Francois Lake Management Plan
May 2000

Prepared by
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and Ian Sharpe

for the

Funded by the Ministry of Environment
Lands and Parks

FRANCOIS LAKE MANAGEMENT PLAN

PREPARED BY
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FOR
THE LAKES PROTECTION SOCIETY

PROVINCE OF BRITISH COLUMBIA
BC ENVIRONMENT
SMITHERS, BC
MAY, 2000

ACKNOWLEDGEMENTS

This edition of the Francois Lake Management Plan was prepared under the guidance of Ian Sharpe, Impact Assessment Biologist, B.C Ministry of Environment, Lands and Parks. We extend a special thank you to Shauna Rysavy for being able to draw on the ideas and information contained in the management plans that she prepared for Lake Kathlyn and Tyhee Lake. These management plans had great impact on the format and character of this plan. We would also like to acknowledge Brice Field (1999), and Hina Zaidi (2000) Katimavik Participants for their contributions to updating sections of this plan. We thank the many individuals, citizens and agency staff who provided the information contained in the plan. The co-operation, support and input of the Lakes Protection Society members was greatly appreciated.

This project was funded by the Environmental Protection Branch of the Ministry of Environment, Lands and Parks.

Thanks to the BC Lakes Stewardship Society this plan is available at **www.nalms.org/bclss/lakestewardshiptools.htm**

FOREWORD

This Lake Management Plan was written for the purpose of allowing the residents on and around Francois Lake to have a voice in the future development plans for this area. It is hoped that the Regional District of Bulkley Nechako planners will make use of this plan when deciding on future development strategies.

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1. MANAGEMENT PLAN -GOAL STATEMENT AND OBJECTIVES

1.1 Goal Statement:

The lake management plan will benefit users by providing a mechanism to evaluate and protect lake water quality. Protecting water quality will enhance the quality of life and preserve living aquatic resources. The lake ecosystem includes both the lake and its entire drainage basin. To meet this goal, the plan includes tools to manage land and water uses as well as aquatic life and wildlife.

1.2 Objectives:

- To identify current and potential sources of water quality degradation in the watershed and the lake. To provide workable management options to eliminate or reduce the effect of these sources.

- To provide a set of recommended actions that will implement each option.

- To develop communication links between the Lakes Protection Society, government, industry, First Nations groups, and other stakeholders. This will: a) keep the society advised of activities in the watershed which may affect water quality and b) ensure land use decisions are made with sufficient input and agreement of stakeholders on relevant technical, social and political issues.

- To assist in identifying and applying appropriate regulatory requirements and volunteer driven actions that are consistent with the goal of the plan.

- To improve public education on issues affecting water quality in the lake and the watershed.

- To implement a volunteer monitoring program as an efficient and cost effective method of monitoring the lake condition.

2. EXECUTIVE SUMMARY

2.1 Identifying Issues - What did we spend our time doing?

Protecting water quality and the lake environment is a concern for residents and lake users. Through a consensus exercise issues that may affect water quality and the lake environment were identified and ranked for importance by the members of the Lakes Protection Society (LPS). The results of this process were then used to make a matrix to analyze how parts of the lake ecosystem are related to one another. The issues were ranked again based on this analysis and the issues identified by the LPS.

2.2 Understanding the Issues - What is Involved?

Potential sources of water quality degradation in the Francois Lake Watershed include:

- leaking or failing septic systems
- animal waste causing hazards to human and animal health through drinking water contamination
- sewage from watercraft
- fertilizers and herbicides entering the lake from forestry, residential and resort/campground use
- salts and fuel washed into the lake from the ferry, and runoff of dust control chemicals into the lake
- Endako mine was presented as a potential source of contamination to both surface and ground water and sediments. Analysis of sediment cores taken in February 1997 should indicate any metal enrichment into the lake from the mine. Impact assessment needs will be determined from this information.

Other issues of concern that were presented are:

- potential fish population declines because of overharvesting and loss of habitat
- sedimentation from forestry roads and cutblocks
- degradation of visual quality as a result of forest practices and beaver activity
- riparian habitat degradation resulting from road construction
- growth management and zoning,
- extensive aquatic plant growth at the mouth of the Nithi River

2.3 Actions Needed

In the process of gathering information on the issues, many communication links have been made within the community, various government agencies, and industry. These contacts have helped identify possible management and land use planning options and actions. We have also identified regulations regarding many of the issues and options.
Concerns with potential fish population declines or habitat losses must be addressed by first determining the status of these populations as well as habitat conditions.

In an attempt to gather quantitative information on angling in Francois Lake, a survey sheet was prepared by the Lakes Protection Society in consultation with the Ministry of Environment, Fisheries Branch. In the spring of 1997 survey sheets were handed out to local area sports merchants, lodges, resort owners and marinas. They were to be passed onto, completed and returned by anglers on a volunteer basis. By mid October 1997, very few of the completed surveys were returned and collected. Other options will need to be looked at to try and collect this information.

In the event that fishing pressure can be validated with this information, options which will lessen fishing pressure include changing the way that fishing derbies are run, removing hidden weight and largest fish categories from fishing derbies, partial or complete change to a catch and release fishery, protecting spawning areas with fishing closures, putting harvest restrictions on long lived species, and educating the public about the sensitivity of lake trout to over harvesting.

Habitat concerns can be documented and supported by conducting stream surveys including mapping of obstructions to fish passage and spawning habitat. The Streamkeepers Program can provide the tools and skills necessary for volunteers to effectively conduct a survey of stream habitat. They can also provide professional advice on selecting appropriate restoration methods. In 1998, the LPS mapped and made notes on 18 creeks that flow into Francois Lake. The map and further details can be found in the section on culvert mapping.

Once the present status of fish populations and habitat are determined, then the LPS will have answers regarding suitable management options and monitoring they may wish to promote.

Intensive use of streams or lakes for watering livestock can degrade soils and vegetation and contaminate the water. There are alternatives to direct access watering of livestock that preserve the environment around a natural water source. Concerns regarding shoreline erosion and degradation of water quality due to the presence of livestock and their waste needs to be verified. To identify the locations of cattle impacts, a shoreline survey to map and evaluate shoreline degradation and erosion, coupled with water quality monitoring at specific times of the year, is recommended. The Ministry of Agriculture and the Ministry of Environment, Waste Management Branch can be contacted for guidance on carrying out such surveys as well as interpreting survey results. The results will help identify areas of concern and appropriate management options. There are direct actions that can be taken to lessen and/or prevent the impact of livestock on lakeshore areas. These include alternative watering areas, fencing off sensitive fish habitat, and limiting livestock access to the lakeshore and streambanks.

Giardiasis, often called “beaver fever”, is common in rural and wilderness areas of Western Canada where wildlife are plentiful. It is spread primarily through water that has been contaminated by fecal material from infected animals, including beavers, muskrats, domestic animals, and humans. The best method to deal with the possibility of water borne diseases and parasites in water supplies is to comply with the Ministry of Health’s water treatment recommendations.

The Ministry of Highways currently uses Magnesium Chloride, Calcium Chloride, Calcium Lignosulphonate, and Sodium Lignosulphonate for dust control. Based on the information currently available, these materials are non-toxic when applied as specified in

their guidelines. Dust control is done for health and safety reasons. Residents who do not wish a road to be treated for dust control near their residences or a water body can contact the Ministry of Highways. If stopping treatment does not threaten the health and safety of others this may be a feasible action to pursue.

Solutions through direct actions

The Nithi River is one of several important spawning and rearing area for rainbow trout. A low storage dam that would store water within the high water level of Anzus and Borel Lakes would increase and control the flow during the summer low flow period and through the winter. This will solve the low flow problem in summer that results in high fish mortality. Soils testing, bore holes and some survey was done at the proposed dam site in late fall of 1997 by Agra Earth. In 1998, McElhanney Engineering completed the design and cost analysis phase of the project. Once all the necessary permits are in place, dam construction is scheduled for late summer in 2000.

Direct actions can be taken to solve concerns with residential and resort/campground fertilizer and herbicide use. When using fertilizers and herbicides, there are recommended application methods that minimize impacts to lakes and streams. However, there are alternatives to fertilizer and herbicide use that include biological (i.e. use of beneficial species), chemical (i.e. least-toxic pesticides) and cultural or mechanical (i.e. adjusting planting dates, barriers and row covers and hand-picking) control methods.

Septic system maintenance and remediation are known to have immediate positive effects on water quality. There are methods outlined in the plan about how to test a septic system, what to do if a system is failing or leaking and who to get help from.

Designating “no sewage dumping” through the Canada Shipping Act small vessel regulations is an option to limit the discharge of sewage into the lake. This has been pursued through an application to MELP for this status. The application was accepted and was forwarded to Victoria on September 4, 1998, in a package consisting of 16 other nominated waterbody sites. The Safety Office of Boating, Canadian Coast Guard, is responsible for the administration of the Pleasure Craft Sewage Pollution Prevention Regulation. They have been working on a previous submission of 58 nominated sites, forwarded to them earlier by the province of British Columbia. Of the 58 original sites, 14 are presently in the final stages of preparation for designation as “no sewage dumping” areas. Once this has been completed the Office of Boating Safety, in conjunction with MELP shall re-evaluate how to best proceed with the remaining sites.

Additional information can be acquired from the following website:

http://www.env.gov.bc.ca/epd/epdpa/mwr/pbcwfbsd.html

The regional office on the west coast can be reached at:

Office of Boating Safety (Pacific)
25 Huron Street
Victoria, BC V8V 4V9
Tel: (250) 480-2792

Maintaining vegetation buffer zones around the lake on private property protects habitat for animals and helps filter out contaminants before they enter the lake.

Many of the management actions presented are preventative. If carried out they should prevent certain problems from occurring or worsening. The plan provides information about the issues and how future problems may be avoided. Public education is key to the success of many of the options in a lake management plan.

Action through influencing land use decisions

Influencing land use decisions can be achieved through participating in planning and permitting processes that affect the watershed.

Influencing forestry decisions in the watershed will require the LPS to be involved in all planning processes. A representative of the LPS has been involved in the Land and Resource Management Plan (LRMP) processes in the area for three years. A representative should also be involved in MOF five year development plans. The Regional District should be contacted to ensure that a representative of the LPS is involved in the planning processes for zoning in the Francois Lake watershed. Guidelines for development along lakeshores may be an option that the society may wish to pursue through the Regional District. These types of guidelines would be specific to protecting aquatic habitat. Continued representation of the LPS on the Endako mine public liaison committee is recommended.

Industrial use of herbicides requires a permit through the Ministry of Environment and the permit application must be advertised. Communication between the society and the Ministry of Forests and forestry companies is advised so that the society is informed of applications for herbicide use and proposed fertilizers use.

Public education about the effects of different activities and development on the lake water quality and ecosystem health can influence the choices made by the residents living around the lake. Participation of the residents, recreational and agricultural users of the lake and watershed in the protection of water quality, habitat and wildlife is essential for long term safekeeping of these values. Commitment of the LPS to implement the options in this plan will go a long way towards educating the public and involving all stakeholders in the goals and objectives of this plan.

2.4 Outstanding Issues

There were some issues that it was not possible to address in this plan at this time (Table 1). They were ranked as lower priority and may be included in future revisions of the plan, provided they are deemed worthy of further research and consideration.

TABLE 1. Issues for future consideration.

Issue		Concern
Road Construction	-	establishing LPS input into decsions making process associated with road construction
Beaver Population	-	effect on aquatic plants
	-	effect of dams on fish passage and populations
	-	impact on aesthetic value of riparian area
Aquatic Plants	-	control of aquatic plant growth at the mouth of the Nithi River

3. METHODS

3.1 Strategic Planning/ Systems Design

There are two standard ways of approaching a problem. One way is to use tactical thinking and the other involves strategic thinking (Spitzer 1991). Tactical thinking is short-term and treats only the symptoms of a problem as opposed to strategic thinking which is long-term and treats the causes of the problem. Lake management planning involves complex issues and a strategic approach is the most appropriate one. In general, a tactical approach may be the simplest and appear to be the least expensive. However, a tactical approach to a problem is usually an expensive one because the problem is never solved and the symptoms will keep reappearing (Rast and Holland 1988). A strategic approach requires long term commitment and may be expensive but it is the most practical and efficient approach to solving a complex problem.

To address the problem of designing a strategic lake management plan for Francois Lake, a systems approach was taken. This approach is warranted due to the complexity of the problem(s) and the variety of the stakeholders. This is a problem solving model which is designed to initiate creative thinking about exceedingly complex physical and social phenomena which interact and evolve over time (Spitzer 1991).

The systems design approach is used to set up a framework for decision making which is flexible enough to allow integration and consideration of new information and data as it is made available.

There are five phases to the systems design approach; analysis, design, development, implementation, and evaluation/revision. The design model is interactive and the process is non-sequential as illustrated in Figure 1.

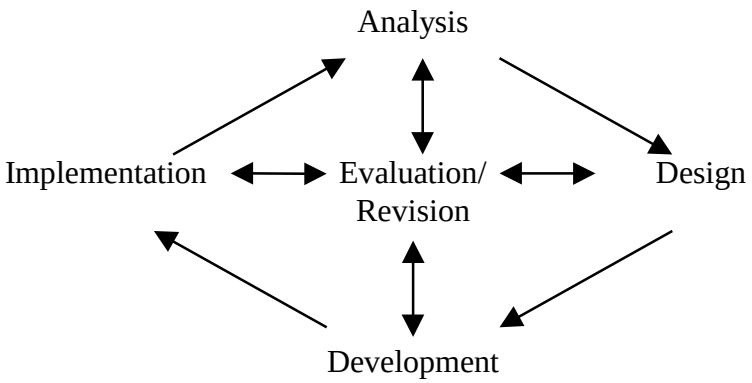


FIGURE 1. Interactive Model of the Systems Design Approach (Spitzer 1991)

- **Analysis** is the process of identifying and refining the goals and requirements of the lake management plan. The water quality characteristics of a specific water-body can affect the selection of specific management goals.
- Phase two is **design**. Specifications for meeting the lake management goal and requirements are identified by this process.
- **Development** is phase three. This is the process of improving and revising the plan according to feedback from the stakeholders based on the initial design.
- The **Implementation** process involves trying out the plan to see if it works.
- **Evaluation and Revision** are implemented throughout the process. Phase five is used to evaluate the system, identify improvements and make changes to the system accordingly. It is acknowledged that evaluation/revision drives the systems design process and therefore the plan is never completely finished, and will always be subject to improvements through testing and evaluation.

Systems design goes from the general, exhaustive inventory and analysis of the inter-related systems and system components, through a process of analysis and refinement, to a decision making process which uses a refined set of systems and system components. The process is iterative in nature and uses an interactive approach that allows and encourages stakeholders to participate throughout. For more information on the analysis of interrelated systems see Section 6 and Appendix A.

A more thorough discussion on the systems design approach and a breakdown of the system components can be found in the Generic Lake Management Plan (Lightowlers 1995).

3.2 Consensus Building

A successful lake management program begins with a lake management plan that has widespread support from stakeholders. It is essential to involve all interested groups and regulatory agencies in the planning process to discuss the issues and work toward

achieving a consensus (Gibbons *et al* 1994). Persons that are invited to participate at an early stage of the planning process are more likely to become advocates of the program. This is essential for implementation and perpetuation of the plan (Rast and Holland 1988). Stakeholders include government agencies, lake residents, lake user groups, environmental groups and others. For a list of contacts and stakeholders involved in the Francois Lake Management Plan, see Appendix B.

Due to the complexity of the concerns and the variety of the stakeholders, consensus building is a very important part of the lake management planning process. The plan design must acknowledge that lake management planning is a group endeavor and that each person's opinion is important and should be recognized (Gibbons *et al* 1994). There is no substitute for local knowledge of the lake's problems and/or a lifetime of observations of a lake (Rast and Holland 1988). This knowledge can be documented for use in developing the management program.

All interested parties should be involved from the formative stages and throughout the planning process to constructively discuss the issues and work towards achieving widespread support. During the planning process it is critical to conduct public meetings and keep the community informed. Key times for conducting stakeholder meetings have been identified and include; during identification of the plan goals and requirements, when possible alternatives have been identified, after a plan has been selected but before it is carried out, during implementation of the selected lake management program, and once a year after a plan has been implemented to conduct post-treatment evaluation and revision of the long term plan (Gibbons *et al* 1994).

Due to the technical nature of various issues, sometimes it is necessary to use the knowledge of experts to clarify misconceptions (Gibbons *et al* 1994). The goal of consensus building is to inform and assist decision making by identifying advantages and disadvantages of different lake management options. The advantages of different lake management options should be compared and assessed by individual stakeholders who then must collaborate and come to an agreement on the most effective and feasible plan (Shaffer 1993).

The key role of the lake management planner is to ensure at an early stage that the goals and objectives of the lake management plan are acceptable to all stakeholders.

4. NUTRIENTS IN LAKE SYSTEMS

Over tens of thousands of years, lake basins change in size and depth as a result of climate, movements of the earth's crust, shoreline erosion, and the accumulation of sediment. The water quality in a lake reflects in part the cumulative effects of the materials carried in all waters flowing into the waterbody (Rast and Holland 1988).

4.1 Trophic Status

Trophic status refers to the amount of biological productivity in a system and is directly related to nutrient inputs. The amount of algae, aquatic plant growth, transparency, chlorophyll a levels, phosphorus concentration, dissolved oxygen in the hypolimnion (bottom layer of a thermally stratified lake), and growth of other organisms, such as fish, are all indicators of trophic state. Highly productive lakes are called eutrophic and are most often relatively shallow and warm in the summer. Lakes which produce little aquatic life (mainly algae and macrophytes) are called oligotrophic. These lakes are characteristically deep and cold, usually with clear water and rocky shores. There is a continuum of trophic states that range from ultra-oligotrophic to hyper-eutrophic.

The productivity of a lake is dependent on many factors. One of the most important is the amount of nutrients, particularly phosphorus, in the water. Individual lakes or reservoirs will respond differently to phosphorus loading because of morphological differences related to depth, water residence time, degree of stratification and watershed characteristics such as geology, soil type, vegetation, topography, and climate (Daniel *et al* 1994).

Eutrophication is part of the natural aging process of small lakes. This is a slow process associated with the gradual build up of organic matter, nutrients and sediments in lake basins through which an open lake can become a marsh and eventually fill in completely. During this process, rooted plant biomass will increase, water clarity will become reduced, the lake volume will decrease and algal blooms can become more frequent.

Cultural eutrophication is a term used to describe the accelerated rate of the eutrophication process due to human settlement, clearing of forests, and development of farms within a lake's watershed (Rast and Holland 1988). These activities increase the rate of nutrient enrichment and biomass production by increasing nutrient inputs to the lake. A lake that is undergoing cultural eutrophication can be restored so that it will again have water quality that is more characteristic of the natural situation . However, if cultural eutrophication is left unmanaged, the result will be significant ecological changes (water quality degradation) and a significant reduction in appeal of the lake for residents and recreational user groups who use it.

Francois Lake is a deep lake with a large surface area and a large volume. It is oligotrophic and moderate inputs of nutrients to the lake do not change the nutrient cycling in the lake. Francois Lake water samples collected between 1997 and 1999 provide an estimate of the concentrations of phosphorus and nitrogen in the lake (Section 5).

4.2 Nutrients- Phosphorus and Nitrogen

Aquatic life has several requirements for survival and growth. For algae and aquatic plants, these requirements include sunlight, oxygen, hydrogen, carbon, nitrogen, phosphorus and other micronutrients. The ratio of carbon(C):nitrogen(N):phosphorus(P) by weight in plants is 40C:7N:1P and this is the ratio that is needed in their environment for growth (Wetzel 1983). If sunlight and other micronutrients are available for growth, then phosphorus will be the first major nutrient to become limiting. Additional phosphorus that enters the lake environment will result in increased levels of photosynthesis and therefore, growth of algae and aquatic plants. If phosphorus is in excess within the lake, then there will be a high level of photosynthesis until nitrogen becomes scarce and therefore, the next limiting nutrient (Wetzel 1983). Most lakes are phosphorus limited but some are nitrogen limited or co-limited by phosphorus and nitrogen. It should be noted that only the dissolved reactive fraction and some portion of the particulate fraction of phosphorus are available to organisms for growth (Cooke *et al* 1993). Therefore, while phosphorus in biota is recycled very quickly phosphorus that is bound in the sediments is not available for growth. Of the major nutrients, phosphorus is the most effectively controlled using engineering and land use management (USEPA 1990).

4.3 Phosphorus Limited Lakes

Growth of algae and aquatic plants can cause low oxygen levels, decreased recreational value due to odors and aesthetics, and poor habitat for other aquatic organisms such as fish (Wetzel 1983). Since the rates of biological productivity of many lakes are governed by the rate of phosphorus cycling (Wetzel 1983), decreasing phosphorus inputs is generally the most effective method to reduce excessive growth of algae and aquatic plants.

Phosphorus is chemically reactive, technologically easier to remove from water than nitrogen, and does not have major reserves in the atmosphere (Wetzel 1983). These characteristics make phosphorus better suited for removal from lakes and for attempting to control its input from various sources. Once external loading to a lake is decreased, the lake will require at least 2 to 10 years to recover from eutrophication symptoms such as increased algae growth (Wetzel 1983). The exact number of years will depend on the water exchange time of the lake (flushing rate).

4.4 Nutrient Sources- Internal and External Loading

Nutrients entering a waterbody can come from both internal and external sources.

Internal sources

Internal sources include nutrient cycling through plant growth and decay, groundwater and sediments. The chemical equilibrium in the lake, and especially at the sediment-water boundary, dictates how much phosphorus is released from the sediments. Phosphorus is resuspended into the water under reducing conditions (chemical reactions favoring reduction reactions as opposed to oxidation), when there is a low oxygen concentration at the sediment- water boundary.

External sources

External sources are grouped into "point" and "non-point" sources.

Non-point nutrient source- A dispersed source that cannot be traced to any single source, such as a pipe. These sources usually originate from land use activities (Gibbons *et al* 1994). Examples include runoff from forest practices and agriculture practices, urban stormwater runoff, and construction sites. These sources can reduce the quality of the surface water through runoff and/or ground waters through leaching.

Point Source- A source that discharges through a pipe, creek, ditch or culvert. Point sources include sewage treatment facilities.

4.5 Nutrient Models

A mathematical model serves as a descriptive and quantitative tool for the construction of a nutrient budget. These models can be useful both in diagnosing problems and in evaluating alternative solutions. Since phosphorus is central to the productivity of many lakes, many models focus on phosphorus loading. These models can account for the phosphorus loading due to climate, watershed characteristics and human activities (including land use). Depending on the model chosen, these values are modified by environmental factors to give the lake's average phosphorus concentration. The relationship between the land use and the lake trophic quality can be explored and quantified through modeling (see Tyhee Lake plan section 2.4 & 4.2.2.5).

The prediction from a model is inherently uncertain because it is a simplification of the "real" world. However, the model can be used along with a prediction of the uncertainty of the model to indicate the relative value of the information contained in the prediction. This allows those making management decisions to understand where and to what degree there are uncertainties. These uncertainties can then be factored into the decisions. There are several different models, some better suited to certain types of lakes. Each model has a certain level of associated uncertainty that is dependent on the complexity of the model and on the factors that are addressed.

Once the phosphorus concentration is predicted through the application of the empirical model, it is useful to interpret this prediction in the context of expected water quality characteristics for the lake of interest. A nutrient budget like that shown in Figure 2 and at least one years worth of lake data is necessary before lake management actions can be identified.

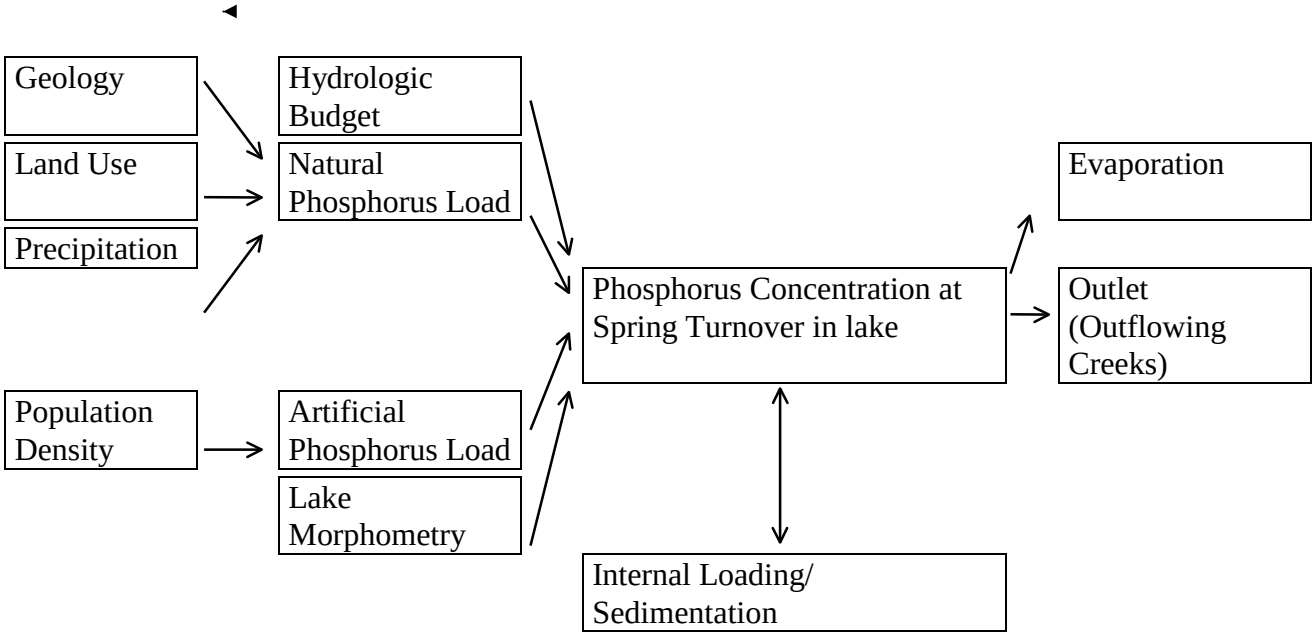


FIGURE 2. Diagram of a Typical Nutrient Budget (adapted from Dillon, and Rigler 1975). Total Nutrients into the lake minus the total nutrients out of the lake should equal the total phosphorus concentration in the lake at Spring turnover plus or minus the internal nutrient loading (if sediments are a source of the nutrient) or sedimentation rate (if sediments are a sink for nutrients).

5. WATERSHED & LIMNOLOGICAL INFORMATION

This section of the lake management plan includes a description of the area, including maps, morphometric and hydrologic data, and an accurate summary of all measurement methods and sampling locations.

5.1 Watershed

Francois Lake is a long (106 km) narrow lake located on the Central Interior Plateau of British Columbia near the geographic centre of the province (Figure 3). The lake lies at 54N latitude, 126W longitude. It is south of the town of Burns Lake and is within the Regional District of the Bulkley-Nechako; Skeena Region. The drainage basin is outlined in Figure 4 (Skeena GIS 1999), and is approximately 1536.1 km^2 in size. The drainage basin is determined by the physical height of the land and the boundary outlines the area within which all water flows towards the lake.

