Information Requests (IR) from April 15, 2014:

MVRB/MVLWB_IR#1: During the presentation entitled "Snap Lake Mine Site Water Balance and Water Quality Model Predictions", the department of Environment and Natural Resources (ENR) enquired about the assumptions used in the model to generate the periodicity shown in the graphs of the model calibration of TDS on page 14 of the presentation. Therefore, DBCI is to provide a description of the assumptions and/or factors used to generate the calibration curves (e.g., ice thickness etc). DBCI also to explain how it carried these assumptions forward in the model. Quantitatively and qualitatively describe level of uncertainty in the model.

Response

The cyclical annual pattern present in the model results is caused by ice formation and ice melting. The magnitude of the cycle varies and depends on ice thickness and the depth of the lake at the monitoring station of interest. For the calibration, ice formation and melting volumes were derived from the annual average of maximum ice thickness measurements between 2004 and 2012 (Table MVRB/MVLWB_IR#1-1), which were calculated by first identifying the maximum ice thickness measurement at each Aquatic Effects Monitoring Program (AEMP) station from each year and then averaging the maximum ice thickness measurements from all AEMP stations in Snap Lake.

Modelling the processes of ice formation and melting involved the following assumptions:

- ice formation occurred over a ninety day period from mid-October to January each year;
- ice melting occurred over a sixty day period from mid-April to mid-June each year;
- for future simulations, an average ice thickness of 1.3 metres (m) was used each year; and,
- as ice forms on the lake, constituents (mass) are rejected from the ice and remain in the lake. As a result, parameter concentrations in the lake increase during the ice-covered season.

Table MVRB/MVLWB_IR#1-1: Snap Lake Ice Thickness Values Used in the Model Calibration

Year	Average of Maximum Measured Ice Thickness (m)
2004	1.3
2005	1.4
2006	1.3
2007	1.4
2008	1.6
2009	1.4
2010	1.3
2011	1.3
2012	1.4

m = metres.

The main model inputs that affect water quality in Snap Lake are effluent discharge and lake water recirculation to the Mine. There is high confidence that the upper and lower bound model scenarios describe the range of variability in effluent discharge and lake water recirculation that will be encountered during future mining. For other calibration inputs and assumptions, refer to Sections 2.2 and 2.3 of the Snap Lake Hydrodynamic and Water Quality Model Report (De Beers 2013). Sections 4 and 5 of the Snap Lake Hydrodynamic and Water Quality Model Report provide further discussion on model uncertainty.

Reference

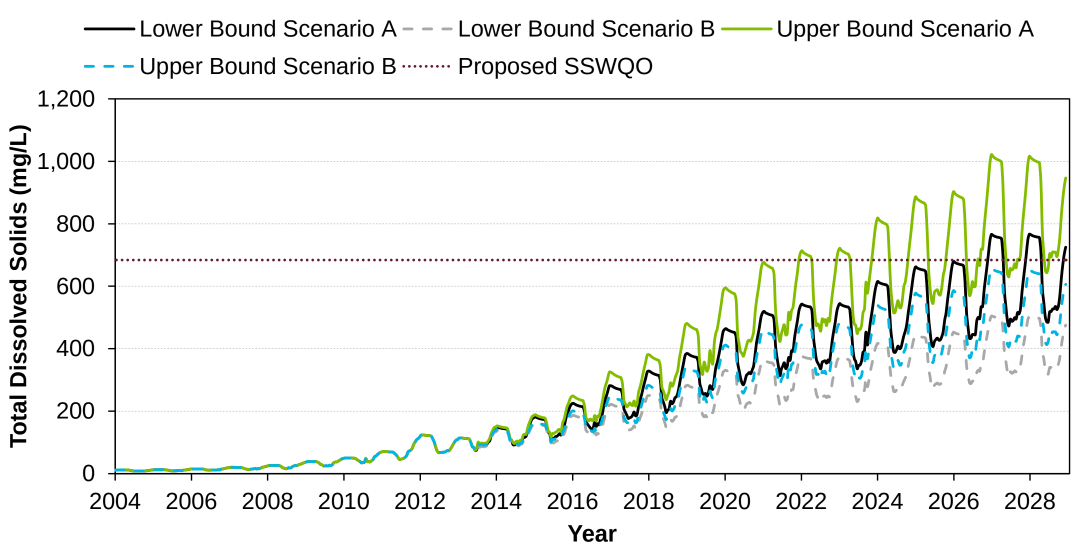
De Beers (De Beers Canada Inc.). 2013. Snap Lake Hydrodynamic and Water Quality Model Report. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

MVRB/MVLWB_IR#2: Based on a request from the Snap Lake Environmental Monitoring Agency, DBCI is to provide information about TDS concentrations in Snap Lake at the water intake location over time.

Response

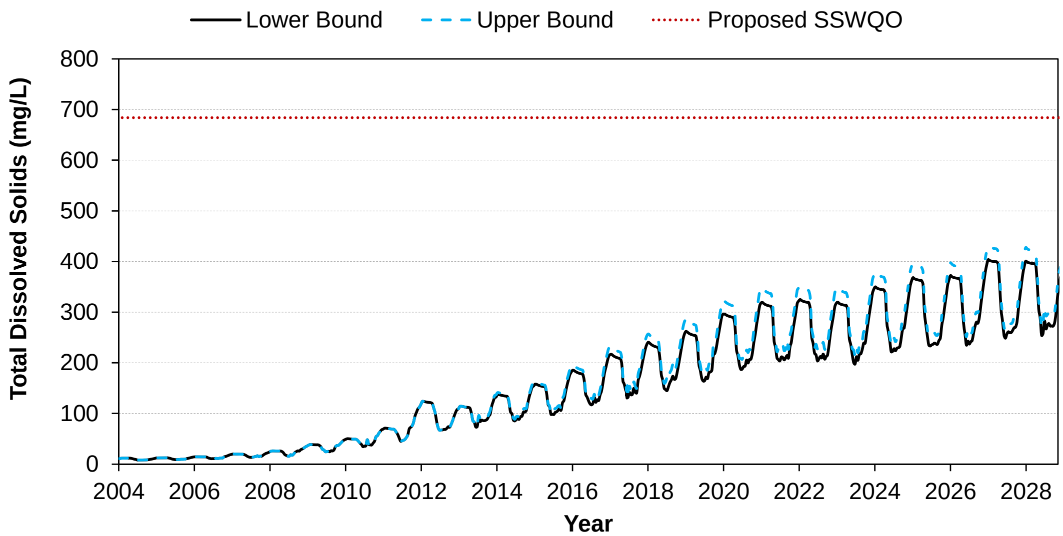
Figures MVRB/MVLWB_IR#2-1 and MVRB/MVLWB_IR#2-2 present predicted depth-averaged TDS concentrations near the water intake location for model scenarios without mitigation and with mitigation, respectively.

Figure MVRB/MVLWB_IR#2-1: Predicted Depth-Averaged Total Dissolved Solids Concentrations in Snap Lake Near the Water Intake (Without Mitigation)



mg/L = milligrams per litre; SSWQO = site-specific water quality objective.

Figure MVRB/MVLWB_IR#2-2: Predicted Depth-Averaged Total Dissolved Solids Concentrations in Snap Lake near the Water Intake (Proposed EQC are Met)



mg/L = milligrams per litre; EQC = effluent quality criteria; SSWQO = site-specific water quality objective.

MVRB/MVLWB_IR#3: DBCI is to provide further information on mitigation options for TDS treatment in the form of historical Best Treatment Available documentation.

Response

The three Best Treatment Available studies that have been completed since 2008 are summarized in the following table together with Interim results from a study completed by Hatch as part of the 10-year review of the Metal Mine Effluent Regulations conducted by Environment Canada. Copies of the reports prepared for De Beers are included in this submission. Please note that a copy of the interim Hatch report is not available for distribution; however, Snap Lake participated in the study and is familiar with the technology assessment results for chloride.

Table MVRB/MVLWB_IR#3-1 Total Dissolved Solids Treatment Study Summary

	2008 SLM Water Management Treatment Alternatives (Golder 2008)	**2012 SLM WTP Alternatives Evaluation (CH2M Hill 2012)**	**2013 Treatment Review Footwall Water TDS Management Plan (Golder 2013)**	**2014 Interim MEND Study BATEA for Mines (Hatch 2014)**
Selected Treatment Systems				
Water to be Treated	Haulage Drifts (Footwall) Water	Mine Water + Water Management Pond (WMP)	Footwall Water	Mine Water, Tailings Seepage
TDS Treatment Processes:				
Forward Flow Treatment Processes (following existing water treatment plant [WTP])	Ultra-filtration (UF), Reverse Osmosis (RO)	Equalization, High-rate Clarification, Micro-filtration (MF)/UF, RO	UF, RO	RO
Brine/Salt Management Processes	1. Evaporator and Crystallizer (isolation cell for salt disposal on-site) 2. Evaporator and Use in Paste Tails 3. Evaporator and Deep Well	Evaporator and Crystallizer (cost analysis by Golder)	Evaporator and Crystallizer	NA
Winter Brine Storage	NA	NA	NA	NA
System Flow Rates (m^3/day)	Initial – 5,000 Future (3 cases) – 1. 10,000 2. 20,000 3. 30,000	Initial – 41,000 Future – 45,000	4,000 to 9,000 5,425 (average for Operational cost estimation)	Average – 48,000 Maximum – 72,000
Treatment Objectives (Water Quality)	TDS-350 mg/L (whole lake limit)	Nitrate-4 mg/L as N Chloride-160 mg/L TDS-NA	TDS-350 mg/L (whole lake limit)	Chloride<13.5 mg/L TDS-NA
Treatment Objectives (Water Management)	Expand treatment as mine development occurs; future footwall flow increases were not understood in 2008	Handle 2015 flow; no phasing; considers split treatment of mine water	Separate footwall water collection and treatment; minimize secondary waste	Meet water quality benchmarks

Table MVRB/MVLWB_IR#3-1: Total Dissolved Solids Treatment Study Summary

	2008 SLM Water Management Treatment Alternatives (Golder 2008)	**2012 SLM WTP Alternatives Evaluation (CH2M Hill 2012)**	**2013 Treatment Review Footwall Water TDS Management Plan (Golder 2013)**	**2014 Interim MEND Study BATEA for Mines (Hatch 2014)**
Notes on Treatment Systems	Technical and regulatory aspects for disposal or reuse of concentrated brine and for disposal of salts were not studied	Brine management/ disposal not studied; although combinations of WMP and partial mine water treatment were discussed, treatment flow was projection of total discharge (mine plus WMP) to Snap Lake	Utilizes ultrafiltration (UF) with flocculant feed for total suspended solids (TSS) removal.	Media filters (best available technology economically achievable [BATEA] and existing treatment) are listed as pretreatment, but it is noted that additional processes could be needed; RO uneconomical so not considered as BATEA for Diamond Sector
Cost Information				
Capital Cost ($Millions-$M)	Initial – $26.2M 1. $56.0M 2. $88.3M 3. $104.6M	$121.5M	$84.0M	$90.3M
Unit Capital Cost ($/m^3/day)	Initial-$5,230/m^3/day 1. $5,600 2. $4,413 3. $3,487	$2,701/m^3/day	$9,333/m^3/day	$1,254/m^3/day
Total Operational Cost ($M/year)	NA	$20.3M/year	$8.1M/year	$7.6M/year
Unit Operational Cost ($/m^3)	NA	$1.24	$4.09	$0.43/m^3
Operational Cost Elements:				
Power Cost ($M/year)	Initial - $5.87M/year 3. $34.7	$13.6M/year	$6.48M/year	NA
Unit Power Rate ($/kw-hr)	$0.264	$0.27	$0.27	NA
Unit Power Cost ($/m^3)	Initial - $3.22 3. $3.17	$0.83	$3.27	NA
Maintenance ($M/year)	NA	$2.03M/year	$1.22M/year	NA
Consumables (chemicals/membranes) ($M/year)	NA	$3.86M/year	$0.16M/year	NA

Table MVRB/MVLWB_IR#3-1: Total Dissolved Solids Treatment Study Summary

	2008 SLM Water Management Treatment Alternatives (Golder 2008)	**2012 SLM WTP Alternatives Evaluation (CH2M Hill 2012)**	**2013 Treatment Review Footwall Water TDS Management Plan (Golder 2013)**	**2014 Interim MEND Study BATEA for Mines (Hatch 2014)**
Labor ($M/year)	NA	$0.81M/year	$0.24/year	NA
Notes on Cost Information	Capital cost includes phased installation of 2,500 m^3/day modules (2 modules initially); only power cost was estimated for annual operations; power cost rate assumes diesel at $1/liter, supplied by De Beers	Costs based on nitrate removal from 45,000 m^3/day; Golder estimated brine management capital and all operational costs; unit power rate supplied by De Beers	Compared to 2008 study, capital cost increase represents 8% inflation; unit power rate supplied by De Beers	Table 10-5 indicates that additional brine management would add significantly to costs
Technical Evaluation				
Water Recovery Rate (% of System Flow Rate)	RO-75% Evaporator-95% Crystallizer-99%	RO – 60–80% RO 2-Stage – 84%	RO-75% Crystallizer-99.5%	NA
System Flexibility	May need equalization to optimize RO	Additional pretreatment steps to handle variations in existing treatment system effluent	Same as 2008	Equalization tank or pond assumed as part of BATEA for TSS to optimize RO
Infrastructure Requirements	Large power demand; makeup water; chemicals	Large power demand; ballast material for some high-rate clarifiers; makeup water; chemicals	Same as 2008	NA
Land Area Requirements	600 m^2; may also need salt/brine disposal cell	260 to 540 m^2 for high-rate clarification (depending on technology selected)	200 m^2; may also need salt/brine disposal cell	NA
Secondary Waste (m^3/year)	18,000 – 110,000 (sludge from UF added to tailings for North Pile disposal)	2,628,000 (large reduction would occur after Evaporator/ Crystallizer; sludge from high-rate clarifier and MF/UF added to tailings for North Pile disposal)	NA	NA; need for brine management/treatment is discussed.

NA = Not analyzed; SLM = Snap Lake Mine; WTP = Water Treatment Plant; WMP = Water Management Pond; RO = Reverse Osmosis; UF = Ultra-filtration; MF = Micro-filtration; TDS = Total Dissolved Solids; TSS = Total Suspended Solids; BATEA = Best Available Technology Economically Achievable.

References

CH2M Hill. 2012. Snap Lake Mine Water Treatment Plant Alternatives Evaluation. Prepared for De Beers Canada Inc. Yellowknife, NWT, Canada.

Golder (Golder Associates Ltd). 2013. Treatment Review for Footwall Water as Part of TDS Management Plan. Technical Memorandum prepared for De Beers Canada, Inc. (Julie L'Heureux and Alexandra Hood), December 12, 2013. Denver, CO, USA.

Golder. 2008. Snap Lake Water Management Treatment Alternatives Report. Technical Memorandum prepared for De Beers Snap Lake Diamond Mine (Josh Harvey and Rob McLean). May 19, 2008. Denver, CO, USA.

Hatch. 2014. MEND Study to Identify BATEA for the Management and Control of Effluent Quality from Mines. Interim Report prepared for the Mine Environment Neutral Drainage Program. February 28, 2014. [Hatch was commissioned by the Mine Environment Neutral Drainage (MEND) Program to complete a study to identify best available technologies economically achievable (BATEA) to manage and control effluent from metal, diamond, and coal mines in Canada].

MVRB/MVLWB_IR#4: During the technical session, Ecometrix pointed out a discrepancy between the selection of TDS concentrations equal to 5728 mg/L and 3,490 mg/L for Scenario A and Scenario B in the water quality predictions models instead of the values of 6,187 mg/L and 3, 170 mg/L TDS, respectively, that were used in August 2013 Itasca model. DBCI provided a clarification for this apparent discrepancy by referencing an additional Itasca model submission dated October 2013. DBCI should now provide this submission for the record (see also IR#6).

Response

The ITASCA October 3, 2013 Memo, "Predicted TDS Concentration in Mine Water Discharge Based on Calculated TDS Values" is attached to this submission.

MVRB/MVLWB_IR#5: In its April 11, 2014 supplemental information submission, DBCI provided predictions of TDS concentrations in lakes downstream of Snap Lake (for 2014 to 2029) under the scenario that no mitigations are applied for TDS and under the scenario that the DBCI's proposed EQC would be met. As initially requested by ENR, DBCI is to provide the same analysis for chloride, as well as the other constituents of TDS that the Review Board scoped in, and hardness downstream of Snap Lake over time.

Response

De Beers acknowledges that the assessment of cumulative effects for this Project is non-Approximate maximum concentrations of total dissolved solids (TDS), chloride, fluoride, sulphate, and hardness at the outlet of Snap Lake, in downstream lake 1 (DSL1), downstream lake 2 (DSL2), and at the outlet of Lac Capot Blanc are presented in Table MVRB/MVLWB_IR#5-1 and 5-2 for scenarios without mitigation and with mitigation, respectively. With the exception of TDS, concentrations presented in Table MVRB/MVLWB_IR#5-1 and 5-2 were not generated using the Snap Lake or downstream lakes models described in De Beers (2013a and 2014, respectively). Simplified methods, as described below, were used to provide approximate maximum concentrations; time-varying results were not available because calcium, chloride, fluoride, magnesium, and sulphate have not yet been incorporated into the downstream lakes model (i.e., set-up, calibration and simulation). As per the Day 1 Transcript from the April 15-16 Technical Session, a simplified approximation was considered appropriate and acceptable by the MVLWB for this IR.

