Water Quality

Ambient Water Quality Objectives For The Tsolum River Basin

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
Regional Operations, April 21, 1995
and
Don Fast, Executive Director, Environmental Protection
Environment and Lands HQ Division, April 24, 1995.

SUMMARY

This document is one in a series that presents water quality objectives for British Columbia. It has two parts: an overview and the report. The overview provides general information about water quality in the Tsolum River basin, and water quality objectives and monitoring tables for those readers requiring this information. It is intended for both technical readers and for readers who may not be familiar with the process of setting water quality objectives. The report presents the details of the water quality assessment in the Tsolum River basin, and forms the basis of the recommendations and objectives presented in the overview.

In 1984, BC Environment became aware of water quality problems created by acid drainage from an abandoned mine on Mount Washington. Several studies were done to assess the impact of the mine on water quality during 1983-89, and the Ministry of Energy, Mines and Petroleum Resources began reclamation of the mine in 1988.

This overview summarizes the results of the water quality assessment of the Tsolum River and its tributaries. Objectives for copper in the Tsolum River basin are proposed to protect water quality, and to guide the reclamation work at the Mt. Washington mine. All available data and current water quality criteria were used to derive the water quality objectives.

FIGURE

Figure 1. Tsolum River Basin and Selected Water Quality Monitoring Sites

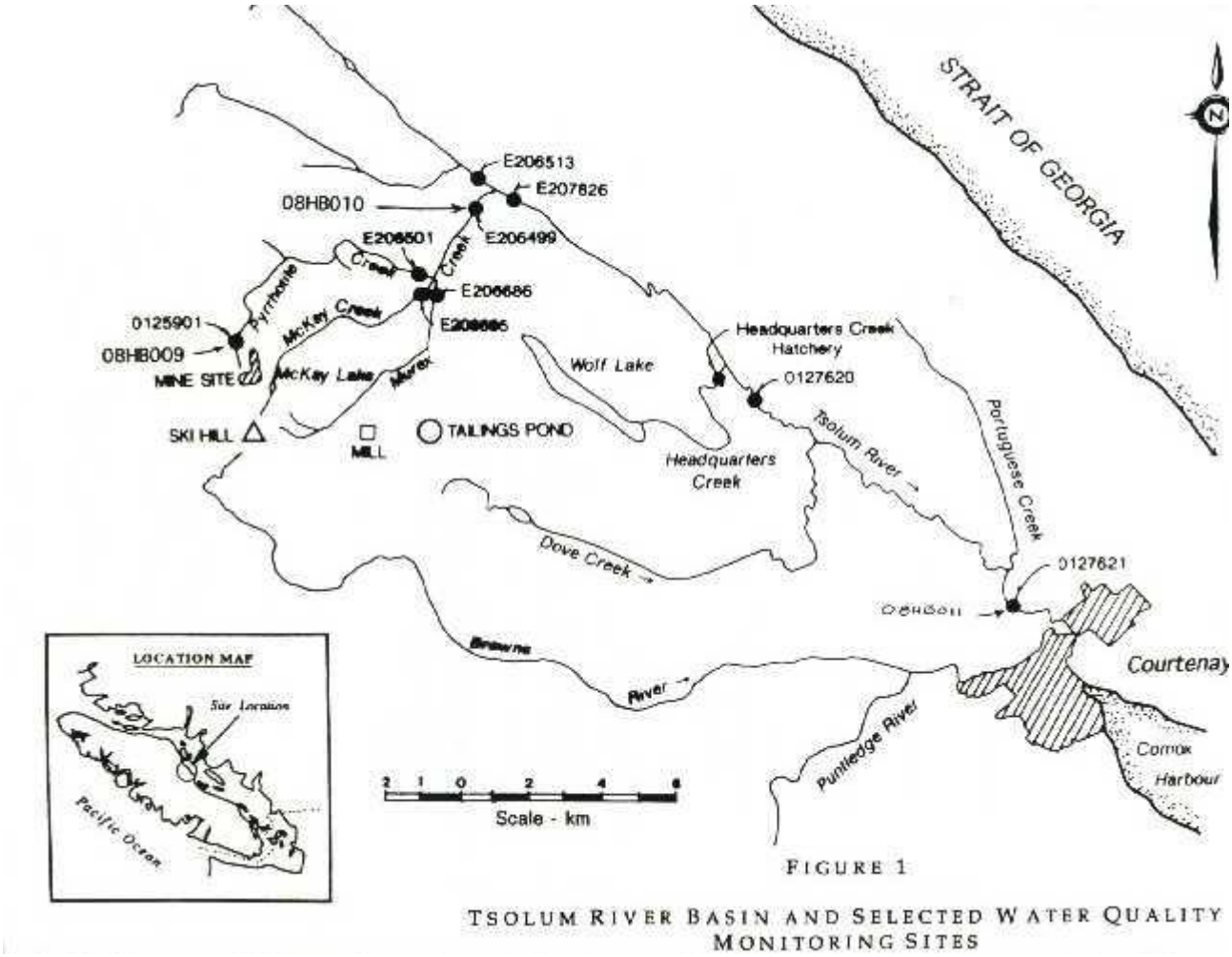

FIGURE 1

TSOLUM RIVER BASIN AND SELECTED WATER QUALITY MONITORING SITES

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 socioeconomic 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

This report assesses water quality in the Tsolum River basin. Water quality objectives for copper and steelhead egg survival in the Tsolum River and its tributaries are set to protect aquatic life (especially salmonid fish), which is the most sensitive water use in the basin for copper. Copper is the predominant toxic substance from the mine on Mt. Washington, and its control is the key to protecting aquatic life in the river. An analysis of the available data suggested that objectives for other substances are not needed at this time.