Land use activities

Land use activities in the Francois Lake Drainage Basin include:

- agriculture -livestock
  -cultivation/harvesting
- forestry
- mining (molybdenum at Endako)
- residential
- fishing lodges / resort/campgrounds

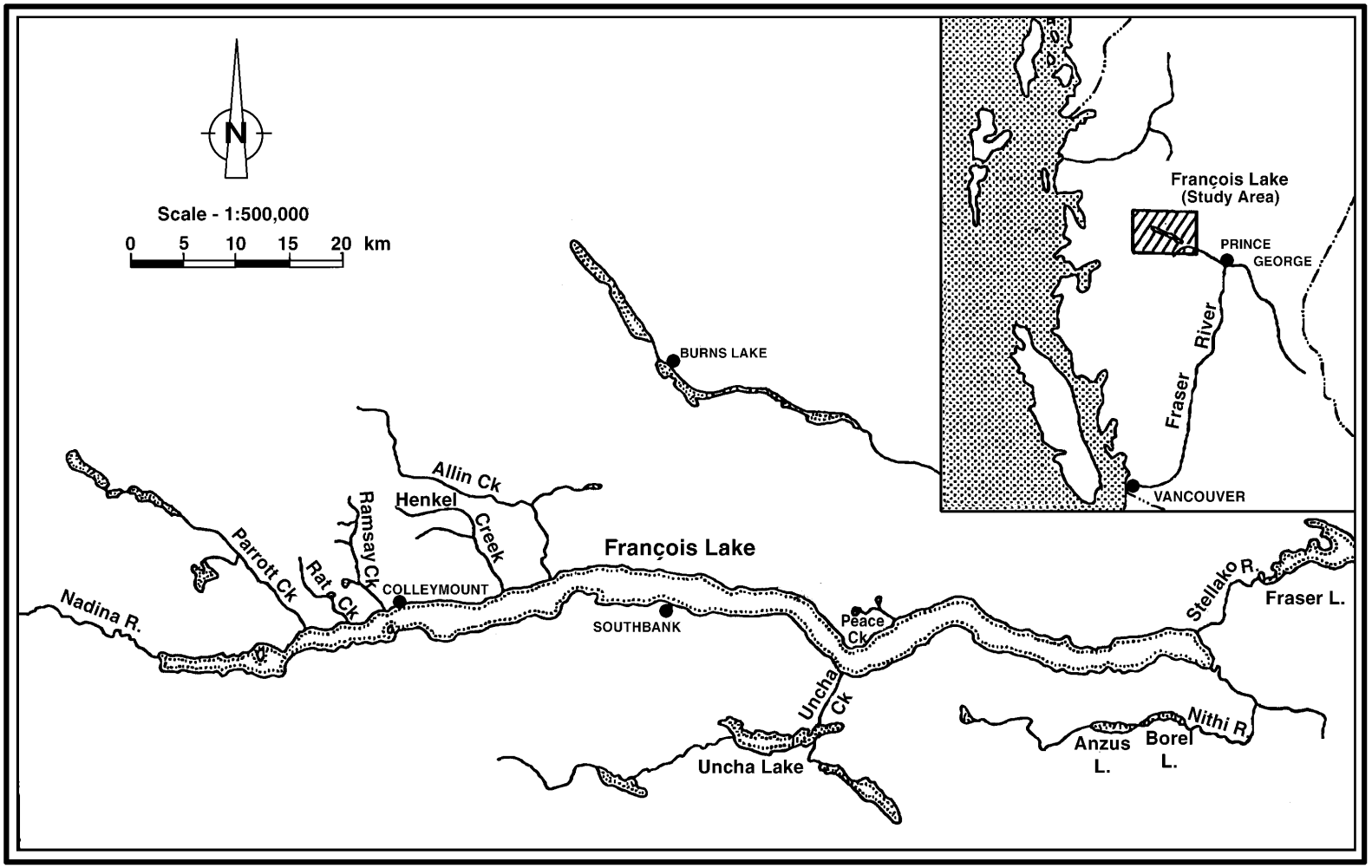
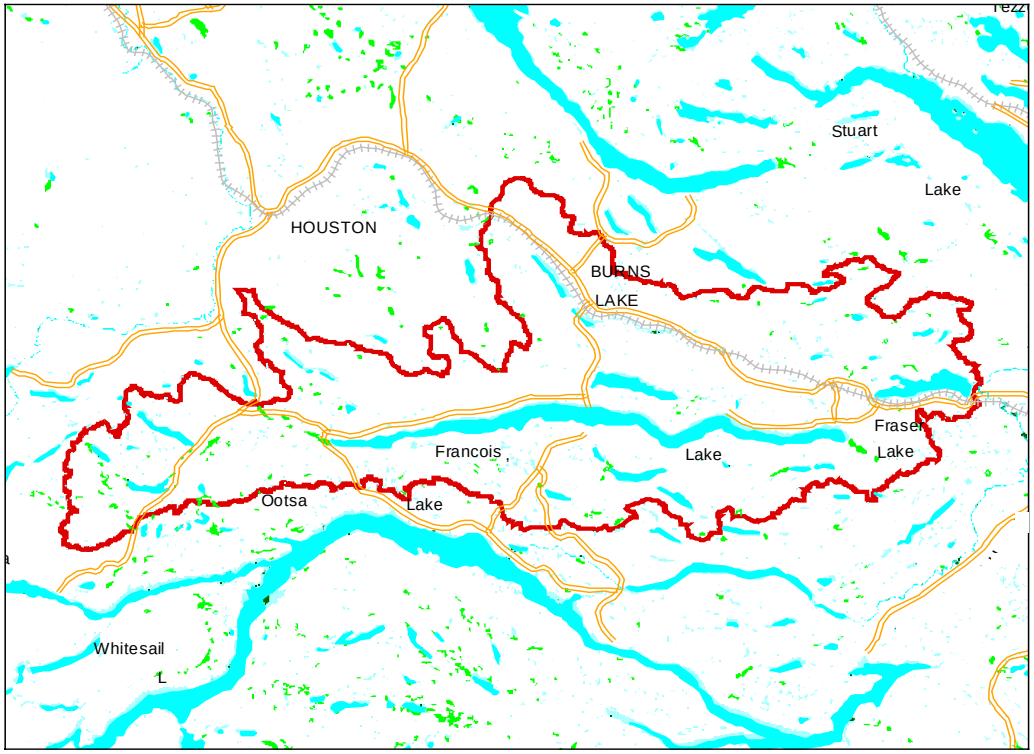


FIGURE 3: Location of Francois Lake

Figure 4: Francois Lake Watershed Area



N
W E
S
(at map centre)

Rivers, Lakes and Wetlands -
Lakes ,River/Stream
Marsh

Transportation
Roads
Railway Tracks

Watershed Boundary

Scale: 1:1105520

20 0 20 Kilometers

BC Min. Env. Lands, Parks
Skeena Region
October 9, 1999

Zoning

Reduction in the productive capacity and loss of the quality of aquatic habitats is occurring at an accelerated rate within the developed and developing portions of regional districts. Considerable effort has been spent by concerned groups over the last several years, to provide the public, land owners and developers with specific information and development guidelines designed to assist them in proceeding with their developments while minimizing the impacts on aquatic ecosystems (White *et al*. 1996) However, even with these initiatives in place, complete loss or reduction in productive capacity of aquatic habitats is still occurring through deliberate or misguided development activities. The Francois Lake watershed is located in Electoral District D and E. Currently the zoning of land within the Francois Lake watershed is determined and restricted by the Bulkley Nechako Regional District Zoning Bylaw No. 700, 1993. This document does not adequately provide protection for aquatic habitat or deteriorating water quality. Therefore, options for the incorporation of lakeshore development bylaws/ regulations need to be explored.

Ilene Benedict is the Director of Electoral District E and Ralph Roy is the Director of Electoral District D in the Bulkley Nechako Regional District. Mark Andison is the Director of Planning in the Regional District. All will be among the reviewers of the plan, since they may play significant parts in achieving consensus on needed management options.

Water sources - tributaries and groundwater

Sources of inflow water into the lake include groundwater, creeks, Nadina River, precipitation, and overland runoff (water flowing over the ground following a precipitation event or spring melt). The four major drainages include the Nadina River, Uncha Creek, Parrott Creek and the Nithi River. As well numerous smaller tributaries, many of which dry up in the summer season, discharge directly into Francois Lake. The major western inlet, the Nadina River, is an important contributor to late summer flows in the system. The only outlet is Stellako River which drains Francois Lake into Fraser Lake (Bustard 1988).

Water body usage map and Bathymetric map

The water body usage map provides a visual representation of the specific uses of the lake. Specific uses of Francois Lake include the ferry crossing, boat launch areas, waterfowl nesting areas, wetland areas for a variety of wildlife including furbearers, water supply intakes, and fish spawning areas. These should be drawn on a water body usage map and included in the next draft of the Francois Lake Management Plan. It should be used and updated by the LPS as conditions in the Francois Lake watershed change over time.

A bathymetric map, provides depth data for the lake. The standard method for collecting bathymetric data is by continuous paper traces from a recording electronic sounder. This type of map was very useful when performing the interrelatedness analysis (considering how parts of this lake's ecosystem are related to one another) and identifying the location

of the deep basins in the lake for sediment core sampling. A bathymetric map of Francois Lake can be obtained through the Ministry of Environment, Lands and Parks, Fisheries Branch.

5.2 Limnological Characteristics

Morphometric data

Francois Lake is one of the largest of lakes in the Lakes District area having a surface area of 258km^2 and a volume of 23,087,948 dam^3. It lies at a mean elevation of 714.8 meters and has a watershed area of 3600 km^2. Table 2 summarizes the morphometric data for Francois Lake as described by Ellickson and Larkin (1969).

TABLE 2: Summary of Morphometric Data Ellickson and Larkin (1969)

Attribute	Value	Units
Elevation	714.8	meters (m)
Surface area	258	square kilometers (km^2)
Volume	23,087,948	cubic decameters (dam^3)
Mean Depth	86.7	meters (m)
Maximum Depth	244	meters (m)

Water Retention Time: This is the average time that the water remains in the lake. It equals the volume of the lake divided by the annual outflow volume. Water retention time is dependent on the bathymetric characteristics, such as lake size and depth. Based on an annual mean water discharge of 21 cubic meters per second for the period of 1929 - 1990 at the Stellako River station, (Water Survey Canada 1990) an approximate value for the water retention time of Francois Lake has been calculated. The average time the water remains in the lake is 35 years.

Flushing Rate: This is how fast the water in the lake is replaced. It is determined by calculating the inverse of the water retention time (1/retention time). Based on the above water retention time of 35 years, the flushing rate of Francois Lake is estimated to be 3% per year.

Physical / chemical water quality characteristics

In February of 1997 two sampling sites were established on Francois Lake. Table 3 lists the sampling sites, their description and their site number. Sampling has been conducted at these sites in the winter of 1997 and the spring of 1998 and 1999. Table 4 contains the temperature, oxygen, conductivity and pH readings obtained in the winter of 1997.

TABLE 3: Sampling sites within Francois Lake established in February of 1997

Station type	Description	Site Number
Deep Station	West End Francois Lake Road - Km 47	E224945
Deep Station	East End Francois Lake Glenannan Road	E224946

It is intended that two more sampling sites will be established. One will be located near the ferry crossing.

TABLE 4: Physical and chemical water quality characteristics at the Francois Lake deep sampling sites in February of 1997.

Site Number	Depth (m)	Temperature (°C)	Oxygen (mg/L & % saturation)	pH	Conductivity (Ts)
E224945	1	0	13.9 (99%)	9.34	83.8
	40.5	1	12.4 (90%)	8.34	72
	78.5	3.5	11.6 (87%)	7.8	66
E224946	1	1	14.8 (112%)	9.78	79
	30	2.5	17.7 (131%)	8.55	66.9
	58	3	11.8 (91%)	9.13	70.4

Transparency (Secchi Disk)

The transparency of the lake is related to the density of algae and total suspended solids. Transparency can be an indicator of the trophic status of a lake (Michaud 1991) but it is a difficult parameter to set objectives for. The more transparent the lake, the deeper light will penetrate resulting in higher growth rates of rooted aquatic plants (Cooke 1993). The black and white Secchi disc is lowered into the water with a rope until it is no longer visible, at which point the depth is recorded. The assumption is that the greater the Secchi depth, the better the water quality of the lake. The Secchi disc reading at sampling stations on Francois Lake in 1971 and 1999 have been listed in Table 5.

TABLE 5: Secchi Disc measurements for Francois Lake in meters (MELP, 1984)

Sampling Date	Station (depth in meters)			Mean
July 28, 1971	Nithi Lodge 10.1	Southbank 10.7	McDonald's Landing 7.9	9.6
July 08, 1999	East End of Lake 7.3 to 7.75			7.5

Temperature profile

A temperature profile indicates the effects of temperature on the aquatic life, chemistry and water density of the lake. Temperature profiles reveal if a lake thermally stratifies (indicated by gradual changes in temperature with depth), whether stratification is complete, and can also indicate how often turnover occurs. Turnover is complete when the water column is isothermal (uniform temperature and density at all depths). At a deep station in the lake temperature measurements are taken at regular depth intervals. If the temperatures differ then the lake is thermally stratified.

Thermal stratification in the summer months consists of three layers; the epilimnion (the upper warm, well mixed and oxygenated zone), the metalimnion (the middle strata of rapidly decreasing temperature), and the hypolimnion (the dark, cold bottom strata). Thermal stratification also occurs in the winter months. The temperature in the hypolimnion during the winter is generally 4° C, while the temperatures in the epilimnion are colder.

Dimictic lakes have a turnover event twice a year, once in the spring and once in the fall. With the onset of spring, the sun will warm the upper layer of water in the lake and when acted upon by wind action this layer will mix with the other layers, termed turnover. With the continued warming, the lake will again slowly become thermally stratified. In the fall, with the cooler temperatures, the lake may once more become isothermal, and have complete mixing, before it stratifies a second time.

Dissolved oxygen profile

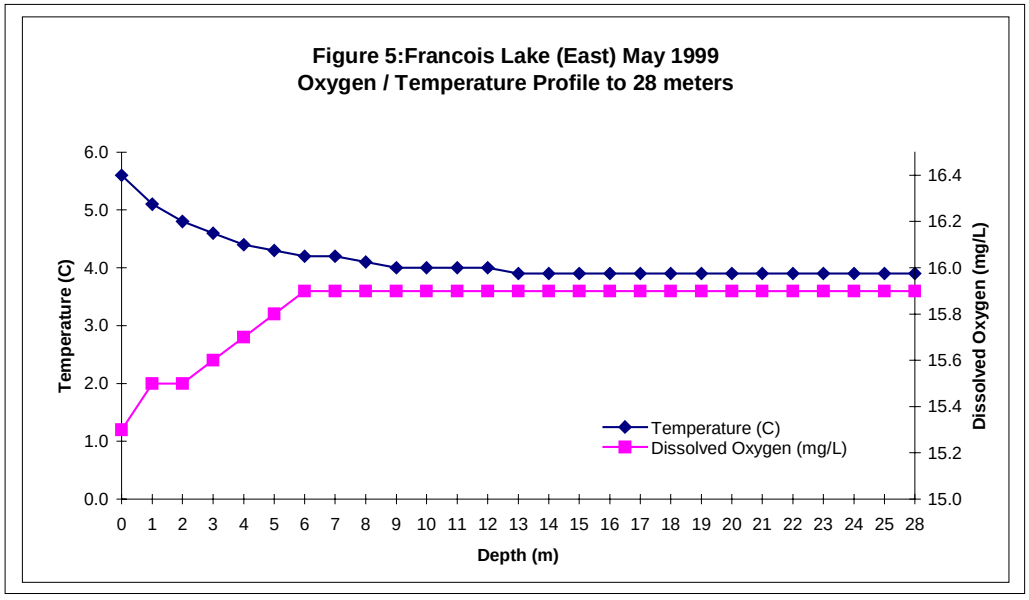
The amount of oxygen in the water is an important indicator of overall lake health. Oxygen drives many of the biological and chemical processes in a lake and is essential to the survival of most aquatic organisms.

Cold water holds more oxygen than warm water, so as the temperature of water increases, oxygen is released to the air (Cooke *et al*., 1993). Dissolved oxygen levels increase through exchange at the surface waters, wind mixing the epilimnion, photosynthesis and the inflow of oxygen rich water into the lake. Dissolved oxygen levels in the lake are strongly correlated to the thermal profile. During spring and fall turnover of the lake, the water becomes isothermal and the lake destratifies. Loss of the thermal layering in the lake allows oxygenated surface waters to mix with oxygen depleted deeper layers. In this way, the water in the lake becomes replenished with dissolved oxygen. Figure 6 illustrates the relationship between temperature and dissolved oxygen.

Dissolved oxygen levels, phosphorus concentrations and algal growth in the water are all related. The movement of phosphorus between the water column and the bottom sediments is regulated by the oxygen concentrations at the sediment/water boundary. If

the water at the sediment-water boundary contains no oxygen, phosphorus is released through "reduction reactions" from the sediments and into the water column (oxidation reactions). If the water at the boundary is oxygenated, phosphorus is trapped in the sediments. An increase in phosphorus concentration leads to increased algal growth. This growth leads to two oxygen related effects. One is that the photosynthesis of algae gives off oxygen, and the second is that the decomposition of algae after they die utilises oxygen. This chemical oxygen demand from the decomposition of algae can be quite high if there has been a lot of algae growth. In addition, plants and algae respire at night, which depletes dissolved oxygen (Cooke *et al*., 1993). The overall, biochemical and chemical oxygen demand can be greater than oxygen replenishment. The resulting anoxic conditions persist until the water is replenished with oxygen during the next turnover.

Figure 5 shows the May 1999 oxygen / temperature profiles for the Francois Lake east sampling site to a depth of 28 meters. The figure illustrates relatively isothermic conditions for both oxygen and temperature. Suspected equipment problems prevented the collection of good data for the lake's west end sampling site. Due to the great depth of the lake and the limitations of the equipment being used there is not a complete set of oxygen or temperature profiles for Francois Lake to date.



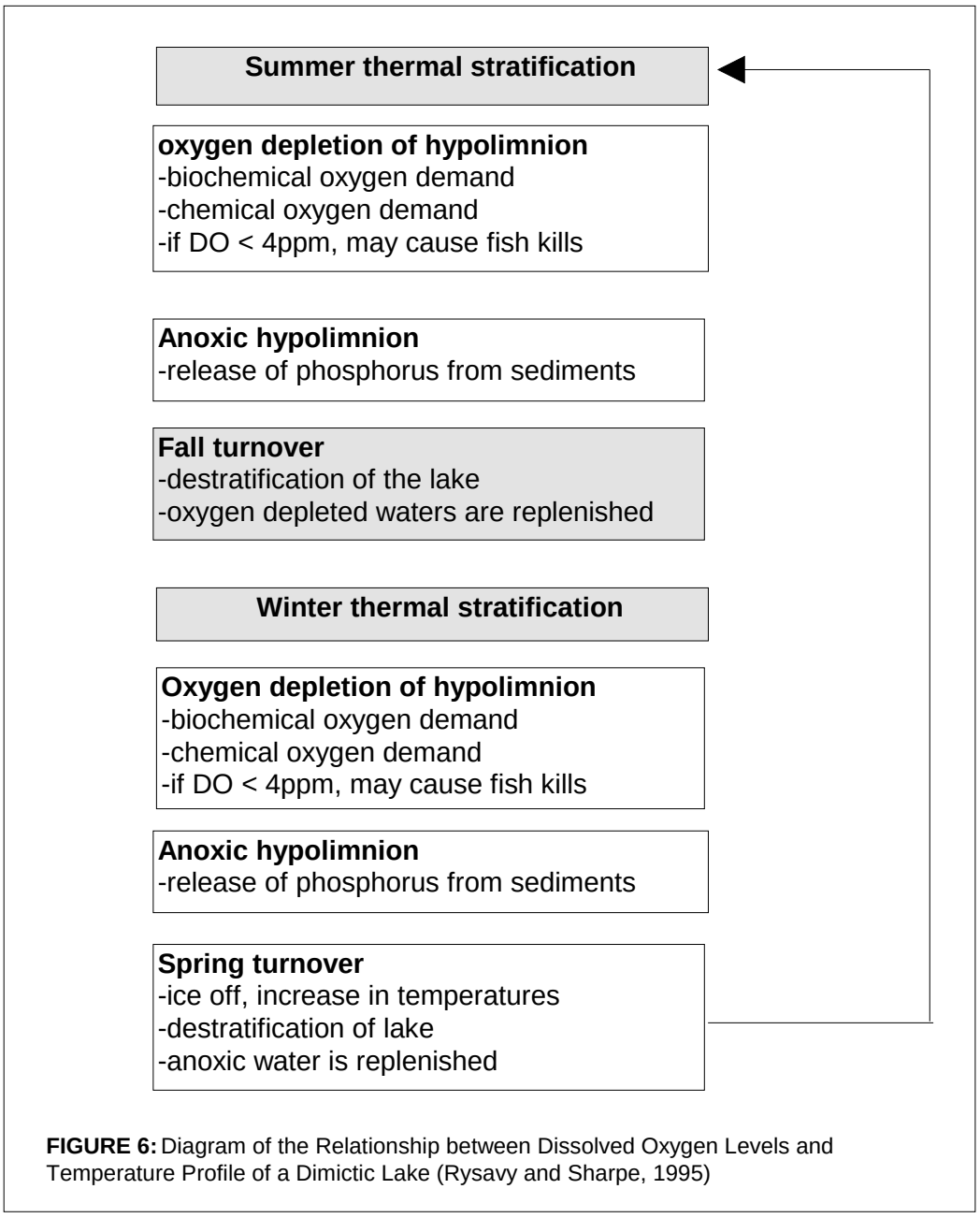


FIGURE 6: Diagram of the Relationship between Dissolved Oxygen Levels and Temperature Profile of a Dimictic Lake (Rysavy and Sharpe, 1995)

Alkalinity/ pH

The buffering capacity (alkalinity) is a measure of a lake's ability to neutralize acid inputs and thereby resist changes in pH. The higher the alkalinity, the greater the ability of water to neutralize acids. Alkalinity is influenced by the geology of the surrounding watershed. pH on the other hand is an indication of water acidity and is measured on a scale of 0 - 14. The lower the pH, the higher the concentration of hydrogen ions and the more acidic the water. Values less than 7 indicate acidic water conditions while values greater than 7 indicate basic conditions. Although pH is easily measured in the field, it is

accurate for up to the minute conditions only. This is because, as a result of gas diffusion, biological activity and chemical reactions, lake water pH values may change rapidly. For this reason alkalinity is considered a more useful parameter as a long term monitoring tool. The water quality standard for alkalinity should be "no measurable change from its natural conditions" (Michaud 1991).

Nutrients - phosphorus and nitrogen

Nitrogen and phosphorus are usually the two limiting nutrients in freshwater systems. Before a lake management action plan can be identified, it is important to determine which is the limiting nutrient in the lake or if the nutrients are co-limiting. Lakes are most commonly phosphorus limited (Rast and Holland 1988). The weight ratio of nitrogen to phosphorus was calculated for Francois Lake using the sampling results obtained between 1997 to 1999. If the weight ratio of total nitrogen to total phosphorus in the lake is greater than or equal to 15:1, plankton growth is limited by the availability of phosphorus and if the weight ratio is less than or equal to 5:1, plankton growth is limited by nitrogen (Boyd *et al.*, 1985). The average total nitrogen to total phosphorus weight ratio for Francois Lake, over the last three years is 45:1. This indicates that plankton growth in this lake is limited by phosphorus. It would be useful to obtain additional data on the ratio of N:P in the lake by sampling about 4-6 times over the course of an entire year. Following identification of the limiting nutrient or nutrients in the lake, it must be determined whether the majority of the nutrient loading to the lake is coming from internal or external sources (Cooke *et al.*, 1993). Internal sources include nutrient recycling, groundwater and sediments whereas external sources can be grouped into point sources such as septic systems and creeks and non-point (diffuse) sources such as overland runoff from agricultural land, forestry practices and new developments.

5.3 Biological Characteristics

In order to document current biological conditions there needs to be the following surveys:

Algae and aquatic plants

Algal biomass and species diversity are an indicator of trophic status in a lake. Excessive growth of one or more species of algae is termed a bloom. The regular occurrence of visible algal blooms generally indicates that nutrient levels in the lake are too high, which is often a symptom of cultural eutrophication. Too many algae and the wrong kinds can interfere with some lake uses by, among other things, clogging the filters in drinking water intakes and causing taste and odour problems in water and fish. The most common use of lakes is aesthetic enjoyment, and excess algae can interfere with this simple pleasure.

There are several types of aquatic plants, submerged plants, emergent plants, rooted plants and floating (non-rooted) plants. Rooted plants are dependent on available nutrients in the sediments, whereas floating plants are dependent on levels of available nutrients in the water column. Like algae, aquatic plants are a vital part of the lake because they provide cover for fish and food for wildlife. However, too many aquatic plants can limit swimming, fishing, boating and aesthetic appreciation.

Based on the information provided by Francois Lake residents, excessive algal growth is not a problem, however there has been concern raised over aquatic plant growth along the Nithi River at the east end of the lake. Work is to be carried out in the next year or two by the Fisheries Branch of the Ministry of Environment to rehabilitate the Nithi River and prevent it from drying up each summer since it contains important fish spawning habitat. An aquatic plant survey and inventory along the river both prior and post rehabilitation would provide useful information when deciding whether aquatic plant control efforts are necessary and which methods would be effective. Interested parties should refer to a guide published by the Washington Department of Ecology called "A Citizen's Manual for developing Integrated Aquatic Vegetation Management Plans" (Gibbons *et al*. 1994).

Elodea canadensis

According to the residents on the east end of Francois Lake, *Elodea canadensis* has been identified as being one of the aquatic plants growing in the mouth of the Nithi River. *Elodea canadensis* is endemic to North America. The northern limit of the plant may be in the vicinity of the town of Vanderhoof (lat:$54^0$1'N, long:$124^0$01'W) and Lake Wabamun (lat:$53^0$33'N, long:$114^0$35'W), (French and Chambers, 1992). It is commonly found at depths of 1 to 8 meters. The literature suggests that once introduced into a region, *E. canadensis* tends to disperse rapidly. It reproduces mainly by fragmentation. Fragments of the plant can be detached from the parent plant by water traffic, animals, currents and waves. The fragments eventually settle to the sediments and take root. (French and Chambers 1992). This plant has two overwintering strategies. It can over winter as an entire plant or as dormant species which germinate in the spring. *E. canadensis* has a history of population explosions and sudden declines, the causes of which are unclear. It has been suggested that iron may be the primary micronutrient limiting the growth of *Elodea* species (French and Chambers 1992).

Aquatic plants can accumulate non-essential elements such as arsenic, copper, mercury lead and cadmium. *E. canadensis* has been shown to mobilize copper, lead and cadmium from the sediments, transport them to the stems and leaves and subsequently release them to the water column. The apparent ability of macrophytes to cycle metals from the sediments to the water column has significant ecological implications. The transport of metals from the sediments to the water column would result in metals being incorporated into the aquatic and terrestrial food chains, especially in the vicinity of certain industrial operations which may inadvertently contaminate bottom sediments with metals.

Zooplankton

Zooplankton are an important part of the food web in a lake system because they feed on algae. In natural food chain interactions zooplankton populations play a balancing role as nature's direct algae control mechanism (Wallis 1995). From an environmental managers point of view zooplankton populations can act as lake "guardians" against algae over abundance. Therefore it is important to maintain healthy zooplankton populations in the lake. Zooplankton also serve as a food source for fish (Gibbons *et al*., 1994).

Fish

Francois Lake has an important population of rainbow trout (per. comm. Sig Hatlevic 1997). Eight tributary streams of Francois Lake were found to be major contributors of juvenile rainbow trout to the lake fishery in a study conducted by David Bustard in 1988. They are the Nadina River, Nithi River, Ramsay Creek, Uncha Creek, Stellako River, Parrott Creek, Henkel Creek, and Allin Creek, all shown in Figure 3.

At the east end of the lake, the section of the Nithi River extending approximately 4 km upstream from its confluence with Burns Creek is classified as excellent rainbow trout spawning habitat (Bustard 1995). The Nithi River has been described as probably the most important spawning system in the Francois Lake System. Other fish species that were inventoried in the lake are lake trout, kokanee, sockeye, burbot and squawfish (per. comm. Sig Hatlevic 1997).

Terrestrial wildlife and waterfowl

Song birds nest in the riparian vegetation near the lake shore. There are large numbers of breeding and migratory waterfowl that utilise the lake. Swans are known to utilise the open channel provided by the ferry in the winter time. Eagles, hawks, owls, moose, black bears, coyotes, beavers, and deer also depend on the lake and nearby wetlands as a part of their life cycle habitat requirements and are therefore a part of the lake biota.

6. DIAGNOSIS OF FRANCOIS LAKE

6.1 Interrelatedness Analysis

In the analysis stage of the plan, three systems (socio-economic, biological, and physical) were identified. The systems are artificial and most likely incomplete but were a systematic attempt at identifying and classifying all the important and controllable aspects of the lake system and it's watershed.

A complete inventory of all components of the lake and watershed was developed in conjunction with the issues identified through the consensus exercise. The interrelatedness analysis created an overview of the entire lake ecosystem and it's components and how these relate to social, economic and political factors.

The matrix of lake components used in the Interrelated Analysis is found in Appendix A. This exercise helped to give direction to the plan by defining the key components relevant to Francois Lake. In the event that a professional limnologist or expert in the field of lake management is developing the plan, some of this exercise may be unnecessary, as the expert may be able to identify key components based on prior experience.

Key components of the physical system

Physical habitat

The lake has three distinct and interacting biotic communities. These include the wetland-littoral zone and its sediments, the open water pelagic zone and the benthic (deep water) zone and sediments (Cooke *et al.*, 1993). The interaction between the three communities is such that any mechanism affecting one zone will ultimately affect the other two zones as well. All three zones provide reproductive, feeding, resting and escape habitat for different species of aquatic and terrestrial wildlife. Through nutrient enhancement, the ecosystem is altered and as a result the populations and species of wildlife will change.

