Tsolum River Agricultural Watershed Plan: Phase 1

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February 2019

Acknowledgements

This report was prepared for:

The Comox Valley Regional District.

Project funding provided by:

Funding for this project has been provided by the governments of Canada and British Columbia through programs delivered by the Investment Agriculture Foundation of BC, and the Comox Valley Regional District.

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Contents

1 Executive Summary

The Tsolum River, running through the heart of the Comox Valley, is an integral part of the Comox Valley Regional District (CVRD). The Tsolum River watershed lies in the heart of the unceded traditional territory of the K'òmoks First Nation (KFN) and has been a vital part of the KFN community since time immemorial. The Tsolum River watershed and its aquifers provide water that is critical to the health of the Comox agricultural community, as well as the fish, wildlife, and all living things in the watershed. The Tsolum River watershed aquifers provide drinking water for homes, businesses, a school and community centres.

Like many watersheds on the east coast of Vancouver Island, the Tsolum is heavily influenced by seasonal variations in precipitation. In the winter, plentiful rain brings high water levels and occasional flooding. In dry summer months, stream flows become very low when agricultural producers, aquatic life, and residents need water the most.

Access to water has been identified as a major obstacle that faces the agriculture sector in the region. To address historical, current and future concerns about water availability for both agriculture and instream flow needs, the CVRD is developing the Tsolum River Agricultural Watershed Plan. This work is funded in part by the governments of Canada and British Columbia through a grant program administered by the Investment Agriculture Foundation of British Columbia (IAFBC).

IAFBC watershed planning is to be completed in two phases: Phase One involves the collection and interpretation of existing data, community engagement, and recommendations for future phases of work. Phase Two involves activities such as hydrologic modelling, scenario evaluation, and plan development. Once complete, an agricultural watershed plan will identify the significance of agriculture in the watershed, lessen the potential for water use conflicts, and ensure that agricultural needs are considered if a Water Sustainability Plan is developed for the area.

To support the development of this plan, an Agricultural Watershed Planning Advisory Committee (AWPAC) was formed. The AWPAC includes representation from local, provincial, and federal governments, the K'ómoks First Nation, local farming institutes, conservation groups, and Timberwest Forest Corporation.

In October 2017 the CVRD initiated the agricultural watershed planning process. In April 2018 a groundwater licensing workshop was held to assist producers with applying for a groundwater license. In May 2018, Elucidate Consulting was engaged to develop an agricultural watershed plan.

To begin, existing information was gathered and analyzed (Deliverable One: May - July 2018). Next, a multi-faceted community engagement and stakeholder consultation process was conducted (Deliverable Two: September 2018 - February 2019). In this phase, information about the watershed was shared with the community and input obtained from stakeholders. Throughout the process, the AWPAC was consulted for guidance (Deliverable Three). Finally, a draft report summarizing this work and providing recommendations for next steps in Phase Two was presented to the CVRD (Deliverable Four: December 2018 – February 2019). This work will complete with a final presentation to the Board (March 2019).

In Deliverable One, it was found that groundwater plays an important role in the watershed and is a major source for irrigation water and in-stream flows in the summer. It is estimated that irrigation accounts for 85% of all consumptive water use in the watershed. It is also estimated that 77% of anthropogenic water use in the Tsolum River watershed comes from groundwater sources. The availability of groundwater supplies varies throughout the watershed and there is currently no information available on how much water is available in Tsolum River watershed aquifers.

As part of Deliverable One, existing aquifer boundaries were assessed and updated by integrating wells data into a 3-dimensional groundwater model. This work identified a new confined aquifer east of the Tsolum River, called 'Tsolum-2' and proposed updates to the boundary of aquifer 408 which lies between the Tsolum River and the Salish Sea.

Deliverable One also included an assessment of current and future agricultural water needs, using data from the Agricultural Water Demand Model (AWDM), developed by the CVRD and Ministry of Agriculture in 2017. The model estimated that with climate change, water needs for existing farms could increase by approximately 139% in the 2050s. If more farmland was placed in production (40% more farming, using a similar distribution of crops and irrigation systems), water needs could increase by as much as 563% in the worst-case scenario.

Finally, Deliverable One included an assessment of agriculture with respect to economic activities. According to Statistics Canada, in the Tsolum watershed, approximately $18.5 million/year in agri-food products are produced and approximately 800 people are employed on-farm. It is estimated that producers in the Tsolum spend approximately $14 million/year in farm operating costs - with much of this going back into the community.

Consumers are increasingly aware of the benefits of eating locally and it is possible that investment in agriculture will grow. The Comox Valley has one of the most favorable growing climates in the country, and while many areas of the province have exhausted their available agricultural land, there is still a relatively large amount of Agricultural Land Reserve in the Tsolum that could be placed in production – provided there is sufficient access to water.

Between September 2018 and February of 2019, the public and watershed stakeholders were invited to share their water quantity and quality concerns, provide feedback on the information gathered to-date, and discuss future water management solutions (Deliverable Two). This was done through a series of activities including: targeted interviews, a public open house event, public survey, a booth at the Comox Valley Farmer's Market, social media posts, news releases, attendance of the Comox Valley Farmer's Institute and Mid-Island Farmer's Institutes Annual General Meetings, an interview and meetings with K'òmoks First Nation representatives, and Advisory Committee engagement.

The community engagement process confirmed that water supply is a real and increasing concern in the Tsolum River watershed. Many community members stated that they did not have sufficient water available on their property for their farm operations or daily household needs. Throughout the engagement process it was clear that the Tsolum River has an active and engaged agricultural and stewardship community that strongly supports future action to ensure that there is enough water available to meet current and future agricultural, environmental, and community needs.