The Tsolum River originates on Mount Washington and flows southeast about 30 km before joining the Puntledge River just before it enters Comox Harbour and the Strait of Georgia. Murex, McKay, and Pyrrhotite creeks are the tributaries that drain the Mt. Washington mine to the Tsolum River.

The river is licensed for domestic and irrigation water supply. In the past, the river supported large populations of steelhead and resident rainbow trout, sea-run cutthroat trout, and coho, pink and to a lesser extend, chum salmon. The fisheries resource is believed to have declined in the basin predominantly because of the acid mine drainage from Mt. Washington. However, other factors such as the reduction of summer low flows by irrigation withdrawals, overfishing, logging and gravel extraction may have also played a role for certain species. The neighbouring Puntledge River has continued to support strong salmonid populations, despite similar human disturbances. In any case, the Tsolum River has the potential to support an extensive fishery, with or without an enhancement program.

HYDROLOGY

The Tsolum River is approximately 30 km long, from its origin on Mt. Washington to the point where it joins the Puntledge River in Courtenay, just upstream from Comox Harbour (Figure 1). The drainage area of the Tsolum River near its mouth at Courtenay is 258 km^2. Murex Creek drains 41 km^2 on the eastern flank of Mt. Washington, including the acid drainage from the abandoned mine. The drainage area of the Tsolum just downstream from Murex Creek is 78 km^2.

A hydrological analysis of the basin downstream from the abandoned mine was conducted to assist in the assessment of the water quality. The majority of the runoff from the mine was at 1300 m near the Mt. Washington ski area flows into the headwaters of Pyrrhotite Creek, through Murex Creek, the Tsolum River, and the Puntledge River, and discharges into Comox Harbour and the Straight of Georgia near Courtenay.

The patterns of runoff in the Tsolum watershed are influenced greatly by the mountain topography. The entire Tsolum watershed has a median elevation of 230 m and an average runoff of 1250 mm (10.2 m^3/s), with 71% of this occurring in winter due to rainfall. In contrast, the high-elevation Pyrrhotite Creek watershed (median elevation of 1300 m) has an average runoff of 2030 mm, with 50% occurring in

spring due to snowmelt. The Murex Creek watershed is intermediate in elevation (670 m median), and exhibits characteristics of both the spring snowmelt and winter rain regimes. All three watersheds experience very low flows during the summer.

