ENVIRONMENTAL PROTECTION DIVISION

ENVIRONMENTAL SUSTAINABILITY DIVISION

MINISTRY OF ENVIRONMENT

Water Quality Assessment and Objectives for the Tsolum River Watershed

TECHNICAL REPORT
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EXECUTIVE SUMMARY

This document presents a summary of the ambient water quality of the Tsolum River, British Columbia, and proposes water quality objectives designed to protect existing and future water uses. The water quality assessment for the river and an evaluation of the watershed form the basis for the objectives.

The Tsolum River, with a length of 39.8 km, joins with the Puntledge River to become the Courtenay River, which runs for a short distance before draining into the Comox Harbour in Courtenay, BC. A copper mine which operated for a few years in the early 1960s has impacted water quality in the Tsolum River because of acid drainage, decimating once-strong salmonid populations. Early reclamation work in the 1980s, followed by the rerouting of Pyrrhotite Creek (a tributary to the Tsolum River carrying acid drainage from the mine) through a wetland, and culminating in the capping of the mine with a thick geomembrane between 2009 and 2011 has led to vast improvements in water quality. The water uses to be protected in the Tsolum River include aquatic life, drinking water, recreation, wildlife and irrigation. Logging roads provide recreational access to the watershed, and hunting, ATV use and hiking occur. These activities, as well as forestry, agriculture and wildlife, all potentially affect water quality in the river. Water quality objectives were developed for the Tsolum River in 1995, and this report examines more recent water quality data to update the existing objectives.

Water quality monitoring considered in this report was conducted between 2009 and 2011. The results of this monitoring indicated that the overall state of the water quality is much improved since the previous water quality report was written. Total and dissolved copper concentrations have decreased to the point where they are generally meeting water quality objectives. In order to maintain and protect water quality in the Tsolum River, ambient water quality objectives are recommended for turbidity, non-filterable residue (total suspended solids), true colour, total organic carbon, temperature, dissolved aluminum, dissolved copper, and *Escherichia coli*.

Future monitoring recommendations include attainment monitoring every 3-5 years, depending on available resources and whether activities, such as forestry, development or

agriculture, are underway within the watershed. This monitoring should be conducted for one year during the spring freshet (April – June) for total and dissolved metals, hardness and turbidity, and during summer low flow (August-September) and fall flush period (October – November) (five weekly samples in 30 days) for those and other parameters at the five existing Tsolum River monitoring locations.

Water Quality Objectives for the Tsolum River

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^{o}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

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AKNOWLEDGEMENTS

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1.0 INTRODUCTION

The British Columbia (BC) Ministry of Environment (MOE) is conducting a program to assess water quality in priority watersheds. The purpose of this program is to accumulate the baseline data necessary to assess both the current state of water quality and long-term trends, and to establish ambient water quality objectives on a watershed specific basis. Water quality objectives provide goals that need to be met to ensure protection of designated water uses. The inclusion of water quality objectives into planning initiatives can help protect watershed values, mitigate impacts of land-use activities, and protect water quality in the context of both acute and chronic impacts to human and aquatic ecosystem health. Water quality objectives provide direction for resource managers, serve as a guide for issuing permits, licenses, and orders by MOE, and establish benchmarks for assessing the Ministry's performance in protecting water quality. Water quality objectives and attainment monitoring results are reported out both to local stakeholders and on a province wide basis through forums such as State of the Environment reporting.

Vancouver Island's topography is such that the many watersheds of the MOE's Vancouver Island Region are generally small (<500 km^2). As a result the stream response times can be relatively short and opportunities for dilution or settling are often minimal. Rather than developing water quality objectives for these watersheds on an individual basis, an ecoregion approach has been implemented. The ecoregion areas are based on the ecosections developed by Demarchi (1996). However, for ease of communication with a wide range of stakeholders the term "ecoregion" has been adopted by Vancouver Island MOE regional staff. Thus, Vancouver Island has been split into six terrestrial ecoregions, based on similarities in characteristics such as climate, geology, soils, and hydrology (Figure 1).

Fundamental baseline water quality should be similar in all streams and all lakes throughout each ecoregion. However, the underlying physical, chemical and biological differences between streams and lakes must be recognized. Representative lake and stream watersheds within each ecoregion were selected (initially stream focused) and a three-year monitoring program was implemented to collect water quality and quantity data, as well as biological data. Standard base monitoring programs have been established for use in streams and lakes to maximize data comparability between watersheds and among ecoregions, regardless of location. Water quality objectives were developed for each of the representative lake and stream watersheds, 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.

Figure 1. Map of Vancouver Island Ecoregions

Partnerships formed between the MOE, local municipalities, and stewardship groups are a key component of the water quality network. Water quality sampling conducted by the public works departments of local municipalities and stewardship groups has enabled the Ministry to significantly increase the number of watersheds studied and the sampling regime within these watersheds. These partnerships have allowed the Ministry to study watersheds over a greater geographic range and in more ecoregions across Vancouver Island, have resulted in strong relationships with local government and interest groups, provided valuable input and local support, and, ultimately, resulted in a more effective monitoring program.

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. Based on this work, a water quality objectives report was developed in 1995 to set objectives for dissolved copper and steelhead egg survival. However, further improvement in water quality was needed to ensure that all uses of the watershed were being protected, and a partnership approach was taken. The Tsolum River partnership has grown to include the Tsolum River Restoration Society, TimberWest, the Pacific Salmon Foundation, the Department of Fisheries and Oceans, Environment Canada, Ministry of Forests, Lands and Natural Resource Operations, Mining Association of B.C., Natural Resources Canada, Breakwater Resources and the Ministry of Environment.

Early work conducted under this partnership included the rerouting of Pyrrhotite Creek (a tributary to Tsolum River which carries runoff from the minesite) through a wetland, but as the wetland's ability to remove copper is finite, a more permanent solution was needed. This involved covering the site with a thick geomembrane, resembling a heavy roofing material, through the summer of 2009. Since that time, the geomembrane has been covered with a substantial layer of glacial till to protect it from the elements, and an additional layer of organic soil and large woody debris. Finally, the site was revegetated and reseeded in 2011. The intent of the project was to minimize the amount of precipitation and groundwater flowing through the minesite. As water quality in the

Tsolum River has improved substantially since the implementation of this 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.

This report examines the existing water quality of the Tsolum River and recommends water quality objectives for this watershed based on potential impacts and water quality parameters of concern. Water uses include important fisheries values, water licences for drinking water and irrigation, and recreational values (both primary and secondary contact recreation). Anthropogenic land use within the watershed includes the abandoned mine, forestry activities, agriculture, residential use and recreational use. These activities, as well as natural erosion and the presence of wildlife, all potentially affect water quality in the Tsolum River. The project consisted of five phases: collecting water quality data, gathering information on water use, determining the land use activities that may influence water quality, assessing water quality based on land use influences and establishing water quality objectives

2.0 WATERSHED PROFILE AND HYDROLOGY

2.1 BASIN PROFILE

The Tsolum River is approximately 39.8 km long, from its origin on Mt. Washington to the point where it joins the Puntledge River in Courtenay, just upstream from Comox Harbour (FISS, 2012; Figure 2). 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.

The lower portion of the watershed falls within the Coastal Western Hemlock (Eastern very dry maritime, CWHxm1) biogeoclimatic zone, changing at about 400 m elevation to the CWHxm2 variant. This in turn gives way to the windward moist montane variant (CWHmm2) biogeoclimatic zone above 600 m, Mountain Hemlock (windward moist montane, MHmm1) above 800 and small areas above 1,200 m of Coastal Mountain-heather Alpine (CMAunp). 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).

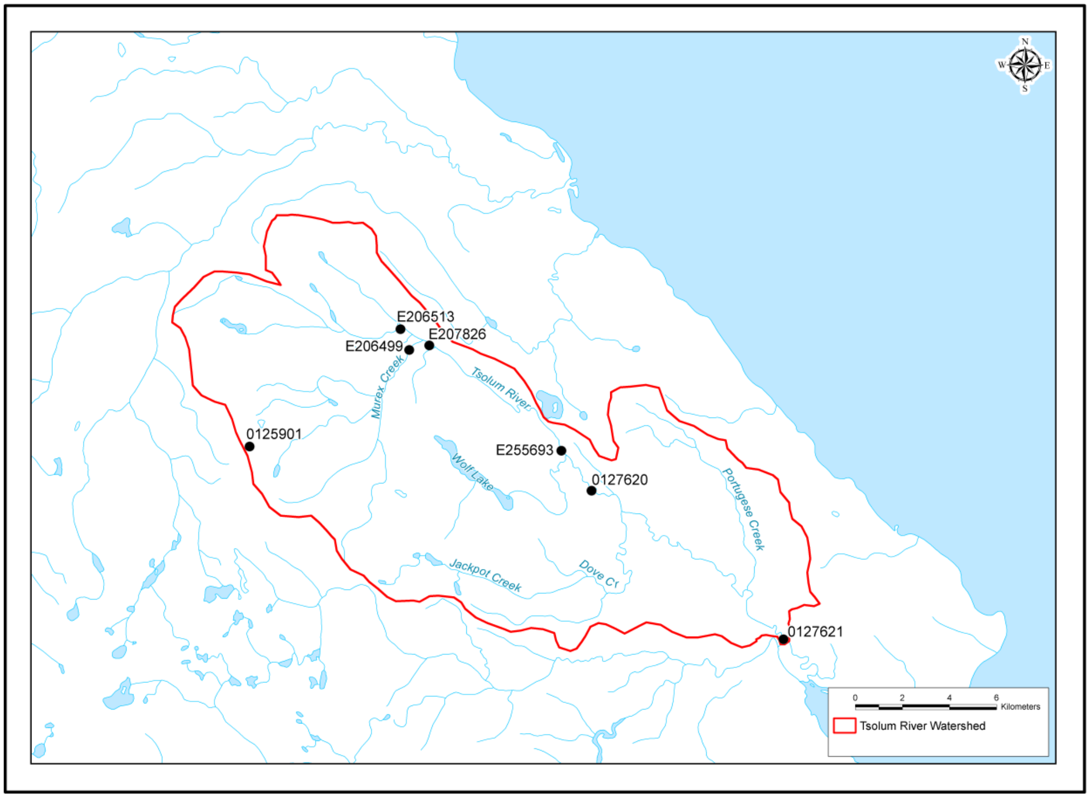

Figure 2. Tsolum River Watershed.

2.2 HYDROLOGY AND PRECIPITATION

A hydrology study conducted in 2011 by Northwest Hydraulic Consultants (NHC, 2011) provides a detailed examination of climate and hydrology within the Tsolum River watershed. The watershed is typical of those on the east coast of Vancouver Island, with mild, wet winters and warm, dry summers. Precipitation is very much a function of elevation, with annual average precipitation ranging from 1,490 mm per year at elevations below 250 metres, to a maximum of 2,410 mm at the highest elevations (NHC, 2011). Mean monthly temperatures measured at the nearest Environment Canada weather station (Comox A, Station 1021830) 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 (Figure 3) (based on 30-year climate normal data collected between 1971 and 2000). Once again, temperatures are a function of elevation and therefore mean monthly temperatures are considerably lower at higher elevations within the watershed. At the nearby Wolf River snow pillow station (BC Environment Automated Snow Pillow #3B17P, elevation 1,490 m), average daily temperatures measured between 1987 and 2011 were considerably lower, with mean monthly temperatures ranging from -2.0°C in December to 12.9°C in August (Figure 4). Obviously, this affects the relative percentage of precipitation that falls in the form of snow: snowfall accumulation is much lower in Comox (where only 6% of the annual precipitation falls as snow, and maximum average snow depth is 2 cm in January) than in Wolf River, which has a considerable snowpack annually (Figure 5).

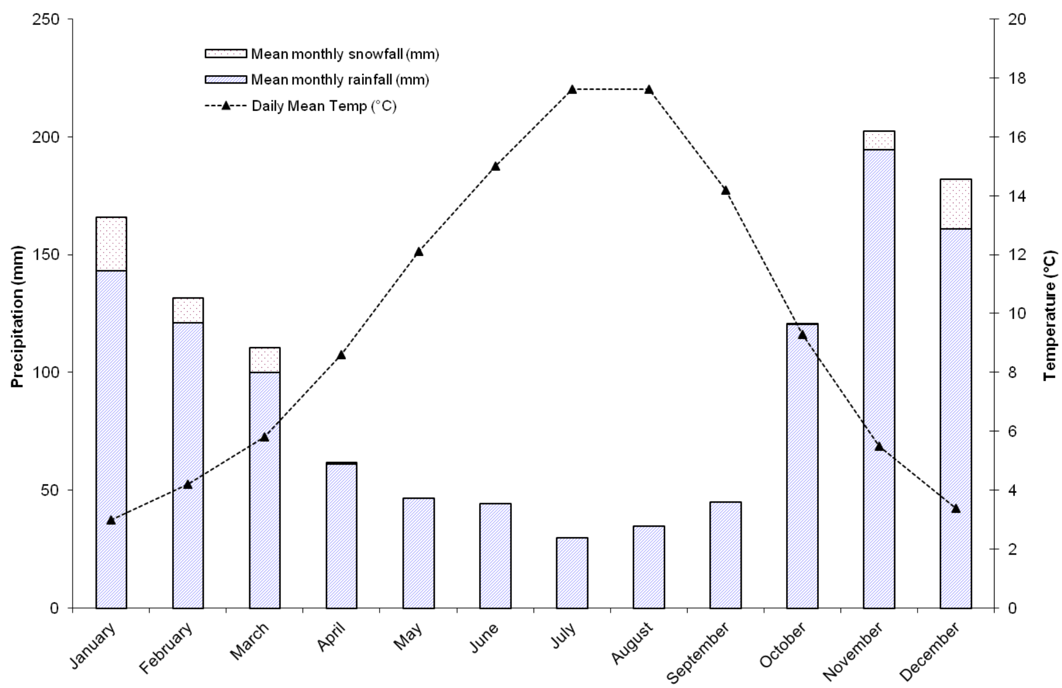

Figure 3. Summary of climate data for Comox from 1971-2000 (Environment Canada Weather Station 1021830).

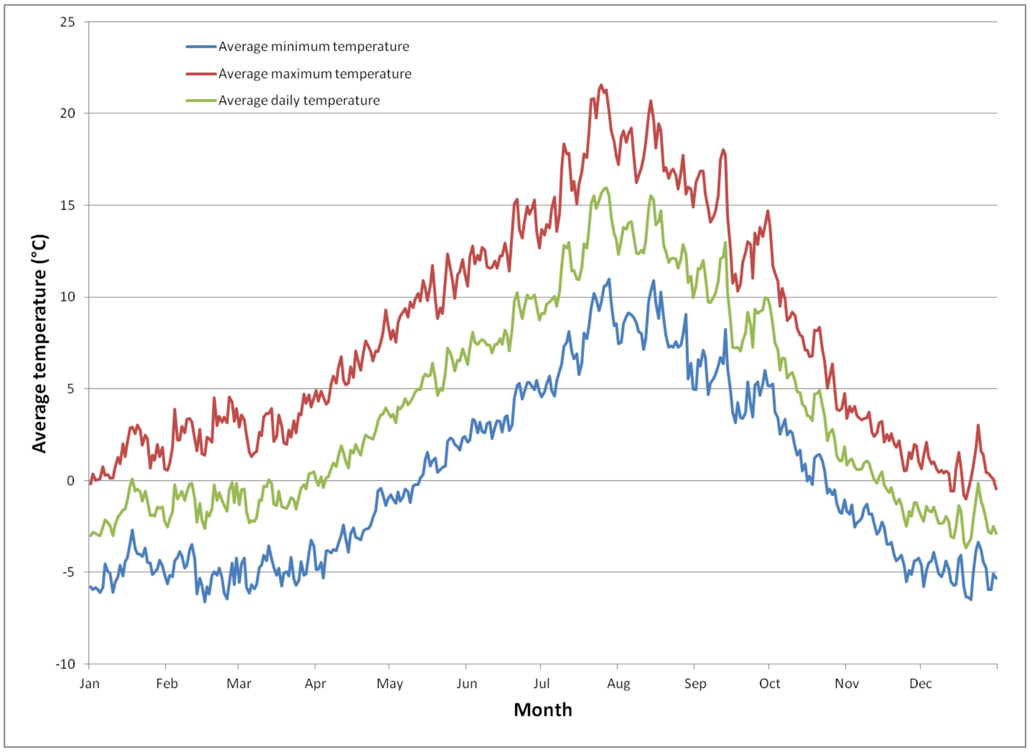

Figure 4. Average minimum, maximum and average daily temperatures measured at Wolf River snow pillow station (3B17P) between 1987 and 2011.

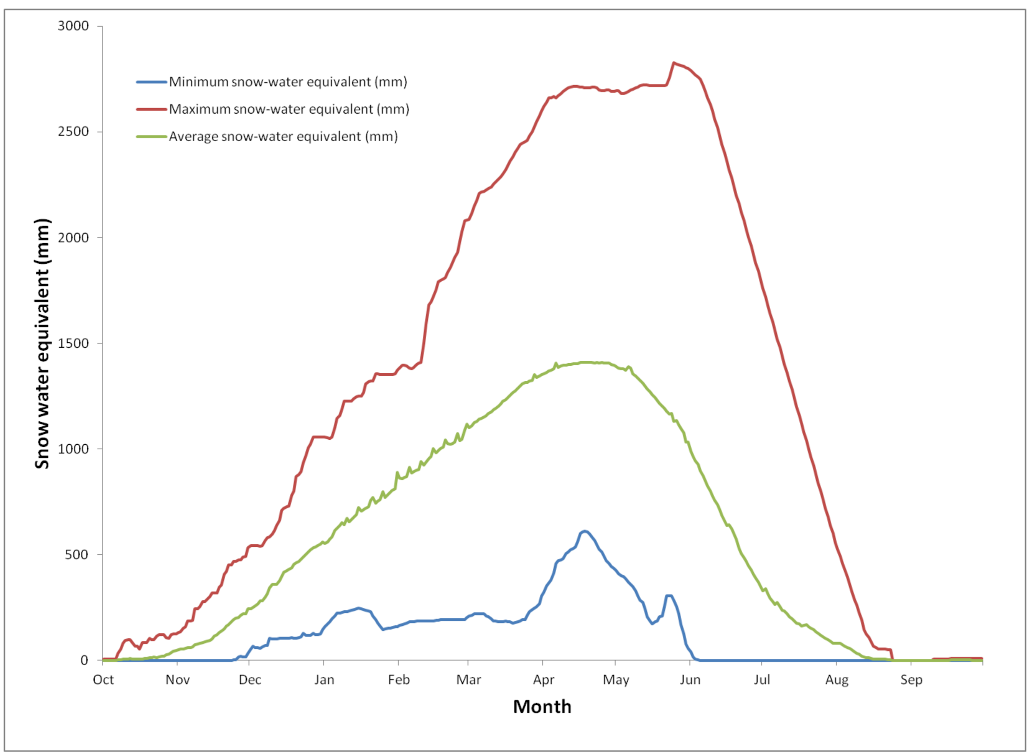

Figure 5. Minimum, maximum and average snow-water equivalent values measured at Wolf River snow pillow station (3B17P) between 1987 and 2011.

Water Survey Canada (WSC) has operated four hydrometric stations within the Tsolum River watershed, but only three of them were operated for a significant period of time. Station 08HB011 has been operating on and off at Tsolum River near Courtenay, upstream of the Puntledge River, since 1914, with approximately 50 years worth of data accumulated to date. Station 08HB089 has operated continually on the Tsolum River below Murex Creek since 1997, and Station 08HB075, Dove Creek near its confluence with the Tsolum River, has operated since 1985. Minimum, maximum and average daily flows for these sites are shown in Figures 6-8. On average, flows were about twice as high in the Tsolum River near Courtenay as they were downstream from Murex Creek. In the Tsolum River near Courtenay, 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.

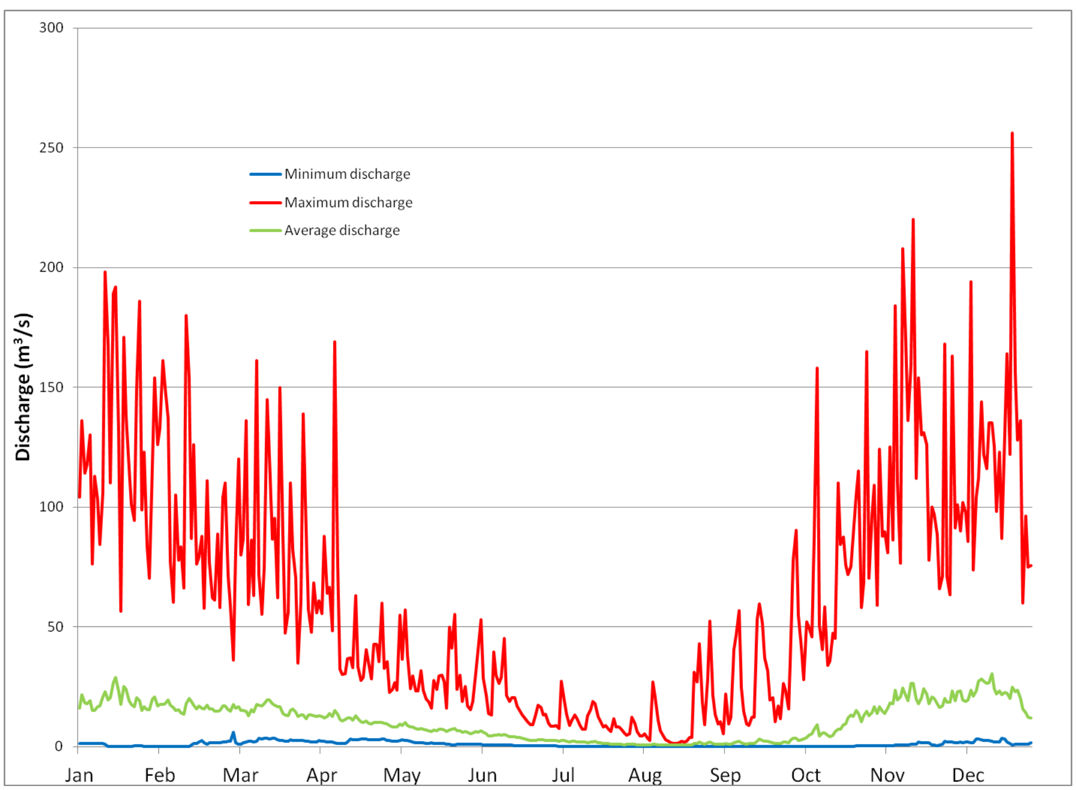

Figure 6. Discharge data for Tsolum River near Courtenay (WSC Station 08HB011) between 1914 and 2010 (Water Survey Canada, 2012).

