Nitrogen Response Plan

Erica Bonhomme, Manager, Environment Snap Lake Mine

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Nitrogen Response Plan

- Licence required Plan to be submitted for approval by December 31, 2013
- To include items 4.a)-d) of Schedule 5, Part F of licence
- Notably, the requirements to recommend:
  - *"…appropriate Water Quality Objectives for ammonia and nitrate in Snap Lake derived from toxicity testing…"; and,*
  - *"…EQCs for ammonia and nitrate, to be applied at SNP station 02-17 that would ensure protection of aquatic life in Snap Lake."*
- The conclusions of these required studies has led De Beers' to recommend higher SSWQOs and EQCs for Nitrogen, and is the foundation of the amendment application.
- The full results are provided in *Development of Nitrate Chronic Effects Benchmark of Aquatic Life in Snap Lake*

Nitrogen Sources and Management

Primary source of nitrogen is nitrate and ammonia from underground blasting activities:

- Predicted loading derived from Snap Lake Site Water Quality Model and Upper and Lower Bound Groundwater Model Scenarios
- 85-87% nitrate loading to Snap Lake is from underground
- 72-77% ammonia loading to Snap Lake is from underground
- Remainder is from North Pile
- Nitrogen loading predicted to increase over life of mine

Primary means of reducing nitrogen loading is to improve blast efficiency underground:

- Reduce number of holes per blast round
- Reduce emulsion over-loading in blast holes
- Remove and re-use old emulsion on surface

Controlled dilution of concentrated minewater also temporarily reduces loading

Nitrogen Sources and Management

Summary of investigations into minimizing Nitrogen loadings to the environment:

- Pre-feasibility comparison of effluent treatment technologies (Densadeg, filtration, Actiflo, RO, ultrafiltration, microfiltration)
- Pre-feasibility screening of conceptual Densadeg, MF/UF/RO/Crystallization system with TSS expansion
- Capital and operating cost estimate
- Technology similar to that required to treat for TDS
- Targeted treatment at Water Management Pond

Snap Lake Mine:
Addressing Water License Requirements for Nitrogen Water Quality Benchmarks

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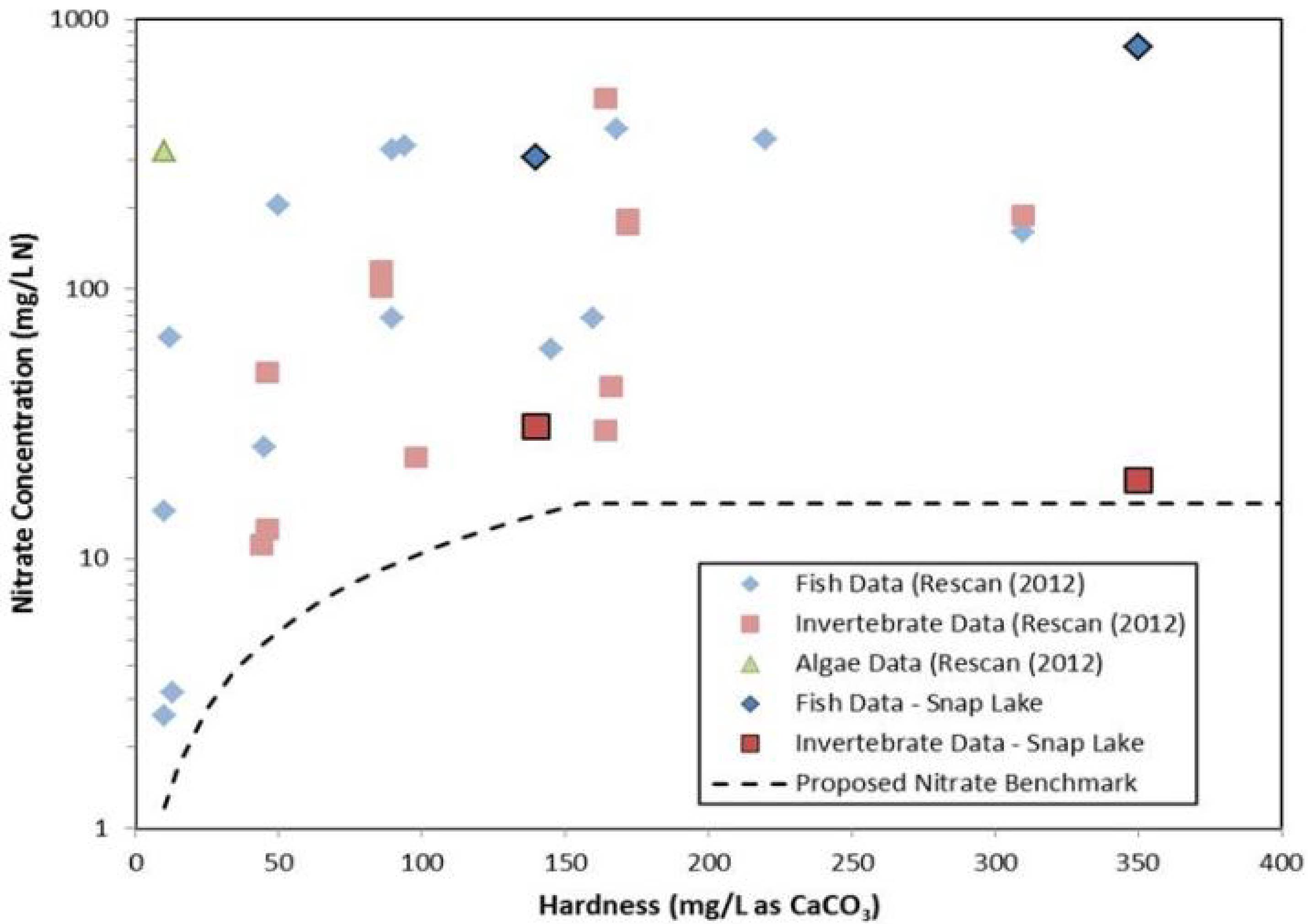
Nitrate

- EKATI has developed nitrate site specific water quality objective (SSWQO) based on varying hardness concentrations
- EKATI nitrate SSWQO accepted by the WLWB and now part of the EKATI renewed Water Licence
- EKATI nitrate SSWQO also applicable to Snap Lake waters – based on testing using two of the three most sensitive species (a water flea and Fathead Minnow)

Underground pumping station – Snap Lake Mine

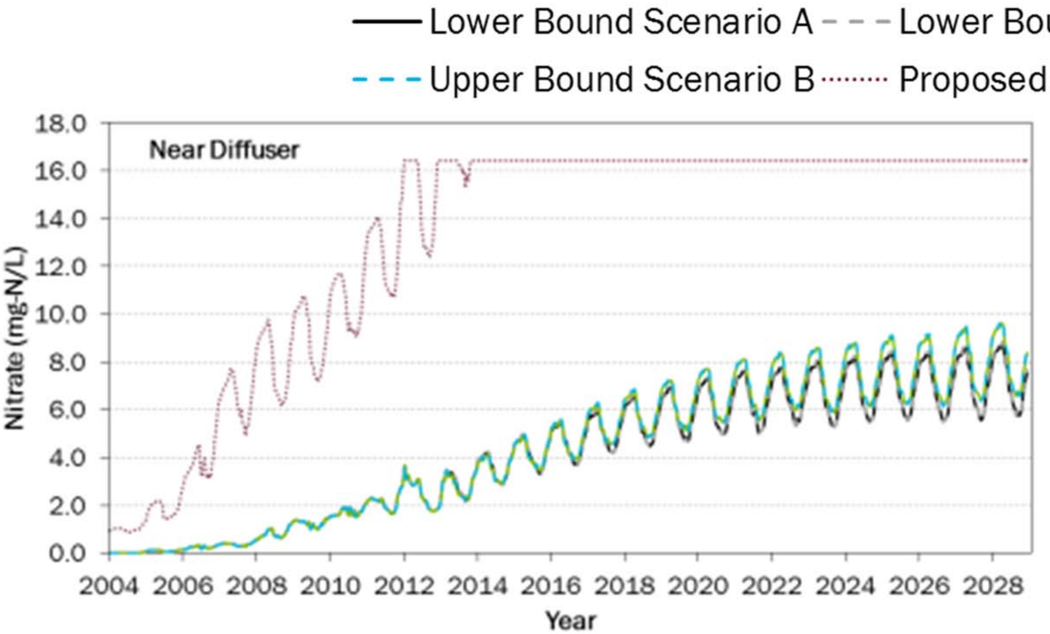
EKATI Nitrate SSWQO Validation for Snap Lake

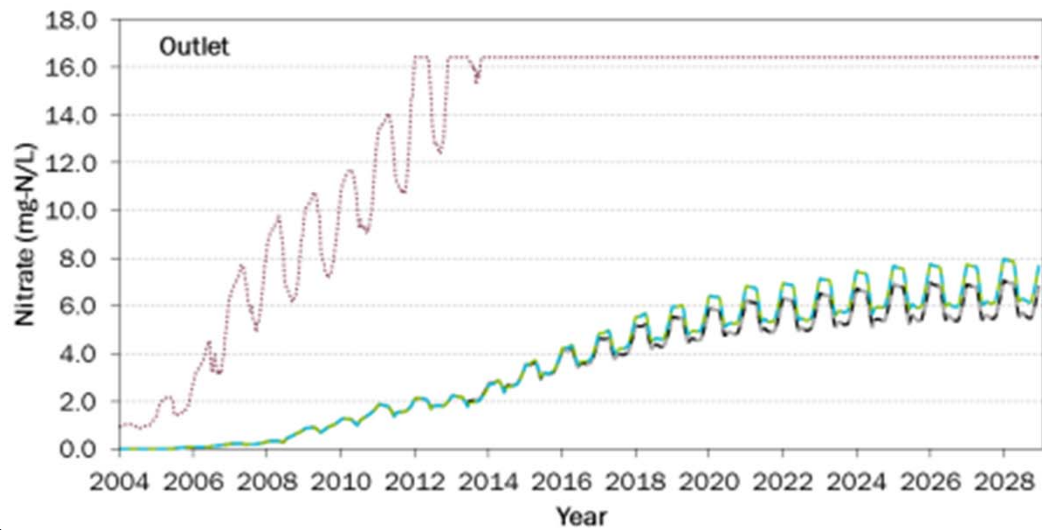


Nitrate (cont'd)

- Maximum nitrate concentration May 2013: ~3.0 mg-N/L (SNP 02-20f)
- Maximum predicted nitrate concentration: 10 mg-N/L
- Using hardness-dependent SSWQO from EKATI at hardness of 160 mg/L
- Nitrate SSWQO = 16.4 mg-N/L

Model Results - Predicted Depth-Averaged Nitrate Concentrations





Ammonia

- Ammonia toxicity modified by pH and temperature (exposure toxicity modifying factors)
- Maximum predicted ammonia concentration: 2.7 mg-N/L
- SSWQO based on the CCME WQG
  - Ammonia SSWQO = 5.21 mg/L

Comments/Questions?

