Technical Report No. 18-09

Glacier Creek Aquatic Studies, 2018

by

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and

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December 2018

Alaska Department of Fish and Game **Division of Habitat**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in reports by the Divisions of Habitat, Sport Fish, and Commercial Fisheries. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figures or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not detected	N
no data	ND
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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December 2018

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Cover: Middle Glacier Creek on May 31, 2018.

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ACKNOWLEDGEMENTS

Constantine North, Inc. provided financial support for this project. Environmental Manager Allegra Cairns and Camp Manager Darsie Culbeck provided logistical support, and Ms. Cairns provided Glacier Creek water quality and discharge data. Vice President of Exploration Darwin Green and Ms. Cairns reviewed the draft report.

Many Division of Habitat staff contributed to this project. Southeast Regional Supervisor Jackie Timothy collaborated on study design, Habitat Biologist Johnny Zutz assisted with sampling, Habitat Biologist Greg Albrecht and Mr. Zutz processed the periphyton samples, and Mr. Albrecht and Habitat Biologist Dylan Krull identified the benthic macroinvertebrates. Division of Habitat Operations Manager Dr. Al Ott and Ms. Timothy reviewed and edited the report.

Thank you all for your contribution.

EXECUTIVE SUMMARY

Constantine North, Inc. (CNI) began exploratory drilling at the Palmer Exploration Project in 2006 and has identified barite, copper, gold, silver, and zinc deposits within the volcanogenic massive sulfide deposit that may support a hard rock mine. CNI contracted with the Alaska Department of Fish and Game (ADF&G) Division of Habitat to study aquatic resources in Glacier Creek, a glacial water body draining the area. With CNI, Division of Habitat biologists developed a plan to study periphyton, benthic macroinvertebrates, fish, and sediment at two sites in Glacier Creek in spring 2016–2018 to document baseline aquatic productivity and sediment conditions.

We sampled the lower and middle reaches of Glacier Creek on May 30 and 31, 2018. Mean chlorophyll *a* density was less than 2 mg/m^2 at both sites and greater among the Middle Glacier Creek samples. The 2018 mean benthic macroinvertebrate densities were lower than previous years at both sites, and while the macroinvertebrate communities were dominated by Diptera: Chironomidae insects in 2016 and 2017, we found few Chironomidae among the Lower Glacier Creek samples in 2018. Generally, Chironomidae insects are fast colonizers, easily adapt to changing habitats, and can exercise more than one feeding strategy (Entrekin et al. 2007).

We captured 13 Dolly Varden char *Salvelinus malma* in Lower Glacier Creek and 7 Dolly Varden char in Middle Glacier Creek; despite extensively fishing, we were unable to capture more Dolly Varden char to achieve 10 samples from Middle Glacier Creek. All fish were in good condition, and we did not capture other fish species. Most median whole body Dolly Varden char concentrations of analyzed elements were greater among the Lower Glacier Creek samples, while arsenic and silver concentrations were often not detected at both sites. Most concentrations were within the ranges observed in whole body Dolly Varden char samples collected from reference and exploration sites elsewhere in Alaska (Legere and Timothy 2016).

We sampled fine sediment at each site for aluminum, arsenic, cadmium, copper, iron, lead, mercury, silver, selenium, and zinc and found the range of element concentrations generally similar among sites. The baseline cadmium, copper, and zinc concentrations were near or above the freshwater sediment guidelines suggested by Buchman (2008); while we find the sediment guidelines useful for evaluating the data, we also recognize organisms can respond differently in nature.

INTRODUCTION

The Palmer Exploration Project is located in the Porcupine Mining District about 55 km north of Haines by air in the southeastern extent of the Saint Elias Mountains near the U.S./Canada border (Figure 1). At the site, placer gold mining in Glacier Creek and its tributaries occurred during the 20th century, and in 1969 local prospector Merrill Palmer discovered base-metal sulfides and barite that initiated exploration drill programs by several different companies in the following years, including CNI beginning in 2006 (CNI 2015). The project is located on the same volcanogenic massive sulfide belt as the Greens Creek Mine[a], and CNI has identified barite, copper, gold, silver, and zinc as potential mineable resources (CNI 2015).

[a] Owned and operated by Hecla Greens Creek Mining Company on Admiralty Island in Southeast Alaska.

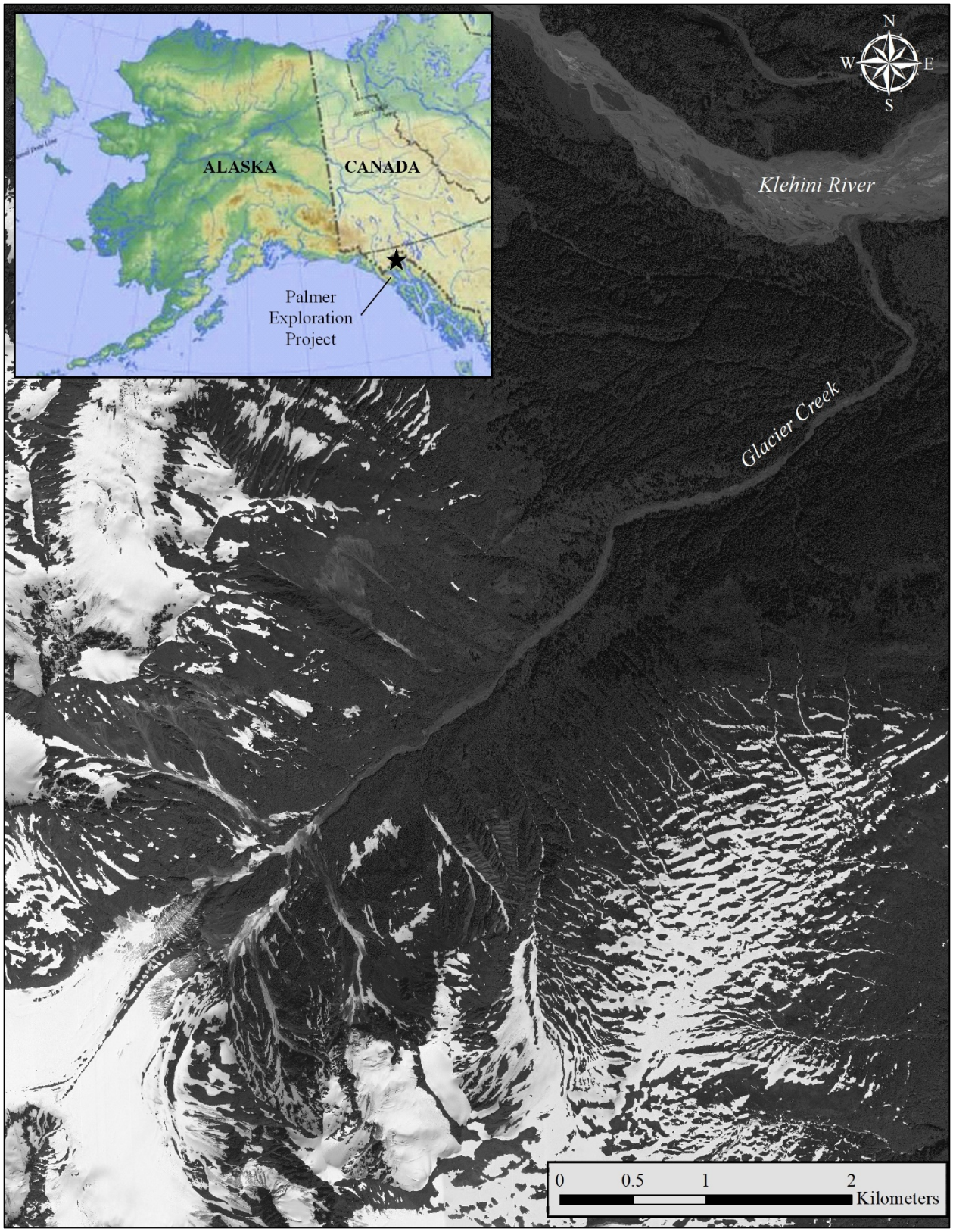

Figure 1.–Palmer Exploration Project area map.

Tetra Tech (2013) and ADF&G biologists have documented[b] Dolly Varden char in Glacier Creek and three tributaries. In 2016, CNI contracted with the ADF&G Division of Habitat to begin baseline studies in Glacier Creek. Following review of CNI's water quality sample data, Division of Habitat biologists developed a study plan to investigate and document aquatic resources in Glacier Creek, similar to aquatic sampling programs at the Greens Creek Mine (Zutz 2018) and Kensington Gold Mine (Timothy and Kanouse 2014), underground hard rock mines in Southeast Alaska. The study plan included sampling periphyton, benthic macroinvertebrates, and fish, aquatic resources influenced by water and sediment quality through natural processes and development, to provide baseline information on aquatic productivity in Glacier Creek; we completed these studies in spring 2016, 2017, and 2018.

PURPOSE

The purpose of this investigation and technical report is to document the condition, abundance, and composition of biological communities and sediments in Glacier Creek.

AQUATIC STUDIES

We completed the following studies in Glacier Creek:

- chlorophyll *a* density and community composition;
- benthic macroinvertebrate density and community composition;
- Dolly Varden char condition and whole body element concentrations; and
- sediment composition and element concentrations.

STUDY AREA

Glacier Creek is about 7 km long, drains a 39 km^2 watershed between its headwaters at the Saksaia Glacier and confluence with the Klehini River, and contributes about 5% of the total Klehini River drainage area measured from the U.S. Geological Survey gage at the Klehini River bridge—about 20 km downstream of the project.[c]

Continuous discharge data do not exist for Glacier Creek. Based on the relative size of the Glacier Creek and Klehini River drainage areas, Integral Consulting, Inc.[d] estimates mean Glacier Creek discharge between May and September at 150 ft^3/s, less than the discharges measured in June 2015, August 2015, June 2016, and September 2017 which ranged 146–272 ft^3/s; CNI staff measured streamflow in Lower Glacier Creek on August 18, 2018 and September 19, 2018, and estimate discharge was 155 ft^3/s and 57 ft^3/s (A. Cairns, Environmental Manager, Constantine North Inc., Vancouver, personal communication).

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[b] Matthew Kern, Habitat Biologist, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: Glacier Creek investigation trip report; dated 6/26/2014. Unpublished document, can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

[c] Marcia Greenblatt and Alice Conovitz, Integral Consulting, to Darwin Green, Constantine North. Memorandum: Klehini River and Glacier Creek hydrologic data summary; dated 2/24/2016. Unpublished document, can be obtained from Constantine North, Inc., 800 W. Pender St. Ste. 320, Vancouver, BC, Canada.

[d] Marcia Greenblatt and Alice Conovitz, Integral Consulting, to Darwin Green and Allegra Cairns, Constantine North. Memorandum: Klehini River and Glacier Creek hydrologic data summary–fall 2016 update; dated 12/19/2016. Unpublished document, can be obtained from Constantine North, Inc., 800 W. Pender St. Ste. 320, Vancouver, BC, Canada.

CNI's 2008–2014, 2017, and 2018 Glacier Creek year-round basic water quality data documents total suspended solids ranging 9–2,470 mg/L, turbidity ranging 18–2,760 nephelometric turbidity units (NTU), and pH ranging 6.59–8.33 (DOI 2016; A. Cairns, Environmental Manager, Constantine North Inc., Vancouver, personal communication).

The lower 1 km of Glacier Creek (Stream No. 115-32-10250-2077-3151) provides habitat for coho salmon *Oncorhynchus kisutch*, cutthroat trout *O. clarkii*, and Dolly Varden char (Johnson and Blossom 2018), though we have only captured Dolly Varden char while opportunistically sampling fish use in 2016, 2017, and 2018.[e,f,g,h] In 2017, we captured Dolly Varden char 0.6 km upstream of the Christmas Creek confluence, a nonglacial tributary located 4.5 km upstream of the Glacier Creek confluence with the Klehini River; previously, Tetra Tech (2013) and ADF&G documented the upper extent of Dolly Varden char below the Christmas Creek confluence. In 2018, we sampled fish use near the upper extent of Glacier Creek and did not find fish.[i]

We sampled two locations in Glacier Creek: Lower Glacier Creek and Middle Glacier Creek (Figure 2).

[e] Kate Kanouse, Habitat Biologist, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: 2016 Palmer Project: Glacier Creek sampling; dated 7/19/2016. Unpublished document, can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

[f] Kate Kanouse, Habitat Biologist, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: 2017 Palmer Project Glacier Creek sampling; dated 8/9/2017. Unpublished document, can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

[g] Nicole Legere, Habitat Biologist, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: 2018 Palmer Project Glacier Creek sampling; dated 7/19/2018. Unpublished document, can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

[h] Dylan Krull, Habitat Biologist, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: 2018 Palmer Project Glacier Creek coho surveys; dated 12/7/2018. Unpublished document, can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

[i] Dylan Krull, Habitat Biologist, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: Waterfall and Hangover Creeks fish investigations; dated 10/22/2018. Unpublished document, can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

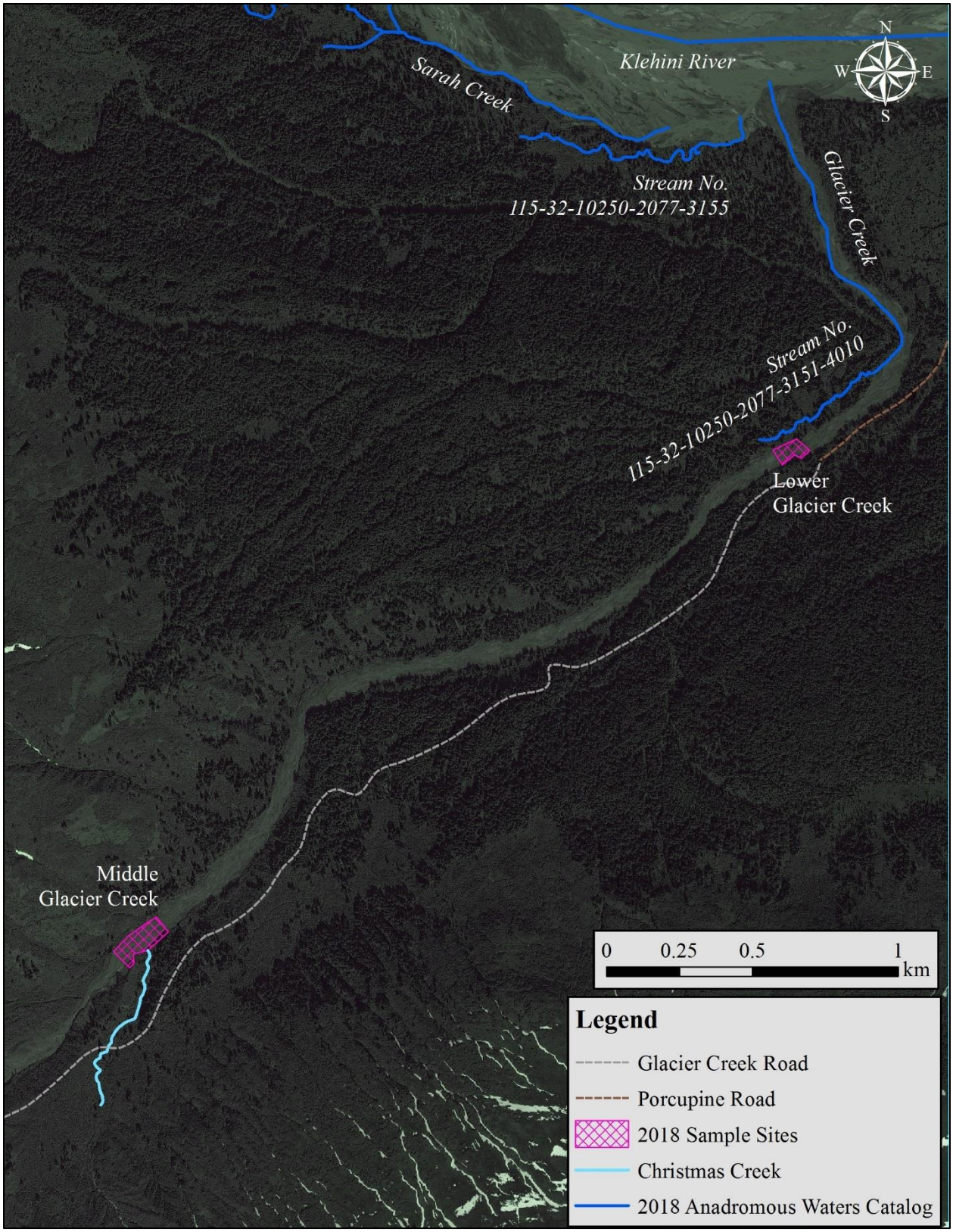

Figure 2.–Glacier Creek sample site map.

Lower Glacier Creek

The Lower Glacier Creek sample site is located at the former Glacier Creek bridge near 230 m elevation, about 1.5 km upstream of the Klehini River (Table 1; Figure 3). We accessed the site from the old bridge crossing at the end of Porcupine Road.

Lower Glacier Creek is a medium glacial outwash channel (Paustian 2010). Streambed gradient ranges 1–5% and the substrate is composed of cobble, gravel, sand, and silt. In 2018, we sampled an 80 m reach, a smaller reach than in 2016 and 2017 due to low water level and suitable sampling areas available, collecting periphyton, benthic macroinvertebrate, and sediment samples in channel braids and along the main channel margin upstream of the old crossing, and fish throughout the sample reach. Of note in 2018, we captured dozens of young-of-year Dolly Varden char (20–25 mm) while electrofishing, which suggests successful spawning may have occurred in the area last fall.

Comparing stream characteristics of the Lower Glacier Creek sample site 2016–2018, we observed similar channel braids upstream of the old crossing and a similar main channel course. A vegetated island and side channel downstream of the old crossing and within our 2016 sample reach had washed-out by spring 2017.

Table 1.–2018 Lower Glacier Creek sample site location data.

	Latitude	Longitude
Upper extent	59.41684	-136.30327
Lower extent	59.41728	-136.30203

Note: WGS84 datum.

Figure 3.–Lower Glacier Creek, looking upstream.

Middle Glacier Creek

The Middle Glacier Creek sample site is located near 350 m elevation, about 4.5 km upstream of the Klehini River (Table 2; Figure 4). We accessed the site by helicopter.

Middle Glacier Creek also is characterized as a medium glacial outwash channel (Paustian 2010). Streambed gradient ranges 4–6% and the substrate is composed of cobble, gravel, sand, and silt. In 2018, we sampled a 180 m reach at the Christmas Creek confluence, a smaller reach than in 2016 and 2017 due to low water level and suitable sampling areas available; we collected periphyton, benthic macroinvertebrate, and sediment samples in channel braids and along the main channel margin, and fish throughout the sample reach. We captured dozens of young-of-year Dolly Varden char (20–25 mm) while electrofishing, suggesting successful spawning may have occurred in the area last fall, most notably on river left in a clear water drainage flowing within the Glacier Creek floodplain that was inaccessible by fish since last fall due to swift main channel flow at its confluence.

Comparing stream characteristics of the Middle Glacier Creek sample site 2016–2018, we observed different main channel courses and channel braids each year. In 2018, the main channel flowed on river left and Christmas Creek flowed into a channel braid.

Table 2.–2018 Middle Glacier Creek sample site location data.

	Latitude	Longitude
Upper extent	59.40036	-136.34497
Lower extent	59.40146	-136.34334

Note: WGS84 datum.

Figure 4.–Middle Glacier Creek and Christmas Creek confluence.

METHODS

We annually review data sets to ensure accuracy and consistency with methods modifications, and report corrections and updates in the document and appendices. The most recent technical report presents the current data sets and should be used to analyze data from previous years.

WATER QUALITY

We collected basic water quality data with a YSI Pro 2030, a Hach 2100P Portable Turbidimeter, and Hanna Instrument model HI98108 pH meter, and calibrated the YSI and the Hach instruments onsite per the manufacturer's instructions before sampling. We present the data by site in a table.

PERIPHYTON: CHLOROPHYLL DENSITY AND COMPOSITION

Periphyton is composed of primary producing organisms, such as algae, cyanobacteria, and heterotrophic microbes, and detritus attached to the submerged surfaces of aquatic ecosystems. Algal density and community structure are influenced by water and sediment quality through physical, chemical, and biological factors, and disturbances that change throughout the year (Barbour et al. 1999).

We sampled periphyton in Lower Glacier Creek and Middle Glacier Creek to estimate algal density and community composition at each site, using concentrations of chlorophylls *a*, *b*, and *c*. Chlorophyll *a* (Chl-*a*) pigment is produced by algae and provides an estimate of active algal biomass (density), while concentrations of chlorophyll *b* (Chl-*b*) and chlorophyll *c* (Chl-*c*) pigments estimate the composition of algal organisms present, such as green algae that produce Chl-*b* and diatoms and brown algae that produce Chl-*c*. We use the chlorophyll data to document baseline primary productivity.

Sample Collection and Analysis

We collected 10 smooth, flat, undisturbed, and perennially wetted rocks from submerged cobble in riffle habitats in less than 0.45 m water depth at each sample site, and submerged the rocks in the creek with the sample area facing up until sampling. We held a 5 × 5 cm square of high-density foam on the sample area and scrubbed around the foam with a toothbrush to remove algae and other organisms outside the sample area, then rinsed the rock by dipping it in the stream while holding the foam in place. We also rinsed the toothbrush in the stream.

We placed a 47 mm diameter Type A/E 1 µm glass fiber filter into a Nalgene® filter holder attached to a vacuum pump with a gauge, then removed the foam square and scrubbed the underside of the foam and the sample area with the toothbrush into the filter holder. We used stream water in a wash bottle to rinse the loosened periphyton from the foam, rock, toothbrush, and the inside of the filter holder onto the filter. We scrubbed the sample area a second time and repeated the rinse cycle. We pumped most of the water through the filter, maintaining pressure less than 34 kPa, and added a few drops[j] of saturated magnesium carbonate solution ($MgCO_3$) to the filter[k] before pumping the sample dry. We removed the glass fiber filter, folded it in half with the sample on the inside, and wrapped it in a white coffee filter to absorb additional water. We

[j] This measurement is not exact as the amount of water and $MgCO_3$ used to create a saturated solution varies and does not affect sample integrity. We used supernatant solution to avoid $MgCO_3$ solids.

[k] To prevent acidification and conversion of chlorophyll to phaeophytin.

placed the samples in a sealed, labeled plastic bag with desiccant and stored the samples in a light-proof cooler containing frozen icepacks during transportation, in a camp freezer while onsite, and in a –20 °C ADF&G Douglas laboratory freezer until processing.

We followed U.S. Environmental Protection Agency (1997) protocol for chlorophyll extraction and measurement, determining instrument and estimated detection limits, and data analysis.[1] We removed the samples from the freezer, cut them into small pieces, and placed the filter pieces for each sample into individual 15 mL screw cap centrifuge tubes containing 10 mL of 90% buffered acetone. We capped the centrifuge tubes and shook each tube vigorously to submerge the filter pieces, placed them in a rack, covered them with aluminum foil, and stored them in a refrigerator overnight to extract the chlorophyll.

The following day, we centrifuged the samples for 20 min at 363 rcf and measured each sample absorbance at wavelengths 664 nm, 647 nm, 630 nm, and 750 nm using a Shimadzu UV-1800 Spectrophotometer. We used 90% acetone stock solution to correct for absorbance of the solvent. We treated each sample with 80 µL of 0.1 N hydrochloric acid to convert the chlorophyll to phaeophytin, and measured absorbance at wavelengths 665 nm and 750 nm.

We used trichromatic equations to estimate Chl-*a*, Chl-*b*, and Chl-*c* concentrations, and corrected Chl-*a* concentrations when phaeophytin was detected. When Chl-*a* was not detected in a sample, we report the concentration at the spectrophotometer estimated detection limit and do not report values for Chl-*b* or Chl-*c*. The 2018 estimated detection limit for Chl-*a* concentration was 0.08 mg/m^2.

Data Presentation

For each site and by year, we present mean Chl-*a*, Chl-*b*, and Chl-*c* densities in a table, Chl-*a* densities in a figure, and mean proportions of Chl-*a*, Chl-*b*, and Chl-*c* in a figure. We compare mean Chl-*a* density among sites in *Comparison Among* Sites, and provide the 2016-2018 data in Appendix A.

BENTHIC MACROINVERTEBRATE DENSITY AND COMMUNITY COMPOSITION

Benthic macroinvertebrates (BMI) classified in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively known as EPT taxa, have complex and short life cycles and many genera are sensitive to changes in water and sediment quality (Barbour et al. 1999). These organisms are secondary producers, feed upon periphyton and other macroinvertebrates, and provide a food source for fish. We sampled BMIs in Lower Glacier Creek and Middle Glacier Creek to estimate density and community composition at each site and document baseline conditions.