The following recommendations have been developed to support the CVRD moving forwards in Phase Two of the Agricultural Watershed Planning process:

1) a) Develop a water budget to identify available groundwater and surface water volumes. Given the volume of groundwater use, attention should be paid to the groundwater component, identifying areas of groundwater-surface water interactions and groundwater recharge.

   b) Develop an understanding of Environmental Flow Needs and the Critical Environmental Flow Threshold.
2) Assess water storage options and alternate supplies
3) Community and Advisory Committee engagement
4) Communicate with the Province to identify an interest in the Water Sustainability Planning and ensure that Phase Two work aligns with the guidelines for establishment of an Agricultural Water Reserve and Water Sustainability Plan.
5) Develop a plan for next steps moving forwards.

2 Introduction

The Tsolum River, running through the heart of the Comox Valley, is an integral part of the Comox Valley Regional District (CVRD). The Tsolum River watershed and its aquifers provide water that is critical to the health of the Comox agricultural community as well as the fish, wildlife, and all living things in the watershed. The Tsolum River watershed aquifers provide drinking water for homes, businesses, a school and community centres.

Agricultural activity has played a role an important part of the Comox Valley community for thousands of years. The K'òmoks First Nation, who have lived in this watershed since time immemorial, hunted, fished, and cultivated crops in the watershed (K'omoks First Nation, 2013). The food supply in the area was so abundant that they referred to the valley as the "land of plenty". In the 1860's, non-Native settlers came to the Comox Valley to farm. They were attracted by the pre-cleared land, enriched soils, gentle climate, abundant flora and fauna, and plentiful seafood (Courtenay and District Museum and Palaeontology Centre, 2019) (Mackie, The Wilderness Profound: Victorian Life of the Gulf of Georgia, 1995).

Today, agriculture plays an important role in the community and statistics suggest that investment in agriculture is growing (Comox Valley Economic Development, 2018). There is significant potential for expansion (Ministry of Agriculture, 2013), but one of the key limiting factors for current and future agricultural production is access to water (Gulik, Neilsen, Fretwell, & Tam, 2014). To address ongoing and future concerns about water availability for both instream and agricultural needs, the CVRD is developing the Tsolum River Agricultural Watershed Plan.

This Plan is funded in part by the governments of Canada and British Columbia through a grant program administered by the Investment Agriculture Foundation of British Columbia (IAFBC). Agriculture watershed planning funded by IAFBC is to be completed in two phases: Phase One involves collection and analysis of existing data, public engagement, collaboration with the Agricultural Advisory Committee, and the development of recommendations for Phase Two. Phase Two may include activities such as hydrology modelling, scenario evaluation, and management plan development.

Once complete, an Agricultural Watershed Plan will identify the significance of agriculture in the watershed, support the agricultural sector, lessen the potential for water use conflicts, and ensure that agricultural needs are considered if a Water Sustainability Plan is developed for the area. Water Sustainability Plans are a mechanism under BC's Water Sustainability Act (2016) to enable local planning and governance.

In October 2017 the CVRD initiated the agricultural watershed planning process. In April 2018 a groundwater licensing workshop was held to assist producers with applying for a groundwater license. In May 2018, Elucidate Consulting was engaged to develop an agricultural watershed plan.

To begin, existing information was gathered and analyzed (Deliverable 1: May - July 2018). Next, a multi-faceted community engagement and stakeholder consultation process was conducted to share information on the watershed and obtain input from stakeholders (Deliverable 2: September 2018 - February 2019). Throughout this process, the Advisory Committee provided feedback, guidance, and local knowledge (Deliverable 3). Finally, the information gathered through these steps was used to develop a report which included recommendations for future work (Deliverable 4: November 2018 – March 2019).

This report summarizes Phase One of the Tsolum River Agricultural Watershed Plan, and includes a summary of available data on:

- Surface Water Resources
- Groundwater Resources
- Water Uses and Values
- Water Quality
- Environmental Flow Needs
- Significance of Agriculture with Respect to Economic Activities
- Data Gaps

This report also includes an overview of the public communications and engagement activities and recommendations for future work in Phase Two of the Tsolum River Agricultural Watershed Planning process.

3 Watershed Overview

The Tsolum River flows from Regan Lake on the northeast side of Mount Washington down to the City of Courtenay. This 248 km^2 watershed is relatively low elevation and includes upland forests, low lying rural residential and agricultural land, and suburban areas near the City of Courtenay. Major tributaries include Portuguese Creek, Dove Creek, Headquarters Creek, and Murex Creek.

According to the Canadian Census (2016), there are up to 8,000 people living in the Tsolum River watershed. Agricultural activity has a long history in the Tsolum River watershed. Although it is not one of the largest sectors in the region, agriculture has been a steady contributor to the community and economy. There is significant potential for growth in the agricultural sector, provided there is sufficient access to water.

Like many watersheds on the east coast of Vancouver Island, the Tsolum River is heavily influenced by extreme seasonal variations in precipitation. Figure 3 shows the monthly variation in precipitation at the Comox Airport from 1981 – 2010 (approximately 4km outside the watershed). As shown in Figure 3, the Tsolum River watershed receives a great deal of water through precipitation in the fall and winter and little precipitation in the summer.

What is a watershed?

A watershed is an area of land that catches rain and snow, and drains or seeps into groundwater, a marsh, river, lake, or ocean.

Figure 1a: What is a watershed? Source: http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2018/013-1817_DraftGuidance.pdf

In the winter, plentiful rain brings high water levels and occasional flooding (Northwest Hydraulic Consultants, 2011). In dry summer months, stream flows become very low and stream temperatures become quite warm (Spooner, 2016). The Tsolum is a relatively low elevation river, with about 59% lying below the 300m elevation contour and 91% lying below 800m (Northwest Hydraulic Consultants, 2011). Because of this, less water is stored as snow in the upper watershed to contribute to summer flows.