Strontium Response Plan

Erica Bonhomme, Manager, Environment Snap Lake Mine

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Strontium Sources and Management

- Strontium originates from mined granite, metavolcanic and kimberlite
- ~91% strontium loading is from underground, with remainder from the water management system, including North Pile
- Site-specific water quality modeling and toxicity studies conclude that strontium loading to Snap Lake will not present a risk to aquatic life, therefore mitigation is not proposed at this time
- Ongoing monitoring and reference against the AEMP Response Framework will identify whether actions may be required in the future

Snap Lake Mine:
Addressing Water License Requirement for Strontium Water Quality Benchmark

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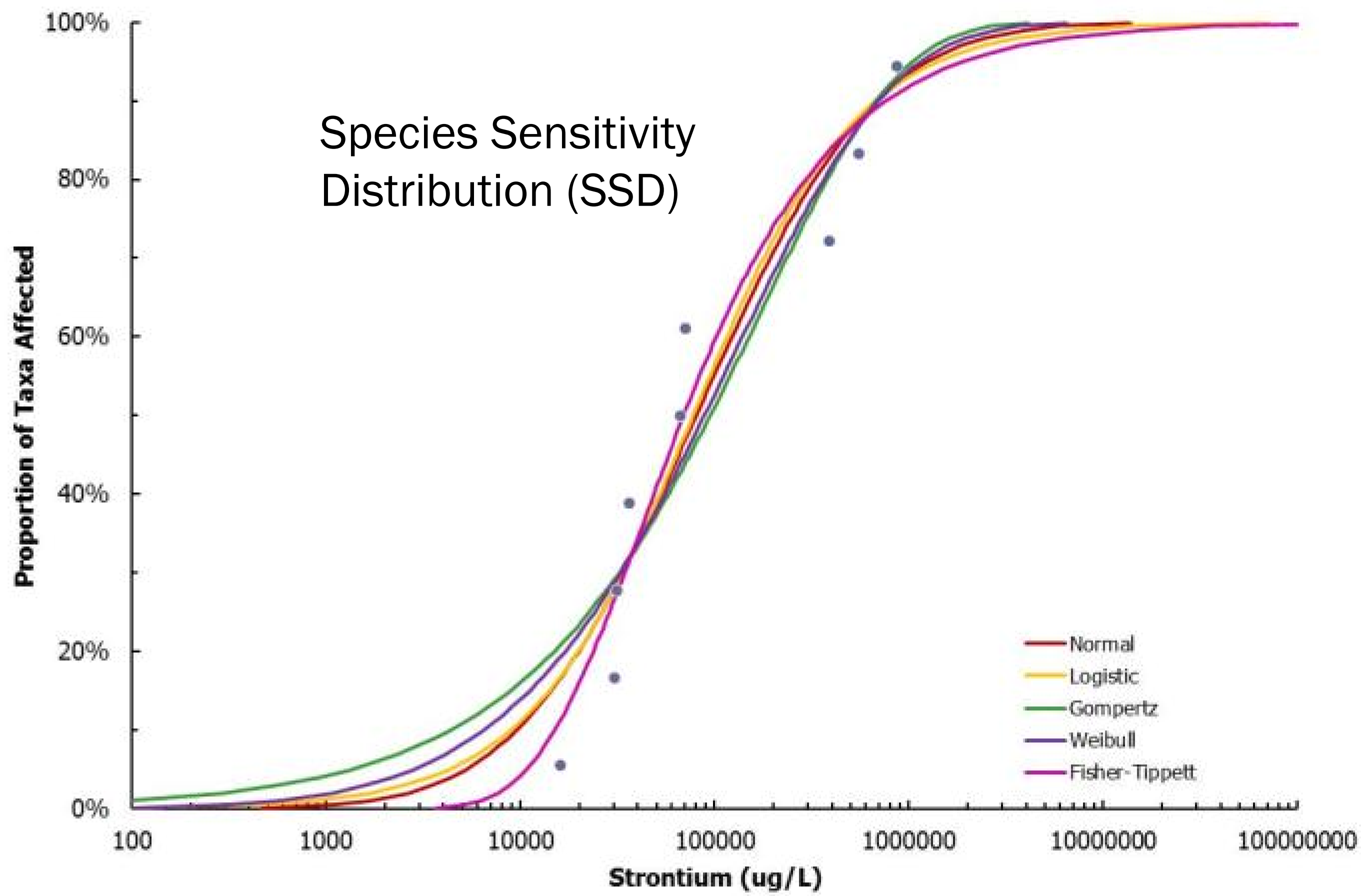
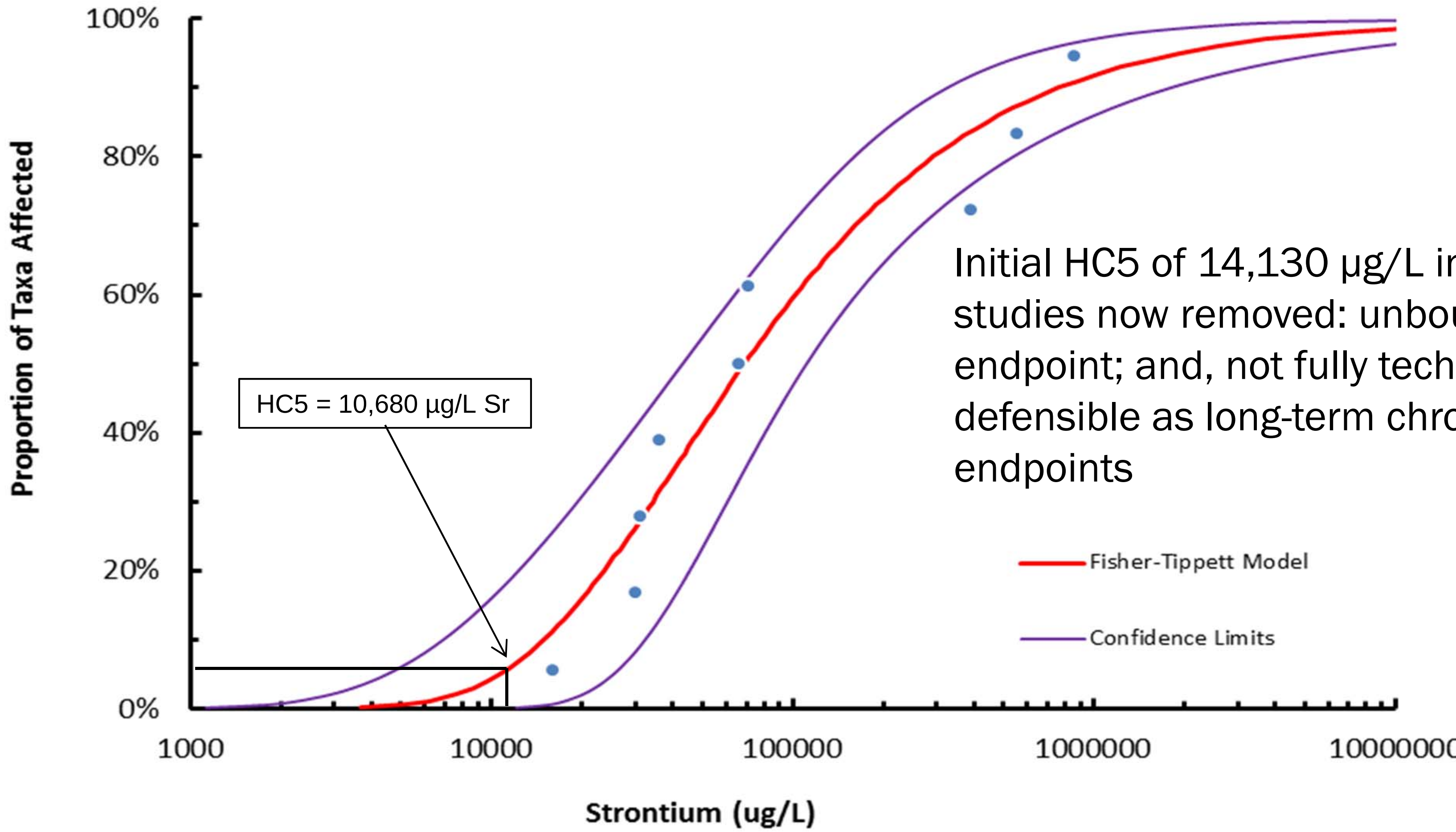
Strontium

Anderson Darling Goodness of Fit Test used to establish best fit

Species Sensitivity Distribution (SSD)



Strontium (cont'd)

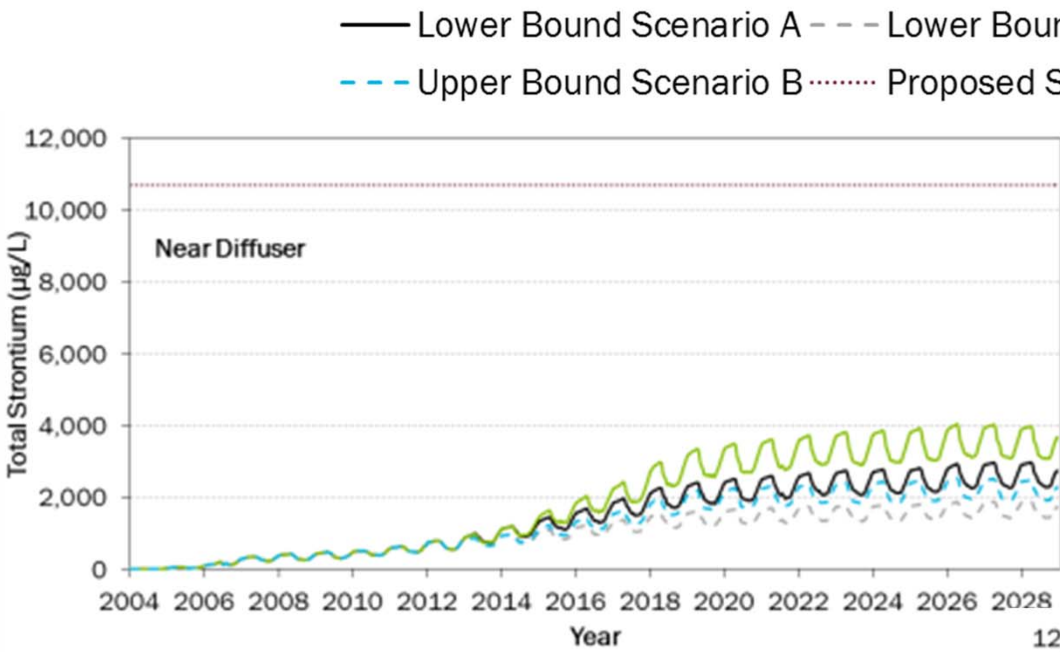


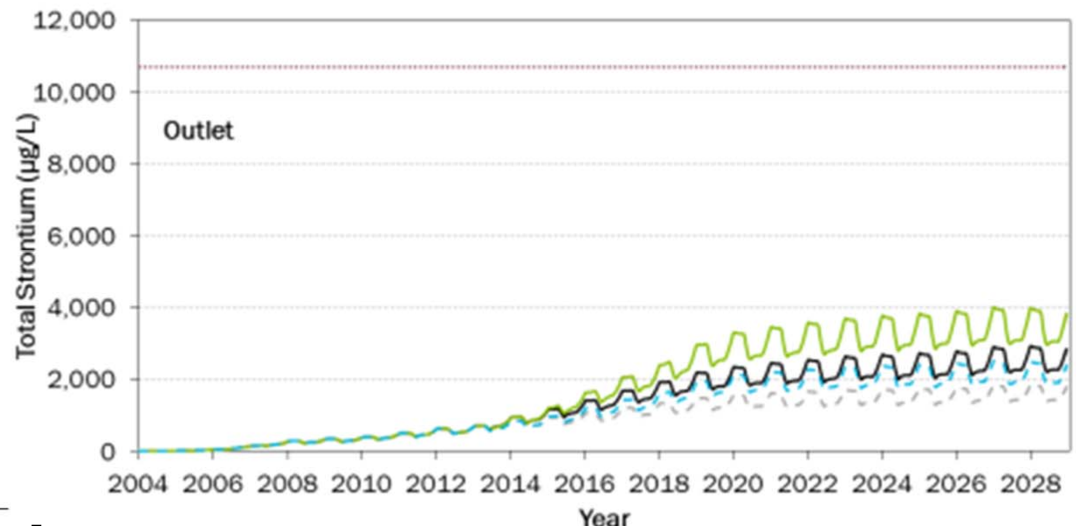
Initial HC5 of 14,130 µg/L included 3 studies now removed: unbounded endpoint; and, not fully technically defensible as long-term chronic endpoints

Strontium (cont'd)

- Maximum strontium concentrations at the diffuser stations: April 2013, 0.85 mg/L (Station SNP 02-20e)
- Updated modeling = upper bound strontium concentrations: 4.08 mg/L
- Chronic effects benchmark: 10.7 mg/L
- Burden of evidence (tissue burdens of strontium in Snap Lake and reference lake fish; toxicology of strontium): no present or future risk of strontium toxicity to the aquatic biota of Snap Lake
- Strontium EQC not necessary

Model Results - Predicted Depth-Averaged Total Strontium Concentrations





Comments/Questions?

Snap Lake Mine
Effluent Quality Criteria

Tasha Hall, Golder Associates Ltd.