Sample Collection and Analysis

We opportunistically collected 6 BMI samples from each site using a Surber stream bottom sampler in riffles and runs with cobble substrate and different flow velocities—habitats that support greater BMI densities and taxonomic richness (Barbour et al. 1999). We do not sample other habitat types (e.g. pools) to reduce variability of the data.

[1] Except, we stored the samples longer than 3.5 weeks; we cut the sample filters to reduce acetone exposure for laboratory staff, rather than homogenize them; and we centrifuged the samples at 363 relative centrifugal force (rcf) rather than 500 rcf.

The Surber stream bottom sampler has a 0.093 m^2 sample area and material is captured in a 200 mL cod end, both constructed with 0.3 mm mesh net. After securing the frame on the substrate, we scrubbed rocks within the sample area with a brush and disturbed gravels, sand, and silt to about 10 cm depth to dislodge macroinvertebrates into the net. We rinsed the net in the stream to ensure all organisms floated into the cod end, transferred each sample from the cod end to a labeled 500 mL plastic bottle, preserved the samples in 75.5% ethanol in the field,[m] and added 95% ethanol at a ratio of three parts ethanol to one part sample upon returning to the ADF&G Douglas laboratory. We discarded samples when material overfilled the cod end.

Habitat biologists used an elutriator system and 0.5 mm and 0.3 mm sieves to sort macroinvertebrates from debris,[n,o] and identified organisms to the lowest practical taxonomic level[p] using Merritt and Cummins (1996) and Stewart and Oswood (2006). Habitat biologists provided quality control by verifying identification of 2 samples.

We calculated BMI density (per m^2) for each sample by dividing the number of macroinvertebrates by 0.093 m^2, the Surber sampling area. We estimated mean BMI density for each site by calculating the mean density among the 6 samples. We report taxa richness as the number of taxonomic groups identified to the lowest practical level and exclude terrestrial[q] organisms from all calculations.

Data Presentation

For each site and by year, we present a table summarizing mean BMI density, total taxa, total EPT taxa, % EPT insects, and % Chironomidae insects, and illustrate BMI densities and community composition in figures. We compare the BMI density and taxa richness data among sites in *Comparisons Among Sites*, and provide the raw data for each 2018 sample and summarize the 2016–2018 data for each site in Appendix B.

RESIDENT FISH CONDITION

Age, sex, season, maturation, diet, gut contents, fat reserve, and muscular development affect fish condition. We used the length and weight of fish captured in Lower Glacier Creek and Middle Glacier Creek for element concentrations analyses to estimate resident Dolly Varden char condition.

Sample Collection and Analysis

We measured FL and weight of resident Dolly Varden char, recording FL to the nearest 1 mm and weight to the nearest 0.1 g. We used the FL and weight data to calculate Fulton's condition

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[m] In 2018, we were unable to transport 95% ethanol from Juneau to Haines by air, so we purchased 75.5% Everclear in Haines for field use.

[n] Gordon Willson-Naranjo and Greg Albrecht, Habitat Biologists, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: Benthic macroinvertebrate elutriation trials amendment; dated 12/17/2013. Unpublished document can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

[o] Katrina Lee, Administrative Assistant, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Division of Habitat. Memorandum: Benthic macroinvertebrate sample enumeration procedures; dated 6/28/2016. Unpublished document can be obtained from the Southeast Regional Supervisor, ADF&G Division of Habitat, 802 3rd St, Douglas, AK.

[p] Insects of the orders Ephemeroptera, Plecoptera, Trichoptera, and Diptera to genus, except nonbiting midges to family Chironomidae, and all others to class or order.

[q] Including adult terrestrial insects of the orders Ephemeroptera, Plecoptera, Trichoptera, and Diptera.

factor (*K*) for individual fish samples using the equation given in Anderson and Neumann (1996), where the fish weight (*W*) is divided by the cubed length (*L*), and the product multiplied by 100,000:

$$K = \frac{W}{L^3} \times 100{,}000$$

Data Presentation

We present the mean fish condition factor of Dolly Varden char for each site, compare mean fish condition among sites in *Comparison Among Sites*, and provide the raw data in Appendix C.

RESIDENT FISH ELEMENT CONCENTRATIONS

Element bioavailability and bioaccumulation depends on physical and chemical factors and interactions among biological communities (Tchounwou et al. 2012). Similar to other studies in Alaska (Legere and Timothy 2016), we sampled resident Dolly Varden char in Lower Glacier Creek and Middle Glacier Creek and measured whole body concentrations of silver (Ag), arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), selenium (Se), and zinc (Zn) to document baseline concentrations and variability. We selected these elements based on CNI's Glacier Creek water sample data and potential target metals identified in the ore body.

Sample Collection and Analysis

We captured fish using a Smithroot LR-24 backpack electrofisher and retained 10 resident Dolly Varden char samples.[r,s] We attempted to only retain fish measuring 90–130 mm FL as other Southeast Alaska Dolly Varden char sampling programs require (Legere and Timothy 2016, Timothy and Kanouse 2014, Zutz 2018), though we retained all fish captured regardless of size due to few fish present. A 90 mm fish provides the minimum weight requirement for laboratory testing, while a 130 mm fish is 2–3 years old and young enough to reasonably conclude it is resident and nonanadromous. We retained fish as they were captured, some outside the size criteria, assuming all fish were resident based on headwater location—about 60 km upriver from Chilkat Inlet. We processed samples as a composite of 2 fish if we were uncertain whether 1 fish would meet the minimum weight requirement for laboratory testing.

We wore latex gloves when handling fish and placed each fish in an individually labeled plastic bag, then measured FL. We placed samples from each site in a larger plastic bag labeled with the sample location. We stored the samples in a cooler with frozen icepacks during transport, in a camp freezer while onsite, and in a –20 ºC freezer in the ADF&G Douglas laboratory. Upon returning to the lab, we measured fish weight in the sample bag and corrected for bag weight.

We shipped the samples to ALS Environmental in Kelso, WA in a cooler with frozen icepacks via overnight air freight, and maintained written chain of custody documentation. ALS Environmental measured total concentrations of Ag, As, Cd, Cu, Pb, Hg, Se, and Zn in each sample on a dry-weight basis, following EPA method 1631E (Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry) for Hg, and EPA method

[r] In 2016, we used baited minnow traps to capture fish in Lower Glacier Creek.

[s] In 2017 and 2018, we were only able to retain 6 samples from Middle Glacier Creek due to low fish abundance.

200.8[t] for the other elements. The laboratory provided Tier II quality control information including results for sample duplicates, matrix spikes, standard reference materials, and blanks.

Data Presentation

For each site and by year, we present Dolly Varden char whole body element concentrations in a figure. We compare the element concentrations data among sites in *Comparisons Among Sites*, and provide a table with the raw data and the laboratory report in Appendix C.

In 2018, the lab reported greater Ag and As method reporting limits than previous years, largely due to underweight samples (K. Clarkson, Senior Project Manager, ALS Environmental, Kelso, personal communication).[u] To avoid misrepresenting those data points as whole body element concentration data, we illustrate element concentrations undetected as an empty circle (◦) at the method reporting limit, and measured element concentrations as a solid circle (•).

SEDIMENT ELEMENT CONCENTRATIONS

Sediment element concentrations are influenced by a variety of factors, such as geochemical composition and weathering within the watershed, sediment grain size, organic content, and development (Tchounwou et al. 2012). Subsequently, sediment element concentrations influence benthic aquatic productivity. We sampled Lower Glacier Creek and Middle Glacier Creek fine sediments for total organic carbon, acid volatile sulfide, and total concentrations of Ag, aluminum (Al), As, Cd, Cu, iron (Fe), Hg, Pb, Se, and Zn to document baseline conditions. We selected these elements based on CNI's Glacier Creek water sample data and potential target elements identified in the ore body.

Sample Collection and Analysis

Wearing latex gloves, we opportunistically collected one sample each from sand/silt bars and retained a total of five replicate samples in glass jars for element analyses and plastic bags for particle size analyses. We stored the samples in a camp refrigerator while onsite, and on June 5, 2018, CNI staff transported the sediment samples in coolers with ice packs to an ALS Environmental lab in Whitehorse, BC.

ALS Environmental measured total organic carbon, acid volatile sulfide, and total Ag, Al, As, Cd, Cu, Fe, Hg, Pb, Se, and Zn concentrations on a dry-weight basis using Canadian methods listed in Table 3.[v] The laboratory provided quality control results for laboratory controls and blanks.

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[t] The same lab used EPA method 200.8 in 2016 and EPA method 6020A in 2017.

[u] We observed the greatest Ag and As method reporting limits for samples that weighed less than 5 g, the lab's minimum weight requirement; we will reconsider submitting fish samples that do not meet the weight requirement in future studies.

[v] The 2016 Glacier Creek sediment samples were processed by an ALS Environmental lab in Kelso, WA. In 2017 and 2018, CNI sent the sediment samples to a different ALS lab; the methods each lab used were different, but the results are comparable, though Al and Fe concentrations were lower in the 2016 samples. The parameters analyzed were different between labs; we present and compare data between years where applicable.

Table 3.–2018 sediment tests, analytes, and methods.

Test Description	Analyte	Method
Particle size distribution	Particle size determination	CSSS (1993) 47.2
Total inorganic carbon in soil	Total inorganic carbon	CSSS (2008) P216-217
Total organic carbon calculation	Total organic carbon	CSSS (2008) 21.2
Total Carbon by combustion method	Total carbon	CSSS (2008) 21.2
Mercury in soil by CVAFS	Hg	EPA 200.2 / 1631E (mod)
Inorganic carbon as CaCO3 equivalent	Inorganic carbon	Calculation
Metals in soil by CRC ICPMS	Ag, Al, As, Cd, Cu, Fe, Pb, Se, and Zn	EPA 200.2/6020A (mod)
Sulfide, acid volatile	Acid volatile sulfides	APHA 4500S2J

Data Presentation

For each site and by year, we present sediment element concentrations data in a figure and report mean values when sample duplicate data are available. Consistent with the whole body Dolly Varden char element concentration data presentations, we illustrate sediment element concentrations undetected as an empty circle (◦) at the method reporting limit and measured element concentrations as a solid circle (•).

We compare the data with the Screening Quick Reference Tables for inorganics in freshwater sediment guidelines developed by the National Oceanic and Atmospheric Administration (Buchman 2008), specifically the threshold effects concentrations (TEC) and the probable effects concentrations (PEC). The guidelines are based on results of controlled laboratory bioassays, wherein element concentrations below the TECs rarely affect aquatic life survival and growth, and element concentrations above the PECs can affect aquatic life survival and growth.

We compare the sediment element concentrations data among sites in *Comparisons Among Sites*. Appendix D contains tables with the composition data and raw element data, and the 2018 laboratory report.

RESULTS

LOWER GLACIER CREEK

We sampled Lower Glacier Creek on May 30, 2018, and measured basic water quality at 1400 (Table 4).[w]

Table 4.–Lower Glacier Creek water quality data.

Sample Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)	pH
06/07/16	3.3	12.6	115	126	6
06/08/17	6.5	13.6	129	306	8.32
05/30/18	5.8	10.8	161	17	ND

Note: In 2016, we used a colorpHast pH indicator strip with 0.5 unit sensitivity.

Periphyton: Chlorophyll Density and Composition

The 2018 Lower Glacier Creek mean Chl-*a* density was 1.25 mg/m^2, less than the 2016 and 2017 mean densities (Table 5; Figure 5). As in previous years, the samples contained about 85% Chl-*a* and 15% Chl-*c*, except 1 sample contained Chl-*b* (Figure 6).

Table 5.–Lower Glacier Creek mean chlorophylls *a*, *b*, and *c* densities.

Sample Date	Chl-*a* (mg/m^2)	Chl-*b* (mg/m^2)	Chl-*c* (mg/m^2)
06/07/16	2.27	0.00	0.35
06/08/17	1.73	0.00	0.26
05/30/18	1.25	0.02	0.24

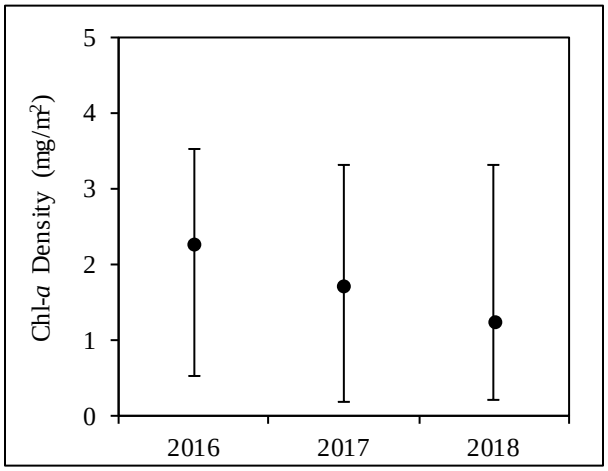

Figure 5.–Lower Glacier Creek chlorophyll *a* densities.

Note: Minimum, mean, and maximum values shown.

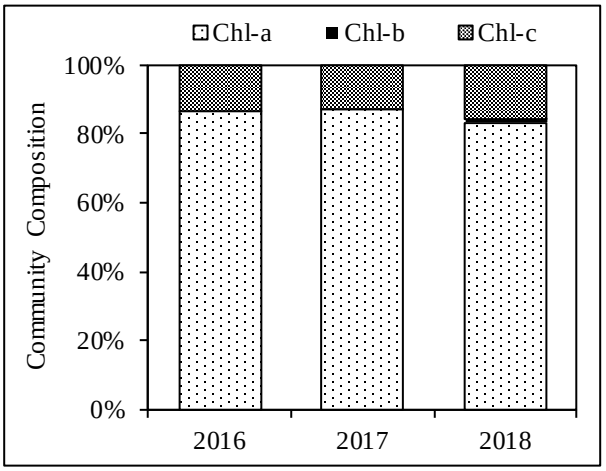

Figure 6.–Lower Glacier Creek mean proportions of chlorophylls *a*, *b*, and *c*.

[w] In 2018, we recorded 10.33 pH and concluded our instrument was not reading correctly after consulting with Ms. Cairns. On June 2, 2018, Ms. Cairns sampled Lower Glacier Creek pH with a YSI ProPlus and measured 8.15 pH, and reports she generally observes Glacier Creek pH values ranging 8.0–8.5 during ice-free months.

Benthic Macroinvertebrate Density and Community Composition

Among the 2018 Lower Glacier Creek BMI samples, we identified 16 taxa and estimate mean density at 217 BMI/m^2, lower than previous years due to fewer Diptera insects present (Table 6; Figures 7, 8). The dominant taxon was Ephemeroptera: *Baetis*, representing 44% of the samples, unlike previous years when samples contained more Diptera: Chironomidae insects.

Table 6.–Lower Glacier Creek benthic macroinvertebrate data summaries.

	06/07/16	06/08/17	05/30/18
Mean BMI density (per m^2)	995	2,136	217
Total BMI taxa	17	30	16
Number of EPT taxa	9	13	10
Proportion of EPT insects	10%	17%	69%
Proportion of Chironomidae insects	85%	78%	26%

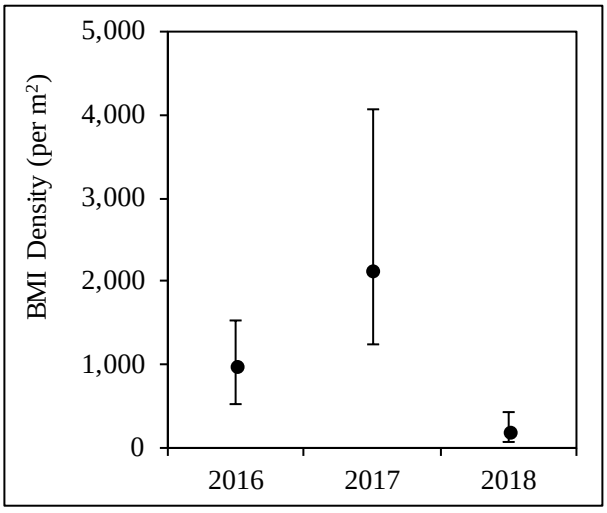

Figure 7.–Lower Glacier Creek benthic macroinvertebrate densities.

Note: Minimum, mean, and maximum values shown.

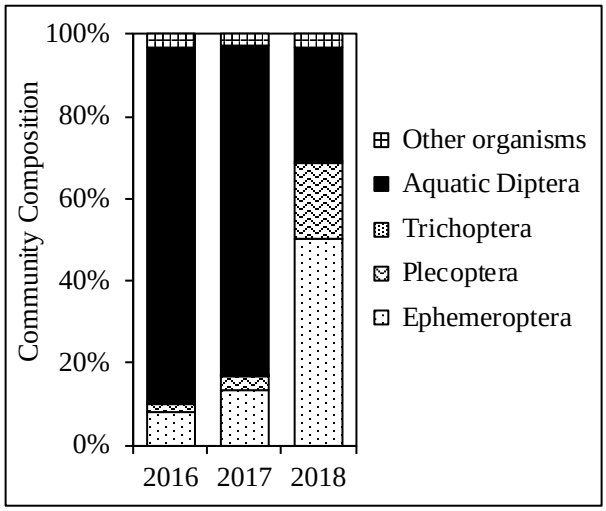

Figure 8.–Lower Glacier Creek mean benthic macroinvertebrate community compositions.

Resident Fish Condition and Element Concentrations

Of the 7 individual whole body Dolly Varden char (81–112 mm) samples we retained from Lower Glacier Creek in 2018, mean fish condition was 1.0.[x] We did not capture other fish species while sampling. The 2018 whole body Dolly Varden char element concentrations generally were similar to concentrations observed in 2016 and 2017 (Figure 9).

[x] Not including 6 Dolly Varden char processed as 3 composite samples.

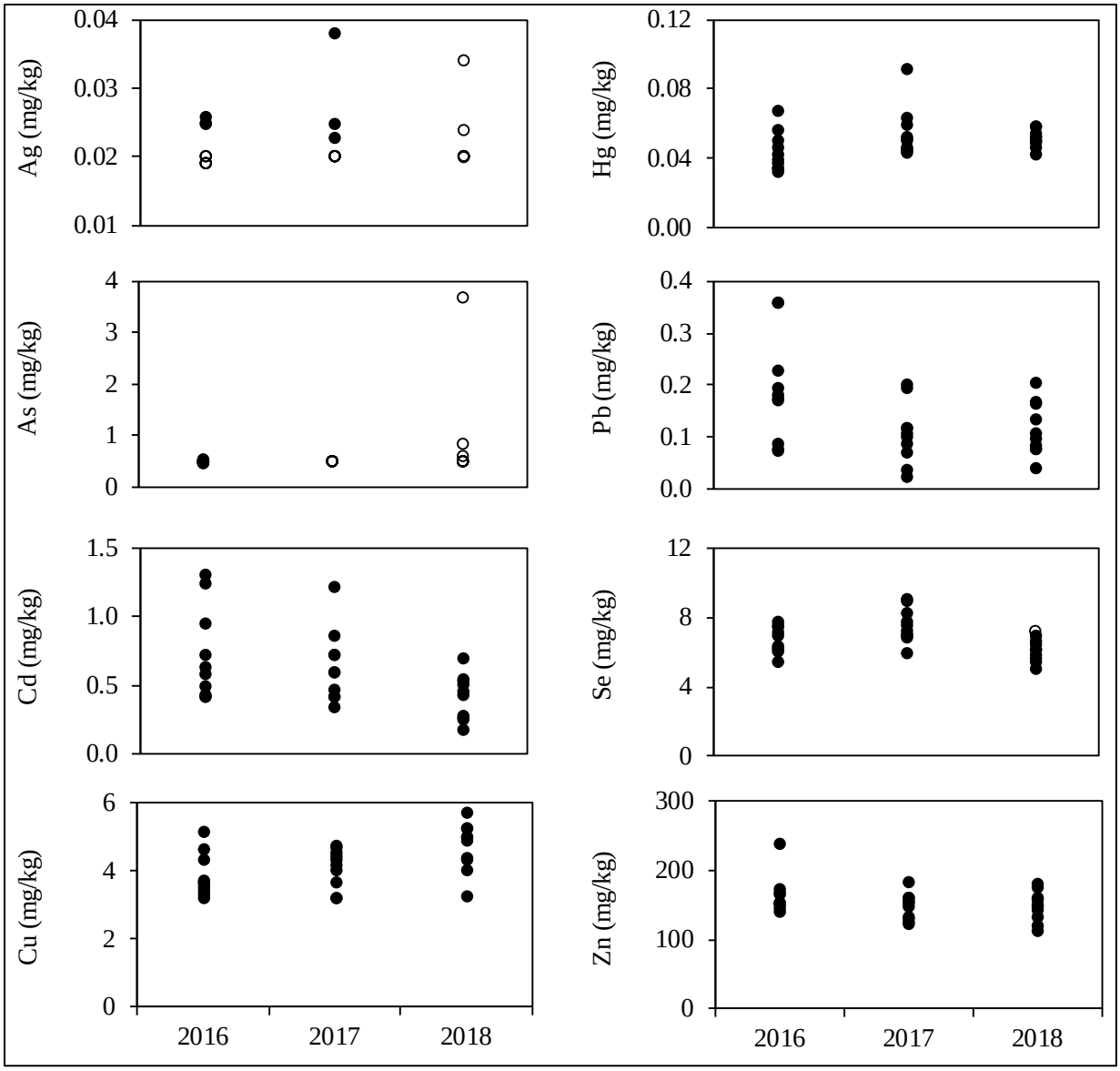

Figure 9.–Lower Glacier Creek whole body Dolly Varden char element concentrations.
Note: Element concentrations undetected (o) are presented at the method reporting limit.

Sediment Composition and Element Concentrations

The 2018 Lower Glacier Creek sediment samples included particle sizes less than 4.75 mm. Total organic carbon concentrations were less than 0.29%, and acid volatile sulfide was detected in 1 sample. The predominant elements were Fe and Al, and the 2018 element concentrations generally were similar to the 2016 and 2017 results.

We evaluated the 2018 sediment sample element concentration data against the guidelines for freshwater sediments published in Buchman (2008), and similar to the 2016 and 2017 results we found Cd, Cu, and Zn concentrations near or above the TEC values, and As, Hg, and Pb concentrations below the TEC values (Figure 10).[y]

[y] Metals concentrations below the TEC value rarely affect aquatic life survival and growth (Buchman 2008).

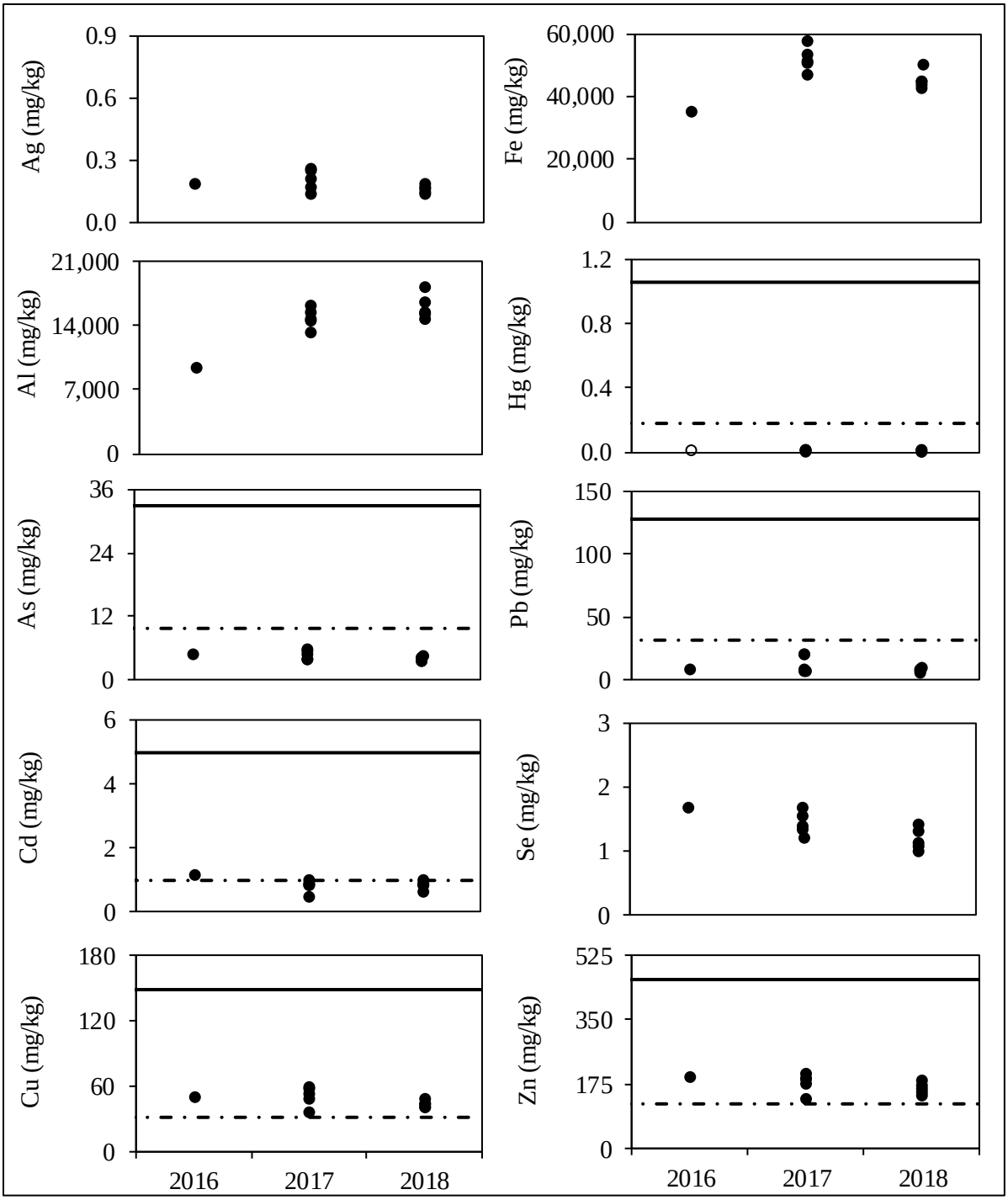

Figure 10.–Lower Glacier Creek sediment element concentrations.