WATER USES

Licences

The Tsolum River is licensed for domestic and irrigation water supply. There are 9 domestic water licenses and 23 irrigation licenses on the river, all downstream from Murex Creek.

Recreation

Water-based recreation in the Tsolum River, including fishing and swimming, occurs mainly downstream from Headquarters Creek.

Fisheries

In the past, the Tsolum River supported large populations of steelhead and resident rainbow trout, sea-run cutthroat trout, and coho, pink and to a lesser extent, chum salmon. Peak escapement (spawning returns) were: pink salmon - 100 000, coho salmon - 15 000, chum salmon - 11 000, and steelhead - 3 500, but there are virtually no escapements at present. The fisheries resource is believed to have declined in the basin predominantly because of the acid mine drainage from Mt.Washington, but other factors such as the reduction of summer low flows by irrigation withdrawals, overfishing, logging and gravel extraction may have also played a role for certain species. With the exception of Murex Creek, tributaries of the Tsolum have good water quality and are suitable for fish. However, the mainstem of the Tsolum exposes fish to higher copper levels at various stages of their life cycle.

The Tsolum River hatchery on Headquarters Creek was built by the Department of Fisheries and Oceans to maintain and enhance fish stocks in the Tsolum River. It was originally designed as an adult capture and egg-take facility to produce 3 million pink salmon fry. But in spite of its output, returns have been extremely poor.

In 1987 the 50-year values of the Tsolum River fishery were estimated to be $1.6 million with the current harvest, $9.5 million at the natural capability harvest, and $12.1 million with enhancement. Similarly, the 1987 number of annual angler-days was 188, with 3000 and 6000 possible at the natural capability and enhanced capability, respectively.

WASTE DISCHARGES

Several human activities influence water quality in the Tsolum River basin to varying degrees. They include residential development in and around Courtenay, logging in the headwaters of the tributaries,

road development and agriculture. However, the primary concern is the impact of acid drainage from the abandoned copper mine on Mt. Washington on water quality in the Tsolum River.

Mining

A small open pit copper mine was operated near the summit of Mt. Washington during 1964-67. The area disturbed was about 13 ha, with 940 000 t of waste rock and 360 000 t of ore excavated. The ore body is an iron-copper-sulphide despoit, which produces sulfuric acid when oxidized by bacteria in the presence of water and atmospheric oxygen. The acid dissolves the metals in the ore and waste rock remaining at the mine, resulting in acid drainage with very low pH and very high dissolved metals concentrations. The acid drainage flows into Pyrrhotite and McKay creeks, which flow into Murex Creek and the Tsolum River. Several metals are present at elevated concentrations in the acid mine drainage, but copper is the most toxic (to fish) by a factor of 10 or more.

The Ministry of Energy, Mines and Petroleum Resources began to reclaim the mine in 1988 to reduce the impacts on water quality, and work is anticipated to continue at least through 1994. Reclamation has focussed on diversion of water around the mine, covering waste rock to shed precipitation, and other measures to minimize water contact with acid-producing materials.

WATER QUALITY ASSESSMENT

During the assessment of the data, several observations were made regarding water quality in the Tsolum River basin:

The background water quality in the Tsolum basin indicates soft water, with near-neutral pH, and relatively little buffering capacity for acid inputs. Background metals are low, generally meeting water quality criteria for aquatic life. A few metals, including copper, slightly exceed these criteria, but the high organic binding capacity of the water renders the metals nontoxic to aquatic life.

Immediately downstream from the mine in Pyrrhotite Creek, the water is acidic (pH 3.6 - 4.7), and copper, cadmium, aluminum, manganese, zinc, chromium, iron, nickel and cobalt exceeded water quality criteria for aquatic life or drinking water. Copper is the most toxic metal to aquatic life by a factor of 10 or more.

Water quality improved with distance downstream from the mine as the acid drainage was diluted, neutralizing the pH and precipitating the metals. By the time the water reached the Tsolum River, where fish reside and the water is used for drinking and irrigation, copper was the only substance that was still at toxic levels. Copper exceeded criteria for aquatic life and was toxic in long-term fish bioassays, particularly during spring when the majority of the runoff was snowmelt.

