Eklutna Hydroelectric Project

Eklutna Lake Aquatic Habitat and Fish Utilization

Year 2 Study Report

FINAL

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Terms, Acronyms, and Abbreviations

1991 Agreement	1991 Fish and Wildlife Agreement
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ATV	all-terrain vehicle
AWWU	Anchorage Water and Wastewater Utility
BP	beaver pond
BR	boulder
bw	backwater
C	Celsius
cfs	cubic feet per second
CH	chute
CS	cascade
DC	dry channel
DO	dissolved oxygen
El	elevation
ft	Feet
FS	falls
GL	glide
GPS	global positioning system
IHN	Infectious Hematopoietic Necrosis
in	Inch
m	Meter
mm	Millimeter
NMFS	National Marine Fisheries Service
NTU	nephelometric turbidity unit
NVE	Native Village of Eklutna
PD	puddle
PL	pool
PME	protection, mitigation, and enhancement
PVC	polyvinyl chloride
QA	Quality Assurance
QC	Quality Control
RF	riffle
RM	river mile
RP	rapid
RTK	real time kinetics
sc	scour
TEK	Traditional Ecological Knowledge
TSI	trophic state index
TWG	Technical Work Group

USACE	United States Army Corps of Engineers
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service

1 INTRODUCTION

The 1991 Fish and Wildlife Agreement (1991 Agreement) was executed amongst the Municipality of Anchorage, Chugach Electric Association, Inc., Matanuska Electric Association, Inc. (collectively "Project Owners"), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and the State of Alaska as part of the sale of the Eklutna Hydroelectric Project (Project) from the Federal government to the now Project Owners. The 1991 Agreement requires that the Project Owners conduct studies that examine and quantify, if possible, the impacts to fish and wildlife from the Project. The studies must also examine and develop protection, mitigation, and enhancement (PME) measures for fish and wildlife affected by such hydroelectric development. This examination shall consider the impact of fish and wildlife measures on aquatic habitat and fish utilization in the Eklutna Lake as well as available means to mitigate these impacts. The Project Owners initiated consultation in 2019 and have implemented studies to inform the development of the future Fish and Wildlife Program for the Project. As part of these studies, the Project Owners contracted Kleinschmidt Associates to describe and evaluate Eklutna Lake aquatic habitat and fish utilization.

1.1. Physical Environment

Eklutna Lake is a natural lake formed by the retreating Eklutna glacier. It is approximately 7 miles long, 1 mile wide, and 200 feet deep at its deepest point. The natural lake elevation is 850 feet. The existing dam raises the water level of Eklutna Lake by 21 feet to a maximum regulated lake level of El. 871 feet (the elevation of the spillway crest). At this elevation, the lake has a surface area of 3,420 acres. The lake surface elevation annually ranges from approximately 825 to 871 feet and is typically lowest in May just before spring breakup and highest in September at the end of the summer (Loso et al. 2017).

The primary inflow into Eklutna Lake is Eklutna Creek[1]. The East and West Forks of Eklutna Creek converge a short distance upstream from the lake creating a complex, braided creek segment that moves within a broad floodplain before emptying into the lake (R&M Consultants 1985). The drainage areas of the East and West Forks are 38.9 and 24.7 square miles respectively, and they contribute approximately 80 percent of the lake's inflow. The East Fork has a few unnamed cirque glaciers within the watershed, accounting for approximately 12% of the drainage area. The West Fork is dominated solely by the Eklutna Glacier, which occupies more than 46% of the drainage area (Larquier 2010). The remainder of the lake watershed is drained by numerous small tributaries. Typical of glacial fed streams and rivers, Eklutna Creek is turbid during most of the year (>100 NTU), fluctuating based on the melt rate of the headwater glaciers.

[1] Some historical documentation refers to the East and West Forks above the lake as Eklutna Creek, while other historical documentation refers to the East and West Forks above the lake as the Eklutna River. Similarly, some historical documentation refers to the river below the lake as the Eklutna River, while other historical documentation refers to the river below the lake as Eklutna Creek. For the purposes of this Project and to avoid confusion, the East and West Forks above the lake will be referred to as Eklutna Creek, and the river below the lake will be referred to as the Eklutna River.

Turbidity, as measured in nephelometric turbidity units (NTUs) is a metric of light penetration which is an important factor affecting primary productivity. Turbidity is affected by the amount of glacial melt and precipitation in the form of rain. Consequently, turbidity tends to be highest in the summer and lower in the winter.

In the Eklutna River basin, the turbidity of side channels to glacier rivers is generally low with inflows dominated by clear water tributaries and groundwater sources. During extensive juvenile fish habitat surveys of the nearby Susitna River in the early 1980s, fish collection by beach seine and backpack electrofishing were used to analyze differences in use of clear and turbid water areas (Suchanek et al. 1984a, 1985). Results of these surveys along with monitoring of turbidity in areas sampled led to a number of conclusions regarding the influence of turbid and clear water zones on habitat utilization for spawning and rearing of salmonid fishes.

In the Susitna River, turbidity was found to be a significant factor in analysis of variance of catch rates for Age 0 Chinook and coho juveniles (Dugan et al. 1984). Chinook juveniles were found to use relatively turbid water greater than 30 NTU as cover (Dugan et al. 1984, Suchanek et al. 1984a). In contrast, coho juveniles were found to prefer relatively clear water zones for rearing. Turbidity, and high level of very fine sediment that contributes to it can be an important factor in the overwintering survival of salmon eggs. Sockeye salmon in the Taku River, Alaska, selected redd sites with available groundwater and substrate containing less than 15% fine sediment (<2 mm) (Lorenz et al. 1989). Generally, increasing amounts of fine sediment (<3.4 mm) reduces egg to fry survival for salmonids such as Chinook, Chum, and Coho salmon (Jensen et al. 2009). While redd digging can reduce the fine sediment load in spawning gravel, when sediments are deposited after spawning as in glacial rivers, survival can also be decreased (Chapman 1988).

Turbidity was also considered an important factor for rainbow trout adults, Arctic grayling adults, round whitefish adults and juveniles, and longnose sucker adults (Suchanek et al. 1984b). Suchanek et al. (1984b) found these species utilized cover differently depending upon whether using turbid or clear water. In general, rainbow trout and Arctic grayling had higher catch rates in areas with lower turbidity levels while round whitefish and longnose sucker had higher catch rates in more turbid areas (Suchanek et al. 1984b).

Turbidity in the lake is generally high but seasonally variable. During surveys in the 1980s, turbidity dropped in the winter and peaked in mid to late summer (R&M Consultants 1985). Values ranged from 0.5 to 580 NTU in the inflow streams, from 1.8 to 220 NTU in the lake, and from 3.0 to 46 NTU in the outflow (R&M Consultants 1985). The range of turbidity in the lake ranged from low values of less than 10 NTU during spring and early summer before the glacial melt began, and high values of greater than 60 NTU from August to early October (R&M Consultants 1985). The compensation depth (1 percent light level) for 15 NTU is 5.3 meters and drops to 1.5 meters for an NTU of 50 (Lloyd 1985).

A 1982-1984 study of Eklutna Lake limnology documented seasonal stratification of the lake and turnover twice a year, in May after breakup and in September or October prior to freeze-up (R&M Consultants 1985). This was corroborated by 2021-2022 thermal monitoring in Eklutna Lake (Sauvageau and Schult 2023). Water surface temperature peaked at 13°C to 15°C in July and August during the study period in 1985 (R&M Consultants). Surface water peaked at about 15°C in July during 2021/2022 water quality monitoring (Sauvageau and Schult 2023). The

Eklutna Creek inflow created a colder, more turbid plume that was detected at varying depths, depending on its temperature compared to the lake, but was most often an interflow (at mid-depth), and could be detected as far as three miles downstream (R&M Consultants 1985).

Analysis of Eklutna Lake trophic status (Trophic State Index, TSI) was completed in 2021 and 2022 using measurements of chlorophyl A. The resulting TSI of 18.9 and 10.6 in Eklutna Lake in 2021 and 2022, respectively, are in a range (TSI< 30) considered oligotrophic (i.e., of low nutrient level). Low levels of Chlorophyl a indicate low biomass of algae in the lake, likely due to low light penetration in the glacially turbid water column. Correspondingly, the zooplankton community may be limited by the low availability of algal food and other nutrients, which may in turn affect the ability of the lake to sustain populations of fish. As stated by the USACE (2011), "[l]ow numbers and small size of the native land locked sockeye salmon (kokanee) found in the lake support these biological assumptions."

1.2. Fish Stocking

Documented fish species in Eklutna Lake include rainbow trout, Dolly Varden, and landlocked Sockeye Salmon (kokanee; *Oncorhynchus nerka*). Alaska Department of Fish and Game (ADFG) sport fish surveys in 1962 did not capture any fish in Eklutna Lake using a 24-hour set of a variable mesh, 125-foot experimental type gill net, although the report mentions that "a few Dolly Varden inhabit one clear water inlet stream" (McGinnis 1963). Overnight gill net sampling by ADFG in 1973, 1980, and 1985 captured Dolly Varden and kokanee (ADNR n.d.).

ADFG stocked Eklutna Lake with excess Rainbow Trout (*Oncorhynchus mykiss)* fry and fingerlings from 1987 through 1997 but stopped stocking the lake due to low catch rates and low angler participation (USACE 2011). Stratton et al. (1994) reported that stocking varied from 50,000 in 1990 to nearly 2.5 million in 1991.

Sampling efforts in 1988, 1989, and 1990 with fyke nets and minnow traps captured Dolly Varden (*Salvelinus malma*), kokanee, and rainbow trout. During all sampling events, kokanee had the lowest catch. Initially, Dolly Varden were relatively more abundant in the catch, but in the third year of sampling, rainbow trout became the most abundant species captured.

1.3. Fish Spawning

Spawning areas for the fishes observed in Eklutna Lake are previously undocumented. Typically, kokanee spawn in tributaries to juvenile nursery lakes after maturing in lakes (Burgner 1991). However, kokanee populations also spawn on lakeshore gravel beaches (Averett and Espinosa 1968; Hassemer and Rieman 1981; Shepherd 1999; Frazer and Russello 2013; Whitlock et al. 2015). In glacial systems, kokanee spawning is often associated with a clear water source, such as an inlet tributary or upwelling. However, fall spawning coincides with cooler temperatures and the associated decrease in glacial turbidity. Kokanee in glacial habitats can minimize the impacts of turbidity on incubation by delaying spawning, as has been documented in both tributary and lake-spawning Sockeye Salmon in Lake Clark, Alaska (Young 2005) and in Tustumena Lake, Alaska (Burger et al. 1995).

Traditional Ecological Knowledge (TEK) from members of the Native Village of Eklutna (NVE) indicate that historically there was a Sockeye Salmon run into Eklutna Lake before the hydropower project was constructed in 1929. It has been speculated that the kokanee in Eklutna Lake could be descendants of that historic Sockeye Salmon run. However, in their 2011 report, the USACE stated that it is unlikely that significant numbers of Sockeye Salmon ever spawned in the Eklutna River drainage due to limitations of suitable spawning area in tributaries upstream and in the littoral zone of the lake. The remaining available and suitable spawning area would likely not be sufficient to support large numbers of spawning anadromous salmon. In addition, the physical limnology studies of Eklutna Lake suggest that the turbidity in Eklutna Lake during much of the year is not conducive to significant primary production (USACE 2011). However, many significant Sockeye Salmon systems in Alaska are predominantly glacial fed, like Eklutna Lake. In some instances, Sockeye Salmon have been found to spawn and rear at great depths in glacial systems. While these systems are more turbid and not as conducive to significant primary production, they do support stable fish runs.

A recent study was conducted to determine "whether there was an anadromous salmon run into Eklutna Lake prior to 1929" by using marine-derived nutrients as a biochemical marker in lake sediment. The technique relies on the nitrogen isotopic analysis of well-dated lacustrine sediments. The study found that there was no significant difference in the nitrogen composition of sediment layers from before and after 1929. However, a sensitivity test was conducted to assess the possibility that a small salmon run may have gone undetected by the isotopic analysis. It was determined that a salmon run of up to 1,000 per year, and potentially as many as 15,000 per year, would be possible without noticeably altering the measured isotopic composition of the sediments in Eklutna Lake. Therefore, the results provide no evidence that such runs occurred, but do not preclude the possible existence of a relatively small Sockeye Salmon fishery in Eklutna Lake before 1929 (Loso et al. 2019).

Now that the lower dam has been removed, several stakeholders have requested that the Project Owners look at the possibility of providing the necessary flows and infrastructure that would be needed to restore fish passage into and out of Eklutna Lake.

1.4. Presence of IHN

Infectious Hematopoietic Necrosis (IHN) is a Rhabdovirus that affects salmon and trout. Susceptible species include Sockeye Salmon, kokanee, Chinook Salmon, Coho Salmon, Rainbow trout and others (Dixon et al. 2016). Larval fish are the most susceptible to the virus, becoming more resistant as they mature. Mortality in infected salmonid fry ranges from 60 – 95%, though this is highly variable (Kim et al. 2016). The IHN virus can survive in freshwater from three days to several months when the water temperature is between 8-14°C (Kim et al. 2016). Exposure time, and intensity of the shed virus influence transmissibility between individuals. Virus shed occurs through gills, the base of fins, feces, sexual fluids, and external mucus (Dixon et al. 2016).

One factor that may have management implications for the consideration of fish passage options is the potential presence of Infectious Hematopoietic Necrosis (IHN). In Alaska, infectious hematopoietic necrosis virus (IHN) is transmissible and potentially lethal to juvenile salmonids of other species (Emmenegger et al. 2000). Transmission between individuals occurs following the shedding of the virus in feces, urine, and external mucus and by direct or close contact with the surrounding water, entering fish at the base of the fins (Harmache et al. 2006). According to ADFG, kokanee in Eklutna Lake tested positive for the virus when last surveyed over 20 years ago. The positive identification of the IHN virus in the Eklutna lake kokanee population, reported as part of this study, may have implications for fisheries and water quality management in the basin.

1.5. Coordination with Native Village of Eklutna

The Native Village of Eklutna has conducted various habitat, fish utilization, and spawning surveys in tributaries inflowing to Eklutna Lake in 2021 and 2022. These studies provide important complimentary data to those data presented in this report. NVE has provided data on habitat mapping efforts in tributaries to Eklutna Creek including survey dates, substrate classifications, and observations of fish presence and behavior. These data have been included in this report where appropriate. NVE has indicated a plan to distribute a complete report of their work in Eklutna Creek in the fall of 2023.

1.6. Goals and Objectives

The goals of this study were to characterize the current aquatic habitat in Eklutna Lake and its tributaries and to begin to understand the current and potential future use of that habitat by fishes. In combination with objectives of the Eklutna Water Quality Study (Sauvageau and Schult 2023), the Eklutna Lake Fish Habitat and Utilization Study was designed to determine the existing conditions of fish species and habitat use in the lake and its tributaries and to determine the potential for those habitats to support spawning of ocean run Pacific salmon. To achieve these goals, this study has been subdivided into four tasks and associated objectives that were implemented between May of 2021 and October of 2022.

1. **Task 1**: Eklutna Lake Habitat and Fish Use: 2021
    a. Document potential spawning habitat for *O. nerka* (Sockeye Salmon and kokanee);
    b. Assess fish access to tributaries within the lake littoral zone; and
    c. Survey the composition of the fish community in the littoral zones of Eklutna Lake.
2. **Task 2**: Habitat and Fish Use in the Seasonal Pond: 2021
    a. Characterize the habitat and fish use of the seasonally isolated pond upstream of the existing dam and lake outlet.
3. **Task 3**: Eklutna Lake Tributaries: 2021-2022
    a. Characterize and document potential spawning habitat for *O. nerka*, Chinook (*O. tshawytscha)*, and Coho (*O. kisutch)* in the lower tributary reaches of small tributaries inflowing to Eklutna Lake (2021), the East and West Forks of glacially-fed Eklutna Creek, and clearwater Tributary 4.1, which inflows at the North end of the Lake.
    b. Characterize the current and potential use of major lake tributaries by salmonid fishes.

4. **Task 4**: Presence of Infectious Hematopoietic Necrosis (IHN) in resident Kokanee salmon population
    a. Collect samples of kidney and liver tissue from kokanee spawners at Eklutna Lake for IHN analysis by ADFG Fish Pathology Lab, Anchorage, AK.

It is notable that while we are focusing on the existing kokanee population given their relationship to the anadromous form of Sockeye Salmon, they should not be considered a direct surrogate for Sockeye Salmon. Habitat preferences, life cycles, spawning and migration timing, fecundity, and energetic demands all vary between the two, especially since year 1 studies on Kokanee in Eklutna Lake documented that the size range of Eklutna kokanee is only 4.5-6.5 in., which is significantly smaller than typically-size Sockeye Salmon from Alaska rivers (18-22 in).

1.7. Study Area

The area for this study includes the waters of Eklutna Lake and drainage area upstream of the existing dam. Three distinct habitat types present in the study area were surveyed: 1) Eklutna Lake; 2) the Seasonal Pond between the existing dam and the lake outlet; and 3) select tributaries to Eklutna Lake (Figure 1.7-1).

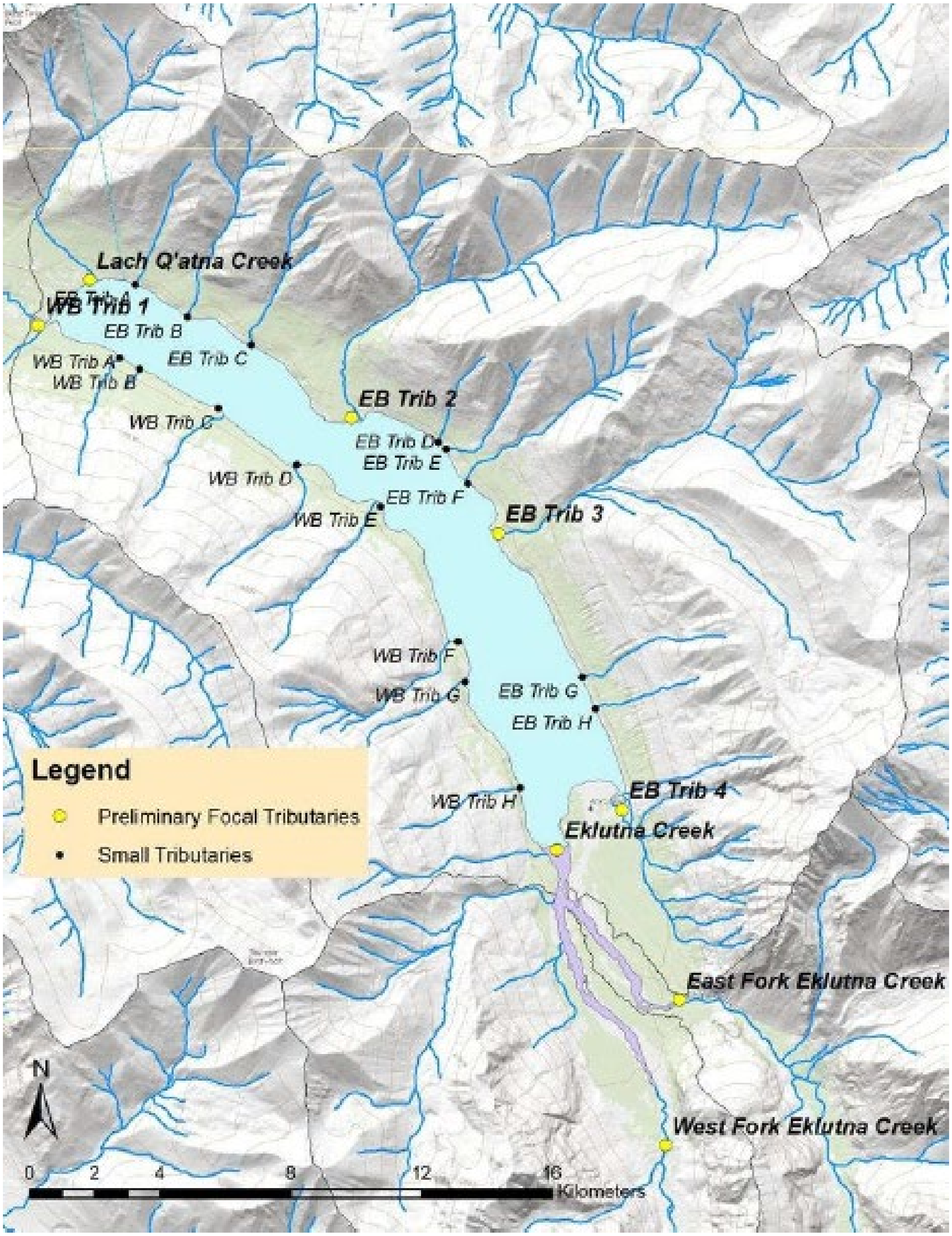

Figure 1.7-1. Eklutna Lake Study Area including primary tributaries (yellow dots), secondary tributaries (black dots).

1.7.1. Task 1 Study Area: Lake Habitat and Fish Use

The goal of Task 1 was to identify the areas of Eklutna Lake with the greatest potential for supporting fishes. Bathymetric mapping of Eklutna Lake in July 2016 (Praet et al. 2020) shows that a vast majority of the lake is greater than 30 m (100 ft) deep and, with the exception of a few areas, the shorelines drop off quickly and steeply (Figure 1.6-1). Thus, the shallower, nearshore areas in the northern and southern ends of the lake and clearwater areas associated with tributary input and associated alluvial fans were expected to be the areas with highest fish use. These preliminary areas of interest for fish habitat are depicted by ellipses in Figure 1.7-2.

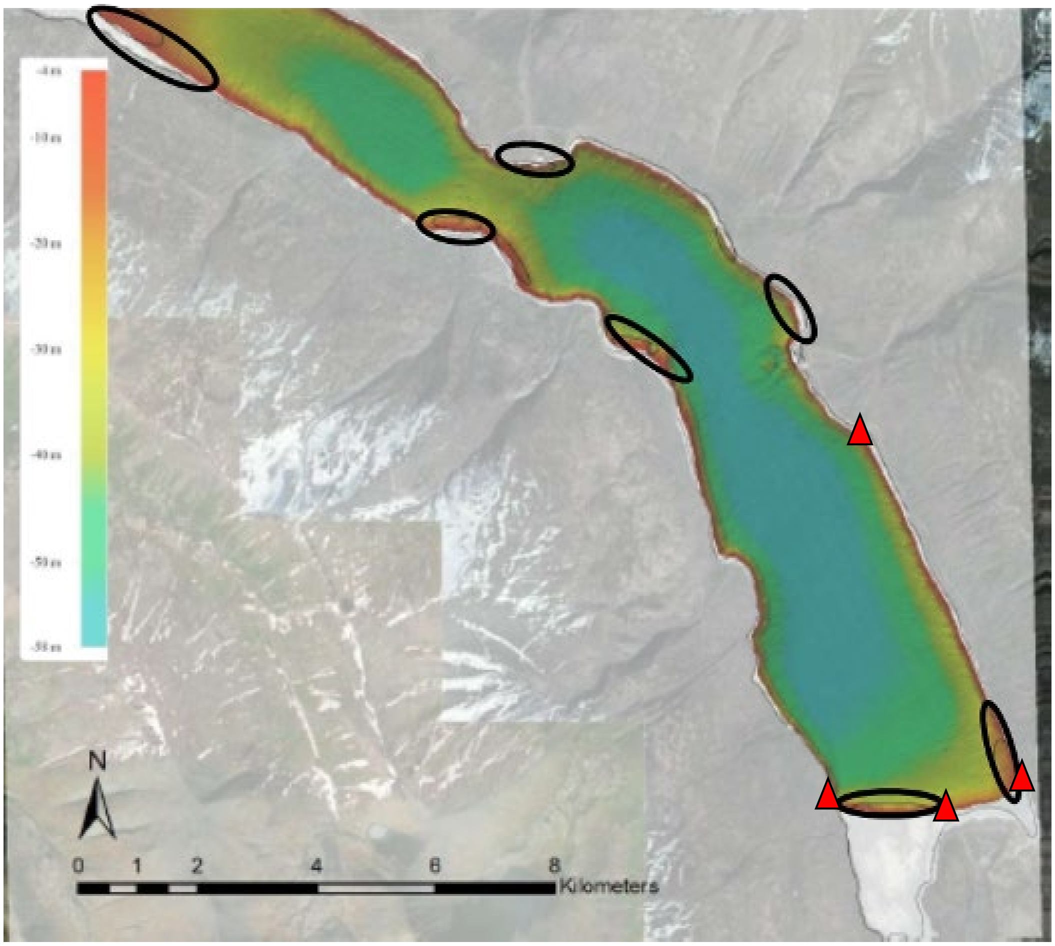

Figure 1.7-2. Eklutna Lake Bathymetry (Praet et al. 2020) and preliminary areas of study for 2021 habitat and fish use assessments (black circles). Red triangles indicate IHN sampling locations under Task 4.

1.7.2. Task 2 Study Area: Seasonal Pond Habitat and Fish Use

The objective of Task 2 was to characterize habitat availability and fish use in the pond that forms seasonally between the existing dam and the lake outlet when the lake level is below elevation ~860 feet (Figure 1.7-3). The pond is approximately 390 m (1,280 ft) x 35 m (115 ft). As it becomes disconnected from the main lake body (typically November to early-August), suspended glacial sediment settles out of the water in the pond. With increased water clarity, the pond has a greater potential for seasonal productivity. Additionally, one small tributary (sampled under Task 3) enters the seasonal pond from the south and has an associated alluvial fan of sediment at its outlet.

Figure 1.7-3. Aerial view of the Seasonal Pond between the existing dam and lake outlet. Contributing tributary is noted (blue line).

1.7.3. Task 3 Study Area: Eklutna Lake Tributaries

A preliminary list of eight tributary basins was selected for initial habitat evaluation based on drainage area, hydrography, aerial videography, and specific input from resource agencies. Three of the drainage basins are associated with glacial runoff from the Eklutna Glacier (East Fork of Eklutna Creek, West Fork of Eklutna Creek, and Eklutna Creek downstream of the confluence of the forks). Four of the remaining five tributaries enter the lake on the northeastern shoreline while one tributary enters the seasonal pond (see Task 2) from the south. These tributaries include the following and are depicted in Figure 1.7-1 (above):

- Unnamed Tributary 1 (enters the Seasonal Pond)
- Lach Q'atnu Creek (enters Eklutna Lake at campground parking area)
- Bold Creek (East Bank Eklutna Lake)
- Yuditnu Creek (East Bank Eklutna Lake)
- Unnamed Tributary 4 (and adjacent Trib. 4.1 entering Eklutna Lake at SE Corner)
- Eklutna Creek (Between Eklutna Lake and confluence of East and West Forks)
- East Fork Eklutna Creek (above confluence with West Fork)
- West Fork Eklutna Creek (above confluence with East Fork)

In 2021 and 2022, additional surveys of unnamed tributaries and clear water inputs that feed the East and West Forks of Eklutna Creek were performed to document habitat type and presence of resident fish in those areas including spawning of Dolly Varden (2021). The location of waterways explored in the Eklutna Creek watershed is presented in Figure 1.7-4 and include in part:

- West Fork Eklutna Creek – Serenity (West Fork Tributary) Creek (enters West Fork at RM 1.3)
- West Fork Eklutna Creek – Sidewall Tributary (enters West Fork at RM 3.2)

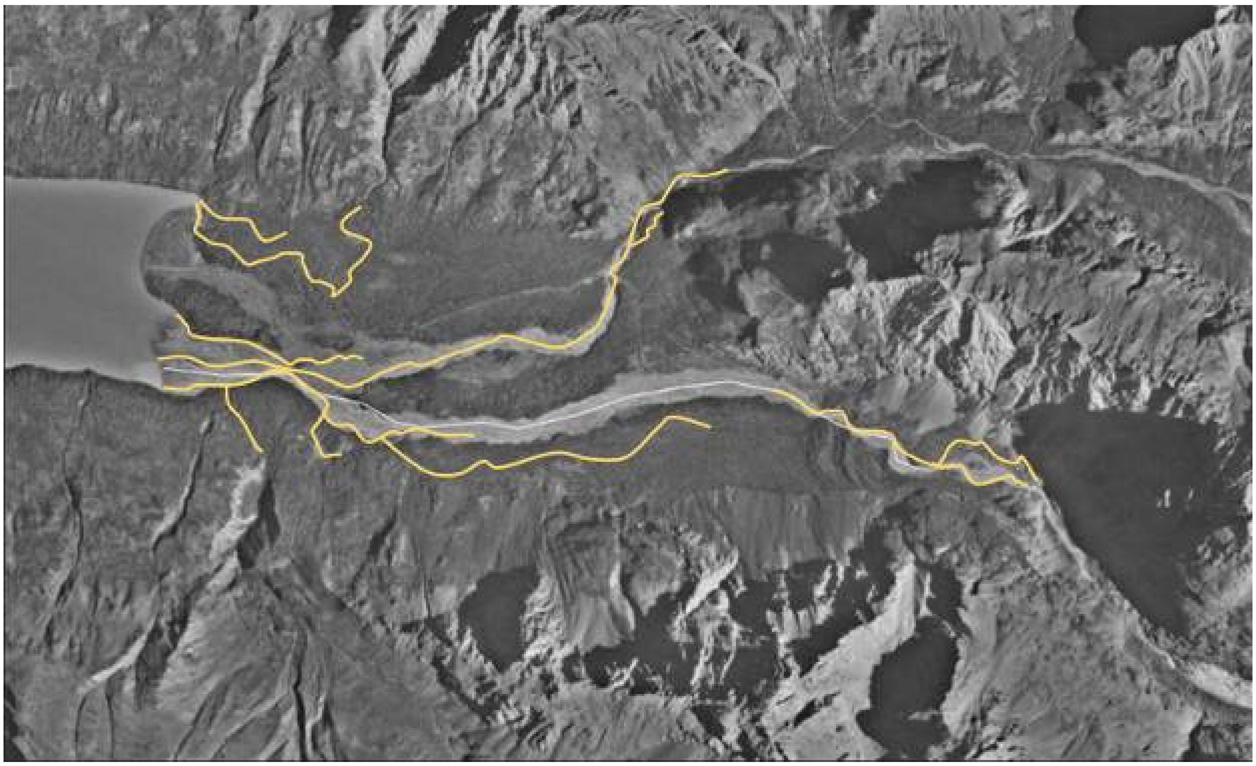

Figure 1.7-4. Location of small streams and clear water seeps that were surveyed for presence of fishes and habtiat type between 2021 and 2022. ***This map will be updated with input from NVE on their spawning surveys in 2022.*

1.7.4. Task 4 Study Area: IHN Presence in Eklutna Lake

The study area for collection of IHN samples in kokanee included shorelines of Eklutna Lake near the confluence with Eklutna Creek, Tributary 4/4.1 and along the East Bank of Eklutna Lake near the entrance with Yuditnu Creek (Figure 1.7-2).

2 METHODS

2.1. Task 1: Eklutna Lake Habitat and Fish Use

A reconnaissance survey was conducted in May 2021 to evaluate the preliminary areas of interest that were identified in the lake (Figure 1.4-2). During this survey, any potential salmon spawning habitats were identified and characterized. Basic physical habitat data were collected including a delineation of area (ft^2) and elevation (feet), slope (percent), pebble count (Wolman 1954, Kondolf 1992), and embeddedness (percent). The May reconnaissance coincided with low lake elevation allowing for identification of any littoral upwelling areas or springs that could be utilized at higher lake levels by late summer and fall spawning fish species (e.g., Dolly Varden and kokanee). Areas that appeared to have groundwater seepage or springs in the varial zone were delineated. All survey points were collected using a GNSS RTK rover and base station. This equipment allowed for precise collection of elevation, latitude, and longitude of each survey point, as well as adding a point-specific descriptor.

A total of 14 areas were surveyed for suitability of spawning habitat including presence of groundwater, total area of suitable substrate, substrate (pebble) size and embeddedness, and gradient at areas along both the East and West shores, and within the seasonal pond.

The Year 1 study focused on targeted sampling efforts in littoral areas identified as potential spawning habitat during the May reconnaissance survey and any additional areas observed with potential to support fish (e.g., tributary deltas, clearwater plumes, littoral habitats, and low-relief benches or shoals). Sampling to characterize fish utilization of Eklutna Lake took place in late July and October. During summer and fall sampling events, each potential spawning area was visited to collect depth and water quality data. Any visual observations of fish present and their behavior were documented.

The fish sampling was conducted with fyke nets, beach seines, and baited minnow traps. Fyke nets are passive, low stress methods for sampling the presence and relative abundance of juvenile and adult anadromous and resident fish (O'Neal 2007). Fyke nets are typically an effective gear type for capturing a wide range of species and life stages in littoral zone habitat. In general, a fyke net consists of a large hoop net with wings that act as funnels to direct fish into the network of hoops. A hoop net has a similar set up but lacks wings for directing fish into the net.

Fyke nets were deployed to collect fish in nearshore lake habitats. The fyke net was approximately 40 ft long and consisted of two rectangular steel frames (3 ft wide by 2.5 ft high) and four steel hoops, all covered by 0.25-in. Delta stretch mesh nylon netting. A 26-ft-long by 4.1-ft-deep leader net made of 0.33-in Delta stretch nylon netting was attached to a center bar of the first rectangular frame (net mouth). The throats, 4-6 in. diameter, were located between the second and third hoops. The net ended in a cod-end bag 8 ft. long with an 8-in. opening at the end, which was tied shut while the net was fishing (O'Neal 2007). Each fyke net was configured with two wings, set perpendicular to the shore, to guide fish to the net mouth. A live car located at the downstream end of the fyke net throat held captured fish until they were processed. Fyke nets were fished overnight for 16-24 hours and the net wings and live car were checked at least once a day while fishing to record and measure captured fish. The location of the net sets was mapped using a handheld Global Positioning System (GPS) receiver (latitude/longitude in decimal degrees in the WGS84 datum) and marked on high-resolution aerial photographs. Fyke nets were marked with ADFG Fish Resource Permit holder information.

Beach seines are an effective method to capture a range of fish species and life stages in a multitude of slow-water habitats. In addition, seining allows the sampling of relatively large areas in short periods of time as well as the capture and release of fish without significant stress or harm. Limitations to beach seining include fast flows, deep water, coarse substrates, and woody and organic debris (Hahn et al. 2007). Woody debris and boulders can create snags and lift the lead line allowing the fish to escape. Ideal habitats for beach seining are wadeable, slow moving water with level uniform substrate (e.g., gravel and/or sand). In wadeable systems, smaller nets are used and deployed by hand with one end of the net anchored to the shore and the other end extended out from shore and then looped around to encircle the fish as the ends are pulled in against the beach or gravel bar. With most seine sets, lead and cork lines should be withdrawn at approximately equivalent rates until close to shore. Once the lead line approaches the shore, it should be withdrawn more than the cork line until a secure pond or corral is formed in the bag of the net and the lead line is on the beach or gravel bar (Hahn et al. 2007). To the extent possible, the same area was fished during each sampling event; and net sizes and soak times were standardized. Care was taken during seining to avoid disturbance to gravels suitable for salmon spawning and spawning areas identified during Task 2 Adult Salmon Surveys.

Two sizes of beach seine were deployed. In areas with steep banks and water too deep to wade (3 ft.), a 6 ft. deep x 120 ft. long beach seine with 0.25 in. mesh was deployed from the work boat. One crew member held one end of the seine against the shoreline while a second person slowly backed the boat in an arc to enclose the desired sample area. Both people then worked together to pull the seine into the shore, keeping the bow of the net in deep water until crowded fish could be transferred to a bucket. In wadeable areas, a smaller seine 5 ft. by 14 ft with 0.25 in. mesh was used to sample fish. The short ends of this seine were attached to 6-ft. poles to provide rigidity—one person stood on the shoreline with the pole planted firmly in the substrate while the second person waded slowly in an arc, keeping the bottom edge of the seine as close to the substrate as possible. Both people then worked together to pull the seine into the shore, keeping the bow of the net in deep water until crowded fish could be transferred to a bucket.

Gee-type minnow traps (17.5 in. x 9 in. with 1 in. openings and ¼ in. mesh) were baited with salmon eggs that were commercially preserved and soaked (or disinfected with a 10-minute soak in a 1/100 Betadyne). Minnow traps were set in areas with cover or complex habitat to maximize catch and were set overnight for a period ranging from 16-24 hours. The number of traps deployed, and their locations were recorded. Trap retrieval lines were tethered to lake vegetation or a retrieval buoy and marked with fluorescent flagging that included a trap identification number and ADFG permit information.

Habitat at fish sampling locations was characterized in a qualitative, descriptive manner to denote sampling conditions. The following variables were measured: depth; temperature (°C, at surface, 5 m, and 10 m); dissolved oxygen (mg/L and percent saturation, at surface, 5 m, and 10 m); water clarity (Secchi depth, tenths of m); and turbidity (NTU) at the lake surface (Myre and Shaw 2006). If determinable based on visibility, the following three parameters were also assessed: substrate, vegetation, and cover. Additional sampling for lake productivity was completed by the Water Quality Study (Sauvageau and Schult 2023). The data collected by that study will be used to inform characterization of fish habitat as appropriate.

Lakeshore spawning surveys were completed from September 30 to October 4, 2021 and covered 5.8 miles of Eklutna Lake shoreline. Surveys were completed in areas where potential lakeshore spawning habitat was documented during habitat mapping in May 2021. Additional surveys were completed opportunistically in areas where spawning kokanee or carcasses were observed while boating slowly along the shoreline (see Study Area Figure 1.7-2).

2.2. Task 2: Seasonal Pond Habitat and Fish Use

The seasonal pond between the historic and current spillway was surveyed for available spawning habitat on June 1, 2021, during low reservoir elevation. Methods to characterize habitat and fish use in the seasonal pond were similar to the lake sampling methods. Physical habitat and potential spawning areas were evaluated during the May reconnaissance survey. In addition, Task 2 included visual observations of the littoral zone for macrophytes, large wood, and other types of cover. The seasonal pond was sampled for fish use on August 1, 2021, during the annual period when the pond was separated from Eklutna Lake.

The seasonal pond was sampled again using only minnow traps on October 2, 2021, during a period when it was fully connected to Eklutna Lake (lake elevation 863.88 ft.), and during the 25 cfs (cubic feet per second) study flow releases from Eklutna Lake into the Eklutna River. While the seasonal pond is generally connected to the lake during fall full reservoir, the lake elevation during test flow releases was especially high (864.2 ft. on 9/28).

2.3. Task 3: Eklutna Lake Tributaries

2.3.1. Potential Spawning Habitat in Lake Tributaries

An initial reconnaissance survey of the eight preliminary focal tributaries was conducted in May 2021 to determine which tributaries possess potential salmon spawning and rearing habitat. During this survey, potential salmon spawning and rearing habitat was identified and characterized. Basic physical habitat data were collected including an estimate of the area (ft^2), average water depth (nearest 0.1 m), gradient, pebble count (Wolman 1954, Kondolf 1992), embeddedness (percent), water quality data (Temperature [$^{\circ}C$], dissolved oxygen [mg/L and percent], and specific conductance [µs/cm]). Precise stream gradient was measured at selected east bank and west bank tributaries using an RTK-GPS, and barriers to access such as culverts, large wood/boulder steps, cascades, and other features were documented photographically and measured (see Study Area Figure 1-7.2).

For the four focal tributaries that did contain potential salmon spawning and rearing habitat, tributary connectivity in the lake varial zone was initially evaluated by characterizing the longitudinal profile, gradient estimates, and measures of thalweg depth. Tributary connectivity and fish access was reevaluated during subsequent survey events. The 16 smaller tributaries identified in Figure 1.4-1 (small black dots) were visited and photo documented in May to determine if any rearing or spawning habitat was present. None of these smaller tributaries (WB

A-H, and EB A-H) had suitable spawning habitat. Very steep and persistent gradient, and cascade/washing varial zones precluded fish access to any of these streams.

Fish sampling in the tributaries occurred in July/August and visual surveys for spawning fish occurred in May and October of 2021. During summer and fall sampling/survey events, each potential spawning area was visited to collect depth and water quality data. Any visual observations of fish present and their behavior were documented. Yuditnu Creek and Tributary 4 were surveyed in both spring and fall for the presence of spawning fish and redds, while Bold Creek was surveyed only in the spring, and Lach Q'atnu Creek and Eklutna Creek were surveyed only in the fall. Spring surveys were focused on rainbow trout while fall surveys were focused on Dolly Varden and kokanee. Surveys ranged in length from 492 to 5774 ft. and were focused on the lowest gradient section of the creeks above the varial zone upstream to a point where gradient, absence of spawning habitat, or fish passage barriers (i.e., culverts) made likelihood of spawning minimal.

In 2022, additional spawning surveys were completed in Tributary 4/4.1 and both forks of Eklutna Creek. Salmon spawning habitat surveys were conducted using methods established in the May 2021 FSP. Potential salmon spawning habitat in the study area was identified and characterized. Basic physical habitat data were collected including an estimate of the area ($m^{2)}$, average water depth (nearest 0.1 m, gradient (%), pebble count (Wolman 1954; Kondolf 1992), and embeddedness (%). Any visual observations of fish present and their behavior were documented.

Between September 28 and October 4, 2022, spawning and spawning habitat surveys were completed in accessible portions of Eklutna Creek and Tributary 4 and its east fork, Tributary 4.1, that were determined to be accessible to lake fish and totaled approximately 4.5 river miles. The East Fork of Eklutna Creek was surveyed to a point ~0.3 mi above the boulder cascade located about 0.75 mi above the ATV trail bridge. In 2021, the boulder cascade was plugged with large woody debris and appeared to be a potential barrier to migrating fish. In 2022, the cascade was free of large wood and did not appear to represent a significant barrier to passage. The gradient and substrate size did change at this location as the river enters a constricting canyon. The survey was continued approximately 0.3 mi past this point. Additional habitat information may be available from NVE 2022 habitat and spawning surveys that extended further upstream in the East Fork. NVE has indicated that this information will be available in spring of 2023.

The West Fork of Eklutna Creek was surveyed to a point approximately 0.3 mi above the end of the Eklutna Lakeside Trail. Similar to the East Fork, the Creek near this location has a steeper gradient (>5%), contains significantly larger substrates, and is constrained by steep canyon walls. Additionally, the river at this point is very glacially turbid (>100 NTU) and colder than is typically suitable for target species (Coho and Chinook salmon) that prefer a stream temperature range of (6°C – 12°C) for spawning. Tributary 4 and its branch (Tributary 4.1) was surveyed upstream approximately 1.2 miles until a point where accumulations of large wood, water depth under 0.1 m, and lack of solid gravel substrate suggested an end of potential spawning habitat. A portion of the East and West Forks were omitted due to inaccessibility for survey crew and safety concerns., though the gradient and substrate at interim points were similar to the surveyed lower portions and are accessible to potential ocean-run fish. Both surveys were continued upstream to a point when the forks entered a narrower canyon likely to result in changes in substrate and gradient (Figure 2.3-1). Habitat characteristics including substrate size, gradient, channel complexity, and embeddedness, were measured at 12 locations throughout the East and West Forks of Eklutna Creek (Figure 2.3-2).

Figure 2.3-1. Potential spawning habitat and spawning surveys completed in September/October of 2022.

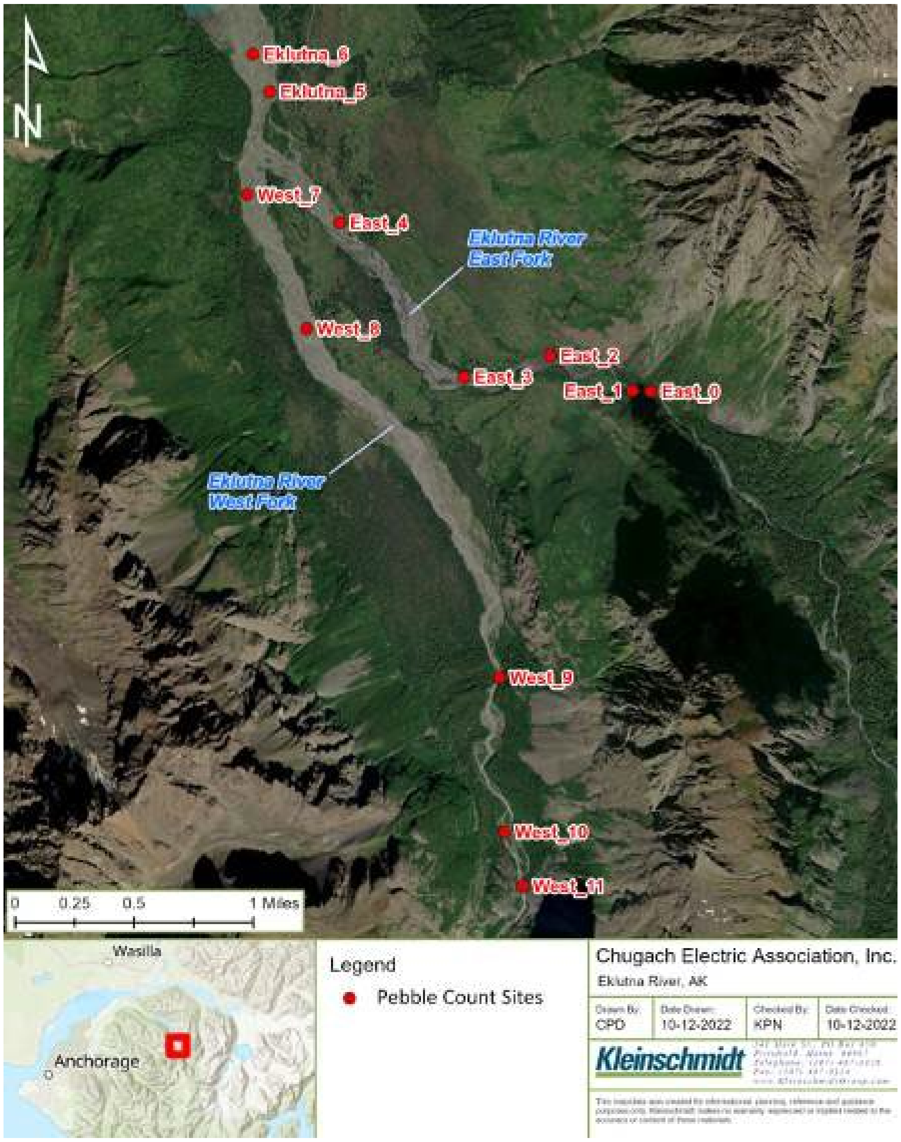

Figure 2.3-2 Spawning habitat substrate assessment (pebble count) sites in East and West Forks of Eklutna Creek, 2022.

