



Snap Lake Environmental Monitoring Agency
Main Floor, Lahm Ridge Tower
4501 Franklin Avenue
P.O. Box 95, Yellowknife, NT X1A 2N1
Phone: 867-765-0961 FAX: 867-765-0963
Website: www.slema.ca

Shannon Hayden
Regulatory Officer
Mackenzie Valley Land and Water Board
7th Floor – 4910 50th Avenue
P.O.Box 2130, Yellowknife, NT X1A 2P6

MV2001L2-0002
File: Adaptive Management and
Sampling Plan for TDS, Calcium and Chloride

September 2, 2010

Re: Predictions of Total Dissolved Solids, Calcium and Chloride Concentrations in Snap Lake

Dear Ms. Hayden,

Snap Lake Environmental Monitoring Agency (SLEMA) is pleased to provide Mackenzie Valley Land and Water Board (MVLWB) with the following results of water quality modeling for Total Dissolved Solids (TDS), Calcium and Chloride and related analysis and recommendations.

TDS Forecasting and Action Levels

De Beers Sampling Plan for TDS, Calcium and Chloride (March 2005) requires annual reporting of the results of the mass balance modeling. Unfortunately, **the model forecasts have been outstanding since then.**

The observed whole-lake average concentrations of TDS, Calcium and Chloride show a clear uptrend. The reason is the discharge of mine effluent from the Water Treatment Plant (WTP), which has been containing high concentrations of TDS, Calcium and Chloride. The uptrend was predicted in the Environmental Assessment Report (EAR). However, the extent of the increase observed from the monitoring data appears to be more than EAR expected. That indicates a potential for concentrations of TDS, Calcium and Chloride to increase faster than expected and exceed the action levels for adaptive management earlier than expected.



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Table 1. Action Levels

Parameter	EAR Prediction, mg/L	Action Level for Adaptive Management, mg/L	Water Licence Limit, mg/L	Action Level for Fisheries Authorization, mg/L	Guideline Criteria, mg/L
TDS	350	600	350	350	≤500
Calcium	88	110			
Chloride	137	160			≤250 230 for aquatic life (USEPA)
<i>Note</i>	<i>Maximum predicted whole-lake annual average concentrations</i>	<i>Concentrations beyond the diffuser mixing zone (<u>hotspot area</u>)</i>	<i>Whole-lake average concentration</i>	<i>Spot concentrations in 3 consecutive events</i>	<i>Aesthetic objective for drinking water</i>

SLEMA has been closely watching the change of water quality in Snap Lake. The concern on TDS and related impacts on aquatic life in Snap Lake made SLEMA have a try in mass balance model forecasting for TDS. The TDS modeling results were discouraging and the findings were reported to Mackenzie Valley Land and Water Board and De Beers in a letter dated July 19, 2010. The following sections represent the on-going efforts of SLEMA on this issue.

