Regional District of East Kootenay

# COLUMBIA LAKE MANAGEMENT STRATEGY

August, 1997

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# REGIONAL DISTRICT OF EAST KOOTENAY
# COLUMBIA LAKE MANAGEMENT STRATEGY

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*"...The Spirit Trail is a bridle path leading from Fairmont Springs, ten miles to Canal Flats, along the east shore of Columbia Lake. This route is interesting at all times, the view in fair weather unsurpassed, but by the subdued light of the sun, fixed like a great red seal, one felt the spell of enchantment; a fitter place to peoples by fairies and elves never was..."*

Chas D. Ellis (1912) Rod and Gun in Canada Magazine.

From an article describing the first nations Spirit Trail on the East side of Columbia Lake.

Responding to local public concern about Columbia Lake's water quality and hydrology, the Regional District of East Kootenay implemented this management strategy. Ever expanding development pressures in the Columbia Valley and increasing demands on the foreshore of Columbia Lake provided the impetus to develop a strategy that would serve to direct lake and foreshore use in a manner which would respect community values and protect the existing ecosystem.

A strong message stated by the public during this process was that Columbia Lake must be conserved. Very often the statement was expressed that "Columbia Lake not become another Windermere Lake," referring to the perceived overuse of that Lake. The beauty and serenity of Columbia Lake make it a unique feature in the Valley and many residents saw this as a critical element to protect and enhance.

The purpose of this management strategy is to provide a framework of lake and foreshore management recommendations. These recommendations will enable the Regional District of East Kootenay, B.C. Lands, the Ministry of Environment, other relevant government regulatory bodies and private citizens to manage foreshore development and lake use.

## 1.1 PURPOSE AND SCOPE OF THE COLUMBIA LAKE MANAGEMENT STRATEGY

The intent of the strategy was to gain a clear understanding of the lake's water quality, water levels, condition of habitat, foreshore and recreational use. Through the collection of new data and comparisons to old, trends were noted and a benchmark established that will assist in monitoring the health of Columbia Lake into the future. This strategy was prepared with the following purposes in mind:

- To assess the current condition of Columbia Lake;
- To gain an understanding of the historic evolution of the lake;
- To determine the water quality of the lake, current condition of its foreshore and the condition of the lake's habitat;
- To identify environmentally sensitive areas and critical wildlife, waterfowl and fisheries habitat;
- To obtain empirical data that will serve as a benchmark for future investigations;
- To inform the public of the condition of the lake and whether its condition is improving, deteriorating or staying the same;

- To determine through consultation with government and citizens the most appropriate way to manage the lake;
- To set out roles and responsibilities and provide an action plan to ensure that the management strategy recommendations are implemented.

It was a conscious decision to focus this management strategy specifically on the lake and foreshore. The foreshore is defined as the land between the high and low water marks. It includes lands sometimes covered by water that adjoins the boundaries of privately owned shoreland property. The Province is the owner of foreshore lands in British Columbia. To protect the public's right of access to the foreshore, any development or use of the foreshore requires the approval of the B.C. Lands.

## 1.2 ISSUES FACING COLUMBIA LAKE

This management strategy focuses upon issues as they relate to the overall condition of the lake and the foreshore. Four broad areas of inquiry were identified at the start of research:

- Water quality and level
- Fish and waterfowl habitat
- Foreshore use and access
- Boating and recreational use

These broad categories were further clarified with the assistance of public input. A wide variety of issues and public concerns were expressed, both prior to this study and during the public workshops held specifically to assist in the preparation of the management strategy. Public input helped focus research on specific areas of concerns. The public concerns expressed during the planning process included:

- ***The deterioration of Columbia Lake's water quality.***
- ***Declining lake levels.***
- ***A blocked culvert at the southwest corner of the lake.***
- ***Dutch Creek channel movements potentially affecting lake levels.***
- ***Growth of the Dutch Creek alluvial fan.***
- ***Increasing weed growth.***
- ***Types of boating activities on Columbia Lake.***
- ***Conservation of fish and waterfowl habitats.***
- ***Sensitivity of the habitat relative to activities occurring on the lake.***

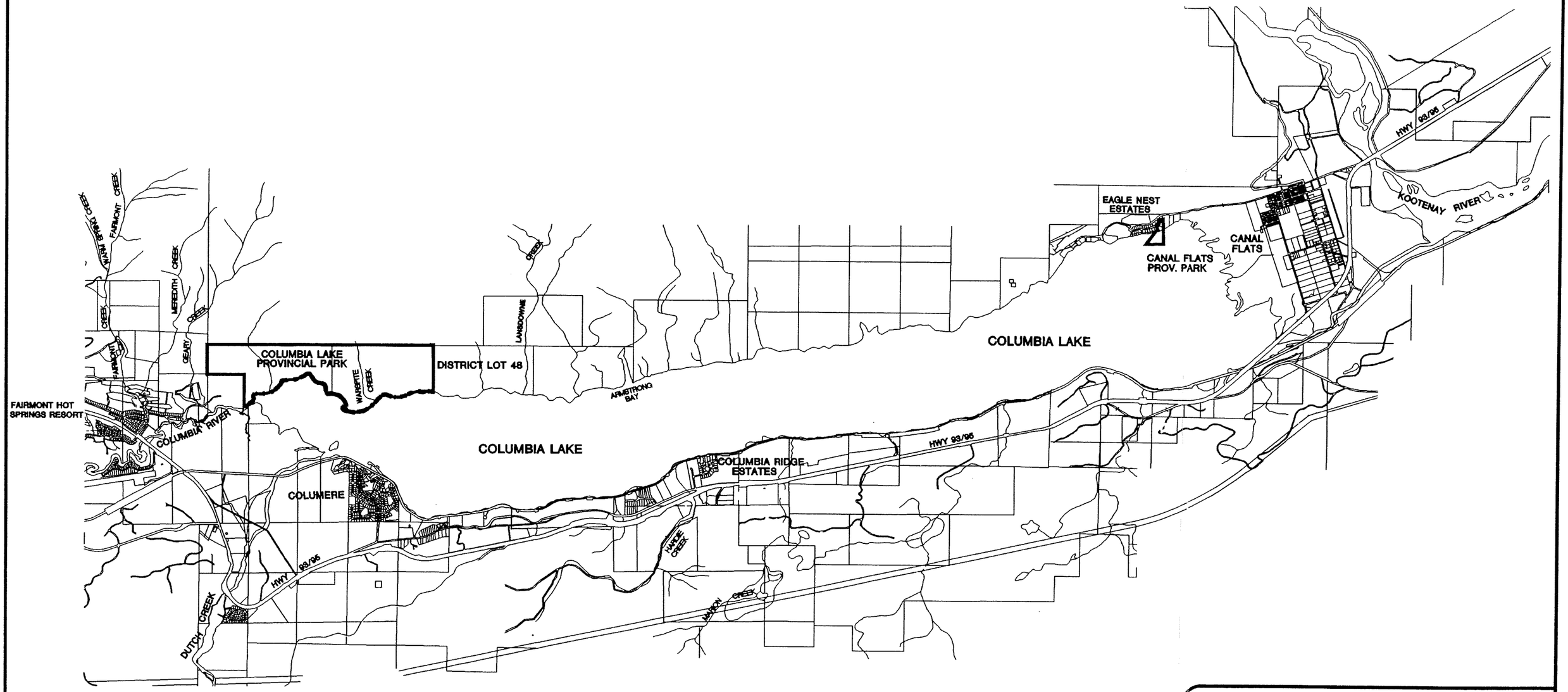
- *The protection of the aesthetic qualities of the lake.*
- *The regulation of private marina development.*
- *The number and location of additional boat launches.*
- *Availability of public access points.*
- *Concern with development and shoreland construction practices.*
- *The CPR's activities and practice of side casting.*

These issues formed the direction of research, guided analysis and helped shape the final recommendations of this management strategy.

## 1.3 REPORT OVERVIEW

This management strategy is organized in four broad sections:

1. **Introduction**, sets out the purpose and scope of the strategy, as well as the key issues which the strategy is to address.
2. **Inventory and Analysis**, provides an evaluation of scientific data on water quality, water level and habitat.
3. **Management Strategy**, outlines the operational and management recommendations for Columbia Lake.
4. **Implementation and Action Plan**, provides a recipe for action on how the management strategy recommendations can be implemented. This section also assigns roles and responsibilities, and establishes a general timeframe, for the various activities which need to be carried out.




GRAPHIC SCALE
( IN METRES )

500 0 250 500 1000 1500 2000 2500 3000

1 : 60,000

REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

# MAP 1
# ORIENTATION TO COLUMBIA LAKE

NORTH

LEGEND

PROVINCIAL PARK BOUNDARIES

URBAN SYSTEMS

## 2.1 PHYSICAL SETTING

Columbia Lake is located in the Rocky Mountain Trench at $50^0$ 15' N and $115^0$ 50' W with an average elevation of 2654 feet (809m). It is bounded to the east by the Kootenay Ranges of the Rocky Mountains, to the west by the Purcell Range of the Columbia-Omineca Mountains, to the south by the glacial terrace of the Kootenay River at Canal Flats, and to the north by the alluvial fan of Dutch Creek. Based on historic data, the Kootenay River flowed north during the last glacial period not south as it does presently, and Columbia Lake currently occupies the Kootenay River glacial channel.

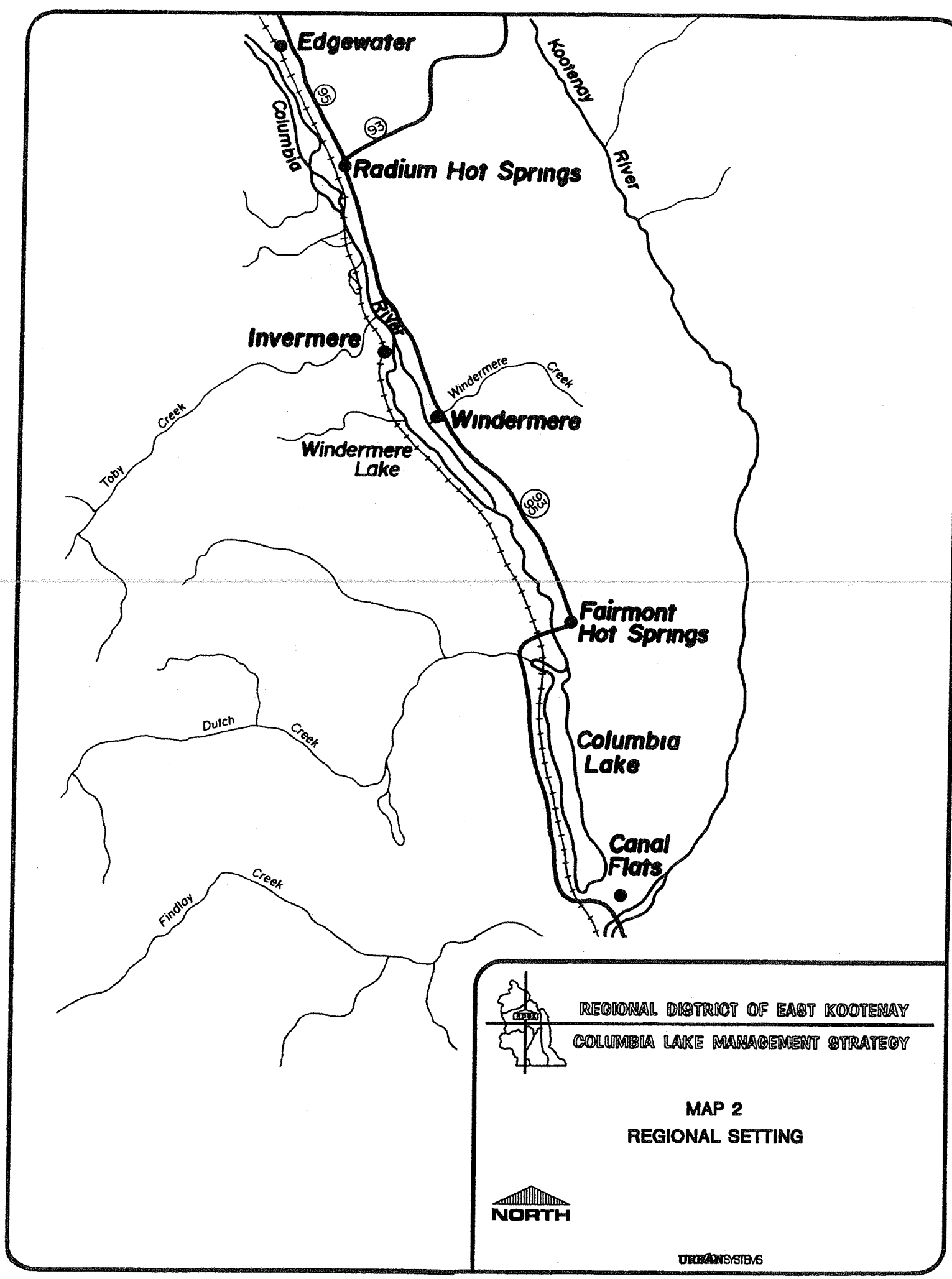
Columbia Lake is a high altitude, large, shallow lake with a surface area of 25.74 $km^2$, with a length of 13.6 km. The lake's mean depth is 2.9 metres with a maximum depth of 5.2 metres. As compared to Windermere Lake, the drainage basin of Columbia is small and restricted. The lake's location, configuration and morphometry, combined with the frequent wind action present in the Rocky Mountain Trench, produces well-mixed water throughout the lake during the ice free period.[2] The climate, at the valley bottom, is relatively dry because the Purcell Mountains isolate the area from moist Pacific air. Winters are generally mild but severe cold spells occur when Arctic continental air spills across the Rockies. Spring and fall are noticeably drier than either summer or winter. Precipitation amounts increase as elevation rises up the valley slopes. Table One provides an overview of the lake's characteristics.

**Table One: Columbia Lake Characteristics**

| Parameter | Amount |
|---|---|
| Volume | 74.87 x $10^6 m^3$ |
| Surface Area | 25.74 $km^2$ |
| Maximum Depth | 5.2 m |
| Mean Depth | 2.9 m |
| Length | 13.6 km |
| Average Width | 1.7 km |
| Shoreline Perimeter | 42,184 m |

[2] Kootenay River Diversion Project, Vol 11 Physical Environment. (1978) Entech Environmental Consultants Ltd.

Columbia Lake is recognized as having regional significance in the East Kootenays because it serves as the headwaters of the Columbia River. The Columbia River is home to areas of critical habitat, and has been designated as Wildlife Management Area. The Columbia River is also a significant water source to Windermere Lake.




REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

**MAP 2**

**REGIONAL SETTING**

NORTH

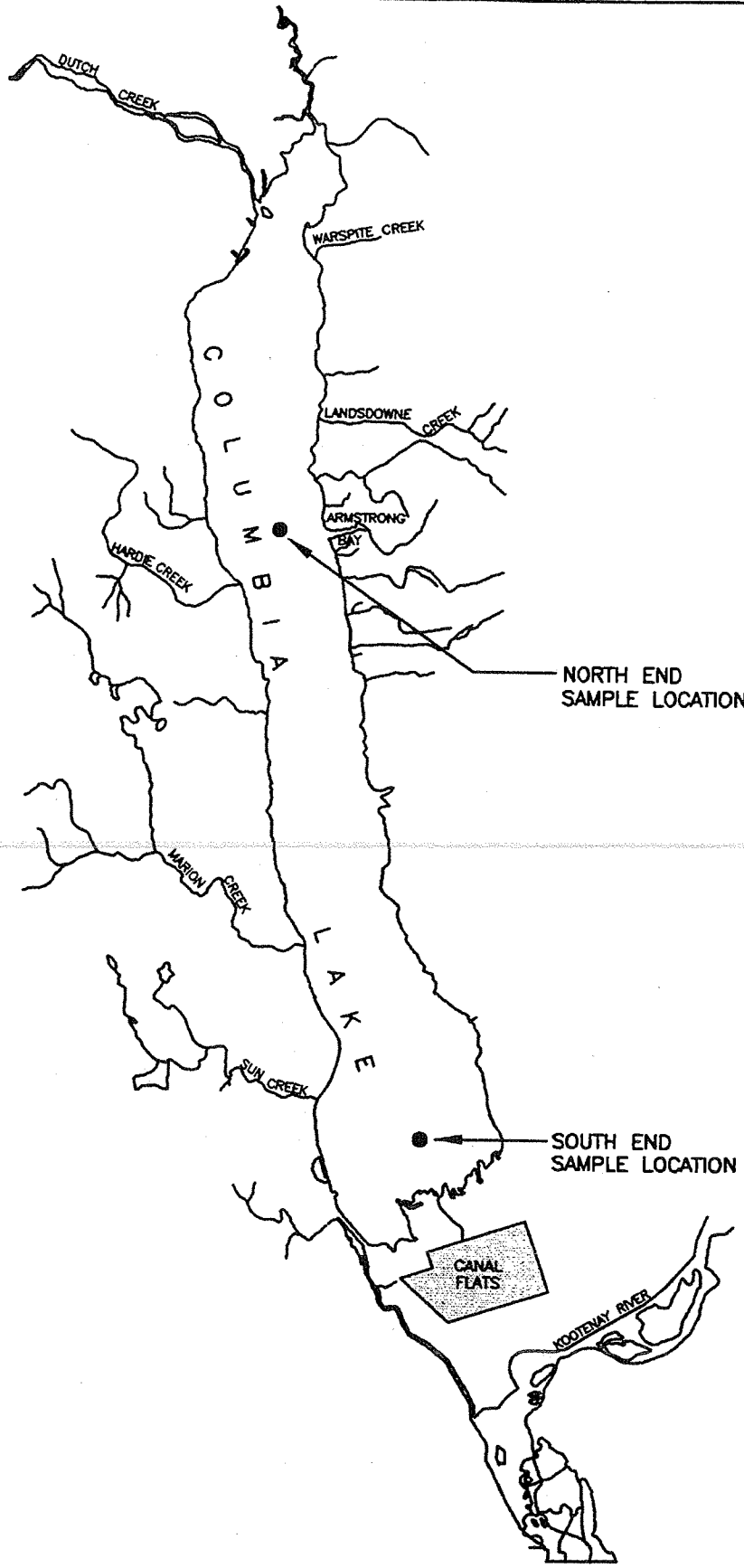
URBAN SYSTEMS

## 2.2 WATER QUALITY

An important goal of this management strategy is to evaluate the current and historic water quality of Columbia Lake. Water quality is a basic gauge for measuring environmental health and ecosystem integrity. In order to draw conclusions and determine water quality trends water samples were collected and compared to the results of past studies. New water samples were collected in June 1996 and compared to studies dating back to 1973. The locations of the water samples taken in 1996 were the same as those taken in previous studies. Table Two provides an overview and comparison of water quality testing results from 1973 and 1983 to the new samples collected for this strategy.

**COLUMBIA LAKE WATER QUALITY**

| | 1973 - September | | 1983 - June | | 1996 - June | |
|---|---|---|---|---|---|---|
| **PARAMETER** | *SOUTH END* | *NORTH END* | *SOUTH END* | *NORTH END* | *SOUTH END* | *NORTH END* |
| **ALKALINITY** Total mg/l | 126 | 106 | 132 | 102 | 150 | 131 |
| **pH** | 8.4 | 8.5 | 8.3 | 8.4 | 8.21 | 8.19 |
| **DISSOLVED SOLIDS** Total mg/l | | | 178 | 135 | 199 | 164 |
| **TURBIDITY** | 1.1 (JTU) | 0.6 (JTU) | 1.1 (NTU) | 0.7 (NTU) | 1.6 (NTU) | 2.1 (NTU) |
| **TEMPERATURE** $C^{o}$ | | 13.5 | 12.3 | 12.1 | 16.3 | 16.3 |
| **PHOSPHORUS** Total mg/l | 0.007 | 0.004 | 0.006 | 0.0045 | 0.01 | 0.008 |
| **PHOSPHORUS** Total Dissolved mg/l | 0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| **CARBON** Total Organic mg/l | 6 | 5 | 1.3 | 3.5 | 1.7 | 2.31 |
| **NITROGEN** Total mg/l | 0.16 | 0.17 | | | 0.43 | 0.27 |
| **NITROGEN**,Nitrite/Nitrate mg/l | <.02 | <.02 | <.02 | <.02 | <.01 | <.01 |
| **HARDNESS** Total Dissolved mg/l | 142 | 118 | 149 | 117 | 189 | 155 |




REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

**MAP 3**
**WATER QUALITY SAMPLE LOCATIONS**

NORTH

URBAN SYSTEMS

LEGEND

● WATER QUALITY SAMPLE SITES

### 2.2.1 Nutrient Analysis

#### 2.2.1.1 Phosphorous

A nutrient is a chemical that plants need in order to grow. Phosphorous is known as a limiting nutrient because once phosphorous in the surface water of a lake is exhausted, algae stop growing and die. If more phosphorous is added, algae populations will increase until their growth is limited by other nutrients or light. Compared to algae, shoreline aquatic plants do not respond directly to phosphorus in the water. Larger aquatic plants take their required nutrients from the bottom sediments though roots, rather than from the open water. Concentrations of phosphorous are also highly correlated to recreational water quality.

Sources of phosphorous include external inputs such as overland runoff, dust and precipitation and internal inputs from sources within the bottom sediments of the lake. Atmospheric loading from rain, snow and dust is the largest portion of external input to lakes with a small drainage basin. Internal inputs involve the transfer from the bottom sediments into the water column. In shallow lakes, such as Columbia Lake, bottom waters gradually warm as the summer progresses. Bacterial activity and chemical reactions consume dissolved oxygen. When this happens phosphorous stored in the bottom sediments is released to the overlying water. Once phosphorous has moved into the overlying water, wind action mixes the nutrient rich water throughout the lake resulting in an algae bloom. Total iron and calcium concentrations can regulate phosphorous cycling in lakes. Studies have shown that, under specific chemical conditions, when calcium concentrations have been increased, phosphorous appears to be more effectively sealed in the bottom mud.[3]

Lake scientists use different measurement techniques to determine the amount of phosphorous in a water body. Two forms of measurement of inorganic phosphorous are total dissolved phosphorous and soluble reactive phosphorus. These are biologically available for plant growth. Total dissolved phosphorous (TDP) is very low in Columbia Lake at <3, which is an undetectable except with specialized equipment. The TDP levels have remained consistently low over the past ten years. Dissolved phosphorus was not detectable in Columbia Lake in 1973, 1983 or 1996.

Organic phosphorous present in fresh water lakes is measured as particulate phosphorous, and suspended in particles within the water body. The measurement of total phosphorous, as presented in Table Two, is the sum of organic and inorganic phosphorous. In Columbia Lake, total phosphorous exists mainly in the non-available form and cannot be readily utilized for aquatic plant growth. Levels vary from .004 to .01 mg/l with the highest concentrations at the south end of the lake. Total phosphorous concentrations are a powerful predictive tool for lake management, particularly recreational water quality. Lakes with lower total phosphorous levels, such as Columbia Lake, are valued for their recreational value and clear water.

