SCIENCE & INFORMATION BRANCH
WATER STEWARDSHIP DIVISION
MINISTRY OF ENVIRONMENT

Water Quality Assessment and Objectives for Shawnigan Lake

Overview Report

Prepared pursuant to Section 5(e) of the
Environmental Management Act, 2003

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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 the water quality of Shawnigan 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 technical report presents the details of the water quality assessment for Shawnigan 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 Shawnigan Lake. These are potentially derived from urban development, poorly maintained and/or located septic tank systems, logging operations and agriculture.

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

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's 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 future.

How Objectives are Determined

Water quality objectives are based on scientific guidelines formerly called water quality criteria[1]. Water quality guidelines/criteria are safe limits for 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 guidelines 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 the most sensitive to the physical, chemical or biological characteristics affecting that water body.

[1] The process for establishing water quality objectives is outlined more fully in documents available electronically at: *http://www.env.gov.bc.ca/wat/wq/wq_procedure.html#protocols*

How Objectives are Used

Water quality objectives have no legal standing at this time and are not directly enforced. However, they do 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 water body can be checked, and help 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.

Objectives and Monitoring

Water quality objectives are established to protect all uses which may take place in a water body. 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 the 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 on upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (i.e., mean value, 95^{th} percentile etc.).

INTRODUCTION

Shawnigan Lake (Figure 1), located on southern Vancouver Island has long been a popular recreational destination. Since the early 1970's, the land-use has gradually changed from seasonal to permanent residential. The lake provides the primary source of domestic drinking water in this watershed and therefore protection of the water quality is a primary concern for residents, purveyors and resource managers. The purpose of this report was to develop water quality objectives for this lake to help ensure long-term sustainability of the water resource.

SHAWNIGAN LAKE PROFILE

Watershed and Hydrology

Shawnigan Lake is a medium-sized lake with a surface area of 537 ha, a volume of over 64 Mm^3, a mean depth of 12 m and a maximum depth of 52 m. It is approximately 7.2 km long and 1.4 km across at its widest point. The narrowest point is approximately 150 m wide in the West Arm; this part of the lake is quite distinct in that it is a long, narrow, shallow arm isolated from the main body of the lake. The lake has one main deep basin in the northern half of the lake and several smaller basins to depths of 28 m in the southern half.

Shawnigan Lake has a watershed size of approximately 69 km^2 (Figure 1). The Shawnigan Community Watershed is larger at 110 km^2 and includes the land draining to Shawnigan Creek below the lake outlet to Mill Bay. The watershed has a maximum elevation of 610 m and a minimum elevation of approximately 116 m at the lake level.

Shawnigan Lake empties from south to north. There are three main inflows to the lake: Shawnigan Creek at the south end of the lake, McGee Creek on the west shore and the West Arm inflow in the northwest corner of the lake. Shawnigan Lake has a relatively short water residence time of approximately one year. Water levels are controlled by a dam on Shawnigan Creek located 450 m downstream from the lake outlet.

Water Uses

There are three major waterbodies licensed for water withdrawal in the Shawnigan Lake watershed: Shawnigan Lake, Shawnigan Creek and McGee Creek. In total, there are 225 active water withdrawal licenses permitted to extract over 7,000 m^3/day. In addition, there is approximately 5,500 m^3/day of water licensed for storage in Shawnigan Lake. The largest withdrawals for Shawnigan Lake are located near the northeastern portion of the lake, servicing the Village and Shawnigan Lake Estates. These are treated water supplies with chlorine disinfection.

Shawnigan Lake provides a number of recreational opportunities including swimming, water skiing, boating, and fishing. Although the majority of the residences are now occupied year round, there are number of campgrounds and resorts that receive the heaviest use in the summer months.

Shawnigan Lake provides a good recreational fishery that has been supported by rainbow (*Onchorhynchus mykiss*) and cutthroat trout (*O. clarki*) stockings since 1903. In 2004, Shawnigan Lake was stocked with 26,000 rainbows and 15,000 cutthroat. There is also a native population of kokanee salmon (*O. nerka*) present in Shawnigan Lake and several introduced species including smallmouth bass (*Micropteus dolomieui*) and yellow perch (*Perca flavescens).*

Waste Discharges

Forestry is the dominant land use in this watershed with urban development and agriculture using the majority of the remaining land base. Approximately 9.5% of the land base is under the Agricultural Land Reserve (ALR).

The majority of Shawnigan Lake waterfront is developed and zoned as either Suburban Residential or Urban Residential. The only waterfront area that is not zoned this way is approximately one kilometre of the lake's most southern shoreline, which is included in the ALR.
Within the Shawnigan Lake watershed there are five waste management discharge permits for point discharges, all of which are to ground and adequately set back from the lake.