2.3.2. Current and Potential Fish Use in Lake Tributaries

To document tributary fish presence and habitat use, sampling of 40x wetted channel width in each tributary occurred during the July/August survey with a minimum sample length of 328 ft. meters and maximum of 1,312 ft. The starting location for each tributary was estimated by the stream/lake elevation at full pool. Additional qualitative sampling for fish presence in the tributary mouth/tributary extent between full pool elevation and the elevation of Eklutna Lake at the time of sampling occurred using electrofishing.

Each tributary identified as potential fish habitat was sampled using single-pass backpack electrofishing and baited minnow traps. Electrofishing and minnow trapping were implemented together in as many habitat types as possible. Electrofishing is effective for a wide range of fish species, life stages, and habitat types (Temple and Pearsons 2007). Electrofishing can be an effective technique in habitats that are not easily sampled by traps or nets, especially for benthic fish (e.g., sculpin) or species that hide in undercut banks (Temple and Pearsons 2007); however, electrofishing does have some limitations and can be harmful if not conducted properly.

Use of electrofishing as a fish capture technique is tightly regulated by ADFG. ADFG-recommended target voltage settings for juvenile salmonid sampling in cold water were used as a reference at the onset of sampling (Bales and Geifer 2015). Electrofishing may not be effective in some glacial systems subject to high turbidity and low conductivity (Temple and Pearsons 2007). Suspended materials in turbid water can affect conductivity, which may result in harmful effects on fish, especially larger fish due to a larger body surface in contact with the electrical field. All backpack electrofishing procedures were followed in the NMFS (2000) Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act to avoid any harm to stream fishes.

A Smith-Root LR-24 backpack electrofishing unit was operated by a trained field crew leader and assisted by one or two people with dipnets. Each backpack unit was equipped with a standard Smith-Root cathode and a single anode pole with a steel ring. Single-pass electrofishing surveys were conducted through the selected tributary reach moving in an upstream direction. All stunned fish were captured with dipnets away from the electric field and held in buckets for later processing. Backpack electrofisher settings were determined in the field based on water quality conditions, professional judgment, and the overall goal of minimizing impacts to fish health (Temple and Pearsons 2007). Prior to electrofishing, ambient water chemistry was recorded including specific conductance (µs/cm), turbidity (NTU), and surface water temperature (°C) with a digital meter at the downstream end of the sampling site to help determine initial backpack electrofishing unit settings. In all cases, the electrofishing unit was operated and configured with settings consistent with guidelines established by the manufacturer (Smith-Root 2009), ADFG (Bales and Giefer 2015) and NMFS (2000). Personnel operating electrofishing units were trained and certified per ADFG permit requirements. The location of each electrofishing unit was mapped using hand-held GPS units and marked on high-resolution aerial photographs. Start and stop times and total effort (seconds) for the electrofishing survey was recorded to quantify and standardize sampling effort between surveys and across seasons.

Gee-type minnow traps (17.5 in. x 9 in. with ~1 in. openings and ¼ in. mesh) were baited with salmon eggs that were commercially preserved (or disinfected with a 10-minute soak in a 1/100 Betadyne) and soaked overnight at a density of > 1 trap/20 m sample length. Distance between traps depended on habitat complexity and traps were set more densely in complex habitats with appropriate depth (Bryant 2000). Minnow traps were set in habitats with slow water and/or cover to maximize catch and were left overnight for a period ranging from 16-24 hours. The number of traps deployed, and their locations were recorded. Trap retrieval lines were tethered to streamside vegetation or staked and marked with florescent flagging that included a trap identification number and ADFG permit information.

Fish collected within each habitat unit were counted and processed separately and to the extent possible. Fish were identified to species, measured for fork length (mm), and released alive near the point of capture. The resources “Field Identification of Costal Juvenile Salmonids” by

Pollard et al. (1997), and "Juvenile Salmonid and Small Fish Identification Guide" by Weiss (2003) was used for field verification of juvenile salmonid species. Sculpin were recorded as "*Cottus* sp." A dip net was used when removing fish from holding buckets for measurement. Hands, dip nets, and measuring boards were wetted before contacting fish. Length measurements were taken on a clean, smooth wet PVC cradle with easy-to-read gradations in millimeters. Ancillary data including fish condition, sex, spawning coloration, and any injuries or mortality was recorded on field forms.

At the time of sampling, the following water quality parameters were collected for each tributary: temperature (°C), dissolved oxygen (mg/L and percent saturation), and specific conductance (µs/cm) using a calibrated multiparameter probe. Water visibility (tenths of meters) was estimated using a survey rod and turbidity (NTU) was estimated using a turbidity tube (Myre and Shaw 2006). To allow for an evaluation of fish use of habitats, a standard suite of physical habitat data and descriptive information was collected where fish sampling occurred. These parameters have been modified from the U.S. Forest Service (USFS) Aquatic Habitat Tier One survey (USFS 2001, Chapter 20). Channel morphology characteristics for each survey reach were documented at a single channel riffle, or where no significant side channels were present, and included:

- Channel type
- Channel pattern
- Average bankfull width
- Bankfull maximum depth
- Water surface gradient
- Riparian vegetation
- Location/type area of off-channel habitats
- Width and statue of side channels

Individual habitat units that fell within the survey reach and were greater than 33 ft. in length were delineated. Habitat types were classified as followed: backwater pool (PL-bw), scour pool (PL-sc), beaver pond (BP), glide (GL), riffle (RF), boulder riffle (BR), rapid (RP), chute (CH), cascade (CS), falls (FS) dry channel (DC), and puddled (PD) (Appendix 1). Photographs of representative habitat as well as any special habitat features were taken at each survey reach. For each habitat unit the following data were collected:

- Unit type and number
- Unit length (m)
- GPS location of upstream and downstream endpoints (latitude/longitude using WGS84 datum)
- Average wetted width (m) based on 3 measures
- Average wetted depth (m) based on 3 measures
- Maximum pool depth (m) if applicable
- Modified Wentworth substrate composition (%) Table 2.3-1.

Table 2.3-1. Modified Wentworth scale for substrate size classifications.

Substrate Description	Size Class (Metric/Imperial)
Fines	<2 mm / <0.1 in.
Small Gravel	2-16 mm / 0.1 – 0.6 in.
Large Gravel	16–64 mm / 0.6 – 2.5 in.
Small Cobble	64-128 mm / 2.5 – 5.0 in.
Large Cobble	128-256 mm / 5.0 – 10.0 in.
Boulder	>256 mm / > 10.0 in.
Bedrock	Bedrock

2.4. Presence of Infectious Hematopoietic Necrosis (IHN)

IHN samples were collected under guidance provided by ADFG and using methods described by Laurin et al. (2020). Fresh moribund post-spawned kokanee were collected along the shorelines of Eklutna Lake where spawning was observed in 2021. Kidney and liver tissue were removed aseptically, and all tools were rinsed in 70% isopropyl alcohol. Tissue samples were placed in individually labeled 2-ounce (oz.) Whirl-Pak bags, labelled and stored under refrigeration. Samples were transported within 24 hours to the ADFG Fish Pathology Laboratory (Anchorage, Alaska) for processing.

2.5. Data Management and QA/QC

The goals of data management were to establish a data quality assurance/quality control (QA/QC) protocol to be applied at logical stages of data collection and processing and to ultimately create a database of all QC'd fish composition and distribution data collected for the Eklutna Project. Five levels of QC (QC1 to QC5) were completed to govern data collection efforts and ensure a rigorous and high-quality product. Each QC level is tracked either within tabular datasets (Excel and database tables), or within file path names (as for raw field data files). This allows for quick determination of the QC status of all data. A data dictionary describing the database entities and attributes was compiled to accompany the database and to provide an understanding of data elements and their use by anyone querying or analyzing the database deliverable to be provided in 2023 following completion of all data collection and analysis. All original field data will be preserved during the QA/QC process as well as complete documentation of any adjustments (e.g., conversion of units) or qualifiers as to the appropriate use of data for analysis.

The five QC documentation steps were as follows:

- **Q1 Field Review**: Review of field forms before leaving the field, or the QC level of raw data collected via field equipment such as cameras, GPS units, etc. The goal of QC1 was to identify errors and omissions and correct them under similar field conditions prior to leaving the field. Review was done on 100% of data and includes completeness, legibility, codes, and logic on all information recorded. This was typically completed in the field daily. Paper and electronic field forms were backed up nightly in the field by scanning and downloading to a storage unit or photocopying to paper.

- **QC2 Data Entry**: Data from paper forms was entered (or downloaded from tablets) into an electronic format and verified by a second party against the field forms. The goal of QC2 was to verify correct, complete, and consistent data entry. Verification was done on 100% of data entered and includes extrapolation of shorthand codes that might be used in the field into longhand or standard codes during data entry.
- **QC3 Senior Review:** Final review by senior professional before submitting field data, or the QC level of raw data cleaned up for delivery. Data were reviewed by a senior professional on the consultant team, checking for logic, soundness, and adding qualifiers to results if warranted. Calculated results such as average lengths, spawning area, relative abundance, etc. were added at this time.
- **QC4 Database Validation**: Tabular data files were verified to meet project database standards. Data were verified for completeness, project standards (codes, field name conventions, date formats, units, etc.), calculated and derived fields, QC fields, etc. The data files were incorporated into the project database schema, splitting into normalized tables as necessary, and all primary and foreign keys checked.
- **QC5 Technical Review**: Data revision or qualification by senior professionals when analyzing data for reports. Data calculations were stored with the data. QC5 may be iterative, as data are analyzed in multiple years.

3 RESULTS

3.1. Task 1: Eklutna Lake Habitat and Fish Use

3.1.1. Water Quality

Temperature (°C) and turbidity (NTU) were measured at all sample sites and habitats of Eklutna Lake. Water temperature in Eklutna Lake ranged from 1.0°C in early spring to 15°C in mid-summer with a mean of 8.8°C. The seasonal pond ranged from 8.1°C – 14°C with a mean of 11°C, while the tributaries ranged from 1.9°C (upper West Fork in October) to 12°C (Eklutna Creek in August) with a mean of 6.5°C.

Turbidity in Eklutna Lake ranged from 7 – 70 NTU (n=29 samples) over the 2021 season from June – October. The seasonal pond turbidity ranged from less than 7 – 60 NTU (n=4 samples). Eklutna Creek, sampled over the course of 2022 ranged from less than 7 NTU in early spring to over 250 NTU during the highest summer flows (and associated higher rate of glacial melt) (Figure 3.1-1).

Figure 3.1-1. West Fork Eklutna Creek just above the confluence with the East Fork showing turbidity and inflowing left bank tributary with steep entrance.

3.1.2. Lake Spawning Habitat for *O. Nerka*

In late May and early June 2021, dewatered shorelines in the varial zone of Eklutna Lake were surveyed for suitability to support spawning of kokanee with focus on those areas identified by Eklutna Lake bathymetry from Praet et al. (2020) as appropriate based on slope (see Figure 1.4-2, above). Additional areas were surveyed where seeping groundwater or potentially suitable substrate was observed (Figure 3.1-2).

Figure 3.1-2. Groundwater seepage in varial zone of Eklutna Lake at WB Tributary D (61.38470ºN, -149.07747ºW) on June 3, 2021.

Within the 14 areas surveyed, 68,512 square ft. of potential spawning habitat was identified around the lakeshore and pond with mean pebble size range from 0.4 – 1.2 in. and mean embeddedness ranging from 32 – 68%. The shoreline gradient was variable with some areas as shallow as 2.5% while others were in excess of 25%. Characteristics of each surveyed spawning area are presented in Table 3.1-1, and all visualized RTK data, site photos, pebble size distribution, and other site notes are provided in detail in Appendix 2.

Table 3.1-1. Survey results for varial zone spawning habitat assessment (June 2021) at Eklutna Lake east and west banks (EB and WB), and at the seasonal pond (Pond). See Appendix 2 for further detail.

Varial Zone Spawning Areas	Spawning Area (ft^2)	Mean Pebble Count (in)	Mean Embeddedness (%)	Gradient (%)	Groundwater
WB Varial Bench 1	5741.5	1.31	37.5	3	present
WB Varial Bench 2	4042.6	1.16	67.5	5	present
WB Varial Bench 3	7168.8	0.88	52.5	10	present
WB Varial Bench 4	2583.3	0.53	40	25	present
EB Varial Bench 1	7970.9	0.48	35	2.5	dry
EB Varial Bench 2	2852.9	1.11	50	7	dry
EB Varial Bench 3	2310.2	0.76	65	14	present
EB Varial Bench 4	15367.8	1.06	40	5	dry
EB Varial Bench 5	3092.0	0.62	37.5	5	dry
EB Varial Bench 6	9570.9	0.47	55	16	present
Pond Varial Bench 1	4961.7	0.44	35	20	dry
Pond Varial Bench 2	11341.2	0.71	32.5	5	dry

3.1.3. Lake Spawning of *O. Nerka*

During lake shore spawning habitat surveys, water temperature ranged from 8.5-8.6°C and turbidity was relatively low (<10 NTU) but still precluded observation of lake substrates at depths greater than 6-8 ft. A total of 331 spawned-out kokanee were observed during the survey period including several fish that were in the process of expiring in shallow shoreline areas. Dead fish were washed up along the shoreline in areas with small gravel and a gently sloped bank. No fish were observed in shoreline areas at the north end of the lake where grass and other vegetation is inundated, and the substrate is heavily sedimented. Kokanee were likewise not observed in areas with very large and angular rock or steep drop-offs into very deep water. No redds were observed in areas where carcasses were found.

Spawned kokanee ranged from 4.5-6.5 inches and included both males and females. A portion of observed fish were dissected to verify maturation stage of gonads. Both fully mature eggs and milt were observed in spawned-out fish (Figure 3.1-3). No sexual dimorphism or typical *O. nerka* spawning coloration was observed. Approximately 100 caudal fins were collected for genetic analysis by ADFG Genetics Laboratory in Anchorage, Alaska.

Figure 3.1-3. Kokanee carcasses collected on October 1, 2021 on Eklutna Lake shorelines near 61.39104ºN, -149.05747ºW. Mature eggs were removed from several carcasses (lower left). Eroded anal and caudal fins were indicative of spawning activity. *Inset* shows typical aspect of observed carcasses.

3.1.4. Fish Access to Eklutna Lake Tributaries

West Bank tributaries A-H were high-gradient, narrow, appeared impassible from the lake, and had substrate unsuitable for fish spawning. Many were ephemeral and did not maintain water throughout the season. Figure 3.1-4 shows the elevation profile and photograph for West Bank Tributary B which is typical of tributaries on the West Bank of Eklutna Lake. Figure 3.1-5 shows the elevation profile of all RTK-surveyed tributaries, not including Eklutna Creek for which an elevation profile was not collected. No fish were observed in any West Bank tributaries.

Figure 3.1-4. Visualized RTK data (left) of stream surface elevation for West Bank Tributary B and photograph (right) of tributary aspect and gradient. Data collected June 3, 2021.

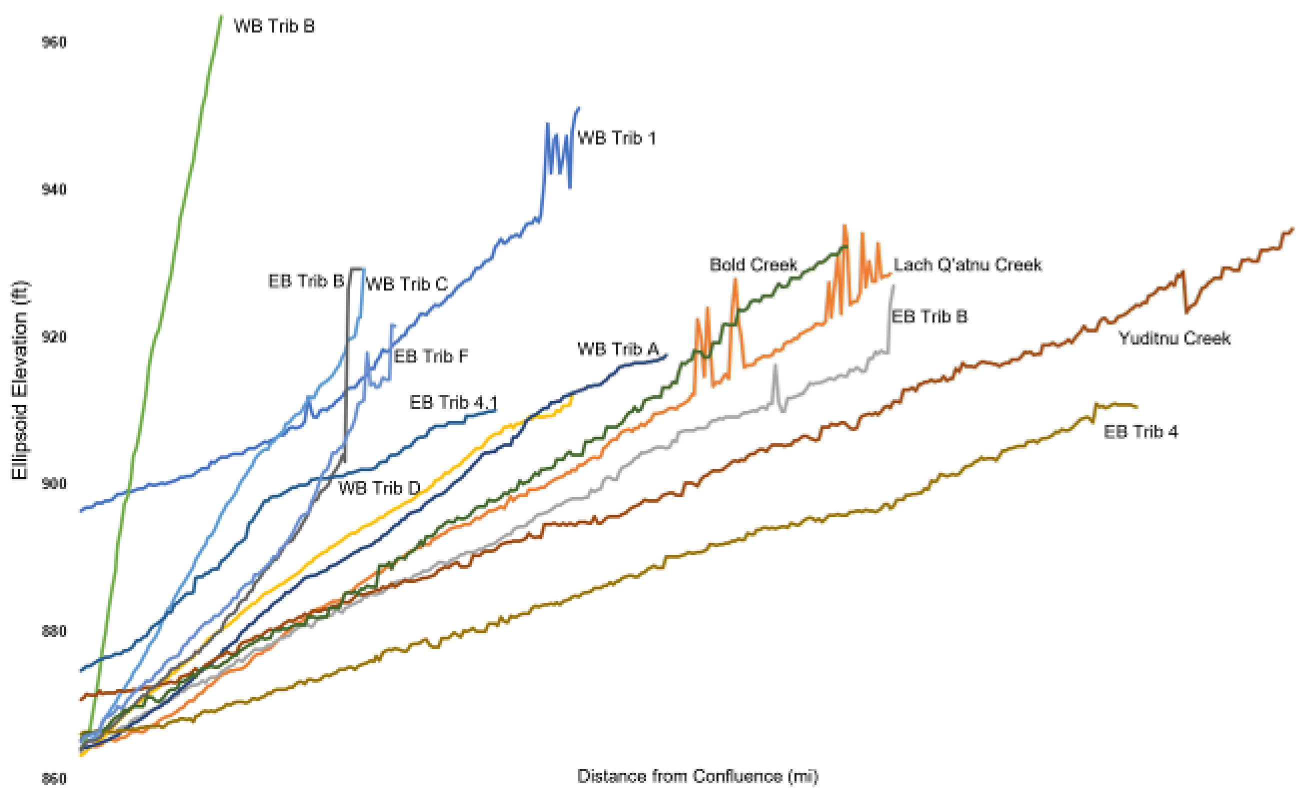

Figure 3.1-5. Tributary elevation profiles relative to distance from confluence with Eklutna Lake. Data does not include Eklutna Creek. Data collected 2021.

While some of the tributaries on the East Bank of Eklutna Lake including Lach Q'atnu Creek, and Yuditnu Creek were found to support resident populations of Dolly Varden in their lower reaches, access to these creeks from the lake presents a substantial challenge for lake fish. Data indicate that at low reservoir elevations, there would be no access to these creeks as the varial zones were steep, shallow, and characterized by swift water cascades. Even at full pool, steep gradient, shallow water, and debris obstacles indicate that fish access may be limited, and fish size may be an important factor in successful access. Figure 3.1-6 shows the transition from the top of the varial zone at Lach Q'atnu Creek to the low-gradient bench (2-5%) that extended approximately 0.9 mi. from the varial zone to the base of the hillslope where the gradient increased significantly. Pebble size ranged from 0.31-1.53 in. with mean embeddedness of 45%, and mean thalweg depth of 4 in. Access to much of this 0.9 mi. of habitat was further restricted by the presence of paired 3.5-foot diameter culverts where Eklutna Lake Road crosses Lach Q'atnu 750 feet from the confluence with Eklutna Lake (Figure 3.1-6).

Figure 3.1-6. Lach Q'atnu Creek transition from varial zone to low-gradient stream (left) and paired culverts 250 meters from the location lake. Photos from September 30, 2021.

Three tributaries to Eklutna Lake had unobstructed fish access throughout the year, resident populations of Dolly Varden, and potential spawning habitat—Tributary 4, Tributary 4.1, and Eklutna Creek. Tributary 4 (and adjacent Tributary 4.1) flowed through the low-gradient bench moraine within the floodplain of Eklutna Creek and entered the southeast end of the lake at the end of a deep slough impacted with large woody debris. Tributary 4 was a clearwater tributary (turbidity <7 NTU) that received water from several steep rivulets on the west slopes of the mountains. Pebble size ranged from 0.23-0.98 in. with low embeddedness (mean = 30%). The average thalweg depth was 12 in. with a maximum measured gradient of 3% and mean wetted width of 14.5 ft. A pair of culverts with a 0.65 ft. drop separates the lower 800 feet of Tributary 4 (and Tributary [Trib] 4.1) from the upper creeks where the majority of the potential spawning habitat exists. During spawning surveys in October 2021, numerous Dolly Varden were observed spawning both above and below the culverts (See Section 3.3.2). In 2022, spawning kokanee were observed in Tributary 4.1 below the culverts (See Section 3.3.3 below).

The confluence of Eklutna Creek with Eklutna Lake was a wide, braided gravel delta over 2,200 ft. wide with numerous channels providing unobstructed access to fish. Eklutna Creek extended approximately 1.1 mi. from Eklutna Lake before splitting into East and West Forks. There were various small tributaries entering both forks of Eklutna Creek with low-gradient (<3%) access points and available rearing and spawning habitat including Serenity Creek and West Fork Sidewall Tributary. Fish use of these habitats is discussed in Section 3.3, below.

3.1.5. Fish Community in Littoral Zones of Eklutna Lake

Baited minnow traps and seining were the most effective sampling methods in the lake shallows and resulted in capture of 156 fish including Dolly Varden, rainbow trout, and kokanee. Dolly Varden were the most commonly encountered and most abundant fish species ranging from emergent fry (33 mm) to adults (228 mm). The size range of rainbow trout was 60-135 mm, and kokanee 44-104 mm. All three species were captured in multiple size classes, as indicated in Figure 3.1-7, though only Dolly Varden size distribution could be distinguished in age-classes, four in lake samples and three in tributary samples (all tributaries combined).

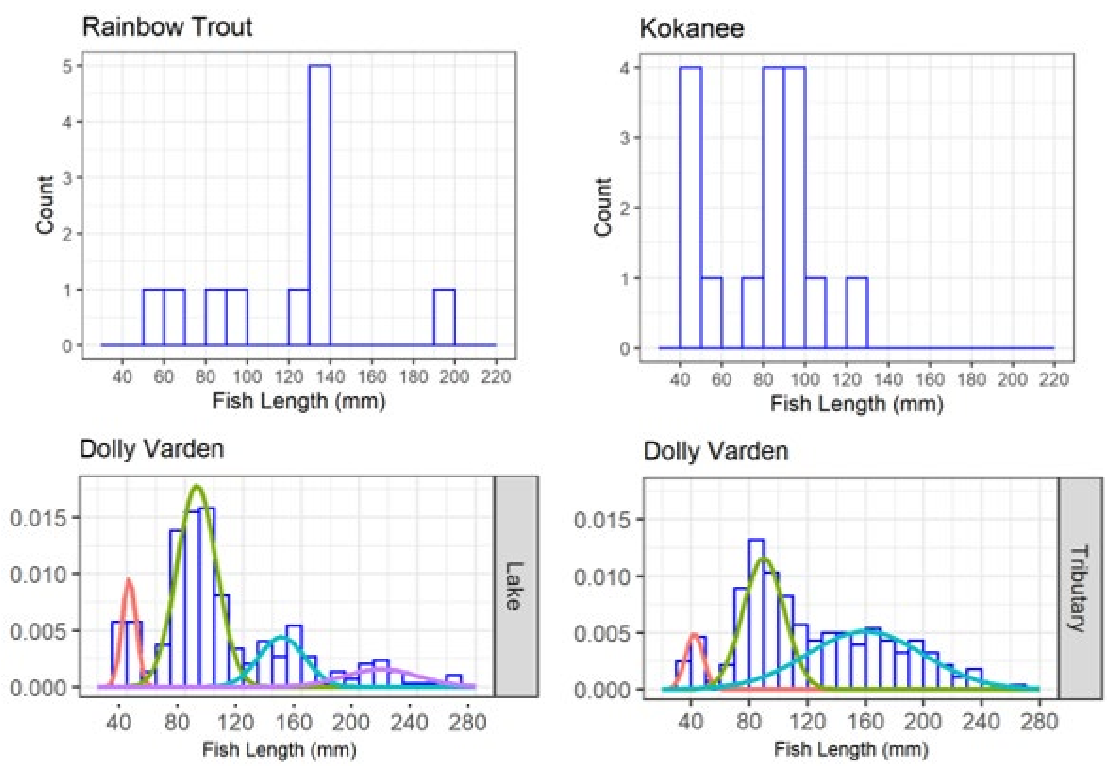

Figure 3.1-7. Length distribution of fish species captured in the littoral zone of Eklutna Lake including rainbow trout (n=11), and kokanee (n=16) by count. Dolly Varden length distribution represented as Density. Sampling locations include shorelines near the outflow of Yuditnu, Bold, and Eklutna Creeks, and Tributaries 2-4.

The delta of Eklutna Creek had the greatest abundance of juvenile fish with the most size classes represented as compared to all other sampling locations. Seining in the shallow mixing zones, where very turbid (>120 NTU) Eklutna Creek water mixed with the less turbid (<10 NTU) lake water and depth was under 3.5 ft. produced the greatest catch per unit effort (CPUE). Catch rate and abundance at other sampling areas was comparatively less (Table 3.1-2). A repeated seining event at this location in October during low-flow, less turbid conditions resulted in capture of only a few Dolly Varden.

Table 3.1-2. Fish capture data for sample areas of Eklutna Lake where fish were captured using a combination of seines, fyke net, and baited minnow traps. Data are mean total fork length (mm) and sample size (n), reported for July and October 2021.

Fish Distribution	Kokanee, mm (n)	Rainbow Trout, mm (n)	Dolly Varden, mm (n)
Eklutna Lake @ Bold Creek	-	-	120.0 (2)
Eklutna Lake @ Eklutna Creek	92.7 (12)	131.0 (1)	78.1 (121)
Eklutna Lake @ Yuditnu Creek	-	88.4 (5)	102.8 (30)
Eklutna Lake @ North End	97.5 (2)	-	154.1 (9)
Eklutna Lake @ WB Trib G	53.0 (1)	124.0 (2)	101.0 (6)
Eklutna Lake @ WB Trib E	53.0 (1)	131.0 (1)	123.1 (25)

3.2. Task 2: Seasonal Pond Habitat and Fish Use

3.2.1. Habitat and Fish Use of Seasonal Pond

A potential kokanee spawning area of approximately 160 ft x 49 ft was identified on the east shoreline of the seasonal pond (Figure 3.2-1). Pebble size of the substrate ranged from 0.27-1.06 in., though a large proportion of fine sediment and sand resulted in mean embeddedness for the area of over 50%. No groundwater seepage or upwelling was observed.

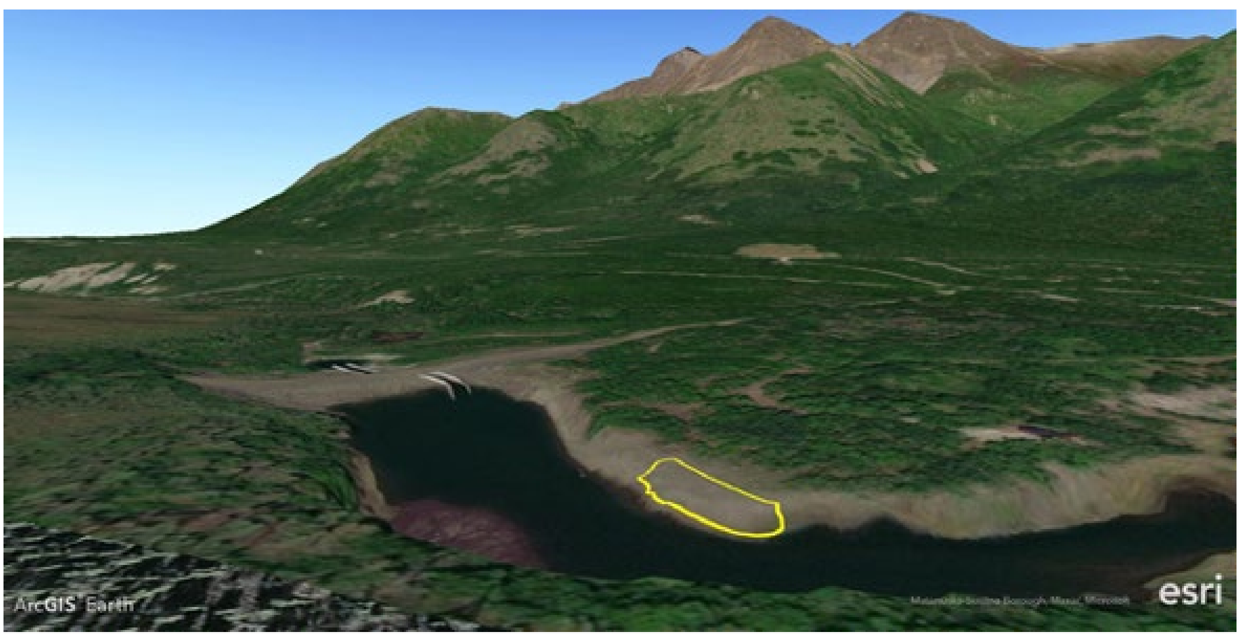

Figure 3.2-1. Seasonal Pond potential spawning area (yellow polygon) from RTK survey. Substrate sampling indicates suitable size but high embeddedness of substrate.

During the first summer sampling event when the pond was not connected to Eklutna Lake (Figure 3.2-2) the combination of minnow traps, active seining, and fyke nets resulted in capture of one rainbow trout (200 mm), one kokanee (125 mm), and 48 Dolly Varden in the pond, ranging in size from 88--270 mm. This size range is notably skewed toward larger fish with few if any young-of-year relative to fish collections from the littoral zone of Eklutna Lake where Dolly Varden ranged from 33-225 mm.

Figure 3.2-2. Seasonal Pond shown disconnected from Eklutna Lake (background) on August 1, 2021 including deployments of a fyke net (right) and buoy-supported minnow trap (left).

No fish were captured or observed during the second pond fish sampling event in October. Furthermore, no fish were captured or observed at the north end of Eklutna Lake on either side of the connecting inlet from the pond in the fall.

3.3. Task 3: Eklutna Lake Tributaries

3.3.1. Potential Spawning and Rearing Habitat for Salmonids in Tributary Reaches

Most west-bank (WB) tributaries (A-H) and east-bank (EB) tributaries (A-H) were not accessible from the lake, even when revisited during full reservoir conditions in the fall (Figure 3.3-1). Yuditnu and Bold Creeks, Tributary 4, Eklutna Creek, the West Eklutna Creek Sidewall Tributary, and Serenity Creek (a tributary to West Fork Eklutna Creek) were found to be accessible from the lake, and to contain spawning and rearing habitat suitable for salmonid fishes. Dolly Varden were observed in each of those aforementioned creeks. Table 3.3-1 shows the surveyed spawning habitat, pebble counts, and accessibility of surveyed tributaries to Eklutna Lake in 2022.


Figure 3.3-1. (LEFT) Inaccessible entrance to WB Trib F. Steep gradient (20%) and shallow cascade without plunge pools to facilitate access results in inaccessible status for spawning and rearing. (RIGHT) Low-gradient potential spawning habitat above the culvert on Tributary 4.

Table 3.3-1. Tributary spawning and rearing habitat and access assessment completed in May 2021 for named and unnamed east-bank (EB) and west-bank (WB) tributaries to Eklutna Lake. W. Eklutna Sidewall Tributary and W. Eklutna Serenity Creek are tributaries to West Fork Eklutna Creek, not Eklutna Lake directly.

Tributary	Spawning Area (ft^2)	Ave. Pebble size (in)	Ave. Embedded. (%)	Gradient (%) < varial zone	Lake Accessible	Fish Observed
WB Trib A, B, C, D	0.0	-	-	15, 14, 20, 14	no	
WB Trib E	0.0	-	-	4	no	
Lach Q'atnu Ck.	7319.0	0.92	45.0	3.5	marginal (culvert)	Dolly Varden
Pond Tributary	334.0	0.35	40.0	3.5	no	
EB Trib B	0.0	-	-	9	no	
EB Tribs C, D, G, H	0	-	-	32, 31, 38, 36	no	
EB Trib F	0.0	-	-	2	no	
Yuditnu Ck.	1101.0	0.82	25.0	3	marginal	Dolly Varden
Bold Ck.	0.0	-	-	12	no	
Tributary 4	-	0.59	32.5	3	yes (culvert)	Dolly Varden
E. Fork Eklutna Ck	-	-	-	-	Yes	Dolly Varden
W. Fork Eklutna Ck.	-	-	-	-	Yes	Dolly Varden
-W. Fork Tributary	10611	0.57	55.0	1	yes	Dolly Varden
-W. Eklutna Serenity		1.57	55.0	1	yes	Dolly Varden

In 2022, additional spawning surveys were completed on Eklutna Creek East and West Forks and in Tributary 4 and 4.1. Both forks of Eklutna Creek have braided channels with extensive exposed gravel bars that appear to be dynamic and contain substrates ranging from small gravel to large cobble and bedrock (Kondolf 1992). In some areas, side channel and off-channel habitat complexes were found including sheltered vegetated alcoves, backwaters, and shallow pools with predominantly small gravel substrates. In 2021, rearing and spawning Dolly Varden were documented in these areas, and in 2022, a small number of spawning kokanee were observed in this habitat type in the lower mainstem of Eklutna Creek (see Section 1.4.2).

Gravel and cobble substrates potentially suitable for ocean-run salmon spawning were documented throughout the East and West Forks of Eklutna Creek from the confluence with the lake to a point approximately 3.0 miles up the East Fork and 3.2 miles up the West Fork (Figure 3.3-2) where surveys ended. Aquatic habitat in the lower reaches was predominantly riffle and glide, containing gravels and cobbles (1.7-5 in) (Figure 3-3.3). At the upper points, the stream gradient steepened, and the aquatic habitat changed with an increase in rapid and cascade habitats that contained large cobble (>10 in) and boulders—conditions not suitable for salmonid spawning. The substrate size distribution at each site is presented in Figure 3.3-4 and Appendix 2, showing the distribution of substrate size trending toward larger substrates in upper survey reaches. The average substrate size was generally smaller at lower reaches, though there was no substantial difference in gravel size among reaches, except for the most upstream reaches (Table 3.3-2).

Figure 3.3-2. Typical substrate observed in the lower 3.0 miles of East and West forks of Eklutna Creek. A gravelometer was used to categorize substrate size.

Figure 3.3-3. Typical aquatic habitat observed in the canyonised upper reaches of East (left) and West (right) Fork Eklutna Creek above River Mile 3-3.2.

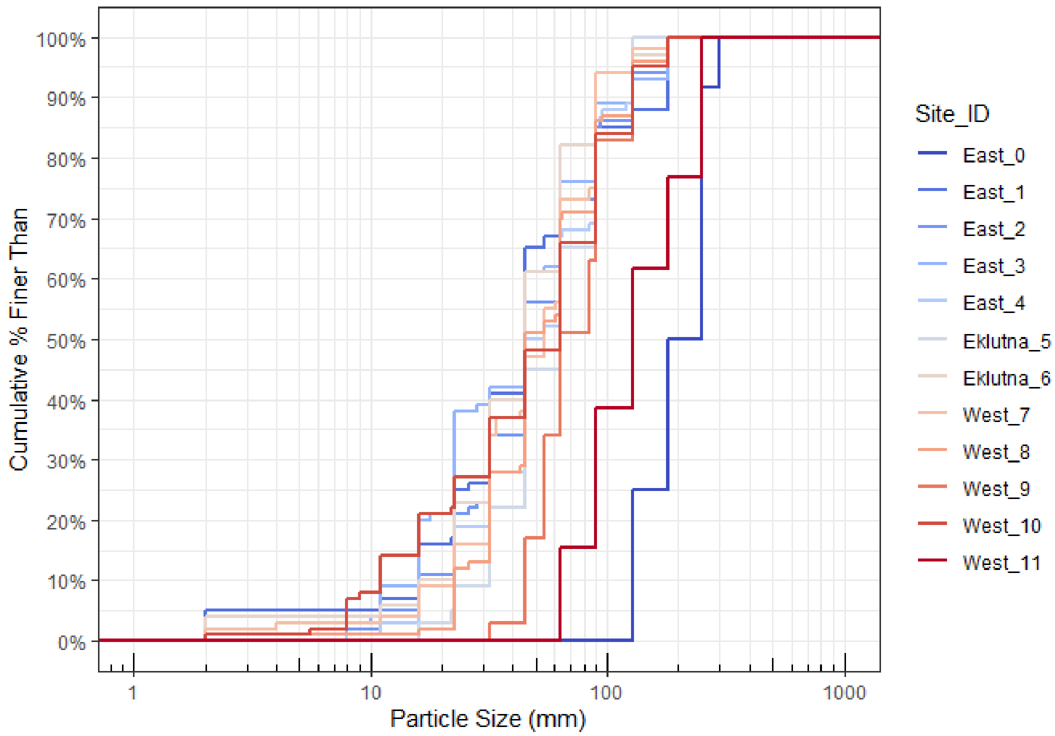

Figure 3.3-4. Pebble Size comparison between sample sites on East and West Fork Eklutna Creek. On the East Fork, East_0 is the uppermost site, while West_11 is the uppermost site on the West Fork.

Table 3.3-2. Pebble size of substrate collected at spawning survey reaches at Eklutna East and West Forks.

Site_ID	Location	Average in.	Minimum in.	16th ‰ in.	50th ‰ in.	84th ‰ in.	Maximum in.
East_0	upstream	8.1	5.0	5.0	8.4	9.8	11.8
East_1		2.4	0.1	0.8	1.8	3.5	7.1
East_2		2.4	0.1	0.9	1.8	3.5	7.1
East_3		2.2	0.1	0.6	1.8	3.5	7.1
East_4		2.5	0.3	0.9	2.0	3.5	7.1
Eklutna_5		2.6	0.6	1.3	2.5	3.8	5.0
Eklutna_6	downstream	2.0	0.1	0.9	1.8	3.5	7.1
West_7		2.2	0.1	1.2	2.1	3.5	7.1
West_8		2.5	0.1	1.3	1.8	3.5	7.1
West_9		3.1	1.3	1.8	2.5	5.0	7.1
West_10		2.5	0.1	0.6	2.5	3.8	7.1
West_11	upstream	5.7	2.5	3.5	5.0	9.8	9.8

A summary of the physical characteristics of potential spawning reaches in East and West Fork Eklutna Creek is provided in Table 3.3-3 including range and median substrate size by site, embeddedness, average wetted area, and average depth. Inspection of the data indicates that physical habitat containing water depths and substrate sizes conducive to salmon spawning is present in the mainstem Eklutna Creek East and West Forks. However, the conditions providing suitable spawning habitat are, among other factors, flow dependent and therefore estimates of total spawning habitat based on a single survey representing one flow condition should be viewed as first approximations.

The estimation of spawning habitat was derived from the mesohabitat mapping at locations in the East and West Forks of Eklutna Creek that included measurements of habitat characteristics by habitat type. Habitat surveys were completed during spawning surveys from September 30-October 1 of 2022 during low flow conditions. This time period was selected to coincide with periodicity of target ocean-run fish species spawning in the Eklutna River (see Eklutna River Fish Report 2023). Riffle habitat was the dominant habitat type observed in both East and West Forks of Eklutna Creek, comprising approximately 47.2% of the total habitat by length and 58.4% by width. Riffle habitat ranged in depth from 0.3-0.9 ft (0.1-0.3 m). Substrate in riffles included primarily small and large gravel and small cobble. Glide habitats comprised 24.8% of total habitat by length and 22.2% by width and ranged in depth from 0.9-1.9 feet in depth (0.3-0.6 m). Substrate in glides included large gravel and cobble. Remaining habitats by length included cascades (13.2 %), and chutes (12.3%) (Table 3.3-4). These swifter habitats had larger substrates and deeper depths. Depth in chutes was estimated in some instances where swift water conditions were too dangerous to obtain measurements.

The results of the mesohabitat mapping were compared to published depth and substrate requirements for Pacific salmon spawning, though information on salmon spawning in glaciated streams in Alaska is generally lacking. In general, the substrate sizes surveyed through both mesohabitat mapping and pebble counts indicated that gravels of suitable size for ocean run salmon including Chinook, Coho, and Sockeye are present throughout the East and West Forks of Eklutna Creek within the surveyed reaches. However, as noted above other factors influence the suitability of habitat for spawning including the flow dependent parameters of water depth and water velocity, embeddedness of substrate, consolidation of substrate, presence and character of groundwater interactions, temperature regime, etc.

The total surveyed habitat in the East and West Forks of Eklutna Creek included approximately 18 total acres of wetted habitat (Table 3.3-3). The 6.3 acres of shallow riffle habitat between the confluence of East and West Fork and Eklutna Lake was considered too shallow in 2022 to support spawning fish. Cascade, Chute, and Pool habitat (totaling 2.4 acres) in East_0, West_9, West_11 and smaller sections elsewhere were likewise not considered suitable due to high velocity (e.g., Cascade and Chute) or too low velocity (e.g., Pool) and inappropriate substrate sizes for ocean-run salmon spawning. While the substrate in riffle habitats was suitable, the measured depths during the three-day survey period were generally too shallow (depth range 0.3 -0.9 ft) (Table 3.3-4), and therefore most remaining (i.e., upstream of confluence) riffle habitat was considered unlikely spawning habitat at the late-fall flow levels observed in 2022. It should be noted that during periods of higher flow, habitats classified as too shallow in 2022 may be more suitable.

The estimates of spawning habitat were therefore largely based on the distribution of glide habitats in the main channel East and West Forks of Eklutna Creek in late-September 2022. These habitats contained suitable spawning conditions (substrates and water depth ranges) for ocean-run fish at the time of the survey. The estimates range from 0.765-3.61 acres (Table 3.3-4) depending on the wetted widths and depths of the surveyed reaches in the mainstem. An additional 0.24 acres may be available in the West Fork Tributary, though water depth may be a factor in which species could access or use available habitat which tends to be on the shallow end of the suitability criteria for Chinook and coho. Estimated spawning habitat area was calculated based on total length of surveyed (and unsurveyed) habitat in the East and West Forks that was appropriate in depth and substrate type. Minimum bounds of 0.765 acres were made based on the minimum wetted width and 50% suitability of surveyed habitat as a conservative estimate. Maximum habitat area estimate of 3.61 acres was based on 100% suitability of surveyed and unsurveyed habitat and the maximum measured wetted width (Table 3.3-5).

Spawning habitat surveys were conducted in the mainstem of the Eklutna Creek East and West Forks in 2022. Repeat surveys of the small tributaries that enter the West Fork which were surveyed in 2021 by KA and summer of 2022. KA and NVE both documented substrate suitable for spawning and rearing of Dolly Varden in the 1-mile long clearwater tributary to the West Fork particularly, a full analysis of suitability of this tributary for spawning pacific salmon with respect to both substrate and water depth and velocity during the period when adult ocean-run fish might be present was not conducted. Table 3.3-6 summarizes physical habitat characteristics of habitat in the West Fork Tributary and as is presented for mainstem reaches in Table 3.3-4 and Table 3.3-7 presents an estimate of available spawning habitat for ocean-run fish based on a total of 1.34 acres of wetted habitat, 18% of which is glide (i.e., suitable for spawning, or 0.24 acres) as is presented in Table 3.3-5 for mainstem habitats. NVE is planning to continue evaluation of the East and West forks of Eklutna Creek in 2023 and is planning to release the results of their 2021 and 2022 habitat studies in the fall of 2023.

Table 3.3-3 Eklutna Creek substrate survey for East and West fork mainstem areas and the confluence area (Eklutna) – substrate size range and median and embeddedness are presented for potential spawning habitat reaches.

Site ID Column	North	East	Channel Type	Dominant Habitat	Ave. wet width (ft)	Ave. depth (ft)	Reach length (mi)	Wetted area (ac)	Substrate range (in)	Substrate Median (in)	Embed (%)
East_0	61.312750	-148.955917	Braided	Cascade	27.8	1.6	0.1	0.12	5-12	8.5	25
East_1	61.312810	-148.958250	Braided	Riffle-Glide	21.3	1.3	0.36	0.94	.07-7	1.7	25
East_2	61.315010	-148.968610	Braided	Riffle-Glide	31.2	0.9	0.3	1.88	.07-7	1.7	25
East_3	61.313805	-148.979507	Braided	Riffle-Glide	29.5	0.65	0.72	1.67	.07-7	1.7	50
East 3.5	No survey						.5				
East_4	61.323266	-148.994854	Braided	Riffle-Glide	31.2	0.65	0.6	2.29	0.3-7	2.1	50
Eklutna_5	61.331290	-149.003400	Braided	Riffle-Glide	59.0	0.9	3.41	2.24	0.6-5	2.5	50
Eklutna_6	61.333590	-149.005430	Braided	Riffle-Glide	72.2	0.65	.43	3.80	.07-7	1.7	50
West_7	61.325051	-149.006434	Braided	Riffle-Glide	26.2	1.6	0.3	1.18	.07-7	2.1	50
West_8	61.316886	-148.999213	Braided	Riffle-Glide	24.6	1.6	0.4	1.38	.07-7	1.7	50
West 8.5	No survey						.8				
West_9	61.295517	-148.975599	Single	Chute	14.7	2.3	0.2	0.45	32-7	2.5	75
West_10	61.286130	-148.975270	Braided	Riffle-Glide	41.0	0.3	.8	0.94	.07-7	2.5	75
West_11	61.282859	-148.973091	Braided	Cascade	34.4	0.9	.2	1.03	2.5-10	5.0	25
West_Trib*	61.326693	-149.007482	Tributary	Riffle-Glide	13.5	.7	.82	1.34	fine/cobble	N.R	N.R

Notes:

* West_Trib data were collected in August of 2021 during summer flows, so water depth may not be representative of what exists during the late fall period when the mainstem surveys were completed.

