Avalon Rare Metals Inc.

RESPONSE TO THE SEPTEMBER 2012 ROUND 2 INFORMATION REQUESTS FROM THE MACKENZE VALLEY REVIEW BOARD FOR THE THOR LAKE RARE EARTH ELEMENT PROJECT DEVELOPER'S ASSESSMENT REPORT

Submitted To:
MACKENZIE VALLEY ENVIRONMENTAL IMPACT REVIEW BOARD

October 2012

Avalon Rare Metals Inc. (Avalon) is pleased to provide the following responses to the second round of Information Requests conveyed by the Mackenzie Valley Environmental Impact Review Board, Board (MVEIRB) dated September 22, 2012. Avalon's responses are found after each information request.

IR Number: **MVRB #2.01**
To: Avalon Rare Metals Inc.
Subject: Modeled Concentrations vs. SSWQOs
Source:
DAR, Section 6.3.4.2 Mine Operations, Figure 6.3-6
DAR, Section 6.4.2.5 Model Results, Table 6.4-2
DAR, Appendix C.13, Thor Lake Project – (Updated) Feasibility Study Water/Solids Balance Analysis Results, p.3, Water Management Constraints
Response to Deficiency MVEIRB #41 (Part 2)
Response to Information Request MVRB #1.2, TMF Tracer Concentrations
Avalon handout in the Technical Session titled "Day 1 & 2 (Aug 14 and 15), Nechalacho, Thor Lake, SSWQO's, Table "Rare Earth Element Concentrations"
Avalon response to Technical Session Homework Items #4, #5, and #10.

Preamble:

The table labeled "Rare Earth Element Concentrations" in the handout titled "Day 1 & 2 (Aug 14 & 15), Nechalacho, Thor Lake, SSWQO's" that Avalon presented during the Technical Session presents updated modeling results for the maximum concentrations of rare earth elements in Drizzle Lake and in Thor Lake over the life of the proposed mine and compares these results to Avalon's proposed Site Specific Water Quality Objectives (SSWQOs).

The table shows that the modeled concentrations exceed the values of the SSWQOs for cerium and lanthanum in Drizzle, Murky and Thor Lakes. The modeled concentrations exceed or nearly equal Avalon's proposed SSWQOs for iron, mercury, neodymium, and praseodymium in Drizzle Lake (in addition to the cerium and lanthanum mentioned above). Mercury may also exceed the SSWQO in Drizzle Lake.

<u>MVRB Request #2.01</u>

a) Given the much higher concentrations in the corrected modeling results, please explain how Avalon intends to meet the proposed SSWQOs.
b) During Day 1 of the Technical Session (14 August 2012), Avalon said "They're actually concentrations selected from the approximate centre of the water body, and it's spatially resolved in horizontal and vertical. But there's so much wind mixing, I guess

small amount of winds, that most of lakes were pretty well homogeneous in -- in plan view in terms of the concentration." Please clarify the definitions of the Modelled Maximum 20-yr Values shown in the table. For example, should the reported values for Drizzle Lake be interpreted as a fully-mixed average value for the lake? Should the reported values for Drizzle Lake be interpreted as essentially equal to the values at the outlet from Drizzle Lake which will be assessed against the SSWQOs? Should the reported values for Thor Lake be interpreted as essentially equal to the values at the outlet from Thor Lake?

c) The modeling shows that the concentrations in the lakes increase over the proposed 20 year life of the mine. Please predict, by extended tracer modeling or other means, the rate at which the lakes will recover to background conditions after mining operations cease.

Avalon Response #2.01

a) To assist in responding to this information request, the handout titled "Day 1 & 2 (Aug 14 and 15), Nechalacho, Thor Lake, SSWQOs" that Avalon presented during the Technical Session, which presented updated water quality modeling results for numerous parameters, is re-presented as Attachment 1 to this submission.

Avalon acknowledges that the corrected modeling results presented in the Attachment 1 tables indicate that the predicted concentrations of a few parameters, as identified by the MVEIRB, based on the "Worst Case" 5 Day Decant parameter concentrations, are shown in these tables to exceed Avalon's proposed SSWQOs. Nevertheless, it is important to note that for most of the predicted parameter concentrations presented in these tables, the 5 Day decant concentrations are predicted to be below the proposed SSWQOs before the effluent is released to the downstream receiving environment.

As previously indicated, Avalon remains fully committed to achieve MMER regulation requirements, as well as existing CCME guidelines at the outlet of Drizzle Lake, and has proposed Site Specific Water Quality Objectives based on CCME protocols for establishing such parameters for the suite of rare earth metals associated with the Thor Lake Project.

In addition, as previously indicated, the predicted concentrations presented in the Attachment 1 tables continue to represent the "Worst Case" potential condition. Avalon has stated that it will treat its effluent to achieve these criteria and guidelines if determined to be necessary, but remains optimistic that it will be able to optimize its mineral processes such that this will not be required. However, as a precaution, Avalon has developed the water treatment process and tested it using the worst case water collected from the March 2012 pilot plant.

This information, which was conveyed to MVEIRB in Avalon's Responses to Clarification letter dated May 10, 2012 provided treated water quality data that clearly demonstrate that the treatment technology will allow Avalon to achieve water quality to meet all of the above commitments. Tables 1 and 2 presented below provide comparative effluent quality data for the key metals and rare earth elements parameters, the proposed SSWQOs for the outlet of Drizzle Lake and the CCME Guideline values.

TABLE 1: COMPARATIVE FLOTATION PLANT EFFLUENT QUALITY, PROPOSED SSWQOS AND CCME GUIDELINE VALUES FOR METALS

Parameter	Day 5 Decant Metal Concentration (µg/L)	March 2012 Treated Pilot Plant Effluent (µg/l)	Proposed SSWQO [For Drizzle Lake] (µg/L)	CCME Guideline (µg/L)
Aluminum (Al)	620	120	100	100
Arsenic (As)	2.2	0.9	5	5.0
Cadmium (Cd)	0.067	<0.003	Background	0.052
Chloride				
Chromium (Cr)	1.1	<0.5	8.9	8.9
Copper (Cu)	2.3	1.9	3	2-4
Iron (Fe)	570	44	Background (seasonal)	300
**Lead (Pb)	0.60	0.92	4	1-7
Mercury (Hg)	<0.10	<0.01	0.026	0.026
Molybdenum (Mo)	47.1	1.27	73	73
Nickel (Ni)	7.0	2	110	25-150
Nitrate				
Selenium (Se)	<1.0	<1.0	1	1
Silver (Ag)	0.03	<0.0.1	0.1	0.1
Thallium (Tl)	<0.2	0.017	0.8	0.8
Uranium (U)	10.0	0.01	15	15
Vanadium (V)	0.58	0.19	6	6*
**Zinc (Zn)	7	28	Background	30

TABLE 2: COMPARATIVE FLOTATION PLANT EFFLUENT QUALITY AND PROPOSED SSWQOS FOR RARE EARTH ELEMENTS*

Parameter	Day 5 Decant Metal Concentration (µg/L)	March 2012 Treated Pilot Plant Effluent (µg/l)	Proposed SSWQO** [Drizzle Lake] (µg/L)
Cerium (Ce)	139	0.92	3.2
Dysprosium (Dy)	2.52	0.063	16.2
Erbium (Er)	0.581	0.022	19.1
Europium (Eu)	1.09	0.014	11.2

