DRAFT Technical Memorandum

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Subject: Evaluation of Aquatic Life Criteria for Copper Using the Biotic Ligand Model for the Stibnite Gold Project

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Introduction

The United States Environmental Protection Agency (EPA) recently approved Idaho's request to utilize the Biotic Ligand Model[1] (BLM) for determining aquatic life freshwater quality criteria for copper for Idaho Pollutant Discharge Elimination System (IPDES) permit limits; thus, the BLM is now in effect for IPDES permitting purposes, replacing the former hardness-based copper criteria (Idaho Administrative Procedures Act [IDAPA] 58.01.02.210). Previously, calculation of hardness-based aquatic life freshwater quality criteria required only total hardness data from the receiving water. The BLM is substantially more complex and requires a dozen parameter values, not including copper itself, for the model to derive the criteria. The model input parameters are: temperature, pH, alkalinity, dissolved organic carbon (DOC), the humic acid fraction of DOC, calcium, magnesium, potassium, sulfate, sodium, chloride, and sulfide.

Midas Gold Idaho, Inc. (Midas Gold) expects the BLM to be used to derive site-specific copper limits for the IPDES permit issued for its Stibnite Gold Project (SGP). This document provides an evaluation of currently available data from the SGP site for the BLM and offers preliminary estimates of copper criteria that may be applicable to surface waters at the SGP site based on that data and Idaho Department of Environmental Quality (IDEQ) guidance. These estimates are meant to be used for planning purposes, while discharge permit limits for copper will be determined with IDEQ during the IPDES process.

Midas Gold Monitoring at Stibnite

As part of its environmental planning and baseline characterization efforts at the SGP site, Midas Gold has been monitoring surface water quality for more than seven years (2012 to present), including most of the parameters required to run the BLM. However, several of the BLM input parameters are not typically monitored and initially were not part of the suite of constituents that comprised the Midas Gold monitoring program. Specifically, the initial years of monitoring (2012 through May 2018) did not include analysis for DOC, the humic acid fraction of DOC, or sulfide. The Idaho Implementation Guidance for the BLM[1] notes that the humic acid fraction of DOC is seldom quantified and often quite low in surface waters, especially so for clear, mountain streams, and recommends using a value of 10 percent when site-specific data are unavailable. The guidance also notes that sulfide is normally very low in oxygenated surface waters and recommends using a very small non-zero value like 0.0000001 milligrams per liter (mg/L) in the absence of site-specific data. However, DOC is a primary component of the BLM calculations because it binds with copper directly and thus reduces its bioavailability to organisms. In waters with low copper concentrations, even small amounts of DOC afford reductions in copper toxicity. At the SGP site, DOC does not directly correlate with other constituents that were collected during early monitoring and cannot be estimated for those events; thus, only those post-May 2018 samples that include concurrent DOC monitoring are suitable for the BLM calculations at the SGP site.

Midas Gold added DOC to its surface water monitoring program in June 2018 in response to the Idaho Legislature's adoption of BLM as the Idaho copper criteria methodology (effective under Idaho law on March 28, 2018; approved by EPA on May 2, 2019). The humic acid fraction and sulfide were not added to the monitoring program at that time because the model guidance offered default values that were acceptable to Midas Gold.

[1] From the August 2017 Idaho Implementation Guidance for the Idaho Copper Criteria for Aquatic Life (http://www.deq.idaho.gov/media/60180619/58-0102-1502-implementation-guidance-copper-criteria-0817.pdf):
The BLM version 3.1.2.37 and associated user's guide can be downloaded from www.windwardenv.com/bioticligand-model/. More information can be found in the BLM user's guide (Windward 2015).

