SCIENCE & INFORMATION BRANCH
WATER STEWARDSHIP DIVISION
MINISTRY OF ENVIRONMENT

Water Quality Assessment and Objectives for Langford 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 Langford 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 recommendations are included. The technical report presents the details of the water quality assessment for Langford 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 Langford Lake. These are potentially derived from urban runoff, land development and on-site sewage systems.

Water quality objectives are recommended to protect aquatic life and recreational uses of the lake.

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;
- Recreation and aesthetics;
- Agriculture (livestock watering and irrigation)
- 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 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 twice during the calendar year, 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, 95^{th} percentile etc.).

INTRODUCTION

Langford Lake (Figure 1), located on southern Vancouver Island, is a popular recreational spot for local residents. At one time the lake provided domestic water for lakeshore residents; now it supports a good sport fishery and provides other recreational opportunities (boating and swimming) as well as aesthetic values for lakeshore residents. Continuing urban development within the watershed may present challenges for maintaining or improving the current level of water quality in Langford Lake. The purpose of this report is to develop water quality objectives for this lake to help ensure long-term sustainability of the water resource.

LANGFORD LAKE PROFILE

Watershed and Hydrology

Langford Lake is a small lake with a surface area of 60 ha, a volume of approximately 3,800 dam^3, a mean depth of 6.4 m and a maximum depth of 16 m. The lake has one main deep basin in the south-east end of the lake. Approximately half of Langford Lake's 60 ha surface area represents littoral areas less than 3 m in depth. The perimeter of the lake is 4.8 km.

Langford Lake has a watershed size of approximately 3.3 km^2 (Figure 1) with approximately 40% of this area covering Skirt Mountain to the north. There is one main inflow to the lake at the southeast corner of the lake and the outflow to the Goldstream River is at the northwest corner of the lake (Figure 1). There are also several smaller seasonal inflows around the lake. Lake levels are highest during the winter months and typically around 63 m above sea level. Water levels drop throughout the summer and generally reach a low of around 62.5 m at the beginning of October. The fall freshet normally starts around this time and the water levels quickly rise over the next several weeks to winter levels. The water residence time of Langford Lake is approximately 3.6 years.

Water Uses

There are four current water licences authorized to withdraw water from Langford Lake. It is unlikely that any of these are actually used for domestic (i.e., drinking) purposes and are probably used for watering lawns and other non-consumptive uses. Langford Lake provides significant recreational values for both lakeshore residents and visitors. With approximately half of the shoreline developed and occupied full-time, aesthetics are an important aspect of the lake for shoreline residents. There are four established swimming areas on Langford Lake including two public beaches which are well used in the summer months. Boating and canoeing are also popular activities although the use of outboard motors and personal water craft is not permitted.

Langford Lake provides a popular recreational fishery and is stocked annually with rainbow trout (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki clarki*). Between 1996 and 2005 Langford Lake has been stocked with more than 66,000 rainbow trout (the majority of which were of catchable size) and over 25,000 cutthroat trout (yearlings and fingerlings) with an estimated value at the time of release of approximately $80,000. Smallmouth bass (*Micropterus dolomieui*), pumpkinseed (*Lepomis gibbosus*) and yellow perch (*Perca flavescens*) also provide angling opportunities.

Land Use

Residential development is concentrated along the southeast and northeast shorelines with significant riparian vegetation along the northwest shoreline. There is a gravel pit at the northeast end of the lake which is partially encompassed within the watershed boundaries. This area is currently undergoing residential development which may result in removal of some of the native vegetation in that area. The Hull's Field area at the southeast end of the lake is being developed to enhance its recreational value. Included in the development will be a series of detention ponds to treat stormwater before it flows into the lake. There are also developments planned for the southwest end of the lake, which includes 105 ha of land between Langford Lake and Glen Lake, and on Skirt Mountain to the north of the lake.

Land-based recreational opportunities in this watershed include hiking trails and boardwalks along the western and northern shore of the lake, which are popular with local residents.

There are no permitted waste discharges within the Langford Lake watershed.