TABLE 2: COMPARATIVE FLOTATION PLANT EFFLUENT QUALITY AND PROPOSED SSWQOS FOR RARE EARTH ELEMENTS*			
Parameter	**Day 5 Decant Metal Concentration (µg/L)**	**March 2012 Treated Pilot Plant Effluent (µg/l)**	**Proposed SSWQO** [Drizzle Lake] (µg/L)**
Gadolinium (Gd)	9.37	0.11	15
Hafnium (Hf)	0.267	<0.005	100
Holmium (Ho)	0.312	0.01	14.3
Lanthanum (La)	68.8	0.41	1.8
Lutetium (Lu)	0.033	0.002	2.9
Niobium (Nb)	2.57	0.045	2.6
Neodymium (Nd)	61.6	0.049	14.3
Praseodymium (Pr)	17.3	0.11	3.5
Samarium (Sm)	11.0	0.11	7.4
Scandium (Sc)	3.39	0.82	2.9
Tantalum (Ta)	0.230	0.009	0.2
Terbium (Tb)	0.819	0.014	8.4
Thulium (Tm)	0.046	0.003	0.001
Ytterbium (Yb)	0.324	0.012	6.9
Zirconium (Zr)	3.29	0.07	100

* based on CCME Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life 2007
* *Based on 10% of 7-day (Chronic) LC-50 Testing *H.azteca* (Borgmann et al., 2005), US EPA Ecotox Data Base or Ng et al., 2011

Given this background, as requested by the MVEIRB, the following brief discussions are provided to explain how Avalon intends to meet the proposed SSWQOs for the specific parameters highlighted by the Board and others identified by Avalon.

Aluminum

As noted in the original Attachment 1 table presented at the Technical Sessions, aluminum was predicted to reach a maximum modeled 20-year value of 148 µg/l in Drizzle Lake which would have exceeded the proposed SSWQO/CCME guideline value for aluminum of 100 µg/l. Thor Lake was predicted to reach a maximum modeled 20-year value of 60.1 µg/l, which is below these guideline values.

However, as previously indicated, Avalon has stated that it will treat its effluent to achieve these criteria and guidelines if determined to be necessary, but remains optimistic that it will be able to optimize its mineral processes such that this will not be required.

Table 1 provided with this response indicates that with the application of appropriate in-plant optimization/treatment measures, the concentration of aluminum in the flotation plant effluent could be reduced from the 620 μg/l reported in the 5 Day Decant effluent to approximately 120 μg/l, based on the March 2012 pilot plant effluent. Following initial mixing with the water in Drizzle Lake (minimum 3:1), Avalon is confident that the proposed SSWQO concentration for aluminum at the outlet of Drizzle Lake will not be exceeded.

Iron

As noted in the original Attachment 1 table presented at the Technical Sessions, iron was predicted to reach a maximum modeled 20-year value of 972 μg/l in Drizzle Lake which would have exceeded the proposed SSWQO/CCME guideline value of 300 μg/l. However, as also noted in this table, the mean background value for iron in Drizzle Lake was determined to be 1091 μg/l.

The high mean iron values in Drizzle (and Murky) lakes are skewed due to very high concentrations of this metal found in samples collected under the ice in March and April (as indicated by a standard deviation that is more than twice the mean). In all cases, iron values are less than CCME guideline levels during open water periods. This can be explained by the fact that iron is released from the sediments under anoxic conditions, which exist under the ice in Drizzle and Murky lakes. Iron levels in Thor Lake did not exceed CCME guideline levels at any time during the study period and Thor Lake was predicted to reach a maximum modeled 20-year value of 116 μg/l, which is below the guideline values.

Notwithstanding the natural iron-rich condition of the water in Drizzle and Murky lakes during the winter period, as indicated in Table 1 provided with this response, with the application of appropriate in-plant optimization /treatment measures, the concentration of iron in the flotation plant effluent could be reduced from 570 μg/l in the 5 Day Decant effluent to approximately 44 μg/l, based on the March 2012 pilot plant effluent. Avalon is therefore confident that the proposed SSWQO concentration for iron at the outlet of Drizzle Lake will not be exceeded, except as a result of the inherent natural variations in iron levels that occur in Drizzle Lake.

Mercury

As noted in the original Attachment 1 table presented at the Technical Sessions, mercury was predicted to reach a maximum modeled 20-year value of <0.027 μg/l in Drizzle Lake, which would have been comparable to the proposed SSWQO/CCME guideline value for mercury of 0.026 μg/l. However, this modeled value was based on the relatively high detection limit used by the laboratory to measure mercury in the 5 Day Decant effluent (<0.1 μg/l).

Although mercury was analyzed in the treated water quality data presented in Table 1 with the same detection limit, given that mercury in the solids fraction of the ore and tailings is also undetectable and is not used in the process, it is reasonable to assume that the actual concentration of mercury in the effluent will be lower than 0.1 μg/l. Thus Avalon is confident that the proposed SSWQO concentration for mercury at the outlet of Drizzle Lake will not be exceeded.

Cerium

As noted in the original Attachment 1 table presented at the Technical Sessions, cerium was predicted to reach a maximum modeled 20-year value of 31.8 μg/l in Drizzle Lake, and 12.8 μg/l in Thor Lake, which would have exceeded the proposed SSWQO value for cerium of 3.2 μg/l.

However, as previously indicated, Avalon has stated that it will treat its effluent to achieve the specified criteria and guidelines if determined to be necessary, but remains optimistic that it will be able to optimize its mineral processes such that this will not be required.

Table 2 provided with this response indicates that with the application of appropriate in-plant optimization/treatment measures, the concentration of cerium in the flotation plant effluent could be reduced from the 139 μg/l reported in the 5 Day Decant effluent to approximately 0.92 μg/l, based on the March 2012 pilot plant effluent. Thus Avalon is confident that the proposed SSWQO concentration for cerium at the outlet of Drizzle Lake will not be exceeded.

Lanthanum

As noted in the original Attachment 1 table presented at the Technical Sessions, lanthanum was predicted to reach a maximum modeled 20-year value of 16 μg/l in Drizzle Lake, and 6.4 μg/l in Thor Lake, which would have exceeded the proposed SSWQO value for lanthanum of 1.8 μg/l.

Table 2 provided with this response indicates that with the application of appropriate in-plant optimization/treatment measures, the concentration of lanthanum in the flotation plant effluent could be reduced from the 68.8 μg/l reported in the 5 Day Decant effluent to approximately 0.41 μg/l, based on the March 2012 pilot plant effluent. Thus Avalon is confident that the proposed SSWQO concentration for lanthanum at the outlet of Drizzle Lake will not be exceeded.

Neodymium

As noted in the original Attachment 1 table presented at the Technical Sessions, neodymium was predicted to reach a maximum modeled 20-year value of 14.1 μg/l in Drizzle Lake, which would have been comparable to the proposed SSWQO value for neodymium of 14.3 μg/l.