Table 3.3-4 Mesohabitat mapping of dominant habitat types present at four representative reaches of the East and West Forks of Eklutna Creek where pebble counts were conducted in 2022. Habitat type percentage by length (%) is reported for each type along with measured ranges of depth, average depth, wetted width, dominant substrate, and suitability for ocean-run fish spawning based on criteria defined in Bjornn and Reiser (1991). It should be noted that these ranges are not definitive for all species in all watersheds and are presented here as general guidelines from which estimates can be made regarding the approximate amount of suitable habitat for ocean-run salmon in the East and West Forks of Eklutna Creek.

Habitat Type	% by Length		Average Depth		Depth Range		Wetted Width	Dominant substrate	Suitability for Spawning		
		% by Width	m	ft.	m	Ft.	ft.		Substrate	Depth	Velocity[1]
Riffle	47.2	58.4	0.2	0.8	0.1-0.3	0.3-0.9	21.3-79.1	sm. Gravel – sm. Cobble	yes	unlikely	-
Glide	24.8	22.2	0.4	1.3	0.3-0.6	0.9-1.9	20.0-31.2	lg gravel – lg cobble	yes	yes	-
Chute	12.3	10.8	0.6	1.9	0.4-0.8	1.3-2.6	8.2-16.5	sm. Cobble – lg. cobble	yes	yes	unlikely
Cascade	13.2	7.3	0.5	1.6	0.5 -0.6	1.6-1.9	22.3-36.8	lg cobble – bedrock	unlikely	yes	unlikely
Pool	2.5	1.3	n/a	n/a	n/a	n/a	18	fines, sm. gravel	unlikely	unlikely	unlikely

Notes:

1 Velocity over 1 m/s or 3.2 ft/s is too swift for spawning of ocean run Pacific Salmon (Bjornn and Reiser 1991). Velocities were not measured in 2022 though chute and cascade habitats are characterized by swift velocities and are unsuitable for spawning.

Table 3.3-5 Calculated estimated range of available spawning habitat in the West Fork Tributary based on a total for ocean run pacific salmon. A minimum of 0.765 acres of glide habitat is estimated based on 50% suitability of glide habitat, and a maximum of 3.61 acres based on 100% capacity of glide habitat, including unsurveyed reaches of the East and West Forks (see Figure 3.2-1).

	Total Length Surveyed	Proportion Glide	Wetted Width		50% Capacity		100% Capacity	
			Min.	Max.	Total Ac. Min	Total Ac. Max	Total Ac. Min	Total Ac. Max
Total Length Surveyed	3.41 miles	.76 miles			0.765	1.205	1.53	2.41
	6001.1 yards	1215.8 yards	6.1 yd	9.6 yd				
Total Length Incl. Unsurveyed	4.71 miles	1.04 miles	6.1 yd	9.6 yd				
	8289.6 yards	1823.4 miles			1.145	1.805	2.29	3.61

Table 3.3-6 Mesohabitat mapping of dominant habitat types present on the West Fork Tributary (see map, above) surveyed by KA for mesohabitat characteristics in 2021. Habitat type percentage by length (%) is reported for each type along with measured ranges of depth, average depth, wetted width, dominant substrate, and suitability for ocean-run fish spawning based on criteria defined in Bjornn and Reiser (1991). It should be noted that these ranges are not definitive for all species in all watersheds and are presented here as general guidelines from which estimates can be made regarding the approximate amount of suitable habitat for ocean-run salmon this West Fork Tributary.

Habitat Type	% by Length	% by Width	Average Depth		Depth Range		Wetted Width	Dominant substrate	Suitability for Spawning		
			m	ft.	m	Ft.	ft.		Substrate	Depth[2]	Velocity[1]
Riffle	54.3	26.5	0.2	0.65	0.2-0.2	0.65-0.65	11.8	lg gravel- lg cobble	yes	-	-
Glide	17.4	28.4	0.25	0.82	0.2-0.3	0.65-0.98	12.5	fines, cobble	Some areas	-	-
Chute	0.0	0.0	-	-	-	-	-	-	-	-	-
Cascade	0.0	0.0	-	-	-	-	-	-			-
Pool	28.3	44.9	0.2	0.65	0.2	0.2	19.7	fines	unlikely	unlikely	unlikely

Notes:

1 Velocity over 1 m/s or 3.2 ft/s is too swift for spawning of ocean run Pacific Salmon (Bjornn and Reiser 1991).

2. Depth was measured during summer flows (August of 2021) and it is unknown how flow in this spring-fed tributary may change over the year or what depth profiles are available during potential spawning periods for ocean-run fish.

Table 3.3-7 Calculated estimated range of available spawning habitat in the West Fork Tributary for ocean run pacific salmon. Mesohabitat mapping covered a total of 0.15 miles of habitat based on study plan methodology. The total wetted length of the tributary is estimated at 0.82 linear miles and mesohabitat mapping data are extrapolated to estimate total available spawning habitat in the Tributary. A total of 1.34 acres (0.24 acres of which are glide) are present in the Tributary. A minimum of 0.12 acres of glide habitat is estimated based on 50% suitability of glide habitat, and a maximum of 0.24 acres based on 100% capacity of glide habitat, including unsurveyed portions.

	Total Length Surveyed	Total Glide	Wetted Width		50% Capacity	100% Capacity
			Min.	Max.		
Total Length Surveyed	0.15	0.03 miles			**0.02 acres**	0.04 acres
	264 yards	52.8 yards	2.7 yd	5.6 yd		
Total Length Incl. Unsurveyed	0.82	0.14 miles				
	1443.2 yards	146.4 yards			0.12 acres	**0.24 acres**

3.3.2. Fish Use of Tributaries for Spawning / Rearing: 2021

Dolly Varden in a variety of size ranges were captured in six surveyed tributaries (Table 3.3-8). Dolly Varden abundance was greatest in the East Fork of Eklutna Creek which is much larger than the other tributaries. Most fish were captured in clearwater side channels and channel margins rather than in the mainstem, turbid areas of the mainstem Eklutna Creek. The upper West Fork right bank side channel identified by both teams was nearly dry in the fall of 2022 and was not considered suitable for inclusion in estimates of habitat for spawning ocean run fish (Figure 3.3-5a). An approximately 1-mile-long clear water tributary flows (Called West Fork Tributary; Table 3.3-8) flows from a spring in the mountain side. Both KA and NVE surveyed this tributary during the summer of 2021 (KA, Figure 3.3-5b) and 2022 (NVE). As noted in Table 3.3-8, large Dolly Varden were observed spawning and various age classes of fish were captured by both teams. It should be noted that sampling effort was not equal between tributaries, so abundance estimates are not directly comparable. Survey locations covered by both teams are presented in Figures 3.3-6a and 3.3-6b.

Habitat surveys of tributaries to the mainstem Eklutna Creek were conducted by both NVE and KA survey teams in 2021 and 2022. The 1-mile long clearwater tributary flowing into the West Fork on river left was surveyed for juvenile rearing during summer months. KA surveyed the tributary for potential rearing habitat for juvenile salmonids in 2021 and conducted mesohabitat mapping. Both teams documented the presence of gravel and cobble substrate during summer flows that are potentially suitable for spawning fish. Rearing of Dolly Varden was observed by both teams during summer surveys. KA documented spawning Dolly Varden in in the fall of 2021 when water levels were lower than those observed during summer habitat surveys. Both teams documented the presence of small gravel and cobble (see Table 3.3-1 above) that may be suitable for spawning of ocean-run fish. KA did not re-survey this tributary during the 2022 mainstem spawning habitat surveys presented above.

Figure 3.3-5a. Tributary of the West Fork Eklutna Creek upstream of the end of the Lakeside Trail ATV trail.

Figure 3.3-5b. Sidewall tributary flowing from the East slopes of the drainage. Both NVE and KA surveyed the trbutary in 2021 (KA left photo) and 2022 (NVE, right photo).

Table 3.3-8. Fish capture data for tributaries to Eklutna Lake sampled in July 2021 using both electrofishing and baited minnow trapping. W. Eklutna Sidewall Tributary and W. Eklutna Serenity Creek are tributaries to West Fork Eklutna Creek, not Eklutna Lake directly.

Eklutna Lake Tributary	Species	Mean Length (mm) [sample size]	Size Range (mm)	Spawning Observed
Yuditnu Creek	Dolly Varden	120.5 [31]	79-192	yes
Tributary 4	Dolly Varden	170.1 [30]	88-232	yes
Eklutna Creek Main	Dolly Varden	131.5 [15]	50-186	yes
East Fork Eklutna Creek	Dolly Varden	148.0 [75]	36-162	yes
West Fork Eklutna Creek	Dolly Varden	131.5 [15]	50-186	yes
- W. Fork Tributary	Dolly Varden	123.4 [12]	52-200	yes
- W. Eklutna Serenity	Dolly Varden	160.5 [16]	111-196	--

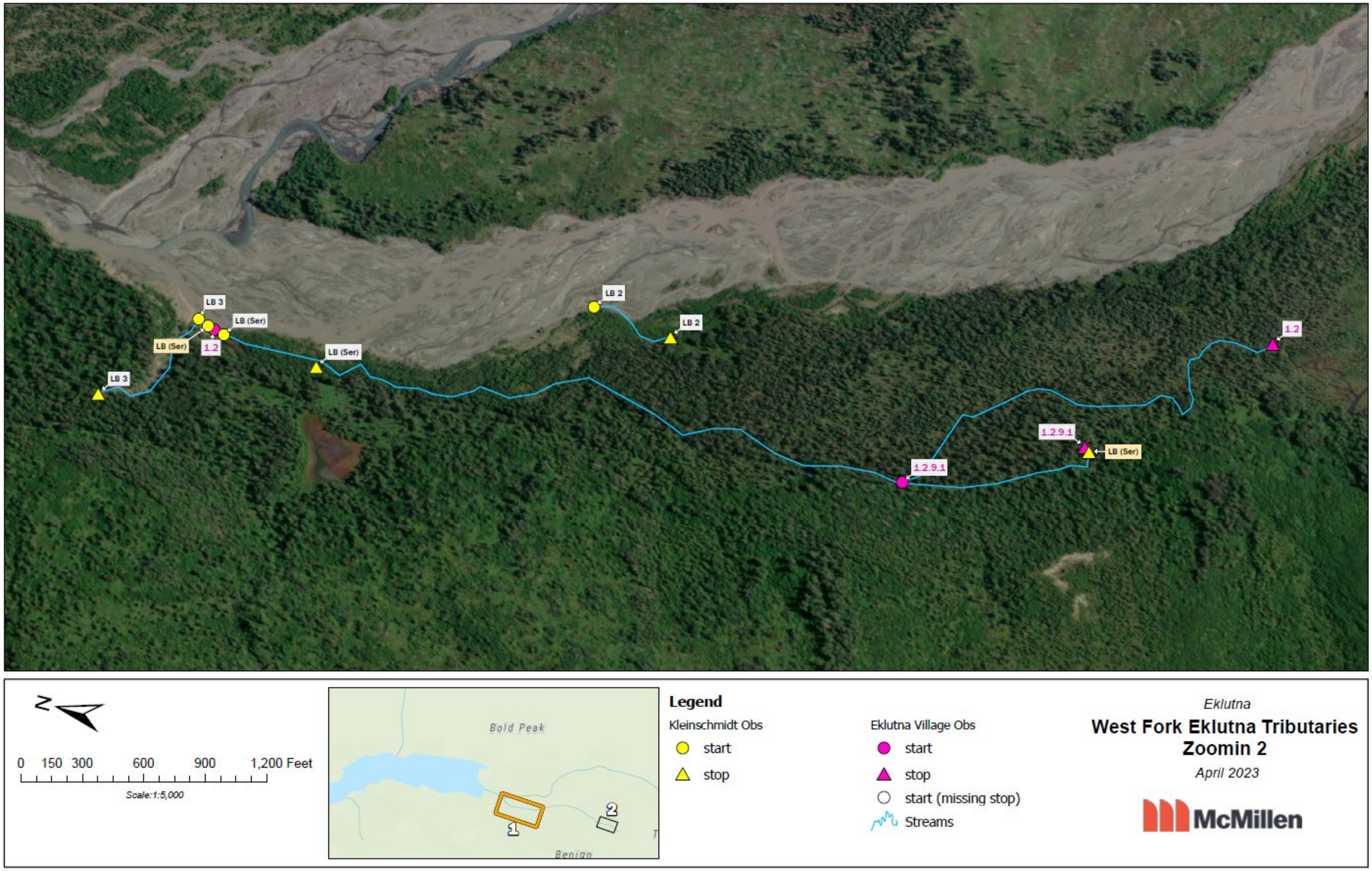

Figure 3.3-6a. Clearwater sidewall tributary (named Serenity by Alaska Parks) entering the West Fork Eklutna Creek at river left. Surveys by KA (late July 2021 mesohabitat mapping) and September 2021 (Dolly Varden Spawning) and NVE (June 2022).

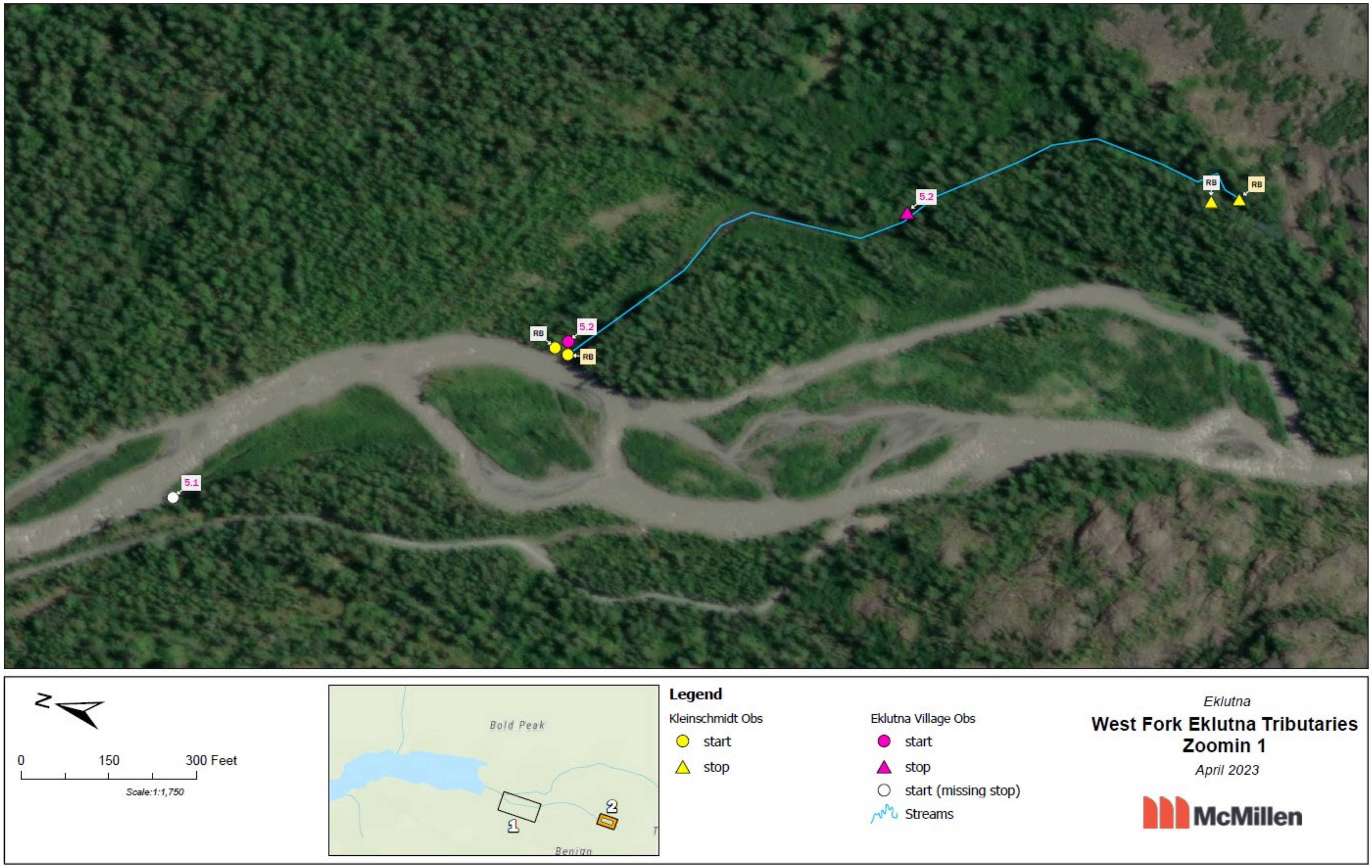

Figure 3.3-6b. Spring-fed channel entering the West Fork Eklutna Creek at river right. Surveys by KA (October 2022) and NVE (June 2022). See photo, Figure 3.3-5a above.

No redds or spawning fish were observed in Yuditnu Creek, Tributary 4, or Bold Creek in the spring of 2021, though spawning rainbow trout and five completed redds were observed in the lake at the mouth of Yuditnu Creek on June 4, 2021. Redds and spawning fish were observed in the fall of 2021 in the lower-gradient Tributary 4, and Eklutna Creek with the highest number of spawning Dolly Varden and redds observed in East Fork Eklutna Creek (Table 3.3-9). Spawning kokanee were observed in lower Eklutna Creek and Tributary 4 in 2022 (see below). Fish were captured both rearing and spawning in W. Eklutna Sidewall Tributary. No spawning fish were ever observed in Lach Q'atnu Creek.

Table 3.3-9. Spawning survey data for tributaries to Eklutna Lake completed in June and October of 2021. No spawning activity was observed in the spring in the tributaries. Fall spawning Dolly Varden was observed in Tributary 4, East Fork Eklutna Creek, and the West Fork Sidewall Tributary of Eklutna Creek.

Eklutna Lake Tributary	Survey length (ft)	Date (2021)	Redds	Fish
Lach Q'atnu Creek *Fall*	1837	28-Sep	0	0
Yuditnu Creek *Spring*	492	4-Jun	0	0
Yuditnu Creek *Fall*	689	4-Oct	0	2
Tributary 4 *Spring*	1444	5-Jun	0	0
Tributary 4 *Fall*	1509	4-Oct	3	2
East Fork Eklutna Creek *Fall*	5774	3-Oct	5	41
West Fork Eklutna Sidewall *Fall*	1509	4-Oct	4	0

3.3.3. Fish Use of Tributaries for Spawning / Rearing: 2022

In Tributary 4 and 4.1, surveys were completed both up- and downstream of the paired culverts at the Eklutna Lakeside Trail crossing. The portion of Tributary 4 that was actively flowing was considerably shorter in 2022 than was observed in 2021 due to the difference in the lake elevation between years (864.02 ft on 10/1/2021, 867.77 ft on 10/1/2022). In 2022, much of Tributary 4 was backwatered from the lake and packed with large woody debris from the 2010 Eklutna fire. Downstream of the culverts, approximately 150 m of Tributary 4 was riverine habitat as was 25 m of Tributary 4.1. Upstream of the culverts, the substrate was characterized mostly by compacted silt and fine sediment, macrophytes, large woody debris, and silt-embedded small gravels. Small areas (<20 $ft^{2)}$ of gravel were observed in upper portions of Tributary 4 where Dolly Varden were observed spawning in 2021, but these were rare (Figure 3.3-7). Water depth in both tributaries was generally from 0.3-0.5 ft with very few areas of greater depth.

Figure 3.3-7. Tributary 4 downstream of the culverts under the Eklutna Lakeside Trail (right) and example of substrate size in limited areas with gravel (left).

While the small gravel in Tributary 4 and 4.1 appeared to be suitable for small-bodied Dolly Varden and the kokanee present in Eklutna Lake, no portions of either tributary were identified as potential habitat for ocean-run salmon of typical body size. Currently, the culverts under the Eklutna Lakeside Trail likely make these habitats inaccessible to most fish.

In 2022, kokanee spawning activity was documented in the East Fork of Eklutna Creek near the confluence with a small (<6 sq ft wetted width) clear water side channel (Figure 3.3-8). Spawning activity in kokanee was determined by the presence of degraded fins and growth of fungus, the presence of carcasses with mature gonads (unspawned eggs and milt), and milling/guarding behavior. Active spawning was not observed. A total of 35 kokanee spawners were documented in a 0.1 mi. reach of Tributary 4 downstream of the culverts. A total of 3 kokanee spawners were documented in a small clear side channel of the mainstem Eklutna Creek near the split into East and West forks (Figure 3.3-9). Observed kokanee spawners ranged from 4.0-6.5 in, expressed no sexual dimorphism, and none of the coloration typical of spawning O. nerka in other systems. Disturbed substrate where kokanee were observed redd-guarding (0.3-1.5 in.) was smaller than that typically considered appropriate for adult kokanee, likely due to the small size of adult kokanee in area.

No kokanee were observed spawning elsewhere in the East or West forks, though Dolly Varden in spawning colors were observed throughout both systems in clearwater side- and off-channel locations.

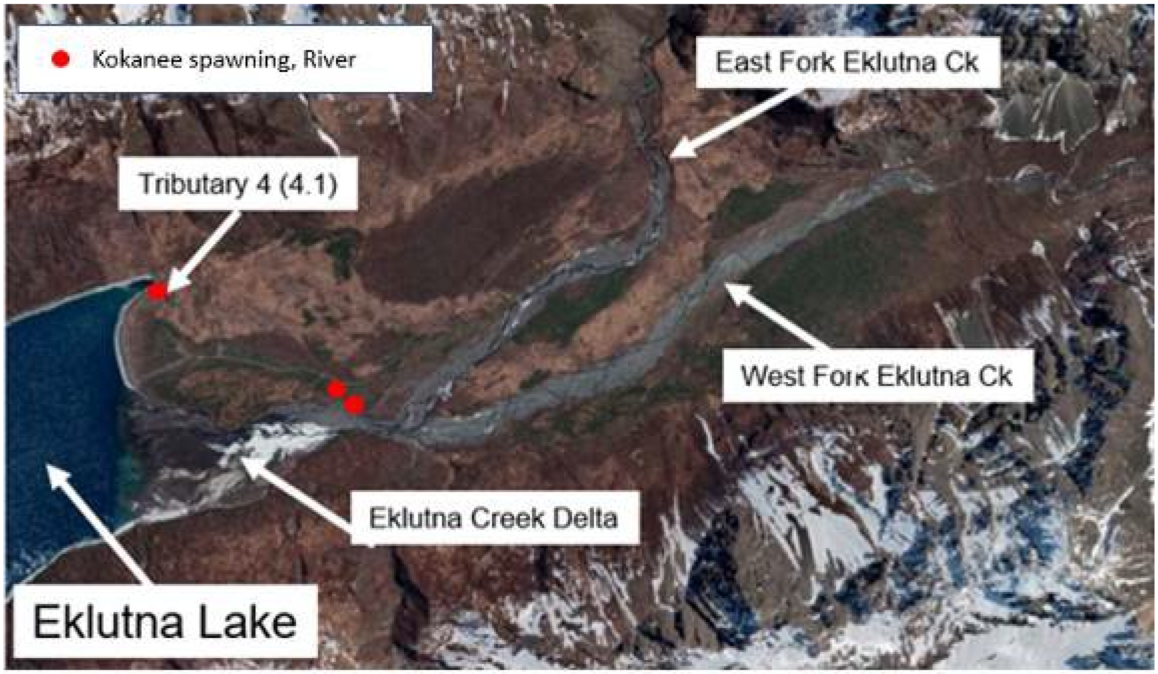

Figure 3.3-8. Location in the Mainstem Eklutna Creek and Tributary 4 where kokanee spawners were observed in fall 2022.

Figure 3.3-9. Kokanee spawner collected in mainstem Eklutna Creek below the confluence of East and West forks (left) and a kokanee carcass in lower Tributary 4 (right).

3.4. Task 4: Presence of Infectious Hematopoietic Necrosis (IHN)

Length of kokanee carcasses collected at Eklutna Lake in 2021 ranged from 4.5-6.5 in. There was no external indication of sex (dimorphism) or coloration typical of spawning kokanee (Figure 3.4-1). Tissue samples from 100 individuals were sent to ADFG for genetic analysis to identify origin stock. ADFG does not currently have funding to analyze these samples to determine how Eklutna lake kokanee fit in with other *O. nerka* in the Cook Inlet Area (*A. Barclay ADF&G, pers comm. October 2022*). In 2022, post-spawned kokanee were sampled for IHN by removing kidney and liver tissue from individual fish for processing by the ADF&G

Fish Pathology Lab under Dr. Jayde Ferguson. A total of 60 samples are required to detect IHN in populations of O. nerka. Due to the small size of the fish and the potential that some samples might need to be pooled to obtain enough tissue for the analysis, a total of 75 tissue samples and 25 whole kokanee were collected on October 2, 2022, and delivered to the Pathology Lab on October 3, 2022. The processing of IHN samples can take weeks to months, depending on culturing success and workload at the lab. A subset of these samples (~20 fish) was taken from Tributary 4 near the confluence with Eklutna Lake. Several of the sampled fish from Tributary 4 were post-spawned but had un-digested terrestrial invertebrates in their stomachs. Feeding during spawning migration and active spawning is atypical for ocean run pacific salmon (Quinn 2005) as well as landlocked kokanee that typically stop feeding while nutrients from their tissue are used to fuel gonad development and spawning activity (Miller et al. 2009).

Figure 3.4-1. Kokanee carcass showing the position of liver and kidney to be collected for IHN analysis (left) and representative kokanee carcasses from Eklutna Lake (right).

As of December of 2022, 58 out of 75 (77.3%) samples processed by the ADFG Fish Pathology Lab tested positive for IHN virus with 19 out of 58 samples (32.8%) representing the highest infection level with high viral transmission. A conventional PCR confirmed representative isolates as IHNV, which were also negative for the only other rhabdovirus in fish currently documented, Viral Hemorrhagic Septicemia Virus. These results confirm the presence of IHN in the kokanee population in Eklutna Lake. The documentation of spawning kokanee in the lower reaches of Eklutna Creek in 2022 suggests that the virus may also be transmissible to other fish species in Eklutna Creek, in the Eklutna Tailrace Fishery, or to other juvenile and adult fish in the Eklutna River which may be exposed to IHN from Eklutna Lake source water (J. Ferguson, *pers. comm* 11/16/2022).

4 CONCLUSIONS

The results and conclusions from this study will be utilized during the alternatives analysis to evaluate any potential impacts to Eklutna Lake aquatic habitat and fish utilization that may result from future water management changes.

4.1. Eklutna Lake Habitat and Fish Use

The 2021 assessment of potential spawning habitat for kokanee and/or Sockeye Salmon in the varial zone of Eklutna Lake identified several areas (Appendix A) with upwelling or groundwater seeping into the substrate that can be an indicator of likely spawning locations for Sockeye Salmon or kokanee, both of which can also spawn and rear in rivers (Quinn 2005). Lake shore spawning of kokanee was observed in 2021 and both lake and river spawning of kokanee was observed in 2022. The substrate type and slope documented by this study are suitable for Sockeye and kokanee, however, in some other Alaska lakes such as the Wood Lakes system, *O. nerka* prefer to spawn in deep water (>50 ft., McGlauflin et al. 2011) which suggests we may not have been able to capture all potentially available habitat in areas that were not dewatered at low lake elevations in 2021. During fall spawning surveys in 2021 and 2022, we noted that carcasses of spawned kokanee were present along many of the small-substrate, lower gradient beaches with apparent groundwater influence, though kokanee were also observed in many other places. Due to their small size (<7 in.) and the propensity of wind on Eklutna Lake, it is likely that kokanee carcasses were easily distributed by the wind and waves to places other than their spawning location, making a finer-scale determination of where spawning occurred in these years challenging.

A steep lake varial zone and high gradient hillslopes make most tributaries that inflow into Eklutna Lake inaccessible to fish. Those short, steep tributaries that are occasionally accessible during periods of extremely high lake elevations (i.e., Bold Creek, Yuditnu Creek, Lach Q'atnu Creek) were not found to have habitat suitable for ocean run salmon spawning or rearing, being suitable instead for limited rearing and spawning of small-bodied Dolly Varden.

Tributary 4 and Tributary 4.1, drain the North slopes above the terminal glacial moraine, meandering through a low gradient area of grass, shrubs, and large woody debris remaining from a stand-replacement fire in 2010. These creeks are very small at only 5-10 ft wide, generally shallow (< 10 in. deep) and plugged in many places by large wood jams and are probably not accessible to ocean run fish, nor suitable for their spawning or rearing. The Eklutna Lakeside Trail crosses over both tributaries, which are routed through paired perched culverts approximately 500 ft from the lake confluence. Dolly Varden were documented upstream of the culverts in 2021.

Eklutna Creek, including glacially fed East and West Forks and several small inflowing, clearwater tributaries represent the majority of accessible habitat to fishes from Eklutna Lake with nearly 7 miles of accessible low gradient habitat and braided main channel. Within the available mainstem habitat surveyed in 2022, there are between 0.77-3.61 acres of potential spawning habitat based only on depth and substrate type measured during one year in late fall low flows. As noted above, there are various other factors that also affect suitability of habitat for individual species including thermal conditions, groundwater exchange, velocity, and substrate consolidation. The confluence between Eklutna Creek and Eklutna Lake was observed during various conditions of both creek outflow and lake elevation. At low flows in the creek and concurrent low lake elevation in late summer and fall, the mouth of the creek ranged from 0.2-1.0 ft in depth, with the main channel divided into several braids. Some of these channels may post access challenges for larger bodied fish such as Chinook or Coho salmon into the watershed in fall because they are less than 0.3 ft (0.09 m) deep, which falls below the minimum depth range required as identified in Bjornn and Reiser (Table 4.1-1). However, at least one mainstem channel, the far left bank braid, in 2022 was deep enough (~1.0 ft/0.3 m) for larger bodied fish to reach the area upstream of the delta where the East and West Forks diverge and the braided channels are narrower and deeper in places.

Table 4.1-1. Water Temperatures and Depths/Velocities that enable upstream migration adult Pacific Salmon and Trout (From Bjornn and Reiser 1991).

Species	Minimum Depth, m (ft)	Maximum Velocity (m/s)
Fall Chinook Salmon	0.24 m (0.82 ft)	2.44
Spring Chinook Salmon	0.24 m (0.82 ft)	2.44
Chum Salmon	0.18 m (0.59 ft)	2.44
Coho Salmon	0.18 m (0.59 ft)	2.44
Sockeye Salmon	0.18 m (0.59 ft)	2.13
Steelhead	0.18 m (0.59 ft)	2.44

Fish surveys in 2021 indicate that Eklutna Lake is used by kokanee, rainbow trout, and Dolly Varden. Dolly Varden and rainbow trout were captured successfully in minnow traps, beach seines, fyke nets, and hand seines along lakeshores but predominantly near the mouth of tributaries (i.e., Bold Creek, Lach Q'atnu Creek, Yuditnu Creek, Tributary 4/4.1, and Eklutna Creek) which represent a likely source of food items (Stockner and Shortreed 1989). Kokanee were not well represented in the catch data from the sampling methods deployed, including attempts to fish at greater depths with small gill nets. In studies at Glacial Lake and Salmon Lake near Nome, AK which are similar in size, depth, and glaciation to Eklutna Lake, researchers used hydroacoustics to document kokanee at depths over 18 m (Todd and Kyle 199). It is possible that the low encounter rate of kokanee in lake sampling efforts may be due in part to the depth at which they are feeding (some zooplankton species have diel vertical migration patterns), holding, or avoiding predation rather than low numbers of kokanee in the lake. Spawning surveys in 2021, during which over 1,000 spawned kokanee were documented, suggests that kokanee are present in the lake, but their use of nearshore habitats and tributary mouths may be limited. This would be consistent with *O. nerka* feeding more on plankton than invertebrates (Quinn 2005). The Eklutna Water Quality report (Sauvageau and Schult 2023) documented very low standing crop of phytoplankton which may indicate poor food source for zooplankton, the preferred food of *O. nerka*. This may account for the extremely small size of Eklutna Lake kokanee.

4.2. Habitat and Fish Use in the Seasonal Pond

Fish use of the seasonal pond in 2021 was restricted to the summer sampling period where only one exemplar of rainbow trout and one kokanee were collected along with nearly 50 Dolly Varden. The pond did have a slightly larger size distribution of fishes than was observed in lake samples, but the fact that no fish were captured in this habitat in the fall suggests that it is unlikely that increased availability of food contributed to the size discrepancy. Summer sampling was conducted in July while Fall sampling was completed after study flows were released from Eklutna Dam. The release of water may have impacted the use of this habitat by fishes in the fall of 2021.

4.3. Fish Use of Eklutna Lake Tributaries for Rearing and Spawning

A geomorphic analysis including sediment transport has not been completed for Eklutna Creek, but gravel bars in East and West Forks of Eklutna Creek tended to lack vegetation, large wood, or other features likely to result in the development of more stable gravel bars and therefore channel position (McKean and Tonina 2013). Channel migration associated with dynamic sediments can lead to challenges for overwintering survival of eggs, though floodplain topography and channel confinement are determining factors (McKean and Tonina 2013). One right-bank pool greater than 5 ft deep was documented near the ATV bridge on the East Fork of Eklutna Creek (measured in 2021). Water temperature in the East Fork ranged from 4.5-5.5 ℃ while the West fork ranged from 2.9-5.5℃. While these incidental surface measurements are within ranges reported for Sockeye Salmon spawning in Alaska rivers and lakes (4-12℃; Lisi et al 2012), temperatures may affect upstream migration, spawning behavior, and egg incubation success of Pacific salmon (Bjornn and Reiser 1991).We do not have enough information on the thermal regime in the Eklutna Creek watershed to speculate on what role temperature may play in suitability of habitat for spawning ocean-run fish.

Water depth ranged from 0.3 ft-0.5 ft in riffle habitats, and from 0.9 ft-3.2 ft in glides which is suitable for Coho and Chinook salmon adults to use for spawning (Table 4.3-1, Bjornn and Reiser 1991). Some mainstem riffle complexes had long (>350 ft) stretches of water under 0.6 ft deep which may play a role in the accessibility of habitat for larger bodied fish (Bjornn and Reiser 1991), though the system is clearly dynamic and may change annually during spring run-off, creating geomorphic features which can be advantageous for creating microhabitats required by Chinook Salmon and other ocean-run Pacific Salmon (Geist et al. 1998), but also represent potentially negative influence through redd scour (Moir et al. 2010) or sedimentation (Jensen et al. 2009).

Substrate size documented throughout the East and West Forks of Eklutna Creek falls into the range suitable for spawning of ocean run Pacific salmon such as Sockeye, Chinook, and Coho (Table 4-3-1). While embeddedness measurements were outside of the range typically suitable for spawning fish at 3 out of 10 locations (Bjornn and Reiser 1991), the act of digging redds can dramatically reduce the amount of fine sediment present in a redd. In glacial streams where fine glacial sediments can be deposited over winter, overwinter survival of eggs may be impacted (Jensen et al. 2009).

Table 4.3-1. Substrate Size, Depth, and Velocity appropriate for spawning of Pacific Salmon by species (from Bjornn and Reiser 1991).

Species	Water Depth meters	feet	Velocity Velocity (m/s)	Substrate Size cm	inches
Fall Chinook Salmon	0.24	0.8	0.3-0.91	1.3-10.2	0.5-4.0
Spring Chinook Salmon	0.24	0.8	0.3-0.91	1.3-10.2	0.5-4.0
Chum Salmon	0.18	0.6	0.46-1.01	1.3-10.2	0.5-4.0
Coho Salmon	0.18	0.6	0.3-0.9	1.3-10.2	0.5-4.0
Sockeye Salmon	0.15	0.5	0.21-1.01	1.3-10.2	0.5-4.0
Kokanee	0.06	0.2	0.15-0.75	1.3-10.2	0.5-4.0
Steelhead	0.24	0.8	0.4-0.9	1.3-10.2	0.5-4.0

Sampling in 2022 did not include measurement of stream velocity. For target species such as Sockeye, Chinook, or Coho salmon to access the Eklutna Creek watershed, the velocity at which access is limited has been reported to be under 2.13-2.44 m/s (Table 4.1-1).

Analyzing the suitability of physical habitat for spawning of salmonid fishes within a river system is usually determined based on development of Weighted Useable Area curves as part of a Physical Habitat Simulation system (PHABSIM) or River2D modeling exercise. These models can take into account and integrate measured velocity over two-dimensional (2D) space in the river channel, incorporate substrate size and hydraulic conditions, and assess changes in suitability of depth, velocity, and substrate size based on changes in flow levels. A model of this type was not developed for Eklutna Creek, but assessment of physical features of the habitats including only the distribution of substrate size and water depth indicates that a range of 0.77-3.61 acres of suitable spawning habitat may exist for spawning of ocean run fish, distributed throughout the East and West Forks of Eklutna Creek, but not in the confluence area. It should be noted that survey data used produced this estimate were completed over a short period of time during low flow conditions in 2022, and habitat availability estimates are based on only two of the many factors that control suitability and use of potential spawning habitat by individual species, therefore this estimated range of available spawning habitat should be taken as an estimate in lieu of a quantitative modeling effort such as that performed for the Eklutna River in 2021 and 2022.

Habitat suitability for ocean run fish goes beyond only the suitability of the physical habitat for spawning adults. Following emergence, rearing habitat for emergent juveniles is required as well as food resources adequate to support survival and growth in both warmer summer months, and the extended iced-in conditions of a seven-month winter. Within northern latitude riverine ecosystems like the Eklutna Creek watershed, nearly all fish species exhibit physiological and/or behavioral responses to the seasonal change in habitat from summer to winter (Reynolds 1997), such as reduced metabolic rate (Brown et al. 2011), swimming ability (Beamish 1978), movement to off-channel and low-velocity habitats (Peterson 1982; Jakober et al. 1998), shifts in diel activity patterns (Roni and Fayram 2000; Heggenes et al. 1993), and decreased territorial aggression (Reynolds 1997). In stream systems like the Eklutna River, the complex interaction between winter water temperature, low stream flow, ice formation, habitat accessibility and suitability for stream-dwelling fish species all play a role in successful egg incubation and juvenile rearing (Huusko et al. 2013; Linderschmidt et al. 2018; Prowse 2001a, b). Our surveys did not investigate the availability of overwintering habitat for salmonids. Clearly Dolly Varden populations in the Eklutna Creek watershed are sustaining, but accessibility and availability of overwintering habitats for other species is unknown.

During surveys in both 2021 and 2022, very little evidence of productivity in Eklutna Creek East or West Forks was observed. In mainstem glacially-turbid habitats, no macroinvertebrates or macrophytes were observed though some algae was noted in clearwater off-channel or backwater areas. The periphyton layer on in stream substrate that is also typical of productive river systems was absent from the West Fork Eklutna Creek, but evident in some side channels of the East Fork about 2.5 miles from the confluence, in Serenity and Sidewall tributaries of the West Fork, and in limited other off-channel habitats. These side-channel and tributary habitats may play a critical role in the productivity of the current population of Dolly Varden. Whether there are adequate food resources in these non-mainstem areas to support populations of river-rearing ocean run species such as Chinook or Coho salmon is unknown. Since Sockeye Salmon typically migrate to nursery lakes following emergence, food resources for these populations would come from lake sources (Quinn 2005).

The 2021-2022 Water Quality Study (Sauvageau and Schult 2023) found that primary production in Eklutna Lake is low, with chlorophyll a levels that produced a TSI below 30, which is typical of heavily glaciated lakes in the region with high turbidity and therefore low levels of light penetration and associated low biomass of phytoplankton (Sauvageau and Schult 2023). The lack of productivity observed in the Water Quality Study may help to explain the unusually small size of adult kokanee present in Eklutna Lake.

Kokanee spawners collected from Eklutna Lake were smaller than those reported in many other lake systems with kokanee (Table 4.3-2). Since kokanee is a less common life history type in Alaska than other portions of the range of *O. nerka*, there is limited size data from glacial systems (McGurk 2000). Adult kokanee included both male and female fish with mature gonads. Some females contained unspawned eggs which ranged in size from 0.1 -0.2 in, a size consistent with eggs produced by typical-sized kokanee (7.5-10 in.) from other oligotrophic systems (Kaeriyama et al. 1995). The fecundity of females found prior to spawning or partially-spawned ranged from only 20-30 eggs which is less than is typically reported for kokanee (500-700 eggs) (Kaeriyama et al. 1995). The tradeoff between egg size and fecundity has been well studied in Pacific salmon, including kokanee, and can be related to energetics, migratory distance, stock origin, adaptation to spawning gravel (Quinn et al. 2015) and even latitude where higher latitude has been correlated to smaller bodied and less fecund kokanee (McGurk 2000). In Eklutna Lake, the size-at-maturity, condition factor (length-weight ratio) and low fecundity are likely an indication of poor nutrient conditions and limited food sources in the environment (Quinn 2005; McGurk 2000), which is corroborated by data from the Water Quality (Sauvageau and Schult 2023).

Table 4.3-2. Comparison of *O. nerka* (Sockeye Salmon and kokanee) adult size and fecundity (average # eggs per female) for other systems where data are available. There is limited data available for kokanee in Alaska because they are less common than ocean-run Sockeye in Alaska (McGurk 2000).

Location	Fork Length (inches)	Fecundity (avg.)	Source
KOKANEE			
Eklutna Lake, Alaska	4.5-6.5	20-30	MJA 2023, this report
Peace River System, BC	8.0-11.0	--	Wilson et al. 2021
Kootenay Lake, BC	8.0-10.0	817	Vernon 2017
Seely Lake, Montana	8.0-16.0	--	McGurk 2000
Hokkaido Lakes, Japan	9.0-12.0	415	Kaeriyama et al. 1995
Lake Shikotsu, Japan	7.8-16.2	430	Kaeriyama et al. 1995
Takla Lake, BC	7.5-8.0	148	Wood and Foote 1996
Kinbasket Lake, BC	8.9-9.5	304	Wigle 1999
Upper Arrow Lake, BC	8.5-13.0	270	Thorp and Miller 2010
Shuswap Lake, BC	10.3-12.4	696	Quinn et al. 1998
SOCKEYE			
Karluk Lake, Alaska	20.8	2,750	Gilbert and Rich 1927
Tikchik, Alaska	21.8	4,065	Burgner 1991
Chignik Lake, Alaska	24.5	4,060	Hartman and Conkle 1969
Bare Lake, Alaska	22.8	4,130	Nelson 1959

The kokanee in Eklutna Lake are also different from other kokanee in their lack of sexual dimorphism and development of spawning color that is typical of the species (Quinn 2005). Sexual dimorphism includes the development of a dorsal hump and hooked nose in males which was not evident in any kokanee observed in Eklutna Lake, nor did any observed kokanee display the red sides and green head that is also typical of the species during spawning (Figure 4.1-1).

Figure 4.1-1. Typical exemplar of a 13-inch male kokanee in spawning colors with dorsal hump and hooked kype (nose) (LEFT), and a typical exemplar of a 5-inch kokanee spawner from Eklutna Lake, 2022.

4.4. Infectious Hematopoietic Necrosis (IHN)

This study has documented the presence of IHN in kokanee currently present in Eklutna Lake and Eklutna Creek. Talks are currently underway between stakeholders, ADFG, and other natural resource managers to determine whether there are management concerns associated with these results. The presence of IHN in Eklutna Lake kokanee, and the potential for transmission to Sockeye Salmon that may be introduced to Eklutna Lake if fish passage is considered, will be further discussed with stakeholders during development of the Eklutna River Fish and Wildlife Program in 2023.

5 VARIANCES FROM FINAL STUDY PLAN

No variances from the final approved study plan were required during execution of 2021 or 2022 field work on Eklutna Lake and its tributaries.

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7 APPENDICES

APPENDIX 1: TRIBUTARY HABITAT-TYPE CLASSIFICATION

APPENDIX 2: LAKE TRIBUTARY AND SPAWNING HABITAT SUMMARY AND FIELD NOTES

APPENDIX 3: EKLUTNA CREEK PEBBLE COUNT DATA

APPENDIX 4: COMMENT/RESPONSE MATRIX

Appendix 1: Tributary Habitat-Type Classification

Table A1-1. Mesohabitat unit types for fish composition and distribution studies.

