ENVIRONMENTAL PROTECTION DIVISION

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MINISTRY OF ENVIRONMENT

Water Quality Assessment and Objectives for the Tsolum River Watershed

OVERVIEW REPORT

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SUMMARY

This document is one in a series that presents water quality objectives for British Columbia. This overview report summarizes the findings of the technical report, which is available as a separate document. The overview report provides general information about the water quality of the Tsolum River, a watershed on the east coast of Vancouver Island in British Columbia. It is intended for both technical readers and for readers who may not be familiar with the process for 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 the Tsolum River, and forms the basis of the recommendations and objectives presented here.

Acid drainage from a copper mine which operated for a few years in the early 1960’s impacted water quality in the Tsolum River . Reclamation work in the 1980’s, early 2000’s, and most recently in 2009-2011 has led to vast improvements in water quality. The current primary activities within the watershed that could potentially impact water quality are timber harvesting, recreation, agriculture and residential use.

Water quality objectives are recommended to protect source water (raw drinking water supply), wildlife, aquatic life, recreation and irrigation.

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 (MoE) 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.

Authority to set Water Quality Objectives

The MoE has the authority to set water quality objectives under Section 5(e) of the *Environmental Management Act*. In addition, Section 150 of the *Forest and Range Practices Act* (FRPA) contains provisions for the MoE to establish objectives to protect water quality in designated community watersheds. This legislation is intended to protect consumptive uses of water in designated community watersheds within working Crown forests. For this reason, water quality objectives developed for community watersheds generally focus on potential impacts from timber harvesting, range activities, and forestry-related road construction.

The Tsolum River watershed has not been designated as a community watershed. The majority of the watershed is on private land, so the FRPA does not apply to most of the watershed. However, the MOE uses other tools, such as water quality objectives, and legislation such as the *Private Managed Forest Land Act* and the *Drinking Water Protection Act*, to ensure that water quality within these watersheds is protected and managed in a consistent manner.

How Objectives Are Determined

Water quality objectives are the safe limits for the physical, chemical, and biological characteristics of water, biota (plant and animal life), and sediment that protect all designated water uses in a given waterbody or a watershed. The water uses considered in this exercise are the following:

- source water for public water supply and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- industrial (e.g., food processing) water supplies.

Objectives are established in British Columbia for waterbodies on a site-specific basis, taking into consideration provincial water quality guidelines, local water quality, water uses, water movement, and waste discharges. 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, and biological characteristics affecting that waterbody.

How Objectives Are Used

In certain cases, objectives are used to address specific legislative requirements (e.g., *Water Act*, Municipal Sewage Regulation, Private Managed Forest Land Council Regulation). However, compliance with water quality objectives is often not directly enforceable unless established under the Government Actions Regulation (B.C. Reg. 582/2004). Objectives are most commonly used to guide the evaluation of the state of water quality in a watershed, the issuance of permits, licenses and legal orders, and the management of fisheries and the province's land base. Water quality objectives are also a standard for assessing the ministry's performance in protecting water uses.

Monitoring Requirement

Monitoring of water quality objectives is undertaken to determine if the designated water uses are being protected. Monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may not be met. In the case of forestry-related impacts, these critical times may be associated with periods of peak flows when the majority of suspended and dissolved particulates and other contaminants, such as bacteria, are introduced into a waterbody. Late summer periods of low flow could also be sensitive to impacts due to human disturbances. It is assumed that if all designated water uses are protected at the critical times, then they also will be protected at other times when the threat to water quality 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 water bodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses and the way objectives are expressed (e.g. mean value, maximum value, 95th percentile, etc.).

Vancouver Island Eco-Region Approach

There are over 60 community watersheds within the Vancouver Island Region of the Ministry of Environment. Rather than develop water quality objectives for each of these watersheds on an individual basis, an ecoregion approach has been implemented, whereby Vancouver Island has been split into six ecoregions based on similar climate, geology, soils and hydrology. Representative lake and stream watersheds within each ecoregion are selected and a three year monitoring program is implemented to collect water quality and quantity data, as well as biological data. Watershed objectives will be developed for each of the representative lake and stream watersheds based on this data, and these objectives will also be applied on an interim basis to the remaining lake and stream watersheds within that ecoregion. Over time, other priority watersheds within each ecoregion will be monitored for one year to verify the validity of the objectives developed for each ecoregion and to determine whether the objectives are being met for individual watersheds.