Table 2 provided with this response indicates that with the application of appropriate in-plant optimization/treatment measures, the concentration of neodymium in the flotation plant effluent could be reduced from the 61.6 μg/l reported in the 5 Day Decant effluent to approximately 0.49 μg/l, based on the March 2012 pilot plant effluent. Thus Avalon is confident that the proposed SSWQO concentration for neodymium at the outlet of Drizzle Lake will not be exceeded.

Praseodymium

As noted in the original Attachment 1 table presented at the Technical Sessions, praseodymium was predicted to reach a maximum modeled 20-year value of 3.99 μg/l in Drizzle Lake, which would have been slightly above the proposed SSWQO value for praseodymium of 3.5 μg/l.

Table 2 provided with this response indicates that with the application of appropriate in-plant optimization/treatment measures, the concentration of praseodymium in the flotation plant effluent could be reduced from the 61.6 μg/l reported in the 5 Day Decant effluent to approximately 0.11 μg/l, based on the March 2012 pilot plant effluent. Thus Avalon is confident that the proposed SSWQO concentration for neodymium at the outlet of Drizzle Lake will not be exceeded.

Thulium

As noted in the original Attachment 1 table presented at the Technical Sessions, thulium was predicted to reach a maximum modeled 20-year value of 0.049 μg/l in Drizzle Lake, and 0.05 μg/l in Thor Lake, which would have been slightly above the corrected proposed SSWQO value for thulium of 0.001 μg/l, as discussed further in response to 2.03 item a).

Table 2 provided with this response indicates that with the application of appropriate in-plant optimization/treatment measures, the concentration of thulium in the flotation plant effluent could be reduced from the 0.046 μg/l reported in the 5 Day Decant effluent to approximately 0.003 μg/l, based on the March 2012 pilot plant effluent, which after mixing in Drizzle Lake will meet the very conservative proposed SSWQO value for thulium of 0.001 μg/l.

Thus even with the highly conservative manner in which the SSWQO value for thulium was calculated, and given the dramatic decrease in toxicity of Thulium that is demonstrated in the literature at the much higher hardness value that naturally characterizes the water of Drizzle Lake, Avalon is confident that the proposed SSWQO concentration for thulium at the outlet of Drizzle Lake will not be exceeded.

b) The values provided with regard to the concentration of metals in the Thor Lake system were extracted at the water surface in the month of May. The metal concentration decreases as water flows downstream from one water body to another, but the concentration within a particular water body remains homogenous. The annual Fall and Spring overturns of the lake, coupled with the relatively shallow depth of the Thor Lake system, is anticipated to lead to the homogeneity in metal concentration.

During summer thermal stratification, the warmer, lighter water stays near the surface and the colder, heavier water resides near the bottom. On the other hand, the metal concentration increases with water depth. The stratification leads to a formation of a density barrier and results in reduced mixing of deeper lake water with surface water. As a result, the circulation becomes short-circuited and the freshwater runoffs that enter the water body remain near the surface and further reduce the metal concentration.

In this case, due to the fact that both the Drizzle Lake and Thor Lake outlets drain surface water in their respective water bodies, it is more conservative to extract the metal concentration when the lake is homogenous without the bias created by the direct mixing of tailings water with the freshwater runoffs as a result of the thermal stratification.

In any event, the horizontal variation of surface metal concentrations is considered to be negligible, and the concentrations reported are considered to be representative of the concentrations at the outlet.

c) Although the water quality modeling conducted for the Thor Lake Project has shown that the concentrations of the various effluent parameters in the downstream lakes are predicted to increase over the proposed 20 year life of the mine, it is important to note that with the application of appropriate in-plant optimization/treatment measures as discussed previously, the proposed SSWQOs and CCME guideline values are anticipated to be met throughout this extended period of time.

As indicated in the DAR, during the closure and reclamation phase of the Thor Lake Project, effluent from the Tailings Management Facility (TMF) will cease to flow downstream and the surface of the TMF will be reclaimed to a more natural condition. Closure and reclamation strategies will focus on stabilizing and covering the exposed tailing surfaces and re-establishing surface flow patterns, while ensuring that acceptable downstream water quality is maintained.

Post closure water quality monitoring is anticipated to occur for as long as may be required for downstream water quality to approach natural pre-development baseline conditions. This is currently anticipated to occur over a period of three to five years.

IR Number: **MVRB #2.02**
To: Avalon Rare Metals Inc.
Subject: Contribution of Mine Water to TMF Effluent Concentrations
Source:
Response to Technical Session Undertaking No. 1: Water Balance Flow Sheet, Average Precipitation Conditions (Years 1-20)
Technical Session transcript, Day 2, p.61ff.

Preamble:

The water quality modelling does not appear to account for the contaminant load coming from mine water, an input which the water balance indicates contributes 157,700 m^3/yr to the TMF. The ground water quality results show a lot of variability, but overall there are large quantities of TDS, TSS, chlorides, sulphate, fluoride, aluminum, iron etc. The input of contaminants from groundwater should be factored into the water quality to provide a more accurate prediction of downstream water quality. The quantity of REE's in the groundwater should also be accounted for in the water quality model predictions.

The Technical Session transcript says "...the [5-day decant] numbers in the DAR that we [Avalon] used for the modelling that you saw in the DAR, and now -- of course now you see numbers that are next to that, those are and still remain to be the worst-case scenarios."

MVRB Request #2.02

a) Please provide concentration data for the constituents and water quality parameters of the mine water, including but not limited to TDS, TSS, chlorides, sulphate, fluoride, metals, explosive residues, and REEs.

b) Please clarify whether inputs from the mine water were used, simulated, or otherwise considered in the determination of the 5-day decant values. If so, how were the inputs used, simulated, or otherwise considered?

c) If not, please demonstrate that the 5-day decant concentrations used reflect the worst-case scenario for each constituent or parameter by providing a table comparing the expected concentrations in the mine water to the 5-day decant concentrations. If the expected concentrations in the mine water were not determined from actual measurements, please describe how they were estimated ?

Avalon Response #2.02

a) Avalon has committed to achieve MMER regulation requirements, as well as existing CCME guidelines at the discharge of Drizzle Lake, and has proposed Site Specific Water Quality Objectives based on CCME protocols for establishing such parameters for the suite of rare earth metals associated with the Thor Lake Project.

Avalon has further stated that it will treat its effluent to achieve these criteria and guidelines if required, but is optimistic that it will be able to optimize its mineral processes such that this will not be required. However, as a precaution, Avalon has developed the water treatment process and tested it using the worst case water collected from the March 2012 pilot plant.

This information was provided to MVEIRB in Avalon's Responses to Clarification letter dated May 10, 2012 which provided treated water quality data that clearly demonstrate that the treatment technology will allow Avalon to achieve water quality to meet all the commitments above.

Tables 1 and 2 presented in response to IR 2.01 summarize the data previously transmitted to the MVEIRB and provide comparative effluent quality data for the key metals and rare earth elements parameters, the proposed SSWQOs for the outlet of Drizzle Lake and the CCME Guideline values.

