Memorandum

To:	Ben Pierce (Gibraltar Mines Ltd.) Georgia Bock (Xatśūll First Nation)
From:	Hanna Van de Vosse (EDI)
Date:	February 10, 2017
Project No:	16P0298
Re:	Results of Salmon Tissue Sampling from August 2016

Background

Gibraltar Mines Ltd. (Gibraltar) holds a permit from the BC Ministry of Environment to discharge effluent to the Fraser River. As a condition of this permit, Gibraltar is required to develop and implement an Environmental Effects Monitoring Program. A component of this program is collaboration with local First Nations on a salmon tissue sampling program with the objective to provide information to First Nations regarding the safety of consuming fish captured at traditional fishing sites near the discharge location.

In August 2016, the Xatsull First Nation and Northern) Shuswap Tribal Council in partnership with Gibraltar conducted sampling to help determine if Xatśūll and ?Esdilagh First Nations members are exposed to high levels of metal contaminants by eating salmon. Some metals can be easily passed through the food chain and collect in tissue. Dietary intake of metals in trace amounts is necessary to maintain human health; however, at high levels, some metals can cause serious negative health effects in humans.

Using traditional dip netting methods, adult sockeye salmon were captured by band members from two popular fishing locations: Soda Creek Heritage Site and the Rudy Johnson Bridge. Tissue and scale samples were collected from 30 fish and submitted to a laboratory for metal analysis.

A select group of metals are presented in this summary, including aluminum, arsenic, cadmium, copper, iron, mercury, selenium, vanadium and zinc. These metals were chosen because human health guidelines are readily available from various public health agencies.

2016 Results

Samples from both fishing locations had similar levels of metals in fish tissue (Figure 1). The bars represent the average metal concentration values and the vertical black lines represent the distribution of approximately 68% of the values at each sample location. For example, the average concentration of mercury in the Soda Creek samples was 0.071 mg/kg with approximately 68% of the samples between 0.061 and 0.081 mg/kg. This distribution of values typically decreases with increased sample size which allows greater ability to compare the data against health guidelines, historic data, and to future sample events; therefore, it is advantageous to combine data from the two sample locations. Figure 1 indicates it is appropriate statistically to combine the data from Soda Creek and Rudy Johnson Bridge locations because the distributions of the values overlap between locations.