[3] Ibid.

#### 2.2.1.2 Nitrogen

Nitrogen is also an essential nutrient for aquatic plant growth. Both nitrogen and carbon are usually present in much higher concentrations than phosphorous and are normally in excess of the needs of aquatic plants. The lowest total nitrogen levels are recorded in the less productive freshwater lakes. In Columbia Lake, total nitrogen is composed exclusively of organic nitrogen and decreases in concentration from the south to north end of the lake. Concentrations range from 0.16 to 0.43 mg/l and are not considered excessively high.

The 1996 elevated total phosphorous and total nitrogen levels at the south end of Columbia Lake could be indicative of increase algae production. These levels have not, however, resulted in an increase in algae growth as clear water was demonstrated with secchi readings and low turbidity.

#### 2.2.1.3 pH

The pH level indicates the acidity or alkalinity of water and it is measured on a scale extending from 1 (acidic) to 14 (basic). When the pH is less than 7 the solution is acidic, at pH 7 it is neutral, and above this level it is alkaline. Many aquatic animals are intolerant to a pH lower than 5.7. Columbia Lake's pH ranges from 8.19 - 8.5, is slightly alkaline and similar to other lakes whose source flows over rocks and percolates through glacial deposits and soils rich in carbonate salts. Alkalinity indicates that Columbia Lake is a well buffered water body favourable for a diverse assemblage of plant and animal species.

The pH level of Columbia Lake has remained fairly constant over time. This consistency is a good indication as change in water chemistry would typically result in a change in the pH level. The consistency of Columbia Lake's pH level over time confirms that there has been very little change in water quality.

#### 2.2.1.4 Total Dissolved Solids

A measure of salinity of lake water is total dissolved solids (TDS). Total dissolved solids of Columbia Lake range from 164 - 199 mg/l and include dissolved particles and dissolved organics. These levels are typical of a headwater lake and the level favours diverse plant growth but does not promote dense plant growth.

#### 2.2.1.5 Temperature

Temperature, oxygen and pH are the "master variables" structuring aquatic habitat. The temperature of water changes less rapidly than that of air so aquatic plants and animals are protected from sudden changes and can adapt gradually. Good circulation exists between the surface and the bottom indicating that Columbia Lake probably remains unstratified throughout most of the year.

A survey conducted in 1992[4] concluded that Columbia Lake probably does not thermally stratify. The shallow nature of the lake basin and wide exposure to the prevailing winds creates well-mixed conditions, where water temperature is the same at both the top and the bottom. Both temperature and oxygen concentration (11.2°C and 11.5 mg/L, respectively) displayed no variation with depth and were suitable for salmonid species. During the 1996 in-situ survey, temperatures ranged from 16.3 to 19.9 °C and dissolved oxygen concentrations ranged from 8.21 to 9.15 mg/L from the lake surface to a maximum depth of 4.5 m. (See Appendix One)

### 2.2.1.6. Oxygen

Based upon the data reviewed for this strategy, the water column of Columbia Lake is thought to be well oxygenated throughout the year. Oxygen concentrations in Columbia Lake below ice during the winter were found by McKean and Nordin (1985) to be favourable for salmonid species such as trout and whitefish. (i.e., ranged from 10 to 15 mg/L) Dissolved oxygen in Columbia Lake is high ranging from 8.21-9.15 mg/l (91.2% - 102.1% saturated). This provides an indication of overall healthy conditions in Columbia Lake. If oxygen saturation were low, the potential would exist for fish kills.

An algae bloom is known to have occurred during hot weather in August 1994. This bloom resulted in a small fish kill.[5] Algae respiration at night can reduce dissolved oxygen concentrations below the level required for fish survival. Salmonid species are particularly susceptible to summer kills as a result of algae blooms.

Releases of phosphorus from the bottom sediments and subsequent algae blooms can occur in Columbia Lake during periods of high water temperatures and accompanying low dissolved oxygen concentrations over the sediments. This issue requires further study, particularly if future development on the lake has the potential to increase phosphorus loadings and the risk of fish kills.

### 2.2.1.7 Turbidity

Turbidity is a measure of the amount of material such as mud, silt and algae present in a suspended form. The Dutch Creek plume during freshet is a minor source of turbidity and is generally confined to the north end of the lake. The most noticeable source of localized turbidity can be attributed to the extremely erosive shoreline material of Columbia Lake. Shoreline turbidity is especially noticeable during windy conditions when the windward end of the lake's shallows can become very muddy.[6] Throughout the world, water clarity is measured by estimating the depth that a black and white plate, called a secchi disk, can be seen. In addition to providing a measure of clarity, the secchi disk can also help determine the extent of the lake bottom where sufficient light is available for aquatic plant growth. Secchi disk measures of Columbia Lake indicate clear water conditions and light penetration depths which encourage aquatic plant growth over 100% of the lake bottom.

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[4] R.L. and L Environmental Services Ltd. (1992) Fisheries Investigation of Columbia Lake.

[5] Bill Westover, pers. comm. (1996)

[6] Kootenay River Diversion Project, Vol 11 Physical Environment. (1978) Entech Environmental Consultants Ltd.

## 2.3 TROPHIC STATUS

The determination of Columbia Lake's trophic status is a measure of the lake's overall sensitivity to additional inputs of nutrients. The trophic status of any lake is a measure of productivity. Lake productivity is determined by the extent of algae blooms, aquatic weed growth, and the number and size of fish. There are three terms used to describe the varying trophic status of lakes.

i. *oligotrophic* lakes are unproductive lakes that have clear water and little algae or weed growth. These lakes are desirable because they are aesthetically pleasing, they are excellent sources of domestic water, and desirable for most water oriented recreation activities.

ii. *eutrophic* lakes typically have heavy algae blooms (giving them a "pea soup" appearance) and extensive areas of shoreline weeds. Although *eutrophic* lakes produce large fish populations, they are susceptible to fish kills because of oxygen depletion in the water. These lakes are less desirable and have poor water quality.

iii. *mesotrophic* lakes are a general class between *oligotrophic* and *eutrophic* lakes.

The transition from an oligotrophic to an eutrophic state in a lake is a natural aging process. Without the influence of man's activities, this natural transition process may take thousands or millions of years. Nature fertilizes lakes by the transport of sediments and natural organic debris flowing into the lake. The activities of people, including agriculture, forestry, settlements and shoreland habitation can increase the natural rate of input of nutrients into a lake. This may result in an acceleration of the natural aging process of lakes.

Eutrophication, is caused by the enrichment of surface waters with nutrients. Nutrient poor lakes (oligotrophic) become nutrient rich lakes (eutrophic) as nutrient concentrations increase in the lake water. As a result of eutrophication, a significant increase in plant and algae growth occurs. As the nutrient concentrations increase and more plant growth occurs, the following consequences may occur:

- dissolved oxygen concentrations exhibit seasonal cycles of supersaturation and deficit, and the lake bottom becomes deficient in oxygen;
- loss of diversity and stability in plant life; blue-green algae become more competitive and dominant;
- blue-green algae blooms cause problems of taste and odor, and eventually will render water undesirable for domestic consumption without treatment. Blue-green algae are also responsible for the muddy taste of fish;
- recreational and aesthetic values are diminished, skin rashes may be experienced after swimming;
- fish populations change from game fish to coarse fish (if coarse fish are present in a lake), largely due to low dissolved oxygen concentrations, but also due to changes in the food source;
- aquatic weed growth interferes with recreation and other uses.

### 2.3.1 Chlorophyll a Concentration

The phosphorous concentration, as measured by the in-situ sampling, is directly proportional to the chlorophyll a concentration. The chlorophyll a concentration is directly related to the trophic status of a lake. The following table illustrates the relationship between chlorophyll a concentration and trophic state.

**Table Three: Trophic State**

| COMPUTED CHLOROPHYLL A CONCENTRATION | TROPHIC STATE |
|---|---|
| 0 - 3 mg/cu.m. | Oligotrophic |
| 3 - 7 mg/cu.m | Mesotrophic |
| 7 + mg/cu.m | Eutrophic |

The actual chlorophyll a concentration in relation to the limits shown above, is a measure of the relative degree of trophic status. For example,. McLeese Lake has a computed chlorophyll concentration of 1.6 mg/cu.m., indicating that the lake is well down in the *oligotrophic* range. Williams Lake has a reported chlorophyll a concentration of 20 - 40 mg/cu.m, indicating the lake is in an advanced, highly *eutrophic* state. Dragon Lake has a reported chlorophyll a concentration of 8.9 mg/cu. m, indicating the lake is slightly into the *eutrophic* range.

Columbia Lake's computed Chlorophyll a concentrations varied from 1-7 mg/cu.m. and is characteristic of an *oligotrophic* to *mesotrophic* status with good water clarity and little plankton growth.

## 2.4 WATER QUALITY SENSITIVITY RATING

The capability of a lake to assimilate additional phosphorus without a detrimental effect on water quality is a function of how "fast" the trophic status of that lake may change. A more descriptive term for this concept is the "sensitivity" rating. A lake with a high sensitivity rating has a low capability to assimilate additional phosphorus without a detrimental effect on water quality. Conversely, a lake with a low sensitivity rating has a high capability to assimilate additional phosphorus.

The sensitivity of a lake to change in trophic status is a function of a number of physical characteristics, described as follows:

i. **flushing period** - flushing period, or resident time, is a measure of the time (expressed in years) that natural inflow actually replaces the lake water volume. Lakes with a short retention time have a higher capacity to assimilate additional phosphorus without a change in trophic state. The capacity to assimilate additional phosphorous occurs because the lake flushes out each year. Lakes with a long flushing period have a higher sensitivity because of the potential for accumulation of added nutrients.

ii. **mean depth/volume** - as the mean depth of a lake increases in relation to its volume, the assimilation capacity of the lake increases, and the sensitivity rating decreases. This is attributable to a greater nutrient dilution and a reduction in shallow or littoral areas where biological activity generally is most pronounced.

iii. **physical/chemical indicators** - the knowledge of various chemical parameters (e.g. total dissolved solids, pH levels, etc.) and lake temperature or oxygen profile can provide further insight into the assimilation capacity of the lake. For example, the presence of a high pH level and salt content can create a buffering capability in the lake.

iv. **watershed characteristics** - the watershed and the activities that occur within it are considered the single most important factor in terms of the eventual disposition of a lake. Lakes that experience any significant change in land use in the watershed are more likely to experience a trophic state change as compared to lakes where the watershed remains in its natural state.

Three sensitivity ratings classify water quality sensitivity - high, moderate and low. The typical examples of the application of these three ratings follow:

i. **high water quality sensitivity** - generally lakes with a combination of all or several of the following characteristics:

- range of the trophic scale from oligotrophic to slightly eutrophic (e.g. chlorophyll a concentration of less than 12 - 15 mg/cu.m.);
- long flushing period - generally greater than 8 years;
- relatively shallow lake - low mean depth - generally less than 5 metres;
- small watershed or watershed with a significant degree of activity - agriculture, logging, development, etc.

ii. **moderate water quality sensitivity** - are generally lakes with a combination of all or several of the following characteristics:

- range on the trophic scale similar to high sensitivity lakes, although somewhat further into the eutrophic range (e.g. chlorophyll a concentration of less than 20 mg/cu.m.);
- average flushing period - generally 2 - 8 years;
- average mean depth - generally 5 - 15 metres;

- possible physical and chemical parameters which may retard quantity and composition of plant growth;
- larger watersheds or watersheds with less activity.

Lakes with a moderate water quality sensitivity have a moderate capability to assimilate additional phosphorus without a detrimental effect on water quality.

iii. **low water quality sensitivity** - generally lakes at either extreme of the trophic scale.

- short flushing periods - generally 0 - 2 years;
- higher mean depth - greater than 15 m;
- probable natural state of watershed or large watershed;
- highly oligotrophic lakes;
- highly eutrophic lakes - lakes which are sufficiently advanced into a eutrophic state than only large amounts of additional nutrients will result in a noticeable further deterioration in water quality;

Lakes with these characteristics have a relatively high capability to assimilate additional phosphorus without a detrimental effect on lake water quality.

A further consideration in evaluating water quality sensitivity is the potential for localized portions of a given lake to have a higher sensitivity rating than the general rating for the lake as a whole. Lakes with the following characteristics are likely to be the most susceptible to localized problems, even though the lake as a whole may have a low sensitivity rating:

a) **lakes with an irregular shoreline** and characterized by numerous embayments. Embayments are likely to be more sensitive than the lake as a whole. The retention of nutrients is more likely in the embayment and the average depth of bays is usually less than that for the main lake.

b) **lakes with shallow littoral zones**. The shallow littoral zones, or areas of light penetration to the bottom, are the most productive areas of a lake and are therefore the most susceptible to the added nutrients. The concentration of nutrients in the potentially productive littoral zone of a lake will result in enhanced plant growth in the localized area. This can result in a healthy oligotrophic lake dotted with excessive weed growth along the shoreline. Weed growth will be particularly evident in shallow gently sloping beaches most favorable for swimming and other shore oriented activities, and also the shoal spawning habitat of fish.

### 2.4.1 Water Quality Sensitivity Rating of Columbia Lake

Twelve water samples were collected from four locations on Columbia Lake from January 1973 to May 1983. Total phosphorus concentrations ranged from 0.004 to 0.009 mg/L, and chlorophyll a concentrations varied from 1 - 7 ug/l. From these results, it was estimated the trophic status of

Columbia Lake to be *oligotrophic* or nutrient poor.[7] This nutrient poor status of Columbia Lake is generally consistent with the AGRA Earth and Environmental conclusions based on testing performed in June 1996.

Although the highest concentrations of the 1996 survey indicate possible *mesotrophic* or moderately productive conditions, the exceptionally clear secchi disc and turbidity reading provide a strong indication that Columbia Lake has an *oligotrophic* status. Secchi reading indicating good light penetration in the water column are thought to be generally inconsistent with *eutrophic* conditions. The June survey indicated that total phosphorus concentrations ranged from 0.004 to 0.017 mg/L.

Based on the water quality samples and nutrient analysis, Columbia Lake has a moderate water quality sensitivity. It's capability to assimilate additional phosphorous without a detrimental effect on water quality is not exceptional nor is it extremely sensitive to additional sources of phosphorous that may enter the Lake.

The following factors increase Columbia Lake's sensitivity to the introduction of phosphorous:

- Columbia Lake has a littoral zone where aquatic plants are capable of growing over the entire bottom of the Lake;
- The lake is very shallow;
- Columbia Lake is characterized by certain areas of embayments, specifically at the north and south ends and areas on the eastern side;
- Some development activity occurs in the watershed;

Alternately, Columbia Lake is buffered in its sensitivity to the introduction of phosphorous because:

- the lake is classified as *oligotrophic*;
- forestry activities in the watershed are minimal;
- Columbia Lake has a fast rate of flushing which occurs at least once per year. This helps flush phosphorous inputs from the lake.

## 2.5 WATERSHED CHARACTERISTICS - POTENTIAL SOURCES OF PHOSPHORUS

Although shoreland development and individual on-site sewerage systems are often perceived to be the primary "offender" affecting lake water quality, this is often not the case. It is important to recognize that these systems are only one of several potential sources of phosphorus nutrients.

[7] McKean and Nordin (1985)

Phosphorus sources may be in the immediate vicinity of the lake, or may be removed from the lake, but within the contributing watershed. Other potential sources include:

- storm drainage from higher density developments;
- natural runoff - phosphorus contributions increase as a result of clearing (by clear cut logging or clearing for agriculture). Ontario studies indicate that if 15% or more of the watershed has been cleared, the natural phosphorus load will double. The increased nutrient effects of clear cut logging decrease with time and approach a negligible amount after a period of 7 years;
- agriculture sources - animal wastes and agricultural land runoff are the most probable agriculture related phosphorus sources. The degree of phosphorus contribution from agricultural sources is unpredictable. Specific studies of certain lakes in the Caribou (Williams Lake Study and Dragon Lake Study by the Ministry of Environment) identify agricultural operations as major nutrient contributors - much higher than contributions from shoreland development even if it were assumed that all septic tank effluent discharged directly into the lake with no phosphorus removal.[8]

In the case of on-site sewerage systems serving shoreland developments, the amount of phosphorus entering a lake is highly variable, and depends on a number of factors, including:

- soil types and disposal system standards;
- seasonal or permanent residency;
- total number of units both in the watershed and along the lakeshore.

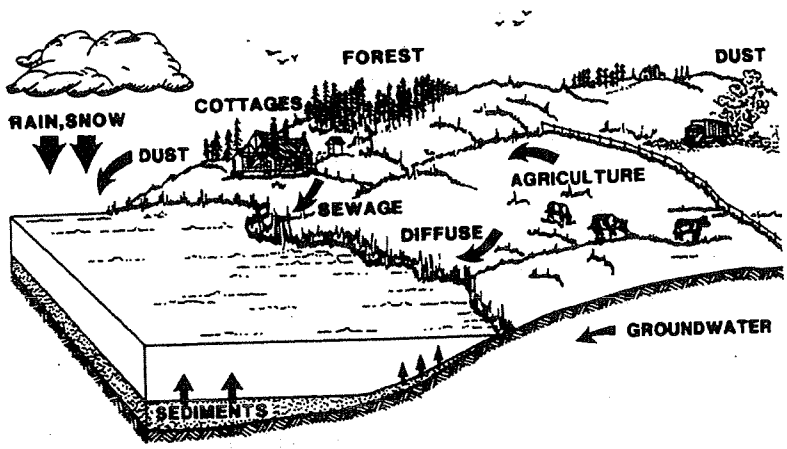



***Diagram illustrates sources of lake nutrient input.***

[8] In the Williams Lake Study, agriculture was shown to be a much higher nutrient contributor than shoreland development, which is relatively extensive around Williams Lake. It was estimated that only 3% of the total phosphorus loading of Williams Lake could be attributed to shoreland development, even under the worst case assumption that all septic tank effluent discharged directly into the lake with no phosphorus removal. In the Dragon Lake Study, a similar estimate attributed some 13% of total phosphorus loading under the same worst case assumptions to residential development.

## 2.6 WATER LEVEL

### 2.6.1 Introduction

Examining the water level status and fluctuations was an essential component of the preparation of this management strategy. A question that was posed at the beginning of this project was:
***"Is the water level of Columbia Lake changing?"***

Generally the water level of Columbia Lake does change from year to year. However, evidence of dramatic fluctuations or a generalized lake level decline is not supported by the data. The water level of Columbia Lake is positively correlated to annual precipitation, where, in years of limited precipitation, the lake level declines and in high precipitation years the lake level increases. Generally there have been more dry and low lake level years since 1975. Actual fluctuations from the average are not extreme and from 1990-1995 the levels closely approximate long term average lake levels.

### 2.6.2 Water Level

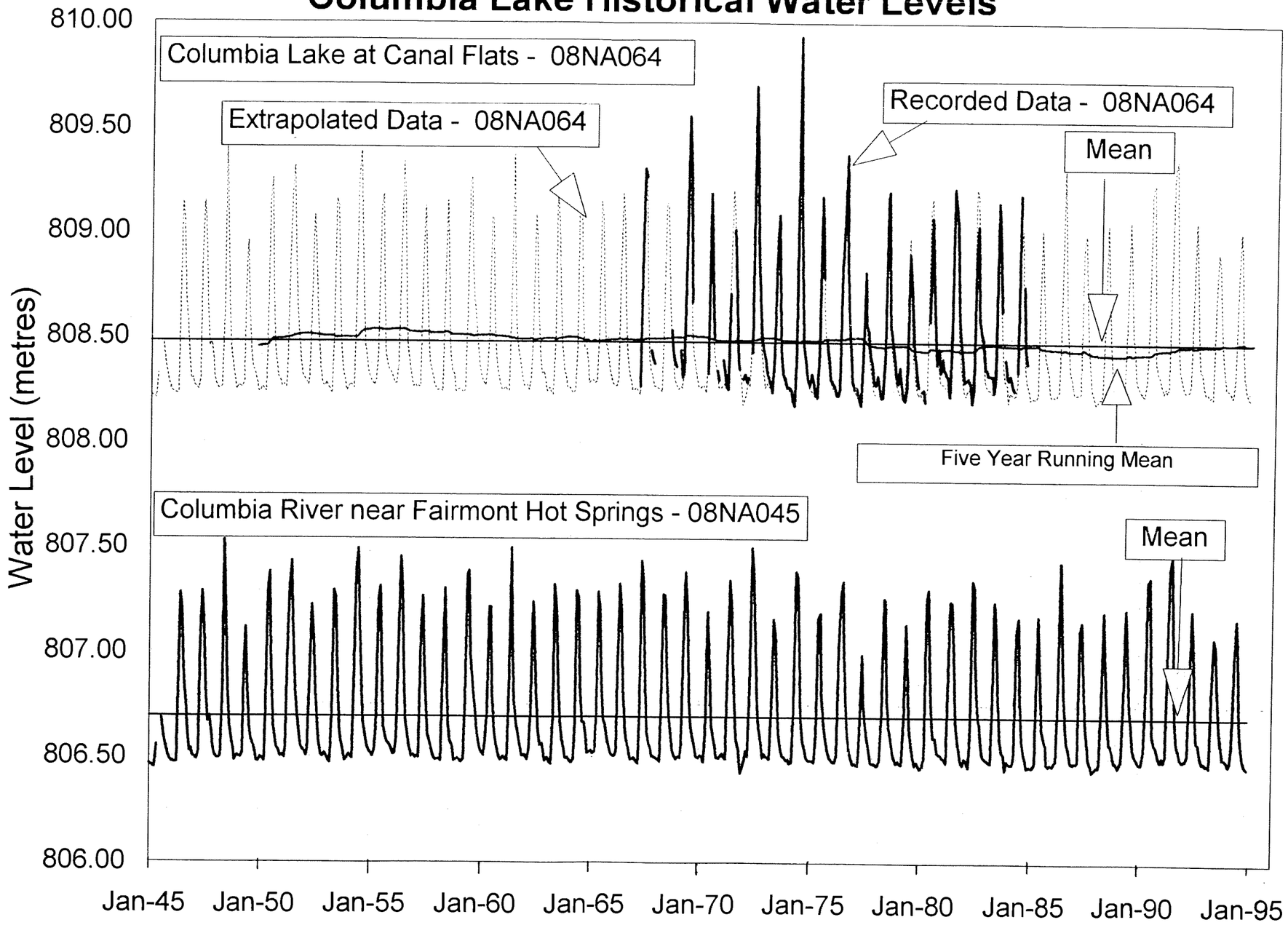
Columbia Lake water level readings, taken once a month, are available for the period from 1967 to 1984. Figure One illustrates recorded and extrapolated Columbia Lake monthly water levels. There is a considerably longer period of record of Columbia Lake outflows than Columbia Lake water levels. Since lake levels are directly related to lake outflows, the lake level database was extended by obtaining a relationship between lake levels and lake outflows. The top half of Figure 1 shows that there is a good fit between the extrapolated lake levels and the actual recorded lake levels for the period from 1962 to 1982. The bottom half of Figure One shows the recorded lake outflow information.