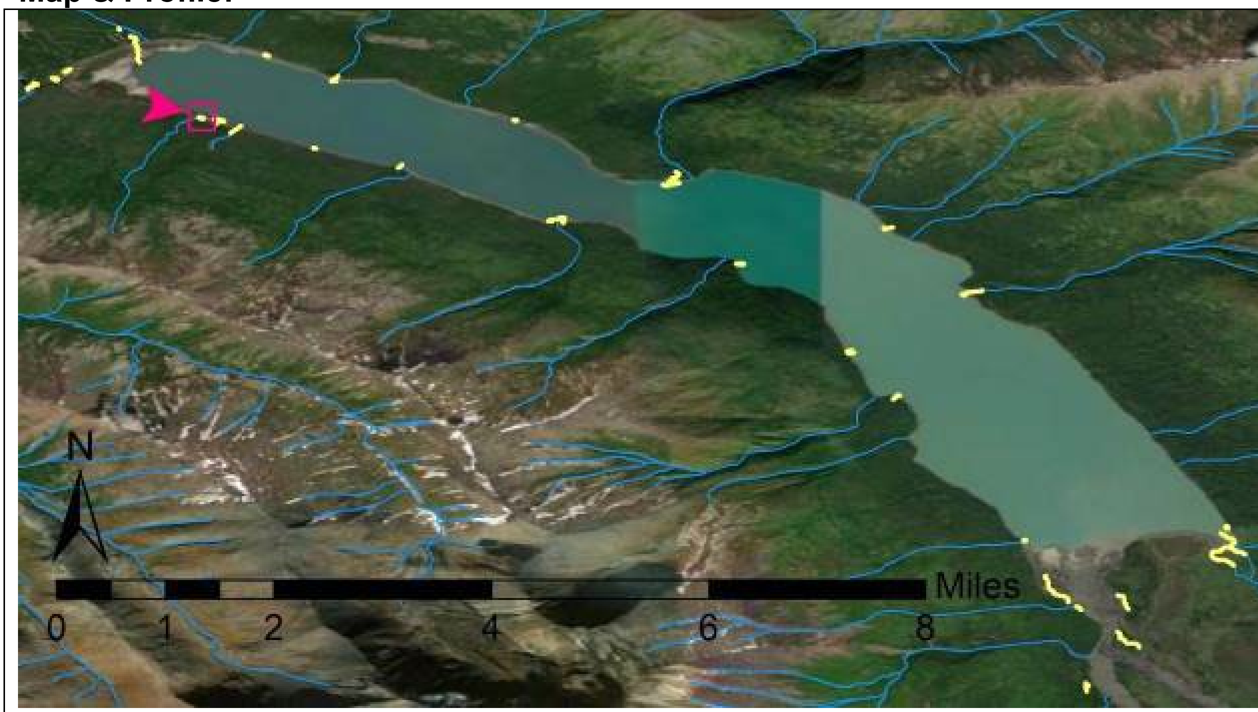
Macro-scale Habitat Type	Meso-scale Habitat types	Description
Slow Water	Backwater Pool (PL-BW)	Found along channel margins, created by eddies around obstructions such as boulders, root wads, or woody debris. Alcoves included
	Scour Pool (PL-SC)	Formed by flow impinging against a stream bank, partial obstruction (logs, root wad, or bedrock), or substrate. Includes both lateral and mid-channel scour pools.
	Beaver Pond (BP)	Water impounded by the creation of a beaver dam
Fast Water	Glide (GL)	An area with generally uniform depth and flow with no surface turbulence. Glides may have some scour areas but are distinguished from pools by their overall homogeneity and lack of structure.
	Riffle (RF)	Fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates.
	Boulder Riffle (BR)	Same flow and gradient as Riffle, but with numerous boulders than can create sub-unit sized pools or pocket water created by scour.
	Rapid (RP)	Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0 -4.0 percent slope, occasionally 7.0-8.0 percent.
	Chute (CH)	An area where most of the flow in constricted to a channel much narrower than the average channel width. Laterally concentrated flow in generally created by a channel impingement or a laterally asymmetric bathymetric profile. Flow is fast and turbulent.
	Cascade (CS)	Fast water habitat with turbulent flow; many hydraulic jumps, strong chutes, and eddies and between 30-80 percent white water. High gradient; usually greater than 4.0 percent slope. Much of the exposed substrate composed of boulders organized into clusters, partial bars, or steep-pool sequences.
	Falls (FS)	Steep near vertical drop in water surface elevation greater than approximately 5 feet over a permanent feature, generally bedrock.
Special Case Units	Dry Channel (DC)	Section of the stream channel that is completely dry at the time of survey.
	Puddled (PD)	Nearly dry channel but with sequence of small isolated sour pools less than one channel width in length or width.

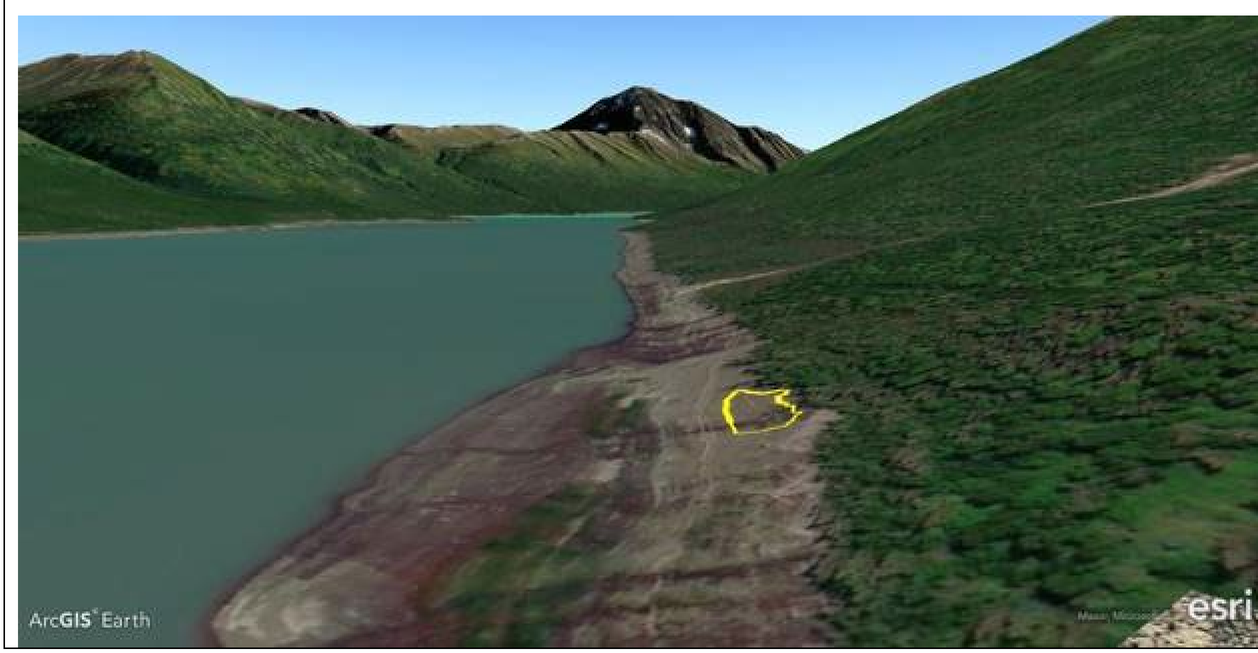
Appendix 2: Lake Tributary and Spawning Habitat Summary and Field Notes

Site Name	Date
WB Lake varial bench 1	6/3/2019

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.39868	-149.12543	61.39885	-149.12587

Map & Profile:





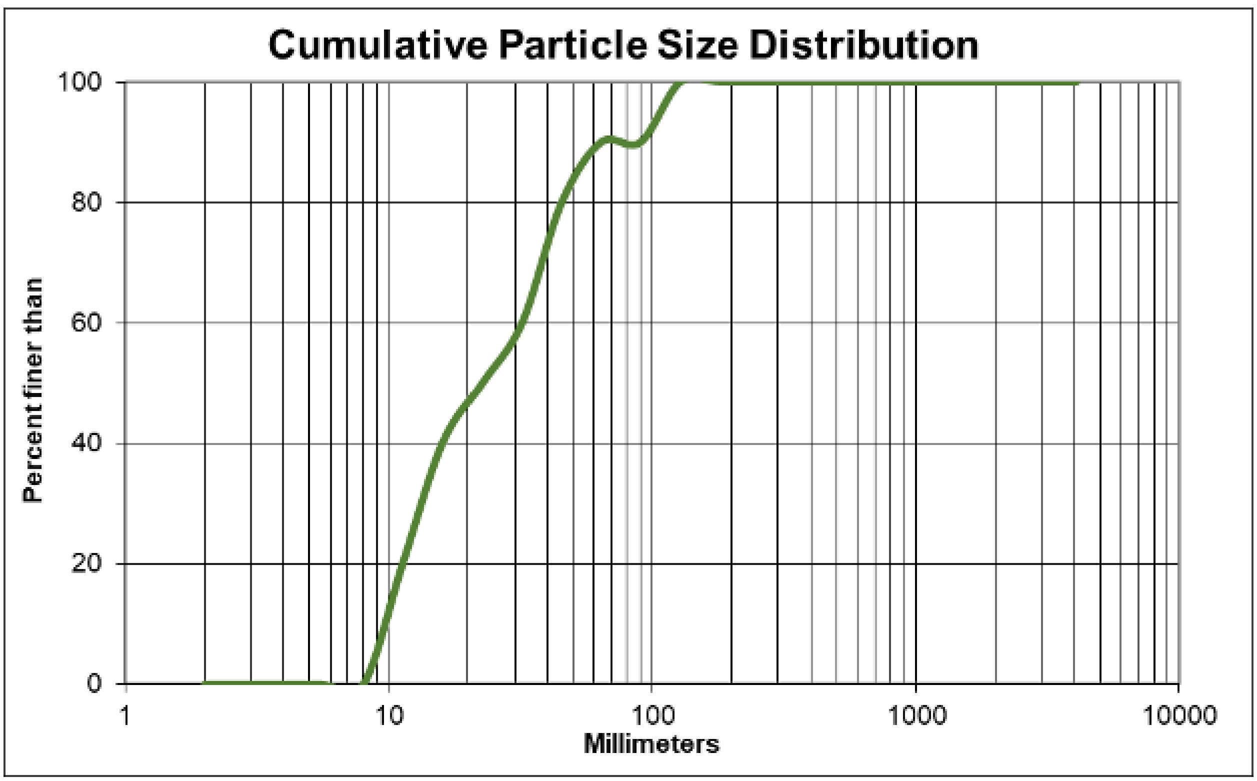
Site Photos:

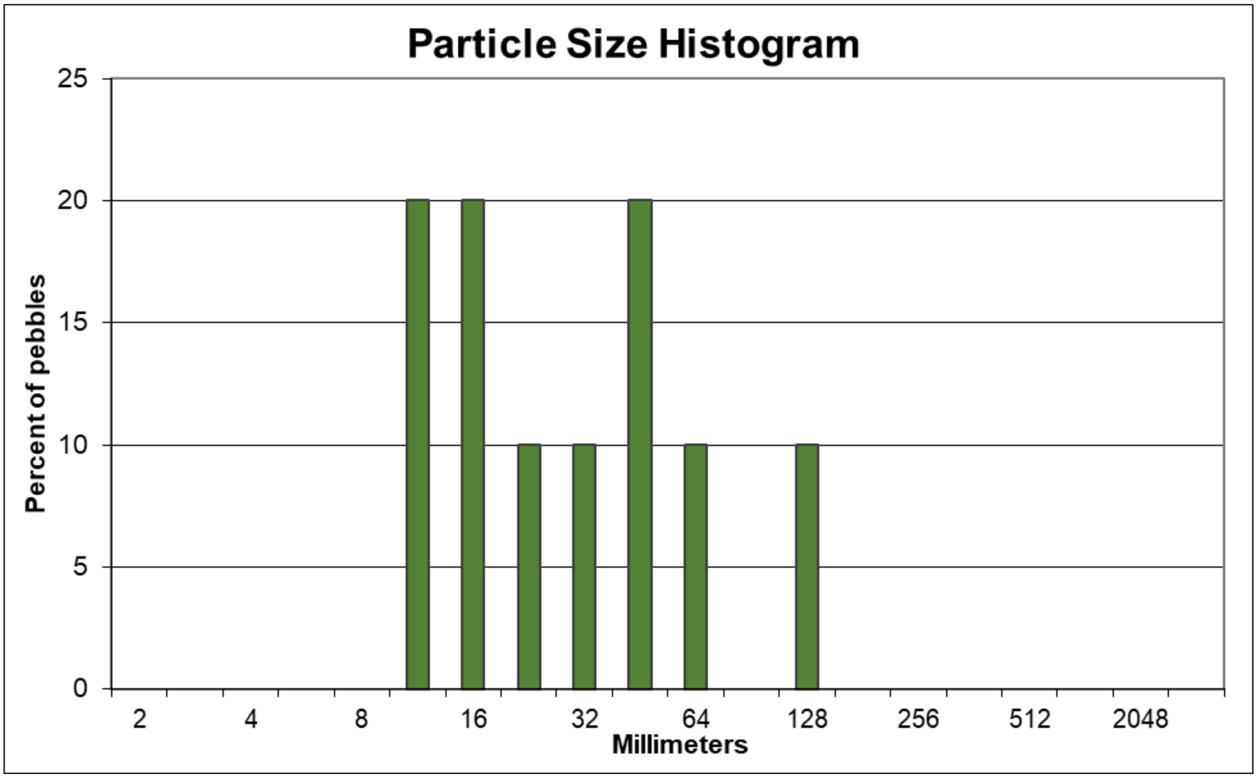
View to east toward lake outlet

View facing west

Field Notes:

Some weak seepage/springs near full pool elevation, photo of seepage 8065, seepage depth not sufficient for water quality, moderately flat bench

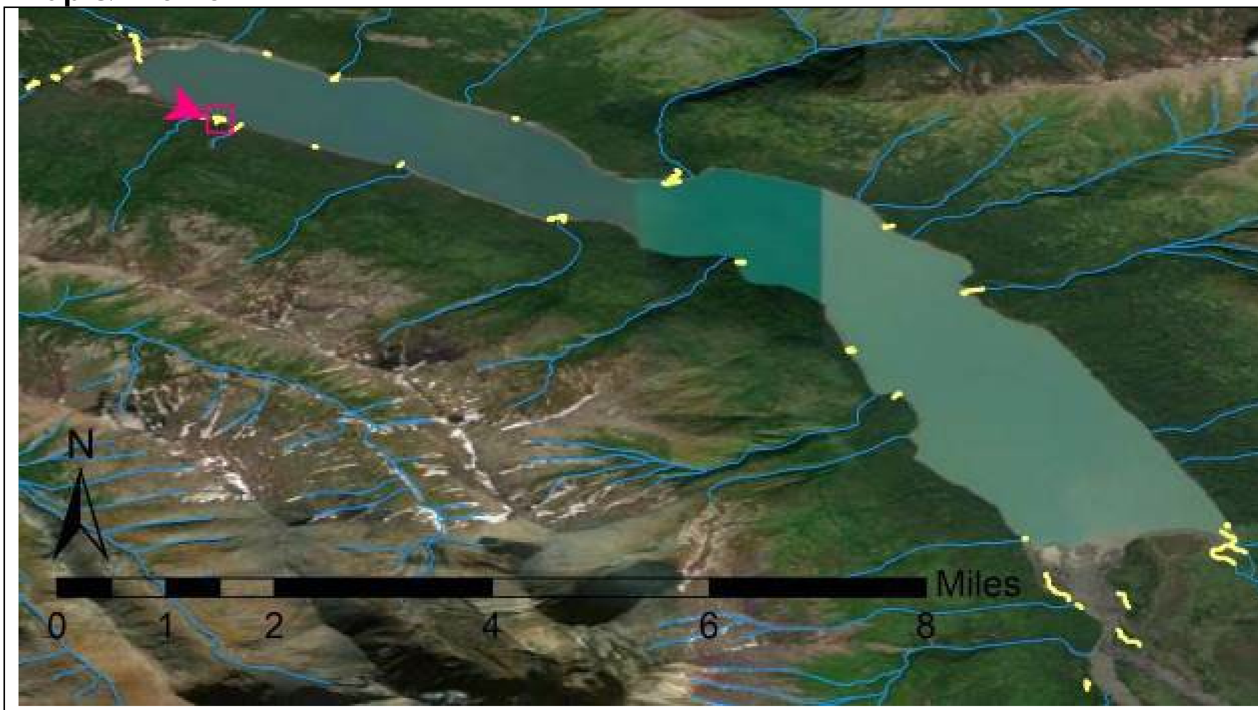


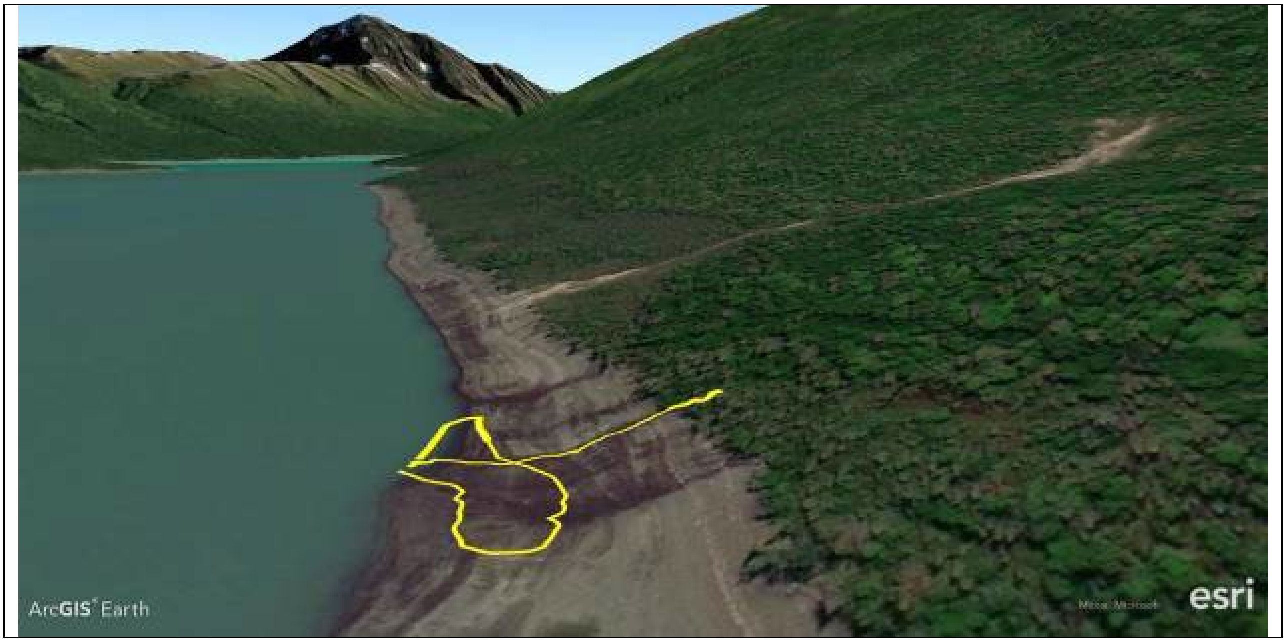

Particle Size Histogram
Percent of pebbles
25
20
15
10
5
0
2
4
8
16
32
64
128
256
512
2048
Millimeters

Site Name	Date
WB Trib A	6/3/2021

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.39849	-149.12291	61.39792	-149.12383

Map & Profile:

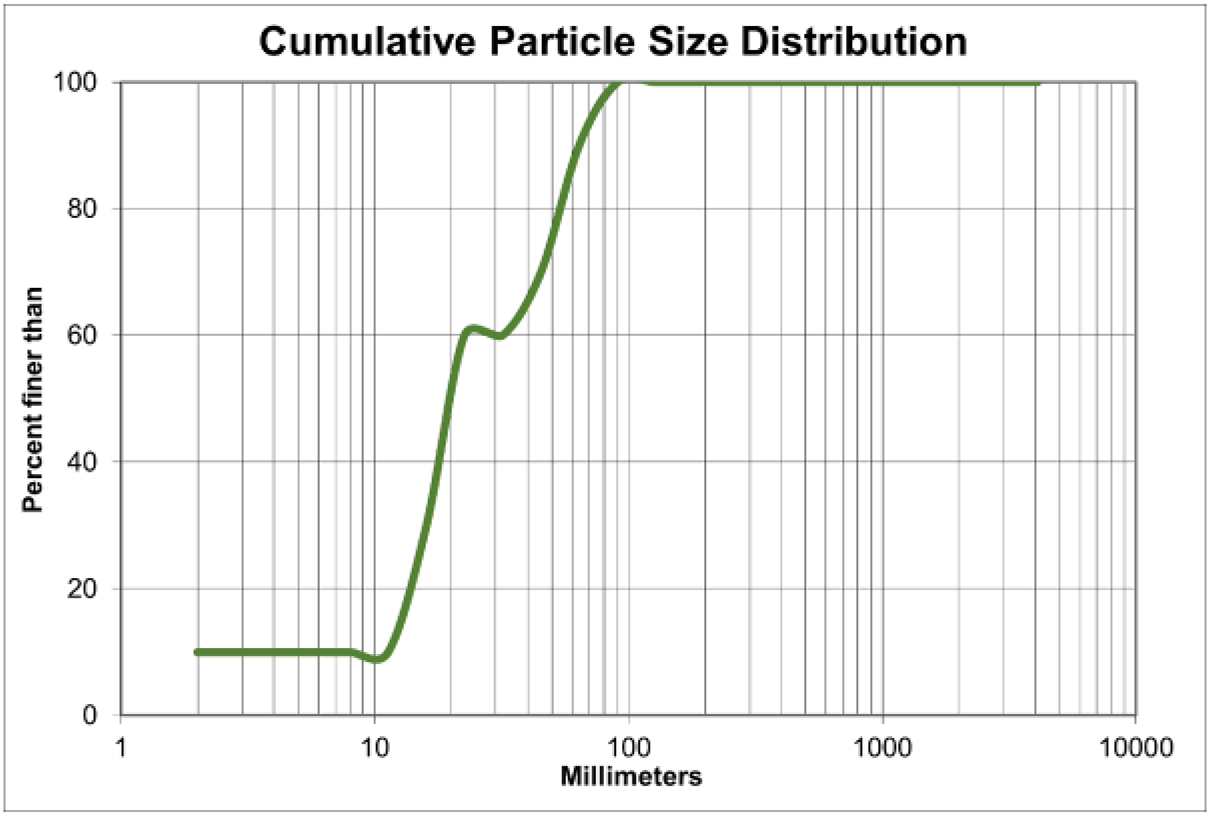


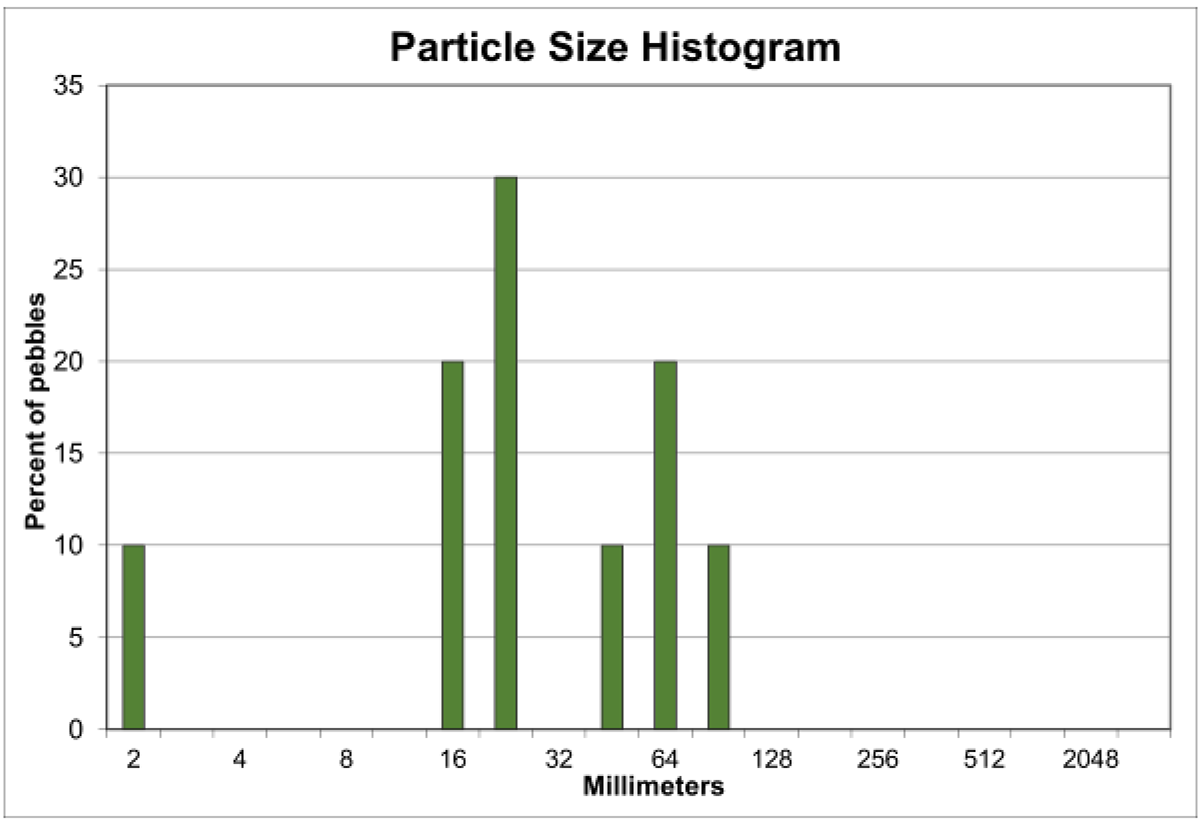


Site Photos:

Field Notes:

D/S photo 8600, trib too small to support spawning, lake elevation 2455, top 2584 lake full pool, upstream of varial zone slope ~15%, 8061u/s 8062 D/s, delineated a varial spawning area on moderately flat slope ~10ft above current lake WS, very steep drop where trib enters lake at full pool


Cumulative Particle Size Distribution
Percent finer than
100
80
60
40
20
0
1
10
100
1000
10000
Millimeters


Particle Size Histogram
Percent of pebbles
35
30
25
20
15
10
5
0
2
4
8
16
32
64
128
256
512
2048
Millimeters

Site Name	Date
WB Lake varial bench 2	6/03/2021

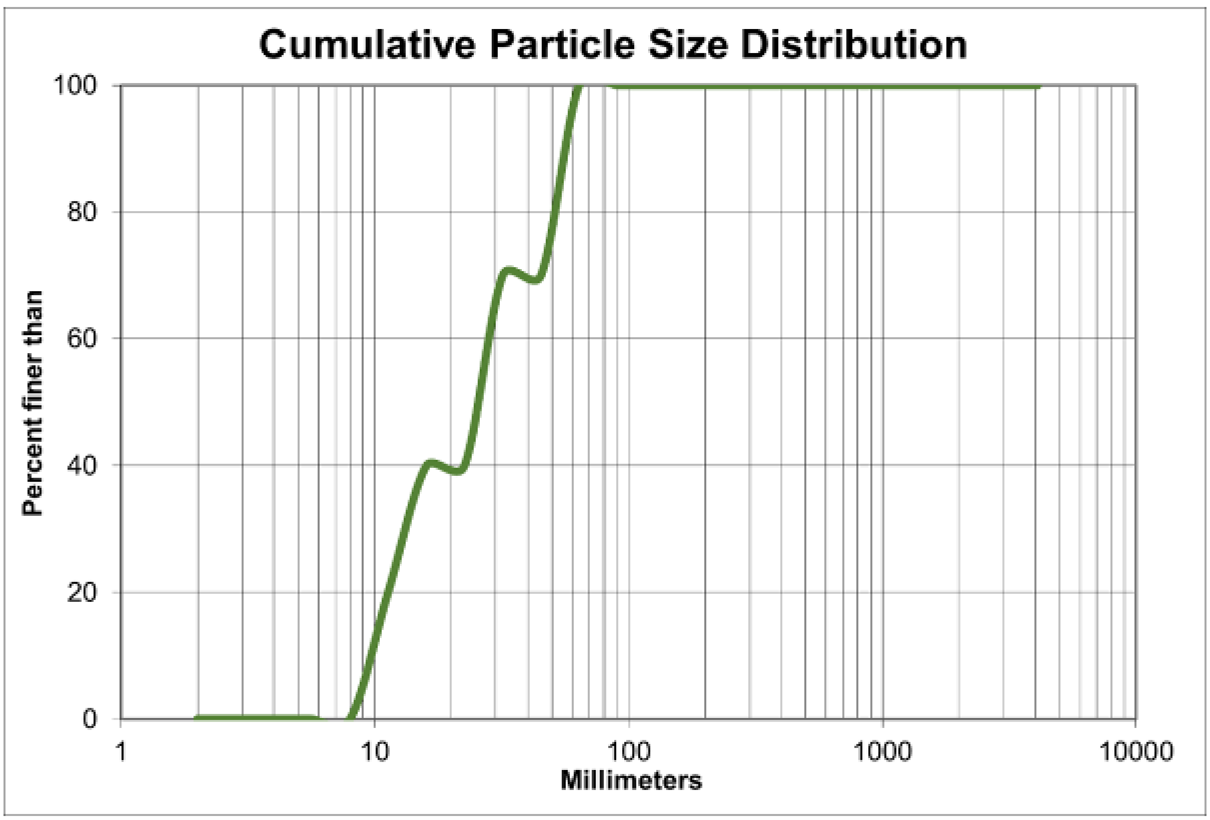
Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.39476	-149.11057	61.39461	-149.11024

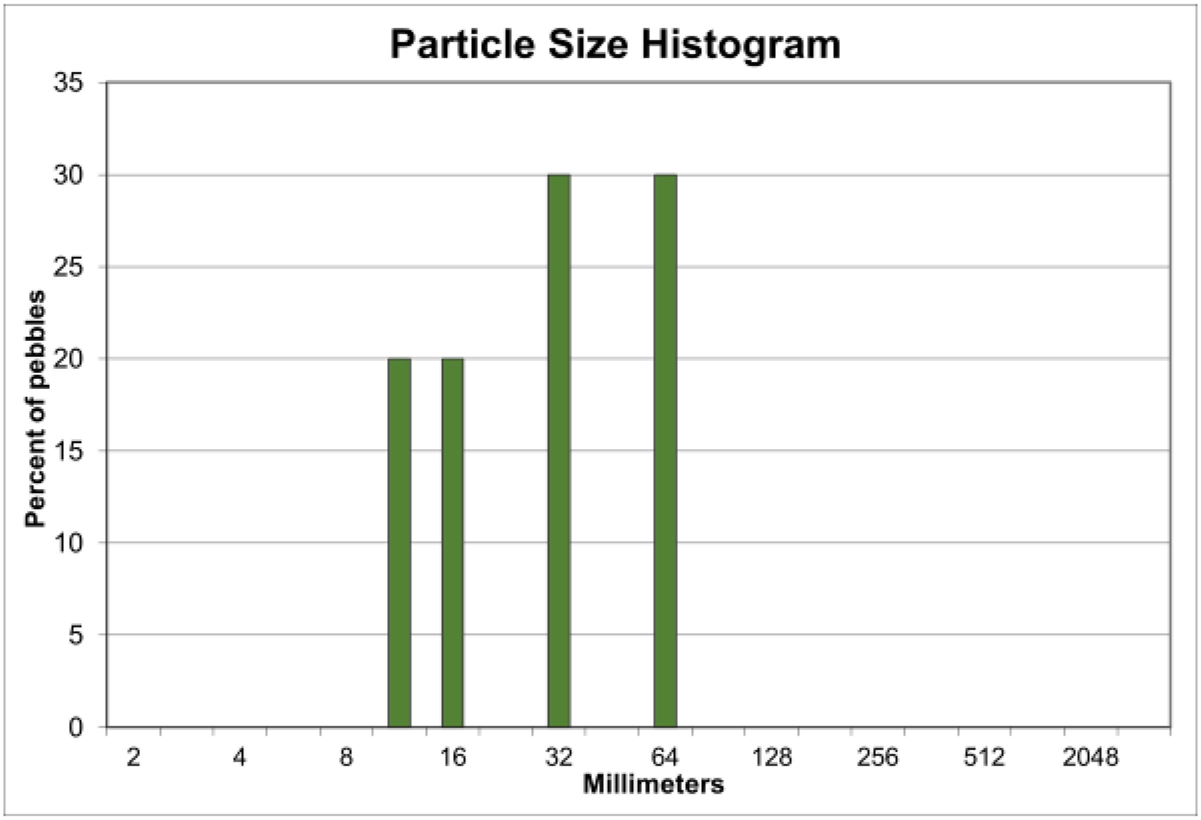
Map & Profile:

Site Photos:

Field Notes:

lots of seeps/groundwater expression along shoreline, best gravels are high up near full pool, lower in varial zone lots of fines sand/silt, additional photos 8039-8042, water quality WPT 262-another seep 10.25C, 375ms/cm, 519 specific conductivity, 10.25mg/L, 9.01pH, photos 8043-8044 looking across seeps



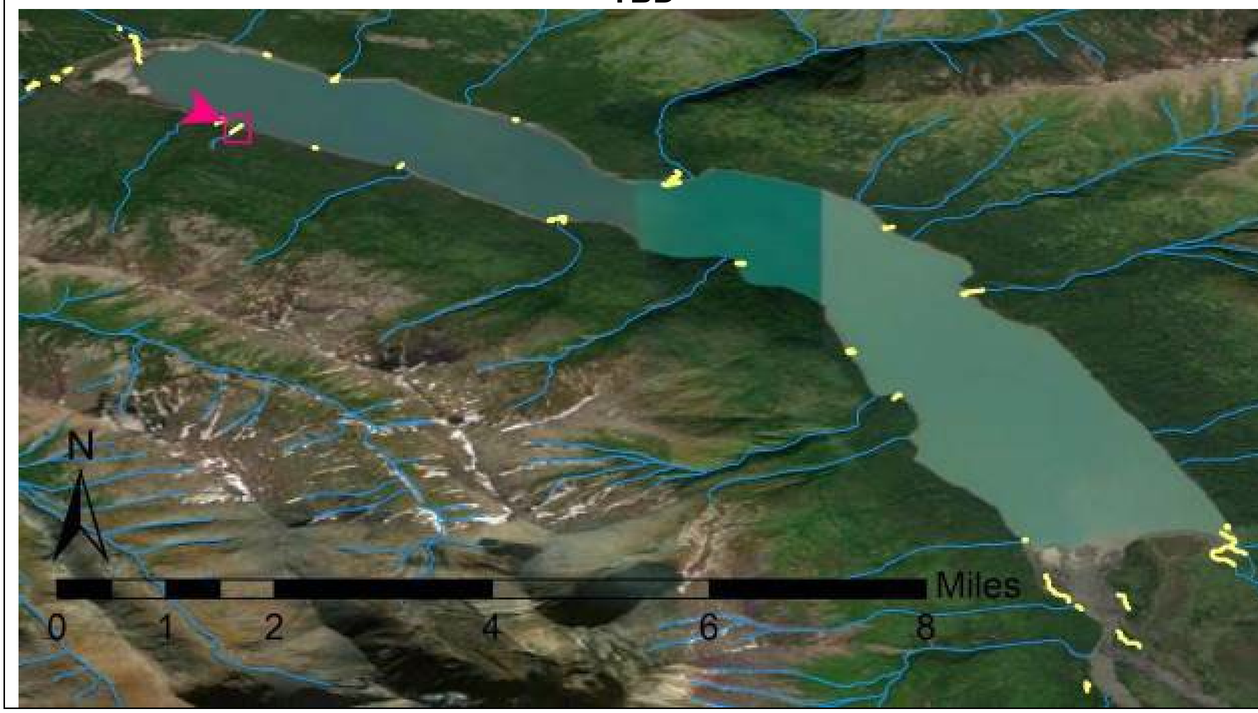

Particle Size Histogram
Percent of pebbles
35
30
25
20
15
10
5
0
2
4
8
16
32
64
128
256
512
2048
Millimeters

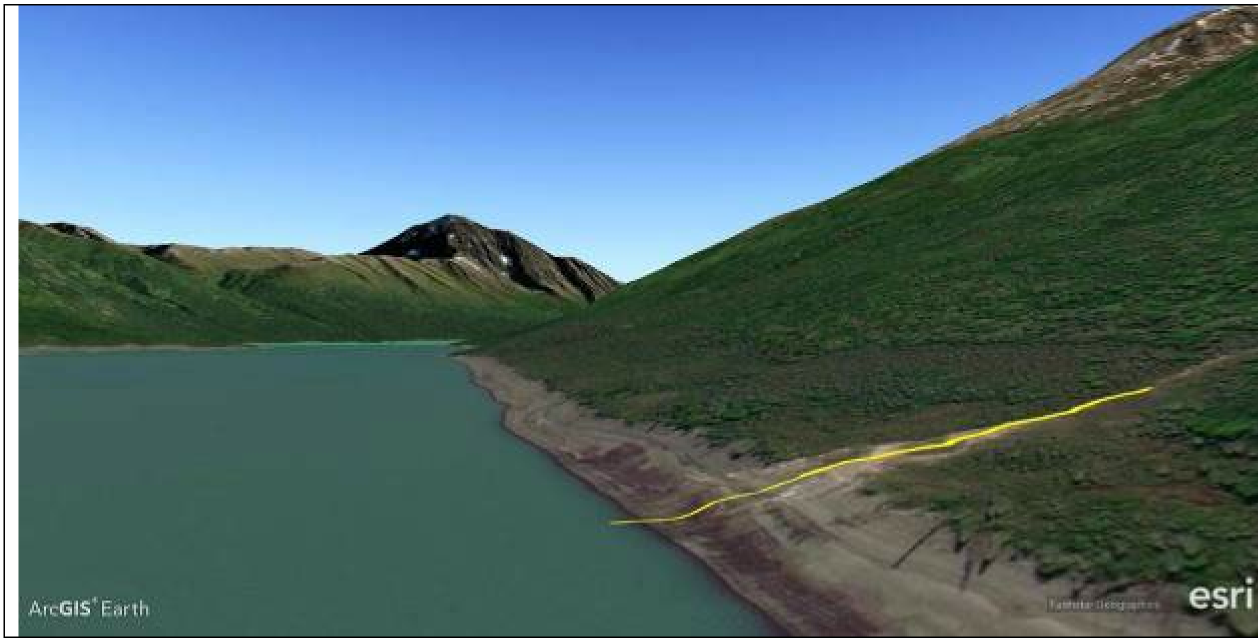
Site Name	Date
WB Trib B	6/03/2021

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.39774	-149.12039	61.3967	-149.09932

Map & Profile:

TBD





Site Photos:

Field Notes:

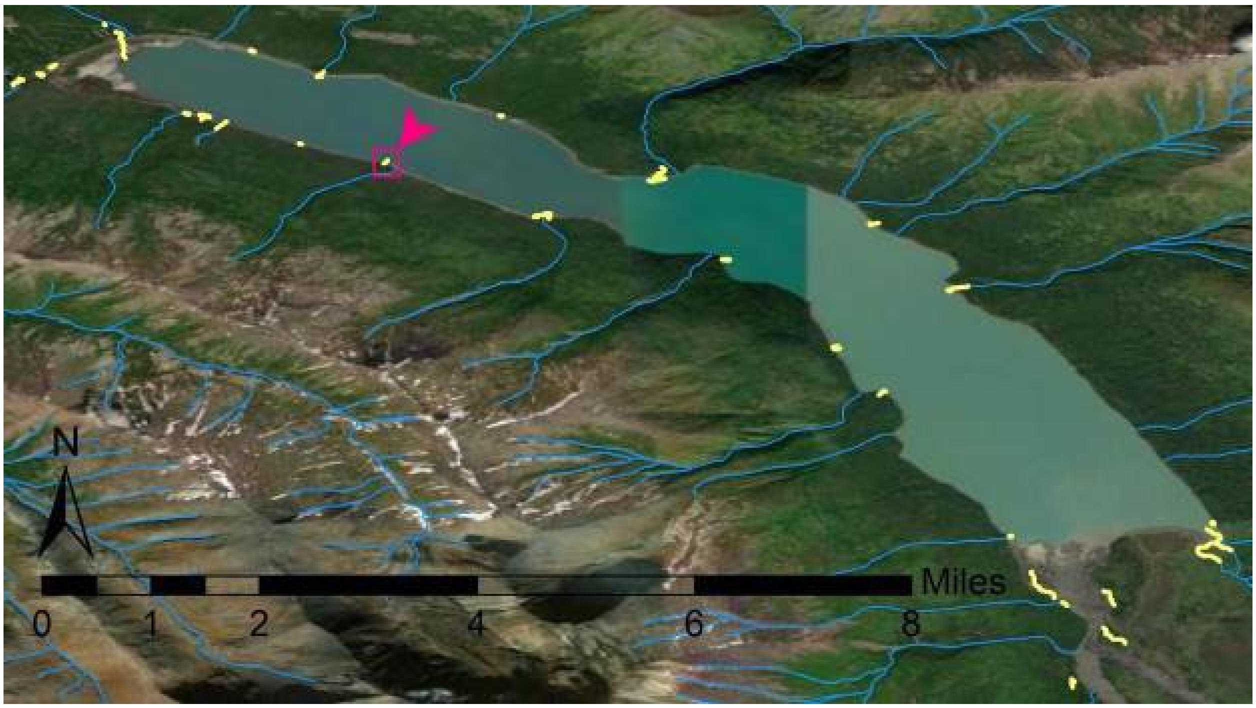
mineralized groundwater influenced Tributary, too small to support spawning, varial zone, no spawning gravels in Benchmark DOI Bureau Land man 2008 S9/S16 T15N RZE, WPT 265, Photo 8050, Lots of groundwater, steep slope, silt and boulders present

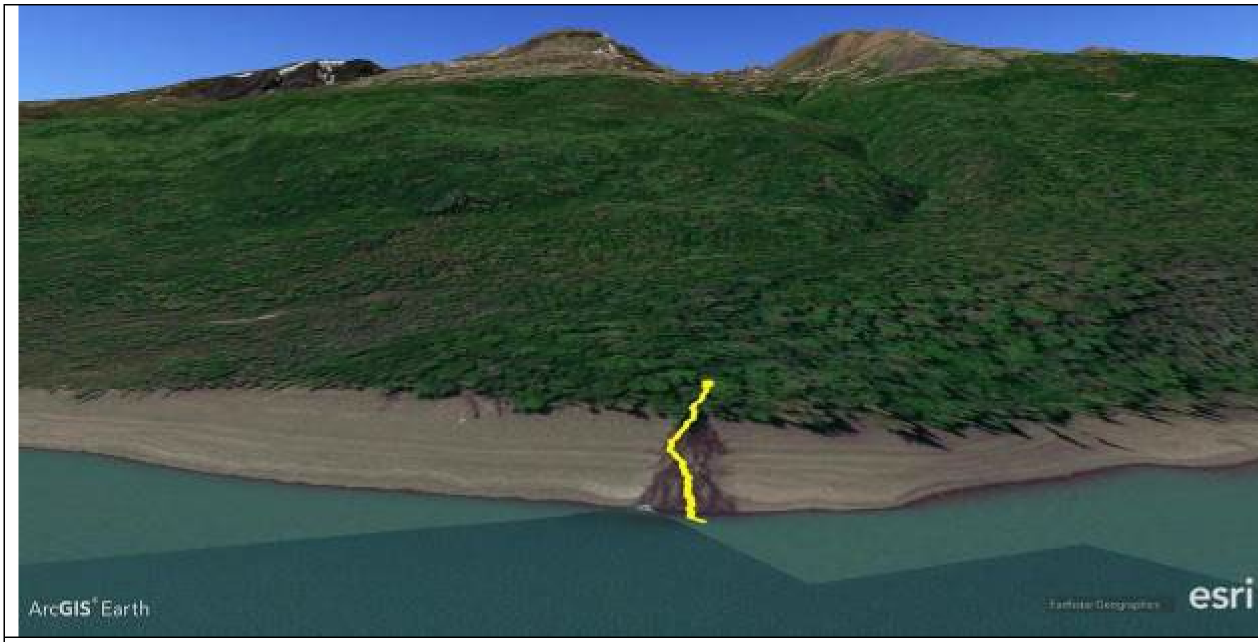
Site Name	Date
WB Trib C	6/03/2021

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.39253	-149.09909	61.39217	-149.09932

Map & Profile:

TBD





Site Photos:

Field Notes:

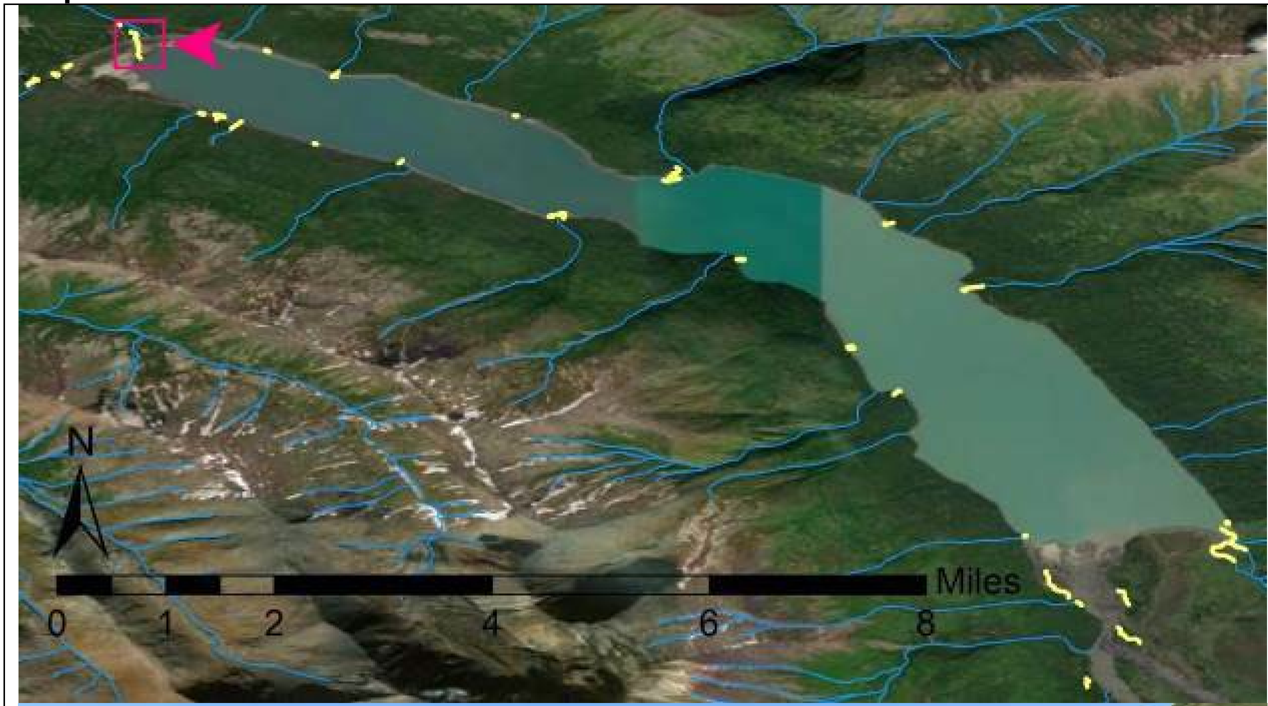
High slope too small to support spawning in stream, u/s of varial zone, photos 8029-8035 are

of site, 2129 Lake surface elevation, 2194 flow pool, Tributary upstream of varial zone greater than 20% slope, Specific Conductivity 867

