The University of British Columbia

Department of Zoology
6270 University Boulevard
Vancouver, BC Canada V6T 1Z4
Tel: 604-353-4097
Fax: 604-822-2416
brix@zoology.ubc.ca

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Michael Harstone
Compass Resource Management
#200-1260 Hamilton Street
Vancouver, BC V6B 2S8

Dear Michael,

In the following, I provide comments on the three workplans provided as part of work package 2a. Overall, I found the workplans to be well developed and scientifically sound. The comments below are in addition to those provided as technical advice to Teck during TAC Meeting #2, although there is some overlap, as I wanted to ensure my comments were fully documented.

Selenium Workplan

Section 2.1, Bullet 2: A number of studies have now shown that selenomethionine is not always the dominant organo-Se form in tissues (Misra et al. 2010). Other forms (e.g., selenocysteine) can also be important and these forms have different toxicities compared to selenomethionine.

Section 2.1, Bullet 4: It should be clarified that sulphate antagonism of Se accumulation appears to be largely limited to selenate (Brix et al. 2001).

Page 4, Top Paragraph: The recent study by Conley et al. (2013) suggests that some invertebrates (e.g., mayflies) are comparable in sensitivity to vertebrates. Some of the toxicity testing performed with mayflies also suggests they may be sensitive to Se at instream concentrations (see NO_3/SO_4 workplan). Given this, its seems premature to rule out this pathway in the ecological effects matrix. At a minimum, an explicit analysis of this pathway should be included in the ecological effects matrix and depending on the details of the toxicity testing (to be provided by Teck) where effects were observed, additional studies may be necessary.

Cadmium Workplan

Page 11, 2nd Paragraph: Given the site waters will be a mixture of contaminants it is not clear how any observed toxicity can be associated with Cd. Additionally, 3 of the 4 taxa to be used in testing for the NO_3/SO_4 program are not particularly sensitive to Cd, especially using the short-term chronic tests described in the workplan. Even for *Hyalella*, the 14-d test design described in the workplan is unlikely to be as sensitive as the 42-d test design that generated the toxicity data that is currently driving the Cd WQG.

It is critical that Teck properly validate the Cd BLM developed for this site. To do this, Teck will need to conduct experiments in which site waters with varying water chemistry (reflecting both spatial and temporal variability) are spiked with concentrations of Cd and toxicity testing is performed with a sensitive organism/endpoint. I would avoid the 7-d test with *Ceriodaphnia* test for this validation as the YCT food (a source of DOC with low binding affinity) will confound results (this is likely why *C. dubia* are apparently relatively insensitive to Cd). Instead, I recommend either a 14 or 28-d *Hyalella* test (preferable) or the 21-d test with *Daphnia magna* for this validation study. The critical issue in test organism/endpoint selection is that it is comparable in sensitivity to the Cd WQG and therefore critically evaluating whether the BLM can predict how transport proteins involved in Cd uptake at these concentrations are interacting with the environment (see next comment).

Page 12, 1st Paragraph: I understand that previous efforts to develop chronic BLMs from existing acute BLMs have generally relied on adjusting LA50s (i.e., effectively extrapolating to an LA10/20) rather than log K's for metals. Conceptually of course this makes sense and an increase in intrinsic sensitivity is highly likely to explain some of the differences between acute and chronic toxicity. However, there is increasing evidence that multiple transport proteins are involved in metal uptake with different transporters dominant over the range of concentrations involved in acute toxicity versus chronic toxicity (i.e., low versus high affinity transporters). This is certainly the case for Zn (Hogstrand et al. 1998, Qui et al. 2005), and Cd is often considered a Zn analog. Hence the conditional log K's derived by Playle et al. (Playle and Dixon 1993, Playle et al. 1993) based on exposures with 6 $\mu g\ l^{-1}$ Cd, are not necessarily relevant to organisms exposed to Cd concentrations an order of magnitude lower, near the WQG. Of course, differences in the log $K_{gill\text{-}Cd}$ will influence how the BLM predicts interactions with other water quality parameters and hence is important to understand. This issue highlights the need for some sort of field validation program to test the reliability of the chronic Cd BLM.