Underneath the Tsolum watershed lie groundwater aquifers. These aquifers are used as drinking water and irrigation supplies by local residents, producers, and businesses. It takes a great deal of technical work to fully understand how these aquifers connect to the river system. In this project, a 3-dimensional conceptual model was developed to better understand local groundwater systems. If approved, Phase Two of the Tsolum River Agricultural Watershed Plan will further contribute to the understanding of these aquifers.

What is an aquifer?

An aquifer is an area of rock that has spaces which allow water to be contained and move. An aquifer can be in consolidated rock like limestone, sandstone, or conglomerate (as shown in the left) or in unconsolidated sand and gravel, or overburden (as shown on the upper right).

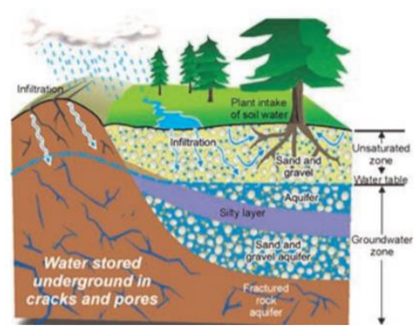

Figure 2b: What is an aquifer? Source: Department of Natural Resources Canada

The Tsolum River's seasonal variations in flow can bring challenges to the water users in the watershed. Although there is substantial water available in winter (Figure 3), precipitation and stream flows are lowest in the summer when water is most needed by irrigators, residents, and aquatic life. It is predicted that these challenges will grow as climate changes and population increases.

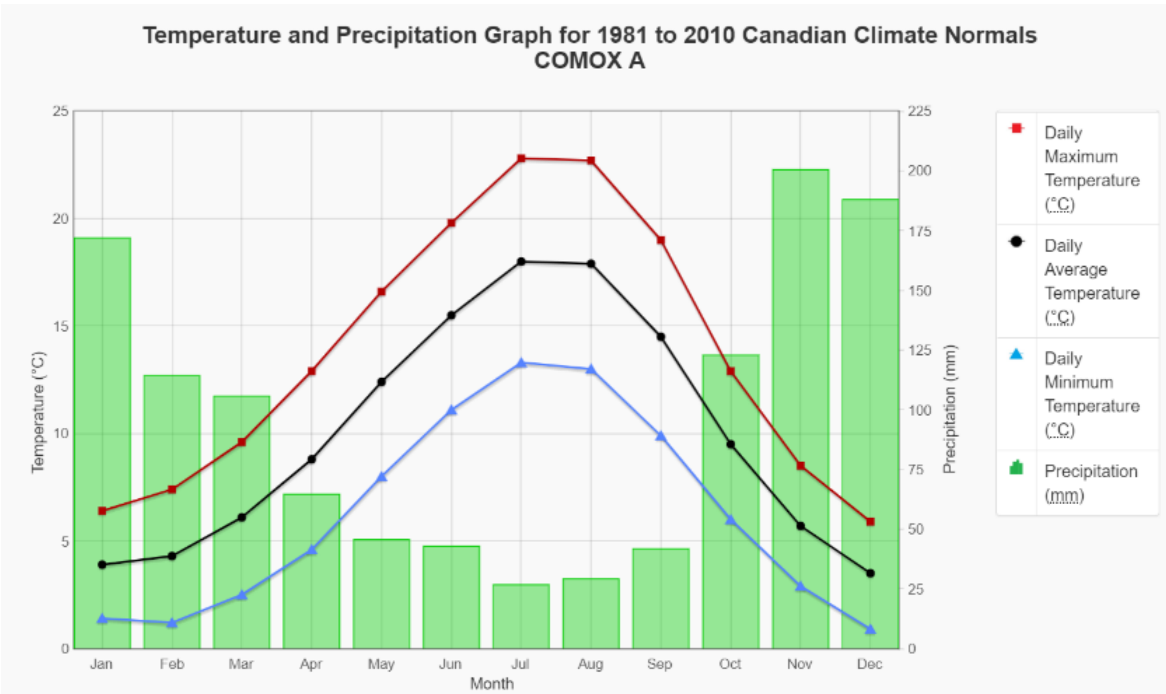

Figure 3: Climate Normals from Environment Canada. Source: http://climate.weather.gc.ca

4 Stakeholders and Partners

There are many people living in and using the Tsolum River watershed. Today, the watershed contains almost 300 farm properties, many rural residential homes, a school, multiple community centres, and several small businesses. The Tsolum River watershed lies in the unceded traditional territory of the K'ómoks First Nation and flows through the administrative boundaries of IR#2 Puntledge, CVRD Electoral Areas B, C, and the City of Courtenay.

This watershed has been home to the K'ómoks First Nation (KFN) for thousands of years. Prior to colonial settlement, the Tsolum valley was used by the KFN for hunting and fishing, medicine procurement, agriculture, and recreation. Agricultural areas were managed under sophisticated Indigenous agricultural management regimes, including prescribed burning, bulb spacing and re-seeding. Root and berry crops were cultivated and domestic surpluses used in economically beneficial ways (K'omoks First Nation, 2013).

Today, many in the KFN community hunt and fish in the watershed. They also gather berries and medicinal plants. Many recreate and spend time in the watershed with their children and families, especially in the summer. The KFN is also an active participant in watershed stewardship. Through the KFN Guardian Watchmen Program, the community participates in monitoring and restoration activities (C. Frank, personal communication, January 7, 2019).

In the lowlands of the Tsolum River watershed, the primary land uses today are agriculture and rural residential. The local agricultural community is represented by two Farmer's Institutes: the Comox Valley Farmer's Institute and the Mid-Island Farmer's Institute.

In the forested upper portion of the watershed TimberWest Ltd. owns several large portions of land that are actively logged. Residents of the surrounding area and tourists come to the upper and lower watershed to recreate and participate in agritourism activities.