Ongoing monitoring at the SGP site is conducted quarterly. Five samples that include concurrent DOC monitoring are currently available per station. Seasonal variability for several parameters, including DOC, is apparent in the small data set (June 2018 – May 2019, 5 samples) currently available for the SGP (Table 1). The BLM guidance points to the importance of thoroughly characterizing the receiving waters, recommending at least 24 months of sampling to characterize seasonal and interannual variability. The current quarterly sampling program will not meet BLM guidance for the frequency and duration of sampling, but IDEQ has indicated that any IPDES permit will likely include a monthly monitoring condition for a period of time to adequately characterize the stream conditions and determine the copper discharge limit for SGP outfalls.

Copper Biotic Ligand Model Methodology

For IPDES permitting purposes, the BLM guidance points to the derivation of two aquatic life criteria – a Criterion Maximum Concentration (CMC) or acute value for the daily maximum concentration and a Criterion Continuous Concentration (CCC) or chronic value for the monthly average. These would apply to a single compliance point in the receiving waters associated with a point source discharge, rather than a set of criteria based upon an entire water body Assessment Unit that might be developed in establishing a Total Maximum Daily Load. Outfall locations have not yet been finalized; thus, Brown and Caldwell (BC) used the BLM to calculate criteria for three locations on the East Fork of the South Fork of the Salmon River (EFSFSR) for planning purposes only:

1. Station YP-SR-13 on the upper portion of EFSFSR and downstream of the approximate proposed location of the proposed IPDES sanitary wastewater outfall near the employee housing facility
2. Station YP-SR-8 on the EFSFSR downstream of the proposed Tailings Storage Facility, Hangar Flats pit, Hangar Flats development rock storage facility (DRSF), Ore Processing Facility, and the approximate proposed location of the proposed IPDES industrial wastewater outfall
3. Station YP-SR-2 on the EFSFSR below its confluence with Sugar Creek, and downstream of the Fiddle DRSF, Yellow Pine pit, and West End pit, and effectively downstream of the entire SGP site

Biotic Ligand Model Input and Output

Input data used in the BLM are provided in Table 1, and model output for each run is shown in Table 2. Table entries in italics are default values from the BLM guidance. It is evident from Table 2 that BLM copper criteria generated from this limited input data set show considerable variation. BC explored the model output with respect to the input data and noted that a substantial portion of the variability in calculated criteria is associated with variability in the DOC input values. Currently, the volume of DOC monitoring data is small, which puts some limitations on our ability to characterize the relationships between BLM inputs and the calculated copper criteria values. As stated above, the BLM guidance recommends a larger input data set than is currently available to derive acute and chronic criteria values for use as IPDES permit limits.

Because Midas Gold has monitored most BLM input parameters from 2012 through early 2019, it is tempting to assume there could be a way to conduct additional BLM model runs of data prior to June 2018 with estimated or extrapolated values for DOC. However, because of the limited amount of DOC data on which to base any extrapolations, the results of extrapolating the BLM backwards are dubious and not suitable for deriving regulatory criteria. For example, if a single value of DOC (e.g., the mean of reported values for the station) is assigned to all prior records without a DOC value, then the BLM-derived copper criteria all co-vary closely with pH. Because the available data are not sufficient to characterize the relationship between pH and DOC, this is not an acceptable approach for deriving BLM-based copper criteria. The Idaho BLM guidance cautions that using estimates for missing data can lead to overly stringent

criteria.[2] Therefore, until additional DOC data are available from ongoing or post-permit monitoring, the values in Table 2 comprise the best available information for estimating IPDES permit limits from site-specific data. Based upon the nature and distribution of the BLM output values, the guidance offers several different approaches for establishing protective but reasonable criteria.