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Presentation Overview

Terminology Review

Types of Effluent Quality Criteria (EQC)

Method for Calculating EQC

Proposed EQC

Summary and Questions

Terminology

Effluent Quality Criteria (EQC)

- Apply at end-of-pipe
- Typically higher than in-lake benchmarks due to dilution
- Regulated under the Water Licence
- Operational control

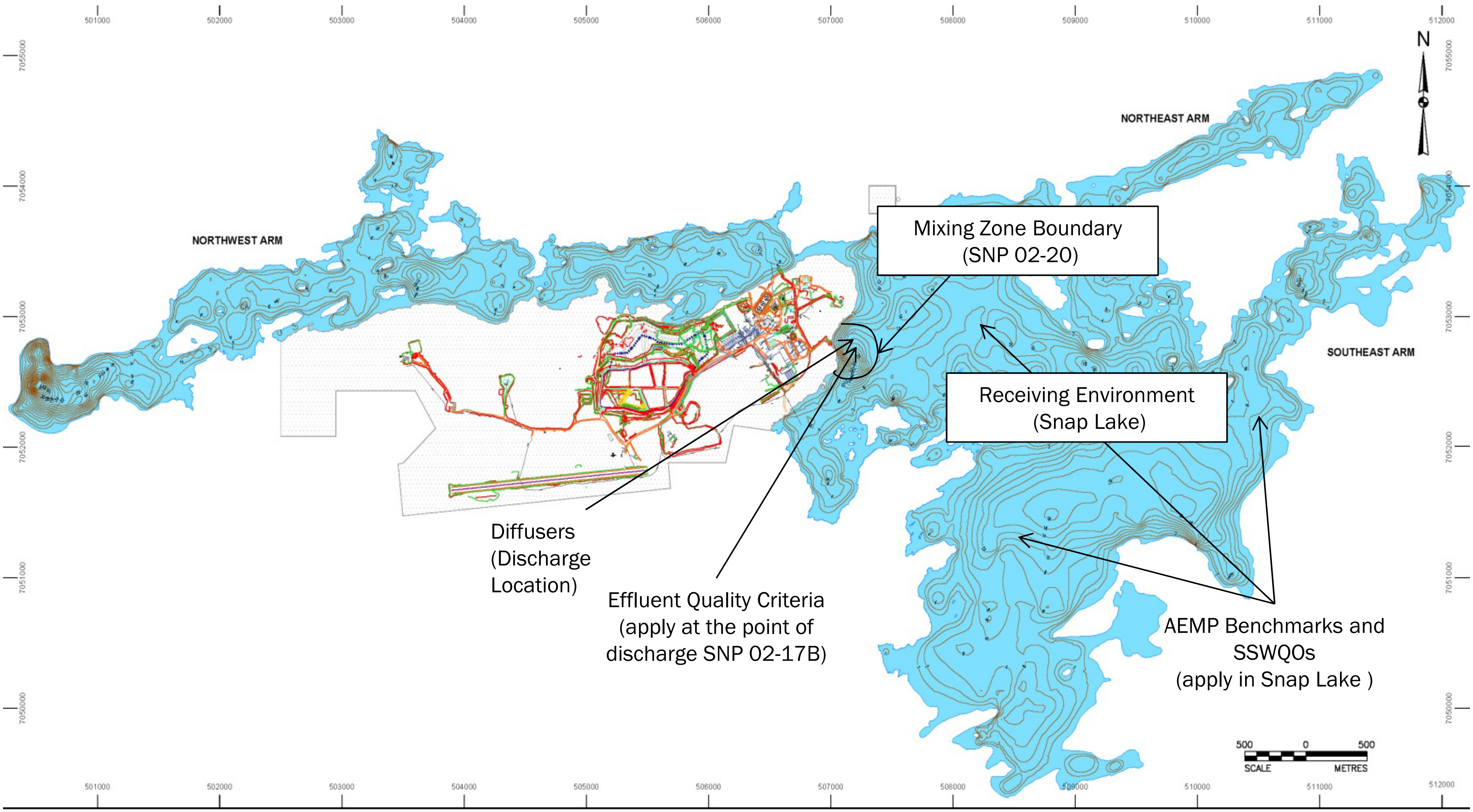
Aquatic Effects Monitoring Program (AEMP) Benchmarks

- Apply in-lake
- Term used for ease of reference
- Generic water quality guidelines, benchmarks, criteria published by government agencies
- May include site-specific water quality objectives (SSWQOs)

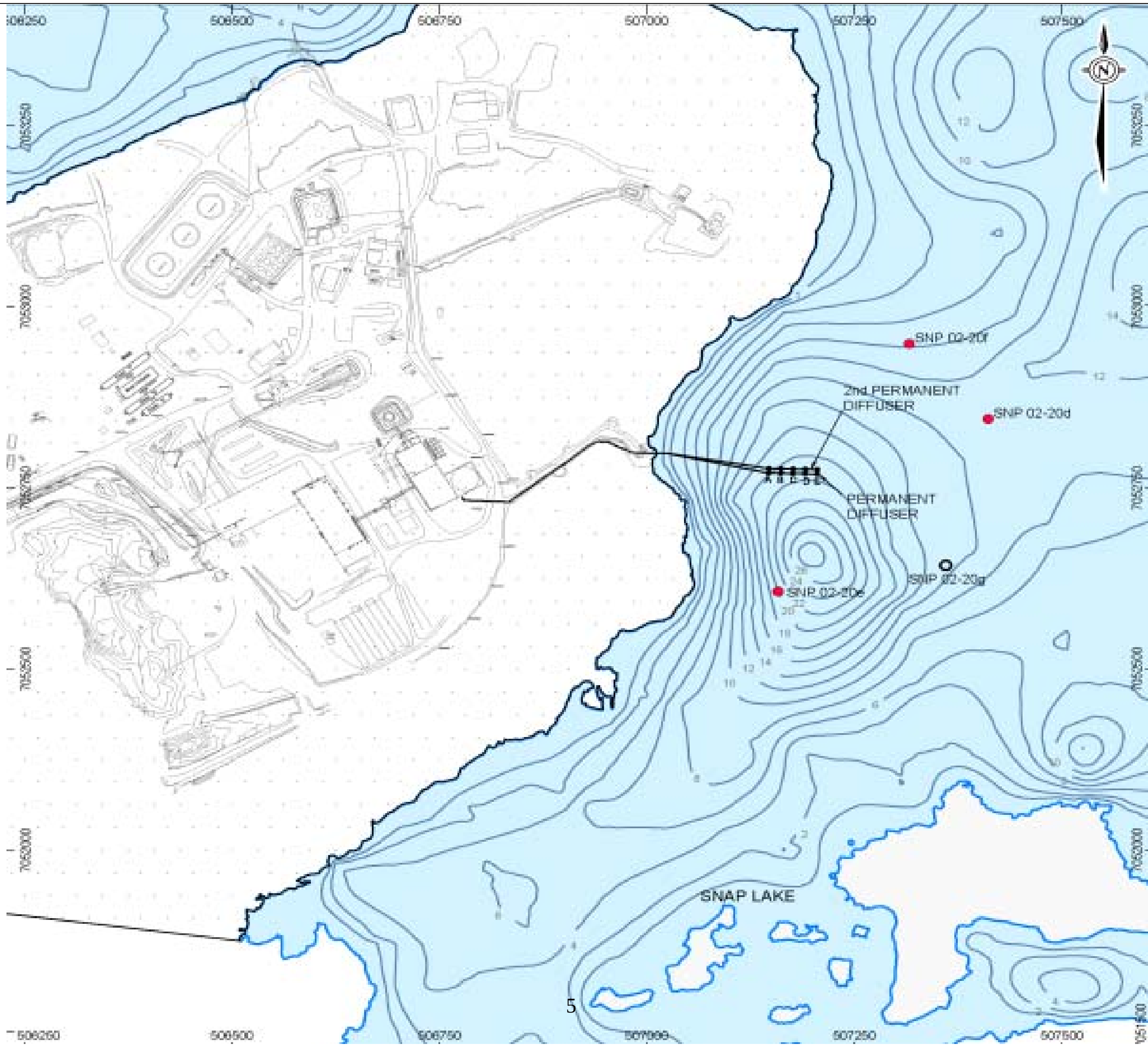
Site-specific Water Quality Objectives

- Apply in-lake
- Based on local biota and conditions
- Development can be supplemented by laboratory studies and literature

Effluent Quality Criteria



Diffuser Sampling Locations



Effluent Quality Criteria

Maximum daily limit (MDL):

- Maximum daily limit (MDL), which represents the maximum concentration of a parameter measured in a single grab sample of the treated effluent; and,

Average monthly limit (AML):

- Average monthly limit (AML), which represents the average concentration of a parameter that the Mine may discharge to Snap Lake, determined by averaging consecutive samples collected at six-day intervals over a thirty-day period

Current Water Licence Parameters

- Total suspended solids
- Ammonia
- Nitrite
- Nitrate
- Chloride
- Fluoride
- Sulphate
- Aluminum
- Arsenic
- Chromium
- Copper
- Lead
- Nickel
- Zinc
- Extractable petroleum hydrocarbons
- Total phosphorus (annual loading)
- pH (regulated range)

Calculating EQC

- Board Policy[1] does not outline specific methods
- Used manuals from other jurisdictions (United States Environmental Protection Agency 1991; Alberta Environmental Protection 1995)
- **EQC Derivation:**
  - Consider parameters to assess
  - Select AEMP Benchmarks and SSWQOs to be met at mixing zone boundary (200 m)
  - Determine the assimilative capacity of lake in late operations
  - Calculated a waste load allocation then MDL and AML (multiple steps)

Mackenzie Valley Land and Water Board . 2011. Water and Effluent Quality Management Policy. Yellowknife, NWT, Canada

Parameter Identification

Required Parameters

- from Schedule 5: Part F, 3b (ii) and 4b (ii) of the Water Licence
- TDS, chloride, fluoride, ammonia, nitrate

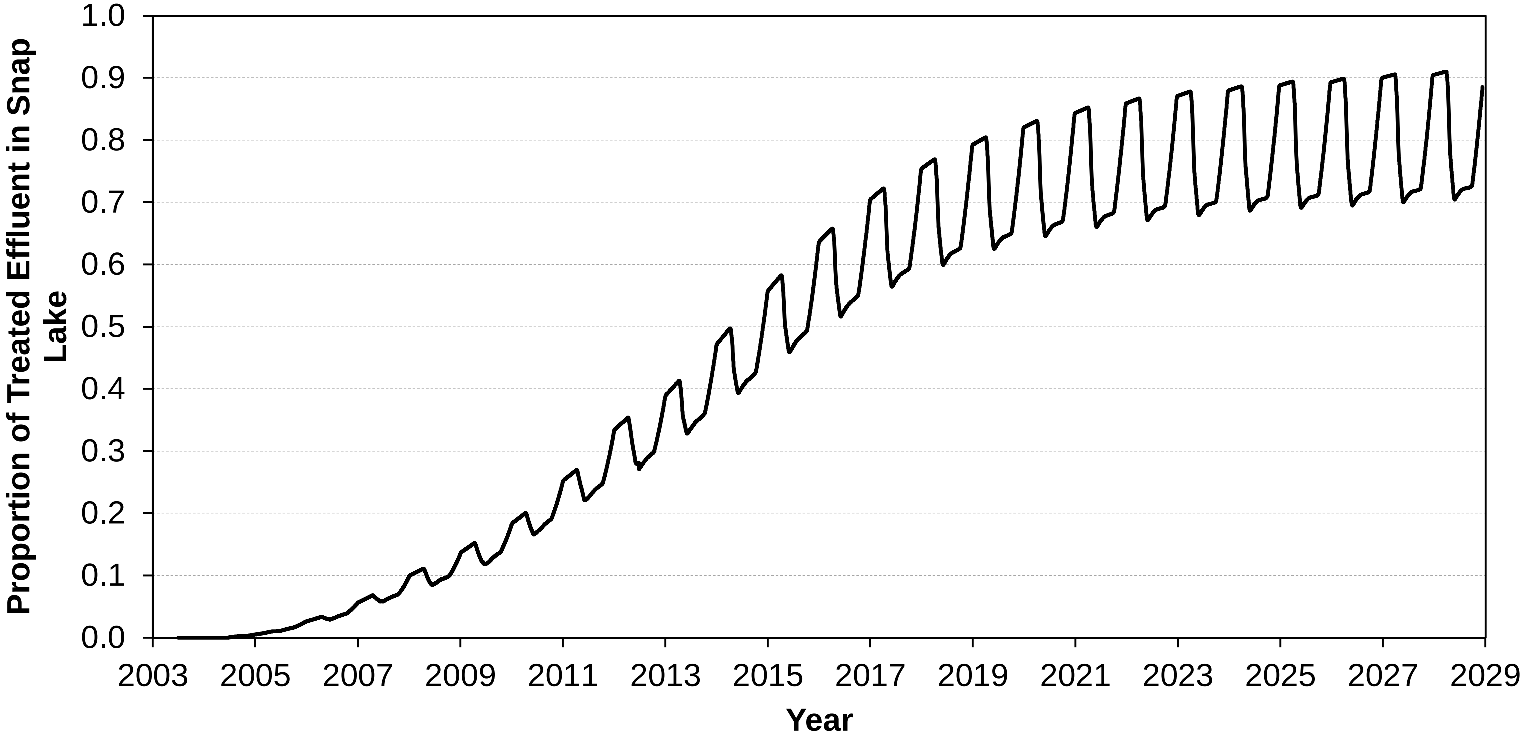
Remaining Parameters

- Nitrite, sulphate, aluminum, arsenic, chromium, copper, lead, nickel, zinc, and total phosphorus
- Assessed due to operational changes at the Mine