The top half of Figure One shows that the historical mean lake level is 808.48 metres. The five year running mean has also been plotted. This plot shows the five year mean has been within about 10 cm of the long term mean and the recent five year mean is near the long term average. Figure Two shows both annual precipitation and annual lake outflow volumes. Although precipitation does not solely account for changes in lake levels, it does show a strong correlation with lake outflow volumes. Other factors, such as temperature, snow, rain, sunshine hours, etc. also affect the lake hydrology.

Monthly precipitation data for Canal Flats from 1962 to 1982 was extrapolated to 1992. The extended 1962-92 mean annual precipitation for Canal Flats Range Station is 425 mm, as opposed to a published normal of 369.1 mm (Canadian Climate Normals 1951 - 1980, Environment Canada).

A statistical analysis of both lake levels and precipitation was undertaken to determine if there were any discernible trends in water level fluctuations. Figure Three shows a plot of the cumulative sum of the difference between the annual and mean values for both precipitation and lake levels. Both the precipitation and lake levels show similar trends. There is a general trend in precipitation and water level values that are above mean values up to 1975. There has been a general trend in precipitation and water levels that are below mean values from 1975 to 1996. It is important to note that Figure 3 is a cumulative plot used to determine trends. The actual fluctuation in water level above or below the mean annual water level is in the order of 0.1 metre. The differences between the maximum and minimum mean annual water level is approximately 30 cm.

# Columbia Lake Historical Water Levels

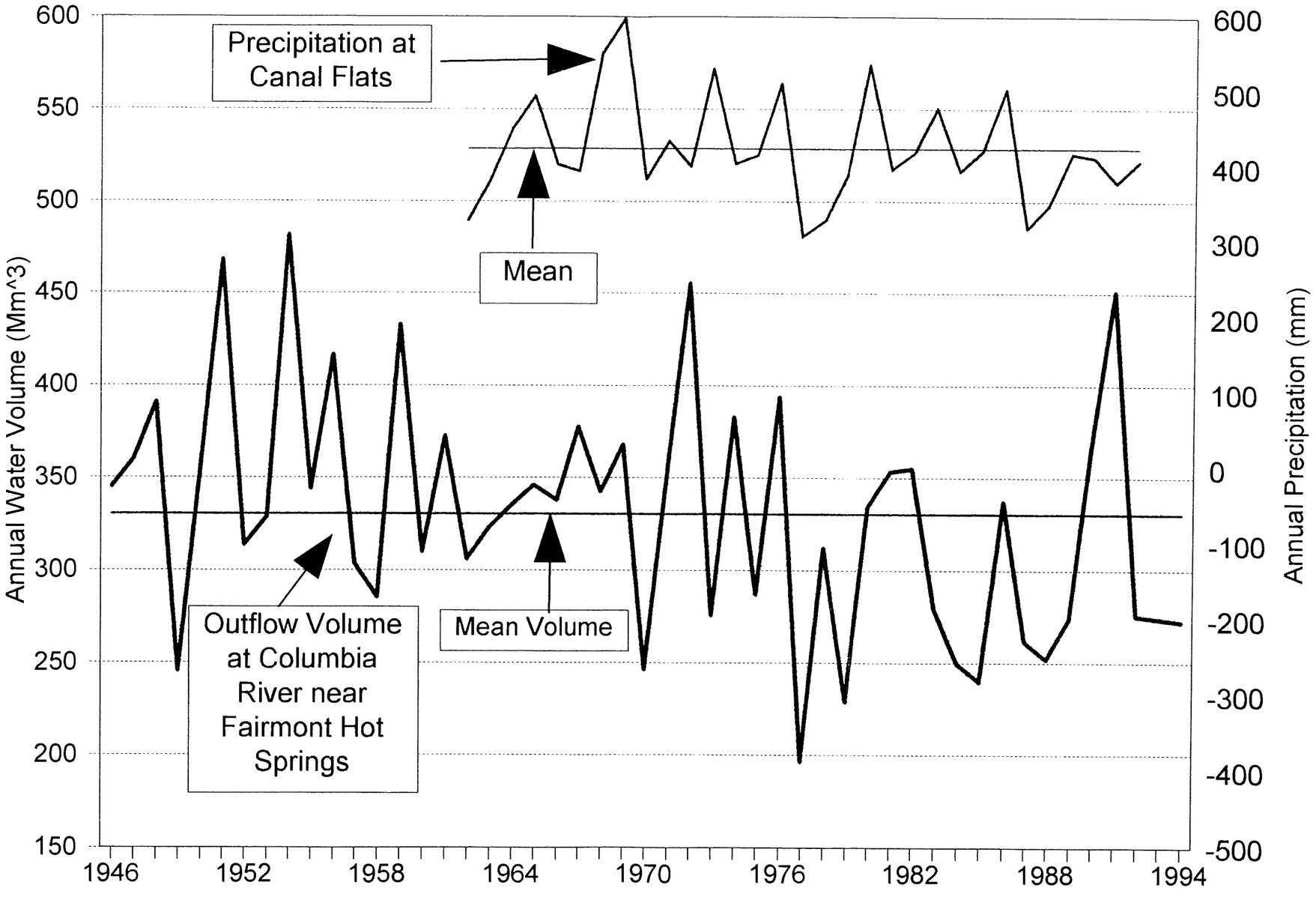



REGIONAL DISTRICT OF EAST KOOTENAY
COLUMBIA LAKE MANAGEMENT STRATEGY

**FIGURE 1**

**COLUMBIA LAKE WATER LEVELS**

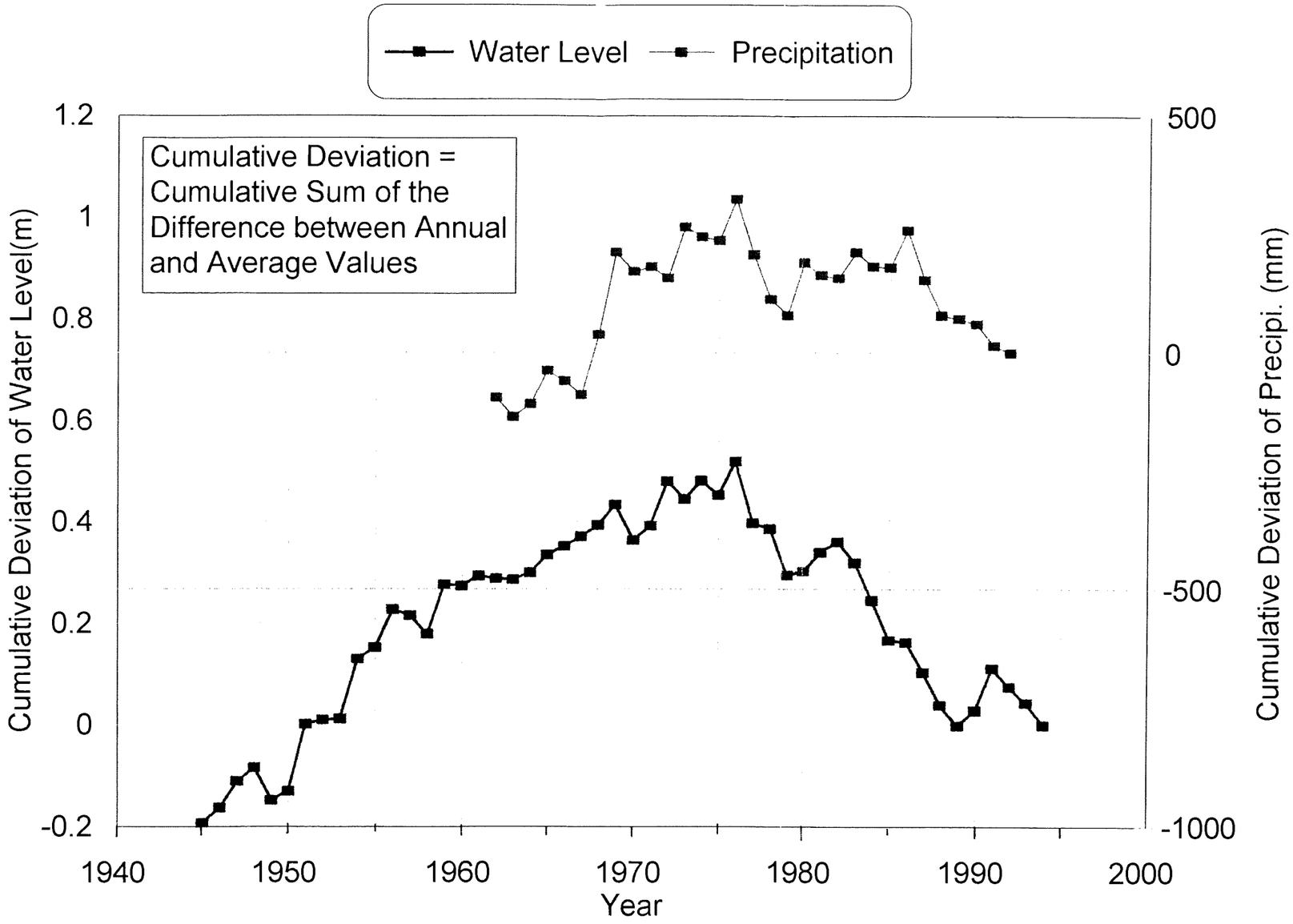
## Precipitation and Outflow
## Columbia Lake (1946 - 1994)




REGIONAL DISTRICT OF EAST KOOTENAY
COLUMBIA LAKE MANAGEMENT STRATEGY

**FIGURE 2**

**CORRELATION BETWEEN PRECIPITATION AND OUTFLOW VOLUMES**




**Cumulative Deviation of Annual Precipitation and Water Level**

REGIONAL DISTRICT OF EAST KOOTENAY
COLUMBIA LAKE MANAGEMENT STRATEGY

**FIGURE 3**

**GENERAL TRENDS IN PRECIPITATION AND WATER LEVEL VALUES**

### 2.6.3 Inflow and Outflow Hydrology

Columbia Lake's drainage basin is considered to be small and restricted. Several small creeks that flow down the steep mountain slopes flanking the lake basin make only a minor contribution to the lake's water budget. Principal 'named' east side tributaries are Warspite and Lansdowne Creeks. West side tributaries are Dutch, Hardie, Marion and Sun creeks. The Columbia Lake basin upstream of the outlet drains 881 $km^2$, composed of 696 $km^2$ from Dutch Creek and the remaining 185 $km^2$ from the other local drainages and the lake itself.

There is evidence that a considerable volume of Dutch Creek is not flowing into the lake as it is being lost to the alluvial fan, ground water and channeled directly into the Columbia River. The annual flow of Dutch Creek above the alluvial fan is 397 million $m^3$/yr. Due to unknowns, however, it was difficult to estimate actual lake inflow from Dutch Creek into Columbia Lake.

Pertinent Regional Water Survey of Canada (WIC) streamflow and lake level gauges are listed in Table Four. Toby Creek, the watershed immediately to the North, is gauged. The drainage area of the Toby Creek station is similar to Dutch Creek. Therefore, the hydrologic characteristics of the two watersheds are likely very similar and the Toby Creek data can be used to estimate the hydrologic characteristics of Dutch Creek above its alluvial fan. This still cannot provide an accurate representation of Dutch Creek inflows into Columbia Lake since there is a considerable loss of surface water, at the alluvial fan, to groundwater and to the outlet.

Even though the Kootenay River at Canal Flats is not part of the Columbia Lake drainage basin a considerable quantity of water is known to be contributed via groundwater from the Kootenay River. The groundwater inflow at the south end of the lake is sufficient to prevent lake freeze-up in most winters, in areas where there are groundwater upwellings. Simplified calculations suggest groundwater contributions probably exceeds 100 million $m^3$/yr.

**Table Four: Regional WSC Stations**

| Station Number | Station Name | Drainage Area ($km^2$) | Years of Record | Mean Annual Runoff (mm) |
|---|---|---|---|---|
| 08NA045 | Columbia River at Fairmont Hot Springs | 891 | 1945 to present | 363 |
| 08NA072 | Toby Creek near Athalmer | 684 | 1943-54 1978-84 | 570 |
| 08NF002 | Kootenay River at Canal Flats | 5 390 | 1939 to present | 510 |
| 08NA024 | Windermere Creek near Windermere | 84.2 | 1920 - 79 | 222 |
| 08NA064 | Columbia Lake at Canal Flats (Monthly levels) | 881 (at outlet) | 1967 - 84 | --- |

The Columbia River at Fairmont data is representative of Columbia Lake outflows since there are no significant drainages between the outlet and the gauge. Therefore, an excellent record of total Columbia Lake outflow, including Dutch Creek, is available.

**Table Five: Columbia Lake Discharges**

| Location | Drainage Area ($km^2$) | Discharge (millions $m^3$) |
|---|---|---|
| Dutch Creek above Alluvial Fan [9] | 696 | 397 |
| Dutch Creek contribution to Lake | 696 + | unknown |
| Local Inflow to Columbia Lake [10] | 185 | 40 |
| Columbia Lake Outflow [11] | 881 | 323.5 |

[9] Estimate based on Toby Creek near Athalmer, WSC station no. 08NA072.
[10] Based on Windermere Creek runoff data.
[11] Based on Columbia River at Fairmont Hot Springs, WSC station no. 08NA045.

### 2.6.4 Flushing Rate

The productivity of a lake is generally dependent upon how long it takes to replace existing water. The faster the flushing rate the lower the productivity. Conversely, the longer the water residence time the higher the productivity. Comparatively speaking, the flushing rate of Columbia Lake is very fast with a flushing rate of at least once per year. Okanagan Lake, on the other hand, has a water residence time in the hundreds of years.

In Columbia Lake's water balance, the known or readily estimated parameters are the lake outflow and the local surface water inflow. The unknown parameters are the Dutch Creek contribution to the lake, and the groundwater inflow and outflow. Because of these factors an exact estimation of the retention time and flushing rate cannot be made. However, a lower bound estimate based on the known data and assumed minimal groundwater contributions can be calculated.

Given that the ground water contribution of the Kootenay River may likely exceed 100 million $m^3/yr$ and the contributions from local inflow (40 million $m^3/yr$) plus a minor portion of Dutch Creek the average rate of the lake exchange is likely to be greater than once a year (i.e., 75 million $m^3/yr$). Previous studies have estimated that the flushing rate of Columbia Lake to be 1.0 times.[12]. Because of the short residence time, Columbia Lake, is less likely to be negatively affected by the addition of additional nutrients.

### 2.6.5 Dutch Creek Siltation Effects

Residents around Columbia Lake have expressed the concern that the Dutch Creek channel movement toward the Columbia River is a major source of lowered lake levels and that the silt deposition associated with the alluvial fan is creating water quality problems. However, the water level analysis indicated that Dutch Creek may not be a critical source of water to Columbia Lake. Because of this factor, the entrenchment of the Dutch Creek channel toward the outlet of Columbia River is not of significant concern. Siltation effects and channel movements were evaluated through an examination of comparative air photos from 1976, 1988 and 1995

It should be noted that alluvial fan deposition is a natural process and fans will increase in size with time. The rate of deposition varies greatly and depends on the geomorphic characteristics and flow regime of the watershed. Channels typically shift across the surface of an alluvial fan as the fan builds and forms shape. Channel entrenching typically occurs during periods of average or low flood years and dramatic shifts can occur during a major flood. Based on air photos, the location of the main Dutch Creek channel on the alluvial fan has shifted from a southerly course to an easterly direction and now exits closer to the Columbia River.

[12] McKean and Nordin, (1985)

The change in channel direction has also resulted in a shift in the area where deposition occurs and in the direction of growth of the fan. In 1976 the growth of the fan was likely in a southerly direction, whereas now the fan is likely growing in an easterly direction. It is conceivable that if deposition was significant enough, it could affect the outflow characteristics. However, there is no evidence that this is presently occurring. Depending upon the flow regime, an entrenchment along the North end of the lake could occur or a shift back to the South is also quite possible during an extreme flood event.

Bottom siltation build-up was a concern voiced at the August 1996 public workshop in Canal Flats. In order to follow up upon the concern the Regional District of East Kootenay directed an examination of bottom siltation effects in 1996 using the same survey pins used in 1957 and 1979 surveys. The result of the 1996 survey indicates that, at the location of the survey pins over the past 40 years the bottom of Columbia Lake has not experienced siltation build up. In fact, the survey results indicate that there are many locations where the lake bottom elevation has dropped.

### 2.6.6 Water Licenses

The largest water licensee is the Columere Water Works Ltd., with a total annual withdrawal of 213,000 $m^3$. The total annual quantity of water withdrawal from Columbia Lake, and its tributaries, for all water licenses are estimated to be 6.28 million $m^3$, which is a relatively minor amount. This is less than two percent of the average annual lake outflow of 323.5 $m^3$ and has an insignificant impact on actual lake levels. It should be noted that this is the maximum licensed withdrawal. Total annual actual withdrawals likely never approach this amount due to a lack of supply at the right time on intermittent creeks and the fact that licensees typically do not use their full allotment.

## 2.7 COLUMBIA LAKE WILDLIFE MANAGEMENT AREA

### 2.7.1 Introduction

Comprising an area of 8,576 hectars, the Columbia Lake Wildlife Management Area (WMA) includes the east side of Columbia Lake, the wetlands at the North and South ends of the lake, and a portion of the eastern shoreline of the lake. Map Four outlines the boundary of the Columbia Lake Wildlife Management Area.

Stemming from the land use recommendations of the Commission on Resources and Environment (CORE) for the East Kootenays, the Columbia Lake Wildlife Management area was established in April 1996. The east side of Columbia Lake has long been acknowledged as an important and critical wildlife habitat. The area was first designated as a "game reserve" in 1957. The area supports a variety of wildlife species and is a critical winter range for elk, mule and white-tailed deer, Rocky Mountain bighorn sheep, black bear, coyote, cougar, bobcat golden eagle, osprey and red-tailed hawk. The area provides habitat for a variety of other animals that are dependent on grassland or open forest habitat. It is a provincially significant area for elk and mule deer. (Map Five provides an overview of uplands wildlife)

The rare grassland and semi-desert ecosystem found on the east side has almost entirely been eliminated in other regions in the province. It supports a number of rare or endangered plants and animals such as the Flammulated Owl and Poor-will. Other rare and endangered species, such as the Alp Lily, American White Pelican, Rubber Boa, Prairie Falcon and rare bats and frogs are supported by the ecosystem. According to information gathered during the CORE process this area is internationally signficant in its biological diversity as it is home to many rare and endangered species.[13]

### 2.7.2 Columbia Lake Wildlife Managment Area -- Management Objectives

The primary management objective of the Columbia Lake Wildlife Management Area is to protect and preserve in perpetuity the area's diverse ecological characteristics and values. The presence of rare and endangered flora and fauna, as well as important heritage sites, dictates that all management activities will be designed where possible according to "leave alone" approach where natural processes will continue without interruption.[14]

Where technically feasible and biologically desirable habitat enhancement designed to maintain and increase the carrying capacity of the forage base will be conducted. Operational plans will be designed to create a vegetation base consisting of a range of types and ages of forest cover. Forage enhancement will be geared to preferred natural vegetation for the species present in the respective habitat types and terrain.

The emphasis of habitat management will be the maintenance of biodiversity, to ensure special attention to rare or threatened species and where possible, to optimize benefits for a wide range of species.[15]

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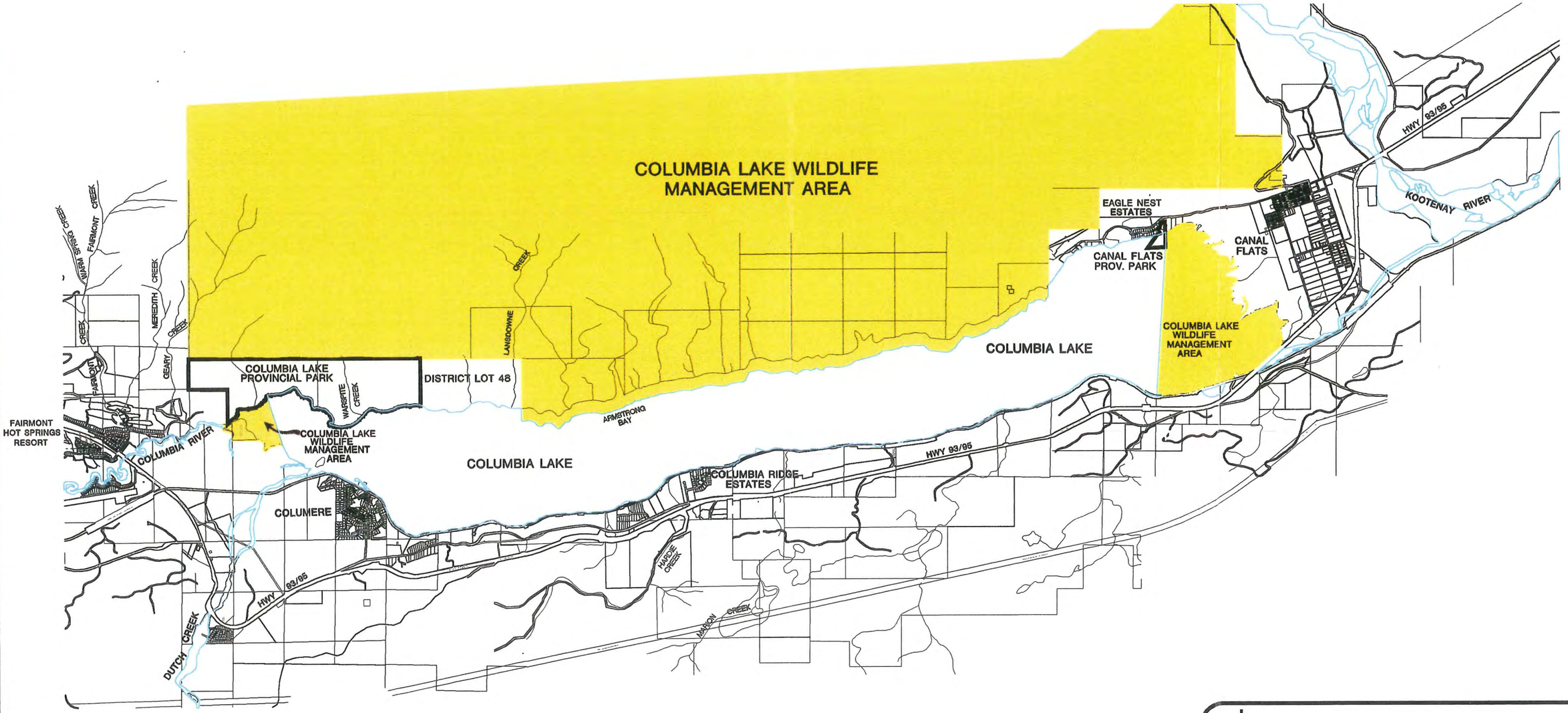
[13] East Kootenay Regional Table Land Unit Polygons Record of Information. Vol 3 - Final Draft (July, 1994)
[14] Brief provided to study team by Dave Phelps (August 1996) Fish and Wildlife Branch, B.C. Ministry of Environment. Cranbrook, B.C.v
[15] Ibid.