INTRODUCTION

This report examines the existing water quality of the Tsolum River and recommends updates to the existing water quality objectives for this watershed based on potential impacts of certain key water quality parameters of concern.

The Tsolum River was significantly impacted by acid draining from and abandoned copper mine on Mount Washington that operated for a few years in the 1960s. Early reclamation work was done in the 1980s by the Ministry of Energy, Mines and Petroleum Resources, and water quality objectives were developed in 1995 for dissolved copper and steelhead egg survival. As further water quality improvement was needed, a partnership approach was taken. Work by the partnership included the rerouting of Pyrrhotite Creek, a tributary to the Tsolum River which carries runoff from the minesite, through a wetland. This was not a permanent solution, and the partnership began more reclamation work in 2009. This involved covering the site with a thick geomembrane, glacial till, soil and large woody debris, followed by revegetation. The intent of this project was to minimize the amount of precipitation and groundwater flowing through the minesite.

The Tsolum River water uses include water licences for drinking water and irrigation, recreational values (both primary and secondary contact), and important fisheries values with pink, coho and chum salmon, and resident and anadromous rainbow and cutthroat trout, Dolly Varden and three-spine stickleback present. Current anthropogenic land uses within the watershed include timber harvesting, recreation, agriculture and residential use. These activities, as well as natural erosion and the presence of wildlife, all potentially affect water quality in the Tsolum River.

As water quality in the Tsolum River has improved substantially since the implementation of the minesite reclamation project, the original water quality objectives report is being updated to include other water quality parameters of interest, to ensure that all uses of the watershed are protected.

BASIN PROFILE

Watershed Description

The Tsolum River is approximately 40 km in length, from its origin on Mt. Washington to the point where it joins the Puntledge River in Courtenay, just upstream from Comox Harbour. The drainage area of the Tsolum River near its mouth at Courtenay is 258 km^2. Murex Creek, a significant tributary to the Tsolum River, 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. Other significant tributaries to the Tsolum River include Portuguese Creek, Dove Creek and Headquarters Creek. There are a number of named lakes within the watershed, including Wolf Lake, Regan Lake and Anderson Lake. Elevations in the watershed range from 1,592 m at the peak of Mt. Washington to near sea-level at the confluence with the Puntledge River.

