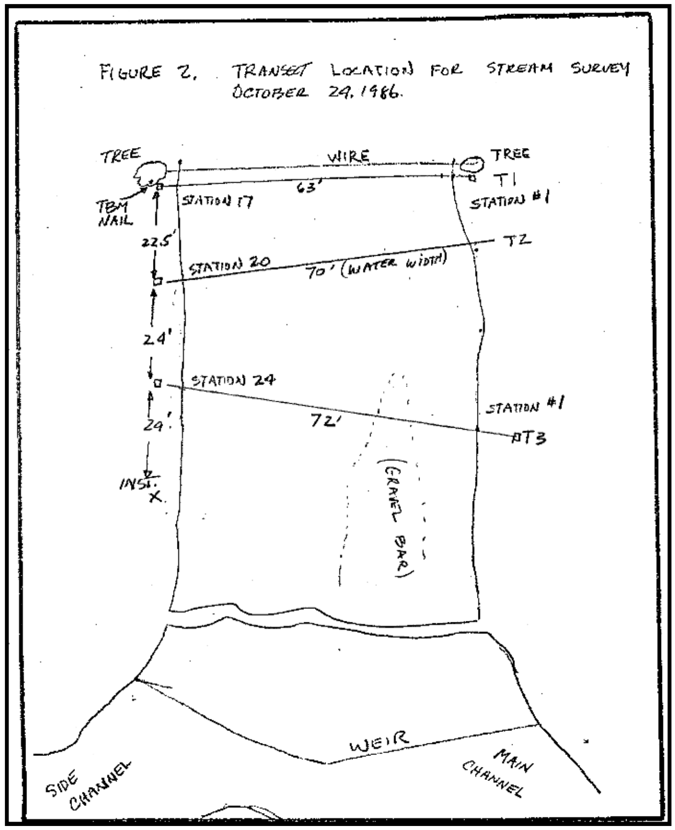


Figure 3. Transect locations for KHI stream survey, October 24, 1986

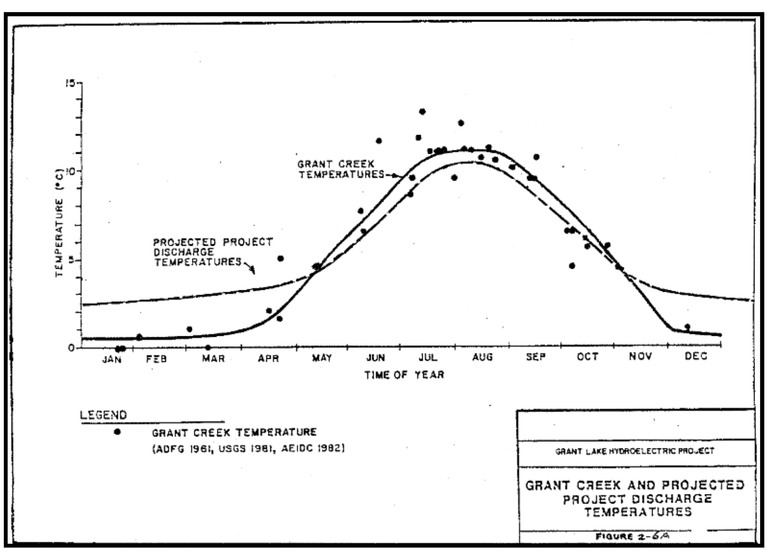


Figure 4. Anticipated post-project temperature regime in Grant Creek

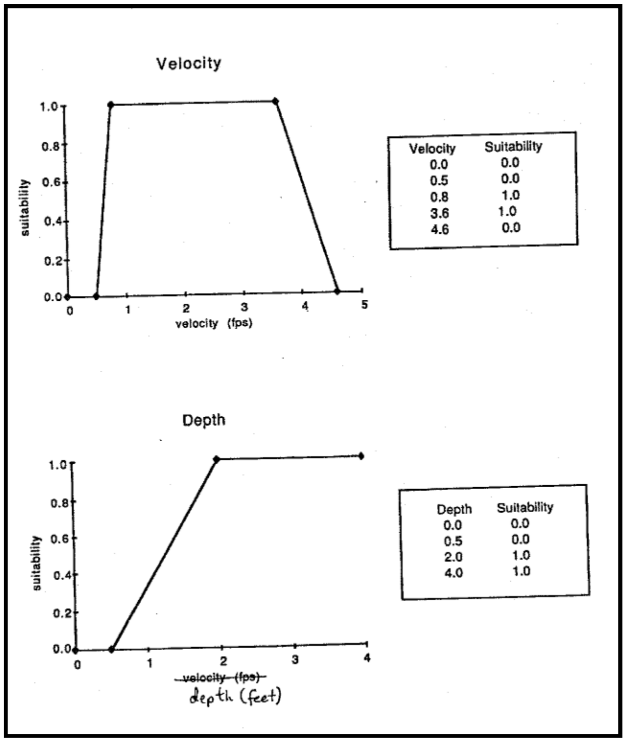


Figure 5. Habitat Suitability Criteria for adult Chinook salmon

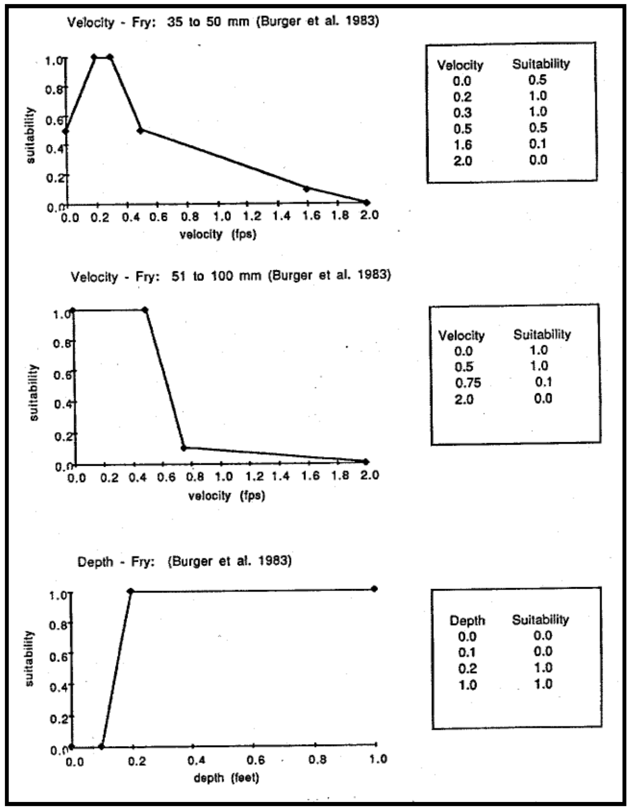


Figure 6. Habitat Suitability Criteria for juvenile Chinook salmon