Note: Element concentrations undetected (o) are presented at the method reporting limit. The dashed line represents the TEC and the solid line represents the PEC for freshwater sediments (Buchman 2008); guidelines are not published for Ag, Al, Fe, or Se.

MIDDLE GLACIER CREEK

We sampled Middle Glacier Creek on May 31, 2018, and measured basic water quality at 0900 (Table 7).[z]

Table 7.–Middle Glacier Creek water quality data.

Sample Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)	pH
06/08/16	3.1	14.1	129	57	6
06/09/17	3.1	16.7	113	> 1000	8.38
05/31/18	4.1	11.3	182	16	ND

Note: In 2016, we used a colorpHast pH indicator strip with 0.5 unit sensitivity.

Periphyton: Chlorophyll Density and Composition

The 2018 Middle Glacier Creek mean Chl-*a* density was 1.76 mg/m^2, greater than the 2016 and 2017 mean densities (Table 8; Figure 11). As in previous years, the samples contained about 85% Chl-*a* and 15% Chl-*c* (Figure 12).

Table 8.–Middle Glacier Creek mean chlorophylls *a*, *b*, and *c* densities.

Sample Date	Chl-*a* (mg/m^2)	Chl-*b* (mg/m^2)	Chl-*c* (mg/m^2)
06/08/16	1.50	0.00	0.25
06/09/17	0.81	0.00	0.10
05/31/18	1.76	0.00	0.29

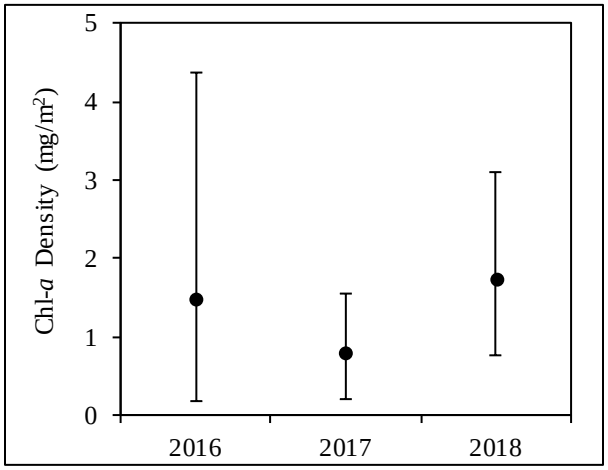

Figure 11.–Middle Glacier Creek chlorophyll *a* densities.

Note: Minimum, mean, and maximum values shown.

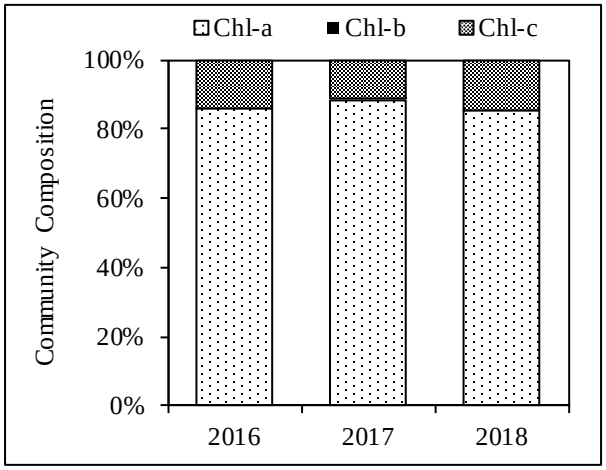

Figure 12.–Middle Glacier Creek mean proportions of chlorophylls *a*, *b*, and *c*.

[z] In 2018, we recorded 9.55 pH and concluded our instrument was not reading correctly after consulting with Ms. Cairns.

Benthic Macroinvertebrate Density and Community Composition

Among the 2018 Middle Glacier Creek BMI samples, we identified 12 taxa and estimate mean density at 504 BMI/m^2, of which 9% were EPT insects, similar to the 2017 sample results (Table 9; Figures 13, 14). The dominant taxon was Diptera: Chironomidae, representing 87% of the samples, as in previous years.

Table 9.–Middle Glacier Creek benthic macroinvertebrate data summaries.

	06/08/16	06/09/17	05/31/18
Mean BMI density (per m^2)	2,299	593	504
Total BMI taxa	22	14	12
Number of EPT taxa	12	6	5
Proportion of EPT insects	13%	12%	9%
Proportion of Chironomidae insects	85%	82%	87%

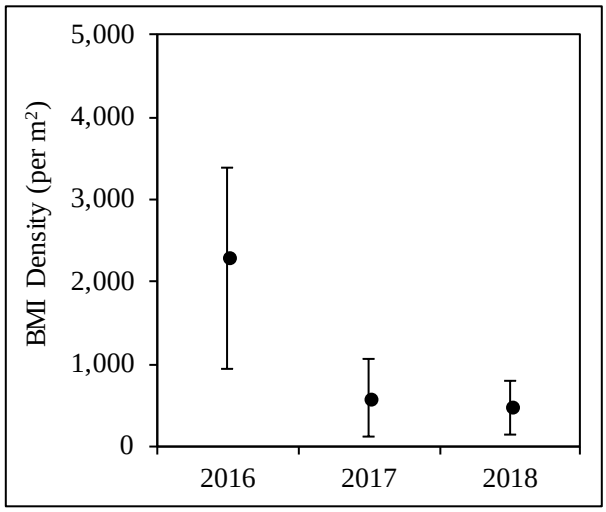

Figure 13.–Middle Glacier Creek benthic macroinvertebrate densities.

Note: Minimum, mean, and maximum values shown.

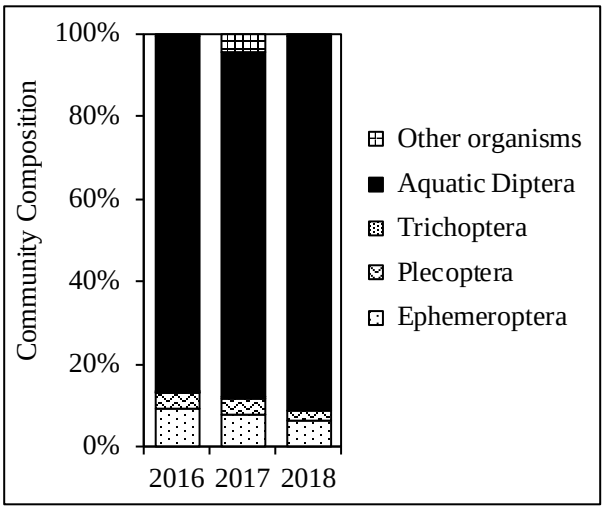

Figure 14.–Middle Glacier Creek mean benthic macroinvertebrate community compositions.

Resident Fish Condition and Element Concentrations

Of the 5 individual whole body Dolly Varden char (100–188 mm) samples we retained from Middle Glacier Creek in 2018, mean fish condition was 1.1.[aa] We did not capture other fish species while sampling. The 2018 whole body Dolly Varden char element concentrations generally were similar to concentrations observed in 2016 and 2017, except two Cu concentrations were greater (Figure 15).

[aa] Not including 2 Dolly Varden char processed as 1 composite sample.

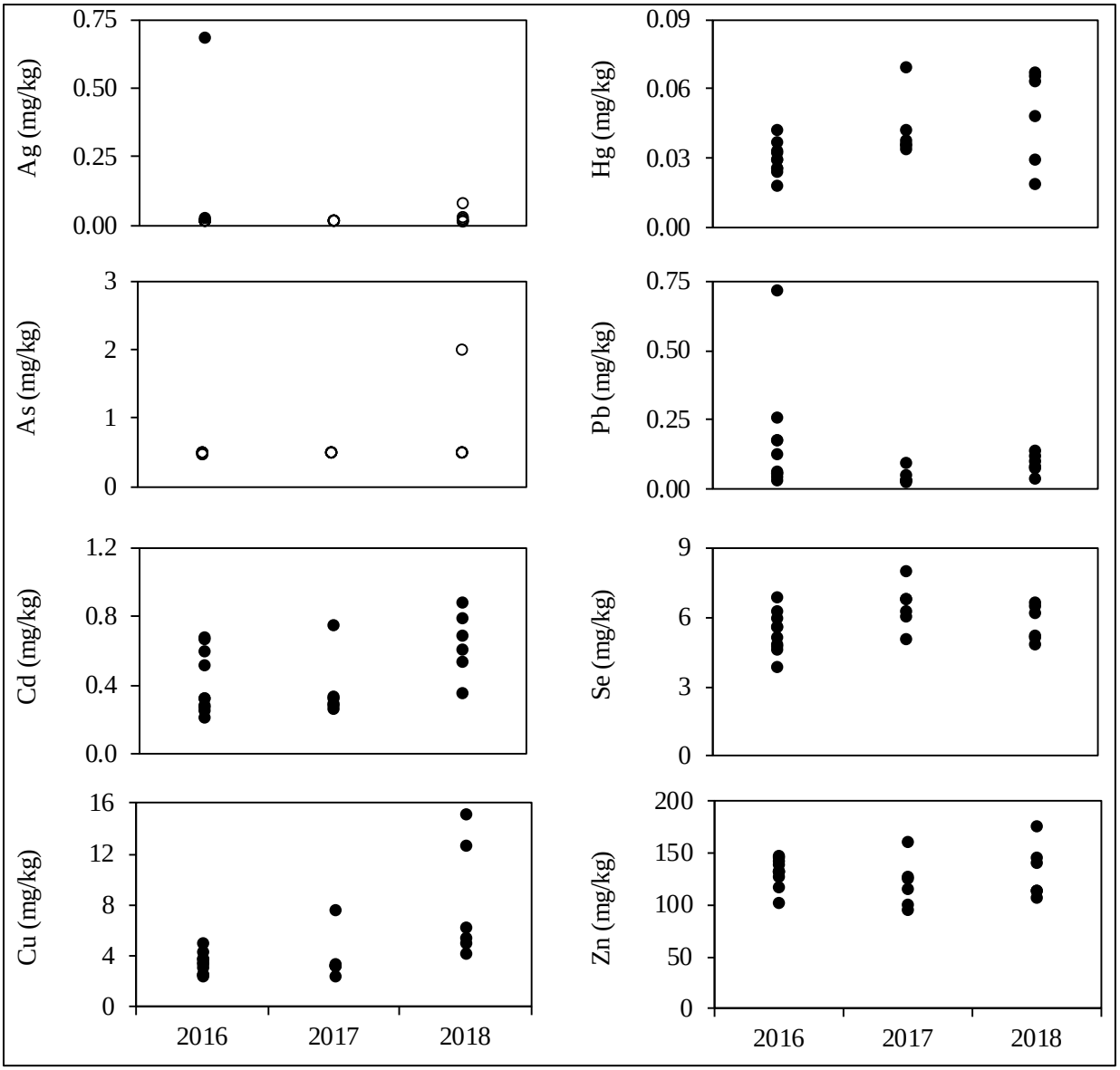

Figure 15.–Middle Glacier Creek whole body Dolly Varden char element concentrations.
Note: Element concentrations undetected (o) are presented at the method reporting limit.

Sediment Composition and Element Concentrations

The 2018 Middle Glacier Creek sediment samples included particle sizes less than 9.5 mm. Total organic carbon concentrations were less than 0.37%, and acid volatile sulfide was detected in 1 sample. The predominant elements were Fe and Al, and the 2018 element concentrations generally were similar to the 2016 and 2017 results, except Al concentrations were greater.

We evaluated the 2018 sediment sample element concentration data against the guidelines for freshwater sediments published in Buchman (2008), and similar to the 2016 and 2017 results we found Cd, Cu, and Zn concentrations near or above the TEC values, and As, Hg, and Pb concentrations below the TEC values (Figure 16).[bb]

[bb] Metals concentrations below the TEC value rarely affect aquatic life survival and growth (Buchman 2008).

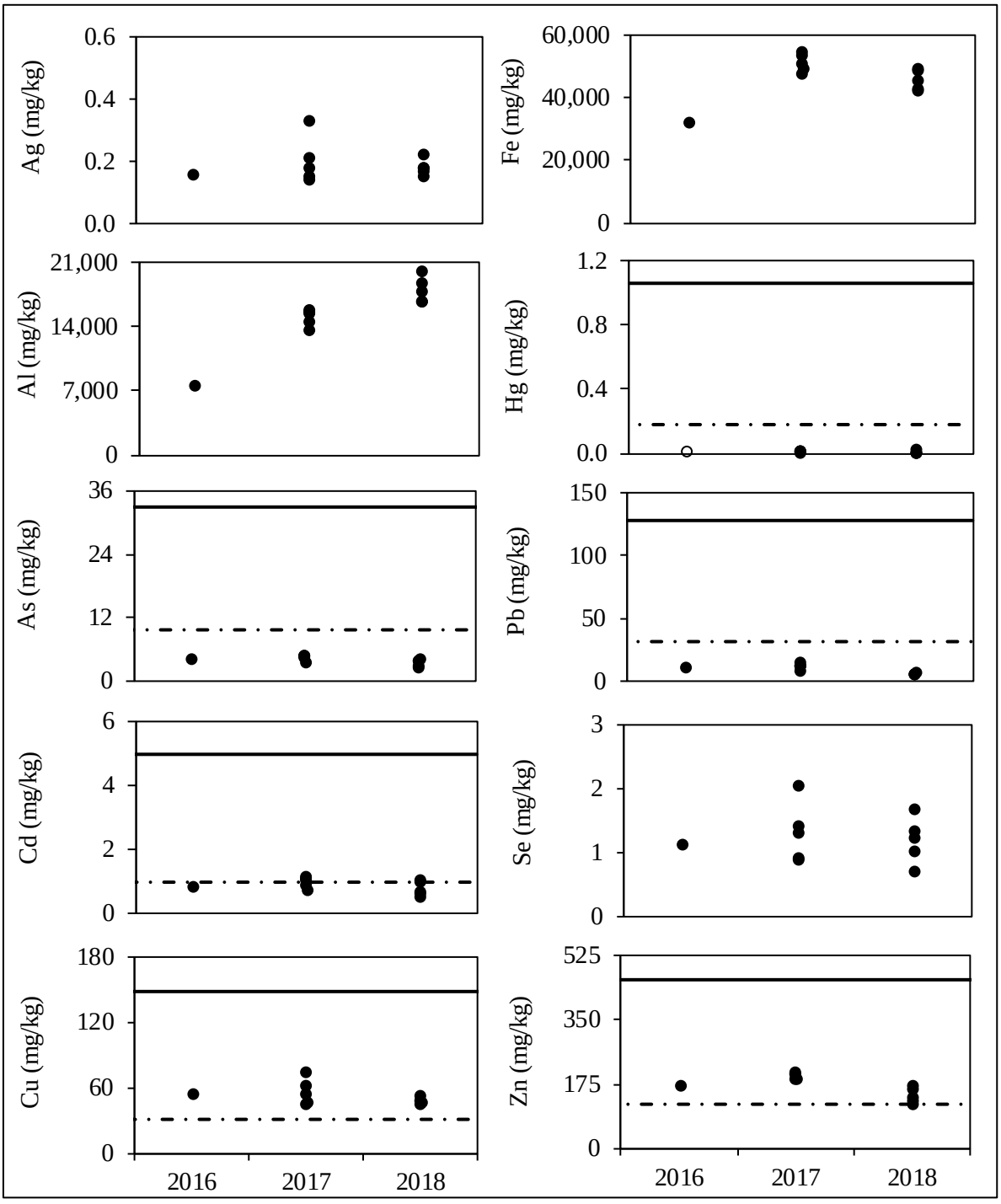

Figure 16.–Middle Glacier Creek sediment element concentrations.

Note: Element concentrations undetected (o) are presented at the method reporting limit. The dashed line represents the TEC and the solid line represents the PEC for freshwater sediments (Buchman 2008); guidelines are not published for Ag, Al, Fe, or Se.

COMPARISON AMONG SITES

Periphyton: Chlorophyll Density and Composition

Unlike the 2016 and 2017 results, Chl-*a* density was greater among the 2018 Middle Glacier Creek samples than the 2018 Lower Glacier Creek samples (Figure 17). Most periphyton samples contained about 85% Chl-*a* and 15% Chl-*c* at both sites all years.

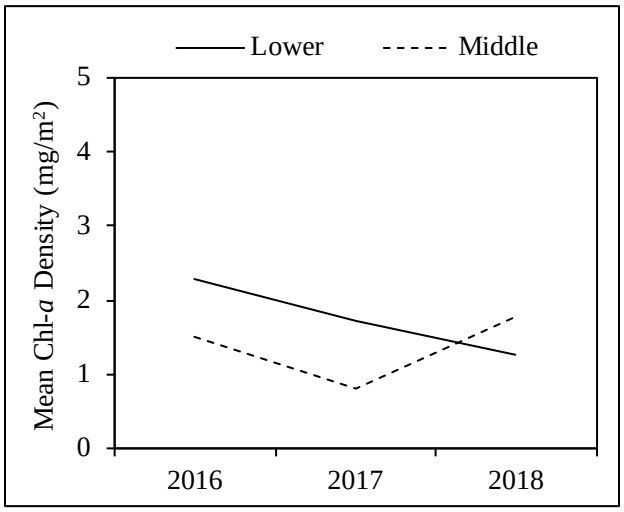

Figure 17.–Glacier Creek chlorophyll *a* densities.

Benthic Macroinvertebrate Density and Community Composition

In 2018, we documented lower mean BMI density and taxa richness at the Lower and Middle Glacier Creek sample sites (Figures 18, 19). Mean BMI density and taxa richness followed similar trends at each site 2016–2018, but not among sites. While the dominant taxon was usually Diptera: Chironomidae insects at both sites, the dominant taxon among the 2018 Lower Glacier Creek samples was Ephemeroptera insects, largely due to fewer Chironomidae insects present and resulting in the low 2018 mean density.

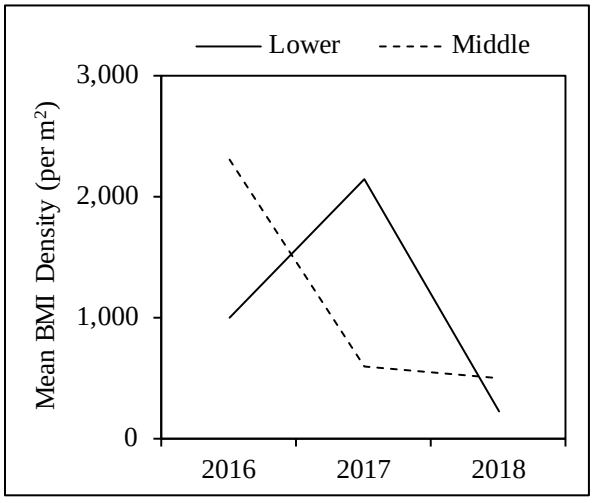

Figure 18.–Glacier Creek mean benthic macroinvertebrate densities.

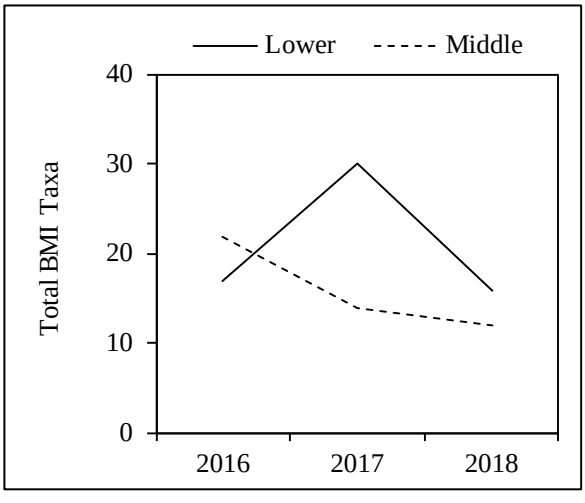

Figure 19.–Glacier Creek benthic macroinvertebrate taxa richness.

Resident Fish Condition and Element Concentrations

Mean fish condition among the 2018 Lower and Middle Glacier Creek Dolly Varden char samples was 1.0 and 1.1, lower than in 2016 and 2017 though similar to other Dolly Varden char condition data collected in Southeast Alaska (Zutz 2018).

When we pooled the 2016–2018 Dolly Varden char element concentration data by site, median element concentrations were greater among the Lower Glacier Creek samples, except median Ag and As concentrations were similar as those elements are often not detected (Figure 20). All concentrations were within the ranges observed in whole body Dolly Varden char samples collected from reference and exploration sites elsewhere in Alaska (Legere and Timothy 2016).[cc]

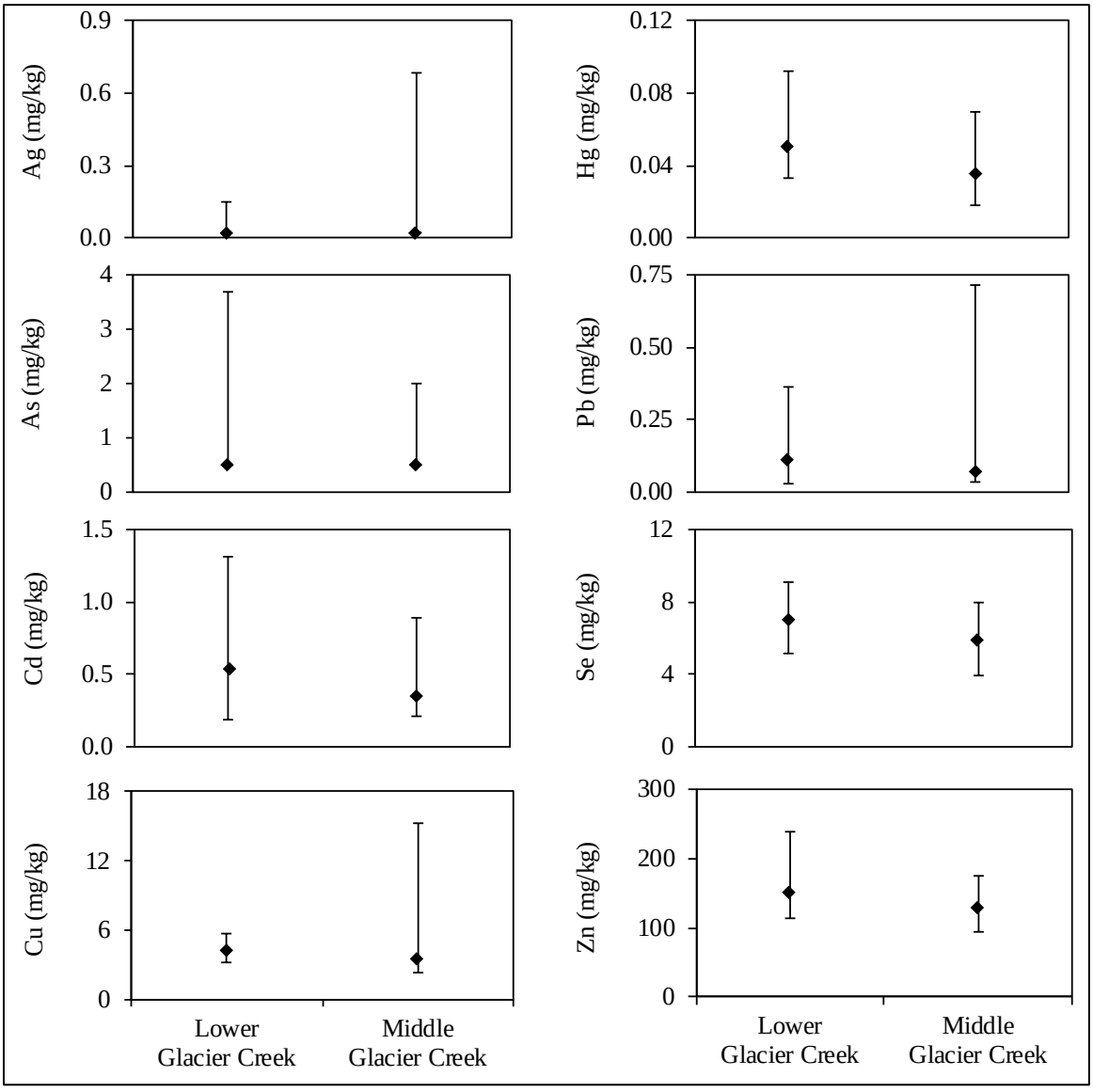

Figure 20.–Glacier Creek whole body Dolly Varden char element concentrations, 2016–2018.