There are also numerous smaller residential septic and onsite disposal systems which are regulated by the Ministry of Health. Septic systems are the dominant means of disposing of domestic effluent in the Shawnigan Lake watershed and are effective at treating household sewage if designed properly and maintained regularly. If the system is improperly located, constructed, serviced or maintained, it can fail, discharging untreated wastewater to nearby waterbodies. This can impact the suitability of the water for drinking, recreational activities and aquatic life.

The Cowichan Valley Regional District (CVRD) Stage Three South Sector Liquid Waste Management Plan has outlined an initiative to sewer the densest areas of Shawnigan Lake. Shawnigan Lake Beach Estates, near the Village is the only area serviced by a centralized sewage collection system. Presently, there are approximately 275 sewer connections in this area which receive secondary wastewater treatment and in-ground disposal by the CVRD.

WATER QUALITY ASSESSMENT AND OBJECTIVES

Water Quality Assessment

The monitoring results for Shawnigan Lake show that water quality has been consistently good over the period of study, despite significant changes within the watershed. No parameters measured showed levels or trends which would cause concern at this time.

Water temperature, thermal stratification patterns and water clarity were similar with previous reports. Dissolved oxygen concentrations appear to be higher than those previously reported with greater periods of epilimnetic oxygen supersaturation in the summer months and greater hypolimnetic oxygen concentrations.

Phosphorus (P) is probably the most influential parameter with respect to water quality and aquatic ecosystems. The productivity of most lakes is limited by P and very small increases can have significant effects on both the chemical and biological aspects of water quality. Even though the population within the watershed has doubled since the last assessment and significant development and logging has taken place, total phosphorus concentrations have not increased and remain relatively low. This is probably the result of the lake's short residence time which flushes out approximately half the phosphorus inputs for a given year.

The low P levels in Shawnigan Lake are also reflected in the ratio of total nitrogen to total phosphorus (N:P). The N:P ratio is useful for confirming the limiting nutrient for a given lake and its trophic status, as well as tracking changes in nutrient inputs into the system. N:P ratios greater than 27:1 indicate oligotrophic conditions while a decreasing trend in N:P ratios would indicate a shift towards eutrophic conditions. Spring overturn N:P ratios for Shawnigan Lake are showing an overall increasing trend which appears to be the result of lower phosphorus concentrations rather than higher nitrogen levels. The N:P ratios indicate that Shawnigan Lake is oligotrophic and very phosphorus-limited.

The one area of concern would be the West Arm which has always had the highest inputs of nutrients and sediments. Because this area is relatively

shallow and isolated from the main basins of the lake it could be more susceptible to increasing nutrient inputs in the future.

Overall, the biological analysis component of this study indicates no impairment to water quality. Phytoplankton and zooplankton concentrations and communities were consistent with good water quality.

Microbiological indicator guidelines were exceeded during 2003 in both the inflow streams and the lake itself. This prompted a follow-up effort at two sites located near the two largest domestic intakes on the lake during the 2004 fall freshet. The results of this sampling were all below guideline levels, however the earlier exceedances demonstrate the need to treat any water withdrawn for domestic purposes to prevent potential health risks.

Water Quality Objectives

Water quality objectives proposed for Shawnigan Lake are summarized in Table 1. The objectives are based on B.C. approved and working guidelines for water quality and on available data on ambient water quality, waste discharges and water uses. As future 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 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 waterbody, or may describe water quality conditions which can be met 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 water quality objectives for Shawnigan Lake are for the protection of drinking water supplies, aquatic life and recreation. These objectives, which are based on or exceed approved B.C. water quality guidelines, are proposed for dissolved oxygen, water clarity (Secchi depth), total phosphorus, total nitrogen, nitrogen:phosphorus (N:P) ratios, turbidity, total organic carbon, chlorophyll *a*, *E. coli*, enterococci and fecal coliforms. The objectives are required to ensure that inputs from non-point sources of contaminants do not impair water uses.

Monitoring Recommendations

It is recommended that spring overturn sampling continue on an annual basis at the four established lake basin sites. It is also recommended that two additional sites, located in close proximity to the main domestic water intakes, be sampled at spring overturn for microbiological indicators. The recommended monitoring program is summarized in Table 2.