As also discussed in the May 10th submission, the natural background concentrations in Drizzle Lake for several parameters are regularly elevated above their CCME guideline values and in such cases, the water quality in Drizzle Lake may be improved by the introduction of the effluent.

While it is impossible to provide actual water quality of the mine water prior to construction and operation of the mine, Avalon has committed to install water treatment capacity within the Flotation Plant to treat all of the mine water arising from the mining operations as necessary to meet its commitments. This water will thus be treated prior to discharge to the tailing management facility, and provides the further benefit of allowing this water to be recycled for use within the plant as required. This commitment was made in our response to MVEIRB in the updated water balance provided on August 23, 2012, as requested in the technical review sessions.

Given that the mine water is anticipated to be considerably cleaner than the tailings water, it is reasonable to conclude that as a minimum, the water quality achieved by treating the tailings water can also be achieved with the mine water.

As stated above, Avalon is optimistic that with the improved process design and in-plant mine water treatment, additional water treatment from the tailing management area will not be required. Given that there will be no discharge from the tailing management area for over a year, Avalon will have more than enough time to assess the actual water quality and to construct a treatment plant if required.

b) As stated on several previous occasions, the 5-day decant values from the pilot plant testing program presented in the DAR were used in an effort to be conservative and consistent and to avoid potential confusion. Inputs from the mine water were not considered in the determination of the 5–day decant values.

However, as per Avalon's commitments in the technical review sessions and as provided to the MVEIRB in the updated water balance on August 23, 2012, since the mine water will be treated in the flotation plant, it is anticipated that this will result in significant improvements in overall water quality for all parameters of concern. As discussed at the technical review sessions, only lead and zinc values were higher in the treated effluent compared to the results of the original 5 day decant. Nevertheless, even with these small predicted increases, conformance with the proposed SSWQOs was still achieved prior to release of the decant effluent into Drizzle Lake.

The water quality model for the Nechalacho site has not been updated to reflect the significant improvement in water quality anticipated with the addition of the treated mine water. The water volume component of the model has been reviewed to include the mine water and has determined the mixing ratio is 3:1 Drizzle Lake water with tailing management area effluent, including the mine water volume. It is thus demonstrated that given that all parameters will meet the MMER's, CCME guidelines and Avalon's proposed CCME guidelines for the rare earth metals with this blending ratio, additional model runs are not value added.

c) Given that the mine has yet to be constructed, it is difficult to assess how MVEIRB would anticipate that Avalon or any mine could have made actual measurements of mine water quality at this stage of our approvals process. Avalon continues to use conservative assumptions in the assessment of mine water quality and environmental impact assessment.

Given that Avalon has committed to treat the mine water (as per d and e above), and given that mine water will contact ore and rock underground in a less vigorous manner than in the concentrator, and that seepage water entering the mine will be relatively clean, Avalon remains confident that using the concentrator pilot plant tailing water continues to represent the worst case and conservative representation of anticipated effluent water quality associated with the Project

Tables 1 and 2 previously provided in response to IR 2.01 demonstrate that with the application of appropriate in-plant optimization/treatment measures, Avalon is confident that the proposed SSWQO and CCME guideline values for all parameters of potential concern can be achieved at the outlet of Drizzle Lake.

IR Number: **MVRB #2.03**
To: Avalon Rare Metals Inc.
Subject: Chronic Toxicity Values and SSWQOs
Source:
Avalon Rare Metals Inc., Response to the April 16, 2012 Clarifications Letter from Mackenzie Valley Environmental Impact Review Board for the Thor Lake Rare Earth Element Project Developer's Assessment Report, 10 May 2012. Attachment 4 "Review of Aquatic Effects of Lanthanides and Other Uncommon Elements" by Tania Ng, D. Scott Smith, Anthony Straus and James C. McGeer, Wilfrid Laurier University, 2011,
Avalon handout in the Technical Session titled "Day 1 & 2 (Aug 14 & 15), Nechalacho, Thor Lake, SSWQO's", Table "Rare Earth Element Concentrations".
Avalon response to Technical Session Homework Items #4, #5, and #10.

Preamble:

The table labeled "Rare Earth Element Concentrations" in the handout titled "Day 1 & 2 (Aug 14 & 15), Nechalacho, Thor Lake, SSWQO's" that Avalon presented during the Technical Session presents SSWQOs for 19 elements. The table footnote says "Based on 10% of 7-day (Chronic) LC-50 Testing H.azteca (Borgmann et al., 2005)". Table 5 of Attachment 4 in the 10 May 2012 response includes data for H. azteca attributed to Borgmann 2005. Some of the data do not match in the two tables.

MVRB Request #2.03

a) Thulium: The handout table shows an SSWQO for thulium (Tm) of 6.9 ug/L, implying a chronic toxicity value of 69 ug/L. The Wilfrid Laurier paper lists a toxicity value of 0.001 ug/L. Please correct the handout table or explain the basis for the proposed SSWQO.

b) Tantalum: The handout table shows an SSWQO for tantalum (Ta) of 0.2 ug/L, implying a chronic toxicity value of 2.0 ug/L. The Wilfrid Laurier paper does not list a H. azteca toxicity value for tantalum. Please explain the basis for the proposed SSWQO.

c) Scandium: The handout table shows an SSWQO for scandium (Sc) of 2.9 ug/L, implying a chronic toxicity value of 29 ug/L. The Wilfrid Laurier paper does not list a H. azteca toxicity value for scandium. Please explain the basis for the proposed SSWQO.

d) Hafnium: The handout table shows an SSWQO for hafnium (Hf) of 4.4 ug/L, implying a chronic toxicity value of 44 ug/L. The Wilfrid Laurier paper does not list a H. azteca toxicity value for hafnium. Please explain the basis for the proposed SSWQO.

e) Holmium: The handout table shows an SSWQO for holmium (Ho) of 0.7 ug/L, implying a chronic toxicity value of 7.0 ug/L. The Wilfrid Laurier paper lists a toxicity value of 143 ug/L. Please correct the handout table or explain the basis for the proposed SSWQO.

f) Zirconium: The handout table shows an SSWQO for zirconium (Zr) of 11.2 ug/L, implying a chronic toxicity value of 112 ug/L. The Wilfrid Laurier paper does not list a H. azteca toxicity value for zirconium. Please explain the basis for the proposed SSWQO.

Avalon Response #2.03

The following general response will be followed by responses that are specific to each of the six elements identified in this Information Request.

Derivation of site specific water quality objectives (SSWQO) for the rare earth elements (REE) were guided by the CCME procedure that sets guideline levels at 10% of minimum toxicity concentrations, unless otherwise stated. Toxicity data related to the rare earth elements are based on the work of Borgmann et al. (2005)[1], which investigated chronic toxicity (7-day LC50) effects on the amphipod *Hyalella azteca*. The toxicities of some of the REEs determined by Borgmann et al. (2005) were reported in Ng et al. (2011)[2], while the remainder was found in the U.S. Environmental Protection Agency Ecotox database[3].

