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Snap Lake Diamond Project
Technical Sessions

Aquatic Habitat and Aquatic Organisms

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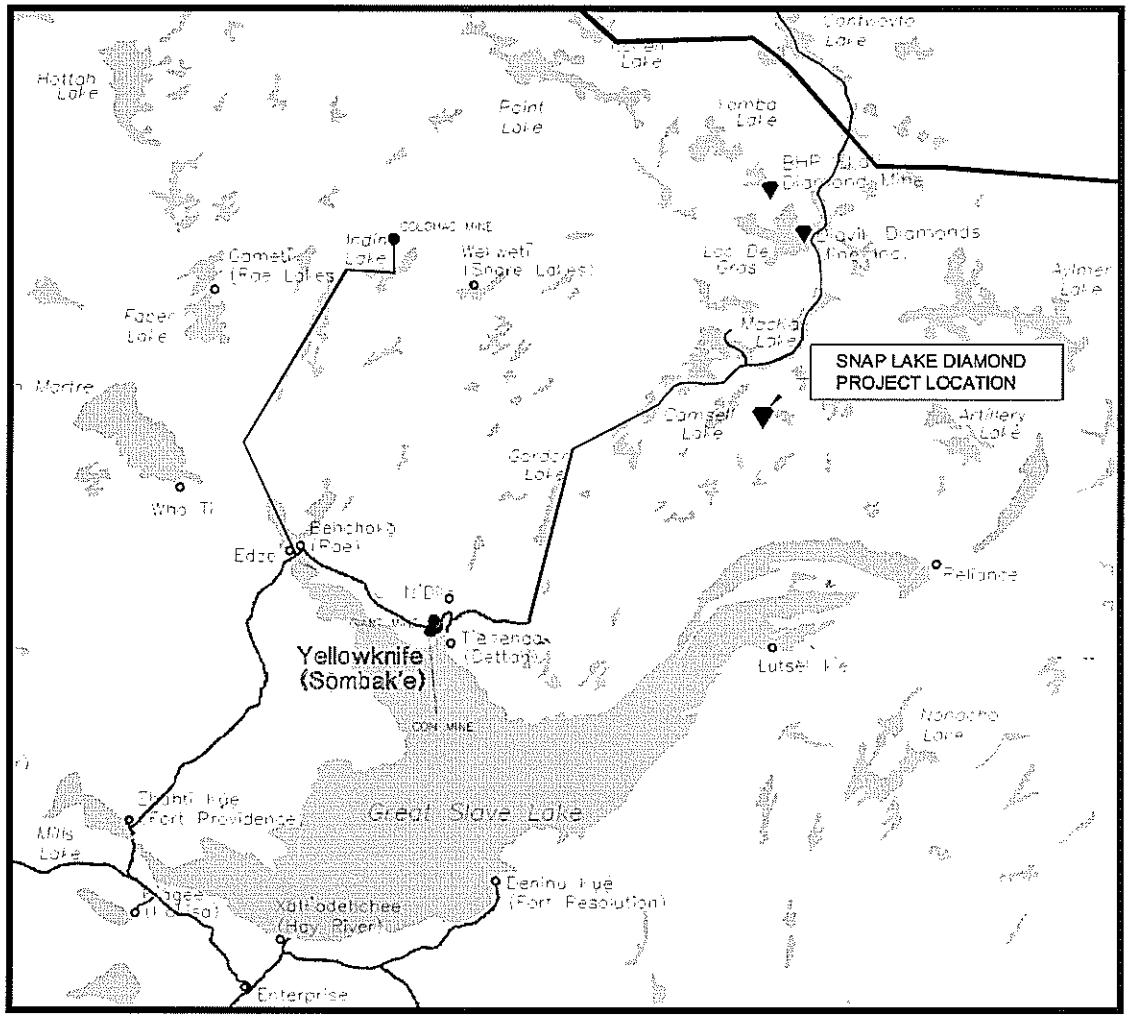
Project Location



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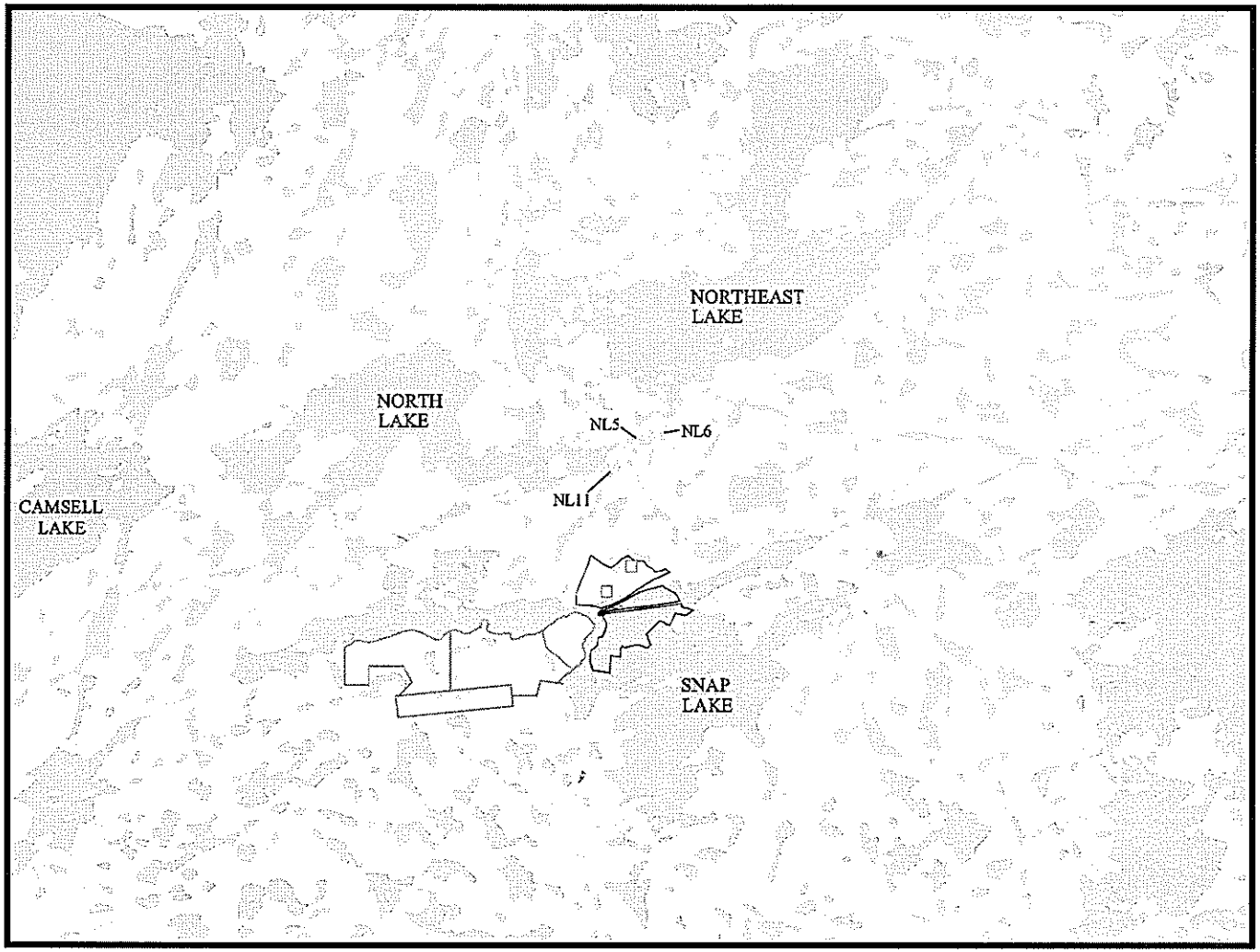
Location of North Lake, Northeast Lake and Snap Lake