New waterfront development may destroy shoreline vegetation and wetland areas, thereby destroying habitat for wildlife including waterfowl. Many residents and recreational users maintain an interest in waterfowl and other wildlife and wish to see their long term survival. Working towards this goal would also serve to maintain the visual quality of the lake which would benefit all lake users.

Riparian vegetation can slow overland runoff to the lake, thereby slowing the flow of nutrients into the lake. Lush riparian vegetation is often an indication of added nutrients from sources such as leaky sewage systems, animal wastes or fertilizers. Riparian vegetation is an essential part of waterfowl habitat which is often altered or destroyed by gardening, landscaping and creating views of the lake. Removal of riparian vegetation can also lead to increased shoreline erosion thereby altering vital feeding, escape and reproductive habitat for fish, waterfowl, and invertebrates.

Key components of the biological - chemical system

Fish populations

As well as adding to the quality of life for people living in the surrounding communities, the lake contributes substantially to the economy of Burns Lake and area. Sportsfishing on Francois Lake provides valuable recreational opportunities for a large number of anglers. Francois Lake has provided a popular sportsfishery for rainbow trout and lake trout for many years. Residents, recreationalists and resort owners are concerned about maintaining healthy fish populations in Francois Lake and have suggested that fishing success on the lake has been deteriorating over the past number of years.

Reasons which have been suggested for possible declines in the fish populations include increased fishing pressure, obstructions to fish passage (i.e. culverts and beaver dams) and habitat loss resulting from erosion and sedimentation. Although Rainbow trout and Lake trout are the predominant species angled, the lake also supports burbot, squawfish and kokanee (Bustard 1989). It is essential that the lake fisheries are managed to ensure that stocks are not over-exploited and that enhancement opportunities are identified and pursued (Bustard 1989). Fish populations are protected under the Fish and Wildlife Act and are regulated by B.C Environment, Fish and Wildlife.

In the spring of 1999 (between May 20-28th), residents reported both dead and distressed Kokane and trout, first in the Uncha Creek area and then at the west end of the lake. As no potential or obvious cause could be identified, the reason for these deaths remain un-determined.

The basic needs of fish populations are; oxygenated water that is free from excessive nutrient and toxic input, and habitat - places to hide from predators and carry out their basic activities of feeding and reproduction. Most fish are both predators and prey so they depend heavily on cover - both for feeding and for safety. Some of their best hiding places are found, within 30 meters of the shore. Spawning and rearing habitat, in the lake, tributaries and outflow streams are specific habitat types that are essential to fulfill certain life cycle requirements.

Large organic debris, rocks, sediment, cut banks and food resources are all important habitat components. However, just as the lake ecosystem is dependent on influences outside the water so too are fish. Riparian vegetation, like trees, shrubs, grass and other plants around the edge of the lake are also important components of fish habitat. Riparian vegetation acts as a nursery for many insect species. Insects that fall into the water from overhanging vegetation are eaten by fish. Overhanging banks and downed wood in the water are used as hiding places because of the accumulation of food around these structures. Riparian vegetation helps ensure access to spawning areas by maintaining a high water table in dry seasons and reducing erosion and sedimentation inputs to the lake. Access to important spawning and rearing habitats, that is limited by man made or beaver obstructions can be detrimental to fish populations.

Fish also require a certain level of dissolved oxygen in their environment (> 5 mg/L for most lake species). The concentration of dissolved oxygen in the water column can be especially critical for overwintering conditions. Francois Lake is not susceptible to

oxygen deficits in the winter as demonstrated by February oxygen concentrations which were relatively high in the lower layers of the water column.

Key components of the socio-economic system

Health issues

Many lake residents still rely on drinking water that comes directly from the lakes on or near where they reside. Most of these people are connected to small community systems, or have their own private water supplies.

According to the Ministry of Health, all surface water supplies must be considered to be of doubtful sanitary quality, unless given adequate treatment, depending on the type and degree of pollution received. Surface water quality is continually changing, and is always at risk of contamination by animal feces, therefore this water needs to be disinfected regardless of periodic lab results which may show little or no contamination. Deep groundwater is usually safer than shallow groundwater, lakes or streams, and less susceptible to contamination.

Each spring as the snow melts and the ground thaws, accumulated contaminates are carried into resident's water supplies. Many of the contaminants will cause disease (i.e. Giardiasis -beaver fever, Cryptosporidiosis, Camplyobacter, Amoebiasis, Bacillary Dysentery, Hepatitis, and Typhoid - salmonella, to name a few). The toxicity of elevated metals concentrations may cause damage to aquatic ecosystems and human health problems. Metals, especially molybdenum are of special interest to the residents at the east end of Francois Lake due to their relative proximity to the Endako molybdenum mine.

A safe water supply is critical to health and well-being. Careful preparation and maintenance of domestic water supplies can avoid problems and protect human health.

Proper disposal of sewage wastes are also an essential part of health protection and disease prevention. Regardless of the wastewater treatment system being used , all require proper design, operation and maintenance.

Development / Changes to landuse

New development and forest harvesting displaces wildlife and often alters the habitat of many aquatic organisms. They can lead to increased overland runoff and the input of nutrients into a lake which over time can alter the water quality and trophic status.

External sources which contribute to nutrient loading into a lake include, fertilizer (through overland runoff), septic systems, animal waste inputs, and boat sewage discharges. This can lead to a decrease in the lake's potable water quality as well as it's aesthetic value, resulting in water that is unsafe for human contact.

Flood periods (change in the peak flows) often result from changes in land use such as timber harvesting near streams and land cleared for agriculture and residential development. Flood periods can change the water level for short periods and may be very destructive over a short time causing shoreline erosion, external nutrient loading, and damage to riparian vegetation and property on the lake.

New development and forestry practices can affect fish passage and populations by destroying riparian vegetation and wetland areas that are important for absorbing overland

runoff and preventing erosion. Fish habitat can be lost by backfilling to further develop shoreline property, harvesting too close to creeks and streams, poor placement and construction of roads and culverts near or through waterways.

Development / Forest management around Francois Lake

The watersheds of Francois Lake fall within three forest districts; Lakes Forest District, Morice Forest District and Vanderhoof Forest District. The Lakes and Morice Forest Districts are part of the Prince Rupert Regional Forest District and the Vanderhoof Forest District is part of the Prince George Regional Forest District. Within the Francois Lake watersheds there are five companies holding forest licenses to cut crown timber; Northwood, Houston Forest Products, Decker Lake/Babine Forest Products and Fraser Lake Sawmills. In addition, two Small Business Programs administered by both the Lakes and Morice Forest Districts have cutting rights within the watersheds. There are also several wood lot licenses administered by both districts. Forest development around Francois Lake and its watersheds has been taking place for over thirty years.

Forest practices (i.e. clear-cut harvesting in sensitive soils and on sloping/steep terrain near waterways) can have negative impacts on wildlife, fish and their habitats by increasing the sediment and nutrient loads of the receiving environments. For aquatic environments this will have a negative affect on the quality and quantity of water over time.

Development / Highways and Transportation around Francois Lake

There is an extensive network of unpaved roads throughout the Francois Lake watersheds. Most of these unpaved roads are haul and spur logging roads that were constructed and are maintained by the Ministry of Forests. A small portion of the north east side of the lake is unroaded. Approximately 48km of road is seal coated or paved adjacent to Francois Lake. These roads are maintained by the Ministry of Highways and Transportation. The south side of the lake is mainly unroaded along the shoreline. With the exception of a few kilometres of paved roads around the south ferry dock, there are mostly unpaved spur roads leading down to various lakeshore properties.

Francois Lake has a provincially operated ferry, the Ominica Princess, which operates year round transporting cars and passengers between the north and south sides of the lake. This ferry has a self-contained holding tank that is pumped and emptied into a septic tank on the south side which uses a septic field located just south of the restroom building. Because of the extensive number of unpaved roads adjacent to the lake that carry high traffic loads daily, there is a potential for increased sediment loading to the lake as a result of erosion and runoff. Herbicide use along the sides of these roads, removal of vegetation along banks beside these roadways can have negative impacts on the lake.

Resources at risk

Sport fishing and recreational uses of the lake are extremely important to user groups. As well the lake supports a wide variety of wildlife. Disruption of the natural balancing forces, which maintain the lake ecosystem in its present form, will result in the inability of some species to meet their life cycle requirements. In addition to supporting aquatic and terrestrial wildlife resources, Francois Lake is a source of drinking water for residents

and park users. It is a popular recreation area with high levels of boating activity. These uses are dependant on water quality being maintained within limits which may be defined by setting water quality objectives for a range of physical and chemical attributes.

6.2 Range of desired outcomes of varied user groups

Each group of lake users has their own interests to protect. Recreational users include boaters, swimmers, tourists, campers, beach users, anglers, and wildlife observers. Residential users include those that have permanent homes and seasonal cottages. For all users, high water quality and lake aesthetic quality are a top priority. It is likely that residential users have the most at stake. The value of their land, their quality of life and the water which they drink are all dependant on the state of the water in the lake. Some factors that will affect the condition of the lake relate to the surrounding land uses, including agricultural, forestry, development and construction practices.

6.3 Regulatory requirements

Many lake components are protected by federal, provincial, regional district or municipal legislation. Table 6 contains some of the regulatory requirements for specific lake components. See Appendix C for further explanations on the role of the various regulatory agencies.

TABLE 6: Regulatory Requirements for Specific Lake Components

Component	Legislation	Regulatory Agency
agriculture	Agricultural Waste Control Regulation and Code of Agricultural Practice for Waste Management	Agriculture Canada BC Ministry of Agriculture, Fisheries and Foods
beavers	Water Act Wildlife Act	BC Environment, Fish and Wildlife, and Water Management
boat launch		BC Parks
Endako Mine	Waste Management Act Water Act Mines Act	BC Environment BC Mines
ferry		BC Transportation and Highways Marine Branch
fish	Fish and Wildlife Act Federal Fisheries Act	BC Environment, Fish and Wildlife, and/or Department of Fisheries and Oceans
park use		BC Parks
motorized watercraft	Navigable Waters Act	Canada Coast Guard
residential subdivision development and land use (forestry, agriculture)	Regional District Zoning Bylaws Municipal Act Forest Practices Code	Regional District of Bulkley Nechako BC Transportation and Highways Ministry of Forests
riparian vegetation	Fisheries Act Forest Practices Code	DFO Ministry of Forests
roads / highways	Highways Act Forest Practices Code	Ministry of Transportation and Highways Ministry of Forests
septic systems sewage disposal from small vessels	Health Act Canada Shipping Act	Ministry of Health BC Environment, Pollution Prevention Program Canada Coastguard Small Vessel Regulations
waterfowl	Migratory Game Bird Act	Canadian Wildlife Service
wildlife	Fish and Wildlife Act	BC Environment, Fish and Wildlife

7. ASSESSING LAKE MANAGEMENT ALTERNATIVES

To this point specific lake issues and watershed physical characteristics have been identified. Next a set of actions must be identified so that the goals and objectives of the plan may be achieved given local constraints (Rast and Holland 1988). The process of identifying lake management options that are feasible can be complex. Decisions must be made with serious regard to cultural, social and political dimensions (Brewer 1986) as well as ecological and financial dimensions. This is a complex, uncertain process as there is difficulty in assessing cultural, social, political, ecological, and financial dimensions and expressing each in terms of relative value on a common scale.

Each of the lake management options will have consequences that must be analyzed in terms of the basic objectives of the lake management plan (McDaniels 1992). It is expected that one or more of the lake management alternatives will be determined to be the most effective in terms of achieving the goals of the plan.

7.1 Types of Analysis

Cost benefit

One approach used to assess the worth of lake management alternatives is the cost-benefit analysis. The cost-benefit analysis is based on a branch of Economic Theory called "welfare economics" (Rast and Holland 1988). Cost-benefit analysis compares all of the positive and negative elements of each lake management alternative in a general, broad context.

Traditionally, cost-benefit analysis looks only at monetary costs and benefits which can be estimated in dollar figures. However, the problem with this approach is that some dimensions are difficult to quantify, such as cultural values, long-term sustainability of natural resources, political realities, societal and governmental structure and stability, and the national or regional distribution of wealth (Rast and Holland 1988). Some of these elements cannot be quantified at all, or else can only be quantified in an artificial and perhaps inaccurate manner. An approach that encompasses ecological, social, political and cultural dimensions as well as the financial dimension is needed to determine whether or not the expected benefits are a good investment of funds (Rast and Holland 1988).

7.2 Selecting options

To assess options it is important that social, biological, economic, cultural, and political costs and benefits are included in the ranking criteria.

Initially an exhaustive list of options should be developed. Each option should be thoroughly researched and the negative and positive aspects of the alternatives recorded in a chart. An example of this type of chart is in Appendix D.

If resistance to implementation of an option is experienced, it may be necessary to complete further iterations of the matrix. This will allow the determination of the most important plan objectives based on social impact values. It is possible that different

ranking criteria are needed and this should not be overlooked in subsequent iterations of the social-impact matrix.

7.3 Lake management alternatives

Before discussion of the specific lake management alternatives, two points about costs and benefits need to be made. The first is that it is important that all available resources be considered for each option including technical expertise, financial resources, volunteer labour and equipment among others. It should also be noted that costs can vary substantially in different areas due to the local cost of labour, equipment, supplies and availability of specialized equipment (Rast and Holland 1988).

The option of doing nothing

It is important to consider the consequences of doing nothing because it offers one basis of comparison with the potential effects of implementing a lake management program (Rast and Holland 1988). Evaluation of the option of doing nothing can help decide if implementation of a lake management program is even required. However, it can be difficult to estimate when or how quickly some concerns will impact the lake and therefore it may be difficult to estimate the state of the lake at any given time in the future.

Other lake management options

There are three general categories of lake management options; those which treat the symptoms of a problem, those which treat the causes, and those "in-lake" methods which attempt to restore lake conditions.

When the symptoms are treated without any effort to identify and correct the problem and it's causes, this treatment will only be temporary. Until the problem is identified and the causes of the problem are addressed, it will continue to occur and the symptoms will continually reappear.

Most options that treat the causes involve improving and implementing specific land use and/or watershed management practices.

External sources that can degrade lake water quality must be addressed before internal management options are considered (Rysavy and Sharpe 1995). Since the watershed and lake are interconnected, any reduction in contaminant loading to a water body as a result of land use management practices can maintain or extend effectiveness of in-lake controls (Gibbons *et al.*, 1994). In general, the in-lake methods are usually more expensive and less effective over the long term than those options which treat the causes of a problem (Rysavy and Sharpe 1995). Often a combination of lake management options is required to maximize the effectiveness of restoration and control of the lake conditions.

8. POTENTIAL LAKE MANAGEMENT OPTIONS

8.1 Control of Forest Management

Land use management practices within the watershed catchment basin of Francois Lake, all have some effect on external nutrient and sediment loading. Forest management programs such as logging, and forest renewal may involve uprooting vegetation, decreasing stability of soils, and application of fertilizers. Erosion reduction and runoff control measures can minimize sediment and nutrient inputs to the lake. The cost of these programs would be borne by forest managers and the practices would have to be evaluated as to their effect on forest productivity (I. Sharpe, pers. comm. 1997).

The new Forest Practises Code of British Columbia (FPC) establishes mandatory requirements for planning and forest practises, sets enforcement and penalty provisions, and specifies administrative arrangements. Many of the concerns related to forest practices are addressed in the regulations and standards of the new FPC.

8.2 Chemical Applications within the Watershed

To address the concern over various chemical applications (fertilizer, herbicide, dust control) within the Francois Lake watershed, committed volunteers must establish communications with those parties using and approving these chemicals. This would include residents, resort owners, Ministry of Forests, Ministry of Transportation and Highways and the Ministry of Environment, Lands and Parks.

Chemical use by lakeshore residents and resort owners

The biggest problem is convincing shore land owners that they can't have fertilised and beautifully manicured city lawns at the lake, that run right down to the water, and then expect high water quality. The two are mutually exclusive.

Environmentally safe lawn care practices for lakeshore residents are simple and should include the following:

- Instead of chemical herbicides, handpulling and grubbing are generally effective methods used to eliminate weed species that do not reproduce vegetatively from rootstocks and where the infestation is light.

- Phosphorus is the most common limiting nutrient to aquatic plant and algal production and is a common ingredient of garden fertilizers. When improperly applied the phosphorus gets into the lake water through storm runoff. Consider not fertilizing, or instead of using commercial fertilizers, pump water out of the lake to water the lawn to obtain nutrients contained in the lake. Alternatively, use a low phosphorus fertilizer where the middle number on the bag is less than 3 or if it is a liquid fertilizer, the phosphorus content should be less than 1/2 %.

- When watering your lawns provide just enough water without creating runoff.

- Maintain a 10 to 15 metre buffer zone of native vegetation along the lakeshore, with as narrow as possible pathway through the buffer zone to the lake/dock.

- Do not throw grass clippings or lawn rakings in the lake.

- In a log book keep track of the amount and frequency of chemical applications each year. Take note of local conditions before and after applications so that as a responsible shore land owner you can be sure you are only using what is necessary and not more.

Pesticides

To keep pesticide use to a minimum in the three LPS watersheds, the membership may wish to participate in the pesticide use permitting process

Permitting process - Pesticide Use Permits and Pest Management Plans

The British Columbia *Pesticide Control Act* has been amended to allow pesticide uses under a Pesticide Use Permit to be authorized under an approved Pest Management Plan (PMP). The ministry intends to replace the existing Pesticide Use Permit system with PMPs.

A Pest Management Plan has two major parts which describe, a program for controlling pests or reducing pest damage using integrated pest management, and methods of handling, preparing, mixing and applying pesticides within that program. There are four major goals to this type of plan:

- To promote IPM to ensure that pesticides are used in the context of an IPM program.

- To reduce, and eliminate where possible, pesticide impacts on the environment and to protect human health.

- To broaden public awareness of, and involvement in, IPM programs.

- To make more efficient and effective use of administrative and technical efforts currently devoted to the Pesticide Use Permit system.

Integrated Pest Management (IPM) is a decision making process that uses a combination of techniques to suppress pests and includes the following six elements:

- planning and managing ecosystems to prevent organisms from becoming pests;

- identifying potential pest problems;

- monitoring populations of pests and beneficial organisms, pest damage and environmental conditions;

- using injury thresholds in making treatment decisions;

- reducing pest populations to acceptable levels using strategies that may include a combination of biological, physical, cultural, mechanical, behavioral and chemical controls;

- evaluating the effectiveness of treatments.

Approved PMPs will authorize pesticide use within the context of a plan by stating *why* and *how* pesticides will be used, and may identify specifically *where* pesticides will be used. If necessary, the ministry will require the proponent to provide detailed site-specific information of proposed pesticide use. A Pest Management Plan term may vary from one to five years depending on the period of pest management required, with five years being the maximum term duration. The system for Pest Management Plan approvals will operate in a similar way to the current Pesticide Use Permit system. As with the Pesticide Use Permit process, applicants/proponents will be required to give the public notification of their proposed pesticide use. It is expected that this will continue to be done through advertisements published in local newspapers or in local regional offices, and will contain information on a location where copies of the plan, permit application and maps of the treatment area may be examined in detail.
The PMP process will require that proponents get public input during the preparation stage of their plan , before they submit it to the Ministry for approval, thereby enhancing the public awareness and involvement. PMPs will be reviewed by government Regional Pesticide Review Committees which will recommend approval, denial or modification. The Deputy Administrators of the *Pesticide Control Act*, acting at the regional level, will use guidance from the review agencies, program policies and procedures in making a decision. The final approval of a plan will normally be given by the Deputy Administrator at the regional level, although the review of province wide PMPs will be coordinated by the Administrator in Victoria. In addition to adhering to the terms of the PMP, conditions and standards may be added by the ministry in the approval. Holders of approved PMPs will be legally required to apply pesticides in accordance with the approved PMP and will still be required to record and report their pesticide use. PMPs may be suspended or revoked for reasons of noncompliance. Decisions of the Administrator or Deputy Administrators of the *Pesticide Control Act* on PMPs are appealable before the Environmental Appeal Board.

For more information, visit the following web sites
Pesticide Control Act Regulation www.env.gov.bc.ca/epd/cpr/regs/pcareg.html
Pest Management Plans www.elp.gov.bc.ca/epd/epdpa/eripm/uoipmipm.html
or contact Pesticide Management Officer, Jennifer McGuire in Prince George at (250) 565-6945 or Pollution Prevention and Remediation Branch, (250) 387-4441.

If it is the wish of the LPS to be provided with notice of applications within their watershed, the following are potential options.

Pesticide permit applicants and the public

The most effective strategy for obtaining notice of application is for a subcommittee of the LPS to establish communications with the permit holders and applicants, which may include individuals, companies, public or private corporations, associations and Provincial Government employees. Through such contacts the LPS could be provided with direct notice of both present and potential future applications for pesticide use permits within their watershed.

A first step to identifying the past, present and future applications/permits for pesticide use within the watersheds containing Francois, Takysie and Ootsa Lakes, would be to contact the Pesticide Management Section of the Pollution Prevention and Pesticides Branch of the Ministry of Environment in Victoria. Most permit applications are received between November and May. A request to the above office at the end of May would provide the LPS with information necessary to further the objective of establishing updates to the society by the applicants.

Northwest BC Coalition to Alternative Pesticides

This group of individuals work mainly on increasing public awareness of pesticide use in the Smithers area. They are a good source of information on how to keep advised of pesticide use within your area, the pesticide use permit process and pesticide alternatives (Contact provided in Appendix B).

Northwest Weed Committee

This committee is made up of representatives from the Ministry of Agriculture, the Ministry of Environment, Skeena Cattlemen's Association, Northwest BC Coalition for Alternatives to Pesticides, Regional District of Bulkley-Nechako, Ministry of Forests and other liaisons with public agencies including CN Rail, BC Hydro.

This committee deals with applications of pesticides throughout the Northwest and the LPS may find their scope too broad to get actively involved at meetings. If the LPS wishes to pursue representation on this committee at their next meeting, they should contact the committee chairman, Dave Riendeau (Appendix B). However, it would be useful for the society to first canvas LPS members which may also be members of those associations already represented on the Northwest Weed Committee. Through their associations the LPS may be able to obtain the information they need.

Permit conditions

Due to government reorganization, the Skeena Regional office does not have a Pesticide program at present, and it has not yet been determined how the permitting process will be managed in the long term in this region. Once this has been decided, the LPS may wish to approach the appropriate Pesticide Manager to discuss the possibility of including specific public notification requirements for those permit applications within the Francois Lake, Takysie Lake and Ootsa Lake watersheds. The requirement would be that the applicant notify the LPS directly of their application and provide the society with a copy of the permit and permit details.

Alternatives to using herbicides

Efforts to manage the problem of noxious weed invasion involves many activities other than spraying with herbicides and include:

- Prevention of inadvertent introductions of noxious species into uninfested areas

- Cultural control (i.e. adjusting planting dates, barrier and row covers)
- Mechanical Control, Handpulling and Grubbing
- Biological Control (i.e. use of beneficial species)

These methods will only be adopted after efforts to educate and inform herbicide users have met with success. The LPS may undertake and/or promote these efforts.
For further information on these herbicide alternatives refer to the letter from the Central/North East Region Ministry of Transport and Highways in Appendix E.

Fertilizer use

Fertilization is a silvicultural treatment that can be effectively used to increase the merchantable yield and value of established forests. By adding nutrients that are limited on a site, fertilizers can improve the growth of individual stands (FPC 1995). Although fertilizers are normally applied to accelerate stand development, an alternative objective is the rehabilitation of disturbed sites.
There are two general classes of fertilizer: organic and inorganic. Most operational fertilization has focused on the application of inorganic fertilizers because of their known chemical and physical properties and their cost-effective means of application.

Operational costs

The operational costs of fertilization can be high. Those factors which affect the operating costs include location , access, slope and project and block size. Large-scale fertilization programs (e.g. >300 ha) conducted every 2-5 years are generally more cost effective than small-scale programs every year.
The limited use of fertilizers in the Lakes Forest District in the past has been due to the lack of money available to support these practices. Recently, however, FRBC is funding forestry work which includes fertilization of some of the older forest stands in the Lakes District that have been fertilized once already.

Season and method of application

A single application of fertilizer will generally increase the growth of a treated area for more than six years. In the Interior of BC the season of application is usually May 15 - September 15, while more specifically; application in the Lakes Forest District is generally in September and October.
The method of fertilizer application in BC which is the most efficient and cost effective for large-scale projects is the aerial approach.

"No fertilizer application zone"

Nutrients from forest fertilization applications can enter water bodies through leaching, runoff, or directly when fertilizers are applied aerially. Sensitive areas are protected using buffers and limiting the area receiving the fertilizer treatment.

A 10-meter "no fertilizer application zone" or buffer zone should be left around the following water bodies:

- a fisheries lake
- any designated fishery stream
- a stream that can be identified, on a pre-flight inspection, as one observable as open water that flows into any designated fishery stream.

Water quality sampling should be done when fertilizing near fisheries-sensitive zones.

Five Year Silviculture Plan / Forest Development Plan

The Five Year Silviculture Plan was an operational plan as required by the Forest Practices Code outlining proposed silviculture activities for a five year period. It allowed other resource agencies and the public the opportunity to assess and make comment on the potential impact of proposed silviculture treatments on a landscape basis. To date, the public have generally been in support of silviculture treatment and have not shown interest in review of the five year silviculture plans. On June 9, 1997 an Order in Council was passed which eliminated the requirement to produce five year silviculture plans. This decision has been made in response to the Operational Planning Review Report which recommended a number of changes to improve the efficiency of planning requirements under the Forest Practices Code. Any plans already in existence and retroactive to June 1995 are now void. The Five Year Silviculture Plan will be replaced by a policy that sets up a much less onerous Strategic Referral Process for silviculture treatments. However, this process will likely not be in place provincially for at least a year. For more information contact the Lakes Forest District Office, Silviculture Officers or Al Waters, Site Preparation Program Specialist in Victoria (Appendix B).

The public can still make comments on proposed silviculture treatments by asking appropriate questions during viewing of forest development plans. A forest development plan is a document that describes and illustrates how harvesting and road development for a specific area will be managed for a period of at least five years. These issues are of greater concern to the public and therefore receive more public involvement than the five year silviculture plans for silviculture treatments did. The forest development plan must demonstrate conformity with objectives and strategies established in higher-level plans for an area or region, including such plans as resource management zones, interpretative forest sites, recreation sites/trails, landscape units, and sensitive areas. Forest development plans must be updated and submitted for approval annually with the exception of woodlot licences which are approved every five years. The objective is to provide a minimum of two years of approved operations (years 1 & 2) and notice of intended operations for years 3, 4, and 5. This allows for any necessary future amendments. It is required that advertisements of these plans are placed in local newspapers for 60 days, for the purpose of public notification. The advertisement indicates where the details of the plan can be publicly viewed and to whom any

information, comments and/or concerns should be directed. This is usually the Forest District Manager.
The Lakes Forest District Office welcomes and invites communication with the public to address any concerns they have regarding forest practices within their district. It would be beneficial for representatives of the LPS to approach the Lakes Forest District with their questions and concerns.
The LPS could invite the managers of the relevant Forest District(s) to a special LPS meeting to introduce the various parties to one another and address the society's wish to establish and maintain communication links with the Forest District(s).

Dust control

Environmentally sensitive areas adjacent to public roads, especially fish habitat water bodies, are treated with caution during dust palliative application. Legislation to protect such areas include the Canada Fisheries Act and the Province of British Columbia Pollution Control Regulations.

Public involvement

Since there is no formal process through which the public is notified of road dust control applications it is suggested that the LPS organize a committee of volunteers to establish and maintain an active liaison with the Lakes Highways District of the Ministry of Transportation and Highways.
If there is concern over dust control activities along a specific section of road for explicit reasons, these should be brought to the attention of the Lakes Highways District so that they can evaluate and address these concerns. For health and safety reasons it may not be advisable to discontinue dust control treatments, however if these are not a problem then treatment to the specific area may be stopped.

Alternative to chemical control of road dust

According to the Ministry of Transport and Highways alternatives are limited. Water application is inefficient and not practical due to re-applications needed several times daily, and hence very expensive. Pavement is expensive and at this time not a viable alternative based on provincial re-surfacing priorities. Seal Coating is less expensive and can reduce the need to apply dust control chemicals. Not controlling road dust could lead to deterioration of the road base through loss of fine particles.
For more information on the dust control chemicals currently being used by the Ministry of Transport and Highways in the Lakes District refer to Appendix E.