It is important to note that toxicity levels are highly dependent, and inversely correlated, with water hardness (measured as $CaCO_3$). For example, the 7-day LC50 concentration for thulium (Tm), using *H. azteca* as the test organism) at a hardness of 18 mg/L was 0.01 μg/L, while at a hardness of 124 mg/L the toxicity concentration was 739 μg/L. The hardness of waters within the Thor Lake watershed generally exceed 124 mg/L (mean values: Thor L.-174 mg/L; Murky L.-169 mg/L; Drizzle L. 148 mg/L (Stantec 2011[4]), indicating that toxicity concentration thresholds of the REEs in these lakes are likely even higher than those found in the studies by Borgmann et al. (2005).

Notwithstanding the important role that water hardness plays in reducing the toxicity of the REEs to aquatic organisms, the SSWQO values that are proposed for this project were based on the more conservative values derived from tests using very low hardness waters. It is also noted that the background mean concentrations for all of the REE elements, except scandium, were below the analytical detection limit.

Normally, 0.5 of the detection limit value is used for modeling purposes, where concentrations of water quality parameters are less than the detection limit. However, the input values for the model in this case were the actual detection limits, which suggests that the modeled 20 year maximum

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1 Borgmann, U., Y Couillard, P. Doyle, and D.G. Dixon. 2005. Toxicity of sixty-three metals and metalloids to *Hyalella azteca* at two levels of water hardness. Environ Toxicol Chem. 24(3):641-52.

2 Ng, Tania, Anthony Straus and James C. McGeer. 2011. Review of aquatic effects of lanthanides and other uncommon elements. Final Project Report, prepared for the EC Contribution Agreement with the CNTC for 2010/2011. Wilfrid Laurier University.

3 US EPA Ecotox database: http://cfpub.epa.gov/ecotox/quick_query.htm.

4 Stantec. 2011. Thor Lake Rare Earth Metals baseline project: Environmental baseline report: volume 3-aquatics and fisheries. Prepared for Avalon Rare Metals Inc.

values are very conservative. The following sections identify the calculations that were made for each of the six REEs listed in the IR. The test organism in all cases was *Hyalella azteca*. In some cases, SSWQO values that were originally proposed and submitted to the MVEIRB have been modified based on a reevaluation of published toxicity information. Table 1 provides updated information for each of the six elements identified and discussed in this IR response.

a) **Thulium (Tm)**. The SSWQO value of 6.9 μg/L previously submitted to the MVEIRB was based on toxicity levels at higher concentrations of water hardness, which were calculated prior to access to the published Borgmann et al. (2005) toxicity information. In further investigation of the paper quoted, the reported 7-day LC50 value for this element was 0.01 μg/L at a hardness of 18 mg/L, and 739 μg/L at a hardness of 124 mg/L (reported in Ng et al. 2011).

   Using the more conservative approach, the SSWQO would be 0.001 μg/L. Based on conservative calculations for the maximum 20 year predicted concentration of Tm in Drizzle Lake, the SSWQO value of 0.001 μg/L is lower than the maximum 20 year predicted concentration for this element (0.049 μg/L), calculated using the 5 day decant metal concentration of 0.046 μg/l. However, the most recent Pilot Plant treated effluent analysis provided to the MVEIRB on May 10, 2012, indicates an effluent quality of 0.003 μg/l, which after mixing in Drizzle Lake will meet the very conservative SSWQO value of 0.001 μg/l. Thus even with the highly conservative manner in which the SSWQO values were calculated, and with the reduced levels of parameters in the treated effluent, the SSWQO concentration will not be exceeded.

   Given the water hardness in Drizzle Lake and the suggested reliance on the Borgmann paper by the MVEIRB, the more appropriate SSWQO should be greater than 739 mg/l. This is further supported by the fact that the indicator organism utilized in this study cannot be successfully cultured below a hardness of 50-60 mg/l, indicating that the low value is not credible for a long term standard (Dr J. McGeer, Wilfred Laurier University and co-author of Ng et al. (2011) referenced above, Pers. Comm.).

b) **Tantalum (Ta)**. Tantalum is not a lanthanide, so was not considered in the Wilfrid Laurier University study (Ng et al. 2011).The 7-day LC50 value for Ta was 2.0 μg/L at a hardness of 18 mg/L, and 1,977 μg/L at a hardness of 124 mg/L (reported in EPA Ecotox). Using the more conservative approach, the SSWQO would be 0.2 μg/L, as submitted previously to the MVEIRB.

   Based on conservative calculations for the maximum 20 year predicted concentration of Ta in Drizzle Lake, which used a conservatively high 5 day decant initial concentration, the SSWQO value of 0.2 μg/L is 1.5 times the maximum predicted level for this element. The reported concentration of Ta in treated effluent (May 10, 2012) is reported as 0.009 μg/l, well below the SSWQO prior to mixing with Drizzle.

c) **Scandium (Sc)**. Scandium is not a lanthanide, so was not considered in the Wilfrid Laurier University study (Ng et al. 2011). The 7-day LC50 value for Sc was 29 μg/L at a hardness of

18 mg/L, and 175 μg/L at a hardness of 124 mg/L is reported in EPA Ecotox. Using the more conservative approach, the SSWQO would be 2.9 μg/L, as submitted previously to the MVEIRB.

Based on conservative calculations for the maximum 20 year concentration of Sc in Drizzle Lake, and the conservatively high 5 day decant data, the SSWQO value of 2.9 μg/L is 2.0 times the maximum predicted level for this element. Using the Treated Pilot Plant effluent data provided May 10, 2012, this provides an even greater level of comfort that the guideline is achievable.

d) **Hafnium (Hf)**. Hafnium is not a lanthanide, so was not considered in the Wilfred Laurier University study (Ng et al. 2011). The 7-day LC50 value for Hf was 1000 μg/L at a hardness of 18 mg/L, and 3,150 μg/L at a hardness of 124 mg/L (reported in EPA Ecotox). Using the more conservative approach, the SSWQO would be 100 μg/L. The previously suggested SSWQO for this element (4.4 μg/L) was reported in error.

   Based on conservative calculations for the maximum 20 year predicted concentration of Hf in Drizzle Lake, and utilizing the conservative 5 day decant data, the SSWQO value of 100 μg/L is 725 times the maximum predicted level for this element. Using the Treated Pilot plant data provided May 10, this factor is even greater.

e) **Holmium (Ho)**. The 7-day LC50 value for Ho was 143 μg/L at a hardness of 18 mg/L, and 755 μg/L at a hardness of 124 mg/L (reported in Ng et al. 2011). Using the more conservative approach, the SSWQO would be 14.3 μg/L. The previously suggested SSWQO for this element (0.7 μg/L) was reported in error.

   Based on conservative calculations for the maximum 20 year predicted concentration of Ho in Drizzle Lake, and using the conservative 5 day decant data, the SSWQO value of 14.3 μg/L is 130 times the maximum predicted level for this element. Using the Treated Pilot Plant data provided on May 10, this safety factor is even greater.

f) **Zirconium (Zr)**. Zirconium is not a lanthanide, and so was not considered in the Wilfrid Laurier University study (Ng et al. 2011). The 7-day LC50 value for Zr was >1000 μg/L at a hardness of 18 mg/L, and >3150 μg/L at a hardness of 124 mg/L (reported in EPA Ecotox). Using the more conservative approach, the SSWQO would be 100 μg/L. The previously suggested SSWQO for this element (11.2 μg/L) was reported in error.