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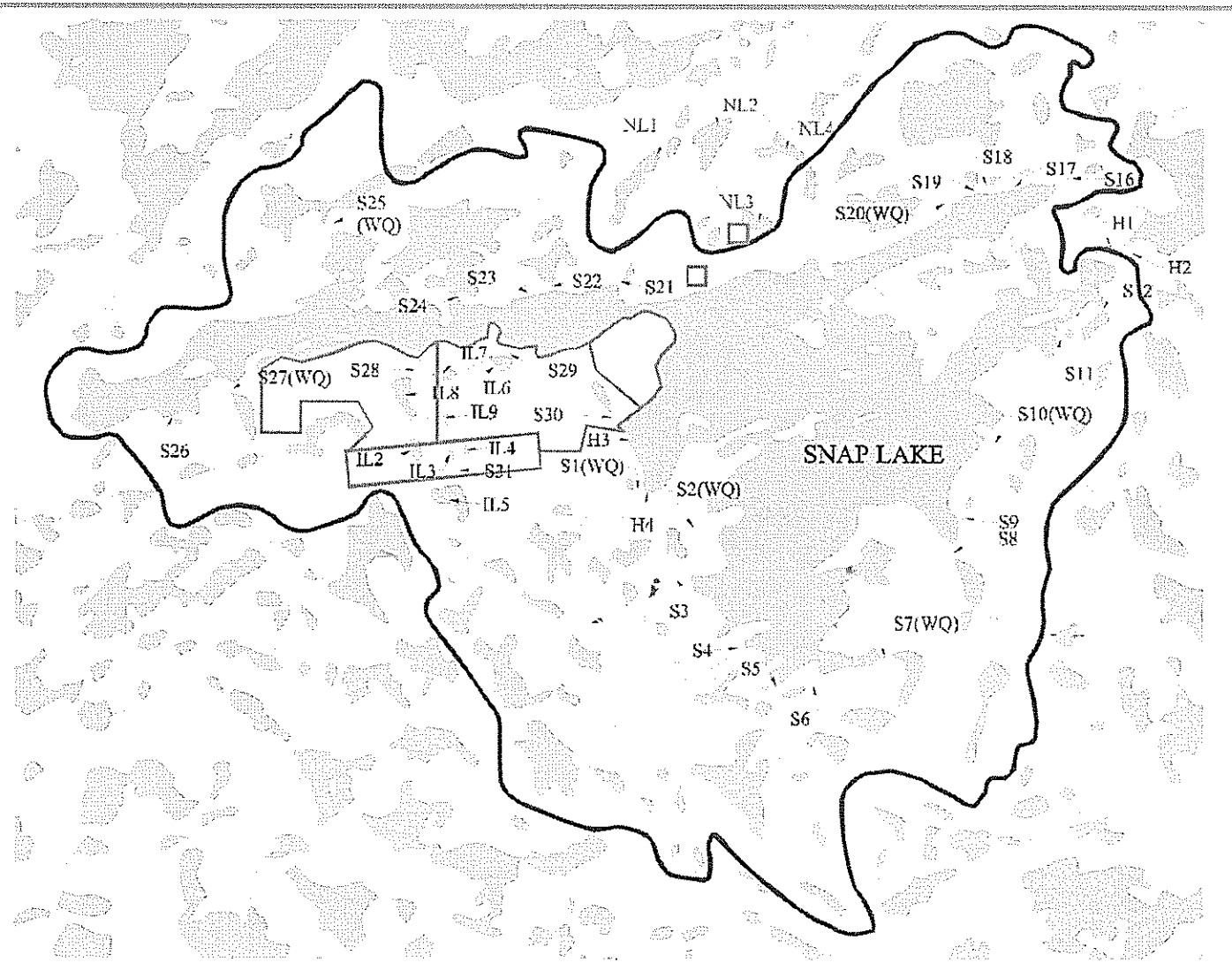
Snap Lake Watershed



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Aquatic Habitat and Aquatic Organisms Session

Morning

- Aquatic Organisms and Habitat Evaluation
- Bioaccumulation
- TDS/Chloride Effects on Aquatic Organisms

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Aquatic Habitat and Aquatic Organisms Session

Afternoon

- Snap Lake Levels
- Phytoplankton Community Shifts
- Dissolved Oxygen Levels
- Small Lake Habitat

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Dissolved Oxygen in Snap Lake

- Purpose:
  - to determine whether a reduction of dissolved oxygen of 1-2 mg/L could impact fish and fish habitat