Biotic Ligand Model Discussion

The limited stream data that is available for the SGP site provides some estimates of potential copper criteria for the EFSFSR at these locations, although there is not enough data collected to set the criteria at this time. Values toward the lower end of ranges in in Table 2 suggest chronic and acute criteria on the order of 2.6 micrograms/liter (µg/L) and 4.2 µg/L, respectively, in the vicinity of Station YP-SR-8 (the general location of plant site discharge). The values in Table 2 also suggest chronic and acute criteria on the order of 1.5 µg/L and 2.5 µg/L, respectively, in the vicinity of Station YP-SR-13 (the general location of worker housing facility discharge); however, copper is not a parameter of concern for the worker housing facility discharge location, which will generate only conventional domestic wastewater associated with typical residential activities. The Idaho BLM guidance points to the determination of conservative criteria, but acknowledges it is possible to derive criteria that are overly protective. Given the limitations of the current data set, we also looked to the Idaho BLM guidance and the previous hardness-based criteria calculation method to make our evaluation of potential copper criteria more robust.

Both sets of values noted above would also be protective of aquatic life at YP-SR-2 (downstream of all proposed SGP mine activities), which had generally higher BLM-based criteria from the available data (Table 2). Importantly, these values correspond well with conservative criteria estimates provided in the Idaho BLM guidance for third-order streams (the EFSFSR is a third-order stream from the Meadow Creek confluence to its exit from the SGP site) and for the Salmon River Basin overall.[3] The Idaho BLM guidance gives estimates of conservative chronic and acute criteria of 2.5 µg/L and 4.0 µg/L, respectively, for third-order streams and 2.4 µg/L and 3.9 µg/L for the Salmon River basin. This suggests that the currently available site-specific data used to derive criteria for the SGP site aligns with the much broader data set used by Idaho for the same size streams and for the Salmon River watershed.

The Idaho BLM guidance also provides a comparison of copper criterion values derived from the BLM with those resulting from the former hardness-based criteria method. Hardness monitoring of the EFSFSR reflects relatively low hardness, with values ranging from less than 10 mg/L to around 250 mg/L and a median of about 40 mg/L. In addition, 40 mg/L is approximately the 5th percentile hardness measured in the EFSFSR during the driest 4 months of the year. IDAPA 58.01.02 sets the minimum hardness value for the methodology at 25 mg/L. Using 25 mg/L as a very conservative hardness level would yield a chronic copper criterion of 3.5 µg/L and an acute value of 4.6 µg/L (using the EFSFSR 5th percentile hardness in the four dry months of 40 mg/L would result in higher criteria). Thus, the BLM calculation, BLM guidance, and hardness-based approaches are in close agreement for the SGP site, based on the available data and conservative assumptions.

Summary

Midas Gold understands that copper limits for its IPDES permit will be derived using the BLM. There is currently very little site-specific DOC data for the SGP site, which is a key input for the BLM. Preliminary BLM

[2] See August 2017 Idaho Implementation Guidance for the Idaho Copper Criteria for Aquatic Life, Page 22 (http://www.deq.idaho.gov/media/60180619/58-0102-1502-implementation-guidance-copper-criteria-0817.pdf)

[3] See August 2017 Idaho Implementation Guidance for the Idaho Copper Criteria for Aquatic Life, Table 2 (http://www.deq.idaho.gov/media/60180619/58-0102-1502-implementation-guidance-copper-criteria-0817.pdf)

runs were made using the available data. Published guidance from IDEQ was also consulted, from which conservative criteria can be obtained based upon stream magnitude and the specific watersheds. In addition, calculations were made using the former method of calculating criteria based on site-specific water hardness. Each of the three approaches led to preliminary criteria estimates on the order of 1.5 to 3 µg/L as chronic criteria and 2.5 to 5 µg/L as acute criteria. Midas Gold anticipates a requirement for additional monitoring of BLM input parameters during the initial IPDES permit cycle to allow for more definitive criteria to be developed for future permit renewals.