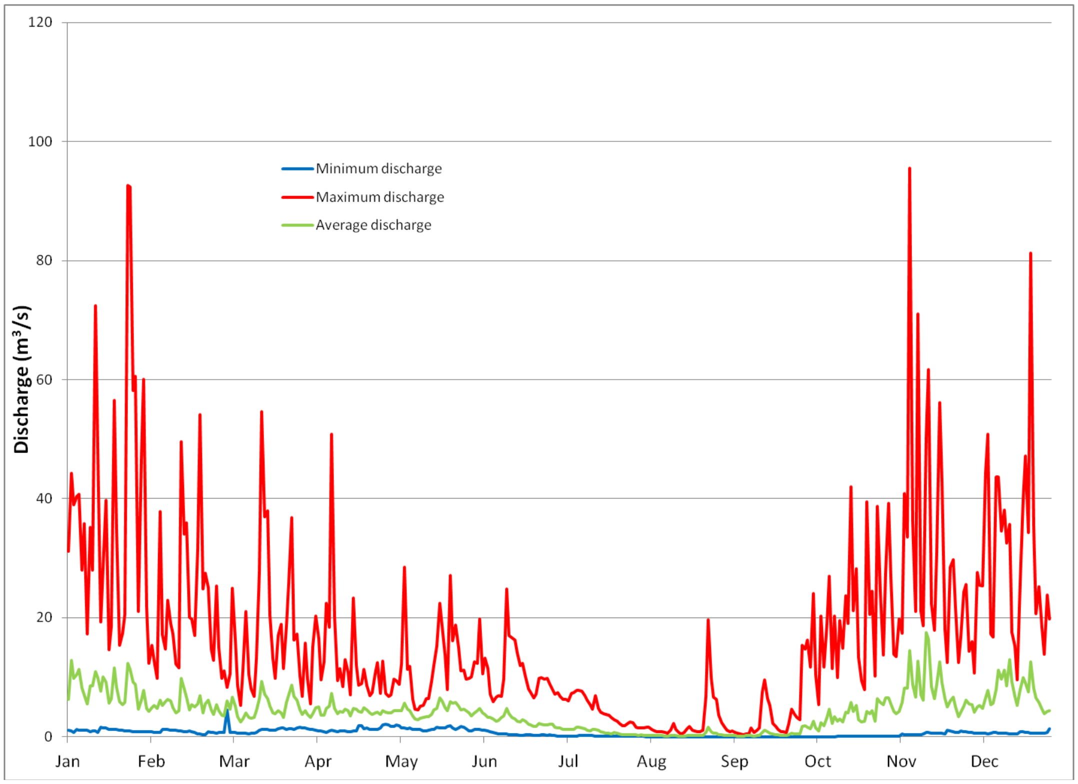

Figure 7. Discharge data for Tsolum River below Murex Creek (WSC Station 08HB089) between 1997 and 2010 (Water Survey Canada, 2012).

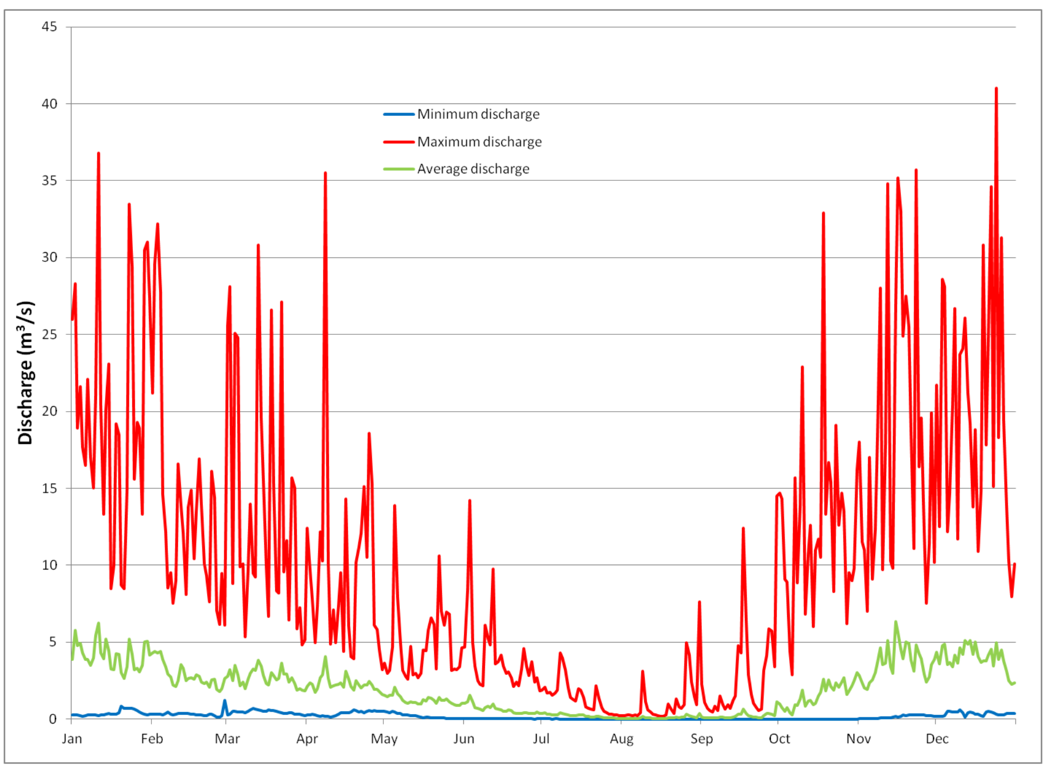

Figure 8. Discharge data Dove Creek near the mouth (WSC Station 08HB075) between 1985 and 2010 (Water Survey Canada, 2012).

Both extremely high and extremely low flows on the Tsolum River are of concern, and are the focus of a number of studies commissioned by various members of the Tsolum River partnership. The hydrology study conducted by NHC found that both overall precipitation and the number of significant floods have increased in the Tsolum River over the period of record (NHC, 2011), and the highest flood on record occurred in 2010. It is thought that bedload movement during these higher floods is impacting salmonid eggs and fry survival, and is contributing to the variability in the recovery of pink salmon populations. Low flows, especially in the lower mainstem of the Tsolum River, are a significant concern as they represent an obstacle to returning spawning salmon and the survival of their offspring. For this reason, water is stored in Wolf Lake from spring melt and rain events and partitioned out over the course of the summer, in an attempt to maintain a flow of at least 10% mean annual discharge (MAD). Another study (Gooding, 2007) examines the feasibility of increasing storage within the watershed by calculating the potential storage of the various lakes, should control structures be constructed, to facilitate meeting the goal of 10% MAD flows in the Tsolum River (as well as tributaries, if possible) over the course of the summer.

3.0 WATER USES

3.1 WATER LICENSES

Thirty-six water licenses have been issued for the Tsolum River mainstem, as well as seven licences on tributaries to the Tsolum River (four on Headquarters Creek, two on Portuguese Creek and one on Dove Creek) (Table 1). 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.

Table 1. Summary of water licences issued within the Tsolum River watershed.

Stream Name	Use	Number of licences	Total volume of licences (dam^3/yr)	Principle Licensee
Tsolum River	Domestic	13	16.59	Various
Tsolum River	Irrigation	23	506.10	Various
Dove Creek	Domestic	1	0.83	Various
Headquarters Creek	Conservation	4	599,451.94	DFO
Portuguese Creek	Domestic	2	0.83	Various
Total:		43	599,976.33	

3.2 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 and chinook. There have also been populations of resident and anadromous rainbow and cutthroat trout, Dolly Varden, and three-spine stickleback. Maximum historical escapements are summarized in Table 2.

Table 2. Summary of maximum and minimum escapements for salmonids in the Tsolum River watershed.

	Maximum		Minimum	
Species	Number	Year	Number	Year
Pink	100,000	1935, 1936, 1951	10	1984
Coho	15,000	1952, 1954, 1964, 1966	1	1997
Chum	18,000	2004	25	1958
Sockeye	25	1958, 1965-1968	0	most years
Chinook	10	1980	0	most years
Steelhead	3,500	unknown	0	since 1986

Populations of most species, including pink salmon, began to decrease in the early 1960's, prior to the operation of the copper mine, suggesting that other factors such as the reduction of summer low flows by irrigation withdrawals, over-fishing, logging and gravel extraction may have also played a role in the reduction of certain species. Analysis of aerial photographs of the watershed taken between 1938 and 1995 show a "severe" breakdown of mid-elevation boulder morphology in the upper Tsolum and Murex watersheds in the late 1950's and early 1960's followed by high levels of aggradation in the lower Murex Creek and in the Tsolum River upstream from Murex Creek in the early 1960's as the bedload material was carried downstream (Gooding, 2010). These fundamental changes in stream structure coincided with the first incidences of decreased salmonid populations.

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 three million pink salmon fry. Despite this output, returns of pink salmon were extremely poor through much of the 1990's. The facility began operation again in 2000, and since then another 2.5 million pink salmon fry have been produced. More recent escapements have improved significantly, with 45,000 pinks and returning in 2009 and 1,000 coho returning in 2010. However, returns of pink salmon have continued to be erratic. A number of possible contributing factors to this variability have been posited, including 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 (Brown *et al*., 2003).

3.3 RECREATION

Historically, there has been a strong recreational fishery within the Tsolum River watershed. Angler effort in the late 1960's was over 2,100 angler days/year for steelhead alone (BC Steelhead Harvest Analysis, from Campbell, 1999). Angling effort dropped of rapidly to less than 100 angler days/year in the 1980's, and only a few steelhead have been caught since 1987. However, with water quality in the Tsolum River improving due to the minesite remediation, and the health of other salmonid escapements in the river increasing, it is anticipated that steelhead will return to the Tsolum River and recover. Recent operation of a rotary screw trap by the Tsolum River Restoration Society (TRRS) has shown healthy populations of both rainbow and cutthroat trout, thought to be indicative of a remnant of the original steelhead population.

As well as angling, some reaches of the lower Tsolum River are 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 swimming activities in the Tsolum River will increase in future years.

3.4 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 (Table 3) (BCCDC, 2012). The most threatened species on the list, the Vancouver Island marmot, has been observed on Mount Washington.

Table 3. List of endangered species observed within Tsolum River watershed*.

Group	Species	Common name	Global status	Provincial status	COSEWIC	BC List
Vascular Plant						
	Euonymus occidentalis var. *occidentalis*	Western Wahoo	G5TNR	S1		Red
	Oxypolis occidentalis	Western cowbane	G4?	S2		Red
	Sidalcea hendersonii	Henderson's checker-mallow	G3	S3		Blue
Vertebrate						
	Sorex palustris brooksi	American Water Shrew, *brooksi* subspp.	G5T2	S2		Red
	Marmota vancouverensis	Vancouver Island Marmot	G1	S1	E	Red
	Megascops kennicottii kennicottii	Western Screech-Owl, *kennicottii* subspp.	G5T4	S3	SC	Blue
	Rana aurora	Northern Red-legged Frog	G4	S3S4	SC	Blue
	Mustela erminea anguinae	Ermine, *anguinae* subspp.	G5T3	S3		Blue
	Butorides virescens	Green heron	G5	S3S4B		Blue

KEY:
Global Status:
G1 - Critically imperiled; G3 - Vulnerable; G4 - Apparently secure; G5 - Secure; NR - not assessed; T - refers to subspecies
Provincial Status:
S1 - Critically imperiled; S2 - Imperiled; S3 - Vulnerable; S4 - Apparently secure; B – Breeding
COSEWIC:
E - Endangered; SC - Special Concern

3.5 DESIGNATED WATER USES

Designated water uses are those water uses that are designated for protection in a watershed or waterbody. Water quality objectives are designed for the substances or conditions of concern in a watershed so that their attainment will protect all designated uses.

As discussed above, water licenses have been issued for the Tsolum River watershed for drinking water and irrigation. In addition, salmonid species and other fauna are present in the river and surrounding area. Finally, the lower watershed is used for swimming. These suggest that water uses to be protected should include aquatic life, wildlife, drinking water, irrigation and recreation.

4.0 INFLUENCES ON WATER QUALITY

The majority of the watershed is privately owned, including large portions of the upper watershed by various logging companies. The most significant anthropogenic impact on water quality within the watershed has unquestionably been the acid rock drainage (ARD) from the closed copper mine on Mt. Washington. The lower portion of the watershed contains significant agricultural activity, as well as residential development in and around Courtenay. Forestry activities occur more in the upper portions of the watershed. These land uses, as well as recreational activities, all potentially affect water quality.

4.1 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 deposit, 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. Extensive work was carried out in 1988 and 1989. Through the early 1990's, reclamation activity gradually came to a halt. Total copper concentrations decreased somewhat, but not sufficiently to allow a complete recovery of the fishery. The re-routing of Pyrrhotite Creek through the Spectacle Wetland in 2003 further improved water quality, however a long term remediation plan was needed.

The Tsolum River partnership hired SRK Consultants in 2006 to determine the best remediation option for the mine site. In 2007, SRK completed the detailed design and cost estimates to complete the work. In April 2008, the Province of BC announced $4.5 million in funding to complete the needed work.

Lead by Quantum Murray (with SRK Consultants and Stantech), the remediation work had largely been completed by the summer of 2011. The work at the mine site involved covering the site with a thick geomembrane, resembling a heavy roofing material. The material was laid down in large rolls through the summer of 2009. Since that time, the geomembrane has been covered with a substantial layer of glacial till to protect it from the elements. The till layer has been covered with an additional layer of organic soil and large woody debris and 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 the next several years.

4.2 LAND OWNERSHIP

As mentioned above, the majority of the land within the Tsolum River watershed is privately owned. Lands upstream from Headwaters Creek are generally owned in large tracts by forestry companies and managed as a timber resource. Between Headquarters Creek and Dove Creek, land use is divided between agricultural use and rural residential properties. Population density increases in the lower portion of the watershed, with residential and commercial properties the predominant land use.

Lands within the Agricultural Land Reserve (ALR) are found in the lower portion of the watershed (Figure 9), often directly adjacent to the mainstem of the Tsolum River. Agricultural activity also occurs outside of the ALR and sediments, nutrients, pesticides, and animal waste can all be transported from farmland into the river. Many farm properties have limited riparian areas along the river and its tributaries.

Urbanization can impact water quality due to an increase in impervious surfaces (including parking lots, roads, houses, etc.) where water cannot be absorbed into the soil but rather runs directly into the nearest waterway. Pollutants associated with automobiles, rubbish, waste from domestic dogs and cats, and a wide variety of other potential contaminants can be washed into waterways. As well, clearing of the riparian areas in urban areas contributes to increased water temperatures, especially during the summer. Significant erosion has occurred along the stream banks of the lower Tsolum

River, as much of the stream bank has been historically logged, leaving immature conifers and deciduous trees that are prone to undercutting. Restoration work by TimberWest and the Tsolum River Restoration Society, including streambank armoring with rip-rap, boulder groynes, and large woody debris on various stretches of the river, is being conducted to minimize streambank erosion and siltation problems.

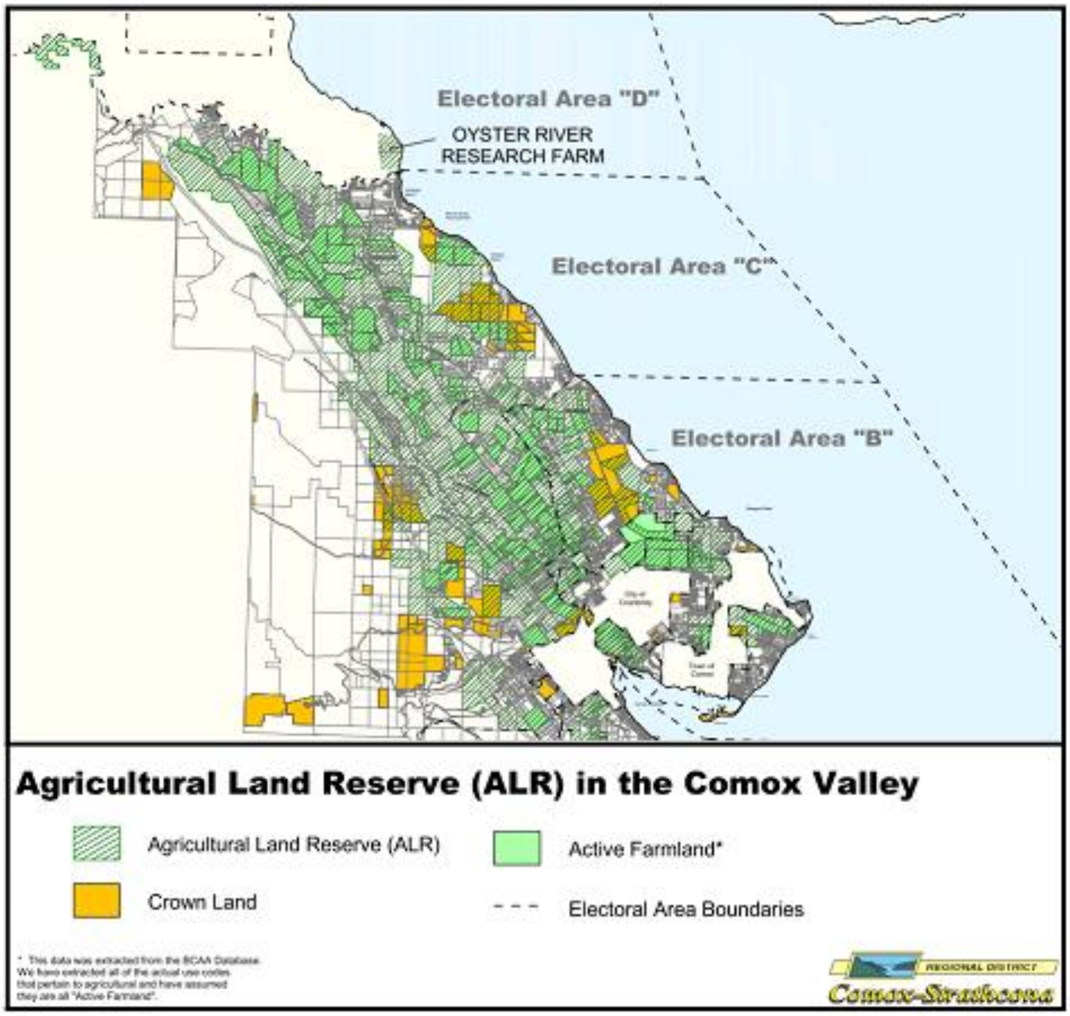

Figure 9. Tsolum River watershed, showing outlines of Agricultural Land Reserve (from CVRD, 2012).

4.3 LICENSED WATER WITHDRAWALS

There are 43 water licences issued within the Tsolum River watershed, of which 39 are for water withdrawals. Licenced withdrawals allow a maximum volume of 522.7

dam^3/year to be withdrawn from the Tsolum River mainstem, as well as 0.83 dam^3/year from both Dove Creek and Portuguese Creek. The remaining licenses for storage on Wolf Lake have been issued to DFO, allowing them to augment summer low flows to protect fish habitat. Water is released from Wolf Creek according to a rule curve developed to ensure a minimum flow of 10% mean-annual discharge (determined to be approximately 1 m^3/s) in the Tsolum River mainstem, 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.

4.4 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 freshets. The improper construction of roads can change drainage patterns, destabilize slopes, and introduce high concentrations of sediment to streams.

No recent coastal watershed assessment procedure (CWAP) has been conducted for the Tsolum River watershed. An aerial photograph analysis was conducted by Gooding in 2010, which shows that harvesting in the lower watershed was well underway by 1938, and harvesting activities in the upper watershed peaked in the 1960's, corresponding with massive bedload movement in both the upper Tsolum River and Murex Creek channels (Gooding, 2010). However, the equivalent clearcut area (ECA) of the watershed has decreased considerably over the past few decades, from a high of about 50% throughout the watershed and 60% or more in many sub-basins to the low 20% range currently (as reported to NHC, 2011 by TimberWest). The hydrology study conducted by NHC (2011) includes a summary of an earlier study which concluded that logging effects on peak flows in large, rain dominated Vancouver Island watersheds appear to be small. This fact, coupled with the decreasing ECA in the watershed, suggests that current forestry activities are likely not significant contributors to recent flooding events in the Tsolum River.

4.5 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.

No specific studies have been conducted on recreation within the Tsolum River watershed, and therefore an accurate assessment of actual impacts from recreation cannot be made. There are no forest recreation sites located within the Tsolum River watershed. Any swimming that occurs in the watershed would take place in the lower Tsolum River, where water temperatures are higher and the gradient is not as steep.

4.6 WILDLIFE

Wildlife can influence water quality because warm-blooded animals can carry pathogens such as *Giardia lamblia*, which causes giardiasis or “beaver fever”, and *Cryptosporidium* oocysts which cause the gastrointestinal disease, cryptosporidiosis (Health Canada, 2004). In addition, warm-blooded animals excrete pathogens, including *Escherichia coli*, in their feces, and can cause elevated levels of microbiological indicators in water. Fecal contamination of water by animals is generally considered to be less of a concern to human health than contamination by humans because there is less risk of inter-species transfer of pathogens. However, without specific source tracking methods, it is impossible to determine the origins of indicator bacteria.

The Tsolum River watershed contains a variety of habitat types, and provides a home for a wide variety of warm-blooded species including Columbia blacktail deer, black bear, cougar, Roosevelt elk, martin, river otter, red squirrels, eagles, hawks, owls, grouse and numerous other species of small birds. Therefore, a risk of fecal contamination from natural wildlife populations within the watershed does exist.

5.0 STUDY DETAILS

Total and dissolved metals concentrations (especially copper, as this has traditionally been the key metal of concern in this watershed) are considered to protect fisheries values, the most sensitive water use for these characteristics. Key drinking water characteristics, such as *E.coli*, turbidity, total suspended solids, true colour, pH, and specific conductivity, are considered to protect raw drinking water supplies. Drinking water is the most sensitive water use in the Tsolum River for these characteristics. In addition, based on current knowledge of potential anthropogenic impacts to the sub-watersheds (generally associated with historical mining, forestry, agriculture and urban development), these are the water quality parameters, in addition to metals such as copper, most likely to change should impacts occur. Nutrient (nitrate, nitrite and phosphorus) concentrations are also considered as these parameters may be influenced by forestry, urban or agriculture-related activities.

Six water quality monitoring sites were selected within the Tsolum River watershed: their BC Environment Environmental Monitoring System (EMS) identification numbers and site descriptions are given in Table 4 and illustrated in Figure 2.

Table 4. Summary of water quality monitoring locations within the Tsolum River watershed.

EMS Site Number	Description
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
0127621	Tsolum River upstream from Puntledge River

Sites were selected to enable us to examine 1) background water quality in the Tsolum River (upstream from its confluence with Murex Creek, which carries the ARD from the copper mine), 2) the “worst-case scenario” water quality of undiluted water in Murex Creek before it flows into the Tsolum River, and 3) four sites downstream from the inflow of ARD-impacted water, reflecting increasing dilution and therefore hopefully improving water quality. These lower sites will also reflect impacts from other land uses within the lower watershed, including agriculture and rural residential. The Tsolum River upstream from Murex Creek is in a forest harvesting area, and none of the sample sites represent completely unimpacted conditions.

Water samples have been collected at these sites (and other sites within the watershed) for a considerable period of record dating back to the 1980's. However, for this report, only the most recent data (from 2009-2011 for the Tsolum River site 500 m downstream from Murex Creek, and for 2010-2011 for the remaining five sites) were examined and used to recommend additional water quality objectives. This is due to the substantial improvement in water quality observed after the geomembrane was installed in 2009 and the subsequent recovery work which was conducted, resulting in effectively 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.

6.0 WATER QUALITY ASSESSMENT AND OBJECTIVES

There are two sets of guidelines that are commonly used to assess water quality. The BC MOE water quality guidelines are used to assess the source of water prior to the point of diversion into a waterworks system. These BC guidelines are also used to protect other designated water uses such as recreation and habitat for aquatic life. The development of water quality objectives (i.e. the site-specific application of BC water quality guidelines) for a specific water body can be integrated into an overall fundamental water protection program designed to protect all uses of the resource, including drinking water sources.

The *British Columbia Drinking Water Protection Act* (2005) and its associated regulation set minimum disinfection requirements for all surface supplies as well as requiring drinking water to be potable. The Vancouver Island Health Authority (VIHA) determines the level of treatment and disinfection required based on both source and end of tap water quality. As such, VIHA requires all surface water supply systems to provide two types of treatment processes.

The following sections describe the characteristics considered in assessing the water quality of the Tsolum River. Data are summarized in Appendix I.