Note: Median (♦), minimum, and maximum concentrations presented; element concentrations not detected are included at the at the method reporting limit.

[cc] Except Ag concentration in 1 sample from Middle Glacier Creek which was greater.

Sediment Composition and Element Concentrations

The 2016–2018 Lower and Middle Glacier Creek sediment samples were largely composed of sand and silt, and total organic carbon and acid volatile sulfide were low or not detected.

We evaluated the element concentration data against the guidelines for freshwater sediments published in Buchman (2008), and similar to the 2016 and 2017 results found Cd, Cu, and Zn concentrations near or above the TEC values, and As, Hg, and Pb concentrations below the TEC values at both sites (Figure 21).[dd] Guidelines are not published for Ag, Al, Fe, or Se.

[dd] Metals concentrations below the TEC value rarely affect aquatic life survival and growth (Buchman 2008).

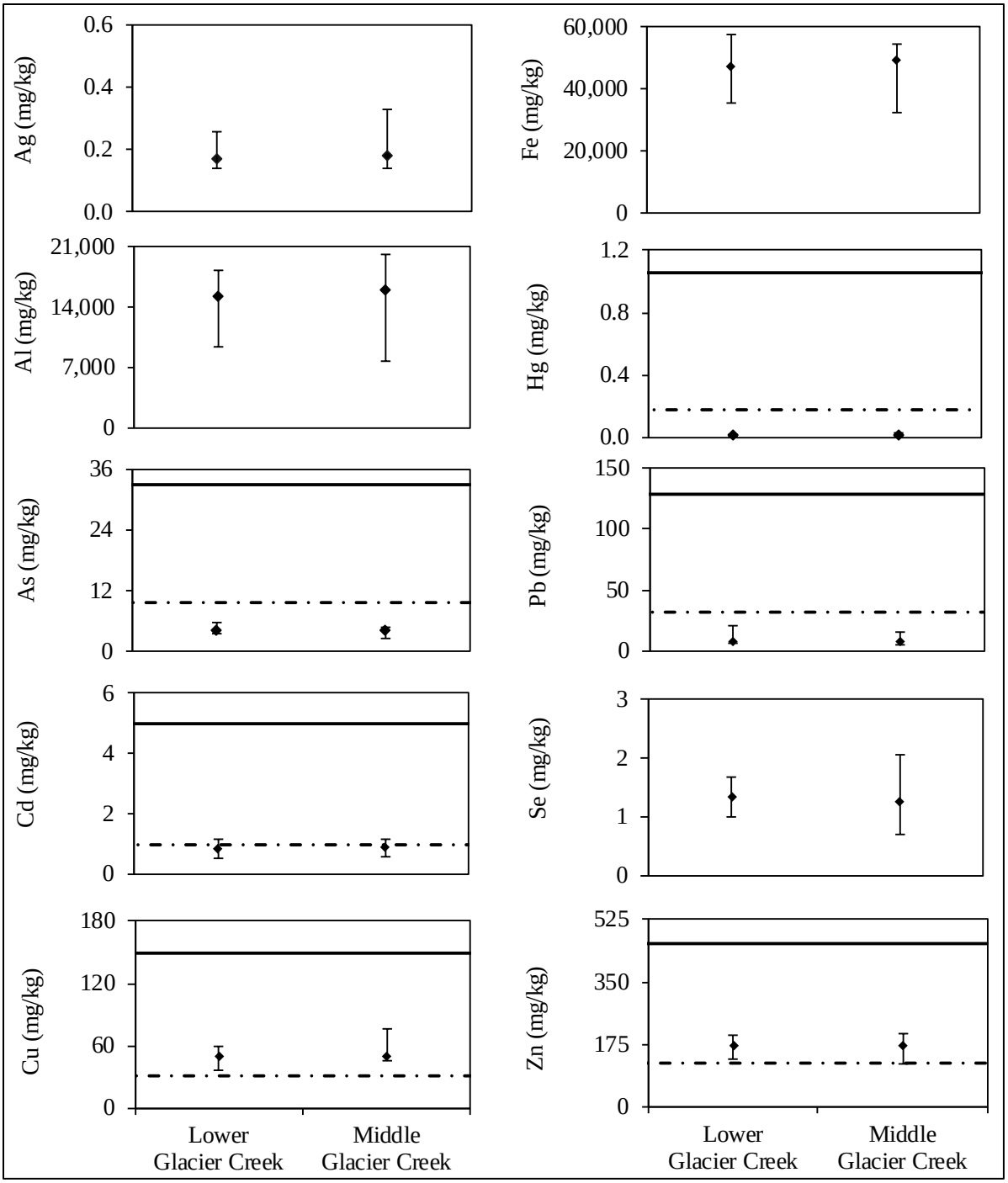

Figure 21.–Glacier Creek sediment element concentrations, 2016–2018.

Note: Median (♦), minimum, and maximum concentrations presented; element concentrations not detected are included at the at the method reporting limit.

Note: The dashed line represents the TEC and the solid line represents the PEC for freshwater sediments (Buchman 2008); guidelines are not published for Ag, Al, Fe, or Se.

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APPENDIX A: CHLOROPHYLL DATA

Appendix A.1.–Lower Glacier Creek chlorophylls *a*, *b*, and *c* densities.

	06/07/16			06/08/17			05/30/18		
mg/m²	Chl-*a*	Chl-*b*	Chl-*c*	Chl-*a*	Chl-*b*	Chl-*c*	Chl-*a*	Chl-*b*	Chl-*c*
	3.35	0.00	0.47	1.50	0.00	0.17	0.21	0.00	0.08
	3.31	0.00	0.51	1.28	0.00	0.25	1.23	0.00	0.20
	2.56	0.00	0.45	2.89	0.00	0.30	3.31	0.00	0.51
	1.28	0.00	0.29	1.82	0.00	0.20	0.53	0.00	0.08
	3.10	0.00	0.38	1.92	0.00	0.25	0.53	0.00	0.07
	1.97	0.00	0.29	3.31	0.00	0.46	0.96	0.00	0.22
	0.53	0.00	0.11	1.92	0.00	0.24	3.10	0.00	0.53
	2.03	0.00	0.30	**0.19**	ND	ND	1.28	0.00	0.24
	3.52	0.00	0.63	1.39	0.00	0.21	0.43	0.15	0.27
	1.01	0.00	0.09	1.09	0.00	0.22	0.96	0.00	0.15
Mean	2.27	0.00	0.35	1.73	0.00	0.26	1.25	0.02	0.24
Minimum	0.53	0.00	0.09	0.19	0.00	0.17	0.21	0.00	0.07
Maximum	3.52	0.00	0.63	3.31	0.00	0.46	3.31	0.15	0.53

Note: Bold value is the spectrophotometer estimated detection limit, chlorophyll *a* not detected.

Appendix A.2.–Middle Glacier Creek chlorophylls *a*, *b*, and *c* densities.

	06/08/16			06/09/17			05/31/18		
mg/m²	Chl-*a*	Chl-*b*	Chl-*c*	Chl-*a*	Chl-*b*	Chl-*c*	Chl-*a*	Chl-*b*	Chl-*c*
	1.82	0.00	0.30	0.96	0.00	0.15	1.50	0.00	0.20
	4.38	0.00	0.75	0.75	0.00	0.15	1.92	0.00	0.27
	0.96	0.00	0.10	1.38	0.00	0.08	2.24	0.00	0.41
	1.60	0.00	0.26	1.56	0.00	0.22	2.78	0.00	0.44
	0.19	ND	ND	0.43	0.00	0.00	3.10	0.00	0.51
	1.17	0.00	0.13	0.75	0.00	0.05	0.96	0.00	0.14
	0.96	0.00	0.15	0.50	0.00	0.03	0.78	0.00	0.16
	1.82	0.00	0.27	1.17	0.00	0.23	1.60	0.00	0.25
	0.28	0.00	0.00	0.21	0.02	0.10	1.82	0.00	0.35
	1.82	0.00	0.27	0.43	0.00	0.02	0.85	0.00	0.20
Mean	1.50	0.00	0.25	0.81	0.00	0.10	1.76	0.00	0.29
Minimum	0.19	0.00	0.00	0.21	0.00	0.00	0.78	0.00	0.14
Maximum	4.38	0.00	0.75	1.56	0.02	0.23	3.10	0.00	0.51

Note: Bold value is the spectrophotometer estimated detection limit, chlorophyll *a* not detected.

APPENDIX B: BENTHIC MACROINVERTEBRATE DATA

Appendix B.1.–2018 Lower Glacier Creek BMI sample data.

				Sample Number						
Class or Subclass	Order	Family	*Genus*	1	2	3	4	5	6	**Total**
Insecta	Ephemeroptera	Baetidae	*Baetis*	7	7	0	0	16	23	**53**
		Ephemerellidae	*Drunella*	0	0	0	0	1	0	**1**
		Heptageniidae	*Cinygmula*	0	0	0	0	0	2	**2**
			Epeorus	0	0	0	0	1	0	**1**
			Rhithrogena	1	0	0	0	1	1	**3**
		Leptophlebiidae	*Paraleptophlebia*	0	0	0	0	0	1	**1**
	Plecoptera	Chloroperlidae	*Suwallia*	2	5	1	8	2	0	**18**
		Nemouridae	*Zapada*	0	0	0	0	0	1	**1**
		Taeniopterygidae	*Taeniopteryx*	1	0	0	0	1	1	**3**
	Trichoptera	Uenoidae	*Oligophleboides*	0	0	0	0	0	1	**1**
	Diptera	Chironomidae	unidentified	2	4	4	1	11	10	**32**
		Limoniidae	*Gonomyodes*	0	0	0	0	1	0	**1**
	Hemiptera	unidentified	unidentified	0	0	0	0	1	0	**1**
Arachnida	unidentified	unidentified	unidentified	0	0	1	0	0	0	**1**
Entognatha	Collembola	unidentified	unidentified	1	0	0	0	0	0	**1**
Oligochaeta	unidentified	unidentified	unidentified	1	0	0	0	0	0	**1**
			Total	**15**	**16**	**6**	**9**	**35**	**40**	**121**

Appendix B.2.–Lower Glacier Creek BMI data summaries.

	06/07/16	06/08/17	05/30/18
Total BMI taxa	17	30	16
Number of EPT taxa	9	13	10
Total counts			
Ephemeroptera	44	158	61
Plecoptera	13	41	22
Trichoptera	1	3	1
Aquatic Diptera	478	955	33
Other organisms	19	35	4
% Ephemeroptera	8%	13%	50%
% Plecoptera	2%	3%	18%
% Trichoptera	0.2%	0.3%	0.8%
% Aquatic Diptera	86%	80%	27%
% Other organisms	3%	3%	3%
% EPT	10%	17%	69%
% Chironomidae	85%	78%	26%
Total aquatic invertebrates	555	1,192	121
Total terrestrial invertebrates	17	18	13
Total invertebrates	572	1,210	134
% Sample aquatic	97.0%	98.5%	90.3%
% Sample terrestrial	3.0%	1.5%	0.0%
Total sample area (m^2)	0.558	0.558	0.558
Mean BMI density (per m^2)	995	2,136	217
±1 SD	373	1,015	151

Appendix B.3.–2018 Middle Glacier Creek BMI sample data.

				Sample Number						
Class	Order	Family	Genus	1	2	3	4	5	6	**Total**
Insecta	Ephemeroptera	Baetidae	*Baetis*	6	1	0	0	6	3	**16**
		Heptageniidae	*Rhithrogena*	0	0	0	0	2	0	**2**
	Plecoptera	Capniidae	*Capnia*	0	0	0	0	1	0	**1**
		Chloroperlidae	*Suwallia*	1	0	0	2	2	0	**5**
		Leuctridae	unidentified	0	0	1	0	0	0	**1**
	Diptera	Chironomidae	unidentified	64	11	63	22	35	50	**245**
		Empididae	*Clinocera*	0	0	0	0	0	1	**1**
		Limoniidae	*Gonomyodes*	0	1	0	1	1	3	**6**
		Simuliidae	*Prosimulium*	1	0	0	0	0	0	**1**
		Stratiomyidae	unidentified	0	0	0	1	0	0	**1**
Oligochaeta	unidentified	unidentified	unidentified	0	0	0	0	0	1	**1**
Ostracoda	unidentified	unidentified	unidentified	1	0	0	0	0	0	**1**
			Total	**73**	**13**	**64**	**26**	**47**	**58**	**281**

Appendix B.4.–Middle Glacier Creek BMI data summaries.

	06/08/16	06/09/17	05/31/18
Total BMI taxa	22	14	12
Number of EPT taxa	12	6	5
Total counts			
Ephemeroptera	119	25	18
Plecoptera	45	14	7
Trichoptera	4	1	0
Aquatic Diptera	1,107	276	254
Other organisms	8	15	2
% Ephemeroptera	9%	8%	6%
% Plecoptera	4%	4%	2%
% Trichoptera	0.3%	0.3%	0.0%
% Aquatic Diptera	86%	83%	90%
% Other organisms	1%	5%	0.7%
% EPT	13%	12%	9%
% Chironomidae	85%	82%	87%
Total aquatic invertebrates	1,283	331	281
Total terrestrial invertebrates	19	7	1
Total invertebrates	1,302	338	282
% Sample aquatic	98.5%	97.9%	99.6%
% Sample terrestrial	1.5%	2.1%	0.4%
Total sample area (m^2)	0.558	0.558	0.558
Mean BMI density (per m^2)	2,299	593	504
±1 SD	976	392	249

APPENDIX C: RESIDENT FISH DATA AND LABORATORY REPORT

Appendix C.1.–Lower Glacier Creek whole body Dolly Varden char element concentrations.

Sample Date	Length (mm)	Weight (g)	Condition (*K*)	Ag (mg/kg)	As (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Hg (mg/kg)	Pb (mg/kg)	Se (mg/kg)	Zn (mg/kg)
06/07/16	108	12.7	1.0	<0.019	<0.48	0.429	3.55	0.0466	0.076	7.23	153
06/07/16	68	4.8	1.5	<0.020	<0.50	0.501	3.75	0.0330	0.182	7.60	173
06/07/16	112	17.7	1.3	0.025	<0.48	1.310	3.63	0.0567	0.230	5.48	145
06/07/16	105	15.9	1.4	<0.019	<0.48	0.585	3.23	0.0509	0.078	7.56	150
06/07/16	113	14.3	1.0	<0.020	0.50	0.420	3.42	0.0427	0.177	6.21	154
06/07/16	94	10.8	1.3	<0.019	0.52	0.441	4.35	0.0381	0.195	7.83	167
06/07/16	109	14.6	1.1	0.026	<0.50	1.250	5.20	0.0683	0.362	6.46	238
06/07/16	97	11.2	1.2	<0.019	<0.49	0.641	3.71	0.0401	0.172	6.11	154
06/08/16	93	9.5	1.2	<0.020	<0.49	0.960	3.32	0.0349	0.091	7.04	141
06/08/16	73	4.7	1.2	0.025	0.54	0.730	4.67	0.0353	0.360	6.31	168
06/08/17	133	29.1	1.2	0.023	<0.50	0.727	4.47	0.0599	0.109	6.00	184
06/08/17	113	15.7	1.1	<0.020	<0.50	0.426	3.69	0.0505	0.027	7.01	148
06/08/17	105	12.6	1.1	<0.020	<0.50	0.601	3.23	0.0523	0.038	7.16	134
06/08/17	90	9.2	1.3	0.038	<0.50	1.230	3.24	0.0473	0.088	8.33	123
06/08/17	106	12.8	1.1	<0.020	<0.50	0.606	4.06	0.0532	0.104	9.09	153
06/08/17	175	60.5	1.1	<0.020	<0.50	0.355	4.71	0.0924	0.119	6.90	162
06/08/17	75	5.7	1.4	<0.020	<0.50	0.429	4.77	0.0438	0.202	7.86	157
06/08/17	110	17.3	1.3	0.025	<0.50	0.736	4.35	0.0446	0.074	9.03	126
06/08/17	59, 118[a]	20.2	ND	<0.020	<0.50	0.472	4.20	0.0456	0.119	7.30	160
06/08/17	102, 70[a]	15.6	ND	<0.020	<0.50	0.865	4.55	0.0642	0.196	7.62	130
05/30/18	112	12.3	0.9	<0.020	<0.50	0.183	3.26	0.0511	0.042	5.14	114
05/30/18	66, 65[a]	4.7	ND	<0.034	<0.84	0.458	5.30	0.0467	0.098	5.90	142
05/30/18	109	15.1	1.2	<0.020	<0.50	0.257	4.34	0.0592	0.080	6.70	121
05/30/18	103	11.6	1.1	<0.020	<0.50	0.272	4.05	0.0426	0.108	7.04	132
05/30/18	78, 65[a]	7.0	ND	<0.020	<0.50	0.545	5.03	0.0589	0.136	6.19	182
05/30/18	97	7.8	0.9	<0.020	<0.50	0.558	5.04	0.0529	0.165	6.25	160
05/30/18	61, 63[a]	4.1	ND	<0.15	<3.7	0.710	5.29	0.0511	0.170	7.30	158
05/30/18	92	6.5	0.8	<0.020	<0.50	0.512	5.74	0.0545	0.207	5.47	175
05/30/18	81	4.5	0.8	<0.024	<0.59	0.440	4.43	0.0496	0.080	6.50	150
05/30/18	106	12.2	1.0	<0.020	<0.50	0.284	4.91	0.0530	0.087	5.76	149

[a] Composite sample of two fish.

Appendix C.2.–Middle Glacier Creek whole body Dolly Varden char element concentrations.

Sample Date	Length (mm)	Weight (g)	Condition (*K*)	Ag (mg/kg)	As (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Hg (mg/kg)	Pb (mg/kg)	Se (mg/kg)	Zn (mg/kg)
06/08/16	150	36.0	1.1	0.031	<0.48	0.605	3.37	0.0429	0.069	5.66	143
06/08/16	108	15.9	1.3	<0.020	<0.50	0.327	4.33	0.0337	0.183	6.91	147
06/08/16	123	26.5	1.4	<0.020	<0.50	0.683	3.83	0.0301	0.717	5.64	117
06/08/16	73	5.2	1.3	<0.020	<0.49	0.288	4.99	0.0260	0.128	3.94	128
06/08/16	180	66.7	1.1	<0.020	<0.50	0.329	3.11	0.0376	0.061	5.17	132
06/08/16	77	6.0	1.3	<0.020	<0.50	0.215	3.53	0.0259	0.259	4.80	146
06/08/16	83	7.8	1.4	<0.020	<0.50	0.280	3.75	0.0247	0.182	6.05	132
06/08/16	146	31.5	1.0	<0.020	<0.50	0.521	2.50	0.0299	0.062	4.90	103
06/08/16	83	7.0	1.2	<0.020	<0.50	0.678	2.56	0.0328	0.046	4.66	139
06/08/16	70	5.0	1.5	0.682	<0.50	0.257	2.63	0.0184	0.036	6.29	133
06/09/17	154	45.5	1.2	<0.020	<0.50	0.267	3.29	0.0364	0.036	5.14	116
06/09/17	130	24.3	1.1	<0.020	<0.50	0.333	3.23	0.0343	0.056	6.86	95
06/09/17	210	115.0	1.2	<0.020	<0.50	0.758	7.67	0.0701	0.031	6.34	161
06/09/17	141	34.7	1.2	<0.020	<0.50	0.291	3.33	0.0430	0.037	8.02	126
06/09/17	131	24.3	1.1	<0.020	<0.50	0.299	3.26	0.0385	0.100	6.10	128
06/09/17	90	7.4	1.0	<0.020	<0.50	0.343	2.40	0.0361	0.034	6.86	101
05/31/18	171	55.9	1.1	<0.020	<0.50	0.696	15.20	0.0641	0.080	6.56	176
05/31/18	138	28.3	1.1	<0.020	<0.50	0.541	6.22	0.0659	0.044	5.30	114
05/31/18	58, 57[a]	4.2	ND	<0.082	<2.0	0.357	4.25	0.0191	0.087	4.90	114
05/31/18	188	76.2	1.1	0.027	<0.50	0.889	12.70	0.0487	0.143	6.22	140
05/31/18	175	58.1	1.1	<0.020	<0.50	0.612	5.47	0.0296	0.107	5.20	108
05/31/18	100	11.2	1.1	0.029	<0.50	0.802	5.07	0.0676	0.122	6.72	146

[a] Composite sample of two fish.

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August 23, 2018

Analytical Report for Service Request No: K1805612

Kate Kanouse
Alaska Department of Fish and Game
Division of Habitat
802 3rd Street
P.O. Box 110024
Douglas, AK 99811-0024

RE: 2018 Palmer Project Biomonitoring

Dear Kate,

Enclosed are the results of the sample(s) submitted to our laboratory June 20, 2018
For your reference, these analyses have been assigned our service request number **K1805612.**

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. All results are intended to be considered in their entirety, and ALS Group USA Corp. dba ALS Environmental (ALS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Please contact me if you have any questions. My extension is 3356. You may also contact me via email at Kurt.Clarkson@alsglobal.com.

Respectfully submitted,

ALS Group USA, Corp. dba ALS Environmental

Kurt Clarkson
Sr. Project Manager

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Table of Contents

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LOD	Limit of Detection
LOQ	Limit of Quantitation
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Inorganic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated value.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.
H	The holding time for this test is immediately following sample collection. The samples were analyzed as soon as possible after receipt by the laboratory.

Metals Data Qualifiers

#	The control limit criteria is not applicable. See case narrative.
J	The result is an estimated value.
E	The percent difference for the serial dilution was greater than 10%, indicating a possible matrix interference in the sample.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The reported value was determined by the Method of Standard Additions (MSA).
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.
Q	See case narrative. One or more quality control criteria was outside the limits.

Organic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
A	A tentatively identified compound, a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimated value.
J	The result is an estimated value.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.

Additional Petroleum Hydrocarbon Specific Qualifiers

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

ALS Group USA Corp. dba ALS Environmental (ALS) - Kelso
State Certifications, Accreditations, and Licenses

Agency	Web Site	Number
Alaska DEH	http://dec.alaska.gov/eh/lab/cs/csapproval.htm	UST-040
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0339
Arkansas - DEQ	http://www.adeq.state.ar.us/techsvs/labcert.htm	88-0637
California DHS (ELAP)	http://www.cdph.ca.gov/certlic/labs/Pages/ELAP.aspx	2795
DOD ELAP	http://www.denix.osd.mil/edqw/Accreditation/AccreditedLabs.cfm	L16-58-R4
Florida DOH	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E87412
Hawaii DOH	http://health.hawaii.gov/	-
ISO 17025	http://www.pjlabs.com/	L16-57
Louisiana DEQ	http://www.deq.louisiana.gov/page/la-lab-accreditation	03016
Maine DHS	http://www.maine.gov/dhhs/	WA01276
Minnesota DOH	http://www.health.state.mn.us/accreditation	053-999-457
Nevada DEP	http://ndep.nv.gov/bsdw/labservice.htm	WA01276
New Jersey DEP	http://www.nj.gov/dep/enforcement/oqa.html	WA005
New York - DOH	https://www.wadsworth.org/regulatory/elap	12060
North Carolina DEQ	https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/laboratory-certification-branch/non-field-lab-certification	605
Oklahoma DEQ	http://www.deq.state.ok.us/CSDnew/labcert.htm	9801
Oregon – DEQ (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	WA100010
South Carolina DHEC	http://www.scdhec.gov/environment/EnvironmentalLabCertification/	61002
Texas CEQ	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704427
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C544
Wyoming (EPA Region 8)	https://www.epa.gov/region8-waterops/epa-region-8-certified-drinking-water-	-
Kelso Laboratory Website	www.alsglobal.com	NA

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. A complete listing of specific NELAP-certified analytes, can be found in the certification section at www.ALSGlobal.com or at the accreditation bodies web site.
Please refer to the certification and/or accreditation body's web site if samples are submitted for compliance purposes. The states highlighted above, require the analysis be listed on the state certification if used for compliance purposes and if the method/anlayte is offered by that state.