In recent years, the Tsolum River watershed has seen a great deal of community involvement and investment. In the 1960's the Mount Washington Copper Mine became a major source of contamination to the Tsolum River. What was once a rich aquatic habitat and popular fishing destination was declared biologically dead. However, thanks to the efforts of the Tsolum River Partnership (TRP) and a highly dedicated stewardship community, the abandoned mine has been remediated and salmon are returning to the river. The TRP, which is comprised of representatives from government, industry, KFN, and the stewardship community, is now represented by the Tsolum River Restoration Society (TRRS), which actively works to improve channel conditions, enhance riparian areas, and monitor flows and fish populations.

Many private landowners have also taken a role in watershed stewardship. Actions on the land relate directly to water quantity and quality. Producers compromise a large percentage of land ownership in the watershed and several farmers in the area have completed Environmental Farm Plans to help protect water quality and flows. Others have worked with the TRSS to support stewardship actions.

4.1 Agricultural Watershed Planning Advisory Committee

The CVRD has identified the Electoral Area Services Committee to act as the Steering Committee for Phase One of the Tsolum River Agricultural Watershed Plan. The CVRD has established an Agricultural Watershed Planning Advisory Committee (AWPAC) to support the Steering Committee by providing input, perspective, guidance, and feedback on Phase One of the Tsolum River Agricultural Watershed Plan.

The AWPAC includes representation from:

- City of Courtenay
- Comox Valley Farmer's Institute
- Comox Valley Conservation Partnership
- Comox Valley Regional District
- K'òmoks First Nation
- Fisheries and Oceans Canada (DFO)
- Mid-Island Farmer's Institute
- Ministry of Agriculture
- Ministry of Forests, Lands and Natural Resource Operations
- TimberWest Forest Corporation
- Tsolum River Restoration Society

The AWPAC met five times to support Phase One work.

4.2 Relationship to the Tsolum River Recovery Plan

In 2016, the Tsolum River Restoration Society (TRRS) developed a Recovery Plan for the Tsolum River watershed. The Recovery Plan was developed with multi-stakeholder input and contains guidance on how to manage the water to support ecological health. The TRRS has been implementing this plan since 2016 through annual restoration projects, ongoing community outreach and engagement, fish counts, and flow augmentation work conducted in partnership with the Department of Fisheries and Oceans (DFO).

The Tsolum River Agricultural Watershed Planning process is occurring in parallel with the Recovery Plan work. The goal of the agricultural watershed planning process is to ensure that a sufficient quantity of water is available for agriculture now and in the future, while reducing conflicts between agricultural users and instream flows needs.

Through the Tsolum River Agricultural watershed Planning process, the CVRD will refine the understanding of available water supply and demand in the watershed and assess how to best address growing agricultural water needs, while protecting stream health. This will allow decision-makers to manage water wisely and ensure that the Tsolum River watershed supports both a viable and healthy agricultural community and a productive salmon and trout habitat for the enjoyment of future generations. Given that agricultural water use currently accounts for approximately 85% of water use in the watershed (and has substantial potential to increase), actions to proactively address agricultural water supply and demand, while considering aquatic needs, will be of great benefit to stream health.

It will be important that the TRRS is an active partner in the Tsolum River Agricultural Watershed Planning process to ensure synchronicities between the Recovery Plan and the Agricultural Watershed Plan, where possible.

5 Surface Water Resources

The Tsolum River watershed, shown in Figure 4, originates at Regan Lake on the east side of Mount Washington at approximately 530m in elevation. It flows relatively steeply down the mountainside for approximately 7km and then, at a lower gradient, runs parallel to the coastline for 30km south easterly towards Courtenay. Much of the river is a low-gradient channel, flowing along the base of the mountains.

The watershed is a dendritic, or 'tree-like', watershed and has several branches, or sub-watersheds. These branches, or tributaries, include Portuguese Creek, Dove Creek, and Headquarters Creek in the lower watershed. In the upper watershed, Murex Creek, McKay Creek, Pyrrhotite and Hell Diver Creeks drain the abandoned open pit copper mine previously operated by Mt. Washington Copper Co.