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Topic Has Been Addressed

- Environmental Assessment Report
  - Section 9.4.2.2.4
- Responses to Information Requests
  - IR 2.1.6
  - IR 3.4.6

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Dissolved Oxygen Concentrations – Snap Lake

- Dissolved oxygen (DO) levels in Snap Lake in winter remain high near surface and decline with depth
- A gradual decline in DO levels in lakes over the winter period is common

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Dissolved Oxygen - Predicted

- Worst case prediction for DO in Snap Lake is a decrease to 3 mg/L
- CCME guideline is 5.5 mg/L
- This would occur in the deepest holes
- Effect would be limited to late winter
- Overall impact to aquatic community would be low since exposure to reduced DO would occur over a limited area and over a limited time

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Small Lake Habitat Criteria

- Purpose:
  - to clarify the criteria used to evaluate fish habitat potential in small lakes and streams within or near the project footprint

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Topic Has Been Addressed:

- Environmental Assessment Report
  - Section 9.5.2.1
  - Appendix IX.9
  - Appendix IX.12
- Responses to Information Requests
  - IRs 2.1.1, 3.10.12, 3.10.14, 3.10.16, 4.11.12, 4.11.14

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Small Lake Habitat Criteria

- Impact Assessment Process:
  - **Step 1:** Establish habitat criteria for small lakes and streams
  - **Step 2:** Determine which lakes have the potential to be directly or indirectly affected by the project
  - **Step 3:** Assess the habitat of the lakes chosen
  - **Step 4:** Compare habitat features of lakes with habitat criteria

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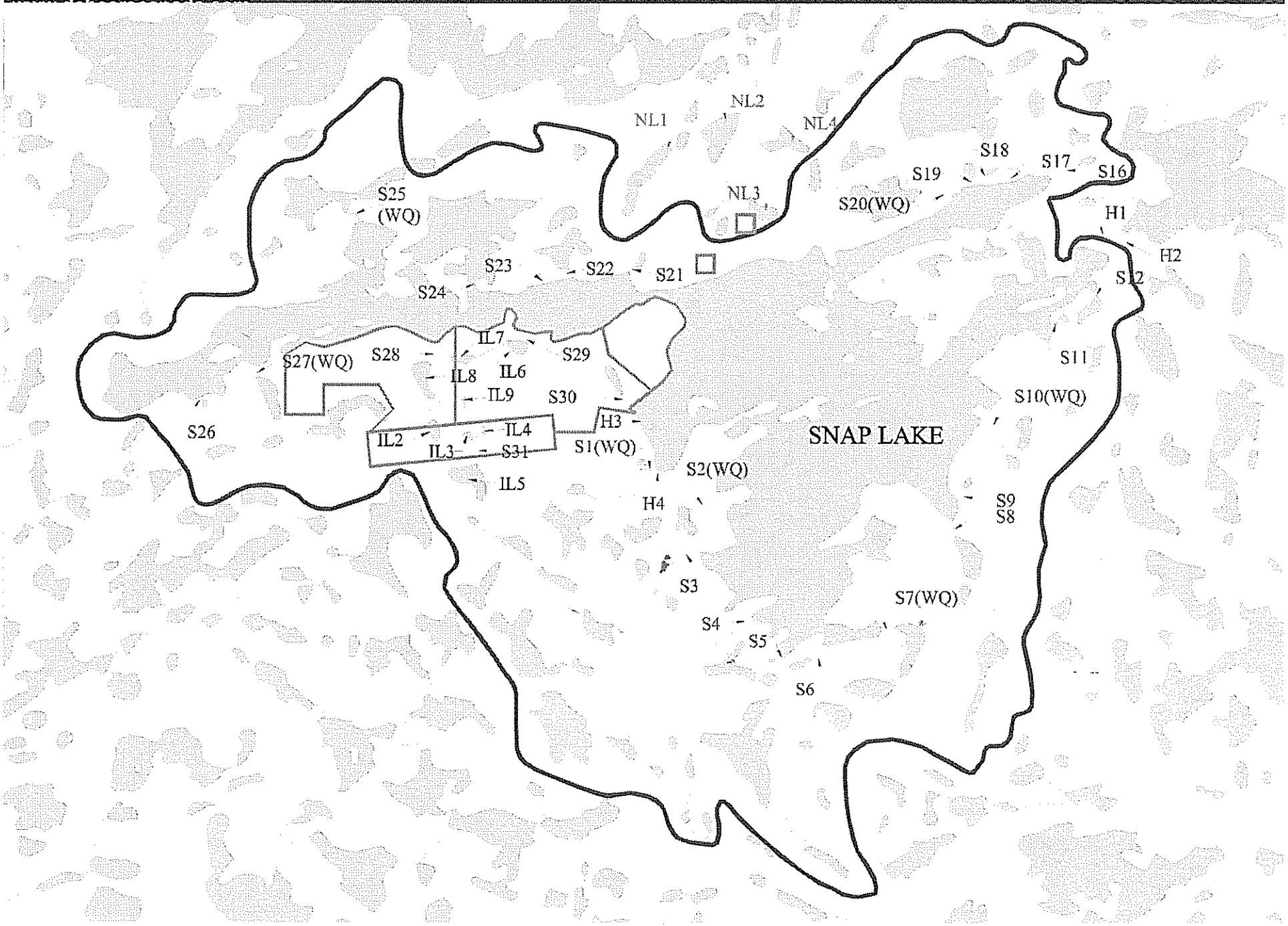
Small Lake Habitat Criteria

- Potentially affected water bodies included water bodies:
  - Directly affected by infrastructure (sedimentation ponds, water management pond)
  - Located within a sub-basin with infrastructure resulting in run-off alteration
  - In close proximity to mine activity