8.3 Aquatic Plant Management

Plants are an important part of a balanced aquatic ecosystem. They perform a wide variety of ecological functions that include providing nesting sites for waterfowl, food, oxygen and cover for many types of aquatic life. Rooted aquatic plant communities help to stabilize shorelines and thereby slow erosion. However, under certain conditions, aquatic plants can be a problem. Excessive growth can negatively affect recreation and aesthetic enjoyment of a waterbody. Aquatic plants can form dense stands that create poor habitat for fish and wildlife. The solution to problem plant growth lies in careful

management. Through integrated aquatic plant management, solutions can be found that are effective, ecologically sensitive, and economically feasible (Gibbons et al 1994). Formal permission is required from the Department of Fisheries and Oceans and the Ministry of Environment before any instream or river work can be conducted.

Integrated aquatic vegetation management plan

Residents have raised some concern over aquatic plant growth along the Nithi River at the east end of Francois Lake.

A volunteer committee should assess the aquatic plant problem by completing the fundamental steps listed below:

- **Develop a Problem Statement**: Before a group can make good decisions about managing aquatic plants, they need to agree on what the problem is. This is done by identifying the important uses and values of the water body that are being limited by aquatic plants. The existing film (taken from a helicopter) of the entire river would be useful in this activity.

- **Identify Management Goals**: Management goals define what the community wants to achieve in response to the aquatic plant problem. Defining goals helps in selecting the best methods to deal with the problems. Here is an *example* of management goals for the Nithi River: "The management goals are to restore the Nithi River habitat to its historical values by reducing the size and amount of *Elodea canadensis* mats at the mouth of the river. Additional goals should be, with professional advise, to choose appropriate plant control methods that are environmentally sensitive, and reduce overall control costs by using volunteer labour when possible."

- **Public Involvement**: Identifying interested groups, involving and informing the public and obtaining widespread support for proposed aquatic plant management actions is crucial.

- **Identify and Map Aquatic Plants**: The types of aquatic plants growing, their location, and abundance must be determined. An aquatic plant survey and inventory along the river both prior and post rehabilitation would provide useful information in designing and maintaining an effective management program specific to the area. The survey involves systematically walking the area to record and map aquatic plant conditions. An important part of the survey is collecting samples of aquatic plants to verify the species. This would most likely take place in the early fall. Collection and preparation of aquatic plant specimens for identification involves rinsing a few healthy specimens, carefully placing between two sheets of paper towel, and securely sealing in a plastic bag. The Ministry of Environment can refer those collecting the samples, to recognized aquatic plant experts to aid in determining species identification. Based on the results obtained from the water and sediment samples taken from Francois Lake there may or may not a need to analyze aquatic plant samples for metal content due to the presence of the Endako molybdenum mine on the east end of the lake.

- **Characterize Aquatic Plants**: This involves determining problem areas and beneficial plant zones.

- **Investigate Control Alternatives and Specify Control Intensity**: A variety of methods are available to control nuisance aquatic plants. This plan will not discuss the different methods but rather refers interested parties to a guide published by the Washington Dept. of Ecology called A Citizen's Guide to an Integrated Aquatic Vegetation Management Plan (Gibbons 1994) and the second edition of the Lake and Reservoir Restoration Guidance Manual prepared by the North American Lake Management Society for the U.S Environmental Protection Agency (1990). Specifying control intensity involves determining how much control is needed for particular plant problems in certain areas. Are there some places that should be left alone? Under what circumstances should low versus high levels of control be used? These are also addressed in the above mentioned guide book(s).

- **Develop and Implement the Management Plan:** This is where all the carefully acquired background information pays off from a plan that provides the community with guidance and direction for aquatic plant management. However, the decision to proceed with aquatic plant management is just the beginning. Aquatic plant control is an ongoing concern that requires long-term commitment.

8.4 Zoning and Development

There are several planning processes that affect zoning and development of the lakeshore and foreshore area. Involvement of the LPS in any and all of these planning processes is recommended for the inclusion of the Society's concerns and interests. A representative of the LPS should contact the Regional District planning co-ordinators to request that the LPS be included as a community group in the following planning processes.

Bylaw 700: rural plan

Land use and development in the Bulkley Nechako Regional District is governed by the Zoning Bylaw No. 700 document. Bylaw 700 was developed for the rural areas of the Regional District that are outside the boundaries of the municipalities. This document establishes zones and regulates within the zones the use of land, buildings and structures, the density of use of land, buildings and structures, and the siting, size and dimensions of buildings, structures and uses permitted on the land. In addition, the bylaw regulates the shape, dimensions and area of parcels of land that might be created by subdivision.
Applications for rezoning are treated as applications to amend the Bylaw 700. Rezoning applications are initially sent to the Regional District office using a standard form that addresses the current zoning bylaw and the amendment to the bylaw. Included in an application for rezoning must be a legal description of the area to be rezoned. The application for rezoning is reviewed three times. The Regional District first reviews the application before distributing the application to various agencies, such as the Ministry of Environment, for comment. The application is reviewed a third time during a Public Hearing. At this time, comments from the various agencies are made available to the public and community groups. Individuals are given the opportunity to address changes

to bylaws. The Regional District votes on the application to amend the bylaw and based on the results of this vote, the amendment is either allowed or disallowed. Public hearings are advertised on the radio and by written public notices.
Developing a zoning document and maintaining the provisions in that document is an ongoing process. Community involvement will ensure that public interests are considered during development and amendment of zoning plans.
The Lakes Protection Society should contact Mark Andison or the appropriate area director at the Regional District to ask that referrals be sent to the executive as part of public comment efforts.

Land and Resource Management Plan (LRMP)

Planning exercises such as the Land and Resources Management Plan (LRMP), have advisory committee(s) comprised of various stakeholders, including local residents. The LRMP for the Lakes area is in its final stages of completion. Several residents in the Lakes Protection Society have been actively involved in the development of this plan. These types of plans are generally reviewed after several years. It is strongly advised that a representative of the each of the lakes in the Society participate in any future reviews and revisions of the LRMP. The Ministry of Forests District Manager should be contacted to ensure standing on these committees.

Other development plans

There should also be some involvement of the society in any other planning processes that will potentially affect land use and development in the Francois Lake watershed.
For example, the purpose of an Official Community Plan (OCP) is to state the broad land use objectives and policies of the Regional District of Bulkley- Nechako for the area of focus. Currently only under this plan are there established lakeshore guidelines to minimize the potential for negative impacts to aquatic habitats. For more information on the Official Community Plan, Lakeshore Guidelines and Guidelines for Riparian Management Areas refer to Appendix F.

User Recreation for Entertainment Purposes (U.R.E.P.)

A UREP is a type of map reserve. The term “map reserve” applied to a parcel of crown land means that it has been withdrawal or withheld from alienation for all other purposes except that which is designated. Map reserves were established pursuant to section 16 of the Lands Act. UREPs were established in the 1950s by BC Assets and Lands Corporation (BCALC), formerly BC Lands, on behalf of BC Parks. They were created to provide the public with access to lakeshore lands. Since the development and establishment of Ministry of Forest Recreation sites no new UREP sites have been established. In the past, UREPs were reviewed every 5 years by BC Lands and Parks to maintain their status on Ministry maps. These 5 year reviews are no longer carried out, instead any existing UREP sites will remain as such until further notification is given by BC Parks to BCALC. Land applications entertained by BCALC are referred to the agency whose interest has been recorded (for UREPs this is BC Parks), to provide input to the adjudication process. Should BC Parks provide written approval for BCALC to further proceed with the land application, BCALC would then initiate its referral process

that requires the applicant to notify the public in the form of advertisements published in local newspapers and the BC Gazette. At this point the public can communicate any objections they may have in writing to BCALC.
BCALC strives to allocate crown lands to its most suitable use. This is done through the use of inter-agency referral of land applications and proposals; through development studies and planing programs of a variety of government agencies; and through analysis of economic indicators, social requirements and land capability. Crown Land is a limited and valuable resource. Allocation according to its highest and best or most suitable use will generate the greatest benefits for all British Columbians.
Organizations like the Lakes Protection Society, interested in protecting existing UREPs should be aware of all UREPs that exist in the area of concern, communicate with BCALC periodically regarding any applications for designation changes and look for notices in the paper. If there are objections then this should be communicated in writing to BCALC.

Allocation of Surface Water

Recently there has been some concern over the potential for bulk water removal from Francois Lake by three native nations located on the south side of the lake. In April of 1995, the Department of Indian Affairs and Northern Development provided funding to the Cheslatta Carrier Nation to complete a feasibility study of the water supply in Southbank. The study confirmed that there is an inadequate water supply for the Nee Tahi Buhn/Skin Tyee and Cheslatta Carrier Nations. The study reccommends a plan to remove water from Francois Lake via underground piping to supply three native communities, with the possibility of supplying other residence along the route. For this to occur, a water licence application would have to be filed with the Comptroller of Water Rights or with the Regional Water Manager for Skenna Region, Indian and Northern Affairs. The Indian Band or their Consultants could file a water licence application to start the licencing process that will include referrals to other government agencies and persons who would be directly affected by the proposal. This application would be subject to the government referral process which includes public notification and an opportunity for submissions of written public input. Water Rights information can be obtained from following MELP web page: www.elp.gov.bc.ca/wat/wrs/brochure.html. Any follow up on this issue can be directed to the Skeena Region, Water Section Head.
It is the opinion of the LPS that “any bulk removal of water to supply outside communities and/or for commercial sales would set a precedent that could jeopardize the health and ecological integrity of Francois Lake. This in turn could have serious ramifications to the people who are currently living around this lake and who depend on a healthy and abundant supply of water.”

8.5 Endako Mine

General operation

Endako Mine is about 500 miles north of Vancouver and 115 miles west of Prince George, near the geographic centre of British Columbia. The mine has been in operation since 1965. The average daily mill throughput is presently 30,000 tons of ore per day. Higgenbotham, Sweetnam, and No Name Creek are all mine influenced creeks.

Metal accumulation in sediments

Metals, especially molybdenum are of special interest to the residents at the east end of Francois Lake due to their relative proximity to the mine. Although metal concentrations in the water is regularly tested to assure good water quality, long term accumulation of metals in the lake sediments had not been tested. In February of 1997, sediment core samples from either end of Francois Lake were collected. These cores have been dated and tested for their concentration of metals over the past 400 years. Thus providing an indication of whether there was metal enrichment of sediments due to mining, specifically any molybdenum loading. The findings of the sediment metals analysis, with respect to molybdenum indicate that between the mid-1960s and the early 1990s, molybdenum concetrations in the sediments were persistently increasing as a direct result of mining activities. Molybdenum enrichment was lake wide over the first decade of mine operations. Concentrations peaked first in sediments at the east end of the lake, which are closer to the mine, and later in sediments from the west end of the lake. This observed delay in metals deposition between the two sites is likely due to the large distance between them. In the last decade these sediment concentrations of Molybdenum have been decreasing. Existing rehabilitation measures, such as water treatment and effluent controls, have probably improved water quality to some degree (Reavie and Smol, 1997).

Fish and algal studies

In the spring of 1997 a joint project between the Ministry of Environment and Endako Mine was undertaken to study the effects of site discharges containing up to 20mg/L of molybdenum concentrations on early life stages of fish and algae growth. The objective of these studies was to gain information to update water quality objectives for molybdenum discharges from the Endako Mine. These experiments were carried out using three control sites and four sites influenced by various concentrations of molybdenum. Water sampling and analysis had been done to determine the concentrations of molybdenum at the sites.

Fish Study

It is well documented that developing embryos and early life stages are highly sensitivity to foreign toxicants. It has been shown that for many toxicants including metals, the early life stages of fish (egg, alevin, fry) are often the most sensitive when compared to adult fish and a range of other organisms. This has been demonstrated for molybdenum, although not consistently.

The fish studies began with eggs that had just come into the "eyed stage" of development. This is defined as the stage between the time the eyes become visible and hatching occurs. This stage of development guarantees the eggs are fertilized, and are hardy enough to be handled and transported. One hundred eggs were placed in each egg box (3 per site) and the boxes were placed in creeks. Two end-points were used for this study. Egg survival and mortality was recording for up until hatching occurred at the control sites. Alevin mortality was then recorded for a three week exposure period (to the "button up" stage when the yolk sac has been absorbed and the alevin have just become "fry"). Each week field parameters such as temperature, dissolved oxygen and pH were measured at each site, egg boxes were checked and samples and analysis for metals including molybdenum were carried out. The results indicate that there were no egg mortality difference between the control sites and those sites influenced by up to 18mg/L molybdenum. Therefore at concentrations of molybdenum up to 18mg/L there was no effect on the hatching success of the eggs. The alevin portion of the study was invalidated due to disappearances of organisms. The egg portion of the study was also done under laboratory conditions, however due to poor egg stock, it failed.

Algae Study

Also conducted in the laboratory, algae were allowed to grow exposed to different concentrations of molybdenum in the water. The results of the algae growth studies indicate that molybdenum concentrations up to 18mg/L did not inhibit algae growth.

Since the in situ egg and fry test failed, BC Research conducted a streamside tank style egg/alvin/fry (EAF) test at Endako Mine in the spring of 1998. Data was collected from pit containing Molybdenum only and from N1 tailings seepage, containing Molybdenum with Copper and Iron. The results were the same for both. BCRI study results indicated no measureable effect of 30mg/L of Molybdenum on the early life stages of Rainbow trout.

Water quality objectives for Molybdenum

Water quality objectives for Molybdenum are soon to be set at 30mg/L for the protection of aquatic life.

Endako Mine Community Liaison Committee

Endako Mines gives high priority to environmental protection by following practices that minimize the impact of operations on the surroundings. The method of tailings disposal keeps waste water contaminants from coming in contact with adjoining habitats. Sulphur dioxide from the roasting process is removed from air borne emissions and disposed of with the mill tailings and impounded. Reclamation of mined out and disturbed areas is an ongoing process. Endako operations are subject to internal environmental audits annually and to external audits every two or three years.

Endako Mine established a Community Liaison Committee (EMCLC) in February of 1996. The Ministry of Environment, Endako Mine and local community interests are all

represented at committee meetings. The committee meets quarterly to discuss major environmental issues. To date, a high priority at these meetings has been the concentration of molybdenum in the mine influenced water leaving the mine site. The East Francois Community Association and the Lakes Protection Society currently have members that are involved in the Endako Mine Community Liaison Committee helping to ensure environmental protection remains high priority. Members of the LPS interested in being observers at a meeting of the EMCLC could arrange to do so, or else the LPS could arrange that quarterly updates on the EMCLC meetings are presented at society meetings to keep the larger community informed on various mine issues.

Closure plan

Every five years the mine is required to provide the Ministry of Mines with an updated 'Closure Plan' detailing how the mine is to be closed down once all operations have ended. It indicates things like the removal of buildings, the remediation of land and outlines the continuation of water quality monitoring to be carried out. The most recent closure plan for Endako Mine was published in January 1997. This plan is available for public viewing through the Ministry of Mines

8.6 Fisheries Options

The first step in addressing expressed concerns about potential fish population declines or habitat losses is to obtain verification that these concerns are justifiable or valid. Anecdotal information needs corroboration through a more accurate means of tracking fisheries trends and conditions.

Volunteer monitoring

An inexpensive, and feasible method to obtain an assess potential fish population declines in Francois Lake would be to examine the fishing derby and seasonal fishing records kept by lodge and resort owners on the lake. However, the LPS has learned that such records do not exist, and there is no interest at this time, on the part of lodge, resort or marina owners to keep these records because of the extra effort they feel it would involve. This said, it is still believed that fishing records and monitoring age structure through a fish head collection program at fishing lodges resorts and marinas could provide valuable management data. These records may indicate trends of declining catches or sizes of fish. They will provide insight into the lake's current fish populations. An alternate way of collecting this could be to find local volunteers willing to regularly visit the lodges, resorts and marinas around the lake and to record fishing information by personally surveying anglers. Alternatively, an application could be made to the Environmental Youth Team Program to hire a student to survey anglers for this information. Either option could make use of the angler survey sheet that has already been drawn up by the LPS. Once a reasonable amount of information has been collected, the Fisheries Branch of MELP could then evaluate population trends and possibly make management decisions based on this information**.**

There are many associated benefits. These include acquiring information that would aid identification of fish population trends and would help management decisions for

fisheries in the lake. This is a first step that the Fisheries section of Ministry of Environment, Smithers endorses because of the low cost.

On the dock - Angler surveys

The results of a passive volunteer creel survey conducted in 1998 was somewhat disappointing for the LPS. Perhaps if a more active approach were taken, as suggested above, by a volunteer or a paid individual, more information could be gained. Again, this information could be collected on a weekly basis, on a monthly basis or over a long weekend during the fishing season. Careful records providing information about where and when the survey was done, who did the survey and the results of the survey will have to be kept.

Ideally, this survey should be repeated every year so that any trends can be followed. The information gathered would provide data about angler effort and catch per unit, and would help determine fishing pressure and fish population trends.

Streamkeepers program

The Streamkeepers Program is sponsored and supported by the Department of Fisheries and Oceans (DFO), Canada. The program educates volunteers in habitat assessment and re-habilitation and touches on activities that involve monitoring of fish populations**.**

Volunteer driven fish monitoring programs could be set up under the framework and guidance of the Streamkeepers modules.

To monitor fish in the tributaries of Francois Lake, indicator streams would have to be chosen because there are so many streams and there are limited resources to monitor them with.

The Fisheries Branch of the MELP would be available to advise and to provide guidance about choosing indicator streams. A stream survey has been done on Francois Lake (Bustard 1988; Pinsent 1973) and this document would be useful for identifying potential indicator streams.

Before indicator streams are selected, the type of monitoring information that can be collected should be determined based on volunteer training and knowledge. The type of information that is collected must be quantitative and will have to be collected in a scientific manner.

The streamkeepers program can also be applied in the context of increasing habitat quality for fish.

The streamkeeper contacts in this area are Brenda Donas who is the DFO, Community Advisor and Al McCracken, Director of Community Futures and a volunteer for the Streamkeepers Program. It is Ms. Donas' recommendation that the Lakes Protection Society become involved in the Streamkeepers Program.

Although there has been some talk of developing a Lakekeepers Manual and Program, currently one is not available. If the LPS are interested in the development of such a program letters to this effect should be written to the Pacific Streamkeepers Federation co-ordinators at 720 Orwell Street, North Vancouver, BC. V7J 2G3. The phone number is 1-800-723-7753 or 604-986-5059.

Harvest restrictions

A major sport fishery for rainbow and lake trout occurs on Francois Lake, which is supported by the fact that the estimated angler days on the lake exceeded all other lakes in the Skeena Region with the exception of Babine Lake for 1985 and 1986 (Bustard, 1988). Changes to the catch limit are based on angler effort and population size. Closure periods are based on sensitive times when fish are spawning. For several years there has been a fall closure on Lake Trout in Francois Lake. The harvest of lake trout in 1988 was approaching the lake's maximum potential (Bustard, 1988). This potential may have been reached and surpassed. Changes to catch limits or changes to the type of fishery, such as a change to catch and release, should be based on data collected about the present conditions. Most local anglers feel that "catch and release" wastes fish because most fish die. Data about present conditions, along with documentation on mortality rates for Lake Trout caught and released needs to be available before management decisions can be made.

The Fisheries Branch can address overharvest issues for long-lived species, such as lake trout, by implementation of very conservative angling regulations.

Fishing derbies

Fishing derbies can be a large strain on fish populations in the lake. The effect on fish populations is compounded by several derbies in a season and by categories such as hidden weight and largest fish. The hidden weight category encourages anglers to kill all fish caught, regardless of size, in pursuit of a prize. The largest fish category places an unbalanced strain on the oldest, largest fish in the system.

It is recommended that fishing derbies be organized so as to keep the harvest of fish as minimal as possible. This can be accomplished in part by limiting the number of entrants in a derby, by minimum size requirements for derby entry or a move to catch, measure and release derbies and no hidden weight prizes.

A representative of the Lakes Protection Society could address this option by approaching the Derby sponsors. It has been determined that some of the fishing derbies held on Francois Lake are sponsored by companies in Prince George and the local Rod and Gun Club. Catch, measure and release derbies have been successfully held in other places and it would be a straightforward option to stop the hidden weight category.

Catch and release derbies aim to minimize fish mortality. The basic procedure is to catch, measure, perhaps photograph, and release. There are numerous guidelines that may be followed to ensure the success of such a practice.

Anglers are usually placed in groups so as to confirm each other's entries. Catch and release practices also encourage the use of barbless hooks, reducing catches with unattended gear, and they can easily be disposed of by the fish themselves. Stainless steel hooks should be discouraged because they do not dissolve in the stomach acids of fish. Anglers are also encouraged to measure and release larger fish without lifting them out of the water, reducing the likelihood of injury. Fish that must be lifted from the water should be handled appropriately. Anglers are asked to support the fish with wet hands and to place them on wet towels, so as to protect their slime coating. Hooks must also be removed carefully. If the hook is lodged within the fish, it is best to simply cut the line off as close to the mouth as possible, and to allow the fish to swim away. The fish will

simply dispose of the hook itself, or it will be dissolved. Anglers should release the fish by holding them upright in the water into a current, until the fish swim off on their own. Catch and release derbies allow anglers to continue fishing practices while at the same time responding to the growing concern about our fisheries. Though catch and release fishing practices are viable for most species of fish found in Francois Lake, lake trout tend to suffer high mortality rates even with such practices. During the summer months lake trout tend to delve deep into the cooler depths of the water. If they are hooked, and pulled up rapidly, their swim bladders, which keep them buoyant in the water, may burst due to the rapid change in pressure. If they are caught, measured and released, they tend to float on top of the water rather than swimming back into the depths because of their swim bladders. This leads them to be easy targets to predators. Hence it is essential that the species of fish is viable to such practices for it to be successful (per comm. Sig Hatlevic 2000). Further information concerning catch and release fishing practices can be found through Native Fish Australia Inc. at:

www.nativefish.asn.au

Indexed gillnetting sites

Gillnets capture fish that swim into a net that is suspended in the water column. The capture process is called gilling and occurs when the maxillary or opercular area is caught in a single mesh when the fish encounters the net. Fish may also be entangled by their teeth, spines, girth or scales as they try to pass through or free themselves. This method is only used when the intent is to kill the sample, as the fish do not live through the gilling process. The nets are very selective for both fish size and type because of where it hangs in the water column and the size of the net mesh.

Care must be taken to avoid over sampling a lake especially when the lake may support population or species sensitive to harvest. As a rule the length, weight and age data from thirty fish of each species is required to develop statistically useful relationships. In areas where it is necessary to minimize the number of fish killed in the gillnet, short sets of one hour or less can be used. The crew can also monitor the net for any movement of the corl line that indicates fish have been caught.

Indexed gillnetting sites could be established on Francois Lake that would act as a long term monitoring tool. Index netting sites involve setting a gill net at a specific, catalogued site each year with the same net at the same time of year. On a lake as large as Francois Lake, several of these sites may be chosen. This would track long term fish population trends.

This information is useful on a long term basis and would be moderately expensive. Presently, the Fisheries section does not have sufficient staff to undertake this type of project but alternative methods for achieving this should be explored.

Creel survey

A creel survey would entail an intensive evaluation of the current fish population of lake trout, rainbow trout, and kokanee in Francois Lake. This survey could replicate the study that was done in 1987-1988 by Dave Bustard and Associates and the data from a current study could be compared to this past information. If fish population declines have

occurred, this should be evidenced by a reduction in catch per unit effort, or by a significant shift in the population size and/or age structure. A survey of this nature would accomplish the first step by verifying the validity of expressed concerns. This would be the most thorough survey to assess the status of fish populations.
A creel survey or similar type of survey would be relatively expensive and time consuming to undertake and the Ministry of Environment Fisheries Section does not currently have the staff or financial resources to undertake them. Funding for a project of this type would have to be obtained from other sources. Possible sources are listed in Section 11.

Habitat restoration/protection

Nithi River

The Nithi River is an important recruitment area for Francois Lake (Bustard 1988) and probably contributes significantly to the east end fishery. Rainbow trout spawning typically occurs in early May when the water flows are high. The fry emerge in July. The juveniles usually spend the first two years of their life cycle in streams before returning to the lake. This makes them susceptible to the low water flow in the late summer resulting in high fish mortality.
A low storage dam that would store water within the existing high water level of Anzus and Borel lakes would increase and control water flow during the low flow rate period and through the winter. This would substantially increase the fry and parr survival in this system and result in higher recruitment from the Nithi River into east end of Francois Lake (Bustard 1988).
The project has received approval from the Fisheries Branch, a proposal to obtain funding from for dam construction was submitted to the Habitat Conservation Trust Fund November, 1997. The engineering reconnaissance has been completed and once all necessary permits have been signed the construction of the dam is scheduled for the summer of 2000. A formal application to the Water Management Branch has been made, and the various processes they require prior to licensing have been initiated (for example, in the legal section of two local newspapers, letters have been addressed to all property owners within the Nithi watershed, advertising the intent to construct the dam. With the help of Sig Hatlevik, the East Francois Lake Community Association has submitted an application for funding from Action 21 to install hydrometric stations on the Nithi. Liaison has been established with DFO and the fisheries biologist of the Carrier Sikkani Tribal Council in Prince George, both of which have offered financial assistance, support and potential involvement as well.
A representative from the society remains in contact with the Fisheries Branch, MELP, Smithers, for updates on the status of this project.

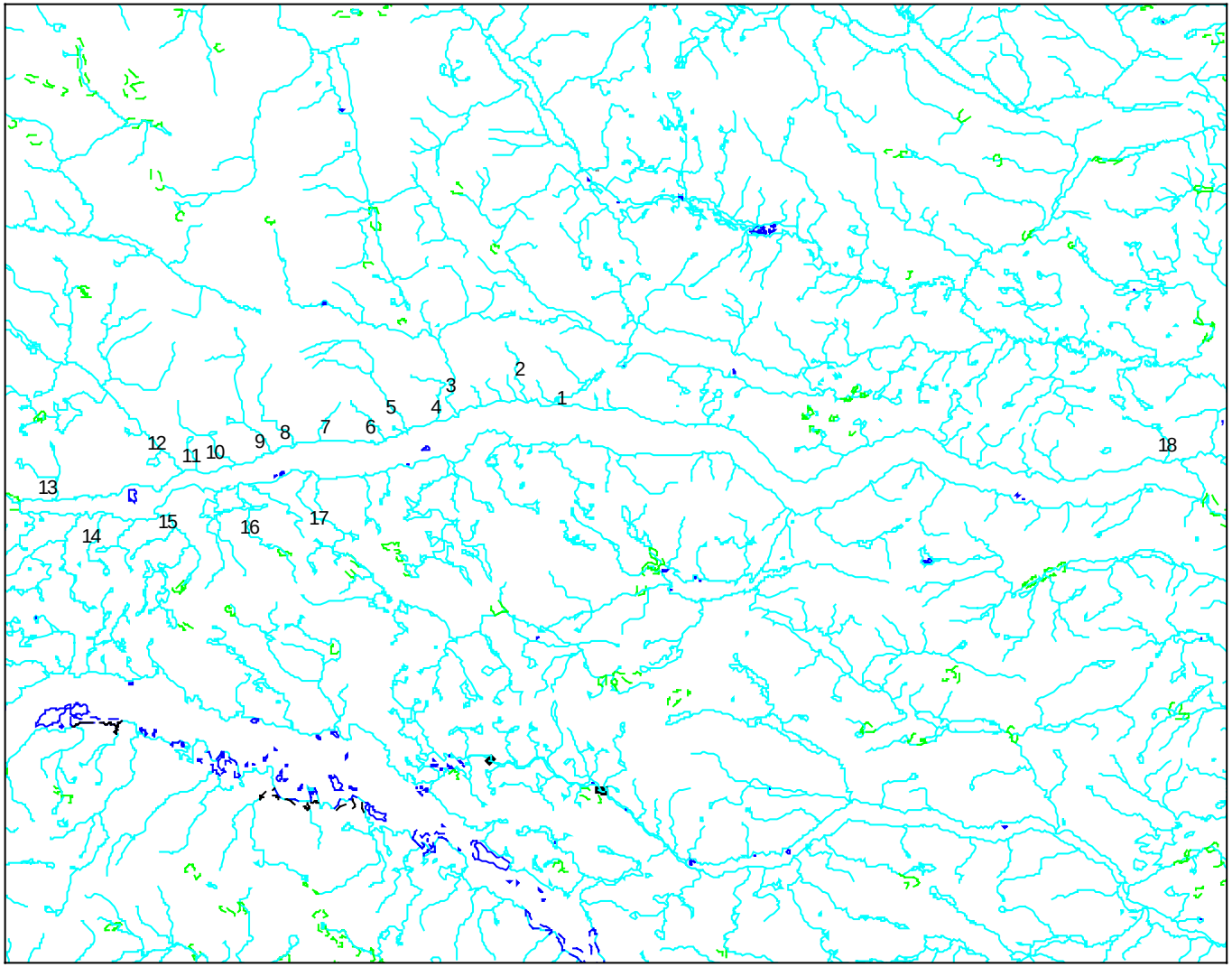
Mapping culverts

Poorly placed culverts may inhibit movements of rainbow trout or kokanee to ascend streams to reach preferred spawning beds. To reseat poorly placed culverts, the Ministry of Highways may be amenable to re-seating them or replacing them, but an outside source

of funding would be required and is very expensive. Some of the forestry related culverts may be eligible for funding under the Forest Renewal BC Watershed Restoration Program.