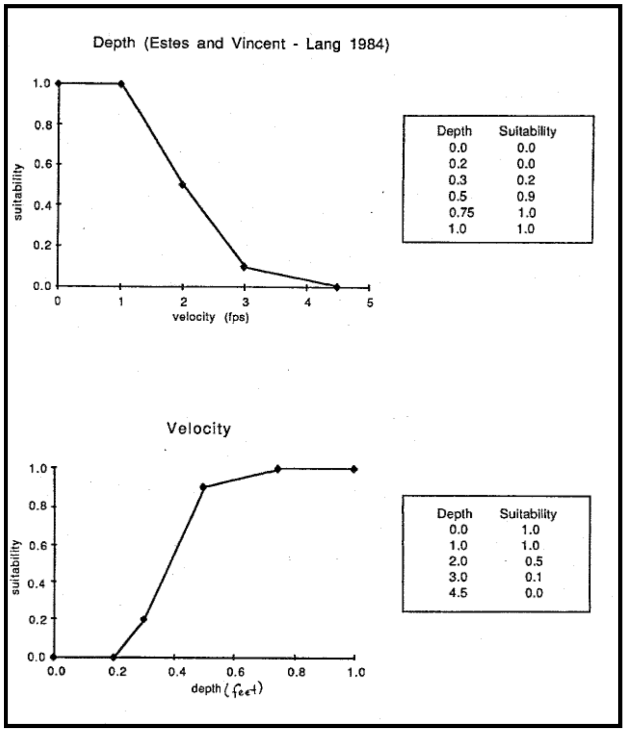


Figure 7. Habitat Suitability Criteria for adult sockeye salmon

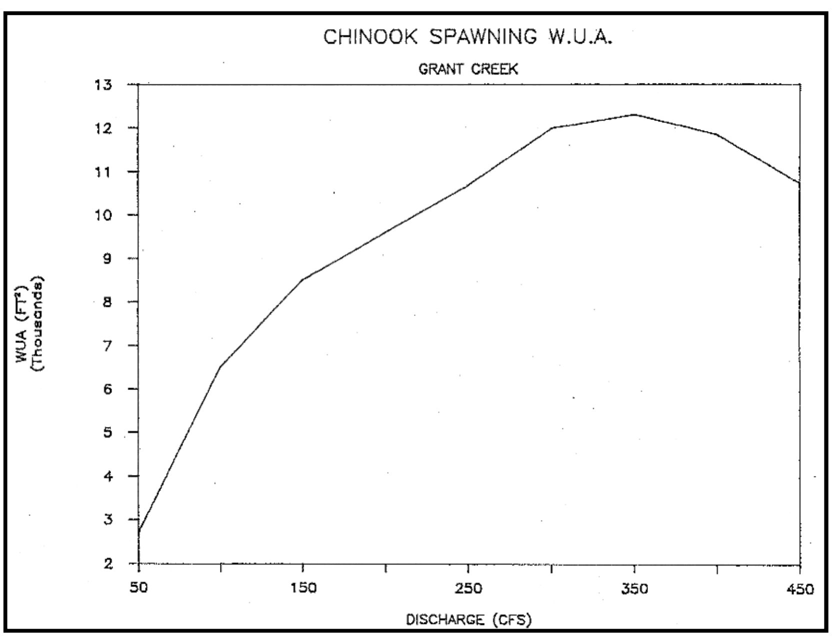


Figure 8. Weighted Usable Area for spawning adult Chinook salmon

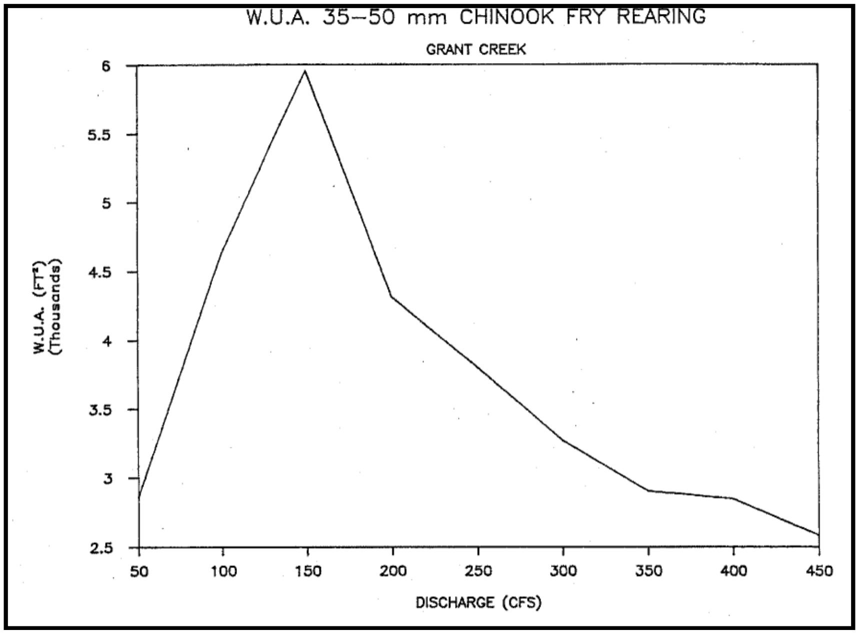


Figure 9. Weighted Usable Area for juvenile rearing Chinook salmon 35-50 mm

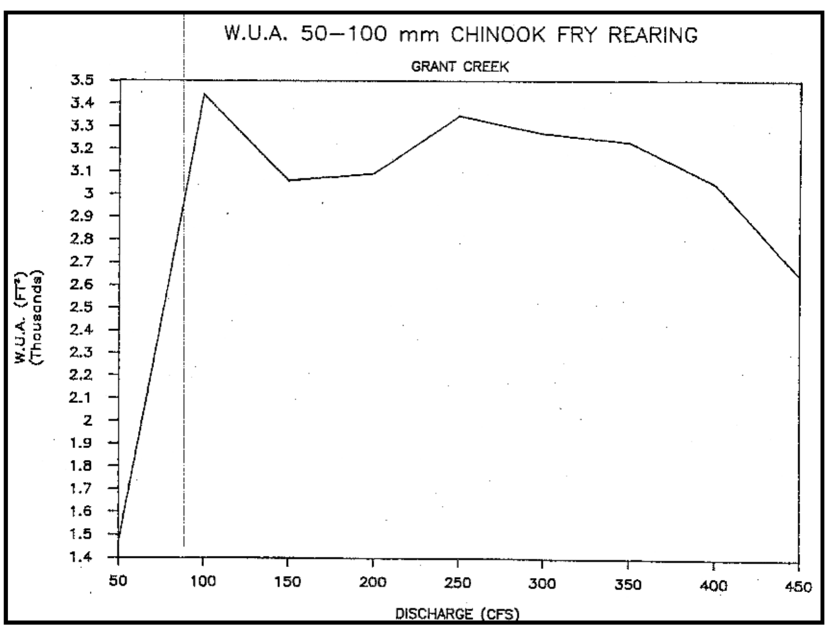


Figure 10. Weighted Usable Area for juvenile rearing Chinook salmon 50-100 mm

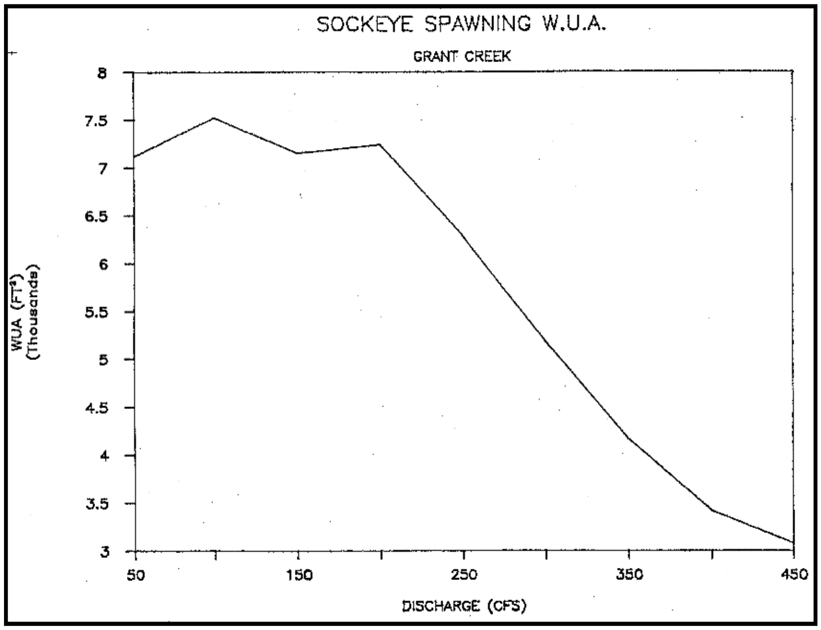


Figure 11. Weighted Usable Area for adult spawning sockeye salmon

Appendix B

Photo 1. Reach 1 looking upstream on the right bank during June, 2009.

Photo 2. Grant Creek Reach 2 during June, 2009.

Photo 3. Grant Creek Reach 3 during June, 2009.

Photo 4. Grant Creek Reach 4 looking upstream during June 2009.

Photo 5. Grant Creek in Reach 5 looking downstream from the right bank during May, 2009.

Photo 6. Reach 6 looking upstream during June, 2009.

Photo 7. Measuring the discharge on Grant Creek in Reach 2 during June, 2009.

Photo 8. A gill netting set in the narrows of Grant Lake during August 2009.

Photo 9. A gill net set in the front basin of Grant Lake during June, 2009.

Photo 10. Falls Creek looking upstream from the mouth during July, 2009.

Photo 11. Falls Creek below the canyon looking downstream during July, 2009.

Photo 12. Discharge measurement taken on Falls Creek during June, 2009.