NL1
NL2
NL4
NL3
S18
S19
S17
S16
S25
(WQ)
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H1
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S24
S12
IL7
S28
S29
S27(WQ)
IL8
IL6
S11
IL9
S30
S10(WQ)
S26
H3
IL2
IL4
SNAP LAKE
IL3
S31
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S5
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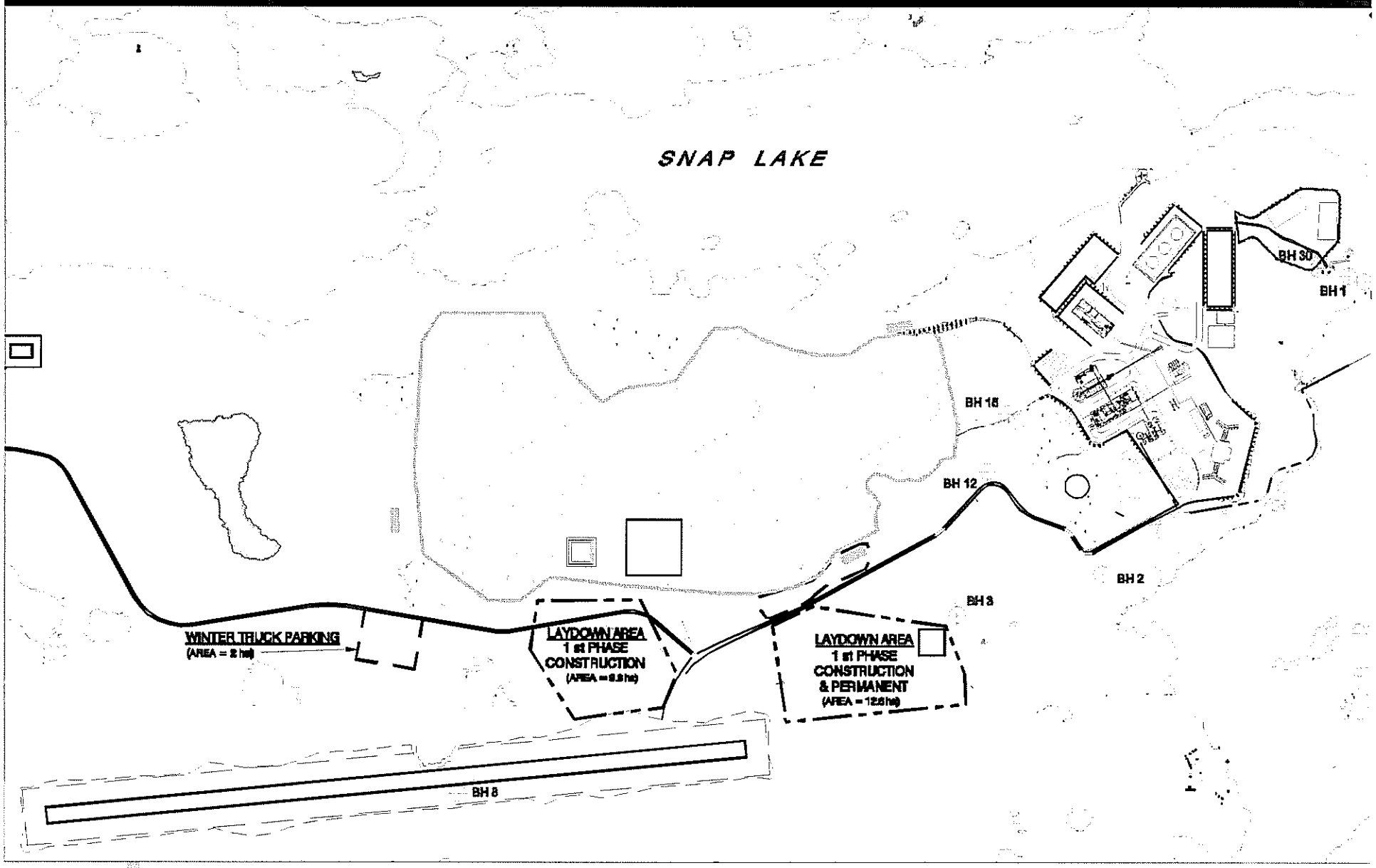
SNAP LAKE
BH 30
BH 1
BH 15
BH 12
BH 2
BH 3
WINTER TRUCK PARKING
(AREA = 2 ha)
LAYDOWN AREA
1 st PHASE
CONSTRUCTION
(AREA = 6.3 ha)
LAYDOWN AREA
1 st PHASE
CONSTRUCTION
& PERMANENT
(AREA = 12.6 ha)
BH 8

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Small Lake Habitat Criteria

- Water body depth
  - <2 m – no overwintering potential
  - 2 to 3 m – marginal overwintering potential
  - > 4 m – overwintering available
- Connectivity to other water bodies
  - Is there a passable channel?
  - How persistent is the channel?
- Observation or capture of fish

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Small Stream Habitat Criteria

- Physical characteristics of the flow path
  - Is there a channel?
  - Observations of depth, width, and obstructions
- Sub-basin size
  - What is the expected flow pattern for a stream in this basin (seasonal flow duration and volume of flow)?

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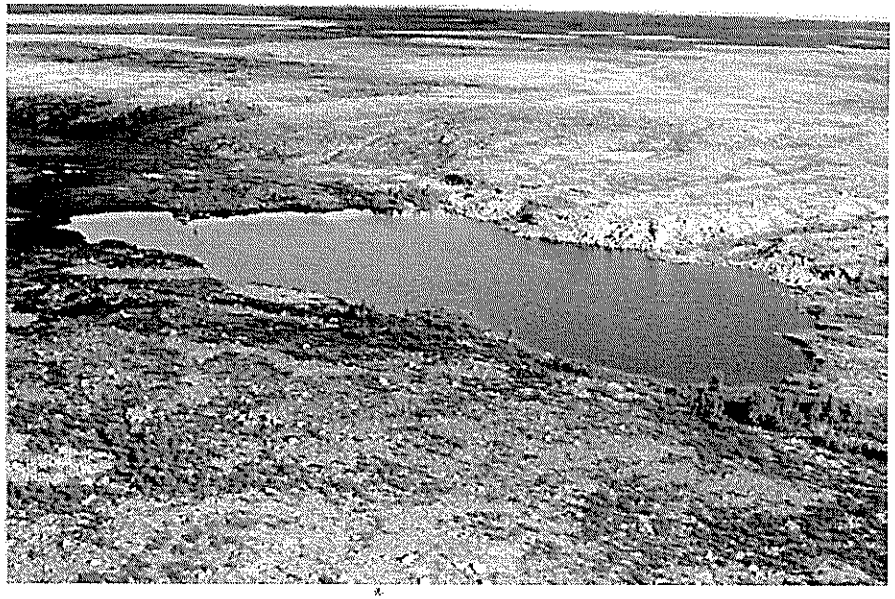
Small Lake Example: IL6