GRAPHIC SCALE
( IN METRES )
500 0 250 500 1000 1500 2000 2500 3000
1 : 25,000

REGIONAL DISTRICT OF EAST KOOTENAY
COLUMBIA LAKE MANAGEMENT STRATEGY

# MAP 4
# COLUMBIA LAKE WILDLIFE MANAGEMENT AREA

NORTH

LEGEND

PROVINCIAL PARK BOUNDARIES

COLUMBIA LAKE WILDLIFE MANAGEMENT AREA

URBAN SYSTEMS

LEGEND

- WATERFOWL PRODUCTION HABITAT
- WATERFOWL STAGING HABITAT
- IMPORTANT BEAVER HABITAT
- IMPORTANT MUSKRAT HABITAT
- OSP — OSPREY FEEDING AREA

WILDLIFE MANAGEMENT AREA

SPRING AND FALL USE BY SWANS AND CANADA GEESE

BIGHORN SHEEP WINTER RANGE

VERY IMPORTANT UNGULATE WINTER RANGE

SCATTERED OSPREY NESTS ON UPLANDS

BIGHORN SHEEP WINTER RANGE

BIGHORN SHEEP WINTER RANGE

IMPORTANT EARLY SPRING ICE FREE AREA FOR MIGRATING SWANS

FINDLAY CREEK BENCH (VERY IMPORTANT UNGULATE WINTER RANGE)

OSP

OSP

OSP

OSP

FLOCKS OF DIVING DUCKS, COOTS, LOONS OR GREBES DURING MIGRATION

LAKE

COLUMBIA

HABITAT FOR CLIFF NESTING RAPTORS (DUTCH CREEK HOODOOS)

EXCELLENT UNGULATE WINTER RANGE

REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

**MAP 5**

**UPLANDS WILDLIFE**

NORTH

URBAN SYSTEMS

## 2.8 LAKE HABITAT

### 2.8.1 Introduction

As part of the primary research performed for this managment strategy, Agra Earth and Environmental evaluated the condition of fish and waterfowl species and habitat. It was concluded that the ecosystem in and around Columbia Lake provides good to excellent habitat for a variety of species fish and waterfowl species.

### 2.8.2 Fisheries Resources at Columbia Lake

A total of 20 species of fish are known or expected to occur in Columbia Lake.

.1 *Sport Fish*

The following five species of sport fish were captured, in decreasing order of abundance during a 1992 survey of the lake:

- mountain whitefish (*Prosopium williamsoni*);
- burbot (*Lota lota*);
- kokanee (*Oncorhynchus nerka*);
- rainbow trout (*Oncorhynchus mykiss*); and
- bull trout (*Salvelinus confluentus*).

It is also likely that cutthroat trout (*Oncorhynchus clarki*) inhabit the lake since stocking of the species was conducted in 1977[16].

Seventy-three percent of the sport fish captured during the 1992 study were mountain whitefish. Burbot was the second most abundant sport fish species captured, which represented 10.6% of the sport fish catch. Kokanee, rainbow trout and bull trout represented 6.7%, 3.8% and 1.0%, respectively, of the total sport fish catch.

Columbia Lake has been stocked in the past with rainbow trout, yellowstone cutthroat trout and kokanee. Stocking has occurred intermittently from 1974 to 1996. The majority of the stock has included Girard rainbow trout that until fall 1994 were primarily hatchery surplus. The lake provides good rainbow trout and cutthroat trout habitat, but survivorship of the stock would have likely been low since the two species are unable to compete with and are highly susceptible to predation by coarse (non-sport) fish such as northern squawfish, which are common in Columbia Lake.

In 1995 and 1996 Columbia Lake was stocked with blackwater rainbow trout. This strain of rainbow trout has better survivorship than the Girard strain in lakes that support coarse fish. [17] It is possible that this species of rainbow trout should enhance the sport fishing opportunities at Columbia Lake.

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[16] Fisheries Investigation of Columbia Lake (1992) R.L. and L Environmental Services Ltd.
[17] R.L. and L. Environmental Services Ltd, 1992; Bill Westover, pers. communication

.2 *Non-Sport Fish*

The following six species of non-sport (coarse or forage) fish were captured, in decreasing order of abundance:

- peamouth chubb (*Mylocheilus caurinus*);
- northern squawfish; (*Ptychocheilus oregonensis),*
- large-scale sucker (*Catostomus macrocheilus*);
- redside shiner (*Richardsonius balteatus*);
- sunfish (*Lepomis spp.*); and
- longnose sucker (*Catostomus catostomus*).

.3 *Overview of Fish Habitat*

In general the fisheries habitat capability of Columbia Lake is rated as high[18]. Columbia Lake is utilized by several species of sport and non-sport fish for spawning, rearing, feeding, migration and overwintering. Most of the lake bottom is probably suitable for coarse fish and burbot spawning. The primary bottom substrate identified in Colombia Lake is loose rock fragments and organic particles. There are small localized gravel shoals at numerous locations along the shoreline, and a small area of cobble in the southwest corner of the lake.[19] Details of known and suspected sport and non-sport fish habitats are listed in Table Six.

[18] .Entech Environmental Consultants Ltd., 1978
[19] R.L. and L. (1992)

## Table Six
## Sport and Non-Sport Fish Habitat Availability in Columbia Lake, Outlet Streams and Tributary Streams

| Waterbody | Fish Species | Quality of Habitat Provided | Life History Function Provided[a] | Season Used[b] |
|---|---|---|---|---|
| **Columbia Lake** | burbot | good | S, R, F, O | Y |
| | mountain whitefish | good | R, O | Y |
| | rainbow trout | good[c] | R, F, M, O | Y |
| | cutthroat trout | good[c] | R, F, M, O | Y |
| | kokanee | poor (resident adults) | F, O | Y |
| | | good (spawning adults) | M | F |
| | | good (fry) | R | Sp |
| | bull trout | poor | R, F, M, O | Y |
| | large-scale sucker | good to excellent | S, R, O | Y |
| | northern squawfish | good | S, R, F, O | Y |
| | peamouth chubb | good | S, R, F, O | Y |
| | redside shiner | good | S, R, F, O | Y |
| **Outlet Streams** | | | | |
| Columbia River from Outlet of Columbia Lake Downstream to Highway 93/95 Bridge | mountain whitefish | good to excellent | S, R, F, M | Sp, Su, F |
| | rainbow trout | good to excellent | S, R, F, M | Sp, Su, F |
| | burbot | good | | Sp, Su, F |
| | large-scale sucker | good | | Sp, Su, F |
| | redside shiner | good to excellent | | Y |
| **Inlet Streams** | | | | |
| Dutch Creek and Alluvial Fan | mountain whitefish | excellent | S, R, F, M | Sp, Su, F |
| | kokanee | good | S | F |
| | rainbow trout | good | S, R, F, M | Sp, Su, F |
| | cutthroat trout | poor to moderate | S | Sp |
| | bull trout | good | S | F |
| | longnose sucker (possible) | good | S, R, F, M | Sp, Su, F |
| Un-named Stream (spring) Northwest of Canal Flats | Burbot | excellent | S | W |
| | kokanee | good | S | F |

Source: Entech Environmental Consultants Ltd., 1978; Thurber Consultants Ltd., 1980; pers. comm. with Bill Westover, BCMOE, Cranbrook.

[a] R = rearings, F = feeding, M = migration, S = spawning, O = potential overwintering.

[b] W = winter; Sp = spring, Su = summer, F = fall, Y = year-round.

[c] Habitat is good but survival of fry and juveniles is likely low as a result of high competition and predation from coarse fish (e.g., squawfish).

[d] Spawning habitat is of good quality (i.e., gravel substrate), but it is limited in extent

### .4 *Spawning Habitat*

There are numerous good spawning areas within and adjacent to Columbia Lake. Known and suspected sport and non-sport fish spawning habitats are listed in Table Six and shown in Map Six. The lake outlet, shoreline, and especially the shallow south end provide suitable spawning habitat for redside shiner, peamouth chub, northern squawfish, longnose large-scale suckers and burbot.[20] Fifteen streams drain into Columbia Lake. The majority of the tributary streams on the east and west sides of the lake run intermittently and as such do not provide suitable spawning habitat.[21]

Spawning potential for sport fish in the inlet spring that drains the marshy area to the northwest of Canal Flats (District Lot 110) was thought to be low since the predominance of fine substrates (80%) will limit the availability of suitable spawning habitat. The stream did not yield any fish during backpack electrofishing of a 100 m section.[22] However, discussions with Bill Westover (Fisheries Biologist with B.C. Ministry of Environment) indicated that the stream does provide critical spawning habitat for burbot and is used as spawning habitat by some kokanee. This area contains good gravel substrate but limited in extent. Over 1,300 adult spawning burbot were captured during a BCMOE survey of the stream during February of 1995.

Dutch Creek and the alluvial fan of the creek provide suitable spawning habitat for bull trout, rainbow trout, mountain whitefish, kokanee and possibly longnose suckers. Cutthroat trout spawning habitat in the creek is limited since the substrate is probably too large.[23]

A concern has been raised regarding limited fish access into Dutch Creek due to a shift in the alluvial fan and channel. Due to the dynamic nature of these types of channels, caused by braiding and side-channel formation, fish access and habitat utilization often vary from year to year. In this instance, it is expected that if access is indeed unavailable, at least a portion of the rainbow trout (spring spawners) and mountain whitefish (fall spawners) would utilize other areas for spawning, egg incubation and fry rearing (e.g., the Columbia River outlet and the Columbia River downstream). Where whitefish are concerned, it may be that no matter where the fan channel(s) occur, seasonally low flows would restrict access to suitable spawning areas. It is worth noting however, that seemingly poor access can actually be negotiated by fish.

[20] E.L.U.C. Secretariat, 1978c; Entech Environmental Consultants Ltd., 1978.
[21] Bill Westover, pers. communication
[22] R.L. and L. (1992)
[23] Entech Environmental Consultants Ltd., 1978; Thurber Consultants Ltd., 1980; Bill Westover, pers. communication

The dynamic nature of the lower reaches of Dutch Creek would preclude channelization/stablization measures to assist spawning activities in Dutch Creek. Dredging is not advisable given the likelihood of increased silt loadings to the lake, outlet and river, and because the dredged channel(s) will continue to shift and infill rapidly to achieve equilibrium. A watershed study would be necessary in order to determine if shifts in the fan are in any way associated with land-use activities and increased silt-loadings that have caused re-direction of drainage through the fan.

The Columbia River which drains the lake may provide adequate fish spawning habitat as a result of its gravel substrate and high flow rates. The stretch of Columbia River from the outlet of Columbia Lake downstream to the Highway 93/95 Bridge provides good to excellent spawning habitat for rainbow trout, mountain whitefish, burbot, suckers and redside shiners.[24] During the 1992 R.L. and L. survey, numerous kokanee in spawning condition were observed in the Columbia River between Fairmont Hot Springs and Columbia Lake.

### 2.8.3 Potential Adverse Impacts to Fishery of Columbia Lake

Of particular importance to the development of this management strategy was to evaluate the sensitivity of the fisheries resource to human use. Predicted impacts to the fishery of Columbia Lake from further future development include the following:

- as a result of poor stormwater and hazardous waste management practices, water and substrate quality would be reduced in the un-named stream northwest of Canal Flats. This would result in reductions in the quality of spawning habitat;
- forestry and development activities that destroy vegetation along streams draining into Columbia Lake would significantly increase sediment and nutrient inputs;
- water quality could be reduced through increased inputs of nutrients from more intensive agricultural activity and from golf course, cottage and resort development;
- reductions in water quality through increased sediment inputs from poor agricultural, construction and logging practices in upland areas and subsequent erosion;
- spills of hazardous substances from rail or road traffic on the west side of the lake;
- loss of habitat through the development of poorly planned recreational developments (e.g., marina and lake-side market development along the foreshore of Columbia Lake adjacent to Canal Flats and subsequent physical disruption of rearing habitat in the marsh area and spawning habitat in the un-named stream); and
- reduction in population viability as a result of increased recreational angling pressure.

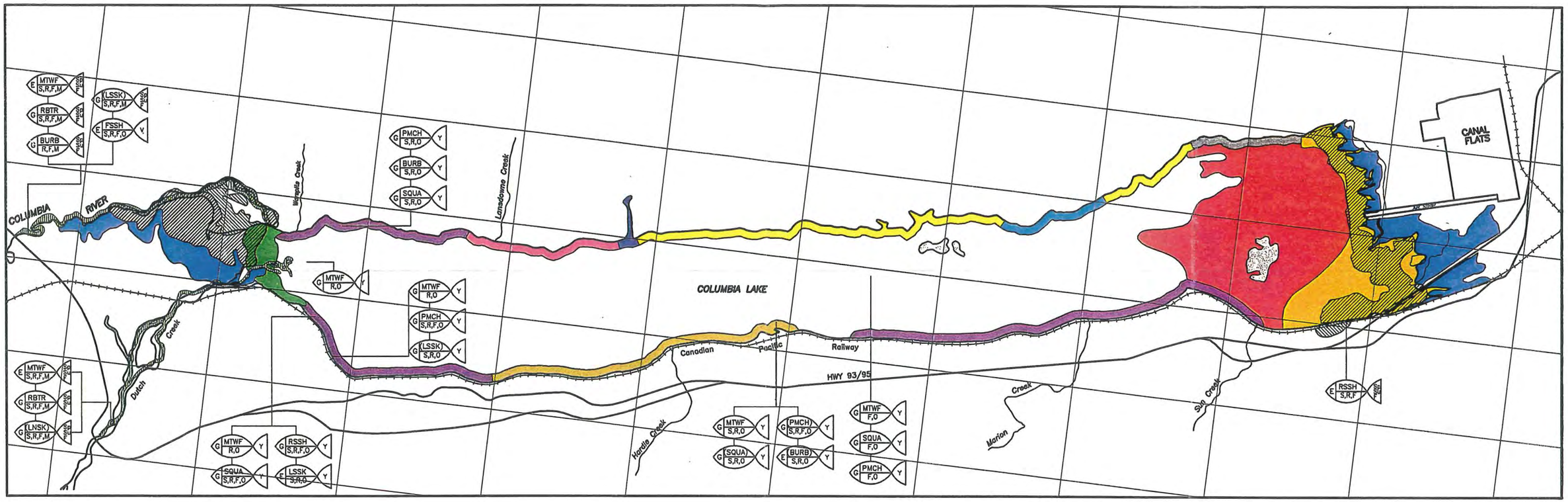
[24] Entech Environmental Consultants Ltd., 1978; Thurber Consultants Ltd., 1980

### 2.8.4 Habitat Creation

It is also possible that increased future developments on Columbia lake would improve habitat conditions for fish as a result of the following:

- to a certain degree, increased nutrient inputs to the lake from cattle ranching operations, and from cottage and recreational resort development would increase productivity of the lake and potentially improve the food base for fish species.

This positive impact, however, is unlikely to outweigh the negative impact to fish, as discussed previously, that would result from increased development activities.




LEGEND

- BULRUSH
- BULRUSH/CATTAIL/SEDGE/COONTAIL/REEDGRASS/MILFOIL/MACROPHYTIC ALGAE
- BULRUSH/PONDWEED/COONTAIL/MILFOIL
- BULRUSH/PONDWEED/COONTAIL/MILFOIL/CATTAIL/POND LILY
- BULRUSH/PONDWEED/CATTAIL/SEDGE
- BULRUSH/PONDWEED/SEDGE/POND LILY
- BULRUSH/PONDWEED/SEDGE/POND LILY/HORSETAIL
- BULRUSH/PONDWEED/SEDGE
- BULRUSH/PONDWEED/CATTAIL/REEDGRASS
- BULRUSH/PONDWEED/CATTAIL/SEDGE/REEDGRASS
- MACROPHYTIC ALGAE
- WILLOW–SHRUB

  Shrub and tree forms occur on river banks, levees, alluvial fans, islands and surrounding marshes. Stands often include black cottonwood, birch, alder and aspen. Sedge, horsetail and grasses are common ground cover.

- SEDGE–BULRUSH MARSH

  Emergent vegetation of marshes and other seasonally wet areas. Generally occur as near–homogeneous stands but also include horsetails, grasses, cattails, rushes and other emergent species.

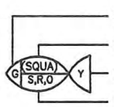
- AQUATIC PLANT COMMUNITIES

  Submergent and floating–leaved aquatic vegetation in relatively permanent water bodies. Emergent species such as bulrush cattail and horsetail are often found in these areas.

- GOOD TO EXCELLENT SPORT FISH HABITAT
- GOOD TO EXCELLENT COARSE FISH HABITAT

0 500 1000 1500 2000 2500 Metres

Source: Thurber Consultants Ltd., 1980.




Habitat utilization is shown for the following activities: spawning, rearing, feeding and migrating. Because no winter survey was conducted to determine specific overwintering habitat, only potential overwintering areas are shown.

An E at the head of the fish indicates excellent fish habitat; G indicates good fish habitat.

The common names are abbreviated as follows:

Coarse Fish:
SQUA – northern squawfish
PMCH – peamouth chub
LKCH – lake chub
RSSH – redside shiner
LNSK – longnose sucker
LSSK – largescale sucker
LNDA – longnose dace

Sport Fish:
RBTR – rainbow trout
MTWF – mountain whitefish
DVAR – Dolly Varden char
YCTR – yellowstone cutthroat
BURB – burbot

Parentheses around a fish name abbreviation indicate possible habitat utilization by this species.

The season of the year during which the species indicated is present in the habitat: Sp for Spring, Su for Summer, F for Fall, W for Winter, while Y indicates Year–round use.

The activity for which fish utilizes the habitat: R – rearing, F – feeding, M – migration, S –spawning, O – overwintering.

REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

**MAP 6**

AGRA Earth & Environmental Limited
ENGINEERING & ENVIRONMENTAL SERVICES

# FISH AND FISH HABITAT IN COLUMBIA LAKE

| | |
|---|---|
| DATE: | 96/07/30 |
| JOB No. | CE01607 |
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| FIGURE 1 | REV. – |

PLOT 1:50

## 2.9 WATERFOWL RESOURCES AT COLUMBIA LAKE.

### 2.9.1 Overview of Lake Capability for Waterfowl Habitat

The establishment of the Columbia Lake Wildlife Management Area was based to a large extent upon the Columbia Lake's importance to waterfowl. It is known as a key nesting and staging ground for a variety of species. The north and south ends of the lake provide important staging or stopover habitat for ducks and swans during the spring and fall migrations. The south end is also used by staging Canada geese. Trumpeter swans (*Cygnus buccinator*) and tundra swans (*Cygnus columbianus*) have also been reported to use the lake for staging.[25] During migration, relatively large and consistent numbers of waterfowl occur at these two locations. The south end of Columbia Lake is particularly important as a stopover area since it is free of ice early in the season.[26]

The Columbia Lake basin is rated as having high capability (classes 1 to 3) for the production of waterfowl according to the Canada Land Inventory (CLI) system[27]. The best waterfowl habitat on Columbia Lake occurs where lake bottom slopes are gentle and allow for maximum aquatic plant growth and where shoreline complexity improves habitat diversity. Excellent habitat is also found in the moist transitional area between truly aquatic and truly terrestrial environment, as it provides good nesting cover. Dabbling ducks (i.e., those that generally feed by tipping up), prefer wetland habitats that average 50 cm in depth, but their optimal feeding depth is 5 - 25 cm. Geese and swans also feed in shallow waters. Diving ducks (i.e., those that feed by diving) generally prefer greater water depths.[28]. The sedge-bulrush marsh at the south end of Columbia Lake provides above-average to critical nesting and brood rearing habitat for ducks and Canada geese (*Branta canadensis*).[29]See Map Seven for waterfowl habitat and overview of species.

The main body of Columbia Lake is characterised by more sharply sloping bottom and upland contours, and a fairly straight shoreline along the east and west shorelines as compared to the north and south ends. These factors create in narrower zones of riparian vegetation and emergent and submergent aquatic vegetation. Therefore, the east and west shorelines have less diverse and lower quality waterfowl habitat. In addition, considerable wind and wave action down long axis of the lake would also be hazardous to young birds and likely contributes to the lack of emergent aquatic vegetation productivity and cover along the eastern and western shorelines.[30] The main body of the lake is moderately used by staging ducks. Flocks of diving ducks and also American coots (*Fulica americana*), loons (*Gavia* spp.) and grebes (Order *Podicipediformes*) have been observed during migration.[31]

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[25] Trevor Mathews, pers. comm (1996)
[26] E.L.U.C. Secretariat, 1978b; Thurber Consultants Ltd., 1980
[27] E.L.U.C. Secretariat, 1978a
[28] Loekmoen *et. al.*, 1984; Fredrickson and Reid, 1988
[29] E.L.U.C. Secretariat, 1978b; Thurber Consultants Ltd., 1980.
[30] (Nietfeld, *et.al.*, 1985).

[31] ibid.

Waterfowl species, other than those previously mentioned, that are known to use Columbia Lake for staging or breeding purposes include the following:

**Staging**

- mallard (*Anas platyrhynchos*);
- pintail (*Anus acuta*);
- blue-winged teal (*Anas discors*);
- green-winged teal (*Anas crecca*);
- some cinnamon teal (*Anas cyanoptera*);
- common goldeneye (*Bucephala clangula*);
- some Barrow's goldeneye (*Bucephala islandica*);
- lesser scaup (*Aythya afinis*);
- ring-necked duck (*Aythya collaris*);
- bufflehead (*Bucephala albeola*);
- some scoter (*Melanitta spp.*); and
- western grebe (*Aechmophorus occidentalis*).