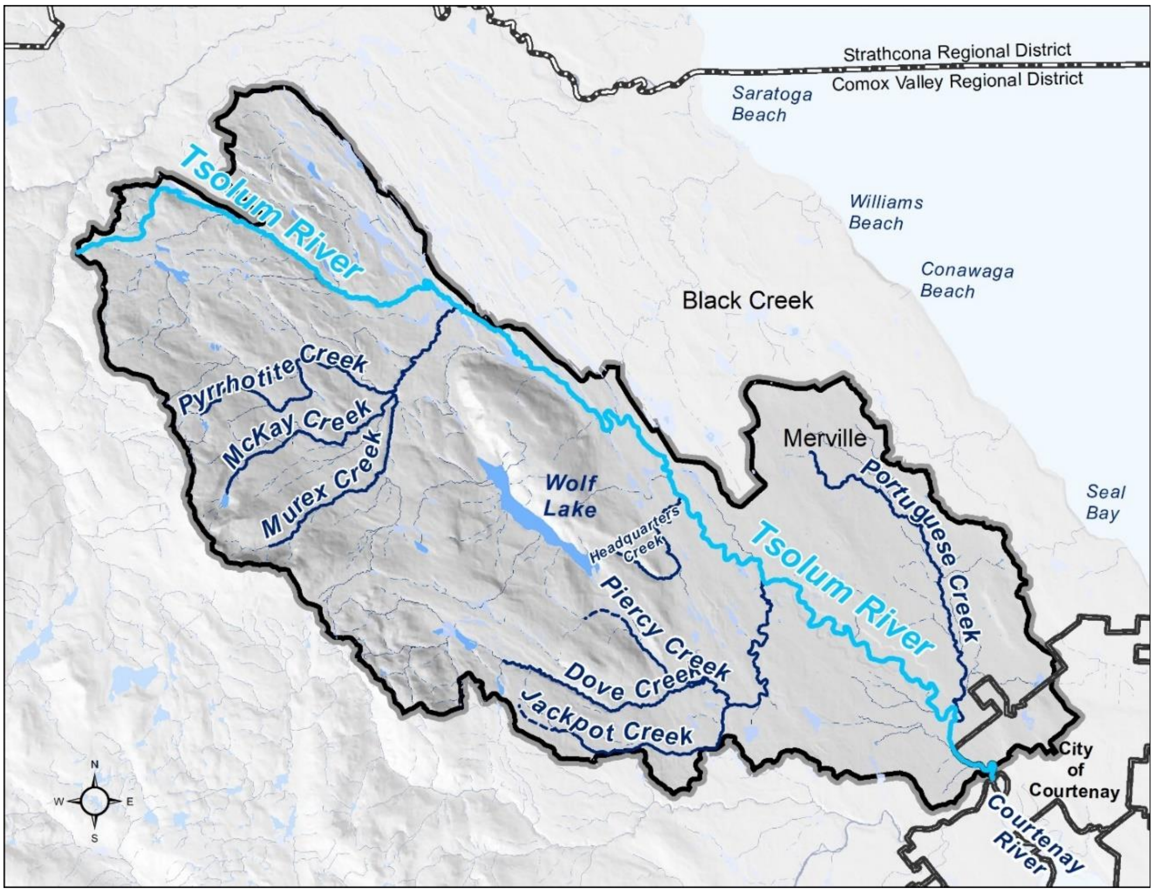

Figure 4: Study area, Tsolum River Watershed

Table 1 summarizes the length of the main waterbodies within the Tsolum River Watershed.

Watercourse name	Length (km)	Watercourse name	Length (km)
Dove Creek	14.8	Piercy Creek	4.4
Headquarters Creek	6.3	Portuguese Creek	11.6
Jackpot Creek	7.6	Pyrrhotite Creek	8.2
McKay Creek	6.6	Tsolum River	41.8
Murex Creek	10.5		

Table 1. Length in kilometers for the main waterbodies

The watershed is fed by several small lakes, starting with Regan and Blue Grouse Lake in its uplands, Anderson Lake at the headwaters of Dove Creek, and Wolf Lake at the head of Headquarters Creek. Wolf Lake is the largest lake in the watershed and it acts as an important reservoir, storing water to be released in the Lower Tsolum River during times of low flow. This water is stored under a license for conservation purposes held by Fisheries and Oceans Canada. There are also a number of smaller lakes in the watershed including Hell Diver Lake, Little Lost Lake, Lost Lake, and McKay Lake. In addition, several large swamps in the north-east part of the headwaters act as important water storage areas.

5.1 Water Flows

On the East Coast of Vancouver Island rivers tend to experience extreme seasonal fluctuations in flow due to seasonal variations in rainfall. The Tsolum River watershed is no exception and the Tsolum experiences very high flows during winter rains (Northwest Hydraulic Consultants, 2011) and very low flows during summer dry periods (Riddell & Bryden, 1996).

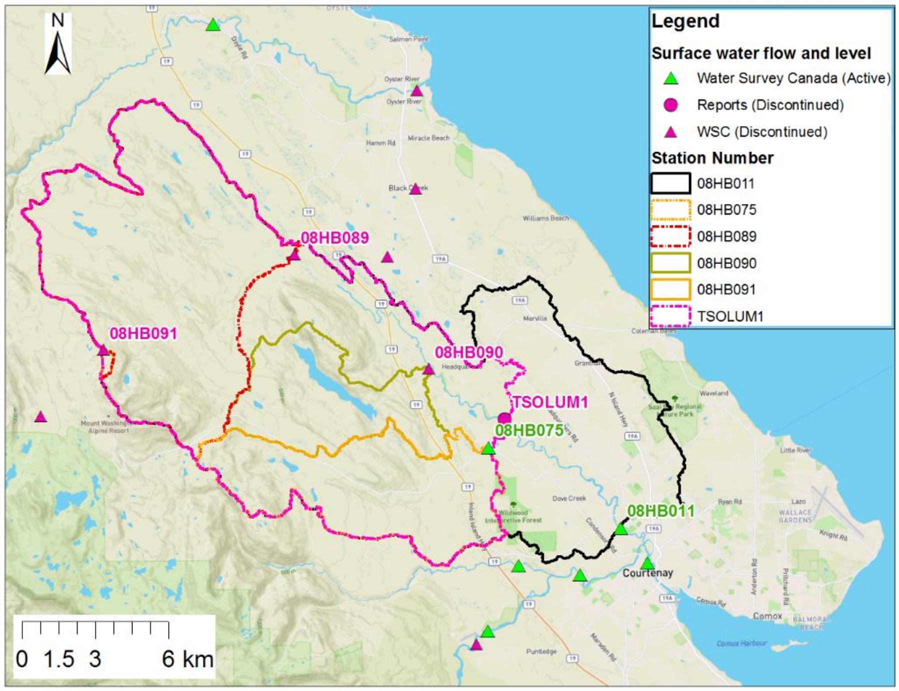

Figure 5 Location of flow gauged stations and upstream contributing watershed

In the Tsolum watershed, there are two active and three inactive Water Survey of Canada (WSC) streamflow monitoring stations (Figure 5). The BC Conservation Foundation (BCCF) has also partnered with the Tsolum River Restoration Society (TRRS) to collect hydrometric and water temperature data from the Tsolum River. This station is shown as TSOLUM1 in the Figure 5.