- Is the lake potentially affected? Yes, as a sedimentation pond
- Habitat Evaluation:
  - Maximum depth is 2.5 m, 2.88 ha in size
  - Ephemeral flow to Snap Lake – no access
  - No fish captured or observed



- Evaluation effort:
  - Fished using minnow traps and gill nets in 1999, 2001
  - Habitat assessed in spring and summer 1999, summer 2001, and spring 2002 – on-the-ground surveys

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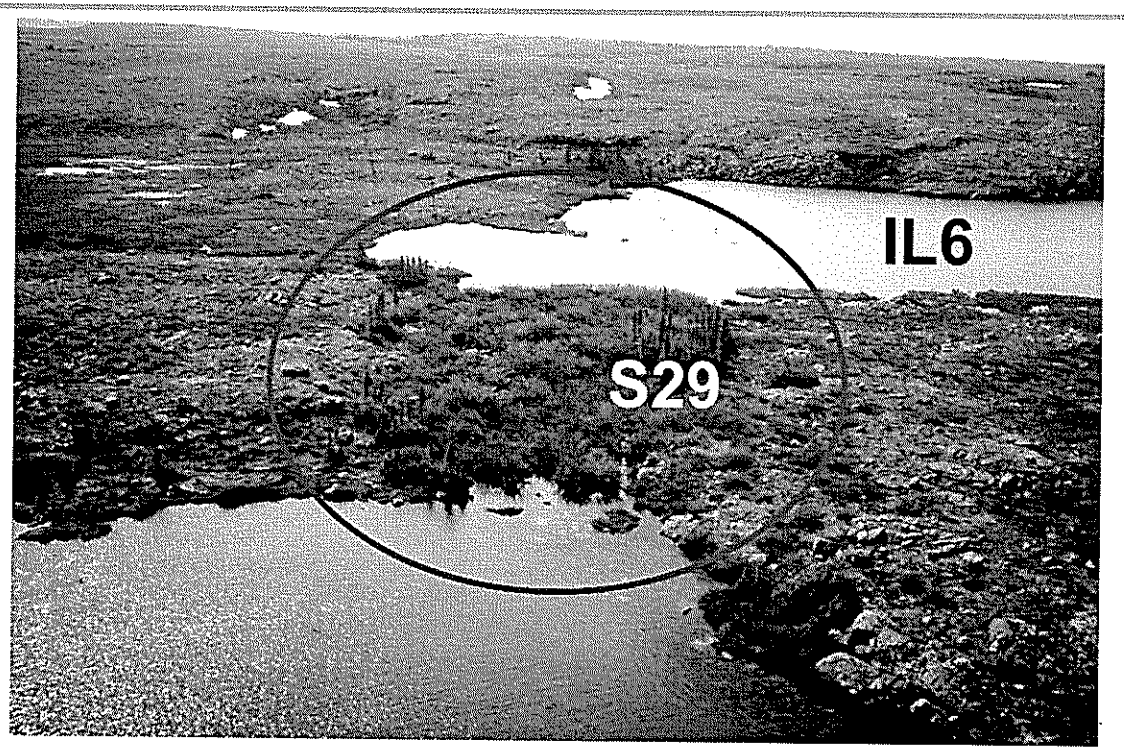
Small Stream Example: S29 (Between IL6 and Snap Lake)



- No defined or visible stream channel, dispersed flow through vegetated terrain, areas of completely sub-surface flow
- No access for fish, no migration corridor to other habitat
- Located in sub-basin "O" with an area of 0.89 km^2, run-off conditions expected to be short-term spring flow (approximately 1-2 week duration)

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Conclusions

- Criteria were established to determine the fish-bearing status of small lakes
- Lakes that will be affected by the project footprint were determined to be non-fish bearing
- Contribution of non-fish bearing lakes to Snap Lake fishery were evaluated as negligible due to very low, seasonal and dispersed flows

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Phytoplankton/Zooplankton Communities in Snap Lake

- Purpose:
  - to discuss the relationship between predicted chlorophyll a levels (algal concentrations) and a shift in the community structure of phytoplankton and zooplankton in Snap Lake

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Topic Has Been Addressed

- Environmental Assessment Report
  - Section 9.4.2.2.4
  - No IR's directly related to this topic

