Water Quality

Ambient Water Quality Assessment And Objectives For Middle Quinsam Lake Sub-Basin Campbell River Area

Overview Report

Water Management Branch
Ministry Of Environment

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SUMMARY

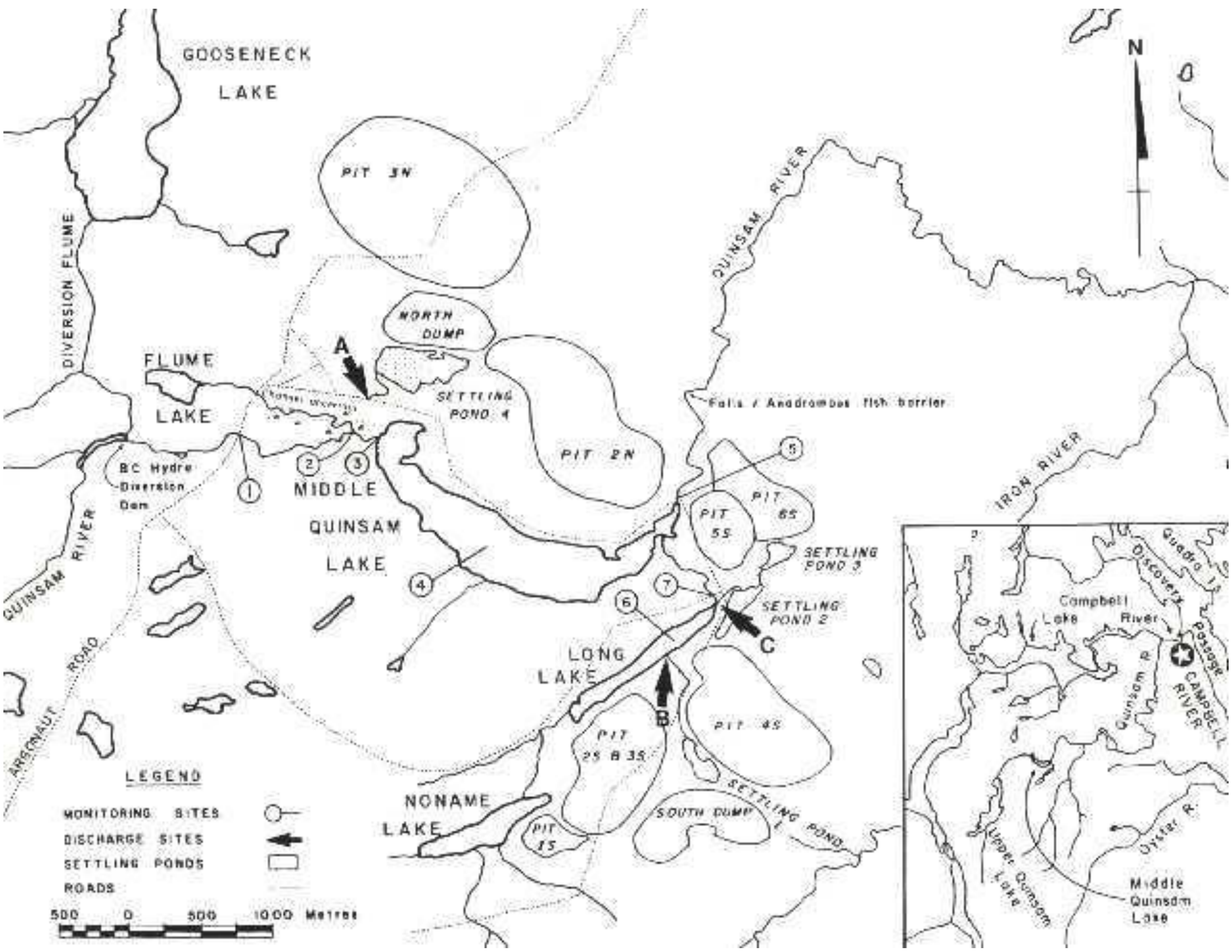
This report assesses the water quality of the Middle Quinsam Lake sub-basin within the Campbell River system on Vancouver Island. The sub-basin includes Middle Quinsam Lake, Long Lake and a portion of the Quinsam River. An open pit coal mine eventually producing 910,000 tonnes of thermal coal per year is being developed in this sub-basin. Provisional water quality objectives have been set to ensure protection of existing and future water uses.