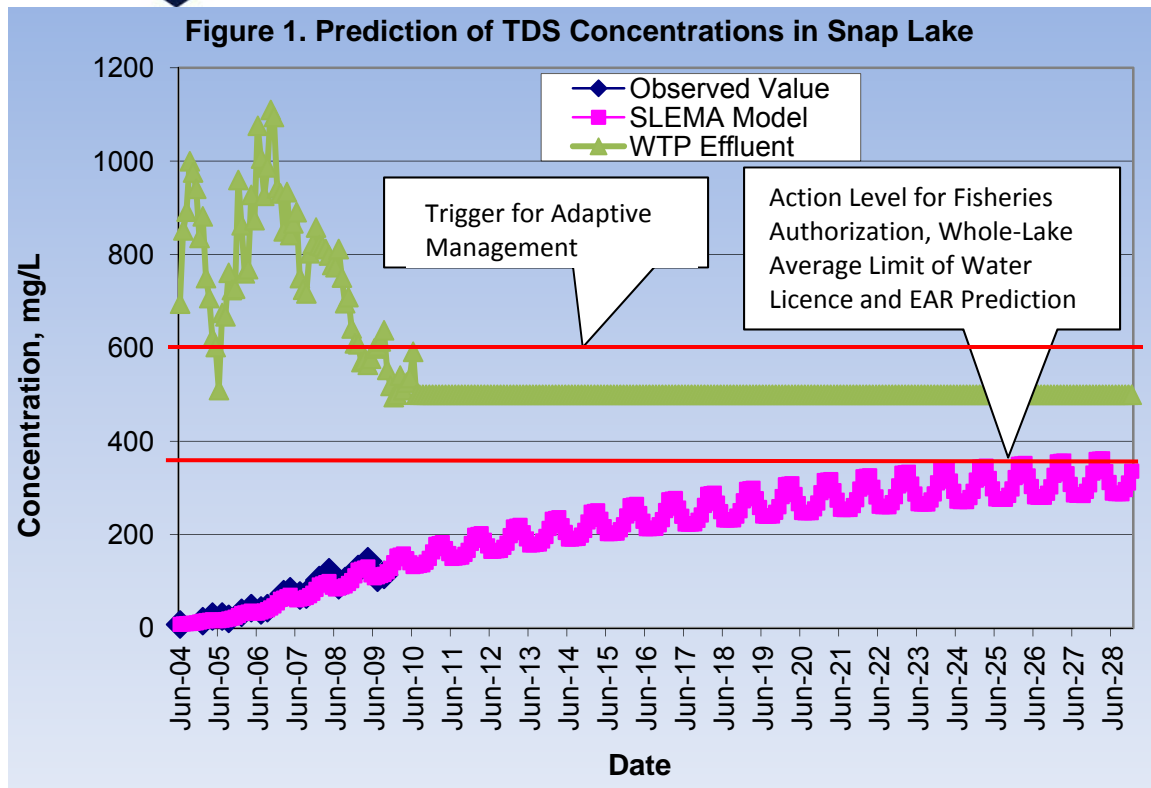
Prediction of TDS Concentrations in Snap Lake

A highly simplified “box” model (SLEMA Model) was applied to simulate the **whole-water average** TDS concentrations in Snap Lake (see Briefing Note for AEMP 2009). The results of one scenario (Scenario #2 in the letter dated July 19, 2010, see Figure 1) of the two TDS load assumptions raised serious concern on TDS concentrations in Snap Lake: if current WTP discharge level continues (i.e. 500,000 m³/month with TDS concentration of 500 mg/L), the TDS level in Snap Lake is expected to be above the EAR prediction and Water Licence limit (350 mg/L) in January 2026, which would be a **non-compliance**.

Because the TDS concentrations at and or near the diffuser mixing zone (**hotspot area**) of Snap Lake are surely above the **whole lake average concentrations** of TDS, the action level for TDS (350 mg/L) prescribed in Fisheries Authorization might be exceeded and related action might be triggered **earlier than 2026**.



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Prediction of Calcium Concentrations in Snap Lake

The SLEMA Model could be applied not only to TDS, but also to Calcium and Chloride.

By using the historical data, the correlation co-efficient of observed values and simulated values for Calcium was calculated and the number is 0.991 (see Figure 2). As a result, the modeling is acceptable and the model could be used for prediction of **whole lake average concentrations** for Calcium.

If current WTP discharge level continues (i.e. 500,000 m³/month with Calcium concentration of 100 mg/L), the Calcium level in Snap Lake (see Figure 3) is expected to be below the EAR prediction (88 mg/L) and the trigger for adaptive management (110 mg/L) by 2028.