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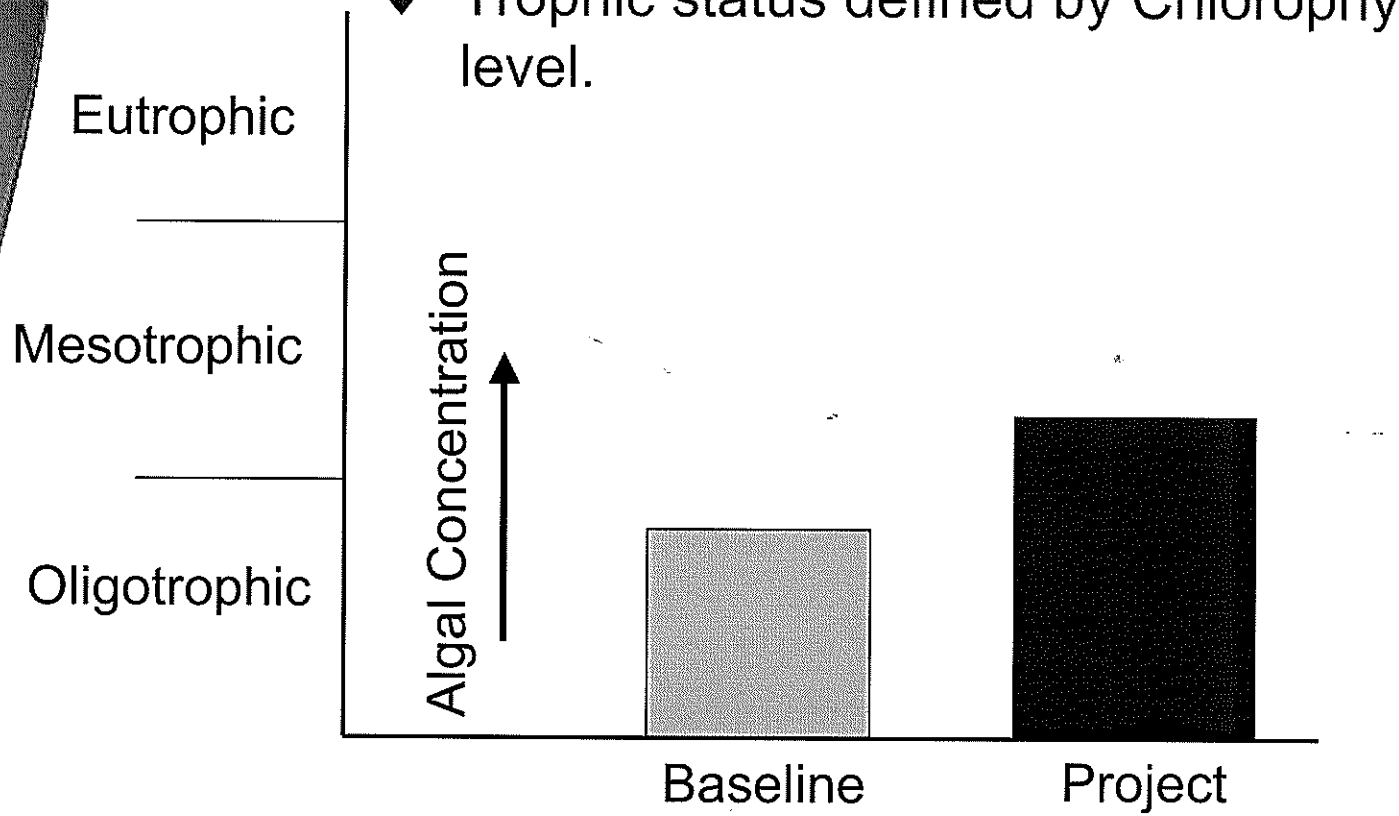
Increase in Algal Concentrations

- Under baseline conditions, trophic status of Snap Lake is upper oligotrophic
- Trophic status defined by Chlorophyll *a* level.



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Typical Arctic/Subarctic Oligotrophic Phytoplankton Communities

- Holmgren (1983) established four phytoplankton assemblages for unpolluted arctic and subarctic lakes:

1 - Golden algae dominant

2 - Golden algae/diatoms dominant

3 - Golden algae/small flagellates dominant

4 - Golden algae/dinophytes dominant

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Baseline Phytoplankton Community in Snap Lake

- Phytoplankton community characteristics:
  - High density/moderate biomass of Cyanophytes (blue-greens)
  - High density/High biomass of diatoms (*Tabellaria*)
  - Moderate density/low biomass of Chlorophytes (greens)
  - Low density/low biomass of Cryptophytes (small flagellates)
  - Low density/low biomass of Chrysophytes (golden)

- Snap Lake phytoplankton community displays characteristics of both oligotrophic and mesotrophic lakes

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Baseline Zooplankton Community in Snap Lake

- Community is characteristic of a mesotrophic lake
  - Calanoid copepods had the highest density/biomass
  - Cyclopoid copepods had the second highest density/biomass
  - Cladoceran density/biomass was much lower than either previous group

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Oligotrophy to Mesotrophy

- Phytoplankton/zooplankton communities differ naturally between lakes
- When lakes are changing from oligotrophic to mesotrophic, the following changes are known to occur:
  - Decline of golden algae and diatoms
  - Replaced with green algae and increasing presence of blue-green algae
  - Cyclopoid and calanoid copepods increase in dominance as conditions approach mesotrophy

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Conclusions

- Snap Lake may shift from upper oligotrophic to lower mesotrophic – based on algal concentrations

However,

- increased productivity caused by nutrient inputs will not likely cause a shift in phytoplankton/zooplankton community structure since community structure is already typical of mesotrophic lakes

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Clarification of Snap Lake Water Levels

- Lake level fluctuations may impact fish and fish habitat
- Purpose:
  - to describe the adequacy of baseline data to determine fluctuations in lake levels
  - to compare the frequency, timing and duration of fluctuations to natural water levels and the effect on fish habitat

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Topic Has Been Addressed:

- Environmental Impact Assessment
  - Section 9.3.1.4.4
  - Section 9.3.2.2.3
  - Appendix 9.4
- Response to Information Request
  - IR 3.10.17

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Setting – Lake Levels

- Lake level and outflow data collected daily over the open water period from 1999 to 2000
- Flow data were extended over a 22 year period by using statistical methods and regional flow data
- Peak flow and water level were from snowmelt in June
- Small amounts of outflow occur in winter
- Range in lake level is approximately 50 cm

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Lake Level Change

- Outflow rates and lake levels are closely related
- Long-term lake levels established from long-term flow estimates
- Natural monthly outflow and lake levels adjusted according to net change in outflow from mining operations
- Minewater and site runoff collection are main factors contributing to flow increase
- Groundwater recharge and intercepted site runoff reduce flow

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Results of Lake Level Assessment

- Results incorporate both short-term local baseline data and regional data to extend the period of record
- Project related inflows and losses were evaluated over three representative periods of mining operations

Operating Year	Average Annual Lake Level Increase (cm)
1	4.2
6	5.3
17-22	3.3

- By month, the largest increase (8-14 cm) is expected in low flow months
- By month, the smallest change would occur during the spring runoff period (1-3 mm)