Mapping of culverts was undertaken by members of the Lakes Protection Society in 1998, to facilitate the identification of poorly placed culverts. Included in the mapping survey are photographs of the downstream and the upstream end of the culvert, measurements of the length and diameter of the culvert and a subjective guess of whether it is a barrier to fish passage. Carol Imus of the LPS contacted Sig Hatlevik for his assistance to identify those creeks most in need of attention, and options to rectify the situation. On June 9, and 10,1999 they visited Parrot, Rat, Ramsey, and Vanzanten Creeks. Figure 7 shows eighteen culvert sites identified by the Francois Lake Culvert Mapping Survey conducted in 1998.

Figure 7.Francois Lake Culvert Mapping Survey



N
W E
S
(at map centre)

NTS, Water - 1:250K-M

1. Vanzanten Creek (Snodgrass)
2. Sandy's Creek (Reed)
3. Nourse Creek (Allin)
4. Swanson Creek
5. Hewitt Creek (Henkel)
6. Cyril Shelford Creek
7. Parkland Creek
8. Imus Creek
9. Ramsey Creek
10. Rat Creek
11. Streeters Creek (Kivi)
12. Trout Creek (Parrot)
13. Noralee West Creek
14. Gallager Creek
15. Smiths Creek
16. Unknown Name
17. Unknown Name
18. Sweetnam Creek

1:577651

10 0 10 Kilometers

BC Min. Env. Lands, Parks
Skeena Region
February 25, 2000

8.7 Septic System Failure, Remediation and Maintenance

Leaking and failing septic systems will contribute to the nutrient load of the lake. The amount of nutrient loading to the lake through septic systems can be variable and difficult to estimate. Using a water budget formulation where input is equal to output (black box model) other sources of nutrient loading can be measured and the nutrient contribution from septic systems can be estimated indirectly (Cooke *et al.*,1993).

It is a fact that problems associated with septic system failure are difficult to diagnose, therefore it is up to the individual house owner to maintain the system. Often, people do not realise that there is a problem with their system until it has reached a serious failure stage.

Each septic system which is on lakefront property should be assessed and any maintenance needed should be undertaken by the owners. Information on proper system maintenance can be obtained from the system manufacturer, Ministry of Health, Ministry of Environment and resources in the public library.

The regional health officer may be able to inspect each septic system on a request basis. Residents should be encouraged by the Lakes Protection Society to participate in a sanitary survey and to register on a voluntary basis with the Health Officer for a maintenance inspection.

One way of diagnosing failing systems is through the use of a septic leachate detector. The Health Inspector adds a dye to the septic system and then assesses whether any of the dye seeps into the lake (detection of plumes). This process is made more effective if a flourometer is available to improve the detection of low concentrations of dye.

The efficiency of removal of phosphorus is directly related to groundwater flow characteristics and soil type (Kerfoot 1981). Kerfoot et al. (1981) observed a high correlation between location of nutrient rich plumes and attached plant growth. Well-drained, porous soils were observed to be the most efficient for attenuation of nutrients from wastewater. Percolation tests are used to determine the ability of the soil to absorb effluent.

Depending of the soil's ability to remove nutrients recommended septic system set backs on some lakes have ranged from 30 to 300 metres from the shoreline to prevent nutrient loading to the lake. Identification of soil types around the lake and respective septic system setbacks could be addressed through Zoning Bylaws for lakefront property that is presently undeveloped. Soil surveys in aid of these zoning efforts are required.

Another option to reduce nutrient contributions from septic system leachate, is to install a community sewage treatment plant. The cost of this would be millions of dollars, part of which would be borne by the lake residents. An immediate result would be a reduction in nutrient input to the lake. Due to the high cost of this option, it is feasible only for high density residential or commercial developments.

There are many new and innovative ways to deal with the treatment of waste water. The LPS is undertaking a sewer awareness program to make residents along the lakeshores aware of the dangers of leaking septic systems to the lake's water purity.

8.8 Agricultural Land: Maintenance and Remediation

Agricultural land and farming practices are regulated by the Ministry of Agriculture, Fisheries and Food. However, when the question of pollution is raised with regarding to agricultural land and practices the Ministry of Environment may need to become involved also. Runoff from agricultural land that enters surface or groundwater may or may not be considered pollution, depending on the composition of that runoff and the nature of the receiving waters. The first step in addressing concerns on the impact of agricultural practices on water quality is to obtain verification that these concerns are justifiable.

Shoreline survey

Sufficient information must be collected before time and money are invested in changing present practices. This would include a survey of the shorelines for degradation and erosion as well as water quality monitoring at key times and locations along the shoreline. Such a survey can be both expensive and time consuming and would be conducted by the Ministry of Environment biologists with help from LPS members.

Volunteer monitoring

An alternative to / or in addition to a shoreline survey, residents can seek advisement from the Ministry of Environment and the Ministry of Agriculture on how to perform shoreline observations with careful written and photographic documentation, with minimal costs to the LPS. Coupled with water sampling at key locations this could provide very useful information on the impact of agricultural practises on shoreline conditions and water quality.

Environmentally sound farming practices - controlling runoff and erosion

The Code of Agricultural Practices for waste management requires that contaminants not go beyond the farm boundary, therefore producers should attempt to reduce or eliminate the contaminants in runoff from their land.

There are farming practices which can be implemented that would have an immediate effect on reducing nutrients and pathogens to the lake. Farmers must be convinced of the benefits to the lake of new runoff control and treatment practices, especially if the suggested changes may be more expensive than the status quo (Rast and Holland 1988). An education program must include those farms within the catchment basin.

Manure storage - bunkers

One very effective practice involves the use of manure storage bunkers which trap and hold runoff that is mixed with animal waste. This can be highly effective provided that animal waste is adequately collected and stored, and by-products (rotted manure and collected runoff) are properly used as soil amendment on lands at some distance from the lake and its tributaries.

Ditches and impoundments

These can be used to catch and hold nutrient rich runoff from pastures from entering the lake, and can provide additional benefits. The runoff is diverted into settling ponds where suspended solids, including nutrients, settle out. The water which seeps out of the

treatment pond to the lake is much reduced in nutrient concentration. An advantage of this practice is that the nutrient rich pond water can be used for irrigation of fields which may improve forage production. However, the treatment works are expensive to install, require regular maintenance, and may reduce the area of pasture available (per comm. I. Sharpe 1997).

Soil conservation practices

A change in tillage practices from conventional types (soil annually cultivated in some fashion) to reduced tillage or to no-tillage results in soils better retaining their structure and integrity, and therefore are less subject to surface erosion during heavy rains. Nutrients or chemicals which are strongly absorbed/adsorbed by soil particles also tend to remain in place to a much greater extent under reduced/no-tillage practices. Phosphorus, a common fertilizer nutrient, has a relatively low water solubility, and is an example of a nutrient which remains predominately sorbed to soil particles (Bowman 1997).

Farmers who practise conservation tillage tend to cultivate fields less often and use equipment that does not actually turn the soil. This leaves crop residues, such as stubble from grain crops, on the surface where they can trap water and protect loose soil, reducing soil erosion and organic matter loss (Statistics Canada 1997).

Leaving a fringe of vegetation between pastures and the lake allows attenuation of nutrients from runoff before it reaches the lake. If the suggested practice can be demonstrated to benefit the farmer directly, it will be most easily implemented.

Further information on conservation tillage practices can be obtained through the Ministry of Agriculture, the BC. Federation of Agriculture, the BC. Cattlemen's Association, the BC. Horticultural Coalition. Reference material includes the Conservation Tillage Handbook, the Journal of Soil and Water Conservation among others.

Non-regulatory environmental programs

The British Columbia Ministry of Agriculture, Fisheries and Food has 3 non-regulatory environmental programs available to beef producers.

Best agricultural waste management plans

This program provides waste management suggestions to beef cattle producers who have pollution concerns caused by: manure, dead animals, feed, yard runoff (not pesticide pollution). The plans are prepared by request of the producer to the local agricultural office and are designed to address the pollution concerns. The plan includes descriptions of current problems and suggestions for improvement.

Best soil management plans

These plans are intended to provide soil management recommendations for farms that have problems with: soil erosion, compaction, structure deterioration, moisture deficit, acidity (not fertility). They are prepared by request of the producer to the local agricultural office and are designed to address the specific problem.

Nitrogen behaviour simulation computer model

This model simulates nitrogen behaviour from the time it leaves the animal as manure until it enters the soil and is eventually taken up by a crop, lost to the environment, or becomes part of the soil's organic mater. It is used to assess manure management practices and to determine effects on crop production. It will also predict the potential for environmental contamination. This model is prepared by request of the producer to the Soils and Engineering Branch of the Ministry of Agriculture.

Livestock watering

Intensive use of streams or lakes for watering livestock can degrade vegetation and contaminate the water source. This direct access may erode the soils, deteriorate water quality and reduce habitat for wildlife and waterfowl. But there are alternatives to direct access watering that preserve the environment around a water source while still providing clean drinking water for animals. Some of the alternatives can be categorized as follows:

- dugout - runoff collection
- gravity supply
- pump systems - onsite energy
- pump systems - offsite energy
- storage of precipitation
- water hauling
- water storage tanks

The costs of these various systems depends on how elaborate the system is (detailed information can be obtained from the Ministry of Agriculture). For the producer, the cost of a watering system is justified by the size of the herd or the number of animals to be serviced.

Detailed information on these and the many other management practices, available to producers, can be obtained through, but are not limited to the following agencies; Ministry of Agriculture, Fisheries and Food, Ministry of Environment, the BC Federation of Agriculture, the BC Cattlemen's Association and the BC Horticultural Coalition.

8.9 Public Education

Every lake management plan must include a public education program. Public education and involvement is an important option for most issues. It is important to educate the public about how they affect the lake through their choices and activities. The long term life of the plan depends on public awareness and volunteer involvement.

A public education program should be designed and implemented to encourage the community, schools and area visitors to be aware of the lake ecosystem that they are enjoying. Education programs could include a stream stewardship or lake stewardship program in the schools where children are educated about the life cycle requirements of the aquatic organisms in the lake.

Other public education ideas include the watershed stewardship program that has families in the watershed adopt a stream. A family will choose a stream near their home that they monitor over the year.

Public education can also be effectively used to reduce external loading of nutrients and sediments. The public must be informed about land use/management practices to reduce nutrient loading. This may include using phosphate free detergents, choosing to promote the growth of riparian vegetation and reducing fertilizer use.

Active circulation and discussion of the information contained in this plan can help to promote public awareness. To facilitate this option the Lakes Protection Society has become a member of the BC Lakes Stewardship Society (BCLSS, the BC chapter of the North American Lakes Management Society). The Francois Lake Management plan is available on the BCLSS Internet site in an attempt to achieve widespread circulation of the plan. (www.nalms.org/bclss/lakestewardshiptools.htm)

9. MONITORING AND EVALUATION OF LAKE QUALITY

9.1 Water Quality

Monitoring data is essential to compare the quality of the lake from year to year. When included in the lake management plan, a well-organized and maintained volunteer lake monitoring program can achieve the following goals;

- provide credible information on water quality conditions to local agencies;
- educate the public about water quality issues ;
- and build a constituency of involved citizens.

Collection of a comprehensive set of baseline data would allow comparison of water quality before and after implementation of lake management techniques.
The collected data should be made available to the following; BC Ministry of Environment biologists, (Pollution Prevention, Fisheries and Wildlife Programs), agricultural agencies, parks and recreation staff, as well as local government planning and zoning agencies.
A monitoring plan is key to aid in decision making. Once a decision to proceed with a management option is made, specific parameters which may assist in demonstrating a change (if one occurs) are identified and tracked over the implementation period. This allows continuing evaluation of the effectiveness of the actions taken.
The involvment of stakeholders as volunteers has been found to be of enormous value in the lake monitoring process. It is an efficient and cost effective method of monitioring lakes, which benefits both local agencies and stakeholders.
The volunteers learn about water sampling, lake biology, and the impacts of land use activities.
There are two approaches to designing a water quality monitoring program, both should be given consideration when developing long term monitoring strategies. The first approach is to target variables that will represent general water quality. It has been suggested that to fingerprint the productivity status of a water body the following seven parameters are of great importance;

alkalinity: The buffering capacity (alkalinity) is a measure of a lake's ability to neutralize acid inputs and thereby resist changes in pH. The higher the alkalinity, the greater the ability of water to neutralize acids.

pH: is an indication of water acidity and is measured on a scale of 0 - 14. The lower the pH, the higher the concentration of hydrogen ions and the more acidic the water. Values less than 7 indicate acidic water conditions while values greater than 7 indicate basic conditions.

true colour: Colour in water may result from the presence of coloured organic substances (i.e. humus, peat material, plankton and weeds), natural metallic ions (iron and manganese and copper) or highly coloured industrial waste. The colour value of water is extremely pH-dependent, increasing as the pH of the water is raised.

conductivity: is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their various properties and is a surrogate for the potential contaminant load of the water.

total dissolved solids (TDS): represents chemical constituents in the water that will pass through a filter 0.45 microns in size. The results provide a measure of the dissolved mineralization in the water.

total suspended solids (TSS): Nonfilterable residue, also referred to as total suspended solids is the term applied to the material retained by a filter of a standard size.

total phosphorus: Phosphorus generally occurs in water as phosphates. The various types of phosphates may occur in solutions, in particulate detritus, and in the bodies of aquatic organisms. Total phosphorus is a measure of the total concentration of phosphorus species present in the sample. Fertilizers and commercial cleaners are major sources of phosphorus.

The second approach is to target variables based on special situations in the lake. For example the presence of a mine warrants testing for the specific metals and/or by-products that it produces, or the presence of a log dump might warrant on site measurements for turbidity, leachates such as resin acids and phenols, and dissolved oxygen concentration.

To ensure a specific degree of confidence in the data collected, sampling must be conducted under a sound quality assurance program. For more detailed information on quality assurance and quality control refer to Appendix G. Also provided in this appendix is additional information and sample data sheets to facilitate the development of a volunteer monitoring program.
This section affects what action plan decisions are made. It should continually be reassessed as more monitoring information is made available and interpreted.

9.2 Sediment Cores

In February of 1997 sediment core samples were obtained from Francois Lake. A single sample was taken from the east and west end of the lake. The sediment cores were separated into 1 cm thin slices and shipped to Dr. John Smol at Queens University in Kingston for analyses. The results are in a report entitled, "Paleolimnological assessment of Tchesinkut, Takysie and Francois lakes, British Columbia" and is available through the Pollution Prevention Branch of MELP.

Types of analysis

The analysis of relative diatom abundance identifies species assemblages in each slice of the sediment core analysed. Through applying what we know about species affinities for a variety of nutrient regimes trophic status of the lake over the long term can be inferred. This would help in setting lake watershed management strategies for the future. According to Reavie and Smol (1997), the relative diatom abundance in the sedimentary profiles indicate that Francois lake is probably a naturally productive lake. Diatom-inferred total phosphorus concentrations indicate that some increased nutrient loading has likely occurred in response to human development. However, some reduction has occurred in recent decades.

The Endako molybdenum mine opened in 1965 and is located near the east end of Francois Lake. With core samples obtained from both the east and west ends of Francois Lake, we are provided with the opportunity to examine the sediments and compare their metal concentrations (especially molybdenum) both spatially and over time (hundreds of years). Geological analysis for Francois lake indicates that significant inputs of metals to the lake have occurred in response to mining and metallurgical activities during the first two decades of mine operations (Reavie and Smol, 1997). Metal enrichment was lake wide over the first decade. Results show persistent increases in Molybdenum (Mo), Calcium (Ca), and Strontium (Sr) since mining began(Reavie and Smol, 1997). Increases in the following metals were observed in the first two decades of mining, Arsenic (As), Barium (Ba), Silver (Ag), Beryllium (Be), Cadmium (Cd), Lead (Pb), and Antimony (Sb). In the last ten years, their concentrations have decreased or returned to those found for pre-mine sedimemts. Existing rehabilitation measures, such as water treatment and effluent controls, have probably improved water quality to some degree (Reavie and Smol, 1997).

The estimated costs for these analysis is between $5000 and $6000 per core. Now completed, core sampling and analysis would not need to be repeated in the foreseeable future.

10. RECOMMENDATIONS

10.1 Public Education Program

The long term life of the plan depends on public awareness and volunteer involvement. The Lakes Protection Society should pursue their goals through publicising the plan and it's contents and seeking support from the public for funding and obtaining the necessary regulatory approvals. Means of heightening awareness through educational opportunities might include:

- Solicit help from resort owners, to promote environmentally friendly recreational use on and around the lake (no power boat use zones in sensitive areas for waterfowl nesting and brood rearing) by putting up signs and distributing information brochures at resorts. The brochures can also be distributed at the ferry docks and other public access areas.

- Volunteer run booths at public functions such as fall fairs will promote public education and membership.

- Make presentations to service clubs, chambers of commerce, town councils and schools, showing off the management plan and any progress having been made to date.

- Solicit media coverage for the implementation of the plan and again at milestones within it, such as fund-raising targets to pay for various management option equipment or maintenance.

In addition, public education and awareness programs should encompass reduction and control of external nutrient loading through agricultural runoff treatment, septic system maintenance and control of inputs from new development as discussed in Section 8. Residential owners should be educated about the need to keep septic systems maintained and the potential impacts of gardening, shoreline development and other activities on water quality.

It is recommended that the LPS invite guest speakers to be on the agenda of their monthly meetings to provide information and discussion on the various issues that have been brought out as a result of this plan. Refer to list of contacts in Appendix B.

10.2 Septic System Maintenance

Leaking and failing septic systems will contribute to the nutrient load of the lake. If there is discharge of raw sewage it is a potential health hazard to both humans and wildlife that consume water from the lake. It will also have impacts on aquatic life. Each septic system which is on lakefront property should be assessed and any maintenance needed should be undertaken by the owners. The regional health officer may be able to inspect

each septic system on a request basis and provide recommendations for improvement if required. Residents should be encouraged by the Lakes Protection Society to participate and register on a voluntary basis with the Environmental Health Officer (EHO) for a maintenance inspection. Residents may also be interested in viewing a 24min. video on septic system use, operation, maintenance and care available on loan from MELP in Smithers. Viewing of this video at an LPS meeting may help to raise public awareness on public health issues.

10.3 Aquatic Plant Management

Understanding the factors that control aquatic plant growth is the first step to controlling them. Plant densities vary seasonally between lakes in an area and among regions. Before decisions on appropriate aquatic plant management options can be made and implemented it is necessary to document the present condition of aquatic plants in the lake especially those in the mouth of the Nithi River. The LPS needs to establish a sub-committee to deal with the issue of aquatic plant infestation.

A mapping exercise to identify the types and determine the approximate extent and locations of the aquatic plant infestation is needed. Aquatic plants are usually surveyed once or twice during the growing season. Several further observations that could be made during a survey include describing plant abundance (i.e. A=abundant, B=common, S=sparse), density, frequency and depth of growth of each community type (i.e. emergent, floating and submergent plants). This information is useful in deciding if and/or where to concentrate control efforts.

Once the problems have been identified and management options have been selected, a monitoring program would need to be set up to evaluate the effectiveness of the management program over time. The *Volunteer Lake Monitoring: Methods Manual* (U.S EPA 1991) should be consulted for this purpose.

10.4 Fisheries Management

Short term

The current status of the fish communities in Francois Lake needs to be investigated to determine whether fish populations are in fact declining in the lake. A volunteer sub-committee of the LPS and any other interested parties can implement an active volunteer monitoring program and an on the dock - angler survey to get some idea of the current status of the Francois Lake fishery. The Ministry of Environment, Fish and Wildlife Branch can assist in interpreting survey results and can suggest possible fishery management strategies for Francois Lake.

The LPS can begin a volunteer group to survey indicator streams to further characterise the Francois Lake fishery. To decide on indicator streams it is recommended that the Department of Fisheries and Oceans, the Ministry of Environment, Fish and Wildlife Branch and the Pacific Streamkeepers Federation are contacted and that a stream survey conducted by Bustard (1988), is carefully reviewed.

Long term

It is possible to approach fishing derby sponsors and the Ministry of Environment, Fish and Wildlife Branch about implementing changes to fishing derby rules and harvesting restrictions to sustain fish populations in the lake. However, this will require that some of the data describing the current status of the lake's fish populations has been compiled and interpreted, showing that such measures are warranted.

10.5 Habitat Restoration and Protection

Mapping of culverts has been organised and accomplished by the LPS. In conjunction with the volunteer monitoring and angler survey data, this data will help to answer some of the questions about the fish populations in the lake.

Habitat restoration and protection can be accomplished by seeking out the involvement of groups like, Ducks Unlimited, North American Lakes Management Society and the Canadian Wildlife Service.

10.6 Growth Management

One of the long range goals of the management plan is to ensure development in the Francois Lake watershed is managed in such a way that water quality and the quality of life for all who use the lake is preserved and maintained. These goals should be documented through the use of a periodically updated land use map and database. It should include the location and type of every potential loading source in the watershed, including livestock pasturing locations and number of animals present, onsite sewage disposal systems, and their state of functioning (to be documented on a voluntary basis), and any other discharges such as stormwater runoff from new housing subdivisions in the watershed. This map will then serve as a focus for such things as educational initiatives and loading source monitoring.

Involvement of the LPS in all of the planning processes is recommended so that their concerns and interests are addressed as part of these processes. In the short term, the LPS should contact the Regional District Planning Co-ordinators to ensure the society is represented during the various planning processes. Each process should be further researched by a LPS sub-committee and all additional information should be presented at appropriate LPS general meetings, as a method of updating all interested parties. It is important that the LPS takes an active role in monitoring development within the watershed. They should continually convey and publicise their concerns on issues having potentially negative impacts on the lake, its surrounding and the organisms supported by these resources. This would also include negative impacts on human health and enjoyment of these resources.

10.7 Monitoring Chemical Use in the Watershed

The LPS should support and publicise the use of alternative methods to chemical applications of herbicides, fertilizers and pesticides, by residents and resort owners. Information on available alternatives can be gained by contacting the Northwest B.C Coalition to Alternative Pesticides. It is recommended that a sub-committee of the LPS be formed to watch for advertisements of any large scale chemical applications within the Francois Lake watershed and provide regular reports at the LPS general meetings.

Recommended activities of this sub-committee would include regularly looking for newspaper advertisements on Applications for Pesticide Use Permits or Five Year Silviculture Plans by various companies, the Ministry of Forests and the Ministry of Transportation and Highways. Contacting those who will be using the chemicals and requesting arrangements be made to keep the society advised of present and future work is also suggested.

There is no formal public process with respect to dust control treatment by the Ministry of Transportation and Highways. To address this issue a small group of LPS representatives must make the effort to contact the Lakes District Ministry of Transportation and Highways to discuss concerns of the group over dust control treatment on roads near environmentally sensitive waterbody areas.

10.8 Endako Mine

A presentation by Endako representatives and mine updates at select LPS general meetings would aid in information exchanges between the two groups. This relationship should continue. Additional contact with the MELP Pollution Prevention Program through the mine public liaison committee is also advised. Recent impact assessment results would be a suitable topic for a presentation to the membership by MELP

10.9 Agricultural Land Use

Any fine tuning of livestock operations and pollution control that could reduce potential water quality degradation and nutrient inputs to the lake is suggested. This may be best accomplished through liaison with the cattlemen's association voluntary audit program.

11. IMPLEMENTATION - ACTION PLAN

11.1 Plan Review and Revision - Testing

A systems design approach is subject to ongoing evaluation and revision, and it is accepted that a portion of the resources allocated to its implementation must be focused on refining it. In the first year of implementation, there should be a review of the plan by lake management experts. The review should also include those regulators who may be called upon to write permits and licenses or cooperate in some way to implement the various management options. Ensuring that this occurs should be the first priority, and could be easily accomplished with assistance from the MELP Pollution Prevention Program.

11.2 Financial Support

To begin implementation of the lake management plan, an overall budget is required. Costs may include:

- use of government program funding to publish the plan
- planning - sending the draft plan out for review to experts in the province and elsewhere
- equipment
- monitoring and evaluation programs
- monitoring and evaluation programs - training volunteers and carrying out needed water, sediment and biota monitoring
- permits

Acquiring adequate funding to cover implementation costs will be challenging, therefore a funding strategy must be developed. Once a consensus on the management options and monitoring strategies have been reached, the level and duration of funding needed must be identified.

Some options for raising funds include:

- using current government programs to fund aspects of the plan such as water quality monitoring.
- voluntary donations, which should be sought in a systematic manner, such as an appeal campaign.

- modifying the lake association to allow the ability to collect revenue in the form of membership dues from anyone interested in helping.

- formation of a taxing district regulated by the Regional District. There are two possibilities for forming one, the Local Service Area or the Local Improvement District. More information on the process of establishing one of these areas can be obtained from the Bulkley Nechako Regional District.

- application for grants or loans from public agencies. Grants or loans from public agencies include options such as the Habitat Conservation Fund, the Public Assistance Conservation Fund, and the Water Stewardship Grant. The Habitat Conservation Fund deals with projects on habitat rehabilitation and maintenance (i.e. Rainbow trout spawning habitat). They also fund various research projects. Grants can be obtained through the Volunteer Lake Stewardship Program to establish lake management science and awareness programs in area schools. This is a new government initiative which provides funding, technical support through the Ministry, monitoring assistance and establishes a user group support network to produce educational materials and provide guidance. The goal of the program is to increase community awareness about lake management science. Such a program could potentially be initiated in the Francois Lake School or other school in the area, with the school's co-operation and appropriate funding.

- Other private initiatives for raising funds include protection society membership dues, fund-raising events, and donor campaigns.

Committees should be struck immediately to formulate the financial strategy. Fund raising methods should be inventoried, evaluated and decisions made as to their applicability in this instance.

11.3 Volunteer Groups

Committed volunteers are essential to the success of the plan. Managing a lake is an ongoing process and a mechanism is needed to keep the plan in motion after it is written. Therefore an aggressive membership program is needed, that is flexible enough to accommodate more than one level of participation (both financial and volunteer wise).
Volunteer groups who will assist with the implementation of the plan must be identified.
In the Bulkley Valley and Lakes District, this may include, but is not limited to:

- Lake Protection Societies
- youth and service clubs (4H, Rotary Club, Scouts etc.)
- North American Lake Management Society, BC chapter

Volunteers can also assist with monitoring. One method of ensuring that tasks are completed successfully includes placing the volunteers in groups (committees), delegating tasks to each group and making sure adequate training is provided. Each

group consists of one leader and their assistants. Each group is responsible for completing a set of well defined tasks. Examples of volunteer subcommittees are:

- funding
- sampling and monitoring
- land use
- education

To ensure that the tasks are carried out indefinitely, no leadership position is to be vacant in any given year. Election of new subcommittee chair positions should occur every 2-3 years. An evaluation of the group's status should be held at regular intervals.

11.4 Regulatory Agencies

Most of the affected regulatory agencies have been consulted and involved in the development of the lake management plan. It is essential to identify all affected regulatory agencies and obtain the necessary approvals and permits. When applying for permits and approvals, it is helpful to include a deadline for which the approval is needed as it will allow the agency to prioritise incoming applications for approval. Allow sufficient time for the agencies to respond.

REFERENCES

Bowman, B.T. 1997. Effect of Tillage Practices Upon the Risk of Pesticide or Nutrient Losses from Cropland.

Boyd, I.T., C.J.P. McKean, and R.N. Nordin. 1985. Kathlyn, Seymour, Round and Tyhee Lakes Water Quality Assessment and Objectives. Ministry of Environment. Province of British Columbia.

Brewer, G.D. "Methods for Synthesis: Policy Exercises." In Sustainable Development of the Biosphere. Edited by W.C. Clark and R.E. Munn. Laxenburg: International Institute for Applied Systems Analysis., 1986, p. 455 - 472.

Bustard, D. and Associates. 1988. Assessment of Rainbow Trout Recruitment From Streams Tributary To Francois Lake. Prepared for B.C Conservation Foundation.

Bustard, D. and Associates. 1989. Francois Lake Creel Survey 1987 - 1988.

Cooke, G.D., E.B. Welch, S.A. Peterson and P.R. Newroth. 1993. Restoration and Management of Lakes and Reservoirs. Second Edition. Lewis Publishers. Florida.