6.1 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control was verified by collecting duplicate and blank samples. Duplicate (or triplicate) co-located samples are collected by filling two (or three) sample bottles in as close to the same time period as possible (one right after the other) at a monitoring location, and then calculating the percent difference between the laboratory results reported for the various samples. The maximum acceptable percentage differences between duplicate samples is 25%. However, this interpretation only holds true if the results are at least ten times the detectable limits for a given parameter, as the accuracy of a result close to the detectable limit shows more variability than results well above detectable limits. As well, some parameters (notably bacteriological indicators) are not homogeneous throughout the water column and therefore we expect to see a higher degree of variability between replicate samples. The Guidelines for Interpreting Water Quality Data (B.C. RISC, 1998) indicate that contamination has occurred when

5% or more of the blanks show any levels above the method detection limit. If the blanks are within the guidelines, the data is to be considered clean and the real sample data are to be treated as uncontaminated.

Twenty sets of duplicate samples were collected during the sampling program (two at site E206513, one at E206494, 11 at E207826, three at 0127620 and three at 0127621) (Appendix II). In 83% of the instances (905 of 1,090 variables monitored), relative percent mean differences were found to be within acceptable limits as discussed above. For the remaining samples, concentrations were almost invariably less than ten times the detection limits, and therefore the guidelines for interpreting acceptability do not apply. Twelve blank samples were also analyzed. Of the 550 parameters analyzed in the 12 blank samples, 478 were below detection limits and 14 were at detection limits, leaving 58 variables above detection limits. The majority of these were for low level nutrients (various forms of nitrogen or phosphorus), although there were also low levels of a few metals seen. Based on these samples, the data can be considered to be within acceptable limits for data quality.

6.2 pH

pH measures the concentration of hydrogen ions (H^+) in water. The concentration of hydrogen ions in water can range over 14 orders of magnitude, so pH is defined on a logarithmic scale between 0 and 14. A pH between 0 and less than 7 is acidic (the lower the number, the more acidic the water) and a pH greater than 7 and 14 is alkaline (the higher the number, the more basic the water). The aesthetic guideline for drinking water is a pH between 6.5 and 8.5 (McKean and Nagpal, 1991). Corrosion of metal plumbing may occur at both low and high pH outside of this range, while scaling or encrustation of metal pipes may occur at high pH. The effectiveness of chlorine as a disinfectant is also reduced outside of this range. The water quality guideline for pH for the protection of aquatic life is no statistically significant change in pH when ambient pH is outside of the range of 6.5 to 9.0 pH units (McKean and Nagpal, 1991). Inside of this range, there is no restriction on change.

pH in the Tsolum River watershed ranged from a minimum of 6.0 at the Farnham Road Bridge site to a maximum of 8.1 pH units upstream from the confluence with Murex Creek, with mean values at each site ranging from 7.1 to 7.4 pH units (Table 5). Two values were slightly below the lower threshold of 6.5 pH units for both drinking water and aquatic life. However, the minimum value measured at the Farnham Road bridge site was collected five minutes after another sample at the same site, which had a pH of 7.2 pH units, suggesting that there might have been a reporting or laboratory error. Regardless, the vast majority of values were well within the guidelines and there do not appear to be significant changes between sites, suggesting that pH is not presently a concern within the Tsolum River watershed. Therefore, no objective is proposed for pH in the Tsolum River.

Table 5. Summary of pH values (pH units) measured for the five Tsolum River sites and for the Murex Creek site.

Site Number	Minimum	Maximum	Average	No. of values
E206513	7.0	8.1	7.4	20
E206499	6.5	7.2	6.9	18
E207826	6.4	7.6	7.1	100
E255693	6.6	7.7	7.2	21
0127620	6.0	7.4	7.1	24
0127621	6.9	7.7	7.3	18

6.3 TEMPERATURE

Temperature is considered in drinking water for aesthetic reasons. The aesthetic guideline is 15°C. Temperatures above this level are considered to be too warm to be aesthetically pleasing (Oliver and Fidler, 2001). For the protection of aquatic life the allowable change in temperature is +/-1°C from naturally occurring levels. The optimum temperature ranges for salmonids and other coldwater species are based on species-specific life history stages such as incubation, rearing, migration, and spawning, and each species has its own optimum temperature range. Of the species of fish present in the Tsolum River, chum are the most sensitive to warmer temperatures (12-14 °C for rearing). Chum juveniles, however, are not present in the river during the summer months. Coho, cutthroat trout and Dolly Varden, which are present throughout the year, all have a maximum optimum temperature for rearing of 16 °C (Oliver and Fidler, 2001).

Water temperature data were collected for this study at only one site on the Tsolum River, downstream from the confluence with Murex Creek. Here, maximum summer temperatures measured between 2009 and 2011 were 20°C. However, as discussed in Section 2.2 and 4.3 the lower sections of the Tsolum River (where salmon typically spawn, and where water licence points of diversion tend to be located) are prone to very low water levels and elevated water temperatures during the summer. Studies examining the effects of temperature on pink salmon survival in the Tsolum River show that water temperatures typically exceed the optimum ranges for egg viability and result in increased adult mortality (Campbell, 2010). Releases from Wolf Lake help to ameliorate these low flows, and plans to increase storage on Wolf Lake will help to do so even in drier years. However, the outlet of Wolf Lake is shallow and therefore warmer surface waters are released during the summer months, rather than deeper, cooler water that would help keep water temperatures down in lower stretches of the Tsolum River. ***Due to the high summer temperatures and the high fisheries habitat values of the Tsolum River, a water quality objective is proposed to protect juvenile salmonids, in particular coho, cutthroat trout and Dolly Varden (the most temperature sensitive species in the river). The average weekly temperature should not exceed 16°C at any time during the year.*** While maximum temperatures in the lower portion of the river may exceed the guideline, as long as refuges remain with average temperatures below the guideline, juveniles should be able to retreat to these areas during periods of elevated temperatures. As stream enhancement projects, including planting and stabilizing banks and improving riparian cover, continue in the lower watershed, increased cover will hopefully help keep maximum summer temperatures within a more acceptable range.

6.4 CONDUCTIVITY

Conductivity refers to the ability of a substance to conduct an electric current. The conductivity of a water sample gives an indication of the amount of dissolved ions in the water. The more ions dissolved in a solution, the greater the electrical conductivity.

Because temperature affects the conductivity of water (a 1ºC increase in temperature results in approximately a 2% increase in conductivity), specific conductivity is used (rather than simply conductivity) to compensate for temperature. Coastal systems, with high annual rainfall values and typically short water retention times, generally have low specific conductivity (<80 µS/cm), while interior watersheds generally have higher values. Increased flows resulting from precipitation events or snowmelt tends to dilute the ions, resulting in decreased specific conductivity levels with increased flow levels. Therefore, water level and specific conductivity tend to be inversely related. However, in situations such as landslides where high levels of dissolved and suspended solids are introduced to the stream, specific conductivity levels tend to increase. As such, significant changes in specific conductivity can be used as an indicator of potential impacts. While elevated concentrations of metals such as copper contribute to specific conductivity, this contribution tends to be relatively minor. For example, concentrations of total copper in Murex Creek in the 1980’s in the range of 100 to 130 µg/L (well above aquatic life guidelines, see Section 6.9 corresponded to specific conductivity measurements in the range of 19 to 24 µS/cm.

In the Tsolum River, specific conductivity was measured the most frequently at the site 500 m downstream from the confluence with Murex Creek, where values ranged from 16 µS/cm to 64 µS/cm, with an average of 41 µS/cm. Values were correlated with flows, with the highest conductivity occurring during summer low flows (when dilution was lowest) and conductivity values dropping during the winter (when dilution from rainfall was highest). As there is no BC Water Quality Guideline for specific conductivity and the average specific conductivity observed was typical of coastal systems, no objective is proposed for specific conductivity.

6.5 TURBIDITY

Turbidity is a measure of the clarity or cloudiness of water, and is measured by the amount of light scattered by the particles in the water as nephelometric turbidity units (NTU). Elevated turbidity levels can decrease the efficiency of disinfection, allowing microbiological contaminants to enter the water system. As well, there are aesthetic concerns with cloudy water, and particulate matter can clog water filters and leave a film on plumbing fixtures. The guideline for drinking water that does not receive treatment to remove turbidity is an induced turbidity over background of 1 NTU when background is less than 5 NTU, and a maximum of 5 NTU (during turbid flow periods) (Caux *et al.*, 1997). VIHA's goal for surface source drinking water for systems that do not receive filtration is that they demonstrate 1 NTU turbidity or less (95% of days) and not above 5 NTU on more than 2 days in a 12 month period when sampled at the intake (Enns, pers. comm., 2009).

Turbidity levels ranged from a low of between 0.3 and 0.4 NTU at the five Tsolum River sites to a high of between 2.8 NTU at the Farnham Road bridge site to 16.3 NTU at the site 500m downstream from Murex Creek (Table 6). The maximum value of 16.3 NTU occurred on December 7, 2010, when 66 mm of rainfall was recorded in Comox. No water samples were collected at the other four Tsolum River sites on that day, but it is likely that they too would have shown elevated turbidity levels.

Table 6. Summary of turbidity values (NTU) measured at the five Tsolum River sites and the Murex Creek site.

Site number	Minimum	Maximum	Average	No. of values
E206513	0.4	3.2	1.2	35
E206499	0.1	3.0	0.7	30
E207826	0.1	16.3	1.0	113
E255693	0.3	9.5	1.8	31
0127620	0.4	8.0	1.6	39
0127621	0.4	7.6	1.6	22

Turbidity values were occasionally elevated at all of the Tsolum River sites. Turbidity measured in Murex Creek was lower on average than the Tsolum River sites (average of 0.5 NTU versus an average of 1.1 NTU to 1.6 NTU in the Tsolum River), suggesting that that Murex Creek is not a significant source of turbidity to the Tsolum River. It is likely that streambank erosion contributes to elevated turbidity values during rainfall and peak flow events. Regardless, it appears that occasional elevated turbidity levels are a concern.

Water quality objectives can be developed using a background concentration approach. However, in the Tsolum River, water quality data collected during the sampling period at the upstream site (Tsolum River at Duncan Main Road) do not reflect natural or background conditions due to past timber harvesting practices. Therefore, using the ecoregion approach described in the introduction, objectives developed from another watershed within the same ecoregion can be applied to other watersheds without objectives on an interim basis. As turbidity for the Tsolum River site it not considered background, the water quality data for the nearby Englishman River (Barlak *et al.* 2010) were incorporated into this review.

Turbidity in the Tsolum River was slightly higher on average than in the Englishman River (Table 7), but similarly was driven by storm events and was slightly higher in the fall than in the summer. As there was little or no activity in the upper Englishman River watershed during the monitoring, the data are reflective of background conditions in the Nanaimo Lowlands ecoregion. Therefore, it is recommended that the turbidity objectives be based on those from the Englishman River. ***To protect drinking water quality in the Tsolum River, it is recommended that from October to December (when turbid flows can occur), turbidity should not exceed 5 NTU; during the remainder of the year (clear flow periods), turbidity should not exceed 2 NTU (1 NTU above ambient levels, as measured in the Englishman River upstream from Morison Creek).*** It should be noted that turbidity values above 2 NTU are considered likely to affect disinfection in a chlorine-only system. An alternative to the average objective of 2 NTU would be to treat the raw water prior to chlorination to remove some of the turbidity and increase chlorine efficiency. Given the concerns identified in the Tsolum River regarding floods, channel instability, legacy logging impacts, TSS and turbidity, it may be worth considering continuous monitoring of turbidity to capture the magnitude and duration of turbidity peaks caused by storm events.

Table 7. Comparison of turbidity values measured in the Tsolum River at Duncan Main Road with those measured at the upstream site in the Englishman River (Englishman River upstream from Morison Creek).

	Tsolum River	Englishman River
Minimum	0.4	0.1
Maximum	3.2	4.3
Average	1.0	0.5
No. of samples	20	34

6.6 TOTAL SUSPENDED SOLIDS

Total suspended solids (TSS, also referred to as non-filterable residue or NFR) include all of the undissolved particulate matter in a sample. This value should be closely correlated with the turbidity value; however, unlike turbidity, it is not measured by optics. Instead, a quantity of the sample is filtered, and the residue is dried and weighed so that a weight of residue per volume is determined. No guideline has been established for drinking water at this time. For the protection of aquatic life, the maximum concentration allowed is an induced TSS concentration over background of 25 mg/L at any one time in 24 hours when background is less than or equal to 25 mg/L (clear flows) and an induced TSS concentration of 5 mg/L over background concentrations at any one time for a duration of 30 days (clear flows). Initially, less frequent monitoring may be appropriate to determine the need for more extensive monitoring (Caux *et al.*, 1997).

Concentrations of total suspended solids were often at or below detectable limits at all of the sites (126 of 201 measurements were < 1 mg/L) with a maximum value of 27 mg/L (Table 8**Error! Reference source not found.**). Three samples had TSS concentrations igher than 10 mg/L, and these all occurred between October and December, and are associated with winter rain events. The maximum value occurred in the Tsolum River 500 m downstream from Murex Creek on December 7, 2010, a day when 66 mm of rainfall was recorded in Comox.

Table 8. Summary of total suspended solids concentrations (mg/L) measured at the five Tsolum River sites and in Murex Creek.

Site number	Minimum	Maximum	Average	No. of values
E206513	< 1	3	1.3	20
E206499	< 1	2	1.1	19
E207826	< 1	27	1.5	99
E255693	< 1	12	2.2	21
0127620	< 1	5	1.8	24
0127621	< 1	19	2.8	18

As with turbidity, TSS in the Tsolum River at Duncan Main Road is likely affected by past logging practices and does not represent true background conditions. Data from the nearby Englishman River were incorporated into this review to indicate background conditions for the Nanaimo Lowlands ecoregion (Table 9). TSS concentrations were actually considerably lower on average in the Tsolum River at Duncan Main Road than in the Englishman River upstream from Morison Creek. As the guideline for total suspended solids is expressed in terms of increase above ambient levels, and because ambient levels in the upper Tsolum River watershed are low (regardless of historical forestry activities), it is more protective to use the Tsolum River data than the Englishman River data in the case of total suspended solids. The Englishman River objective included a seasonal component, however the data from the Tsolum River at Duncan Main Road did not show nearly as strong a seasonal trend. Therefore, using a background of 1 mg/L, ***it is recommended that total suspended solids measured in the Tsolum River should not exceed 26 mg/L at any time and the mean of five samples in 30-days should not exceed 6 mg/L .***The objective is meant to apply to situations that are not natural but may have been triggered by human activities, including streambank failures where historical logging has occurred.

Table 9. Comparison of total suspended solids concentrations measured in the Tsolum River at Duncan Main Road and the Englishman River upstream from Morison Creek.

	Tsolum River	Englishman River
Minimum	< 1	< 1
Maximum	3	51
Average	1.3	4.1
No. of samples	20	58

6.7 COLOUR AND TOTAL ORGANIC CARBON

Colour in water is caused by dissolved and particulate organic and inorganic matter. True colour is a measure of the dissolved colour in water after the particulate matter has been removed, while apparent colour is a measure of the dissolved and particulate matter in water. Colour can affect the aesthetic acceptability of drinking water, and the aesthetic water quality guideline is a maximum of 15 true colour units (TCU) (Moore and Caux, 1997). Colour is also an indicator of the amount of organic matter in water. When organic matter is chlorinated it can produce disinfection by-products (DBPs) such as trihalomethanes, which may pose a risk to human health.

Colour was only measured consistently at the site 500 m downstream from Murex Creek. Colour ranged from below detection limits (< 5 TCU) to 30 TCU, with an average of 13 TCU for 80 samples collected, and 21 of the 80 samples exceeded the drinking water guideline of 15 TCU (Appendix I). It is likely that colour in the watershed is a result of natural processes (high concentrations of organics in the boggy portions of the upper watershed) rather than anthropogenic activities, but it is possible that human activities may cause futher increases in true colour. Based on the 90th percentile of the data set, the true colour background level in the Tsolum watershed is 20 TCU, which indicates that the drinking water supply guideline for raw water based on aesthetic considerations is not appropriate. To protect aquatic life, the true colour guideline is that the averate of 5 weekly samples in 30 days not exceed the background level by more than 5 TCU in clear water systems (background levels less than or equal to 20 TCU). Given that background levels are at 20 TCU, an objective has been developed based on the 90th percentile of the dataset (background) plus 5 TCU. ***Thus, an objective of 25 TCU is proposed based on the mean of 5 weekly samples in 30 days to reflect no further increases to true colour concentrations from any future activities in the watershed.***

Elevated total organic carbon (TOC) levels (above 4.0 mg/L) can result in higher levels of trihalomethanes (THMs) and other potentially harmful byproducts in finished drinking water if chlorination is used to disinfect the water, which is the recommendation of the Vancouver Island Health Authority. TOC was only measured at the site 500 m downstream from Murex Creek, and only on two occasions, with values of 1.3 mg/L and 1.6 mg/L. However, dissolved organic carbon (DOC) was measured more frequently at this site (81 times), with values ranging from below the detection limit (< 0.5 mg/L) to 6.1 mg/L. As DOC is one component of TOC, it follows that when DOC concentrations exceed the guideline, then TOC levels must as well. Nine of the 81 DOC values exceeded the 4.0 mg/L guideline. For this reason, it appears that organic carbon is occasionally a concern, and therefore we recommend an objective: ***maximum TOC concentrations should not exceed 4.0 mg/L at any time in the Tsolum River.*** It is recognized that this objective may be exceeded frequently due to natural conditions. When additional TOC data have been collected, the objective should be re-evaluated.

6.8 NUTRIENTS (NITRATE, NITRITE AND PHOSPHORUS)

The concentrations of nitrogen (including nitrate and nitrite) and phosphorus are important parameters, since they tend to be the limiting nutrients in biological systems. Productivity is therefore directly proportional to the availability of these parameters. Nitrogen is usually the limiting nutrient in terrestrial systems, while phosphorus tends to be the limiting factor in freshwater aquatic systems. In watersheds where drinking water is a priority, it is desirable that nutrient levels remain low to avoid algal blooms and foul tasting water. Similarly, to protect aquatic life, nutrient levels should not be too high or the resulting plant and algal growth can deplete oxygen levels when it dies and begins to decompose, as well as during periods of low productivity when plants consume oxygen (*i.e.*, at night and during the winter under ice cover). The guideline for the maximum concentration for nitrate plus nitrite in drinking water is 10 mg/L as nitrogen and the guideline for nitrite is a maximum of 1 mg/L as nitrogen. For the protection of aquatic life the maximum concentration of nitrate is 32.8 mg/L and the average concentration is 3.0 mg/L (Meays, 2009).

Nitrogen concentrations were measured in terms of dissolved nitrate (NO_3) plus nitrite (NO_2). Dissolved nitrate + nitrite concentrations ranged from below detection limits (< 0.002 mg/L as N) to a maximum of 0.305 mg/L as N, both at the Duncan Main road site (Table 10). All values were well below the existing aquatic life guidelines, and therefore no guideline is recommended.

Table 10. Summary of nitrate+nitrite concentrations (mg/L) measured at the five Tsolum River sites and at the Murex Creek site.

Site number	Minimum	Maximum	Average	No. of values
E206513	< 0.002	0.305	0.062	20
E206499	0.007	0.177	0.037	18
E207826	0.007	0.243	0.060	92
E255693	0.014	0.105	0.042	21
0127620	0.013	0.106	0.039	24
0127621	0.010	0.205	0.062	18

While there are no BC guidelines for phosphorus in streams, the BC MOE is working towards a phosphorus objective for Vancouver Island. This proposed objective takes into consideration the fact that elevated phosphorus is primarily a concern during the summer low flow period when elevated nutrient levels are most likely to lead to deterioration in aquatic life habitat and aesthetic problems. The proposed total phosphorus guideline applies from May to September and is an average of 5 µg/L and a maximum of 10 µg/L (BCMOE, *in prep*). As this objective is under development, the numbers and the way in which they are applied are subject to change.

Total phosphorus concentrations ranged from below detectable limits (< 2 µg/L) to a maximum of 41 µg/L for the six monitoring sites, with an average of 4 to 6 µg/L (Table 11). These occasional elevated concentrations of total phosphorus may result in increased algal productivity that can impact fish populations and decrease recreational values. While some of the elevated concentrations occurred during the winter months (outside of the growing season, when solar outputs are lowest) and are therefore of less concern, some samples with higher total phosphorus concentrations were collected during the summer months (including the sample with a concentration of 18 µg/L collected at the Duncan Main Road site, collected on July 6, 2010). Total phosphorus concentrations did not appear to increase in a downstream direction with the exception of the maximum value measured at the Farnham Road bridge site, and so there is no strong indication that agricultural activities are contributing significantly to total phosphorus concentrations. In fact, the second highest concentration occurred at the Duncan Main Road site, well above agricultural activity. However, as total phosphorus concentrations were generally low, no objective is proposed for total phosphorus at this time. The need for an objective should be re-evaluated after the next attainment monitoring period.

Table 11. Summary of total phosphorus (µg/L) concentrations measured at the five Tsolum River sites and at the Murex Creek site.

Site number	Minimum	Maximum	Average	No. of values
E206513	3	18	6	19
E206499	< 2	7	4	18
E207826	< 2	12	6	60
E255693	2	8	5	21
0127620	3	41	6	24
0127621	3	9	5	18

6.9 METALS

Total and dissolved metals concentrations were measured on a number of occasions in the Tsolum River and Murex Creek. The concentrations of most metals were well below the guidelines for drinking water and aquatic life (including total silver, total arsenic, total boron, total barium, total beryllium, total cobalt, total chromium, total manganese, total molybdenum, total nickel, total lead, total selenium, and total zinc). However, there were a few metals present in concentrations that may be cause for concern, and these are discussed below.

6.9.1 Dissolved aluminum

The guidelines for the protection of aquatic life allow a maximum dissolved aluminum concentration of 100 µg/L and a mean concentration (based on a minimum of five samples collected within a 30-day period) of not more than 50 µg/L when water pH is greater than 6.5 (which is the case in both the Tsolum River and Murex Creek; see Section 6.1) (Butcher, 1991). Dissolved aluminum concentrations exceeded the maximum guideline at two of the Tsolum River sites (500 m downstream from Murex Creek, and upstream from Headquarters Creek), as well as at the Murex Creek site (Table 12). Average concentrations also exceeded the guideline in two sites on the Tsolum River (upstream from Headquarters Creek and at the Farnham Road bridge site) as well as in Murex Creek. While ambient levels of dissolved aluminum are relatively high in the watershed (based on concentrations measured at Duncan Main road, which is upstream from the mine influence), elevated concentrations in Murex Creek are sufficient to increase dissolved aluminum concentrations to above guideline levels on occasion. Therefore, a water quality objective is proposed for dissolved aluminum in the Tsolum River. ***The objective is that maximum dissolved aluminum concentrations should not exceed 100 µg/L, and average dissolved aluminum concentrations (based on a minimum of five samples collected within a 30-day period) should not exceed 50 µg/L, to protect aquatic life in the Tsolum River.***

Table 12. Summary of dissolved aluminum concentrations (µg/L) in the Tsolum River and Murex Creek.