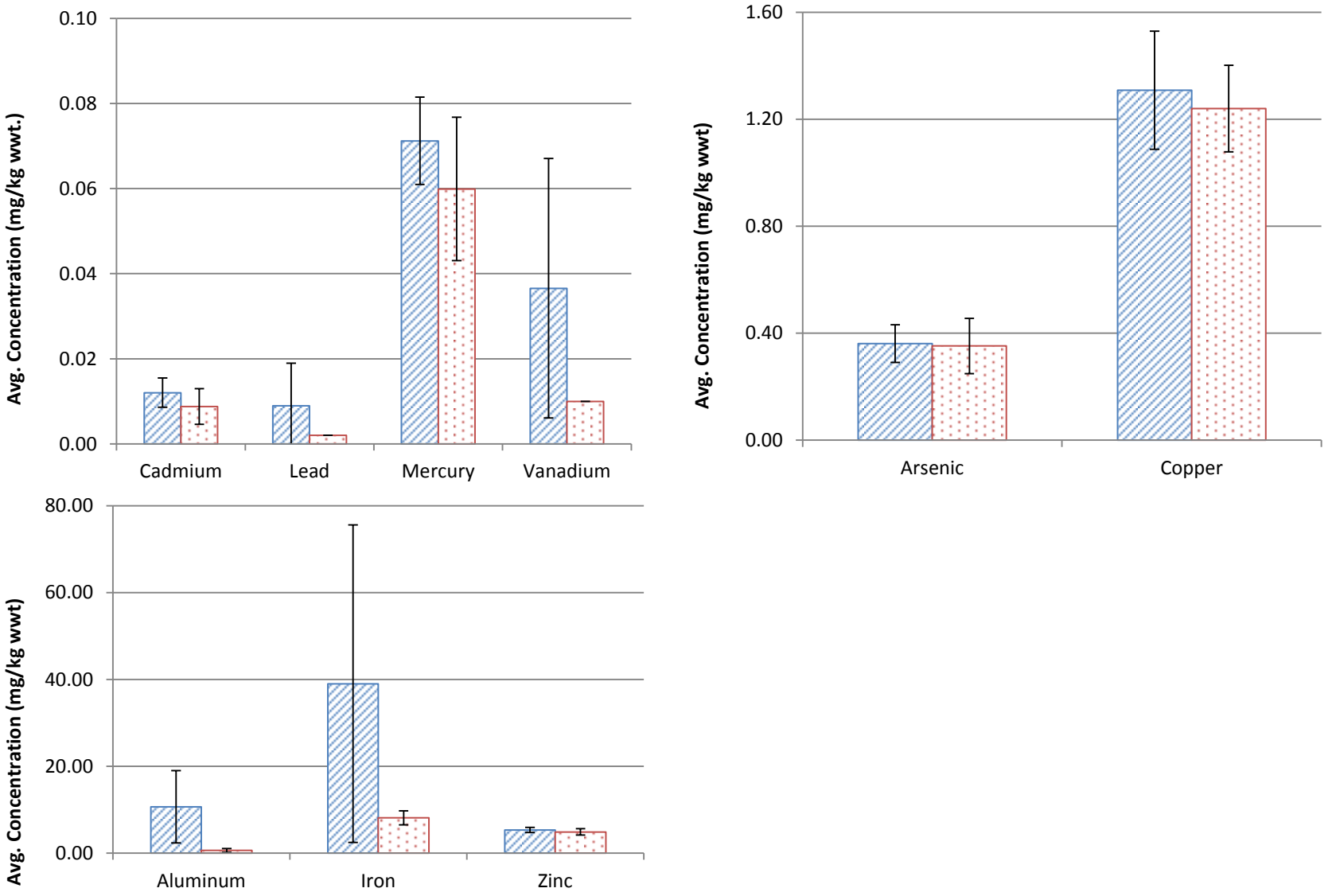

Figure 1. Comparison of average levels of metals (mg/kg wet weight) in salmon tissue between Soda Creek (blue diagonal) and Rudy Johnson Bridge (red shading) samples collected in August 2016. Black vertical bars represent standard deviation.

Comparison to Human Health Guidelines

Various agencies concerned with public health have developed guidelines regarding safe consumption of fish when certain metals are present in the tissue. These agencies include BC Ministry of Environment (MOE), Health Canada (HC), the World Health Organization (WHO), the European Food Safety Authority (EFSA) and the US Institute of Medicine (USIM) to name a few. Where available, average metal concentrations from the 2016 study have been compared to guidelines compiled from these organizations.

Dr. Elmar Plate from LGL Ltd - Environmental Research Associates reviewed the 2016 laboratory results. He used these results to determine a maximum number of weekly portions of salmon that an adult weighing 70kg (~155 lbs) could safely consume based on known public health guidelines for metals. Portions were also determined for a child weighing 25 kg (~55 lbs). Maximum weekly portions for adult and children are presented in Table 1. Since maximum number of weekly portions is based on consumption of 300 g of fish, the number of weekly portions could be doubled if the average portion size were to decrease to 150 g. Maximum number of weekly portions could also increase with an increase in bodyweight. For example, the weekly tolerable portion for mercury is based on 0.0033 mg/kg bodyweight; therefore, an adult weighing ~310 lbs could consume up to six portions per week.

Table 1. Maximum number of portions of salmon that an adult weighing 150 lbs could safely consume on a weekly basis for select total metals.

Metal	Max. No. of Weekly Tolerable Portions[1] (Adult)	Max. No. of Weekly Tolerable Portions[1] (Child)	Max. Consumption Guideline (mg)/week	Organization
Aluminum	39	14	490	WHO
Arsenic[2]	37	13	1.05	WHO
Cadmium	29	10	0.4	WHO
Copper	48	17	73.5	USIM
Iron	10	4	392	WHO
Lead	133	48	1.75	EFSA
Mercury	3	1	0.231	WHO
Selenium	31	11	11.2	MOE
Vanadium	24	8	1.5	Crebeli & Leopardi 2012
Zinc	78	28	490	WHO

1 Portion size is 300 g. Note that Health Canada equates 300 g to 2 cups (500 mL).
2. Guideline based on inorganic Arsenic (As). Assumes ratio of organic As to inorganic As is 1:15 based on Shinagawa et al 1983.