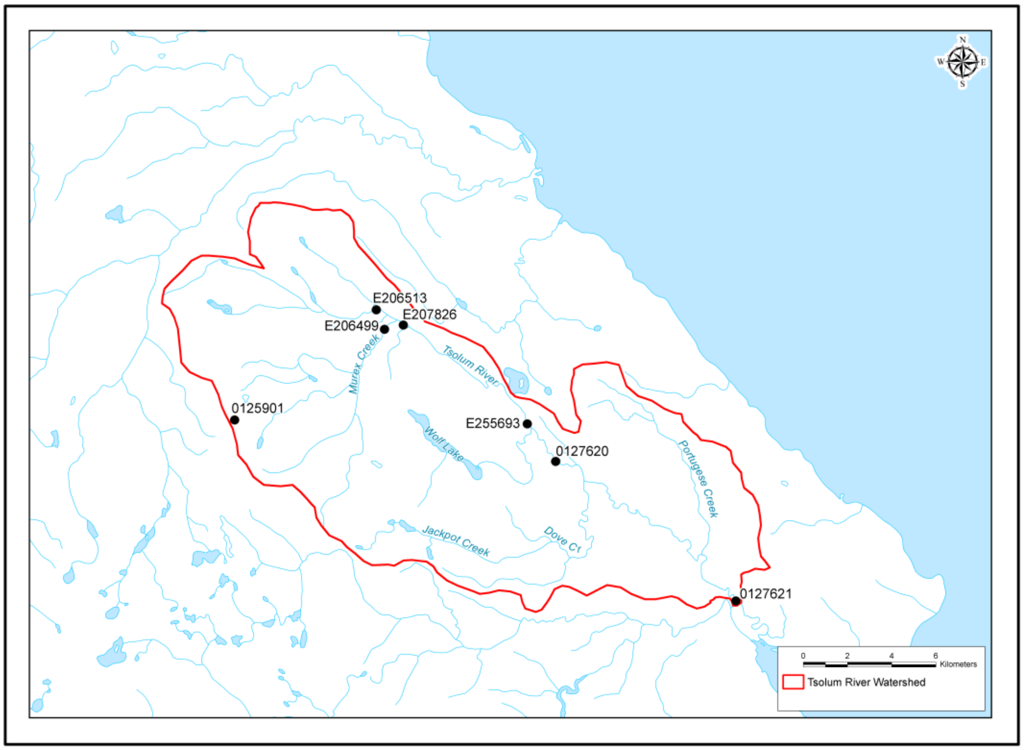

Figure 1. Map of the Tsolum River watershed, with sampling locations.

The Tsolum River watershed transitions from the Leeward Island Mountains (LIM) eco-region in the upper watershed to the Nanaimo Lowland (NAL) eco-region in the lower portion of the watershed (as established for Vancouver Island by MOE staff).

Hydrology

Water Survey Canada (WSC) operated three long term hydrometric stations in the Tsolum River watershed, the earliest installed in 1914. On average, flows were twice as high in the lower reaches of the Tsolum River as they were in the mid-watershed. In the Tsolum River just upstream of the confluence with the Puntledge River, mean daily flows ranged between a low of 0.001 m^3/s on July 31, 1985 to a maximum of 256 m^3/s on December 24, 2010. Flows are very low during the summer months, especially August and September, although storage on Wolf Lake licenced to the Department of Fisheries and Oceans and released by the BC Conservation Foundation augments these low flows.

Climate

The nearest climate station to the watershed for which climate normal data are available is the Comox A Station (Environment Canada Climate Station 1021830). Mean monthly temperatures between 1971 and 2000 ranged from 3.0°C in January to 17.6°C in both July and August, with an average annual temperature of 9.7°C; mean monthly temperatures are considerably lower at higher elevations within the watershed. Precipitation is very much a function of elevation, with annual average precipitation ranging from 1,490 mm per year at elevations below 250 m, to a maximum of 2,410 mm at the highest elevations. Only 6% of annual precipitation in Comox falls as snow, whereas the BC Environment Snow Pillow Station at the nearby Wolf River, elevation 1,490 m, has a considerable snowpack annually.

Water Uses

Water Licenses

Thirty-six water licenses have been issued for the Tsolum River mainstem, as well as seven licences on tributaries, allowing for the withdrawal of nearly 600,000 dam^3/year. The majority of the licensed volume is for use by the Department of Fisheries and Oceans (DFO) in Wolf Lake to maintain minimum summer flows to support fish populations. The remaining licenses are for domestic use and irrigation.

Recreation

Logging roads provide access to most of the watershed. Recreational use includes hiking, angling, mountain biking, and ATV riding, as well as hunting in the fall. The lower reaches of the Tsolum River are also used for primary contact recreation (i.e. swimming). As water quality continues to improve and population density in the area increases, it is likely that angling and swimming activities in the Tsolum River will increase in future years.

Fisheries

The Tsolum River historically has supported an extremely diverse and important fish population. Prior to the operation of the copper mine on Mt. Washington between 1964 and 1967 and extensive logging conducted in the watershed in the 1960's, the Tsolum produced large escapements of pink, coho and chum salmon as well as a few sockeye. There have also been populations of resident and anadromous rainbow and cutthroat trout, Dolly Varden, and three-spine stickleback. The copper mine, summer low flows, over-fishing, logging and gravel extraction may have all played a role in the reduction of certain species. 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, in particular pink salmon. Returns of pink salmon have continued to be erratic. Possible contributing factors include shifting substrates due to flood events reducing egg and fry survival, and high mortality in migrating young and adults due to habituated seal predation downstream of the Courtenay River bridge.

Flora and Fauna

The Tsolum River watershed provides habitat to a wide variety of both animal and plant species. In addition to flora and fauna typical of Vancouver Island, there are also a number of threatened or endangered species that have been observed within the watershed, including the Vancouver Island marmot, which has been observed on Mt. Washington.

Designated Uses

Based on the information presented here, the water uses to be protected should include aquatic life, wildlife, drinking water, irrigation and recreation.