The lakes, streams and river are valuable habitat for wild trout and hatchery-raised salmon. A public inquiry into the potential impact of the coal mine concluded that the project can proceed if certain

environmental safeguards are met. Present water quality is characterized by very low levels of dissolved and particulate matter and a low pH-buffering capacity.

The coal mine represents the only major source of waste loading to the sub-basin. A system of settling ponds incorporating flocculation treatment will capture all surface water draining the mine site. Waste water from the coal preparation plant will be recycled. The potential for acid mine drainage exists; a program of material testing and handling is expected to prevent its occurrence. The close proximity of valuable fish habitat and salmon migration corridors to the proposed effluent discharge sites may require further study.

Figure 1. Middle Quinsam Lake sub-basin and Quinsam Coal Project



PREFACE

Purpose of Water Quality Objectives

Water quality objectives are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of the Ministry of Environment, Lands and Parks' mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the near future.

How Objectives Are Determined

Water quality objectives are based the BC approved and working criteria as well as national water quality guidelines. Water quality criteria and guidelines are safe limits of the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the criteria by considering local water quality, water uses, water movement, waste discharges, and socio-economic factors.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. A designated water use is one that is protected in a given location and is one of the following:

- raw drinking water, public water supply, and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- industrial water supplies.

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical or biological characteristics affecting that waterbody.

How Objectives Are Used

Water quality objectives routinely provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licences and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular waterbody can be checked, and help to determine whether basin-wide water quality studies should be initiated.

Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses. While water quality objectives have no legal standing and are not directly enforced, these objectives become legally enforceable when included as a requirement of a permit, licence, order, or regulation, such as the Forest Practices Code Act, Water Act regulations or Waste Management Act regulations.

Objectives and Monitoring

Water quality objectives are established to protect all uses which may take place in a waterbody. Monitoring (sometimes called sampling) is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at the critical time, then they also will be protected at other times when the threat is less.

The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as the average condition in the water.

For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (*i.e.*, mean value, maximum value).

INTRODUCTION

This report summarizes the results of an assessment of baseline water quality, hydrology, water uses and waste discharges in that portion of the Quinsam River watershed which will be subject to waste discharges from the Quinsam Coal Project. The waterbodies affected include the Quinsam River, Middle Quinsam Lake, Long Lake and the outflows from Long and Flume Lakes. Receiving water quality objectives are proposed for those characteristics which may be altered by mining activity. These objectives are formulated to protect existing and anticipated water uses and are based on consideration of current water quality criteria and existing water quality and hydrology in the Quinsam watershed. A detailed technical appendix was prepared and forms the basis for the assessment, recommendations and objectives presented here.

Quinsam Coal Ltd. received Stage II approval-in-principle from the Environment and Land Use Committee in February 1983. A Public Inquiry into the Quinsam Coal Project was held in October and November 1983. The Inquiry Commission reported to the Minister of Environment and concluded that: "The Quinsam River and its watershed are very sensitive to environmental damage. Notwithstanding this fact, the Commission has also found that if proper care and attention are paid to the environmental aspects of the construction and operation of this mine, by both the Company and the Government control agencies, the mine can be brought into existence and be operated without doing appreciable damage to the surrounding environment or the Quinsam River fishery". The Commission recommended that: "The Ministry of Environment should prepare water quality objectives for the receiving waters in the mine site area...to protect the use of water for the fishery, recreation, aesthetics and domestic purposes."

Quinsam Coal Limited originally proposed operating at a production rate of 910,000 tonnes/year, but started at a reduced production of 50,000 tonnes/year during 1987. The assessment of waste discharges and the water quality objectives presented in the report are based on the proposed full scale operation.

HYDROLOGY

The Quinsam River is formed at the outlet of Wokas Lake (into which drains Upper Quinsam Lake) and flows east about 5 km into Middle Quinsam Lake. From here it flows east about 10 km into Quinsam Lake and then north another 25 km to join the Campbell River, about 3 km from its estuary. The Iron River is a major tributary of the Quinsam River, entering from the south between Middle Quinsam and Quinsam Lakes (Figure 1).