Nitrate/Sulphate Workplan

Page 7, 2nd Bullet: While I recognize that CCME has stated in the WQG that nitrate toxicity may be caused inhibition of O_2 transport via the formation of methaemoglobin, this is not accurate. Nitrate does not appear to induce

methaemoglobin formation. Most nitrate studies do not detect any methaemoglobin formation. In the few studies where it has been detected, the increase is too small to induce toxicity and is attributed to the metabolism of NO_3 to NO_2, which is well documented to increase methaemoglobin formation.

Page 8, 3rd Bullet: Regarding the mechanisms of SO_4 toxicity, there is no evidence that SO_4 at environmentally relevant concentrations alters TEP. In fact the only study I'm aware of that has looked at this showed no changes to TEP at concentrations up to 60 mM SO_4 (as $MgSO_4$), far higher than those observed to cause toxicity (Wood and Grosell 2008). Note also, neither TDS or conductivity is a useful measure of the interactive effects of multiple ions on TEP as variations in ionic composition for waters with comparable TDS/conductivity will have very different effects on TEP.

Page 19, 1st Paragraph: Generally, these studies did not assess the interactive effects of other contaminants with Se, as the experiments generally did not include a dietary exposure pathway for Se or endpoints that are sensitive for Se (e.g., salmonid reproduction).

Page 30, Section 3.2.2.3: As discussed at TAC meeting #2, I am concerned about the exclusion of mayflies from the testing program, especially given the toxicity observed in one of the tests. It is important that Teck provides additional detail on these studies to support their rationale. Depending on these details, I may have additional comments/recommendations on this issue.

I appreciate the opportunity to provide these additional comments. If you should have any questions or concerns, please don't hesitate to contact me to discuss further.

Sincerely,

Kevin V. Brix

Kevin V. Brix, Ph.D.
University of British Columbia

References

Brix, K. V., J. S. Volosin, W. J. Adams, R. J. Reash, R. G. Carlton and D. O. McIntyre (2001). "Effects of sulfate on the acute toxicity of selenate to freshwater organisms." Environ. Toxicol. Chem. **20**(5): 1037-1045.

Conley, J. M., D. H. Funk, D. H. Hesterberg, L. C. Hsu, J. Kan, Y. T. Liu and D. B. Buchwalter (2013). "Bioconcentration and biotransformation of selenite versus selenate exposed periphyton and subsequent toxicity to the mayfly *Centroptilum triangulifer*." Environ. Sci. Tech. **47**: 7965-7973.

Hogstrand, C., N. Webb and C. M. Wood (1998). "Covariation in regulation of affinity for branchial zinc and calcium uptake in freshwater rainbow trout." J. Exp. Biol. **201**: 1809-1815.

Misra, S., D. Peak and S. Niyogi (2010). "Application of XANES spectroscopy in understanding the metabolism of selenium in isolated rainbow trout hepatocytes: insights into selenium toxicity." Metallomics **2**: 710-717.

Playle, R. C. and D. G. Dixon (1993). "Copper and cadmium binding to fish gills: modification by dissolved organic carbon and synthetic ligands." Can. J. Fish. Aquat. Sci. **50**: 2667-2677.

Playle, R. C., D. G. Dixon and K. Burnison (1993). "Copper and cadmium binding to fish gills: estimates of metal-gill stability constants and modelling of metal accumulation." Can. J. Fish. Aquat. Sci. **50**: 2678-2687.

Qui, A., M. Shayeghi and C. Hogstrand (2005). "Molecular cloning and functional characterization of a high-affinity zinc importer (*Dr*ZIP1) from zebrafish (*Danio rerio*)." Biochem. J. **388**: 745-754.

Wood, C. M. and M. Grosell (2008). "A critical analysis of transepithelial potential in intact killifish (*Fundulus heteroclitus*) subjected to acute and chronic changes in salinity." J. Comp. Physiol. B **178**: 713-727.