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Figure 2. Simulation of Calcium Concentrations in Snap Lake

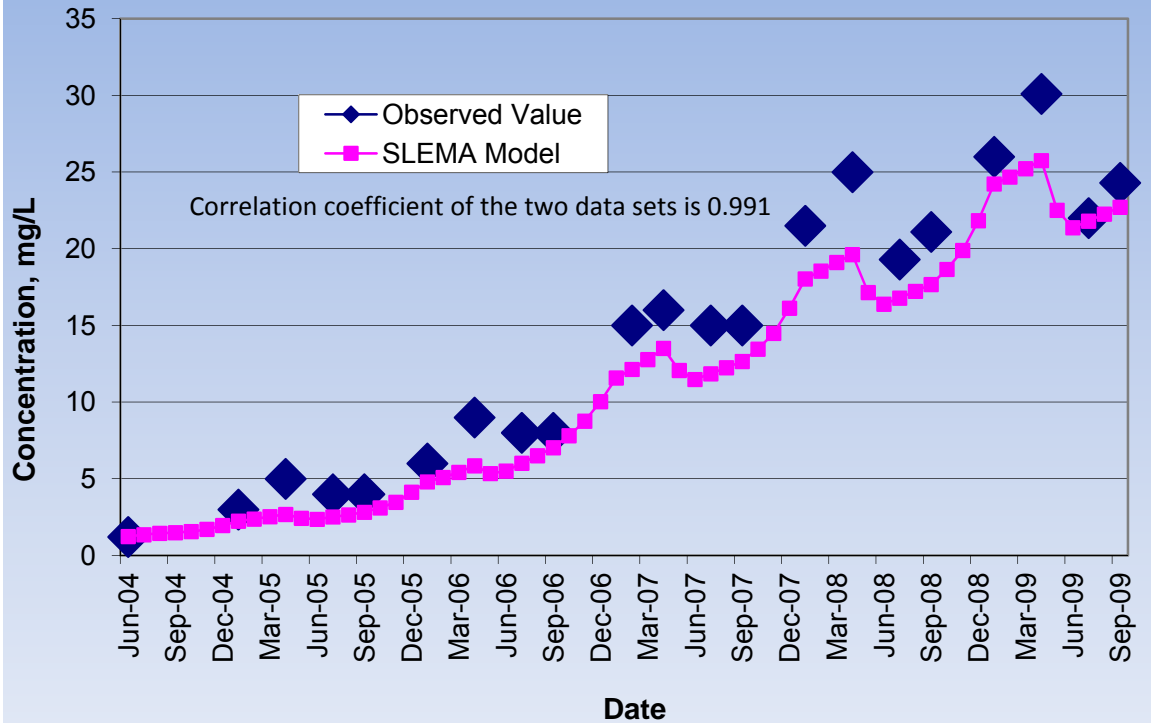
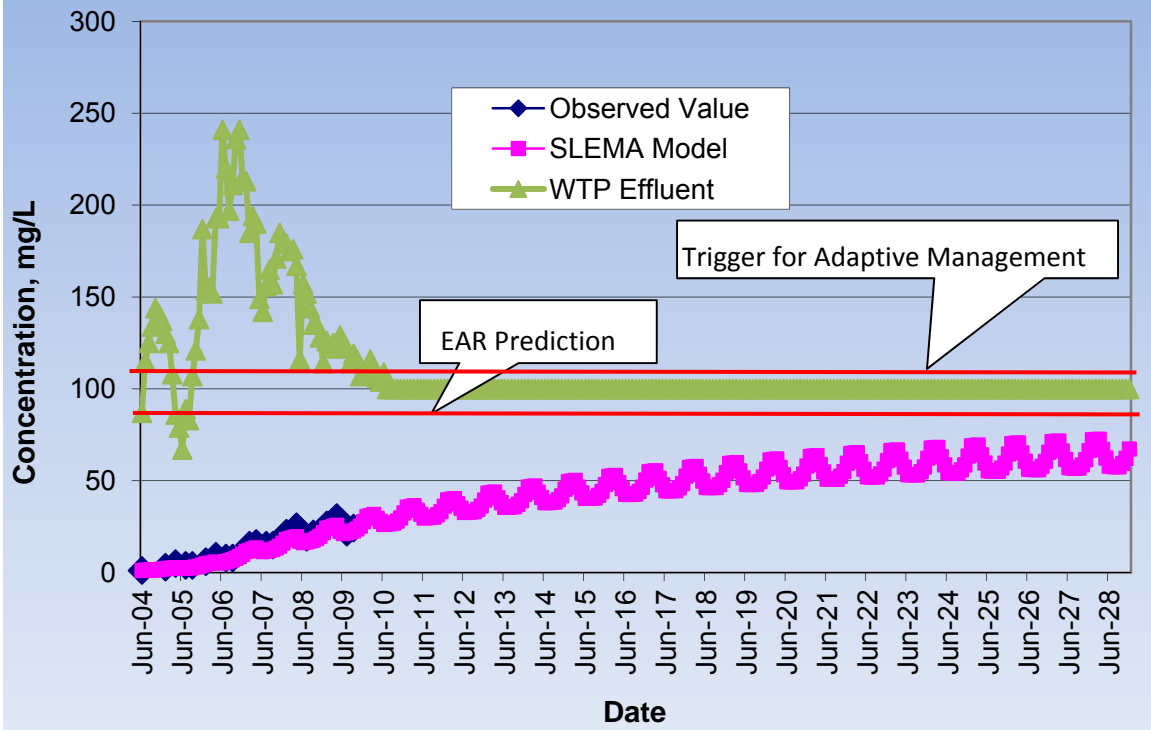