   Based on conservative calculations for the maximum 20 year predicted concentration of Zr in Drizzle Lake, and using the conservative 5 day decant water quality data, the SSWQO value of 100 μg/L is 120 times the maximum predicted level for this element. Using the Treated Pilot Plant data, the safety factor is even greater.

TABLE 3. MODELLED 20 YEAR MAXIMUM AND PROPOSED SSWQO CONCENTRATIONS FOR SELECTED REE ELEMENTS IN DRIZZLE AND THOR LAKES.

		Drizzle Lake		Thor Lake		
Parameter	**Day 5 Decant Metal Concentration (µg/L)**	**Background Mean (µg/L)**	**Modelled Maximum 20-yr Value (µg/L)**	**Background Mean (µg/L)**	**Modelled Maximum 20-yr Value (µg/L)**	**Proposed SSWQO (µg/L)**
Thulium	0.046	<0.05	0.049	<0.05	0.05	0.001*^
Tantallum	0.230	<0.1	0.130	<0.1	0.112	0.2
Scandium	3.39	0.9	1.47	0.5	1.13	2.9
Hafnium	0.267	<0.1	0.138	<0.1	0.115	100*
Holmium	0.312	<0.05	0.110	<0.05	0.074	14.3*
Zirconium	3.29	<0.1	0.83	<0.1	0.39	100*

* indicates a change in the proposed SSWQO from the originally submitted value.
^See discussion in response a) above.

IR Number: **MVRB #2.04**
To: Avalon Rare Metals Inc.
Subject: Surficial Geology
Source:
DAR, Appendix A.3, Figure 3

Preamble:

The surficial geology map in DAR Appendix A.3, Figure 3 (Stantec 2010) shows the presence of various geologic materials as required in the TOR. However there are several abbreviations for rock and surficial deposit types that are not described in the explanation. For example General Rock groupings C, R and M, and Surficial Expression types j and p are not explained in the figure key.

MVRB Request #2.04

Please provide an explanation of the abbreviations for all rock and surficial deposit types in DAR Appendix A.3, Figure 3.

Avalon Response #2.04

The surficial material and surface expression terms and symbols presented in DAR Appendix A.3 Figure 3 (Stantec 2010) were based on the British Columbia Terrain Classification System (1988) as applied to the Nechalacho Project Area. Avalon is pleased to provide the following information on the surficial material and surface expression terms and symbols, as extracted directly from the BC Terrain Classification System report (1988).

The identified terms and symbols for the Nechalacho Project area are applicable to DAR Figure 2.9-1, DAR Appendix A.3, Figure 3 and DAR Appendix A.4, Figure 2-2. However it should be noted, that the map symbol used for describing bedrock in each of these figures was incorrectly labeled as B and should have been labeled R.

Reference

BC 1988. Terrain Classification System for British Columbia (Revised Edition), 1988. Co-published by: Surveys and Resource Mapping Branch and Environment and Land Use Committee.

SURFICIAL (GENETIC) MATERIALS

Surficial materials are defined as non–lithified, unconsolidated sediments occurring on the earth's surface. They are materials produced by weathering, biological accumulation, man and volcanic activity. They include residual materials weathered from rock in situ; transported materials composed of mineral, rock and organic fragments deposited by water, wind, ice, gravity, or any combination of these agents; accumulated materials of biological origin including man–made deposits; and unconsolidated pyroclastic sediments.

In general, surficial materials are of relatively young geological age and they constitute the parent material of most (pedological) soils. Other terms that are virtually synonymous with "surficial material" are the "Quaternary sediments" and "unconsolidated materials" of the geologist and the "soil" and "earth" of the engineer. Surficial materials are classified according to their mode of formation. Specific processes of erosion, transportation, deposition, mass wasting and weathering produce materials that have specific sets of physical characteristics. This is the single most useful descriptor of surficial materials.

Surficial materials are also described by the status of their formative process. ***Each surficial material has an assumed status of activity*** The status is either active or inactive, and is indicated by a qualifying descriptor symbol through the use of the superscripts "I" (inactive) or "A" (active). Status of activity is indicated only when the actual state of formation is contrary to the assumed state defined for each material. Surficial materials displaying direct evidence that glacier ice exerted a strong, but secondary or indirect control, upon their mode of origin are indicated by a qualifying descriptor symbol, superscript "G". For further details see "Qualifying Descriptors", pages 56–58.

SURFICIAL MATERIAL TERMS AND SYMBOLS

Material Name	*Map Symbol*	*Assumed Status of Formative Process*
Anthropogenic	**A**	active
Colluvial	**C**	active
Weathered Bedrock (in situ)	**D**	active
Eolian	**E**	inactive
Fluvial	**F**	inactive
Glaciofluvial	$\mathbf{F^G}$	inactive
Ice	**I**	active
Lacustrine	**L**	inactive
Glaciolacustrine	$\mathbf{L^G}$	inactive
Morainal (Till)	**M**	inactive
Organic	**O**	active
Bedrock	**R**	–
Undifferentiated	**U**	–
Volcanic	**V**	inactive
Marine	**W**	inactive
Glaciomarine	$\mathbf{W^G}$	inactive

SURFICIAL EXPRESSION

Surface expression refers to the form (assemblage of slopes) and pattern of forms expressed by a surficial material at the land surface. This three–dimensional shape of the material is equivalent to "landform" used in a non–genetic sense (e.g. ridges, plain). Surface expression symbols also describe the manner in which unconsolidated surficial materials relate to the underlying unit (e.g. veneer).

It is assumed that a terrain map will be presented on topographic base map. The function of the surface expression terms is to augment and highlight the information provided by the topographic base map. They may describe features that are not evident from the contours of the map or highlight the topographic information where necessary. It is recommended that data provided by the topographic contours (e.g. slope angle and configuration) be included on a terrain map presented on a planimetric base map or for a terrain map stored on computer databases (e.g. CAPAMP).

The surface expression of surficial materials is classified according to slope, geometric shape and spatial pattern. The surface expression terms have no genetic implication.

SURFACE EXPRESSION TERMS AND SYMBOLS

Surface Expression Name	*Map Symbol*
moderate slope	**a**
blanket	**b**
cone(s)	**c**
depression(s)	**d**
fan(s)	**f**
hummock(s)	**h**
gentle slope	**j**
moderately steep slope	**k**
rolling	**m**
plain	**p**
ridge(s)	**r**
steep slope	**s**
terrace(s)	**t**
undulating	**u**
veneer	**v**

IR Number: **MVRB #2.05**
To: Avalon Rare Metals Inc.
Subject: Groundwater Elevations and Drawdown Effects
DAR, Section 2.7.1.2, Groundwater Level Measurements (Nechalacho Mine Site) DAR, Section 2.7.2.2, Site Hydrogeology (Hydrometallurgical Plant Site)
DAR, Section 6.5.1.2, Groundwater Inflow Model
DAR, Figure 6.5-1, Predicted Groundwater Drawdown due to Mine Dewatering

Preamble:

A groundwater map for the mine site has not been provided in accordance with the TOR requirements. DAR Section 2.7.1.2 indicates that only seven locations were used for groundwater level measurements at the Nechalacho Mine Site.