Table 2: Flow gauging stations within Tsolum Watershed

Source	Station Name	Station Number	Data available from	Data available to	Status	Watershed area (km²)	Years of records
WSC	Tsolum River Courtenay	08HB011	5/1/1914	12/31/2016	active	254.74	102.7
WSC	Dove Creek (near mouth)	08HB075	1/1/1985	12/31/2016	active	41.82	32.0
WSC	Tsolum River Below Murex Creek	08HB089	4/1/1997	3/31/2015	discontinued	87.36	18.0
WSC	Headquarters Creek Above Tsolum R	08HB090	4/1/1997	8/31/1999	discontinued	28.40	2.4
WSC	Pyrrhotite Creek At Branch 126	08HB091	6/1/1997	12/31/1999	discontinued	0.43	2.6
BCCF/TRRS	Tsolum River Todd Rd station	TSOLUM1	9/13/2012	6/18/2015	active	195.22	2.8

The Tsolum River Todd Road semi-permanent hydrometric station was established on the Tsolum River in 2012, 11.7 km upstream of its confluence with the Puntledge River and 0.85 km downstream of the Dove Creek confluence (Figure 5). Table 2 summarizes available data for these stations.

WSC station 08HB011, established 103 years ago, provides the longest flow record. Figure 6 shows the flow analysis report for this station. The upper diagram shows the historical flows from 1914-2016. The middle graph presents the monthly average flows. Finally, the diagram at the bottom summarizes the average daily flow in a normal year. The map shows the location of the gauged station within the study area.

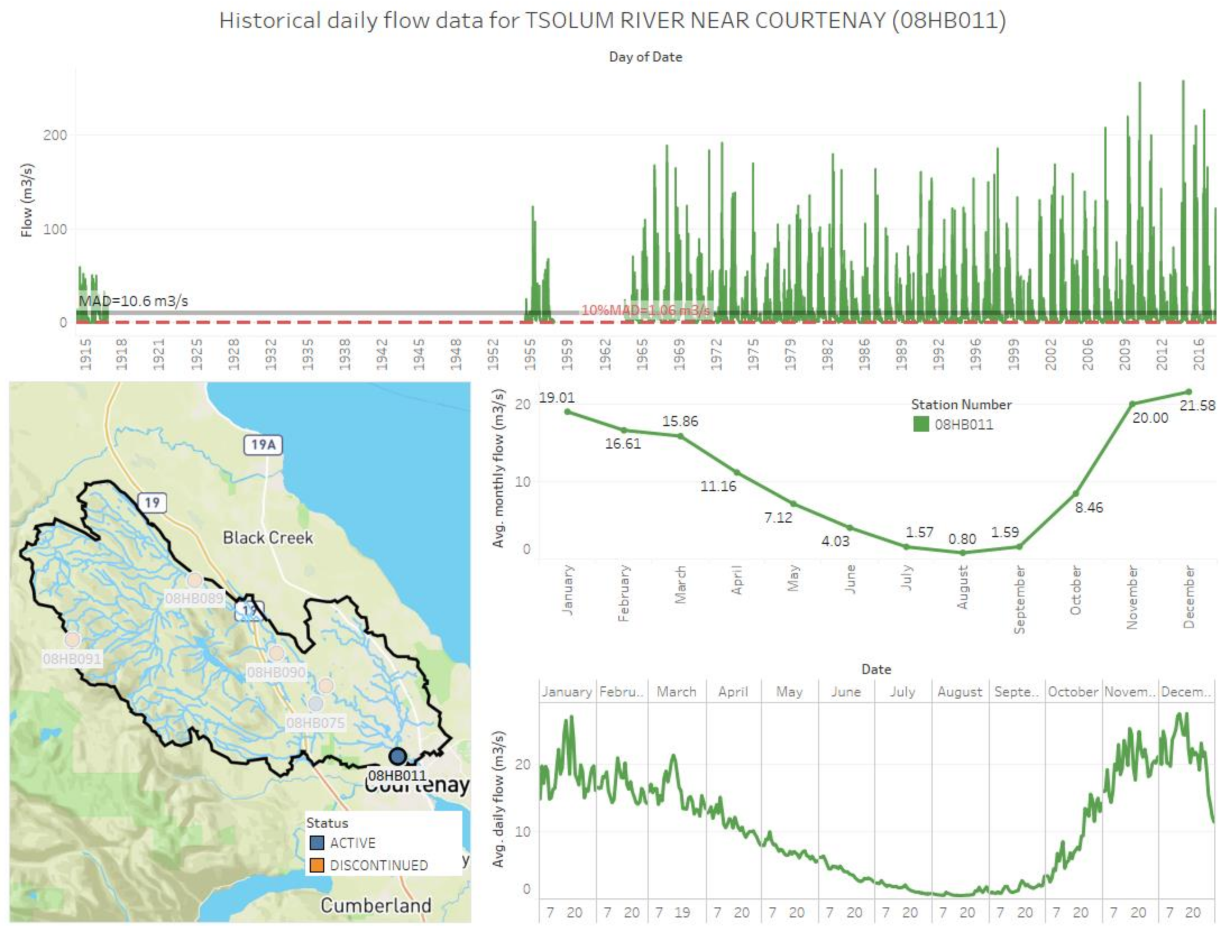

Figure 6: Flow analysis for station 08HB011 (Tsolum River Near Courtenay)

As shown in Figure 6, winter flows are substantially greater than summer flows. August flows are often less than five per cent of the mean annual discharge (MAD), which is below the suggested minimum flow guideline for maintaining spawning and rearing habitat for fish. The MAD for the river is $10m^3/s$, and it is suggested that 5-10% of this flow, or $0.5\ m^3/s – 1.0\ m^3/s$ should be maintained in the river at all times for fish health (J. Szczot, personal communication, June 11, 2018) (more information on this can be found in the Section 9: Environmental Flow Needs).

The greatest river flows occur from direct runoff of rainfall or 'rain on snow events', from November to March. Beginning in March, flows diminish rapidly during the spring and into the summer, resulting in excessively low late summer flows. Because the Tsolum is a relatively low elevation watershed, snow tends to melt earlier than in the higher elevation neighboring catchments (Riddell & Bryden, 1996). Most of the dry season flow is diverted for irrigation and domestic purposes, except for minimum flows maintained for fisheries (Riddell & Bryden, 1996). The lowest flows are recorded from July to September.

