Memorandum

Date:	December 22, 2017
To:	R. Brent Murphy, M.Sc., P.Geo., VP Environmental Affairs Seabridge Gold Inc.
From:	Amy Elliott Ph.D., and Gareth Wolff, B.Sc., P.Geo.
Cc:	Deborah Muggli, Ph.D., M.Sc., R.P.Bio.
Subject:	**Predicted Water Quality and Loadings to the Unuk River**

1. INTRODUCTION

The proposed KSM Project (the Project) will develop a large gold reserve in the coastal mountains of northwestern British Columbia (B.C.). The north and west areas of the Project, which include the Mine Site area and proposed Water Treatment Plant (WTP), are within the Unuk River watershed, which crosses into Alaska and discharges into Burroughs Bay and eventually the Pacific Ocean. The Project has successfully gone through the Provincial and Federal processes and the appropriate certificates/approvals have been obtained. Permits for early stage construction activities have also been obtained.

ERM was requested to provide a comparison of predicted water quality and metal loadings of waters flowing into Alaska under existing (baseline) conditions and during development of the Project, when the proposed WTP is operating and discharging to Mitchell Creek. The WTP is located at the proposed Mine Site, which is located south of the closed Eskay Creek Mine, within the Mitchell, McTagg, and Sulphurets Creek valleys (Figure 1). Sulphurets Creek is a main tributary of the Unuk River. Along its flow path to its confluence with the Unuk River, Sulphurets Creek flows receive inputs from several tributaries, the largest being Mitchell Creek.

2. METAL LOADINGS & WATER QUALITY TO ALASKA

High concentrations of metals naturally occur in surface waters around the Project area, particularly in Mitchell Creek, due to the extensive natural sulphide mineralization in the area. Mining activity would increase the potential for metal leaching and acid rock drainage at the Mine Site by exposing sulphide-rich rock. For this reason, Seabridge will manage not only water that has been in contact with mining activities, but other naturally poor water quality in the Mine Site area. An extensive water management system will divert clean water away from the Mine Site, and collect contact water to be stored and treated by the WTP, which, in turn, will be released to Mitchell Creek.

A comparison of WTP effluent quality, existing water quality of Mitchell Creek, and water quality guidelines is presented in Table 1. These data highlight that:

a) existing waters of Mitchell Creek currently flowing into the Unuk River via Sulphurets Creek are naturally high in metals;
b) existing concentrations of water quality parameters in Mitchell Creek are above both applicable B.C. and Alaskan guidelines for the Protection of Aquatic Life; and
c) WTP effluent is of better quality than the existing water quality of Mitchell Creek, indicating that Project effluent represents an improvement over natural background conditions. That is, WTP discharges to Mitchell Creek throughout the life of the KSM Project will improve water quality (dilution) and largely decrease metal loadings in waters flowing into Alaska via Mitchell Creek, Sulphurets Creek and the Unuk River.

Table 1. Comparison of Water Treatment Plant (WTP) Effluent Quality, Existing Water Quality of Mitchell Creek, and Water Quality Guidelines (mg/L)

Water Quality Parameter	B.C. Water Quality Criteria -- Fresh Water [a]		Alaska Water Quality Criteria -- Fresh Water [b]		Average Annual Baseline Water Quality, Mitchell Creek	WTP Effluent Quality
	Short-Term (Acute)	Long-Term (Chronic)	Acute	Chronic		
Copper	0.018	0.007	0.023	0.015	0.91	0.0046
Lead	0.16	0.0097	0.164	0.005	0.0095	0.00067
Selenium	-	0.002	-	0.005	0.0042	0.001[c]
Iron	0.35	-	-	-	6.1	0.025
Cadmium	0.001	0.0003	0.003	0.0004	0.013	0.000108
Zinc	0.07	0.039	0.19	0.19	0.99	0.0025
Manganese	2.5	1.4	-	-	1.2	0.00302
Cobalt	0.004	0.11	-	-	0.017	0.00025