WATER QUALITY ASSESSMENT AND OBJECTIVES

Water Quality Assessment

Human land use and development (agriculture, septic systems and urban stormwater runoff) have contributed to the eutrophication of Langford Lake over time. The high level of productivity results in conditions within the lake that promotes the ongoing cycling of these nutrients, particularly phosphorus. Despite this, Langford Lake continues to provide many recreational opportunities including fishing, swimming, boating and hiking. Efforts to limit the impacts on water quality include the operation of an aerator since the mid-1980s and the local stewardship activities of the Langford Lake Area Protection Society

Langford Lake began to show signs of nutrient enrichment in the 1960s and studies resulted in an aerator being installed in 1984. Based on the 2005 temperature profiles, the aerator, which was originally designed to destratify the water column and increase dissolved oxygen concentrations, appears to have lost its effectiveness over the years. The temperature profiles from 2005 are very similar to those for pre-aeration conditions, with a thermocline established at 7 m to 8 m. The hypolimnetic summer water temperatures were well within the proposed water quality objective of 15° C, however the dissolved oxygen concentrations were very low in the summer months and did not meet the proposed water quality guideline of 5 $mg \bullet L^{-1}$ from June to October 2005.

The water chemistry parameters of concern in Langford Lake are phosphorus (P) and nitrogen (N). Spring overturn P concentrations typically exceed the water quality guidelines to protect recreational activities and aquatic life. In 2005, a maximum hypolimnetic total phosphorus concentration of 560 $\mu g \bullet L^{-1}$ was measured in November demonstrating the ongoing problem of internal nutrient loading in Langford Lake. Hypolimnetic total nitrogen concentrations also peaked in November 2005 at 2,300 $\mu g \bullet L^{-1}$, however other forms of N (e.g., ammonia and nitrate) were not found in excess. The increasing fall total phosphorus and total nitrogen concentrations and the resulting change in N:P ratio resulted in conditions more favourable for blooms of cyanobacteria (blue-green algae).

Other water chemistry parameters measured in this study were low and do not suggest any problems at this time.

The aquatic plant community has changed over the past 25 years with a shift in dominance from *Ceratophyllum demersum* to *Potamogeton amplifolius*. This shift may be due to an increase in water clarity which is demonstrated in reduced chlorophyll *a* concentrations and small increases in Secchi depth. Prior to aeration, the phytoplankton community was dominated by eutrophic diatoms in the winter and eutrophic cyanophytes throughout the rest of the year. In 2005, there was a more diverse community in the spring and summer months consisting of green algae, diatoms and cyanophytes, and a more cyanophyte-dominated community in the fall and winter. Based on these observations, it appears the water quality of Langford Lake has improved since the early 1980s.

The zooplankton community is indicative of eutrophic conditions; it is dominated by small grazing crustaceans and rotifers and species richness is low for the copepod and cladoceran components, however biomass and density is relatively high.

Microbiological contamination at public beaches on Langford Lake does not appear to be an issue based on available monitoring data.

While the overall eutrophic condition of Langford Lake does not seem to be degrading at the present time this is likely the result of the ongoing operation of the aerator. Phosphorus accumulations in the sediments are recycled within the lake during periods of low dissolved oxygen concentrations in the hypolimion and contribute to the high level of productivity. To address this problem, phosphorus must be removed from the system and options available include hypolimnetic withdrawal and increased flushing through periodic vegetation removal at the outlet. Continuing operation and maintenance of the aerator will help limit conditions (i.e., low dissolved oxygen) that promote internal nutrient loading; however, an assessment of the system by a qualified specialist would help determine if an upgrade or replacement is necessary. Lakeshore residents can also help limit nutrient inputs to the lake by maintaining their septic systems and, if possible, switching from septic to centralized sewer service and limiting their use of fertilizers for lawns and gardens.

Efforts to protect the water quality of Langford Lake will help protect property values around the lake; investments in the lake, such as the annual stocking of trout for the recreational fishery; and the recreational value of the lake for the many users of this popular urban lake.

Water Quality Objectives

Water quality objectives proposed for Langford Lake are summarized in Table 1. The objectives are based on B.C. approved and working guidelines to protect water quality for designated uses and on available ambient water quality data. 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 water quality objectives for Langford Lake are for the protection of aquatic life and recreation. Objectives are proposed for temperature, dissolved oxygen, water clarity (Secchi depth), total phosphorus, total nitrogen, nitrogen:phosphorus (N:P) ratios, chlorophyll *a*, phytoplankton community 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 deep station in Langford Lake. Samples should also be collected at this time from the inflow to determine the water quality of the inflow from the newly constructed detention ponds. It is also recommended that additional sampling be conducted at the deep station if water withdrawals occur at this site in the future. The recommended monitoring program is summarized in Table 2.