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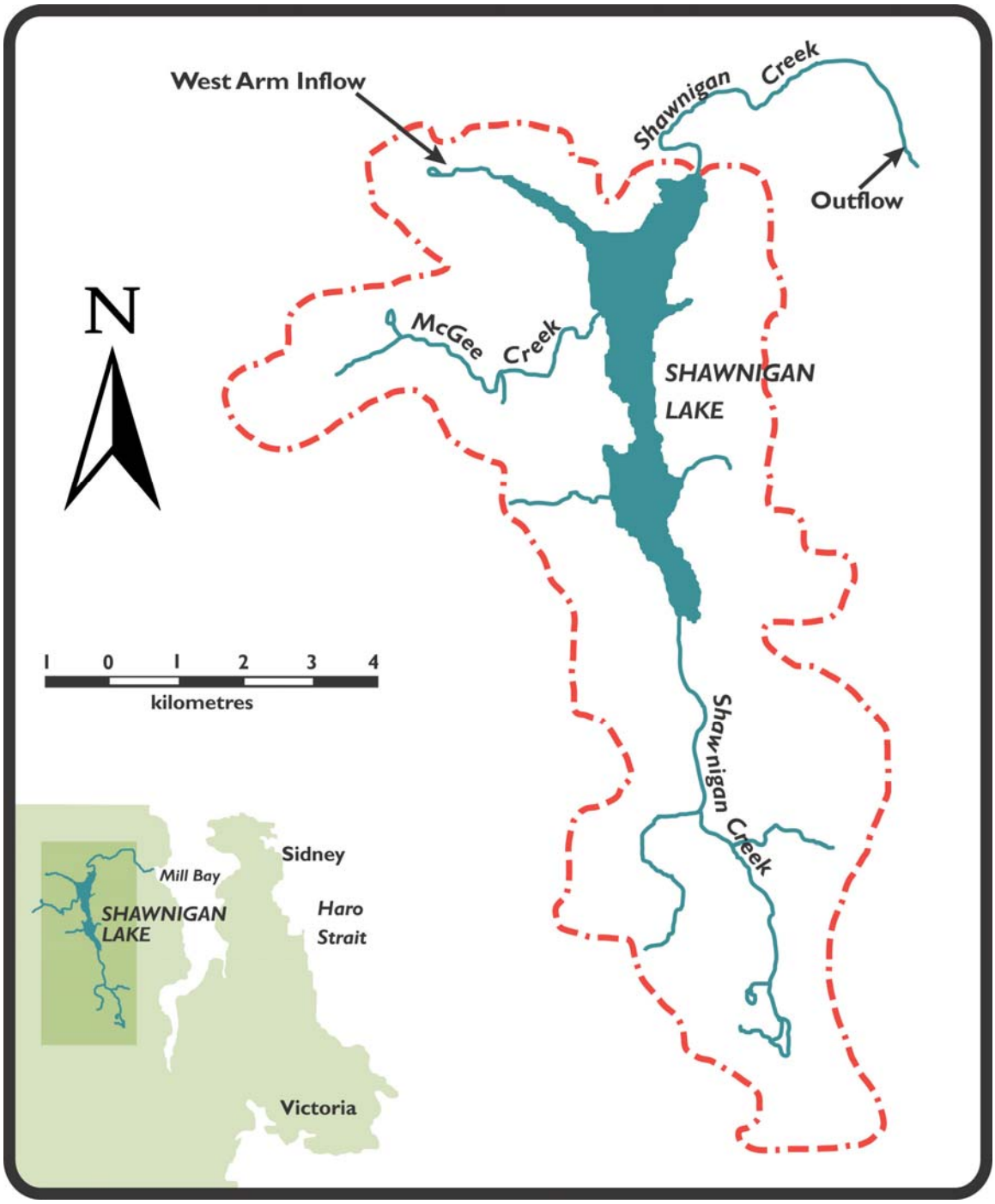
FIGURE 1

LOCATION AND WATERSHED BOUNDARY MAP



WATER QUALITY OBJECTIVES AND MONITORING TABLES

The following tables provide a summary of the objectives data and monitoring requirements.

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 and 90th percentile. Maximum concentration means that a value for a specific variable should not be exceeded. The term 90th percentile indicates that 9 values out of 10 should be less than a particular level.

TABLE 1
WATER QUALITY OBJECTIVES FOR SHAWNIGAN LAKE

Site	1199901	1199902	1199903	1199904	E257436	E257437
Designated Water Uses	Drinking water, recreation (primary contact), aquatic life					
Characteristics						
Dissolved Oxygen[1]	≥ 5 mg/L					
Secchi Depth[2]	≥ 5 m					
Total Phosphorus[3]	≤ 8 µg/L at spring overturn					
Total Nitrogen[4]	≤ 250 µg/L					
N:P Ratio[5]	≥ 30:1					
Turbidity[6]			≤ 1 NTU			
Total Organic Carbon	≤ 4 mg/L					
Chlorophyll *a*[7]	≤ 2 µg/L					
Escherichia coli[8]			≤ 10 CFU/100 mL (90th percentile)			
Enterococci[8]			≤ 3 CFU/100 mL (90th percentile)			
Fecal coliforms[8]			≤ 10 CFU/100 mL (90th percentile)			

[1]This objective applies to any depth of the water column throughout the year.
[2]Annual mean.
[3]This objective applies to the average of at least three samples taken throughout the water column (surface, mid depth, one metre above bottom) for sites 1199901 and 1199902 and to the average of at least two samples (surface and one metre above bottom) for sites 1199903 and 1199904.
[4]This objective applies to the average of at least three samples taken throughout the water column (surface, mid depth, one metre above bottom) for sites 1199901 and 1199902, at spring overturn.
[5]The N:P ratio is calculated using average total nitrogen and total phophorus concentrations.