Site Name	Date
Lach Q'atna Creek	6/01/2021

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude

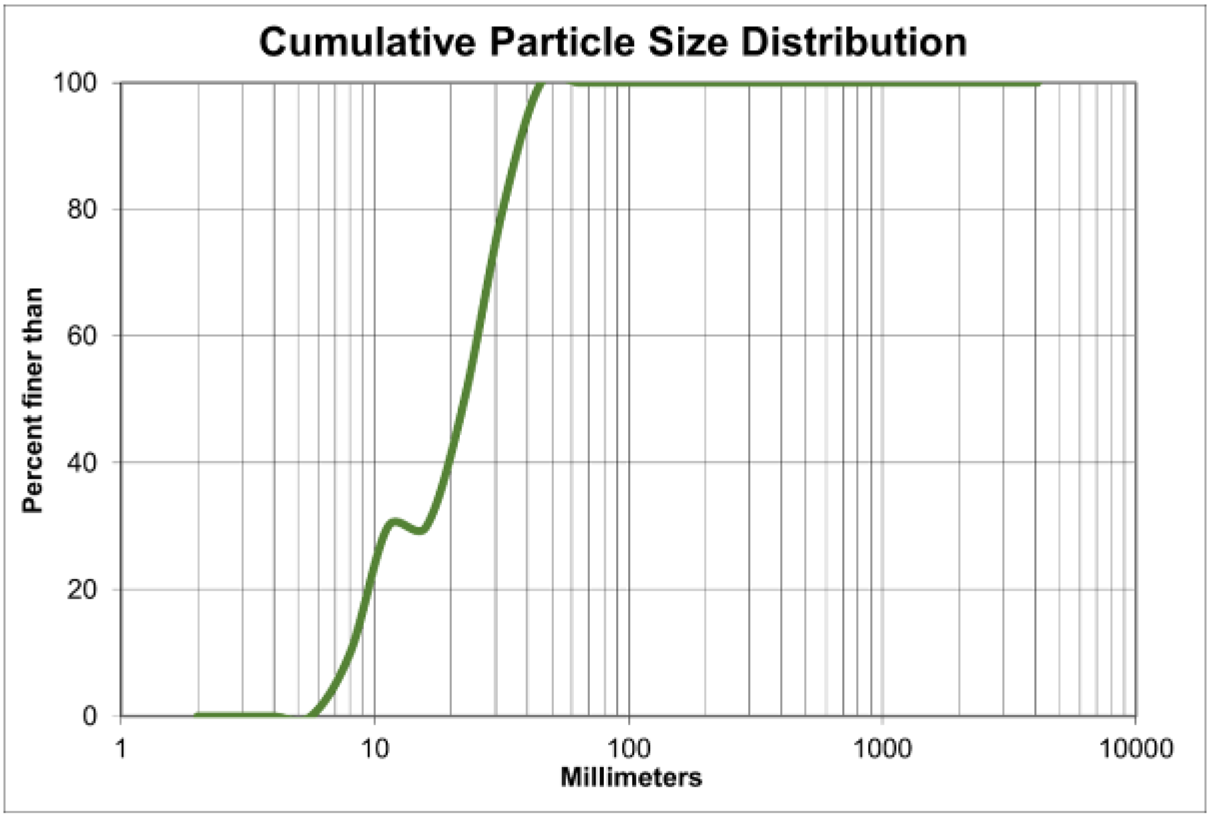
Map & Profile:

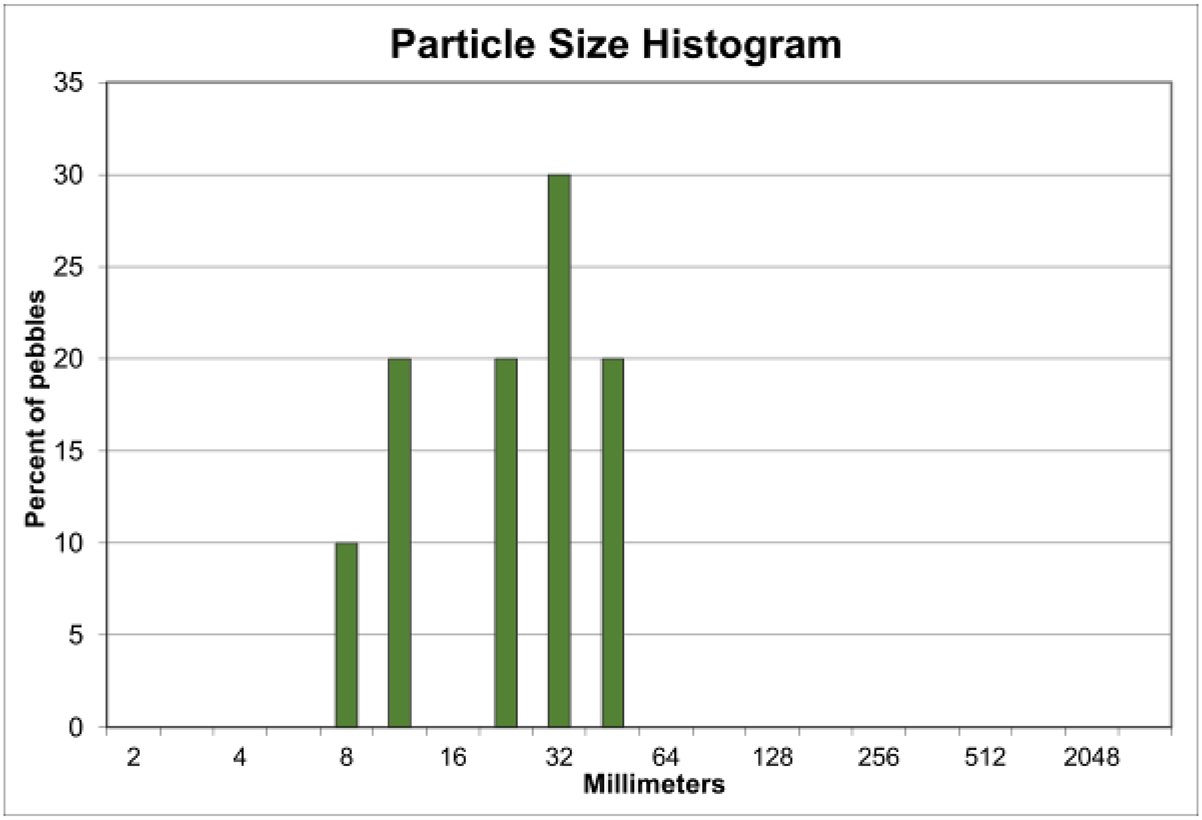


Site Photos:

Field Notes:

Leftside Culvert(7998-7999), rightside culvert(8000) Double culvert, D/S pool plunge pt1649-1658, water surface pH1659-1669, water surface drop approx. 1ft. 3.5 ft diameter, u/s culvert side leftside(8004) rightside (8005), culvert inlet(1680-1689), wetted for spawning area 47ft,49ft, 33ft,17ft, Specific Conductivity 361



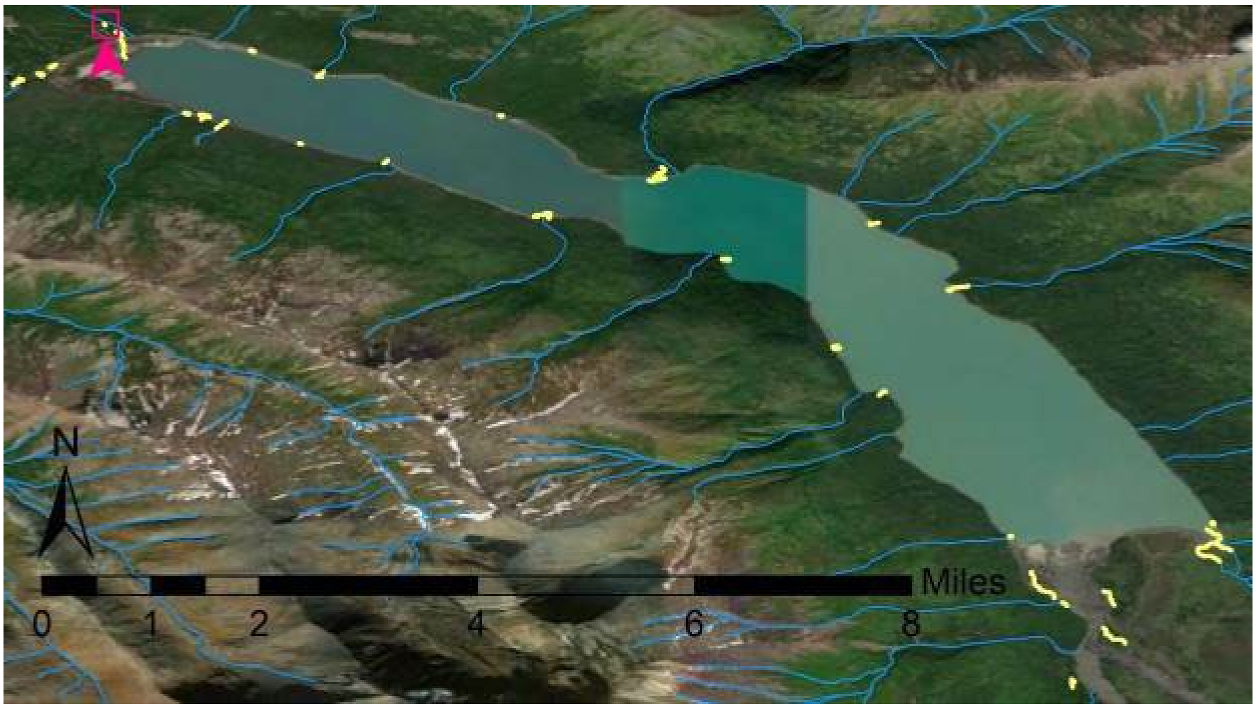

Particle Size Histogram
Percent of pebbles
0
5
10
15
20
25
30
35
2
4
8
16
32
64
128
256
512
2048
Millimeters

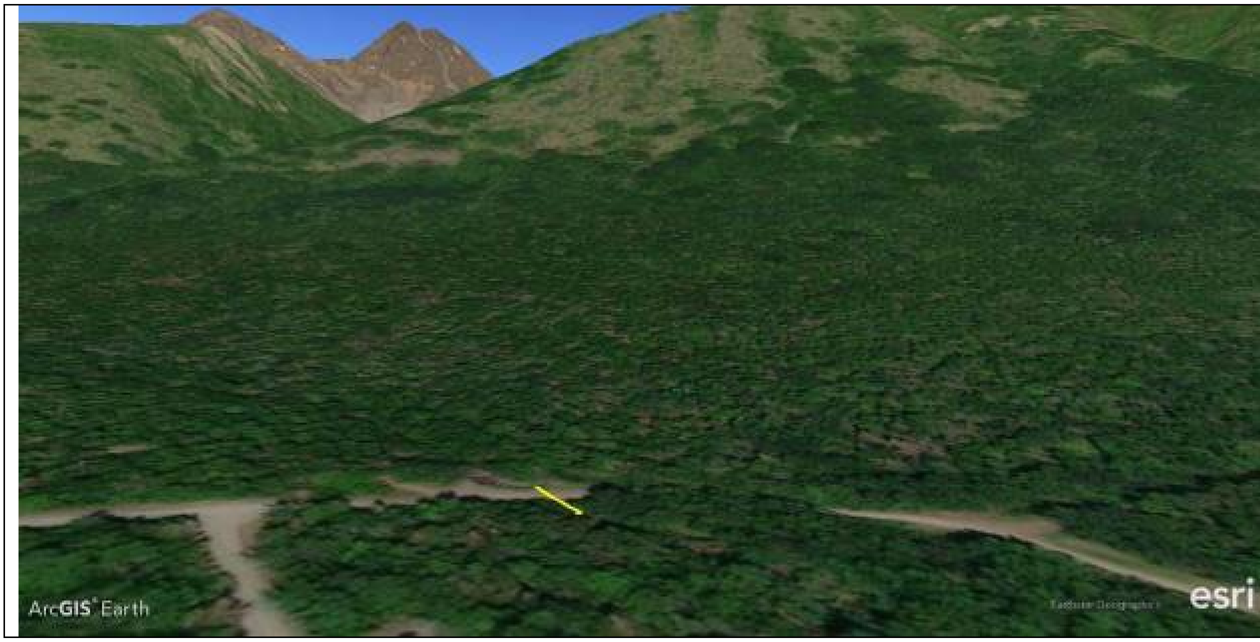
Site Name	Date
Lach Q'atna Creek culvert	6/03/2021

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.40946	-149.17415		

Map & Profile:

TBD





Site Photos:

Field Notes:

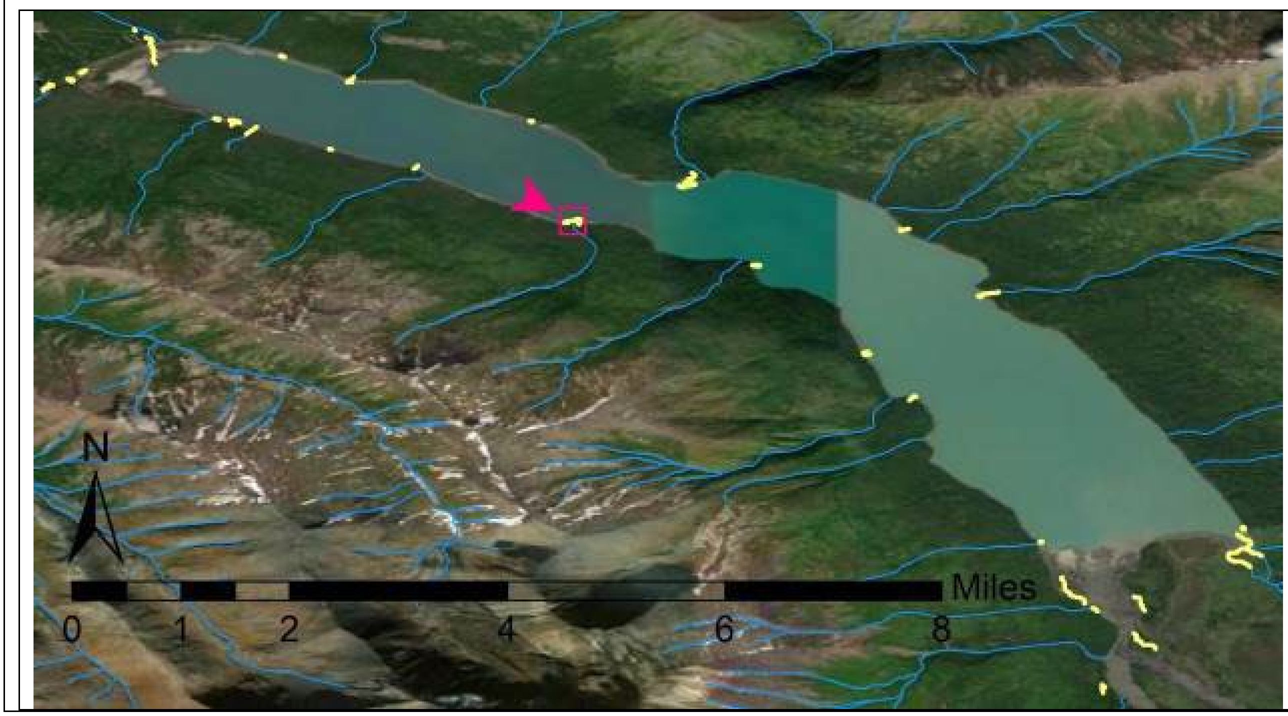
Leftside Culvert(7998-7999), rightside culvert(8000) Double culvert, D/S pool plunge pt1649-1658, water surface pH1659-1669, water surface drop approx 1ft. 3.5 ft diameter, u/s culvert side leftside(8004) rightside (8005), culvert inlet(1680-1689), wetted for spawning area 47ft,49ft, 33ft,17ft, Specific Conductivity 361

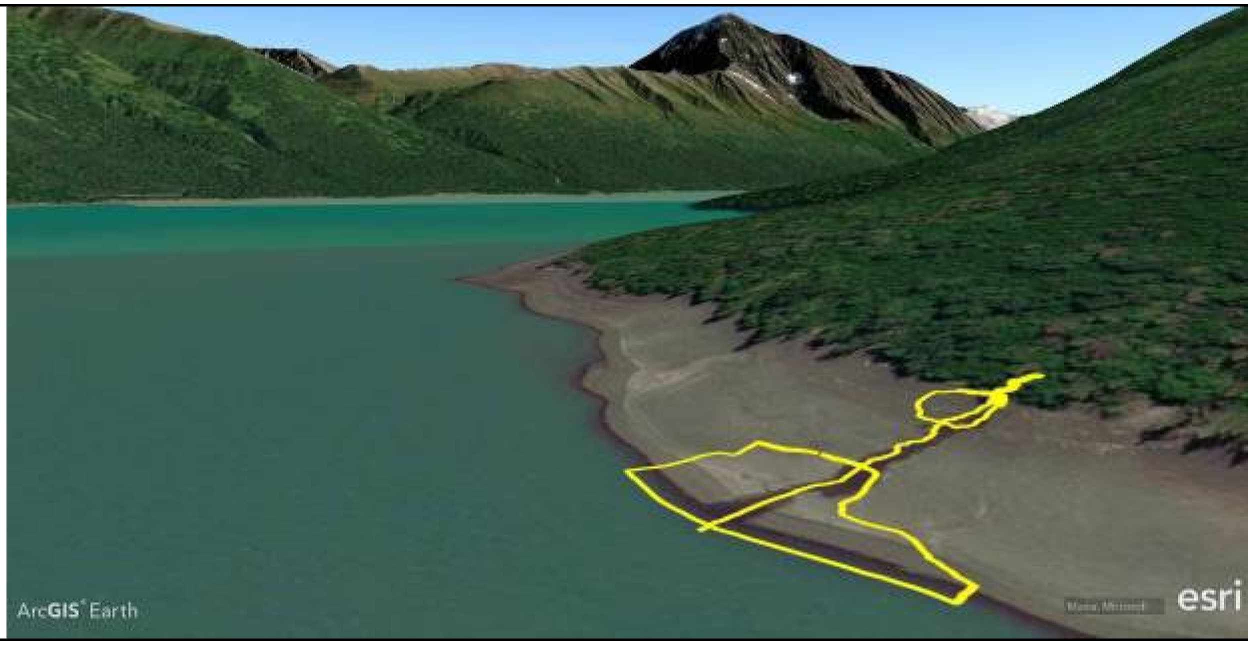
Site Name	Date
WB Trib D	06/03/21

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.38482	-149.07747	61.38470	-149.07747

Map & Profile:

TBD

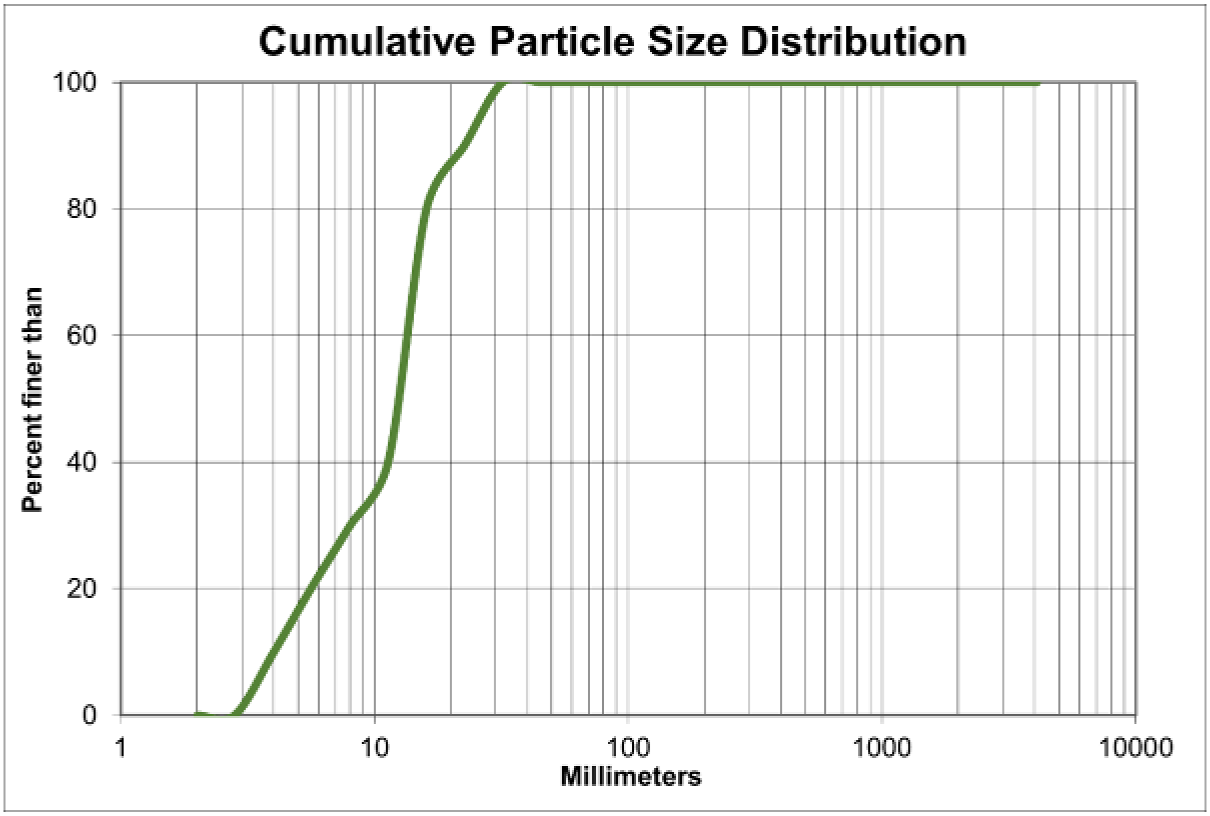


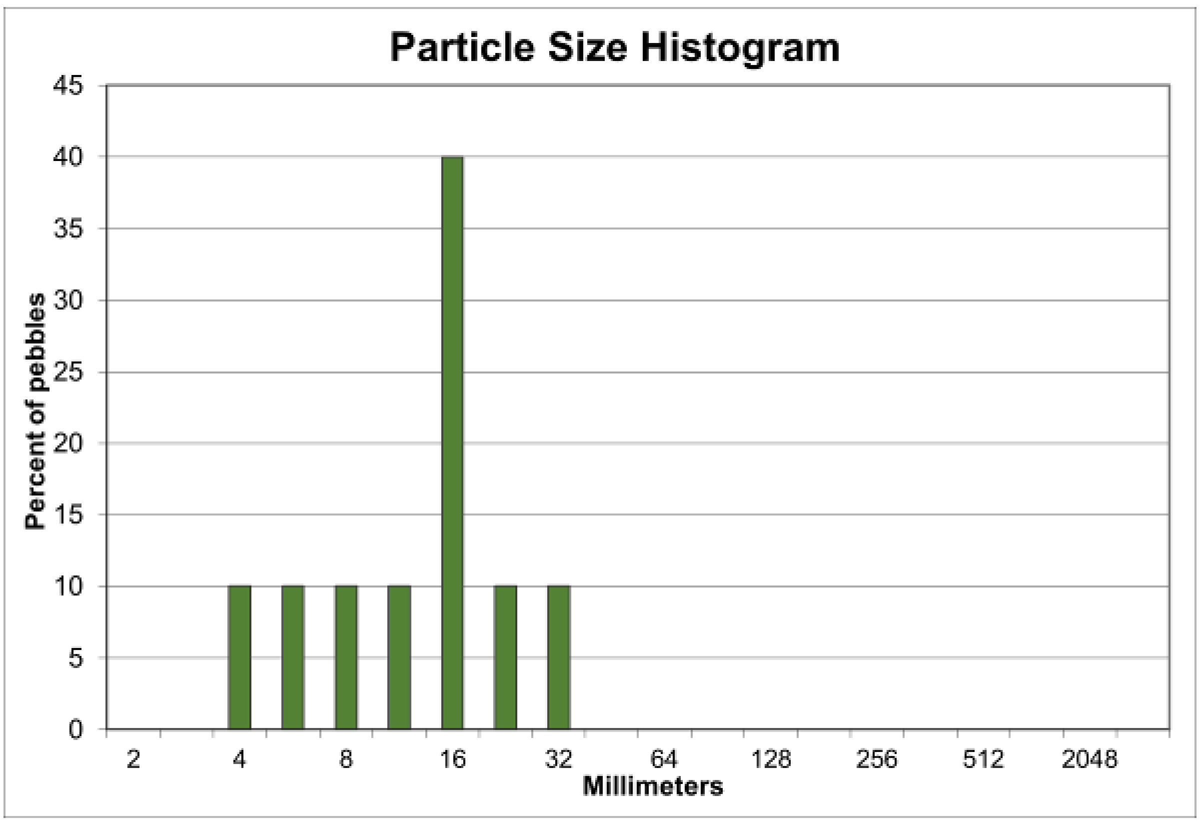


Site Photos:

Field Notes:

pt1697 at lake surface, 1820 at high full pool, Lake WQ at trib <7 NTU7.95C, 18.3us/cm, 273specific conductivity,9.14pH,12.1mg/L, small tribs no spawning potential, good gravels in varial zone mapped as habitat, several small pools just above lake zone then picks up gradient again. photos 8011-8015, High conductivity indicator of groundwater mapped z potential spawning areas in varial good gravels but sloped, mapped a 3rd Hab just south of trib w/ groundwater


Cumulative Particle Size Distribution
Percent finer than
0
20
40
60
80
100
1
10
100
1000
10000
Millimeters

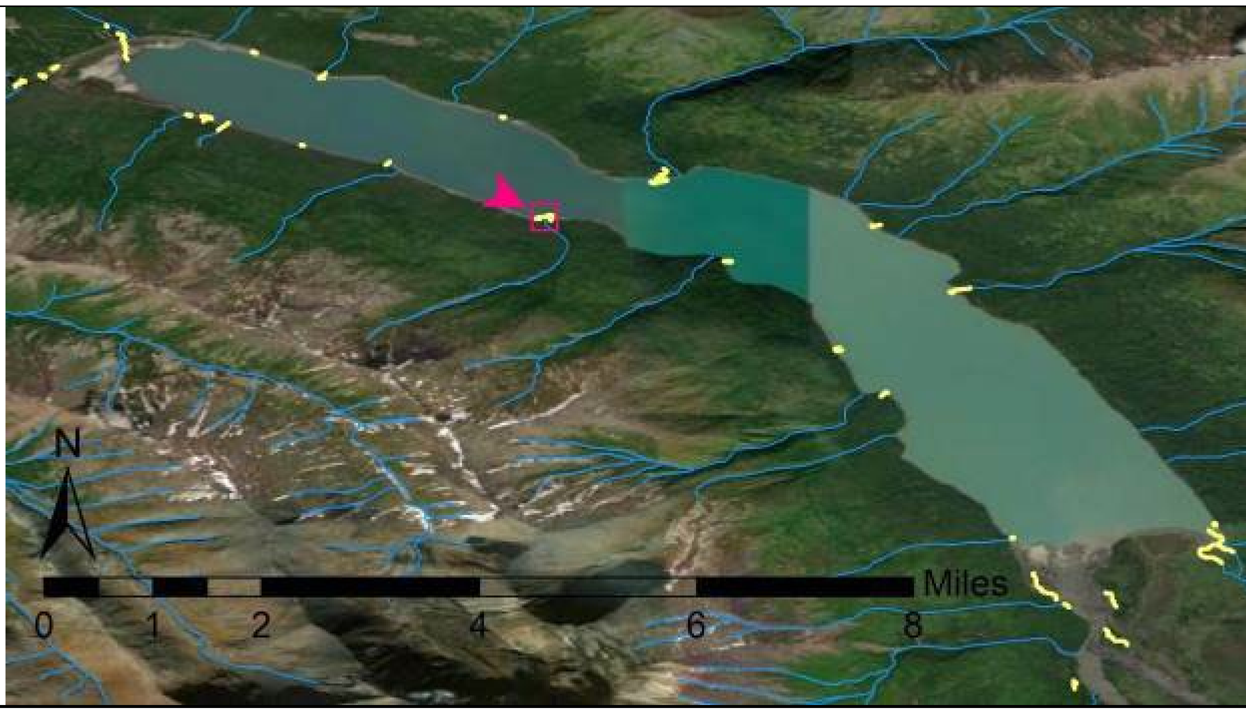

Particle Size Histogram
Percent of pebbles
0
5
10
15
20
25
30
35
40
45
2
4
8
16
32
64
128
256
512
2048
Millimeters

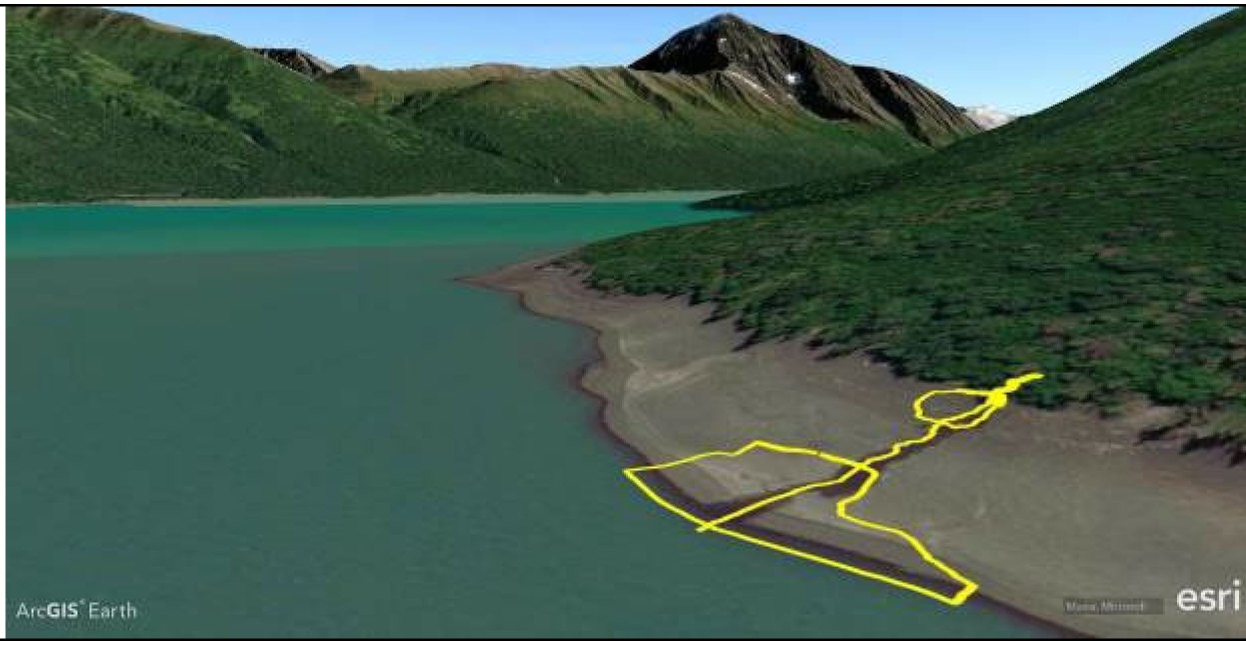
Site Name	Date
WB Trib D Delta	06/03/21

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.38482	-149.07747	61.38470	-149.07747

Map & Profile:

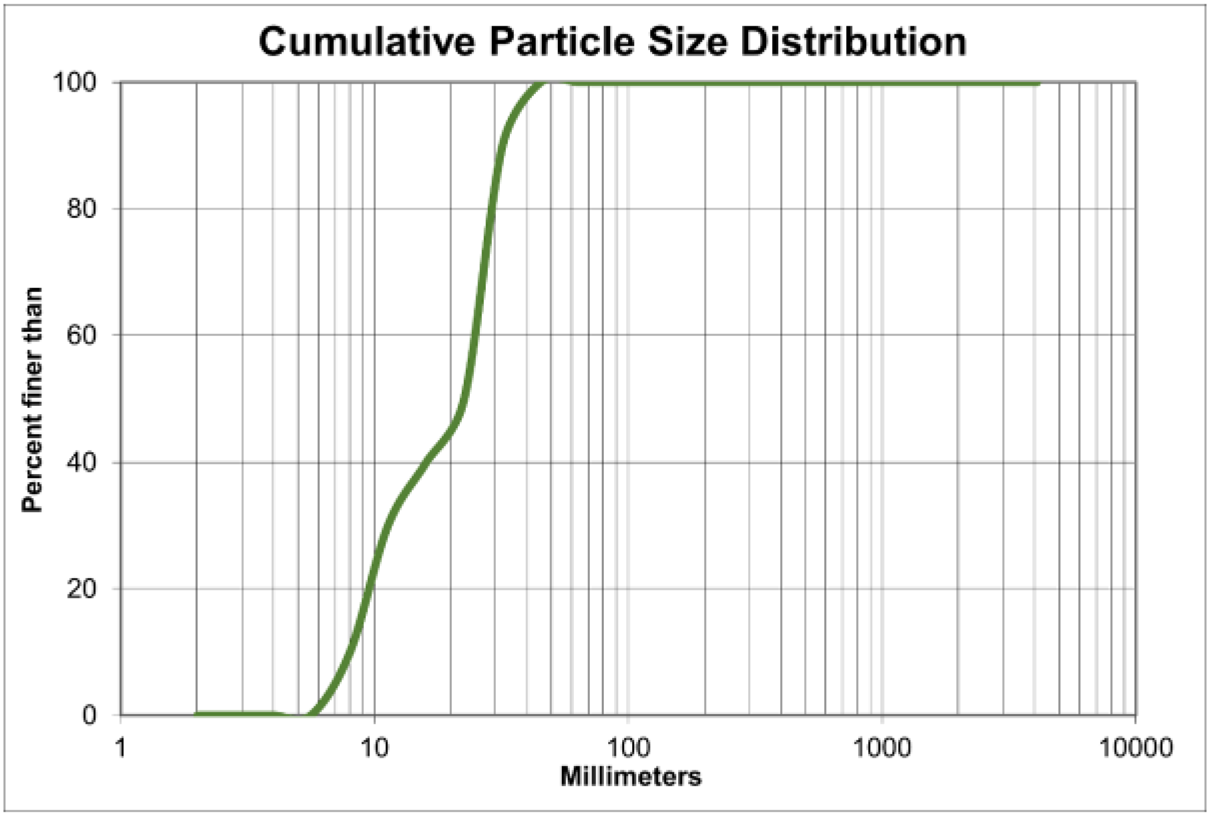
TBD

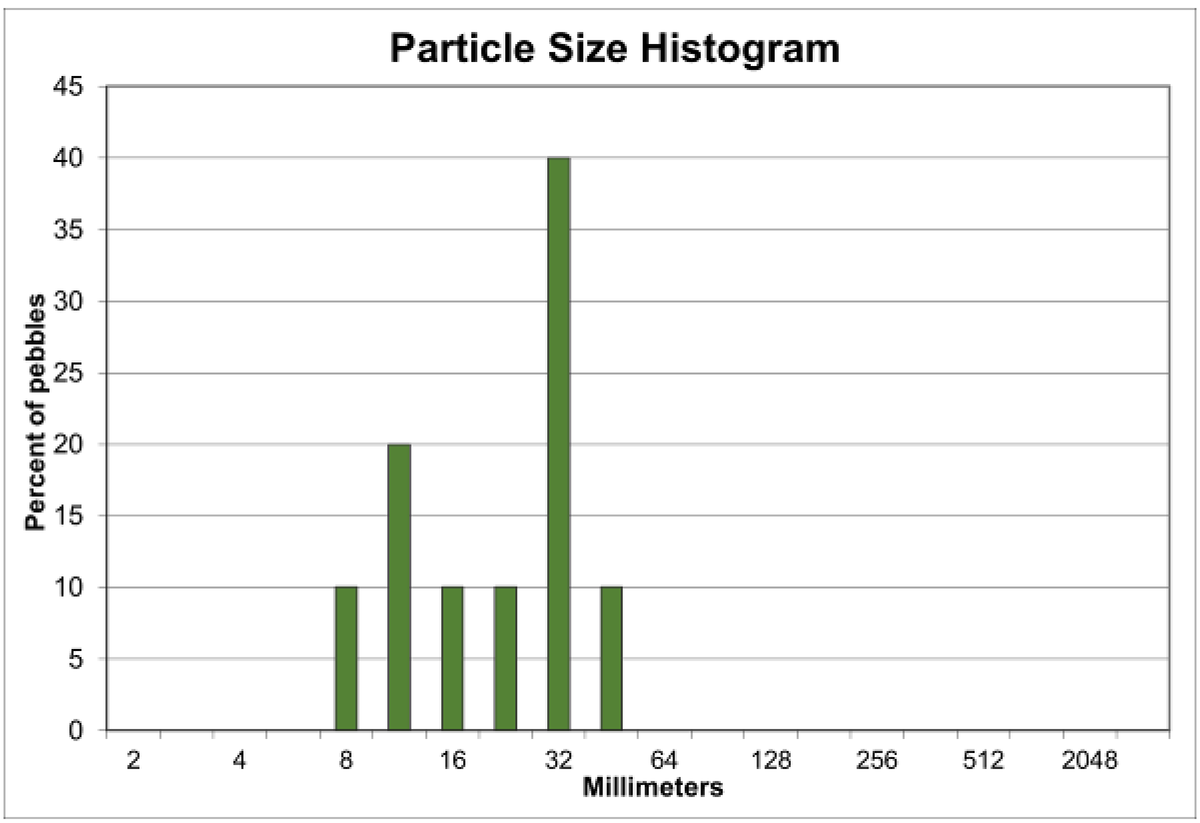




Site Photos:

Field Notes:

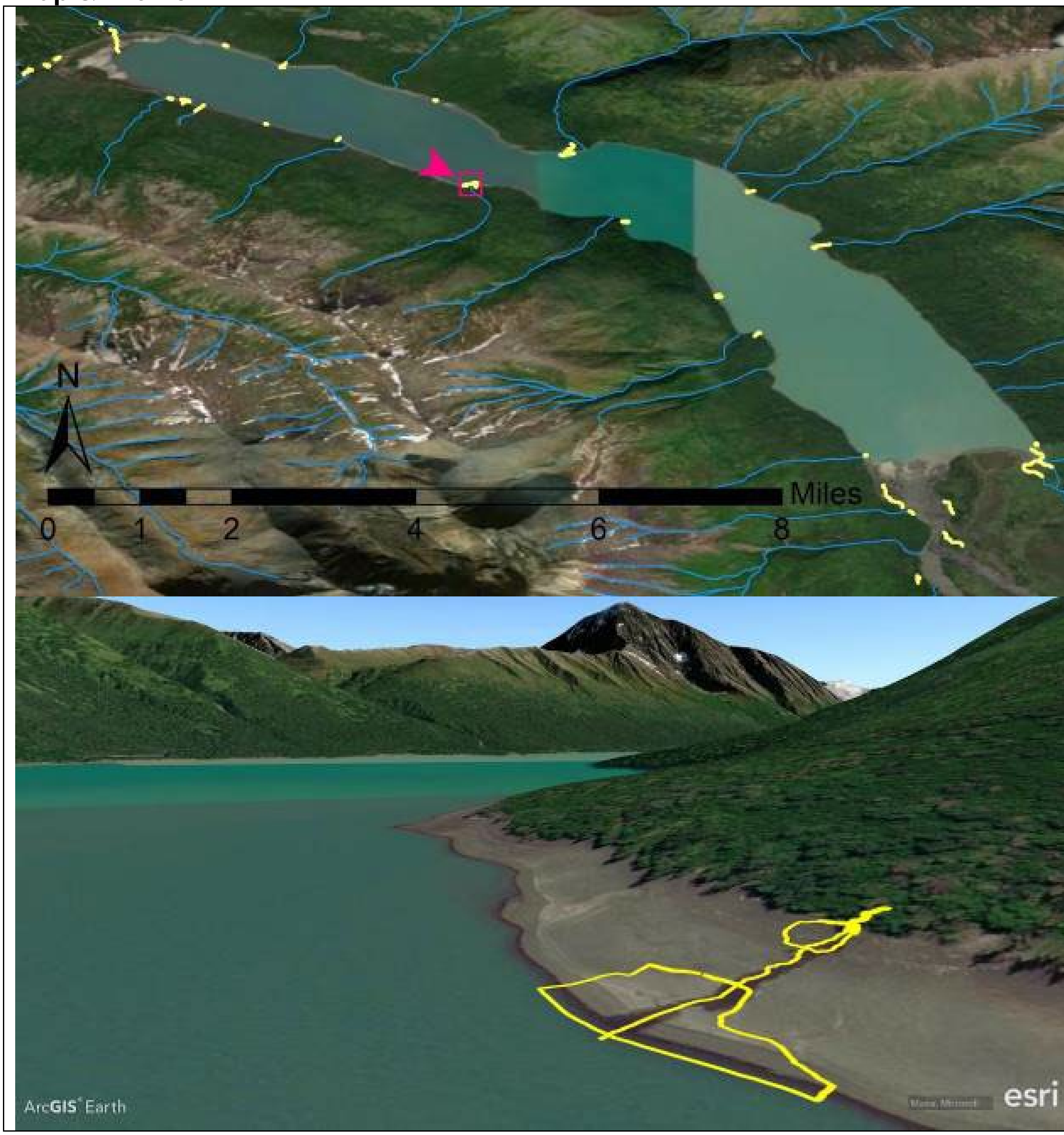

Cumulative Particle Size Distribution
Percent finer than
0
20
40
60
80
100
1
10
100
1000
10000
Millimeters


Particle Size Histogram
Percent of pebbles
0
5
10
15
20
25
30
35
40
45
2
4
8
16
32
64
128
256
512
2048
Millimeters

Site Name	Date
WB Trib D Upper Delta	06/03/21

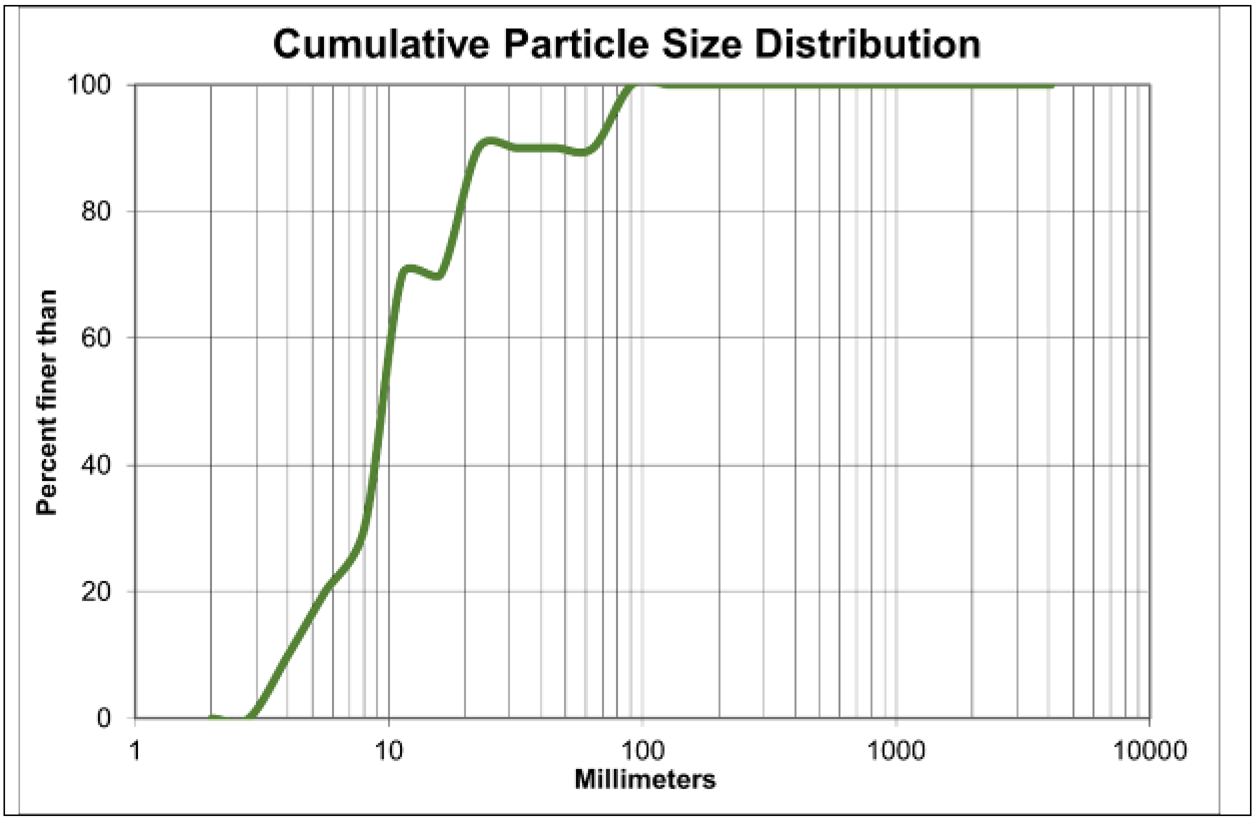
Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.38482	-149.07747	61.38470	-149.07747

