Water Quality

Ambient Water Quality Assessment And Objectives For Christina Lake

Overview Report

Water Management Branch
Environment And Resource Division
Ministry Of Environment, Lands And Parks

Prepared Pursuant To Section 2(E) Of The
Environment Management Act, 1981

Original Signed By:
J. O'riordan, Assistant Deputy Minister, Regions
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Don Fast, Executive Director, Environmental Protection Department
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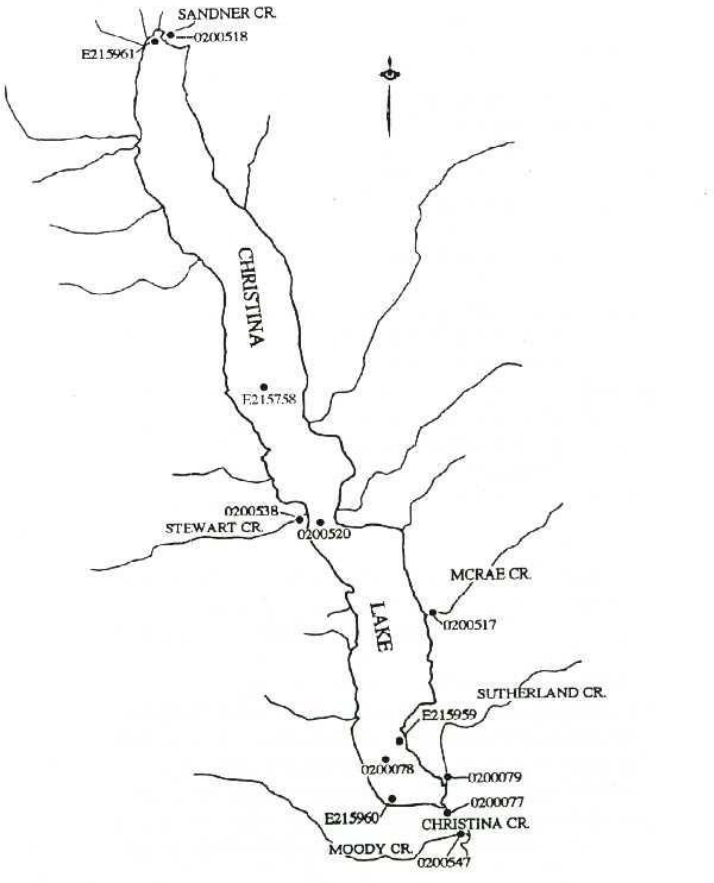
SUMMARY
This document is one in a series that presents ambient water quality objectives for British Columbia. It has two parts: this overview and the technical report, which is available as a separate document. The overview provides general information about water quality of Christina Lake. It is intended for both

technical readers and for readers who may not be familiar with the process of setting water quality objectives. Separate tables listing water quality objectives and monitoring are included for those readers requiring data about the waterbody. The report presents the details of the water quality assessment for Christina Lake and forms the basis of the recommendations and objectives presented in the overview.

Non-point sources of waste are the only major input of pollutants to the lake. These are potentially derived from agricultural activities, past logging operations, past mining activities and most significantly, poorly maintained and/or located septic tank or tile field systems.

Water quality objectives are recommended to protect aquatic life, drinking water supplies, wildlife, irrigation water supplies, industrial water supplies and recreation.

Figure 1. Christina Lake Monitoring Sites and Location Map



PREFACE
Purpose of Water Quality Objectives

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

How Objectives Are Determined

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

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

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

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

How Objectives Are Used

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

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

Objectives and Monitoring

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

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

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

INTRODUCTION

Christina Lake (Figure 1.), located in south-central British Columbia, is a popular summer recreation area that is subject to a 5 fold increase in population during the months of July and August. The lake supplies water for the domestic needs, as well as the industrial and irrigation activities of the local communities. The purpose of this report was to determine the need for and develop water quality objectives for this lake for use by Environment Managers.

HYDROLOGY

Christina Lake's drainage area is 492 km^2 and the elevation at the outlet is at approximately 450 m. The lake drains through Christina Creek, at its south end, into the Kettle River which flows into the Roosevelt Reservoir on the Columbia River in Washington State. The lake volume is 9.295 x 10^5 dam^3 and its surface are is 25.1 km^2. Of this area only 5% is occupied by a littoral zone (less than 6 m depth), the majority of which is located on the southeast shore of the lake.

The lake is strongly stratified during the summer months with the epilimnion (surface layer) extending to a depth of approximately 8-10 m and occupying a volume of nearly 2.0 x 10^5 dam^3 (21.5 % of the lake volume). Surface water temperatures peak in early to mid August and reach a maximum of 25 degrees Celcius. Summer hypolimnetic (bottom layer) temperatures generally do not exceed 10 degrees Celcius and drop to below 6 degrees at depths exceeding 20 m.