Long Lake drains a small sub-basin and its outflow enters Middle Quinsam Lake from the south near its outlet. The proposed Quinsam Coal Project will be located adjacent to Middle Quinsam Lake and Long Lake. Discharges from settling ponds will enter Long Lake directly and Middle Quinsam Lake via a marsh adjacent to the inflow to Middle Quinsam Lake (Figure 1).

The outflow from Flume Lake drains a small sub-basin and flows into the Quinsam River or possibly into the west end of Middle Quinsam Lake, depending on water levels.

Quinsam River flows have been regulated since 1957. A diversion dam upstream from Middle Quinsam Lake diverts roughly 72% of the flow of the Quinsam River into the Campbell River system via Gooseneck Lake.

On the average, approximately 70% of the annual discharge from the Quinsam watershed occurs during the winter months of November through March. Monthly means flow of the Quinsam River near its mouth ranges from approximately 1 to 50 m^3/s. Approximately half this flow originates from the Middle Quinsam Lake outflow. Middle Quinsam and Long Lake have rapid flushing rates. The estimated mean residence time for Middle Quinsam Lake water is approximately 17 days; for Long Lake it is approximately 34 days.

WATER USES

The major water uses in the Quinsam River watershed are related to the salmonid fishery and hydro-electric generation. Other water uses include water-based recreation, irrigation withdrawals and an application for domestic water use by the Greater Campbell River Water District. The Quinsam Fish Hatchery, located near the confluence with the Campbell River, also draws water from the Quinsam River. Elk Falls Provincial Park borders the Quinsam River near the confluence with the Campbell River. The water requirements for the Quinsam Coal project will come from Gooseneck Lake located outside the Middle Quinsam Lake sub-basin or from settling ponds.

Wild anadromous salmon (chinook, chum, pink, coho, sockeye, steelhead and cutthroat) spawn and rear downstream from a cataract near the outflow from Middle Quiinsam Lake (Figure 1). Coho and steelhead from the Quinsam Hatchery are introduced above the cataract to utilize the rearing habitats in Long Lake, Middle Quinsam Lake, Flume Lake and other small tributaries and marshes. Resident cutthroat and Dolly Varden are also present in the watershed.

The direct economic value of wild and hatchery salmon from the Quinsam watershed has been estimated at 2.5 million dollars annually

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WASTE DISCHARGES

There are presently no point-source waste discharges to surface water in the Middle Quinsam Lake watershed with the exception of a discharge from Quinsam Coal Ltd. Watershed activities other than logging are minimal; non-point source influences on water quality are minimal. Another proposed coal mine located partly within the Iron River watershed may influence water quality in the Quinsam mainstream downstream from the Iron River and Quinsam River confluence. The Quinsam Hatchery, operated by the Federal Department of Fisheries and Oceans, discharges hatchery water to the Quinsam near the mouth. The hatchery is presently exempt from requiring a waste management permit.

At full scale operation Quinsam Coal Ltd. proposes to develop a thermal coal mine producing about 910,000 tonnes per year of clean coal. Open pits ans waste rock dumps will be located north of Middle Quinsam Lake and adjacent to Long Lake. Pit drainage and contaminated surface runoff will be treated in four settling ponds. The total overflow drom three ponds in the Long Lake sub-basin will discharge at a rate of approximately 2.4 m^3/s during a one-in-ten-year flood. For the purpose of this assessment, it is assumed that the effluent will be discharged directly to Long Lake as specified in the StageII mine plan. It is acknowledged that this may not necessarily be the case byu the time permits are issued. Settling pond four will overflow to a marsh near the inflow to Middle Quinsam Lake at a rate of 2.1 m^3/s during a one-in-ten-year flood. In December, 1987, Quinsam Coal Limited was issued a permit to discharge 0.54 m^3/s from settling pond four to facilitate a small scale production rate of 50,000 tonnes/year. The coal preparation plant will use water recycle and settling pond water, and will have no tailings effluent discharge. Domestic sewage will be treated and discharged to ground via tile fields.