Historical information from the other gauging stations (including discontinued stations) is shown in Appendix A.

5.2 Review of Available Studies

There have been several prior studies of aquatic habitat, hydrology, and water quality in the Tsolum River watershed. Twenty-two of these historical studies were reviewed and key findings are summarized below.

5.2.1 Low Flows

A review of available studies found that the low flows in the Tsolum are particularly problematic because, due to land clearing and historic logging practices, there is a lot of bedload (e.g. sediment, gravel, and boulders) in the channel in the lower Tsolum. This means that a high proportion of flow is travelling sub-surface through the gravel (Gooding, Tsolum River Biophysical Assessment Hydrology and Channel Assessment, 2010). This sub-surface flow does not allow fish to move upstream to spawn. Low flows also allow the river temperatures to rise into the toxic zone for fish (> 25 degrees Celsius). It is possible that high temperatures may pose an even greater risk to fish than low flows (Neil Goeller, AWPAC meeting, September 26, 2018).

5.2.2 High Flows

The streamflow data also shows an increasing trend in winter high flows in recent years. In 2011, the CVRD, City of Courtenay, and Timberwest commissioned a study to investigate the causes of increased flooding in the Tsolum. The study evaluated the relationship between precipitation patterns and streamflow and assessed whether the Tsolum River floods are of a larger magnitude relative to similar nearby watersheds (Northwest Hydraulic Consultants, 2011).

The study found that the Tsolum watershed is experiencing more frequent and larger precipitation events over the last decade, which is resulting in more frequent and larger runoff events. It found that this pattern was consistent with many other streams on the East Coast of Vancouver Island and suggested that the increased flows are most likely the result of more frequent extreme rainfall events, caused by long-term climate variability or climate change. The study did not include an assessment of the relationship between land cover change and stream flow in the Tsolum River watershed. It did include a literature review, which stated that there is no accepted relationship between forest harvesting and stream flow impacts for large rainfall events.

However, the increased flooding does correlate with an obvious increase in land clearing (observed through satellite imagery, with obvious and significant increases in land clearing occurring between 2006-2009). Although there is uncertainty regarding the precise relationship between large rainfall events and forest harvesting, more recent literature reviews state that “The bulk of the literature concludes that peak flows increase after forest harvesting. The direction is agreed upon, but the magnitude of change is both basin-specific and dependent on the chosen statistical method.” (Perry, Lundquist, & Moore, 2016). There is general agreement in the literature that rain-generated peak flows with return period less than 6 years increase after forest harvesting (Perry, Lundquist, & Moore, 2016).

5.2.3 Flow Augmentation

Historical streamflow data shows the value of flow augmentation in the watershed. In dry summer months, releases from Wolf Lake at the head of Headquarters Creek play a significant role in regulating flows in the Tsolum. In August and September, almost half (48%) of the flow in the Tsolum River is from the Headquarters Creek subwatershed.

There has been significant research undertaken to identify ways to increase flows in the Tsolum River during dry summer months. One of the main ways to do that would be to capture and store water in the winter for release during the summer. To maintain summer flows, a significant amount of water would need to be stored. A recent study commissioned by the TRRS assessed large-scale storage options in the Tsolum and found that (Gooding, 2007):

- Wolf Lake is the most feasible option for increased large-scale storage (because it would require the least road raising and dam construction)
- The volume of water storage required to increase flows by an additional 10% MAD, or 1 CMS, for 45 days, at gauge 08HB011 near Courtenay, is approximately 390 hectare meters (3,900,000m^3)
- Raising the Wolf Lake dam at least 1 meter would provide just under half of the additional 10% MAD flow augmentation needed between the Headquarters-Tsolum confluence and the ocean
- Some water released from Wolf Lake is lost to evaporation from Headquarters Creek and the Tsolum River. Also, water is lost to seepage into the ground in the late summer as water tables get lower. Comparison of the daily gauge readings available from a fisheries service pilot hatchery gauge indicate that up to 0.62m^3/s of water passing through the upper gauge did not reach the lower gauge. Although part of this loss would have been diverted to irrigation, the total is well in excess of likely irrigation diversions.

The Gooding study did not evaluate distributed, smaller-scale storage options (e.g. wetlands, dugouts, water storage ponds).

6 Groundwater Resources

Underneath the land in the Tsolum River watershed lay several groundwater aquifers. The provincial aquifer mapping shows two unconsolidated aquifers and one bedrock aquifer within/near the Tsolum River watershed. As part of this project the provincial aquifer mapping was assessed and updated. This section begins with an overview of the existing mapping and is followed by an assessment of these aquifer boundaries and proposed updates. It finishes with a summary of groundwater levels.

6.1 Existing Aquifer Boundaries

The provincial aquifer mapping shows the following aquifers in the Tsolum River Watershed: aquifers 408, 952, and 413.

Table *3* summarizes the aquifer material, productivity, vulnerability and demand for these aquifers.

Figure 7 shows the location of aquifers according to the current provincial mapping. As shown in Figure 7, the overburden aquifer, Quadra Sand aquifer 408IIC, present on the eastern side of watershed, is by far the most extensive aquifer within the watershed. The overburden aquifer 952IIA and the bedrock aquifer 413 IIB only have a limited extent within the lowermost watershed. The extent of the mapped aquifers (bedrock and overburden) within the Tsolum Watershed represents nearly 20% of the area of the watershed.