For the scenarios *without mitigation*, calculations of maximum parameter concentrations in DSL1, DSL2, and Lac Capot Blanc (Table 1) involved:

- Obtaining the maximum predicted TDS and major ions concentrations at the outlet of Snap Lake from the Snap Lake model (Table 3-1 in De Beers [2013a]);
- Obtaining the maximum predicted TDS concentrations in DSL1, DSL2, and Lac Capot Blanc from the downstream lakes model (Section 2.2 in De Beers [2014]);
- Calculating the percent decrease in maximum predicted TDS concentrations between the outlet of Snap Lake and DSL1, DSL2, and Lac Capot Blanc; and,
- Assuming that the calculated percent decrease in maximum TDS concentrations between the outlet of Snap Lake and DSL1, DSL2, and Lac Capot Blanc would be the same as the percent decrease in maximum major ions concentrations between the outlet of Snap Lake and DSL1, DSL2, and Lac Capot Blanc. This assumption was reasonable because in the Snap Lake model and the downstream lakes model TDS, calcium, chloride, fluoride, magnesium, and sulphate were modelled as conservative parameters (i.e., they do not undergo chemical reactions or physical processes other than advective transport).

For the scenarios *with mitigation*, calculations of maximum parameter concentrations in DSL1, DSL2, and Lac Capot Blanc (Table 2) involved the following steps:

- Obtaining the maximum predicted TDS concentrations at the outlet of Snap Lake from the Snap Lake model (Section 2.1 in De Beers [2014]);
- Obtaining the maximum predicted TDS concentrations in DSL1, DSL2, and Lac Capot Blanc from the downstream lakes model (Section 2.2 in De Beers [2014]);
- Assuming that the ionic composition of TDS in Snap Lake (Figure 1 in De Beers [2013b]) would remain the same with mitigation and calculating the maximum predicted major ions concentrations at the outlet of Snap Lake based on the maximum predicted TDS concentrations;

- Calculating the percent decrease in maximum predicted TDS concentrations between the outlet of Snap Lake and DSL1, DSL2, and Lac Capot Blanc; and,
- Assuming that the calculated percent decrease in maximum TDS concentrations between the outlet of Snap Lake and DSL1, DSL2, and Lac Capot Blanc would be the same as the percent decrease in maximum major ions concentrations between the outlet of Snap Lake and DSL1, DSL2, and Lac Capot Blanc.

Nitrate was not included in the assessment, because:

- The source of nitrate in the minewater discharge is different than the source of TDS. Elevated nitrate concentrations result from explosives use during mining; whereas TDS originates from groundwater release during mining.
- Nitrate participates in nutrient cycling in Snap Lake. Therefore, nitrate concentrations in Snap Lake are affected by processes in addition to dilution.

The maximum concentrations presented in Table MVRB/MVLWB_IR#5-1 and 5-2 for DSL1, DSL2, and Lac Capot Blanc will be verified by adding calcium, chloride, fluoride, magnesium, sulphate and nitrate to the downstream lakes model.

Table MVRB/MVLWB_IR#5-1 Maximum Concentrations in Downstream Lake 1, Downstream Lake 2, and Lac Capot Blanc Without Mitigation

Parameter	Maximum Predicted Concentrations															
	Lower Bound Scenario A				Lower Bound Scenario B				Upper Bound Scenario A				Upper Bound Scenario B			
	Snap Lake Outlet	DSL1	DSL2	LCB Outlet	Snap Lake Outlet	DSL1	DSL2	LCB Outlet	Snap Lake Outlet	DSL1	DSL2	LCB Outlet	Snap Lake Outlet	DSL1	DSL2	LCB Outlet
Total Dissolved Solids (mg/L)	1,280	989	1,114	136	827	640	722	94	1,735	1,381	1,552	192	1,101	879	989	127
Chloride (mg/L)	295	228	257	31	464	359	405	53	634	504	567	70	398	318	357	46
Fluoride (mg/L)	0.45	0.35	0.40	0.05	0.45	0.35	0.40	0.05	0.47	0.38	0.42	0.05	0.47	0.38	0.42	0.05
Sulphate (mg/L)	58	45	50	6	88	68	77	10	118	94	106	13	76	61	68	9
Hardness (mg/L as $CaCO_3$)	489	378	426	52	732	566	639	83	977	777	874	108	639	510	574	74

mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; DSL1 = downstream lakes 1; DSL2 = downstream lakes 2; LCB = Lac Capot Blanc.

Table MVRB/MVLWB_IR#5-2 Maximum Concentrations in Downstream Lake 1, Downstream Lake 2, and Lac Capot Blanc With Mitigation

Parameter	Maximum Predicted Concentrations							
	Lower Bound				Upper Bound			
	Snap Lake Outlet	DSL1	DSL2	LCB Outlet	Snap Lake Outlet	DSL1	DSL2	LCB Outlet
Total Dissolved Solids (mg/L)	638	483	542	67	698	542	609	76
Chloride (mg/L)	287	217	244	30	314	244	274	34
Fluoride (mg/L)	0.29	0.22	0.25	0.03	0.32	0.25	0.28	0.03
Sulphate (mg/L)	46	35	39	5	50	39	44	5
Hardness (mg/L as $CaCO_3$)	372	282	316	39	407	316	355	44

mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; DSL1 = downstream lakes 1; DSL2 = downstream lakes 2; LCB = Lac Capot Blanc.

Reference

De Beers. 2013a. Snap Lake Hydrodynamic and Water Quality Model Report. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

De Beers. 2013b. Development of Total Dissolved Solids (TDS) Benchmark for Aquatic Life in Snap Lake. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

De Beers. 2014. Snap Lake Water Licence Amendment Environmental Assessment EA201314-002 Supplemental Information. Submitted to the Mackenzie Valley Environmental Impact Review Board and the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

MVRB/MVLWB_IR#6: Ecometrix requested that DBCI submit the Itasca updated model dated October 2013 – see IR#4.

Response

Please see De Beers response to IR#4.

MVRB/MVLWB_IR#7: During the technical session, ENR had several questions related to scientific literature on TDS and chloride water quality objectives and guidelines that, in ENR's opinion, may not be consistent with some of the DBCI's conclusions on the toxicity of those parameters. ENR has committed to providing these references by April 22, 2014. DBCI is to provide clarification and rationale on the exclusion of any relevant studies, including those provided by ENR in response to this IR, and any other comments about the material that the Boards may want to consider.

Response

De Beers provides below, as requested by GNWT (ENR), comments regarding each of the 21 documents provided. There are no inconsistencies with De Beer's conclusions regarding site-specific water quality objectives (SSWQOs). De Beers thanks ENR for providing this documentation, which clarified some of ENR's comments at the Technical Session and supports De Beers position regarding the protective nature of the proposed SSWQOs. For instance, it is now clear that cattails will likely not be affected by TDS in Snap Lake or downstream. This evidence further supports De Beers' position that the proposed TDS SSWQO is reasonable and protective.

De Beers notes that ENR did not include the following document in their submission and provides it for the Board's consideration:

WLWB (Wek'èezhìi Land and Water Board). 2013. Decision from Wek'èezhìi Land and Water Board Issued pursuant to Section 26 of the Northwest Territories Waters Act, R.S.C. 1992, c.39. Yellowknife, NWT, Canada.

On pages 7 and 8 of WLWB (2013) it is stated: "DDMI proposed a new Effects Benchmark for TDS because it triggered Action Level 2 in the proposed Response Framework. A benchmark of 1000 mg/L is proposed, which is adopted from the state of Alaska Department of Environmental Conservation's (DEC) 2012 Water Quality Standards. In their reviews, both EcoMetrix Inc. and Environment Canada noted that the guidelines of 1,000 mg/L TDS stated by the Alaska DEC (2012) is an upper bound and that any proposal to increase TDS to a level between 500 mg/L and 1,000 mg/L requires a special permit where the permit applicant must provide information to the department to show the proposed TDS level will not cause an adverse effect to aquatic life…. the Board concludes that the most appropriate TDS benchmark is 500 mg/L."

Diavik received the default 500 mg/L benchmark because they did not provide scientifically defensible studies justifying a higher benchmark. De Beers has provided such studies in the development of site-specific water quality objectives (SSWQOs) following guidance provided by the Canadian Council of Ministers of the Environment. De Beers has provided evidence that Snap Lake TDS concentrations of 684 mg/L and 1,000 mg/L are not toxic to aquatic life in Snap Lake. Note further that the Alaska Department of Environmental Conservation has issued two permits for TDS concentrations in receiving freshwater bodies of 1,000 mg/L, and one permit for up to 1,500 mg/L, as detailed below.

Examples of Other Relevant Jurisdictions[1] with TDS or Chloride Regulations:

De Beers does not understand this footnote. The Snap Lake Environmental Monitoring Agency (SLEMA) has not to our knowledge, as part of the EA, submitted such a summary. SLEMA has not submitted any IRs related to TDS discharges in the United States. However, on April 17 Zhong Liu, a member of SLEMA, sent an e-mail to Simon Toogood of the MVRB providing a 1988 document entitled "USEPA Water Quality Standards Criteria Summary – A Compilation of State and Federal Criteria". It is not clear how such a 26-year old document is applicable to De Beers' proposed SSWQOs.

1. United States Environmental Protection Agency (US EPA) Aquatic Life Criteria Table for chloride.
   Available online at:
   http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable
   Note: Acute Chloride (Cl) Criteria of 860 mg/L and Chronic Criteria of 230 mg/L. Also in the US EPA Office of Water 1986. Quality Criteria for Water (Gold Book).

The USEPA develops national water quality criteria (WQC) that comprise generic, conservative benchmarks, not site-specific benchmarks. [Note that the Canadian Council of Ministers of the Environment (CCME) develops water quality guidelines (WQGs), not WQC.] USEPA allows states to develop State-specific water quality standards (WQS), although these must be approved by USEPA. For example, Kentucky recently developed selenium WQS that differ from national WQC. Kentucky's state-specific selenium WQS were approved by USEPA. Similarly, within states, site-specific water quality criteria (or standards) can be developed for specific projects or circumstances. See for example items 4 and 5, below (State of Pennsylvania; DoEC 2009). De Beers developed TDS and other SSWQOs specific to Snap Lake.

2. British Columbia Ministry of Environment (BC MOE) CAPP Freshwater Salinity Working Group and the Salt Technology Advisory Sub-Committee of the British Columbia Upstream Petroleum Committee. *A Review of the Toxicological Literature for Salt - 2002 to 2007* (attached).
   Note: BC MOE recommends a Cl concentration of 150 mg/L.

This document focuses on NaCl not on TDS in general; it is not relevant to the specific ionic composition of Snap Lake total dissolved solids (TDS). This document predates published research showing the modifying effects of hardness on chloride toxicity; that research is detailed in documentation previously supplied to the Board.

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[1] ENR notes that the Snap Lake Environmental Monitoring Agency has submitted for the Boards consideration a summary of applicable alternate jurisdictions for the regulation of TDS discharges in the United States.

3. BC MOE Ambient water quality guidelines for sulphate- (attached).

The above document was not attached; however, De Beers presumes that ENR is referring to Province of British Columbia, Ministry of Environment, Ambient Water Quality Guidelines for Sulphate (Technical Appendix, Update, April 2013, prepared by Cindy Meays, PhD and Rick Nordin, PhD). This document was used to develop the Snap Lake AEMP benchmark for sulphate as noted in the documentation provided to the Board by De Beers.

4. State of Pennsylvania, Chapter 93. Water Quality Standards. Available online at: http://www.pacode.com/secure/data/025/chapter93/chap93toc.html
Note: TDS limit of 500 mg/L as a monthly average; maximum grab 750 mg/L.

Section § 93.8d. of the above document is entitled "Development of site-specific water quality criteria.". This section notes that a request for site-specific criteria will be considered when "There exist site-specific biological or chemical conditions of receiving waters which differ from conditions upon which the water quality criteria were based." This is in fact the case for Snap Lake where the TDS SSWQO was based on the unique ionic composition of that TDS.

5. Alaska Department of Environmental Conservation (DoEC), Water Quality Standards. 18 ACC 70. 2009 (attached).
Note: Golder identifies a seasonal limit of 1000mg/L for the Teck Resources Red Dog Mine; however, this is mine is located in close proximity to the ocean (Chukchi Sea) where ecosystems may be more adapted to saline influences and a lower value applies during environmentally sensitive periods. For comparison, at an inland mine (Gold Creek), the Alaska DoEC has set TDS at 300mg/L. In addition the TDS limit is set in Alaska depending on the receiving waterbody. Alaska may limit the concentration of chloride to 200 mg/L as per the US EPA aquatic life criteria.

The above document was not attached. However, De Beers referenced this document in the documentation and presentations provided to the Board both in the 2011 Snap Lake Water Licence Renewal and in the present process. ENR is correct that "the Alaska DoEC has set TDS at 300 mg/L" for Gold Creek but fails to provide any information on how that limit was set in 2002 in a permit to the City and Borough of Juneau for the inactive (closed in 1944) Alaska-Juneau (A-J) Mine, whose drainage effluent discharges to Gold Creek.

It is noteworthy that Alaska DoEC has also set limits for TDS of 1,000 mg/L for Camp Creek and Sherman Creek TDS, both freshwater bodies. Limits for the Red Dog Main Stem are: "Total dissolved solids (TDS), with calcium greater than 50% by weight of the total cations, may not exceed 1,500 mg/l, and may not exceed 500 mg/l during the spawning period for Arctic grayling". The Red Dog Mine discharges, as documented in the 3rd document of the next sequence provided by ENR (Brix et al. 2009, p109) "to Red Dog Creek, a first order tributary of the Ikalukrok

River, which is part of the larger Wulik River drainage". While ENR's conjecture that "[freshwater] ecosystems [near marine systems] may be more adapted to saline influences" may be correct where the Wulik River drains to the Arctic Ocean, it is not correct for upstream freshwater systems such as Red Dog Creek. However, adaptation to saline influences does occur and may occur over time as TDS concentrations increase.

6. Health Canada- Drinking Water Quality Guidelines (attached).
   Note: The Aesthetic Objective is 500 mg/L for TDS.

The above document was cited in the documentation provided to the Board by De Beers including the Supplementary Information, and was discussed at length during the Technical Sessions. As noted in the above document, there are no health issues identified with drinking water containing elevated concentrations of TDS. As stated in the above document, TDS in drinking water has been recorded at concentrations up to 2,510 mg/L in Manitoba, 5,376 mg/L in Saskatchewan, 1,000 mg/L in Alberta, and 4,662 mg/L in British Columbia. The aesthetic objective of 500 mg/L was set based on a panel of tasters who found that waters with TDS concentrations between 300 and 600 mg/L tasted good (but waters with low concentrations of TDS did not ; they had a [p2] "flat, insipid taste"). The 500 mg/L aesthetic objective includes considerations regarding (p2) "excessive scaling in water pipes, water heaters, boilers and household appliances". Note that the panel of tasters only found taste to be unacceptable above 1,200 mg/L; water with 600 to 900 mg/L was rated as "fair".

Note also that mineral water, which many prefer to drink rather than tap water, typically has relatively high TDS concentrations. For example, Vichy water has >3,000 mg/L TDS.

http://www.thenibble.com/reviews/main/beverages/waters/vichy-catalan-mineral-water.asp

Amendment - relevant Scientific Journal Articles (attached within GNWT IR response):

1. Weber-Scannel P.K and Duffy L.K. 2007. Effects of Total Dissolved Solids on Aquatic Organisms: A Review of Literature and Recommendation for Salmonid Species. *American Journal of Environmental Sciences.*

This publication was cited repeatedly in the information provided during the 2011 Water Licence Renewal and in the present Water Licence Amendment process in both written documentation and slide presentations. It was a key document in the development of the Snap Lake TDS SSWQO. Two key points from that publication that form the basis for De Beer's development of a TDS SSWQO are:

- define separate limits for different categories of ions or combinations of ions comprising TDS; and,

- do not set universal TDS limit – all TDS is not the same.

The latter point is important; ENR and others have provided TDS and chloride benchmarks that are not relevant to Snap Lake as they were not developed for the unique TDS composition in Snap Lake.

2. Mount et al. 1997. Statistical Models to Predict the Toxicity of Major Ions to Ceriodaphnia Dubia, Daphnia Magna and Pimephales Promelas (Fathead Minnows*)*. *Environmental Toxicology and Chemistry*.

This publication is concerned with using regression models to screen toxicity of different major ion combinations. Predictions were not perfect and the authors note that over-prediction occurred (e.g., with *Daphnia magna*). As noted by the authors in the first sentence of the Abstract "Toxicity of fresh waters with high total dissolved solids has been shown to be dependent on the specific ionic composition of the water." This is why De Beers developed a SSWQO for the unique TDS in Snap Lake.

3. Brix K.V et al. 2009. The effects of total dissolved solids on egg fertilization and water hardening in two salmonids- Arctic Grayling (*Thymallus arcticus*) and Dolly Varden (*Salvenlinus malma*). *Aquatic Toxicology*.

This publication, which led to the Alaska Department of Environmental Conservation site-specific water quality standard for TDS in Red Dog Creek (see item 5 under Examples of Other Relevant Jurisdictions with TDS or Chloride Regulations, above) was a key consideration in the design of the Snap Lake TDS toxicity tests with Arctic Grayling and Lake Trout, in particular the early life stage testing and the use of both dry and wet fertilization. This publication is cited in the documentation provided to the Board related to the TDS SSWQO. Note that the authors found that (Abstract and p 114) "Arctic Grayling and Dolly Varden fertilization success is not sensitive to elevated TDS with EC20s (concentration causing 20% effect) of >2782 and >1817 mg/L (the highest concentrations tested), respectively." Note that this publication also confirms the use of a 20% effect level as having negligible effects.

4. Hallock R.J. and Hallock L.L. 1993. Detailed Study of Irrigation Drainage in and near Wildlife Management Areas, West-central Nevada. United States Geological Survey*.*

This document is comprised of 5 detailed reports: historical conditions; toxicity of irrigation drainage; movement of selenium and mercury; effects of boron, mercury, and selenium on waterfowl production; and, mercury and selenium in edible tissue of waterfowl. Salinity and contaminant concentrations increased in Carson Lake and Stillwater Marsh after they were hydrologically isolated. In 1863 TDS concentrations in Carson Lake were "about 1,500 mg/L" (p 16); however, in January 1987 they had "reached a dissolved-solids concentration of 20,000 mg/L" (p 17). On page 18 it is noted that cattails are "extremely sensitive to dissolved-solids concentrations" quoting Stewart and Kantrud (1972, Vegetation of prairie potholes, North Dakota, in relation to quality of water and other environmental factors. US Geological Survey Professional Paper 585-D, 36pp), and that cattails "are now found only in scattered patches".