Notes:
Hardness-dependent guidelines are calculated using average annual hardness of Mitchell Creek (173 mg CaCO3 /L ; MC1B)
[a] represent working and approved BC MOE guidelines for the Protection of Aquatic Life (BC MOE 2015; BC MOE 2016). Applicable guidelines for dissolved concentrations are presented for iron and cadmium.
[b] Alaska State Metals Guidelines adapted from Parnell and Hartig (2008)
[c.] Se concentrations represent discharges from the Se-IX Plant (0.001 mg/L), which are at or below existing concentrations for total Se in Mitchell Creek.
***Red font** indicates that baseline water quality of Mitchell Creek is greater than Alaska Water Quality Criteria for Fresh Water*

Figure 2 and Figure 3 expand on bullet c), *above*, to further demonstrate that WTP discharges throughout the life of the Project will largely improve water quality and decrease metal loadings of waters flowing into Alaska via Sulphurets Creek and the Unuk River.

A comparison of metal loadings (lb/year) and water quality (mg/L) of Sulphurets Creek waters flowing into the Unuk River under existing (baseline) conditions and during development of the Project is presented in Figure 1. Shown are annual averages for existing conditions and for Project Years 5, 20, 40, and the end of mine life (EOM, Year 57+). Similarly, Figure 2 presents a comparison of metal loadings and water quality of the Unuk River waters flowing into Alaska under existing

(baseline) conditions. These figures show that when the proposed WTP is discharging to Mitchell Creek (Years, 5, 20, 40, and EOM), downstream metal loadings in Sulphurets Creek, the Unuk River, and through to Alaska are largely reduced and predicted water quality improves relative to existing conditions.

Note, selenium concentrations are predicted to slightly increase relative to existing conditions, particularly in a localized, non-fish bearing area immediately downstream of the Mine Site in Sulphurets Creek (SC2, and extending 1.5 km downstream to a monitoring site in the Unuk River). However, selenium concentrations are expected to meet receiving environment water quality standards at a regional scale, including at the B.C./Alaska border, 35 kilometres downstream of the Mine Site. Specifically, the concentration of selenium predicted downstream of the Project is lower than applicable guidelines: less than 5 µg/L (Alaskan guideline, Table 1) in the Unuk River just downstream of Sulphurets Creek, and less than 2 µg/L (B.C. guideline, Table 1) in the Unuk River near the Alaska border. The reason for the slight increase in selenium concentrations relative to existing conditions is that concentrations in the contact waters collected, stored, and treated by the WTP are predicted to increase over operations of the Project. This is related to the progression of open pit mining and block caving; selenium concentrations decrease again as the underground and pit flood at closure (Figure 1, Figure 2). The selenium treatment plant (Se-IX) treats up to 500 L/s of these contact waters to 0.001 mg/L, preferentially treating contact waters with the highest selenium concentrations, but does not treat all of the contact waters collected, stored, and treated by the WTP. While selenium concentrations will be minimized in the Unuk River by staging the WTP discharge to seasonal flows, predicted WTP effluent concentrations can be greater than existing concentrations of Mitchell Creek, which results in slight increases downstream. Selenium concentrations in Mitchell Creek, Sulphurets Creek and the Unuk River were the focus of the water quality effects assessment during the Application/EIS review. The reduced concentrations as a result of the 500 L/s Se-IX resulted in Project effects that were deemed by the provincial and federal agencies to be not significant and the Project received both provincial and federal approvals.

Similarly, dissolved iron concentrations are predicted to very slightly increase relative to existing conditions. This is related to high degree of conservatism incorporated into the model predictions and iron concentrations are likely to be overestimated. Specifically, unlike what is observed naturally in surface waters around the Project area, no attenuation or precipitation is incorporated into these predictions, which will reduce predicted iron loadings and concentrations along Mitchell Creek, Sulphurets and Unuk river flow pathway. In this case, iron loadings are result of conservative assumptions assigned to diversion tunnels that will route the majority of the non-contact runoff and glacial meltwater around the Mine Area, as well as uncaptured seepage beyond the seepage collection dams.

REFERENCES:

BC MOE. 2015. *Working Water Quality Guidelines for British Columbia (2015).* British Columbia Ministry of Environment, Water Protection & Sustainability Branch: Victoria, BC.