The BC Ministry of Environment has also developed consumptive guidelines for mercury in fish tissue. These guidelines are based on Health Canada recommendations. The provincial guideline states that for fish with a tissue concentration of 0.1 ug/g (note the maximum concentration detected in the 2016 samples was 0.102 ug/g) people should limit consumption to 1050 g per week, or 3.5 weekly portions that are 300 g in size. This is comparable to the WHO guideline that suggested three weekly portions could be safely consumed by an adult.

What Do the Study Results Mean?

There seems to be little risk in eating salmon with these metal concentrations provided the maximum number of weekly portions for mercury (refer to Table 1) is not exceeded. These portions are as follows:

- Adult = three portions of fish per week
- Child = one portion of fish per week

This assumes that the presented consumption rates, which are based on existing literature, accurately represent local First Nation consumption. If portion sizes are larger, a smaller number of weekly portions should be consumed. Conversely, a larger number of weekly portions can be consumed if portion sizes are smaller. Bodyweight could also be considered when determining consumption rates.

It is important to keep in mind that the values presented by the various organizations such as WHO and MOE are guidelines rather than strict thresholds. Development of these guidelines is largely based on scientific literature. That body of literature can have data gaps and include biological variability, creating uncertainty. To counter this uncertainty, guidelines have built-in safety factors and should be considered conservative.

Furthermore, the benefits of eating salmon should not be overlooked. Salmon is important to heart, brain and eye health. It can lower blood pressure and reduce the risk of coronary disease and stroke and promotes mental ability. In addition, salmon is an important source of vitamin D and dietary metals and minerals. Negative health effects could be expected if reductions in fish consumption and shifts in diet occur.

Ecological Context

To put these results into context, potential sources of metals and the means by which these metals are taken up by the fish need to be considered.

In general, levels of metals in water are largely influenced by the geology of the metals that the water flows over and through. High iron levels in groundwater and surface water are known to occur throughout BC. Water samples collected from the Fraser River have consistently shown high levels of total iron, often above provincial water quality guidelines. For example, of the 32 samples collected between 1985 and 1991 near Marguerite BC, 27 samples had levels above these guidelines. For total iron the provincial guideline to protect aquatic life is 1.0 mg/L, while the average level of total iron for the samples at Marguerite was 2.18 mg/L. Mercury can also be naturally occurring through weathering of mercury deposits. For example, the cinnabar formation of the Pinchi Fault near Fort St. James is well known. Water quality sampling at Marguerite also included mercury, with average levels ranging between 0.005 ug/L and 0.41 ug/L. While less abundant in the water column, mercury is often deposited in sediments and can be found in unpolluted lakes and rivers.

Metals can also be introduced by man-made sources through industrial and agricultural activities, of which there are numerous sources within the Fraser River watershed. Point sources include effluent discharges from paper and pulp mills in Prince George and Quesnel, the chemical plant in Prince George, and municipality waste water (Vanderhoof, Prince George, Quesnel, and Williams Lake) and the Gibraltar Mine. Non-point sources such as

run-off from agricultural areas and forestry activities can also impact water quality, increasing sedimentation and contributing to higher levels of total metals within the watershed.

Metals are taken up by fish through the food chain. Benthic invertebrates ingest metals from sediment and from the water column. Salmon then eat these benthic invertebrates and other fish that have increased metal levels within their tissues. Over time, metals accumulate in salmon tissue. Given the life-history of pacific salmon, the majority of metal accumulation occurs in the ocean environment; however, metals may also accumulate in the tissue of smolts within their natal streams. It is anticipated that exposure to various effluent discharges during migration of smolts to the ocean will have little influence on metal uptake because of the short duration of their runs. Smolts have been determined to travel downstream at average speeds of 33.6 km/day (Melynchuk *et. al.* 2010). Upon returning to the Fraser River, adult salmon do not feed during their migration to spawning grounds and therefore do not accumulate additional levels of metals in their tissues.