Site number	Minimum	Maximum	Average	No. of values
E206513	10.6	97.7	33.0	19
E206499	19.3	146.0	80.0	19
E207826	10.3	133.0	50.0	117
E255693	12.0	111.0	57.0	21
0127620	11.6	100.0	53.0	24
0127621	11.7	86.1	48.0	17

6.9.2 Total cadmium

The working guideline for the protection of aquatic life from total cadmium is hardness dependent (increased hardness decreases the toxicity of total cadmium). At a hardness of less than 30 mg/L (typical of the Tsolum River watershed), the average permissible total cadmium concentration is 0.01 µg/L (Nagpal *et al*., 2006). This guideline was exceeded at two of the five Tsolum River monitoring locations (Table 13). It does not appear that the copper mine on Mt. Washington is the source of this cadmium, as concentrations in Murex Creek were lower than in the mainstem of the Tsolum River, and lower in fact than those measured at the ambient upstream site at Duncan Main road. It should be noted that the detection limit for total cadmium was 0.01 µg/L and accuracy of results is greatly reduced near detection limits. It is likely that the cadmium concentrations are a reflection of the natural geology of the area, and resident aquatic populations are more tolerant of occasional high concentrations. To ensure that cadmium is monitored in the future, an objective is proposed: ***Average total cadmium concentrations should not exceed 0.01 µg/L.*** This is based on the equation *10 exp (0.86[log{hardness}]-3.2)* where hardness is *reported as mg/L* $CaCO_3$**.** Ideally, detection limits that are no more than 10% of the working guideline level should be used to ensure accuracy, which in this case would mean using an analytical method with a detection limit of 0.001 µg/L for total cadmium. Currently detection limits of only 0.01 µg/L are available.

Table 13. Summary of total cadmium concentrations (µg/L) in the Tsolum River and Murex Creek.

Site number	Minimum	Maximum	Average	No. of values
E206513	< 0.005	0.046	0.010	20
E206499	< 0.005	0.019	0.008	19
E207826	0.001	1.160	0.040	337
E255693	< 0.005	0.138	0.013	21
0127620	< 0.005	0.046	0.010	24
0127621	< 0.005	0.023	0.006	18

6.9.3 Copper

The guideline for maximum total copper concentrations to protect aquatic life is hardness-dependent (increased hardness decreases the toxicity of the copper). Based on an average total hardness of 11 mg/L (measured at the Tsolum River site 500 m downstream from Murex Creek, the only site for which adequate hardness data has been collected), the guideline allows an average concentration of 2 µg/L, and a maximum concentration of 3 µg/L (Singleton, 1987). In the previous objectives report (Deniseger et al. 1995), organic copper complexing capacity in the Tsolum River was used as a rationale to use dissolved, rather than total, copper, and to recommend a maximum 30-day average concentration of 7 µg/L dissolved copper and a maximum concentration of 11 µg/L. Initially, these guidelines were seldom if ever met in the Tsolum River, but since the geomembrane was installed, the objectives are being met on a fairly consistent basis, especially at the sites further downstream (Phippen, 2012).

Dissolved copper concentrations measured at the five Tsolum River sites as well as the site on Murex Creek (E206499) are summarized in Table 14. Rolling 30-day averages (looking at each instance when a minimum of five samples was collected within a 30-day period) are summarized in Table 15. There were eleven instances where the maximum objective was exceeded in the Tsolum River, all at the site 500 m downstream from Murex Creek (E207826), and no instances where the average objective was exceeded. The objectives do not apply to Murex Creek. Since the time of objectives development, dissolved copper concentrations have been steadily decreasing at the Tsolum River 500m downstream Murex Creek site (Figure 10). As benthic invertebrate surveys conducted in the Tsolum River since 2009 show good recovery of the invertebrate populations, it appears that the existing objectives are adequate to protect aquatic life. For this reason, it is recommended that the current water quality objectives for dissolved copper in the Tsolum River (Deniseger et al. 1995) remain in place. That is, ***maximum concentrations of dissolved copper should not exceed 11 µg/L, and average concentrations of dissolved copper (based on a minimum of five samples collected within a 30-day period) should not exceed 7 µg/L).***

Table 14. Summary of dissolved copper concentrations (µg/L) measured in the five Tsolum River sites and the Murex Creek site.

Site number	Minimum	Maximum	Average	No. of values	No. of values exceeding max objective (>11 µg/L)
E206513	0.6	1.9	1.0	19	0
E206499	3.0	12.4	8.0	19	N/A
E207826	1.5	25.5	6.3	117	11
E255693	1.7	9.0	4.6	21	0
0127620	1.0	8.0	4.2	24	0
0127621	1.3	5.5	2.9	17	0

Table 15. Summary of 30-day rolling average dissolved copper concentrations (µg/L) for the five Tsolum River sites and the Murex Creek site.

Site number	Minimum	Maximum	Average	No. of values	No. of values exceeding avg objective (>7 µg/L)
E206513	0.9	1.3	1.1	6	0
E206499	6.1	10.9	8.7	9	N/A
E207826	3.0	9.9	7.6	53	0
E255693	2.9	6.7	5.2	12	0
0127620	2.7	6.5	4.7	15	0
0127621	2.3	4.0	3.1	8	0

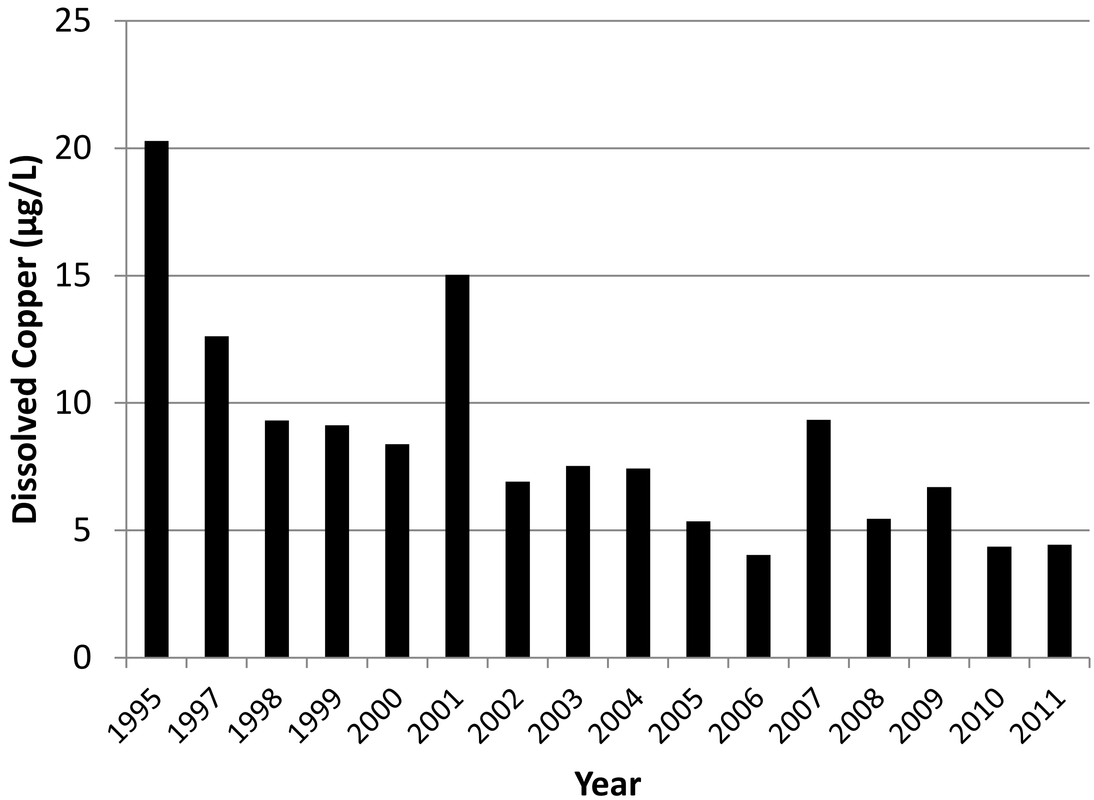

Figure 10. Annual average dissolved copper concentrations, 1995 to 2011, in the Tsolum River 500m d/s Murex Ck.

Metal speciation determines the biologically available portion of the total metal concentration. Only a portion of the total metals level is in a form which can be toxic to aquatic life. Naturally occurring organics in the watershed can bind substantial proportions of the metals which are present, forming metal complexes that are not biologically available. The relationship will vary seasonally, depending upon the metal (e.g. copper has the highest affinity for binding sites in humic materials). Levels of organics as measured by DOC vary from ecoregion to ecoregion. To aid in future attainment monitoring of metals objectives, DOC has been included in the Tsolum River monitoring program. As water hardness can affect the toxicity of copper and some other metals, hardness has also been included in the Tsolum River monitoring program.

6.10 MICROBIOLOGICAL INDICATORS

Fecal contamination of surface waters used for drinking and recreating can result in high risks to human health from pathogenic microbiological organisms as well as significant economic losses due to closure of beaches (Scott *et al*., 2002). The direct measurement and monitoring of pathogens in water, however, is difficult due to their low numbers, intermittent and generally unpredictable occurrence, and specific growth requirements (Krewski *et al*., 2004; Ishii and Sadowsky, 2008). To assess risk of microbiological contamination from fecal matter, resource managers commonly measure fecal indicator bacteria levels (Field and Samadpour, 2007; Ishii and Sadowsky, 2008). The most commonly used indicator organisms for assessing the microbiological quality of water are the total coliforms, fecal coliforms (a subgroup of the total coliforms more appropriately termed thermotolerant coliforms as they can grow at elevated temperatures), and *E. coli* (a thermotolerant coliform considered to be specifically of fecal origin) (Yates, 2007).

There are a number of characteristics that suitable indicator organisms should possess. They should be present in the intestinal tracts of warm-blooded animals, not multiply outside the animal host, be nonpathogenic, and have similar survival characteristics to the pathogens of concern. They should also be strongly associated with the presence of pathogenic microorganisms, be present only in contaminated samples, and be detectable and quantifiable by easy, rapid, and inexpensive methods (Scott *et al*., 2002; Field and Samadpour, 2007; Ishii and Sadowsky, 2008).

Total and fecal coliforms have traditionally been used in the assessment of water for domestic and recreational uses. However, research in recent years has shown that there are many differences between the coliforms and the pathogenic microorganisms they are a surrogate for, which limits the use of coliforms as an indicator of fecal contamination (Scott *et al*., 2002). For example, many pathogens, such as enteric viruses and parasites, are not as easily inactivated by water and wastewater treatment processes as coliforms are. As a result, disease outbreaks do occur when indicator bacteria counts are at acceptable levels (Yates, 2007; Haack *et al*., 2009). Additionally, some members of the coliform group, such as *Klebsiella*, can originate from non-fecal sources (Ishii and Sadowsky, 2008) adding a level of uncertainty when analyzing data. Waters contaminated with human feces are generally regarded as a greater risk to human health, as they are more likely to contain human-specific enteric pathogens (Scott *et al*., 2002). Measurement of total and fecal coliforms does not indicate the source of contamination, which can make the actual risk to human health uncertain; thus, it is not always clear where to direct management efforts.

The BC-approved water quality guidelines for microbiological indicators were developed in 1988 (Warrington, 1988) and include *E. coli*, enterococci, *Psudomonas aeruginosa*, and fecal coliforms. The monitoring programs of the BC MOE have traditionally measured total coliforms, fecal coliforms, *E. coli* and enterococci, either alone or in combination, depending on the specific program. As small pieces of fecal matter in a sample can skew the overall results for a particular site, the 90th percentiles (for drinking water) and geometric means (for recreation) are generally used to determine if the water quality guideline is exceeded, as extreme values would have less effect on the data. The BC MOE drinking water guideline for raw waters receiving disinfection only is that the 90th percentile of at least five weekly samples collected in a 30-day period should not exceed 10 CFU/100 mL for either fecal coliforms or *E. coli*. The primary contact recreation guidelines are that the geometric mean of at least five samples collected in a 30-day period should not exceed 77 CFU/100 mL for *E. coli* or 200 CFU/100 mL for fecal coliforms (Warrington, 2001).

It is not known if individual licensees chlorinate the raw water from the Tsolum River prior to consumption, but that is the recommendation of BC Health. To represent the worst case scenario, bacteriological samples were only collected during summer low flow (August/September) and fall flush (October/November) periods.

Fecal coliform concentrations were measured 77 times in the Tsolum River 500 m downstream from Murex Creek, with values ranging from below detection limits (<1 CFU/100 mL) to a maximum of 2,000 CFU/100 mL. The highest value may have been an anomaly; the next highest value at this site was 210 CFU/100 mL. Samples were collected with sufficient frequency (a minimum of five weekly samples within 30 days) on only one occasion, and the 90th percentile for that group of samples was 5 CFU/100 mL. The geometric mean was 1.9 CFU/100 mL. Fecal coliforms were only measured once each at the other four sampling locations on the Tsolum River, ranging from 18 CFU/100 mL at Duncan Main road to 710 CFU/100 mL upstream from the Puntledge River. While there was insufficient sampling frequency to determine guideline compliance, fecal coliform concentrations increased considerably in a downstream direction.

E. coli concentrations were measured in the summer and fall of 2011 at four of the five Tsolum River sampling locations (none were collected at the Duncan Main site). Five samples collected within a 30-day period in both summer and fall from each site. Concentrations ranged from 1 CFU/100 mL to 2,000 CFU/100 mL for the 40 samples. The highest value appears to have been an anomaly; the next highest value in the entire dataset was 70 CFU/100 mL. As this high value was far outside the normal range of results, and was at a site that does not have known anthropogenic sources of microbiological contamination, this value was removed for data analyses. In the eight instances when the requisite sampling frequency was met (at least five weekly samples in 30 days), 90th percentiles ranged from 5 CFU/100 mL to 56 CFU/100 mL (Table 16). For comparison to the recreation guideline, the geometric means ranged from 3 CFU/100 mL to 30 CFU/100 mL.

Table 16. Summary of *E. coli* concentrations (CFU/100 mL) measured at four Tsolum River monitoring sites, including 90th percentiles.

Site number	Min.	Max.	90th %ile summer	90th %ile fall	Geometric mean summer	Geometric mean fall
E207826	1	26	22	5	10	3
E255693	5	70	56	19	30	9
0127620	3	49	43	25	28	7
0127621	3	45	44	27	24	13

Studies have shown that *E. coli*, a component of the fecal coliforms group, is the main thermo-tolerant coliform species present in human and animal fecal samples (94%)

(Tallon *et al*., 2005) and at contaminated bathing beaches (80%) (Davis *et al.*, 2005). In cases where fecal coliform counts were greater than *E. coli,* we can assume a high likelihood of contributions from non-fecal sources. Thus, the value added benefit of measuring both groups is limited.

The drinking water guideline for raw untreated water in the Tsolum River was almost invariably exceeded when fecal coliforms or *E. coli* were measured five times in 30 days. The primary contact recreational guideline was met at all sites for fecal coliforms and *E. coli*. Sources of coliforms are unknown, but at the Tsolum River 500 m downstream from Murex Creek, it is likely wildlife, and at the other three sites farther downstream, it is possible that agriculture, recreation and residential areas are also contributing. At each site, values were highest in the summer season when dilution was lowest.

In some cases, water quality objectives for *E. coli* have been set higher than the drinking water objective because that was reflective of natural background conditions (e.g. McKelvie Creek, Epps, 2007). In other cases, even though there were no anthropogenic sources of coliform bacteria, activities such as forestry were believed to cause increased sediment transport and therefore higher microbiological results (e.g. Mercantile Creek, Obee and Phippen, 2012), and the objective was then based on another watershed in the ecoregion that represented background conditions. As the Tsolum River 500 m downstream from Murex Creek site is believed to be upstream of any anthropogenic sources of fecal coliforms, but is affected by forestry activity, the Englishman River objectives were included for comparison. Contrary to the Tsolum River, the Enlighsman River microbiological results were higher in the fall than in the summer. Also, the average 90th percentile value for the Englishman River fall (the season with higher results) was 57 CFU/100 mL and was actually higher than the 90th percentile for the Tsolum River summer (the season with higher results) at 22 CFU/100 mL, therefore it is more protective to use the Tsolum River 500 m downstream from Murex Creek as the background site for the Tsolum River.

Given the uncertainty in linking thermotolerant (i.e. fecal) coliforms to human sources of sewage, we recommend using *E. coli* as the microbiological indicator for the Tsolum

River. Therefore, a water quality objective is proposed for *E. coli* in the Tsolum River. ***The seasonally adjusted water quality objective is that the 90th percentile of a minimum of five weekly samples collected within a 30-day period from October to November (to capture the first fall flush) must not exceed 10 CFU/100 mL for*** **E. coli*****. For the remainder of the year, the 90th percentile of a minimum of five weekly samples collected within a 30-day period (sampling should occur during July-September to capture low flow conditions) must not exceed 22 CFU/100mL. The objective applies to the entire river.*** It is recognized that this objective may be exceeded in the downstream portions of the Tsolum River, however it will serve as a long term goal. Protection would not be provided from parasites such as *Cryptosporidium* or *Giardia*. Sampling for these pathogens falls under the auspices of the water purveyor, in this case the individual licensee.

7.0 MONITORING RECOMMENDATIONS

In order to capture the periods where water quality concerns are most likely to occur (*i.e.*, freshet, summer low-flow and fall flush) we recommend that a minimum of five weekly samples be collected within a 30-day period in April/June, August/September, and October/November. The spring and fall samples should be analyzed for total and dissolved metals and hardness, and the summer and fall samples should be analyzed for TSS, turbidity, temperature, true colour, DOC, TOC and *E. coli*. Field measurements of water temperature, dissolved oxygen, pH, and specific conductivity should also be made. Samples collected during the spring should coincide with snowmelt, those collected during the summer should coincide with summer low flows, and those collected during the fall months should coincide with rain events whenever possible.

7.1 BIOLOGICAL MONITORING

Objectives development has traditionally focused on physical, chemical and bacteriological parameters. Biological data has been underutilized due to the highly specialized interpretation required and the difficulty in applying the data quantitatively. Notwithstanding this problem, with few exceptions, the most sensitive use of our water bodies is aquatic life. Therefore biological objectives need to be incorporated into the overall objectives development program.

In streams, benthic invertebrates have been accepted as a very important assessment tool. Considerable progress has been made in the development of benthic invertebrate indices, which can be incorporated into impact assessments and water quality objectives. On Vancouver Island, benthic sampling has been conducted at a limited number of sites over the past few years. The dataset at present is too limited to be able to make a sound judgment as to the state of the ecosystem health. To be able to apply and test the benthic invertebrate approach, Vancouver Island regional staff will be collecting more data at a broad range of both reference and test sites. Once all the data has been compiled and analyzed, biological objectives and/or indices will be developed for those watersheds where water quality objectives have already been developed. It is recommended that benthic invertebrates continue to be monitored in the Tsolum River watershed.

8.0 SUMMARY OF PROPOSED WATER QUALITY OBJECTIVES AND MONITORING SCHEDULE

Table 17. 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 18. Proposed schedule for future water quality 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

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APPENDIX I. SUMMARY OF WATER QUALITY DATA

Table 19. Summary of general water chemistry at Site E206513, Tsolum River at Duncan Main Road.

	Minimum	Maximum	Average	Std. Dev	No. of samples
Ammonia Dissolved (mg/L)	< 0.005	0.27	0.070	0.073	19
Carbon Dissolved Organic (mg/L)	1.4	1.4	1.4		1
Chlorophyll A (g/m2)	4.2	4.2	4.2		1
Fecal coliforms (CFU/100mL)	18	18	18		1
Color True (Col.unit)	15	15	15		1
E. coli (CFU/100mL)	2	2	2		1
Hardness Total (T) (mg/L)	25.2	25.2	25.2		1
Nitrogen Kjeldahl (mg/L)	0.12	0.12	0.12		1
Nitrate (NO3) Dissolved (mg/L)	0.095	0.154	0.125	0.042	2
Nitrate + Nitrite Diss. (mg/L)	< 0.002	0.305	0.062	0.078	20
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	0.002	0.002	0	2
Nitrogen Total (mg/L)	0.27	0.27	0.27		1
NO2+NO3 (mg/L)	0.15	0.15	0.15		1
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0.001		1
pH (pH units)	7.03	8.1	7.35	0.24	20
Phosphorus Tot. Dissolved (mg/L)	0.004	0.004	0.004		1
P--T (mg/L)	0.003	0.018	0.006	0.003	19
Residue Total (mg/L)	< 41	41	41		1
Residue Filterable 1.0u (mg/L)	40	40	40		1
Residue Non-filterable (mg/L)	< 1	3	1.3	0.6	20
Specific Conductance (uS/cm)	65	65	65		1
Turbidity (NTU)	0.4	3.2	1.01	0.58	20
Ag-D (mg/L)	< 0.000005	< 0.000005	< 0.000005	0	19
Ag-T (mg/L)	< 0.000005	0.000017	< 0.000005	0	20
Al-D (mg/L)	0.0106	0.0977	0.033	0.021	19
Al-T (mg/L)	0.0121	0.147	0.050	0.033	20
As-D (mg/L)	0.00017	0.00034	0.00024	0.00004	19
As-T (mg/L)	0.00018	0.00039	0.00028	0.00005	20
Ba-D (mg/L)	0.0008	0.00289	0.0018	0.0006	19
Ba-T (mg/L)	0.00092	0.00301	0.0020	0.0007	20
B--D (mg/L)	< 0.05	< 0.05	< 0.05	0	19
Be-D (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	19
Be-T (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	20
Bi-D (mg/L)	< 0.000005	0.000072	0.000009	0	19
Bi-T (mg/L)	< 0.000005	0.000091	0.000011	0.00002	20

	Minimum	Maximum	Average	Std. Dev	No. of samples
B--T (mg/L)	< 0.05	< 0.05	< 0.05	0	20
Ca-T (mg/L)	6.67	6.67	6.67		1
Cd-D (mg/L)	< 0.000005	0.000021	0.000007	0.000005	19
Cd-T (mg/L)	< 0.000005	0.000046	0.0000099	0.00001	20
Co-D (mg/L)	0.000011	0.00004	0.000027	0.000008	19
Co-T (mg/L)	0.000031	0.000132	0.000074	0.000029	20
Cr-D (mg/L)	< 0.0001	0.0003	0.00016	0.00006	19
Cr-T (mg/L)	< 0.0001	0.0004	0.00018	0.00009	20
Cu-D (mg/L)	0.00063	0.00193	0.00102	0.00029	19
Cu-T (mg/L)	0.00066	0.00206	0.00114	0.00035	20
Li-D (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	19
Li-T (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	20
Mg-D (mg/L)	0.775	2.16	1.39	0.42	19
Mg-T (mg/L)	0.862	2.08	1.45	0.42	20
Mn-D (mg/L)	0.00047	0.0125	0.0039	0.0029	19
Mn-T (mg/L)	0.00062	0.0529	0.0162	0.0145	20
Mo-D (mg/L)	< 0.00005	< 0.00005	< 0.00005	0	19
Mo-T (mg/L)	< 0.00005	0.00006	< 0.00005	0.000002	20
Ni-D (mg/L)	0.00008	0.00047	0.00018	0.00010	19
Ni-T (mg/L)	0.00008	0.00086	0.00023	0.00020	20
Pb-D (mg/L)	< 0.000005	0.000319	0.00006	0.00008	19
Pb-T (mg/L)	< 0.000005	0.000483	0.00009	0.00014	20
Sb-D (mg/L)	< 0.00002	0.00003	0.00002	0.000003	19
Sb-T (mg/L)	< 0.00002	0.00003	0.000022	0.000004	20
Se-D (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	19
Se-T (mg/L)	< 0.00004	0.00005	< 0.00004	0.000002	20
Sn-D (mg/L)	< 0.00001	0.00002	0.000011	0.000002	19
Sn-T (mg/L)	< 0.00001	0.00002	0.000011	0.000002	20
Sr-D (mg/L)	0.00697	0.0215	0.013	0.004	19
Sr-T (mg/L)	0.00698	0.0211	0.013	0.004	20
Ti-D (mg/L)	0.0009	0.0009	0.0009		1
Ti-T (mg/L)	0.0027	0.0027	0.0027		1
Tl-D (mg/L)	< 0.000002	< 0.000002	< 0.000002	0	18
Tl-T (mg/L)	< 0.000002	0.000002	< 0.000002	0	19
U--D (mg/L)	< 0.000002	0.000004	0.000002	0.000001	19
U--T (mg/L)	< 0.000002	0.000006	0.000002	0.000001	20
V--D (mg/L)	< 0.0002	0.0007	0.0004	0.0001	19
V--T (mg/L)	0.0004	0.0011	0.0006	0.0002	20
Zn-D (mg/L)	0.0003	0.004	0.0010	0.0009	19
Zn-T (mg/L)	0.0002	0.0048	0.0013	0.0010	20

Table 20. Summary of general water chemistry at Site E206499, Murex Creek at Duncan Main Road.