Case Narrative

ALS Environmental—Kelso Laboratory
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Phone (360)577-7222 Fax (360)636-1068
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Client: Alaska Department of Fish and Game
Project: 2018 Palmer Project Biomonitoring
Sample Matrix: Animal Tissue

Service Request: K1805612
Date Received: 06/13/2018

CASE NARRATIVE

All analyses were performed consistent with the quality assurance program of ALS Environmental. This report contains analytical results for samples designated for Tier II data deliverables. When appropriate to the method, method blank results have been reported with each analytical test. Surrogate recoveries have been reported for all applicable organic analyses. Additional quality control analyses reported herein include: Laboratory Duplicate (DUP), Matrix Spike (MS), Matrix/Duplicate Matrix Spike (MS/DMS), Laboratory Control Sample (LCS), and Laboratory/Duplicate Laboratory Control Sample (LCS/DLCS).

Sample Receipt:

Sixteen animal tissue samples were received for analysis at ALS Environmental on 06/13/2018. The samples were received in good condition and consistent with the accompanying chain of custody form. The samples were stored frozen at -20ºC upon receipt at the laboratory.

Metals:

No significant anomalies were noted with this analysis.

Approved by _____ Date 08/23/2018

Chain of Custody

ALS Environmental—Kelso Laboratory
1317 South 13th Avenue, Kelso, WA 98626
Phone (360)577-7222 Fax (360)636-1068
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Project Name: 2018 Palmer Project Biomonitoring
Company Name: Alaska Department of Fish and Game
Project Manager: Nicole Legere
Contact Information: nicole.legere@alaska.gov; (907) 465-6979
Sample Type: Whole body Dolly Varden char
Analysis: EPA 6020A total metals and EPA1631E Hg, dry weight basis, report percent solids

Matrix	Sample Date	Sample Name	Sample ID	Analytes	Fork Length (mm)	Weight (g)
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #1	2018LGCDV1	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	112	12.3
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #2	2018LGCDV2	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	66, 65[a]	4.7
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #3	2018LGCDV3	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	109	15.1
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #4	2018LGCDV4	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	103	11.6
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #5	2018LGCDV5	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	78, 65[a]	7.0
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #6	2018LGCDV6	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	97	7.8
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #7	2018LGCDV7	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	61, 63[a]	4.1
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #8	2018LGCDV8	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	92	6.5
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #9	2018LGCDV9	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	81	4.5
Whole Body	5/30/2018	Lower Glacier Creek DV Metals Fish #10	2018LGCDV10	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	106	12.2
Whole Body	5/31/2018	Middle Glacier Creek DV Metals Fish #1	2018MGCDV1	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	171	55.9
Whole Body	5/31/2018	Middle Glacier Creek DV Metals Fish #2	2018MGCDV2	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	138	28.3
Whole Body	5/31/2018	Middle Glacier Creek DV Metals Fish #3	2018MGCDV3	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	58, 57[a]	4.2
Whole Body	5/31/2018	Middle Glacier Creek DV Metals Fish #4	2018MGCDV4	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	188	76.2
Whole Body	5/31/2018	Middle Glacier Creek DV Metals Fish #5	2018MGCDV5	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	175	58.1
Whole Body	5/31/2018	Middle Glacier Creek DV Metals Fish #6	2018MGCDV6	Ag, As, Cd, Cu, Hg, Pb, Se, Zn	100	11.2

[a] Composite sample of two fish.

CHAIN OF CUSTODY

ALS Environmental

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SR# 18050612

PAGE 1 OF 2 COC#

PROJECT NAME: 2018 Palmer Project Biomonitoring
PROJECT NUMBER:
PROJECT MANAGER: Nicole Legere
COMPANY NAME: Alaska Department of Fish and Game
ADDRESS: 802 3rd St.
CITY/STATE/ZIP: Douglas, AK 99824
E-MAIL ADDRESS: nicole.legere@alaska.gov
PHONE #: (907) 465-6079 FAX #:
SAMPLER'S SIGNATURE: Nicole Legere

SAMPLE I.D.	DATE	TIME	LAB I.D.	MATRIX	NUMBER OF CONTAINERS	Semivolatile Organics by GC/MS 625☐ 8270☐ SIM PAH☐	Volatile Organics 624☐ 8270LL☐ 8260☐ 8021☐ BTEX☐	Hydrocarbons (*see below) Gas☐ Diesel☐ Oil☐	Oil & Grease/TRPH 1664 HEM☐ 1664 SGT☐	PCBs Aroclors☐ Congeners☐	Pesticides/Herbicides 608☐ 8081☐ 8141☐ 8151☐	Chlorophenolics 8151M Tri☐ Tetra☐ PCP☐	Metals, Total or Dissolved (See List below)	Cyanide☐ Hex-Chrom☐	(circle) pH, Cond., Cl, SO4, PO4, F, NO2, NO3, BOD, TSS, TDS, Turb.	(circle) NH3-N, COD, TKN, TOC, DOC, NO2+NO3, T-Phos	TOX 9020☐ AOX 1650☐ 506☐	Alkalinity☐ CO3☐ HCO3☐	Dioxins/Furans 1613☐ 8290☐	Dissolved Gases RSK 175☐ Methane☐ Ethane☐ Ethene☐ CO2☐				REMARKS
See attachment		1 oz			16								X								X	Hg - 1631E			
whole body juvenile fish																									
individual samples																									

REPORT REQUIREMENTS

- ___ I. Routine Report: Method Blank, Surrogate, as required
- ✓ II. Report Dup., MS, MSD as required
- ___ III. CLP Like Summary (no raw data)
- ___ IV. Data Validation Report
- ___ V. EDD

INVOICE INFORMATION

~~P.O.#~~ Darwin Green
Bill To: Constantine
darwin@constantinemetals.com

TURNAROUND REQUIREMENTS

___ 24 hr. ___ 48 hr.
___ 5 day
✓ Standard (15 working days)
___ Provide FAX Results

Requested Report Date

Circle which metals are to be analyzed:

Total Metals: Al (As) Sb Ba Be B Ca (Cd) Co Cr (Cu) Fe (Pb) Mg Mn Mo Ni K (Ag) Na (Se) Sr Tl Sn V (Zn) (Hg)

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

*INDICATE STATE HYDROCARBON PROCEDURE: AK CA WI NORTHWEST OTHER: _____ (CIRCLE ONE)

SPECIAL INSTRUCTIONS/COMMENTS:
Please send report to Nicole Legere, and to Allegra Cairns: allegra@constantinemetals.com

☐ Sample Shipment contains USDA regulated soil samples (check box if applicable)

RELINQUISHED BY:		RECEIVED BY:		RELINQUISHED BY:		RECEIVED BY:	
Signature: Kate Kerrick	Date/Time: 6/11/18 0830	Signature:	Date/Time: 6/13/18	Signature:	Date/Time:	Signature:	Date/Time:
Printed Name: Kate Kerrick	Firm: ADFG	Printed Name:	Firm: ALS 1015	Printed Name:	Firm:	Printed Name:	Firm:

PC KC

Cooler Receipt and Preservation Form

Client AK Dept of Fish & Game Service Request *K18* 05612

Received: 6/13/18 Opened: 6/13/18 By: KM Unloaded: 6/13/18 By: KM

1. Samples were received via? *USPS* (*Fed Ex*) *UPS* *DHL* *PDX* *Courier* *Hand Delivered*
2. Samples were received in: (circle) (*Cooler*) *Box* *Envelope* *Other* _____ *NA*
3. Were custody seals on coolers? NA (Y) N If yes, how many and where? 1 Front
   If present, were custody seals intact? (Y) N If present, were they signed and dated? (Y) N

Raw Cooler Temp	Corrected Cooler Temp	Raw Temp Blank	Corrected Temp Blank	Corr. Factor	Thermometer ID	Cooler/COC ID (NA)	Tracking Number NA	File
3.8	3.7	0.6	0.5	-0.1	378		781360095785	

4. Packing material: *Inserts* (*Baggies*) *Bubble Wrap* (*Gel Packs*) *Wet Ice* *Dry Ice* *Sleeves* _____
5. Were custody papers properly filled out (ink, signed, etc.)? NA (Y) N
6. Were samples received in good condition (temperature, unbroken)? *Indicate in the table below.* NA (Y) N
   If applicable, tissue samples were received: *Frozen* *Partially Thawed* (*Thawed*)
7. Were all sample labels complete (i.e analysis, preservation, etc.)? NA (Y) N
8. Did all sample labels and tags agree with custody papers? *Indicate major discrepancies in the table on page 2.* NA (Y) N
9. Were appropriate bottles/containers and volumes received for the tests indicated? NA (Y) N
10. Were the pH-preserved bottles (*see SMO GEN SOP*) received at the appropriate pH? *Indicate in the table below* (NA) Y N
11. Were VOA vials received without headspace? *Indicate in the table below.* (NA) Y N
12. Was Cl2/Res negative? (NA) Y N

Sample ID on Bottle	Sample ID on COC	Identified by:

Sample ID	Bottle Count Bottle Type	Out of Temp	Head-space	Broke	pH	Reagent	Volume added	Reagent Lot Number	Initials	Time

Notes, Discrepancies, & Resolutions: _____

Total Solids

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Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18 - 05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18
Analysis Method:	Freeze Dry	**Units:**	Percent
Prep Method:	None	**Basis:**	Wet

Total Solids

Sample Name	Lab Code	Result	MRL	Dil.	Date Analyzed	Q
2018LGCDV1	K1805612-001	**22.0**	-	1	06/20/18 16:59	
2018LGCDV2	K1805612-002	**21.9**	-	1	06/20/18 16:59	
2018LGCDV3	K1805612-003	**22.5**	-	1	06/20/18 16:59	
2018LGCDV4	K1805612-004	**22.3**	-	1	06/20/18 16:59	
2018LGCDV5	K1805612-005	**21.1**	-	1	06/20/18 16:59	
2018LGCDV6	K1805612-006	**22.4**	-	1	06/20/18 16:59	
2018LGCDV7	K1805612-007	**21.0**	-	1	06/20/18 16:59	
2018LGCDV8	K1805612-008	**22.3**	-	1	06/20/18 16:59	
2018LGCDV9	K1805612-009	**21.2**	-	1	06/20/18 16:59	
2018LGCDV10	K1805612-010	**22.0**	-	1	06/20/18 16:59	
2018MGCDV1	K1805612-011	**23.6**	-	1	06/20/18 16:59	
2018MGCDV2	K1805612-012	**23.6**	-	1	06/20/18 16:59	
2018MGCDV3	K1805612-013	**20.8**	-	1	06/20/18 16:59	
2018MGCDV4	K1805612-014	**23.3**	-	1	06/20/18 16:59	
2018MGCDV5	K1805612-015	**26.0**	-	1	06/20/18 16:59	
2018MGCDV6	K1805612-016	**20.8**	-	1	06/20/18 16:59	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18
		Date Analyzed:	06/20/18

Replicate Sample Summary
Inorganic Parameters

Sample Name:	2018MGCDV1	**Units:**	Percent
Lab Code:	K1805612-011	**Basis:**	Wet

Analyte Name	Analysis Method	MRL	Sample Result	Duplicate Sample K1805612-011DUP Result	Average	RPD	RPD Limit
Total Solids	Freeze Dry	-	23.6	23.4	23.5	<1	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Metals

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Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30-31/18
Sample Matrix:	Animal tissue	**Date Received:**	06/13/18

Mercury, Total

Prep Method: METHOD
Analysis Method: 1631E
Test Notes:

Units: ng/g
Basis: Dry

Sample Name	Lab Code	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
2018LGCDV1	K1805612-001	1.0	1	07/19/18	07/23/18	51.1	
2018LGCDV2	K1805612-002	1.0	1	07/19/18	07/23/18	46.7	
2018LGCDV3	K1805612-003	1.0	1	07/19/18	07/23/18	59.2	
2018LGCDV4	K1805612-004	1.0	1	07/19/18	07/23/18	42.6	
2018LGCDV5	K1805612-005	1.0	1	07/19/18	07/23/18	58.9	
2018LGCDV6	K1805612-006	1.0	1	07/19/18	07/23/18	52.9	
2018LGCDV7	K1805612-007	1.0	1	07/19/18	07/23/18	51.1	
2018LGCDV8	K1805612-008	1.0	1	07/19/18	07/23/18	54.5	
2018LGCDV9	K1805612-009	1.0	1	07/19/18	07/23/18	49.6	
2018LGCDV10	K1805612-010	1.0	1	07/19/18	07/23/18	53.0	
2018MGCDV1	K1805612-011	1.0	1	07/19/18	07/23/18	64.1	
2018MGCDV2	K1805612-012	1.0	1	07/19/18	07/23/18	65.9	
2018MGCDV3	K1805612-013	1.0	1	07/19/18	07/23/18	19.1	
2018MGCDV4	K1805612-014	1.0	1	07/19/18	07/23/18	48.7	
2018MGCDV5	K1805612-015	1.0	1	07/19/18	07/23/18	29.6	
2018MGCDV6	K1805612-016	1.0	1	07/19/18	07/23/18	67.6	
Method Blank 1	K1805612-MB1	1.0	1	07/19/18	07/23/18	ND	
Method Blank 2	K1805612-MB2	1.0	1	07/19/18	07/23/18	ND	
Method Blank 3	K1805612-MB3	1.0	1	07/19/18	07/23/18	ND	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal tissue	**Date Received:**	06/13/18
		Date Extracted:	07/19/18
		Date Analyzed:	07/23/18

Matrix Spike/Duplicate Matrix Spike Summary
Total Metals

Sample Name:	2018LGCDV1	Units:	ng/g
Lab Code:	K1805612-001MS, K1805612-001DMS	Basis:	Dry
Test Notes:			

				Spike Level		Sample	Spike Result		Percent Recovery		ALS Acceptance	Relative Percent	
Analyte	**Prep Method**	**Analysis Method**	**MRL**	**MS**	**DMS**	**Result**	**MS**	**DMS**	**MS**	**DMS**	**Limits**	**Difference**	**Result Notes**
Mercury	METHOD	1631E	5.0	249	248	51.1	294	313	98	106	70-130	6	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal tissue	**Date Received:**	06/13/18
		Date Extracted:	07/19/18
		Date Analyzed:	07/23/18

Matrix Spike/Duplicate Matrix Spike Summary
Total Metals

Sample Name:	2018MGCDV1	Units:	ng/g
Lab Code:	K1805612-011MS, K1805612-011DMS	Basis:	Dry
Test Notes:			

				Spike Level		Sample	Spike Result		Percent Recovery		ALS Acceptance	Relative Percent	
Analyte	**Prep Method**	**Analysis Method**	**MRL**	**MS**	**DMS**	**Result**	**MS**	**DMS**	**MS**	**DMS**	**Limits**	**Difference**	**Result Notes**
Mercury	METHOD	1631E	5.0	249	246	64.1	325	313	105	101	70-130	4	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	NA
LCS Matrix:	Water	**Date Received:**	NA
		Date Extracted:	NA
		Date Analyzed:	07/23/18

Ongoing Precision and Recovery (OPR) Sample Summary
Total Metals

Sample Name: Ongoing Precision and Recovery (Initial)

Units: ng/g
Basis: NA

Test Notes:

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	ALS Percent Recovery Acceptance Limits	Result Notes
Mercury	METHOD	1631E	5.00	5.54	111	70-130	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	NA
LCS Matrix:	Water	**Date Received:**	NA
		Date Extracted:	NA
		Date Analyzed:	07/23/18

Ongoing Precision and Recovery (OPR) Sample Summary
Total Metals

Sample Name: Ongoing Precision and Recovery (Final)

Units: ng/g
Basis: NA

Test Notes:

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	ALS Percent Recovery Acceptance Limits	Result Notes
Mercury	METHOD	1631E	5.00	5.21	104	70-130	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	NA
LCS Matrix:	Animal tissue	**Date Received:**	NA
		Date Extracted:	07/19/18
		Date Analyzed:	07/23/18

Quality Control Sample (QCS) Summary
Total Metals

Sample Name:	Quality Control Sample	Units:	ng/g
Lab Code:		Basis:	Dry
Test Notes:			

Source: TORT-3

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	ALS Percent Recovery Acceptance Limits	Result Notes
Mercury	METHOD	1631E	292	276	95	70-130	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV1	**Basis:**	Dry
Lab Code:	K1805612-001		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 14:29	08/13/18	
Cadmium	200.8	**0.183**	mg/Kg	0.020	5	08/21/18 14:29	08/13/18	
Copper	200.8	**3.26**	mg/Kg	0.099	5	08/21/18 14:29	08/13/18	
Lead	200.8	**0.042**	mg/Kg	0.020	5	08/21/18 14:29	08/13/18	
Selenium	200.8	**5.14**	mg/Kg	0.99	5	08/21/18 14:29	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:29	08/13/18	
Zinc	200.8	**114**	mg/Kg	0.50	5	08/21/18 14:29	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV2	**Basis:**	Dry
Lab Code:	K1805612-002		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.84	5	08/21/18 14:32	08/13/18	
Cadmium	200.8	**0.458**	mg/Kg	0.034	5	08/21/18 14:32	08/13/18	
Copper	200.8	**5.30**	mg/Kg	0.17	5	08/21/18 14:32	08/13/18	
Lead	200.8	**0.098**	mg/Kg	0.034	5	08/21/18 14:32	08/13/18	
Selenium	200.8	**5.9**	mg/Kg	1.7	5	08/21/18 14:32	08/13/18	
Silver	200.8	ND U	mg/Kg	0.034	5	08/21/18 14:32	08/13/18	
Zinc	200.8	**142**	mg/Kg	0.84	5	08/21/18 14:32	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV3	**Basis:**	Dry
Lab Code:	K1805612-003		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 14:35	08/13/18	
Cadmium	200.8	**0.252**	mg/Kg	0.020	5	08/21/18 14:35	08/13/18	
Copper	200.8	**4.17**	mg/Kg	0.099	5	08/21/18 14:35	08/13/18	
Lead	200.8	**0.074**	mg/Kg	0.020	5	08/21/18 14:35	08/13/18	
Selenium	200.8	**6.56**	mg/Kg	0.99	5	08/21/18 14:35	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:35	08/13/18	
Zinc	200.8	**122**	mg/Kg	0.50	5	08/21/18 14:35	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV4	**Basis:**	Dry
Lab Code:	K1805612-004		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 14:45	08/13/18	
Cadmium	200.8	**0.272**	mg/Kg	0.020	5	08/21/18 14:45	08/13/18	
Copper	200.8	**4.05**	mg/Kg	0.10	5	08/21/18 14:45	08/13/18	
Lead	200.8	**0.108**	mg/Kg	0.020	5	08/21/18 14:45	08/13/18	
Selenium	200.8	**7.04**	mg/Kg	1.0	5	08/21/18 14:45	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:45	08/13/18	
Zinc	200.8	**132**	mg/Kg	0.50	5	08/21/18 14:45	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV5	**Basis:**	Dry
Lab Code:	K1805612-005		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 14:54	08/13/18	
Cadmium	200.8	**0.545**	mg/Kg	0.020	5	08/21/18 14:54	08/13/18	
Copper	200.8	**5.03**	mg/Kg	0.10	5	08/21/18 14:54	08/13/18	
Lead	200.8	**0.136**	mg/Kg	0.020	5	08/21/18 14:54	08/13/18	
Selenium	200.8	**6.19**	mg/Kg	1.0	5	08/21/18 14:54	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:54	08/13/18	
Zinc	200.8	**182**	mg/Kg	0.50	5	08/21/18 14:54	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV6	**Basis:**	Dry
Lab Code:	K1805612-006		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 14:57	08/13/18	
Cadmium	200.8	**0.558**	mg/Kg	0.020	5	08/21/18 14:57	08/13/18	
Copper	200.8	**5.04**	mg/Kg	0.099	5	08/21/18 14:57	08/13/18	
Lead	200.8	**0.165**	mg/Kg	0.020	5	08/21/18 14:57	08/13/18	
Selenium	200.8	**6.25**	mg/Kg	0.99	5	08/21/18 14:57	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:57	08/13/18	
Zinc	200.8	**160**	mg/Kg	0.50	5	08/21/18 14:57	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV7	**Basis:**	Dry
Lab Code:	K1805612-007		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	3.7	5	08/21/18 15:01	08/13/18	
Cadmium	200.8	**0.71**	mg/Kg	0.15	5	08/21/18 15:01	08/13/18	
Copper	200.8	**5.29**	mg/Kg	0.73	5	08/21/18 15:01	08/13/18	
Lead	200.8	**0.17**	mg/Kg	0.15	5	08/21/18 15:01	08/13/18	
Selenium	200.8	ND U	mg/Kg	7.3	5	08/21/18 15:01	08/13/18	
Silver	200.8	ND U	mg/Kg	0.15	5	08/21/18 15:01	08/13/18	
Zinc	200.8	**158**	mg/Kg	3.7	5	08/21/18 15:01	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV8	**Basis:**	Dry
Lab Code:	K1805612-008		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 15:04	08/13/18	
Cadmium	200.8	**0.512**	mg/Kg	0.020	5	08/21/18 15:04	08/13/18	
Copper	200.8	**5.74**	mg/Kg	0.10	5	08/21/18 15:04	08/13/18	
Lead	200.8	**0.207**	mg/Kg	0.020	5	08/21/18 15:04	08/13/18	
Selenium	200.8	**5.47**	mg/Kg	1.0	5	08/21/18 15:04	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 15:04	08/13/18	
Zinc	200.8	**175**	mg/Kg	0.50	5	08/21/18 15:04	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV9	**Basis:**	Dry
Lab Code:	K1805612-009		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.59	5	08/21/18 15:07	08/13/18	
Cadmium	200.8	**0.440**	mg/Kg	0.024	5	08/21/18 15:07	08/13/18	
Copper	200.8	**4.43**	mg/Kg	0.12	5	08/21/18 15:07	08/13/18	
Lead	200.8	**0.080**	mg/Kg	0.024	5	08/21/18 15:07	08/13/18	
Selenium	200.8	**6.5**	mg/Kg	1.2	5	08/21/18 15:07	08/13/18	
Silver	200.8	ND U	mg/Kg	0.024	5	08/21/18 15:07	08/13/18	
Zinc	200.8	**150**	mg/Kg	0.59	5	08/21/18 15:07	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018LGCDV10	**Basis:**	Dry
Lab Code:	K1805612-010		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 15:10	08/13/18	
Cadmium	200.8	**0.284**	mg/Kg	0.020	5	08/21/18 15:10	08/13/18	
Copper	200.8	**4.91**	mg/Kg	0.099	5	08/21/18 15:10	08/13/18	
Lead	200.8	**0.087**	mg/Kg	0.020	5	08/21/18 15:10	08/13/18	
Selenium	200.8	**5.76**	mg/Kg	0.99	5	08/21/18 15:10	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 15:10	08/13/18	
Zinc	200.8	**149**	mg/Kg	0.50	5	08/21/18 15:10	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018MGCDV1	**Basis:**	Dry
Lab Code:	K1805612-011		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 15:13	08/13/18	
Cadmium	200.8	**0.693**	mg/Kg	0.020	5	08/21/18 15:13	08/13/18	
Copper	200.8	**15.0**	mg/Kg	0.10	5	08/21/18 15:13	08/13/18	
Lead	200.8	**0.078**	mg/Kg	0.020	5	08/21/18 15:13	08/13/18	
Selenium	200.8	**6.5**	mg/Kg	1.0	5	08/21/18 15:13	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 15:13	08/13/18	
Zinc	200.8	**174**	mg/Kg	0.50	5	08/21/18 15:13	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018MGCDV2	**Basis:**	Dry
Lab Code:	K1805612-012		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 15:23	08/13/18	
Cadmium	200.8	**0.541**	mg/Kg	0.020	5	08/21/18 15:23	08/13/18	
Copper	200.8	**6.22**	mg/Kg	0.10	5	08/21/18 15:23	08/13/18	
Lead	200.8	**0.044**	mg/Kg	0.020	5	08/21/18 15:23	08/13/18	
Selenium	200.8	**5.30**	mg/Kg	1.0	5	08/21/18 15:23	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 15:23	08/13/18	
Zinc	200.8	**114**	mg/Kg	0.50	5	08/21/18 15:23	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018MGCDV3	**Basis:**	Dry
Lab Code:	K1805612-013		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	2.0	5	08/21/18 15:32	08/13/18	
Cadmium	200.8	**0.357**	mg/Kg	0.082	5	08/21/18 15:32	08/13/18	
Copper	200.8	**4.25**	mg/Kg	0.41	5	08/21/18 15:32	08/13/18	
Lead	200.8	**0.087**	mg/Kg	0.082	5	08/21/18 15:32	08/13/18	
Selenium	200.8	**4.9**	mg/Kg	4.1	5	08/21/18 15:32	08/13/18	
Silver	200.8	ND U	mg/Kg	0.082	5	08/21/18 15:32	08/13/18	
Zinc	200.8	**114**	mg/Kg	2.0	5	08/21/18 15:32	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018MGCDV4	**Basis:**	Dry
Lab Code:	K1805612-014		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 15:35	08/13/18	
Cadmium	200.8	**0.889**	mg/Kg	0.020	5	08/21/18 15:35	08/13/18	
Copper	200.8	**12.7**	mg/Kg	0.10	5	08/21/18 15:35	08/13/18	
Lead	200.8	**0.143**	mg/Kg	0.020	5	08/21/18 15:35	08/13/18	
Selenium	200.8	**6.22**	mg/Kg	1.0	5	08/21/18 15:35	08/13/18	
Silver	200.8	**0.027**	mg/Kg	0.020	5	08/21/18 15:35	08/13/18	
Zinc	200.8	**140**	mg/Kg	0.50	5	08/21/18 15:35	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018MGCDV5	**Basis:**	Dry
Lab Code:	K1805612-015		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 15:38	08/13/18	
Cadmium	200.8	**0.612**	mg/Kg	0.020	5	08/21/18 15:38	08/13/18	
Copper	200.8	**5.47**	mg/Kg	0.10	5	08/21/18 15:38	08/13/18	
Lead	200.8	**0.107**	mg/Kg	0.020	5	08/21/18 15:38	08/13/18	
Selenium	200.8	**5.2**	mg/Kg	1.0	5	08/21/18 15:38	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 15:38	08/13/18	
Zinc	200.8	**108**	mg/Kg	0.50	5	08/21/18 15:38	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18 10:15
Sample Name:	2018MGCDV6	**Basis:**	Dry
Lab Code:	K1805612-016		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.50	5	08/21/18 15:42	08/13/18	
Cadmium	200.8	**0.802**	mg/Kg	0.020	5	08/21/18 15:42	08/13/18	
Copper	200.8	**5.07**	mg/Kg	0.10	5	08/21/18 15:42	08/13/18	
Lead	200.8	**0.122**	mg/Kg	0.020	5	08/21/18 15:42	08/13/18	
Selenium	200.8	**6.72**	mg/Kg	1.0	5	08/21/18 15:42	08/13/18	
Silver	200.8	**0.029**	mg/Kg	0.020	5	08/21/18 15:42	08/13/18	
Zinc	200.8	**146**	mg/Kg	0.50	5	08/21/18 15:42	08/13/18	