The total watershed runoff is approximately 226,825 dam^3/year. The flushing rate (lake volume divided by lake outflow) of the lake is estimated at 4.5 years. A large percentage of the precipitation falls during the winter months as snow, consequently maximum lake water levels occur in May and June during the snow melt freshet. Minimum levels occur during October and November.

WATER USES

There are nine water licences registered for direct withdrawal from Christina Lake. Six of these are for domestic use and three for waterworks (one of which also withdraws for industrial purposes). These licences account for a total potential withdrawal of 165.1 dam^3/year (0.08% of the lake outflow of 208,000 dam^3/year). There are an additional 148 licences registered for withdrawal from within the Christina lake drainage basin.

Christina Lake is a very popular recreation area. Due to limited access within the watershed, most recreational activity is water-based as opposed to land-based. The access also limits the majority of the water-related activity to the southern half of the lake. Swimming, boating and particularly water skiing are very popular activities associated with the lake. The lake has a moderate sports fishery with approximately 10,000 angler days per year. A total of 14 fish species are known to inhabit Christina Lake, of which 4 are important sports fish (rainbow trout, kokanee salmon, largemouth bass and smallmouth bass).

WASTE DISCHARGES

There are no true direct discharges of domestic or industrial waste to either Christina Lake or its tributaries. Diffuse-source contamination from land-based activities is the primary source of contamination to the lake.

Perhaps the most significant input is ground water contaminated with domestic waste from individual households or cottages. All permanent sand seasonal dwellings around Christina lake use on-site waste disposal units. The vast majority of these are septic tank and tile field systems, most of which are not maintained in accordance with recommended practices. The near-shore topography and soil conditions further compound this problem. Adverse topography and/or previous zoning has resulted in many small lake-shore lots. Consequently, many older septic systems were installed closer to the lake than the presently required distance of 30 m. Also much of the soil upon which these dwellings are built is unsuitable or marginal for the purpose of on-site wastewater disposal.

Other sources of non-point pollution include agriculture and logging. The most intensive agricultural activity in the watershed occurs along Sutherland Creek. Logging has the potential to increase sediment phosphorus and nitrogen flowing into tributaries to the lake. Because of the steep terrain surrounding the lake, runoff from logging is a potential concern as is runoff from abandoned metal mines. There are few data available for logging or mining effects.

WATER QUALITY ASSESSMENT

The data collected over the past 20 years confirms that Christina Lake is in an oligotrophic (low nutrient level) state and that the overall quality of the water is very good. The parameters assessed did not provide evidence of overall lake deterioration.

Dissolved oxygen concentrations thoughout the water column ranged from very high to supersaturated. All readings significantly surpassed the provincial working criterion of 5 mg/L which is the level below which salmonids begin to experience oxygen stress.

Turbidity readings in Christina Lake are very low (water clarity is good). In no case did the mean turbidity value at any site exceed 1 NTU, and since this is the Canadian drinking water guideline Christina Lake easily meets this criterion.

Nutrient levels (phosphorus and nitrogen) dictate the amount of biotic production in a body of water. High levels of nutrients (particularly of phosphorus) result in algal blooms, excessive growth of aquatic plants and overall undesirable water quality. These nutrients can be of natural origins or derived from human activities (agriculture, logging, sewage waste disposal, etc.). The levels of each of these nutrients in Christina Lake have remained low over the 20 year period of data collection. But, the potential for seasonal, elevated inputs from agricultural activity along Sutherland Creek and highly concentrated individual sewage disposal units along the lake shoreline, may result in poorer water quality in the future.

Metal concentrations in the lake are below the criteria set for aquatic life and drinking water

All BC Environment sites within the lake have had very low concentrations of coliform bacteria throughout the entire 20-year study period. Most of these samples were collected from the deep water sites. Since the late 1960's the Central Kootenay Valley Health Unit (formerly West Kootenay Health Unit) of the Ministry of Health has conducted seassonal coliform analyses at four recreational beach sites on the southern portion of the lake. At these heavily used areas, the summer fecal coliform levels have remained consistently very low throughout the 25-year period. The tributaries to the lake have had elevated coliform counts since testing in these systems commenced in 1991. Because some of the creeks serve as major sources of drinking water, the raw water 90 th percentile values exceeding 10/100 mL for Christina, McRae and Sutherland creeks are cause for concern. The likely reason for the elevated fecal coliform levels is livestock and wildlife activity in close proximity to the creeks. Because these are not human sources, the likelihood of disease transmittance is reduced yet regardless of this fact, the coliform values exceed the criterion established for drinking water that is treated only through disinfection.

WATER QUALITY OBJECTIVES

Water quality objectives proposed for Christina Lake are summarized in Table 1. The objectives are based on BC approved and working criteria for water quality and on available data on ambient water quality, waste discharges, water uses and stream flows. As future water monitoring programs improve the data base and as changes in water quality occur, these objectives will be reviewed and revised if necessary.