	Minimum	Maximum	Average	Std. Dev	No. of samples
Alkalinity Total 4.5 (mg/L)	5.3	5.3	5.3		1
Ammonia Dissolved (mg/L)	< 0.005	0.26	0.057	0.063	18
Nitrate + Nitrite Diss. (mg/L)	0.007	0.177	0.037	0.042	18
pH (pH units)	6.5	7.18	6.91	0.17	18
P--T (mg/L)	< 0.002	0.007	0.004	0.002	18
Residue Non-filterable (mg/L)	< 1	2	1.1	0.3	19
Sulfate:D (mg/L)	2.2	2.2	2.2		1
Turbidity (NTU)	0.1	2.2	0.5	0.5	18
Fecal coliforms (CFU/100mL)	6	6	6		1
E. coli (CFU/100mL)	1	1	1		1
Ag-D (mg/L)	< 0.000005	0.000007	0.000005	0.000001	19
Ag-T (mg/L)	< 0.000005	0.00001	0.000005	0.000001	19
Al-D (mg/L)	0.0193	0.146	0.08	0.03	19
Al-T (mg/L)	0.0222	0.285	0.10	0.06	19
As-D (mg/L)	0.00064	0.00137	0.0010	0.0002	19
As-T (mg/L)	0.00073	0.00176	0.0011	0.0003	19
Ba-D (mg/L)	0.00076	0.00171	0.0011	0.0003	19
Ba-T (mg/L)	0.0008	0.00195	0.0012	0.0003	19
B--D (mg/L)	< 0.05	< 0.05	< 0.05	0	19
Be-D (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	19
Be-T (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	19
Bi-D (mg/L)	< 0.000005	< 0.000005	< 0.000005	0	19
Bi-T (mg/L)	< 0.000005	0.00014	0.00001	0.00003	19
B--T (mg/L)	< 0.05	< 0.05	< 0.05	0	19
Cd-D (mg/L)	< 0.000005	0.000018	0.000007	0.000004	19
Cd-T (mg/L)	< 0.000005	0.000019	0.000008	0.000005	19
Co-D (mg/L)	0.000022	0.000284	0.00010	0.00007	19
Co-T (mg/L)	0.000028	0.000341	0.00014	0.00009	19
Cr-D (mg/L)	< 0.0001	0.0005	0.0002	0.0001	19
Cr-T (mg/L)	< 0.0001	0.0005	0.0002	0.0001	19
Cu-D (mg/L)	0.00302	0.0124	0.008	0.003	19
Cu-T (mg/L)	0.00271	0.0137	0.009	0.003	19
Li-D (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	19
Li-T (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	19
Mg-D (mg/L)	0.327	0.692	0.48	0.13	19
Mg-T (mg/L)	0.334	0.966	0.51	0.16	19

	Minimum	Maximum	Average	Std. Dev	No. of samples
Mn-D (mg/L)	0.00032	0.00258	0.0012	0.0006	19
Mn-T (mg/L)	0.00039	0.00924	0.0022	0.0023	19
Mo-D (mg/L)	0.00009	0.00038	0.0002	0.0001	19
Mo-T (mg/L)	0.00008	0.00034	0.0002	0.0001	19
Ni-D (mg/L)	0.00019	0.00046	0.0003	0.0001	19
Ni-T (mg/L)	0.00018	0.00051	0.0003	0.0001	19
Pb-D (mg/L)	0.000005	0.000859	0.00006	0.00019	19
Pb-T (mg/L)	0.000007	0.00137	0.00010	0.00031	19
Sb-D (mg/L)	0.00006	0.00016	0.0001	0.00003	19
Sb-T (mg/L)	0.00006	0.00016	0.0001	0.00003	19
Se-D (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	19
Se-T (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	19
Sn-D (mg/L)	< 0.00001	0.00002	< 0.00001	0.000003	19
Sn-T (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	19
Sr-D (mg/L)	0.00557	0.0124	0.0080	0.0021	19
Sr-T (mg/L)	0.00576	0.0145	0.0085	0.0025	19
Ti-D (mg/L)	0.0005	0.0005	0.00		1
Ti-T (mg/L)	0.0026	0.0026	0.00		1
Tl-D (mg/L)	< 0.000002	< 0.000002	< 0.000002	0	18
Tl-T (mg/L)	< 0.000002	0.000004	< 0.000002	0.0000005	18
U--D (mg/L)	< 0.000002	0.000003	< 0.000002	0.0000004	19
U--T (mg/L)	< 0.000002	0.000006	< 0.000002	0.000001	19
V--D (mg/L)	< 0.0002	0.0003	0.0002	0.0000	19
V--T (mg/L)	< 0.0002	0.0006	0.0003	0.0001	19
Zn-D (mg/L)	0.0003	0.0036	0.0012	0.0008	19
Zn-T (mg/L)	0.0005	0.0041	0.0014	0.0009	19

Table 21. Summary of general water chemistry at Site E207826, Tsolum River 500 m downstream from Murex Creek.

	Minimum	Maximum	Average	Std. Dev	No. of samples
Fecal coliforms (CFU/100mL)	< 1	2000	44	230	76
E. coli (CFU/100mL)	1	2000	189	601	11
Alk:Tot (ueq/L)	1.8	15.5	7.74	2.53	71
Alkalinity pH 8.3 (mg/L)	< 0.5	< 0.5	< 0.5	0	77
Alkalinity Total 4.5 (mg/L)	4.5	24	9.36	3.70	77
Ammonia Dissolved (mg/L)	< 0.005	0.1	0.02	0.02	98
Ammonia:T (mg/L)	0	0.09	0.02	0.02	37
Bicarbonate (mg/L)	5.5	29	11.44	4.51	77
Carbon Dissolved Organic (mg/L)	< 0.5	6.1	2.55	1.13	81
Carbon Total Organic (mg/L)	1.3	1.6	1.45	0.21	2
Carbonate (mg/L)	< 0.5	< 0.5	< 0.5	0	77
Chlorophyll A (g/m2)	< 0.3	0.6	0.45	0.21	2
Chlorophyll A (mg/L)	0	0			0
Chloride D (mg/L)	< 0.5	5.3	1.40	0.90	77
Color True (Col.unit)	< 5	30	12.63	6.51	80
Diss Oxy (mg/L)	8.8	15	11.73	1.47	76
Hardness Total (D) (mg/L)	6.2	22.2	10.64	3.40	93
Hardness Total (T) (mg/L)	6.2	20.6	10.43	2.52	97
Hydroxide Alkalinity (mg/L)	< 0.5	< 0.5	< 0.5	0	76
Nitrate (NO3) Dissolved (mg/L)	0.007	0.243	0.05	0.05	72
Nitrate + Nitrite Diss. (mg/L)	0.007	0.243	0.06	0.05	92
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	0.004	0.00	0.00	72
Nitrogen (Kjel.) Tot Diss (mg/L)	< 0.02	0.2	0.07	0.04	77
Nitrogen Kjeldahl T (mg/L)	< 0.02	0.38	0.09	0.06	82
Nitrogen Organic Tot-Diss (mg/L)	< 0.02	0.15	0.06	0.03	77
Nitrogen Organic-Total (mg/L)	< 0.02	0.38	0.09	0.06	81
Nitrogen Total (mg/L)	< 0.02	0.41	0.15	0.07	83
Nitrogen Total Dissolved (mg/L)	0.03	0.31	0.12	0.06	77
NO2+NO3 (mg/L)	0.007	0.24	0.06	0.05	80
Ortho-Phosphate Dissolved (mg/L)	< 0.001	0.002	0.00	0.00	79
pH (pH units)	6.38	7.6	7.10	0.21	100
P--T (mg/L)	< 0.002	0.012	0.006	0.003	60
Phosphorus Tot. Dissolved (mg/L)	< 0.002	0.043	0.004	0.005	80
Residue total (mg/L)	21	40	32.00	9.85	3
Residue Filterable 1.0u (mg/L)	20	38	30.67	9.45	3
Residue Non-filterable (mg/L)	< 1	27	1.61	2.75	99
Specific Conductance (µS/cm)	16	64	41	102	79

	Minimum	Maximum	Average	Std. Dev	No. of samples
Sulfat:D (mg/L)	< 0.5	8.5	1.97	1.60	68
Temp (C)	0.1	20	7.80	5.43	77
Temp(Air) (C)	-6	29	11.93	7.16	77
Turbidity (NTU)	0.3	16.3	1.06	1.73	93
Ag-D (mg/L)	< 0.000005	0.000007	< 0.000005	0.0000004	117
Ag-T (mg/L)	< 0.000001	0.000026	0.000006	0.000004	336
Al-D (mg/L)	0.0103	0.133	0.05	0.03	117
Al-T (mg/L)	0.0117	0.231	0.07	0.04	336
As-D (mg/L)	0.00032	0.00152	0.0008	0.0003	117
As-T (mg/L)	0.00025	0.00221	0.0009	0.0003	337
Ba-D (mg/L)	0.00079	0.00379	0.0016	0.0007	117
Ba-T (mg/L)	0.00052	0.00369	0.0014	0.0006	336
B--D (mg/L)	< 0.05	< 0.05	< 0.05	0	117
Be-D (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	117
Be-T (mg/L)	< 0.000001	0.0001	0.00001	0.00002	337
Bi-D (mg/L)	0.000005	0.000005	0.00001	0.00000	117
Bi-T (mg/L)	0.000001	0.001	0.00005	0.0002	337
B--T (mg/L)	0.0018	0.05	0.05	0.01	337
Ca-D (mg/L)	1.74	8.46	3.85	2.03	94
Ca-T (mg/L)	1.81	14.59	5.92	2.35	97
Cd-D (mg/L)	< 0.000005	0.000139	0.00001	0.00002	117
Cd-T (mg/L)	0.000001	0.00116	0.00004	0.00010	337
Cerium Total (mg/L)	0.000016	0.00008	0.00004	0.00002	28
Cesium Total (mg/L)	< 0.000005	0.000005	< 0.000005	0	28
Co-D (mg/L)	0.000011	0.000321	0.00007	0.00005	117
Co-T (mg/L)	0.000013	0.00106	0.00011	0.00013	336
Cr-D (mg/L)	< 0.0001	0.0005	0.00013	0.00006	117
Cr-T (mg/L)	0.000075	0.0038	0.00022	0.00031	337
Cu-D (mg/L)	0.00154	0.0255	0.006	0.004	117
Cu-T (mg/L)	0.0017	0.0603	0.008	0.005	336
Fe-D (mg/L)	0.043	0.356	0.097	0.059	50
Fe-T (mg/L)	0.0565	0.494	0.164	0.082	58
Ga-T (mg/L)	0.000002	0.000022	0.000007	0.000005	28
K--D (mg/L)	0.063	0.26	0.13	0.06	77
K--T (mg/L)	0.11	0.21	0.16	0.03	30
Lathanum Total (mg/L)	0.00001	0.000052	0.00003	0.00001	28
Li-D (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	117
Li-T (mg/L)	< 0.0002	0.0009	0.00048	0.00009	320
Mg-D (mg/L)	0.336	1.62	0.81	0.30	144
Mg-T (mg/L)	0.309	1.61	0.73	0.27	308

	Minimum	Maximum	Average	Std. Dev	No. of samples
Mn-D (mg/L)	0.00023	0.0282	0.0059	0.0065	117
Mn-T (mg/L)	0.0002	0.102	0.0064	0.0092	336
Mo-D (mg/L)	< 0.00005	0.00049	0.00018	0.00012	117
Mo-T (mg/L)	0.000033	0.001	0.00021	0.00021	337
Na-D (mg/L)	0.508	2.92	1.24	0.54	77
Na-T (mg/L)	0.5	1.62	1.10	0.36	16
Ni-D (mg/L)	0.0001	0.00051	0.00022	0.00007	117
Niobium Total (mg/L)	< 0.000001	0.000005	0.000001	0.000001	28
Ni-T (mg/L)	< 0.00004	0.0142	0.00040	0.00082	336
Pb-D (mg/L)	< 0.000005	0.00013	0.000018	0.000017	117
Pb-T (mg/L)	< 0.000005	0.00185	0.000056	0.000119	337
Platinum Total (mg/L)	< 0.000001	< 0.000001	< 0.000001	0	28
Rb-T (mg/L)	0.00003	0.00048	0.00	0.00	28
Sb-D (mg/L)	0.00002	0.00016	0.00	0.00	117
Sb-T (mg/L)	< 0.00002	0.0005	0.00	0.00	337
S--D (mg/L)	< 3	< 3	< 3	0	60
Se-D (mg/L)	< 0.00004	0.00009	0.000042	0.000006	117
Se-T (mg/L)	< 0.00004	0.00011	< 0.00004	0.00001	337
Si-D (mg/L)	1.23	3.9	2.43	0.61	50
Si-T (mg/L)	1.29	3.47	2.38	0.58	30
Sn-D (mg/L)	< 0.00001	0.00006	0.000011	0.000007	117
Sn-T (mg/L)	< 0.000005	0.00066	0.000018	0.000042	321
Sr-D (mg/L)	0.0053	0.021	0.01	0.00	117
Sr-T (mg/L)	0.00434	0.0208	0.01	0.00	336
S--T (mg/L)	< 3	< 3	< 3	0	16
Ti-D (mg/L)	< 0.0005	0.0038	0.0010	0.0008	50
Ti-T (mg/L)	< 0.0005	0.009	0.0040	0.0018	30
Tl-D (mg/L)	< 0.000002	0.000003	0.000002	0.0000001	117
Tl-T (mg/L)	< 0.000001	0.00005	0.000004	0.000010	337
Tungsten Total (mg/L)	< 0.000001	0.000006	0.000002	0.000001	28
U--D (mg/L)	< 0.000002	0.000014	0.000002	0.000001	117
U--T (mg/L)	< 0.0000005	0.000009	0.0000020	0.0000007	320
V--D (mg/L)	< 0.0002	0.0019	0.0003	0.0002	117
V--T (mg/L)	< 0.0002	0.001	0.00029	0.00014	321
Yttrium Total (mg/L)	0.000043	0.000167	0.0001	0.0000	28
Zn-D (mg/L)	0.0001	0.005	0.0010	0.0009	117
Zn-T (mg/L)	< 0.0001	0.0321	0.0021	0.0030	336
Zr-D (mg/L)	< 0.0001	0.0001	< 0.0001	0	50
Zr-T (mg/L)	< 0.0001	0.0005	0.0003	0.0002	30

Table 22. Summary of general water chemistry at Site E255693, Tsolum River upstream of Headquarters Creek.

	Minimum	Maximum	Average	Std. Dev	No. of samples
Fecal coliforms (CFU/100mL)	130	130	130	0	1
E. coli (CFU/100mL)	5	70	22.6	18.7	11
Ammonia Dissolved (mg/L)	< 0.005	0.28	0.050	0.063	21
Nitrate (NO3) Dissolved (mg/L)	0.1	0.1	0.1		1
Nitrate + Nitrite Diss. (mg/L)	0.014	0.105	0.042	0.032	21
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	< 0.002	< 0.002		1
pH (pH units)	6.6	7.71	7.15	0.26	21
P--T (mg/L)	0.002	0.008	0.005	0.002	21
Residue Non-filterable (mg/L)	< 1	12	2.2	2.6	21
Turbidity (NTU)	0.3	7.3	1.5	1.8	21
Ag-D (mg/L)	< 0.000005	< 0.000005	< 0.000005	0	21
Ag-T (mg/L)	< 0.000005	0.000021	0.000006	0.000004	21
Al-D (mg/L)	0.012	0.111	0.057	0.028	21
Al-T (mg/L)	0.0268	0.253	0.090	0.063	21
As-D (mg/L)	0.00049	0.00082	0.00068	0.00010	21
As-T (mg/L)	0.00052	0.00124	0.00080	0.00017	21
Ba-D (mg/L)	0.001	0.00196	0.001	0.0003	21
Ba-T (mg/L)	0.00108	0.00214	0.0015	0.0003	21
B--D (mg/L)	< 0.05	< 0.05	< 0.05	0	21
Be-D (mg/L)	< 0.00001	0.00001	< 0.00001	0	21
Be-T (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	21
Bi-D (mg/L)	< 0.000005	0.000009	0.000005	0.000001	21
Bi-T (mg/L)	< 0.000005	0.000044	0.000007	0.000009	21
B--T (mg/L)	< 0.05	< 0.05	< 0.05	0	21
Cd-D (mg/L)	< 0.000005	0.000109	0.000011	0.000023	21
Cd-T (mg/L)	< 0.000005	0.000138	0.000013	0.000029	21
Co-D (mg/L)	0.000014	0.000121	0.000054	0.000032	21
Co-T (mg/L)	0.000035	0.000238	0.000095	0.000063	21
Cr-D (mg/L)	< 0.0001	0.0003	0.0001	0.0001	21
Cr-T (mg/L)	< 0.0001	0.0004	0.0002	0.0001	21
Cu-D (mg/L)	0.00167	0.00895	0.0046	0.0019	21
Cu-T (mg/L)	0.00206	0.0115	0.0052	0.0024	21
Li-D (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	21
Li-T (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	21
Mg-D (mg/L)	0.431	1.17	0.73	0.21	21
Mg-T (mg/L)	0.489	1.17	0.77	0.21	21

	Minimum	Maximum	Average	Std. Dev	No. of samples
Mn-D (mg/L)	0.00038	0.00365	0.0024	0.0010	21
Mn-T (mg/L)	0.00305	0.01	0.0049	0.0021	21
Mo-D (mg/L)	< 0.00005	0.00032	0.00015	0.00008	21
Mo-T (mg/L)	< 0.00005	0.00031	0.00015	0.00007	21
Ni-D (mg/L)	0.00011	0.00029	0.0002	0.0001	21
Ni-T (mg/L)	0.00007	0.00061	0.0002	0.0001	21
Pb-D (mg/L)	< 0.00005	0.000054	0.000019	0.000016	21
Pb-T (mg/L)	0.000006	0.000137	0.000034	0.000034	21
Sb-D (mg/L)	0.00003	0.00011	0.00007	0.00002	21
Sb-T (mg/L)	0.00004	0.00014	0.00007	0.00003	21
Se-D (mg/L)	< 0.00004	0.00004	< 0.00004	0	21
Se-T (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	21
Sn-D (mg/L)	< 0.00001	0.00001	< 0.00001	0	21
Sn-T (mg/L)	< 0.00001	0.00001	< 0.00001	0	21
Sr-D (mg/L)	0.00691	0.0162	0.0106	0.0028	21
Sr-T (mg/L)	0.007	0.017	0.0109	0.0030	21
Ti-D (mg/L)	0.0006	0.0006	0.0006		1
Ti-T (mg/L)	0.0063	0.0063	0.0063		1
Tl-D (mg/L)	< 0.000002	< 0.000002	< 0.000002	0	20
Tl-T (mg/L)	< 0.000002	0.000004	0.000002	0	20
U--D (mg/L)	< 0.000002	0.00001	0.000002	0.000002	21
U--T (mg/L)	< 0.000002	0.00001	0.000003	0.000002	21
V--D (mg/L)	< 0.0002	0.0006	0.0003	0.0001	21
V--T (mg/L)	< 0.0002	0.0009	0.0004	0.0002	21
Zn-D (mg/L)	0.0003	0.0024	0.0008	0.0006	21
Zn-T (mg/L)	0.0003	0.0029	0.0010	0.0007	21

Table 23. Summary of general water chemistry at Site 0127620, Tsolum River at Farnham Road Bridge.

	Minimum	Maximum	Average	Std. Dev	No. of samples
Fecal coliforms (CFU/100mL)	310	310	310		1
E. coli (CFU/100mL)	3	49	21.9	15.3	11
Ammonia Dissolved (mg/L)	< 0.005	0.096	0.038	0.029	24
Nitrate (NO3) Dissolved (mg/L)	0.027	0.027	0.027		1
Nitrate + Nitrite Diss. (mg/L)	0.013	0.106	0.039	0.025	24
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	< 0.002	< 0.002		1
pH (pH units)	6.0	7.43	7.1	0.3	24
P--T (mg/L)	0.003	0.041	0.006	0.008	24
Residue Non-filterable (mg/L)	< 1	5	1.8	1.3	24
Sulfate: D (mg/L)	2.5	2.5	2.5		1
Turbidity (NTU)	0.4	2.8	1.2	0.9	24
Ag-D (mg/L)	< 0.000005	< 0.000005	< 0.000005	0	24
Ag-T (mg/L)	< 0.000005	0.000006	< 0.000005	0.0000002	24
Al-D (mg/L)	0.0116	0.1	0.053	0.027	24
Al-T (mg/L)	0.026	0.216	0.080	0.050	24
As-D (mg/L)	0.00064	0.00199	0.001	0.0003	24
As-T (mg/L)	0.00063	0.00197	0.001	0.0003	24
Ba-D (mg/L)	0.00094	0.00177	0.001	0.0003	24
Ba-T (mg/L)	0.00106	0.00197	0.002	0.0002	24
B--D (mg/L)	< 0.05	< 0.05	< 0.05	0	24
Be-D (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	24
Be-T (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	24
Bi-D (mg/L)	< 0.000005	< 0.000005	< 0.000005	0	24
Bi-T (mg/L)	< 0.000005	0.000016	< 0.000005	0.000002	24
B--T (mg/L)	< 0.05	< 0.05	< 0.05	0	24
Cd-D (mg/L)	< 0.000005	0.000033	0.000009	0.000008	24
Cd-T (mg/L)	< 0.000005	0.000046	0.000010	0.000011	24
Co-D (mg/L)	< 0.00001	0.000111	0.00005	0.00003	24
Co-T (mg/L)	0.000019	0.000245	0.00008	0.00006	24
Cr-D (mg/L)	< 0.0001	0.0006	0.0002	0.0001	24
Cr-T (mg/L)	< 0.0001	0.0003	0.0002	0.0001	24
Cu-D (mg/L)	0.00101	0.00804	0.004	0.002	24
Cu-T (mg/L)	0.001	0.00963	0.005	0.002	24
Li-D (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	24
Li-T (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	24
Mg-D (mg/L)	0.481	1.01	0.71	0.16	24

	Minimum	Maximum	Average	Std. Dev	No. of samples
Mg-T (mg/L)	0.491	1.02	0.74	0.16	24
Mn-D (mg/L)	0.0004	0.00468	0.0025	0.0012	24
Mn-T (mg/L)	0.00094	0.0087	0.0047	0.0017	24
Mo-D (mg/L)	0.00005	0.00028	0.00014	0.00006	24
Mo-T (mg/L)	< 0.00005	0.00033	0.00014	0.00007	24
Ni-D (mg/L)	0.0001	0.0003	0.00019	0.00005	24
Ni-T (mg/L)	0.00009	0.00037	0.00022	0.00007	24
Pb-D (mg/L)	0.000007	0.000091	0.00003	0.00002	24
Pb-T (mg/L)	0.000011	0.000219	0.00004	0.00004	24
Sb-D (mg/L)	0.00003	0.0001	0.00007	0.00002	24
Sb-T (mg/L)	0.00004	0.00011	0.00007	0.00002	24
Se-D (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	24
Se-T (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	24
Sn-D (mg/L)	< 0.00001	0.00003	0.000011	0.000004	24
Sn-T (mg/L)	< 0.00001	0.00001	< 0.00001	0	24
Sr-D (mg/L)	0.00731	0.0157	0.011	0.003	24
Sr-T (mg/L)	0.00771	0.0164	0.011	0.003	24
Tl-D (mg/L)	< 0.000002	< 0.000002	< 0.000002	0	24
Tl-T (mg/L)	< 0.000002	0.000003	< 0.000002	0.0000002	24
U--D (mg/L)	< 0.000002	0.000003	< 0.000002	0.0000003	24
U--T (mg/L)	< 0.000002	0.000004	< 0.000002	0.0000007	24
V--D (mg/L)	< 0.0002	0.0006	0.0003	0.0001	24
V--T (mg/L)	< 0.0002	0.0008	0.0004	0.0001	24
Zn-D (mg/L)	0.0003	0.0033	0.001	0.001	24
Zn-T (mg/L)	0.0002	0.0487	0.005	0.013	24

Table 24. Summary of general water chemistry at Site 0127621, Tsolum River upstream from Puntledge River.