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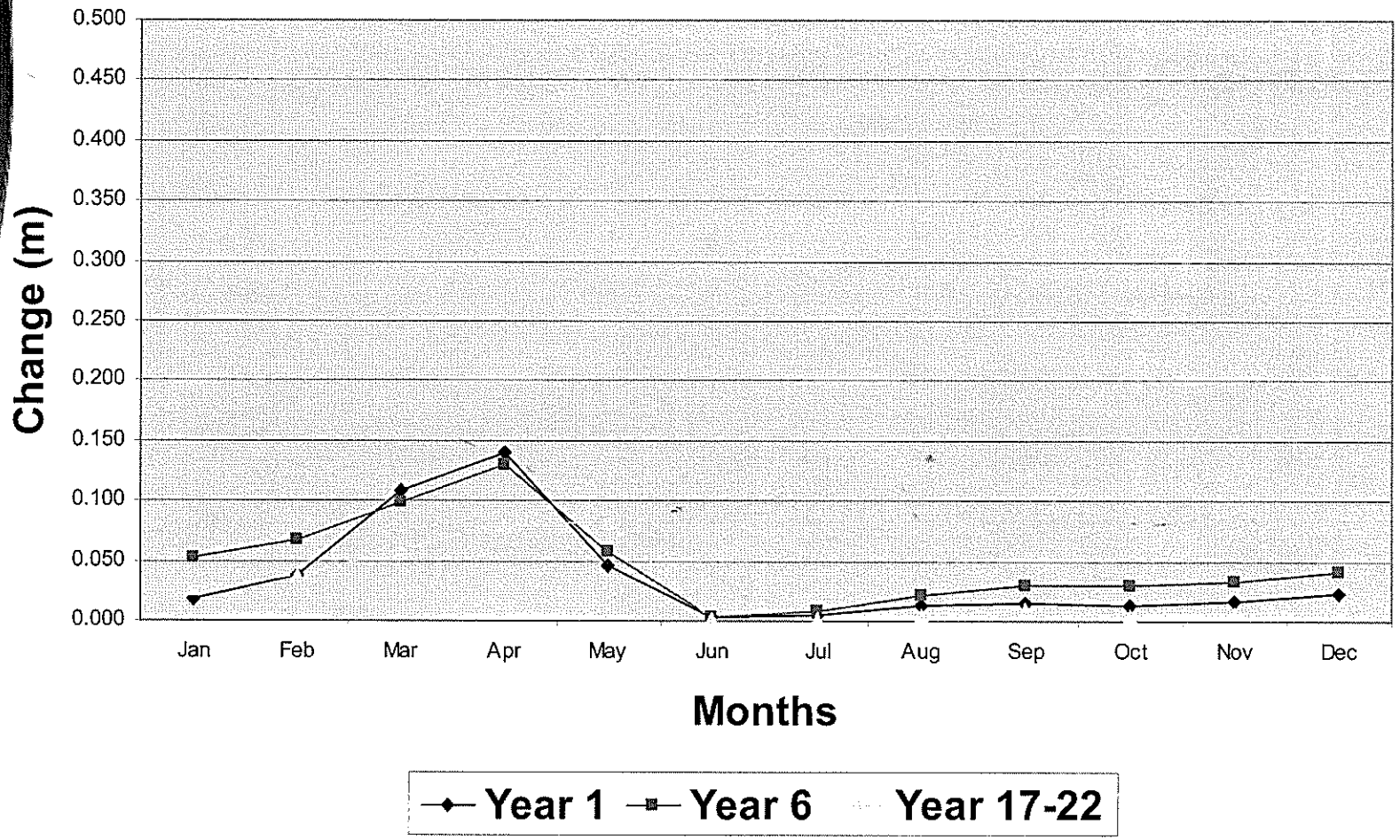
Predicted Snap Lake Water Level Increase by Month



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Conclusions

- Results indicate that increases in Snap Lake level will be very small
- Increases are well within natural ranges (maximum increase occurs during low flow)
- Increases are unlikely to have a negative effect on spawning activity, habitat or recruitment for fish species in Snap Lake
- Snap Lake water level will be monitored over the period of operations

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Total Dissolved Solids in Snap Lake

Purpose:

- to discuss the potential effect of the increase in Total Dissolved Solids (TDS) levels on the aquatic organisms in Snap Lake

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Topic Has Been Addressed:

- Environmental Assessment Report
  - Section 9.5.2.2.3
- Responses to Information Requests
  - IR 2.1.8
  - IR 2.1.9
  - IR 1.67

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Total Dissolved Solids in Snap Lake

Impact Assessment Process:

- **Step 1:** Reviewed water quality modelling results for TDS
- **Step 2:** Determined the ion mixture of the effluent
- **Step 3:** Reviewed available literature on effects of major ions on aquatic organisms
- **Step 4:** Completed impact assessment

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Total Dissolved Solids in Snap Lake

- From 1998-2001, TDS levels observed in Snap Lake ranged from <10 to 70 mg/L
- TDS concentrations are predicted to increase in Snap Lake to a maximum average concentration in Snap Lake of about 330 mg/L
- Chloride (Cl) is a major constituent of the increased TDS
- Maximum predicted Cl concentration within Snap Lake is 137 mg/L

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Chloride Guidelines

- There is no Canadian (CCME) guideline to protect aquatic life for chloride
- An ambient guideline for chloride was recently developed for British Columbia
- In their review of chloride chronic toxicity test results for zooplankton, benthic invertebrates and fish, the lowest LOEC was for *Ceriodaphnia dubia* at 735 mg/L
- Based on this, a guideline of 150 mg/L was developed using a safety factor of 5 (approximately 1/5 of 735)
- Quebec and U.S. EPA guidelines are 230 mg/L

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Conclusions

- Chloride concentrations in Snap Lake will be below any know effects level and below the new BC guideline

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Potential Bioaccumulation of Selenium and Cadmium

- Purpose – to describe and clarify issues pertaining to the potential for:
  - cadmium and selenium in discharge water
  - bioaccumulation of cadmium and selenium in fish in Snap Lake
  - fish health effects from cadmium and selenium
  - human health effects from eating fish that have taken up cadmium and selenium

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Topic Has Been Addressed

- Environmental Assessment Report
  - Section 9.4.2.2.4
  - Section 9.5.2.4
- Reponses to Information Requests
  - IR 1.52
  - IR 2.1.2

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Background: Cadmium

- Cadmium was screened out during the assessment because predicted concentrations in discharge water were less than water quality benchmarks
- The bioaccumulation analyses for cadmium was carried forward to ensure that the water quality benchmark was protective of aquatic life

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Background: Selenium

- Initial selenium analysis of mine water discharge was invalid; atomic adsorption showed that most selenium concentrations were at the analytical detection limits

- The detection limit for selenium (0.4 µg/L) is less than the CCME water quality guideline (1 µg/L)

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How Bioaccumulation was Addressed

- The degree to which fish take up cadmium from water can be calculated using a bioaccumulation factor (BAF)
- BAF = $\frac{\text{concentration in fish}}{\text{concentration in water}}$
- Site-specific BAFs were calculated using baseline Snap Lake water and fish tissue (muscle and liver) concentrations of cadmium

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How Bioaccumulation was Addressed (cont.)