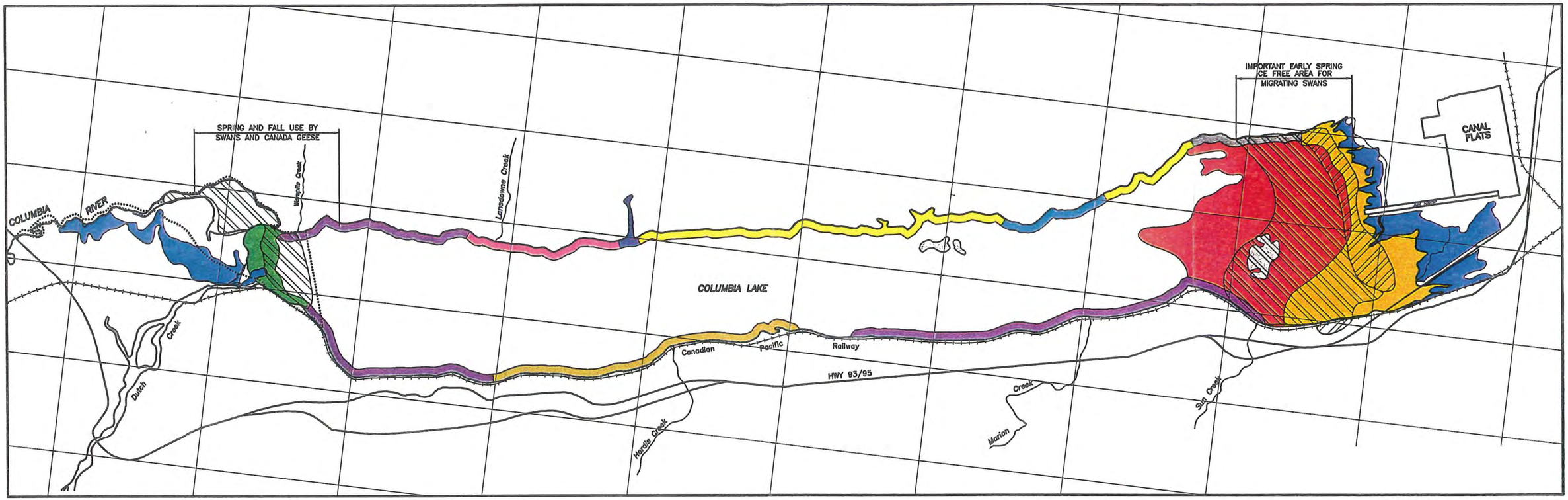
**Breeding**

- mallard;
- lesser scaup;
- some common goldeneye;
- some bufflehead;
- American coot; and
- red-necked grebe (*Podiceps grisegena*)[32]

Cursory observations of waterfowl use of Columbia Lake were made by Agra Earth and Environmental during the June 1996 biophysical survey. The following species of waterfowl were identified:

- mallard;
- pintail;
- redhead (*Aythya americana*);
- white-winged scoter (*Melanitta fusca*);
- common merganser with broods (*Mergus merganser*);
- common loon (*Gavia immer*);
- red-necked grebes; and
- western grebes.

[32] Larry Halverson, pers. communication




LEGEND

- BULRUSH
- BULRUSH/CATTAIL/SEDGE/COONTAIL/REEDGRASS/MILFOIL/MACROPHYTIC ALGAE
- BULRUSH/PONDWEED/COONTAIL/MILFOIL
- BULRUSH/PONDWEED/COONTAIL/MILFOIL/CATTAIL/POND LILY
- BULRUSH/PONDWEED/CATTAIL/SEDGE
- BULRUSH/PONDWEED/SEDGE/POND LILY
- BULRUSH/PONDWEED/SEDGE/POND LILY/HORSETAIL
- BULRUSH/PONDWEED/SEDGE
- BULRUSH/PONDWEED/CATTAIL/REEDGRASS
- BULRUSH/PONDWEED/CATTAIL/SEDGE/REEDGRASS
- MACROPHYTIC ALGAE
- WILLOW–SHRUB

  Shrub and tree forms occur on river banks, levees, alluvial fans, islands and surrounding marshes. Stands often include black cottonwood, birch, alder and aspen. Sedge, horsetail and grasses are common ground cover.

- WATERFOWL PRODUCTION HABITAT[1]
- WATERFOWL STAGING HABITAT[2]
- WATERFOWL SANCTUARY

1. The designated areas are considered to be above average nesting/brood–rearing habitat for ducks and Canada geese. These are generally the wetland units which are most protected from summer floods and which have suitable water level and vegetation characteristics for muskrat. Many Canada geese nest on muskrat houses. Acceptable nesting habitat in the form of high levees, upland brush, and large decadent levee trees usually occurs in close proximity. Goose broods may also accumulate in areas unprotected from spring flooding during the rearing stage.
2. Location where relatively large and consistent numbers of duck, geese, swans, grebes or other waterbirds occur during spring and fall migration, or as a prelude to migration. Habitats included are mostly large open water areas and exposed sand or mud bars of importance for loafing.

0 500 1000 1500 2000 2500 Metres

Source: Thurber Consultants Ltd., 1980; R.L. and L. Environmental Consultants Ltd., 1992; AGRA Earth and Environmental Limited, 1996 (field survey).

REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

MAP 7

AGRA Earth & Environmental Limited
ENGINEERING & ENVIRONMENTAL SERVICES

# WATERFOWL HABITAT AND USE OF COLUMBIA LAKE

DATE: 96/07/30
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FIGURE 2 REV. –

PLOT 1:50

### 2.9.2 Other Important Bird Species

Other bird species that nest in the uplands around Columbia Lake and feed in the lake include great blue heron (*Ardea herodias*), osprey (*Pandion haliaetus*) and bald eagle (*Haliaeetus leucocephalus*). Observations of all three species, particularly ospreys, were made during the biophysical survey of the lake conducted in June 1996.

A heron rookery was reported by Thurber Consultants Ltd (1980) to be located just north of the alluvial fan of Dutch Creek. The status of the heron rookery could not be determined for this report, but herons are commonly observed in the area.[33] These species are sensitive to human disturbance and could be adversely affected by a future increase in activities on and developments around Columbia Lake.

### 2.9.3 Waterfowl Disturbance

Waterfowl are generally wary and seek refuge from sources of disturbance, particularly those producing loud noise and rapid movement. Most disturbances are created by water users such as boaters, anglers, hunters and aircraft. Overall, human activities that cause disturbance to waterfowl can be summarized in decreasing order of disturbance according to the following categories:

- rapid overwater movement and loud noise such as power boating, water skiing, jet skis, aircraft;
- overwater movement with little noise such as sailing, wind surfing, rowing, canoeing;
- little overwater movement or noise such as wading, swimming; and
- activities along shorelines such as fishing, bird watching, hiking, and traffic.

Disturbances displace waterfowl from feeding areas, reduce resting time, increase energetic costs associated with flight and may lower productivity of nesting or brooding waterfowl. Human disturbances can cause declines in a waterfowl population by having the following effects on breeding waterfowl:

- reduced numbers of breeding pairs;
- increased desertion of nests;
- reduced hatching success; and
- decreased duckling survival through either direct mortality or separation from the hen resulting in increased susceptibility to predation.

Human disturbances can also have effects on nonbreeding waterfowl, such as staging migratory birds. Generally, migratory waterfowl attempt to minimize the amount of time they spend in flight and maximize the amount of time spent feeding. Human disturbances, therefore, can have the following adverse effects on migratory waterfowl:

- changed food habits;
- feeding only at night;

[33] Dave Phelps, pers.communication

- increased energy expenditures, depleted fat reserves and loss of weight;
- desertion of the feeding area; and
- changed migration patterns.

Large flocks of waterfowl are more susceptible to disturbance than small flocks.[34] These adverse impacts to waterfowl resulting from human disturbances are particularly relevant in light of the importance of Columbia Lake as staging habitat.

### 2.9.4 Habitat Loss

Increased development around Columbia Lake could also result the loss of habitat. Habitat loss would be most critical at the north and south ends of the lake where the greatest extent of good waterfowl habitat exists. The marsh habitats at the north and south ends of Columbia Lake are protected within the Columbia Lake Wildlife Management Area.[35] At the south end of the lake, beyond the boundary of the Wildlife Management Area the foreshore is privately owned. Lake front development at this location would essentially eliminate existing waterfowl habitat. Increasing motor boat and jet ski traffic has the potential to negatively impact waterfowl habitat because wave action and erosion reduce the viability of emergent vegetation habitat.

Other disturbances of waterfowl occur as a result of the following activities:

- an increase in the amount of water-based recreational activities in general;
- an increase in the number boats launched from the two boat launches at the south end of the lake, adjacent to the important habitat;
- an increase in the amount of aircraft using the landing strip at Canal Flats; and
- development of a float plane docking facility on the lake.

### 2.9.5 Habitat Creation

It is also possible that future developments on Columbia lake would improve habitat conditions for waterfowl. Positive impacts to habitat could occur as a result of the following conditions:

- increased nutrient inputs to the lake from cattle ranching operations, and cottage and recreational resort development would increase productivity of the lake and potentially improve the food base for waterfowl; and
- increased water withdrawals for municipal water supplies and for irrigation could result in lower lake levels. This would potentially expand suitable waterfowl habitats by the spread of emergent aquatic plant communities.

It is concluded, however, that the negative affects of unplanned development upon waterfowl habitat would be more significant than any resulting improvement in habitat as a result of development.

[34] Korschgen and Dahlgren, 1992
[35] Dave Phelps, pers. comm

## 2.10 AQUATIC PLANTS

### 2.10.1 Introduction

Although aquatic plants are not generally valued for recreational or aesthetic reasons they are an important part of a healthy lake's ecosystem. Aquatic plants (aquatic macrophytes) provide cover and spawning areas for fish, and provide habitat for waterfowl. Aquatic plants are necessary for invertebrates and algae that function as food for fish. In addition, aquatic macrophytes release oxygen which is important to the survival of freshwater organisms. Emergent aquatic macrophytes, those growing close to shore with shoots that emerge above the water surface, typically provide nearshore habitat for fish species. Submergent aquatic macrophytes, those rooted in the lake bottom which do not emerge above the water surface, provide fish habitat in deeper water.

### 2.10.2 Littoral Zone and Eurasian Water Milfoil

Aquatic plant communities present in Columbia Lake also commonly occur in other waterbodies in the area. The littoral zone of Columbia Lake, that portion of the lake where sufficient light for aquatic plant growth penetrates to the bottom extends to the lake's maximum depth of 5.2 m. Therefore, 100% of the lake basin is capable of supporting prolific growths of emergent and submergent aquatic plants.

It is important to note that Columbia Lake has the characteristics which would make it a prime candidate to support Eurasian watermilfoil (*Myriophyllum spicatum*). Increased recreational activity on Columbia Lake, particularly boating, would increase the potential for the introduction of Eurasian water milfoil to the lake. This non-native species is highly prolific, and its rapid spread has the potential to displace native aquatic plant species that have higher food value to waterfowl.

### 2.10.3 Distribution of Aquatic Plant Growth

Plant growth requires a variety of nutrients. There are two broad categories - macronutrients and micronutrients. Macronutrients include nitrogen, phosphorus and carbon. Micronutrients include all other elements taken up in minute quantities, including iron and manganese.

Before plant growth can occur, all these nutrients, particularly the macronutrients, must be present in specific concentration ratios. The absence of one of the required nutrients essentially negates plant growth. For most lakes, phosphorus is the limiting nutrient that encourages plant growth proliferation. Management policies for preserving the water quality of Columbia Lake limit the contribution of phosphorus to lakes as a result of man's activities.

Actual density and growth of aquatic plants in Columbia Lake is primarily restricted by the suitable substrate and exposure to wave action. In certain areas of the lake aquatic plant growth is considered to be a nuisance. [36]. Distribution of the most prolific and readily visible nearshore aquatic

[36] .McKean and Nordin, 1985; R.L. and L., 1992

macrophyte communities are shown in Maps Six and Seven. Most of the nearshore area of Columbia Lake is vegetated by a narrow (i.e., 8 - 10 m) band of emergent aquatic plants, especially bulrush (*Scirpus spp.*). Dense growths of bulrush, as well as sedges (*Carex spp.*) and rushes (*Juncus spp.*), occur around the islands and shoals of the extreme south end of the lake. The sedge-bulrush marsh type is particularly extensive in the shallow north and south ends of the lake where bottom slopes are most gradual.

Submergent aquatic plants were recorded in approximately 80% of the main body of the lake by R.L. and L. (1992). The study team observed the following submergent species in descending order of abundance:

- stonewort (*Chara spp.*);
- floating-leaf pondweed (*Potamogeton natans*) (a floating-leaved macrophyte);
- northern watermilfoil (*Myriophyllum exalbescens*);
- sago pondweed (*Potamogeton pectinatus*);
- common bladderwort (*Utricularia vulgaris*) (a free-floating macrophyte);
- small-leaf pondweed (*Potamogeton pusilus*); and
- flat-stemmed pondweed (*Potamogeton zosteriformis*).

Growths of floating-leaf pondweed and common bladderwort are more typical in small bays and shallow areas throughout the lake. Stonewort is probably the most common macrophyte growing in water depths greater than 3 m.

Other aquatic macrophytes observed by AEE during a cursory biophysical survey of the lake during the June 1996 survey included:

- coontail (*Ceratophyllum demersum*);
- Richardson pondweed (*Potamogeton richarsonii*);
- yellow water lily (*Nuphar variegatum*);
- common cattail (*Typha latifolia*); and
- horsetail (*Equisetum spp.*).

## 2.11 BOATING AND RECREATION

### 2.11.1 Introduction

The appropriate use and development of boating and recreational activities on Columbia Lake is an important public and enviromental concern. Habitat disturbances caused by boating activities, the development of new commercial private marinas and the potential for increasing public use of the lake have all been identified as key issues for Columbia Lake.

### 2.11.2 Boating

The effects of motor boats on lakes are difficult to assess and no data directly related to the issue has been collected on Columbia Lake. A couple of the known effects of motor boats on the aquatic environment include increased turbidity in shallow areas, taste concerns in fish and odours caused by emissions. A 1985 technical assessment of Columbia and Windermere Lakes concluded that the effects of motor boats are expected to be minor due to the size of the lakes.[37] It was also noted in that report that the location of boat access and activities should be planned away from existing water intakes.

There was a specific concern that the increasing boating use and recreational pressures on Windermere Lake would serve to create a spill over effect to Columbia Lake. Sea Doos and jet ski usage was a concern, particularly the current trend of ski doo's traversing the Columbia River between Windermere and Columbia Lakes. This activity is also of particular concern given the Columbia River's status as a Wildlife Management Area.

The concept of boating regulations received support from the public during the workshops held in conjunction with the preparation of this management strategy. There are nine types of boating restrictions available under the Boating Restriction Regulations, 1972, namely to:

- prohibit all vessels;
- prohibit power driven vessels (enforcing Columbia Lake as a 'sail power' only lake was considered a possibility by many residents);
- prohibit power driven except for electric battery motors;
- limit engine power;
- limit speed;
- prohibit water-skiing or similar towing;
- limit wake height;
- prohibit boat races, regattas, marine parade unless authorized by permit;
- prohibit commercial river rafting operations unless authorized by permit.

[37] Columbia and Windermere Lakes Sub-Basin Water Quality Assessment and Objectives Technical Appendix. Ministry of Environment, Water Management Branch.

The implementation of any restrictions would first be investigated by the provincial Ministry of Environment to ensure that local interests are taken into consideration. If the province considers a restriction appropriate, then a formal application to the federal government must be made in order to have the restriction imposed. Most restrictions are identified by signs placed in the vicinity of the restricted area and can be enforced by any federal, provincial, or municipal peace officer.

### 2.11.4 Boating and Habitat Interaction

The adverse affect of boating caused disturbance to waterfowl are particularly important in light of the importance of Columbia Lake as a staging habitat. As mentioned previously, human activities that cause disturbance to waterfowl are in decreasing order of impact include:

- rapid overwater movement and loud noise (power boating, water skiing, jet skiis, aircraft),
- overwater movement with little noise (sailing, wind surfing, rowing, canoeing),
- little overwater movement or noise (wading, swimming) and finally
- activities along shorelines (fishing, bird watching, hiking, traffic).

AEE concluded that increased motor boat and jet ski traffic on Columbia Lake could negatively impact areas of emergent vegetation communities through increased wave action and erosion. A reduction in emergent vegetation community would reduce the viability of both fish and waterfowl habitat. The effect of boating and recreation noise on waterfowl could also be significant. Increasing levels of recreational activity on Columbia Lake, particularly boating, also increases the probability of the introduction of Eurasian water milfoil to the lake. Eurasian water milfoil and other non-native species are intrusive invaders to lake ecosystems. The proliferation of non-native species would negatively affect and displace native aquatic plant species that have higher food value to waterfowl.

## 2.12 ACCESS TO COLUMBIA LAKE

### 2.12.1 Introduction

Public access is to Columbia Lake is a key issue in regulating the foreshore. Creating a logical access strategy is crucial. Access will fundamentally determine the use of the lake and will create impacts on the environment. For organizational purposes, access will be discussed in the following categories; public access, private access and marinas.

### 2.12.2 Public Access

*.1 Boat Launch*

There are two formal public boat launch locations on Columbia Lake, both of which are located at the south end of the lake (Map Eight illustrates existing boat launches and access to Columbia Lake). First, the most intensivly utilized public launch location on the lake is Canal Flats

Provincial Park. Public use at this location includes a boat launch, beach area, picnic areas, washroom facilities and a parking lot for boats and trailers. It has been reported that the Park is very busy during summer weekends with optimal weather conditions. [38] Canal Flats Provincial Parks is located on the east side of Columbia Lake and adjacent to the Columbia Lake Wildlife Management Area at the south end.

The second public boat launch location is also located at the south end of the lake, but on the west side of the lake. This launch was originally constructed when Highway 93/95 was built. It was reported that at one time the launch area was noticably deeper and generally free of weeds.[39] This launch area now sits well within the Wildlife Management Area and has noticable Sedge-growth in the vicinity of the launch. The Regional District of East Kootenay has applied for the foreshore lease of this boat launch in response to the divestiture by the Small Craft and Harbours Branch of the Ministry of Oceans and Fisheries. The launch is located near excellent Reside Shiner and Burbot habitat and adjacent to an important staging area for migrating swans and other waterfowl.

Agra Earth and Environmental's waterfowl analysis concluded that an increase in the number of boats launched from the two boat launches at the south end of the lake would produce increased disturbance of waterfowl. Disturbances include:

- displacing waterfowl from feeding areas,
- reduced resting time,
- increased energy costs associated with flight,
- lowered productivity of nesting or brooding,
- population may decline due to reduced numbers of breeding pairs,increased desertion of nests, reduced hatching success and decreased duckling survival.

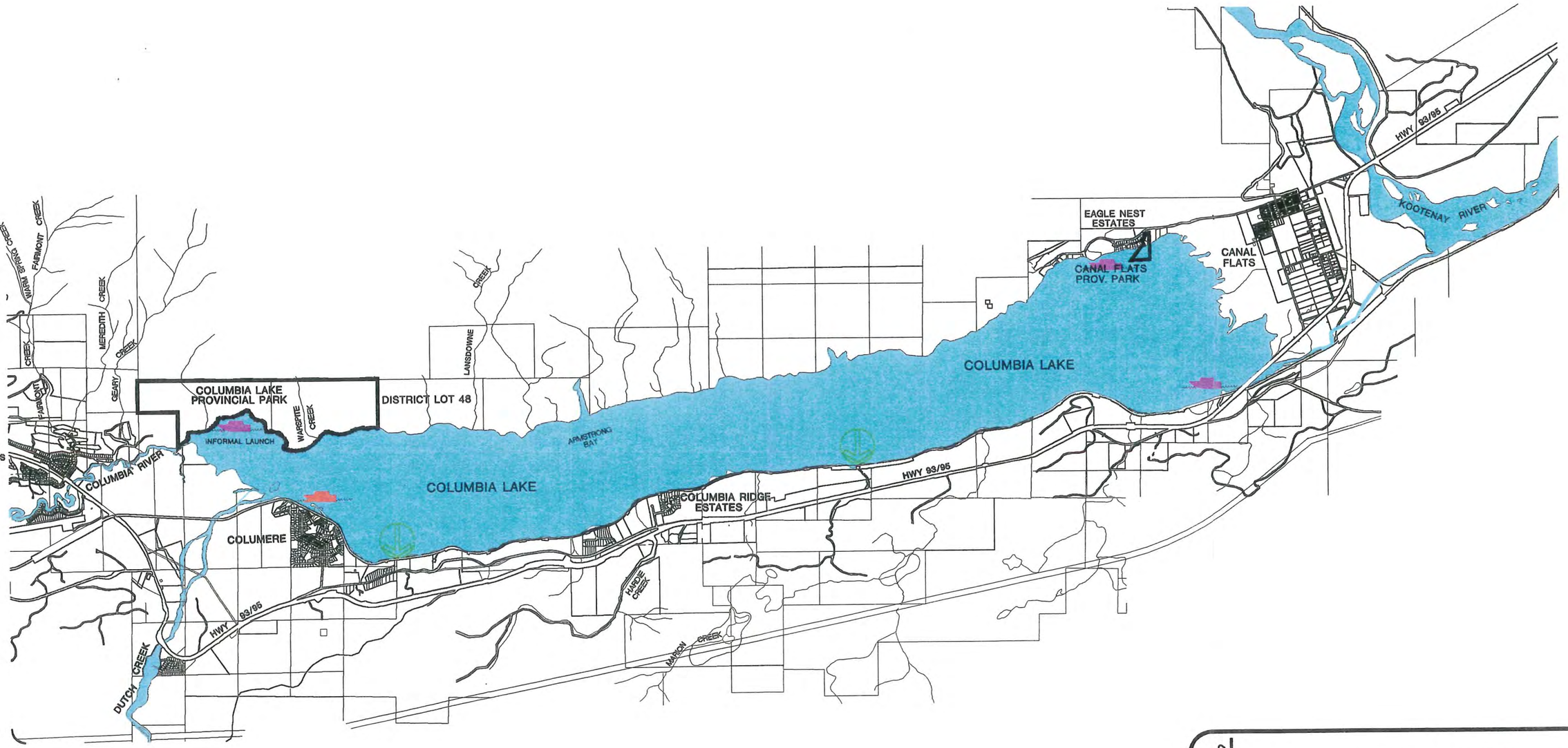
These negative environmental impacts could be compounded by the trends noted in boating behaviour[40]. It was noted as a general trend that boaters tend to remain concentrated in the area where the launch occured.

### .2 *Subdivision Access*

One of the requirements for subdivision is that the subdivision authority, the Ministry of Transportation and Highways, requires 20 metres of public access for every 200 metres of subdivision along Columbia Lake.

Experience has shown that this is not an effective means of providing public access. The area taken does not correspond to topographical features and the space provided is generally too small for public use. The 20 metres allocated for public use often cannot be easily identified as public access, and as such becomes utlized solely by private land owners.

[38] Recreational User Survey performed August 1996 by Urban Systems Ltd.
[39] Walter McKersie. Pers. Communication
[40] Recreational User Survey performed August 1996 by Urban Systems Ltd.




GRAPHIC SCALE
( IN METRES )
500 0 250 500 1000 1500 2000 2500 3000

1 : 25,000

REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

# MAP 8
# LAKE ACCESS

LEGEND

NORTH

- PROVINCIAL PARK BOUNDARIES
- PUBLIC ACCESS
- PUBLIC BOAT LAUNCH LOCATION
- PRIVATE BOAT LAUNCH LOCATION

URBAN SYSTEMS

### 2.12.3 Private Access to Columbia Lake

*.1 Foreshore Leases*

Individuals, corporations, societies and local governments may apply to B.C. Lands for a foreshore lease, to use the lands between the low and high water mark. Licences, leases, easements or permits may be granted for developments such as:

- private wharves or docks
- floating structures
- anchorages
- marinas
- log storage and handling
- underwater cables and pipelines
- waste outfalls
- aquaculture.

Compatibility with the environment and adjacent land uses is critical in order to aquire a lease from B.C. Lands.