Daniel, T.C., A.N. Sharpley, D.R. Edwards, R. Wedepohl, and J.L. Lemunyon. 1994. Minimizing surface water eutrophication from agriculture by phosphorus management. Journal of Soil and Water Conservation 49: 30-38.

Dillon, P.J. and F.H. Rigler. 1975. A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status. *J.Fish.Res. Board Can.* **32**:1519-1531.

Ellickson P.J. and P.A. Larkin. 1969. Feasibility Study of a Net Fishery in Lakes of the Burns Lake Area. Prepared for the B.C MELP, Fish and Wildlife Branch.

French, T. and P.A. Chambers. 1992. Aquatic Marcophytes in the Nechako River, British Columbia: Environmental Factors Regulating the growth of *Elodea canadensis.* B.C Ministry of Environment.

Forest Fertilization Guidebook. 1995. B.C Ministry of Forests.

Gibbons, M.V., H.L. Gibbons and M.D. Sytsma. 1994. A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans. Washington State Department of Ecology.

Kerfoot, W.B., and S.M. Skinner. 1981. Septic Leachate Surveys for Lakeside Sewer Needs Evaluation. *J. Water Pollut. Control Fed*. **53**(12): 1717-1725.

Lightowlers, Christy 1995. Lake Management Planning: A Generic Plan Outline.

Marquis, P. 1995. Nithi River Study. Prepared for the Fisheries Section, Fish and Wildlife Branch, MELP.

McDaniels, T. 1992. A Multiple Objective Decision Analysis of Land Use Options for the Tatshenshini-Alsek Area. Commission on Resources and Environment. Victoria, BC.

Ministry of Environment, Lands and Parks (MELP), 1984. Fish Inventory and Assessment Projects by Lake. File 34560-25 Nechako Francois Lake 93L/E.

Michaud, Joy P. 1991. A Citizen's Guide to Understanding and Monitoring Lakes and Streams. Washington State Department of Ecology.

Pinsent, M.E. 1973. An Initial Inventory of the Streams in the Francois - Fraser Lakes System.

Rast, W. and M. Holland. 1988. Eutrophication of lakes and Reservoirs: A Framework for Making Management Decisions. *Ambio* **17** (1): 2 - 12.

Reavie, E. D and J. P. Smol. 1997 Paleolimnological assessment of Tchesinkut, Takysie and Francois lakes, British Columbia. Prepared for B.C Ministry of Environment Pollution Prevention Program.

Rysavy, S. and I. Sharpe, 1995. Tyhee Lake Management Plan Draft #1. B.C Ministry of Environment Pollution Prevention Program.

Shaffer, M. 1993. Multiple Account Evaluation Guidelines. BC Ministry of Environment. Crown Corporations Secretariat, Vancouver, BC

Spitzer, Dean. 1991. Introduction to Instructional & Performance Technology. Second Edition. Boise State University.

USEPA 1990. The Lake and Reservoir Restoration Guidance Manual. Second Edition. Prepared by the North American Lake Management Society for the United States Environmental Protection Agency.

Wallis, M.A. 1995. Biomanipulation: The Future of Algal Management. *Bio. Line.* **13**(1):8-11.

Water Survey Canada. 1990. Historical Streamflow Summary.

Wetzel, Robert G. 1983. Limnology. Second Edition. New York. Saunders College Publishing.

White, T.C., M.D. Sloat and D.G. Hickey. 1996. Regional District of Bulkley-Nechako Vanderhoof Rural and Fort St. James Rural Official Community Plan Areas. Proposed Development Permit Guidelines For Riparian Management Areas. Volume 1 - Report. Prepared for the Department of Fisheries and Oceans, the Regional District of Bulkley-Nechako and BC Environment. Prepared by EDI Environmental Dynamics Inc.

Appendix A - Francois Lake Issues and Criteria Ranking

FRANCOIS LAKE		CRITERIA				
			Hazard to	Level of	Technical -	
			Human	Adverse	Are there	
ISSUES PRESENTED	BREAKDOWN	Hazard to	Health	Economic	Feasible	Total All
		Ecosystem*	& Safety*	Impacts	Options	Criteria
water craft sewage	(*ferry)	1	1	3	3	8
water temperature	increases	1	1	3	3	8
declining fish stocks	kokanee, lake trout, burbot	3	1	1	3	8
(spawning/rearing)	habitat degradation					
	sport fishing					
sewage	septics	2	2	1	2	7
agricultural waste		2	2	1	2	7
forestry (logging)	sedimentation impacts	3	1	1	3	8
	herbicides	3	3	3	3	12
	fertilizers	3	3	3	3	12
	aesthetics impact	1	1	2	3	7
mine	ground/surface water impacts	3	3	1	2	9
ferry washing	salts, oils, fuels from washing	3	3	2	3	11
dust control in summer	calcium chloride	3	3	3	1	10
road access		1	1	3	1	6
road (Hwy.) construction	obstruction to fish passage	2	1	3	2	8
	aquatic & upland destruction	2	1	3	2	8
	widening=habitat destruction	3	1	3	3	10
	spraying of weeds	3	3	3	3	12
growth management (zoning)	low density zoning	2.5	2.5	2.5	2	9.5
	no water sale	2	2	2	2	8
	no heliports/airport facilities	1	1	3	3	8
	no additional indust.waste discharge	2	2	3	2	9
	no indust/commer. structures on lk	2	2	3	2	9
beavers	impact on trees	3	3	2	3	11
	disease vector	3	3	2	3	11
weeds	Nith. R. mouth	3	1	3	3	10

***** These criteria refer to the level of **resident concern** (actual/perceived hazard)

The **Ecosystem** includes all aspects of the lake environment (plants, animals, water, trees etc..)

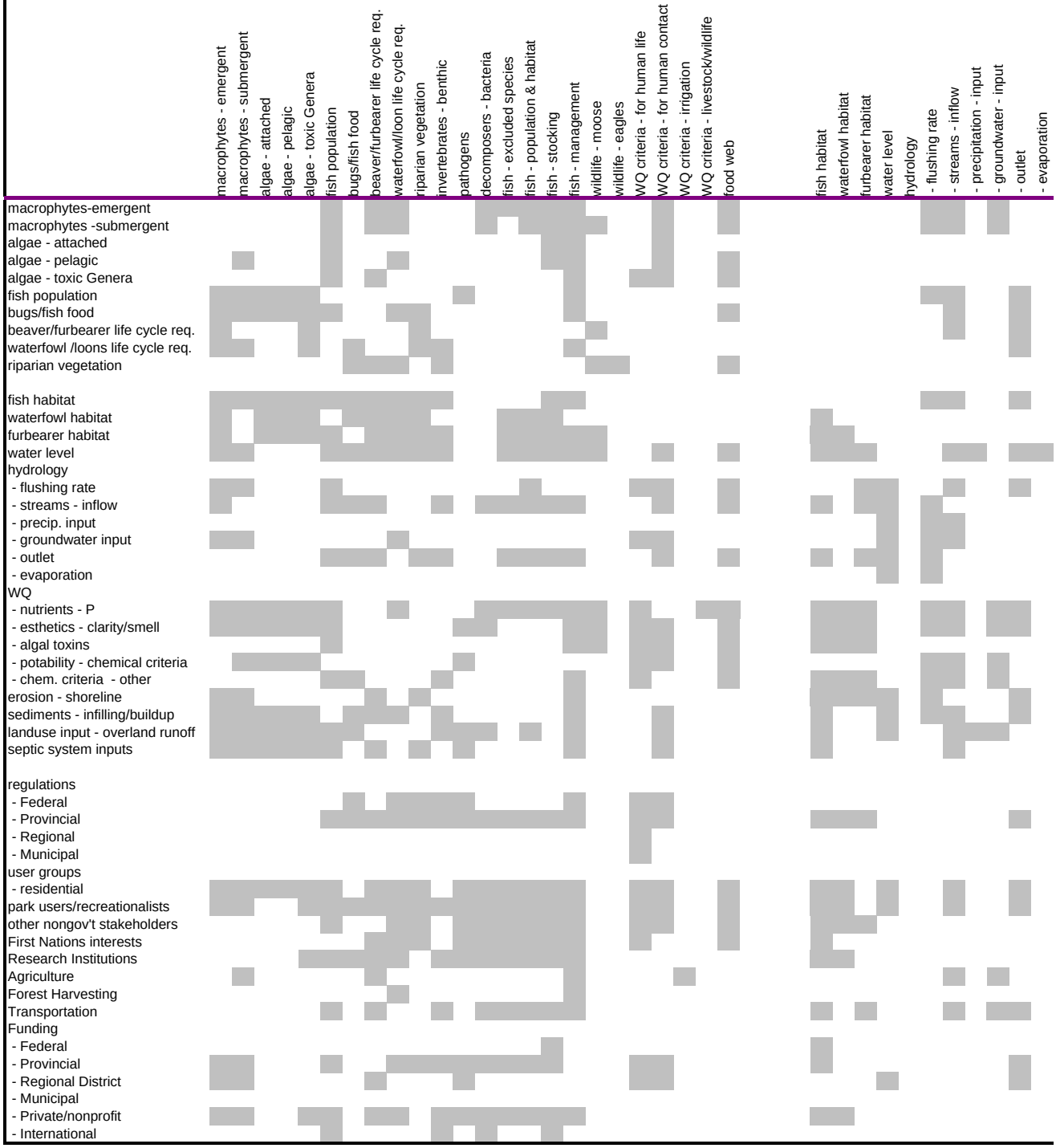
Economic Impacts: livelihood, travel/tourism $

Feasibility: costs; regulations & permits

Ranking: 1(low)2(med)3(high) Criteria 1,2 &4

Ranking: 1(high)2(med)3(low): Criteria 3

This is only a partial list for the top parameters since the complete matrix would have the same list of parameters in the side bar as the top bar. Each parameter on the side bar is then paried with the top parameters one at a time and the question is asked whether the two parameters interact with one another



APPENDIX B
LIST OF STAKEHOLDERS AND CONTACTS

BC Building Corporation	
Floyd Mann,	(250)638-2371
Terrace, B.C.	
BC Lakes Stewardship Society	
Michelle Boshard, President	(250)868-1027
Rick Nordin, Vice-President	(250)387-9517
Lisa Westenhofer, Local Area Director	(250)847-7260
Bulkley Nechako Regional District	(250)692-3195
Ilene Benedict, Director of Electoral District E	
Ralph Roy, Director of Electoral District D	
Mark Andison, Director of Planning	
Cheslatta Carrier Nation	
	(250)694-3334
Coast Guard	
Stephen Mundschutz	(604)775-8877
Endako Mine Ltd.	
Barb Riordan, Environmental Coordinator	(250)699-6211
Lakes Protection Society	
Joel Stratton, President	(250)695-6567
Ministry of Agriculture, Fisheries and Food	
Dave Riendeau, District Agriculturist	(250)847-7246
Ministry of Environment, Lands and Parks	
Ian Sharpe, Impact Assessment Biologist	(250)847-7251
Sig Hatlevik, Fisheries Technician	(250)847-7260
Dan Cronin, Coordinator, Permits and Pest Mgmt Plans	(250)387-9416
Ministry of Forests	
Lakes Forest District Office	
Stuart Abels, Silviculturalist	(250)692-2239
Bob Fowler, Range Resource Officer	(250)692-2220
Vanderhoof District Office	
R.G. Clark, District Manager	(250)567-6363
Silviculture Practices Branch	
Al Waters, Site Preparation Program Specialist	(250)356-6041
Ministry of Health: Northern Interior Health Unit	
Leslie Moody, Environmental Health Officer	(250)692-3171

APPENDIX B
LIST OF STAKEHOLDERS AND CONTACTS

Ministry of Transport and Highways	
Lakes Highways District	
Stephanie Price, District Operations Asst.	(250)692-7161
Marine Branch	
Darcy Byers, P. Eng., Director	(250)387-3403
North West Region	
Val Preston, Reg. Operations Asst.	(250)638-6440
Central/North East Region	
Darly Nolan, Roadside Development Technician	(250)565-6484
Northwest Weed Committee	
Dave Riendeau, Chairperson	(250)847-7246
Northwest BC Coalition to Alternative Pesticides	
Paul Glover (for information)	(250)847-5575
Pacific Streamkeepers Federation	1-800-723-7753
720 Orwell St. North Vancouver, B.C V7J 2G3	(604)986-5059
Brenda Donas, DFO Community Advisor	(250)847-5298
Al McCraken, Volunteer Streamkeeper	(250)696-3221
Tchesinkut Lake Watershed Protection Society	
Tom Blair, President	(250)695-6386
Tyhee Lakes Protection Society	
Gary Rysavy, Board of Directors	(250)847-4045

Appendix C - Summary of Jurisdictions Involved in Lakes and Lakeshore Regulations and Management

Management of lakes and shorelands fall under the jurisdiction of a variety of agencies. Each may have responsibilities for some aspects of resource management which affect lake quality.

PROVINCIAL GOVERNMENT AGENCIES

Ministry of Environment, Lands and Parks

The Fisheries and Wildlife Branch is responsible for the preservation and enhancement of fish and wildlife species and encourages their appreciation by the public. The legal basis for their management derives from the (federal) Fisheries Act and (B.C.) Wildlife Act. Management activities include; drafting of fishing and hunting regulations; stocking of lakes with fish; and protection and management of habitat for fish and wildlife including fish spawning and rearing habitat, winter range for ungulates (hoofed animals), and waterfowl nesting habitat.

The Pollution Prevention Program is responsible for regulating and monitoring all discharges of solid, liquid and gaseous wastes to the ground and water (with the exception of ground disposal of sewage effluents under 22,730 liters per day). The Waste Management Act provides authority for these various functions. In the context of this study, an important monitoring function is periodic sampling of lake water to determine the extent of eutrophication which hastens the filling in or "death" of lakes.

The Water Management Branch has several licensing, management and monitoring functions. All forms of water extraction require licensing; the most common from lakes are for domestic and irrigation uses. The Water Act provides regulating authority.

Lands Operations (B.C. Lands) is responsible for allocating crown lands for various uses and making Crown land available to the public, particularly through the planing, construction and marketing of Crown land subdivisions. These subdivisions may be established as shore frontage properties or as upland properties without direct lake frontage. The divisions regulates dock and marina placement and removal of material from the littoral and shore zone. The Land Branch establishes reserves for public recreation use to ensure public access to all lake sites for future recreation use.

B.C. Lands has a planning process and approval procedure basses on the authority in the Land Act, and information in the Crown land Registry. It administers Crown land dispositions programs , and ensures security and administration of Crown land tenures. B.C. Lands issues lease or licence tenures, or sells parcels, through a disposition program involving public tender or auction.

B.C. Parks has a mandate to protect and manage outdoor recreation with a principal responsibility to plan, develop and operate parks and recreation areas. Often, lakes form the focal point for recreation activities and for the planning of park accommodation facilities. The Division may assist in the development and funding of regional parks in cooperation with a Regional District. The Division implements Provincial Boating Regulations under authority of the (federal) Navigable Waters Act. An important planing functions is in forecasting the need for park sites as demand and access change.

Ministry of Health

In relation to this study; the Ministry of Health is responsible for the regulations (standards, inspections and permits) of most small discharges of sewage effluent (i.e. under 22,730 litters per day) and ensuring that public health is protected from bacteriological contamination of the receiving waters. The Ministry's Environment Health Officers are also responsible for determining and monitoring potability (whether or not water is safe to drink). Clearly comparative water quality information on lake water rests with the Ministry of Environment, Lands and Parks insofar as it may impact on their established fish and wildlife, water licencing and waste management programs. However, when recreational water quality or drinking water quality is involved, the responsibility shifts to the Ministry of Health. The mandate of Ministry of Health is limited to ensure that public health is protect from bacteriological contamination of the receiving water.

Appendix C - Summary of Jurisdictions Involved in Lakes and Lakeshore Regulations and Management

Ministry of Forests

The Ministry of Forests is responsible for management of Crown Forest and range resources. The Ministry's mandate includes timber and forage production, timber harvesting, grazing of livestock, forest oriented recreation (e.g. hiking trails, recreation sites, cross-country trails, ect.), and the realizing and integration of fisheries, wildlife and watershed values. These are regulated through the Forest Act. The "Forest Practices Code", in development, will broaden the Ministry's mandate. The Ministry of Forests also administers various tenures of Crown land which are classed as forest uses. Many timber harvesting and forest management activities have the potential to significantly alter visual landscapes in the vicinity of lakes, and to affect water quality through release of nutrients and silts to the watercourses.

Ministry of Agriculture, Fisheries and Foods

In general terms, the **Ministry of Agriculture, Fisheries and Foods** is responsible for working with those engaged in the agriculture sector towards the maintenance of enhancement of a viable agriculture industry. At the Regional level, the functions of the Ministry are of a service rather then a regulatory nature. Agriculture activities can require storage and regulation of lake water to optimize delivery times and amounts, and live stock grazing may add significant quantities of nutrients and silts to watercourses. Fertilizers and agriculture chemicals may add nutrients and chemicals toxic to fish. The Agriculture waste Control Regulations and Code of Agriculture Practice for Waste Management was adopted in 1992 and is aimed at minimizing these problems. The Ministry also has various polices regulating inland commercial fisheries and access rights (in conjunction with Ministry of Environment, Lands and Parks).

Agriculture Land Commission

The mandate of the **Agriculture Land Commission** is to preserve the agriculture land base of the Province. To carry out this mandate, the Commission is provided with regulatory powers pertaining to the use and subdivision of al lands within the agriculture Land Reserve (A.L.R.) In Fraser-Fort George Regional District, the role of A.L.R. on shorelands is limited.

Ministry of Tourism and Minister Responsible for Culture

The **Archaeology Branch** promotes the conservation, development, and public appreciation of archaeology resources. The potential effects of development on archaeological sites are assessed and managed through branch participation in the provincial environment review process and by collaborating management programs with other ministries. Public and private sector agencies are assisted in developing integrated resource management plans. The branch maintains a detailed archaeology site inventory and a registry of heritage sites which have been designated by other legal means.

The **Heritage Conservation Branch** provides leadership in the promotion, protection, conservation and presentation of the province's historic reserves. Under the Heritage Conservation Act, the branch is responsible for regulating the protection and conservation of historic resources from architecture to artifacts.

Ministry of Municipal Affairs, Recreation and Housing

Regional Districts have several planning functions outside of municipal boundaries. Some settlement is planed within Official Community Plans and there is planning for regional and community parks. There is a regulatory function in development and administering zoning, subdivision, special bylaws and development permits. The Fraser-Fort George Regional District is involved in assessing development applications and has a mandate for provisions and financing of certain financing of certain services (e.g. Solid waste disposal, Community water and sewer systems, Fire protection) on a local service area basis. Again, a significant portion of the planning, assessment and regulatory function is directed to activities on lakes and shorelands areas.

Ministry of Energy, Mines and Petroleum Resources

The Ministry ensures that the province's energy and mineral resources are developed and used in a safe, efficient and environmentally sound manner for the economic benefit of the province.

Ministry of Transportation and Highways

Environmental Services is a specialized section within Highway Engineering which deals with all environmental issues affected by highway location and construction. They provide direction to regions, districts and headquarters to ensure environmental impacts from construction are minimized.

II. FEDERAL GOVERNMENT AGENCIES

Two Federal government agencies have significant interests in lake and stream management. The **Department of Fisheries and Oceans** is active in the preservation and enhancement of salmon spawning and rearing habitat in rivers, streams and lakes, While **Transport Canada** assures that waters remain capable of providing boat passage under the Navigable Water Protection Act.

III. NON GOVERNMETAL ORGINATIONS

A wide range of special interest organizations and citizen groups have interests in development and proper use of water resources and the riparian and upland areas of lakes.

Nature Trust of British Columbia and **Nature Conservancy of Canada** are both organizations dedicated to conserving unique natural areas and the preservation of wildlife habitat. They work with private landowners to develop ways in which the their objectives may be achieved, including land acquisition and conservation easements.

Ducks Unlimited is an international organization dedicated to conservation of wetland areas and to monitoring and enhancing waterfowl populations via a range of management techniques. A number of sites within the Fraser-Fort George Regional District are the focus of Ducks Unlimited preservation and intervention projects.

The **Carrier-Sekani Tribal Council** and the **Shuswap Nation Tribal Council** maintain interests in watershed management, natural resources, environment and fisheries resource management, and heritage sites. Both the Council of Chiefs and some bands often share these concerns. Their interest is on both reserve and traditionally used lands.

The **B.C. Wildlife Federation** promotes wise management of fish, wildlife and recreation resources through lobbying for appropriate management efforts and through providing a "watchdog" role by its thousands of members.

The **B.C. Fishing Resorts and Outfitters Association** strives to retain the viability of its members' businesses in part, by attempting to attempting the natural, enjoyable settings essential to the pleasurable outdoor recreation. As related to lakes this is often involves efforts to limit the extent of industrial activity, residential development and access.

Members of the **B.C. Federation of Naturalists** tend to place the greatest priority on protecting the natural evolution of individual lakes and riparian habitats. This may mean actively resisting disturbing influences.

Other local groups with interests in lakes and lakeshore management include **Lakeshore residents' groups** such as the Ness Lake Environmental Protection Society and West Lake Community Association.

Appendix C - Summary of Jurisdictions Involved in Lakes and Lakeshore Regulations and Management

The range and diversity of agencies, organizations and citizens concerned with the lake shorelines management underscores the need to establish mutually acceptable guidelines to regulate development in such sensitive, yet sough after, areas.

Appendix D: Options Analysis Chart

Cost Benefit Analysis of Lake Management Options for Francois Lake (adapted from Tyhee Lake Management Plan)

Option	Explanation	Costs	Benefits
do nothing	allow eutrophication to proceed at unknown rate	• unknown	• none
lime (calcium carbonate)	not applicable (need alkaline lake)		
alum (aluminum sulfate)	bind P to alum to reduce in-lake P cycling	• lasts 5 - 10 years depending on amt. added • reduces pH (unless applied with a buffer) • increases growth of rooted plants (ex. *Elodea*) • effectiveness is temperature/pH dependent • aluminum:alzheimers correlation (? - concern, but still contentious - no strong tie) • alum is cheap, but application is expensive (in the area of $200,000 for Tyhee Lake)	• immediate results • increased water clarity • decreased algal blooms
copper sulfate	addition of excess copper to the ecosystem works as an algacide	• this option treats a symptom of eutrophication rather than addressing the problem itself • effects are very short term • annual costs are high ($200,000) • negative impacts on nontarget organisms (toxic to fish) • negative impacts on benthic invertebrates and possibility of completely destabilized ecosystem • contamination of sediments with copper (reaching levels of high toxicity) • does not affect macrophyte growth • requires pesticide permit	• decreased algal blooms • can be used to control ‘swimmer’s itch’ • immediate and highly effective results • increased water clarity

Appendix D: Options Analysis Chart

Option	Explanation	Costs	Benefits
diversion/pristine water inflow	pipeline or ditching from source to lake	• need water source with 1/10th nutrient concentrations of lake water • ditching or pipeline required (approx. $50,000 to install) • improvement in water clarity is directly related to increase in flushing rate • need water license • need $ for yearly maintenance (approx. $10,000/year) • uncertain rate of results	• potential long term results • potential increase in flushing rate • potential to improve water esthetics • potential increase dissolved oxygen levels
hypolimnetic withdrawal	removal of P rich hypolimnetic water by siphon through the outlet and into the Bulkley River	• initial installation relatively expensive because of size and topography of lake *(cost estimate coming from Prolite Plastics should be approx. $20,000)* • will have some impact on outfall creek (used for spawning) • very small time window in spring when water can be siphoned off while maintaining water level (if necessary) • *what is volume of hypolimnion? what is max. amt. of water which can be removed (normal outflow volume)?*	• many examples of this technique proven to be effective • maintains lake stratification while eliminating anoxic layer (but this will not happen if pumping only occurs in spring) • easily regulated • low annual maintenance costs • no environmental impact to lake
hypolimnetic aeration	maintenance of oxidative state on bottom reducing P dissolution on bottom of lake	• expensive to install *(need $$)* • expensive to maintain • tricky to make aerator work effectively • only feasible if the P internal loading process is controlled by redox, not likely to see positive effect if P liberation is due to microbial activity or non-oxygen dependent processes	• maintains lake stratification • provides oxygen to oxygen deficient water

Appendix D: Options Analysis Chart

Option	Explanation	Costs	Benefits
circulation/aeration	complete circulation of lake water in order to destratify and aerate the lake	• destratifies lake • most effective in non nutrient-limited lakes • expensive to install ($200,000) • can cause increased P in the water column, if p release from the sediment is controlled by calcium • can increase blue-green algal blooms • increases lake temperature (especially of hypolimnion which is habitat for cold water species of fish) • may increase internal loading (depending on lake processes at sediment/water interface) • open water could create winter safety hazard (if aeration continues throughout winter)	• increases dissolved oxygen content throughout the lake • can prevent fish kill over winter in shallow lakes • increases habitat for aerobic organisms • can decrease P if controlled by iron
sediment removal/pumping	removal of high phosphorus sediments from the lake basin using a hydraulic dredge	• must transport sludge/sediment somewhere • need large disposal area capacity • sediment pile can create a ‘tailings’ pile with acid drainage • expensive equipment needed • cost in $1,000,000’s range • pumping costs very high • very large amount of sediment to be removed from basin • must determine sedimentation rate before dredging • can cause resuspension of fines which may be harmful to organisms	• effective in small applications • sediment/sludge at Tyhee Lake is approx. 50% water (therefore easy removal with hydraulic dredge) • long term/permanent solution • decrease internal P loading (assuming that the deeper sediments are “better” than the surface ones)

Appendix D: Options Analysis Chart

Option	Explanation	Costs	Benefits
weed harvesting	removal of macrophytes from lake	• need area to haul weeds to (compost area) • may see increase in weed growth as an immediate result (fragments escape and may spread plants) • uncertain effects on algae • need equipment - barge/boat and cutting tools • may harvest young fish with plants • harvesting will not eradicate plants as it does not remove root systems	• quick results in small areas (an acre or two per day maximum) • may foster volunteer spirit • localized method/controllable
grass carp	introduction of sterile (triploid) grass carp into the lake to reduce vegetation (control aquatic plant growth)	• introduction of carp to a lake changes the ecosystem • need permit from BCE- Fish and Wildlife Branch (very unlikely to get approval) • grass carp eliminate aquatic vegetation which provides valuable hiding places for young fish and important food for waterfowl • carp are very difficult to eradicate • difficult to estimate stocking rates • very expensive	• reduction of macrophyte biomass • selective feeding (prefer Elodea)
sediment covers	using light blocking screens to cover and kill the rooted plants	• very expensive ($20,000 per acre) • need to cut slits in material because gas evolution from the sediments will cause barrier to “float”	• effective in small areas (good idea for around docks and swimming areas)
water level drawdown	removal of approx. two thirds of the lake water for the winter in order to expose the macrophytes to extreme weather conditions	• very expensive (high pumping costs) • may have negative impact on fish populations • tested on *Milfoil*, didn’t see a lot of benefits • need reservoir • doesn’t actually remove excess P from lake	• may kill rooted macrophyte populations • may compact flocculent sediments

Appendix D: Options Analysis Chart

Option	Explanation	Costs	Benefits
public education - includes household product use fertilizer/detergent	campaign to increase awareness about product use among people living in the catchment basin	• difficult to be effective and hard to judge success • difficult to target large and diverse populations	• long term changes • increased awareness
agriculture runoff control & treatment	use of ditches to catch and divert nutrient rich runoff from entering the lake	• expensive - cost borne by individual farmers • treatment works require maintenance • reduces area of pasturage	• immediately effective - reduces nutrients/pathogens to the lake • may improve forage production
septic system failure definition remediation/maintenance		• difficult to diagnose problems • cost borne by individual • difficult to measure results • inputs from septic systems only comprise a small portion of the nutrient loading problem	• fairly immediate result
sewage systems installation	installation of a community sewage treatment plant	• very expensive • cost borne by lake residents	• immediate result of input from this source is significant
control of forest management			
control of inputs from new development			

Appendix E: Responses to Information Requests

Letter from the Central/North East Region Ministry of Transportation and Highways:

File 47950-33/NE
Date: February 11,1997
To: East Francois Lake Community Association Attention: Gill Kopy, President

RE: Herbicide Use

Thank you for your letter dated January 14, 1997, regarding our ministry's use of herbicides in the Francois Lake area. The only current authorized use of herbicides for vegetation management (by our ministry and ministry contractors) is for noxious weed control programs. I am responsible for implementing the noxious weed control program in the Central/North East Region of the ministry.