AEMP Benchmarks and Site-Specific Water Quality Objectives

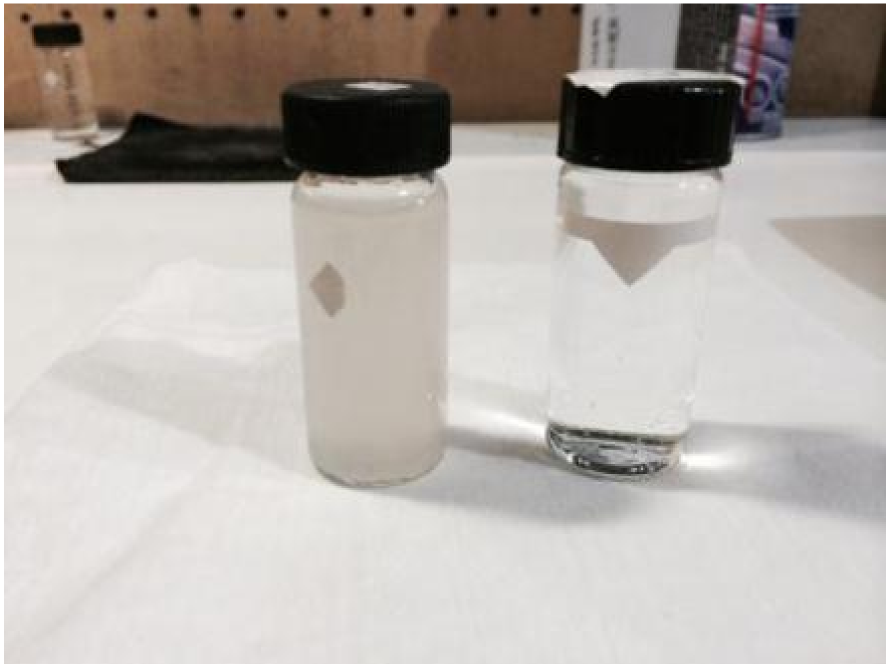
Parameter	AEMP Benchmark or SSWQO (mg/L)	Source
Total dissolved solids	684	De Beers (TDS Benchmark Study)
Chloride	388	Elphick et al. (2011); WLWB (recent Ekati Water Licence)
Fluoride	2.46	De Beers (Literature Review)
Nitrate as N	16.4	Rescan (2012); WLWB (recent Ekati WL), De Beers (Literature Review)
Ammonia as N	5.21 (chronic)	CCME (1999)
	21 (acute)	USEPA (2013)
Nitrite as N	0.06	CCME (1999)
Sulphate	429	BCMOE (2013)
Aluminum	0.1	CCME (1999)
Arsenic	0.005	CCME (1999)
Chromium (hexavalent)	0.0021	De Beers (2002)
Copper	0.0064	De Beers (2002)
Lead	0.007	CCME (1999)
Nickel	0.15	CCME (1999)
Zinc	0.03	CCME (1999)
Total phosphorus	0.011	(Wetzel 2001)

Assimilative Capacity of Snap Lake



Proposed EQC - TDS

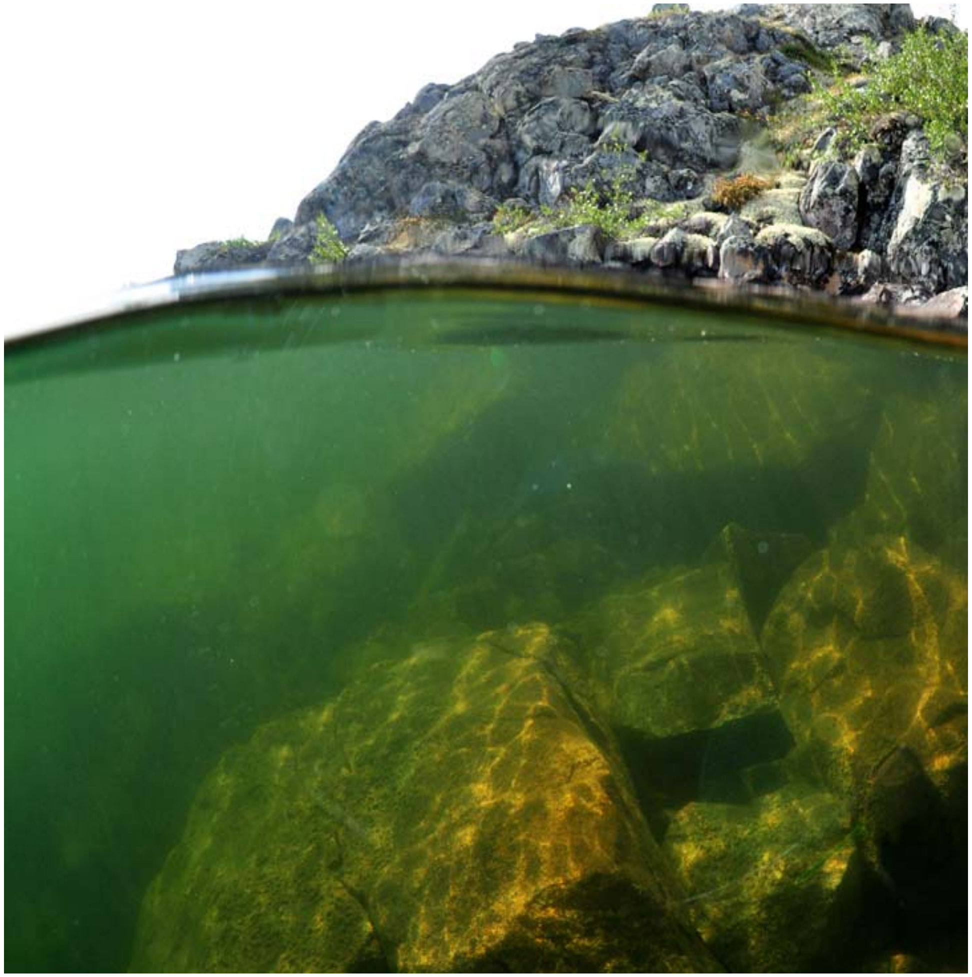
- Whole-lake average TDS limit of 350 mg/L to be removed
- A new EQC was calculated for TDS based on the SSWQO of 684 mg/L
- An EQC for TDS at the Mine affords more operational control
- AML of 684 mg/L and an MDL of 1,003 mg/L



Proposed EQC Required Parameters

AML to come into effect on January 1, 2015:

- Nitrate: from 4 to 14 mg-N/L
- Chloride: from 160 to 378 mg/L
- Fluoride: from 0.15 to 2.43 mg/L



MDL to come into effect on January 1, 2015:

- Nitrate: from 8 to 32 mg-N/L
- Chloride: from 320 to 607 mg/L
- Fluoride: from 0.30 to 3.73 mg/L

Ammonia: no change (10 and 20 mg-N/L)

Remaining Parameters

Nitrite:

- AML from 0.5 to 1 mg-N/L
- MDL from 1 to 3 mg-N/L

TSS:

- No change (AML 7 and MDL 14 mg/L)

Sulphate:

- AML from 75 to 427 mg/L
- MDL from 150 to 640 mg/L

Metals

- AML and MDL for aluminum be retained
- EQC for other metals and metalloids be eliminated (monitoring of these metals should continue to investigate on-going trends)

Total phosphorus maintained below 0.01 mg-P/L to meet the proposed annual loading limit (ALL)

Extractable petroleum hydrocarbons be eliminated

Discharge to be pH-regulated and non-acutely toxic

Proposed EQC Summary

Parameter	AEMP Benchmark or SSWQO (mg/L)	Proposed EQC (mg/L)		Annual Loading Limit (kg/yr)
		AML	MDL	
Total dissolved solids	684	684 mg/L	1,003 mg/L	-
Chloride (from January 1, 2015)	388	378 mg/L	607 mg/L	-
Fluoride (from January 1, 2015)	2.46	2.43 mg/L	3.73 mg/L	-
Nitrate as N (from January 1, 2015)	16.4	14 mg-N/L	32 mg-N/L	161,000
Ammonia as N	5.21 (chronic), 21 (acute)	10 mg-N/L	20 mg-N/L	187,000
Nitrite as N	0.06	1 mg-N/L	3 mg-N/L	-
Sulphate	429	427 mg/L	640 mg/L	-
Aluminum	0.1	0.1 mg/L	0.2 mg/L	-
Arsenic, chromium, copper, lead, nickel, zinc	0.005, 0.0021, 0.0064, 0.007, 0.15, 0.03	-	-	-
Total phosphorus	0.011	N/A	N/A	229
Total suspended solids	-	7 mg/L	14 mg/L	-

Questions/Comments?

Snap Lake Mine
Environmental Assessment Supplemental Information

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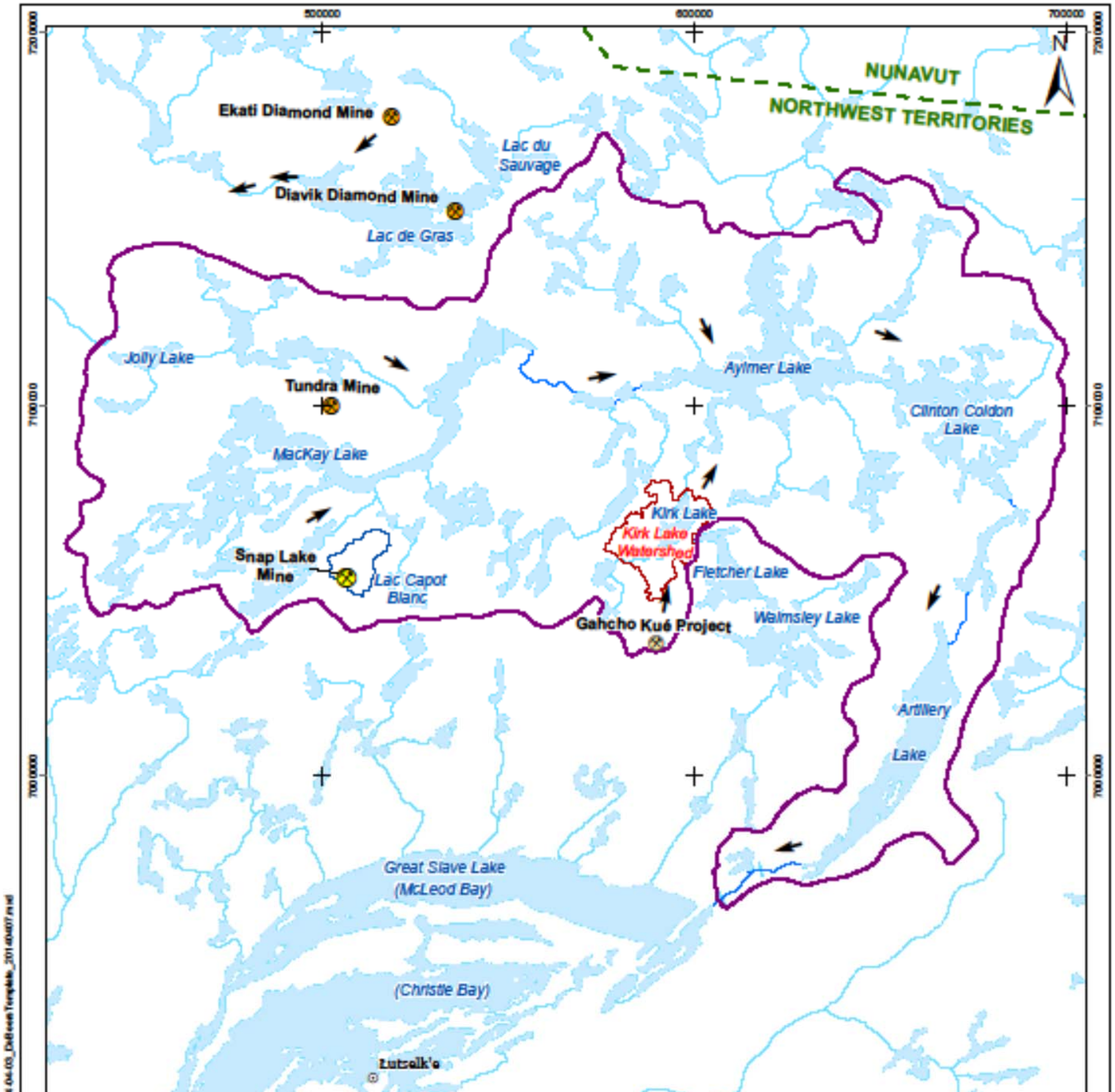
Outline

MVRB required to consider requirements of s.117 related to proposed change in TDS limit:

- Accidents and Malfunctions
- Cumulative Effects
- Alternatives to Development

TH6

Regional Study Area for Assessment



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Slide 3

TH6 Will be updated in De Beers title block

Tasha Hall, 4/6/2014

Accident and Malfunctions – Key Question

Key Question

- What impacts will a potential accident or malfunction related to discharge of treated minewater containing elevated levels of TDS at the Snap Lake Mine have on the environment, specifically Snap Lake?