The public still has access privelages to the foreshore with the issuance of a foreshore lease. The private development of the foreshore does not prevent public access along the shoreline, although public access may be restricted where safety considerations dictate. Foreshore leases may therfore be better described as semi-private access.

On the west side of Columbia Lake there are two foreshore leases with established tenure. The leases are concentrated in the foreshore area of Columere Park residential community. One tenure is for Columere Park Developments for a commercial marina and the other is for the Columere Park Society for community recreation. Map Nine illustrates locations of foreshore leases.

*.2 Riparian Rights*

The ownership of waterfront property is associated with a bundle of common law rights to the foreshore called "riparian" or "littoral" rights and they include the following:

- Right of unimpeded access to and from every point along the waterfront to deep water for the purposes of navigation. This right applies to non-navigable bodies as well. As a result improvements cannot be constructed on a waterfront property if they interfere with access. The right of access is likely the most important of the remaining riparian rights.[41]

[41] Riparian Rishts and Public Foreshore Use (March 1990) BC Ministry of Crown Lands.

- Right to protect private property from erosion, so long as protective works are constructed entirely on private land.
- The right to aquire land that may build up in front of private property through natural processes, deemed to be depositions to the upland.

Riparian rights however do not preclude the requirements for ministrial approval for development on the foreshore. Where ever possible public access along the foreshore must still be provided for within the lease aggrement.

*.3 CPR Legal Survey Lots*

Canadian Pacific Railways owns legal survey lots along the tracks on the west side of the lake. These lots are private property and according to BC Lands, the CPR has riparian rights and the right to control rail crossings at these locations. It is anticipated that much of the access to the lake from the west side will be constrained by the CPR's control of rail crossings.

### 2.12.4 Commercial Marina Foreshore Leases

*.1 Columere Park Marina*

The only commercial marina facility on Columbia Lake is located at Columere Park on the west side of lake near the outlet of Dutch Creek. This private marina provides a boat launch, docks and on water boat moorage during the summer months. The main group of users are the seasonal and permanent residents of Columere Park. The marina is intensively utilized and experiences a minimal vacancy rate of one or two slips per year of a total of 70 slips.

The Columere Park marina is close to excellent fish habitat for Large Scale Sucker and good fish habitat for Mountain Whitefish, Northern Squawfish and Reside Shiner and is located near the Columbia Lake Wildlife Managment area which is used extensively for spring and fall use by migrating ducks and swans. The marina is also located within the same general vacinity as the withdrawl point for the drinking water supply of Columere Park residents.

Sheltered areas with slow moving water are more likely to be negatively affected by marina development. Generally gas floats upon the surface of the water, mixes with the air and evaporates before it sinks to the bottom. The major contamination concern with marina development is when gas tank and gas-up services are provided. Marinas with these facilities should be constantly concerned with the potential spillage from tanks and soil contamination. Columere Park marina does not provide gas-up services. The major concern at Columere would more likely be the potential contamination of insect larvae, which in turn could create taste and odour problems in fish. Negative affects to the Columere drinking water supply resulting from the Columere Marina are considered to be minimal at the present time.

*.2 Other Marina Applications*

Public concern has been expressed about the expansion and development of new private commercial marinas on the lake.

An application to B.C. Lands for a commercial marina at Columbia Ridge Estates is currently on hold until this Management Strategy has been completed. This lease application would be located near good habitat for Mountain Whitefish, Northern Squawfish, Peamouth Chub and close to excellent Burbot habitat.

An application for a commercial marina was received in 1993 just south of Columere. The application was withdrawn due to incomplete upland planning. There may be a further application at this location in the future. This application is located near good habitat for Mountain Whitefish, Peamouth Chub and Large Scale Sucker.

## 2.13 UPLANDS

The use of the uplands is highly correlated to water quality and overall lake ecosystem health. The lake and the foreshore were the focus of this management strategy, not the uplands. The Management Strategy does not preclude further planning for the uplands of Columbia Lake, rather it provides an impetus for further uplands work and management.

### 2.13.1 Settlement in the Uplands

The rapid development experienced in the Columbia River Valley between Canal Flats and Edgewater is attributable to the growing popularity of the area as a recreation, tourism and retirement centre. Urban growth in the Valley is concentrated in the Windermere, Invermere and Fairmont areas. Although Columbia Lake is not as intensively developed as Windermere Lake, there are pockets of urban settlement around Columbia Lake. Development pressures are likely to increase at Columbia Lake as other areas in the Valley become heavily used.

Floodplain mapping has been undertaken by B.C. Environment for Columbia Lake and the mouth of Dutch Creek. This mapping has been incorporated by the Regional District of East Kootenay into Bylaw No. 1034. Most types of building development proposed for the lake must comply with a 7.5 metre setback from the natural boundary of the lake and with a flood construction level of 811.0 metres.

A variety of land uses are distributed in the uplands surrounding Columbia Lake as follows:

**South End:**
The Improvement District of Canal Flats sits at the far southern end of the lake. Ground water percolates from the Kootenay River underneath Canal Flats to Columbia Lake.

**East Side:**
Because most of the land on the east side of Columbia Lake is Crown owned there are only two areas of existing development on the east side. First a small residential area named Eagle Nest Estates and second, the Canal Flats Provincial Park.

Canal Flats Provincial Park is a day use park and boat launch facility adjacent to Canal Flats. No immediate plans for expansion of this 6 ha site have been reported.

The major privately owned parcel on the east side of Columbia Lake is Lot 48. Development approvals for a golf course and resort development have been acquired by Lot 48's land owner. In addition, an access agreement has been secured through Columbia Lake Provincial Park.

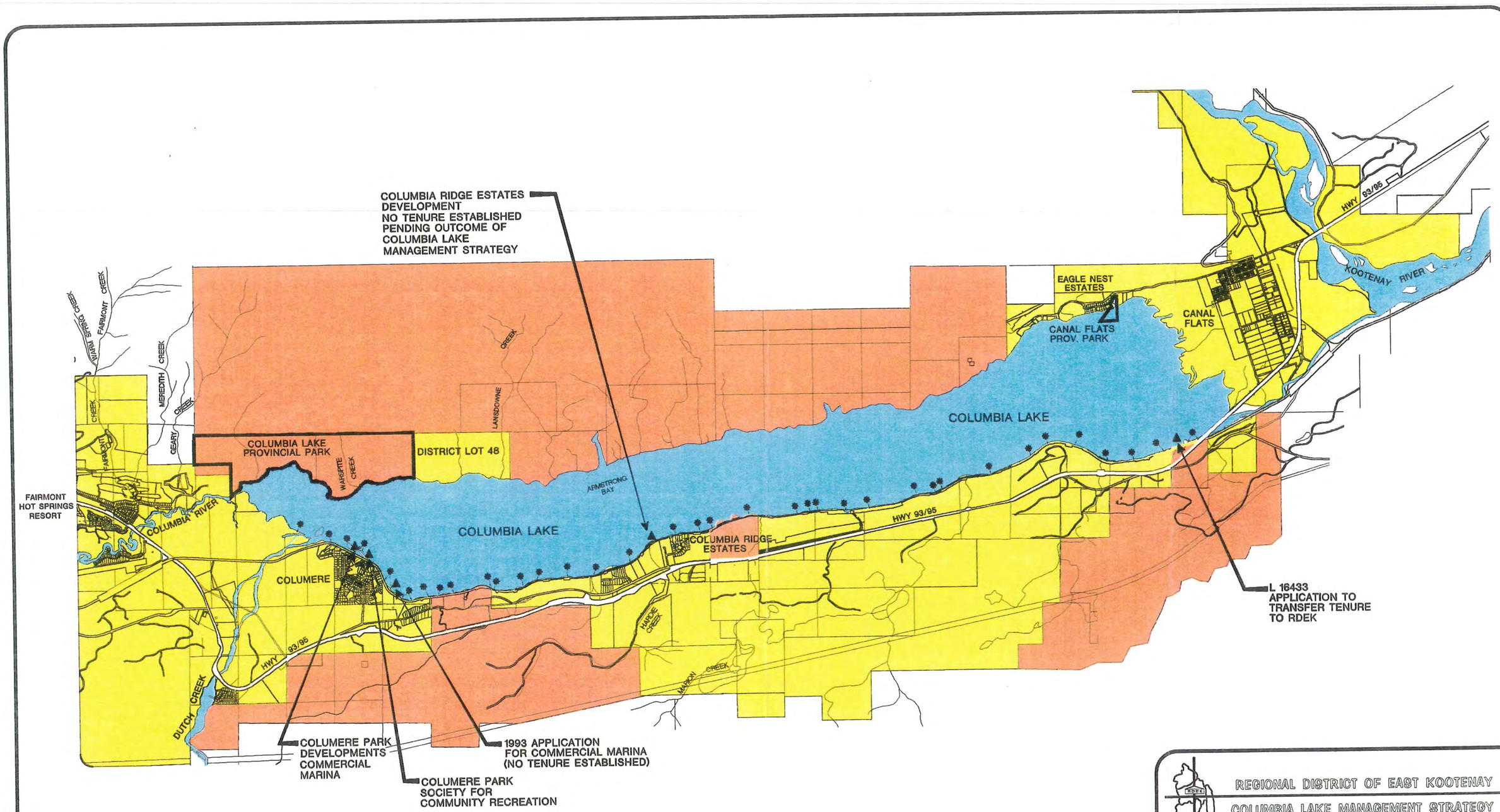
The lake's other provincial park is Columbia Lake Provincial Park. Located immediately south of Fairmont Hot Springs, this 260 hectare park extends south to Lot 48. Plans for Columbia Lake Provincial Park include a campground and day use area within the next 5 to 10 years.

In addition, the east side of Columbia Lake is nationally significant because of the traditional use of the area by the Ktunaxa-KinbasketNation. The area contains historical aboriginal heritage sites, the Spirit Trail, pictographs and other important archaeological features. A tradition use evaluation was completed by the Nation in 1996. The study could not be released. Map Ten illustrates known archeological sites around Columbia Lake which are concentrated mainly on the east side of the lake.

**North End:**
Located along Columbia River at the north end of the lake is the community of Fairmont Hot Springs.

**West Side:**
Settlement is more extensive on the west side of Columbia Lake. The residential community of Columere Park sits close to the outlet of Dutch Creek. Adjacent and upland to Columere Park is Coy's Par 3 Golf Course. The only existing golf course bordering Columbia Lake. Besides the golf course, the one other commercial development on the west side is Timbers Resort which is an RV and cabin style over night accommodation facility.

Some of the privately owned parcels outside the ALR along the west side are utilized for residential development both seasonal and permanent. A residential subdivision named Columbia Ridge Estates has recently been developed on the west side. The infrastructure for this subdivision is installed and the housing stock is currently under construction. Map Nine provides an overview of land ownership and areas of settlement around the lake.




GRAPHIC SCALE
( IN METRES )
500 250 500 1000 1500 2000 2500 3000

1 : 25,000

REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

## MAP 9
## OWNERSHIP

LEGEND

- PROVINCIAL PARK BOUNDARIES
- PRIVATE LANDS
- CROWN RESERVE
- FORESHORE TENURES
- C.P.R. LEGAL SURVEY LOTS

NORTH

URBAN SYSTEMS

### 2.13.2 Agricultural Uses

A significant percentage of land surrounding Columbia Lake is within the Agricultural Land Reserve (ALR) and is used for crop production. Map Ten illustrates the area of ALR, which is quite significant around Columbia Lake. Some cattle grazing has occurred at the southern end of the lake.[42]

The areas within the Agricultural Land Reserve should be considered to be a critical constraint to future non-agricultural development in the uplands. Lands within the reserve are regulated by the Agricultural Land Commission and strictly intended for agricultural uses only.

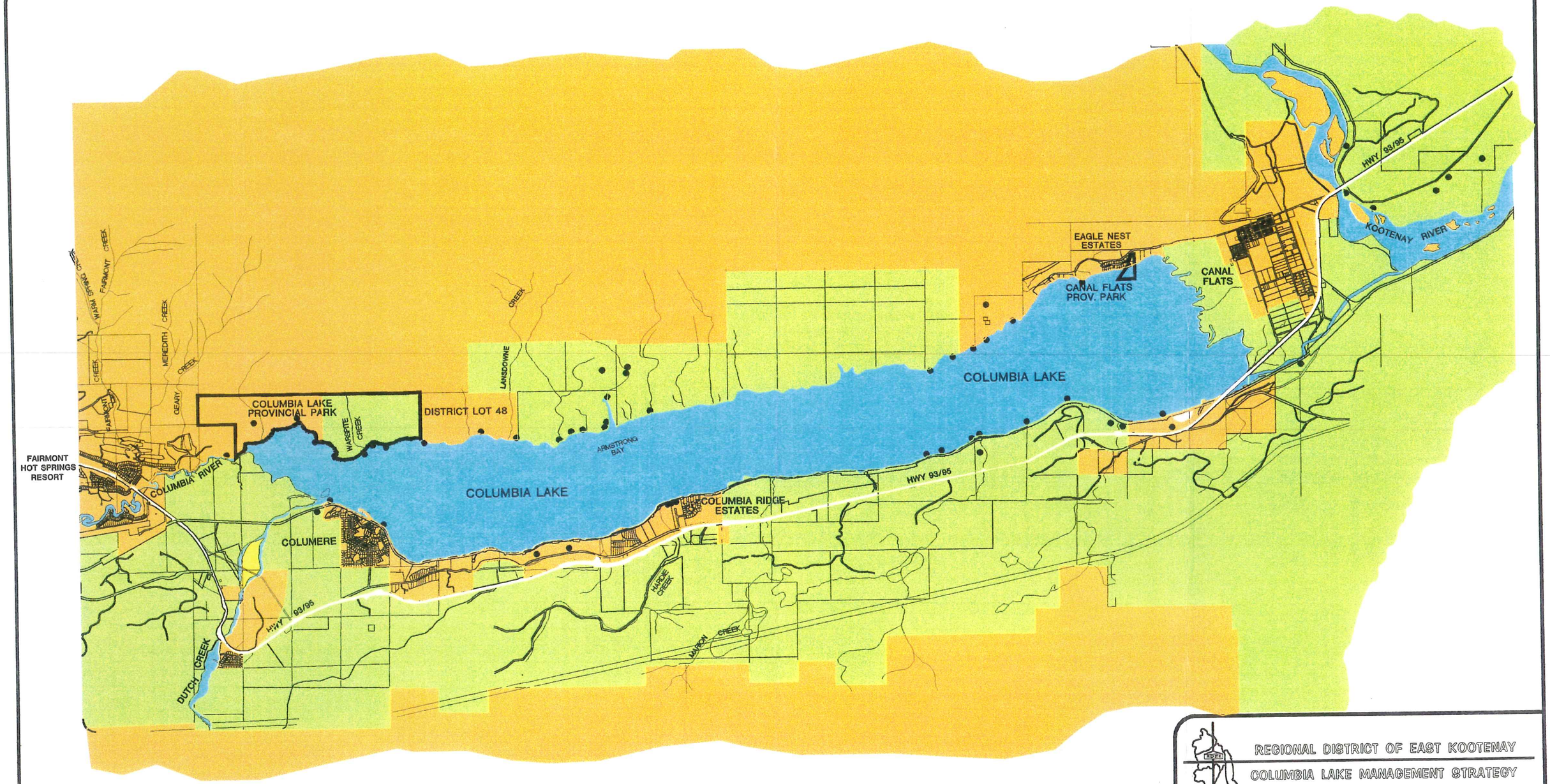
Potential phosphorus loadings from agricultural sources and natural runoff from agricultural areas is considered to be a major nutrient source for lakes. It is also recognized that the Regional District of East Kootenay has little or no jurisdiction over agricultural related phosphorus inputs.

For lakes having a water quality sensitivity classification rating of moderate (Columbia Lake) or high, control of additional phosphorus loads from any source is important. Several phosphorous control techniques and strategies may be applied to agricultural related inputs, and are described as follows:

1) To the greatest extent practical, livestock should be fenced from direct access to watercourses and lakes. This will reduce the direct entry of animal wastes into the water.
2) Livestock wintering areas to the greatest extent possible should be setback from lakeshore areas and the edges of contributing streams.
3) Construction of interception ditches to prevent natural runoff from traversing livestock watering or wintering areas should be encouraged. The interception ditches will reduce the runoff through areas containing significant accumulations of animal wastes and thereby reduce transport of these wastes by runoff.
4) Construction of detention basins to retain runoff from livestock wintering areas or primary feeding areas should be encouraged. The detention basins allow phosphorus carried in sediment or suspended materials to settle prior to entry into the lake or contributing watercourse.

While it is recognized that the control of potential phosphorus loading from agricultural sources is extremely difficult, the potential impact of phosphorus from this source is significant. Detailed lakes studies on Williams Lake and Dragon Lake have confirmed that agricultural sources, in particular related to livestock, are major phosphorus sources having a direct bearing on the trophic states of both lakes. For example, a study of Dragon Lake found that the phosphorus loading from approximately 150 head of cattle in the immediate vicinity of the lake was estimated to be in excess of 200 kg per year. A similar loading of 200 kg/year would be expected from 600 to 700 permanent occupancy residential units.

[42] Walter McKersie. Pers. Communication

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( IN METRES )
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REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

## MAP 10
## AGRICULTURAL LAND RESERVE

LEGEND

- PROVINCIAL PARK BOUNDARIES
- AGRICUCTURAL LAND RESERVE (ALR)
- LANDS OUTSIDE ALR
- ARCHAEOLOGICAL SITE LOCATIONS

NORTH

URBANSYSTEMS

### 2.13.3 Uplands Soils

The soils around a lake and in its drainage basin have a significant effect on the lake water quality by contributing nutrients and by influencing the rate of runoff from the land into the lake. The bedrock geology of the Columbia Valley is typically metamorphosed sedimentary rock, with some volcanic intrusions. The sedimentary rock is composed of dolomite, limestone, and shales. Certain areas surrounding Columbia Lake consist of fine textured lacustrine materials on which active erosion is present in the form of gullies and piping [43]. On lacustrine terraces control of wastewater disposal and storm run-off from buildings and roads require special attention. Setbacks from escarpments are also required. The use of traditional septic tile fields for disposal of domestic wastewater may not be successful. Alternate disposal methods will likely be required to protect water quality in the event of more intensive urban development. Some areas farther backshore are of medium textured moraine fluvial deposits that are better suited to settlement development.[44]

### 2.13.4 On-Site Effluent Disposal

Phosphorus is removed from wastewater as the effluent passes through the soil materials and is absorbed by individual soil particles. the principle variables of the phosphorus removal process are soil type and the contact distance of the effluent with the soil material.

Soil types which are most efficient at removing phosphorus are generally fine textured soils consisting of silts, fine sands, loams and clays. Clay soils are effective in removing phosphorus, but are not considered suitable for effluent disposal because of their low permeability (low percolation rate). On the other end of the scale, coarse materials such as uniform coarse sand or gravel have limited phosphorus removal capacity.

The second variable is the "travel" distance of the effluent in the soil material. As the effluent leaves a disposal system, the effluent generally moves in a vertical direction down to the groundwater table. Upon entering the groundwater, a lateral movement takes place with the groundwater and effluent surfacing in the lake or contributing watercourse. The majority of the phosphorus is removed in the vertical downward movement. Phosphorus continues to be removed after the effluent enters the groundwater, however, the actual amount removed is extremely difficult to predict.

Generally, as the lake sensitivity and the development density increase, the objectives for phosphorus removal are more stringent. The density of development proposed in general will represent the gross number of residential units proposed. As the density increases, it is probable that the gross number of units also increases. This implied relationship between density and gross number of units is further justification for the more stringent phosphorus removal standards with higher density.

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[43] Piping are small hollows and channels which are aligned along routes of subsurface drainage and results from the subsurface removal of particulate matter.

[44] Columbia and Windermere Lakes Sub-Basin Water Quality Assessment and Objectives, Technical Appendix. (1985) Ministry of Environment, Water Management Branch.

## 3.1 INTRODUCTION

In light of the data collected for this strategy, and feedback received from the public, the following areas of action are recommended for Columbia Lake. Part IV of this strategy describes the roles and responsibilities of implementing these recommendations.

## 3.2 COLUMBIA LAKE MANAGEMENT STEERING COMMITTEE RECOMMENDATIONS

.1 Establish a community based Steering Committee with representation from Canal Flats, Fairmont Hot Springs, Columere Park, Columbia Ridge Estates, Eagle Nest Estates and other area representatives.

**Rationale**

The establishment of a lake management steering committee is a crucial management recommendation of this strategy. From this locally based citizen committee will flow the impetus for action and the desire to manage change effectively. The steering committee will act as a watchdog body and will be responsible for the ongoing success of a variety of initiatives. The committee will help ensure that actions are taken to preserve the lake and that information is communicated back to area residents. Although the Steering Committee will be citizen based, it is highly recommended that when technical advise is needed representatives from various government agencies be contacted. The Ministry of Environment has indicated general support for this idea and willingness to participate with the community in a water monitoring program.

The steering committee will have the following broad areas of responsibility:

- To provide "sweat equity" in the water quality and water level monitoring program. The committee will work with the Ministry of Environment to supply samples and other data as required to monitor the health of Columbia Lake.
- In consultation with the Ministry of Environment and the Ministry of Transportation and Highways, to organize a work party to unplug the blocked culvert located in the southwest corner of the lake.
- To provide input and overview to other phases of planning for Columbia Lake, including the watershed management strategy, Official Community Plan and site selection of another public day use boat launch.
- To establish a methodology and monitor motor boat usage of Columbia Lake over the next five to ten years.

- To communicate the hazards of Eurasian watermilfoil contamination to area residents.
- To provide feedback to B.C. Lands at the time the Columere Park Marina lease is up for renewal.

.2 The Steering Committee is encouraged to formulate an organizational structure, membership criteria, and establish lines of communication to relevant provincial government agencies, the Regional District of East Kootenays and the general public.

**Rationale**

The Steering Committee should establish an organizational structure and lines of communication. Contact persons in the relevant agencies should be established and methods of communicating with the broader public decided. A communication protocol is important in order to ensure information is obtained and disseminated. It is also recommended that the Steering Committee hold its meetings in public so that it remains accessible to the general public.

## 3.3 WATER QUALITY RECOMMENDATIONS

**.1 Establish a monitoring program with the cooperation of area citizens to track Columbia Lake's water quality. The following aspects would be examined:**

- **Water Quality**
  - **Seasonal monitoring should include all tributary inflows and the Columbia River outlet.**
  - **Monitoring should also include profile analysis in deep water areas and frequent secchi disc measurements, water temperature/dissolved oxygen profile analysis.**
- **Aquatic Plants**
  - **Seasonal sampling of algae forms likely to affect 'blooms' and changes in water quality.**
  - **Summer assessment of the distribution and abundance of aquatic plants.**

**Rationale:**

Water quality is a critical indicator of environmental health and ecosystem integrity. Based upon the data reviewed for this strategy, Columbia Lake has good water quality with low nutrient and chemical levels. Water quality indicators have remained fairly constant over the past ten years. Water quality, however, does not exist in a static state. It can improve or decline depending on a wide variety of forces, including the use of the lake and development activities in the watershed. Columbia Lake is the source of potable drinking water for large number of lake residents including Columere Park and Columbia Ridge Estates. Ongoing monitoring is important in order to ensure that any negative trends are quickly identified.