- Fish tissue concentrations during the Project operation were predicted

  Concentration in fish = BAF x predicted maximum annual average mine water discharge concentration

- Fish tissue concentrations were compared with no-effect levels for growth, reproduction and survival of lake trout and rainbow trout

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How Bioaccumulation was Addressed (cont.)

- Predicted fish tissue concentrations were also compared with risk-based concentrations (RBCs) for humans and wildlife
- RBCs are safe concentrations based on toxicity data and human or wildlife fish ingestion rates
- RBCs are not guidelines, but provide a concentration for safe exposure

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Results: Cadmium

Predicted Fish Tissue Concentration (mg/kg)	No Effect Level (mg/kg)	Risk-Based Concentration (mg/kg)
	Fish Health	Human and Wildlife Health
0.1 (muscle tissue) 0.2 (muscle and liver tissue) for both lake trout and round whitefish	2	1.4

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Conclusions

- No adverse effects on fish health due to exposure to selenium because predicted concentrations are below the CCME water quality guideline
- No adverse effects on fish health, and human and wildlife health due to uptake of cadmium from water because predicted levels are an order of magnitude below the RBC

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Aquatic Organisms and Habitat Assessment

- Purpose:
  - to provide an overview of the aquatic organism and habitat assessment procedure

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Topic Has Been Assessed

- Environmental Assessment Report
  - Section 9.5.2

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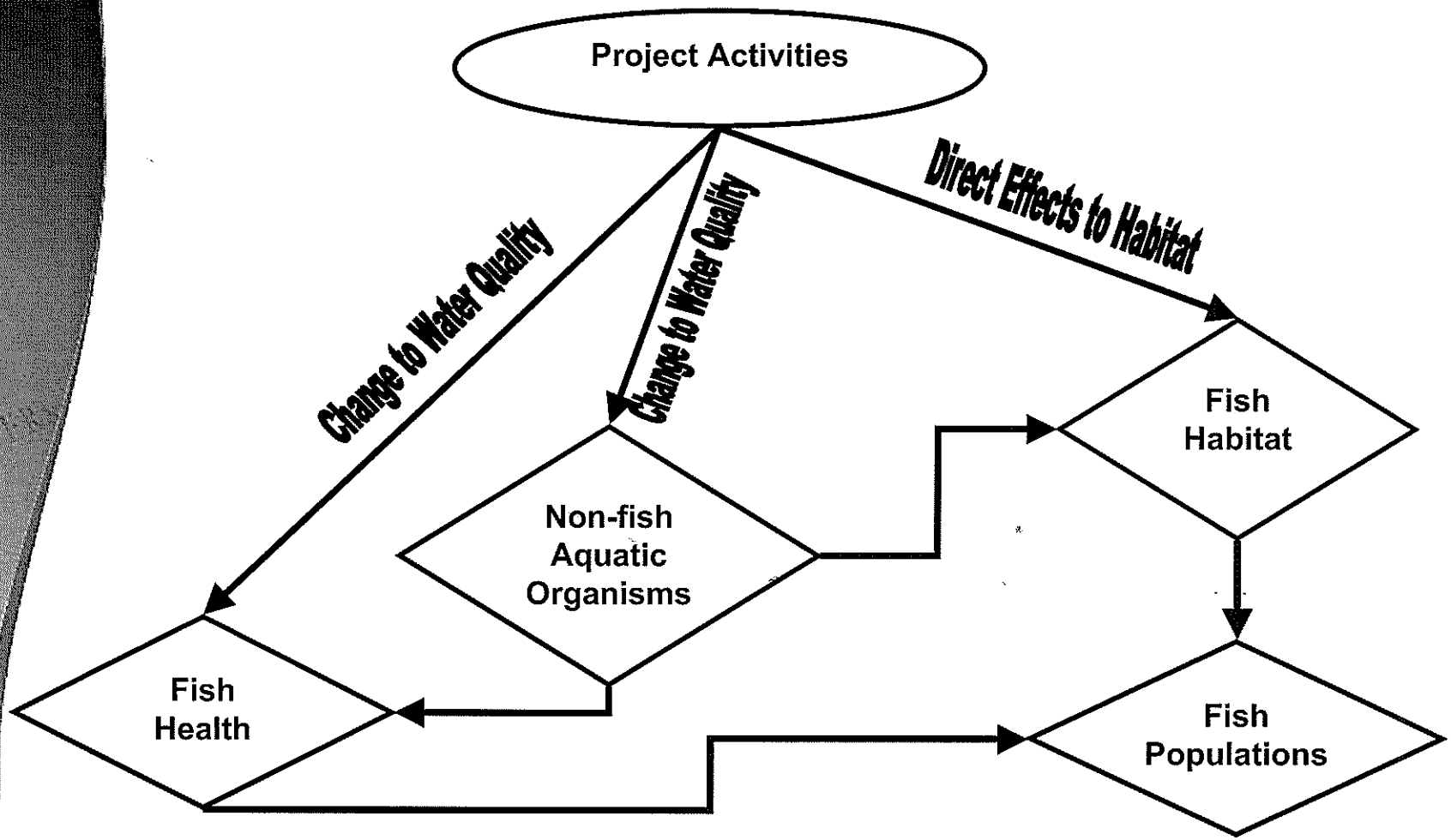
Linkage Summary



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Example – Hexavalent Chromium

- Low environmental consequence in water quality assessment – carried forward to Aquatic Organisms
  - Potential effect to non-fish aquatic organisms evaluated
  - Potential effect to fish health evaluated
    - All life stages
    - Direct and indirect sources
  - If a potential effect to any life stage of fish identified - further evaluation of spatial location and extent
  - Potential effect to fish population