The Stewart and Kantrud (1972) document was not provided by ENR; however, this document was obtained and reviewed. Figure 20 (Characteristic plant species of deep-marsh emergent vegetation) shows that cattails can be common from fresh to moderately brackish water; two species are not common in fresh water and one of those two species is common even in brackish water. Stewart and Kantrud (1972, p D-5, Table 2) characterize moderately brackish as 1,550 mg/L TDS, brackish water as 5,570 mg/L TDS, and subsaline water as 26,400 mg/L TDS. No cattails are common in subsaline water, which presumably is the salinity of the waters described in Hallock and Hallock (1993) as having cattails "now found only in scattered patches".

The chapter in Hallock and Hallock (1993) entitled "Toxicity of irrigation drainage and its effect on aquatic organisms" describes toxicity testing conducted in drainwaters from two locations ranging from about 270 to 17,900 mg/L TDS and about 4,000 to 9,700 mg/L TDS. Page 36 states "Although the elevated salinity in tests with drainwater from both locations undoubtedly stressed the organisms, the results suggest that salinity alone does not account for the mortality observed." Page 37 states "Mortality is attributed primarily to a combination of toxic trace elements regardless of the benefits of increased hardness." This chapter provides additional evidence that freshwater organisms can survive in elevated TDS concentrations; the above TDS concentrations were up to an order of magnitude higher than worst case predictions for Snap Lake.

5. Bodkin et al. 2007. Limiting Total Dissolved Solids to Protect Aquatic Life. *Journal Of Soil and Water Conservation*.

This 4 page document is focused on TDS concentrations in waters of Virginia, Kentucky, and West Virginia. It notes in the last paragraph "Questions still exist as to the level of TDS that is protective of aquatic communities, and the answer may vary among ecosystems". De Beers derived an SSWQO for Snap Lake TDS because the answer does in fact vary among ecosystems.

6. Carmargo et al. 2005. Nitrate Toxicity to aquatic animals: a review with new data for freshwater invertebrates. *Chemosphere* Volume 58.

This publication had previously been reviewed (pers communication between Peter Chapman, Golder Associates Ltd. and James Elphick, Nautilus Environmental) by the authors of the Dominion Mines Ekati Corporation, Board-approved SSWQO for nitrate (WL W2012L2-0001; Rescan. 2012. EKATI Diamond Mine: Site-Specific Water Quality Objective for Nitrate, 2012. Prepared for BHP Billiton Canada Inc, Yellowknife, NWT, Canada). They did not include it in their

SSWQO as Carmargo et al. (2005) conducted acute, not chronic toxicity tests and the SSWQO for nitrate is based on chronic toxicity tests.

De Beers' further review of Carmargo et al. (2005) indicated that nitrate concentrations were not measured and that testing involved 5 day exposures of 5 to 6 nominal nitrate concentrations to 3 invertebrates common in streams in Spain. The toxicity test benchmarks in this publication are thus uncertain and not relevant to the nitrate SSWQO; however, the findings that increasing TDS concentrations reduce nitrate toxicity and that adaptation occurs are relevant. The former finding supports the hardness-based nitrate SSWQO for Snap Lake.

7. Cormier et al. 2013. Assessing causation of the extirpation of stream macroinvertebrates by a mixture of ions. *Environmental Toxicology and Chemistry.*

This publication used a weight of evidence (WOE) approach to implicate specific ion mixtures (different ion mixtures than Snap Lake) in impacts on aquatic invertebrates in Appalachian streams, not a headwater lake. Chloride was not a major component of the specific ion mixtures tested. The WOE approach used was retrospective (i.e., based on events that had already occurred), not prospective (i.e., not based on future possibilities). This publication is not relevant to the development of the Snap Lake TDS SSWQO.

8. Cormier et al. 2013b Relationship of land use and elevated ionic strength in Appalachian watersheds. *Environmental Toxicology and Chemistry.*

This publication focused on exposure to TDS not the effects of TDS. It confirmed that coal mining in Appalachia was the primary source of high conductivity waters in streams. This publication is not applicable to the development of the Snap Lake TDS SSWQO.

9. DeMarch. 1988. Acute Toxicity of Binary Mixtures of Five Cations (Cu2+, Cd2+, Zn2+, Mg2+ and K+) to the freshwater amphipod gammarus lacustris (Sars): Alternative Descriptive Models. *Canadian Journal of Fisheries Aquatic Science.*

This publication, as the title indicates, was focused on acute not chronic toxicity. The TDS SSWQO developed for Snap Lake is based on chronic toxicity. Metals are not a factor in Snap Lake TDS and none of the major ions comprising Snap Lake TDS were tested in this publication (magnesium only comprises 3% of Snap Lake TDS, while potassium comprises less than 1%); thus, the mixtures tested are not relevant to the development of the Snap Lake TDS SSWQO.

10. Kunz et al. 2013. Use of reconstituted waters to evaluate effects of elevated major ions associated with mountaintop coal mining on freshwater invertebrates. *Environmental Toxicology and Chemistry.*

This publication conducted toxicity tests with *Ceriodaphnia dubia*, an amphipod, and a mayfly. None of the species tested are found in Snap Lake. Chloride was not a major constituent of the major ions tested; thus, the toxicity tests are not directly applicable to the development of the Snap Lake TDS SSWQO. However, the publication did note (Abstract) “waters with similar conductivities but, with different ionic compositions had different effects on the test organisms…although elevated TDS can be correlated with toxicity, the specific major ion composition of the water is important”. The publication (p 2834) recommends “conducting toxicity tests with environmentally relevant and sensitive species”. These statements support the approach taken by De Beers in developing a SSWQO for Snap Lake TDS.

11. Pond and North. 2013. Application of a benthic observed/expected-type model for assessing Central Appalachian streams influenced by regional stressors in West Virginia and Kentucky. *Environmental Monitoring and Assessment*.

This publication is concerned with the development of indices for retrospective evaluation of TDS impacts and is specific to Central Appalachian waters. As stated at the end of the Abstract “These indices can be used to supplement existing bioassessment tools crucial to detecting and diagnosing stream impacts in the Central Appalachian region of WV and KY.” This publication is not relevant to the prospective approach of developing a SSWQO for Snap Lake TDS or to freshwater lakes in the NWT.

12. Sorenson et al. 1977. Suspended and dissolved solids effects on freshwater biota: A review. US EPA document number EPA-600/3-77-042.

This 1977 report focuses on literature prior to 1971 and thus does not include scientific studies conducted between 1971 and the present. However, relevant information was used in the literature review of TDS toxicity conducted as part of the Snap Lake TDS SSWQO development.

13. Suter and Cormier. 2013. A Method for assessing the potential for confounding applied to ionic strength in central Appalachian streams. *Environmental Toxicology and Chemistry*, Vol 32.

This publication is not concerned with toxicity testing; it comprises a weight of evidence (WOE) assessment of 12 potential confounders of the relationship between ionic strength and impaired benthos in Central Appalachian streams, not a headwater lake. This publication is relevant to the WOE approach used in the AEMP (the authors of the Snap Lake AEMP benthos and WOE components are aware of this publication), but not to the prospective approach of developing a SSWQO for Snap Lake TDS.

Other Amendment-relevant Articles for the Proponents Response to IR#7 (not attached):

14. Banack et al. 2012. Toxicity of fluoride to a variety of aquatic species and evaluation of toxicity modifying factors. In Harkness J, van Aggelen G, Kennedy CJ, Jarvis RA, Burridge LE (eds), Proceedings of the 39th Annual Aquatic Toxicity Workshop: September 30 to October 3, 2012, Sun Peaks, BC, Canada. Fisheries and Oceans Canada, St. Andrews Biological Station, St. Andrews, NB, Canada, p. 54.

This publication was extensively cited and used in the development of the fluoride SSWQO; documentation to this effect was provided to the Board.

15. Borgmann. 1996. Systematic analysis of aqueous ion requirement of *Hyallea Azteca*- A standard artificial medium including the essential bromide ion. *Environmental Contaminants Toxicology*, 30:356-363.

This publication concerns an artificial medium for culturing the amphipod, *Hyalella azteca*; it has no relevance to the development of a SSWQO for TDs for Snap Lake.

16. Brannock et al. 2002 Salt and Salmon: The effects of hard water ions on fertilization. Aquatic Science Meeting. *American Society of Limnology and Oceanography* Feb 11-15

This reference is a non-peer reviewed presentation at a scientific meeting. The document was not provided but was one of the references relied upon in Weber-Scannel and Duffy (2007; item 1 above under Amendment - relevant Scientific Journal Articles). As previously noted, the Weber-Scannel and Duffy publication was a key document used in the development of the Snap Lake TDS SSWQO.

17. Cowgill and Milazzo. 1991 The sensitivity of Two Cladocerans to Water Quality Variables: Salinity <467 mg NaCl/L and Hardness <200 mg $CaCO_3$/L. *Environmental Contaminants and Toxicology.*

This peer reviewed publication documents no effects to either *Ceriodaphnia dubia* or *Daphnia magna* from <467 mg NaCl/L or > 200 mg $CaCO_3$/L, but does document effects at low hardness. It is not relevant to the development of a SSWQO for TDs for Snap Lake.

18. Evans and Prepas. 1996. Potential effects of climate change on ion chemistry and phytoplankton communities in prairie saline lakes. *Limnology Oceanography.*

This peer reviewed publication documents changes in phytoplankton biomass in P-sufficient lakes; Snap Lake is not a P-sufficient lake. The authors also noted (p 1075) that such changes are “not observed in all saline ecosystems”. This publication has no relevance to the development of a SSWQO for TDs for Snap Lake.

19. Zalizniak et al. 2006. Is all salinity the same? The effect of ionic compositions on the salinity tolerance of five species of freshwater invertebrates. *Marine and Feshwate*r Research 57:75-82.

The conclusions of this peer-reviewed publication support the development of a SSWQO for Snap Lake TDS. As noted in the Abstract, “Variation in ionic proportions should be taken into account when considering sub-lethal effects of salinity on freshwater invertebrates”. In other words, the specific ionic composition of TDS is critically important.

20. EVS Environment Consultants. 1998. Effects of TDS on fertilization and viability of rainbow trout and chum salmon embryos. Revised Final Draft EVS Project No. 9/302-28. Prepared for Cominco Alaska.

This report was prepared by Peter Chapman, presently with Golder Associates Ltd. Dr. Chapman directed development of the Snap Lake TDS SSWQO. The information in the report was used in the development of the Snap Lake TDS SSWQO.

21. Ivey et al. 2013. Sensitivity of freshwater mussels at two life stages to acute or chronic effects of NaCl and KCl. SETAC poster. Society of Environmental Toxicology and Chemistry.

This non-peer reviewed poster presentation at a scientific meeting was not provided but the Abstract was obtained and reviewed. The research outlined indicates that freshwater mussels are sensitive to NaCl and KCl and that toxicity decreases as hardness increases. The latter finding supports the hardness-based chloride SSWQO. The former finding was based on two-ion mixtures not on the TDS-specific ion mixture in Snap Lake, which includes chloride.

MVRB/MVLWB_IR#8: DBCI to provide revised version of CH2MHill Assessment Report.

Response

Please refer to IR#3.

MVRB/MVLWB_IR#9: DBCI to provide the Golder 2008 Snap Lake Water Management Treatment Alternatives Report.

Response

Please refer to IR#3.

MVRB/MVLWB_IR#10: On slide 14 of DBCI's presentation on the TDS Response Plan, DBCI outlined a timeline of the planning, testing and implementation of mitigations to reduce TDS levels in the effluent. At the technical session, MVLWB staff expressed a concern about how to best align the water licensing process to amend the TDS EQC with DBCI's constraints around making final decisions on TDS mitigations and then implementing those mitigations before the current TDS EQC is exceeded. Therefore, the MVLWB staff requests that DBCI provide a graphic or table that aligns their timeline for the TDS mitigations with the predictions of end-of-pipe TDS concentrations. It would be helpful if DBCI could discuss its vision of how best to ensure that the water licensing process can be carried out to ensure that EQC for TDS are in place that are both protective and achievable.

Response

Predictions of TDS concentrations at end-of-pipe (i.e., surveillance network program [SNP] 02-17B) without mitigation and the anticipated timeline for implementation of mitigation are presented in Figure MVRB/MVLWB_IR#10-1. Pilot-scale testing and design are planned for the remainder of 2014, followed by approvals, construction, and implementation in 2015. De Beers anticipates that mitigation will be operational by January 2016 (Figure MVRB/MVLWB_IR#10-1). However, by January 2015, end-of-pipe TDS concentrations are predicted to be higher than the proposed average monthly limit (AML) of 684 milligrams per litre (mg/L) for all four modelled scenarios; De Beers would, therefore, be out of compliance with the Water Licence, should an AML of 684 mg/L be adopted as early as January 2015.

Predictions of TDS concentrations at the diffuser stations (i.e., SNP 02-20) and in the whole-lake without mitigation are presented in Figures MVRB/MVLWB_IR#10-2 and MVRB/MVLWB_IR#10-3, respectively, including the anticipated timeline for implementation of mitigation. TDS concentrations at the diffuser stations are predicted to slightly exceed the proposed site-specific water quality objective (SSWQO) of 684 mg/L by April 2015 under Upper Bound Scenario A, without mitigation (Figure MVRB/MVLWB_IR#10-2 and Table MVRB/MVLWB_IR#10-1). Concentrations of TDS are expected to remain below the SSWQO in all other scenarios until February 2016. Concentrations of TDS and major ions in Snap Lake during operations are anticipated to fall within the range of concentrations predicted by the Upper and Lower Bound model scenarios. As a result, predicted TDS concentrations in Snap Lake are expected to remain below the proposed SSWQO of 684 mg/L in 2015.

The proposed AML of 684 mg/L was calculated based on conditions in Snap Lake at the end of Mine life when concentrations in Snap Lake are predicted to be at steady-state. The factor or condition that has the largest effect on the AML is the proportion of effluent in Snap Lake. The proportion of effluent in Snap Lake is expected to be approximately 90 percent (%) during ice-covered conditions at the end of Mine life (i.e., 2028). As a result, the ability of Snap Lake to dilute TDS concentrations at end-of-pipe would be at a minimum in late operations. In 2015, the proportion of effluent in Snap Lake would be approximately 64%. Therefore, Snap Lake has a greater assimilative capacity and a greater ability to dilute TDS concentrations at end-of-pipe in 2015 than in later years.

To allow for implementation of mitigation, De Beers proposes an interim protective TDS AML of 850 mg/L, which would apply between January 2015 and January 2016 and be inclusive of TDS, chloride, fluoride, and sulphate. The Snap Lake model was used to test whether an end-of-pipe TDS concentration of 850 mg/L would maintain TDS concentrations in Snap Lake below the proposed SSWQO of 684 mg/L. End-of-pipe TDS concentrations were set to a constant value of 850 mg/L from June 2014 to January 2016. The model predicted that an interim TDS AML of 850 mg/L would maintain TDS concentrations in Snap Lake below the proposed SSWQO of 684 mg/L (Figure MVRB/MVLWB_IR#10-4).

An interim TDS AML of 850 mg/L is achievable without mitigation if TDS concentrations at end-of-pipe to January 2016 match predicted TDS concentrations from Upper Bound Scenario B or Lower Bound Scenario B (Figure MVRB/MVLWB_IR#10-5). Monitoring in 2013 and 2014 showed that TDS concentrations at end-of-pipe matched predicted TDS concentrations from Upper Bound Scenario B and Lower Bound Scenario B (Figure MVRB/MVLWB_IR#10-6).