Predicted copper levels in the Tsolum River just downstream from Murex Creek exceeded the proposed average copper objective 85% of the time during 1987 - 1990. Peak concentrations during spring snowmelt and fall rains were up to 6 times greater than the objective.

WATER QUALITY OBJECTIVES

Water quality objectives have been set for the dissolved copper in the Tsolum River basin to protect water quality for aquatic life, the most sensitive water use for copper (Table 1). The objectives consider the organic complexing capacity and background copper levels in the basin. An objective has also been set for steelhead egg survival as a direct measure of aquatic ecosystem health. Aquatic ecosystem health will also be assessed by monitoring benthic invertebrate populations, but we are unable to recommend an objective for these populations at this time.

The objectives apply to the entire Tsolum basin, excluding the Murex Creek basin and a 500 m reach of the Tsolum River immediately downstream from Murex Creek. The proposed water quality objective for copper were exceeded in the Tsolum River 500 m downstream from Murex Creek during 1987-90, indicating that additional reclamation of the Mt. Washington mine is required.

MONITORING RECOMMENDATIONS

There has been substantial water quality monitoring in the Tsolum basin since 1985. Monitoring should now focus on the most critical substance - dissolved copper, at the most critical location - just downstream from Murex Creek, during the most critical periods - spring and fall (Table 2). If the copper objectives can be attained during these times at this location, the rest of the basin will be protected. Monitoring is also recommended for free copper, humic acid and dissolved organic carbon to further develop the copper - organic complexing capacity relationship used to derive the objectives. A quality assurance program including field blanks, field replicates and reference samples is recommended to ensure that high quality data are collected.

To monitor the health of the aquatic ecosystem, we recommend triannual in-situ steelhead egg bioassays and measurement of benthic invertebrate abundance and diversity in the Tsolum River upstream and 500 m downstream from Murex Creek.

TABLES

Table 1. Tsolum River Basin Water Quality Objectives

Designated water uses include aquatic life, wildlife, drinking water, primary contact recreation, irrigation and livestock watering.

Characteristics	Objectives

dissolved copper	**0.007 mg/L as a 30-day mean 0.011 mg/L as a maximum**
***in situ* steelhead egg survival as a percent**	**no significant difference in percent survival at the 95% confidence level between test and control sites**

1. These objectives apply to the entire Tsolum River basin with the exception of the Murex Creek basin, the 500 m reach of the Tsolum River downstream from Murex Creek and the initial dilution zones of effluents. These latter excluded zones extend up to 100 m downstream from the point of discharge, from the surface to the bottom, but not exceeding 50% of the width of the waterbody.
2. The average is calculated from at least 5 weekly samples taken in a period of 30 days. For values below the detection limit use the detection limit to cacuate the statistic.

Table 2. Recommended Water Quality Monitoring for the Tsolum River

Characteristics	Frequency and Timing	Proposed Sites
dissolved copper	**weekly samples between April 15 and June 30 and between September 15 and November 30**	**Tsolum River 500 m d/s from Murex Creek SEAM site# E207826**
humic acids dissolved organic carbon free, dissolved and organic copper	**monthly samples in April, May, June, September, October and November**	**Tsolum River 500 m d/s from Murex Creek SEAM site# E207826**
***in situ*steelhead egg bioassays in modified Whitlock-Vibert boxes**	**triannual, April 15 to June 30, 2 weeks exposure**	**Tsolum River 500 m d/s from Murex Creek SEAM site# E207826 and u/s from Murex Creek at SEAM site# E206513**

benthic invertebrate abundance and diversity by Surber sampler	**triannual, April 15 to June 30**	**Tsolum River 500 m d/s from Murex Creek SEAM site# E207826 and u/s from Murex Creek at SEAM site# E206513**

Return To The Table of Contents

J. Deniseger, R.P.Bio
Environmental Protection
Ministry of Environment, Lands and Parks
Nanaimo

L. W. Pommen, MSc. P.Eng
Water Quality Branch
Ministry of Environment, Lands and Parks
Victoria