	Minimum	Maximum	Average	Std. Dev	No. of samples
Fecal coliforms (CFU/100mL)	710	710	710		1
E. coli (CFU/100mL)	3	45	24.5	15.5	11
Ammonia Dissolved (mg/L)	< 0.005	0.11	0.038	0.032	17
Carbon Dissolved Organic (mg/L)	1.4	1.4	1.4		1
Chlorophyll A (mg/L)	0.0011	0.0011	0.0011		1
Color True (Col.unit)	5	5	5		1
Hardness Total (T) (mg/L)	15.3	15.3	15.3		1
Nitrate (NO3) Dissolved (mg/L)	0.024	0.031	0.028	0.005	2
Nitrate + Nitrite Diss. (mg/L)	0.01	0.205	0.062	0.05	18
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	0.002	0.002	0	2
Nitrogen Total (mg/L)	0.15	0.15	0.15		1
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0.001		1
pH (pH units)	6.9	7.7	7.3	0.2	18
P--T (mg/L)	0.003	0.009	0.005	0.002	18
Residue Tot (mg/L)	< 25	< 25	< 25		1
Residue Filterable 1.0u (mg/L)	24	24	24		1
Residue Non-filterable (mg/L)	< 1	19	2.8	4.3	18
Specific Conductance (µS/cm)	44	44	44		1
Turbidity (NTU)	0.4	7.6	1.6	1.8	18
Ag-D (mg/L)	< 0.000005	0.000005	< 0.000005	0	17
Ag-T (mg/L)	< 0.000005	0.000011	< 0.000005	0.000001	18
Al-D (mg/L)	0.0117	0.0861	0.048	0.024	17
Al-T (mg/L)	0.0162	0.216	0.084	0.059	18
As-D (mg/L)	0.00056	0.00086	0.0007	0.0001	17
As-T (mg/L)	0.00059	0.00101	0.0007	0.0001	18
Ba-D (mg/L)	0.00092	0.00214	0.0017	0.0003	17
Ba-T (mg/L)	0.00129	0.00259	0.0019	0.0003	18
B--D (mg/L)	< 0.05	< 0.05	< 0.05	0	17
Be-D (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	17
Be-T (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	18
Bi-D (mg/L)	< 0.000005	0.000017	0.000006	0.000003	17
Bi-T (mg/L)	< 0.000005	< 0.000005	< 0.000005	0	18
B--T (mg/L)	< 0.05	< 0.05	< 0.05	0	18
Ca-T (mg/L)	4.68	4.68	4.68		1
Cd-D (mg/L)	< 0.000005	0.000028	0.000007	0.000006	17
Cd-T (mg/L)	< 0.000005	0.000023	0.000006	0.000004	18

	Minimum	Maximum	Average	Std. Dev	No. of samples
Co-D (mg/L)	0.000015	0.00005	0.00003	0.00001	17
Co-T (mg/L)	0.000029	0.000206	0.00007	0.00005	18
Cr-D (mg/L)	< 0.0001	0.0003	0.0002	0.0001	17
Cr-T (mg/L)	< 0.0001	0.001	0.0003	0.0002	18
Cu-D (mg/L)	0.00131	0.00549	0.0029	0.0011	17
Cu-T (mg/L)	0.00108	0.00572	0.0031	0.0013	18
Li-D (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	17
Li-T (mg/L)	< 0.0005	< 0.0005	< 0.0005	0	18
Mg-D (mg/L)	0.611	1.18	0.98	0.17	17
Mg-T (mg/L)	0.614	1.27	0.99	0.15	18
Mn-D (mg/L)	0.00076	0.00481	0.0021	0.0012	17
Mn-T (mg/L)	0.00224	0.0111	0.0057	0.0023	18
Mo-D (mg/L)	< 0.00005	0.00019	0.0001	0.0000	17
Mo-T (mg/L)	< 0.00005	0.00019	0.0001	0.0000	18
Ni-D (mg/L)	0.00011	0.0004	0.00020	0.00007	17
Ni-T (mg/L)	0.00008	0.00072	0.00026	0.00017	18
Pb-D (mg/L)	0.000007	0.00004	0.000017	0.00001	17
Pb-T (mg/L)	0.00001	0.000072	0.00003	0.00002	18
Sb-D (mg/L)	0.00004	0.00008	0.00006	0.00001	17
Sb-T (mg/L)	0.00003	0.00066	0.00009	0.0001	18
Se-D (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	17
Se-T (mg/L)	< 0.00004	< 0.00004	< 0.00004	0	18
Sn-D (mg/L)	< 0.00001	0.00001	< 0.00001	0	17
Sn-T (mg/L)	< 0.00001	< 0.00001	< 0.00001	0	18
Sr-D (mg/L)	0.0086	0.0191	0.0141	0.0028	17
Sr-T (mg/L)	0.00883	0.0194	0.0142	0.0026	18
Tl-D (mg/L)	< 0.000002	< 0.000002	< 0.000002	0	17
Tl-T (mg/L)	< 0.000002	< 0.000002	< 0.000002	0	18
U--D (mg/L)	< 0.000002	0.000011	0.000003	0.000003	17
U--T (mg/L)	< 0.000002	0.000011	0.000004	0.000003	18
V--D (mg/L)	< 0.0002	0.0006	0.0004	0.0001	17
V--T (mg/L)	0.0002	0.0011	0.0005	0.0002	18
Zn-D (mg/L)	0.0002	0.0009	0.0005	0.0002	17
Zn-T (mg/L)	0.0003	0.0022	0.0007	0.0005	18

APPENDIX II. QA/QC

Table 25. Summary of analyses of duplicate samples collected at site E206513, Tsolum River at Duncan Main Road.

START DATE	22/06/2010	22/06/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-T (mg/L)	0.039	0.039	0%
B--D (mg/L)	0.05	0.05	0%
B--T (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Cd-T (mg/L)	0.000005	0.000005	0%
Cr-T (mg/L)	0.0001	0.0001	0%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	1.5	1.5	0%
Mo-D (mg/L)	0.00005	0.00005	0%
Mo-T (mg/L)	0.00005	0.00005	0%
Ni-D (mg/L)	0.00012	0.00012	0%
P--T (mg/L)	0.005	0.005	0%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00002	0.00002	0%
Sb-T (mg/L)	0.00002	0.00002	0%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	0.8	0.8	0%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0005	0.0005	0%
V--T (mg/L)	0.0005	0.0005	0%
Zn-D (mg/L)	0.0004	0.0004	0%
Ba-T (mg/L)	0.00228	0.00229	0%
Sr-T (mg/L)	0.0152	0.0153	1%
Sr-D (mg/L)	0.0146	0.0147	1%

START DATE	22/06/2010	22/06/2010	Relative % Difference
Ba-D (mg/L)	0.002	0.00202	1%
Cu-T (mg/L)	0.00092	0.00091	1%
Co-T (mg/L)	0.000081	0.00008	1%
pH (pH units)	7.68	7.56	2%
Mg-T (mg/L)	1.68	1.65	2%
Al-D (mg/L)	0.0241	0.0236	2%
Mn-D (mg/L)	0.00177	0.00173	2%
Nitrate + Nitrite Diss. (mg/L)	0.043	0.044	2%
Mn-T (mg/L)	0.0156	0.0163	4%
As-T (mg/L)	0.0003	0.00028	7%
As-D (mg/L)	0.00026	0.00024	8%
Co-D (mg/L)	0.000023	0.000025	8%
Cu-D (mg/L)	0.00085	0.00077	10%
Ni-T (mg/L)	0.00016	0.00013	21%
Zn-T (mg/L)	0.0005	0.0004	22%
Pb-T (mg/L)	0.000025	0.000019	27%
Amonia Dissolved (mg/L)	0.047	0.07	39%
Pb-D (mg/L)	0.000023	0.000014	49%
Cr-D (mg/L)	0.0002	0.0001	67%

START DATE	30/06/2010	30/06/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0229	0.0236	3%
Al-T (mg/L)	0.0332	0.0325	2%
Amonia Dissolved (mg/L)	0.01	0.005	67%
As-D (mg/L)	0.00025	0.00034	31%
As-T (mg/L)	0.00032	0.00031	3%
Ba-D (mg/L)	0.00244	0.00243	0%
Ba-T (mg/L)	0.00265	0.00268	1%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000005	0.000013	89%
Cd-T (mg/L)	0.000012	0.000037	102%
Co-D (mg/L)	0.000033	0.000032	3%
Co-T (mg/L)	0.000079	0.00009	13%

START DATE	22/06/2010	22/06/2010	Relative % Difference
Cr-D (mg/L)	0.0001	0.0001	0%
Cr-T (mg/L)	0.0001	0.0001	0%
Cu-D (mg/L)	0.00128	0.00129	1%
Cu-T (mg/L)	0.00147	0.00171	15%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	1.67	1.77	6%
Mg-T (mg/L)	1.73	1.75	1%
Mn-D (mg/L)	0.00281	0.00264	6%
Mn-T (mg/L)	0.0201	0.0199	1%
Mo-D (mg/L)	0.00005	0.00005	0%
Mo-T (mg/L)	0.00005	0.00005	0%
Ni-D (mg/L)	0.00024	0.00021	13%
Ni-T (mg/L)	0.0002	0.00031	43%
Nitrate + Nitrite Diss. (mg/L)	0.07	0.061	14%
Pb-D (mg/L)	0.000031	0.000056	57%
Pb-T (mg/L)	0.000049	0.000122	85%
pH (pH units)	7.29	7.3	0%
P--T (mg/L)	0.006	0.006	0%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00002	0.00002	0%
Sb-T (mg/L)	0.00002	0.00002	0%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Sr-D (mg/L)	0.0173	0.0173	0%
Sr-T (mg/L)	0.0173	0.0175	1%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	1.1	1.3	17%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000002	0.000003	40%
V--D (mg/L)	0.0006	0.0005	18%
V--T (mg/L)	0.0006	0.0006	0%
Zn-D (mg/L)	0.0014	0.0021	40%
Zn-T (mg/L)	0.002	0.0031	43%

Table 26. Summary of analyses of duplicate samples collected at site E206494, Murex Creek at Duncan Main Road.

START DATE	08/06/2010	08/06/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000008	46%
Al-D (mg/L)	0.0714	0.0713	0%
Al-T (mg/L)	0.0879	0.0872	1%
Amonia Dissolved (mg/L)	0.033	0.056	52%
As-D (mg/L)	0.00102	0.00096	6%
As-T (mg/L)	0.00095	0.00093	2%
Ba-D (mg/L)	0.00104	0.00099	5%
Ba-T (mg/L)	0.00106	0.00094	12%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000008	0.000007	13%
Cd-T (mg/L)	0.000013	0.000008	48%
Co-D (mg/L)	0.000109	0.000114	4%
Co-T (mg/L)	0.000128	0.00013	2%
Cr-D (mg/L)	0.0001	0.0001	0%
Cr-T (mg/L)	0.0002	0.0001	67%
Cu-D (mg/L)	0.00872	0.00851	2%
Cu-T (mg/L)	0.00906	0.00874	4%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.391	0.382	2%
Mg-T (mg/L)	0.395	0.381	4%
Mn-D (mg/L)	0.00131	0.00117	11%
Mn-T (mg/L)	0.00136	0.00144	6%
Mo-D (mg/L)	0.00022	0.00021	5%
Mo-T (mg/L)	0.00022	0.00021	5%
Ni-D (mg/L)	0.00032	0.00029	10%
Ni-T (mg/L)	0.0003	0.00031	3%
Nitrate + Nitrite Diss. (mg/L)	0.016	0.015	6%
Pb-D (mg/L)	0.000036	0.000018	67%
Pb-T (mg/L)	0.000066	0.000026	87%
pH (pH units)	7	7	0%
P--T (mg/L)	0.002	0.002	0%

START DATE	08/06/2010	08/06/2010	Relative % Difference
Residue Non-filterable (mg/L)	1	34	189%
Sb-D (mg/L)	0.00009	0.00009	0%
Sb-T (mg/L)	0.0001	0.00009	11%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Sr-D (mg/L)	0.00699	0.00705	1%
Sr-T (mg/L)	0.00676	0.0067	1%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	0.4	0.4	0%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0002	0.0002	0%
V--T (mg/L)	0.0002	0.0002	0%
Zn-D (mg/L)	0.0023	0.0011	71%
Zn-T (mg/L)	0.0023	0.0012	63%

Table 27. Summary of analyses of duplicate samples collected at site E207826, Tsolum River 500 m downstream from Murex Creek.

START DATE	29/09/2009	29/09/2009	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0105	0.0103	2%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	21	20	5%
Amonia Dissolved (mg/L)	0.005	0.005	0%
As-D (mg/L)	0.00104	0.00102	2%
Ba-D (mg/L)	0.00348	0.00326	7%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Bicarbnt (mg/L)	25	25	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Ca-D (mg/L)	5.84	6.21	6%
Carbon Dissolved Organic (mg/L)	1.4	2.8	67%
Carbont (mg/L)	0.5	0.5	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Chlrid:D (mg/L)	4	4	0%
Co-D (mg/L)	0.000072	0.000026	94%
Color True (Col.unit)	15	15	0%
Cr-D (mg/L)	0.0001	0.0001	0%
Cu-D (mg/L)	0.00154	0.00146	5%
Fe-D (mg/L)	0.184	0.191	4%
Hardness Total (D) (mg/L)	20.8	21.8	5%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.23	0.23	0%
Li-D (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	1.52	1.54	1%
Mn-D (mg/L)	0.0256	0.0163	44%
Mo-D (mg/L)	0.00014	0.00014	0%
N.Kjel:T (mg/L)	0.05	0.03	50%
Na-D (mg/L)	2.88	2.99	4%
Ni-D (mg/L)	0.00017	0.00013	27%
Nitrate (NO3) Dissolved (mg/L)	0.074	0.067	10%
Nitrate + Nitrite Diss. (mg/L)	0.074	0.067	10%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.07	0.03	80%
Nitrogen Organic Tot-Diss (mg/L)	0.07	0.03	80%
Nitrogen Organic-Total (mg/L)	0.05	0.03	50%
Nitrogen Total (mg/L)	0.12	0.1	18%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Nitrogen Total Dissolved (mg/L)	0.15	0.1	40%
NO2+NO3 (mg/L)	0.07	0.07	0%
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0%
Pb-D (mg/L)	0.000008	0.000011	32%
pH (pH units)	7.4	7.4	0%
Phosphorus Tot. Dissolved (mg/L)	0.002	0.002	0%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00008	0.00009	12%
S--D (mg/L)	3	3	0%
Se-D (mg/L)	0.00004	0.00004	0%
Si-D (mg/L)	3.46	3.62	5%
Sn-D (mg/L)	0.00001	0.00001	0%
Specific Conductance (uS/cm)	58	57	2%
Sr-D (mg/L)	0.02	0.02	0%
Sulfat:D (mg/L)	2.3	1.7	30%
Temp (C)	11	11	0%
Temp(Air) (C)	13	13	0%
Ti-D (mg/L)	0.0005	0.0005	0%
Tl-D (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	1	1.1	10%
U--D (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0002	0.0003	40%
Zn-D (mg/L)	0.0004	0.0005	22%
Zr-D (mg/L)	0.0001	0.0001	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Ag-T (mg/L)	0.000001	0.000001	0%
Al-T (mg/L)	0.0135	0.0198	27%
As-T (mg/L)	0.00136	0.00142	3%
Ba-T (mg/L)	0.00331	0.00343	3%
Be-T (mg/L)	0.000001	0.000001	0%
Bi-T (mg/L)	0.000001	0.000001	0%
B--T (mg/L)	0.007	0.0073	3%
Cd-T (mg/L)	0.000003	0.000003	0%
Cerium Total (mg/L)	0.000018	0.000022	14%
Cesium Total (mg/L)	0.000005	0.000005	0%
Co-T (mg/L)	0.000085	0.000116	22%
Cr-T (mg/L)	0.000083	0.000084	1%
Cu-T (mg/L)	0.00184	0.00196	4%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Fe-T (mg/L)	0.317	0.348	7%
Ga-T (mg/L)	0.000003	0.000004	20%
Lathanum Total (mg/L)	0.00001	0.000012	13%
Li-T (mg/L)	0.0002	0.0002	0%
Mn-T (mg/L)	0.0282	0.0361	17%
Mo-T (mg/L)	0.000141	0.000137	2%
Niobium Total (mg/L)	0.000001	0.000001	0%
Ni-T (mg/L)	0.00013	0.00014	5%
Pb-T (mg/L)	0.000005	0.000008	33%
Platinum Total (mg/L)	0.000001	0.000001	0%
P--T (mg/L)	0.0059	0.0049	13%
Rb-T (mg/L)	0.00038	0.00038	0%
Sb-T (mg/L)	0.000065	0.000065	0%
Se-T (mg/L)	0.00005	0.00005	0%
Sn-T (mg/L)	0.000005	0.000005	0%
Sr-T (mg/L)	0.0198	0.0196	1%
Tl-T (mg/L)	0.000004	0.000003	20%
Tungsten Total (mg/L)	0.000001	0.000001	0%
U--T (mg/L)	0.0000005	0.0000005	0%
V--T (mg/L)	0.000247	0.000292	12%
Yttrium Total (mg/L)	0.000045	0.00005	7%
Zn-T (mg/L)	0.00022	0.00027	14%

START DATE	15/10/2009	15/10/2009	Relative % Difference
Ag-D (mg/L)	0.000007	0.000007	0%
Al-D (mg/L)	0.0814	0.0839	2%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	8.4	7.6	7%
Amonia Dissolved (mg/L)	0.005	0.005	0%
As-D (mg/L)	0.00128	0.0013	1%
Ba-D (mg/L)	0.00185	0.00187	1%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Bicarbnt (mg/L)	10	9.3	5%
Bi-D (mg/L)	0.000005	0.000005	0%
Ca-D (mg/L)	3.75	3.93	3%
Carbon Dissolved Organic (mg/L)	4.5	4.8	5%
Carbont (mg/L)	0.5	0.5	0%
Cd-D (mg/L)	0.000009	0.000009	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Chlrid:D (mg/L)	2.5	2.2	9%
Co-D (mg/L)	0.00012	0.00011	6%
Coli:Fec (CFU/100mL)	220	170	18%
Color True (Col.unit)	20	20	0%
Cr-D (mg/L)	0.0001	0.0001	0%
Cu-D (mg/L)	0.0128	0.0131	2%
Diss Oxy (mg/L)	12	12	0%
Fe-D (mg/L)	0.083	0.083	0%
Hardness Total (D) (mg/L)	12.7	13.3	3%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.25	0.25	0%
Li-D (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.82	0.84	2%
Mn-D (mg/L)	0.00686	0.0072	3%
Mo-D (mg/L)	0.00025	0.00023	6%
N.Kjel:T (mg/L)	0.1	0.1	0%
Na-D (mg/L)	1.61	1.64	1%
Ni-D (mg/L)	0.00035	0.00036	2%
Nitrate (NO3) Dissolved (mg/L)	0.164	0.159	2%
Nitrate + Nitrite Diss. (mg/L)	0.164	0.159	2%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.09	0.1	7%
Nitrogen Organic Tot-Diss (mg/L)	0.09	0.1	7%
Nitrogen Organic-Total (mg/L)	0.1	0.1	0%
Nitrogen Total (mg/L)	0.26	0.26	0%
Nitrogen Total Dissolved (mg/L)	0.26	0.26	0%
NO2+NO3 (mg/L)	0.16	0.16	0%
Ortho-Phosphate Dissolved (mg/L)	0.002	0.002	0%
Pb-D (mg/L)	0.000036	0.00002	40%
pH (pH units)	7	6.9	1%
Phosphorus Tot. Dissolved (mg/L)	0.003	0.003	0%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00012	0.00013	6%
S--D (mg/L)	3	3	0%
Se-D (mg/L)	0.00004	0.00004	0%
Si-D (mg/L)	2.22	2.2	1%
Sn-D (mg/L)	0.00001	0.00001	0%
Specific Conductance (uS/cm)	39	38	2%
Sr-D (mg/L)	0.0124	0.0125	1%
Sulfat:D (mg/L)	5.3	5.3	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Temp (C)	7.5	7.5	0%
Temp(Air) (C)	11	11	0%
Ti-D (mg/L)	0.0014	0.0013	5%
Tl-D (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	1.7	1.8	4%
U--D (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0002	0.0002	0%
Zn-D (mg/L)	0.0019	0.0014	21%
Zr-D (mg/L)	0.0001	0.0001	0%

START DATE	24/11/2009	24/11/2009	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0655	0.0636	2%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	8.7	8.5	2%
Amonia Dissolved (mg/L)	0.005	0.005	0%
As-D (mg/L)	0.00029	0.00032	7%
Ba-D (mg/L)	0.00115	0.00106	6%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Bicarbnt (mg/L)	11	10	7%
Bi-D (mg/L)	0.000005	0.000005	0%
Ca-D (mg/L)	2.29	2.29	0%
Carbon Dissolved Organic (mg/L)	2.2	3.1	24%
Carbont (mg/L)	0.5	0.5	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Chlrid:D (mg/L)	1.4	0.8	39%
Co-D (mg/L)	0.00005	0.000051	1%
Coli:Fec (CFU/100mL)	10	13	18%
Color True (Col.unit)	30	15	47%
Cr-D (mg/L)	0.0002	0.0002	0%
Cu-D (mg/L)	0.00235	0.00226	3%
Diss Oxy (mg/L)	12	12	0%
Fe-D (mg/L)	0.069	0.068	1%
Hardness Total (D) (mg/L)	8.6	8.6	0%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.08	0.08	0%
Li-D (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.69	0.69	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Mn-D (mg/L)	0.0019	0.00181	3%
Mo-D (mg/L)	0.00005	0.00005	0%
N.Kjel:T (mg/L)	0.05	0.08	33%
Na-D (mg/L)	0.94	0.92	2%
Ni-D (mg/L)	0.00016	0.00013	15%
Nitrate (NO3) Dissolved (mg/L)	0.047	0.024	46%
Nitrate + Nitrite Diss. (mg/L)	0.05	0.024	50%
Nitrogen - Nitrite Diss. (mg/L)	0.003	0.002	28%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.05	0.08	33%
Nitrogen Organic Tot-Diss (mg/L)	0.05	0.08	33%
Nitrogen Organic-Total (mg/L)	0.05	0.08	33%
Nitrogen Total (mg/L)	0.1	0.1	0%
Nitrogen Total Dissolved (mg/L)	0.1	0.1	0%
NO2+NO3 (mg/L)	0.05	0.02	61%
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0%
Pb-D (mg/L)	0.000062	0.00001	102%
pH (pH units)	6.9	7.1	2%
Phosphorus Tot. Dissolved (mg/L)	0.002	0.002	0%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00003	0.00003	0%
S--D (mg/L)	3	3	0%
Se-D (mg/L)	0.00004	0.00004	0%
Si-D (mg/L)	2.67	2.75	2%
Sn-D (mg/L)	0.00001	0.00001	0%
Specific Conductance (uS/cm)	23	23	0%
Sr-D (mg/L)	0.00677	0.00672	1%
Sulfat:D (mg/L)	0.5	0.5	0%
Temp (C)	4	4	0%
Temp(Air) (C)	8	8	0%
Ti-D (mg/L)	0.0018	0.0023	17%
Tl-D (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	1.3	0.9	26%
U--D (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0003	0.0003	0%
Zn-D (mg/L)	0.0007	0.0003	57%
Zr-D (mg/L)	0.0001	0.0001	0%