Table MVRB/MVLWB_IR#10-1: Predicted Dates of Exceedance of the Proposed Site-specific Water Quality Objective of 684 mg/L in Snap Lake Without Mitigation

Scenario[(a)]	**Predicted Dates of Exceedance of the Proposed SSWQO (684 mg/L)**	
	Based on Predicted Maximum TDS Concentration near the Diffuser Stations	**Based on Predicted Whole-lake Average TDS Concentration in Snap Lake**
Upper Bound Scenario A	Apr-2015	Jan-2016
Upper Bound Scenario B	Mar-2017	Jan-2018
Lower Bound Scenario A	Feb-2016	Jan-2017
Lower Bound Scenario B	Jan-2019	Feb-2021

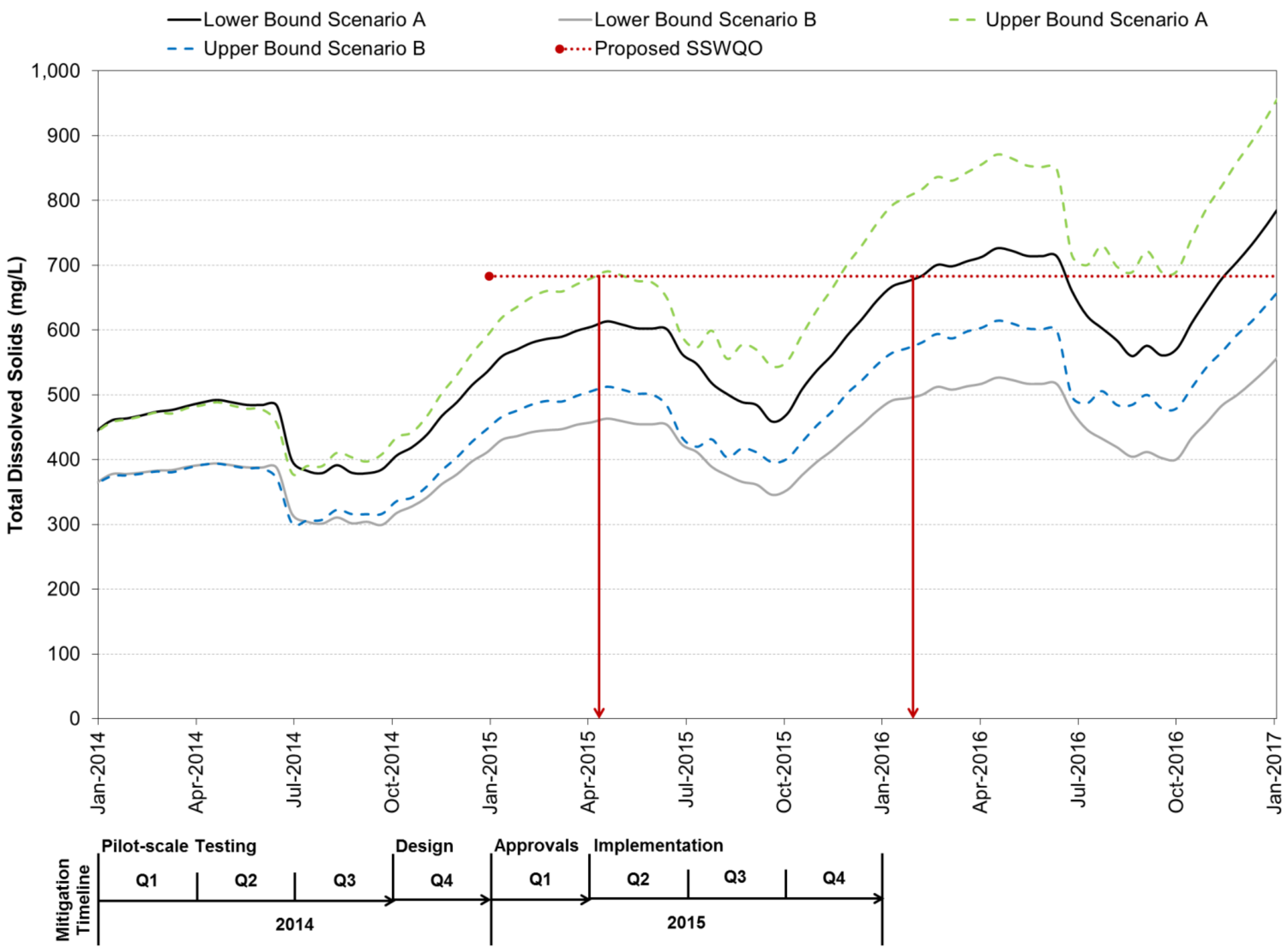
(a) De Beers (2013b)

mg/L = milligrams per litre; TDS = total dissolved solids; SSWQO = site-specific water quality objective.

Figure MVRB/MVLWB_IR#10-1: Predicted Total Dissolved Solids Concentrations at End-Of-Pipe Without Mitigation and Anticipated Timeline for Implementation of Mitigation

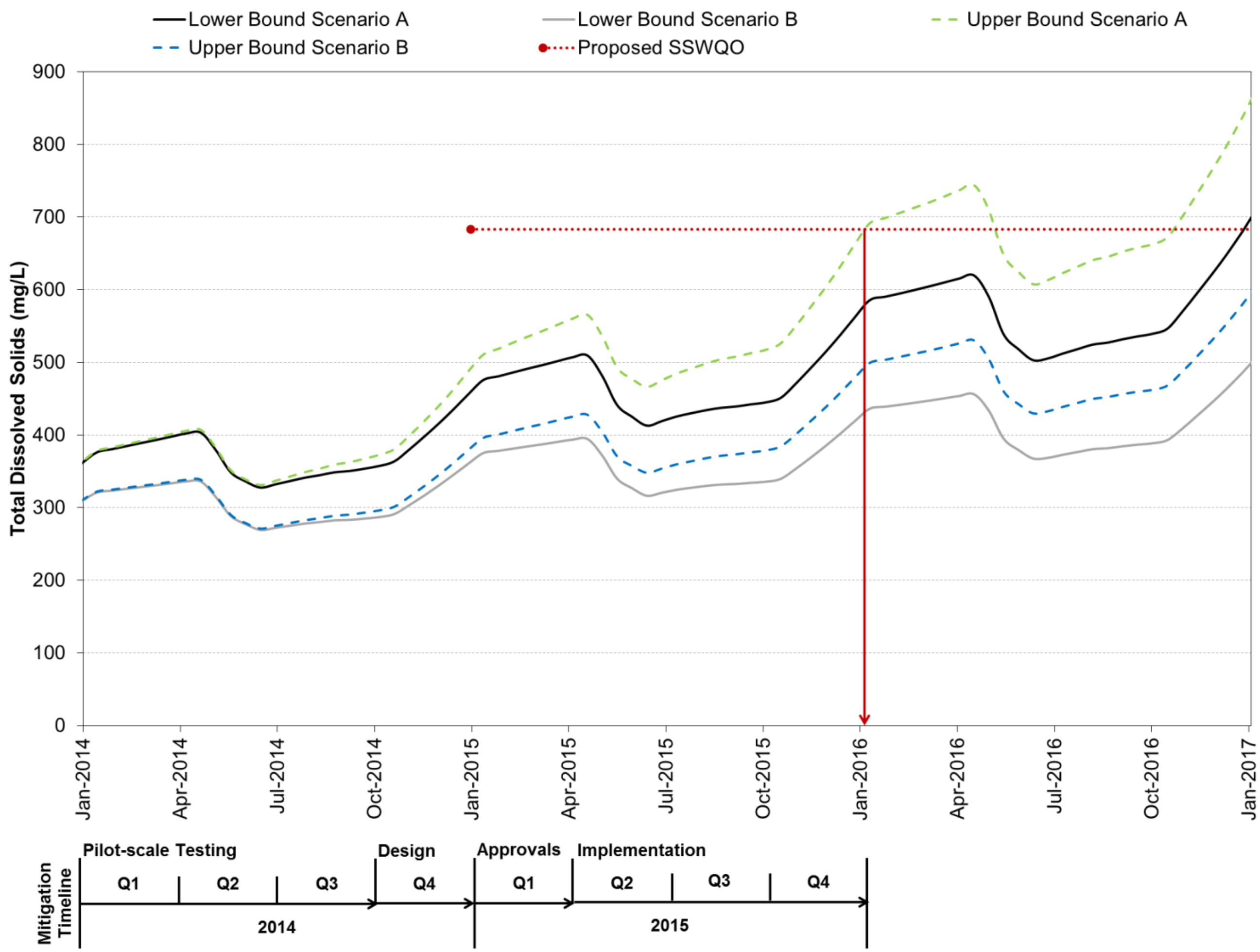
mg/L = milligrams per litre; AML = average monthly limit; Q = quarter.

Figure MVRB/MVLWB_IR#10-2: Predicted Maximum Total Dissolved Solids Concentrations at Diffuser Stations Without Mitigation and Anticipated Timeline for Implementation of Mitigation



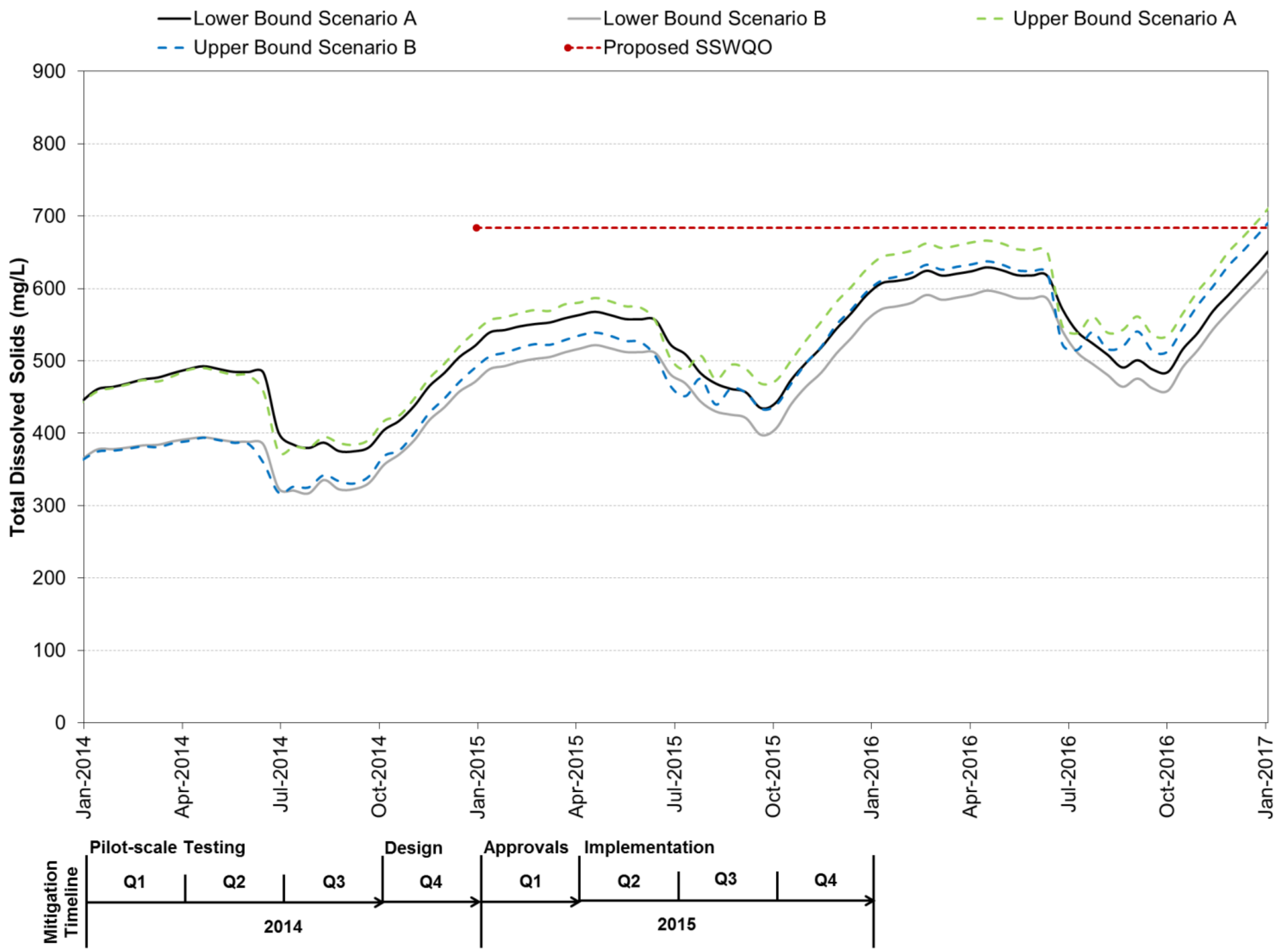
mg/L = milligrams per litre; SSWQO = site-specific water quality objective; Q = quarter.

Figure MVRB/MVLWB_IR#10-3: Predicted Whole-lake Average Total Dissolved Solids Concentrations in Snap Lake Without Mitigation and Anticipated Timeline for Implementation of Mitigation



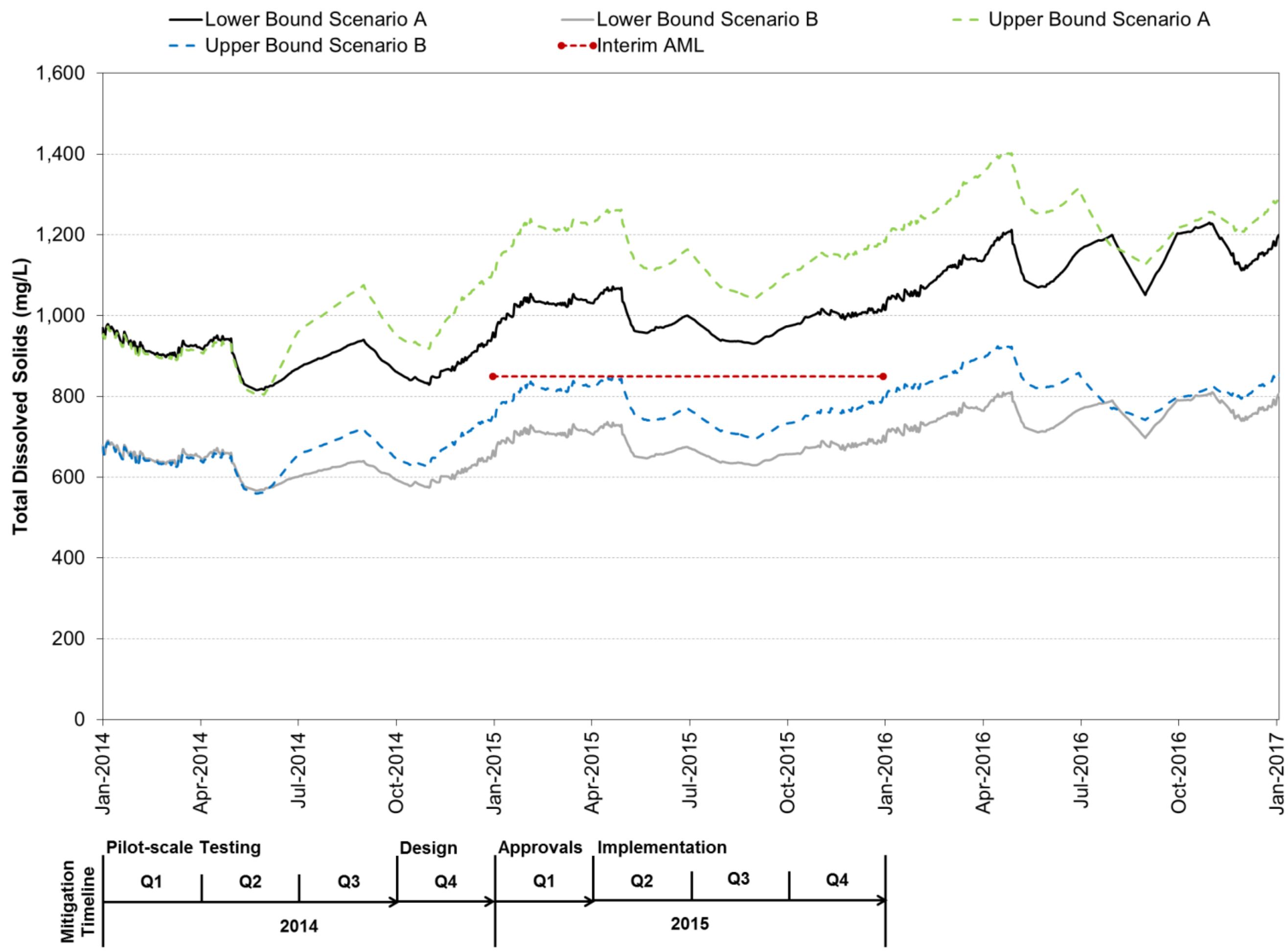
mg/L = milligrams per litre; SSWQO = site-specific water quality objective; Q = quarter.

Figure MVRB/MVLWB_IR#10-4: Predicted Maximum Total Dissolved Solids Concentrations at Diffuser Stations with an Interim Average Monthly Limit of 850 mg/L and Anticipated Timeline for Implementation of Mitigation



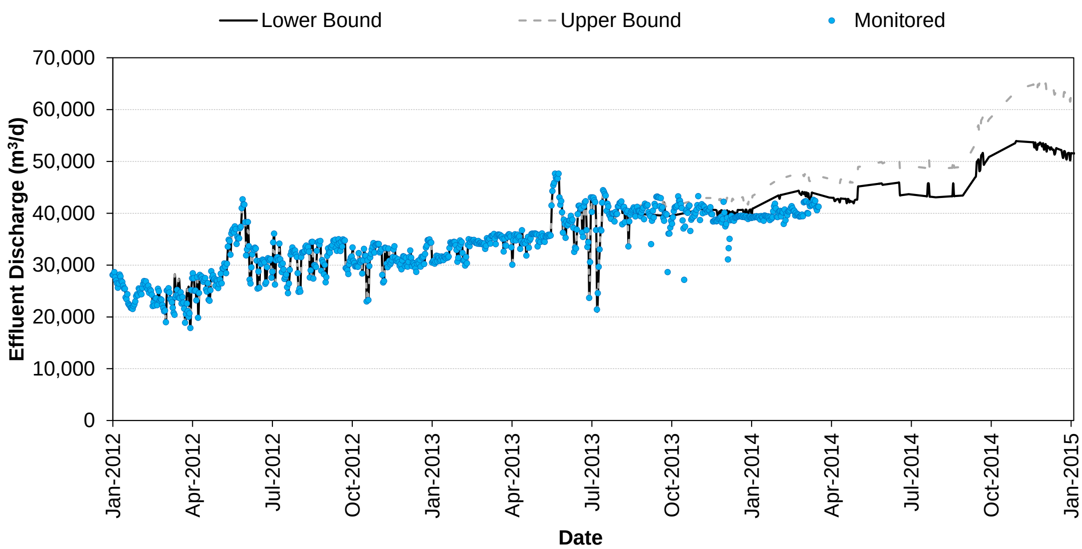
mg/L = milligrams per litre; SSWQO = site-specific water quality objective; Q = quarter.