Patterns of aquatic plant growth can be representative of a healthy lake's ecosystem or an early warning signal of declining lake water quality. Residents around Columbia Lake are concerned with aquatic plant growth trends, however little monitoring and historic information exist. An aquatic plant monitoring and mapping program would assist in highlighting water quality concerns and would help establish a benchmark for future analysis. In addition, a community based monitoring program would be instrumental to the early detection of Eurasian water milfoil if introduced to Columbia Lake.

Citizen based monitoring programs in coordination with the Ministry of Environment have been successful in many lakes in the B.C. Interior.

### .2 A Watershed Management Strategy is recommended for Columbia Lake.

**Rationale:**

Activity in the watershed of Columbia Lake is a determining factor for the future of Columbia Lake's water quality. Forestry, agriculture and urban development in the uplands and watershed all have the capacity to influence Columbia Lake's water quality.

A watershed management strategy is necessary in order to bring together the regulatory requirements that already exist in watershed areas. Currently, the Forest Practices Code has specific management policies for community watersheds. Farm practices legislation legalizes a variety of farming practices and provides avenues for local government to establish 'farm' bylaws and the Code of Agricultural Practice for Waste Management requires that agricultural waste not enter surface or ground water sources.[45]

A watershed management strategy would examine the current state of Columbia Lake's watershed focusing upon terrain stability, water features and hydrology. An analysis of land use, resource management regulations and the potential impacts of activities in Columbia Lake's watershed should be examined. Activities requiring examination include, water use, future urban development, agriculture, forestry and recreation. The study would provide recommendations on watershed restoration and rehabilitation and provide an overall plan for management.

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[45] Forest Practices Code of British Columbia. Community Watershed Guidebook (October 1992) Province of British Columbia. ISBN 0-7726-3004-6.

Bill 22. Farm Practices Protection (Right to Farm) Act. Fourth Session, Thirty-fifth Parliament 44 Elizabeth II, 1995 Legislative Assembly of British Columbia.

Code of Agricultural Practice for Waste Management, April 1, 1992 from Environmental Guidelines for BEEF CATTLE PRODUCERS in British Columbia. See also the Waste Management Act; Section 32(2) and Health Act; Section 5

**.3 A Statutory use plan such as an Official Community Plan (OCP) should be prepared in order to guide future development in the uplands of Columbia Lake in a manner which preserves the environmental quality of the lake.**

**Rationale:**

Due to the fact that the majority of land surrounding Columbia Lake is either owned by the Crown, or is within the Agricultural Land Reserve, there are limited areas of private and developable land in the uplands. However, a land use plan, such as an Official Community Plan, would provide a broad strategy for managing use on private lands, and would provide an opportunity to review the land use patterns as established within the current zoning bylaw.

**.4 CPR involvement is required to address the issues of potential hazardous spills and the occurrences of side casting.**

**Rationale:**

During the course of this study a significant level of community concern was expressed regarding occurrences of CPR side casting dirt and material into Columbia Lake. This practice needs to be examined in light of the appropriate environmental approvals. The CPR has a community liaison program that would inform the community of CPR practices relating to hazardous waste spills and environmental management. The CPR should be requested to hold a public meeting in the area to discuss resident concerns.

## 3.4 WATER LEVEL RECOMMENDATIONS

**.1 Establish a water level monitoring program to examine the following criteria:**

- **Water Level:**
  - **Installation and continuous reading of a staff gauge to describe annual water level variation.**
  - **Seasonal streamflow monitoring of all ground water inputs and the Columbia River output.**
  - **Seasonal groundwater monitoring to quantify subsurface inputs from the Kootenay River.**

**Rationale:**

The data compiled for this management strategy indicates that the water level of Columbia Lake shows no trend toward level decline. It should be noted, however, that the water level sample locations used in this strategy and past studies did not identify locations near Dutch Creek and the area in the south end of the lake identified by the public as a concern due to a blocked culvert. Due to the fact that the levels at these locations have not been examined and because there is tremendous resident concern, the water level of Columbia Lake should be monitored into the future. The community should be involved in both the selection of staff gauge sites and long term monitoring.

**.2 It is recommended that water levels be permitted to fluctuate in accordance with natural processes.**

**Rationale:**
The water level of Columbia Lake changes from year to year. Extreme fluctuations or an overall level decline is not supported by the data. It should be noted that the current data may be limited to the extent that level sample locations did not include measurements from the area adjacent to the Dutch Creek alluvial fan. This information gap should be addressed in the ongoing community monitoring program. Given the present information on water level, redemptive works are not warranted. The Columbia Lake Wildlife Management Area (WMA) is a constraint to level manipulation. The WMA's marshy areas in the north and south ends of the Lake are known to be important nesting and brooding habitat for migratory birds and waterfowl. A sustained level increase would affect habitat status of these areas. Until conditions and or current knowledge change, further examination of methods of achieving a sustained water level increase will not be pursued. The collection of water level data should, however, continue through the monitoring program.

**.3 The Dutch Creek channel and alluvial fan should evolve in accordance with natural processes.**

**Rationale:**
The hydrological analysis highlights that the Kootenay River a major source of water for Columbia Lake and that lake levels are strongly correlated to precipitation. Dutch Creek provides an undetermined quantity of water to Columbia Lake. As indicated by examination of air photos, the alluvial fan has not grown significantly over the past twenty years. The course of the Dutch Creek river channel has, however, significantly shifted from a southerly course to an easterly course and now runs closer to the Columbia River. Given existing data, Dutch Creek may play a secondary role in determining the water level of Columbia Lake especially when compared to the impact of the Kootenay River and precipitation. The alluvial fan is within the boundaries of the Columbia Lake Wildlife Management Area and serves as significant habitat for a variety of species. Any direct manipulation of the channel of Dutch Creek or alluvial fan would likely have negative impacts to existing habitat and be inconsistent with the management policies of the Columbia Lake Wildlife Management Area.

## 3.5 HABITAT RECOMMENDATIONS

**.1 Agencies involved in the management of Columbia Lake are encouraged to incorporate the Management Objectives of the Columbia Lake Wildlife Management Area in the utilization of lands and water within the boundary of the Columbia Lake Wildlife Management Area.**

**Rationale:**
Resulting from the Commission on Resources and Environment planning process, the Columbia Lake Wildlife Management Area was established by the Province of B.C. in 1996. The WMA includes the Crown owned lands on the east side of Columbia Lake and the marshy areas at the north and south ends. The Columbia Lake WMA management objectives that basically follow a 'leave alone' policy shall direct the utilization of lands within the WMA.

**.2 Boating and recreation will be directed away from the Columbia Lake Wildlife Management Area and other areas of sensitive habitat.**

**Rationale:**
Because boating can have a negative impact on species health and habitat, various types of boating regulation are potentially appropriate for Columbia Lake. Adverse impacts to waterfowl are particularly relevant in light of the importance of Columbia Lake as a staging area. Rapid over water movement and loud noise activities such as power boating, water skiing, jet skis and air craft create the most significant disturbances to waterfowl. These types of activities create increased wave action and erosion and have the potential for negatively affecting areas of emergent vegetation. The reduction in emergent vegetation could reduce the viability of both fish and waterfowl habitat. The creation of no boating zones, in areas of sensitive habitat, to restrict activity, speed and wake are appropriate. See Map Eleven for overview of boating restricted zones.

**.3 Examine the potential of re-establishing the Dutch Creek Channel as a fisheries habitat.**

**Rationale:**
Due to a shift in the Dutch Creek alluvial fan, it is a concern that the fish stock in Columbia Lake cannot make it up the Dutch Creek Channel to spawn.

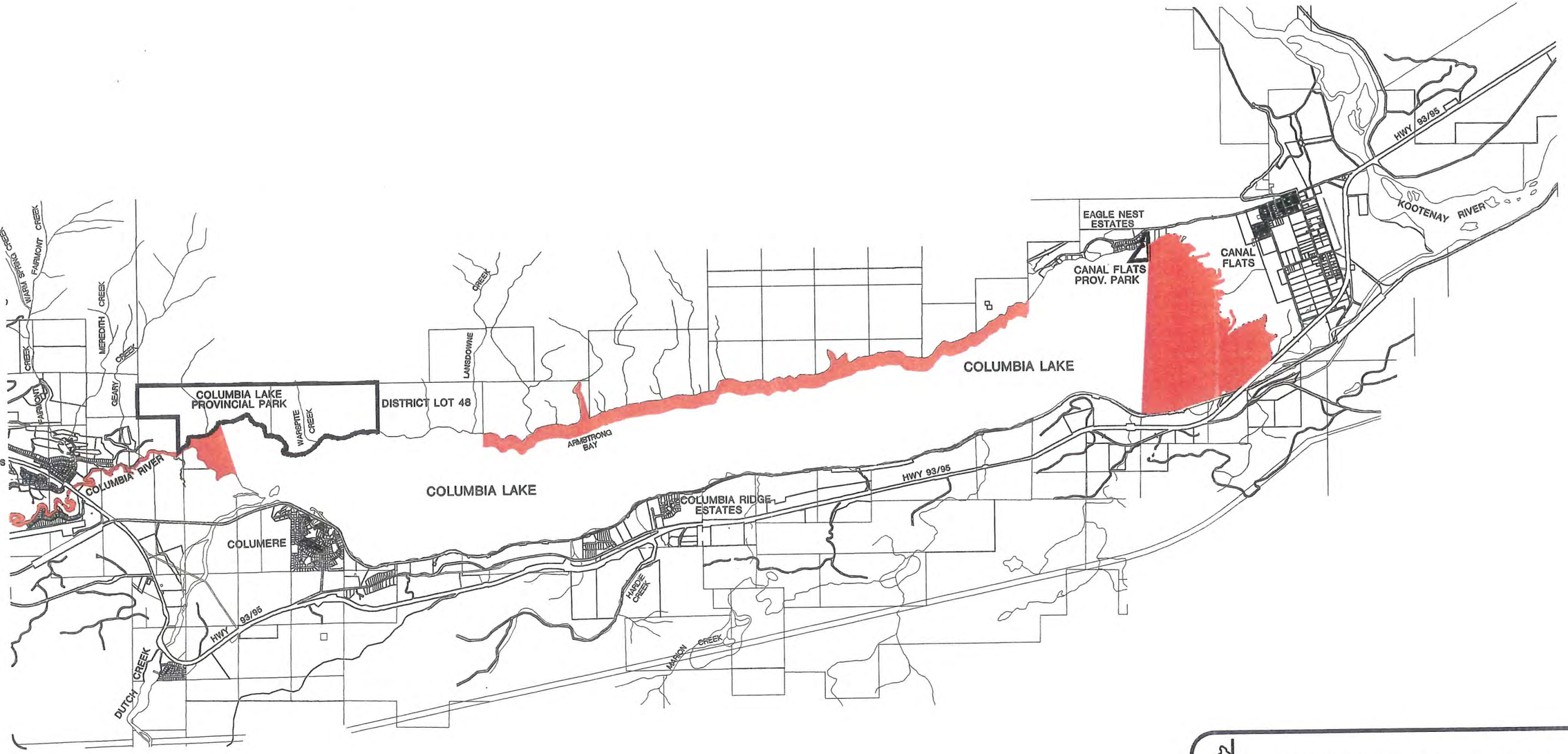
Based on a review by Agra Earth and Environmental Limited (AGRA) , it was noted that due to the dynamic nature of the creek channel, and the potential for braiding and side channel formation, particularly in lower reaches, fish access and habitat utilization can vary from year to year. In this instance, at least a portion of the rainbow trout (spring spawners) and mountain white fish (fall spawners) will utilize other areas.

AGRA advised that channelization / stablization measures would be precluded because of the dynamic nature of the channel. Dredging is not advisable given the likelihood of increased silt loadings to the lake, outlet and river, and because the dredged channel will continue to shift and infill rapidly to achieve equilibrium.

In order to determine if shifts in the fan and/or increased silt loadings are in any way associated with land use activities, it may be worthwhile to conduct a study of Dutch Creek and the surrounding area. This watershed study would describe adjacent land use activities, potential impacts on fish habitat quality and availability and influence on seasonal fish utilization. A previous recommendation under water quality recommendations, suggests a Dutch Creek watershed study is warranted. This analysis would be expanded to address fish habitat within the Creek.

**.4 Check the elevation of, and the blockage from the culvert at the southwest corner of the lake.**

**Rationale:**
This location has been identified as an area of excellent burbot spawning potential. The incoming stream has been known to be blocked due either to the culvert being set at too high an elevation, or it being blocked by a beaver dam. In consultation with Ministry of Environment, the Steering Committee should work towards determining whether the elevation is too high or removing the blockage, possibly during the course of a work clean-up effort.

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REGIONAL DISTRICT OF EAST KOOTENAY
COLUMBIA LAKE MANAGEMENT STRATEGY

# MAP 11
# NO-MOTORIZED BOATING AREAS

LEGEND

PROVINCIAL PARK BOUNDARIES

NO-MOTORIZED BOATING AREAS

NORTH

URBAN SYSTEMS

## 3.6 FORESHORE LEASE AND ACCESS RECOMMENDATIONS

**.1 The development of new private marinas is not recommended.**

**Rationale:**
The development of new private marinas is a pressing issue on Columbia Lake. One private foreshore marina application is currently on hold with BC Lands, pending the results of this management strategy. The following factors where considered when formulating this policy:

- that pressures currently exist and will continue to exist into the future for private marina development;
- that Columbia Lake has a limited carrying capacity and is moderately sensitive;
- that restricting the establishment of all new marinas is a means of controlling boating use of the lake;
- that providing limits to new permanent marinas will benefit waterfowl habitat;
- that access to the Lake may be more appropriately provided through the establishment of one additional public launch facility rather than through the introduction of a number of new private marinas;
- given that public access to the Lake will be limited, the further establishment of private marinas would likely formalize an inequitable distribution of recreational opportunities to those with membership in private marinas.

**.2 In order to better implement the provision of public access at the time of subdivision, the Ministry of Transportation and Highways should establish a Columbia Lake specific subdivision policy in coordination with the Columbia Lake Steering Committee.**

**Rationale:**
The current method used by Ministry of Transportation & Highways of providing public access at the time of subdivision is generally not successful. The areas taken for public use are neither large enough for public use, nor can these locations be readily identified by the public. The Ministry should consider revising the access requirements in consultation with the Steering Committee in order to create usable public spaces at the time of subdivision.

**.3 It is recommended that Columbia Lake could accommodate another public day use boat launch. The site selection should be based upon the following criteria:**

- **that the site is easily accessible with a high standard access road;**
- **that the site must be located away from the Columbia Lake Wildlife Management Area and areas of excellent habitat;**
- **that an environmental assessment be prepared and any negative impacts be mitigated.**

**Rationale:**
It was identified by the public that there is a need for a boat launch at the north end of the lake which would complement the existing boat launch at Canal Flats. While public access to the lake via a launch is considered appropriate, overnight moorage is not. The exact siting of this launch requires a thorough evaluation in order to minimize impacts to habitat, while still providing safe and effective access.

**.4 Foreshore tenure for dock facilities may be appropriate in order to provide an amenity to comprehensively designed subdivisions. On-water overnight storage of boats will not be permitted.**

**Rationale:**
The utilization of the lake for day boating is a means of balancing the recreational requirements of residents and the environmental concerns of full scale marina implementation. Where a dock serves a communal function as part of a comprehensively designed subdivision, the dock may be considered appropriate for foreshore lease.

**.5 The existing public boat launch located at the south end of the lake and adjacent to Highway 93/95 should be closed.**

**Rationale:**
This Crown owned public launch was originally established at the time Highway 93/95 was constructed. As a result of a divestiture from the Ministry of Oceans and Fisheries, Small Craft and Harbors Branch the RDEK has applied for tenure. The area of the launch sits well within a sensitive habitat for Burbot, Reside Shiner and Trumpeter Swans and the Columbia Lake Wildlife Management Area. The cumulative impact of concentrating two public launch sites (the other being Canal Flats Provincial Park) in the ecologically sensitive south end of the lake would have negative impacts to staging, brooding and feeding habitat for waterfowl.

**.6 Approval of foreshore leases be based upon consideration of the impacts to fish and waterfowl habitat. It is recommended that leases not be approved for the Columbia Lake Wildlife Management Area or in areas of excellent fish or waterfowl habitat.**

**Rationale:**
In consideration of all foreshore leases the values of habitat and water quality protection shall be significant factors in rendering a decision.

**.7 Prior to the Columere Park Marina's foreshore lease expiring, the Steering Committee, in conjunction with the Columere Residents Association, review the terms and conditions of the lease, and prepare recommendations on the future status of the marina.**

**Rationale:**
A recommendation of this strategy is that no new marinas be constructed on the Lake. That being the case, the only marina on Columbia Lake would be the existing one at Columere. In order to provide a sense of fairness and equality, it is recommended that the status of the marina be reviewed. The purpose of the review would be to determine whether the operation of the marina is consistent with the objectives of this strategy and, if it is not, what needs to be done to ensure the marina is operated in a manner which respects the environmental and aesthetic objectives. This review of the location and operation of the marina is not to suggest that the only outcome would be to faze out the marina. Although this may be an option, the intent of the review is to ensure that there is ongoing review of the conditions which affect Columbia Lake and measures are being considered to ensure its continued well being.

**.8 It is encouraged that the approval of foreshore leases be a multi-agency process and that the lease decisions take into account the relevant concerns of agencies, local government and area citizens. Within this context it is recommended that foreshore leases be compatible with upland uses.**

**Rationale:**
Relevant provincial agencies and the Columbia Lake Steering Committee are considered important stakeholders in the Lake's Management and as such should be consulted during the lease application process.

## 3.7 BOATING RECOMMENDATIONS

**.1 Motorized boats will be restricted from entering or exiting Columbia Lake from the Columbia River and boating will be restricted on the Columbia River in the area of the Columbia Lake Wildlife Management Area.**

**Rationale:**

The mouth of the Columbia River as it enters Columbia Lake is sensitive fish and waterfowl habitat. This area is within the Columbia Lake Wildlife Management Area and provides excellent spawning habitat for a variety of sport and course fish. Important sport fish species in this location include Kokanee and Rainbow Trout. As jet ski use has evolved into a popular recreational activity there has been an increase in the number of jet ski users who travel the Columbia River between Windermere Lake and Columbia Lake. In addition noise and wake action created by motor boating is considered detrimental to fish and waterfowl habitat and should be restricted. In order to preserve habitat no motorized boats will be permitted to enter Columbia River from Columbia Lake. Neither will they be permitted in Columbia Lake from the River.

It is noted that at the third public meeting held at Canal Flats, that there was some concern expressed relative to restricting boating in the vicinity of the old Gun Club site. The Steering Committee should work with the Ministry of Environment and area residents to more definitively define the area and explore an option which may permit limited, and well defined, boat access to the beach in this area.

**.2 Establish educational panels at all public and private launch locations. These panels will raise awareness of Eurasian water milfoil contamination of Columbia Lake. Instructions will be given to clean crafts prior to lake entry.**

**Rationale:**

The physical characteristics of Columbia Lake make it a good host for the spread of Eurasian water milfoil once contaminated. Given that recreational pressures and boating usage of the lake are likely to increase over time, the threat of Eurasian water milfoil entering the lake must be addressed. Highly visible signage defining the problem and the solution is an important step in educating recreational boaters of the concern.

**.3 The existing private marina should establish a code of practice to reduce the potential for hydrocarbon or other pollutant introduction that may result from on water storage of motor boats and intensity of use.**

**Rationale:**

The existing private marina located at Columere Park has capacity to hold 70 boats and has a vacancy rate of only 1 to 2 slips in a given year. This marina is located in a highly sensitive area because:

- it is adjacent to the Columbia Lake Wildlife Management Area which is a significant staging habitat for migrating ducks and swans;
- close to excellent fish habitat for Large Scale Sucker and good fish habitat for Mountain Whitefish, Northern Squawfish and Reside Shiner;
- it is adjacent to the Columere recreational day use area; and
- it is adjacent to the withdrawal source for the Columere Park drinking water supply.

Given these factors it is highly encouraged that local users develop a code of practice to educate all marina users of these sensitive local conditions.

## 4.1 INTRODUCTION

It was a fundamental goal at the outset of this planning process to prepare a management strategy that could be readily implemented. Implementation of this management strategy will involve overlapping jurisdictions. Fragmented jurisdictions will result in a need for greater coordination between the activities of various agencies to achieve the agreed upon recommendations. Although the Regional District is the level of government closest to the immediate concerns of residents for the management of the lake, it must be recognized that the RDEK is constrained by jurisdictional mandates. The Regional District must take into account the objectives, policies and plans of a variety of provincial and federal agencies. The active involvement and support of other agencies including funding, is necessary in order for this strategy to be implemented.

The implementation of this strategy will also be affected by limitations on government resources and by the need to undertake additional studies before definitive management actions can be taken. Without a concerted effort to implement the management strategy, however, the current status of Columbia Lake may not be retained into the future.

## 4.2 ROLES AND RESPONSIBILITIES

The implementation of the Columbia Lake Management Strategy must be kept as simple and straight forward as possible. Government agencies, as well as members of the public, have critical roles to play in the management of the lake. Agreement amongst agencies and the public with respect to the management recommendations and the delineation of responsibilities is a necessary step in the successful implementation this strategy.

The responsibilities of the following agencies and groups have been outlined with specific regard to the requirements of managing the lake and foreshore of Columbia Lake and may not be representative of boarder responsibilities.

*1) Regional District of East Kootenay (RDEK)*

The RDEK will be responsible for the following general aspects of implementing the Columbia Lake management strategy:

- They will be a key player in the successful implementation of the strategy.
- The RDEK will act as a coordinating body by directing and initiating action on a variety of aspects.
- It will be necessary for the RDEK to network and tap into other sources of agency funding.
- The RDEK is responsible for land use planning control in the uplands and will base future decisions on the recommendations of the management strategy.
- The RDEK will liaise with other government agencies to communicate the recommendations for management of Columbia Lake.

2) *Citizen Steering Committee*

Implementation of this management strategy is a long term process that requires energy, interest and enthusiasm in order to succeed. A citizen's based Steering Committee would help provide the stimulus for action. The Steering Committee would have the following responsibilities:

- The Steering Committee will assist in the implementation of the Columbia Lake Management Strategy.
- The Committee will be extensively involved in the ongoing monitoring of Columbia Lake's water quality, level and habitat.
- The Committee will be responsible for reporting to the RDEK staff and Regional District board.
- Will be responsible for communicating actions to the broader community.