DAR Section 6.5.1.2 describes the modeling for the groundwater inflow into the underground mine and states "Groundwater inflow was modeled by Knight Piésold (2011f) using Visual MODFLOW software. The model was run in steady state. Boundary conditions included: constant head cells for nearby lakes, recharge boundaries for precipitation at surface and drain cells for the proposed underground workings".

Figure 6.5-1 shows groundwater drawdown in excess of 10 m as a result of mine dewatering and a significant area shows drawdown in excess of 2 m. The drawdown contours are clearly affected by the presence of Long Lake, North Tardiff Lake, and South Tardiff Lake. Because these lakes are either small or narrow, the assumption of constant head may not hold.

MVRB Request #2.05

a) Please provide a groundwater contour map of the Nechalacho mine site using available well, boring, seep, or surface water elevations as appropriate.

b) Please justify the constant head assumption for the lakes which drain into the mine. It would be useful to have estimates of the predicted flow quantities from the lakes and a comparison to existing inflow, outflow, precipitation, and evaporation data, i.e. current and predicted water balances for the potentially impacted lakes.

c) The magnitude and areal extent of the drawdown is apt to dewater shallow water bodies, wetlands, or other saturated environments. Please indicate the extent of the predicted dewatering, how the above changes may contribute to changes in local surface water bodies, wetlands, permafrost or active layers; and how the above changes may translate into surface water impacts, groundwater impacts or water quality impacts.

Avalon Response #2.05

a) The existing piezometer network does not support the development of piezometric contour maps for the site. The piezometers are widely-spaced and interspersed among surface water and topographic features that likely create localized variations in the water table that will not be captured by the piezometer network (Figure 1).

Figure 1: Thor Lake Groundwater Wells

However it is apparent from the data presented in the 2011 Stantec report entitled "Thor Lake Project Rare Earth Metals – Baseline Project - Environmental Baseline Report: Volume 2 – Hydrogeology" (Appendix A.3 in the DAR), that the groundwater table is typically very close to ground surface in the area. This is primarily due to the presence of shallow low permeability bedrock and/or permafrost.

The last recorded groundwater level for seven (7) monitoring wells located in the peninsula between Long Lake and Thor Lake demonstrate that the groundwater table is in the range of 0.5 to 3 m below the ground surface (average 1.6 m below surface). This corresponds to an average elevation of 239.2m, or approximately 3 m above the elevation of Thor Lake. This indicates that the groundwater gradient is very low and is perched on the peninsula. This further reinforces that little to no impact on surface waters or wetlands is anticipated due to mine dewatering over the 20 year mine life.

b) The MODFLOW model was run for the purpose of estimating a groundwater inflow rate for the underground mine. For this reason, the use of a constant head boundary condition is appropriate and conservative in this calculation, because a constant head cell provides a potentially-endless supply of water to the model. The rate at which the water reports to the mine (represented as drain cells) is controlled by the hydraulic conductivity assigned to the bedrock, but the source of the water is not restricted.

The constant head boundary condition would not be appropriate for a model with an objective of estimating the impact of groundwater withdrawal on a hydraulically-connected lake. It would be more appropriate to use a general head boundary condition such as MODFLOW's LAKE package to represent the lakes.

In the case of the proposed Nechalacho Mine, there is no hydraulic connection to the lakes and the rate of inflow to the lakes far exceeds the rate of groundwater infiltration into the mine. The water levels within the lakes and wetlands are primarily controlled by hydrologic inputs vs. various outputs to/from the system(s). The infiltration rate (i.e. seepage into mine) versus the net surplus water into the system from the water balance (i.e. recharge rates) controls the surficial water levels.

A numerical model was previously used to estimate the quantity of water that flows from each of the lakes as a result of mine dewatering. The resulting loss of water into the mine working was low in comparison to the estimated inflows to the respective lakes from runoff and precipitation. In each case, the loss of water from each lake due to seepage into the mine was less than 10% of the inflow to the lake.

As a quick example using Long Lake (most conservative due to least watershed when compared to Thor Lake),

- average annual precipitation to the Long Lake system is approximately 2.6 million m^3/yr based on catchment area of 950 ha.
- Assuming a conservative runoff coefficient of 0.2, the total runoff would be 520,000 m^3/yr
- The average annual evaporation from Long Lake would be approximately 156,000 m^3/yr based on lake area of approximately 39 ha

This results in a conservative estimate of net runoff (i.e. runoff minus evaporation) into Long Lake of 360,000 m^3/yr. Assuming that 25% of the estimated annual mine inflows of 94,600 m^3/yr originates from Long Lake (i.e. approx. 23,650 m^3/yr), this equates to less than 10% of the lowest expected net runoff to the system.

The statement used by the MVEIRB "the lakes which drain into the mine" is highly unrepresentative. During investigations completed to-date no direct links have been identified between the proposed mine and the overlying lakes. The bedrock is highly competent with a very low permeability as has been demonstrated through previous studies and explained in previous IR responses. Although not anticipated, should any areas of concern be identified, drilling will be completed in advance of the mine development to further investigate and appropriate measures would be taken to mediate any potential higher flows zones.

There are a significant number of mines throughout the northern Canadian Shield that have underground workings in close proximity (adjacent to and below) to existing lakes and wetlands. In the vast majority of these operating mines, the underground dewatering has had little to no impact on the surface waters including lakes and wetlands.

c) Localized drawdown of the groundwater level (phreatic surface) at the Thor Lake Site, is not expected to significantly impact the water levels for the shallow surface water bodies, wetlands, saturated environments, permafrost or active layers in the area.

The presence of overburden and significant wetlands in the vicinity of the mine is limited. The small lakes North Tardiff and South Tardiff are on the periphery of the zone of influence of the underground workings. The area of influence is generally dominated by poorly-drained shallow overburden pockets between bedrock exposures. Given these conditions and the low rates of surface water infiltration, it is judged that little to no impacts to wetlands, permafrost or active layer is possible from a potentially depressed phreatic surface within the bedrock in the vicinity of the mine.

IR Number: **MVRB #2.06**
To: Avalon Rare Metals Inc.
Subject: Long Term Effects of Paste Backfill on Groundwater Quality
Source:
DAR, Section 6.5.1.5 Groundwater Quality Response to Deficiency MVEIRB #37 (Part 2) Technical Session transcript, Day 2, p. 46.
Golder Associates, Report on Feasibility Study for Paste Backfill, Avalon Rare Metals (Draft), 30 July 2012.

Preamble:

Avalon has stated that "Any water interaction with the paste is expected to make the pH slightly basic during the short time needed for the paste backfill to harden." and "it will be essentially inert and is not expected to affect the existing or future groundwater quality". The Review Board was unable to find chemical test results or detailed analysis of geochemical reactions that support these statements.