Recommendations

As a required component of the Environmental Effects Monitoring program, it is expected that the salmon tissue sampling program will continue with the objective to provide information to First Nations regarding the safety of consuming fish captured at traditional fishing sites. The following suggestions may be taken into consideration to add additional value to the tissue sampling program in future years.

- **Continuation of the fish tissue monitoring program.** There is value in continuing with the monitoring program to track metal accumulation in fish tissue over time to identify long-term trends. An increase in the size of the dataset may also reduce variability and enhance trend detection. Historical levels of metals in Fraser River salmon could be considered when increasing the size of the dataset. Additional options to increase the dataset may include involvement with other First Nation groups and/or potential partnerships with the province and Fisheries and Oceans Canada. For example, the Fraser River Aboriginal Fisheries Secretariat has been testing salmon in conjunction with the First Nations Health Authority in response to the Mount Polley spill. However, metal levels in adult salmon tissue cannot be linked to potential effects of specific point-source discharges, including Gibraltar's effluent discharge, due to the life cycle and wide range of individual salmon. For this reason, pathways to metal uptake such as within water and invertebrate tissue are sampled through the mine's environmental effects monitoring program.

- **Improved details on consumption rates.** Salmon consumption rates should be confirmed by local First Nations. This should include weekly frequency and average portion sizes for adults and children. This information can be used to refine the potential for human health risks.

Closure

We trust that this memorandum meets the objective of the program: to provide information to First Nations with respect to safety of consuming fish caught at traditional fishing sites near the discharge location of Gibraltar Mine. We would like to acknowledge the participation of the Xatśūll and ?Esdilagh First Nations and the Northern Secwepemc te Qelmucw (NStQ) in partnership with Gibraltar Mines Ltd that made this program possible. Special thanks to Dr. Elmar Plate from LGL in providing considerations for potential risks to human health.

Yours truly,

EDI Environmental Dynamics Inc.

Submitted electronically

Hanna Van de Vosse, B.Sc., R.P.Bio.,
Senior Biologist

References

Chan, L., O. Receveur, D. Sharp, H. Schawrtz, A. Ing, and C. Tikhonov (FNES). 2011. First Nations food, nutrition and environment study (FNFNES): Results from BC (2008/2009). Prince George, UNBC.

Environmental Monitoring System Web Reporting (EMS WR). 2016. Provides data access to Environmental Monitoring System. Available at http://www.env.gov.bc.ca/emswr/. Accessed January 9, 2017.

Health Canada. 2016. Mercury in Fish: Consumption Advice: Making Informed Choices about Fish. http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/mercur/cons-adv-etud-eng.php

Inter-Organization Programme for the Sound Management of Chemicals (IOMC). 2008. Guidane for identifying populations at risk from mercury exposure. Issued by UNEP DTIE Chemicals Branch and WHO Department of Food Safety. Geneva. http://www.who.int/foodsafety/publications/chem/mercuryexposure.pdf?ua=1

Melnychuck. M.C., D.W. Welch, and C.J. Walters. 2010. Spatio-temporal migration patterns of pacific salmon smolts in rivers and coastal marine waters. PloS ONE 5(9): e12916. Dol:10.1371/Journal.pone.0012916

Nagpal, N.K., 1989. Ambient water quality criteria for mercury: technical appendix. Prepared for BC Ministry of Environment.

National Research Council (NRC). (2000): Toxicological Effects of Methylmercury. Washington, DC: National Academy Press.

Phippen, B., C. Horvath, R. Nordin, and N. Nagpal. 2008. Ambient water quality guidelines for iron. Prepared for BC Ministry of Environment, Water Stewardship Division.

Shandro, J., M. Winkler, L. Jokinen, and A. Stockwell. 2016. Health impact assessment for the 2014 Mount Polley Mine tailings dam breach: Screening and scoping phase report. Prepared for the First Nations Health Authority, January 2016.

Swain, L.G., D.G. Walton, W.Obedkof. 1997. Water Quality Assessment and Objectives for the Fraser River from Moose Lake to Hope. Prepared for BC Ministry of Environment, Lands and Parks.