- Not an assessment of the risk of an accident/malfunction occurring on site
- Assume an accident or malfunction creates a temporary ‘upset’ and TDS is released, above license limits

Accident and Malfunction – Steps in the Assessment

- Step 1 - Devise Accident or Malfunction Cases
- Step 2 – Determine ‘Environmental Consequence’ Criteria
- Step 3 - Model the lake water quality in each case
- Step 4 - Assess the Environmental Consequence of the release

Accidents or Malfunctions – Step 1 – Devise Cases

- Eight Cases were devised and compared to the Base Case

- Two "**Base Case**" scenarios (no accident or malfunction occurs)
  - Assumes TDS concentrations in treated effluent will be ≤ 684 mg/L
  - Upper Bound, Lower Bound Flows
  - For Comparison (from GEMSS model)

- Four **Near-Term** Accident/Malfunction Cases
  - Occurs in 2017 (selected as relatively near-term, when TDS concentrations in lake not approaching the site-specific water quality objective [SSWQO])
  - Release of either 1,000 or 2,000 mg/L for 7 days
  - Upper Bound, Lower Bound Flows

- Four **Late-Operations** Accident/Malfunction Cases
  - Same as above, only occurs in 2025 (TDS concentrations in lake approaching SSWQO)

Accident or Malfunction – Step 1 – Devise Cases

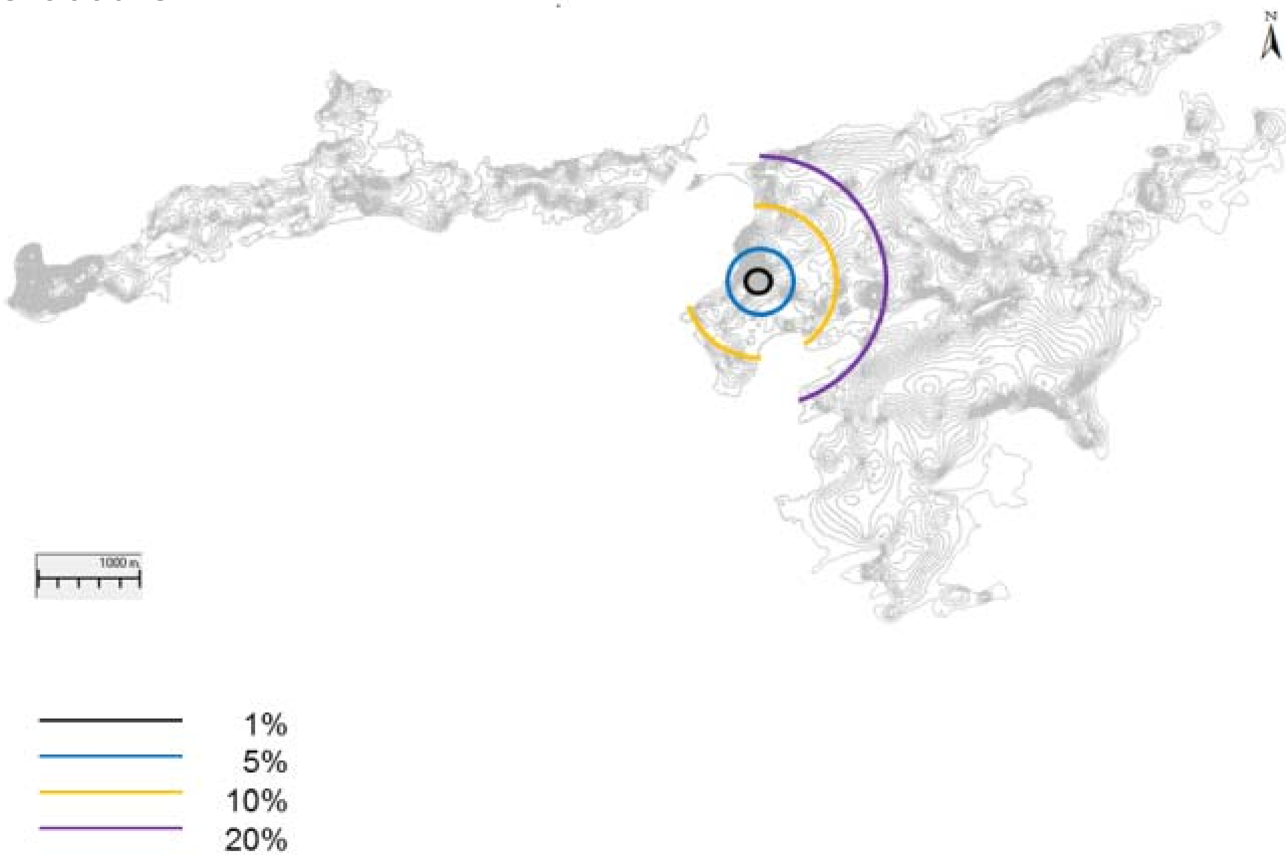
Timeline	Effluent Discharge TDS Concentration during Malfunction (mg/L)	Name	Effluent Discharge Rate
2017	1,000	Malfunction Case 1A	Lower Bound
		Malfunction Case 1B	Upper Bound
	2,000	Malfunction Case 2A	Lower Bound
		Malfunction Case 2B	Upper Bound
2025	1,000	Malfunction Case 1A	Lower Bound
		Malfunction Case 1B	Upper Bound
	2,000	Malfunction Case 2A	Lower Bound
		Malfunction Case 2B	Upper Bound

Assumes:

- In 2015, the effluent average monthly limit is 684 mg/L
- Accident occurs under ice in mid-March for a maximum of 7 days.

Accidents and Malfunctions - Step 2- Env. Consequence

- Original assessment done on the percentage of the volume of the lake where 'toxic effect' occurs



Accidents or Malfunctions – Step 2 – Env. Consequence

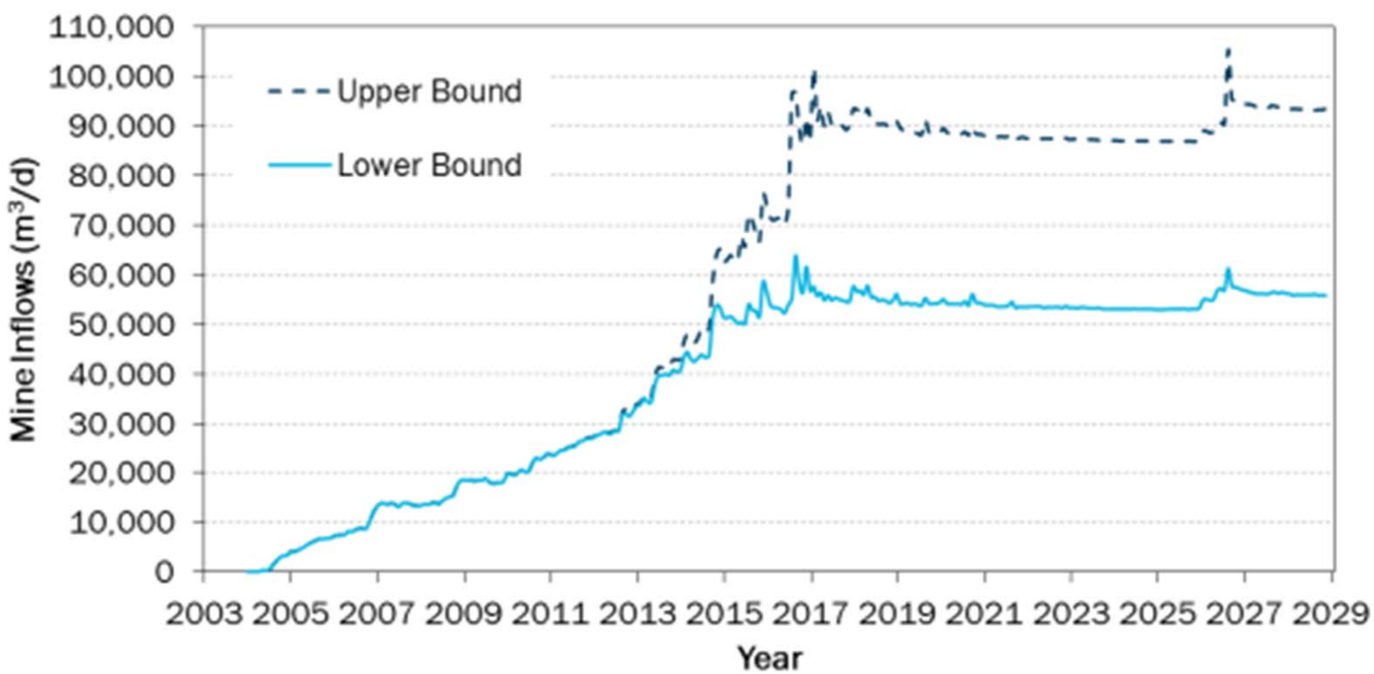
Based on 2002 EA Criteria, updated with TDS Benchmark Study

Environmental Consequence Rating (Level)	Portion of Community Affected	Magnitude (Based on Toxicity to Aquatic Life)	Spatial Extent	Duration (Duration of Toxic Effects)	Reversibility
Negligible	not relevant	no toxicity	not relevant	not relevant	reversible
	sensitive zooplankton (cladocerans)	sublethal	not relevant	<3 days	reversible
	other species	sublethal	<0.04% of total lake volume[1]	<1 day	reversible
	sensitive zooplankton (cladocerans)	sublethal	<10% of total lake volume	>3 days	reversible
Low	sensitive zooplankton (cladocerans)	sublethal	<20% of total lake volume	>3 days	reversible
	sensitive zooplankton (cladocerans)	sublethal	<10% of total lake volume	1 year	reversible
	other species	sublethal	<10% of total lake volume	>3 days	reversible
Moderate	sensitive zooplankton (cladocerans)	sublethal	<20% of total lake volume	1 year	reversible
	sensitive zooplankton (cladocerans)	sublethal	>50% of total lake volume	>3 days	reversible
	other species	sublethal	<20% of total lake volume	>3 days	reversible
	other species	sublethal	<10% of total lake volume	1 year	reversible
High	other species	sublethal	>50% of total lake volume	1 year	reversible
	other species	sublethal	>20% of total lake volume	1 year	irreversible

Note: sublethal to sensitive zooplankton = >684 mg/L; sublethal to other plankton or fish = 1,000 mg/L; lethal to other plankton or fish >1,000 mg/L.