In response to the questions asked in your letter:

What are the names of the herbicides currently being used?

There are three herbicides that might be used in your area: Tordon 22K (picloram), DyCleer (dicamba) and Roundup (glyphosate). Tordon 22K is the product most frequently used for weed control in the Nechako Highways District.

To what extent (quantity and frequency) are they being used?

Quantities of herbicide used

The amount of herbicide used in our program varies from year to year. The following table provides details of the quantities of herbicides used, and the area of land treated, for noxious weed control in the past ten years in the Nechako highways District.

	Tordon 22K		Roundup		
	kg ai used	ha treated	kg ai used	ha treated	Total ha treated
1996	4.08	6.86	0.00	0.00	6.86
1995	9.35	19.47	0.64	0.26	19.73
1994	0.38	0.35	1.99	0.80	1.15
1993	0.00	0.00	0.02	0.03	0.03
1992	2.22	20.60	0.00	0.00	2.06
1991	8.47	7.84	0.00	0.00	7.84
1990	13.99	12.96	0.00	0.00	12.96
1989	15.37	14.24	0.00	0.00	14.24

kg ai = kilograms of herbicide active ingredient used
ha treated = area sprayed with herbicide

The last time our contractors applied herbicide near Francois Lake was in 1995. That year approximately 1.5 hectares were sprayed with Tordon 22K along Serle Road and a two kilometer section of Francois Lake near Serle Road.

Frequency of use

Herbicide can be expected to be used for weed control somewhere in the Nechako Highways District each year. A particular noxious weed infestation targeted for control typically receives one or two herbicide applications in a season. In a few cases, a third application of herbicide may be needed to provide satisfactory control. A particular site may be treated on successive years if it has been identified as a control priority.

What is the method of application?

Herbicides are applied on a spot treatment basis (i.e. only those portions of the roadside infested with noxious weed are treated) using either a hand-held hose-end spray gun connected to a spray tank mounted on a truck, a backpack sprayer, or in some cases wick applicator.

What are the effects on the lake ecosystem?

Before using herbicides, we must obtain a Pesticide Use Permit from the Ministry of Environment, Lands and Parks. Use conditions imposed by the Pesticide Use Permit, together with label use instructions on the product, ensure that the environment is protected. Herbicides used in our program are unlikely to enter into a lake ecosystem as all water bodies are protected by Pesticide Free Zones established next to water during herbicide application.

What are some of the alternatives to using herbicide?

Efforts to manage the problem of noxious weed invasion involves many activities other than spraying with herbicides.

Prevention

Preventing inadvertent introduction of noxious species into uninfested areas is of utmost importance. Seed mixes bought by our ministry for revegetating areas disturbed during construction are required to be free from noxious weed seed contamination. We control infestations in gravel pits to prevent the spreading of infestations when gravels are hauled to projects.

Cultural Control

Our ministry seeds and fertilizes areas disturbed during construction to establish competitive grass-legume swards that provide a competitive barrier to weed invasion.

Mechanical Control, Handpulling and Grubbing

We handpull, grub and cut infestations in environmentally sensitive areas and other locations where this approach can be expected to provide an equally cost effective means of control. Handpulling and grubbing are generally used only for weed species that do not reproduce vegetatively from rootstocks and where the infestation is light; otherwise, this method of control can be prohibitively costly. Mechanical control is generally many times more costly, and not as effective as control using herbicides. Consequently, mechanical control measures are not considered to be viable stand-alone methods of controlling weeds.

Biological Control

provincial efforts to control weeds through the introduction of a complex of insects and other biological control agents have been ongoing for decades. Biological control offers the promise of the most cost effective and environmentally benign means for controlling weeds. Several weed species targeted at one time in spray programs are not treated with herbicide because biological control agents have been successful at reducing plant populations below economically damaging levels. However, there is no guarantee that biological control efforts against any weed will ever be successful. Consequently, efforts to reduce the adverse economic and environmental impacts of weed invasion using conventional approaches will probably continue until experts in the field of weed control determine that control programs against a weed species is no longer warranted because of the success of a biological control program.

The amount of program work done controlling noxious weeds in any specific area reflects factors such as the amount of agricultural production in the area and the expectation for control of weeds from members of the public, agricultural organizations, regional districts, and the Ministry of Agriculture.

Roadsides in the west Francois Lake area have been sprayed several times during recent years as the result of weed control requests received from the public and the Bulkley-Nechako Regional District. Consequently, it is likely that future herbicide applications for weed control could take place in the area

It would be useful if relevant details of the Lakes Protection Society's Lake Management Plan could be forwarded to our office. I can review the plan to identify concerns that can be considered during planning for the 1997 program. For example, notes detailing environmentally sensitive areas can be added to

inventory records for sites in the area. These inventories already note the locations of water bodies, wells and other features. The locations of features on the roadside are referenced by measuring the driven distance from the site to a fixed ministry landmark such as a bridge or an intersecting road. This information is reviewed when our staff develops a control prescription for a site. Inventories are also provided as reference material to contract applicators of herbicide.

I cannot guarantee that the ministry would not use herbicide as a weed control tool on any particular site because herbicides provide the most economical and often the only practical means of controlling many weed infestations.

A compromise solution that we offer to people strongly opposed to herbicide use, is to ask them to take responsibility for controlling the weeds on the roadsides bordering their properties using alternative methods of control. Where there is interest in this approach, those involved are asked to contact our office with details of the site they wish to have excluded from our integrated control program. I can then arrange to have the "adopted" area identified in our records as a site where residents are taking responsibility for the weed control.

There is a second avenue for expressing concern regarding pesticide use that your association should be aware of : the Pesticide Use Permit application process overseen by the Pesticide Management Program of the Ministry of Environment. Agencies occupying public land must make application for a use permit to use pesticides. Information submitted by the public during the application process is reviewed by the Pesticide Management Program during its evaluation of the application. I have recently made application for a new three year permit for the Nechako Highways District. In the next several weeks, a statutory advertisement will be published in the Caledonia Courier and the Omineca Express Bugle to notify the public of the application. The advertisement will include details of the process for submitting information to the Pesticide Management Program.

As you may know, Francois Lake falls within two separate regions of our ministry. The western portion of the lake is within the boundaries of our North West Regional Office. The Ministry contact responsible for overseeing the weed control function there works out of the regional office in Terrace: Val Preston, Regional Operations Assistant, Ministry of Transport and Highways, North West Regional Office, Room 400, 4546 Park Avenue, Terrace, V8G 1V4 (telephone 250 638-6434). I will forward a copy of your letter to our Terrace Office so they are aware of the issue.

Please contact me if you require any further information about the ministry's herbicide use for noxious weed control program.

Sincerely,

Daryl Nolan
Roadside Development Technician
Central/North East

Appendix E: Responses to Information Requests

Additional information provided in letter from the Central/ North East Region, Ministry of Transportation and Highways:

Dicamba (*Banvel, Dyvel*) is one of the benzoic acids. This chemical is available as the dimethylamine salt formulation alone or as a mixture with 2,4-D, MCPA or mecoprop (*Killex, Kil-Mor, Target*). It is effective on a wide range of weeds in grain and turf, particularly smartweed, buckwheats and other *Polygonum* species. Underseeded grain crops cannot be treated because legumes are sensitive. Dicamba is also effective on perennials such as Canada Thistle and on many species of brush. It translocates in the plant in a manner similar to 2,4-D. Root absorption occurs, but the primary action is through the leaves. At normal rates it breaks down rapidly in soil and persists for less than one to three months. It is volatile and, as with 2,4-D, care should be taken to avoid drift to sensitive plants. Spray equipment being used for other purposes must be thoroughly cleaned. It has a low acute mammalian toxicity.
(LD_{50}: oral = 1,000; dermal >2,000 Rb)
(LD_{50} oral 673 to 800 mg/kg for pheasant)
(LD_{50} 35 mg/L for trout, over 48 hours)

Glyphosate (*Roundup, Vision*) is an amino acid compound which is a broad-spectrum, post-emergence, translocated herbicide. It is used for control of many annual and deep-rooted perennial weeds including brush species in noncrop areas. It is also used on cropland before emergence of barley, wheat, oats, soybeans and corn, for preplow cleanup or spot control of perennial weeds in legumes and grasses, and for pasture renovation. Avoid drift onto foliage of any crops or desirable plants. Rain within six hours of application reduces effectiveness. Glyphosate is quickly deactivated in soil. No residue remains in the soil to affect subsequent crops. It has low acute toxicity to mammals, but may cause eye irritation. It has a low toxicity to fish.
(LD_{50}: oral = 4,300; dermal >7,900 Rb)
(LD_{50} oral 3,850 mg/kg for quail)
(LC_{50} 38 to 97 mg/L for trout, over 96 hours; 1.3 to 4.2 mg/L for trout fingerlings, over 96 hours)

Picloram (*Tordon*) is a picolinic acid compound used for control of many broadleaved weeds, woody species, and conifers in established grasses. Picloram is effective on hard-to-eradicate woody species such as conifers and vine maple, and on difficult perennial weeds such as field bindweed and Canada Thistle. Grasses are quite tolerant. A granular picloram formulation is available for spot control. A special formulation of picloram plus 2,4-D containning low levels of picloram is available for broadleaved weed control in wheat and barley. Picloram is absorbed by foliage and roots and translocated, It appears to be a growth regulator, somewhat more active than, but similar to 2,4-D. Picloram is not to be used on cropland (except for spot control on permanent pasture, range land and some crops), because of soil persistence and the extreme sensitivity of some crops such as beans, potatoes, and peas. It will be broken down in clear water by sunlight and is degraded in warm , moist soil having a good organic matter content. It can persist for a number of years in dry , cold soils and in soils low in organic matter. Some leaching may occur in sandy soils. It must be used with caution around desirable trees and shrubs. Picloram has a low acute mammalian toxicity and a low toxicity to fish and wildlife. Avoid direct contact, since some skin and eye irritation may occur.
(LD_{50}: oral = 8,200)
(LD_{50} oral 2,000 mg/kg for mallard duck; 2,000 mg/kg for pheasant)
(LC_{50} 70 mg/L for trout, over 96 hours; however chronic exposure for 60 days reduced survival and growth at 0.035 mg/l)

None of the above noted herbicides have been found to be toxic to honey or wild bees.

Herbicides are generally less acutely toxic to fish and wildlife than most other pesticides. Many organisms, both plant and animal, possess the ability to detoxify or bring about the decomposition of organic herbicides. Picloram is toxic to aquatic insects and crustaceans.

Letter from the Vanderhoof, Ministry of Transportation and Highways Office:

File 11050-40/042
Date: February 25,1997
To: East Francois Lake Community Association Attention: Gill Kopy

RE: Dust Control Products

Thank you for your letter dated January 14, 1997, in which you expressed concerns on the use of dust control products along Francois Lake Road. With respect to the questions required by the East Francois Lake Community Association in co-operation with the Lakes Protection Society, I offer the following:

What are the names of dust control chemicals currently being used? Are any bi-products from the pulp mills used?
The Ministry currently endorses the use of Magnesium Chloride, Calcium Chloride, Calcium Lignosulphate and Sodium Lignosulphate. Calcium and Sodium Lignosulphate are pulp and paper co-products. The Nechako Highways District historically utilized 35% Calcium Chloride (brine) only.

What is the chemical composition of these substances?
$CaCl_2$ and $MgCl_2$. Lignosulphates are complex blends of high molecular compounds comprised of sugar (ammonium, sodium and calcium).

What are the social (human health and safety), ecological (hazard to the environment) and economic (individual and company) costs and benefits of the dust control practices on the roadways surrounding that lake?
The ecological hazard question has been addressed by the Ministry of Environment study which indicated that these products are environmentally safe. The question of costs and benefits of using dust control or not using dust control on roadways surrounding the lakes as it relates to the social and economic aspects is more difficult to assertain. With the increase of traffic volumes some of our roads are experiencing (logging, and tourist as well as residential), safety is a prime concern. Many people residing in remote area have allergies to dust and respiratory problems, which dust can complicate. The use of dust control products is a cost effective maintenance activity on gravel roads, that provides both safer, smoother driving surface and benefit the adjacent residential properties.

What regulations exits regarding their use near and around water bodies?
Environmentally sensitive areas adjacent to public roads such as fish habitat water bodies, are treated with caution during dust palliative applications. Legislation to protect such areas include the Canada Fish Act and the Province of British Columbia Pollution Control Regulations.

Is there any monitoring carried our to determine the amount of dust (sediment) entering the lake?
Our Ministry does not deal with monitoring water quality. This is an environmental issue and may be carried out by the Ministry of Environment (Provincial) or Department of Fisheries and Oceans (Federal). Should you require additional information on monitoring water quality, please contact either agency.

What are some of the alternatives to chemical control of road dust?

Alternatives to dust control on roadways are limited. Water application is inefficient and not practical due to the costs of re-application. Hard surfacing is very costly and, at this time not a viable alternative based on provincial re-surfacing priorities.

Many of these questions were answered with the assistance of Mike McFarlane, who works with the Ministry of Environment in Victoria. Should you require additional information, Mike can be contacted at (250)356-0557. Mike has indicated that the dust control products used by the Ministry of Transportation and Highways, when used according to manufacturer's standards, are considered safe. He also offered the following: USFDA has approved these products as food additives for pet food, and they do not contain dioxins. In addition, he suggests that if the Lakes Protection Society requires additional information, they should contact the Ontario Ministry of Environment, as they have performed extensive environmental testing on these products.

If you require additional information, or clarification for the above response to your questions, please call me at your convenience.

Yours truly,

Frank J.M. Besinger
Area Manager - Nechako Sub-Office

Appendix F: Official Community Plan and Municipal Act: Lakeshore Development Guidelines

Official Community Plan

The purpose of an Official Community Plan (OCP) is to state the broad land use objectives and policies of the Regional District of Bulkley- Nechako for the area of focus.

The intent of the OCP is to build a consensus among the residents, the general public and various government agencies as to the future of the plan area, to establish direction and consistency to decisions pertaining to land use matters, to ensure that development occurs in an orderly, economic and environmentally conscious manner, and form the basis for the preparation, adoption and revision of regulatory land use bylaws. The bylaw 700 document can be a part of the OCP or it can be separate.

A community plan may designate areas for the protection of the natural environment (section 945(4)(a) of the Municipal Act) for the purposes of section 976(1) of the Municipal Act. Under section 976(1), land that is designated under section 945(4) in an official community plan has certain development restrictions for the protection of the natural environment (refer to the section of the Municipal Act included in this appendix).

Lakeshore Guidelines/Guidelines for Riparian Management Areas

Guidelines for lakeshore development are intended to provide specific direction to land adjacent to aquatic habitats as well as permit the staff of the Regional District and the environmental agencies to direct development in the public interest and minimize the potential for negative impacts to aquatic habitats. An additional benefit to these guidelines is to educate land owners and developers with respect to the value and importance of the aquatic habitats within their proposed development areas.

These types of guidelines may only be designated in an Official Community Plan under the authority of the Municipal Act for special purposes, including the 'protection of the natural environment'. Portions of the lake shorelands which are considered environmentally sensitive may be identified in an Official Community Plan and subject to the guidelines of a development permit, pursuant to Section 976 (5)(c) and (d) of the Municipal Act.

For examples of these types of guidelines refer to the Land Development Guidelines for the Protection of Aquatic Habitat, September 1993, Lakeshore Guidelines of the Regional District of Fraser-Fort George, April 1994 and the Proposed Development Permit Guidelines for Riparian Management Areas, October 1996.

There are many benefits associated with the adoption of guidelines that protect and assist in managing the land adjacent to a lake and its tributaries. Guidelines can be developed for the protection of fish habitat, septic system setbacks and development restrictions to protect natural environment or wildlife values. Guidelines that promote leave or buffer strips of riparian vegetation along a lake shore and/or stream result in protecting many aspects of the ecosystem. Riparian buffer strips act as habitat for many creatures, intercept runoff into the lake thereby reducing contaminant inputs into the lake, act as a visual buffer along the shoreline, and moderate stream temperature, an important habitat criterion for migrating, spawning and rearing fish.

Appendix F: Official Community Plan and Municipal Act: Lakeshore Development Guidelines

Division 2 Official Community Plans

Section 0875 Application of community plans

875 (1) A local government may adopt one or more community plans for one or more areas.

(2) An official community plan of a municipality applies to land in the municipality that is designated in the plan as being covered by that plan.

(3) An official community plan applies to the area outside of a municipality that is designated in the plan as being covered by the plan.

Section 0876 General content of community plans

876 (1) A community plan is a general statement of the broad objectives and policies of the local government respecting the form and character of existing and proposed land use and servicing requirements in the area covered by the plan.

(2) To the extent that an official community plan deals with these matters, it should work towards the purpose and goals referred to in section 849.

(3) A community plan must be in writing and may include plans, maps, tables or other graphic material.

Section 0877 Required content

877 (1) A community plan must include statements and map designations for the area covered by the plan respecting the following:

(a) the approximate location, amount, type and density of residential development required to meet anticipated housing needs over a period of at least 5 years;

(b) the approximate location, amount and type of present and proposed commercial, industrial, institutional, agricultural,

recreational and public utility land uses;

(c) the approximate location and area of sand and gravel deposits that are suitable for future sand and gravel extraction;

(d) restrictions on the use of land that is subject to hazardous conditions or that is environmentally sensitive to development;

(e) the approximate location and phasing of any major road, sewer and water systems;

(f) the approximate location and type of present and proposed public facilities, including schools, parks and waste treatment and disposal sites;

(g) other matters that may, in respect of any plan, be required or authorized by the minister.

(2) A community plan must include housing policies of the local government respecting affordable housing, rental housing and special needs housing.

Section 0878 Policy statements in community plans

878 (1) A community plan may include the following:

(a) policies of the local government relating to social needs, social well-being and social development;

(b) a regional context statement, consistent with the rest of the community plan, of how matters referred to in section 850 (2) (a) to (c), and other matters dealt with in the community plan, apply in a regional context;

(c) policies of the local government respecting the maintenance and enhancement of farming on land in a farming area or in an area designated for agricultural use in the community plan;

(d) policies of the local government relating to the preservation, protection, restoration and enhancement of the natural environment, its ecosystems and biological diversity.

(2) If a local government proposes to include a matter in a community plan, the regulation of which is not within the jurisdiction of the local government, the plan may only state the broad objective of the local government with respect to that matter unless the minister has, under 877 (1) (g), required or authorized the local government to state a policy with respect to that matter.

Section 0879 Designation of permit areas

879 (1) For the purposes of section 920, a community plan may designate areas for one or more of the following:

(a) protection of the natural environment, its ecosystems and biological diversity;

(b) protection of development from hazardous conditions;

(c) protection of farming;

(d) revitalization of an area in which a commercial use is permitted;

(e) establishment of objectives and the provision of guidelines for the form and character of commercial, industrial or multi-family residential development.

(2) With respect to areas designated under subsection (1), the community plan must

(a) describe the special conditions or objectives that justify the designation, and

(b) specify guidelines respecting the manner by which the special conditions or objectives will be addressed.

(3) If a community plan designates areas under subsection (1), the plan may, with respect to those areas, specify conditions under which a development permit under section 920 (1) would not be required.

(4) For the purposes of section 921, a community plan may designate areas where temporary commercial and industrial uses may be

allowed and may specify general conditions regarding the issue of temporary commercial and industrial use permits in those areas.

Section 0879.1 Designation of development approval information areas or circumstances

879.1 (1) For the purposes of section 920.1, a community plan may do one or more of the following:

(a) specify circumstances in which development approval information may be required under that section;

(b) designate areas for which development approval information may be required under that section;

(c) designate areas for which, in specified circumstances, development approval information may be required under that section.

(2) A community plan that specifies circumstances or designates areas under subsection (1) must describe the special conditions or objectives that justify the specification or designation.

Section 0880 Designation of heritage conservation areas

880 (1) For the purposes of heritage conservation, a community plan may designate an area as a heritage conservation area to which section 971 (1) applies.

(2) If a heritage conservation area is designated under subsection (1), the community plan must

(a) describe the special features or characteristics that justify the designation,

(b) state the objectives of the designation, and

(c) specify guidelines respecting the manner by which the objectives are to be achieved.

(3) If a heritage conservation area is designated under subsection (1), the community plan may do one or more of the following:

(a) specify conditions under which section 971 (1) does not

apply to property within the area, which may be different for different properties or classes of properties;

(b) include a schedule listing buildings, structures, land or features within the area that are to be protected heritage property under this Act;

(c) for the purposes of section 971 (3) identify features or characteristics that contribute to the heritage value or heritage character of the area.

(4) At least 10 days before the public hearing on a community plan that includes a schedule under subsection (3) (b), the local government must give notice in accordance with section 974 to the owner of each property included in the schedule that is not already included in the schedule.

(5) Within 30 days after the adoption of a bylaw that includes a property in or deletes a property from a schedule under subsection (3) (b) to an official community plan, the local government must

(a) file a notice in the land title office in accordance with section 976, and

(b) give notice to the minister responsible for the Heritage Conservation Act in accordance with section 977.

Section 0920 Development permits

920 (1) If an official community plan designates areas under section 879 (1), the following prohibitions apply unless an exemption under section 879 (3) applies or the owner first obtains a development permit under this section:

(a) land within the area must not be subdivided;

(b) construction of, addition to or alteration of a building or structure must not be started;

(c) a building or structure on a Provincial or designated municipal heritage site must not be altered;

(d) land within an area designated under section 879 (1) (a) or

(b) must not be altered;

(e) land within an area designated under section 879 (1) (d), or a building or structure on that land, must not be altered.

(2) Subject to subsections (3) to (6), a local government may, by resolution, issue a development permit that

(a) varies or supplements a bylaw under Division 7 or 11 of this Part,

(b) includes requirements and conditions or set standards under subsections (7) to (10), and

(c) imposes conditions respecting the sequence and timing of construction.

(3) The authority under subsection (2) must be exercised only in accordance with the applicable guidelines specified in an official community plan under section 879 (2) (b).

(4) A development permit must not vary the use or density of the land from that permitted in the bylaw except as authorized by subsection (5).

(5) If the land was designated under section 879 (1) (b), the conditions and requirements referred to in subsection (7.1) of this section may vary that use or density, but only as they relate to health, safety or protection of property from damage.

(6) A development permit must not vary a flood plain specification under section 910 (2).

(7) For land designated under section 879 (1) (a), a development permit may do one or more of the following:

(a) specify areas of land that must remain free of development, except in accordance with any conditions contained in the permit;

(b) require specified natural features or areas to be preserved, protected, restored or enhanced in accordance with the permit;

(c) require natural water courses to be dedicated;

(d) require works to be constructed to preserve, protect, restore or enhance natural water courses or other specified natural features of the environment;

(e) require protection measures, including that vegetation or trees be planted or retained in order to

(i) preserve, protect, restore or enhance fish habitat or riparian areas,

(ii) control drainage, or

(iii) control erosion or protect banks.

(7.1) For land designated under section 879 (1) (b), a development permit may do one or more of the following:

(a) specify areas of land that may be subject to flooding, mud flows, torrents of debris, erosion, land slip, rock falls, subsidence, tsunami, avalanche or wildfire, or to another hazard if this other hazard is specified under section 879 (1) (b), as areas that must remain free of development, except in accordance with any conditions contained in the permit;

(b) require, in an area that the permit designates as containing unstable soil or water which is subject to degradation, that no septic tank, drainage and deposit fields or irrigation or water systems be constructed;

(c) in relation to wildfire hazard, include requirements respecting the character of the development, including landscaping, and the siting, form, exterior design and finish of buildings and structures;

(d) in relation to wildfire hazard, establish restrictions on the type and placement of trees and other vegetation in proximity to the development.

(8) If land has been designated under section 879 (1) (d) or (e), a development permit may include requirements respecting the character of the development, including landscaping, and the siting,

form, exterior design and finish of buildings and structures.

(9) Despite subsection (8), if land has been designated under section 879 (1) (e), a requirement under subsection (8) may only relate to the general character of the development and not to particulars of the landscaping or of the exterior design and finish of buildings and structures.

(10) A development permit for land that has been designated under section 879 (1) (c) may include requirements for screening, landscaping, fencing and siting of buildings or structures, in order to provide for the buffering or separation of development from farming on adjoining or reasonably adjacent land.

(11) Before issuing a development permit under this section, a local government may require the applicant to provide, at the applicant's expense, a report, certified by a professional engineer with experience in geotechnical engineering, to assist the local government in determining what conditions or requirements under subsection (7.1) it will impose in the permit.

Section 0920.1 Development approval information

920.1 (1) For the purposes of this section, "development approval information" means information on the anticipated impact of the proposed activity or development on the community including, without limiting this, information regarding impact on such matters as

(a) transportation patterns including traffic flow,

(b) local infrastructure,

(c) public facilities including schools and parks,

(d) community services, and

(e) the natural environment of the area affected.

(2) If an official community plan includes a provision under section 879.1 (1), the local government must, by bylaw, establish procedures and policies on the process for requiring development

approval information under this section and the substance of the information that may be required.

(3) If a bylaw under subsection (2) is adopted, the local government or an officer or employee authorized under subsection (4) may require an applicant for

(a) an amendment to a zoning bylaw under section 903,

(b) a development permit under section 920, or

(c) a temporary commercial or industrial use permit under section 921

to provide to the local government, at the applicant's expense, development approval information in accordance with the procedures and policies established under subsection (2) of this section.

(4) A bylaw under subsection (2) may authorize an officer or employee to require development approval information under this section.

(5) An applicant subject to a decision of an officer or employee under subsection (4) is entitled to have the local government reconsider the matter without charge.

(6) A bylaw under subsection (2) that authorizes an officer or employee to require development approval information under this section must establish procedures regarding applying for and dealing with a reconsideration under subsection (5).

(7) Development approval information is not required under this section if the proposed activity or development is a reviewable project under section 3 or 4 of the Environmental Assessment Act.

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SAMPLE COLLECTION

Sample Identification

Sample bottles should be labelled with the following information before sampling, using waterproof ink. Black “Sharpie” brand markers work well.

Date and Time of Sample
Sample ID (eg. Site name or #)
Name of sample collector
Analysis Required

More detailed information should be supplied to the lab on a separate sheet of paper, such as date and time of sampling, sampling site name, sampling method, contact name, address and telephone number, and analysis required. Most labs will provide a standard format called a “Chain-of-Custody” form.

Other information, such as weather conditions, observations about the sample, field measurements (DO, pH, temerature etc.), and detailed location description should be recorded in a separate book.

Sample Bottles

Sample bottles are typically plastic or glass and are provided new or have been cleaned by the lab. For metals analysis, only acid washed bottles should be used.

Sample Collection

Sample bottles should be rinsed three times with the sample water before filling with the sample.

Once the sample is taken, the bottle should be capped immediately and stored as per instructions on “Summary of Water Sampling Requirements” hand-out.

To avoid contamination, do not touch the inside or rim of the cap or bottle when taking the sample. Leave the cap face up on any surface.

When sampling, do not leave an air space in the top of the bottle. This can be accomplished by completely immersing the bottle in the water and capping underwater. If the sample needs to be preserved, pour off a bit of the sample before adding the preservative.

Sample Filtration

Sample filtration does not have to be done at the site of sample collection, but should be done the same day as the sample was collected. Sample filtration should be done before preservation.

The filter apparatus should be rinsed with the sample first and a small portion of the sample should be filtered and discarded before filtering the rest of the sample. Rinse the sample bottle with filtered sample before filling with the actual sample. The filter paper should only be handled with tweezers to avoid contamination.

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Dissolved Metals

To separate the dissolved fraction from the suspended metal fraction, the water sample is filtered through a 0.45 µm polycarbonate filter. The filters are separated by blue paper and the shiny side should be placed facing up on the filter apparatus.

Dissolved Kjeldah Nitrogen (DKN) and Dissolved Phosphate

Gelman A/E filter paper is used to separate suspended Kjeldah nitrogen from the dissolved fraction.
Gelman A/E filter paper is used to separate suspended phosphate from the dissolved fraction.

Preservation

See "Summary of Water Sampling Requirements" hand-out for the appropriate preservatives and volume for each analysis.
When handling strong acids, safety goggles and gloves should be worn.

Sample Shipping

Samples should be shipped to the lab as soon after sampling as it is convenient. Samples should be packed with ice to keep them cold.

Sample Storage

See the "Summary of Water Sampling Requirements" hand-out for the storage conditions and times for each analysis.