Figure MVRB/MVLWB_IR#10-5: Predicted Total Dissolved Solids Concentrations at End-Of-Pipe Without Mitigation and Anticipated Timeline for Implementation of Mitigation

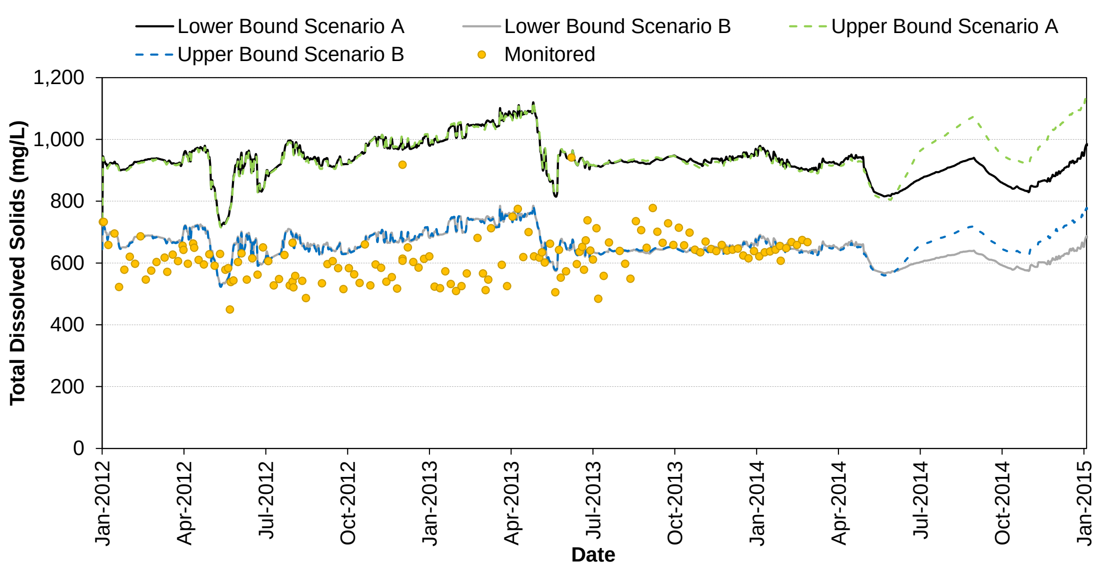


mg/L = milligrams per litre; SSWQO = site-specific water quality objective; Q = quarter.

Figure MVRB/MVLWB_IR#10-6: Predicted and Monitored Effluent Discharge Rates and Total Dissolved Solids Concentrations at End-Of-Pipe



(a) Predicted and Monitored Effluent Discharge



(b) Predicted and Monitored Total Dissolved Solids Concentrations at End-of-Pipe

m^3/d = cubic metres per day; mg/L = milligrams per litre.

References

De Beers (De Beers Canada Inc). 2013a. Evaluation of Effluent Quality Criteria. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

De Beers (De Beers Canada Inc). 2013b. Snap Lake Hydrodynamic and Water Quality Model. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

Health Canada. 2012. Guidelines for Canadian Drinking Water. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water. Ottawa, ON, Canada.

MVRB/MVLWB_IR#11: In the absence of firm details about the mitigations to be put in place to reduce TDS, Board staff request that DBCI provide an assessment of what the environmental effects on Snap Lake would be if no additional mitigation was put in place for TDS at the Snap Lake Mine. The assessment should be similar what was provided by DBCI in the “Accidents and Malfunctions” section of the supplemental material submitted on April 11, 2014. This assessment should be done with respect to any parameter that is predicted to exceed its respective SSWQO in the receiving environment if no additional mitigation is put in place (i.e., TDS, chloride). The purpose of this assessment is to ensure that the Boards have all the information they need to assess this project.

Response

<u>Summary:</u>

Without mitigation, maximum TDS concentrations during operations are predicted to range from: 827 to 1,735 mg/L at the outlet of Snap Lake; from 640 to 1,552 mg/L in Downstream Lakes 1 and 2; from 94 to 562 mg/L in Lac Cabot Blanc; from 89 to 176 mg/L upstream of King Lake, which is approximately 25 kilometres (km) from the Mine; and, lower downstream (Tables 1 to 4). TDS concentrations will decrease following the cessation of mining in 2029 (Figure MVRB/MVLWB_IR#11-1). On the basis of the TDS Benchmark Study (De Beers 2013a), toxicity testing of the effluent at the mine from 2005 to 2013 (Table 5), and the rationale below, there would be:

- minor environmental effects (on daphnid reproduction, a small percentage of the zooplankton community) on Snap Lake up to approximately 1,000 mg/L TDS comprising 46% chloride;
- potentially slightly mineral-tasting drinking water in Snap Lake and the immediate downstream area (areas exceeding 1,200 mg/L TDS [WHO 1996; Health Canada 2012]); and,

- an uncertain level of environmental effects on Snap Lake above approximately 1,400 to 1,500 mg/L TDS comprising 46% chloride (predictions are not possible above tested concentrations).

Note: the assessment conducted for Accidents and Malfunctions was developed for short-term exposures to elevated TDS concentrations. The duration of the exposure in the unmitigated scenario is longer (see Figure 3-1 in De Beers 2013b and Figure MVRB/MVLWB_IR#11-1 below); a qualitative assessment is provided (details below) based on knowledge to date from site-specific testing and the Mine's Surveillance Network Program (SNP) data.

<u>Rationale</u>

The toxicity of TDS is dependent on the ratio of its ionic composition; interaction between ions modifies overall TDS toxicity (Weber-Scannell and Jacobs 2007; McPherson and Dwyer 2011; Soucek et al. 2011). For example, chloride (Cl^-) can modify the toxicity of some substances: Alonso and Camargo (2008) found that chloride ameliorated nitrite toxicity to freshwater invertebrates; Wuertz et al. (2013) recommended a chloride concentration of 240 mg/L as a preventive measure against nitrite toxicity to Pike Perch; Galvez and Wood (1997) found that chloride modified the aquatic toxicity of silver. Other ions including nitrate can also modify toxicity. For instance, Iglesias et al. (2004) found that nitrate modified chloride uptake by salt-stressed plants.

Laboratory toxicity tests that typically provide "worst case" information compared to field conditions (Chapman 2000) were conducted with TDS at an ionic composition specific to Snap Lake (De Beers 2013a; De Beers 2014). Laboratory toxicity tests of TDS concentrations that resulted in negligible effects (i.e., 10 or 20% effect concentrations; Suter et al. 1995) ranged, including the results of the second *Daphnia* test, from 1,005 to >1,490 mg/L (De Beers 2014). Testing of TDS concentrations above 1,500 mg/L was not performed because at the time that concentration was well above the maximum predicted TDS concentration for Snap Lake. Chloride comprises 46% of the TDS in Snap Lake; thus, these toxicity tests involved chloride concentrations of between 462 and >685 mg/L, substantially higher than the chloride SSWQO of 388 mg/L developed based on the Ekati SSWQO at a maximum hardness of 160 mg/L (Rescan 2012). Further, acute toxicity testing has been completed quarterly on Mine effluent since 2005 as part of the SNP under the Water Licence; results indicate that at historical chloride and TDS concentrations, no acute toxicity was detected (Table MVRB/MVLWB_IR#11-5).

Because Snap Lake TDS ionic composition has remained constant for more than seven years and no changes in ionic composition are expected, the Response to this IR is provided based on TDS as a whole; this Response considers the overall toxicity of Snap Lake TDS including chloride rather than considering chloride separately from TDS. As a conservative, worst-case scenario, Snap Lake is considered to be completely mixed such that TDS concentrations are the same throughout the lake. Such complete mixing of Snap Lake waters is not predicted to occur until 2020 as explained in the Technical Session on April 15-16, 2014 (Figure MVRB/MVLWB_IR#11-2).

Based on laboratory toxicity testing conducted to date (De Beers 2013, 201; Table 5), minor environmental effects in Snap Lake are expected up to 1,005 mg/L TDS; toxicity lower than a 20% effect level is not considered environmentally relevant (Suter et al. 1995). At higher TDS concentrations, reproduction of daphnids (i.e., cladocerans) will be reduced. The IC50 (50% effects concentration) for the two *Daphnia* toxicity tests was >1,470 mg/L, which means that reproduction was not reduced by half at the highest tested TDS concentration. TDS concentrations between 1,005 mg/L and 1,470 mg/L would likely result in effects to daphnids in the form of reduced reproduction (greater than 20% reduction but less than 50% reduction), and a corresponding minor environmental effect to Snap Lake as explained below. Note that the daphnid, *Ceriodaphnia dubia*, which does not occur in Snap Lake, also had unbounded IC50 values (i.e., less than 50% inhibition of reproduction occurred at the highest tested TDS concentrations, close to 1,500 mg/L). Daphnid lethality would occur at some presently undetermined TDS concentration greater than 1,470 mg/L, likely above 2,660 mg/L (Table MVRB/MVLWB_IR#11-5).

As discussed at the Technical Session in April 2014 and in the 2011 Water Licence Amendment Application, prior to mining in 2004 daphnids made up 3% of the zooplankton (the small animals living in the water that provide food for fish); between 2005 and 2012 this proportion ranged from <1 to 7% (De Beers 2013b). As TDS concentrations increase above 1,000 mg/L this component of food for fish may be reduced. However, other plankton components (including both phytoplankton [small plants] and zooplankton) will not be affected until TDS concentrations are greater than approximately 1,500 mg/L. Exactly what concentration of TDS above 1,500 mg/L will result in adverse effects to the other plankton has not been established; higher concentrations were not tested. Beneficial effects of the TDS are also not considered at this time, for instance the availability of increased calcium to create shells for those plankton and benthos with shells.

A reduction in daphnids in the zooplankton is not likely to have a significant adverse effect on fish because daphnids comprise a relatively small proportion of the zooplankton, as noted above. The more abundant copepods and rotifers (together 93 to 97% of the zooplankton between 2004 and 2013) would still be available as fish prey up to at least approximately 1,500 mg/L TDS (rotifers showed negligible toxicity to 1,474 mg/L TDS [the maximum tested concentration]; copepods are expected to be similarly tolerant, laboratory toxicity testing is underway). It is presently uncertain at what point above 1,500 mg/L rotifers would be adversely affected by TDS in Snap Lake as higher concentrations were not tested. Sublethal effects (e.g., growth reduction, reduced reproduction) would occur before lethality.

The other components of food for fish are the benthic (bottom-dwelling) invertebrates (animals without backbones). Laboratory toxicity testing with chironomids (insect larvae), which dominate the benthic invertebrate community in Snap Lake, indicated that negligible adverse effects occur up to 1,379 mg/L TDS (the highest tested concentration). Thus, up to this TDS concentration there would be no change to the availability of chironomids as prey for fish; it is presently uncertain at what point above this concentration they would be adversely affected by TDS in

Snap Lake as higher concentrations were not tested for reasons outlined above. Sublethal effects (e.g., growth reduction) would occur before lethality.

Reduced food for fish at elevated TDS concentrations (i.e., at some point above approximately 1,400 or 1,500 mg/L) could result in an energetic bottleneck where fish have less energy available for growth and reproduction. If an energetic bottleneck were to occur, it would likely result in reduced growth and size of fish as energy was shifted from growth to fecundity to maintain reproductive, sustainable fish populations (Sherwood et al. 2002; Campbell et al. 2003). An energetic bottleneck would occur before lethality.

Laboratory toxicity testing with the sensitive early life stages of both Lake Trout and Arctic Grayling indicated negligible adverse effects above approximately 1,400 mg/L for all tests and endpoints except dry fertilization with Lake Trout and only for fry survival, not fry growth. Dry fertilization involved fertilizing the eggs before exposing them to elevated TDS concentrations; wet fertilization, which involved fertilizing the eggs during the exposure to elevated TDS concentrations, is more reflective of actual exposures and showed no such effects. Again, it is presently uncertain at what point above approximately 1,400 mg/L fish in Snap Lake would be adversely affected by TDS as higher concentrations were not tested. Effects on reproduction would occur before lethality.

Effects of longer-term exposure to elevated TDS concentrations were not tested. The resiliency of freshwater aquatic systems to salinity is variable and not well studied (James et al. 2003), although most studies are focused on concentrations of TDS orders of magnitude higher than at Snap Lake. Recently, both Lake Trout and Arctic Grayling have been documented at multiple life stages in northern waters, both in Alaska and in the Northwest Territories, at TDS concentrations of 1,000 to 1,500 mg/L and even higher (Harwood and Sparling 2008; Ott and Morris 2011; Gantner and Gareis 2012; Kissinger et al. 2013). Species such as Slimy Sculpin, Burbot, and Round Whitefish, which are found in Snap Lake, have also been found in these higher TDS waters. Although the TDS composition is not the same as Snap Lake, this suggests that the fish and other organisms in Snap Lake may be adaptable in the long-term (operations through closure) to the concentrations of TDS proposed by De Beers. However, as previously noted, at concentrations above 1,400 to 1,500 mg/L, there is additional uncertainty.

In the unmitigated scenario, the TDS concentrations in the downstream lakes area beyond Lac Capot Blanc are within EAR predictions (Table MVRB/MVLWB_IR#11-4). This is likely due to the assimilative capacity of Lac Capot Blanc. Thus, TDS concentrations in the larger Lockhart River watershed are expected to remain within the original EAR predictions (De Beers 2002). De Beers will continue to monitor the areas downstream of the project and report annually in the AEMP and Environmental Agreement reports on the water quality results. See Response to YKDFN IR#1 for a review of potential effects to land users under the mitigated scenario.

Without mitigation, waters in Snap Lake and into Lac Capot Blanc would be above the aesthetic drinking water guidelines for TDS and chloride (500 mg/L and 250 mg/L, respectively; Health

Canada 2012). Aesthetic effects to water quality could persist from 2018 to approximately 2035 without mitigation, although water quality is predicted to improve quickly in Snap Lake once the mine stops discharging in 2029 (Figure MVRB/MVLWB_IR#11-1).

At the TDS concentrations in the upper-bound scenarios, the predicted maximum chloride concentration of approximately 806 mg/L exceeds the CCME (2011) short-term guideline of 640 mg/L and approaches the USEPA (1988) acute criterion of 860 mg/L for protection of freshwater aquatic life. As noted above, site-specific testing indicated that with the current TDS composition at Snap Lake, chloride concentrations at approximately 600 mg/L did not results in sublethal (chronic) effects to aquatic life other than daphnid reproduction. The SNP acute testing also shows this (Table MVRB/MVLWB_IR#11-5) and that TDS concentrations as high as 2,660 mg/L did not kill young rainbow trout or daphnids. However, as noted above, it is presently uncertain at what point above approximately 1,400 mg/L TDS invertebrates and fish in Snap Lake would be adversely affected by TDS or by chloride as higher concentrations were not tested for reasons previously outlined.

Given the uncertainty of effects to aquatic life beyond 1,400 mg/L TDS, De Beers has proposed mitigation that would result in TDS concentrations below the proposed SSWQO of 684 mg/L in the lake.

Table MVRB/MVLWB_IR#11-1: Maximum Predicted TDS Concentrations in Snap Lake During Operations, Unmitigated Case

SSWQO	Units	Maximum Concentrations at Diffuser Stations				Maximum Concentrations at Lake Outlet			
		Lower Bound Scenario A	Lower Bound Scenario B	Upper Bound Scenario A	Upper Bound Scenario B	Lower Bound Scenario A	Lower Bound Scenario B	Upper Bound Scenario A	Upper Bound Scenario B
684	mg/L	1,311	845	1,753	1,117	1,280	827	1,735	1,101

Table MVRB/MVLWB_IR#11-2: Maximum Predicted Whole-lake Average TDS Concentrations in Downstream Lakes 1 and 2 During Operations, Unmitigated Case

SSWQO	Units	Downstream Lake 1				Downstream Lake 2			
		Lower Bound Scenario A	Lower Bound Scenario B	Upper Bound Scenario A	Upper Bound Scenario B	Lower Bound Scenario A	Lower Bound Scenario B	Upper Bound Scenario A	Upper Bound Scenario B
684	mg/L	989	640	1,381	879	1,114	722	1552	989

Table MVRB/MVLWB_IR#11-3: Maximum Predicted TDS Concentrations in Lac Capot Blanc During Operations, Unmitigated Case

SSWQO	Units	Maximum Concentrations at Inlet				Maximum Concentrations at Lake Outlet			
		Lower Bound Scenario A	Lower Bound Scenario B	Upper Bound Scenario A	Upper Bound Scenario B	Lower Bound Scenario A	Lower Bound Scenario B	Upper Bound Scenario A	Upper Bound Scenario B
684	mg/L	507	388	562	478	136	94	192	127

Table MVRB/MVLWB_IR#11-4: Maximum Predicted Concentrations in Lakes Downstream of Lac Capot Blanc During Operations, Unmitigated Case

Downstream Site	Distance Downstream from Snap Lake (km)	Baseline TDS (mg/L) (range = 10 to 53)	Maximum TDS Concentrations (mg/L)				
			EAR Predictions	2013 Model Predictions			
				Lower Bound Scenario A	Lower Bound Scenario B	Upper Bound Scenario A	Upper Bound Scenario B
37 (upstream of King Lake)	24	17	119	126	89	176	119
22 (Mackay Lake)	44	20	41	57	45	74	55
11 (Mackay Lake)	54	12	16	21	18	24	20
23 (Mackay Lake)	65	10	13	17	14	20	16
24 (Mackay Lake)	81	14	16	19	18	22	19
26 (Mackay Lake)	109	17	19	22	20	24	22
3 (Inlet of Aylmer Lake)	155	20	22	24	22	25	23
4 (Aylmer Lake)	172	24	22	27	26	28	27
53 (Clinton Colden Lake)	227	35	36	37	36	38	37
52 (Ptarmigan Lake)	310	24	25	26	26	27	26
43 (Lockhart River)	419	53	54	55	54	55	55
19 (Lockhart River outlet)	434	14	14	15	15	16	15

Table MVRB/MVLWB_IR#11-5: Acute Toxicity Test Results for Effluent Samples Collected From the Water Treatment Plants at Snap Lake Mine, 2005 to 2013