3) *Ministry of Environment Lands and Parks*

A variety of provincial agencies from the Ministry of Environment are involved in management of Columbia Lake.

a) Fish and Wildlife Branch

- Habitat preservation and conservation on the lake and uplands
- Management of the Columbia Lake Wildlife Management Area
- Management of the Columbia River Wildlife Management Area.

b) BC Lands

This agency is responsible for foreshore leases and processing lease applications on Columbia Lake.

c) Environmental Protection

This agency regulates construction practices and stormwater management on the uplands and regulates the quality of sanitary system discharge.

d) Water Resources Management Branch

This agency will be involved in assisting the water quality monitoring program

e) BC Parks

- They will be preparing a plan for the development of Columbia Lake Provincial Park
- Parks may also be responsible for the establishment of new public access to the lake as part of the development of the Columbia Lake Provincial Park.

4) *Ministry of Health*

- They are responsible for ongoing monitoring of water quality from the perspective of human health and based upon quantity discharged regulate the quality of sanitary effluent.

5) *Ministry of Transportation and Highways*

- They are responsible for the provision of public access at the time of subdivision.
- MOTH is responsible for the maintenance of the culvert located at the southwest corner of Columbia Lake.

6) *Ministry of Forests*

- Responsible for planning forestry activities in the uplands.

7) *Agricultural Land Commission*

- Although not directly involved in the day to day management of Columbia Lake, the Commission broadly directs the utilization of agricultural lands which surround the lake.

8) *Canadian Coastguard - Ship Safety Branch*

- Establish the authority for placing boating restrictions on all lakes.

9) *Minister of Transport*

- May appoint any peace officer to enforce boating restrictions.

## 4.3 ACTION PLAN

A framework for action is necessary to coordinate energies and resources. An important aspect of this action plan is the inclusion of a time frame which provides an indication of priorities and options. This action plan provides a measurable sequence of events that can be used to determine progress and to redirect energies as conditions change.

| ITEM | ACTIONS REQUIRED | TIME FRAME |
|---|---|---|
| 1. **Establish the Columbia Lake Steering Committee** | **STEERING COMMITTEE:**<br>– Establish methods of communication within the Committee, the RDEK and to the broader community.<br><br>**RDEK:**<br>– To request participation from Columere, Canal Flats, Fairmont, Columbia Ridge Estates, other private land owners, the agricultural community, the Ministry of Environment and RDEK.<br>– Orientation meeting with the Steering Committee | Fall 1997 |
| 2. **Boating Restrictions on Columbia Lake and Columbia River** | **RDEK**<br>– Initiate boating restricting process with the province to restrict boating from areas of sensitive habitat.<br>**FISH AND WILDLIFE BRANCH**<br>– To provide input into the delineation of the restricted boating zones on the lake and the Columbia River.<br>– Examine, with the Steering Committee, the potential of providing limited boat access to the beach in the vicinity of the old Gun Club.<br>**CANADIAN COASTGUARD - SHIP SAFETY BRANCH**<br>– Final authority for establishing boating restrictions.<br>**STEERING COMMITTEE**<br>– To communicate areas of restricted boating use to area residents. | Fall 1997 |
| 3. **Close the existing boat launch at the south end of the lake.** | **RDEK:**<br>Remove and close existing boat launch facilities at the southwest corner of the lake. | Fall 1997 |

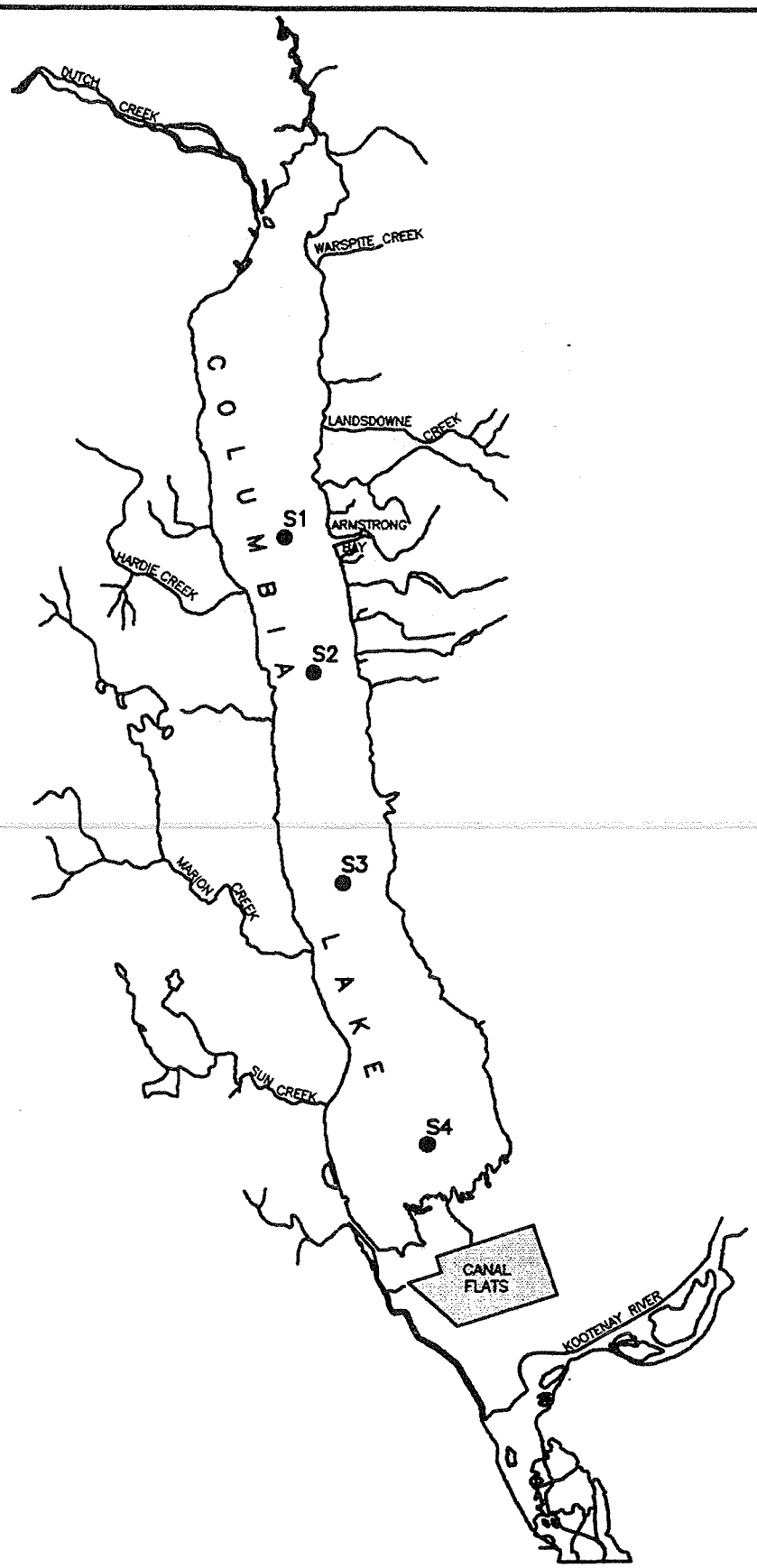
| | | |
|---|---|---|
| **4. Check the elevation and unblock the culvert at the southwest corner of the lake.** | **STEERING COMMITTEE:**<br>– To form a work party<br><br>**MINISTRY OF ENVIRONMENT**<br>– To provide advice to safeguard habitat.<br><br>**MINISTRY OF TRANSPORTATION AND HIGHWAYS**<br>– To assist this action. | Fall 1997 |
| **5. Columbia Lake Wildlife Management Area Inventory** | **FISH AND WILDLIFE BRANCH**<br>– To communicate the results of the inventory to the Steering Committee and the RDEK.<br>– To coordinate inventory with proposed areas of boating restriction. | Fall 1997 |
| **6. Re-evaluation of the existing method of providing public access at the time of subdivision.** | **MINISTRY OF TRANSPORTATION AND HIGHWAYS:**<br>– In consultation with the RDEK and the Steering Committee, re-evaluate the present practice of providing 20 metre public access points at the time of subdivision.<br>– Develop new policies specific to Columbia Lake which will guide the provision of more effective public access. | Winter 1997 |
| **7. Columbia Lake Watershed Management Strategy** | **RDEK:**<br>– To prepare a terms of reference in coordination with the Ministry of Forests, Environmental Protection and the Steering Committee.<br>– Initiate watershed strategy and manage through to completion.<br>– Communicate with Steering Committee.<br><br>**STEERING COMMITTEE**<br>– To participate in the Columbia Lake Watershed Management Strategy. | Possibly phase in the study:<br>A) lower reaches of Dutch Creek spring 1998.<br>B) Larger water shed 1999 - 2000 |

| | | |
|---|---|---|
| **8. Water Quality and Level Monitoring Program** | **RDEK:**<br>– To initiate the monitoring program and act as a liaison between the Steering Committee and the Ministry of Environment.<br><br>**MINISTRY OF ENVIRONMENT**<br>– To work with the RDEK and the Steering Committee to devise an ongoing water quality and level monitoring program.<br><br>**STEERING COMMITTEE:**<br>– To assist in the preparation of monitoring program methodology and sampling locations.<br>– To coordinate sample collection with the broader community. | Spring 1998 |
| **9. CPR Sidecasting** | **STEERING COMMITTEE:**<br>– To organize a community meeting with the CPR to discuss issues of sidecasting and hazardous waste spillage. | Summer 1998 |
| **10. Implement Eurasian Water milfoil - Educational Panels.** | **B.C. PARKS:**<br>– Install signage at public launch in Canal Flats Provincial Park.<br>**STEERING COMMITTEE:**<br>– To ensure that signs are implemented at boat launches.<br>– To investigate other methods of public awareness of the Eurasian Water milfoil danger.<br>– To work with residents of Columere Park to implement educational panels at the private marina at Columere.<br>**MINISTRY OF ENVIRONMENT:**<br>– To provide educational panels information and expertise.<br>– To work with residents of Columere Park to implement educational panels at the private marina at Columere. | Spring 1998 |

| | | |
|---|---|---|
| **11. Site selection of the second public boat launch.** | **RDEK:**<br>– Establish the terms of reference of the site selection study in liaison with the Steering Committee and the Ministry of Environment.<br>– Manage the preparation of the site selection strategy.<br>– Help identify outside sources of funding to prepare study.<br>**B.C. LANDS:**<br>– Issue lease for boat launch in accordance with the site selection analysis.<br>**STEERING COMMITTEE**<br>– Will be involved in assisting study team and final site selection. | Fall 1998 |
| **12. Land Use Planning in the Uplands** | **RDEK:**<br>– To develop the terms of reference in consultation with the Steering Committee for a long range land use plan for the upland.<br>– Initiate an OCP planning process for the uplands of Columbia Lake.<br>**STEERING COMMITTEE:**<br>– To help guide the consultation and planning process. | 2001 - 01 |

# *APPENDIX ONE*

# *1996 COLUMBIA LAKE WATER QUALITY TEST RESULTS*




REGIONAL DISTRICT OF EAST KOOTENAY

COLUMBIA LAKE MANAGEMENT STRATEGY

## WATER QUALITY SAMPLE LOCATIONS

NORTH

LEGEND

● 1996 WATER QUALITY SAMPLE SITES

URBAN SYSTEMS

Columbia Lake Sample Location: S4
Sample Date: 27-06-96

| PARAMETER DESCRIPTION | NAQUADAT CODE | UNITS | RESULTS | DETECTION LIMIT |
|---|---|---|---|---|
| Calcium - (ICP) Dissolved | 20111L | mg/L | 37.6 | 0.01 |
| Magnesium - (ICP) Dissolved | 12111L | mg/L | 20.1 | 0.01 |
| Sodium - (ICP) Dissolved | 11111L | mg/L | 6.09 | 0.01 |
| Potassium - (ICP) Dissolved | 19111L | mg/L | 0.95 | 0.02 |
| Chloride - Dissolved | 17206L | mg/L | 5.6 | 0.5 |
| Sulphate - Dissolved | 16306L | mg/L | 44.0 | 0.5 |
| PP Alkalinity (as CaCO3) | 10151L | mg/L | 0.1 | 0.1 |
| Total Alkalinity (as CaCO3) | 10111L | mg/L | 144. | 0.5 |
| pH | 10301L | Units | 0.24 | 0.01 |
| Carbonate | 06301L | mg/l | 0.5 | 0.5 |
| Bicarbonate | 06201L | mg/L | 176. | 0.5 |
| Total Hardness (as CaCO3) | 10602L | mg/L | 177 | 0.5 |
| Hydroxide | 08501L | mg/L | 0.5 | 0.5 |
| Fluoride | 09105L | mg/L | 0.08 | 0.05 |
| Specific Conductance | 02041L | ug/cm | 332. | 0.02 |
| Turbidity | 02074L | NTU | 1.3 | 0.1 |
| Chlorophyll 'A | 06711L | mg/L | 0.007 | 0.001 |
| Total dissolved Solids | 00201L | mg/L | 202. | 1. |
| Total Organic Carbon | 06005L | mg/L | 1.8 | 0.2 |
| Dissolved Organic Carbon | 06104L | mg/L | 1.7 | 0.2 |
| Total Kjeldahl Nitrogen | 07015L | mg/L | 0.38 | 0.05 |
| Nitrite plus Nitrate Nitrogen as N | 07110L | mg/L | 0.01 | 0.01 |
| Total dissolved Phosphate as P | 15423L | mg/L | 0.003 | 0.003 |
| Total Phosphate as P | 15406L | mg/L | 0.017 | 0.003 |
| Iron - Dissolved (ICP-AES) | 26109L | mg/L | 0.01 | 0.01 |
| Manganese - Dissolved (ICP-AES) | 25109L | mg/L | 0.012 | 0.001 |
| Ion Balance | | Balance | 0.97 | 0.01 |

Columbia Lake Sample Location: S3
Sample Date: 27-06-96

| PARAMETER DESCRIPTION | NAQUADAT CODE | UNITS | RESULTS | DETECTION LIMIT |
|---|---|---|---|---|
| Calcium - (ICP) Dissolved | 20111L | mg/L | 40.7 | 0.01 |
| Magnesium - (ICP) Dissolved | 12111L | mg/L | 21.2 | 0.01 |
| Sodium - (ICP) Dissolved | 11111L | mg/L | 6.76 | 0.01 |
| Potassium - (ICP) Dissolved | 19111L | mg/L | 0.91 | 0.02 |
| Chloride - Dissolved | 17206L | mg/L | 5.7 | 0.5 |
| Sulphate - Dissolved | 16306L | mg/L | 32.0 | 0.5 |
| PP Alkalinity (as CaCO3) | 10151L | mg/L | <0.1 | 0.1 |
| Total Alkalinity (as CaC03) | 10111L | mg/L | 150. | 0.5 |
| pH | 10301L | Units | 0.21 | 0.01 |
| Carbonate | 06301L | mg/l | <0.5 | 0.5 |
| Bicarbonate | 06201L | mg/L | 183. | 0.5 |
| Total Hardness (as CaCO3) | 10602L | mg/L | 189. | 0.5 |
| Hydroxide | 08501L | mg/L | <0.5 | 0.5 |
| Fluoride | 09105L | mg/L | 0.09 | 0.05 |
| Specific Conductance | 02041L | ug/cm | 353. | 0.02 |
| Turbidity | 02074L | NTU | 1.6 | 0.1 |
| Chlorophyll 'A | 06711L | mg/L | 0.001 | 0.001 |
| Total dissolved Solids | 00201L | mg/L | 199. | 1. |
| Total Organic Carbon | 06005L | mg/L | 1.7 | 0.2 |
| Dissolved Organic Carbon | 06104L | mg/L | 1.7 | 0.2 |
| Total Kjeldahl Nitrogen | 07015L | mg/L | 0.43 | 0.05 |
| Nitrite plus Nitrate Nitrogen as N | 07110L | mg/L | <0.01 | 0.01 |
| Total dissolved Phosphate as P | 15423L | mg/L | <0.003 | 0.003 |
| Total Phosphate as P | 15406L | mg/L | 0.010 | 0.003 |
| Iron - Dissolved (ICP-AES) | 26109L | mg/L | <0.01 | 0.01 |
| Manganese - Dissolved (ICP-AES) | 25109L | mg/L | 0.015 | 0.001 |
| Ion Balance | | Balance | 1.07 | 0.01 |

Columbia Lake Sample Location: S2
Sample Date: 27-06-96

| PARAMETER DESCRIPTION | NAQUADAT CODE | UNITS | RESULTS | DETECTION LIMIT |
|---|---|---|---|---|
| Calcium - (ICP) Dissolved | 20111L | mg/L | 34.4 | 0.01 |
| Magnesium - (ICP) Dissolved | 12111L | mg/L | 18.2 | 0.01 |
| Sodium - (ICP) Dissolved | 11111L | mg/L | 5.17 | 0.01 |
| Potassium - (ICP) Dissolved | 19111L | mg/L | 0.82 | 0.02 |
| Chloride - Dissolved | 17206L | mg/L | 4.0 | 0.5 |
| Sulphate - Dissolved | 16306L | mg/L | 26.0 | 0.5 |
| PP Alkalinity (as CaCO3) | 10151L | mg/L | 0.1 | 0.1 |
| Total Alkalinity (as CaCO3) | 10111L | mg/L | 135. | 0.5 |
| pH | 10301L | Units | 0.22 | 0.01 |
| Carbonate | 06301L | mg/l | 0.5 | 0.5 |
| Bicarbonate | 06201L | mg/L | 165. | 0.5 |
| Total Hardness (as CaCO3) | 10602L | mg/L | 161. | 0.5 |
| Hydroxide | 08501L | mg/L | 0.5 | 0.5 |
| Fluoride | 09105L | mg/L | 0.08 | 0.05 |
| Specific Conductance | 02041L | ug/cm | 307. | 0.02 |
| Turbidity | 02074L | NTU | 1.4 | 0.1 |
| Chlorophyll 'A | 06711L | mg/L | 0.005 | 0.001 |
| Total dissolved Solids | 00201L | mg/L | 171. | 1. |
| Total Organic Carbon | 06005L | mg/L | 1.7 | 0.2 |
| Dissolved Organic Carbon | 06104L | mg/L | 1.5 | 0.2 |
| Total Kjeldahl Nitrogen | 07015L | mg/L | 0.27 | 0.05 |
| Nitrite plus Nitrate Nitrogen as N | 07110L | mg/L | 0.01 | 0.01 |
| Total dissolved Phosphate as P | 15423L | mg/L | 0.003 | 0.003 |
| Total Phosphate as P | 15406L | mg/L | 0.004 | 0.003 |
| Iron - Dissolved (ICP-AES) | 26109L | mg/L | 0.01 | 0.01 |
| Manganese - Dissolved (ICP-AES) | 25109L | mg/L | 0.015 | 0.001 |
| Ion Balance | | Balance | 1.03 | 0.01 |

Columbia Lake Sample Location: S1
Sample Date: 27-06-96

| PARAMETER DESCRIPTION | NAQUADAT CODE | UNITS | RESULTS | DETECTION LIMIT |
|---|---|---|---|---|
| Calcium - (ICP) Dissolved | 20111L | mg/L | 33.1 | 0.01 |
| Magnesium - (ICP) Dissolved | 12111L | mg/L | 17.6 | 0.01 |
| Sodium - (ICP) Dissolved | 11111L | mg/L | 4.86 | 0.01 |
| Potassium - (ICP) Dissolved | 19111L | mg/L | 0.81 | 0.02 |
| Chloride - Dissolved | 17206L | mg/L | 3.7 | 0.5 |
| Sulphate - Dissolved | 16306L | mg/L | 23.6 | 0.5 |
| PP Alkalinity (as CaCO3) | 10151L | mg/L | 0.1 | 0.1 |
| Total Alkalinity (as CaCO3) | 10111L | mg/L | 131. | 0.5 |
| pH | 10301L | Units | 0.19 | 0.01 |
| Carbonate | 06301L | mg/l | 0.5 | 0.5 |
| Bicarbonate | 06201L | mg/L | 160. | 0.5 |
| Total Hardness (as CaCO3) | 10602L | mg/L | 155. | 0.5 |
| Hydroxide | 08501L | mg/L | 0.5 | 0.5 |
| Fluoride | 09105L | mg/L | 0.09 | 0.05 |
| Specific Conductance | 02041L | ug/cm | 295. | 0.02 |
| Turbidity | 02074L | NTU | 2.1 | 0.1 |
| Chlorophyll 'A | 06711L | mg/L | 0.004 | 0.001 |
| Total dissolved Solids | 00201L | mg/L | 164. | 1. |
| Total Organic Carbon | 06005L | mg/L | 2.3 | 0.2 |
| Dissolved Organic Carbon | 06104L | mg/L | 1.7 | 0.2 |
| Total Kjeldahl Nitrogen | 07015L | mg/L | 0.27 | 0.05 |
| Nitrite plus Nitrate Nitrogen as N | 07110L | mg/L | 0.01 | 0.01 |
| Total dissolved Phosphate as P | 15423L | mg/L | 0.003 | 0.003 |
| Total Phosphate as P | 15406L | mg/L | 0.008 | 0.003 |
| Iron - Dissolved (ICP-AES) | 26109L | mg/L | 0.01 | 0.01 |
| Manganese - Dissolved (ICP-AES) | 25109L | mg/L | 0.021 | 0.001 |
| Ion Balance | | Balance | 1.04 | 0.01 |

**COLUMBIA LAKE**
**IN-SITU WATER QUALITY**
**as measured on**
**28 June 1996**

| SITE (S) | TIME (hour) | DEPTH (m) | TEMP ($^{O}$C) | pH (units) | COND (MS) | TURB. (NTU) | DO mg/l | | VISIBILITY (m) |
|---|---|---|---|---|---|---|---|---|---|
| S1 | 10:15 | 0.50 | 16.3 | 8.77 | 260 | 9.8 | 8.43 | 93.7 | 4.0 |
| | | 2.5 | 16.3 | 8.70 | 240 | 12.0 | 8.50 | 94.4 | 4.0 |
| | | 4.50 | 16.3 | 8.57 | 230 | 14.0 | 8.21 | 91.2 | 4.0 |
| | | 5.25 | | | | | | | 4.0 |
| S2 | 11:05 | 0.50 | 16.3 | 8.64 | 250 | 14.0 | 8.79 | 97.7 | 3.5 |
| | | 2.50 | 16.5 | 8.57 | 250 | 11.0 | 8.90 | 100.0 | 3.5 |
| | | 4.50 | 16.3 | 8.48 | 295 | 12.0 | 8.66 | 96.2 | 3.5 |
| S3 | 11:55 | 0.50 | 16.7 | 8.47 | 270 | 11.0 | 8.63 | 98.1 | 3.5 |
| | | 2.50 | 16.9 | 8.43 | 255 | 11.0 | 8.55 | 97.2 | 3.5 |
| | | 4.50 | 16.8 | 8.42 | 262 | 9.5 | 8.52 | 96.8 | 3.5 |
| S4 | 1:30 | 0.50 | 16.3 | 8.44 | 280 | 11.5 | 9.15 | 101.7 | 2.5 |
| | | 2.50 | 16.5 | 8.36 | 278 | 13.0 | 9.09 | 102.1 | 2.5 |
| | | 2.75 | | | | | | | 2.5 |