BC MOE. 2016. *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture: Summary Report*. British Columbia Ministry of Environment, Water Protection & Sustainability Branch: Victoria, BC.

Parnell S., Hartig L. 2008. Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances. State of Alaska, Department of Environmental Conservation.

Figure 1
KSM Mine Site Area and Select Monitoring Locations on Sulphurets Creek and the Unuk River

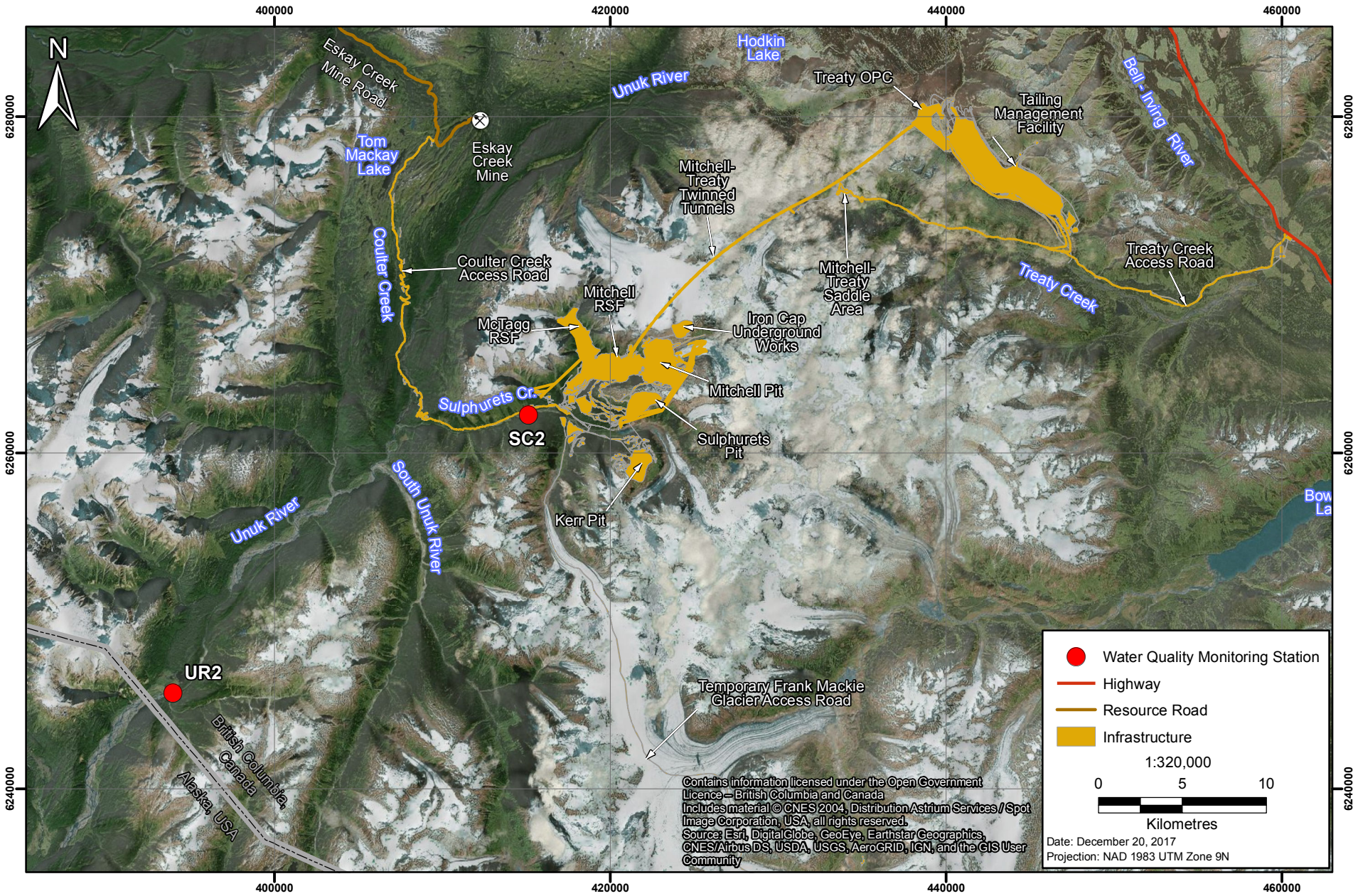
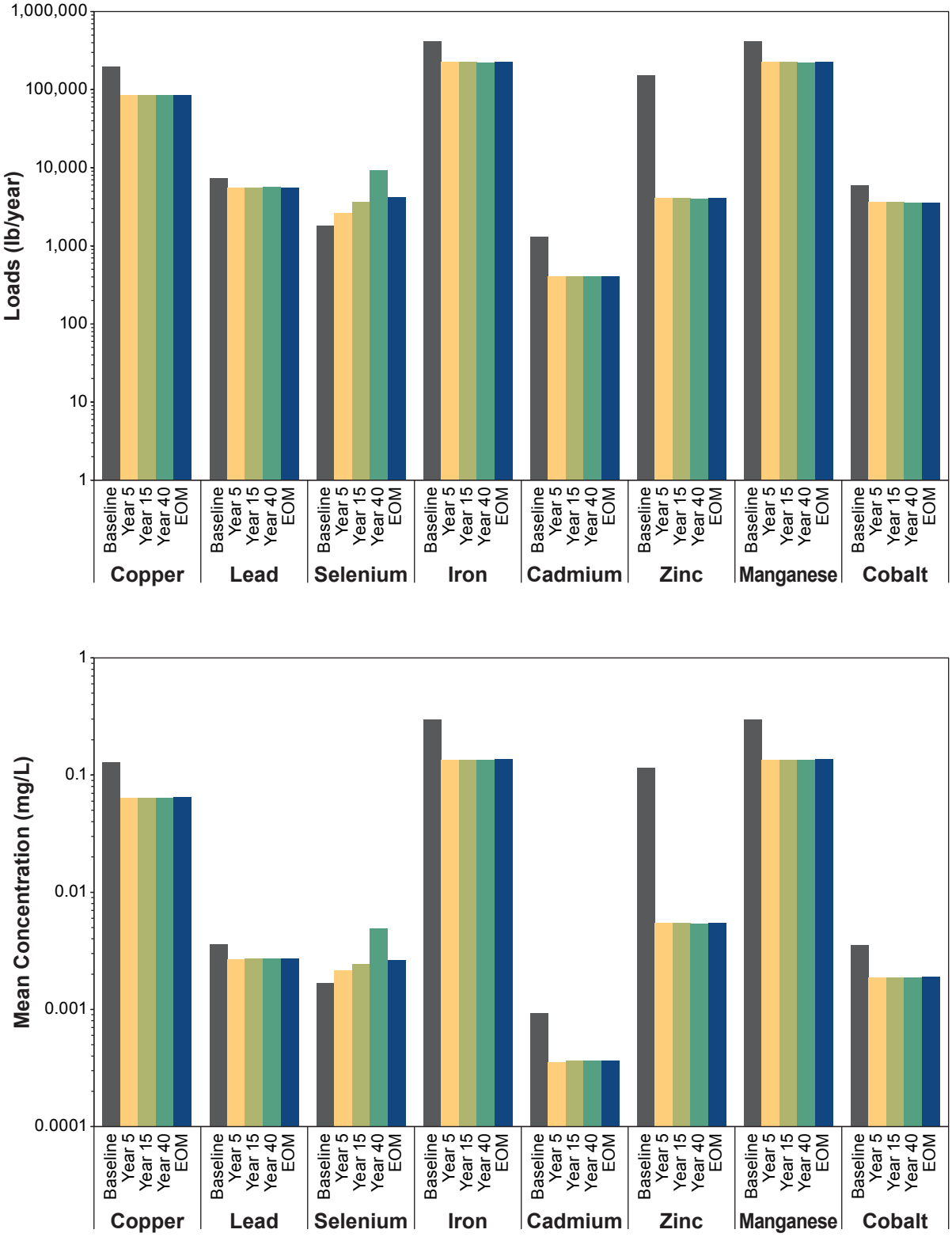