Sampling Location	Date	Acute Toxicity Testing Results[a]						Water Quality	
		Trout LC50[b] (%)	Trout LC25[c] (%)	Daphnia LC50[b] (%)	Daphnia LC25[c] (%)	Daphnia EC50[d] (%)	Daphnia EC25[e] (%)	Total Dissolved Solids, calculated (mg/L)	Chloride (mg/L)
SNP 02-17	2005-Nov-28	>100	>100	>100	>100	>100	>100	-	357
SNP 02-17	2006-Feb-06	>100	>100	>100	>100	>100	>100	666	340
SNP 02-17	2006-Apr-02	>100	>100	>100	>100	>100	>100	719	384
SNP 02-17	2006-Jul-04	>100	>100	>100	>100	>100	>100	1,060	546
SNP 02-17	2006-Dec-04	>100	>100	>100	>100	>100	>100	1,080	605
SNP 02-17	2006-Dec-20	>100	>100	-	-	-	-	941	523
SNP 02-17	2007-Jan-09	>100	>100	>100	>100	>100	>100	984	527
SNP 02-17	2007-Apr-03	>100	>100	>100	>100	>100	>100	922	524
SNP 02-17B	2007-Apr-23	>100	>100	>100	>100	>100	>100	821	436
SNP 02-17B	2007-Jul-09	>100	>100	>100	>100	>100	>100	783	418
SNP 02-17B	2007-Nov-14	>100	>100	>100	>100	>100	>100	821	430
SNP 02-17B	2008-Mar-16	>100	>100	>100	>100	>100	>100	789	399
SNP 02-17B	2008-Apr-02	>100	>100	>100	>100	>100	>100	782	385
SNP 02-17	2008-Apr-13	>100	>100	>100	>100	>100	>100	2,660	1,200
SNP 02-17B	2008-Jul-09	>100	>100	>100	>100	>100	>100	845	359
SNP 02-17B	2008-Oct-22	>100	>100	>100	>100	>100	>100	625	293
SNP 02-17B	2009-Jan-14	>100	>100	>100	>100	>100	>100	650	297
SNP 02-17B	2009-Apr-08	>100	>100	>100	>100	>100	>100	589	278
SNP 02-17B	2009-Jul-13	>100	>100	>100	>100	>100	>100	657	259
SNP 02-17B	2009-Oct-12	>100	>100	>100	>100	>100	>100	674	271
SNP 02-17B	2010-Jan-03	>100	>100	>100	>100	>100	>100	497	242
SNP 02-17B	2010-Apr-06	>100	>100	>100	>100	>100	>100	512	244
SNP 02-17B	2010-Jul-14	>100	>100	>100	>100	>100	>100	716	240
SNP 02-17B	2010-Oct-12	>100	>100	>100	>100	>100	>100	518	216
SNP 02-17B	2011-Jan-17	>100	>100	>100	>100	>100	>100	567	272
SNP 02-17B	2011-Apr-10	>100	>100	>100	>100	>100	>100	529	249

Table MVRB/MVLWB_IR#11-5: Acute Toxicity Test Results for Effluent Samples Collected From the Water Treatment Plants at Snap Lake Mine, 2005 to 2013

Sampling Location	Date	Acute Toxicity Testing Results[a]						Water Quality	
		Trout LC50[b] (%)	Trout LC25[c] (%)	Daphnia LC50[b] (%)	Daphnia LC25[c] (%)	Daphnia EC50[d] (%)	Daphnia EC25[e] (%)	Total Dissolved Solids, calculated (mg/L)	Chloride (mg/L)
SNP 02-17B	2011-Jul-12	>100	>100	>100	>100	>100	>100	454	198
SNP 02-17	2011-Jul-31	>100	>100	>100	>100	>100	>100	509	165
SNP 02-17B	2011-Oct-24	>100	>100	>100	>100	>100	>100	570	232
SNP 02-17B	2012-Jan-22	>100	>100	>100	>100	>100	>100	534	243
SNP 02-17	2012-Mar-11	>100	>100	>100	>100	>100	>100	627	295
SNP 02-17B	2012-Apr-17	>100	>100	>100	>100	>100	>100	606	272
SNP 02-17B	2012-Sep-09	>100	>100	>100	>100	>100	>100	593	288
SNP 02-17B	2012-Oct-15	>100	>100	>100	>100	>100	>100	653	249
SNP 02-17B	2013-Jan-07	>100	>100	>100	>100	>100	>100	523	234
SNP 02-17B	2013-May-07	>100	>100	>100	>100	>100	>100	634	284
SNP 02-17B	2013-Sep-08	>100	>100	>100	>100	>100	>100	778	354
SNP 02-17B	2013-Oct-07	>100	>100	>100	>100	>100	>100	714	307

(a) Acute toxicity testing was conducted with Rainbow Trout, *Oncorhynchus mykiss*, following method EPS 1/RM/13 (Environment Canada 2000a), and a water flea, *Daphnia magna*, following method EPS 1/RM/14 (Environment Canada 2000b)

(b) LC50, or median lethal concentration, is the concentration of sample estimated to be lethal to 50% of the test organisms.

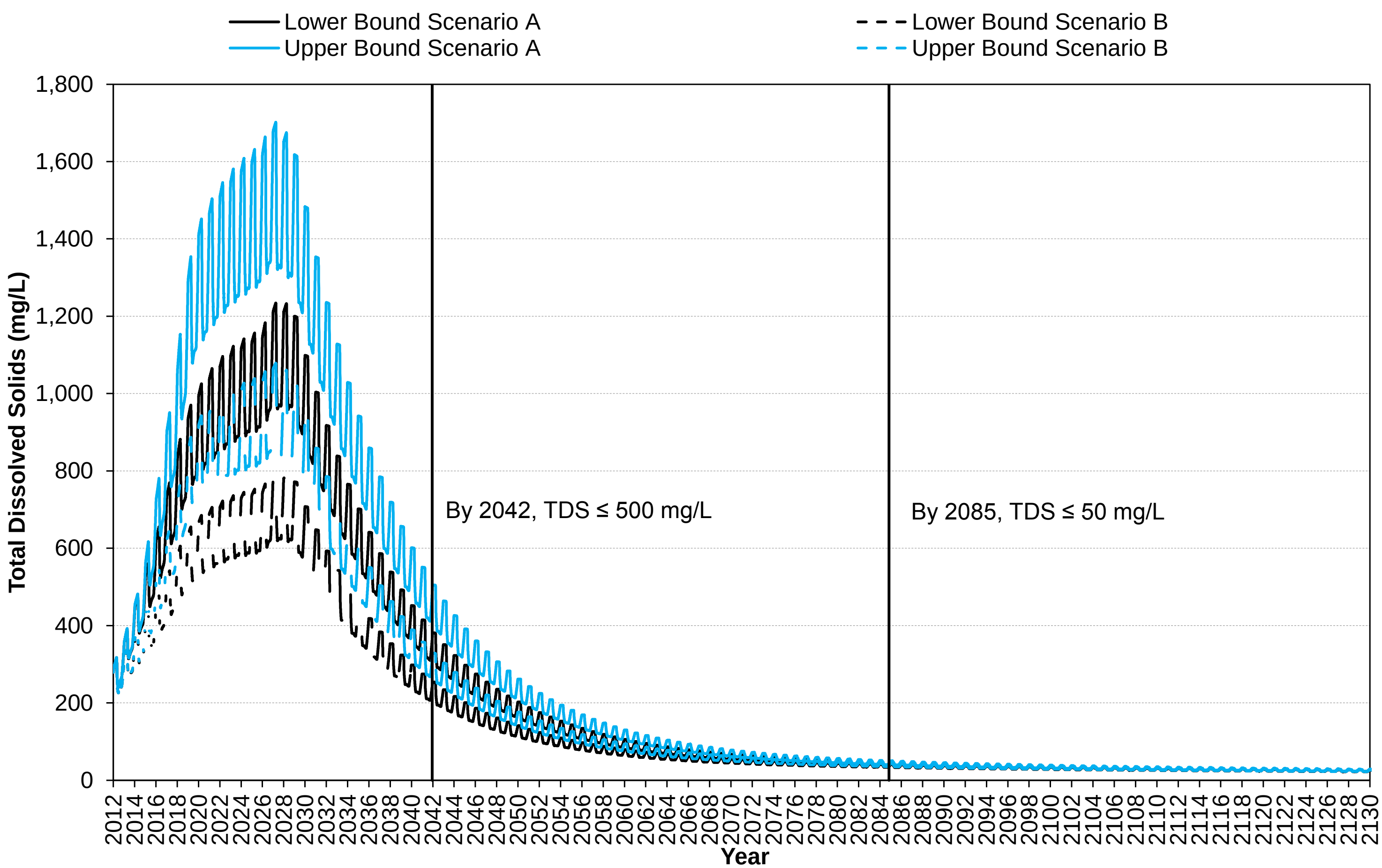
(c) LC25 is the concentration of sample estimated to be lethal to 25% of the test organisms.

(d) EC50, or median effective concentration, is the concentration of sample estimated to cause a specified effect to 50% of the test organisms.

(e) EC25 is the concentration of sample estimated to cause a specified effect to 25% of the test organisms.

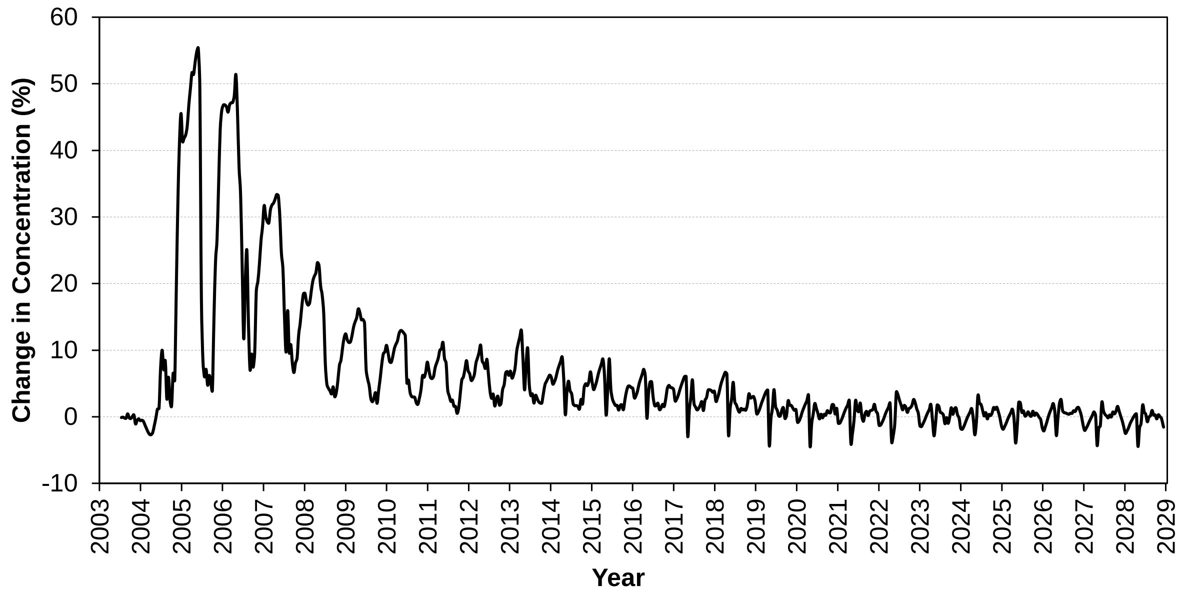
LCx = concentrations of sample estimated to be lethal to x% of the test organisms; ECx = concentrations of sample estimated to cause a specified effect to x% of the test organisms; % = percent; mg/L = milligrams per litre; SNP = Surveillance Network Program; SNP 02-17 = temporary water treatment plant; SNP 02-17B = permanent water treatment plant.

Figure MVRB/MVLWB_IR#11-1: Predicted Whole-lake Average Total Dissolved Solids Concentrations in Snap Lake, 2012 to 2130, Unmitigated Scenario



mg/L = milligrams per litre; TDS = total dissolved solids; ≤ = less than or equal to.

Figure MVRB/MVLWB_IR#11-2: Change in Total Dissolved Solids Concentrations between the Diffuser Stations and the Outlet of Snap Lake, Unmitigated Scenario



% = percent.

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MVRB/MVLWB_IR#12: As requested by EcoMetrix, DBCI is to provide information in regards to nitrate toxicity to Rotifers and Copepods as dominant taxa in Snap Lake.

Response

An extensive review of the available literature has been conducted. The following databases, search engines, and compendia were accessed to search for information regarding the toxicity of nitrate to freshwater copepods and rotifers:

- Google;
- Google Scholar ;
- CCME (2012);
- Rescan (2012);
- Web of Science™ Core Collection (1900-present);
- BIOSIS Previews® (1969-present);
- Proquest (43 databases; 1817-present);
- US EPA ECOTOX Database; and,
- Wiley Online Library.

The databases were searched using combinations of the following keywords: toxic; copepod or rotifer; and, nitrate. At least the first 50 hits from a return were screened manually to check their relevance. Searching the USEPA ECOTOX database involved performing queries for aquatic data with keywords “rotifer” and “copepod”; all results were screened manually. Data on the toxicity of nitrate to aquatic life have also been previously reviewed and compiled by CCME (2012) and Rescan (2012) for use in deriving generic water quality guidelines (WQGs) or site-specific water quality objectives (SSWQOs). Those documents were reviewed to determine whether they contained any nitrate toxicity data from studies using copepods or rotifers.

Hickey et al. (2009) listed three freshwater copepods as being included in a nitrate toxicity database that was compiled to support development of a nitrate WQG for the Canterbury region of New Zealand, but no data for those taxa were presented or used in the New Zealand WQG derivation. Barium nitrate and mercuric nitrate were tested using rotifer (*Brachionus calyciflorus*) and copepod (Cyclopoida, *Acartia tonsa*, *Mesocyclops edax*) taxa (Calleja et al. 1994; Menasria and Pavillon 1994); however, nitrate was the anionic counterpart to the elements that the authors were investigating. Di Lorenzo et al. (2014) conducted acute toxicity tests with two copepod species (*Eucyclops serrulatus* and *Diacyclops belgicus*) using ammonium nitrate, but the test results were reported in terms of ammonia concentrations.

No acute or chronic studies on the toxicity of nitrate to rotifers or copepods were found during our review, although these taxa have been used for toxicity testing of other substances such as: silver (Pedroso et al. 2007; Buikema et al. 1974); lead (Sharma and Selvaraj 1994; Arshaduddin et al. 1989); cadmium (Ghosal and Kaviraj 1996; Radix et al. 1999); nitrogen-based fertilizers and pesticides (Di Lorenzo et al. 2014); and, 50 inorganic and organic substances listed in the Multicentre Evaluation of In Vitro Cytotoxicity (MEIC) program (Calleja et al. 1994). Of 11 Canadian Council of Ministers of the Environment (CCME) WQGs published since 2007, copepod toxicity data were not used to derive any of those WQGs and rotifer toxicity data were only used in 4 of them (chloride, endosulfan, permethrin, and trichlorfon).

Neither rotifers nor copepods are as well established as standard laboratory test species as other freshwater invertebrates such as cladocerans. Cladocerans are generally more sensitive than copepods to trace metals (Baudouin and Scoppa 1974; Brown 2001). Cairns et al. (1977) reported that the rotifer *Philodina acuticornis* was more sensitive to chlorine and zinc, but less sensitive to chromium, copper, and phenol, than two Daphnia species (*Daphnia pulex* and *D. magna*) in acute tests. Of the 50 chemicals tested by Calleja et al. (1994), the rotifer *B. calyciflorus* showed either similar or less sensitivity to the majority of chemicals as compared to acute tests with *D. magna*.

Note that the Dominion Mines Ekati Corporation, Board-approved SSWQO for nitrate (WL W2012L2-0001) was derived by Rescan (2012) using CCME-approved procedures which do not require testing of all possible organisms or groups of organisms present in a water body, but rather representative organisms. As noted by Rescan (2012) “CCME (2007b) data requirements regarding types and number of biological groups were met.”

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MVRB/MVLWB_IR#13: During the technical session, there were several questions by the Yellowknives Dene (YKDFN) and Board staff with respect to DBCI's efforts to reduce the amount of nitrate through improvements to blasting practices underground. In Section 2.3 of the Nitrogen Response Plan, DBCI lists a recommendation to "continue to monitor trends in the amount of explosives used per tonne of ore mined (kg/tonne) as a means of monitoring the effectiveness of explosives management measures". The YKDFN has requested whatever monitoring data has been collected in this regard.

Response

The amount of explosive energy imparted to a rock mass per unit weight blasted is referred to as the "powder factor". It is important to keep in mind when using powder factors that blasting is a dynamic event and each rock mass is unique. Aspects affecting the powder factor are complex and include: rock character (e.g., density, strength, structure), blasthole diameter and spacing, type of explosive, method of loading the holes, number of meters drilled, etc. It is generally recognized that for the similar types of rock underground mines have higher powder factors than open-pit mines, and powder factors are higher in wet versus dry conditions. As requested, the following table, Table MVRB/MVLWB_IR#13-1, provides the annual powder factors for rock blasted underground at Snap Lake.

Table MVRB/MVLWB_IR#13-1: Explosive Use per Tonne Rock Blasted

Year	2012	2013	2014 (to Apr 27, 2014)
Tonnes Blasted	1,079,616	1,332,175	426,844
Explosives Used (kg)	1,436,885	1,747,368	513,853
Explosive Useage (kg) per tonne mined	1.33	1.31	1.20

MVRB/MVLWB_IR#14: In the same line of questioning as IR#13, DBCI said that the rate of mining is driving the increase in Nitrogen loading making it hard to see increased efficiencies of blasting techniques. DBCI to provide supporting rationale for this statement and/or a clarification of how improvements in blasting techniques may be evaluated in future.

Response

Improving blasting efficiency is a continuous process. Improvements made over the last 16 months have focused on:

1. A re-design of the blasting round that results in the drill holes being reduced from 50 holes per round to 43 holes per round;

2. An increase in the collar length from one foot to three feet, which minimizes spillage and over-loading of blast holes by the loading crews; and,

3. Educating miners on proper loading and blasting techniques.

The mine plans to undertake reviews by independent experts of its blasting design, and practices for storage, handling and loading of explosives to ensure the most effective use of explosives in maintained.

The mine will continue to monitor the powder factor as a broad indicator of the effectiveness of explosives management.