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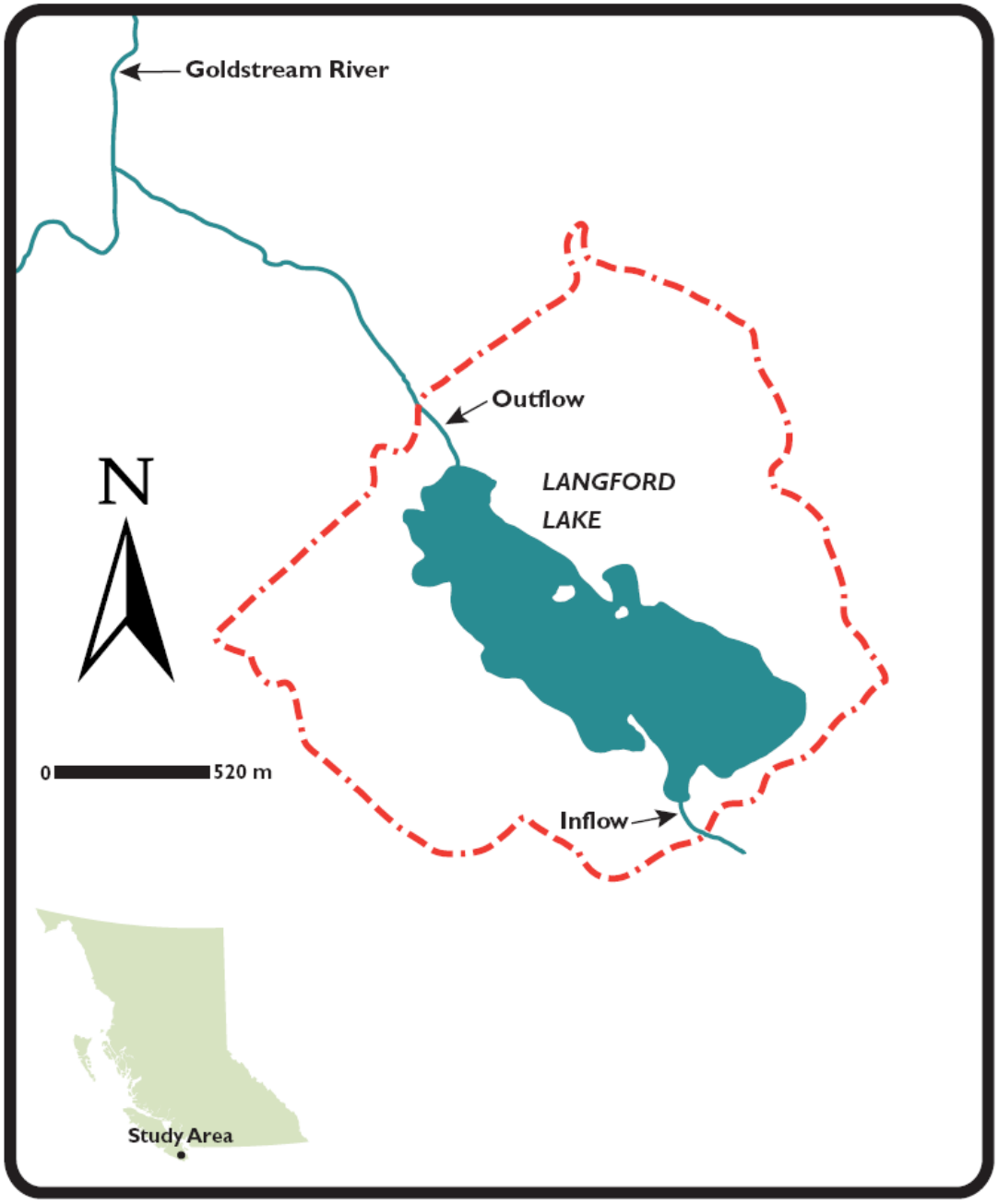
FIGURE 1

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.