Table 1. Input Data Used in Copper BLM for Midas Gold Stibnite Gold Project, 2018-2019

Station	Sample	Temperature (°C)	pH (SU)	Cu (µg/L)	DOC (mg/L)	HA (percent)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Alkalinity (mg/L)	S^{2-} (mg/L)
YP-SR-13	June 2018	6.04	8.47	0.24	1.17	*10*	5.74	1.27	1.37	0.53	0.96	0.20	24	*1.00E-10*
	August 2018	7.79	7.38	0.10	0.84	*10*	8.36	2.43	1.37	0.50	1.44	0.20	39	*1.00E-10*
	October 2018	4.50	7.85	0.37	1.00	*10*	9.69	2.47	1.56	0.77	1.70	0.46	40	*1.00E-10*
	January 2019	0.06	7.44	0.23	1.00	*10*	9.30	2.67	1.68	0.67	1.98	0.20	41	*1.00E-10*
	May 2019	2.92	6.91	0.37	2.80	*10*	5.62	1.22	1.57	0.61	1.08	0.20	24	*1.00E-10*
YP-SR-8	June 2018	9.09	8.07	0.23	1.26	*10*	6.41	1.22	1.58	0.61	2.88	0.22	25	*1.00E-10*
	August 2018	9.29	7.83	0.26	0.83	*10*	11.70	2.83	2.45	0.80	6.01	0.62	45	*1.00E-10*
	October 2018	3.91	7.86	0.46	1.50	*10*	12.60	2.93	2.47	0.96	7.10	1.03	45	*1.00E-10*
	January 2019	0.82	8.06	0.30	1.00	*10*	12.90	3.26	2.85	0.88	9.61	1.04	46	*1.00E-10*
	May 2019	6.28	7.68	0.37	2.60	*10*	7.34	1.64	1.90	0.71	5.63	0.32	27	*1.00E-10*
YP-SR-2	June 2018	6.08	7.62	0.21	1.22	*10*	8.42	1.57	1.52	0.56	4.04	0.21	31	*1.00E-10*
	August 2018	13.88	8.00	0.24	0.73	*10*	15.40	3.45	2.39	0.98	8.97	0.39	53	*1.00E-10*
	October 2018	5.12	7.85	0.12	1.20	*10*	16.40	3.52	2.39	1.02	10.40	0.79	55	*1.00E-10*
	January 2019	0.72	8.21	0.16	1.00	*10*	17.00	3.81	2.51	0.87	12.20	0.66	58	*1.00E-10*
	May 2019	6.29	8.39	0.92	2.30	*10*	9.58	1.84	1.75	0.64	2.79	0.20	30	*1.00E-10*

Note: Numbers in italics for the humic acid (HA) portion of DOC and sulfide (S) are default values from the BLM guidance.

Abbreviations:

°C = degrees Celsius
BLM = Biotic Ligand Model
Ca = calcium
Cl = chlorine
Cu = copper
DOC = dissolved organic carbon
HA = humic acid
K = potassium
Mg = magnesium
mg/L = milligram(s) per liter
µg/L = microgram(s) per liter
Na = sodium
S^{2-} = sulfide
SO_4 = sulfate
SU = standard unit

Table 2. Output Results from Copper BLM for Midas Gold Stibnite Project, 2018-2019

Station	Sample	CMC (µg/L)	CCC (µg/L)	Station	Sample	CMC (µg/L)	CCC (µg/L)	Station	Sample	CMC (µg/L)	CCC (µg/L)
YP-SR-13	June 2018	9.88	6.14	YP-SR-8	June 2018	8.11	5.04	YP-SR-2	June 2018	4.80	2.98
	August 2018	2.48	1.54		August 2018	4.20	2.61		August 2018	4.58	2.84
	October 2018	5.03	3.12		October 2018	7.61	4.73		October 2018	6.09	3.78
	January 2019	3.16	1.96		January 2019	6.01	3.73		January 2019	6.71	4.17
	May 2019	4.32	2.69		May 2019	11.18	6.94		May 2019	18.12	11.26

Abbreviations:

BLM = Biotic Ligand Model

CCC = Criterion Continuous Concentration

CMC = Criterion Maximum Concentration

µg/L = microgram(s) per liter