A relatively small portion of the total volume of material to be encountered during mining is expected to be acid generating. An ongoing program of material testing and disposal of material with acid generating potential near the pit bottom is expected to prevent acid mine drainage. Shopuld acid mine drainage occur during mining or after reclamation, a dramatic increase in the concentration of dissolved metals in the minesite drainage would be expected.

Nitrogen losses from the use of typical noitrogen-based explosives will result in the discharge of large quantities of nitrogen, largely in the forn of nitrate (NO_3). Mine effluent is expected to contain from 1 to 60 mg/L nitrogen.

All water draining the minesite will be routed through settling ponds with flocculation facilities. Under the terms of the permit issued in 1987 for settling pond four, Quinsam Coal Limited is committed to operate the settling pond system to maintain suspended sediment in the effluent below a daily composite of 25 mg/L, with no hourly composite exceeding 35 mg/L. The same effluent quality will be required at the higher effluent volumes during full scale operation.

Mine effluent is expected to contain higher concentrations of total phosphorus than found in receiving waters due to general disturbances, fertilization and pit dewatering.

Comparison of predicted effluent discharge volumes and receiving water flows into Middle Quinsam Lake indicates that effluent dilution ratios will normally range from 8:1 to 38:1. However. dilution ratios considerably lower than 8:1 could occur if BC Hydro were to release relatively low flows at the Quinsam diversion during a period of high discharge from the mine. Based on the outflow from Long Lake, the dilution ratios for Long Lake range from 0:1 to 5:1; dilution ratios are well below 1:1 except during wet weather periods.

The proposed location of the effluent discharge to Long Lake poses a conflict with salmonid migration. One of the two possible discharges to Long Lake is within 100 m of the outflow stream (discharge C, Figure 1). The Long Lake outflow stream is a migration corridor and possible spawning habitat for resident trout, and is a critical corridor for the seaward migration of introduced salmonids. Unless effluent quality meets the receiving water quality objectives presented here, the proposed discharge locations need to be reconsidered.

With respect to the discharge to the marsh near Middle Quinsam Lake as allowed by the present permit, the marsh may serve to improve effluent quality, although initial dilution will be limited until the flow reaches the Quinsam River. Monitoring in the marsh will help determine if this strategy will work during higher effluent flows.

WATER QUALITY

Water quality throughout the Quinsam watershed is characterized as soft, exceptionally clear and oligotrophic. There is a tendency for pH to become slightly acid (6.0 - 7.0), presumably during periods of rain or snowfall. The water has a low concentration of dissolved substances and little buffering capacity to stabilize pH. Median pH is 7.1.

Phytoplankton and periphyton productivity is very low due to nutrient limitation. Phosphorus and nitrogen appear to be co-limiting. Over the life of the mine, productivity will become strongly phosphorus limited due to nitrogen enrichment from mine effluents.

Hypolimnetic oxygen depletion occurs in Long, Middle Quinsam and Quinsam Lakes at the end of the growing season prior to destratification. Rapid flushing during fall and winter probably prevents phosphorus released during this brief anoxic period from contributing to summer algal production.

Suspended sediment concentrations rarely exceed 5 mg/L, even during high flow periods.

Assessment of an extensive surface water data base indicates that the concentration of all metals are generally very low. Water quality criteria for the protection of aquatic life are, however, exceeded infrequently for presumably short periods for total copper, lead and mercury. It is not clear if the infrequent high values are due to analytical errors, sample contamination or natural variability. Metallothionein analysis of cutthroat trout livers from Middle Quinsam Lake suggests these fish were not stressed by background metal concentrations. The high productivity of the fisheries also suggests there is no appreciable impact.