START DATE	16/02/2010	16/02/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Al-D (mg/L)	0.0723	0.0731	1%
Alk:Tot (ueq/L)	5.7	5.9	3%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	7.1	7.5	5%
Amonia Dissolved (mg/L)	0.005	0.005	0%
As-D (mg/L)	0.00037	0.00037	0%
Ba-D (mg/L)	0.00089	0.00089	0%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Bicarbnt (mg/L)	8.7	9.1	4%
Bi-D (mg/L)	0.000005	0.000005	0%
Ca-D (mg/L)	1.97	2.05	4%
Carbon Dissolved Organic (mg/L)	2.7	2.6	4%
Carbont (mg/L)	0.5	0.5	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Chlrid:D (mg/L)	0.6	0.7	15%
Co-D (mg/L)	0.000049	0.000065	28%
Coli:Fec (CFU/100mL)	4	5	22%
Color True (Col.unit)	20	20	0%
Cr-D (mg/L)	0.0001	0.0001	0%
Cu-D (mg/L)	0.00317	0.0032	1%
Diss Oxy (mg/L)	13	13	0%
Fe-D (mg/L)	0.049	0.049	0%
Hardness Total (D) (mg/L)	7.3	7.4	1%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.07	0.07	0%
Li-D (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.57	0.56	2%
Mn-D (mg/L)	0.00164	0.00155	6%
Mo-D (mg/L)	0.00005	0.00005	0%
N.Kjel:T (mg/L)	0.02	0.02	0%
Na-D (mg/L)	0.85	0.85	0%
Ni-D (mg/L)	0.00016	0.00014	13%
Nitrate (NO3) Dissolved (mg/L)	0.018	0.024	29%
Nitrate + Nitrite Diss. (mg/L)	0.018	0.024	29%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.02	0.02	0%
Nitrogen Organic Tot-Diss (mg/L)	0.02	0.02	0%
Nitrogen Organic-Total (mg/L)	0.02	0.02	0%
Nitrogen Total (mg/L)	0.03	0.05	50%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Nitrogen Total Dissolved (mg/L)	0.03	0.04	29%
NO2+NO3 (mg/L)	0.01	0.03	100%
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0%
Pb-D (mg/L)	0.000046	0.000017	92%
pH (pH units)	7	7	0%
Phosphorus Tot. Dissolved (mg/L)	0.043	0.044	2%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00004	0.00002	67%
S--D (mg/L)	3	3	0%
Se-D (mg/L)	0.00004	0.00004	0%
Si-D (mg/L)	2.17	2.19	1%
Sn-D (mg/L)	0.00001	0.00001	0%
Specific Conductance (uS/cm)	19	20	5%
Sr-D (mg/L)	0.00607	0.00602	1%
Sulfat:D (mg/L)	0.5	0.5	0%
Temp (C)	4	4	0%
Temp(Air) (C)	7	7	0%
Ti-D (mg/L)	0.0017	0.0017	0%
Tl-D (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	1.1	1.1	0%
U--D (mg/L)	0.000003	0.000002	40%
V--D (mg/L)	0.0002	0.0003	40%
Zn-D (mg/L)	0.0006	0.0008	29%
Zr-D (mg/L)	0.0001	0.0001	0%

START DATE	22/06/2010	22/06/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0563	0.0603	7%
Alk:Tot (ueq/L)	9.7	7.4	27%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	7	8	13%
Amonia Dissolved (mg/L)	0.005	0.037	152%
Amonia:T (mg/L)	0	0.04	100%
As-D (mg/L)	0.00094	0.00104	10%
Ba-D (mg/L)	0.00113	0.00122	8%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Bicarbnt (mg/L)	8.5	9.7	13%
Bi-D (mg/L)	0.000005	0.000005	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Ca-D (mg/L)	2.47	2.47	0%
Carbon Dissolved Organic (mg/L)	2.3	1.8	24%
Carbont (mg/L)	0.5	0.5	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Chlrid:D (mg/L)	0.5	0.5	0%
Co-D (mg/L)	0.000074	0.000066	11%
Coli:Fec (CFU/100mL)	14	14	0%
Color True (Col.unit)	15	5	100%
Cr-D (mg/L)	0.0005	0.0001	133%
Cu-D (mg/L)	0.00686	0.0074	8%
Diss Oxy (mg/L)	11	11	0%
Fe-D (mg/L)	0.079	0.075	5%
Hardness Total (D) (mg/L)	8.4	8.5	1%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.15	0.16	6%
Li-D (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.54	0.58	7%
Mn-D (mg/L)	0.00328	0.0027	19%
Mo-D (mg/L)	0.00032	0.0003	6%
N.Kjel:T (mg/L)	0.08	0.12	40%
Na-D (mg/L)	0.79	0.73	8%
Ni-D (mg/L)	0.00025	0.00028	11%
Nitrate (NO3) Dissolved (mg/L)	0.018	0.008	77%
Nitrate + Nitrite Diss. (mg/L)	0.018	0.008	77%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.06	0.1	50%
Nitrogen Organic Tot-Diss (mg/L)	0.06	0.06	0%
Nitrogen Organic-Total (mg/L)	0.08	0.08	0%
Nitrogen Total (mg/L)	0.1	0.13	26%
Nitrogen Total Dissolved (mg/L)	0.08	0.11	32%
NO2+NO3 (mg/L)	0.02	0.01	67%
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0%
Pb-D (mg/L)	0.000006	0.000012	67%
pH (pH units)	7.02	7.09	1%
Phosphorus Tot. Dissolved (mg/L)	0.002	0.002	0%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.0001	0.00012	18%
Se-D (mg/L)	0.00004	0.00004	0%
Si-D (mg/L)	1.65	1.75	6%
Sn-D (mg/L)	0.00001	0.00001	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Specific Conductance (uS/cm)	21	23	9%
Sr-D (mg/L)	0.00826	0.00912	10%
Sulfat:D (mg/L)	0.8	1.6	67%
Temp (C)	10	10	0%
Temp(Air) (C)	16	16	0%
Ti-D (mg/L)	0.0005	0.0005	0%
Tl-D (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	0.5	0.4	22%
U--D (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0002	0.0002	0%
Zn-D (mg/L)	0.0008	0.0009	12%
Zr-D (mg/L)	0.0001	0.0001	0%

START DATE	12/10/2010	12/10/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0577	0.0577	0%
Alk:Tot (ueq/L)	9.8	10.7	6%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	10	10	0%
Amonia Dissolved (mg/L)	0.013	0.005	63%
Amonia:T (mg/L)	0.01	0	141%
As-D (mg/L)	0.00077	0.00078	1%
Ba-D (mg/L)	0.00142	0.00141	0%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Bicarbnt (mg/L)	12	12	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Ca-D (mg/L)	3.53	3.38	3%
Carbon Dissolved Organic (mg/L)	3.9	4.2	5%
Carbont (mg/L)	0.5	0.5	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Chlrid:D (mg/L)	0.7	1.3	42%
Co-D (mg/L)	0.000048	0.000058	13%
Coli:Fec (CFU/100mL)	18	17	4%
Color True (Col.unit)	20	20	0%
Cr-D (mg/L)	0.0001	0.0002	47%
Cu-D (mg/L)	0.00506	0.00524	2%
Diss Oxy (mg/L)	11	11	0%
Fe-D (mg/L)	0.176	0.177	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Hardness Total (D) (mg/L)	12.4	12.2	1%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.15	0.16	5%
Li-D (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.88	0.9	2%
Mn-D (mg/L)	0.00242	0.0042	38%
Mo-D (mg/L)	0.00016	0.00016	0%
N.Kjel:T (mg/L)	0.2	0.19	4%
Na-D (mg/L)	1.25	1.27	1%
Ni-D (mg/L)	0.00022	0.00023	3%
Nitrate (NO3) Dissolved (mg/L)	0.034	0.035	2%
Nitrate + Nitrite Diss. (mg/L)	0.034	0.035	2%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.14	0.16	9%
Nitrogen Organic Tot-Diss (mg/L)	0.12	0.16	20%
Nitrogen Organic-Total (mg/L)	0.19	0.19	0%
Nitrogen Total (mg/L)	0.23	0.22	3%
Nitrogen Total Dissolved (mg/L)	0.17	0.19	8%
NO2+NO3 (mg/L)	0.03	0.03	0%
Ortho-Phosphate Dissolved (mg/L)	0.002	0.007	79%
Pb-D (mg/L)	0.000014	0.000024	37%
pH (pH units)	7.08	7.24	2%
Phosphorus Tot. Dissolved (mg/L)	0.003	0.005	35%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00006	0.00006	0%
Se-D (mg/L)	0.00004	0.00004	0%
Si-D (mg/L)	2.66	2.48	5%
Sn-D (mg/L)	0.00001	0.00001	0%
Specific Conductance (uS/cm)	32	33	2%
Sr-D (mg/L)	0.0109	0.0107	1%
Sulfat:D (mg/L)	0.5	1.2	58%
Temp (C)	10.4	10.4	0%
Temp(Air) (C)	14	14	0%
Ti-D (mg/L)	0.0005	0.001	47%
Tl-D (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	0.8	0.8	0%
U--D (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0003	0.0004	20%
Zn-D (mg/L)	0.0005	0.0005	0%
Zr-D (mg/L)	0.0001	0.0001	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Alk:Tot (ueq/L)	5.3	4.6	10%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	5.9	6.5	7%
Amonia Dissolved (mg/L)	0.005	0.031	102%
Amonia:T (mg/L)	0	0.03	141%
Bicarbnt (mg/L)	7.2	8	7%
Ca-D (mg/L)	2.07	2.1	1%
Carbon Dissolved Organic (mg/L)	2.4	2.6	6%
Carbont (mg/L)	0.5	0.5	0%
Chlrid:D (mg/L)	1.3	0.8	34%
Coli:Fec (CFU/100mL)	8	1	110%
Color True (Col.unit)	20	20	0%
Diss Oxy (mg/L)	13	13	0%
Hardness Total (D) (mg/L)	7.8	8	2%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.063	0.068	5%
Mg-D (mg/L)	0.635	0.659	3%
N.Kjel:T (mg/L)	0.08	0.16	47%
Na-D (mg/L)	0.884	0.931	4%
Nitrate (NO3) Dissolved (mg/L)	0.029	0.029	0%
Nitrate + Nitrite Diss. (mg/L)	0.029	0.029	0%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.05	0.03	35%
Nitrogen Organic Tot-Diss (mg/L)	0.05	0.02	61%
Nitrogen Organic-Total (mg/L)	0.08	0.13	34%
Nitrogen Total (mg/L)	0.11	0.19	38%
Nitrogen Total Dissolved (mg/L)	0.08	0.06	20%
NO2+NO3 (mg/L)	0.03	0.03	0%
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0%
pH (pH units)	6.61	6.68	1%
Phosphorus Tot. Dissolved (mg/L)	0.004	0.003	20%
Residue Non-filterable (mg/L)	1	2	47%
S--D (mg/L)	3	3	0%
Specific Conductance (uS/cm)	18	19	4%
Sulfat:D (mg/L)	0.5	0.5	0%
Temp (C)	2.9	3	2%
Temp(Air) (C)	3.7	3.9	4%
Turbidity (NTU)	1.8	1.8	0%
Ag-D (mg/L)	0.000005	0.000005	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0794	0.0798	0%
Al-T (mg/L)	0.0836	0.0982	11%
As-D (mg/L)	0.00068	0.00069	1%
As-T (mg/L)	0.00074	0.00072	2%
Ba-D (mg/L)	0.00074	0.00084	9%
Ba-T (mg/L)	0.00079	0.00086	6%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000005	0.000012	58%
Cd-T (mg/L)	0.000007	0.00001	25%
Co-D (mg/L)	0.000128	0.000104	15%
Co-T (mg/L)	0.000138	0.000144	3%
Cr-D (mg/L)	0.0001	0.0001	0%
Cr-T (mg/L)	0.0001	0.0002	47%
Cu-D (mg/L)	0.00635	0.00629	1%
Cu-T (mg/L)	0.00637	0.00664	3%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.432	0.43	0%
Mg-T (mg/L)	0.421	0.427	1%
Mn-D (mg/L)	0.00244	0.00223	6%
Mn-T (mg/L)	0.0028	0.00325	11%
Mo-D (mg/L)	0.00011	0.0001	7%
Mo-T (mg/L)	0.0001	0.00012	13%
Ni-D (mg/L)	0.00024	0.00024	0%
Ni-T (mg/L)	0.00022	0.00024	6%
Pb-D (mg/L)	0.000011	0.000023	50%
Pb-T (mg/L)	0.000014	0.00002	25%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00006	0.00005	13%
Sb-T (mg/L)	0.00005	0.00005	0%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00002	0.00002	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Sr-D (mg/L)	0.00614	0.00624	1%
Sr-T (mg/L)	0.00592	0.00636	5%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0002	0.0002	0%
V--T (mg/L)	0.0003	0.0003	0%
Zn-D (mg/L)	0.0008	0.0008	0%
Zn-T (mg/L)	0.0009	0.0009	0%

START DATE	21/06/2011	21/06/2011	Relative % Difference
Alk:Tot (ueq/L)	4.2	4.3	2%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	4.8	4.1	11%
Amonia Dissolved (mg/L)	0.027	0.01	65%
Amonia:T (mg/L)	0.03	0.01	71%
Bicarbnt (mg/L)	5.8	5	10%
Ca-D (mg/L)	1.91	1.99	3%
Carbon Dissolved Organic (mg/L)	2.5	2.3	6%
Carbont (mg/L)	0.5	0.5	0%
Chlrid:D (mg/L)	0.5	0.5	0%
Coli:Fec (CFU/100mL)	15	8	43%
Color True (Col.unit)	15	15	0%
Diss Oxy (mg/L)	12	12	0%
Hardness Total (D) (mg/L)	6.3	6.6	3%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.129	0.126	2%
Mg-D (mg/L)	0.361	0.392	6%
N.Kjel:T (mg/L)	0.08	0.08	0%
Na-D (mg/L)	0.508	0.546	5%
Nitrate (NO3) Dissolved (mg/L)	0.021	0.014	28%
Nitrate + Nitrite Diss. (mg/L)	0.021	0.014	28%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.05	0.05	0%
Nitrogen Organic Tot-Diss (mg/L)	0.02	0.04	47%
Nitrogen Organic-Total (mg/L)	0.05	0.07	24%
Nitrogen Total (mg/L)	0.1	0.09	7%
Nitrogen Total Dissolved (mg/L)	0.07	0.07	0%

START DATE	29/09/2009	29/09/2009	Relative % Difference
NO2+NO3 (mg/L)	0.02	0.01	47%
Ortho-Phosphate Dissolved (mg/L)	0.002	0.001	47%
pH (pH units)	6.76	6.74	0%
Phosphorus Tot. Dissolved (mg/L)	0.002	0.002	0%
Residue Non-filterable (mg/L)	1	1	0%
S--D (mg/L)	3	3	0%
Specific Conductance (uS/cm)	17	17	0%
Sulfat:D (mg/L)	2.7	1.6	36%
Temp (C)	6.6	6.7	1%
Temp(Air) (C)	15.5	16.6	5%
Turbidity (NTU)	0.7	0.5	24%

START DATE	25/10/2011	25/10/2011	Relative % Difference
Alk:Tot (ueq/L)	11.5	11.2	2%
Alkalinity pH 8.3 (mg/L)	0.5	0.5	0%
Alkalinity Total 4.5 (mg/L)	11.8	12.4	4%
Amonia Dissolved (mg/L)	0.033	0.024	22%
Amonia:T (mg/L)	0.033	0.025	20%
Bicarbnt (mg/L)	14.4	15.1	3%
Ca-D (mg/L)	3.73	3.74	0%
Carbon Dissolved Organic (mg/L)	3.29	2.5	19%
Carbont (mg/L)	0.5	0.5	0%
Chlrid:D (mg/L)	1.5	1.7	9%
Coli:Fec (CFU/100mL)	1	2	47%
Color True (Col.unit)	15	15	0%
Diss Oxy (mg/L)	12.8	12.8	0%
Hardness Total (D) (mg/L)	13.2	13.3	1%
Hydroxide Alkalinity (mg/L)	0.5	0.5	0%
K--D (mg/L)	0.142	0.124	10%
Mg-D (mg/L)	0.952	0.97	1%
N.Kjel:T (mg/L)	0.123	0.195	32%
Na-D (mg/L)	1.54	1.54	0%
Nitrate (NO3) Dissolved (mg/L)	0.0103	0.007	27%
Nitrate + Nitrite Diss. (mg/L)	0.0103	0.007	27%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0%
Nitrogen (Kjel.) Tot Diss (mg/L)	0.118	0.159	21%
Nitrogen Organic Tot-Diss (mg/L)	0.08	0.13	34%
Nitrogen Organic-Total (mg/L)	0.09	0.17	44%
Nitrogen Total (mg/L)	0.134	0.202	29%

START DATE	29/09/2009	29/09/2009	Relative % Difference
Nitrogen Total Dissolved (mg/L)	0.128	0.166	18%
NO2+NO3 (mg/L)	0.011	0.007	31%
Ortho-Phosphate Dissolved (mg/L)	0.001	0.001	0%
pH (pH units)	7	7.27	3%
Phosphorus Tot. Dissolved (mg/L)	0.004	0.003	20%
S--D (mg/L)	3	3	0%
Specific Conductance (uS/cm)	33.7	35.7	4%
Sulfat:D (mg/L)	0.5	0.5	0%
Temp (C)	6.4	6.4	0%
Temp(Air) (C)	7	6.9	1%
Turbidity (NTU)	0.53	0.42	16%

Table 28. Summary of analyses of duplicate samples collected at site 0127620, Tsolum River at Farnham Road Bridge.

START DATE	22/04/2010	22/04/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.048	0.0471	2%
Al-T (mg/L)	0.0573	0.0568	1%
Amonia Dissolved (mg/L)	0.005	0.005	0%
As-D (mg/L)	0.00064	0.00062	3%
As-T (mg/L)	0.00072	0.00074	3%
Ba-D (mg/L)	0.00101	0.00097	4%
Ba-T (mg/L)	0.00106	0.00109	3%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Cd-T (mg/L)	0.000006	0.000009	40%
Co-D (mg/L)	0.000036	0.000032	12%
Co-T (mg/L)	0.000019	0.000025	27%
Cr-D (mg/L)	0.0001	0.0001	0%
Cr-T (mg/L)	0.0001	0.0001	0%
Cu-D (mg/L)	0.00354	0.0035	1%
Cu-T (mg/L)	0.00375	0.00372	1%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.555	0.541	3%
Mg-T (mg/L)	0.653	0.643	2%
Mn-D (mg/L)	0.00184	0.00166	10%
Mn-T (mg/L)	0.00094	0.00131	33%
Mo-D (mg/L)	0.0002	0.00009	76%
Mo-T (mg/L)	0.0001	0.00009	11%
Ni-D (mg/L)	0.00015	0.00017	13%
Ni-T (mg/L)	0.0002	0.00021	5%
Nitrate + Nitrite Diss. (mg/L)	0.027	0.021	25%
Pb-D (mg/L)	0.000085	0.000087	2%
Pb-T (mg/L)	0.000011	0.000012	9%
pH (pH units)	7.21	6.07	17%
P--T (mg/L)	0.004	0.005	22%

START DATE	22/04/2010	22/04/2010	Relative % Difference
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00005	0.00005	0%
Sb-T (mg/L)	0.00005	0.00005	0%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00003	0.00002	40%
Sn-T (mg/L)	0.00001	0.00001	0%
Sr-D (mg/L)	0.00912	0.00885	3%
Sr-T (mg/L)	0.00883	0.00895	1%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	0.7	0.5	33%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0002	0.0002	0%
V--T (mg/L)	0.0002	0.0002	0%
Zn-D (mg/L)	0.0005	0.0006	18%
Zn-T (mg/L)	0.0008	0.0005	46%

START DATE	28/09/2010	28/09/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0319	0.0328	3%
Al-T (mg/L)	0.0441	0.0676	42%
Amonia Dissolved (mg/L)	0.096	0.1	4%
As-D (mg/L)	0.00099	0.00099	0%
As-T (mg/L)	0.00103	0.00108	5%
Ba-D (mg/L)	0.00172	0.00177	3%
Ba-T (mg/L)	0.00171	0.0019	11%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000012	0.000007	53%
Cd-T (mg/L)	0.000005	0.000005	0%
Co-D (mg/L)	0.000026	0.000026	0%
Co-T (mg/L)	0.000037	0.000062	51%

START DATE	22/04/2010	22/04/2010	Relative % Difference
Cr-D (mg/L)	0.0001	0.0002	67%
Cr-T (mg/L)	0.0002	0.0002	0%
Cu-D (mg/L)	0.00275	0.00278	1%
Cu-T (mg/L)	0.00289	0.00343	17%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.837	0.859	3%
Mg-T (mg/L)	0.84	0.966	14%
Mn-D (mg/L)	0.00082	0.00109	28%
Mn-T (mg/L)	0.00286	0.00472	49%
Mo-D (mg/L)	0.00016	0.00014	13%
Mo-T (mg/L)	0.00015	0.00016	6%
Ni-D (mg/L)	0.00014	0.00014	0%
Ni-T (mg/L)	0.00014	0.00016	13%
Nitrate + Nitrite Diss. (mg/L)	0.106	0.105	1%
Pb-D (mg/L)	0.000015	0.000015	0%
Pb-T (mg/L)	0.00002	0.000029	37%
pH (pH units)	7.23	7.21	0%
P--T (mg/L)	0.006	0.006	0%
Residue Non-filterable (mg/L)	1	3	100%
Sb-D (mg/L)	0.00008	0.00008	0%
Sb-T (mg/L)	0.00008	0.00008	0%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Sr-D (mg/L)	0.0148	0.0148	0%
Sr-T (mg/L)	0.0146	0.015	3%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	0.6	2.1	111%
U--D (mg/L)	0.000003	0.000002	40%
U--T (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0003	0.0004	29%
V--T (mg/L)	0.0004	0.0005	22%
Zn-D (mg/L)	0.0004	0.0004	0%
Zn-T (mg/L)	0.0003	0.0006	67%

START DATE	02/11/2010	02/11/2010	Relative % Difference

START DATE	22/04/2010	22/04/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0946	0.0931	2%
Al-T (mg/L)	0.106	0.135	24%
Amonia Dissolved (mg/L)	0.005	0.008	46%
As-D (mg/L)	0.00072	0.00068	6%
As-T (mg/L)	0.00083	0.00094	12%
Ba-D (mg/L)	0.00145	0.00149	3%
Ba-T (mg/L)	0.00155	0.00174	12%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000032	0.000101	104%
Cd-T (mg/L)	0.000041	0.000127	102%
Co-D (mg/L)	0.000056	0.000062	10%
Co-T (mg/L)	0.000091	0.000122	29%
Cr-D (mg/L)	0.0002	0.0003	40%
Cr-T (mg/L)	0.0002	0.0003	40%
Cu-D (mg/L)	0.0031	0.0034	9%
Cu-T (mg/L)	0.00349	0.00397	13%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	0.777	0.767	1%
Mg-T (mg/L)	0.769	0.774	1%
Mn-D (mg/L)	0.00322	0.00356	10%
Mn-T (mg/L)	0.00446	0.00624	33%
Mo-D (mg/L)	0.00005	0.00005	0%
Mo-T (mg/L)	0.00005	0.00005	0%
Ni-D (mg/L)	0.00022	0.00029	27%
Ni-T (mg/L)	0.00024	0.00032	29%
Nitrate + Nitrite Diss. (mg/L)	0.047	0.049	4%
Pb-D (mg/L)	0.000018	0.000035	64%
Pb-T (mg/L)	0.00003	0.000063	71%
pH (pH units)	6.95	6.93	0%
P--T (mg/L)	0.005	0.005	0%
Residue Non-filterable (mg/L)	4	4	0%
Sb-D (mg/L)	0.00004	0.00005	22%

START DATE	22/04/2010	22/04/2010	Relative % Difference
Sb-T (mg/L)	0.00004	0.00005	22%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Sr-D (mg/L)	0.0108	0.0108	0%
Sr-T (mg/L)	0.011	0.0112	2%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	2.6	3.8	38%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0005	0.0004	22%
V--T (mg/L)	0.0004	0.0006	40%
Zn-D (mg/L)	0.0007	0.0023	107%
Zn-T (mg/L)	0.0008	0.0025	103%

Table 29. Summary of analyses of duplicate samples collected at site 0127621, Tsolum River upstream from Puntledge River.