Influences on Water Quality

Mining

The most significant anthropogenic impact on water quality within the watershed has unquestionably been the acid rock drainage (ARD) from the abandoned copper mine on Mt. Washington. The open pit mine was operated near the summit from 1964-67. The area disturbed was about 13 ha, with 940,000 t of waste rock and 360,000 t of ore excavated. The resulting ARD flowed into Pyrrhotite and McKay Creeks, which flow into Murex Creek and the Tsolum River. Several metals were present at elevated concentrations in the acid mine drainage, with copper being the most toxic (to fish) by a factor of 10 or more.

The reclamation work that the Ministry of Energy, Mines and Petroleum Resources conducted in 1988 and 1989 led to a decrease in copper concentrations, but not sufficiently to allow complete recovery of the fishery.

A partnership was developed to address water quality in the Tsolum River. The partnership has grown to include the Tsolum River Restoration Society, Timber West, Pacific Salmon Foundation, DFO, Environment Canada, Ministry of Energy, Mines and Petroleum Resources, Mining Association of B.C., Natural Resources Canada, Breakwater Resources and the Ministry of Environment. The partnership led the re-routing of Pyrrhotite Creek through the Spectacle Wetland in 2003, which further improved water quality in the Tsolum River but was a short term solution.

The partnership hired SRK Consultants in 2006 to determine the best remediation option for the minesite. Led by Quantum Murray, with SRK Consultants and Stantech, the remediation work began in 2009 and was largely complete in 2011. The minesite was covered with a thick geomembrane, glacial till, soil and woody debris, and then revegetated. The intent of the project was to minimize the amount of precipitation and groundwater flowing through the minesite. The benefits of the project have been immediate, although the overall effectiveness of the work will increase over time.

Land Ownership

The majority of the land within the Tsolum River watershed is privately owned. Lands upstream from Headwaters Creek are generally owned by forestry companies and managed as a timber resource. Between Headquarters and Dove Creeks, land use is divided between agricultural and rural residential use. Population density increases in the lower portion of the watershed, with residential and commercial properties the predominant land use. All of these land uses can have an impact of water quality.

Water Licenses

Water licenses can impact aquatic habitat downstream from the withdrawal, especially during low-flow periods. There are 43 water licences issued within the Tsolum River watershed with an overall maximum volume of 600,000 dam^3/year. The licence with the largest volume is issued to DFO, allowing them to store water in Wolf Lake and augment summer low flows in the river to protect fish habitat. Water is released usually beginning in mid-July until October rainfall begins to augment flow volumes. It is possible that irrigation withdrawals are affecting downstream flow, as maximum withdrawals generally coincide with minimum flows during the mid to late summer.

Forest Harvesting and Forest Roads

Forestry activities can impact water quality both directly and indirectly in several ways. The removal of trees can decrease water retention times within the watershed and result in a more rapid response to precipitation events and earlier and higher spring rain on snow events. The improper construction of roads can change drainage patterns, destabilize slopes and introduce high concentrations of sediment to streams.

Harvesting in the Tsolum River watershed peaked in the 1960's, corresponding with massive bedload movement in both the upper Tsolum River and Murex Creek channels. However, the equivalent clearcut area of the watershed has decreased considerably over the past few decades to approximately 20% currently. A recent hydrology study suggests that current forestry activities are likely not significant contributors to recent flooding events in the Tsolum River.

Recreation

Recreational activities can affect water quality in a number of ways. Erosion associated with 4-wheel drive and ATV vehicles, direct contamination of water from vehicle fuel, and fecal contamination from human and domestic animal wastes (*e.g.*, dogs or horses) are typical examples of potential effects. While no specific studies have been conducted on recreation within the Tsolum River watershed, impacts are possible from the activities listed above, as well as swimming that occurs in the lower watershed. The mine restoration project included the deactivation of roads leading to the minesite, to decreased access to recreational users.

Wildlife

Warm-blooded animals can carry microorganisms such as *Giardia lamblia* and *Cryptosporidium*, which are harmful to humans, causing gastrointestinal disease.

The Tsolum River watershed contains a variety of habitat types and provides a home for a wide variety of warm-blooded species. Therefore, the risk of fecal contamination from endemic wildlife exists.