TABLE 1
WATER QUALITY OBJECTIVES FOR LANGFORD LAKE

Site	**1100944**
Designated Water Uses	Recreation (primary contact), aquatic life
Characteristics	
Temperature	≤ 15° C (summer maximum hypolimnetic temperature)
Dissolved Oxygen	≥ 5 mg•L^{-1} (at any depth throughout the year)
Secchi Depth[1]	≥ 4 m (annual mean)
Total Phosphorus (short-term : 5 – 20 years)[2]	≤ 20 µg•L^{-1} at spring overturn
Total Phosphorus (long-term: > 20 years)[2]	≤ 10 µg•L^{-1} at spring overturn
Total Nitrogen[2]	≤ 500 µg•L^{-1} at spring overturn
N:P Ratio[3]	≥ 20:1
Phytoplankton community	> 50% non-cyannophyte species (cells•mL^{-1})
Chlorophyll *a*[4]	≥ 1.5 µg•L^{-1} ≤ 2.5 µg•L^{-1}
Fecal coliforms[5]	≤ 200 •100 mL^{-1} (geometric mean)

[1]Annual means are calculated from a minimum of 4 seasonal measurements.
[2]This objective applies to the average of at least three samples taken throughout the water column (surface, mid depth, one metre above bottom).
[3]The N:P ratio is calculated using average total nitrogen and total phophorus concentrations.
[4]Values are to be growing season averages for epilimnetic water in the main basin of the lake.
[5]Geometric means are calculated from at least 5 weekly samples in a 30 day period.

TABLE 2
RECOMMENDED WATER QUALITY MONITORING FOR LANGFORD LAKE

Site	Timing	Depth	Parameters
1100944	Spring overturn (preferably before February 15)	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, dissolved organic C, total organic C, total inorganic C, chlorophyll *a* **Total metals** (1) **Anions:** Anion package (Cl, Br, SO_4) **Physical properties:** conductivity, pH, total solids, total dissolved solids, turbidity **General:** alkalinity, true colour, silica **Field measurements:** DO (profile), temperature (profile), Secchi depth **Biological:** phytoplankton (2), zooplankton (3), chlorophyll *a*
E234410		Surface	**Nutrients:** total P, dissolved P, total N, NO_3+NO_2, NO_2, total organic N, ammonia, dissolved organic C, total organic C, total inorganic C **Total metals** (1) **Anions:** Anion package (Cl, Br, SO_4) **Physical properties:** conductivity, pH, total solids, total dissolved solids **General:** alkalinity, true colour, silica

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

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.

Ammonia
A measure of the most reduced inorganic form of nitrogen in water and includes dissolved ammonia (NH_3) and the ammonium ion (NH_4^+).

Chlorphyll *a*
The primary green-coloured pigment found in plants and algae which traps and converts light energy to chemically stored energy.

Colour, true
A measure of the dissolved colouring compounds in water. The colour of water is attributed to the presence of organic and inorganic materials which absorb different light frequencies.

Conductivity (specific conductance)
A quantitative measure of the ability of water to conduct an electrical current, related to the type and concentration of ions in solution. Specific conductance can be used for approximating the total dissolved solids concentration in water.

Cyanophytes (blue-green algae or cyanobacteria)
A group of phytoplankton which often cause nuisance conditions in water, so called because they contain a blue pigment in addition to chlorophyll. Blue-green algae are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen from the air to provide their own nutrients.

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

Dissolved oxygen (DO)
Oxygen dissolved in water and essential for respiration by most aquatic organisms.

Epilimnion
The surface layer of a thermally stratified lake.

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.

Geometric mean
The N^{th} root of the product of N observations.

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

Littoral
The region along the shore of a non-flowing body of water.

Macrophyte
The larger aquatic plants, including aquatic mosses, liverworts, larger algae and vascular plants.

Nitrate + nitrite (NO_3 + NO_2)
A measure of the most oxidized and stable form of N in a water body (NO_3) and an intermediate form (NO_2) that occurs in the biological conversion of NH_4 to NO_3.

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

Ortho-phosphorus
A measure of the inorganic oxidized and biologically available form of soluble phosphorus.

pH
A measure of the hydrogen ion concentration of a solution which provides a quantitative expression of its acidity or alkalinity ranging, from 0 to 14. pH 7 is neutral, less than 7 is acidic and more than 7 is alkaline or basic.

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

Recreational primary contact
Activities like swimming and water sports where a person has or risks direct contact with water through immersion or ingestion.

Secchi disc
A black and white disk used to measure the transparency or clarity of water in a lake by measuring the maximum depth at which it can be seen.

Stratification
The vertical temperature stratification of a lake which consists of: (a) the upper layer (**epilimnion**), (b) the middle layer (**thermocline**) and (c) the bottom layer (**hypolimnion**).

Thermocline
A well defined vertical temperature change or boundary; often associated with **thermal stratification** in lakes.

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.

Watershed
All lands enclosed by a continuous hydrologic drainage divide and lying upslope from a specified point on a waterbody.

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.