Figure 2

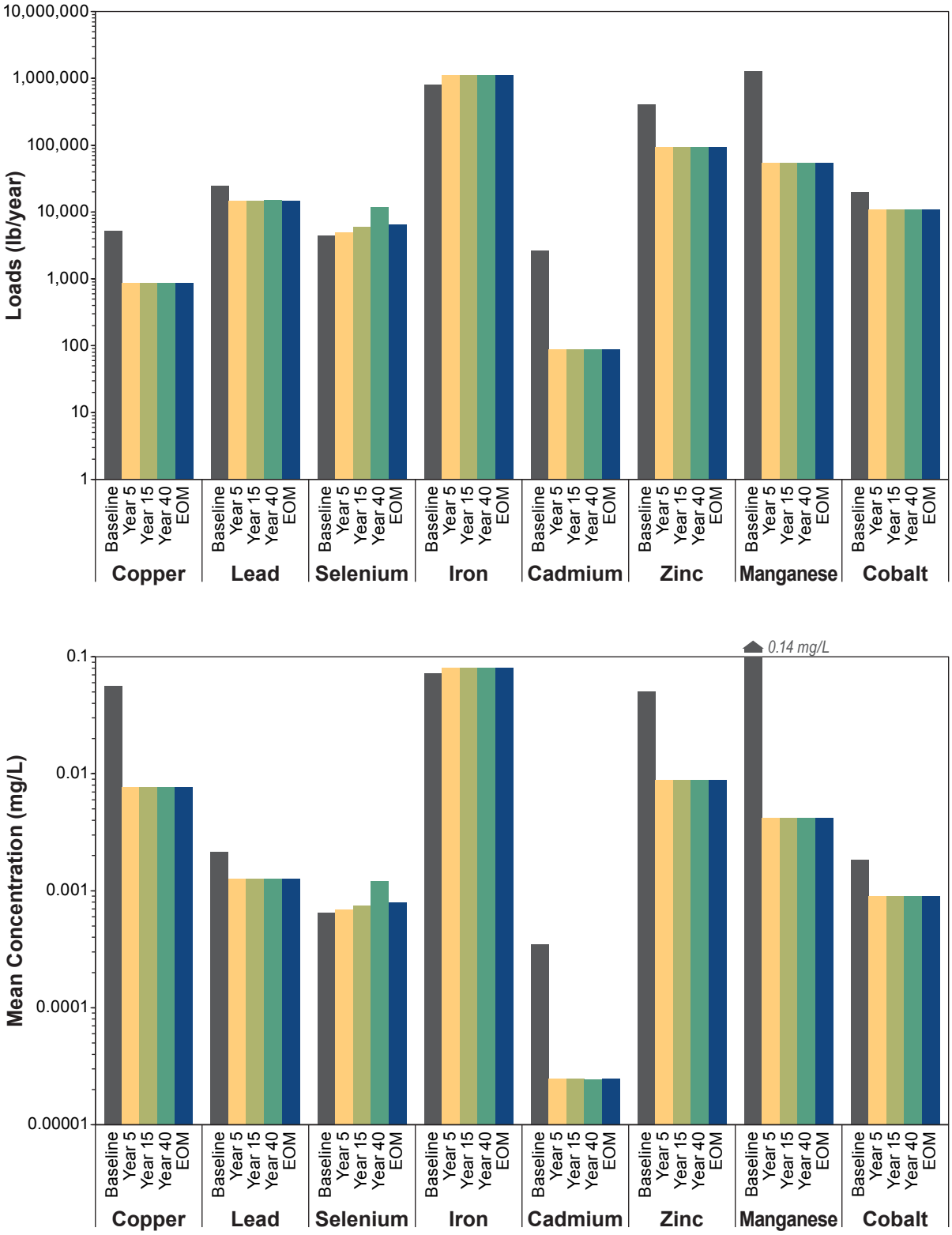
Annual Baseline and Predicted Loads (lb/year) at upper Sulphurets Creek, at the confluence of Mitchell Creek (Station: SC2)



Note: Copper loads are presented as /100 for figure clarity purposes.

Figure 3

Annual Baseline and Predicted Loads (lb/year) at Unuk River through to the Alaska Border (Station: UR2)



Note: Copper loads are presented as /100 for figure clarity purposes.