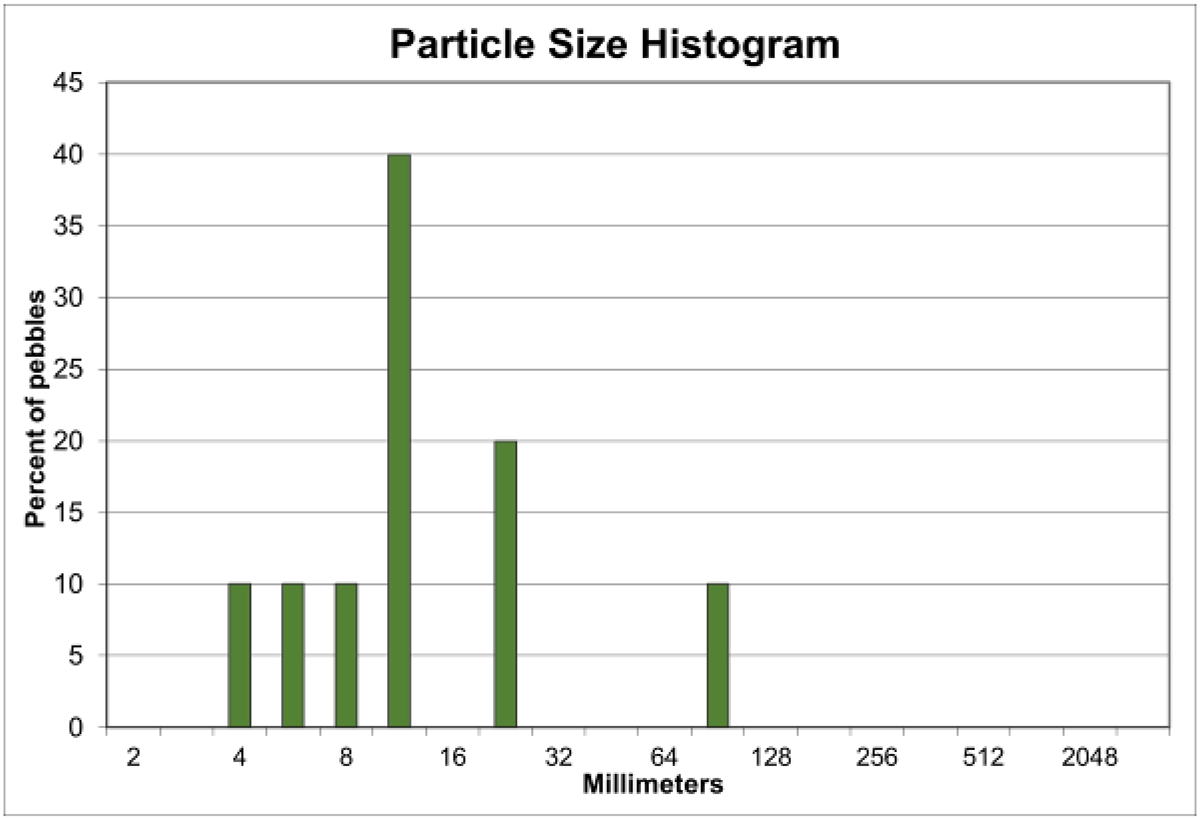
Map & Profile:



Site Photos:

Field Notes:




Particle Size Histogram
Percent of pebbles
45
40
35
30
25
20
15
10
5
0
2
4
8
16
32
64
128
256
512
2048
Millimeters

Site Name	Date
WB Lake varial bench 4	6/02/21

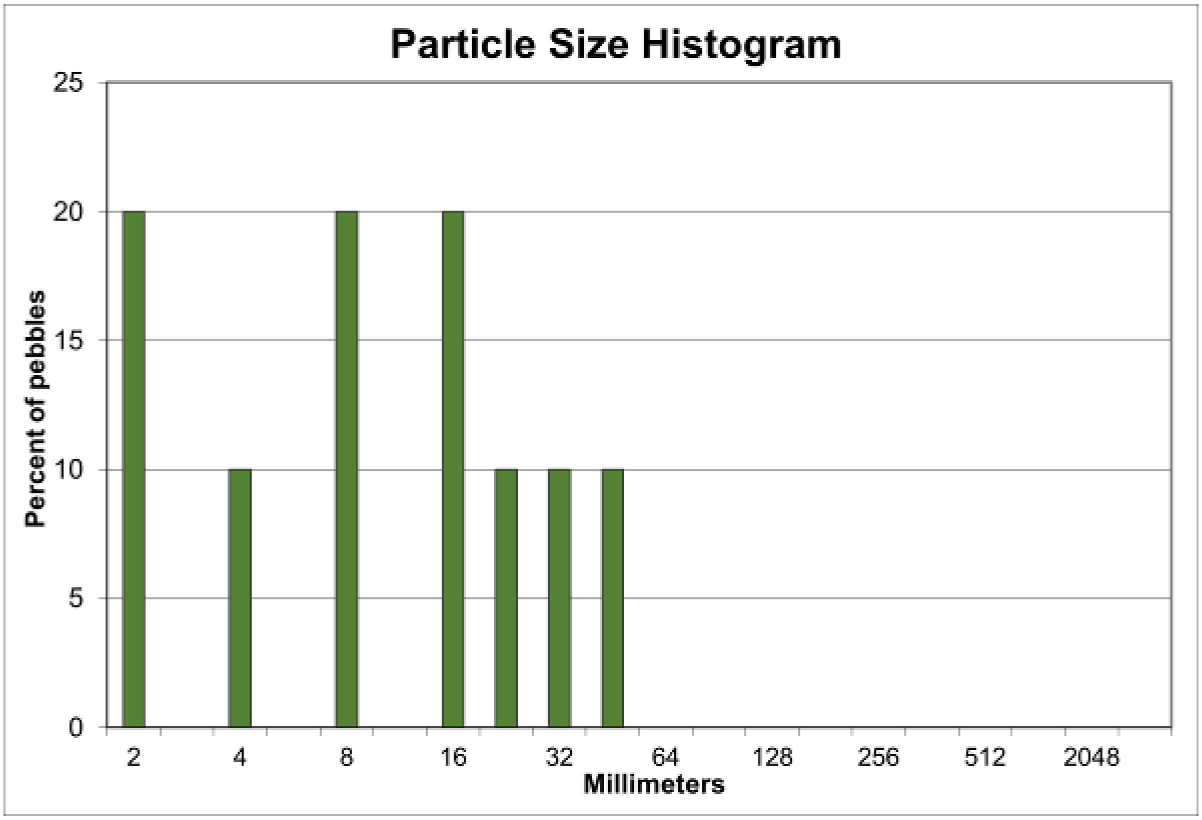
Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.36771	-149.03897	61.36733	-149.03955

Map & Profile:

Site Photos:

Field Notes:

Small trib associated with groundwater seepage, moderate slope, flat benches mixed in, this area was identified as snow/ice free in winter, cond was not extremely high but area has potential for shoreline spawning at certain lake elevations, Flat benches with small gravel approximately 60-80m, long x 2-4m in width, photos 7971-7981 of trib +area, pebble count taken along flat bench 1970-1976 RTK points along top bench, specific conductivity 365


Particle Size Histogram
Percent of pebbles
0
5
10
15
20
25
2
4
8
16
32
64
128
256
512
2048
Millimeters

Site Name	**Date**
WB Trib E delta	6/02/21

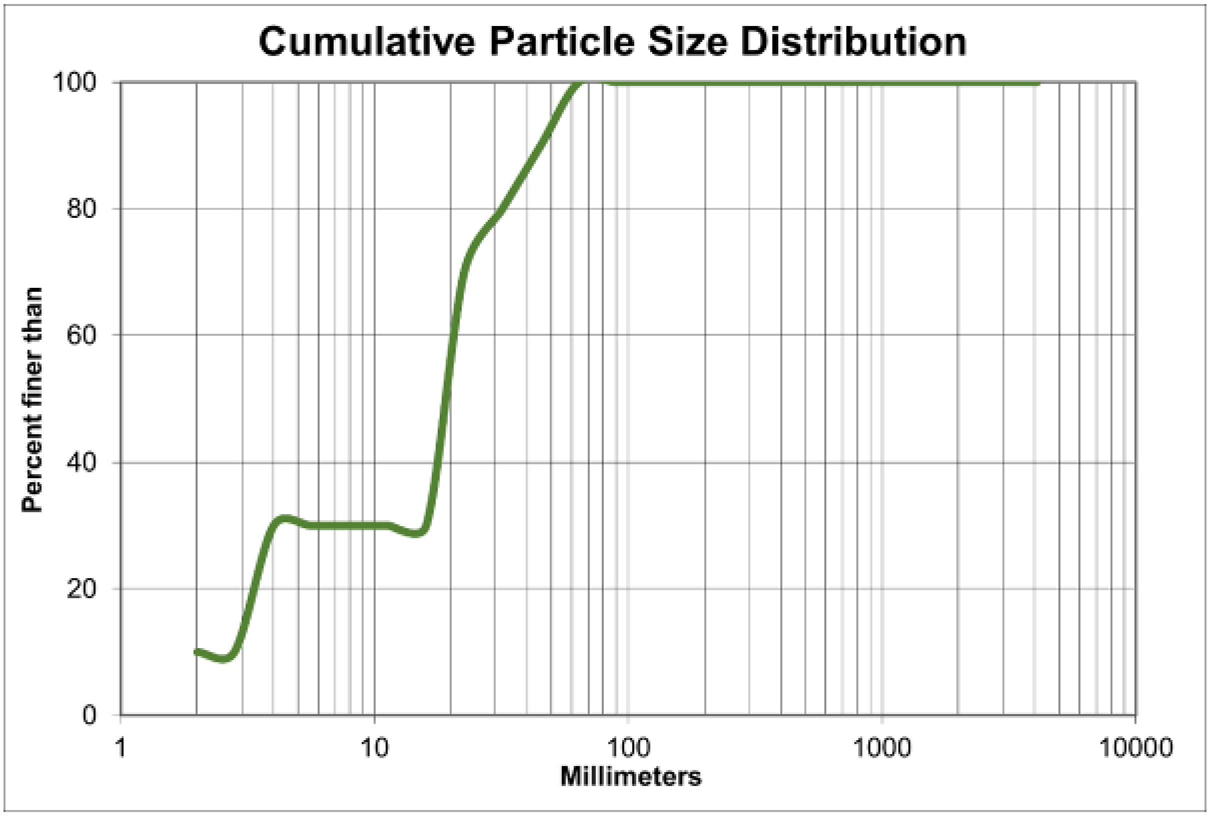
Downstream		**Upstream**	
Latitude	**Longitude**	**Latitude**	**Longitude**
61.37926	-149.05342	61.37933	-149.05438

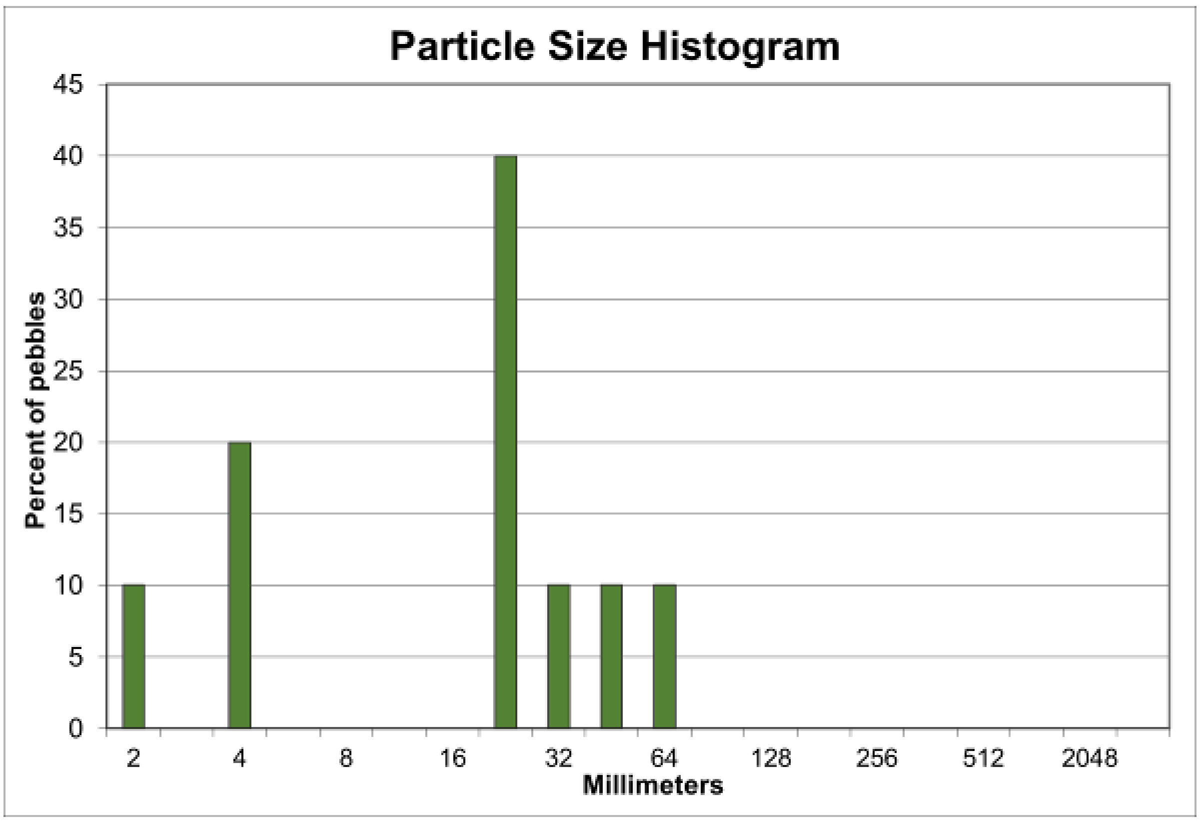
Map & Profile:

Site Photos:

Field Notes:

photo from lake 7985, trib fans out as it descends varial zone, alluvial fan is steeply sloped with gravels and cobbles, RTK 1586 at bottom of plunge/falls pt 1588-1590 at top of falls, ~6-7 ' falls where trib first enters varial zone, trib likely too small for salmonoids -varial is steeply sloped but may provide some spawning opportunities if enough groundwater influence, trib slope u/s varial 8%, specific conductivity 434

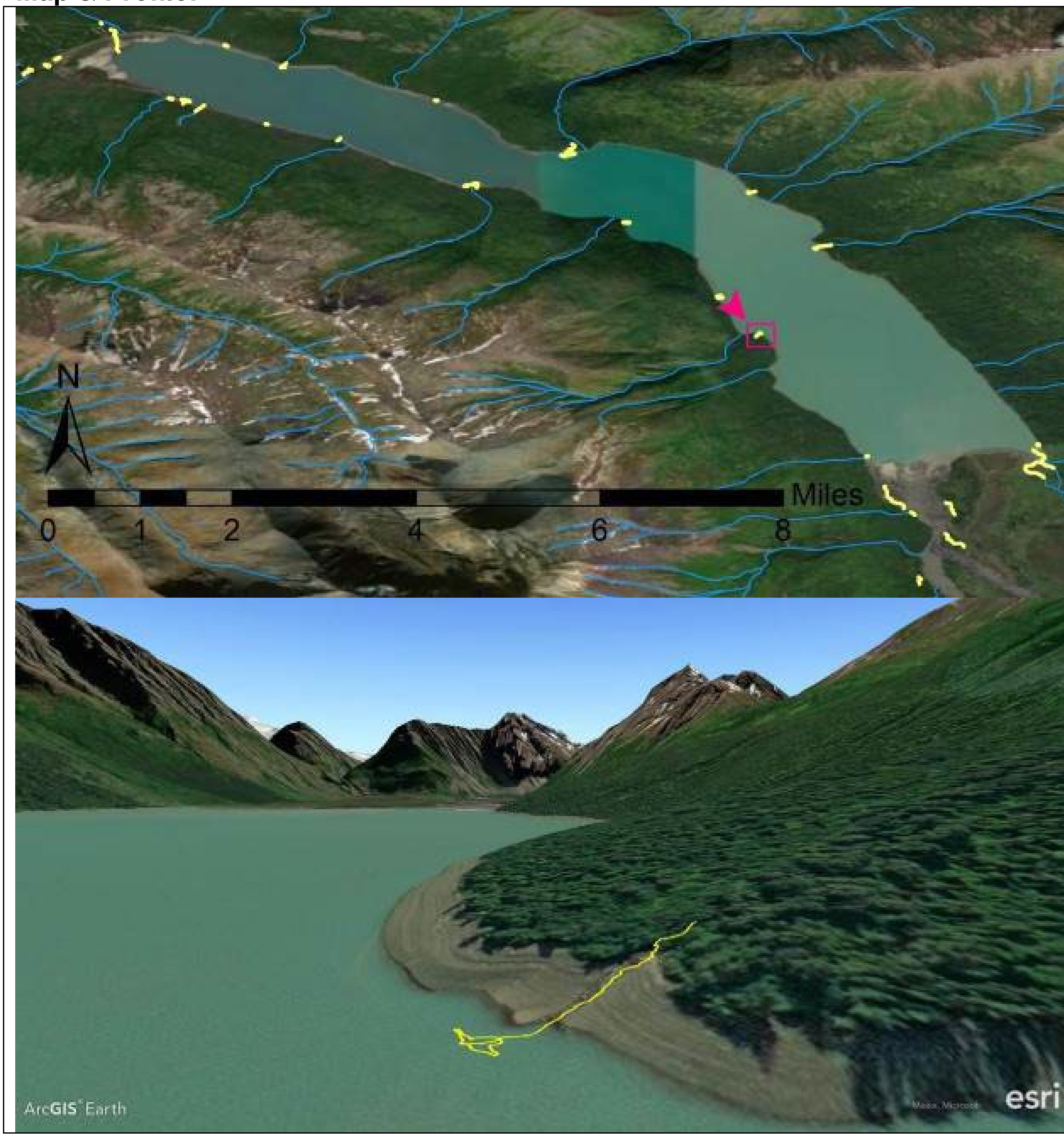

Cumulative Particle Size Distribution
Percent finer than
100
80
60
40
20
0
1
10
100
1000
10000
Millimeters


Particle Size Histogram
Percent of pebbles
45
40
35
30
25
20
15
10
5
0
2
4
8
16
32
64
128
256
512
2048
Millimeters

Site Name	Date
WB Trib F	6/02/21

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.36180	-149.03273	61.36134	-149.03343

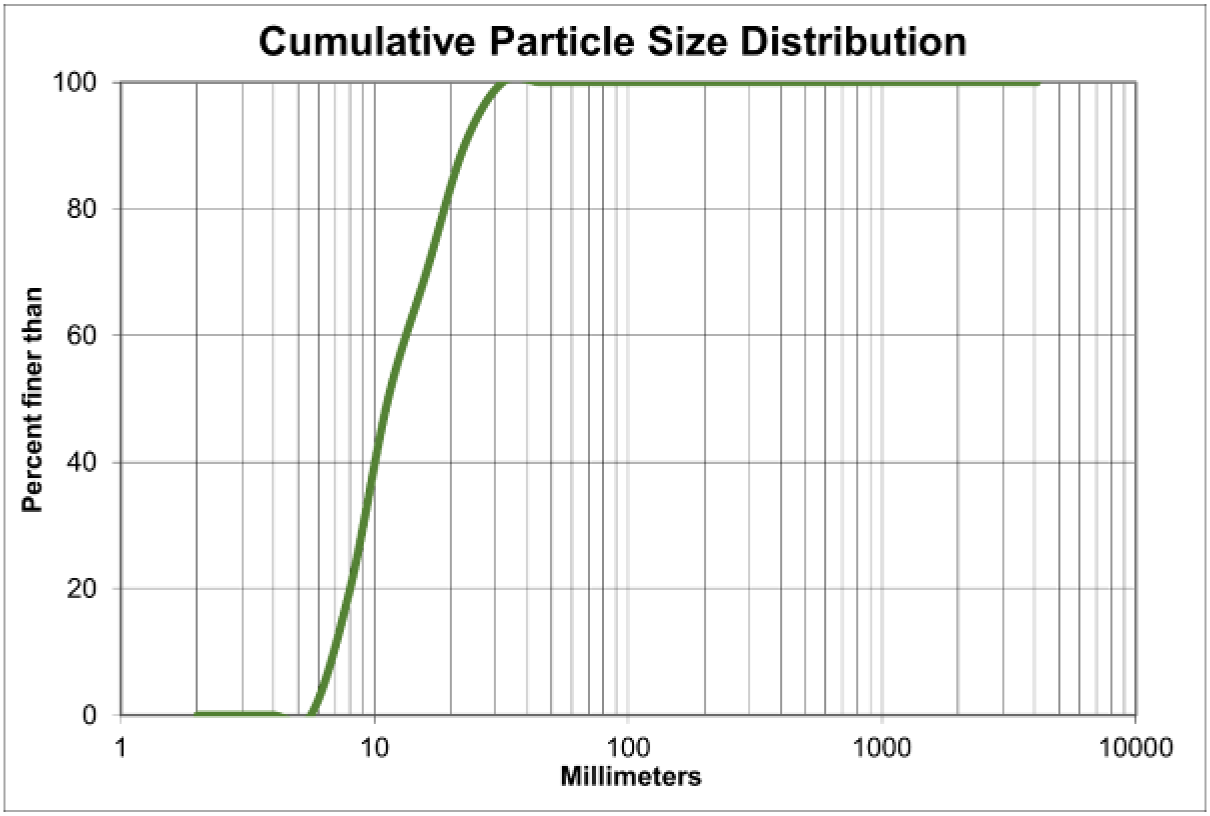
Map & Profile:

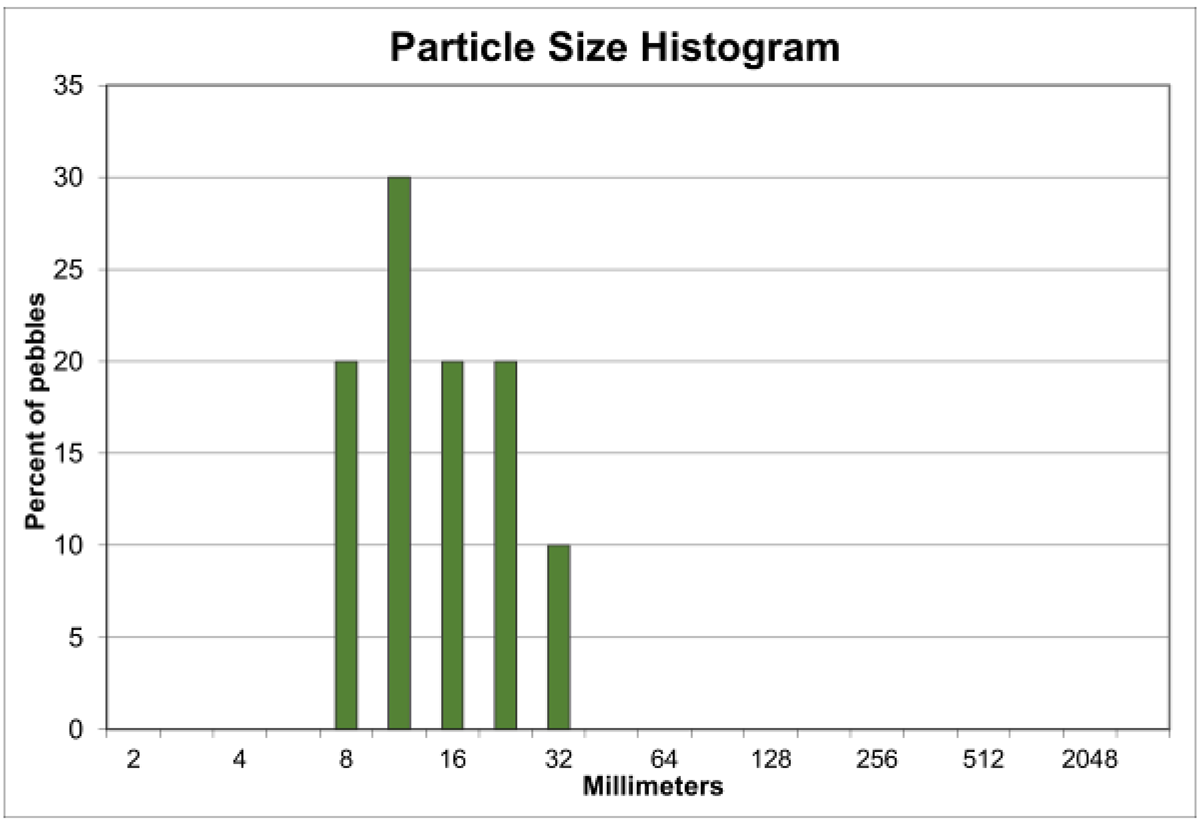


Site Photos:

Field Notes:

Lake to Trib 1007, photo 7929 view of the Trib from lake, 1197 pt at full pool 1, pt 1000 in lake ~2 ' deep, pt 1007 at lake water surface, Good spawning at Trib mouth at this lake elevation, some sand but good overall, Trib too small and steep to provide salmon spawning, photo 7935, photo 7936 at Trib U/S of full pool, Base @ "UPLAKE" WPT 246, 61.35992/-149.03055, ~30ft above water surface continues as gradient, 1520% u/s of lake pool, 7938-7939 more photos, Specific Conductivity 333. No fish observed in trib or CWP


Cumulative Particle Size Distribution
Percent finer than
100
80
60
40
20
0
1
10
100
1000
10000
Millimeters


Particle Size Histogram
Percent of pebbles
35
30
25
20
15
10
5
0
2
4
8
16
32
64
128
256
512
2048
Millimeters

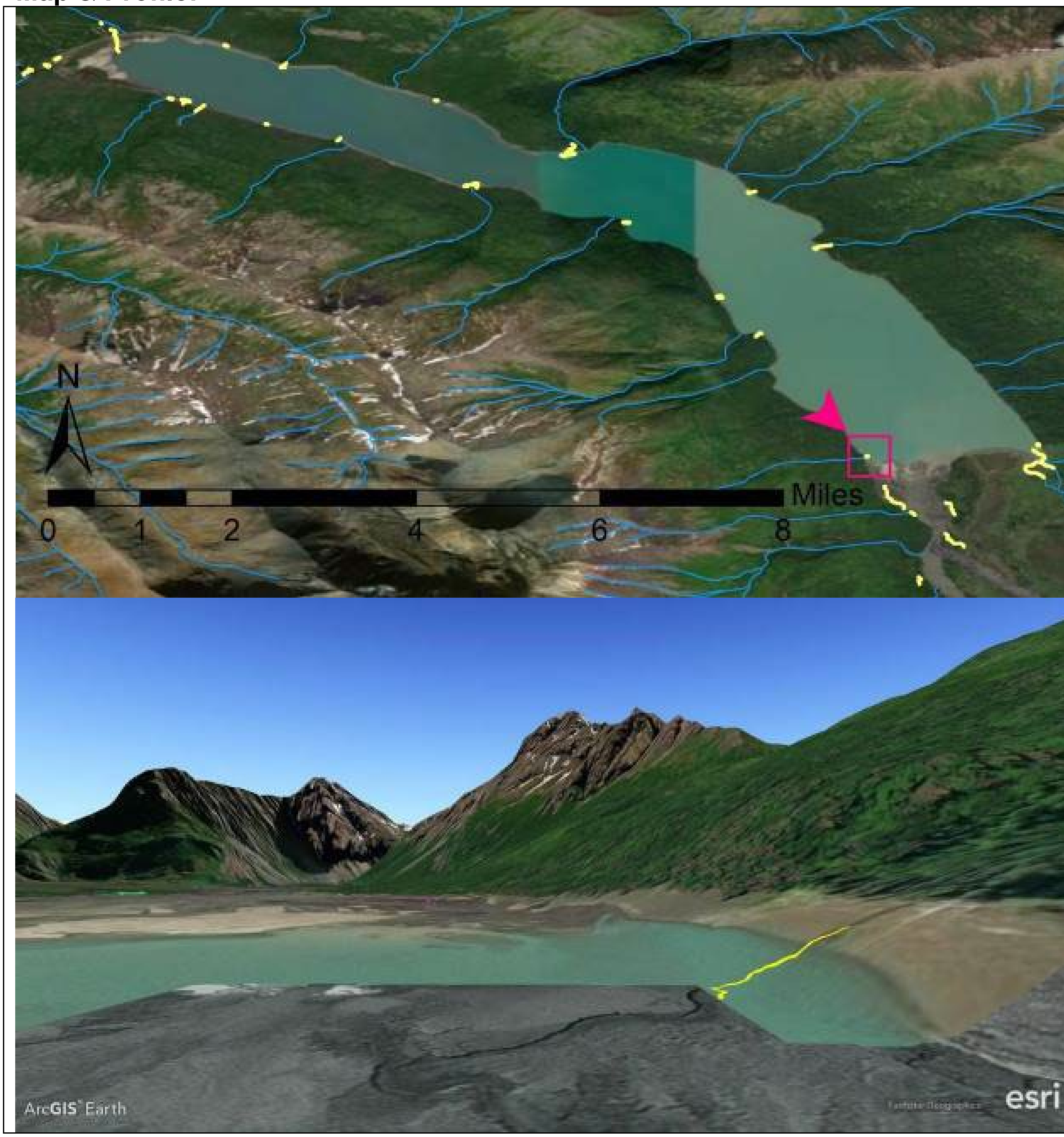
Site Name	Date
WB Trib G	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
	-		

Site Name	Date
WB Trib I	6/02/21

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



Site Photos:

Field Notes:

Site Name	Date
Pond Varial Bench 1	6/01/21

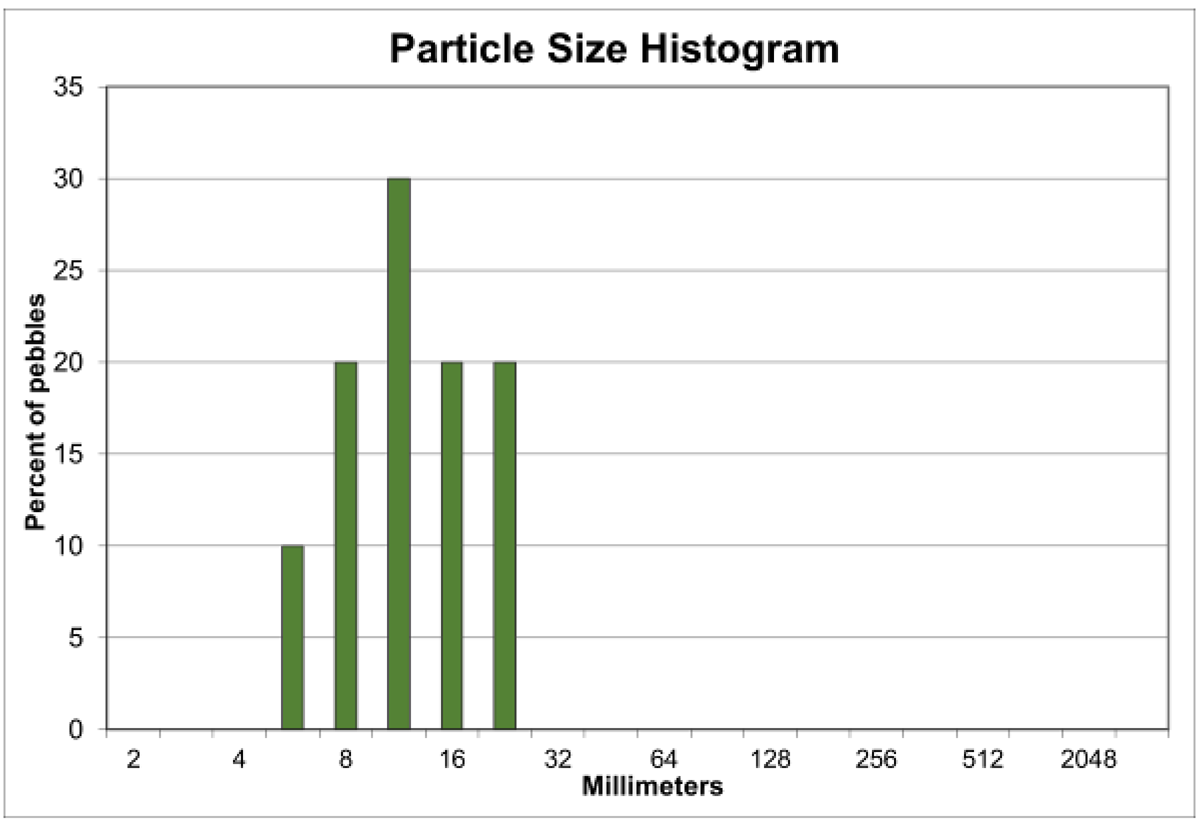
Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.40318	-149.14790	61.40332	-149.14777

Map & Profile:

Site Photos:

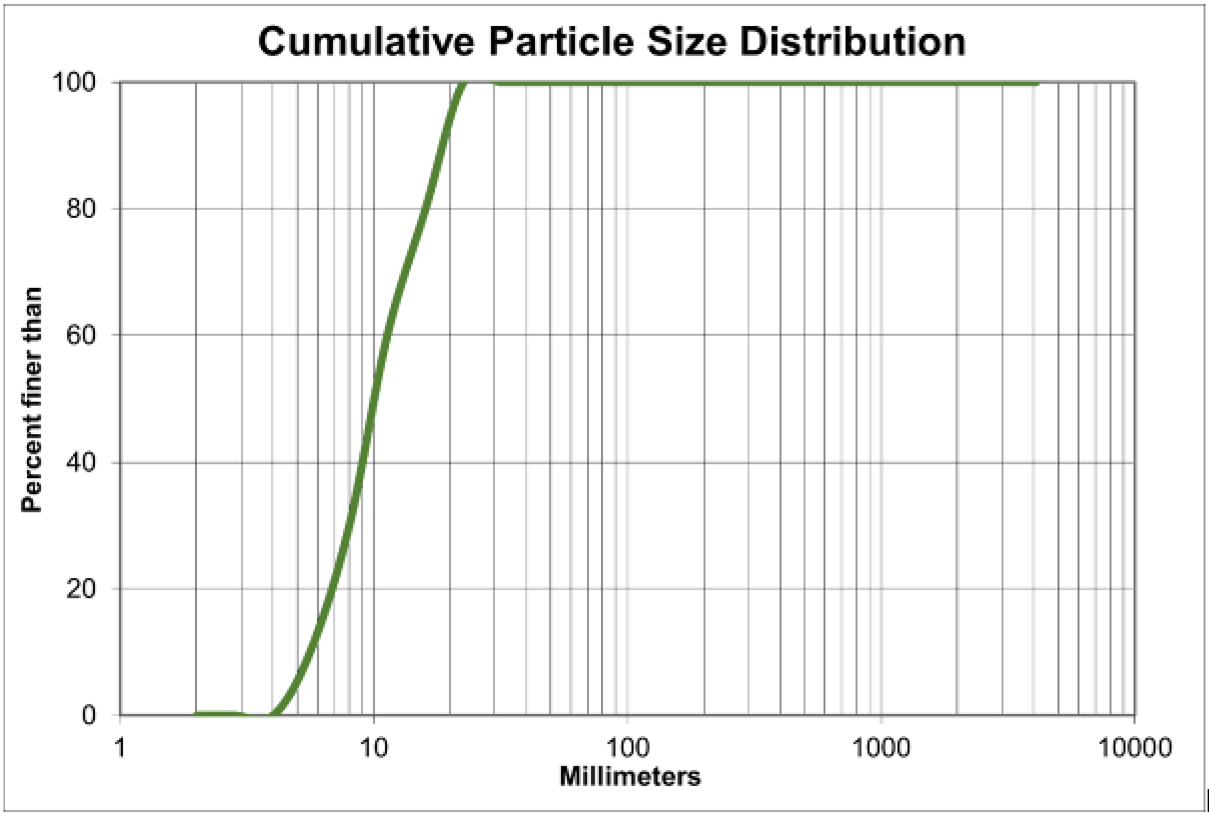
Field Notes:

No groundwater or upwelling. Base station on DAM crest. WPT 228, Lake varial zone

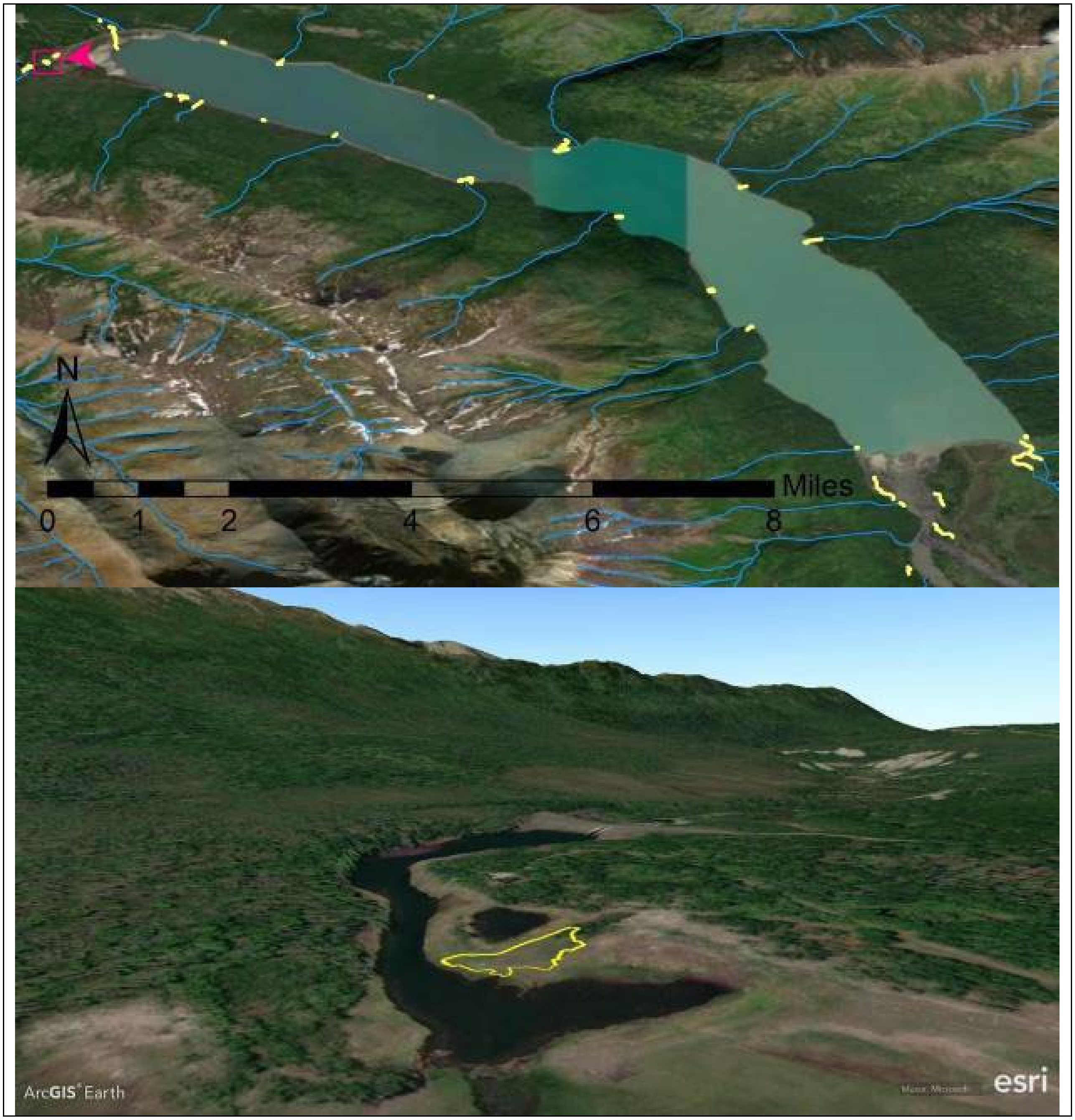


Site Name	Date
Pond Varial Bench 2	6/01/21

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.40377	-149.14487	61.40405	-149.14552



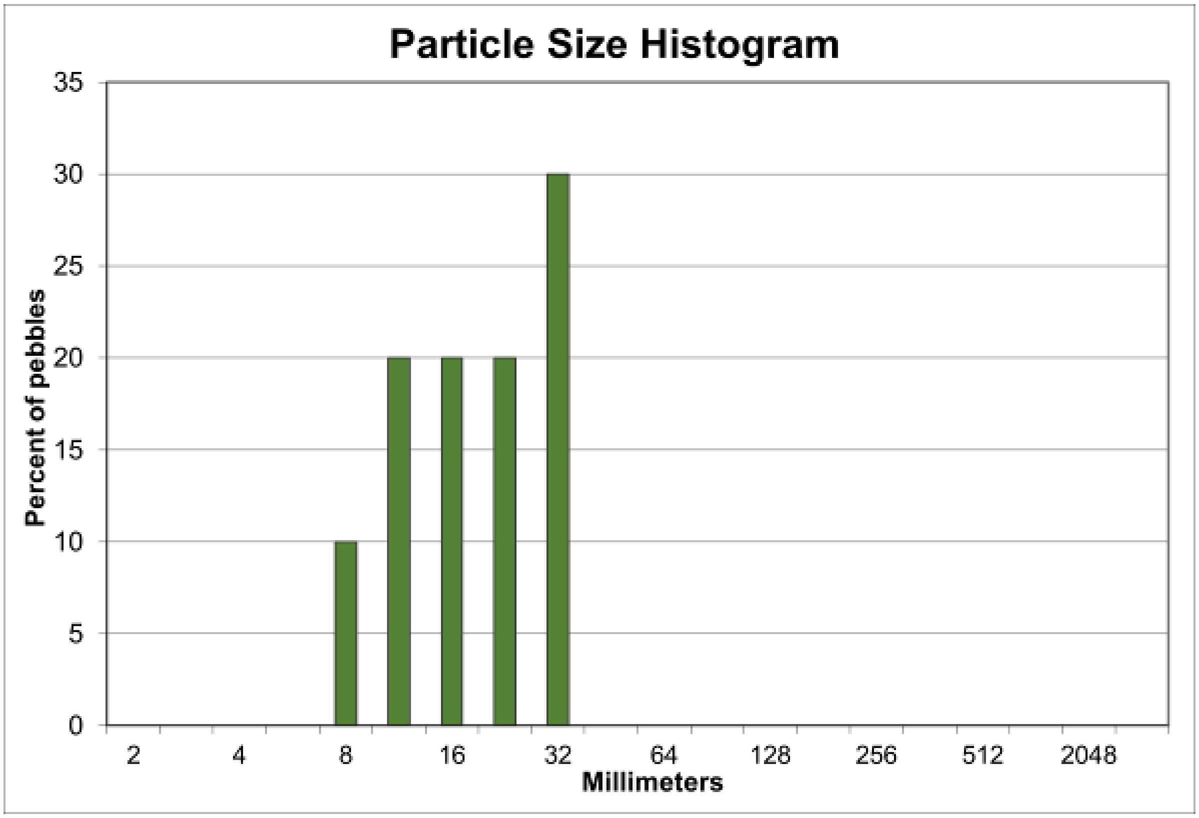
Map & Profile:

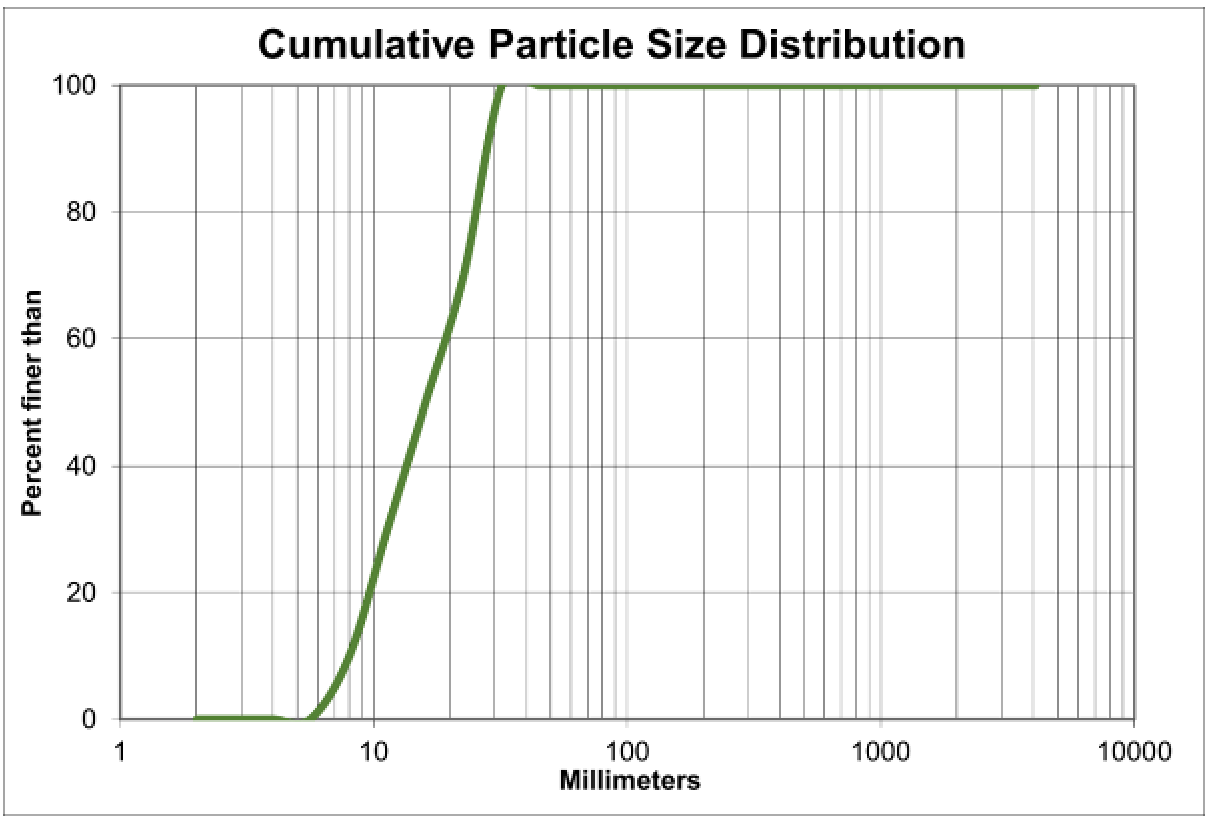

N
Miles
0
1
2
4
6
8
ArcGIS Earth
esri

Site Photos:

Field Notes:

Lake Varial zone, no upwelling or groundwater present, specific conductivity 432


Particle Size Histogram
Percent of pebbles
35
30
25
20
15
10
5
0
2
4
8
16
32
64
128
256
512
2048
Millimeters