Figure 3. Prediction of Calcium Concentrations in Snap Lake





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Prediction of Chloride Concentrations in Snap Lake

By using the historical data, the correlation co-efficient of observed values and simulated values for Chloride was calculated and the number is 0.989 (see Figure 4). As a result, the modeling is acceptable and the model could be used for prediction of **whole lake average concentrations** for Chloride.

If current WTP discharge level continues (i.e. 500,000 m³/month with Chloride concentration of 240 mg/L), the Chloride level in Snap Lake (see Figure 5) is expected to be above the EAR prediction (137 mg/L) in **January 2019**, and the **whole lake average concentration** of Chloride is expected to be above the trigger for adaptive management (160 mg/L) in **January 2024**.

Because the Chloride concentrations near the diffuser mixing zone (**hotspot area**) of Snap Lake are surely above the **whole lake average concentrations** of Chloride, the Adaptive Management action level for Chloride (160 mg/L) might be exceeded earlier than 2024. Consequently, the mitigation measures might be triggered **much earlier than 2024**.

Actions for Adaptive Management

The comparison between the action levels and the forecasted concentrations of TDS, Calcium and Chloride generates a timeline for actions of Adaptive Management to mitigate the potential exceeding occurrences.

The results are listed in Table 2.

Table 2. Timeline for Adaptive Management Actions

Parameter	Date Exceeding EAR Prediction, mg/L	Date Exceeding Action Level for Adaptive Management, mg/L	Date Exceeding Water Licence Limit, mg/L	Date Exceeding Action Level for Fisheries Authorization, mg/L	Date Exceeding Guideline Criteria, mg/L
TDS	January 2026	Not expected	January 2026	Earlier than January 2026	Not expected
Calcium	Not expected	Not expected	N/A	N/A	N/A
Chloride	January 2019	Earlier than 2024	N/A	N/A	Not expected



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Figure 4. Simulation of Chloride Concentrations in Snap Lake