During Day 2 of the technical session, Avalon was asked to provide information on the constituents and physical characteristics of the paste backfill, the chemical composition of the pore water, and the amount of bleed water.

The Golder Associate draft feasibility study contains information on the physical characteristics of the paste backfill, but not the chemical characteristics. This information is needed to assess potential impacts on groundwater.

MVRB Request #2.06

a) Please provide or confirm the chemical characteristics of the paste backfill pore water and the amount of bleed water per ton of solids.

b) Based on the results, please present a discussion of the chemical interactions that are predicted to occur between the paste backfill and the existing groundwater. The analysis should present support for statements regarding the short term and long term interactions and effects on water quality.

Avalon Response #2.06

a) Experience around the world has consistently demonstrated the ability of cemented paste backfill to have minimal material segregation and minimal water bleed at any stage of paste backfill transport or placement (Golder 2012). All water added to the paste (pore water) will be consumed by the chemical reaction during the curing of the backfill and any chemical constituents will be locked into the cement in perpetuity. As an example, Goldcorp's mine in

Red Lake, Ontario uses a similar backfill arrangement and they report no bleed water at all from their cemented backfill.

b) The permeability of the cemented backfill will be similar to that of intact rock. The majority of groundwater flow will occur between the contact of the mined out area and the backfill.

Avalon feels that it is important for the Board to appreciate the current general industry understanding, as reported in MEND Report 10.2 (Mehling 2006) that the use of paste backfill in underground environments has been generally considered beneficial to reduce overall environmental impacts associated with mining, due to:

1) Reduction in the volume of tailings requiring surface disposal, thereby reducing surface impacts through footprint reduction.

2) Use of the full tailings stream in the backfill, rather than the coarse fraction used in more conventional sand fill, thereby reducing the need to handle and dispose of a separate slimes stream.

3) Reduction in the potential for tailings to oxidize or leach due to the nature of thickened tailings placed as underground backfill because of:

   - Less free water, which reduces leachate generation;
   - Less available oxygen as a result of the higher degree of saturation;
   - Preferential flow of ground water around backfill, rather than through it due to the lower hydraulic conductivity of the paste backfill;
   - The addition of cement that provides extra neutralization potential (NP) and decreases effective porosity; and
   - The potential for flooding at closure which reduces sulphide oxidation in long-term.

References

Golder 2012. Golder Pastec Technology Ltd. Company Profile.

Mehling Environmental Management Inc. 2006. Paste Backfill Geochemistry – Environmental Effects of Leaching and Weathering. Report prepared by Mehling Environmental Management Inc. for the Mine Environment Neutral Drainage (MEND) Program.

Attachment 1:

Attachment 1

Day 1 & 2 (Aug 14 & 15)

NECHALACHO, THOR LAKE

SSWQO's

Metal Concentrations

Parameter	***Day 5 Decant Metal Concentration (µg/L)	Drizzle Lake		Thor Lake		Proposed SSWQO [For Drizzle Lake] (µg/L)	CCME Guideline (µg/L)
		Background Mean (µg/L)	Modelled Maximum 20-yr Value (µg/L)	Background Mean (µg/L)	Modelled Maximum 20-yr Value (µg/L)		
Aluminum (Al)	620	8.30	148	3.3	60.1	100	100
Arsenic (As)	2.2	0.92	1.21	0.77	0.90	5	5.0
Cadmium (Cd)	0.067	0.01	0.02	0.02	0.02	Background	0.052
Chromium (Cr)	1.1	<0.5	0.44	<0.5	0.36	8.9	8.9
Copper (Cu)	2.3	0.25	0.72	0.36	0.54	3	2-4
Iron (Fe)	570	1091	972	69.5	116	Background (seasonal)	300
**Lead (Pb)	0.92	0.028	0.30	0.05	0.14	4	1-7
Mercury (Hg)	<0.10	<0.01	<0.027	<0.01	<0.018	0.026	0.026
Molybdenum (Mo)	47.1	1.27	11.7	2.1	6.24	73	73
Nickel (Ni)	7.0	<0.5	1.79	<0.5	0.87	110	25-150
Selenium (Se)	<1.0	<1.0	<0.60	<0.1	<0.50	1	1
Silver (Ag)	0.03	<0.01	0.02	<0.01	0.01	0.1	0.1
Thallium (Tl)	<0.2	<0.1	<0.08	<0.1	<0.06	0.8	0.8
Uranium (U)	10.0	0.08	2.1	0.36	1.1	15	15
Vanadium (V)	0.58	<1.0	0.5	<1.0	0.5	6	6*
**Zinc (Zn)	28.0	0.90	8.70	1.43	4.1	Background	30

*Ontario Water Quality guideline value; no CCME guideline published
**Values from May 10, 2012 IR response to MVEIRB, Table 1 representing pilot plant process water
***Values represent worst case as derived from the DAR

Rare Earth Element Concentrations

Parameter	Day 5 Decant Metal Concentration (µg/L)	Drizzle Lake		Thor Lake		Proposed SSWQO* [Drizzle L.] (µg/L)
		Background Mean (µg/L)	Modelled Maximum 20-yr Value (µg/L)	Background Mean (µg/L)	Modelled Maximum 20-yr Value (µg/L)	
Cerium (Ce)	139	<0.05	31.8	<0.05	12.8	3.2
Dysprosium (Dy)	2.52	<0.05	0.61	<0.05	0.28	16.2
Erbium (Er)	0.581	<0.05	0.171	<0.05	0.099	19.1
Europium (Eu)	1.09	<0.05	0.29	<0.05	0.15	11.2
Gadolinium (Gd)	9.37	<0.05	2.18	<0.05	0.91	15
Hafnium (Hf)	0.267	<0.1	0.138	<0.1	0.115	4.4
Holmium (Ho)	0.312	<0.05	0.110	<0.05	0.074	0.7
Lanthanum (La)	68.8	<0.05	16	<0.05	6.4	1.8
Lutetium (Lu)	0.033	<0.05	0.46	<0.05	0.048	2.9
Niobium (Nb)	2.57	<0.1	0.66	<0.1	0.33	2.6
Neodymium (Nd)	61.6	<0.05	14.1	<0.05	5.72	14.3
Praseodymium (Pr)	17.3	<0.05	3.99	<0.05	1.64	3.5
Samarium (Sm)	11.0	<0.05	2.55	<0.05	1.06	7.4
Scandium (Sc)	3.39	0.9	1.47	0.5	1.13	2.9
Tantalum (Ta)	0.230	<0.1	0.130	<0.1	0.112	0.2
Terbium (Tb)	0.819	<0.05	0.226	<0.05	0.121	8.4
Thulium (Tm)	0.046	<0.05	0.049	<0.05	0.050	6.9
Ytterbium (Yb)	0.324	<0.05	0.113	<0.05	0.075	6.9
Zirconium (Zr)	3.29	<0.1	0.83	<0.1	0.39	11.2

* Based on 10% of 7-day (Chronic) LC-50 Testing H.azteca (Borgmann et al., 2005)