<u>Information Requests from April 16, 2014</u>

MVRB/MVLWB_IR#15: In response to questions from EcoMetrix on the EQC Report, DBCI is to provide an Excel spreadsheet containing the calculations that were used to develop the results in Tables I-1 to I-6 of Appendix 1 of the EQC report.

Response

De Beers referenced the Day 2 Transcript from the April 14-15 Technical Session to identify the supporting dialogue for this request. Mr. Ian Collins specifically asked what parameter, other than the Aquatic Effects Monitoring Program (AEMP) benchmark, was varied to calculate the different AML and MDL values in the Appendix tables. The “other parameter” was the proportion of treated effluent in Snap Lake, as shown in the second column of Appendix Tables I-1 to I-6 of De Beers (2013). The appended spreadsheet provides the relationship between proportion of treated effluent, hardness and AEMP benchmarks as well as calculations for deriving the proposed effluent quality criteria. Because Mr. Collins referred to sulphate, an example worksheet for sulphate is provided. Calculations for other parameters were completed in a similar manner. Please refer to Appendix I of the Effluent Quality Criteria report for further information.

Reference

De Beers. 2013. Evaluation of Effluent Quality Criteria. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada

MVRB/MVLWB_IR#16: MVEIRB staff requests that DBCI submit, for placement on the MVEIRB registry, all pertinent information regarding accidents and malfunctions related to the project. This should include the draft Water Management Plan (which in turn contains a risk assessment matrix) and the risk assessment submitted to the MVLWB for the North Pile.

Response

As per the attached North Pile Risk Assessment (De Beers 2012), potential risks that could result in the incident as described in the Supplemental filing are:

Risk 4 Water Treatment (Major WTP Breakdown or Significant Reduction in Treatment Capacity) Residual Risk: 17

Risk 6 Sampling and Analytical Errors / Missed Samples
Residual Risk 16

A table of the Risk Name and the inherent and residual risk are listed in Section 4 of this document.

In *Risk 4*, the malfunction/accident from a WTP breakdown could result in two incidents:

1) Noncompliant water being released to the environment undiluted when the plant malfunctioned, or;

2) Water stored in the underground and on surface due to a system failure overextends the system holding capacity and water is released undiluted to the receiving environment upon commissioning to prevent flooding and/or spills.

In *Risk 6*, the malfunction/Accident would occur if the inline analytical monitoring devices for chloride and nitrate malfunction allowing elevated levels of TDS to enter the receiving environment unchecked. In a typical scenario these inline meters would trigger a response in the WTP operator's room which would lock out the system and pump water to the WMP.

After the TDS Treatment system is installed in 2015/2016, errors could occur if the TDS treatment system malfunctions, preventing treatment of a portion of the managed water from underground. This would allow for higher than expected TDS water to enter Snap Lake. At this time De Beers is unable to comment on the likelihood of this event, however it would form a component of the design analysis and installation. The resulting risk assessment would align with eth Anglo American Integrated Risk Management Matrix.

The initial Accidents and Malfunction Section of the original EA (February 2002) was resubmitted to the MVEIRB on April 16, 2014.

Please refer to GNWT_IR#3 for additional information.

Reference

2012. Snap Lake Mine – North Pile Risk Assessment. De Beers Canada Inc. Submitted to the MVLWB September 15, 2012.

MVRB/MVLWB_IR#17: DBCI to provide its most recent AEMP Annual Report for the MVEIRB record.

Response

The 2012 Aquatic Effects Monitoring Program Annual Report (AEMP) will be provided on CD to the MVRB on May 1, 2014; it is also available on-line at the MVLWB public registry at: http://www.mvlwb.ca/Boards/MV/SitePages/search.aspx?app=MV2011L2-0004. The 2013 AEMP will be provided May 1, 2014 and will be submitted to both the MVLWB and MVEIRB.

MVRB/MVLWB_IR#18: DBCI to provide the grouting study recently completed by DBCI's grouting expert.

Response

The April 24, 2014 Grouting Letter from MSE Drilling and Grouting is attached to this submission.

MVRB/MVLWB_IR#19: DBCI to provide a PDF version of the Poster titled Effect of total dissolved solids on fertilization and development of two salmonids. Alternatively, DBCI may submit the meeting notes from its information session in January (which contains this poster) to MVEIRB for its registry.

Response

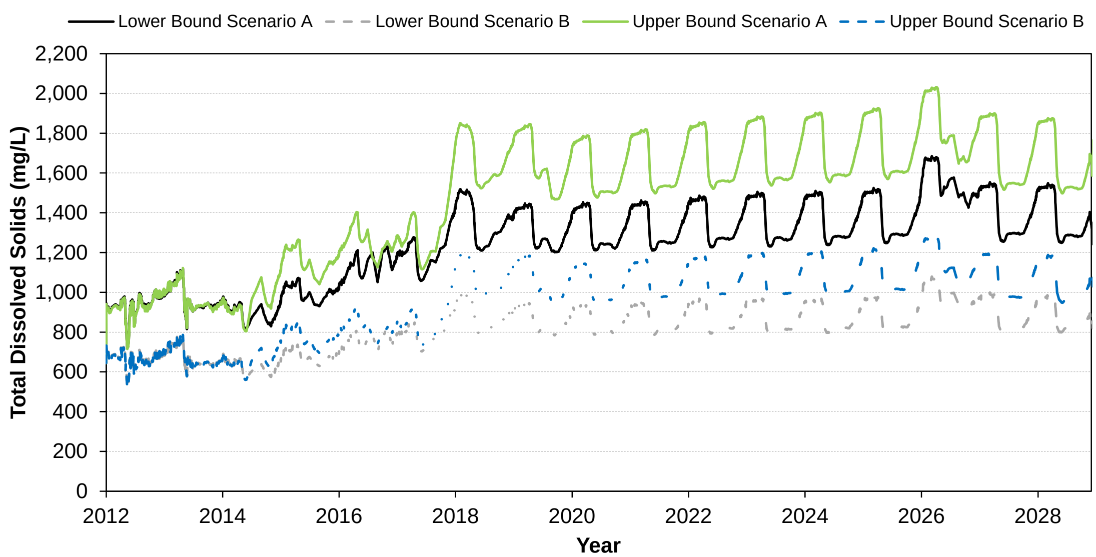
Electronic copies of both the Poster and the meeting notes were provided to Simon Toogood of the MVRB by email the afternoon of April 16, 2014. A hard copy of the Poster was provided to Simon Toogood later that same afternoon.

Attachment 2-EC_IR#1: In IR MVLWB 2, the proponent indicated that " ... effluent discharged to Snap Lake from the Snap Lake Mine will be treated such that TDS concentrations in the effluent will not exceed the proposed average monthly limit (AML) of 684 mg/L from January 1, 2015 to January 1, 2029. For the simulation, if the concentration of TDS in the effluent was predicted to be greater than 684 mg/L in De Beers (2013a), the concentration of TDS was reduced to 684 mg/L." Could the proponent explain what parameter(s) was changed in the simulation to ensure that the concentration of TDS stayed below 684 mg/L?

Response

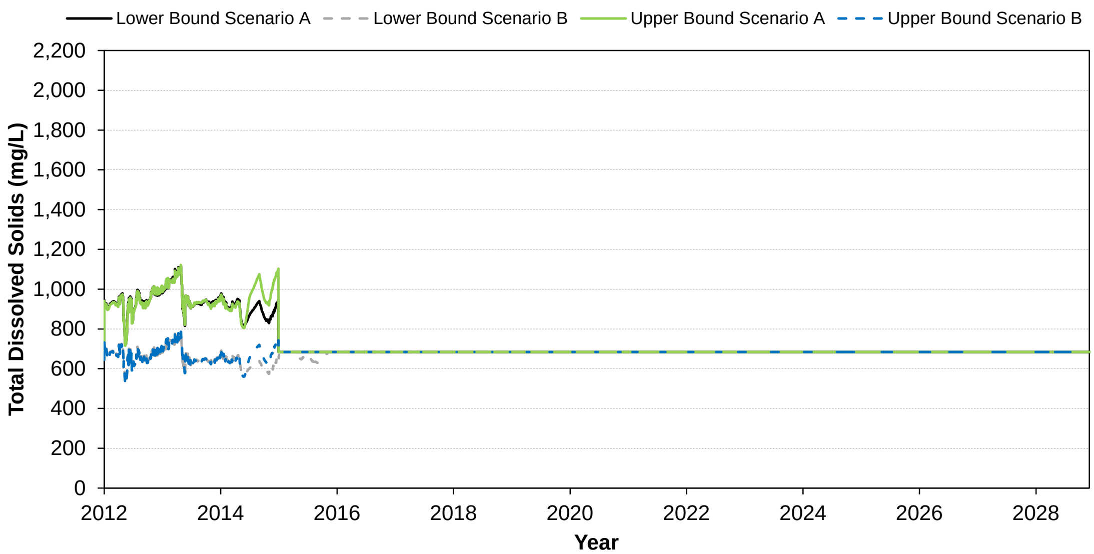
In the scenarios without mitigation the concentrations of TDS in the effluent were predicted to be greater than 800 milligrams per litre (mg/L) (Figure Attachment 2-EC_IR#1-1). Predictions of parameter concentrations in the effluent were generated using the site model (De Beers 2013) and subsequently used as input in the Snap Lake model. In the scenarios with mitigation the predicted concentrations of TDS in the effluent from the scenarios without mitigation (Figure Attachment 2-EC_IR#1-1; De Beers 2013) were directly adjusted such that they did not exceed the average monthly limit (AML) of 684 mg/L from January 1, 2015 to January 1, 2029 (Figure Attachment 2-EC_IR#1-2). For the mitigation scenarios, TDS predictions from Lower Bound Scenario B (i.e., Lower Bound) and Upper Bound Scenario B (i.e., Upper Bound) were input in the Snap Lake model.

Figure Attachment 2-EC_IR#1-1 Predicted Total Dissolved Solids Concentrations in Effluent Discharge to Snap Lake Without Mitigation



mg/L = milligrams per litre.

Figure Attachment 2-EC_IR#1-2 Total Dissolved Solids Concentrations in Effluent Discharge to Snap Lake With Mitigation



mg/L = milligrams per litre.

Reference

De Beers (De Beers Canada Inc.). 2013. Snap Lake Site Model Water Quality Report. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

Attachment 2-EC_IR#2: In the response to IR MVLWB 2, Figure MVLRB 2-1 showed predicted depth averaged total dissolved solids concentrations in Snap Lake "with mitigation". In the response to IR MVLWB 8, Figure MVLWB 8-1 showed predicted depth averaged chloride concentrations in Snap Lake "with treatment". Could the proponent explain the difference between "with mitigation" and "with treatment"? If they mean the same thing, could the proponent explain what percentage of effluent was treated to develop these two figures.

Response

“With mitigation” and “with treatment” mean the same thing.

To develop Figure MVLWB 2-1, the predicted concentrations of TDS in the effluent from the scenarios without mitigation (De Beers 2013) were changed such that they did not exceed the average monthly limit (AML) of 684 mg/L from January 1, 2015 to January 1, 2029. To develop Figure MVLWB 8-1, predicted chloride concentrations in Snap Lake with mitigation were generated by taking 46 percent (%) of the predicted TDS concentrations in Snap Lake with mitigation. Calculations were thus not based on the percent volume of effluent that would require treatment.

Reference

De Beers (De Beers Canada Inc.). 2013. Snap Lake Site Model Water Quality Report. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

Attachment 3-EC_IR#1: In Figure 2-4, the three graphs show that the depth-averaged fluoride concentrations in Snap Lake are well below the proposed SSWQO of 2.463 mg/L from 2014 to 2028. Could the proponent explain why such a high SSWQO is needed for fluoride?

Response

The proposed fluoride SSWQO (2.46 mg/L F-) was not derived relative to fluoride concentrations in Snap Lake. It was derived based on available, applicable toxicity data using the Canadian Council of Ministers of the Environment protocol (CCME 2007. A protocol for the derivation of water quality guidelines for the protection of aquatic life 2007. In Canadian Environmental Quality Guidelines, Winnipeg, MB, Canada). Available data on the chronic toxicity of fluoride to freshwater aquatic life were compiled and reviewed. A total of 11 chronic studies representing 15 species (three fish, eight invertebrates, and four algae/aquatic plants) were used to derive a chronic effects benchmark, applying the species sensitivity distribution approach. A manuscript is currently being prepared for peer-reviewed publication proposing this chronic effects benchmark as generally applicable to freshwaters. The working title of this manuscript is "Development of a fluoride chronic effects benchmark for aquatic life in freshwater".

Attachment 3-EC_IR#2: In Figure 2-5, the three graphs show that the depth-averaged sulphate concentrations in Snap Lake are well below the proposed SSWQO of 429 mg/L from 2014 to 2028. Could the proponent explain why such a high SSWQO is needed for sulphate?

Response

The proposed sulphate AEMP benchmark (not a proposed SSWQO) was not derived relative to sulphate concentrations in Snap Lake. It was derived based on the Province of British Columbia, Ministry of Environment, Ambient Water Quality Guidelines for Sulphate (Technical Appendix, Update, April 2013, prepared by Cindy Meays, PhD and Rick Nordin, PhD), adjusted for the hardness of Snap Lake water.

Attachment 3-EC_IR#3: In Figure 2-6, the three graphs show that the depth-averaged nitrate concentrations in Snap Lake are well below the proposed SSWQO of 16.4 mg/L from 2014 to 2028. Could the proponent explain why such a high SSWQO is needed for nitrate?

Response

The proposed nitrate SSWQO was not derived relative to nitrate concentrations in Snap Lake. It was derived based on the Dominion Mines Ekati Corporation, Board-approved SSWQO for nitrate (WL W2012L2-0001), following additional toxicity testing with Snap Lake water, and adjustment for the hardness of Snap Lake water.

YKDFN_IR#1: Socio-Economic and Cultural Impacts

Preamble

The developer's submission to the Review Board is not in conformity with the direction it has been provided. Particularly, it fails to meet the requirements set forth by the Review Board in their Reasons for Decision, as found on p.ll within that decision- under "Next Steps":

> *'The Review Board wiJJ require the developer to file information to satisfy ss. 114, 115, and 117 of the MVRMA. These sections require that the developer describe the biophysical, socioeconomic and cultural impacts that result from activities associated with the amendments that are within the scope of this assessment. Further, the developer must describe the cumulative impacts; accidents and malfunctions; and alternate means of carrying out these activities".*

YKDFN accept that sufficient information has been placed on the record to illustrate *the company's perspective* regarding the bio-physical impacts, but there are no submissions to address the socioeconomic or [particularly] cultural impacts. Furthermore, the transcript clearly shows that this was not accomplished through the 'engagement sessions' nor is it elsewhere on the registry as evidence.

This Environmental Assessment is not simply about the cheapest way to achieve 684 mg/L of TDS. It is about the consequences of that decision and the methods employed to get there- matters which we have very little about. It is the Yellowknives who will live with the result- and the long view must be that land and water must be clean enough to be accepted as a functional and productive part of the land base again. As Dave Putnam stated during lead up of the last licensing phase- De Beers is only "borrowing" the land- it must be returned in a manner that fits the intended use by those who depend on it.

Request

1) For the 'active mining' period, describe the socio-economic and cultural impacts that will result from the proposed activities and submit evidence to support their position, including community perception of Snap Lake, the adjacent area and the water quality.

2) Following active mining, describe the socio-economic and cultural impacts that will be a consequence of the proposed activities and submit evidence to support their position, with a focus on the perception of Snap Lake, the surrounding area, and the downstream environment

3) The alternatives provided are not 'true' alternatives, as they are non-viable. If something is unacceptable, then it is a false choice- parties cannot see the projects trade-offs and the consequential impacts.

Response

QUESTIONS 1) and 2)

As per the MVEIRB EA guidelines screening forms (MVEIRB 2004), the types of socio-economic effects considered are typically defined as planning / zoning changes or conflicts, increase in facility use or services in a community, airport operation, capacity changes, human health hazards, impairment to recreational use or aesthetic quality of water, effects to water use for other purposes, effects to other land use operations, and quality of life changes. Cultural effects generally include effects to traditional land use and resources, historic property, increased economic pressure on historic properties, change to or loss of historic resources, change to or loss of archaeological resources or change to or loss of aesthetically important site(s), effects to aboriginal lifestyle, and increased pressure on archaeological sites. The effects of the Snap Lake Mine on socio-economic and cultural and aesthetic aspects were assessed in the original environmental assessment for the Mine (De Beers 2002; MVEIRB 2003). For the purposes of addressing this IR, the potential socio-economic or cultural effects are considered to be through traditional land use or changes to water quality.

Water Quality and Traditional Land Use

For this ‘development’ (TDS at SSWQO of 684 mg/L), the area where TDS would exceed the original EA predictions is limited to the main basin of Snap Lake and into the inlet into Lac Capot Blanc, after which concentrations return to near regional background (<50 mg/L; see MVRB/MVLWB_IR#11, Table MVRB/MVLWB_IR#11-3). As such, the focus of the assessment was on the immediate area and not further downstream into the receiving environment.

As noted above, changes to the quality of drinking water, including aesthetic quality, may be considered a socio-economic effect. The SSWQO of 684 mg/L is above an aesthetic drinking water quality guideline of 500 mg/L for TDS in the main basin of Snap Lake downstream into Lac Capot Blanc. This was noted in the Supplemental Information filed in April 2014 (Section 2; De Beers 2014a). The increased TDS is not expected to change the appearance of the water, but may result in a slight saline taste. Most of the northwest arm of Snap Lake, where the camp drinking water is obtained, will remain below the aesthetic drinking water guideline for TDS (see

MVRB/MVLWB_IR#2, Figure MVRB/MVLWB_IR#2-2) and, if necessary, can be treated separately.