[6] This objective applies to any grab sample taken within 10 m of a domestic water intake (E257436 and E257437). It also applies to sites 1199903 and 1199904 which likely reflect conditions near domestic intakes on the lake.
[7]Values are to be growing season averages for epilimnetic water in the main basin of the lake.
[8]The 90th percentiles are calculated from at least five weekly samples collected in a period of 30 days. For values recorded as <1, a value of 0 should be used to calculate the statistic. If any of the objectives are exceeded, further sampling should be conducted during the summer low flow and fall freshet periods, consisting of at least 5 weekly samples in a 30 day period.

TABLE 2
RECOMMENDED WATER QUALITY MONITORING FOR SHAWNIGAN LAKE

Site	Timing	Depth	Parameters
1199901	Spring overturn (preferably before February 28)	Surface, mid-depth, bottom (1 m above bottom)	**Nutrients:** total P, dissolved P, total N, NO_3+NO_2, NO_2, total organic N, ammonia, total organic C, total inorganic C **Total metals** **Anions:** dissolved chloride **Physical properties:** conductivity, pH, total solids, total dissolved solids, turbidity **Miscellaneous:** alkalinity, true colour **Field measurements:** DO (profile), temperature (profile), Secchi depth **Biological:** phytoplankton (1), zooplankton (2), chlorophyll *a*
1199902			
1199903		Surface, bottom (1 m above bottom)	
1199904			
E257436		Surface, bottom (1 m above bottom)	*E. coli*, enterococci, fecal coliforms (3)
E257437			

1. Surface (0.5m) unconcentrated 1 L sample preserved with Lugol's solution.
2. Vertical haul from 10 m to surface. Preserved in 5% formalin. Mouth size of net must be recorded.

If any of these results exceed objective levels, further sampling should be conducted during the summer low flow period and the fall freshet, consisting of at least 5 weekly samples in a 30 day period.

3. GLOSSARY

Readers unfamiliar with the technical terms used in water quality documents may find a glossary helpful. We have attempted to provide clear and concise definitions of those terms most frequently used.

Ambient
Refers to conditions in the surrounding environment.

Community watershed
Any natural watershed area on which a community holds a valid water licence issued under the *Water Act*.

Designated water use
A water use that is to be protected at a specific location.

Disinfection
The process of killing or rendering harmless microbiological organisms in water that cause disease by the application of a disinfectant (e.g. chlorine, chloramines, ozone, ultraviolet radiation).

Enterocci
Bacteria species inhabiting the gut of humans and other warm blooded animals which are used as an indicator of water contamination. Some forms can be pathogenic.

Epilimnion
The surface layer of a thermally stratified lake.

***Escherichia coli* (*E. coli*)**
A coliform bacteria inhabiting the gut of humans and other warm blooded animals which are used as an indicator of water contamination. Some forms are are pathenogenic (e.g., O157:H7).

Eutrophication
Increasing nutrient content in a body of water over time. This natural process may be accelerated by nutrient-rich discharges from agriculture or sewage, resulting in algal blooms, excessive growth of macrophytes or undesirable changes in water quality.

Fall freshet
A sudden increased period of stream flow as a result of heavy rainfall typical of coastal areas in the fall.

Fecal coliforms
Enteric bacteria inhabiting the gut of humans and other warm blooded animals which are used as an indicator of water contamination.

Hypolimnion
The cooler, deeper waters of a thermally stratified lake.

Oligotrophic
A water body with limited nutrient input or cycling, resulting in low levels of biomass production.

Phytoplankton
An assemblage of small plants suspended in the water column with little or no powers of locomotion.

Total nitrogen
A measure of all forms of nitrogen (organic and inorganic).

Total Phosphorus
A measure of all forms of phosphorus (organic and inorganic).

Water column
The portion of an aquatic or marine environment extending from the water surface to the bottom or the surface of the sediment.

Water Quality Guideline
Numerical value(s) for a physical, chemical or biological characteristic of water, biota or sediment which must not be exceeded to prevent specified detrimental effects from occurring to water use.

Water Quality Objective
A water quality guideline adapted to protect the most sensitive designated water use at a specified location with an adequate degree of safety, taking local circumstances into account.

Water residence time
A measure of measure of how often, usually in years, water is replaced in a lake based on flows into and out of the system.

Zooplankton
Microscopic animals which swim freely in the water column or are carried about by water currents. Many feed on **phytoplankton** and are in turn a staple diet of small fish.