Analytical Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	NA
Sample Matrix:	Animal Tissue	**Date Received:**	NA
Sample Name:	Method Blank	**Basis:**	Dry
Lab Code:	KQ1810922-01		

Total Metals

Analyte Name	Analysis Method	Result	Units	MRL	Dil.	Date Analyzed	Date Extracted	Q
Arsenic	200.8	ND U	mg/Kg	0.5	5	08/21/18 14:17	08/13/18	
Cadmium	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:17	08/13/18	
Copper	200.8	ND U	mg/Kg	0.10	5	08/21/18 14:17	08/13/18	
Lead	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:17	08/13/18	
Selenium	200.8	ND U	mg/Kg	1.0	5	08/21/18 14:17	08/13/18	
Silver	200.8	ND U	mg/Kg	0.020	5	08/21/18 14:17	08/13/18	
Zinc	200.8	ND U	mg/Kg	0.5	5	08/21/18 14:17	08/13/18	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18
		Date Analyzed:	08/21/18

Replicate Sample Summary

Total Metals

Sample Name:	2018LGCDV3	**Units:**	mg/Kg
Lab Code:	K1805612-003	**Basis:**	Dry

Analyte Name	Analysis Method	MRL	Sample Result	Duplicate Sample KQ1810922-05 Result	Average	RPD	RPD Limit
Arsenic	200.8	0.5	ND U	ND U	ND	-	20
Cadmium	200.8	0.020	0.252	0.262	0.257	4	20
Copper	200.8	0.10	4.17	4.50	4.34	8	20
Lead	200.8	0.020	0.074	0.086	0.080	15	20
Selenium	200.8	1.0	6.6	6.8	6.7	4	20
Silver	200.8	0.020	ND U	ND U	ND	-	20
Zinc	200.8	0.5	122	119	121	2	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18
		Date Analyzed:	08/21/18

Replicate Sample Summary

Total Metals

Sample Name:	2018MGCDV1	**Units:**	mg/Kg
Lab Code:	K1805612-011	**Basis:**	Dry

Analyte Name	Analysis Method	MRL	Sample Result	Duplicate Sample KQ1810922-07 Result	Average	RPD	RPD Limit
Arsenic	200.8	0.5	ND U	ND U	ND	-	20
Cadmium	200.8	0.020	0.693	0.698	0.696	<1	20
Copper	200.8	0.10	15.0	15.4	15.2	3	20
Lead	200.8	0.020	0.078	0.082	0.080	5	20
Selenium	200.8	1.0	6.50	6.61	6.56	2	20
Silver	200.8	0.020	ND U	ND U	ND	-	20
Zinc	200.8	0.5	174	178	176	2	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Printed 8/22/2018 5:07:37 PM Superset Reference:

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/30/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18
		Date Analyzed:	08/21/18
		Date Extracted:	08/13/18

Matrix Spike Summary
Total Metals

Sample Name:	2018LGCDV3	**Units:**	mg/Kg
Lab Code:	K1805612-003	**Basis:**	Dry
Analysis Method:	200.8		
Prep Method:	PSEP Metals		

Matrix Spike
KQ1810922-06

Analyte Name	Sample Result	Result	Spike Amount	% Rec	% Rec Limits
Arsenic	ND U	17.6	16.7	106	70-130
Cadmium	0.252	5.33	5.00	102	70-130
Copper	4.17	27.7	25.0	94	70-130
Lead	0.074	47.7	50.0	95	70-130
Selenium	6.6	24.4	16.7	107	70-130
Silver	ND U	5.43	5.00	109	70-130
Zinc	122	163	50.0	82	70-130

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	05/31/18
Sample Matrix:	Animal Tissue	**Date Received:**	06/13/18
		Date Analyzed:	08/21/18
		Date Extracted:	08/13/18

Matrix Spike Summary
Total Metals

Sample Name:	2018MGCDV1	**Units:**	mg/Kg
Lab Code:	K1805612-011	**Basis:**	Dry
Analysis Method:	200.8		
Prep Method:	PSEP Metals		

Matrix Spike
KQ1810922-08

Analyte Name	Sample Result	Result	Spike Amount	% Rec	% Rec Limits
Arsenic	ND U	17.2	16.7	103	70-130
Cadmium	0.693	5.80	5.00	102	70-130
Copper	15.0	38.9	25.0	96	70-130
Lead	0.078	48.2	50.0	96	70-130
Selenium	6.5	25.0	16.7	111	70-130
Silver	ND U	5.47	5.00	109	70-130
Zinc	174	228	50.0	107	70-130

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Printed 8/22/2018 5:07:37 PM Superset Reference:

Client: Alaska Department of Fish and Game
Project: 2018 Palmer Project Biomonitoring
Sample Matrix: Animal Tissue

Service Request: K1805612
Date Analyzed: 08/21/18

Lab Control Sample Summary
Total Metals

Units:mg/Kg
Basis: Dry

Lab Control Sample
KQ1810922-02

Analyte Name	Analytical Method	Result	Spike Amount	% Rec	% Rec Limits
Arsenic	200.8	16.6	16.7	100	85-115
Cadmium	200.8	4.94	5.00	99	85-115
Copper	200.8	24.4	25.0	98	85-115
Lead	200.8	48.7	50.0	97	85-115
Selenium	200.8	16.6	16.7	100	85-115
Silver	200.8	5.46	5.00	109	85-115
Zinc	200.8	46.5	50.0	93	85-115

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	NA
LCS Matrix:	Tissue	**Date Received:**	NA
		Date Extracted:	08/13/18
		Date Analyzed:	08/21/18

Standard Reference Material Summary
Total Metals

Sample Name:	Standard Reference Material	Units:	mg/Kg (ppm)
Lab Code:	KQ1810922-03	Basis:	Dry
Test Notes:	Dorm-4 Solids = 94.5%		

Source: N.R.C.C. Dorm-4

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	Control Limits	Result Notes
Arsenic	PSEP Tissue	200.8	6.8	7.1	104	4.93-8.93	
Cadmium	PSEP Tissue	200.8	0.306	0.332	108	0.233 - 0.385	
Copper	PSEP Tissue	200.8	15.9	15.5	97	12.0 - 20.2	
Lead	PSEP Tissue	200.8	0.416	0.393	94	0.290 - 0.563	
Selenium	PSEP Tissue	200.8	3.56	4.14	116	2.58 - 4.68	
Zinc	PSEP Tissue	200.8	52.20	50.5	97	39.2 - 66.5	

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QA/QC Report

Client:	Alaska Department of Fish and Game	**Service Request:**	K1805612
Project:	2018 Palmer Project Biomonitoring	**Date Collected:**	NA
LCS Matrix:	Tissue	**Date Received:**	NA
		Date Extracted:	08/13/18
		Date Analyzed:	08/21/18

Standard Reference Material Summary
Total Metals

Sample Name:	Standard Reference Material	Units:	mg/Kg (ppm)
Lab Code:	KQ1810922-04	Basis:	Dry
Test Notes:	Tort-3 Solids = 99.1%		

Source: N.R.C.C. Tort-3

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	Control Limits	Result Notes
Arsenic	PSEP Tissue	200.8	59.5	64.5	108	44.6-76.0	
Cadmium	PSEP Tissue	200.8	42.3	41.4	98	32.4-52.9	
Copper	PSEP Tissue	200.8	497	483	97	380-623	
Lead	PSEP Tissue	200.8	0.225	0.203	90	0.166-0.292	
Selenium	PSEP Tissue	200.8	10.9	11.3	104	7.9-14.3	
Zinc	PSEP Tissue	200.8	136	123	90	104-170	

APPENDIX D: SEDIMENT DATA AND LABORATORY REPORT

Appendix D.1.–Lower Glacier Creek sediment compositions.

Sample Date	Particle Size Data						
	% Clay	% Silt	% Sand	% Course Material (> 2 mm)	% Total Solids	% Total Organic Carbon	Acid Volatile Sulfides (mg/kg)
06/07/16	4.0	29.2	66.8	0.0	78.6	0.274	ND
06/09/17	2.0	26.7	71.1	0.3	82.3	<0.16	<0.20
06/09/17	1.6	39.3	59.0	0.1	73.3	<0.17	<0.20
06/09/17	0.7	18.4	81.0	0.0	73.9	0.20	<0.20
06/09/17	1.3	27.8	70.3	0.6	77.8	0.25	<0.20
06/09/17	0.4	3.2	95.6	0.6	76.3	<0.16	<0.20
05/30/18	1.2	14.0	84.7	0.1	74.7	0.25	<0.20
05/30/18	1.9	44.3	50.1	3.7	77.7	0.29	0.63
05/30/18	2.0	41.8	56.2	0.0	78.0	<0.27	<0.20
05/30/18	1.1	9.6	85.0	4.3	79.1	<0.20	<0.20
05/30/18	1.4	16.1	81.9	4.3	78.6	<0.20	<0.20

Appendix D.2.–Lower Glacier Creek sediment element concentrations.

Sample Date	Concentration (mg/kg dry weight)									
	Ag	Al	As	Cd	Cu	Fe	Hg	Pb	Se	Zn
06/07/16	0.190	9,460	4.98	1.17	51.1	35,700	<0.020	9.06	1.69	193
06/09/17	0.14	15,500	3.91	0.510	37.0	47,300	0.0120	7.90	1.22	133
06/09/17	0.25	16,300	5.68	0.910	58.5	57,800	0.0194	20.6	1.35	202
06/09/17	0.26	14,700	5.49	1.01	53.6	51,100	0.0204	8.49	1.67	186
06/09/17	0.21	14,900	4.66	0.821	60.1	53,600	0.0144	20.1	1.39	173
06/09/17	0.17	13,300	3.94	0.818	48.9	51,400	0.0135	7.03	1.54	186
05/30/18	0.19	18,300	4.65	1.02	49.3	50,400	0.0125	9.84	1.44	185
05/30/18	0.14	16,600	4.08	0.880	44.4	42,600	0.0079	5.88	1.07	150
05/30/18	0.17	14,900	3.60	0.858	44.1	43,600	0.0119	6.58	1.31	160
05/30/18	0.16	15,400	4.27	0.835	41.6	45,100	0.0142	8.11	1.12	168
05/30/18	0.15	15,500	3.46	0.639	40.7	44,900	0.0092	7.53	1.00	141

Appendix D.3.–Middle Glacier Creek sediment compositions.

Sample Date	Particle Size Data						
	% Clay	% Silt	% Sand	% Course Material (> 2 mm)	% Total Solids	% Total Organic Carbon	Acid Volatile Sulfides (mg/kg)
06/08/16	4.1	31.2	64.8	0.0	80.5	0.491	ND
06/09/17	0.7	11.1	84.0	4.3	82.5	<0.16	<0.20
06/09/17	0.6	16.1	80.8	2.5	80.3	<0.17	<0.20
06/09/17	1.2	28.4	70.4	0.1	76.1	<0.19	0.30
06/09/17	2.3	48.5	49.2	0.0	74.8	0.27	<0.20
06/09/17	2.6	45.5	51.9	0.0	74.7	<0.19	<0.20
05/31/18	1.6	33.8	63.5	1.2	83.8	<0.28	0.40
05/31/18	1.7	26.5	71.5	0.4	80.1	<0.29	<0.20
05/31/18	1.2	10.7	74.6	13.5	77.7	<0.25	<0.20
05/31/18	1.6	25.9	71.9	0.6	75.0	<0.27	<0.20
05/31/18	1.6	15.7	80.8	1.9	71.4	0.37	<0.20

Appendix D.4.–Middle Glacier Creek sediment element concentrations.

Sample Date	Concentration (mg/kg dry weight)									
	Ag	Al	As	Cd	Cu	Fe	Hg	Pb	Se	Zn
06/08/16	0.156	7,650	4.33	0.871	55.8	32,400	<0.020	12.0	1.14	170
06/09/17	0.14	15,700	3.68	0.758	48.1	49,400	0.0094	8.67	0.90	190
06/09/17	0.15	13,800	4.76	0.902	45.5	53,400	0.0179	14.8	0.93	203
06/09/17	0.33	14,700	4.88	1.11	75.6	54,500	0.0161	12.5	2.05	189
06/09/17	0.18	16,000	4.47	1.14	55.7	47,500	0.0210	12.3	1.30	205
06/09/17	0.21	15,600	4.73	1.07	62.1	50,800	0.0181	11.9	1.42	199
05/31/18	0.18	18,000	4.17	0.564	47.4	49,000	0.0072	6.89	1.25	122
05/31/18	0.22	16,900	3.95	1.03	49.6	45,400	0.0260	5.48	1.67	167
05/31/18	0.18	20,200	2.80	0.675	49.1	49,200	0.0079	5.49	1.03	139
05/31/18	0.15	18,900	2.48	0.645	45.6	42,500	0.0093	5.24	0.71	129
05/31/18	0.17	16,900	3.74	1.02	52.8	43,000	0.0118	5.99	1.34	160

Constantine North Inc.
ATTN: Allegra Cairns
Suite 320 - 800 West Pender St.
Vancouver BC V6C 2V6

Date Received: 05-JUN-18
Report Date: 15-JUN-18 15:53 (MT)
Version: FINAL

Client Phone: 604-329-5982

Certificate of Analysis

Lab Work Order #: L2106386

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 17-653126
Legal Site Desc:

Carla Fuginski
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	Sample ID Description Sampled Date Sampled Time Client ID	L2106386-1 Soil 30-MAY-18 16:00 2018LGCS1	L2106386-2 Soil 30-MAY-18 16:00 2018LGCS2	L2106386-3 Soil 30-MAY-18 16:00 2018LGCS3	L2106386-4 Soil 30-MAY-18 16:00 2018LGCS4	L2106386-5 Soil 30-MAY-18 16:00 2018LGCS5
MISC.							
Miscellaneous	Special Request		See Attached	See Attached	See Attached	See Attached	See Attached

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2106386-6	L2106386-7	L2106386-8	L2106386-9	L2106386-10
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	31-MAY-18	31-MAY-18	31-MAY-18	31-MAY-18	31-MAY-18
	Sampled Time	12:00	12:00	12:00	12:00	12:00
	Client ID	2018MGCS1	2018MGCS2	2018MGCS3	2018MGCS4	2018MGCS5
Grouping	**Analyte**					
MISC.						
Miscellaneous	Special Request	See Attached	See Attached	See Attached	See Attached	See Attached

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2106386-1	L2106386-2	L2106386-3	L2106386-4	L2106386-5
Description	Soil	Soil	Soil	Soil	Soil
Sampled Date	30-MAY-18	30-MAY-18	30-MAY-18	30-MAY-18	30-MAY-18
Sampled Time	16:00	16:00	16:00	16:00	16:00
Client ID	2018LGCS1	2018LGCS2	2018LGCS3	2018LGCS4	2018LGCS5
Grouping / **Analyte**					
SOIL					
Physical Tests Loss on Ignition @ 550 C (%)	1	1	1	1	1
Moisture (%)	25.3	22.3	22.0	20.9	21.4
pH (1:2 soil:water) (pH)	8.38	8.44	8.49	8.65	8.60
Organic / Inorganic Carbon Total Organic Carbon (%)	0.25	0.29	<0.27	<0.20	<0.20
Inorganic Parameters Acid Volatile Sulphides (mg/kg)	<0.20	0.63	<0.20	<0.20	<0.20
Metals Aluminum (Al) (mg/kg)	18300	16600	14900	15400	15500
Antimony (Sb) (mg/kg)	0.46	0.39	0.48	0.46	0.34
Arsenic (As) (mg/kg)	4.65	4.08	3.60	4.27	3.46
Barium (Ba) (mg/kg)	137	137	117	97.7	106
Beryllium (Be) (mg/kg)	0.20	0.19	0.18	0.21	0.18
Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
Cadmium (Cd) (mg/kg)	1.02	0.880	0.858	0.835	0.639
Calcium (Ca) (mg/kg)	31100	31200	30900	29500	27400
Chromium (Cr) (mg/kg)	41.9	39.7	33.2	31.6	27.9
Cobalt (Co) (mg/kg)	26.3	20.8	22.3	23.1	22.1
Copper (Cu) (mg/kg)	49.3	44.4	44.1	41.6	40.7
Iron (Fe) (mg/kg)	50400	42600	43600	45100	44900
Lead (Pb) (mg/kg)	9.84	5.88	6.58	8.11	7.53
Lithium (Li) (mg/kg)	7.0	7.0	6.4	6.8	6.8
Magnesium (Mg) (mg/kg)	15100	14000	12500	13100	12700
Manganese (Mn) (mg/kg)	873	792	740	735	714
Mercury (Hg) (mg/kg)	0.0125	0.0079	0.0119	0.0142	0.0092
Molybdenum (Mo) (mg/kg)	2.25	2.10	2.18	1.97	1.74
Nickel (Ni) (mg/kg)	31.9	30.2	27.0	24.7	22.7
Phosphorus (P) (mg/kg)	1050	925	949	1000	986
Potassium (K) (mg/kg)	1730	1690	1440	1470	1390
Selenium (Se) (mg/kg)	1.44	1.07	1.31	1.12	1.00
Silver (Ag) (mg/kg)	0.19	0.14	0.17	0.16	0.15
Sodium (Na) (mg/kg)	194	149	142	129	145
Strontium (Sr) (mg/kg)	75.4	77.3	72.0	67.6	67.8
Sulfur (S) (mg/kg)	<3000 DLB	<2000 DLB	<3000 DLB	<3000 DLB	<2000 DLB
Thallium (Tl) (mg/kg)	0.102	0.108	0.093	0.083	0.081
Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti) (mg/kg)	1620	1190	983	947	1250
Tungsten (W) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2106386-6	L2106386-7	L2106386-8	L2106386-9	L2106386-10
Description	Soil	Soil	Soil	Soil	Soil
Sampled Date	31-MAY-18	31-MAY-18	31-MAY-18	31-MAY-18	31-MAY-18
Sampled Time	12:00	12:00	12:00	12:00	12:00
Client ID	2018MGCS1	2018MGCS2	2018MGCS3	2018MGCS4	2018MGCS5
Grouping / **Analyte**					
SOIL					
Physical Tests Loss on Ignition @ 550 C (%)	1	1	1	1	1
Moisture (%)	16.2	19.9	22.3	25.0	28.6
pH (1:2 soil:water) (pH)	8.74	8.59	8.55	8.52	8.46
Organic / Inorganic Carbon Total Organic Carbon (%)	<0.28	<0.29	<0.25	<0.27	0.37
Inorganic Parameters Acid Volatile Sulphides (mg/kg)	0.40	<0.20	<0.20	<0.20	<0.20
Metals Aluminum (Al) (mg/kg)	18000	16900	20200	18900	16900
Antimony (Sb) (mg/kg)	0.38	0.33	0.28	0.25	0.39
Arsenic (As) (mg/kg)	4.17	3.95	2.80	2.48	3.74
Barium (Ba) (mg/kg)	128	187	196	148	164
Beryllium (Be) (mg/kg)	0.21	0.20	0.23	0.22	0.16
Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
Cadmium (Cd) (mg/kg)	0.564	1.03	0.675	0.645	1.02
Calcium (Ca) (mg/kg)	39700	41400	41000	41400	35600
Chromium (Cr) (mg/kg)	46.7	45.2	53.5	53.6	47.9
Cobalt (Co) (mg/kg)	27.4	23.4	25.7	22.5	21.9
Copper (Cu) (mg/kg)	47.4	49.6	49.1	45.6	52.8
Iron (Fe) (mg/kg)	49000	45400	49200	42500	43000
Lead (Pb) (mg/kg)	6.89	5.48	5.49	5.24	5.99
Lithium (Li) (mg/kg)	7.1	7.1	8.0	7.8	6.1
Magnesium (Mg) (mg/kg)	14200	13500	15700	15000	13300
Manganese (Mn) (mg/kg)	712	723	801	744	764
Mercury (Hg) (mg/kg)	0.0072	0.0260	0.0079	0.0093	0.0118
Molybdenum (Mo) (mg/kg)	2.58	2.83	1.92	2.07	2.40
Nickel (Ni) (mg/kg)	32.5	33.8	37.7	36.9	37.1
Phosphorus (P) (mg/kg)	1080	1070	1080	956	968
Potassium (K) (mg/kg)	2100	1860	2670	2590	1970
Selenium (Se) (mg/kg)	1.25	1.67	1.03	0.71	1.34
Silver (Ag) (mg/kg)	0.18	0.22	0.18	0.15	0.17
Sodium (Na) (mg/kg)	180	173	223	196	205
Strontium (Sr) (mg/kg)	86.1	92.5	91.0	92.5	81.9
Sulfur (S) (mg/kg)	<3000 DLB	<3000 DLB	<2000 DLB	<1000	<1000
Thallium (Tl) (mg/kg)	0.125	0.122	0.161	0.164	0.117
Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti) (mg/kg)	1350	1340	1440	1370	1190
Tungsten (W) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2106386-1 Soil 30-MAY-18 16:00 2018LGCS1	L2106386-2 Soil 30-MAY-18 16:00 2018LGCS2	L2106386-3 Soil 30-MAY-18 16:00 2018LGCS3	L2106386-4 Soil 30-MAY-18 16:00 2018LGCS4	L2106386-5 Soil 30-MAY-18 16:00 2018LGCS5
SOIL						
Metals	Uranium (U) (mg/kg)	0.346	0.326	0.309	0.261	0.325
	Vanadium (V) (mg/kg)	118	104	95.7	102	104
	Zinc (Zn) (mg/kg)	185	150	160	168	141
	Zirconium (Zr) (mg/kg)	1.8	<1.0	1.1	1.1	1.3