PROVISIONAL WATER QUALITY OBJECTIVES

Provisional water quality objectives are proposed for 21 characteristics (Table 1, Table 2 and Table 3). These objectives apply to all surface waters which may be influenced by the Quinsam Coal Project including Middle Quinsam Lake, Long Lake, the outflow streams from Long Lake and Flume Lake and the Quinsam River between the confluence with the Flume Lake outflow and the confluence with the Iron River. Objectives usually apply outside an initial dilution zone of 100 m radius from the point of discharge. The zone should not exceed 50% of the width of the lake or stream. The initial dilution zone radius for Long Lake discharge B is 50 m (approximately half the width of Long Lake). No initial dilution zone is available for Long Lake discharge C due to its proximity to the outflow. Should mine effluent exceed the proposed water quality objectives, alternate locations for discharge C should be implemented, Figure 1. Discharge A enters a marsh near the inflow to Middle Quinsam Lake, Figure 1. In this situation the 100 m initial dilution zone within the marsh is not used to determine where the objectives apply, instead the objectives will apply to the main channel connecting Flume Lake with the Quinsam River and will also apply to the Quinsam River.

All of the metal objectives, except those for aluminum, are expressed in terms of total rather than dissolved or extractable analyses; this is the most conservative measure of the presence of a toxic metal and therefore incorporates a safety margin. If, however, any of the metal objectives proposed here are exceeded, other fractions should be included in further monitoring to assist interpretation.

The objectives are subject to revision depending on results from monitoring programs and revisions to criteria upon which the objectives are based.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. They will guide the evaluation of water quality, the issuing of permits, licences and orders and the management of the fisheries and of the Province's land base. They will also provide a reference against which the stae of water quality in a particular water body can be checked and serve to make decisions on whether to initiate water quality studies.

The objectives presented here are largely based on assessment of pre-operational (historical background) data rather than upstream control sites. The availability of an extensive pre-operational data base makes this possible. Objectives based on a fixed reference also are more practical for assessing future changes in water quality. Monitoring should, however, include the upstream control site at the Argonaut Road crossing to aid interpretation of results.

No objective for fecal coliforms is proposed because there will be no sewage discharge to surface waters

Each objective presented in Table 1 is designed to protect the water use most sensitive to each characteristic. The water uses considered include aquatic life, wildlife, recreational use, aesthetic values, irrigation and drinking use. Thesee objectives apply to Middle Quinsam Lake, Long Lake, the outflow streams from Long Lake and Flume Lake and the Quinsam River between the confluence with the Flume Lake outflow and the confluence with the Iron River. The objectives only apply to specific portions of these water bodies as specified in Table 1. This will ensure that all the water uses which now occur and are expected to occur will be protected from degradation caused by the Quinsam Coal Project. The objectives are not designed to apply further downstream due to: 1) possible influences from proposed developments in the Iron River, 2) other activities in the lower portion of the Quinsam watershed and 3) the fact that baseline water quality downstream from the confluence of the Iron and Quinsam Rivers differs from water quality upstream.

MONITORING RECOMMENDATIONS

Figure 1 indicates key locations to be considered for monitoring purposes. Monitoring to assess whether objectives are being met should be carried out at least annually. Actual monitoring details, and the responsibility for carrying out the monitoring, is subject to negotiation and may involve various concerned government agencies.

Shopuld an objective be exceeded, increased monitoring frequency and additional monitoring sites may be required to assist interpretation and to aid in planning corrective action. If a metal objective is exceeded it is recommended that further metal testing include analysis of both total and dissolved fractions.

With respect to copper, the average background concentration is 0.002 mg/L or less, with occasional high values up to 0.035 mg/L. Consequently, if future monitoring consists of the minimum frequency of 5 weekly samples in a 30-day period, a single isolated high value could result in the objective being exceeded without necessarily representing an actual increase relative to background data. It is therefore recommended that, if the objective is exceeded, copper be monitored more frequently in subsequent months. The use of replicates and blanks should also be considered.