The TDS drinking water guideline was obtained by having the palatability of drinking water rated by a panel of tasters (Health Canada 2012). Table YKDFN_IR#1-1 summarizes the ranges of TDS concentrations and the corresponding palatability ratings. Water with extremely low TDS concentrations may also be unacceptable because of its flat, insipid taste (Health Canada 2012).

Table YKDFN_IR#1-1: Total Dissolved Solids Concentration and Corresponding Palatability Ratings

TDS Concentration (mg/L)	Palatability Rating
<300	Excellent
Between 300 and 600	Good
600 and 900	Fair
900 and 1,200	Poor
>1,200	Unacceptable

mg/L = milligrams per litre.

On this basis, lakes receiving the treated mine effluent at TDS 684 mg/L would be rated as 'good' to 'fair' for drinking water taste in the area of the main body of Snap Lake to the inlet of Lac Capot Blanc, and would still be of 'excellent' quality in the main body of Lac Capot Blanc and downstream to Mackay Lake. In a worst case scenario with upper bound flows and no mitigation, the TDS concentrations in the immediate project area would remain above 500 mg/L during the closure and post-closure of the mine until approximately 2040 (see MVRB/MVLWB_IR#11, Figure MVRB/MVLWB_IR#11-1). With mitigation, the TDS in the immediate project area is predicted to drop below the drinking water aesthetic guideline before 2040. There are communities in the Northwest Territories that have TDS concentrations in their drinking water with concentrations similar to the SSWQO (GNWT 2011) and communities elsewhere in Canada with drinking water concentrations well above the SSWQO (Health Canada 2012).

There are few land users in the area immediately surrounding Snap Lake, largely due to the rocky habitat (De Beers 2002). A traditional knowledge study also outlined that the area immediately around Snap Lake was not likely an area of substantial historical use (De Beers 2002). There are other land users (including non-traditional users) further away from Snap Lake (De Beers 2002, 2010) including tourist lodges, hunting camps, trap lines, and other land leases for exploration activities (map to be provided as soon as is available from the GNWT). Due to the distance from the Snap Lake Mine, these other users are not expected to be affected by the increase in TDS in the immediate mine area.

Therefore, while the development will result in a change in aesthetic drinking water quality in the immediate area of the Mine during operations and closure (2040), the water is safe to drink, there are few users in the immediate Snap Lake area who would be affected, the area will return to a TDS level below the drinking water guideline within 10 years of operations, and the area with elevated TDS concentrations would be localized.

On the basis of site specific toxicity studies, effects to fish are not expected. Further, in higher TDS areas in the Husky Lakes areas in Northwest Territories, fish size and fishing catch improved in areas of higher salinity (Harwood and Sparling 2008). Given this, changes to fishing opportunities for traditional land users are not expected. Fish abundance, health, tissue concentrations and taste in the Snap Lake area are monitored by De Beers (De Beers 2014b). Communities have gathered annually at Snap Lake for fish-tasting since 2004, fish were generally thought to taste good and sometimes rated as excellent (De Beers 2012, 2014b). Monitoring will continue such that the taste of fish can be evaluated annually by Elders.

Monitoring and Mitigation

This analysis recognizes that, notwithstanding the above anticipated changes, traditional land users may avoid using Snap Lake (including water, fish, or wildlife consumption) due to perception of contamination. De Beers acknowledges the importance of the regional area, the Lockhart River watershed. The watershed is of cultural and socio-economic value to the Northwest Territories and to local Aboriginal people. It is also acknowledged that land use in the immediate Snap Lake area may have changed since the Snap Lake EA or since community interviews on land use for the Gahcho Kué Project EA in 2009 and 2010 (De Beers 2010). De Beers is working with the Government of Northwest Territories Lands Department to determine whether land use has altered since 2009. This information will be provided as soon as it becomes available. Further, De Beers will be hosting YKDFN Chiefs Sangris and Bettsina at Snap Lake Mine on May 14, 2014 and plans to meet with community members at the end of May. De Beers will document these meetings, particularly information on the perception of Snap Lake and water quality, to the Boards.

De Beers will continue to conduct regional water quality monitoring as it has since 1999, and to report on the regional water quality three times a year reports to the MVLWB, a summary annual water license report to the MVLWB, and the annual AEMP report, as well as reporting to Aboriginal groups in the annual Environmental Agreement report. De Beers will also share data with the GNWT and Aboriginal Affairs and Northern Development Canada and communities as part of regional cumulative effects monitoring.

QUESTION 3

3) De Beers notes this is not a question, but provides a statement of clarification.

In the Supplemental Information filed April 2014, De Beers outlined alternatives to the development (SSWQO of 684 mg/L TDS). De Beers has suggested alternatives dating back to the original EA and has worked to test many of them. De Beers has provided evidence that the alternatives are ineffective on their own at managing TDS. De Beers tried the alternative of grouting to control the water inflows and areas of high TDS inflows for numerous years. It is now clear that this is not a practical method for controlling TDS (see Response to MVRB/MVLWB_IR#18). De Beers did not consider leaving TDS unmitigated. De Beers has accordingly proposed an option that balances mining method, economics, feasibility, and environmental protection: a SSWQO of 684 mg/L TDS.

References

De Beers (De Beers Canada Inc.). 2002. The Snap Lake Diamond Mine Environmental Assessment Report. Submitted to the Mackenzie Valley Environmental Impact Review Board. Yellowknife, NWT, Canada.

De Beers. 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. Yellowknife, NWT, Canada.

De Beers. 2012. Aquatic Effects Monitoring Program Re-evaluation Report: Snap Lake AEMP. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NWT, Canada.

De Beers. 2014a. Supplemental Information to the EA#201314-002. Submitted to Mackenzie Valley Environmental Impact Review Board and the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada. April 2014.

De Beers. 2014b. 2013 Aquatics Effects Monitoring Program Design Plan in Support of Water Licence (MV2011L2-0004). Snap Lake Project. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

GNWT (Government of the Northwest Territories). 2011. 2010 GNWT Report on Drinking Water. Yellowknife, NWT.

Harwood LA, Sparling P. 2008. Lake trout distribution and salinity: an assessment of the relative abundance and distribution of lake trout throughout Husky Lakes, 2001-2004. In Mills KH, Dyck M, Harwood AL (eds), Proceedings of the Second North American Lake Trout

Symposium 2005, Yellowknife, Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 2778, 247 pp.

Health Canada. 2012. Drinking water guidelines: total dissolved solids. Ottawa, ON, Canada.

MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2003. Report of Environmental Assessment and Reasons for Decision on the De Beers Canada Mining Inc. Snap Lake Diamond Project. Yellowknife, NWT, Canada

MVEIRB. 2004. Environmental Impact Assessment Guidelines March 2004. Yellowknife, NWT, Canada.

GNWT_IR1: GNWT requests that the proponent provide projected TDS concentrations (both mitigated and unmitigated) spatially in Snap Lake over time to assess cumulative effects, as per the supplemental information.

Response

Please refer to Figure 3-4 of the Total Dissolved Solids Response Plan (De Beers 2013), which presents predicted TDS concentrations at the diffuser area, main basin, and outlet of Snap Lake from 2004 to 2028 for model scenarios without mitigation.

Please refer to Figure 2-2 of the Snap Lake Water Licence Amendment Supplemental Information (De Beers 2014), which presents predicted TDS concentrations at the diffuser area, main basin, and outlet of Snap Lake from 2004 to 2028 for model scenarios with mitigation.

Reference

De Beers. (De Beers Canada Inc.). 2013. Total Dissolved Solids (TDS) Response Plan. Submitted to the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

De Beers. 2014. Snap Lake Water Licence Amendment Environmental Assessment EA201314-002 Supplemental Information. Submitted to the Mackenzie Valley Environmental Impact Review Board and the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

GNWT_IR2: In the supplemental information the proponent indicated that they require mitigation. GNWT requests that the proponent provide all mitigation options for TDS treatment, including all full reports.

Response

Please see De Beers response to MVRB/MVLWB_IR#3.

GNWT_IR3: The proponent has stated during the presentation of supplemental information (accidents and malfunctions), that the required mitigation for the treatment of water will likely generate a waste product. The proponent has not provided an impact assessment for these waste streams. The proponent must describe all potential waste streams generated from all proposed mitigation options and the potential for accidents and malfunctions.

Response

De Beers has identified high-efficiency Reverse Osmosis (RO) technology as the preferred mitigation alternative and is presently conducting to determine the design parameters and system configuration. Please note that the following information is representative of the type of system being considered and will need to be confirmed during the detailed engineering phase of implementation.

RO generates a continuous liquid reject stream containing 90-95% of the TDS in the original mine water influent. This brine stream would be expected to be approximately 25% of the mine water flow or less. RO brine would receive additional management/treatment (e.g. through evaporation and crystallization) to recover additional treated water and reduce the final volume that would require storage and disposal. A concentrated brine would be high in solids slurry from concentration of the ions that makeup TDS; its volume is expected to be less than 5% of the original mine water flow. If a crystallizer is used, the low moisture salt solids volume is expected to be less than 1% of the mine water flow.

Potential accidents and malfunctions that may occur with these types of system are:

1. A malfunction in one of several modules of the RO treatment system could allow RO brine to enter the permeate system. This would potentially occur due to a breach in the RO membrane, allowing leakage into the effluent discharge to Snap Lake. The consequence in this type of malfunction would likely be an incremental increase in the TDS of the lake discharge.

2. An accidental release of high solids slurry could occur from a pipeline conveyance between treatment and storage or a crystallizer. Consequences would depend on the rate of release, the location of the leak or failure, secondary containment features built

into the design, and the response actions taken to contain and remove the released material.

3. Transport of crystallizer salts in a truck could result in an accident with spillage of salt onto the ground. Such an accident would have a minor consequence in that the release of dry material would be known quickly and the lack of a liquid stream would allow for relatively easy containment and cleanup.

As noted in the response to MVRB/MVLWB_IR#16 it is not possible to assess the likelihood of the above unwanted events until the pilot testing and engineering is complete at which time a detailed risk assessment will be completed and reviewed as part of the regulatory approval process.

GNWT_IR4: The proponent stated during the Technical Session that baseline data will be collected for the downstream environment. GNWT requests a timeline for the submission of this baseline data.

Response

The downstream lakes assessment of the EAR includes baseline data collected in 1993/94 and 1999 from the Lockhart River Watershed (i.e., pre-development). The same dataset was used in the Snap Lake Water Licence Amendment Supplemental Information (De Beers 2014).

Additional data has been collected in the Lockhart River Watershed since the original EAR was prepared, including sampling conducted by De Beers as part of the Aquatic Effects Monitoring Program (AEMP). During the Technical Session, De Beers indicated that it would request recent water quality data from Environment and Natural Resources (ENR), collected as part of the Government of Northwest Territories (GNWT) Water Stewardship program. That request was submitted on April 25, 2014 by Golder Associates Ltd. on behalf of De Beers (Staples 2014, personal communication; Gue 2014, personal communication). Once that information is obtained (projected to be the week of April 28, 2014), it will be reviewed, and a determination will be made as to whether the information can be incorporated into the downstream lakes modelling assessment.

Reference

De Beers. 2014. Snap Lake Water Licence Amendment Environmental Assessment EA201314-002 Supplemental Information. Submitted to the Mackenzie Valley Environmental Impact Review Board and the Mackenzie Valley Land and Water Board. Yellowknife, NWT, Canada.

Staples R. 2014. Aquatic Specialist. Environment and Natural Resources. Yellowknife, NWT, Canada. Telephone conversation with Tasha Hall (Golder Associates Ltd). April 25 2014.

Gue A. 2014. Aquatic Scientist. Water Quality Monitoring and Surveillance, Science and Technology Branch. Environment Canada. Yellowknife, NWT, Canada. Email to Tasha Hall (Golder Associates Ltd). April 25 2014.

GNWT_IR5: In the supplemental information the proponent was required by the Mackenzie Valley Review Board to provide a cumulative effects assessment. The information provided in the supplemental information did not identify valued ecosystem components (VECs), nor did it identify potential effects from the project or other stressors to the valued components. GNWT request that the proponent provide a cumulative effects assessments as per the direction provided in the Mackenzie Valley Environmental Impact Review Board's *Environmental Impact Assessment Guidelines, Appendix H, 2004.*

Response

De Beers acknowledges that the assessment of cumulative effects for this Project is non-traditional given the nature of the development (i.e., a change in a WQ licence limit) and the nature of the regulatory process. The focus for valued ecosystem components (VECs) was, commensurate with a WQ issue, on the aquatic environment. The AEMP Design Plan (De Beers 2014) details the water quality VECs, which form the basis for the AEMP Response Framework. The AEMP Response Framework was designed to identify the valued components in relation to changes to water quality, 'thresholds' at which change is deemed unacceptable for these components and the level at which action would be taken before any thresholds are exceeded. It was identified that the level of change in Snap Lake that is not acceptable, based on the original EA, would occur when the water might not be safe to drink, and fish might not be plentiful and safe to eat.

Accordingly, De Beers identified the aquatic environment as the overall VEC for assessment of the effects of increased concentrations of total dissolved solids (TDS) on: drinking water, fish; and, food for fish. This approach is consistent with the VECs identified related to TDS in the original EA and in the conceptual design of the recently approved AEMP Design Plan (De Beers 2014). It is also consistent with comments provided on changes to the Snap Lake Water Licence limits since the renewal of the licence in 2011.

The cumulative effects section of the Supplemental Information identified that, while there are developments in the Lockhart River Watershed, there is no overlap between these and the Snap Lake treated effluent discharge; thus, there is no overlap related to possible cumulative effects from TDS. It was acknowledged in the April 14 to 15, 2014 Technical Session that other developments may potentially occur in the future but that De Beers could not foresee details on TDS concentrations from those developments and as such neither qualitative nor quantitative predictions about either overlap or effects could be made. It was also noted in the Technical Session that concentrations of TDS from Snap Lake will generally remain within the original EA predictions in the downstream environment. Finally, it was noted that the predicted TDS concentrations downstream of Snap Lake are generally low and within regional norms for the watershed; cumulative effects relate to such relatively low concentrations of TDS are not reasonably expected to occur. Thus, further assessment of cumulative effects was not required and was not conducted. De Beers is, however, continuing regional monitoring to document TDS concentrations downstream of the mine to King Lake, near Mackay Lake. The Mine's sampling coupled with the GNWT's as well as Aboriginal Affairs and Northern Development Canada and CIMP data in the Lockhart River will allow continued monitoring of regional water quality.

Reference

De Beers. 2014. 2013 Aquatic Effects Monitoring Program Design Plan. Snap Lake Project. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NWT, Canada.

SLEMA_April 22/14_IR#1: During the Technical Sessions from April 15 to 16, 2014, De Beers presented options to reducing Total Dissolved Solids (TDS) in effluent, and stated that treatment of full mine effluent was not cost-effective.

Snap Lake Environmental Monitoring Agency (SLEMA) investigated the impacts of TDS level in mine water and TDS removal efficiency of mitigations such as reverse osmosis on the ratio of mine water which must be treated to meet the proposed Effluent Quality Criterion (EQC) for TDS. SLEMA would like to request De Beers review the equation and results provided below and confirm whether they are justifiable.

$$R>100(C-EQC/(\eta C)$$

Where, R – Ratio of mine water to be treated, %

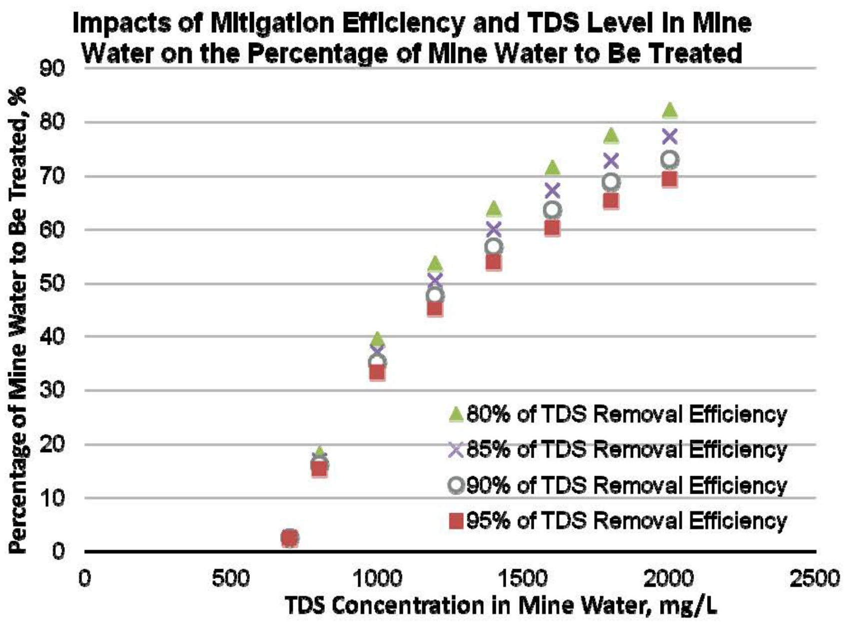
C – TDS concentration in mine water, mg/L

EQC - Effluent Quality Criterion for TDS, mg/L

η – TDS removal efficiency, %

If EQC for TDS is 684 mg/L, the percentage of mine water to be treated is calculated and illustrated as below.

TDS Removal Efficiency, %	TDS Concentration in Mine Water, mg/L							
	700	800	1000	1200	1400	1600	1800	2000
80	2.9	18.1	39.5	53.8	63.9	71.6	77.5	82.3
85	2.7	17.1	37.2	50.6	60.2	67.4	72.9	77.4
90	2.5	16.1	35.1	47.8	56.8	63.6	68.9	73.1
95	2.4	15.3	33.3	45.3	53.8	60.3	65.3	69.3



It is clear that the more TDS removal efficiency could be achieved, the less mine water has to be treated; the more TDS is in mine water, the more mine water has to be treated.

Response

The equation provided by SLEMA is a valid approximation of the volume of water that will require treatment. It is important to keep in mind that the type of technologies under consideration and being pilot tested are well understood and are capable of TDS removal efficiencies greater than 90%.