START DATE	25/05/2010	25/05/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0633	0.0633	0%
B--D (mg/L)	0.05	0.05	0%
B--T (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Cd-T (mg/L)	0.000005	0.000005	0%
Cr-T (mg/L)	0.0003	0.0003	0%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
P--T (mg/L)	0.004	0.004	0%
Residue Non-filterable (mg/L)	7	7	0%
Sb-D (mg/L)	0.00007	0.00007	0%
Sb-T (mg/L)	0.00007	0.00007	0%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000004	0.000004	0%
V--D (mg/L)	0.0003	0.0003	0%
V--T (mg/L)	0.0006	0.0006	0%
Zn-T (mg/L)	0.0008	0.0008	0%
pH (pH units)	7.2	7.2	0%
Al-T (mg/L)	0.17	0.171	1%
Mg-T (mg/L)	0.874	0.866	1%
Sr-T (mg/L)	0.0108	0.0109	1%
Sr-D (mg/L)	0.0104	0.0105	1%
Mg-D (mg/L)	0.767	0.777	1%
Ba-D (mg/L)	0.00141	0.00143	1%
Ba-T (mg/L)	0.00181	0.00184	2%
Co-D (mg/L)	0.000031	0.000032	3%

START DATE	25/05/2010	25/05/2010	Relative % Difference
Mn-D (mg/L)	0.00165	0.00172	4%
As-T (mg/L)	0.00077	0.00081	5%
As-D (mg/L)	0.0006	0.00064	6%
Ni-T (mg/L)	0.00031	0.00029	7%
Cu-T (mg/L)	0.00522	0.00561	7%
Nitrate + Nitrite Diss. (mg/L)	0.027	0.025	8%
Mo-T (mg/L)	0.00013	0.00012	8%
Turbidity (NTU)	2.4	2.6	8%
Mo-D (mg/L)	0.00011	0.00012	9%
Mn-T (mg/L)	0.00633	0.00699	10%
Cu-D (mg/L)	0.00412	0.0046	11%
Zn-D (mg/L)	0.0006	0.0005	18%
Ni-D (mg/L)	0.00023	0.00028	20%
Co-T (mg/L)	0.000115	0.000148	25%
Pb-T (mg/L)	0.000053	0.000095	57%
Cr-D (mg/L)	0.0001	0.0002	67%
Pb-D (mg/L)	0.000019	0.000053	94%
Amonia Dissolved (mg/L)	0.04	0.005	156%

START DATE	15/06/2010	15/06/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000023	129%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0406	0.041	1%
Al-T (mg/L)	0.067	0.0581	14%
Amonia Dissolved (mg/L)	0.037	0.13	111%
As-D (mg/L)	0.00061	0.00057	7%
As-T (mg/L)	0.00059	0.00058	2%
Ba-D (mg/L)	0.00173	0.00178	3%
Ba-T (mg/L)	0.00185	0.0018	3%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000005	0.000006	18%
Cd-T (mg/L)	0.000005	0.000006	18%
Co-D (mg/L)	0.000019	0.000023	19%
Co-T (mg/L)	0.000046	0.000048	4%

START DATE	25/05/2010	25/05/2010	Relative % Difference
Cr-D (mg/L)	0.0002	0.0001	67%
Cr-T (mg/L)	0.0002	0.0002	0%
Cu-D (mg/L)	0.00415	0.00283	38%
Cu-T (mg/L)	0.00287	0.00293	2%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	1.16	1.11	4%
Mg-T (mg/L)	1.07	1.08	1%
Mn-D (mg/L)	0.00101	0.00073	32%
Mn-T (mg/L)	0.0033	0.00329	0%
Mo-D (mg/L)	0.00013	0.00013	0%
Mo-T (mg/L)	0.00012	0.00012	0%
Ni-D (mg/L)	0.00029	0.00021	32%
Ni-T (mg/L)	0.00018	0.00023	24%
Nitrate + Nitrite Diss. (mg/L)	0.047	0.041	14%
Pb-D (mg/L)	0.00004	0.000062	43%
Pb-T (mg/L)	0.00005	0.000086	53%
pH (pH units)	7.5	7.5	0%
P--T (mg/L)	0.004	0.004	0%
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00006	0.00006	0%
Sb-T (mg/L)	0.00005	0.00006	18%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Sr-D (mg/L)	0.0143	0.014	2%
Sr-T (mg/L)	0.0142	0.0137	4%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	0.8	1	22%
U--D (mg/L)	0.000003	0.000003	0%
U--T (mg/L)	0.000002	0.000002	0%
V--D (mg/L)	0.0005	0.0005	0%
V--T (mg/L)	0.0006	0.0005	18%
Zn-D (mg/L)	0.0005	0.0005	0%
Zn-T (mg/L)	0.0006	0.0007	15%

START DATE	28/09/2010	05/10/2010	Relative % Difference

START DATE	25/05/2010	25/05/2010	Relative % Difference
Ag-D (mg/L)	0.000005	0.000005	0%
Ag-T (mg/L)	0.000005	0.000005	0%
Al-D (mg/L)	0.0381	0.0161	81%
Al-T (mg/L)	0.0648	0.0338	63%
Amonia Dissolved (mg/L)	0.11	0.061	57%
As-D (mg/L)	0.00068	0.00065	5%
As-T (mg/L)	0.00077	0.00064	18%
Ba-D (mg/L)	0.00193	0.00216	11%
Ba-T (mg/L)	0.00197	0.0022	11%
B--D (mg/L)	0.05	0.05	0%
Be-D (mg/L)	0.00001	0.00001	0%
Be-T (mg/L)	0.00001	0.00001	0%
Bi-D (mg/L)	0.000005	0.000005	0%
Bi-T (mg/L)	0.000005	0.000005	0%
B--T (mg/L)	0.05	0.05	0%
Cd-D (mg/L)	0.000005	0.000005	0%
Cd-T (mg/L)	0.000005	0.000006	18%
Co-D (mg/L)	0.000026	0.000025	4%
Co-T (mg/L)	0.000059	0.000055	7%
Cr-D (mg/L)	0.0001	0.0001	0%
Cr-T (mg/L)	0.0002	0.0001	67%
Cu-D (mg/L)	0.00231	0.00134	53%
Cu-T (mg/L)	0.00259	0.00145	56%
Li-D (mg/L)	0.0005	0.0005	0%
Li-T (mg/L)	0.0005	0.0005	0%
Mg-D (mg/L)	1.01	1.21	18%
Mg-T (mg/L)	1.01	1.2	17%
Mn-D (mg/L)	0.00106	0.0047	126%
Mn-T (mg/L)	0.00374	0.00679	58%
Mo-D (mg/L)	0.00015	0.00011	31%
Mo-T (mg/L)	0.00012	0.00014	15%
Ni-D (mg/L)	0.00016	0.00012	29%
Ni-T (mg/L)	0.0002	0.00014	35%
Nitrate (NO3) Dissolved (mg/L)		0.033	200%
Nitrate + Nitrite Diss. (mg/L)	0.104	0.033	104%
Nitrogen - Nitrite Diss. (mg/L)		0.002	200%
Pb-D (mg/L)	0.00001	0.000006	50%
Pb-T (mg/L)	0.000019	0.000014	30%
pH (pH units)	7.27	7.13	2%
P--T (mg/L)	0.006	0.005	18%

START DATE	25/05/2010	25/05/2010	Relative % Difference
Residue Non-filterable (mg/L)	1	1	0%
Sb-D (mg/L)	0.00007	0.00006	15%
Sb-T (mg/L)	0.00007	0.00006	15%
Se-D (mg/L)	0.00004	0.00004	0%
Se-T (mg/L)	0.00004	0.00004	0%
Sn-D (mg/L)	0.00001	0.00001	0%
Sn-T (mg/L)	0.00001	0.00001	0%
Sr-D (mg/L)	0.0153	0.0184	18%
Sr-T (mg/L)	0.0158	0.018	13%
Tl-D (mg/L)	0.000002	0.000002	0%
Tl-T (mg/L)	0.000002	0.000002	0%
Turbidity (NTU)	1.2	0.8	40%
U--D (mg/L)	0.000002	0.000002	0%
U--T (mg/L)	0.000007	0.000002	111%
V--D (mg/L)	0.0004	0.0003	29%
V--T (mg/L)	0.0007	0.0004	55%
Zn-D (mg/L)	0.0003	0.0005	50%
Zn-T (mg/L)	0.0003	0.0008	91%

Table 30. Summary of analyses of field blanks collected at Site E207826, Tsolum River 500 m downstream from Murex Creek.

START DATE	29/09/09	29/09/09	15/10/09	15/10/09	24/11/09	24/11/09
Ag-D (mg/L)	< 0.000005		< 0.000005		< 0.000005	
Ag-T (mg/L)		< 0.000001		< 0.000001		< 0.000001
Al-D (mg/L)	< 0.0002		< 0.0002		< 0.0002	
Alkalinity pH 8.3 (mg/L)	< 0.5		< 0.5		< 0.5	
Alkalinity Total 4.5 (mg/L)	1.2		0.7		1	
Al-T (mg/L)		< 0.0002		0.0005		< 0.0002
Amonia Dissolved (mg/L)	< 0.005		< 0.005		< 0.005	
As-D (mg/L)	< 0.00002		< 0.00002		< 0.00002	
As-T (mg/L)		< 0.00001		< 0.00001		< 0.00001
Ba-D (mg/L)	< 0.00002		< 0.00002		< 0.00002	
Ba-T (mg/L)		< 0.00005		< 0.00005		< 0.00005
B--D (mg/L)	< 0.05		< 0.05		< 0.05	
Be-D (mg/L)	< 0.00001		< 0.00001		< 0.00001	
Be-T (mg/L)		< 0.000001		< 0.000001		< 0.000001
Bicarbnt (mg/L)	1.4		0.8		1.2	
Bi-D (mg/L)	< 0.000005		< 0.000005		< 0.000005	
Bi-T (mg/L)		< 0.000001		< 0.000001		< 0.000001
B--T (mg/L)		< 0.0001		< 0.0001		0.0001
Ca-D (mg/L)	< 0.05		< 0.05		< 0.05	
Carbon Dissolved Organic (mg/L)	0.8		< 0.5		0.9	
Carbont (mg/L)	< 0.5		< 0.5		< 0.5	
Cd-D (mg/L)	< 0.000005		< 0.000005		< 0.000005	
Cd-T (mg/L)		< 0.000001		< 0.000001		< 0.000001
Cerium Total (mg/L)		< 0.000002		< 0.000002		< 0.000002
Cesium Total (mg/L)		< 0.000005		< 0.000005		< 0.000005
Chlrid:D (mg/L)	0.6		< 0.5		< 0.5	
CLASS CODE						
Co-D (mg/L)	< 0.000005		< 0.000005		< 0.000005	
Coli:Fec (CFU/100mL)	< 2		< 1		< 1	
Color True (Col.unit)	< 5		< 5		< 5	
Co-T (mg/L)		< 0.000002		< 0.000002		< 0.000002
Cr-D (mg/L)	< 0.0001		< 0.0001		< 0.0001	
Cr-T (mg/L)		< 0.000005		< 0.000005		< 0.000005
Cu-D (mg/L)	< 0.00005		< 0.00005		< 0.00005	
Cu-T (mg/L)		0.00053		< 0.00002		< 0.00002
Fe-D (mg/L)	< 0.001		< 0.001		< 0.001	
Fe-T (mg/L)		< 0.0005		< 0.0005		< 0.0005
Ga-T (mg/L)		< 0.000001		< 0.000001		< 0.000001
Hardness Total (D) (mg/L)	< 0.5		< 0.5		< 0.5	

START DATE	29/09/09	29/09/09	15/10/09	15/10/09	24/11/09	24/11/09
Hydroxide Alkalinity (mg/L)	< 0.5		< 0.5		< 0.5	
K--D (mg/L)	< 0.05		< 0.05		< 0.05	
Lathanum Total (mg/L)		< 0.000001		0.000001		< 0.000001
Li-D (mg/L)	< 0.0005		< 0.0005		< 0.0005	
Li-T (mg/L)		< 0.0002		< 0.0002		< 0.0002
Mg-D (mg/L)	< 0.05		< 0.05		< 0.05	
Mn-D (mg/L)	< 0.00005		< 0.00005		< 0.00005	
Mn-T (mg/L)		< 0.00005		< 0.00005		< 0.00005
Mo-D (mg/L)	< 0.00005		< 0.00005		< 0.00005	
Mo-T (mg/L)		< 0.000005		< 0.000005		< 0.000005
N.Kjel:T (mg/L)	< 0.02		< 0.02		< 0.02	
Na-D (mg/L)	< 0.05		< 0.05		< 0.05	
Ni-D (mg/L)	< 0.00002		< 0.00002		< 0.00002	
Niobium Total (mg/L)		< 0.000001		< 0.000001		< 0.000001
Ni-T (mg/L)		< 0.00002		< 0.00002		0.00004
Nitrate (NO3) Dissolved (mg/L)	< 0.002		< 0.002		0.003	
Nitrate + Nitrite Diss. (mg/L)	< 0.002		< 0.002		0.003	
Nitrogen - Nitrite Diss. (mg/L)	< 0.002		< 0.002		< 0.002	
Nitrogen (Kjel.) Tot Diss (mg/L)	< 0.02		< 0.02		< 0.02	
Nitrogen Organic Tot-Diss (mg/L)	< 0.02		< 0.02		< 0.02	
Nitrogen Organic-Total (mg/L)	< 0.02		< 0.02		< 0.02	
Nitrogen Total (mg/L)	< 0.02		< 0.02		< 0.02	
Nitrogen Total Dissolved (mg/L)	< 0.02		< 0.02		< 0.02	
Ortho-Phosphate Dissolved (mg/L)	< 0.001		< 0.001		0.001	
Pb-D (mg/L)	< 0.000005		< 0.000005		< 0.000005	
Pb-T (mg/L)		< 0.000005		< 0.000005		< 0.000005
Phosphorus Tot. Dissolved (mg/L)	< 0.002		< 0.002		< 0.002	
Platinum Total (mg/L)		< 0.000001		< 0.000001		< 0.000001
P--T (mg/L)		0.0007		0.0009		0.0013
Rb-T (mg/L)		< 0.00001		< 0.00001		< 0.00001
Residue Non-filterable (mg/L)	< 1		< 1		< 1	
Sb-D (mg/L)	< 0.00002		< 0.00002		< 0.00002	
Sb-T (mg/L)		< 0.000001		< 0.000001		< 0.000001
S--D (mg/L)	< 3		< 3		< 3	
Se-D (mg/L)	< 0.00004		< 0.00004		< 0.00004	
Se-T (mg/L)		< 0.00005		< 0.00005		< 0.00005
Si-D (mg/L)	< 0.1		< 0.1		< 0.1	
Sn-D (mg/L)	< 0.00001		< 0.00001		< 0.00001	
Sn-T (mg/L)		< 0.000005		< 0.000005		< 0.000005

START DATE	29/09/09	29/09/09	15/10/09	15/10/09	24/11/09	24/11/09
Specific Conductance (uS/cm)	< 1		< 1		2	
Sr-D (mg/L)	< 0.00005		< 0.00005		< 0.00005	
Sr-T (mg/L)		0.00005		< 0.00005		< 0.00005
Sulfat:D (mg/L)	< 0.5		< 0.5		< 0.5	
Ti-D (mg/L)	< 0.0005		< 0.0005		< 0.0005	
Tl-D (mg/L)	< 0.000002		< 0.000002		< 0.000002	
Tl-T (mg/L)		< 0.000001		< 0.000001		< 0.000001
Tungsten Total (mg/L)		< 0.000001		< 0.000001		< 0.000001
Turbidity (NTU)	< 0.1		< 0.1		< 0.1	
U--D (mg/L)	< 0.000002		< 0.000002		< 0.000002	
U--T (mg/L)		< 0.0000005		< 0.0000005		< 0.0000005
V--D (mg/L)	< 0.0002		< 0.0002		< 0.0002	
V--T (mg/L)		0.00001		0.000015		< 0.000005
Yttrium Total (mg/L)		< 0.000001		< 0.000001		< 0.000001
Zn-D (mg/L)	< 0.0001		< 0.0001		< 0.0001	
Zn-T (mg/L)		< 0.00005		< 0.00005		< 0.00005
Zr-D (mg/L)	< 0.0001		< 0.0001		< 0.0001	

Table 28 (continued)

START DATE	16/02/10	22/06/10	12/10/10	15/02/11	21/06/11	25/10/11
Ag-D (mg/L)	< 0.000005	< 0.000005	< 0.000005			
Ag-T (mg/L)						
Al-D (mg/L)	< 0.0002	0.0018	0.0036			
Alkalinity pH 8.3 (mg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Alkalinity Total 4.5 (mg/L)	0.8	0.6	0.5	< 0.5	0.9	< 0.5
Al-T (mg/L)						
Amonia Dissolved (mg/L)	< 0.005	0.006	< 0.005	0.006	< 0.005	< 0.005
As-D (mg/L)	< 0.00002	< 0.00002	< 0.00002			
As-T (mg/L)						
Ba-D (mg/L)	< 0.00002	0.00003	< 0.00002			
Ba-T (mg/L)						
B--D (mg/L)	< 0.05	< 0.05	< 0.05			
Be-D (mg/L)	< 0.00001	< 0.00001	< 0.00001			
Be-T (mg/L)						
Bicarbnt (mg/L)	1	0.7	0.6	< 0.5	1.1	< 0.5
Bi-D (mg/L)	< 0.000005	< 0.000005	< 0.000005			
Bi-T (mg/L)						
B--T (mg/L)						
Ca-D (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	0.085	< 0.05

START DATE	16/02/10	22/06/10	12/10/10	15/02/11	21/06/11	25/10/11
Carbon Dissolved Organic (mg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Carbont (mg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Cd-D (mg/L)	< 0.000005	< 0.000005	< 0.000005			
Cd-T (mg/L)						
Cerium Total (mg/L)						
Cesium Total (mg/L)						
Chlrid:D (mg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CLASS CODE						
Co-D (mg/L)	< 0.000005	< 0.000005	< 0.000005			
Coli:Fec (CFU/100mL)	< 1	< 1	< 1	< 1	< 1	< 1
Color True (Col.unit)	< 5	< 5	< 5	< 5	< 5	< 5
Co-T (mg/L)						
Cr-D (mg/L)	< 0.0001	< 0.0001	< 0.0001			
Cr-T (mg/L)						
Cu-D (mg/L)	< 0.00005	< 0.00005	< 0.00005			
Cu-T (mg/L)						
Fe-D (mg/L)	< 0.001	< 0.001	< 0.001			
Fe-T (mg/L)						
Ga-T (mg/L)						
Hardness Total (D) (mg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Hydroxide Alkalinity (mg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
K--D (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lathanum Total (mg/L)						
Li-D (mg/L)	< 0.0005	< 0.0005	< 0.0005			
Li-T (mg/L)						
Mg-D (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mn-D (mg/L)	< 0.00005	< 0.00005	< 0.00005			
Mn-T (mg/L)						
Mo-D (mg/L)	< 0.00005	< 0.00005	0.00006			
Mo-T (mg/L)						
N.Kjel:T (mg/L)	< 0.02	0.03	0.04	< 0.02	< 0.02	0.029
Na-D (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ni-D (mg/L)	< 0.00002	< 0.00002	< 0.00002			
Niobium Total (mg/L)						
Ni-T (mg/L)						
Nitrate (NO3) Dissolved (mg/L)	0.002	< 0.002	< 0.002	0.002	< 0.002	< 0.002
Nitrate + Nitrite Diss. (mg/L)	0.002	< 0.002	< 0.002	0.002	< 0.002	< 0.002
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nitrogen (Kjel.) Tot Diss (mg/L)	< 0.02	0.03	0.04	< 0.02	< 0.02	0.038
Nitrogen Organic Tot-Diss (mg/L)	< 0.02	0.03	0.04	< 0.02	< 0.02	0.04
Nitrogen Organic-Total (mg/L)	< 0.02	0.03	0.04	< 0.02	< 0.02	0.03

START DATE	16/02/10	22/06/10	12/10/10	15/02/11	21/06/11	25/10/11
Nitrogen Total (mg/L)	< 0.02	0.03	0.04	< 0.02	< 0.02	0.029
Nitrogen Total Dissolved (mg/L)	< 0.02	0.03	0.04	< 0.02	< 0.02	0.038
Ortho-Phosphate Dissolved (mg/L)	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Pb-D (mg/L)	< 0.000005	0.000009	< 0.000005			
Pb-T (mg/L)						
Phosphorus Tot. Dissolved (mg/L)	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.004
Platinum Total (mg/L)						
P--T (mg/L)						
Rb-T (mg/L)						
Residue Non-filterable (mg/L)	< 1	< 1	< 1	< 1	< 1	< 1
Sb-D (mg/L)	< 0.00002	< 0.00002	< 0.00002			
Sb-T (mg/L)						
S--D (mg/L)	< 3			< 3	< 3	< 3
Se-D (mg/L)	< 0.00004	< 0.00004	< 0.00004			
Se-T (mg/L)						
Si-D (mg/L)	< 0.1	< 0.1	< 0.1			
Sn-D (mg/L)	< 0.00001	< 0.00001	< 0.00001			
Sn-T (mg/L)						
Specific Conductance (uS/cm)	< 1	1	1	1	1	1.2
Sr-D (mg/L)	0.00005	< 0.00005	< 0.00005			
Sr-T (mg/L)						
Sulfat:D (mg/L)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Ti-D (mg/L)	< 0.0005	< 0.0005	< 0.0005			
Tl-D (mg/L)	< 0.000002	< 0.000002	< 0.000002			
Tl-T (mg/L)						
Tungsten Total (mg/L)						
Turbidity (NTU)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
U--D (mg/L)	< 0.000002	< 0.000002	< 0.000002			
U--T (mg/L)						
V--D (mg/L)	< 0.0002	< 0.0002	< 0.0002			
V--T (mg/L)						
Yttrium Total (mg/L)						
Zn-D (mg/L)	< 0.0001	0.0003	0.0002			
Zn-T (mg/L)						
Zr-D (mg/L)	< 0.0001	< 0.0001	< 0.0001			