Accidents or Malfunctions – Step 3 – Predict WQ

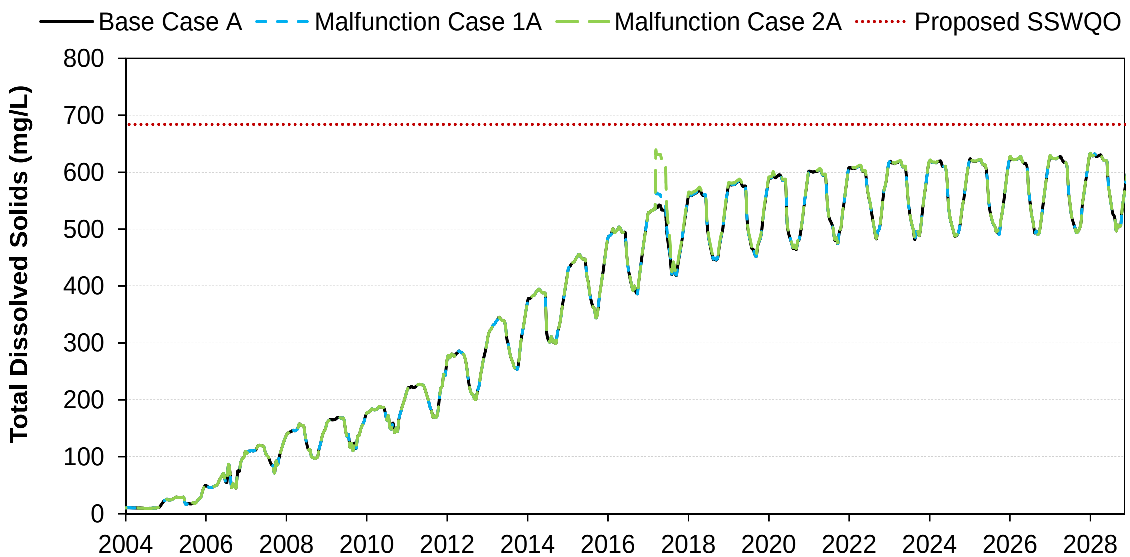
- Used a Water Quality Model to predict the in-lake water quality for each accident and malfunction case
- Modelled maximum TDS concentration for 7 day ‘upset’

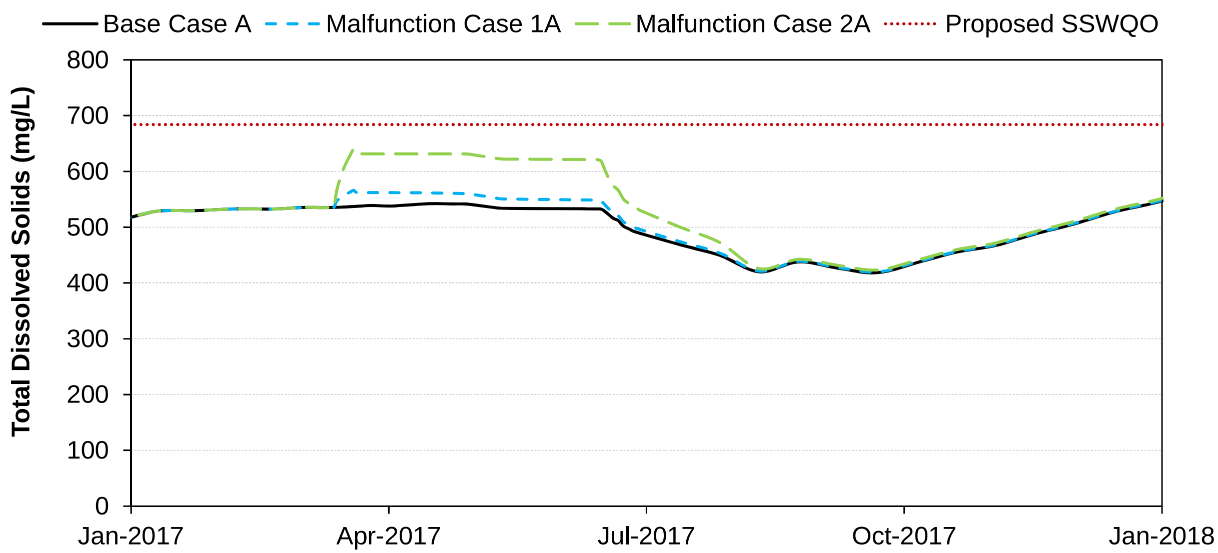


Accident/Malfunction - Low Flow Case - 2017

- No exceedance of SSWQO at 1000 mg/L or 2000 mg/L release

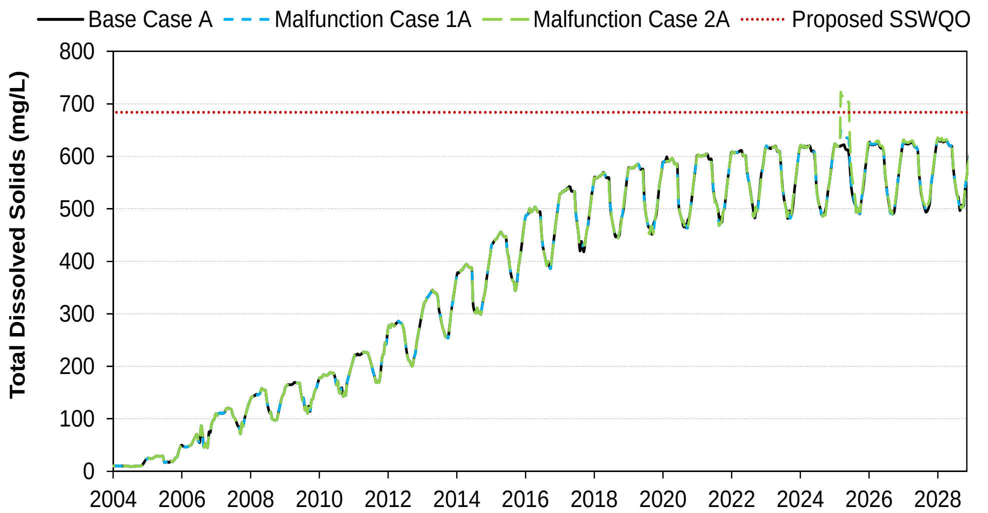
- Negligible Environmental Consequence (small volume of lake for short time below SSWQO)

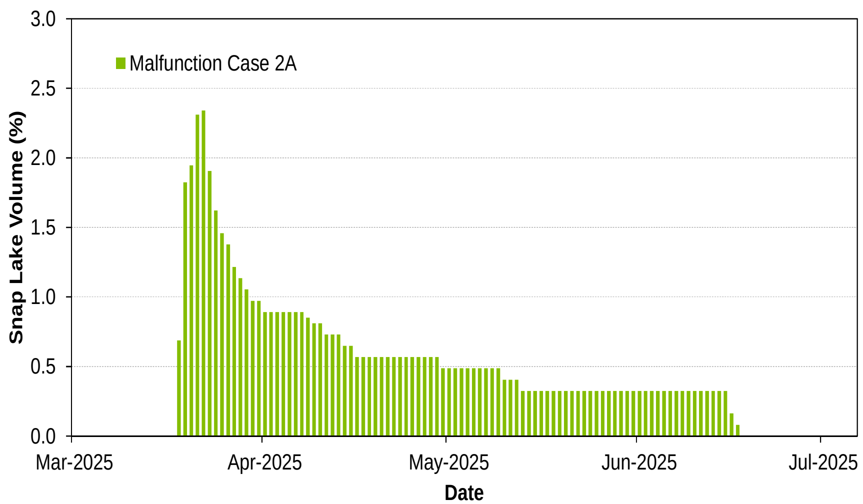


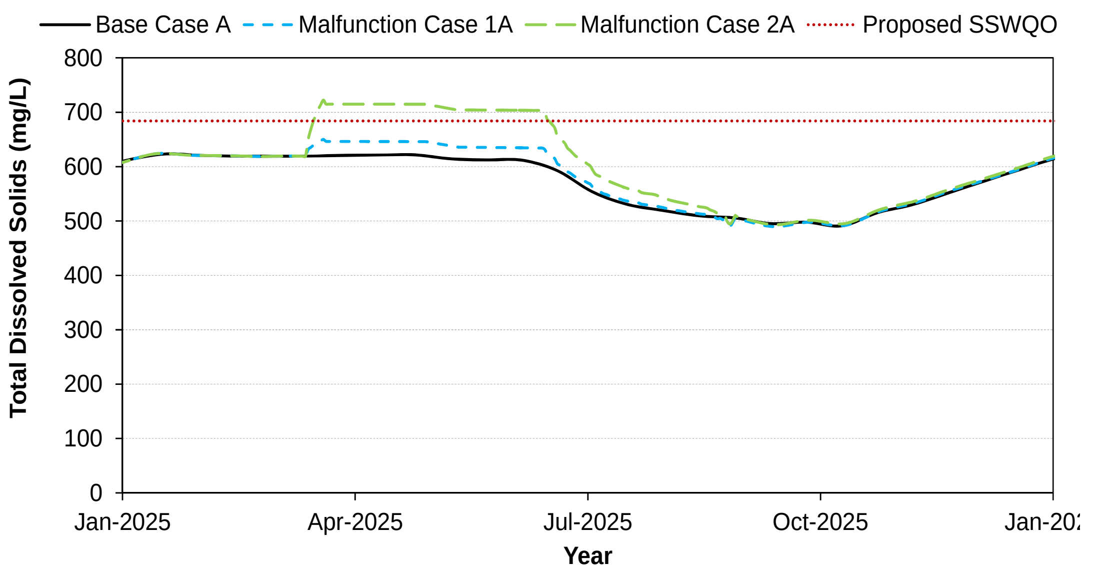


Accident/Malfunction - Low Flow Case - 2025

- Slight exceedance of SSWO at 2000 mg/L at low flow in 2025
- 2% of the lake
- Negligible Environmental Consequence

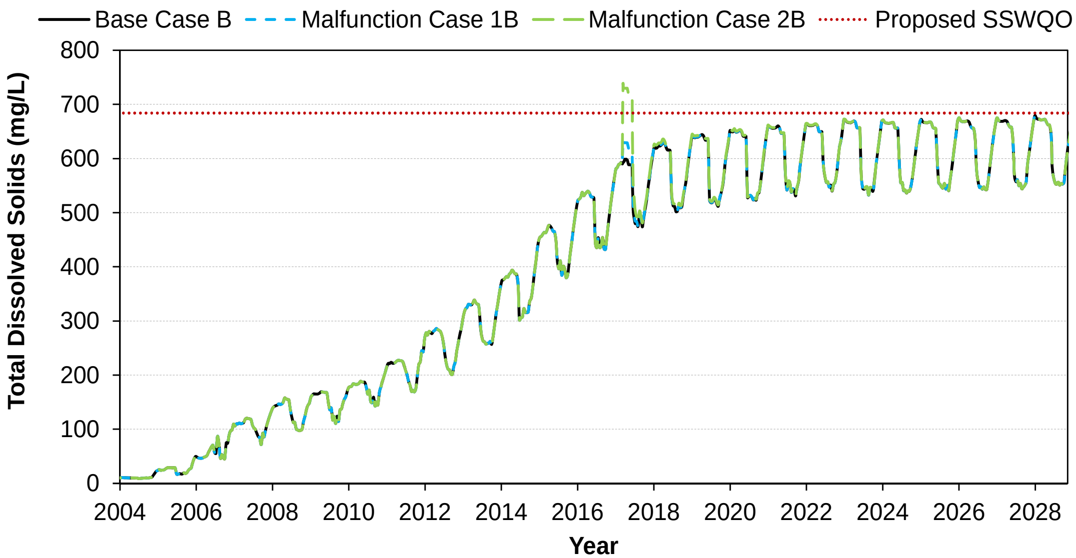


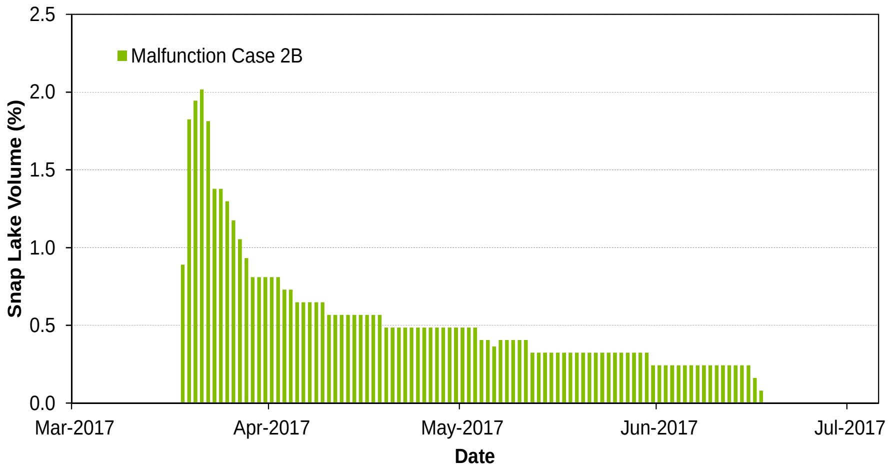


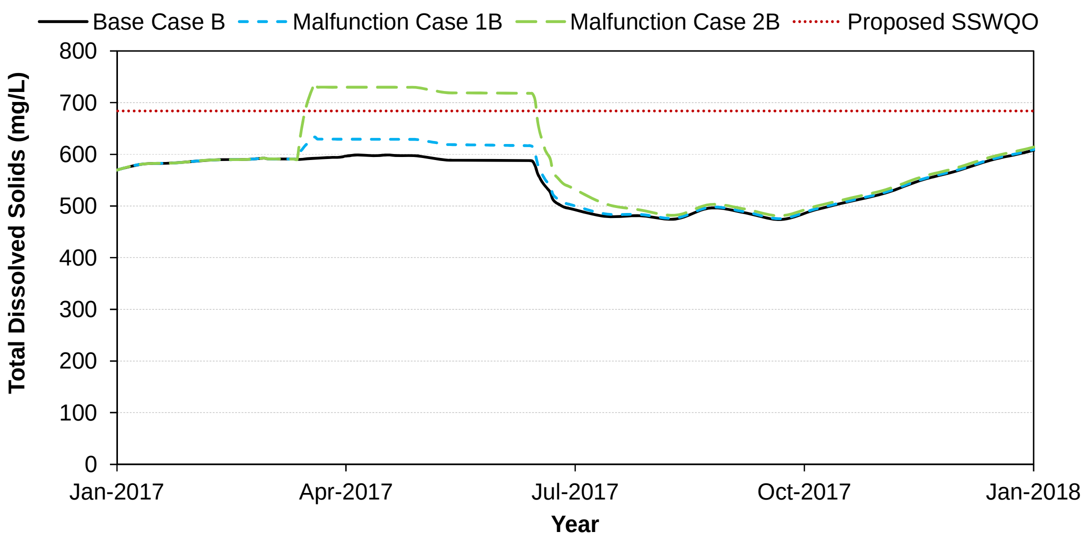


Accident/Malfunction - Upper Flow Case - 2017

- Slight exceedance of SSWO at 2000 mg/L at upper bound flow in 2017
- 2% of the lake
- Negligible Environmental Consequence