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2106386-6 Soil 31-MAY-18 12:00 2018MGCS1	L2106386-7 Soil 31-MAY-18 12:00 2018MGCS2	L2106386-8 Soil 31-MAY-18 12:00 2018MGCS3	L2106386-9 Soil 31-MAY-18 12:00 2018MGCS4	L2106386-10 Soil 31-MAY-18 12:00 2018MGCS5
Sample ID / Description / Sampled Date / Sampled Time / Client ID						
SOIL						
Metals	Uranium (U) (mg/kg)	0.314	0.384	0.370	0.339	0.319
	Vanadium (V) (mg/kg)	117	106	122	108	100
	Zinc (Zn) (mg/kg)	122	167	139	129	160
	Zirconium (Zr) (mg/kg)	1.5	1.7	1.5	<1.0	<1.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Sulfur (S)	MB-LOR	L2106386-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Laboratory Control Sample	Magnesium (Mg)	MES	L2106386-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Laboratory Control Sample	Sodium (Na)	MES	L2106386-1, -10, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLB	Detection Limit Raised. Analyte detected at comparable level in Method Blank.
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MES	Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217
A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.			
C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2
Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)			
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	CSSS (2008) 21.2
The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.			
HG-200.2-CVAF-VA	Soil	Mercury in Soil by CVAAS	EPA 200.2/1631E (mod)
Soil samples are digested with hot nitric and hydrochloric acids, followed by CVAAS analysis. This method is fully compliant with the BC SALM strong acid leachable metals digestion method.			
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
LOI-550-SK	Soil	Loss on Ignition @ 550 C	CSSS (1993) p.461-462
The sample is air dried at 40C overnight, then ground to < 2mm in particle size using a flail grinder. A portion of the dried and ground sample is dried at 105C overnight, then ignited at 550C for 16-20 hours. Loss on ignition at 550C is reported on a dry sample basis.			
Loss on Ignition at 550C can be used as an estimation of Organic Matter (CSSS 2008)			
MET-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A (mod)
This method uses a heated strong acid digestion with HNO3 and HCl and is intended to liberate metals that may be environmentally available. Silicate minerals are not solubilized. Dependent on sample matrix, some metals may be only partially recovered, including Al, Ba, Be, Cr, Sr, Ti, Tl, V, W, and Zr. Volatile forms of sulfur (including sulfide) may not be captured, as they may be lost during sampling, storage, or digestion. Analysis is by Collision/Reaction Cell ICPMS.			
MOISTURE-VA	Soil	Moisture content	CWS for PHC in Soil - Tier 1
This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.			
PH-1:2-VA	Soil	pH in Soil (1:2 Soil:Water Extraction)	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL
This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.			
SPECIAL REQUEST-SK	Misc.	Special Request Sask Lab	SEE SUBLET LAB RESULTS
SULPHIDE-WT	Soil	Sulphide, Acid Volatile	APHA 4500S2J
This analysis is carried out in accordance with the method described in APHA 4500 S2-J. Hydrochloric acid is added to sediment samples within a purge and trap system. The evolved hydrogen sulphide (H2S) is carried into a basic solution by inert gas. The acid volatile sulfide is then determined colourimetrically.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Reference Information

VA ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

17-653126

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

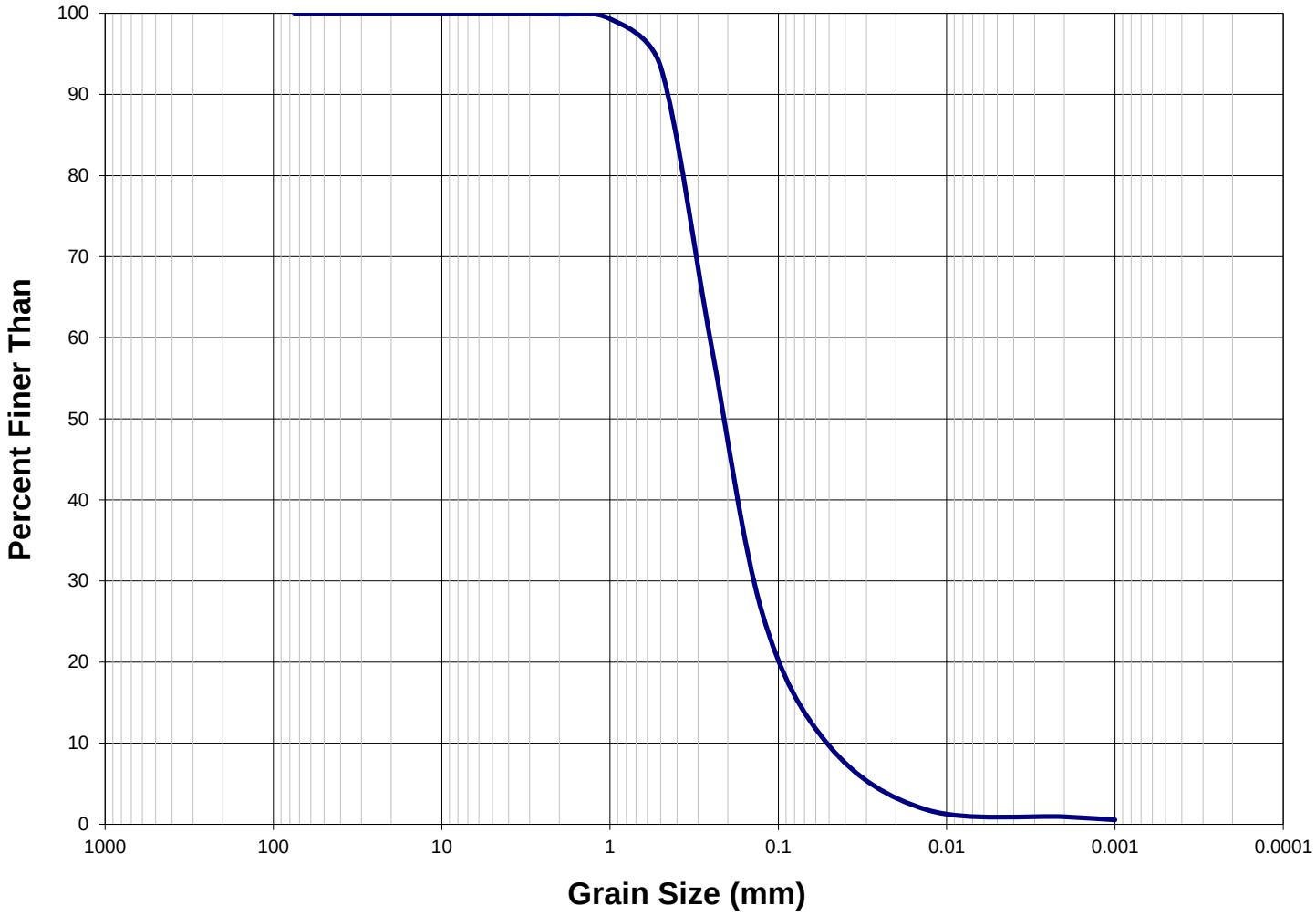
Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018LGCS1
Lab ID: L2106386-1

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.86	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.00	Gravel, Medium			
4.75 - 2	0.10	Gravel, Fine			
2 - 0.85	2.37	Gravel Very Coarse			
0.85 - 0.425	14.45	Sand, Coarse			
0.425 - 0.25	24.06	Sand, Medium			
0.25 - 0.106	37.06	Sand, Fine			
0.106 - 0.075	6.79	Sand, Very Fine			
0.075 - 0.074	0.22	Silt and Clay			
0.074 - 0.005	13.79	Silt and Clay			
0.005 - 0.001	0.30	Silt and Clay			

Texture: Sand

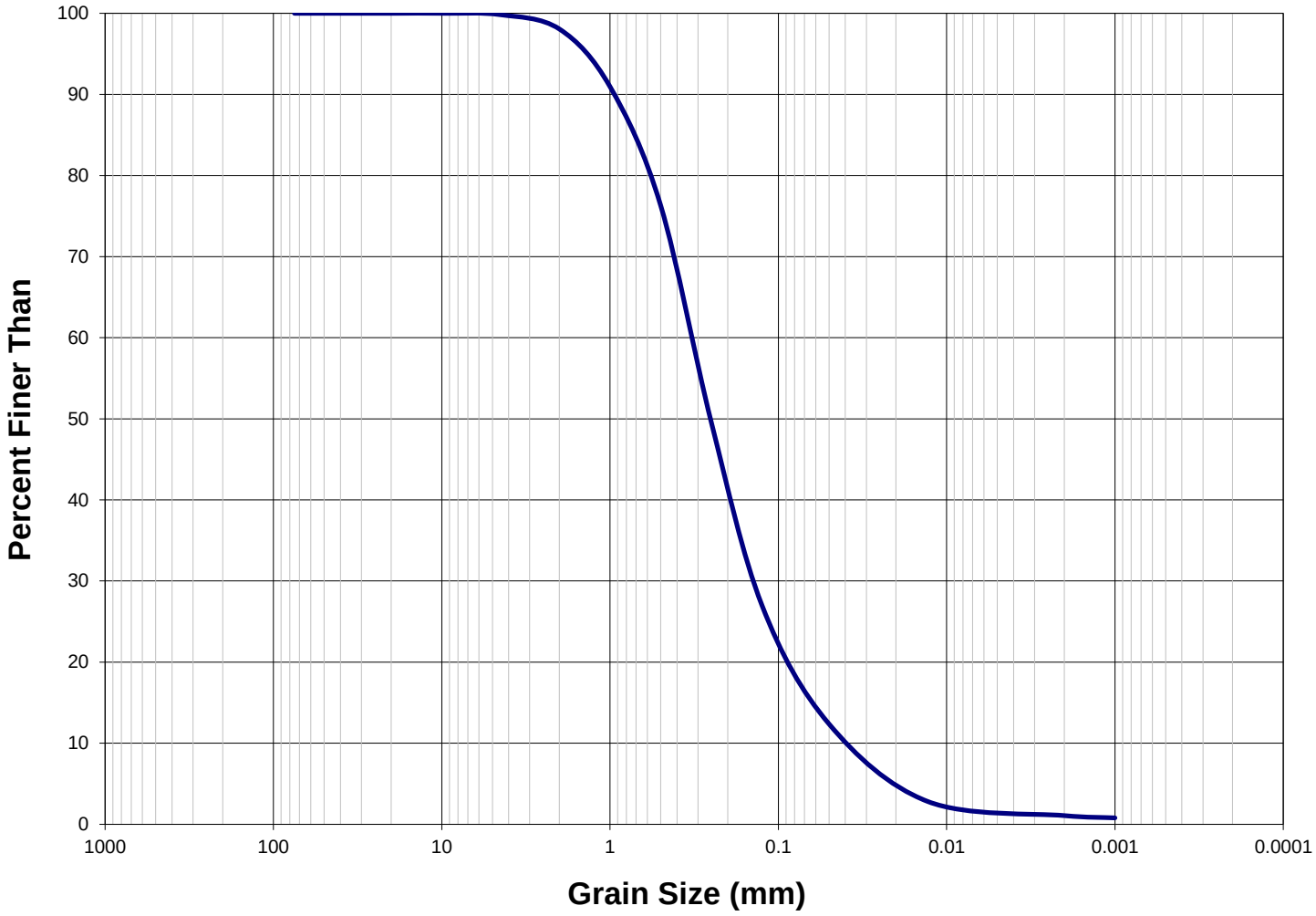
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018MGCS5
Lab ID: L2106386-10

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.92	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.16	Gravel, Medium			
4.75 - 2	1.78	Gravel, Fine			
2 - 0.85	11.51	Gravel Very Coarse			
0.85 - 0.425	18.28	Sand, Coarse			
0.425 - 0.25	18.73	Sand, Medium			
0.25 - 0.106	26.26	Sand, Fine			
0.106 - 0.075	6.04	Sand, Very Fine			
0.075 - 0.074	0.19	Silt and Clay			
0.074 - 0.005	15.50	Silt and Clay			
0.005 - 0.001	0.64	Silt and Clay			

Texture: Sand

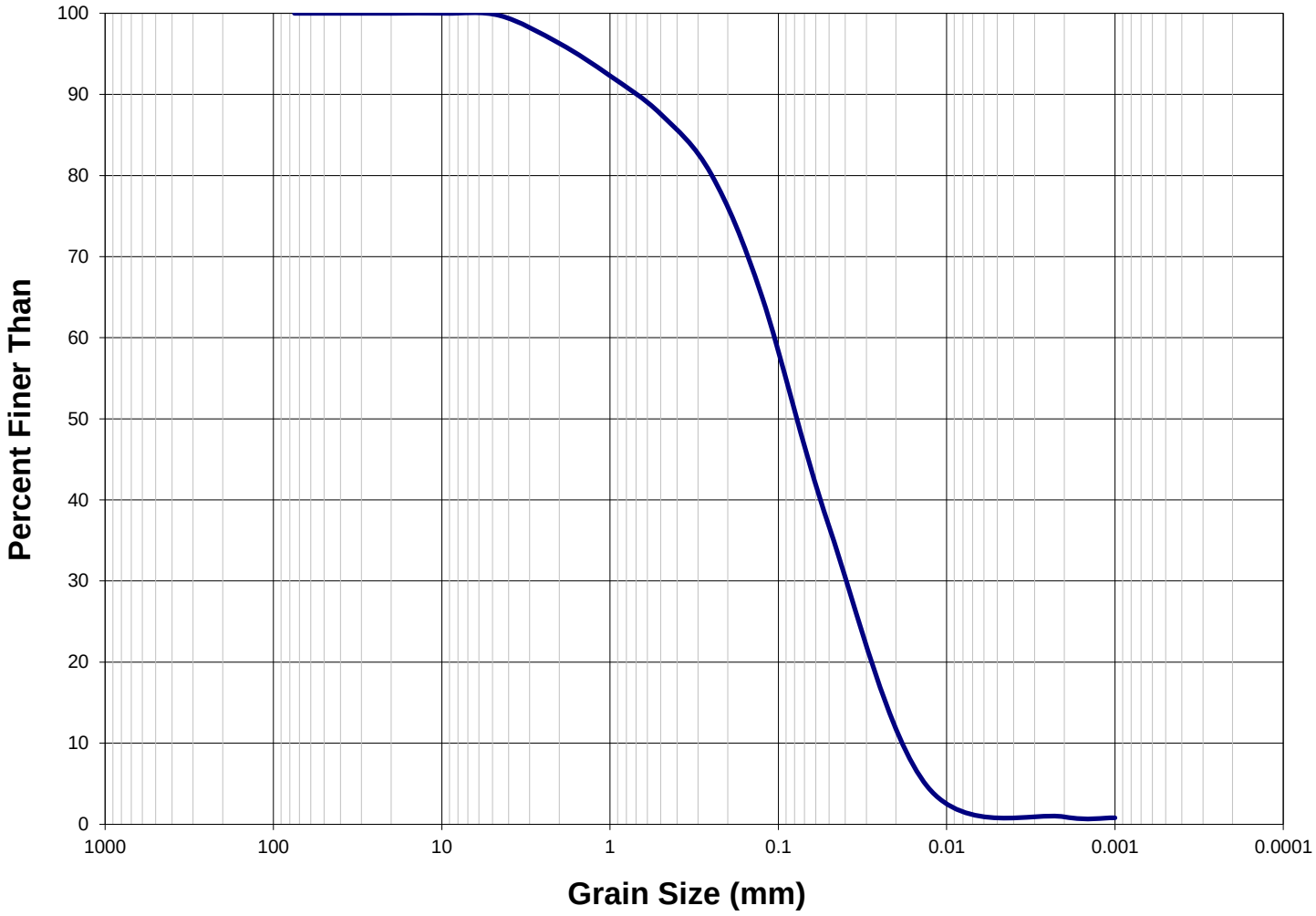
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018LGCS2
Lab ID: L2106386-2

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.58	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.28	Gravel, Medium			
4.75 - 2	3.44	Gravel, Fine			
2 - 0.85	5.41	Gravel Very Coarse			
0.85 - 0.425	5.54	Sand, Coarse			
0.425 - 0.25	5.22	Sand, Medium			
0.25 - 0.106	22.25	Sand, Fine			
0.106 - 0.075	11.70	Sand, Very Fine			
0.075 - 0.074	0.38	Silt and Clay			
0.074 - 0.005	43.87	Silt and Clay			
0.005 - 0.001	1.35	Silt and Clay			

Texture: Sandy loam

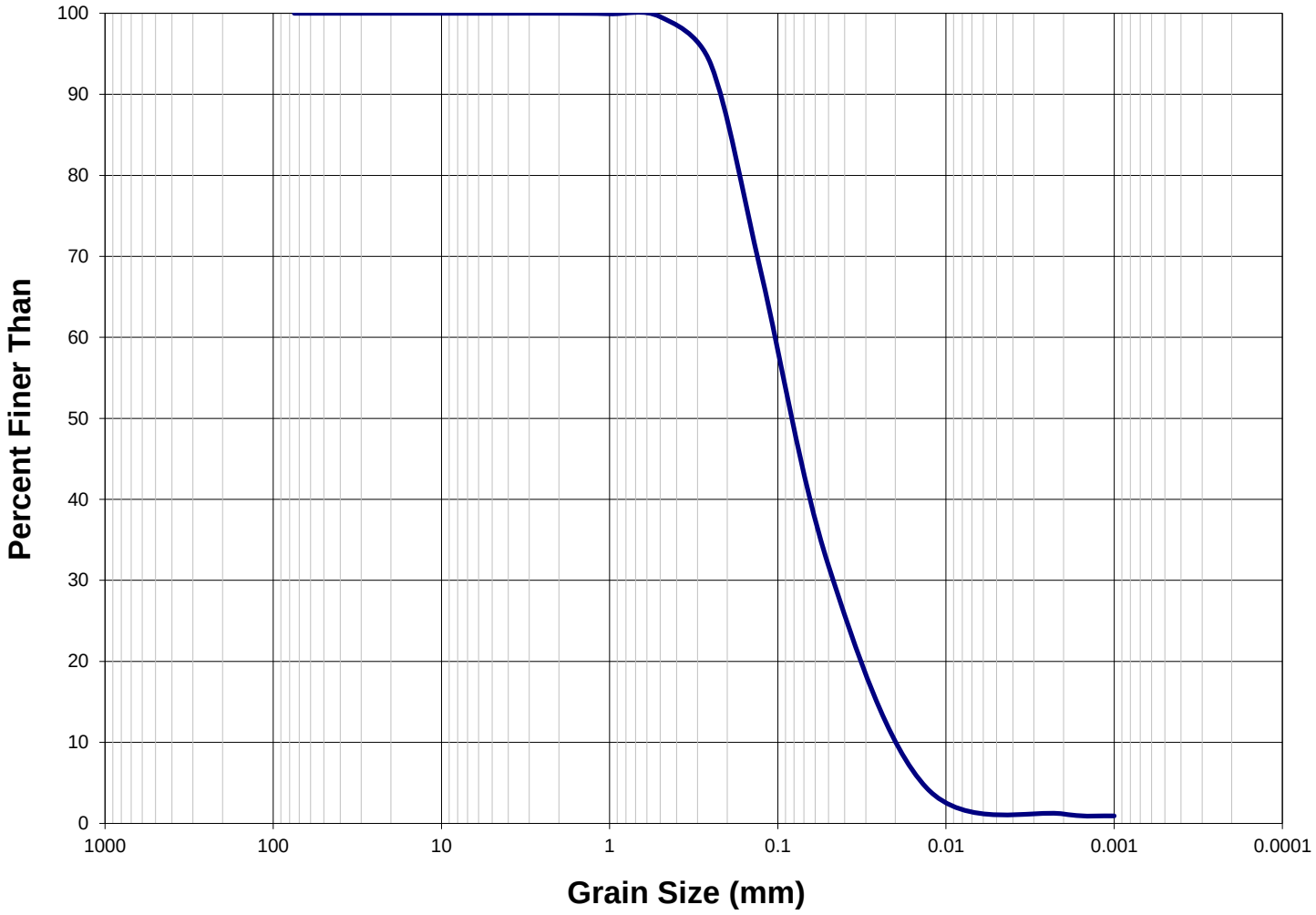
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018LGCS3
Lab ID: L2106386-3

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.88	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.00	Gravel, Medium			
4.75 - 2	0.00	Gravel, Fine			
2 - 0.85	0.18	Gravel Very Coarse			
0.85 - 0.425	2.02	Sand, Coarse			
0.425 - 0.25	4.11	Sand, Medium			
0.25 - 0.106	35.03	Sand, Fine			
0.106 - 0.075	14.85	Sand, Very Fine			
0.075 - 0.074	0.48	Silt and Clay			
0.074 - 0.005	41.30	Silt and Clay			
0.005 - 0.001	1.16	Silt and Clay			

Texture: Sandy loam

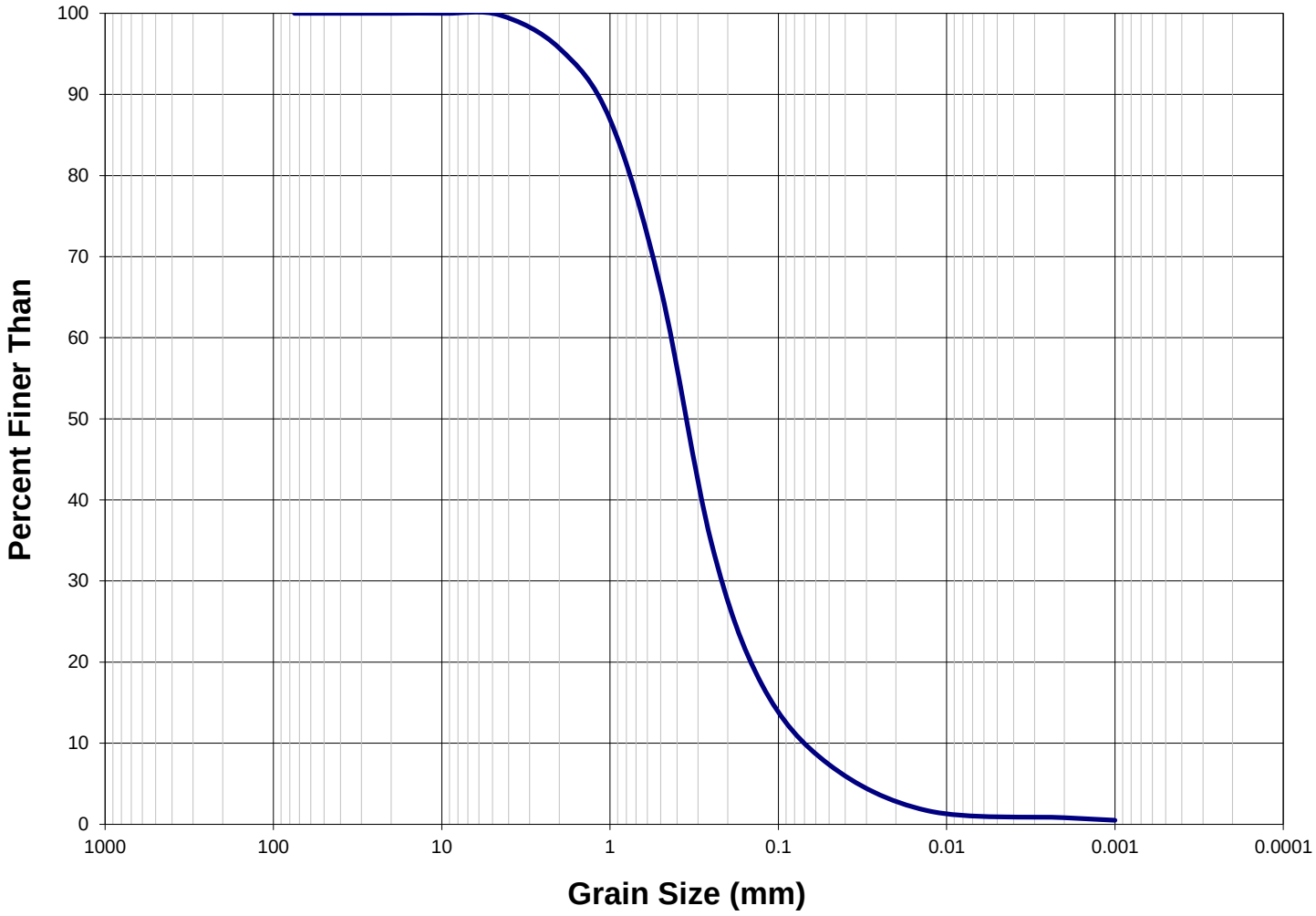
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018LGCS4
Lab ID: L2106386-4

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.74	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.22	Gravel, Medium			
4.75 - 2	4.10	Gravel, Fine			
2 - 0.85	15.03	Gravel Very Coarse			
0.85 - 0.425	23.97	Sand, Coarse			
0.425 - 0.25	21.97	Sand, Medium			
0.25 - 0.106	20.01	Sand, Fine			
0.106 - 0.075	4.06	Sand, Very Fine			
0.075 - 0.074	0.13	Silt and Clay			
0.074 - 0.005	9.46	Silt and Clay			
0.005 - 0.001	0.31	Silt and Clay			