Water Quality Assessment and Objectives

Water Quality Assessment

Six water quality monitoring locations were selected within the Tsolum River watershed: Site E206513 Tsolum River upstream from Murex Creek, E206499 Murex Creek upstream from Tsolum River, E207826 Tsolum River 500 m downstream from Murex Creek, E255693 Tsolum

River upstream from Headquarters Creek, 0127620 Tsolum River at Farnham Road, and 0127621 Tsolum River upstream from Puntledge River. Sites were selected to examine background water quality in the Tsolum River upstream from the ARD input, worst-case scenario water quality of undiluted water in Murex Creek, and four sites downstream from the inflow of ARD-impacted water, reflecting increasing dilution and therefore hopefully improving water quality, although lower sites also reflected impacts from other land uses in the lower watershed.

Water samples have been collected at various sites in the watershed dating back to the 1980's. However, for this report, only the 2009-2011 data were considered. This is because the vast improvement in water quality observed after the geomembrane was installed effectively resulted in a pre-remediation and post-remediation shift in water quality. As this most recent work is hoped to be a permanent solution, water quality objectives will therefore be based on the recent, post-remediation water quality. Samples were collected biweekly year-round between 2009 and 2011 at the Tsolum River site 500 m downstream from Murex Creek for a wide variety of parameters. For an eight-week period in the fall of 2009, as well as spring and fall of 2010, sampling frequency was increased to weekly and all six sites were sampled. In 2011 during the summer low flow (August-September) and fall flush (October-November) periods, samples were collected for *Escherichia coli* at the Tsolum River 500 m downstream from Murex Creek, upstream from Headquarters Creek, at Farnham Road and upstream of the Puntledge River. All samples were collected according to Resource Inventory Standards Committee (RISC) standards (BC MOE, 2003) by trained personnel.

The monitoring results for the Tsolum River show that the overall state of the water quality is much improved since the original water quality objectives report was written. Total and dissolved copper concentrations have decreased to the point where they are generally meeting water quality objectives. There were a few exceedances of provincial guidelines (temperature, turbidity, true colour, total organic carbon, copper, aluminum, cadmium, fecal coliforms and *Escherichia coli*) which have been associated either with rainfall events or summer low flows. Parameters of importance include turbidity, total suspended solids, true colour, total organic carbon, temperature, dissolved aluminum, dissolved copper and *E. coli*.

Water temperatures exceeded the aesthetic drinking water guideline and aquatic life guideline in the summer months. Temperature was only measured at the Tsolum River 500 m downstream Murex Creek, but with very low flows in the summer months in the lower watershed it is likely that elevated temperatures exist there too.

Turbidity levels in the Tsolum River were generally good throughout the year, with averages for each site ranging between 0.7 NTU and 1.8 NTU. The drinking water guideline was exceeded occasionally. Turbidity was slightly higher in the Tsolum River than in the Englishman River, the representative watershed for background conditions in the Nanaimo Lowland ecoregion. The higher turbidity the Tsolum River is likely related to forestry impacts and natural bedload movement. Elevated levels were usually associated with rainfall.

Total suspended solids concentrations (also referred to as non-filterable residue) were typically low with elevated values generally occurring between October and December after rain events.

Both true color and total organic carbon (TOC) values were occasionally above the BC drinking water guidelines. Disinfection with chlorine can result in disinfection byproducts such as trihalomethanes when raw water has high colour or TOC. As such, these parameters should continue to be monitored.

Nutrient values were generally low, although total phosphorus values were occasionally elevated. MoE is working towards a phosphorous objective for Vancouver Island streams. Phosphorous data should continue to be collected, and the need for a phosphorous objective should be re-evaluated after the next attainment monitoring period.

The impact of ARD has led to elevated concentrations of some metals in the Tsolum River watershed. Several sites had occasional exceedances of the aquatic life guidelines for dissolved aluminum. The Tsolum River 500 m downstream from Murex Creek had occasional exceedances of the site-specific dissolved copper maximum objective established for the Tsolum River, but the average copper objective was not exceeded. Murex Creek continued to show elevated copper concentrations, but the objective does not apply to this site. Attainment monitoring should show a decrease in aluminum and copper as the effects of the minesite remediation continue. The natural geology of the area also appears to have led to some elevated metal concentrations. The aquatic life guideline for cadmium was exceeded at two Tsolum River sites; however, it does not appear that the copper mine on Mt. Washington is the source, as concentrations in Murex Creek were lower than in the mainstem of the Tsolum River.