Water quality objectives have no legal standing nor can they be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified waterbodies. They will guide the evaluation of water quality, the issuing of permits, licences and orders and the management of the fisheries and of the Province's land base. They will also provide a reference against which the state of water quality in a particular waterbody can be checked and serve to make decisions on whether to initiate basin-wide water quality studies.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions which can be net in the future. To limit the scope of the work, objectives are only being prepared for waterbodies and for water quality characteristics which may be affected by human activity now and in the foreseeable future.

The following objectives for Christina Lake are for the protection of aquatic life, drinking water supplies, wildlife, irrigation, livestock watering and industrial water supplies.

Water quality objectives which are based on or exceed approved BC water quality criteria are proposed for phytoplankton, periphyton and zooplankton community structure, dissolved oxygen, turbidity, Secchi depth, total phosphorus, total nitrogen, chlorophyll-a (to reflect the impacts from nutrients, especially phosphorus) and fecal coliform bacteria. The objectives are required to ensure that inputs from non-point sources of contaminants do not impair water uses.

MONITORING RECOMMENDATIONS

We recommend that monitoring be carried out for at least the period 1994-95 to check whether the objectives are being achieved. Three additional near-shore sites are recommended to better assess the degree of contamination from the septic systems. The extent of the monitoring in the future will depend on the results, as well as on regional priorities and available funding. The recommended monitoring program for 1994-95 is presented in Table 2.

WATER QUALITY OBJECTIVES AND MONITORING TABLES

The following tables provide a summary of the objectives data and monotoring recommendations.

To protect water uses in a waterbody, objectives specify a range of values for characteristics (variables) that may affect these uses. These values are maximum and/or minimum values that are not to be exceeded.

Some readers may be unfamiliar with terms such as maximum concentration, 30-day mean concentration and 90th percentile. Maximum concentration means that a value for a specific variable should not be exceeded; 30-day mean concentration means that a value should not be exceeded during a period of 30-days, when five or more samples are collected at approximately equal time intervals. The term 90th percentile indicates that 9 out of 10 values should be less than a particular variable.

Table 1. Water Quality Objectives for Christina Lake

Parameter	Objective
pelagic phytoplankton	-stable community structure not dominated by blue-greens (less than 10% of cells in any sample) -dominant genera (greater than 10% of cells) should include *Melosira*, *Asterionella*, *Fragilaria*, *Synedra*, *Peridinium*, *Dinobryon*, and *Mallomonas*
zooplankton	stable community structure dominated (greater than 10% of cells) primarily by *Bosmina longirostris*, *Epischura nevadensis* and *Kellicotia longispina*
periphyton	stable community structure dominated (greater than 50% of cells) primarily by pennate diatoms
dissolved oxygen	8 mg/L minimum at any site and depth
turbidity	-mean value less than or equal to 1 NTU -maximum value less than or equal to 5 NTU
Secchi depth	-3 meter minimum at any time -annual mean greater than 10 meters
total phosphorus	less than 7 micrograms/L
total nitrogen	less than or equal to 200 micrograms/L
chlorophyll-a (30-day mean)	-less than or equal to 2.5 micrograms/L for phytoplankton -less than or equal to 10 mg/m^2 for periphyton
fecal coliforms	less than or equal to 10/100 mL (90th percentile)

The chlorophyll-a objective applies in the photic zone which is defined as 2.5 times the Secchi depth

Table 2. Recommended Water Quality Monitoring for Christina Lake for 1994-95

Location	Frequency and Dates	Parameters Measured
deep stations	monthly, April to October	phytoplankton, zooplankton, dissolved oxygen and temperature profiles, Secchi depth, MF fecal coliforms, chlorophyll-a, turbidity
deep stations, 3 depths/station		total phosphorus, total dissolved phosphorus, nitrate, nitrite, ammonia, organic nitrogen
6 shallow stations		periphyton
6 tributaries and 6 shallow stations		dissolved oxygen, temperature, total phosphorus, total disslved phosphorus, nitrate, nitrite, ammonia, organic nitrogen, turbidity
6 tributaries		MF fecal coliforms
6 shallow stations	weekly, July and August	

1. Phytoplankton is a 1 liter sample from the first 0.5 m depth, unconcentrated and preserved with Lugol's solution.
2. The zooplankton sample is a vertical haul from 50 m to the surface, preserved in 1% formalin and the mouth size of the net must be recorded
3. The deep stations must be taken at at least 3 depths including the epilimnion, thermocline and hypolimnion
4. Periphyton taxonomy and chlorophyll-a are from natural substrates. Chlorophyll-a is a composite of 6 sub-samples at each site.

Nigel Cavenagh
Rick Nordin
Water Quality Branch
Environmental Protection, Victoria
Jim Bryan
Environmental Protection, Penticton
Ministry of Environment, Lands and Parks