Texture: Sand

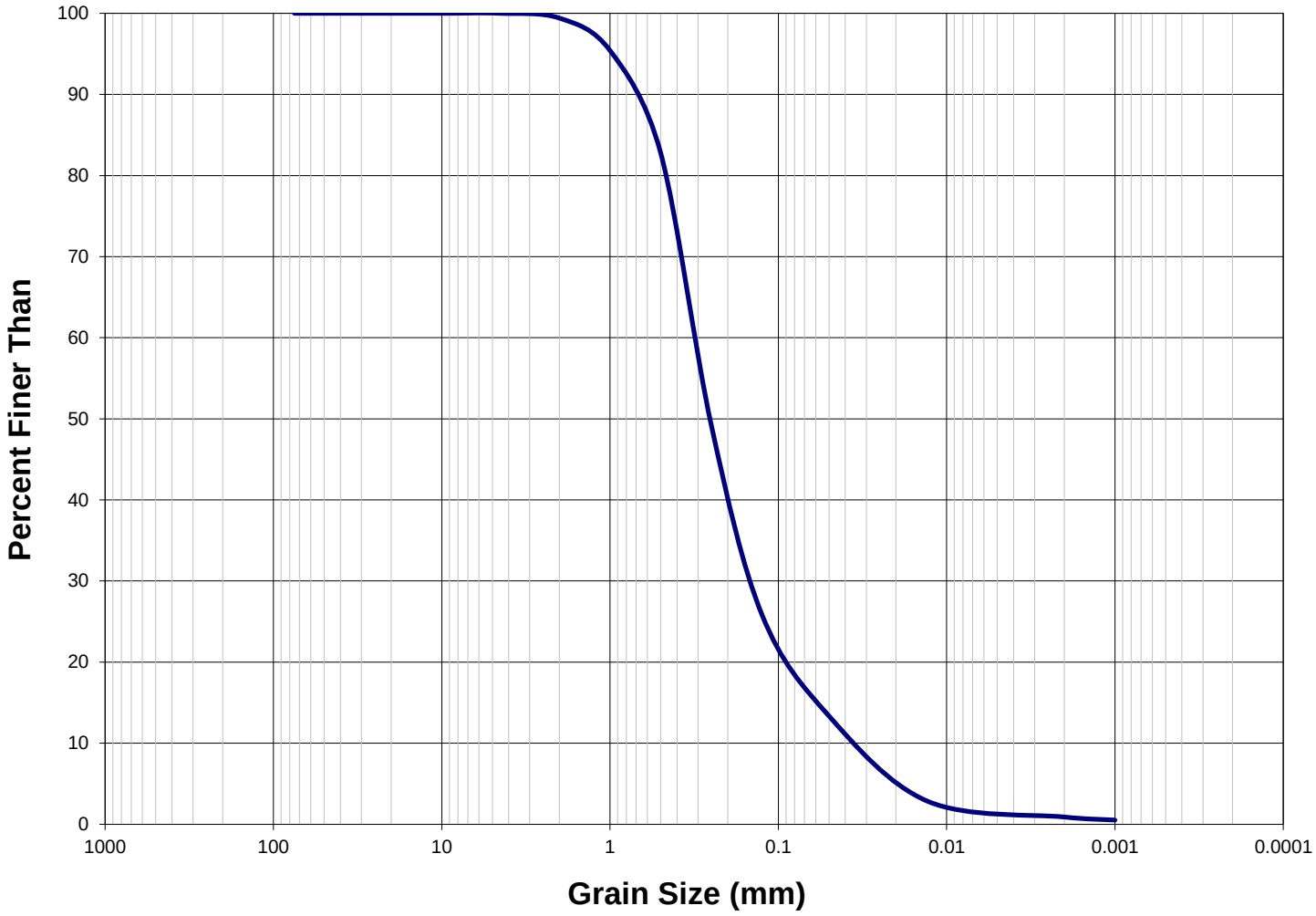
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018LGCS5
Lab ID: L2106386-5

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.73	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.00	Gravel, Medium			
4.75 - 2	0.59	Gravel, Fine			
2 - 0.85	7.79	Gravel Very Coarse			
0.85 - 0.425	18.92	Sand, Coarse			
0.425 - 0.25	23.52	Sand, Medium			
0.25 - 0.106	26.50	Sand, Fine			
0.106 - 0.075	5.15	Sand, Very Fine			
0.075 - 0.074	0.17	Silt and Clay			
0.074 - 0.005	15.91	Silt and Clay			
0.005 - 0.001	0.71	Silt and Clay			

Texture: Sand

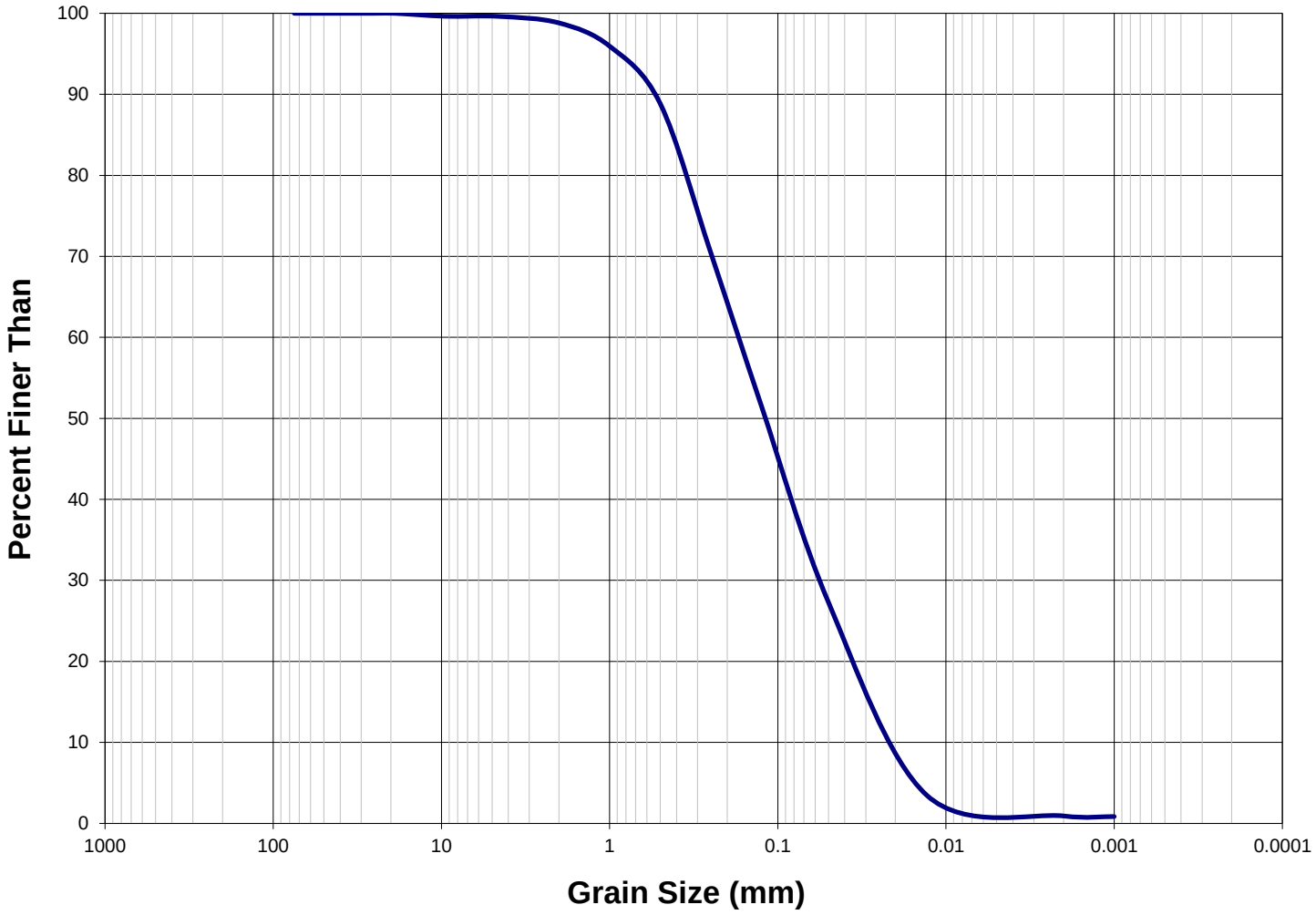
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018MGCS1
Lab ID: L2106386-6

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.69	Clay
19 - 9.5	0.37	Gravel			
9.5 - 4.75	0.02	Gravel, Medium			
4.75 - 2	0.80	Gravel, Fine			
2 - 0.85	5.00	Gravel Very Coarse			
0.85 - 0.425	10.50	Sand, Coarse			
0.425 - 0.25	12.91	Sand, Medium			
0.25 - 0.106	25.04	Sand, Fine			
0.106 - 0.075	10.00	Sand, Very Fine			
0.075 - 0.074	0.32	Silt and Clay			
0.074 - 0.005	33.43	Silt and Clay			
0.005 - 0.001	0.93	Silt and Clay			

Texture: Loamy sand

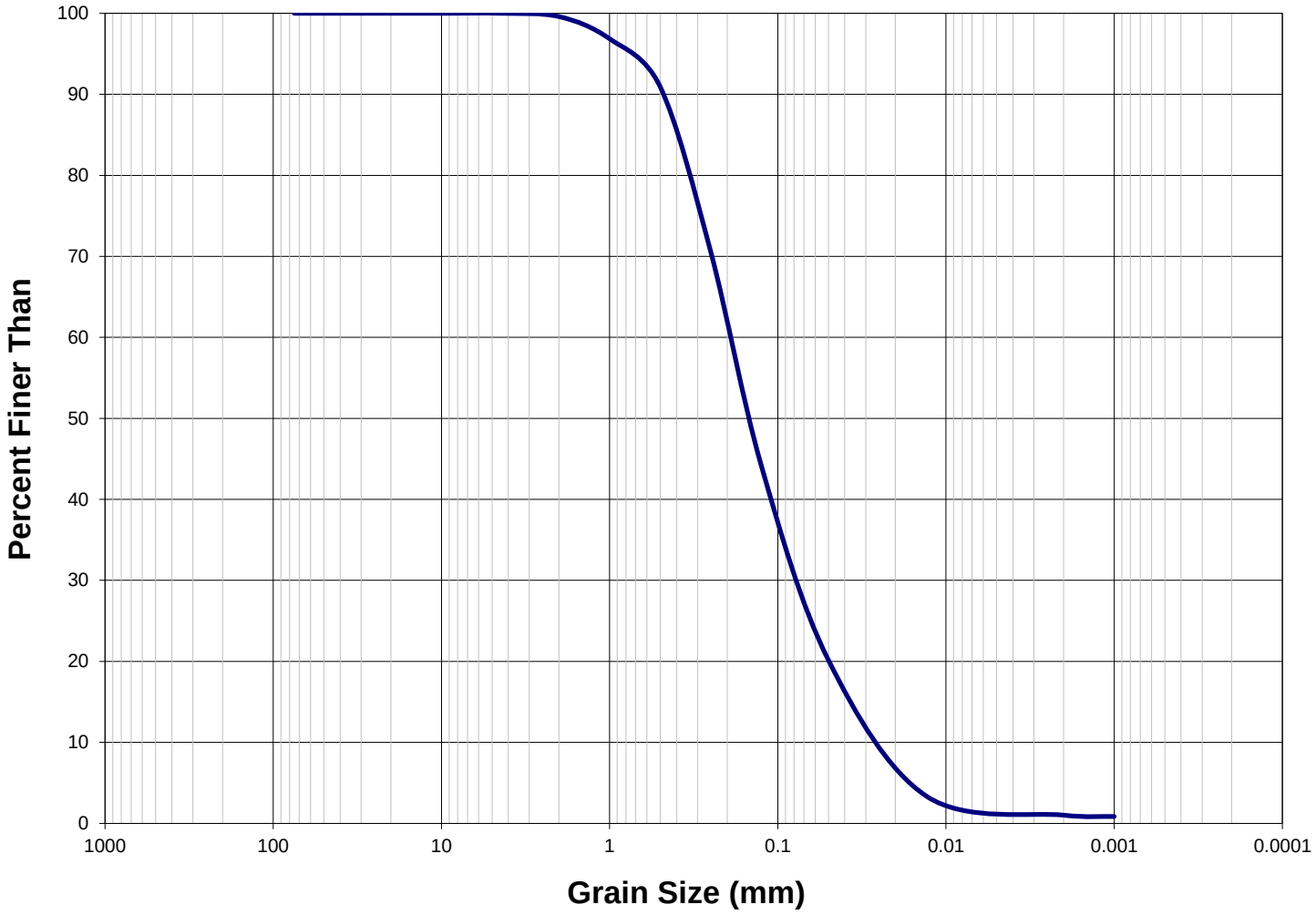
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018MGCS2
Lab ID: L2106386-7

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.81	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.00	Gravel, Medium			
4.75 - 2	0.41	Gravel, Fine			
2 - 0.85	4.52	Gravel Very Coarse			
0.85 - 0.425	10.28	Sand, Coarse			
0.425 - 0.25	14.29	Sand, Medium			
0.25 - 0.106	32.47	Sand, Fine			
0.106 - 0.075	9.89	Sand, Very Fine			
0.075 - 0.074	0.32	Silt and Clay			
0.074 - 0.005	26.16	Silt and Clay			
0.005 - 0.001	0.84	Silt and Clay			

Texture: Loamy sand

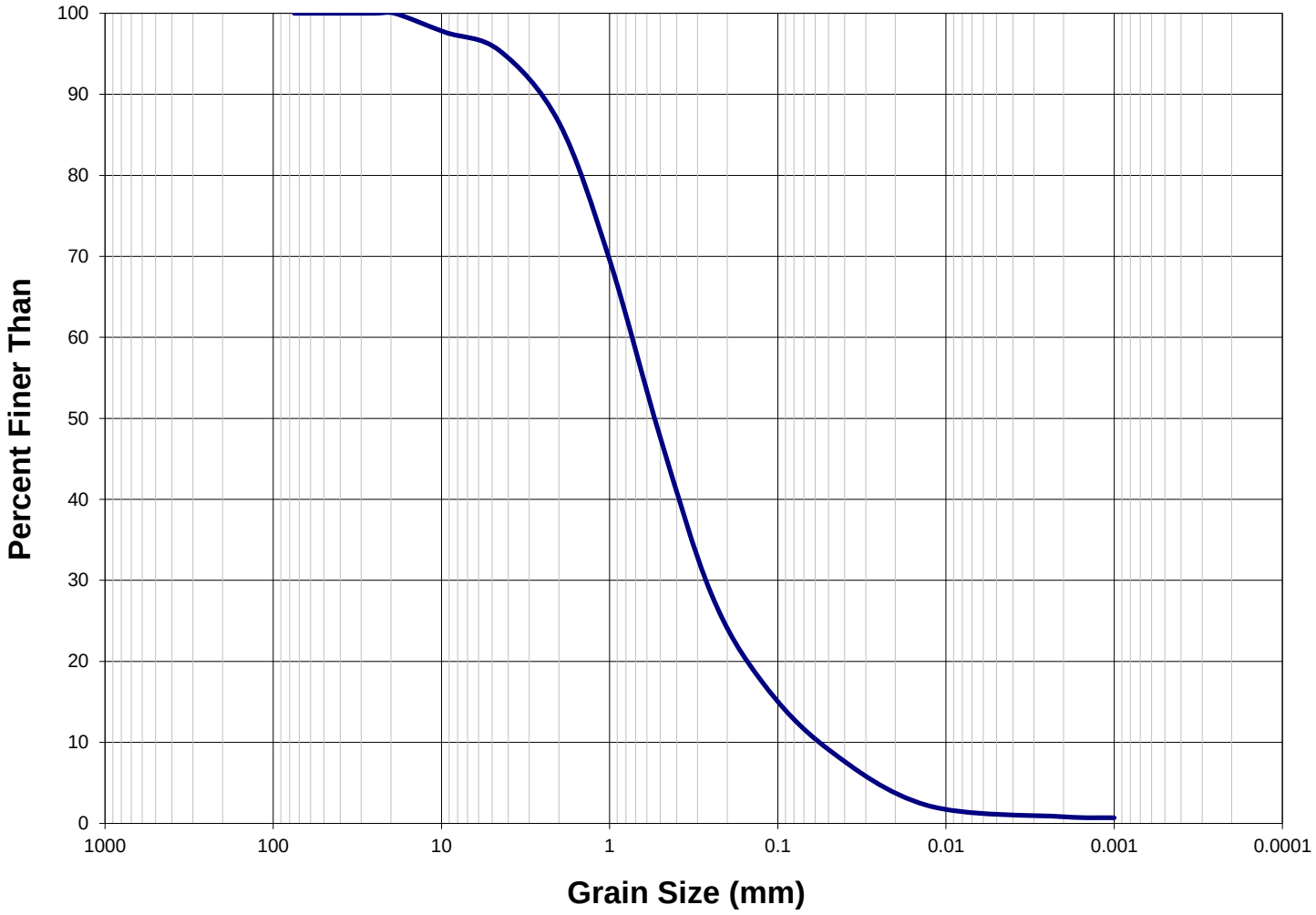
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018MGCS3
Lab ID: L2106386-8

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.69	Clay
19 - 9.5	2.34	Gravel			
9.5 - 4.75	2.17	Gravel, Medium			
4.75 - 2	8.98	Gravel, Fine			
2 - 0.85	23.52	Gravel Very Coarse			
0.85 - 0.425	21.09	Sand, Coarse			
0.425 - 0.25	13.45	Sand, Medium			
0.25 - 0.106	13.02	Sand, Fine			
0.106 - 0.075	3.49	Sand, Very Fine			
0.075 - 0.074	0.11	Silt and Clay			
0.074 - 0.005	10.62	Silt and Clay			
0.005 - 0.001	0.52	Silt and Clay			

Texture: Sand

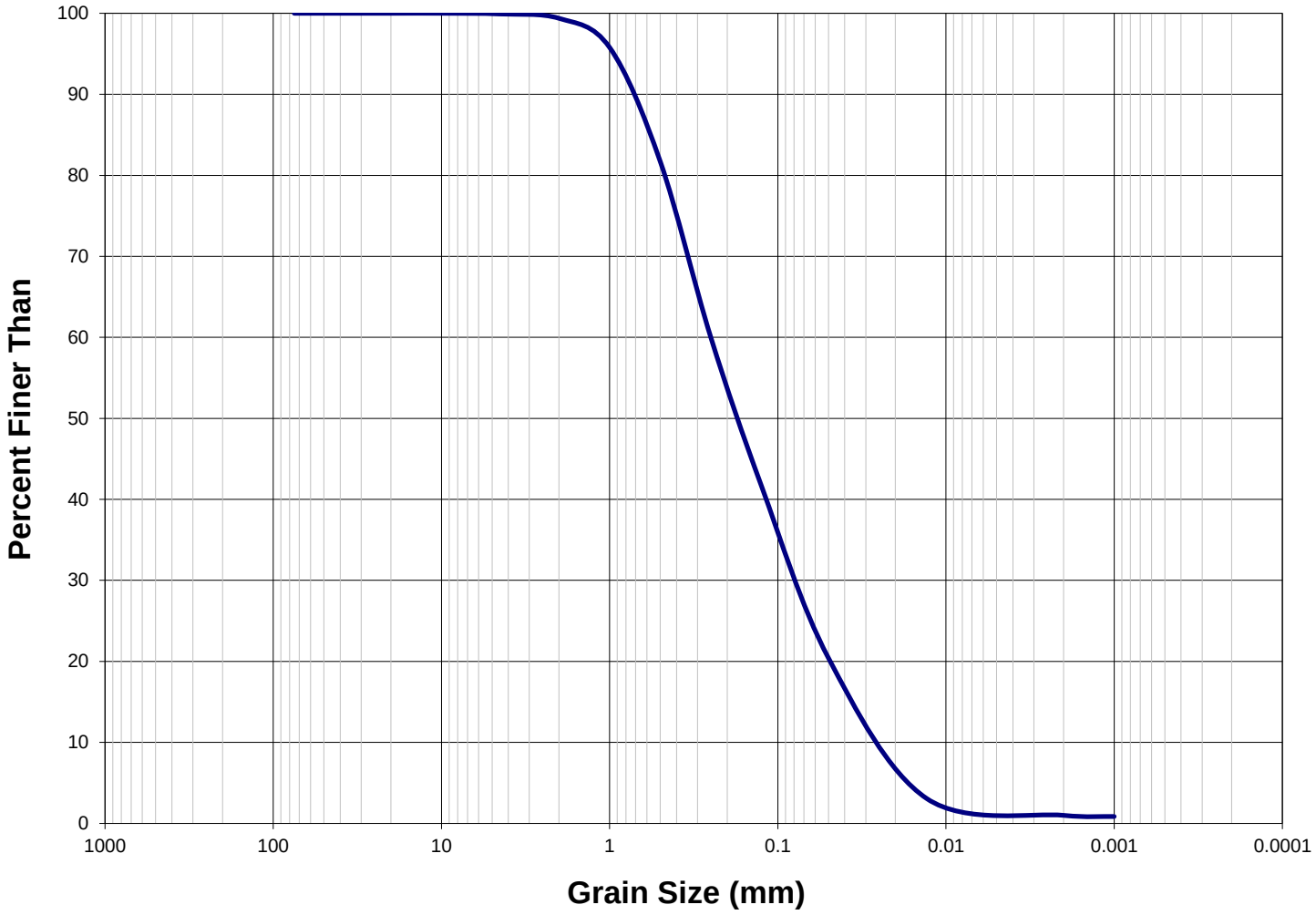
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: Constantine North Inc.
Project:
Sample ID: 2018MGCS4
Lab ID: L2106386-9

Particle Size Distribution Curve



Particle Size Distribution

Range (mm)	Wt. (%)	Class	Range (mm)	Wt. (%)	Class
> 19	0.00	Gravel	<0.001	0.81	Clay
19 - 9.5	0.00	Gravel			
9.5 - 4.75	0.08	Gravel, Medium			
4.75 - 2	0.54	Gravel, Fine			
2 - 0.85	7.82	Gravel Very Coarse			
0.85 - 0.425	16.37	Sand, Coarse			
0.425 - 0.25	15.22	Sand, Medium			
0.25 - 0.106	23.71	Sand, Fine			
0.106 - 0.075	8.77	Sand, Very Fine			
0.075 - 0.074	0.28	Silt and Clay			
0.074 - 0.005	25.65	Silt and Clay			
0.005 - 0.001	0.75	Silt and Clay			

Texture: Loamy sand

Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2106386-COFC

COC Number: 17 - 653126

Page 1 of 1

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)
Company:	ADF&G Division of Habitat	Select Report Format: [x] PDF [x] EXCEL [ ] EDD (DIGITAL)	Regular [R]: [x] Standard TAT if received by 3 pm - business days - no surcharges apply
Contact:	Kate Kanouse	Quality Control (QC) Report with Report: [x] YES [ ] NO	PRIORITY (Business Days): 4 day [P4-20%] [ ]; 3 day [P3-25%] [ ]; 2 day [P2-50%] [ ]
Phone:	(907) 465-4290	[ ] Compare Results to Criteria on Report - provide details below if box checked	EMERGENCY: 1 Business day [E-100%] [ ]; Same Day, Weekend or Statutory holiday [E2-200%] (Laboratory opening fees may apply)] [ ]
	Company address below will appear on the final report	Select Distribution: [x] EMAIL [ ] MAIL [ ] FAX	Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
Street:	PO Box 110024	Email 1 or Fax: Kate.Kanouse@alaska.gov	For tests that can not be performed according to the service level selected, you will be contacted.
City/Province:	Juneau, AK, USA	Email 2: allegra@constantinemetals.com	
Postal Code:	99811-0024	Email 3:	
Invoice To	Same as Report To: [ ] YES [x] NO	**Invoice Distribution**	**Analysis Request**
	Copy of Invoice with Report: [ ] YES [x] NO	Select Invoice Distribution: [x] EMAIL [ ] MAIL [ ] FAX	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
Company:	Constantine Metals Resources	Email 1 or Fax: ~~allegra@constantine.com~~	AS PER QUOTE # Q62329
Contact:	Allegra Cairns	Email 2: allegra@constantinemetals.com	

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:	Q62329	AFE/Cost Center:	PO#:
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):		ALS Contact: Brent Makelki	Sampler: Kate Kanouse

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type		SAMPLES ON HOLD	Sample is hazardous (please provide further details)	NUMBER OF CONTAINERS
	2018LGCS1	5/30/18	1600	soil	/			3
	2018LGCS2	5/30/18	1600	soil	/			3
	2018LGCS3	5/30/18	1600	soil	/			3
	2018LGCS4	5/30/18	1600	soil	/			3
	2018LGCS5	5/30/18	1600	soil	/			3
	2018MGCS1	5/31/18	1200	soil	/			3
	2018MGCS2	5/31/18	1200	soil	/			3
	2018MGCS3	5/31/18	1200	soil	/			3
	2018MGCS4	5/31/18	1200	soil	/			3
	2018MGCS5	5/31/18	1200	soil	/			3

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Are samples taken from a Regulated DW System? [ ] YES [ ] NO	invoice also to: arise constantinemetals.com sherrie constantine metals.com
Are samples for human consumption/ use? [ ] YES [ ] NO	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ] SIF Observations Yes [ ] No [ ]
Ice Packs [ ] Ice Cubes [ ] Custody seal intact Yes [ ] No [ ]
Cooling Initiated [ ]

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
8°C				9			

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Kate Kanouse	Date: 5/31/18	Time: 1500	Received by:	Date: June 5/18	Time: 13:32	Received by: JC	Date: 6/6/18	Time: 12:15pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JULY 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.