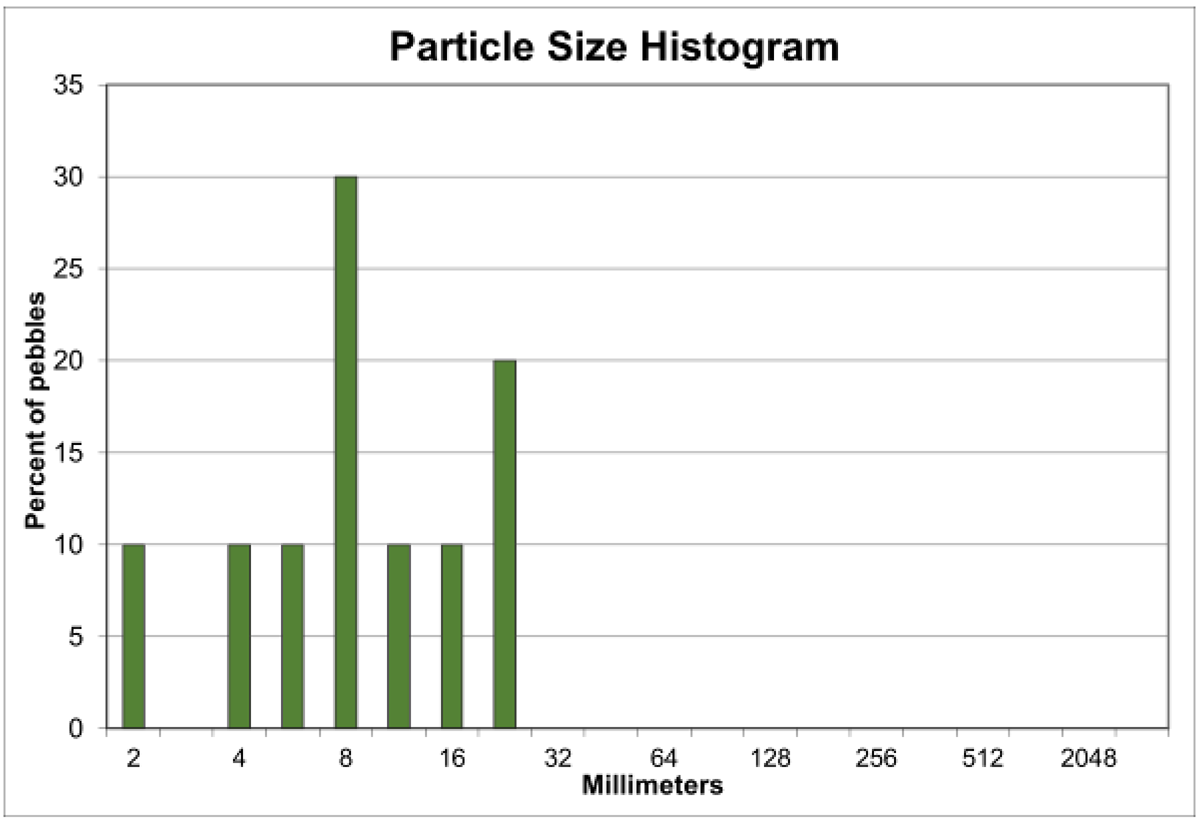

Cumulative Particle Size Distribution
Percent finer than
100
80
60
40
20
0
1
10
100
1000
10000
Millimeters

Site Name	Date
WB Trib 1 Delta (Pond Trib)	6/01/21

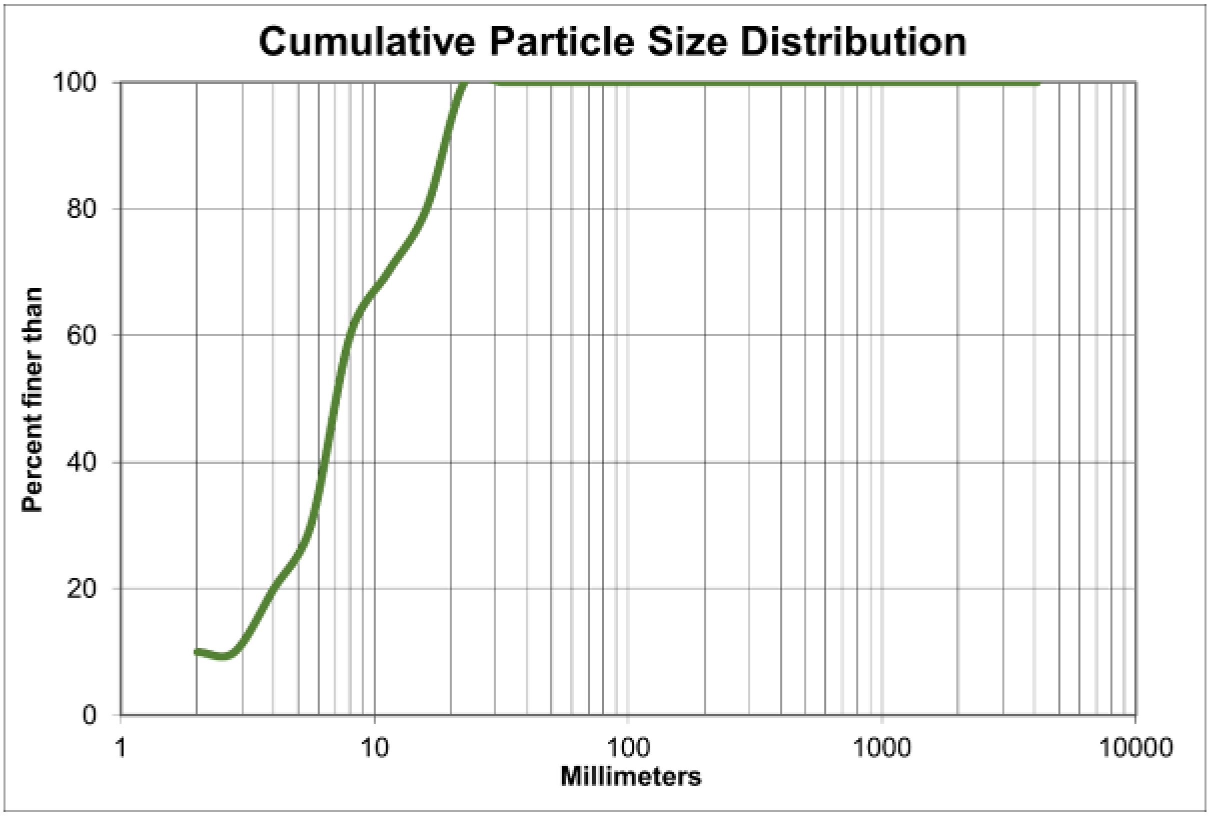
Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
61.40422	-149.15028	61.40273	-149.14851

Map & Profile:

Site Photos:



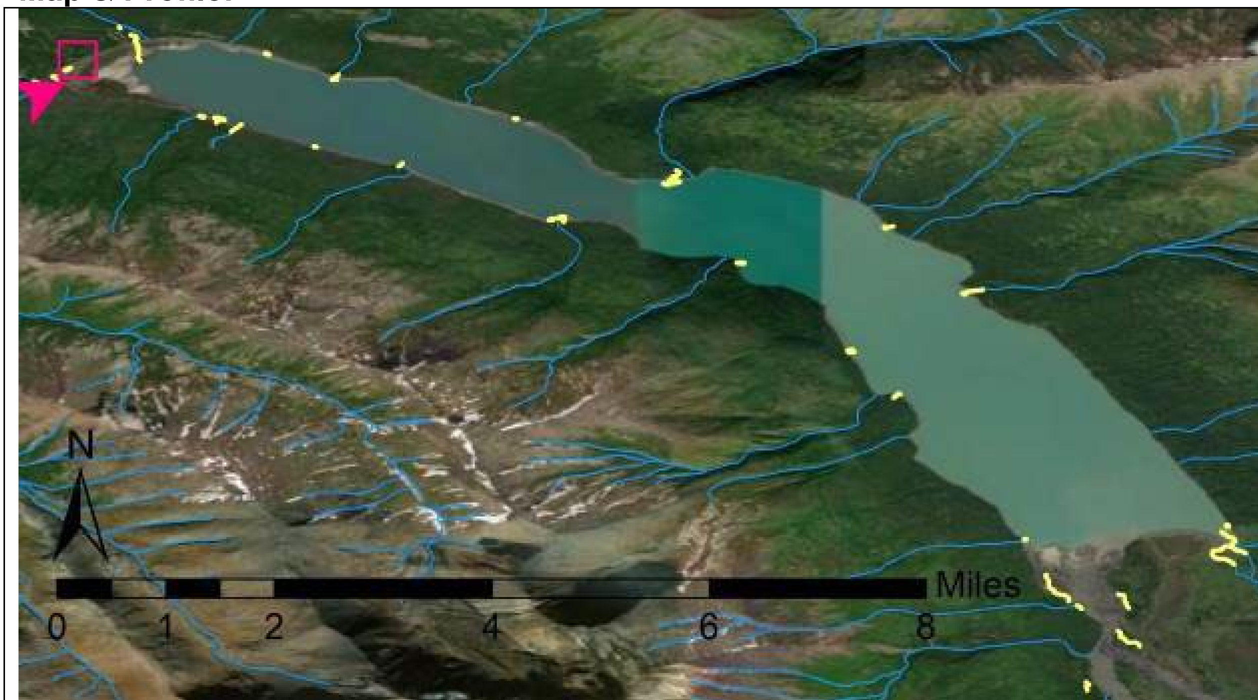
Field Notes:

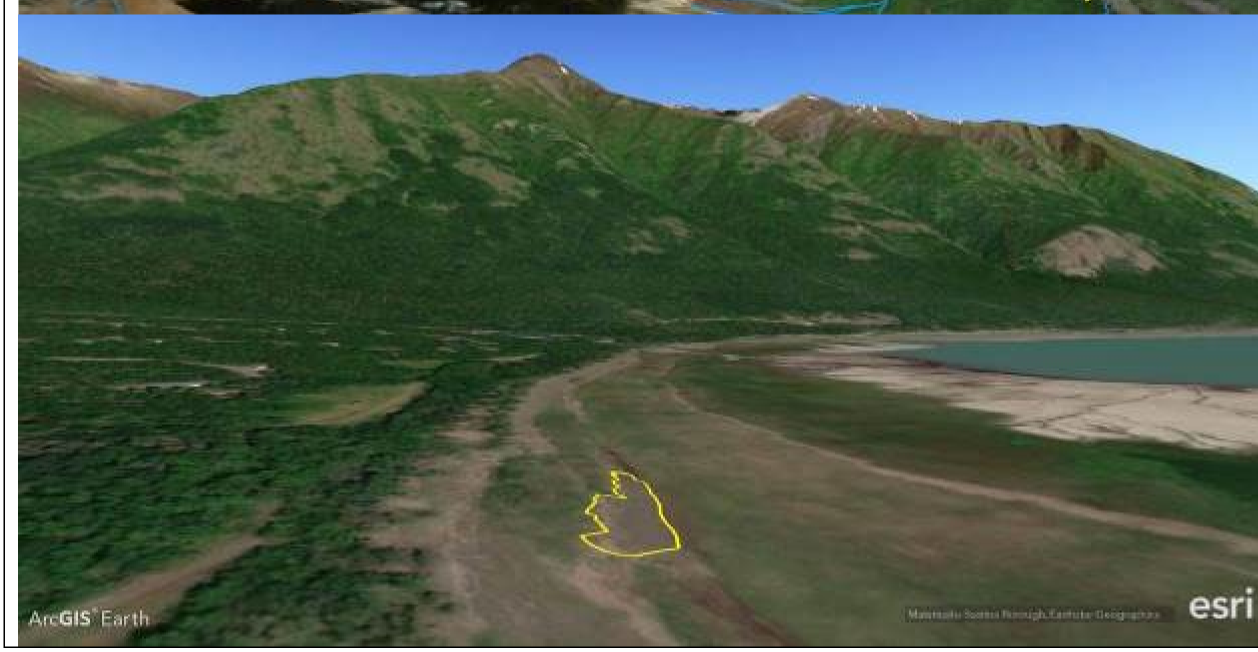

Cumulative Particle Size Distribution
Percent finer than
0
20
40
60
80
100
1
10
100
1000
10000
Millimeters

Site Name	Date
EB Lake Varial Bench 1	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:





Site Photos:

Field Notes:

Site Name	Date
EB Lake Varial Bench 2	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:

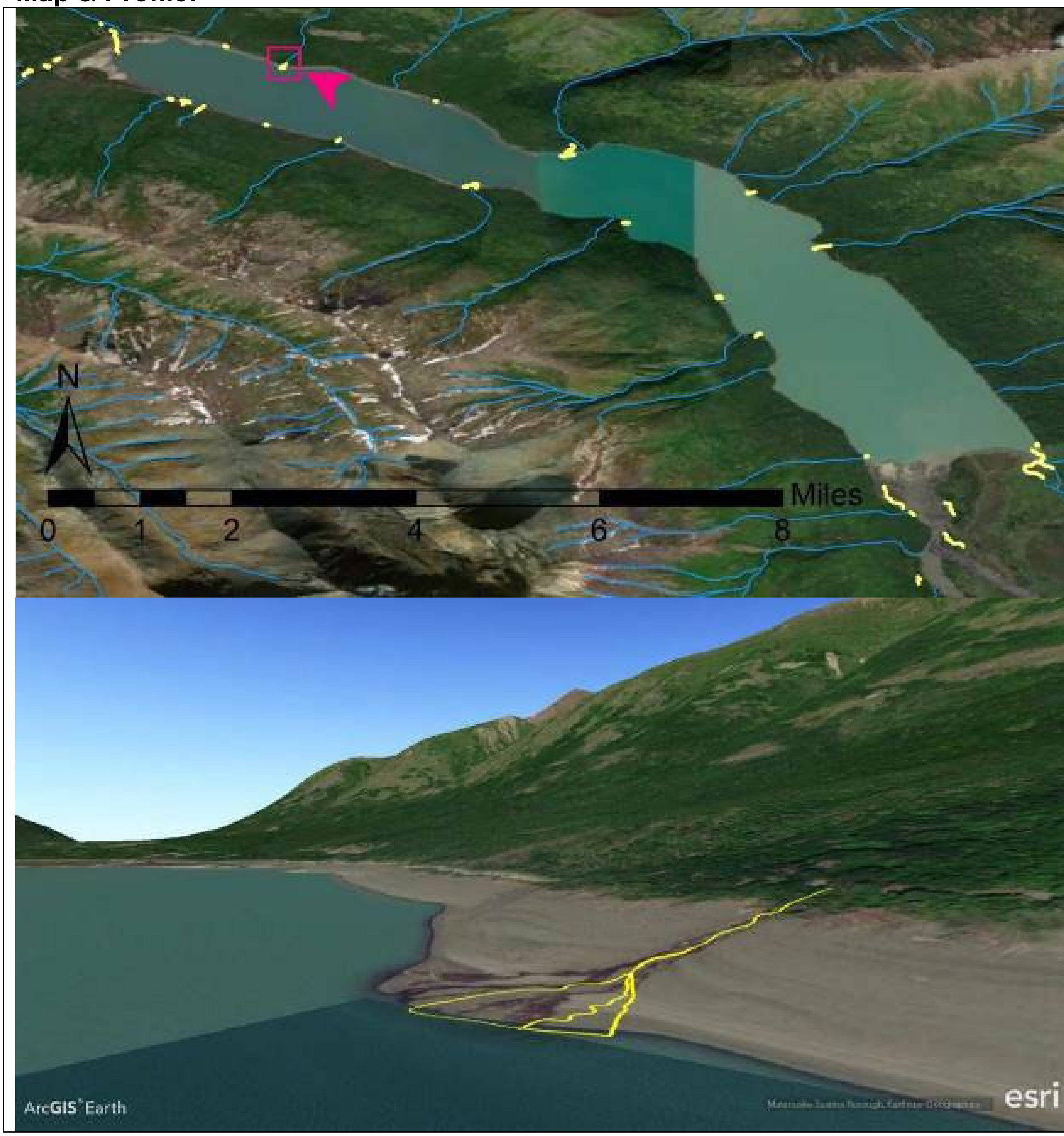
Site Photos:

Field Notes:

Site Name	Date
EB Lake Trib B	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



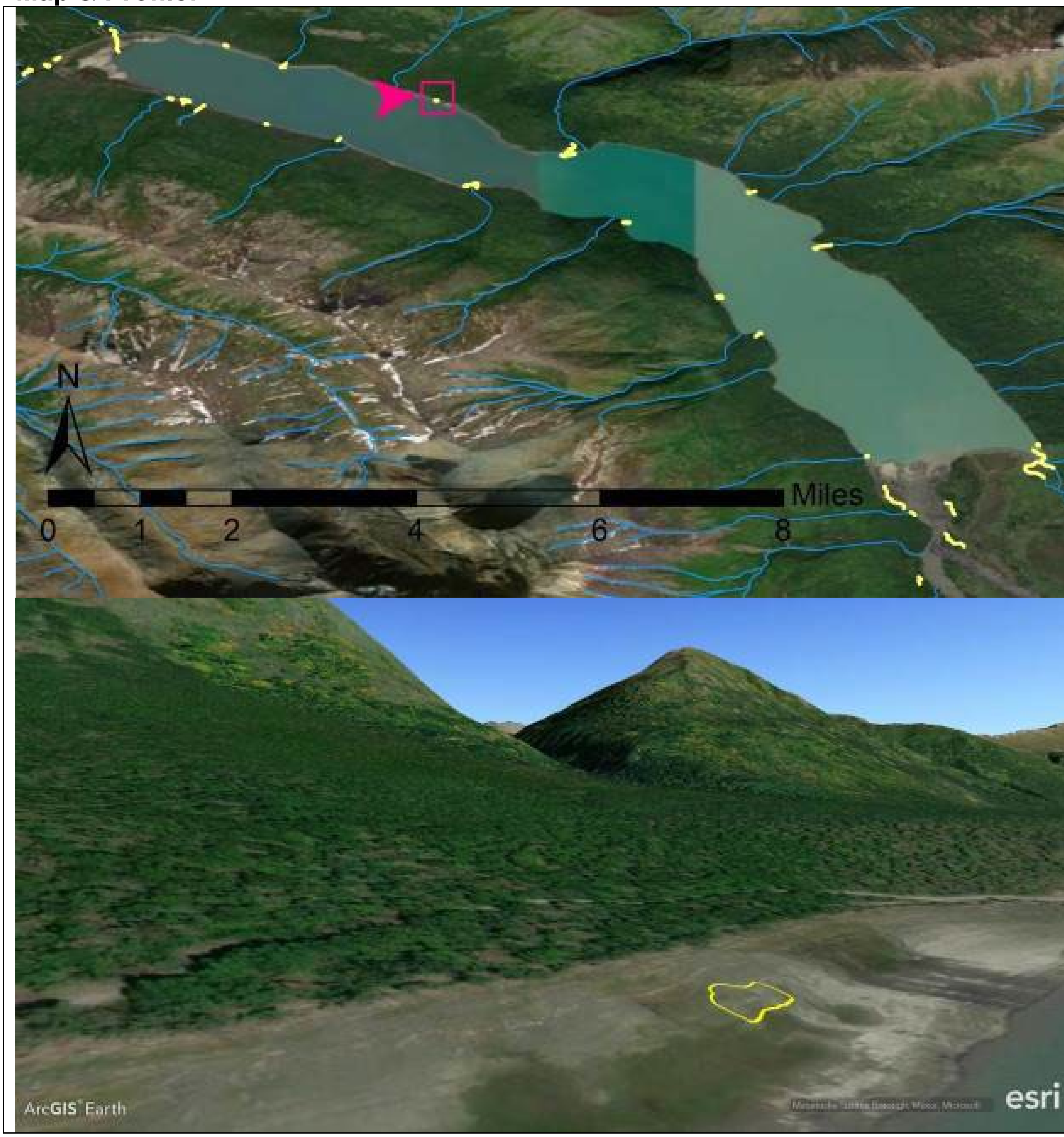
Site Photos:

Field Notes:

Site Name	Date
EB Lake Varial Bench 3	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



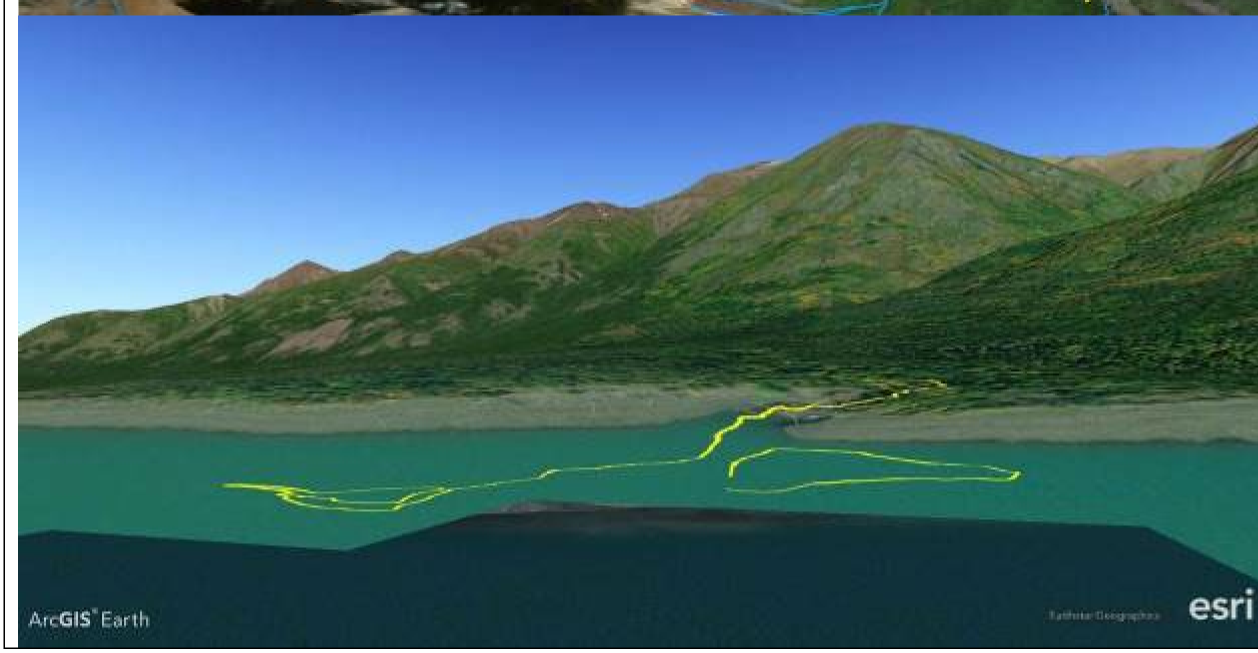
Site Photos:

Field Notes:

Site Name	Date
EB Lake Varial Bench 4	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



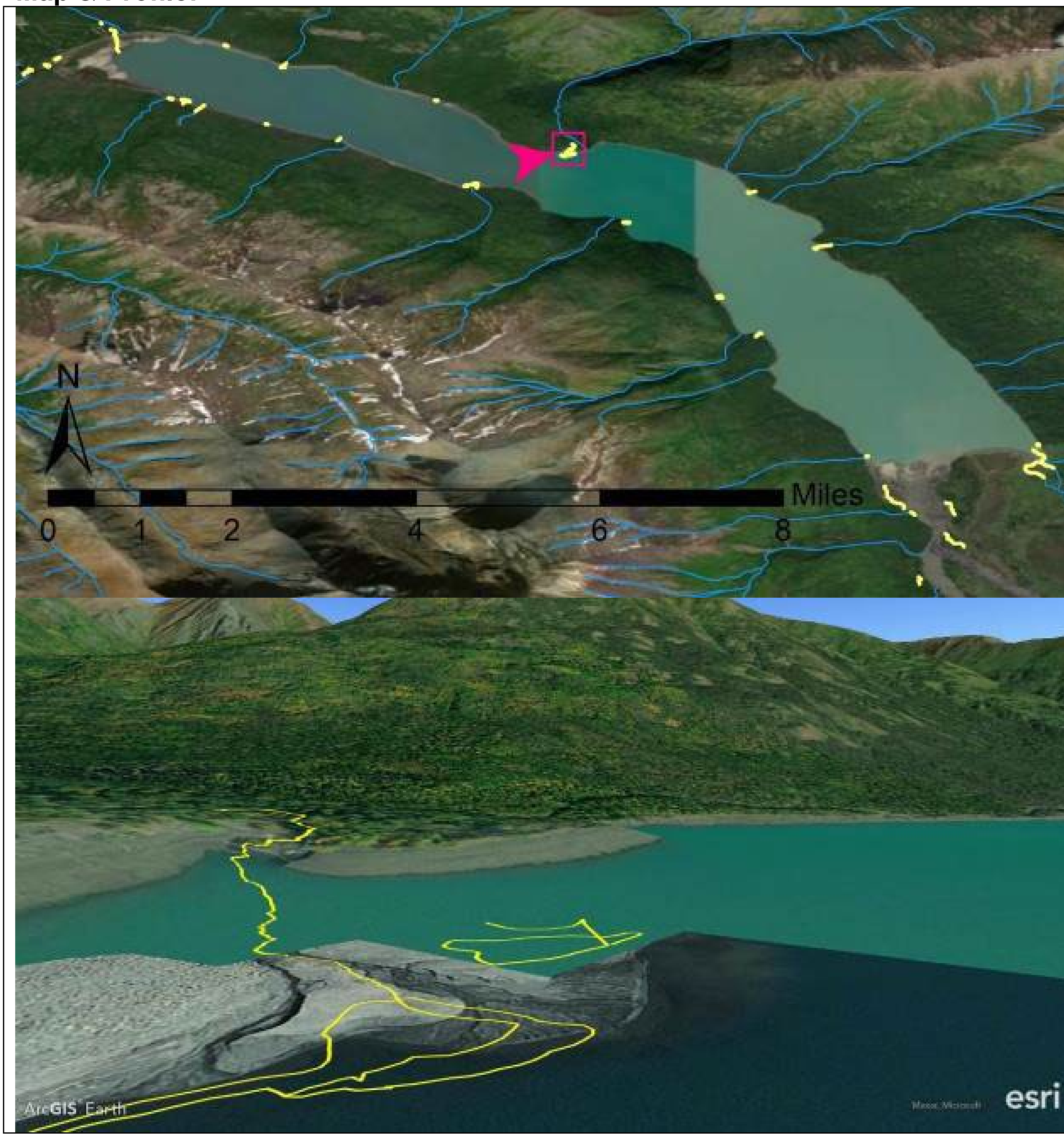
Site Photos:

Field Notes:

Site Name	Date
EB Lake Varial Bench 5	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



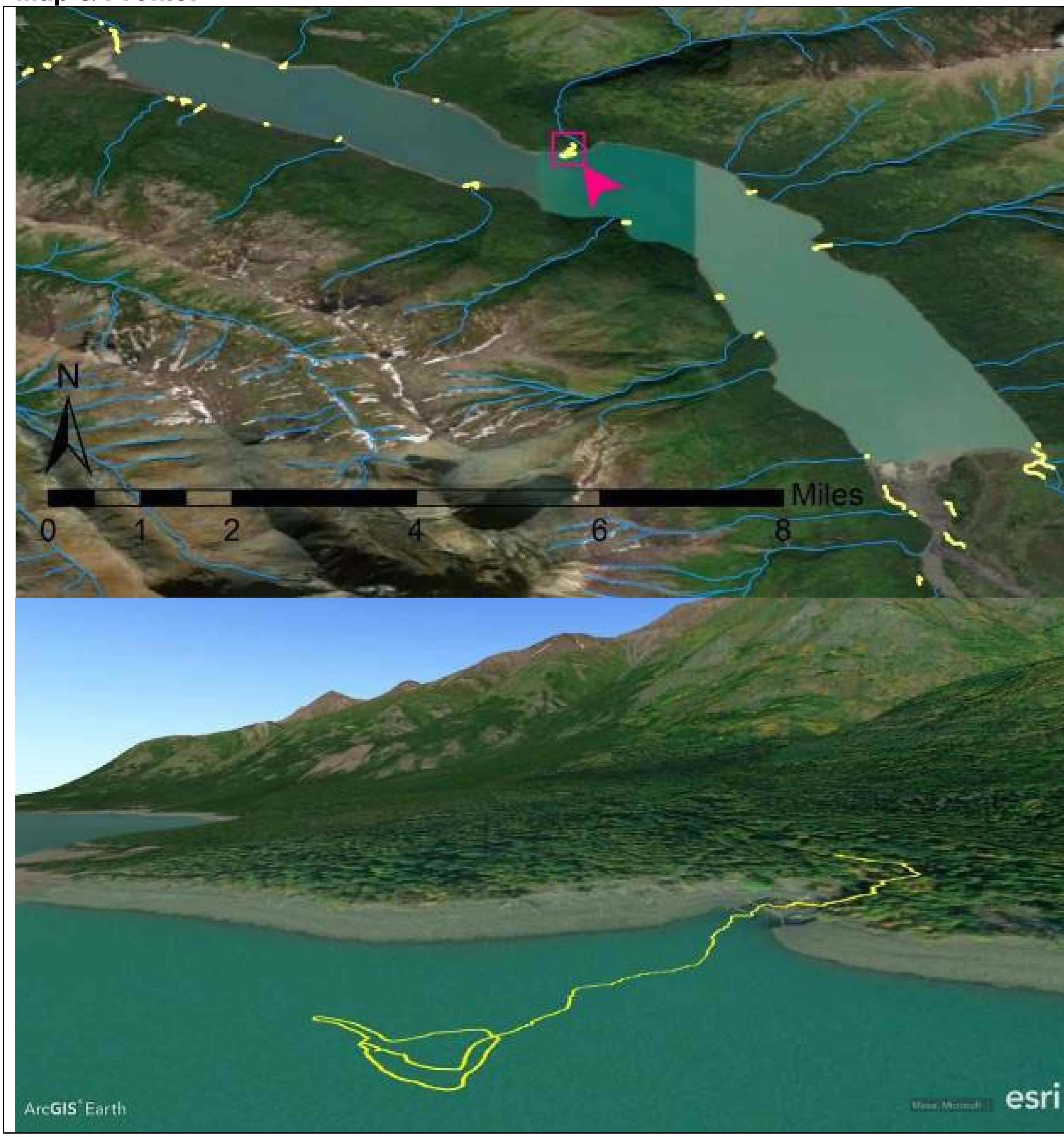
Site Photos:

Field Notes:

Site Name	Date
Yuditnu Creek and Delta	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



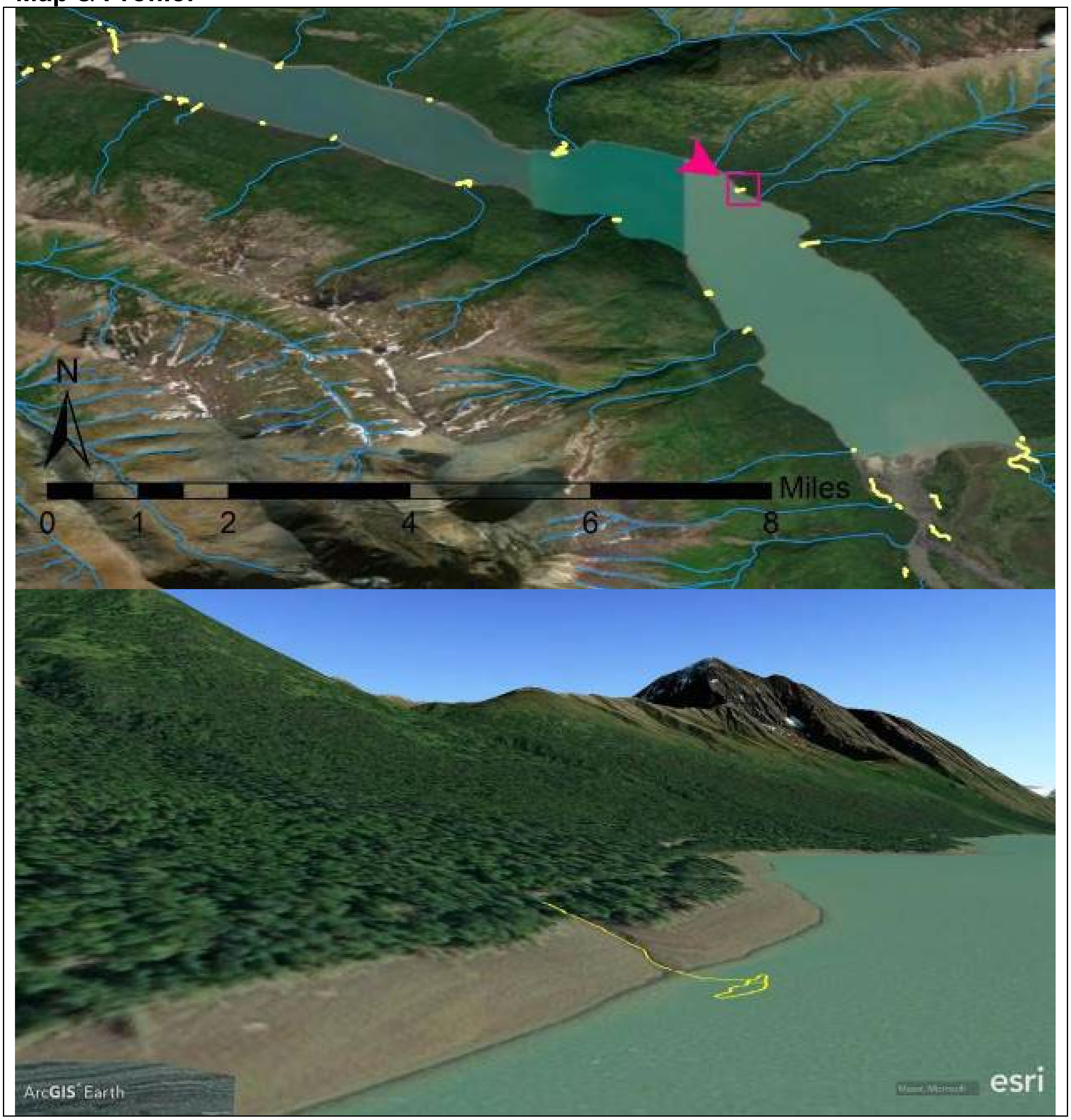
Site Photos:

Field Notes:

Site Name	Date
EB Lake Trib F	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



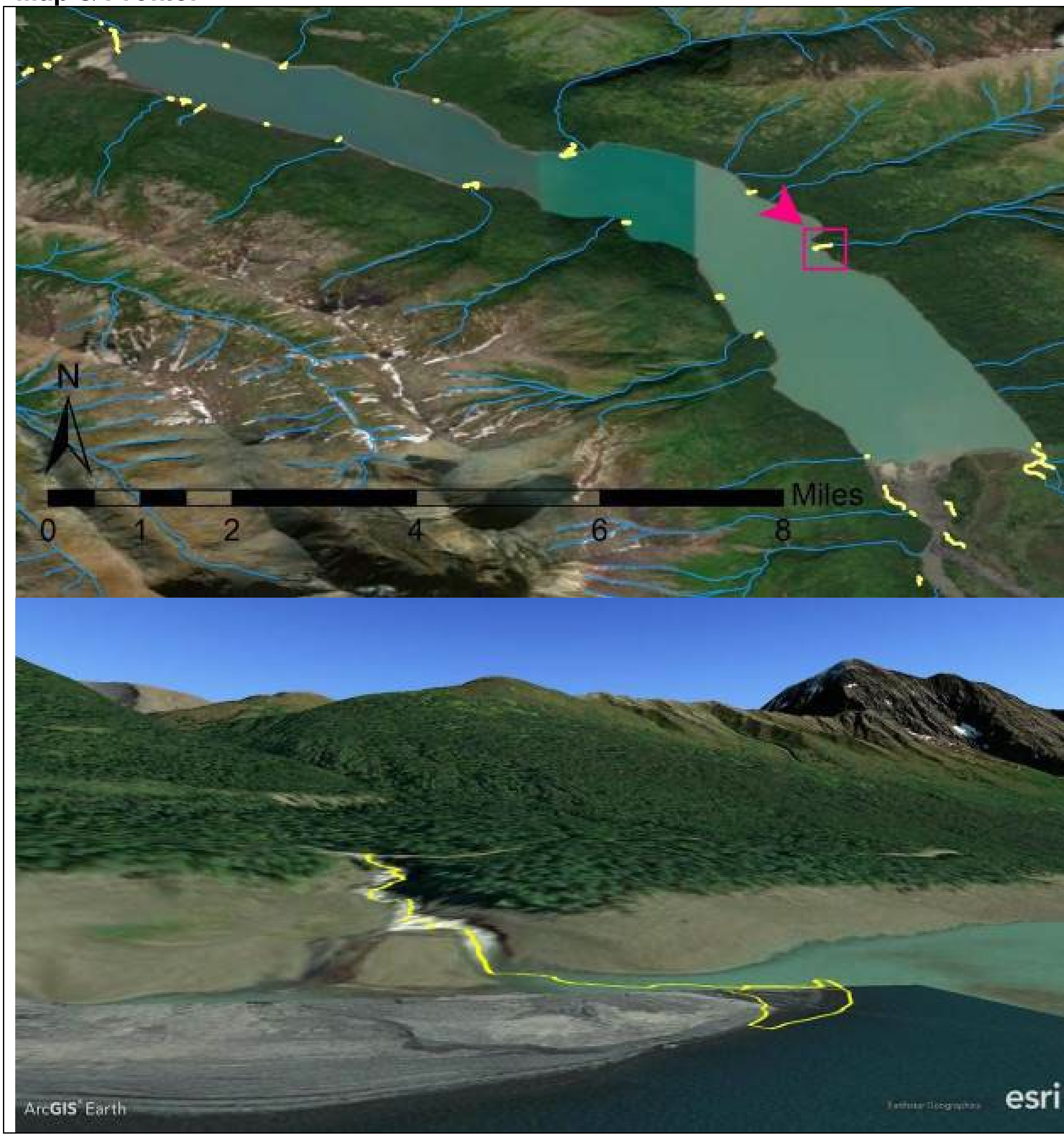
Site Photos:

Field Notes:

Site Name	Date
Bold Creek	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



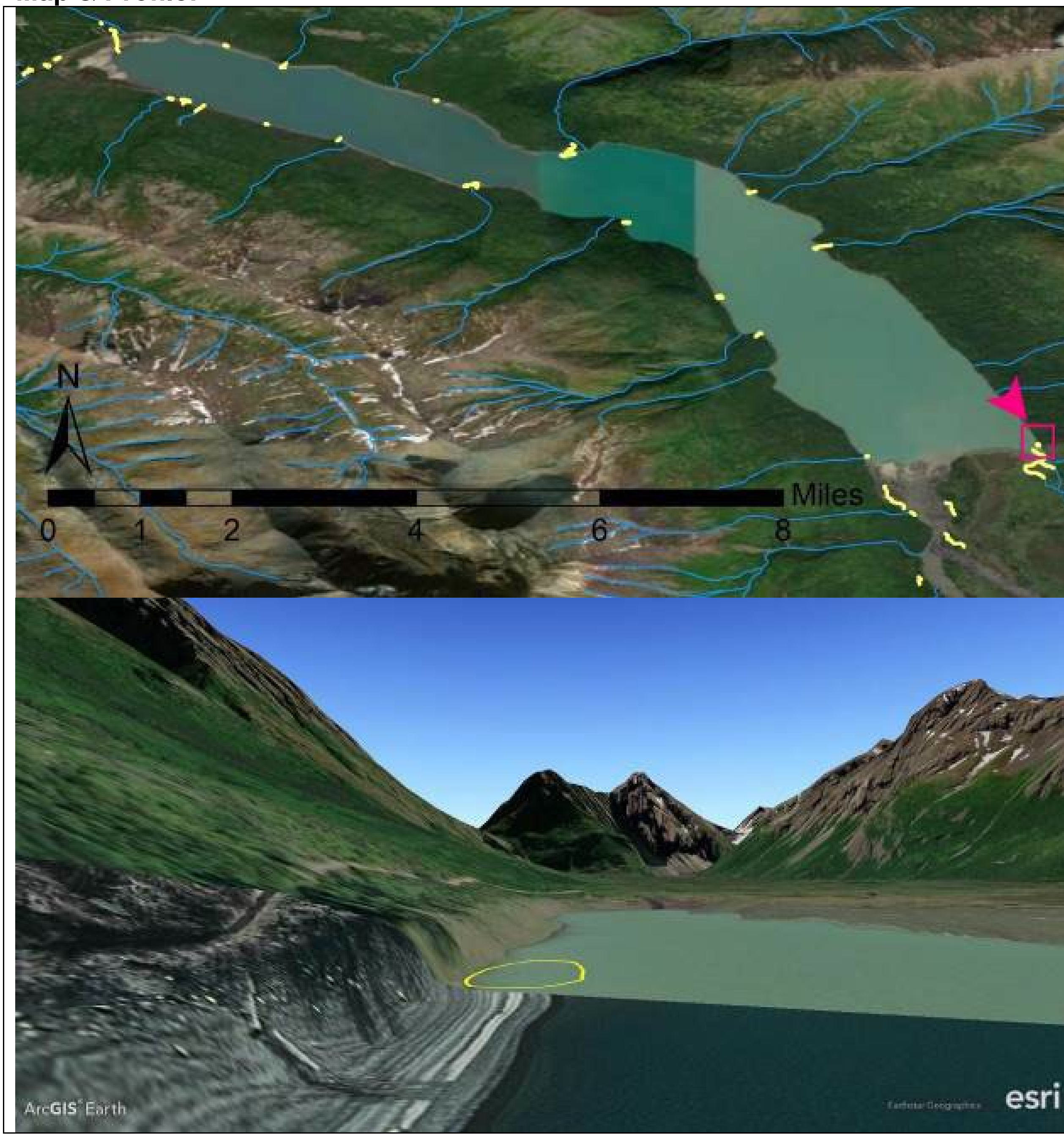
Site Photos:

Field Notes:

Site Name	Date
EB Lake Varial Bench 6	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



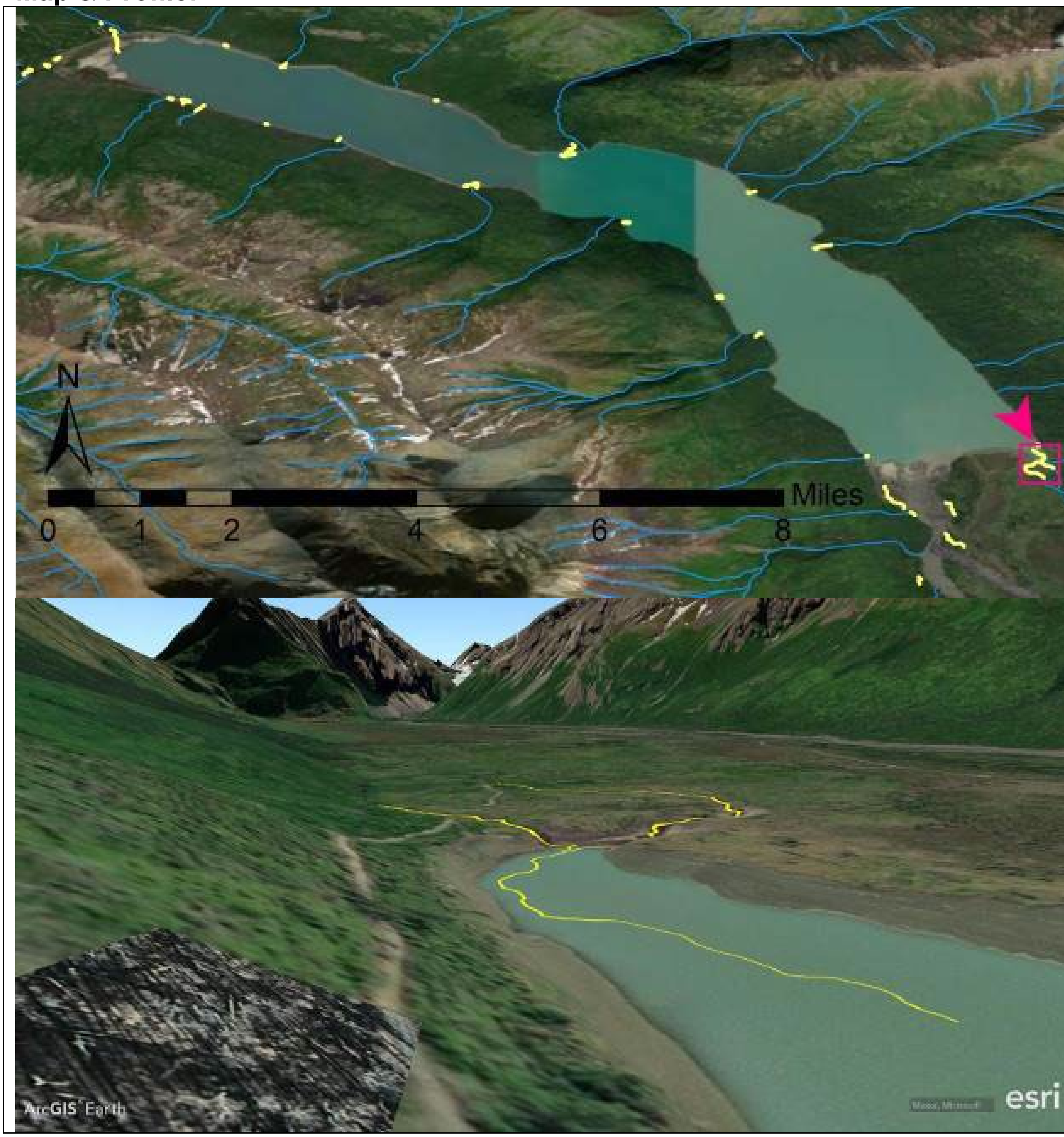
Site Photos:

Field Notes:

Site Name	Date
EB Tribs 4.0 and 4.1	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