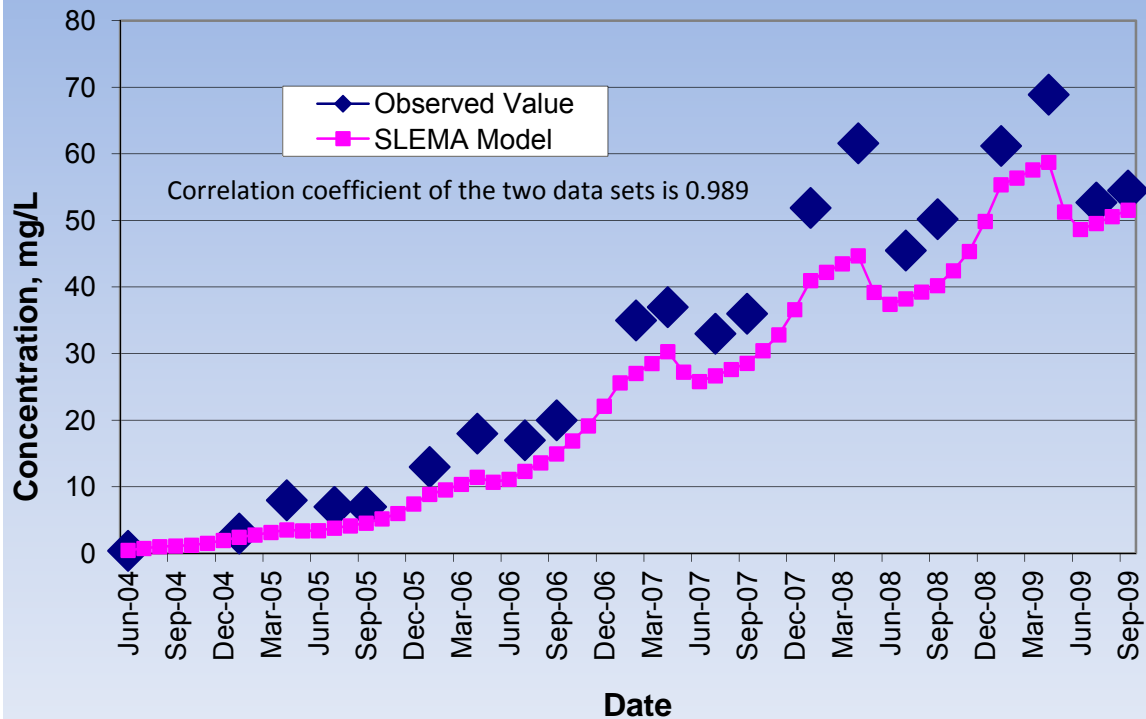
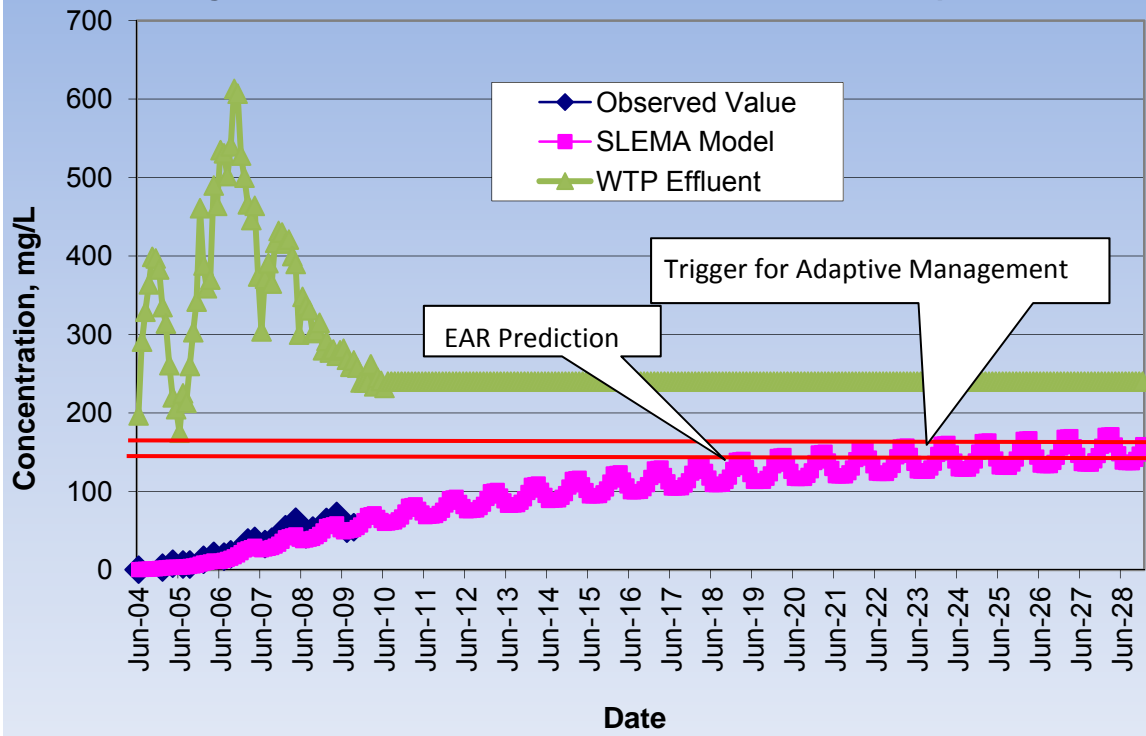