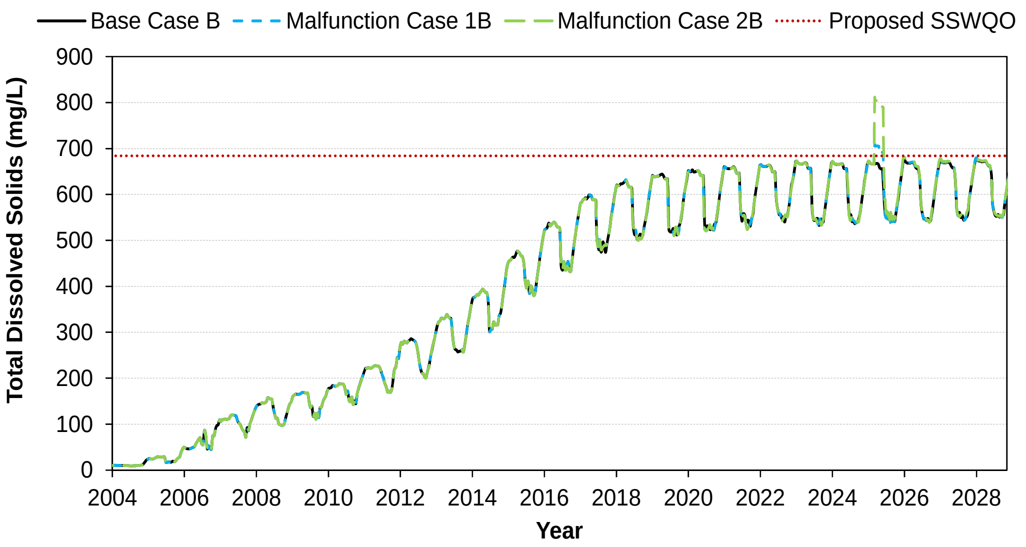


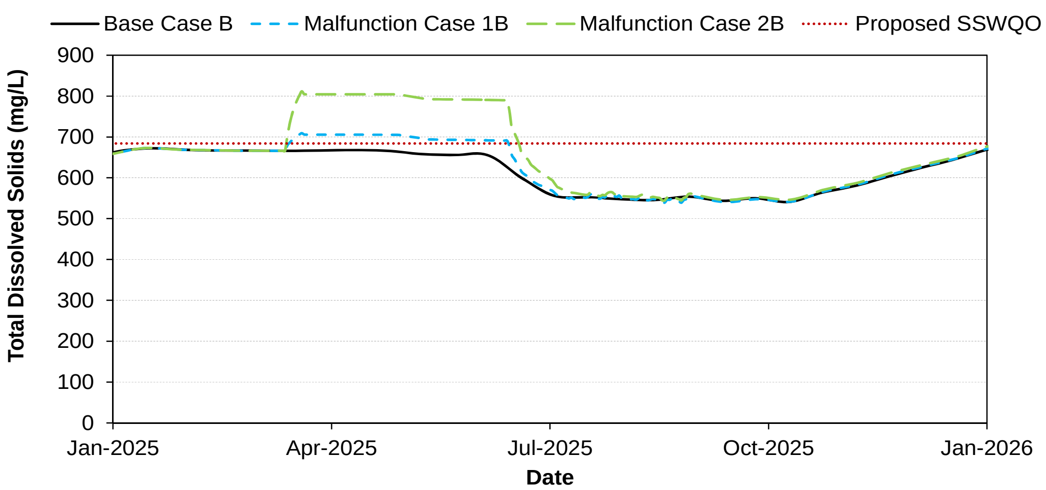


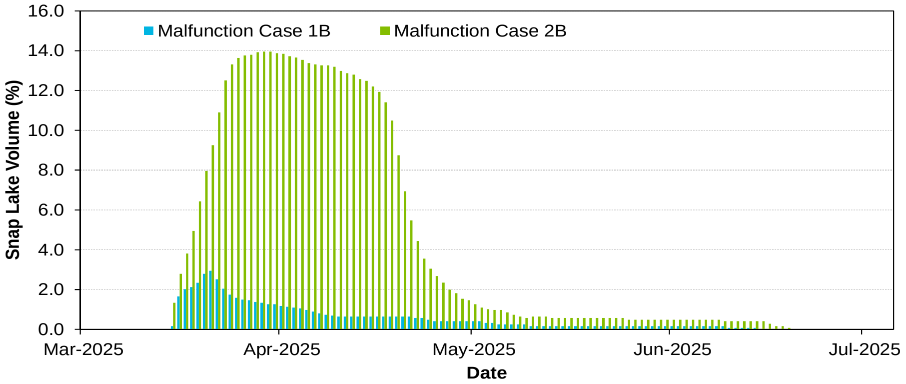
Accident/Malfunction - Upper Flow Case - 2025

- Slight exceedance of SSWO at 1000 mg/L at upper bound flow in 2025
- 2% of the lake
- Negligible Environmental Consequence

- Exceedance of SSWO at 2000 mg/L at upper bound flow in 2025
- 14% of the lake
- Low Environmental Consequence







Environmental Consequence – Accidents or Malfunctions

Timeline	TDS Concentration during Malfunction (mg/L)	Effluent Discharge Rate	Exceedance of the SSWQO in Snap Lake?	Volume of Lake Affected by Exceedance	Predicted Environmental Consequence
2017	1,000	Lower Bound	No	None	Negligible
		Upper Bound	No	None	Negligible
	2,000	Lower Bound	No	None	Negligible
		Upper Bound	Yes	<2% of lake	Negligible
2025	1,000	Lower Bound	No	None	Negligible
		Upper Bound	Yes	<2% of lake	Negligible
	2,000	Lower Bound	Yes	2% of lake	Negligible
		Upper Bound	Yes	14% of lake	Low

Accidents or Malfunctions - Conclusion

What impacts will a potential accident or malfunction related to discharge of treated minewater containing elevated levels of TDS at the Snap Lake Project site have on the receiving environment, specifically Snap Lake?

On the basis of the cases assessed, the effects are:

- Negligible to Low
- Restricted to sensitive species of zooplankton (cladocerans) and not to the larger aquatic community
- Restricted to a small volume of the lake
- Reversible

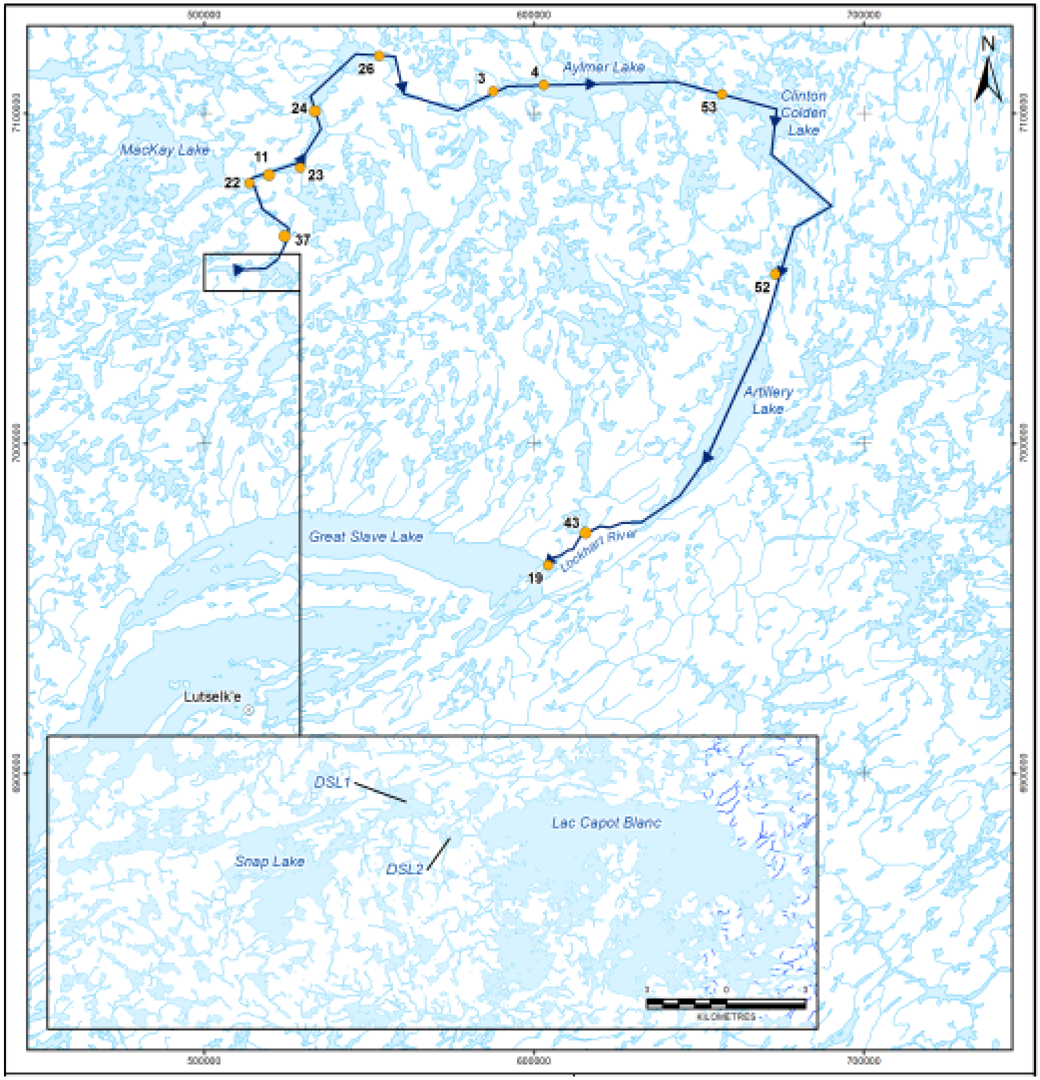
Cumulative Effects

- What potential cumulative effects will the discharge of treated effluent with TDS concentrations equal to the SSWQO of 684 mg/L (i.e., the proposed average monthly limit) from the Snap Lake Mine have on water quality in the Lockhart River Watershed?