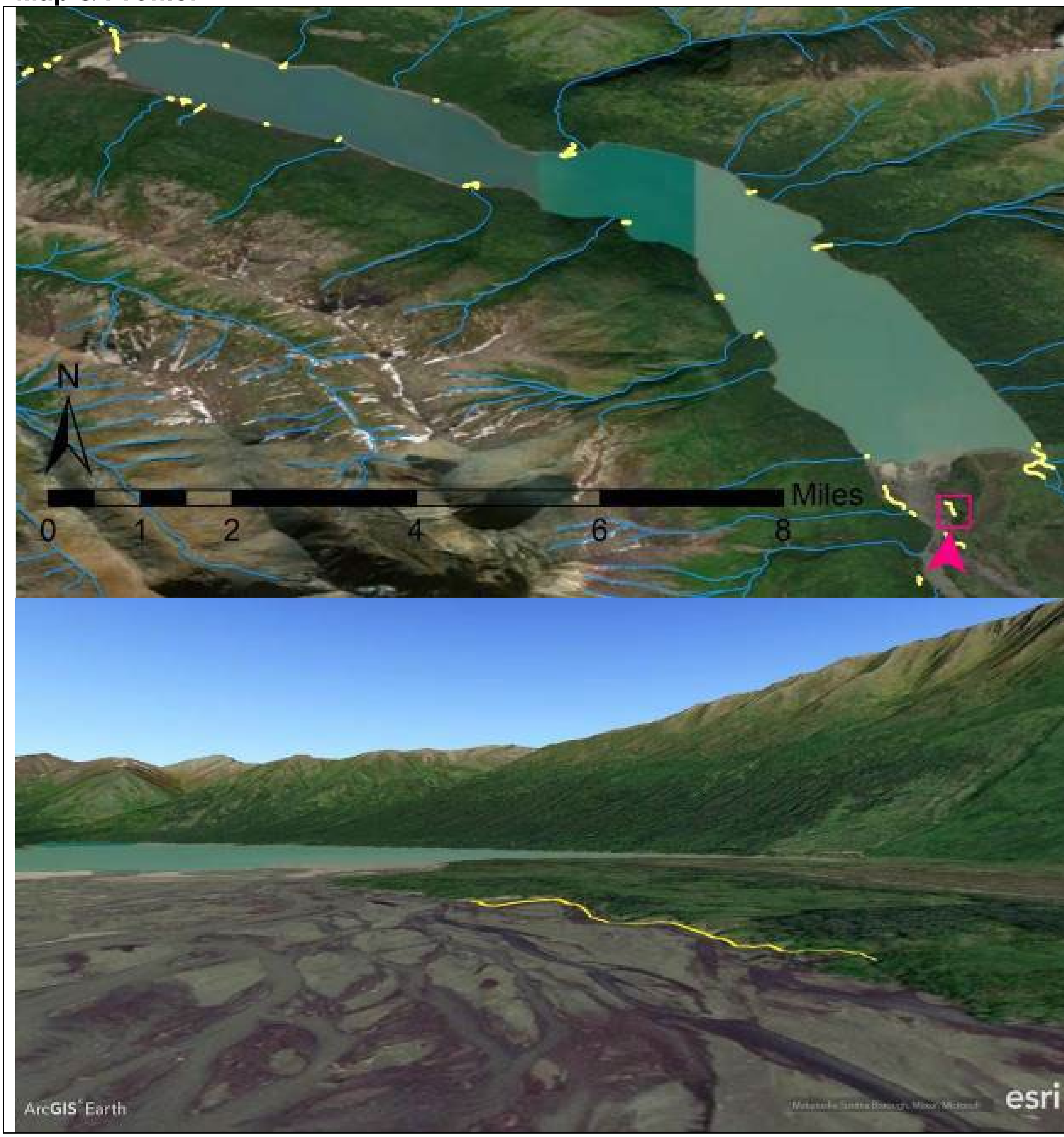
Site Photos:

Field Notes:

Site Name	Date
Eklutna Creek EB Clearwater Channel 1	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



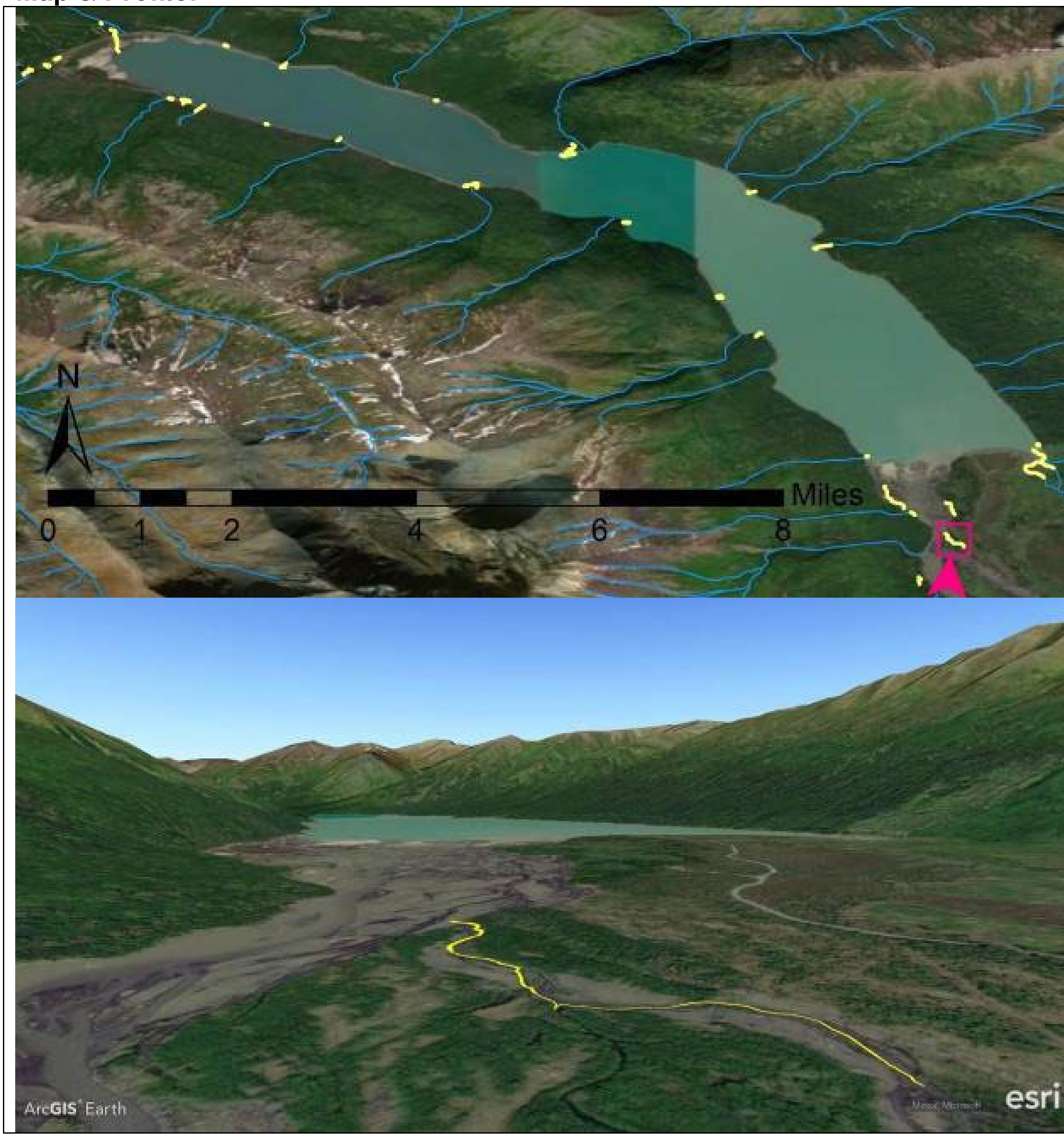
Site Photos:

Field Notes:

Site Name	Date
Eklutna Creek EB Clearwater Channel 2	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



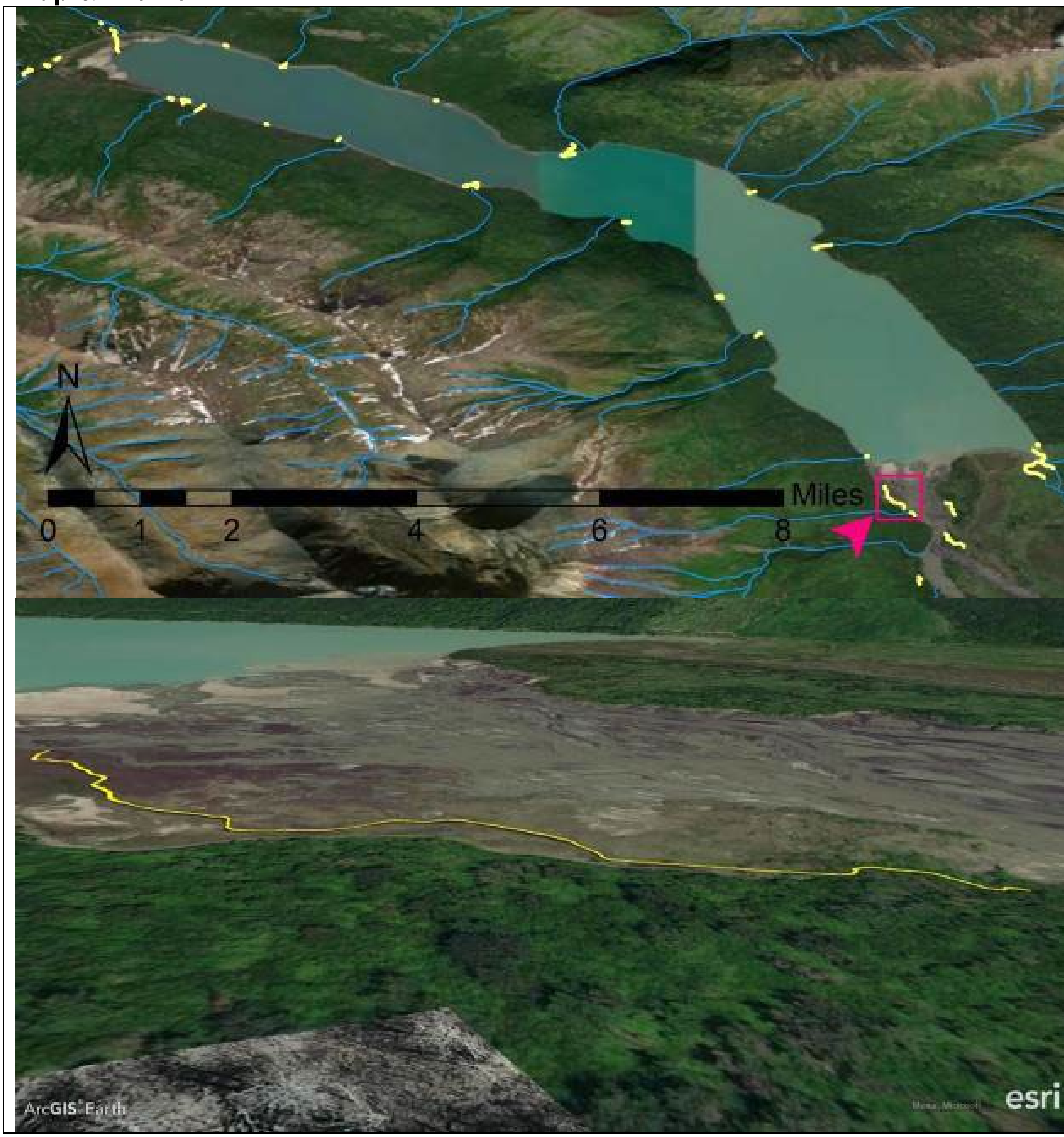
Site Photos:

Field Notes:

Site Name	Date
Eklutna Creek WB Clearwater Channel 1	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



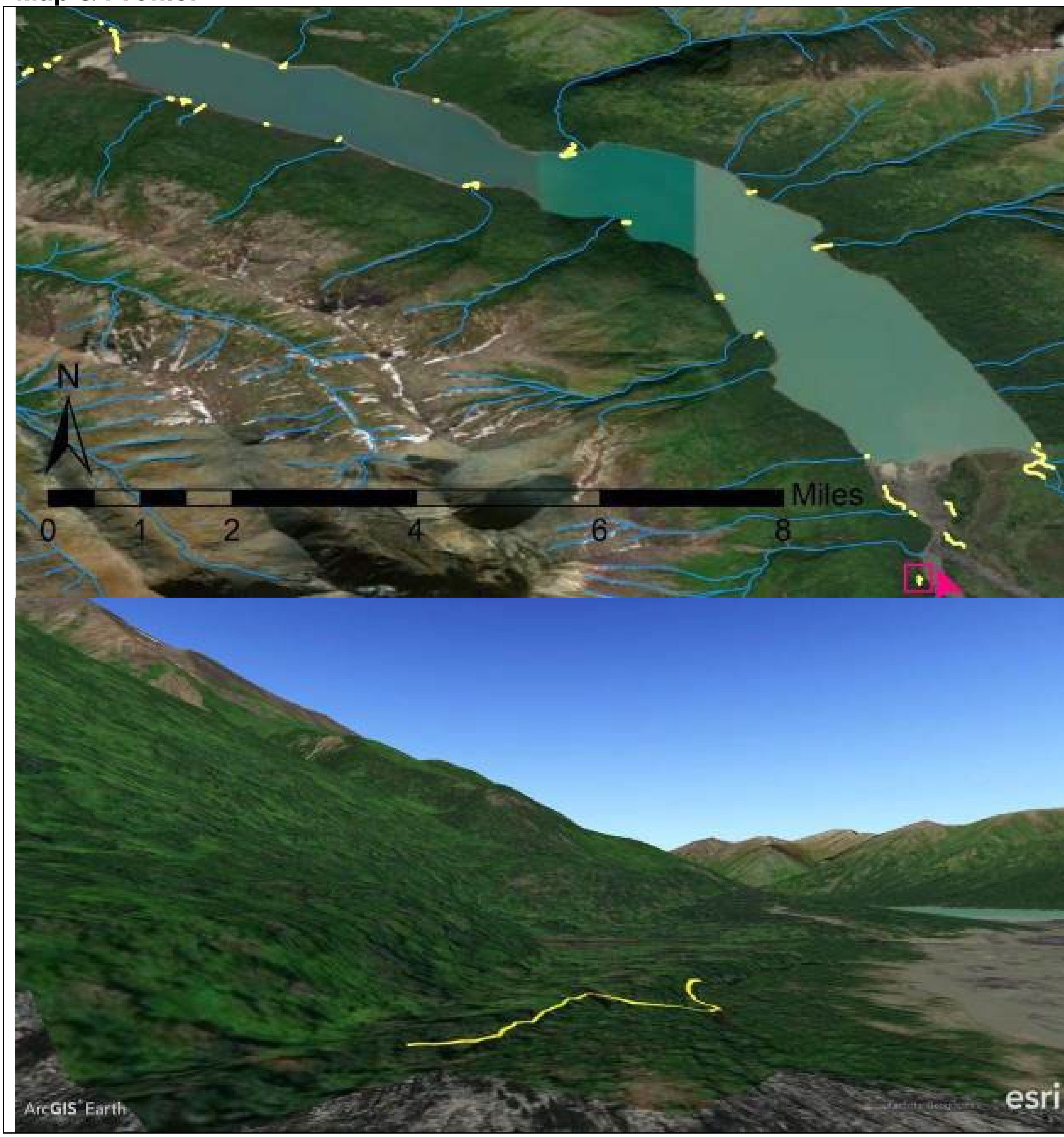
Site Photos:

Field Notes:

Site Name	Date
WF Eklutna Creek Trib 1	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

Map & Profile:



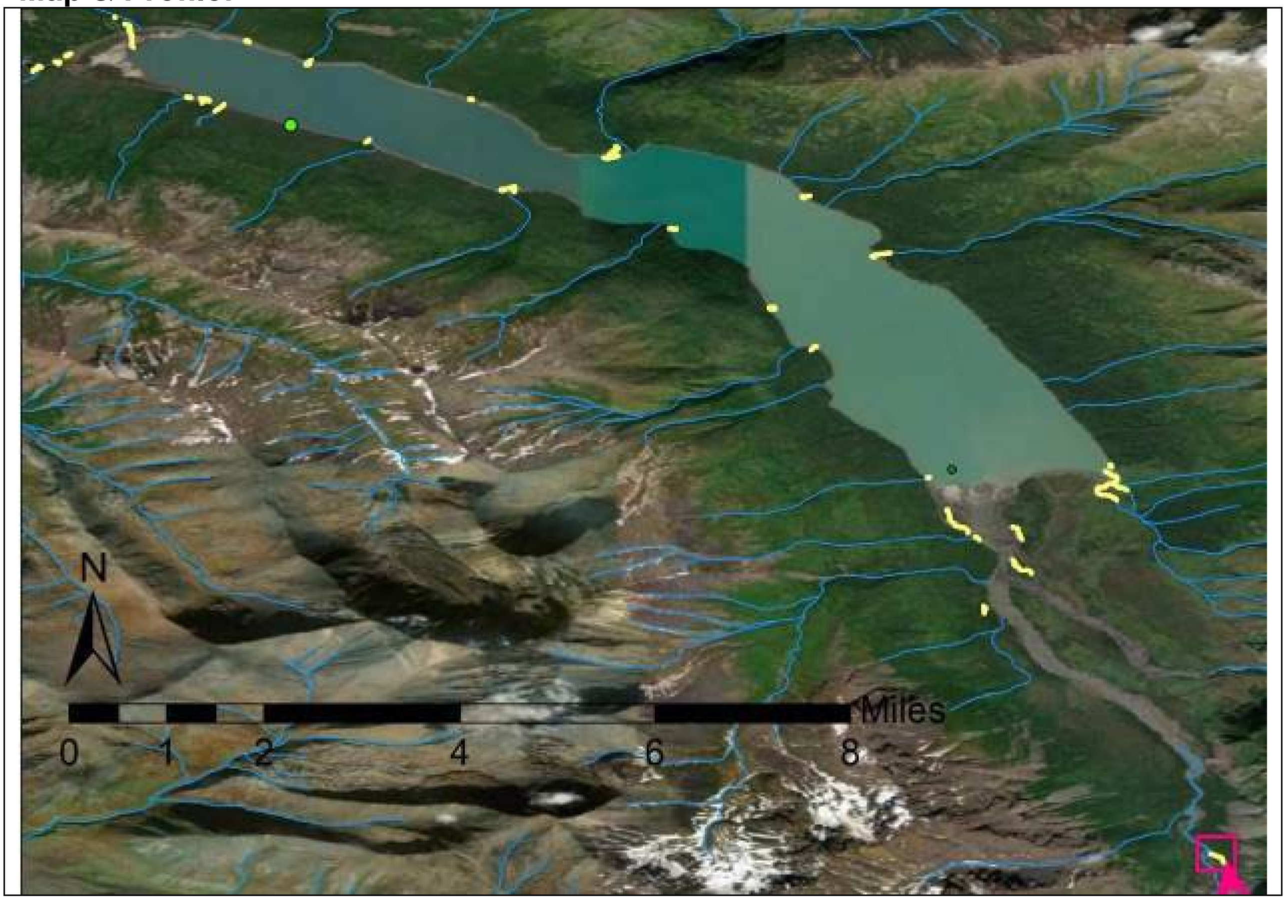
Site Photos:

Field Notes:

Site Name	Date
WF Eklutna Creek Trib 2	

Downstream		Upstream	
Latitude	Longitude	Latitude	Longitude
			-

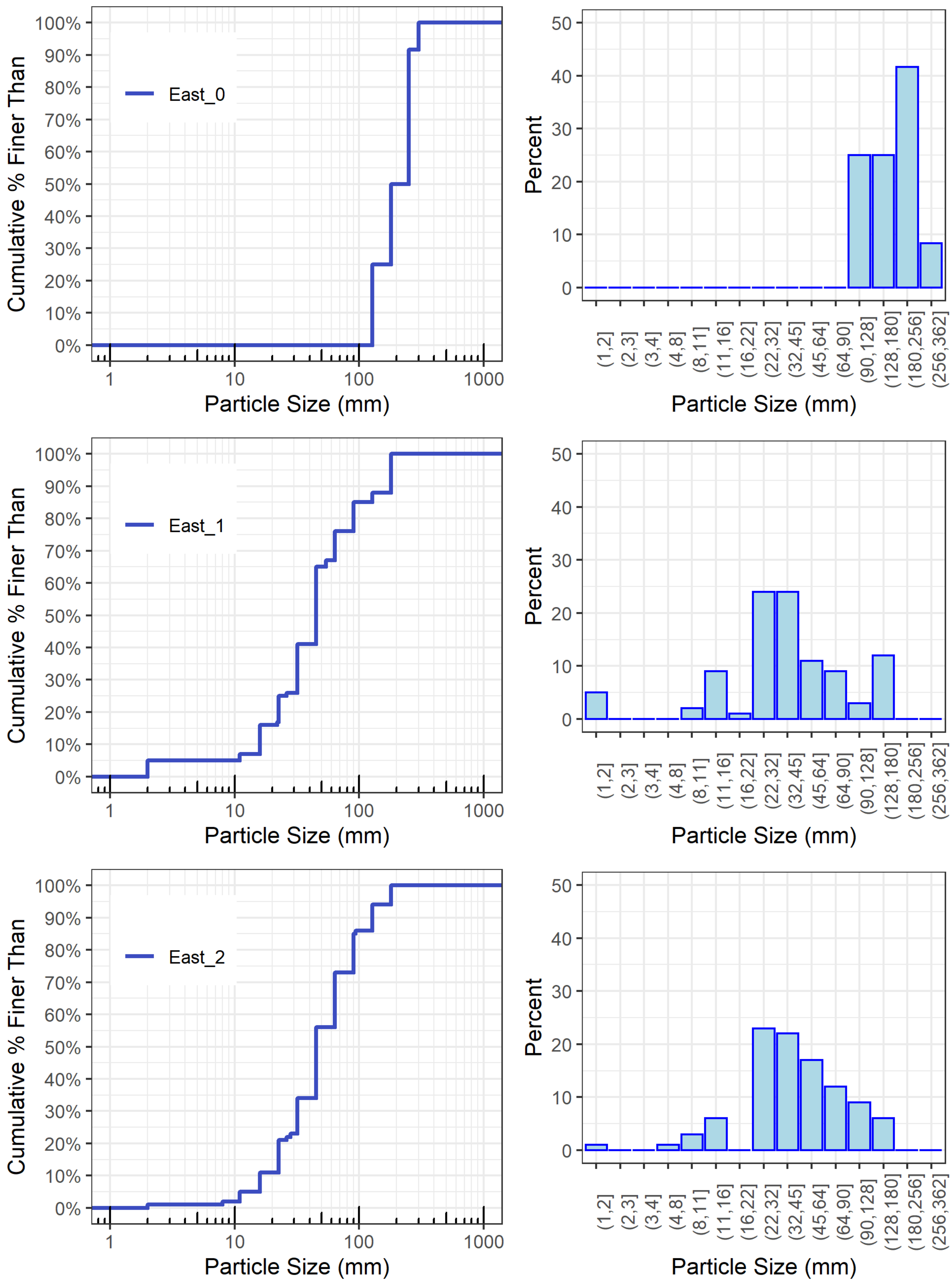
Map & Profile:

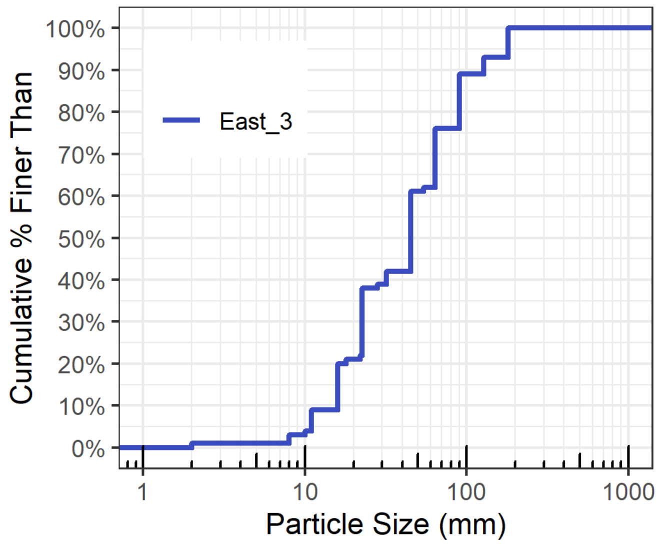


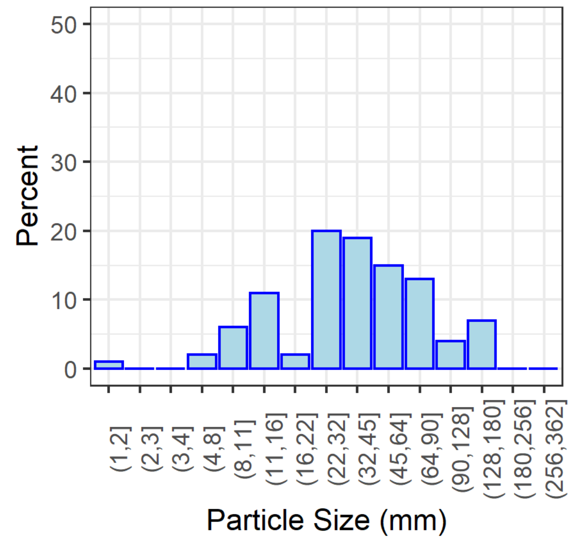
Site Photos:

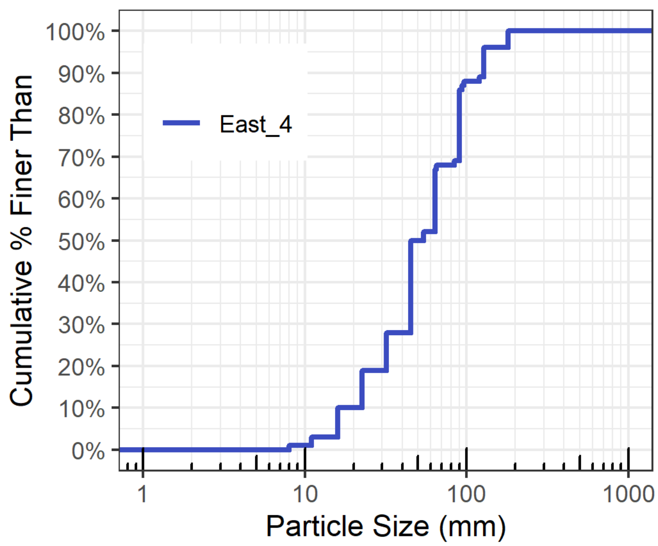
Field Notes:

Appendix 3: Eklutna Creek Pebble Count Data


Cumulative % Finer Than
Particle Size (mm)
East_0
East_1
East_2
Percent
Particle Size (mm)
(1,2] (2,3] (3,4] (4,8] (8,11] (11,16] (16,22] (22,32] (32,45] (45,64] (64,90] (90,128] (128,180] (180,256] (256,362]


Cumulative % Finer Than
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
East_3
1
10
100
1000
Particle Size (mm)


Percent
50
40
30
20
10
0
(1,2]
(2,3]
(3,4]
(4,8]
(8,11]
(11,16]
(16,22]
(22,32]
(32,45]
(45,64]
(64,90]
(90,128]
(128,180]
(180,256]
(256,362]
Particle Size (mm)


Cumulative % Finer Than
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
East_4
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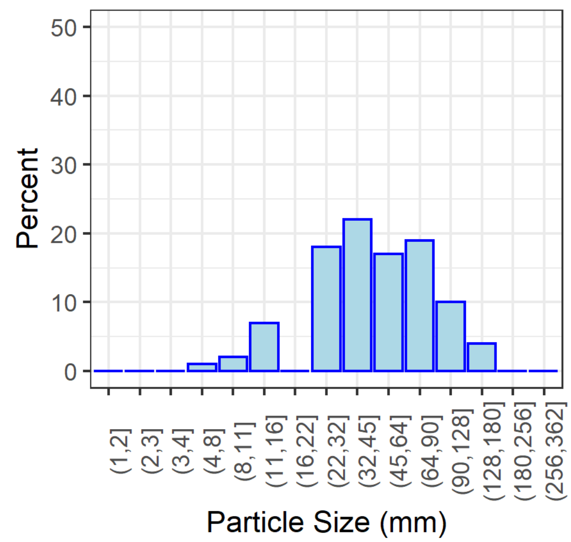
10
100
1000
Particle Size (mm)


Percent
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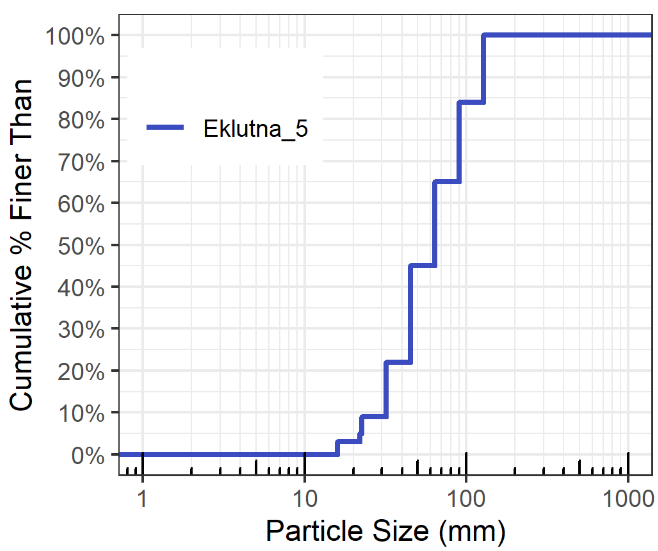
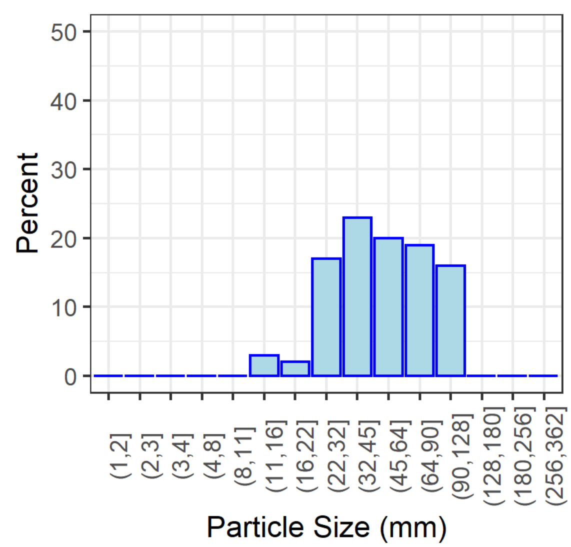
40
30
20
10
0
(1,2]
(2,3]
(3,4]
(4,8]
(8,11]
(11,16]
(16,22]
(22,32]
(32,45]
(45,64]
(64,90]
(90,128]
(128,180]
(180,256]
(256,362]
Particle Size (mm)


Cumulative % Finer Than
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eklutna_5
1
10
100
1000
Particle Size (mm)


Percent
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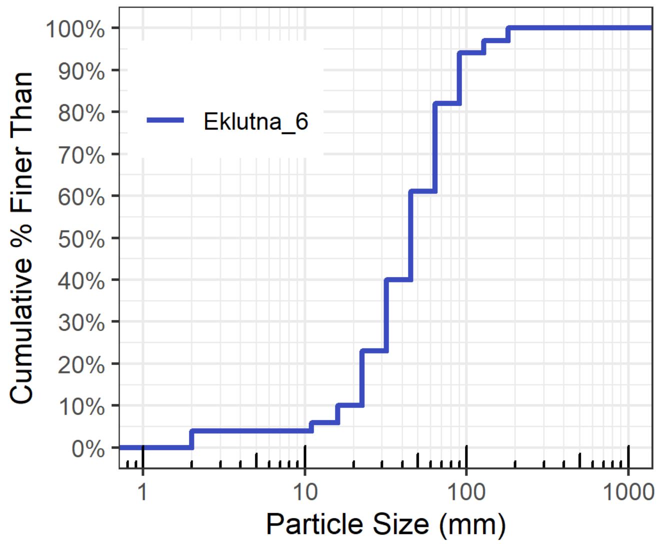
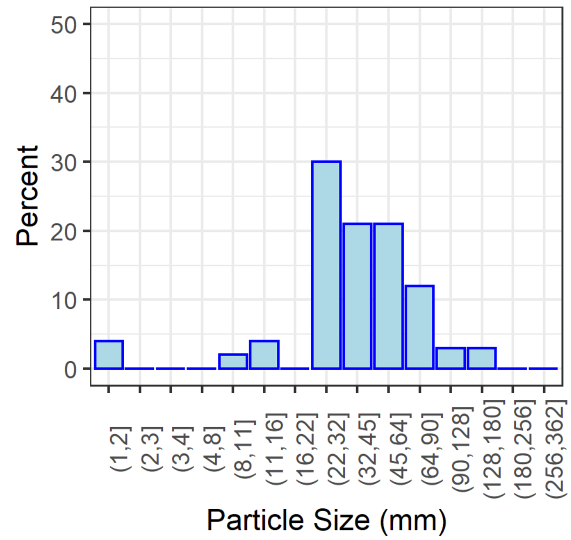
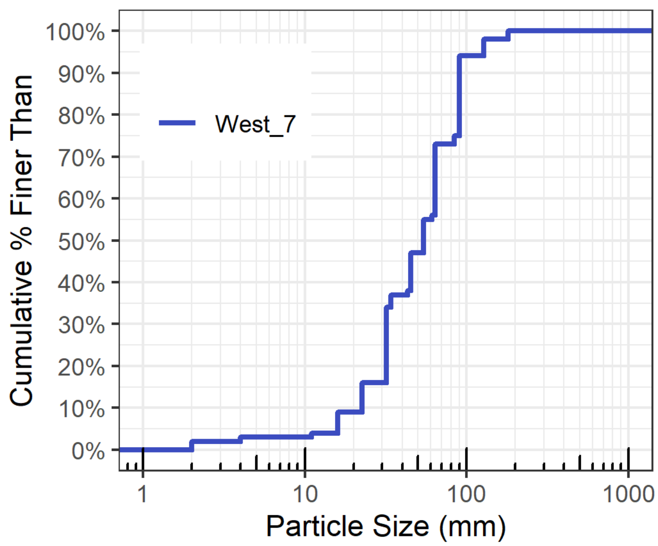
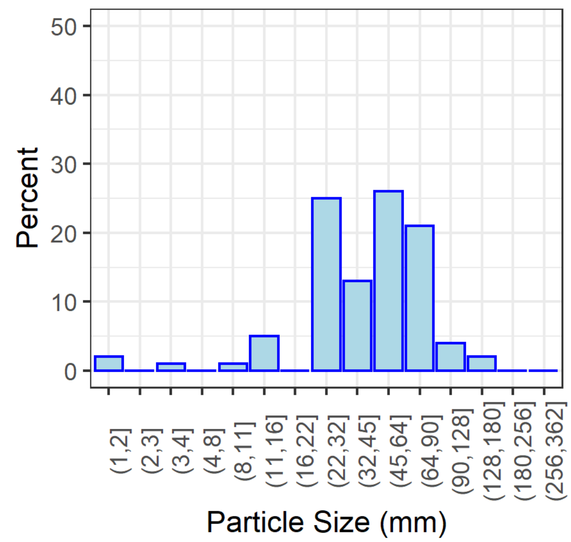
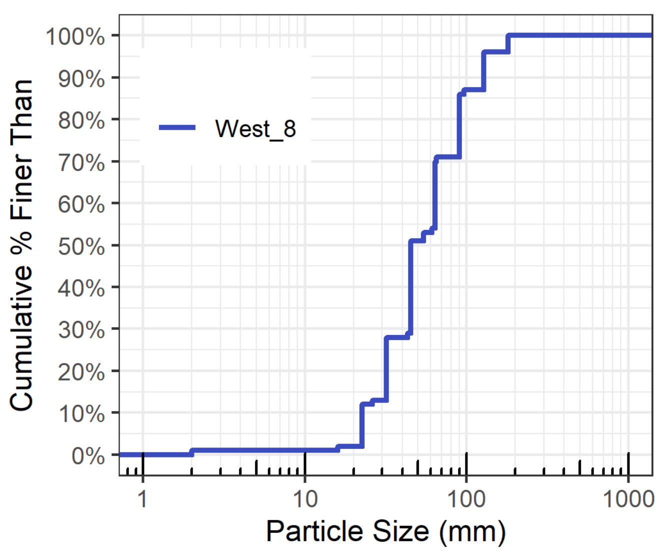
40
30
20
10
0
(1,2]
(2,3]
(3,4]
(4,8]
(8,11]
(11,16]
(16,22]
(22,32]
(32,45]
(45,64]
(64,90]
(90,128]
(128,180]
(180,256]
(256,362]
Particle Size (mm)

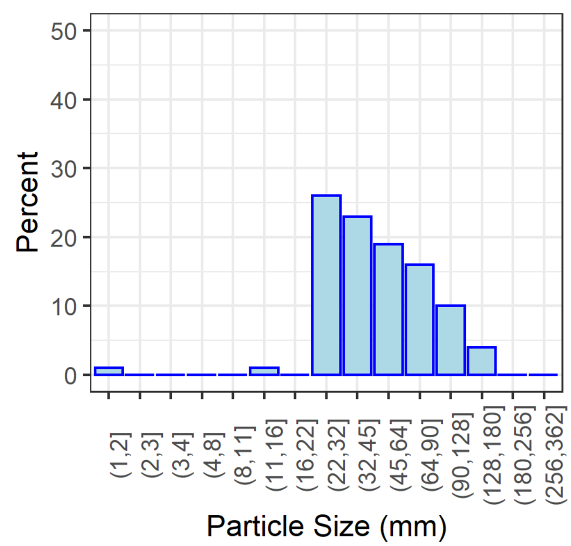

Eklutna_6
Cumulative % Finer Than
Particle Size (mm)

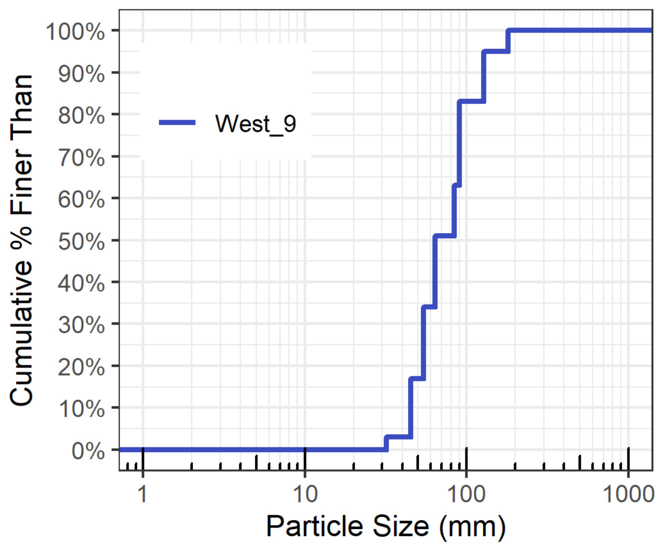

Percent
Particle Size (mm)

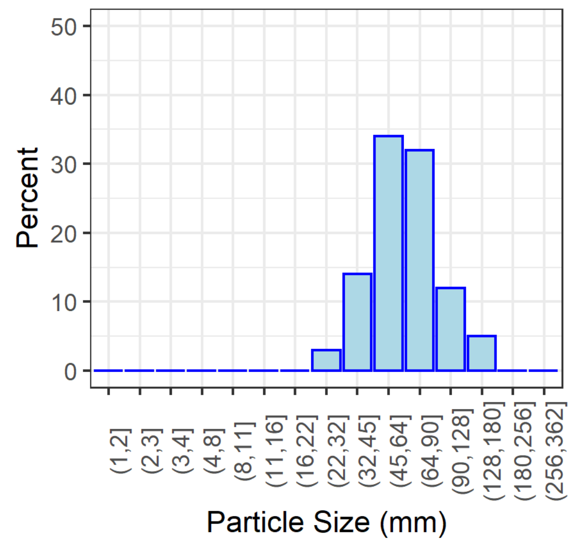

West_7
Cumulative % Finer Than
Particle Size (mm)


Percent
Particle Size (mm)


West_8
Cumulative % Finer Than
Particle Size (mm)


Percent
Particle Size (mm)


West_9
Cumulative % Finer Than
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
1
10
100
1000
Particle Size (mm)


Percent
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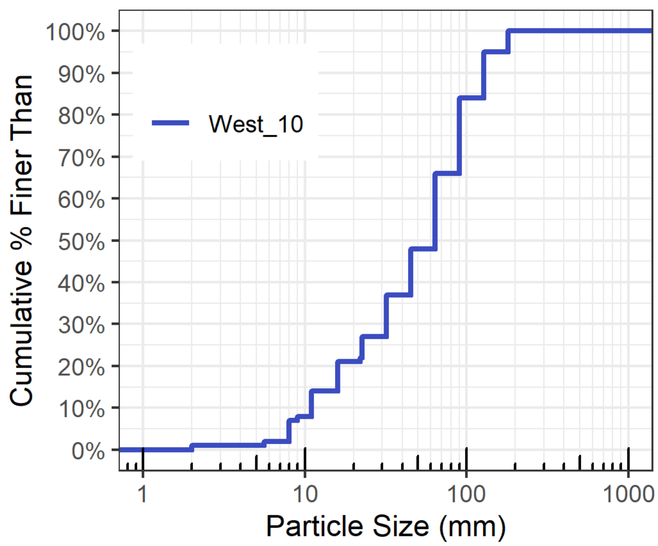
20
30
40
50
(1,2]
(2,3]
(3,4]
(4,8]
(8,11]
(11,16]
(16,22]
(22,32]
(32,45]
(45,64]
(64,90]
(90,128]
(128,180]
(180,256]
(256,362]
Particle Size (mm)


West_10
Cumulative % Finer Than
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40%
50%
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70%
80%
90%
100%
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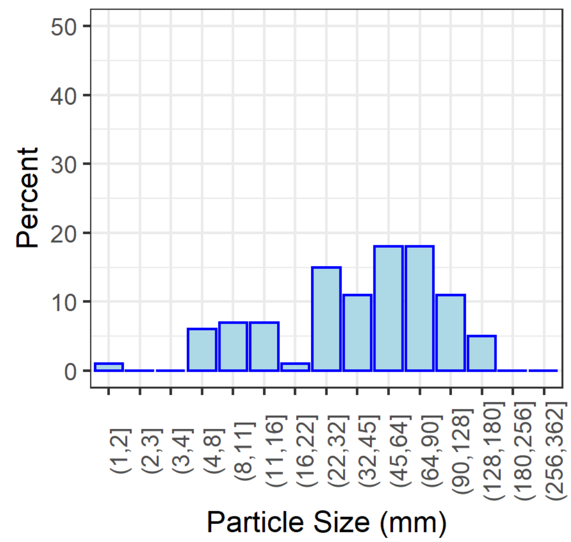
10
100
1000
Particle Size (mm)


Percent
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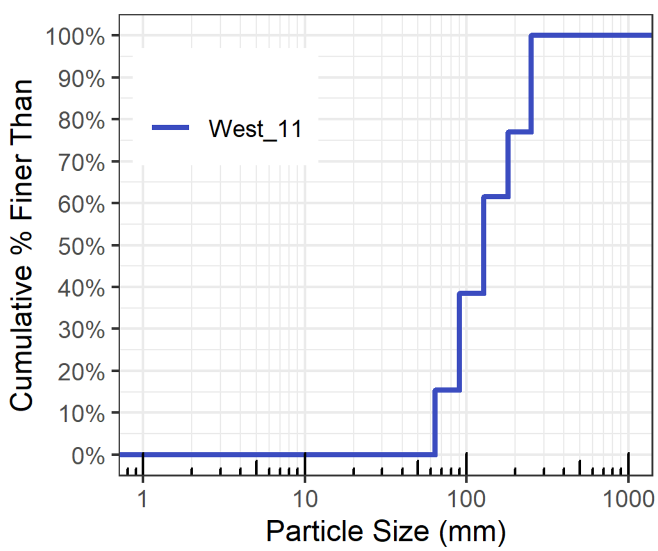
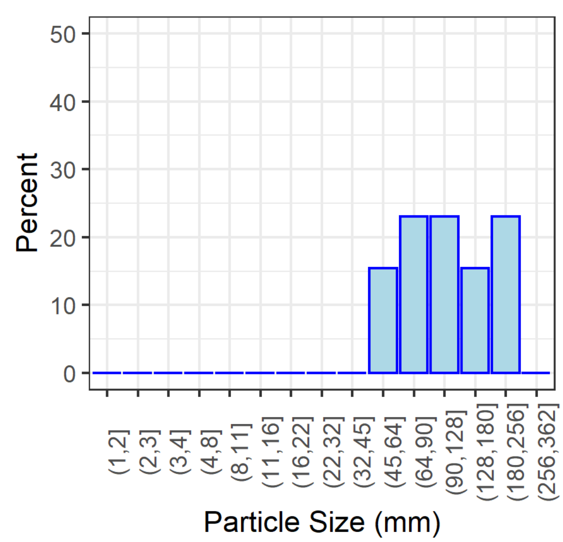
20
30
40
50
(1,2]
(2,3]
(3,4]
(4,8]
(8,11]
(11,16]
(16,22]
(22,32]
(32,45]
(45,64]
(64,90]
(90,128]
(128,180]
(180,256]
(256,362]
Particle Size (mm)


West_11
Cumulative % Finer Than
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
1
10
100
1000
Particle Size (mm)


Percent
0
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20
30
40
50
(1,2]
(2,3]
(3,4]
(4,8]
(8,11]
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(16,22]
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(64,90]
(90,128]
(128,180]
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(256,362]
Particle Size (mm)

Appendix 4: Comment/Response Matrix

Eklutna Lake Aquatic Habitat and Fish Utilization
Study Comment-Response Table

Comment #	Agency/Interested Party	Draft Instream Flow Section (Page) *"Text"*	Comment	Response
General				
1	U.S. Fish and Wildlife Service		The Reports do not include the most recent information from studies conducted by the Native Village Eklutna (NVE 2023), but do mention the intention to reference these data when they become available. We are specifically interested in NVE's findings of redds, salmon migrating upstream past the lower dam site in Reach 6, and potential spawning habitat along the tributaries of Eklutna Lake and upstream of the lake.	NVE provided McMillen with data from their West Fork Eklutna Creek tributary surveys on 3/29/2023. The data included typos in the position of surveys on River Left tributaries. These were resolved on 4/24/2023 and a the information has been added to the report as was indicated in the 2022 draft report.