Naturally occurring organics in the watershed can bind substantial proportions of the metals which are present, forming metal complexes which are not biologically available. To aid in the future development of metals objectives, monitoring levels of organics, as measured by dissolved organic carbon (DOC), has been recommended. As increasing water hardness can affect the toxicity of some metals to some organisms, hardness has also been included in the Tsolum River monitoring program.

Concentrations of microbiological indicators were at times elevated during the low flow and high flow sampling periods. The drinking water guideline for *E. coli* for water receiving disinfection only was exceeded at every site in both summer and fall, with the exception of the Tsolum River 500 m downstream from Murex Creek in the fall. The primary contact recreation guideline was met at all sites in both summer and fall. While the source of these contributions is not known, it is likely that in the upper watershed, the source is wildlife. In the lower reaches of the Tsolum River, it is possible that agriculture, recreation and residential activities are also contributing to the fecal contamination. *E. coli* should continue to be monitored and assessed. These exceedances demonstrate the need to treat water for human consumption to prevent potential health risks.

Water Quality Objectives

Water quality objectives set for TSS, temperature, dissolved aluminum, dissolved copper and total cadmium are for the protection of aquatic life, while the remaining objectives are for the protection of drinking water (Table 1). Objectives are often developed using the background concentration approach, where data collected reflect natural or background conditions in the watershed. As the watershed has shown some impacts from previous forestry activity, data from the Englishman River, the representative watershed for background conditions in the Nanaimo

Lowland ecoregion, were considered for any parameters that were likely influenced by forestry-related impacts. The objectives are required to ensure that inputs from forestry activities, recreation, agriculture and residential use do not impair water uses. The objectives apply to the entire watershed except Murex Creek and its tributaries. Murex Creek has high winter flows and low or subsurface summer flows, as well as physical barriers to fish movement, and therefore does not represent a significant portion of the watershed's aquatic life habitat.

Monitoring Recommendations

The recommended minimum monitoring program for the Tsolum River watershed is summarized in Table 2. In order to capture the periods where water quality concerns are most likely to occur (i.e., spring freshet, summer low-flow and fall flush) we recommend that a minimum of five weekly samples be collected within a 30-day period between April and June, August and September, and October and November. Samples collected during the fall should coincide with rain events whenever possible. In this way, the three critical periods (maximum ARD influence from spring freshet, minimum dilution and maximum turbidity) will be monitored. Benthic invertebrate monitoring is proposed to provide a better understanding of the overall ecosystem health.

Table 1. Summary of proposed Water Quality Objectives for the Tsolum River watershed.

Variable	Objective Value
Turbidity	October to December: 5 NTU maximum January to September: 2 NTU maximum
Total suspended solids	26 mg/L maximum and ≤ 6 mg/L average
True colour	≤ 25 TCU average
Total organic carbon	4.0 mg/L maximum
Temperature	≤16°C weekly average
Dissolved aluminum	100 µg/L maximum ≤ 50 µg/L average
Total cadmium	≤ 0.01 µg/L average
Dissolved copper	11 µg/L maximum ≤ 7 µg/L average
Escherichia coli	October to November: ≤ 10 CFU/100mL 90th percentile December to September: ≤ 22 CFU/100mL 90th percentile

Note: all calculations are based on a minimum of 5 samples in 30 days

Table 2. Proposed schedule for future water quality and benthic invertebrate monitoring in the Tsolum River.

Frequency and timing	Parameters to be measured
April - June (spring freshet): five weekly samples in a 30-day period	Total and dissolved metals, hardness
August – September (low-flow season): five weekly samples in a 30-day period	TSS, turbidity, temperature, true colour, DOC/TOC, and *E. coli*
October-November (fall flush season): five weekly samples in a 30-day period	Total and dissolved metals, hardness, TSS, turbidity, true colour, DOC/TOC, *E. coli*
Once every five years	Benthic invertebrate sampling