Lac Capot Blanc, July 2013

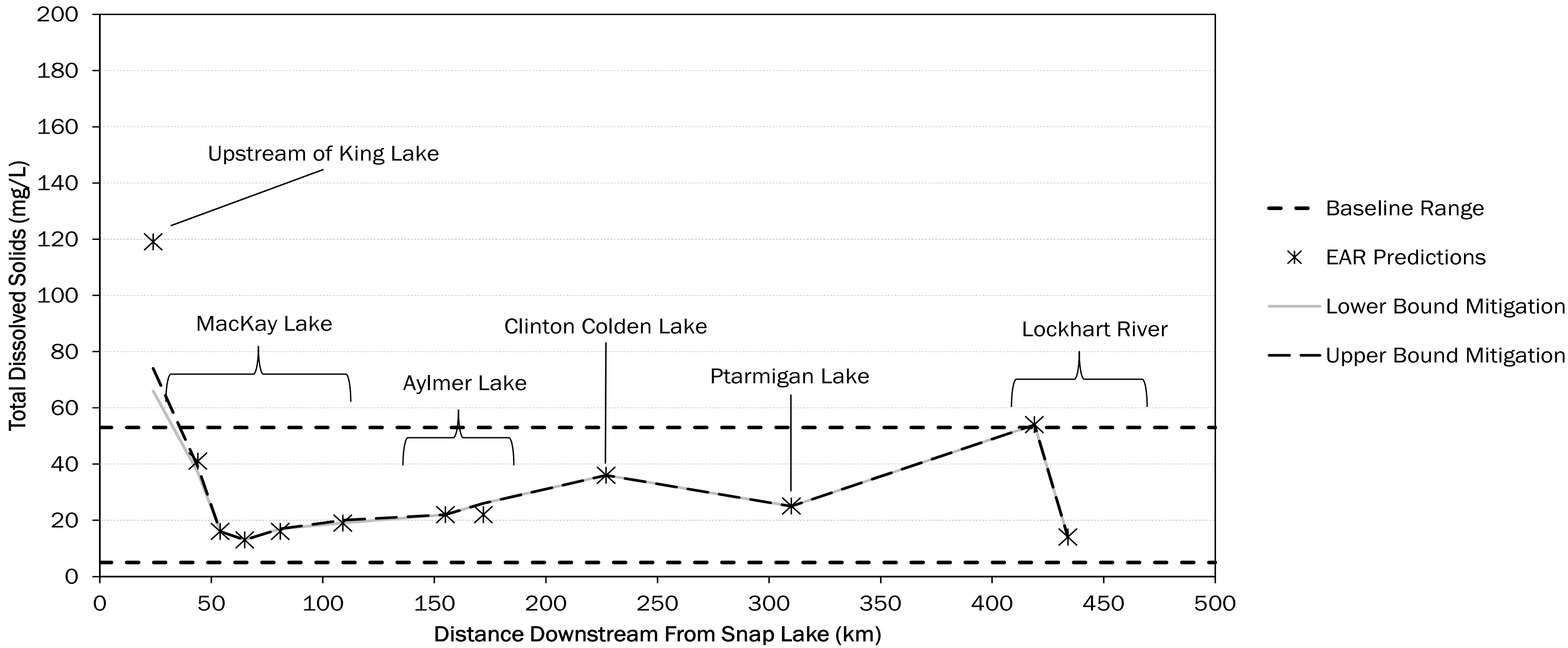
Cumulative Effects – Steps in the Review

- Step 1 – Model extent of the plume downstream in the Lockhart River watershed
- Step 2 - Review developments within the Lockhart River Watershed
- Step 3 – Review areas of overlap to assess effects



Cumulative Effects – Step 1 – Downstream Water Quality

Maximum Predicted TDS Concentrations in Lakes Downstream of Lac Capot Blanc



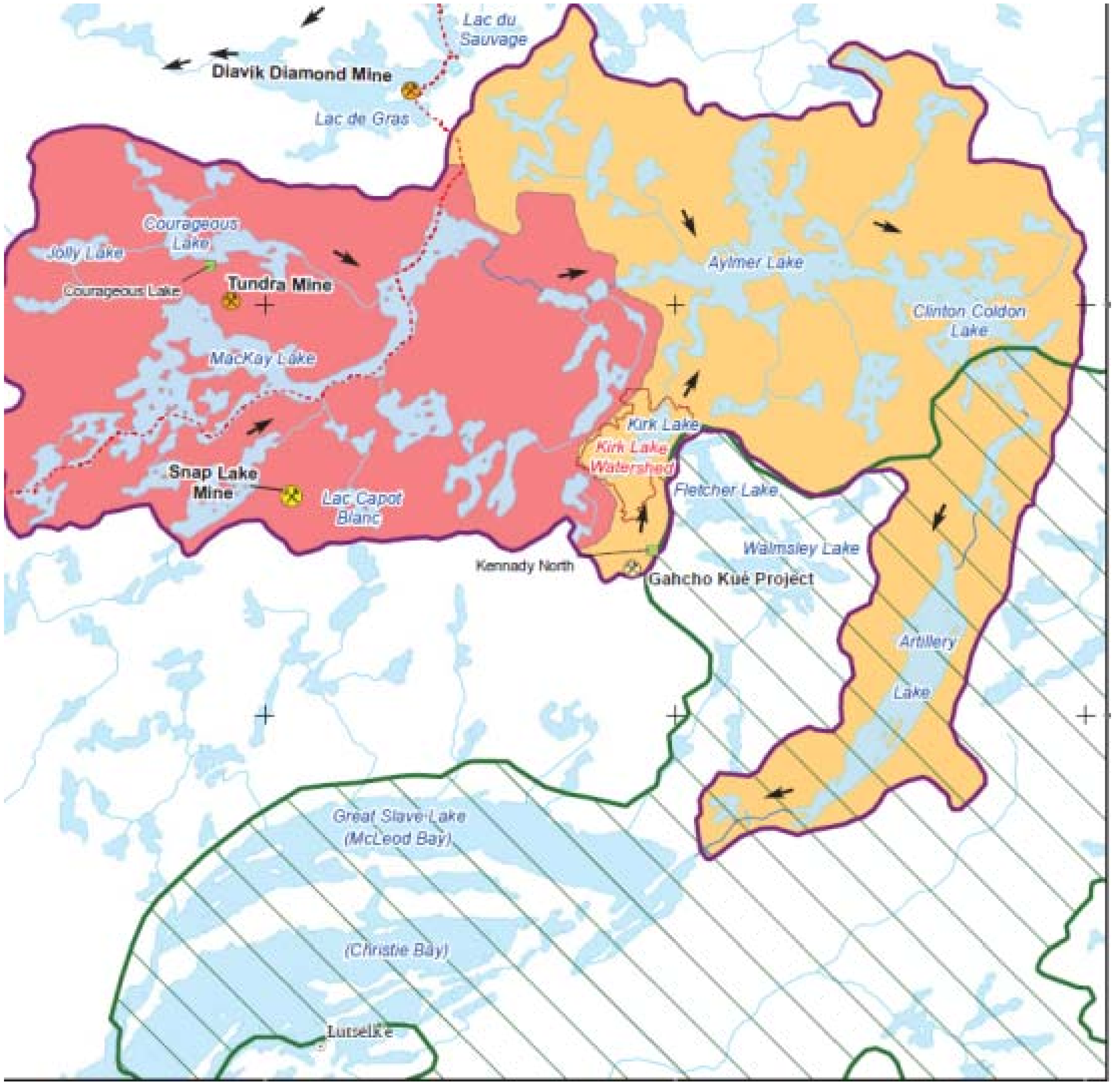
Note: Assumes Proposed EQC is met

Cumulative Effects – Step 2 - Developments in the Watershed

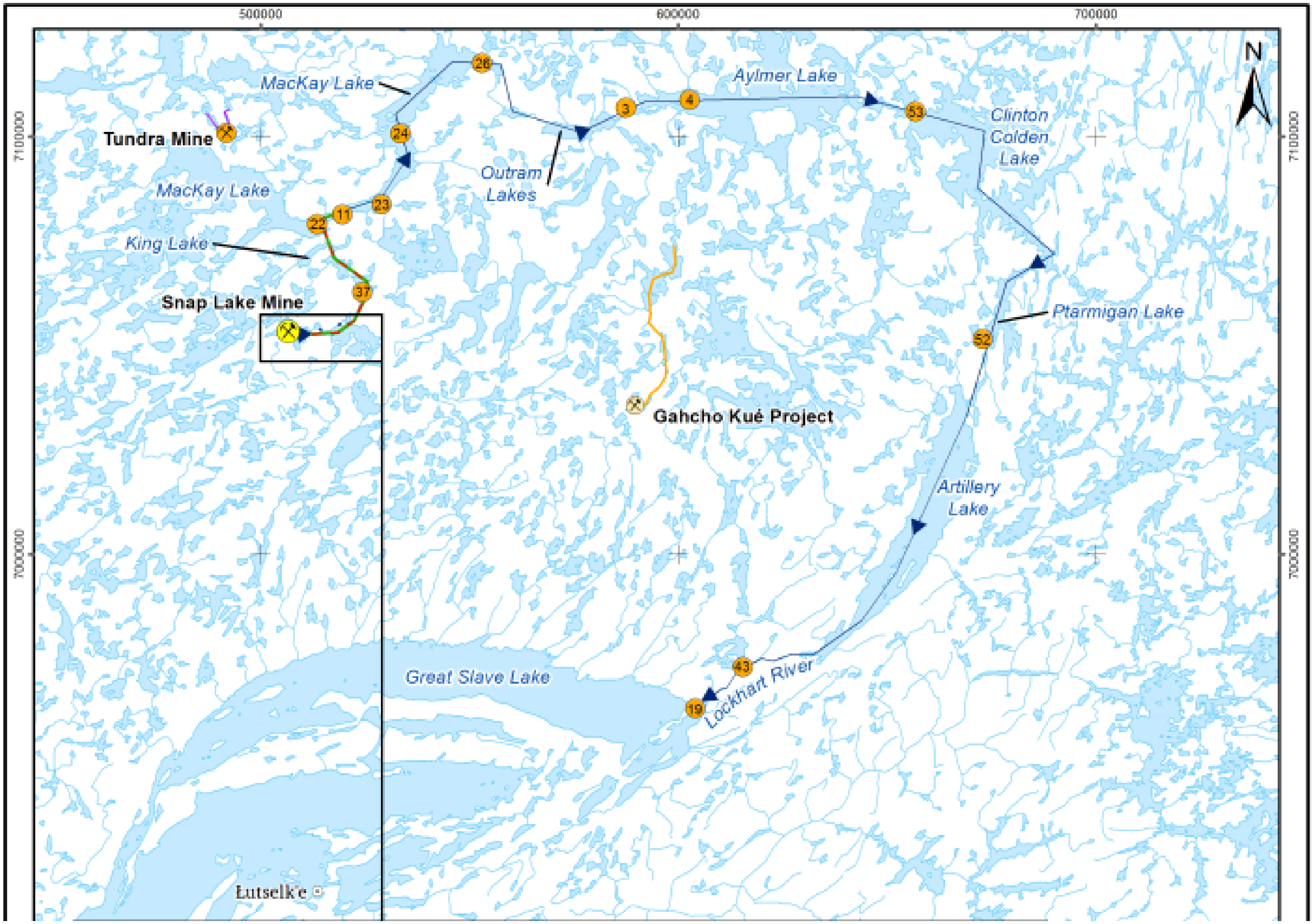
- Includes past, present, forseeable future activities

  o De Beers Gahcho Kué Project
  o Tundra Mine
  o Tibbitt-Contwoyto Winter Road
  o Potential East Arm National Park (Thaydene Nene) area of interest

- Excludes:
  o Activities not permitted for discharge to the watershed
  o Activities with no current project Plans (Talston Hydro)



Cumulative Effects – Step 3 – Areas of Overlap



Cumulative Effects

Conclusion

No linkage between developments to perform a cumulative effects assessment


Downstream Lake 2 – outlet stream, July 2013


Lac Capot Blanc – August 2013

Alternatives

- De Beers evaluated two potential alternatives to the development proposal, namely alternatives to discharging mine effluent at concentrations not exceeding AML of 684 mg/L mg/L TDS; 14 mg/L nitrate; 378 mg/L chloride; 2.43 mg/L fluoride; 1 mg/L nitrite and 427 mg/L sulphate
- Alternative 1: Effluent Quality Criteria Unchanged
- Alternative 2: Reduction of Footwall Development
- Alternative 3: Reducing Water Flows

Alternatives - Option 1

Alternative 1: Effluent Quality Criteria Unchanged

- licence limits effective January 1 2015 for TDS, chloride and nitrate not realistically achievable with current mine practices
- De Beers has conducted pre-feasibility of treatment technologies

  (see TDS Response Plan for details)
- Cost to implement treatment of the whole effluent to achieve current licence limits using available technology very high ($188 million)

Conclusion – Alternative not viable

Alternatives - Option 2

Alternative 2 - Reduction of Footwall Development

- The greatest contributor to TDS loadings to Snap Lake is mine effluent from connate water during the advancement of the footwall (mining)
- The increases in TDS in mine effluent directly related to continued mining as proposed in the mine plan
- Slowing advancement of the footwall as part of mining would decrease rate of TDS loading to the environment
- Footwall development is essential to current methods for mining the ore deposit
- Reduction in footwall development is not achievable to support the current mine plan and results in the mine becoming not economically viable in the long term

Conclusion – Alternative not viable

Alternatives – Option 3

Alternative 3: Reducing Water Flows

- Discussed in the TDS Response Plan
  - Grouting in high flow areas is only partially effective
  - Full grouting not feasible