TABLES

Table 1 Provisional Water Quality Objectives for Middle Quinsam Lake sub-basin

Water Bodies	**Long Lake**	**Middle Quinsam Lake**	**Flume and Long Lake outflows, Upper Quinsam River**	**Quinsam River d/s from Middle Quinsam Lake**
Designated Uses	**aquatic life, wildlife**	**aquatic life, wildlife**	**aquatic life, wildlife**	**aquatic life, wildlife, aesthetics, irrigation, drinking water**
total phosphorus	**less than or equal to 0.007 mg/L summer mean**	**less than or equal to 0.006 mg/L summer mean**	**not applicable**	
periphyton biomass	**not applicable**		**less than or equal to 50 mg/m^{2}chlorophyll-a mean**	

<table>
<tr><td>hypolimnetic dissolved oxygen</td><td>3 mg/L minimum during June, July and August</td><td colspan="2">not applicable</td></tr>
<tr><td>turbidity</td><td colspan="2">not applicable</td><td>less than or equal to 1.0 NTU 30-day mean
5.0 NTU maximum or
1 NTU over u/s control during major rainstorms</td></tr>
<tr><td>nitrate-nitrogen</td><td colspan="2">less than or equal to 40 mg/L 30-day mean
200 mg/L maximum</td><td>10 mg/L maximum</td></tr>
<tr><td>total cobalt</td><td colspan="2">not applicable</td><td>0.05 mg/L maximum</td></tr>
<tr><td>total manganese</td><td colspan="2">not applicable</td><td>0.05 mg/L maximum</td></tr>
<tr><td>non-filterable residue</td><td colspan="3">less than or equal to 5 mg/L 30-day mean
25 mg/L maximum or
10 mg/L over u/s control during major rainstorms</td></tr>
<tr><td>total ammonia</td><td colspan="3"><u>Maximum and Average Concentration of Total Ammonia Nitrogen for Protection of Aquatic Life.</u></td></tr>
<tr><td>nitrite-nitrogen</td><td colspan="3">less than or equal to 0.02 mg/L 30-day mean
0.06 mg/L maximum</td></tr>
<tr><td>pH</td><td colspan="3">greater than or equal to 6.5 mg/L 30-day 90th percentile
greater than or equal to 6.9 mg/L running 30-day median</td></tr>
<tr><td>dissolved aluminum</td><td colspan="3">less than or equal to 0.05 mg/L 30-day mean
0.1 mg/L maximum</td></tr>
<tr><td>total arsenic</td><td colspan="3">0.05 mg/L maximum</td></tr>
</table>

total cadmium	**less than or equal to 0.0002 mg/L 30-day mean 0.0003 mg/L maximum**
total copper	**less than or equal to 0.002 mg/L 30-day mean**
total iron	**less than or equal to 0.3 mg/L 30-day mean**
total lead	**less than or equal to 0.003 mg/L 30-day mean 0.005 mg/L maximum**
total mercury	**less than or equal to 0.0001 mg/L maximum 0.5 mg/kg total Hg in fish muscle by wet weight**
total nickel	**0.025 mg/L maximum**
total silver	**0.0001 mg/L maximum**
total zinc	**0.03 mg/L maximum**

Note: All 30-day average values should be calculated from at least 5 weekly samples taken in a period of 30 days.
1. Upper Quinsam River refers to the Quinsam River between the confluence with Flume Lake outflow and the inflow to Middle Quinsam Lake.
2. The growing season average phosphorus concentration is calculated from samples taken at least every three weeks from May to September, from near the surface, at the middle of the epilimnion and near the bottom of the epilimnion.
3. Average chlorophyll-a per m^2 is calculated from at least 10 samples of periphytic algae taken at random from representative natural stream substrate at one time from a single site.
4. Turbidity and non-filterable residue means are calculated from at least 5 weekly samples taken in a period of 30 days. Extra samples taken during major rainstorms should not be used in calculating the average as this would bias the average upward. During major rainstorms (when total precipitation exceeds 25 mm per 24 hour period) the objective may be based on comparison with u/s control monitoring.
5. Hypolimnetic oxygen samples are to be collected 1 m above the bottom in the deepest portion of the lake during May to September at least every three weeks.
6. The 90th percentile and median pH are calculated from at least 5 weekly samples taken during a period of 30 days.
7. The silver objective is lower than the present minimum detection limit (0.0005 mg/L).

Measurements of less than 0.0005 mg/L will be deemed to be meeting the objective until detection limits can be reduced. The objective should be used in back-calculating allowable discharge concentrations. Silver concentrations based on loading calculations also should meet the objective.

B. J. Kangasniemi
Resource Quality Section
Water Management Branch
Ministry of Environment