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QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

1. Quality Assurance

A Quality Assurance (QA) Program details the policies, organization and operations established for assuring the integirty of the results as follows:

- To ensure a Quality System that is documented and incorporates adequate review, audit and internal quality control. For any project, the quality system is designed in advance, to ensure that the proper quality control procedures are followed.
- To ensure personnel are adequately supervised and are proficient to carry out assigned activities.
- To ensure test methods and related procedures are validated and incorporate adequate quality control.
- To ensure all equipment, supplies and services are functionin properly and/or meet required specifications.
- To ensure that facilities are adequate to carry out the testing activity.
- To ensure data management procedures that incorporate adequate procedures for the security, recording, calculation,validation, authorization, transmittal, storage and disposal of all test data and related records.
- To ensure sample management procedures that incorporate adequate procedures for thesecurity, receipt, identification, checking, routing, storage and disposal of all samples.
- To ensure workload management procedures that incorporate acceptable turnaround time and verification of resource availability prior to the acceptance of additional work.

2 Quality Control

Quality Control (QC) consists of specific activities and procedures designed to measure and control the quality of the data being produced.

Quality Control in the Field

The quality control techniques used in the field to ensure data quality are:

- Sampling Techniques: See “Sample Collection” hand-out.
- Sample Preservation and Storage: Samples should be preserved according to instructions given on “Summary of Water Sampling Requirements” hand-out.
- Field Duplicates: Field duplicates are a set of two samples taken at the same time and location and are labelled as two separate samples. This set of samples allows you to compare the results from the lab, to ensure that the analyses are precise.
- Transportation Blanks: Transportation blanks are provided by the lab and are to ensure that no contamination occurred during sample transportation. Transportation blanks are filled with deionized

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water at the lab. They should remain unopened and are transported back to the lab with the actual samples.

- Method Blanks: Method blanks are prepared to ensure that no contamination occured during sample filtration or preservation. Deionized water is prepared exactly as the sample is prepared (i.e. filtered, preserved). This is a check that contaminaiton is not occuring in the handling method.

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SUMMARY OF WATER SAMPLING REQUIREMENTS

Parameter	Method	Container	Volume Required	Holding Temp. (4 C)	Holding Time	Preservative	Amount
Nutrients							
Ammonia							
Total	Lab	P,G	500 mL	Refriderate	7 days	H2SO4	pH<2
Kjeldahl	Lab	P,G	500 mL	Refriderate	7days	H2SO4	pH<2
Nitrate	Lab	P,G	100 mL	Refriderate	48 hours	-	-
Nitrite	Lab	P,G	100 mL	Refriderate	48 hours	-	-
Phosphate							
Total	Lab	G (A)	100 mL	Refriderate	48 hours	-	-
Dissolved	Lab	G (A)	100 mL	Refriderate	48 hours	Filtration	-
Particulates							
Suspended Sediments (SS)	Lab	P,G	500 mL	Refriderate	7 days	-	-
Turbidity	Lab	P,G	-	Refriderate In Dark	24-48 hours	-	-
Total Organic Carbon (TOC)	Lab	G	100 mL	Refriderate	7 days	HCl	pH<2
Metals							
Total	Lab	P(A),G(A)	250 mL	Refriderate	6 months	HNO3	pH<2
Dissolved	Lab	P(A),G(A)	250 mL	Refriderate	6 months	Filtration, HNO3	pH<2
General Characteristics							
Dissolved Oxygen (DO)	Meter (in field)	-	-	-	-	-	-
Temperature	Thermometer (in field)	-	-	-	-	-	-
Total Dissolved Solids (TDS)	Lab	P,G	500 mL	Refriderate	7 days	-	-
Conductivity	Meter (in field)/Lab	P,G	500 mL	Refriderate	28 days	-	-
pH	Meter/Paper (in field)	-	-	-	-	-	-
Alkalinity	Lab	P,G	200 mL	Refriderate	14 days	-	-
Sulfide	Lab	P,G	1 L	Refriderate	7 days	2N Zinc Acetate NaOH	2 mL pH>9

Notes: P=Plastic, G=Glass, A=Acid Washed

Chemical Abbreviations

H2SO4 = Sulfuric Acid
NaOH = Sodium Hydroxide
HNO3 = Nitric Acid
HCl = Hydrochloric Acid

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Parameters and Sampling Procedures (refer to data recording sheet - next page)

The specific parameters to be sampled for, should be carried out in the order they are listed below:

Chlorophyll a at 0.5m

Label a 1 litre poly bottle with lake, date, time depth, samplers initials, test requested. Rinse with sample water 3X. Collect sample at arm's length. Store at 4 degree C until delivery to the lab (within 24 hours).

Bacteria at 0.5m

Label a 1 litre poly bottle with lake, date, time depth, samplers initials, test requested. Rinse with sample water 3X. Collect sample at arm's length. Store at 4 degree C until delivery to the lab (within 48 hours).

Water Collection (at depth)

For water collection at depth, set sampler, ensuring misfire will not occur, lower sampler to desired depth, sway rope to exchange water in sampler, drop messenger, retrieve sampler.

Temperature

Air Temperature: measure this parameter with a thermometer, or if using an electronic meter, measure this parameter before getting the sampler wet. Open sampler for air flow and place in shaded area.

Surface Temperature: measure the surface water temperature directly in the water, allowing the thermometer to come to equilibrium before recording the value.

Temperature at 0.5m, mid depth and bottom 1m: from grab sample decant some water into a 1 litre "field bottle", Measure the temperature immediately, allowing the thermometer to come to equilibrium before recording the value. Ensure that the corresponding depth id identified for each temperature recorded on the data sheets.

Dissolved Oxygen at 0.5m, mid-depth and botom 1m: DO readings from water samples colled at depth other than the surface require particular care, since any contact between the sample and the air will modify the results. From a grab sample slowly dribble some water into a 1litre "field bottle". Measure the oxygen immediately with DO meter, allowing meter to come to equilibrium before recording the value. Ensure that the corresponding depth id identified for each temperature recorded on the data sheets.

pH at 0.5m, mid-depth and botom 1m: Rapid changes that occur as a result of gas diffusion, biological activity, and chemical reactions dictate that pH measurements be performed immediately upon sample collection. Rinse electrode on meter with distilled water. From a grab sample slowly dribble some water into a 1 litre "field bottle". Immerse electrode directly into the surface water of the field bottle. Allow it to equilibrate before recording the value. If a digital pH meter is not available, pH paper ranging from pH5-10 is adequate for field use.

Nutrients at 0.5m, mid-depth and botom 1m: (includes Total Phosphorus, Nitrogen, pH, Residue(TSS), Conductivity, & Turbidity). Label a 2 litre sample poly bottle with lake, date, time,depth, samplers initials, test requested. Collect sampler of water, use some of water collected to rinse poly bottle, and fill to bottom of neck of bottle. Store in the dark at 4^{o}C until delievered to the lab (within 24 hours).

Total Metals: Label a 250mL litre sample poly bottle with lake, date, time,depth, samplers initials, test requested. These bottles should have been acid washed by the supplier and therefore are not to be rinsed before filling with the water sample. No filteration is required but the sample must be preserved with Nitric Acid (HNO3) to pH2. Store in the dark at 4^{o}C until delievered to the lab (within 6 months).

Dissolved Metals: Label a 250mL litre sample poly bottle with lake, date, time,depth, samplers initials, test requested. These bottles should have been acid washed by the supplier and therefore are not to be rinsed before filling with the water sample. The sample must be filtered through a non-metallic 0.45 µm membrane immediately after collection and preseved with Nitric Acid (HNO3) to pH2. A new filter should be used with each new sample collected to prevent any cross contamination of samples. Store in the dark at 4^{o}C until delievered to the lab (within 6 months).

Odour: smell water in each sample collected for odour and record the result on the data sheet. Nil, organic, sulphide etc.

Water colour: observe the colour of each water sample collected, preferably against a white backdrop and record the result on the data sheet. Clear, green, brown etc

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DATA RECORDING SHEET						
LAKE NAME:						
SITE IDENTIFICATION:						
SAMPLER'S INITIALS:	**DATE:**		**DATE:**		**DATE:**	
GENERAL OBSERVATIONS	**TIME**	**DATA**	**TIME**	**DATA**	**TIME**	**DATA**
?/10 OVERCAST (clear is 0/10)						
WIND DIRECTION FROM:						
WIND SPEED (calm, low, med, high)						
SURFACE (flat, ripple, chop, ice)						
AIR TEMP: (oC to nearest 0.5 oC)						
DEPTH READING (m):						
Trip Blank (check)						
Oxygen at 0.5m (to 0.5 mg/L)						
Temp at 0.5m (to nearest 0.5 oC)						
Conductivity at 0.5m (us)						
pH at 0.5m						
General Chem sample at 0.5m (1L check)						
Residue (TSS) sample at 0.5m (1L check)						
Total Metals sample 0.5m (250mL check)						
Dissolved Metals sample 0.5m (250mL check)						
Odour at 0.5m						
Water Colour at 0.5m						
Depth of mid-depth sample (m)						
Oxygen at mid-depth (to 0.5 mg/L)						
Temp at mid-depth (to nearest 0.5 oC)						
Conductivity at mid-depth (us)						
pH at mid-depth						
General Chem sample at mid-depth (check)						
Residue (TSS) sample mid-depth (1L check)						
Total Metals sample mid-depth (250mL check)						
Dissolved Metals sample mid-depth (250mL check)						
Odour at mid-depth						
Water Colour at mid-depth						
Depth of bottom-1m sample (m)						
Oxygen at bottom-1m (to 0.5 mg/L)						
Temp at bottom-1m (to 0.5 oC)						
Conductivity at bootom-1m (us)						
pH at bottom-1m						
General Chem sample at bottom-1m (check)						
Residue (TSS) sample bottom-1m (1L check)						
Total Metals sample bottom-1m (250mL check)						
Dissolved Metals sample bottom-1m (250mL check)						
Odour at bottom-1m						
Water Colour at bottom-1m						
Depth of duplicate sample (m):						
Duplicate Gen. Chm. sample (check)						
Dup. Residue (TSS) sample (check)						
Dup. Total Metal sample (check):						
Dup. Dissolved Metals sample (check)						

Appendix 2.1 Site Identification Guide

Lake / river name _____
Watershed code _____
EMS site number _____
Latitude _____
Longitude _____
Map sheet number _____ Elevation _____
Access road names or numbers _____
NOTES:
Distinguishing features
_____
_____
_____
_____
Best access point to water
_____
_____
Photograph/Access Map

Appendix 2.2 Site Data Sheet (Lake)

EMS site number _____
Date _____
Time _____
Weather _____
Air temperature _____
Field Measurements:
Secchi depth _____

Depth (m)	Temp		D.O.		pH	Cond	ORP
	down	up	down	up			
0							
2							
4							
6							
8							
10							
12							
14							
16							
18							
20							
22							
24							
26							
28							
30 (or depths appr. to lake)							

APPENDIX H

Summary and Interpretation of Water Sampling Results from Francois Lake in February 1997

In 1997 the water uses of Francois Lake, as confirmed by local residents, were raw drinking supply, primary contact recreation, transportation, industrial, livestock watering and aquatic life. Water quality objectives can be set for the lake based upon the above listed water uses. The guidelines for drinking water quality are the most relevant and therefore were chosen to compare with the water sample results obtained from Francois Lake in February 1997. However, many of the aquatic life criteria for metals are lower than those for drinking water therefore the Francois Lake water sample results have been compared against these guideline metal concentrations for the protection of aquactic life as well. (note: the box of reference material provided to the LPS contains a copy of Approved and Working Criteria for Water Quality-1995).

The guidelines and recommendations established by Health Canada and presented here are intended to apply to all drinking water supplies, public and private. Sensible use of the guidelines will result in the provision of drinking water that is both wholesome and protective of public health. It is recommended that all public and private drinking water supplies aim to reduce the concentration of all parameters to below the specified values. The guidelines defined by Health Canada should not be regarded as implying that the quality of drinking water may be degraded to the specified levels. Rather, a continuous effort should be made to ensure that drinking water is of the highest possible quality. In addition, the Ministry of Health advises that all open water sources of drinking water be subject to disinfection prior to use.

Explanation of Terms

*adapted from Health Canada's Guidelines for Canadian Drinking Water Quality, sixth edition, 1996.

Maximum Acceptable Concentration (MAC)

Maximum acceptable concentrations have been established for certain substances that are known or suspected to cause adverse effects on health. Each MAC has been derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration. The amount by which and the period for which, the

MAC can be exceeded without posing a health risk must be assessed by taking into account the toxicity of the substance involved. When the MAC for a substance is exceeded, the minimum action required is immediate re-sampling. If the MAC continues to be exceeded, the local authority responsible for drinking water supplies should be consulted concerning appropriate corrective action.

Interim Maximum Acceptable Concentration (IMAC)

For those substances for which there are insufficient toxicological data to derive a MAC with reasonable certainty, interim values are recommended, taking into account the available health-related data, but employing a larger safety factor to compensate for the additional uncertainties involved. Because of their nature, IMACs will be reviewed periodically as new toxicological data and new methods of quantification and treatment become available.

Aesthetic Objective (AO)

Aesthetic objectives apply to certain substances or characteristics of drinking water that can affect its acceptance by consumers or interfere with practices for supplying good-quality water. For certain parameters, both AOs and health-related guidelines (MACs) have been established. Where only AOs are specified, these values are below those considered to constitute a health hazard. However, if a concentration in drinking water is well above an AO, there is a possibility of a health hazard.

Parameters Without Guidelines

A number of parameters have been identified as not requiring a numerical guideline. The reasons for parameters having no numerical guideline include the following:

- currently available data indicate no health risk or aesthetic problem (e.g. calcium);
- data indicate the compound, which may be harmful, is not registered for use in Canada (e.g. 2,4,5-TP) or is not likely to occur in drinking water at levels that present a health risk (e.g. silver); or

- the parameter is composed of several compounds for which individual guidelines may be required (e.g. pesticides [total]).

When the water samples for Francois Lake were submitted to the Pacific Environmental Science Centre in Vancouver a number of chemical and physical parameters were analyzed for. Tables 1 and 2 provide a summary of the guidelines that have been established for those parameters. These summary tables will provide a quick reference as to the level of specifications placed on each of these parameters with regards to drinking water quality. It provides the name of the substance or characteristic and the specified acceptable concentration. Under the comments column MAC, IMAC, AO indicate the classification level for a substance. In some cases additional information has been provided in this column also. For some parameters guidelines have not been specified or are under review (e.g. beryllium and tin). For other parameters guidelines for drinking water were not specified, in which case the next most rigorous specification has been indicated (e.g. cobalt). These concentrations have come from the 1995 Approved Criteria for Water Quality and are indicated with an asterisk. Following these concentrations, the water use protected by such concentration specifications is noted in brackets.

Table 1: Summary of Guidelines for Elements Analyzed

Elements Analyzed Total / Diss. Substances (as indicated)	Guidelines for Canadian Drinking Water Quality (MAC, IMAC, AO or other level of specification)	Comments
Silver (Ag), Total	0.05mg/L (MAC in 1979)	MAC not considered necessary to specify(1996)
Aluminum (Al), Dissol.	0.2mg/L *	MAC; specification under review (1996)
Arsenic (As),Total	0.025mg/L	IMAC
Boron (B), Total	5mg/L	IMAC
Barium (Ba), Total	1mg/L	MAC
Beryllium (Be), Total	-----	guidelines have not been specified
Calcium (Ca), Dissol.	-----	guidelines have not been specified
Cadmium (Cd), Total	0.005mg/L	MAC
Cobalt (Co), Total	0.05mg/L (Aquatic life specifications)*	drinking water guidelines have not been specified
Chromium (Cr), Total	0.05mg/L	MAC
Copper (Cu), Total	1.0mg/L	AO
Iron (Fe), Total	1mg/L	AO
Potassium (K), Dissol.	20mg/L (dairy sanitation)*	drinking water guidelines have not been specified
Magnesium (Mg), Dissol.	100-500mg/L (range of taste threshold)*	>700mg/L has laxative effect; MAC not specified
Manganese (Mn), Total	0.05mg/L	AO
Molybdenum (Mo), Total	0.25mg/L *	
Sodium (Na), Dissol.	200mg/L	AO; 20-270mg/L (diet restriction dependent)*
Nickel (Ni), Total	0.2mg/L	specification under review (1996)
Phosphorus (P), Total	-----	
Lead (Pb), Total	0.01mg/L	MAC
Sulfur (S)	-----	
- sulfate	500mg/L	AO
- sulfide	0.05mg/L	AO
Antimony (Sb), Total	0.6mg/L (taste threshold)*	specification under review (1996)
Selenium (Se), Total	0.01mg/L	MAC
Silica (Si), Total	0-50mg/L (food processing)*	drinking water guidelines have not been specified
Tin (Sn)	-----	guidelines have not been specified
Strontium (Sr)	-----	guidelines have not been specified
Titanium (Ti), Total	0.1mg/L *	
Vanadium (V), Total	0.1mg/L *	
Zinc (Zn), Total	5mg/L	AO

* Approved Criteria for Water Quality (1995)

Table 2: Summary of Guidelines for Chemical and Physical Parameters Analyzed.

Chemical and Physical Parameter Analyzed	Guidelines for Canadian Drinking Water Quality (MAC, IMAC, AO or other level of specification)	Comments
True Colour	15TCU *	AO
Hardness, Tot. Diss.	80-100mg/L	>200tolerated/>500unacceptable; No MAC
Nitrogen (N), Total	10mg/L	
Nitrogen(nitrate+nitrite)	10mg/Lmax; 1mg/Lmax	respective MAC specifications
pH	6.5-8.5	AO
Phosphorus, Total	0.01mg/L	
Residue, non-filterable (TDS)**	500mg/L	AO
Turbidity	1NTU ***	MAC; AO<5NTU at the point of consumption

* TCU: True Colour Unit
**TDS: Total Dissolved Solids
***NTU: Nephelometric Turbidity Unit

Table 3 compares the measured concentrations of each parameter from the water samples with the water quality guidelines provided in tables 1 and 2. The results from the water samples obtained from the east and west ends of the lake are reported separately.
For the most part, water quality guidelines for a parameter are reported as the concentration of that substance found in the total unfiltered water sample. However, you will note from table 1 and 2 that the guidelines for a few parameters (e.g. aluminium, magnesium and hardness) are reported as the amount of the substance found to be dissolved in a water sample that has been filtered through a non-metallic 0.45um membrane immediately after collection. The concentration of a substance contained in a filtered water sample is intuitively lower that the concentration of that same substance from a water sample that not been filtered. The dissolved concentrations are often of greater value to biologists because they represent the amount of the substance that is readily available for assimilation. On the other hand for the purpose of volunteer collected water samples, it is generally suggested that volunteers do not carry out the filtering step. This is because filtering would require volunteers to handle the samples further and the possibility of contaminating them increases.

Table 3: Comparison of Francois Lake East/West Water Sampling Results and Guidelines
Francois Lake Water Sampling Summary Paragraph

Parameter Analyzed Total / Diss. Metals (as indicated)	Francois Lk East Deep Station avg. (mg/L)	Francois Lk West Deep Station avg. (mg/L)		Canadian Water Quality Guidelines (acceptable concentration in drinking water)
Silver (Ag), Total	< 0.01	< 0.01	<	0.05mg/L MAC
Aluminum (Al), Dissol.	< 0.05	< 0.06	<	0.2mg/L MAC*
Arsenic (As),Total	0.0006	0.0005	<	0.025mg/L IMAC
Boron (B), Total	< 0.01	< 0.01	<	5mg/L IMAC
Barium (Ba), Total	0.016	0.016	<	1mg/L MAC
Beryllium (Be), Total	< 0.001	< 0.001		-----
Calcium (Ca), Dissol.	11.1	9.45		-----
Cadmium (Cd), Total	< 0.0002	< 0.0002	<	0.005mg/L MAC
Cobalt (Co), Total	< 0.006	< 0.006	<	0.05mg/L (aquatic life)*
Chromium (Cr), Total	< 0.006	0.01	<	0.05mg/L MAC
Copper (Cu), Total	< 0.006	< 0.006	<	1.0mg/L AO
Iron (Fe), Total	0.026	0.026	<	1mg/L AO
Potassium (K), Dissol.	0.8	0.8	<	20mg/L (dairy sanitation)*
Magnesium (Mg), Dissol.	2.7	2.5	<	100-500mg/L (taste range thresholds)*
Manganese (Mn), Total	0.003	0.003	<	0.05mg/L AO
Molybdenum (Mo), Total	< 0.01	< 0.01	<	0.25mg/L MAC*
Sodium (Na), Dissol.	3.4	3.2	<	200mg/L AO
Nickel (Ni), Total	< 0.02	< 0.02	<	0.2mg/L MAC*
Phosphorus (P), Total	<0.1	<0.1		-----
Lead (Pb), Total	< 0.0007	0.0008	<	0.01mg/L MAC
Sulfur (S)	1.57	1.4		-----
Antimony (Sb), Total	< 0.06	< 0.06	<	0.6mg/L (taste threshold)*
Selenium (Se), Total	<0.001	<0.001	<	0.01mg/L MAC
Silica (Si), Total	1.38	1.45	<	0-50mg/L (food processing)*
Tin (Sn)	<0.06	<0.06		-----
Strontium (Sr)	0.088	0.081		-----
Titanium (Ti), Total	< 0.002	< 0.002	<	0.1mg/L
Vanadium (V), Total	< 0.01	< 0.01	<	0.1mg/L
Zinc (Zn), Total	< 0.002	< 0.002	<	5mg/L AO
True Colour	10TCU	11TCU	<	15TCU
Conductivity	87.75uS/cm	84.25uS/cm		-----
Hardness, Tot. Diss.	35.2	34.1	<	80-100mg/L
N/ total	0.25	0.28	<	10mg/L
N/ nitrate+nitrite	0.063	0.066	<	10mg/Lmax; 1mg/Lmax
pH	7.75	7.67		6.5-8.5
Phosphorus, Total	0.006	0.007	<	0.01mg/L
Residue, non-filterable (TDS)	< 5	< 5	<	500mg/L
Turbidity	0.15NTU	0.26NTU	<	1NTU

A comparison of results from table 3 of the Francois Lake water samples (East and West) and the Guidelines for drinking water indicates the following:

- where drinking water quality guidelines have been specified for a parameter, the reported concentrations for that parameter from the analyzed water samples are below the guidelines.
- where drinking water guidelines were not specified for a parameter but the next stringent guideline is listed, the water sample results were again below the guideline concentrations.
- for parameters where no guideline specifications have been provided a comparison cannot be made.

In general there does not seem to be much, if any difference when concentrations for parameters at the east end deep station versus the west end deep station are compared. Some of the reported differences may be due to the small number of samples taken at each site. If more samples had been taken at each site, calculated averages and/or seasonal trends might have shown no differences between sites. Alternatively, the observed differences may be due to differences in local conditions, for instance, land use (both type and extent) and/or soil and rock types.

- Average calcium and hardness concentrations were greater at the east deep site than the west deep site.
- The average conductivity values were also greater at the east deep site than the west deep site.

The fact that the calcium concentrations were greater at the east deep station than the west deep station may be the result of differences in the surrounding rock, such that there is a higher content of calcium rich rock and/or more leaching of it into the lake from the surrounding soils. The higher hardness at the east end is most likely related to the calcium concentrations.

Calcium

Calcium is an abundant natural element, entering the freshwater system through the weathering of rocks, especially limestone. Calcium also makes its way into the water through seepage, leaching and runoff from the soils. Calcium is one of the principal cations associated with hardness in drinking water. Undesirable effects due to the

presence of calcium in drinking water may result from its contribution to hardness. These effects are dealt with in the "Hardness" review. Human bodies efficiently control the use of calcium such that adverse effects are observed only following the intake of extremely large quantities. There is no evidence of adverse effects specifically attributable to calcium in drinking water. Insufficient data are available to establish an AO for calcium in drinking water. A guideline for calcium has therefore not been specified.

Hardness

Water hardness is caused by dissolved polyvalent metallic ions, principally calcium and magnesium, and is expressed as the equivalent quantity of calcium carbonate. Hard waters, when heated, tend to form scale deposits, while heated soft water can result in water pipe corrosion.

Depending on the interaction of factors such as pH and alkalinity, hardness levels between 80 and 100 mg/L are considered to provide an acceptable balance between corrosion and scaling. Water supplies with hardness values greater than 200mg/L, while poor, have been tolerated by consumers. Once values are in excess of 500mg/L they are considered unacceptable for most domestic purposes. Although hardness may have significant aesthetic effects, public acceptance of hardness varies considerably according to local conditions. There is some evidence that suggests hardness may be inversely related to the incidence of cardiovascular disease. However, without sufficient data a MAC for hardness in drinking water has not been established.

Conductivity

The conductivity results indicate the possibility of increased ion content at the east end deep site compared to the west end deep site at the time of sampling. This is consistent with the findings of higher hardness and calcium concentrations at the east end deep station. Calcium (in all it's forms including ionic) is abundant in freshwater systems and increased water hardness is caused by greater amounts of dissolved ions in the water, particularly calcium and magnesium.

Turbidity

Although turbidity was not measured to be much different for the sites sampled, it is important that the parameter is defined. Turbidity measurements within water provide insight into its clarity. Turbidity is normally caused by suspended matter such as clay, plankton or silt. Control of turbidity in public drinking water supplies is important for both health and aesthetic reasons. High turbidity detracts from the appearance of the water and has often been associated with unacceptable tastes and odours. Turbidity can serve as a source of nutrients for waterborne bacteria, viruses and protozoa, which can be embedded in or adhere to particles in the raw water. Surface water sources in particular may be susceptible to organic substances and undesired organisms that can impede disinfection or otherwise cause drinking water quality problems. Appropriate technology is available to treat and monitor turbidity problems. Turbidity in excess of 5NTU becomes apparent and may be objected to by a majority of consumers. Therefore, an AO of less than or equal to 5NTU has been set for water at the point of consumption and the MAC for turbidity in water entering distribution systems has been set at 1NTU.

Table 4 provides a summary of freshwater, water quality guidelines that have been established for the protection of aqauatic life. Just as with the drinking water guidelines, not all the elements analyzed for, have established guidelines for the protection of aquatic life.

Table 4: Summary of Guidelines for the protection of Aquatic Life

Elements Analyzed Total / Diss. Substances (as indicated)	Water Quality Guidelines for the Protection of Aquatic Life (Fresh Water) (mg/L)	Comments
Silver (Ag), Total	0.0001mg/L	
Aluminum (Al), Dissol.	0.01mg/L 0.1mg/L	pH<6.5; [Ca]<4.0mg/L; DOC<2.0mg/L pH>6.5; [Ca]>4.0mg/L; DOC>2.0mg/L
Arsenic (As),Total	0.05mg/L	
Beryllium (Be), Total	ID	insufficient data to recommend a guideline
Cadmium (Cd), Total	0.0002mg/L 0.0008mg/L 0.0013mg/L 0.0018mg/L	Hardness 0 - 60 mg/L Hardness 60 - 120 mg/L Hardness 120 - 180 mg/L Hardness >180 mg/L
Chromium (Cr), Total	0.02mg/L 0.002mg/L	to protect fish to protect aquatic life, zooplankton/phytoplankton
Copper (Cu), Total	0.002mg/L 0.003mg/L 0.004mg/L	Hardness 0 - 120 mg/L Hardness 120 - 180 mg/L Hardness >180 mg/L
Iron (Fe), Total	0.3mg/L	
Nickel (Ni), Total	0.025mg/L 0.065mg/L 0.11mg/L 0.15mg/L	Hardness 0 - 60 mg/L Hardness 60 - 120 mg/L Hardness 120 - 180 mg/L Hardness >180 mg/L
Lead (Pb), Total	0.001mg/L 0.002mg/L 0.004mg/L 0.007mg/L	Hardness 0 - 60 mg/L Hardness 60 - 120 mg/L Hardness 120 - 180 mg/L Hardness >180 mg/L
Antimony (Sb), Total	ID	insufficient data to recommend a guideline
Selenium (Se), Total	0.001mg/L	
Zinc (Zn), Total	0.03mg/L	
Nitrogen (N), Total	2.2mg/L 1.37mg/L	pH 6.5; temperature 10 degrees celcus pH 6.5; temperature 10 degrees celcus
pH	6.5 - 9.0	
* numbers are from the Canadian Water Quality Guidelines		

A comparison of the guideline concentrations in table 4 with those obtained from the water samples taken from the lake in February of 1997 (table 3) suggests that Francois Lake water quality is acceptable for the protection of aquatic life. For good quality waters, such as Francois Lake, impairment to guideline concentrations should not be acceptable.

The above summary provides an indication of the water quality at two deep stations on Francois Lake as a drinking supply in February of 1997. Monitoring water quality implies collecting water samples for analysis of specific parameters over an extended period of time to be able to detect improvements or deterioration in water quality. Upon establishment of the Lake Water Monitoring Program recommended in **section 9** and outlined in this appendix of the Francois Lake Management Plan long-term water quality trends can be determined and assessed.