Figure 5. Prediction of Chloride Concentrations in Snap Lake





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The mitigation measures are described in Section 3.1.5 (page 15) of Adaptive Management Plan:

*“If the concentrations of TDS, **chloride** and calcium in Snap Lake outside of the initial mixing zone are forecast to exceed 600 mg/L, **160 mg/L** and 110 mg/L, respectively, the following actions would be taken:*

- *Review **the forecasts** to make sure that future concentrations really have a reasonable potential to exceed these levels. If they do, then undertake studies required to determine actual effects thresholds in Snap Lake. This could include **literature review, toxicity testing and/or mesocosm (medium-sized biological communities) studies**. Compare forecast concentrations to effects thresholds.*
- *If **forecast concentrations** are greater than effects thresholds, **undertake an evaluation of the risk to aquatic life.**”*

Item 5.2.5 of Fisheries Authorization (SC00196) also prescribes an action for Adaptive Management:

“If the monitoring results indicate that discreet depth concentrations of TDS exceed 350 mg/L at any depth in 3 consecutive sampling events at any of the sampling locations, De Beers shall develop a study plan within 3 months of the most recent exceedance to determine the potential impacts on egg development and larval fish survival that shall be subject to DFO review and approval.”

Recommendations

SLEMA modeling may not be perfect, but do provide some useful information and could be good reference for MVLWB, De Beers and other stakeholders.

It is recommended that De Beers conduct comprehensive water quality modeling and compare the modeling results with EAR predictions and action levels of Adaptive Management Plan to confirm whether they will be exceeded or not.

Annual reporting of comprehensive water quality modeling may not be practical due to the intensive use of resources. Mass balance modeling is much easier, and annual reporting is possible and it is also a requirement of the Sampling Plan for TDS, Calcium and Chloride.

It is recommended that De Beers fulfill the reporting requirements prescribed in the Sampling Plan for TDS, Calcium and Chloride, in the coming annual reports (either in AEMP annual reports or separate TDS, Calcium and Chloride Sampling annual reports), which should include, but be not limited to:



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- Results of the mass balance modeling,
- Time-series plots for forecasted whole lake average concentrations of TDS, Calcium and Chloride,
- Summary and discussion of historical and forecasted loadings of Calcium and Chloride.

Non-compliance against Water Licence water quality requirement in Snap Lake is a high possibility based on SLEMA modeling results. It is recommended that De Beers consider a study plan for pollution prevention or source control, i.e. taking proactive initiatives to reduce the minewater quantity and reduce TDS concentrations in minewater.

The action level for TDS (600 mg/L) established in the Adaptive Management Plan is higher than Water Licence limit (350 mg/L). Exceeding Water Licence limit is not acceptable, thus the action level of higher than Water Licence limit is not reasonable. In contrast, the action levels for SO₂, TSP, PM₁₀, PM_{2.5}, and NO₂ established in the Air Quality and Emissions Monitoring and Management Plan (August 2008) are lower than applicable air quality criteria (NWT Ambient Air Quality Standard). It is recommended that De Beers re-establish the action level for TDS. In addition, current Adaptive Management Plan was submitted in August 2004, and it is time for De Beers to update this document.

If you have any questions whatsoever please feel free to contact the undersigned or David White at 867-765-0961 / dwhite@slema.ca.

Sincerely,

(original signed by)

Johnny Weyallon
Chairperson

cc: De Beers Canada Inc.
Indian and Northern Affairs Canada
Environment and Natural Resources, GNWT
Environmental Canada
Fisheries and Oceans Canada