Table 3: Summary of BC Ministry of Environment Mapped Aquifers intersecting the Tsolum River watershed

Aquifer Number	Lithostratigraphic Unit	Aquifer Materials	Productivity	Vulnerability	Demand
408	Quadra Sediments	Sand and Gravel	Moderate	Low	High
952	Capilano Sediments, likely sand & gravel lenses within till	Sand and Gravel	Low	High	Low
413	Nanaimo Group; likely the Comox Formation	Bedrock	Low	Moderate	Low

6.1.1 Aquifer Description

The current aquifer mapping in the lower Tsolum River is dominated by Aquifer 408, which is litho-stratigraphically classified as Quadra Sand. The Quadra Sand is a pre-Fraser glacial deposit consisting mainly of well sorted sand, with minor silt and gravel (Clague, 1975). Gravel content increases with proximity to the Vancouver Island mountain front. It is overlain by till deposited during the Fraser Glaciation and is underlain by fluvial and marine sediments deposited during the preceding non-glacial interval. Aquifer #952 comprises sand and gravel of post-glacial origin, deposited in fluvial outwash areas shedding off Vancouver Island mountain front.

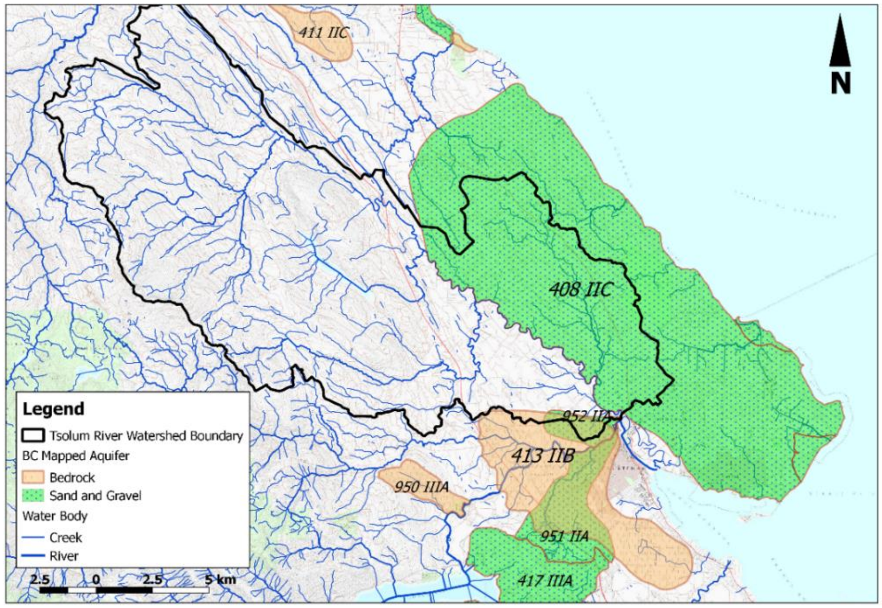

Figure 7: Mapped aquifer extension according to Imap BC (data catalogue)

6.2 Review and Updating of Aquifer Boundaries

As part of this project, the team was asked to assess and update the provincial aquifer boundaries. To do this, GW Solutions reviewed existing well records and then developed a 3D hydrogeological model based on the most up-to-date well information from the BC Ministry of Environment and Climate Change Strategy (BC MoE) provincial wells database.

GW Solutions developed the 3D hydrogeological model using a geological modelling and visualization software, called Leapfrog 3D (ARANZ Geo Ltd.), in combination with a variety of database and Geographic Information System (GIS) tools. The technical details of this work are included in Appendix A. The Tsolum River model can be updated as new information becomes available; however, preliminary output includes imagery, maps, data tables and 3D model viewer files.

6.2.1 Review of Existing Wells

GW Solutions began the assessment of aquifer boundaries by reviewing existing wells from the provincial wells database. There are approximately 500 wells in the database in the Tsolum River watershed. Most of the deeper wells are located on the east side of the Tsolum River and deepen towards the ocean.

Figure 9 shows the location of the water wells within the Tsolum Watershed by completion depth.

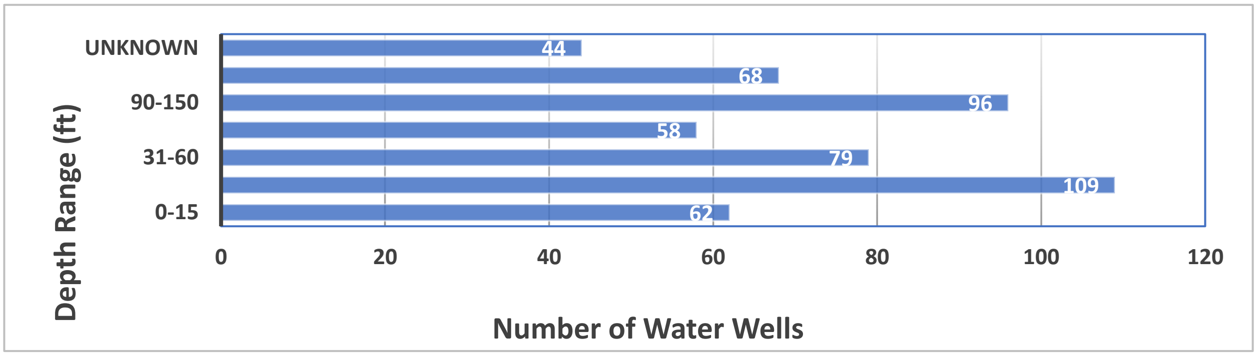

Figure 8: Number of water wells by depth range

As summarized in Figure 8 there are approximately 500 water wells within the watershed and approximately 50% are completed at a depth less than 20 m (60 feet). In conducting this work, GW Solutions found that most of the watershed's wells draw from surficial (i.e. non-bedrock) units comprising relatively thin intervals of water-bearing sand and gravel.

High salinity groundwater was noted in nine wells within the Tsolum watershed. The majority of these were drilled into bedrock (sandstone and shale) and occur west of the Tsolum River mainstem. It is notable that saline water was encountered at various elevations in these wells, not necessarily below sea level, and at considerable distances from the ocean (up to 11 km inland).

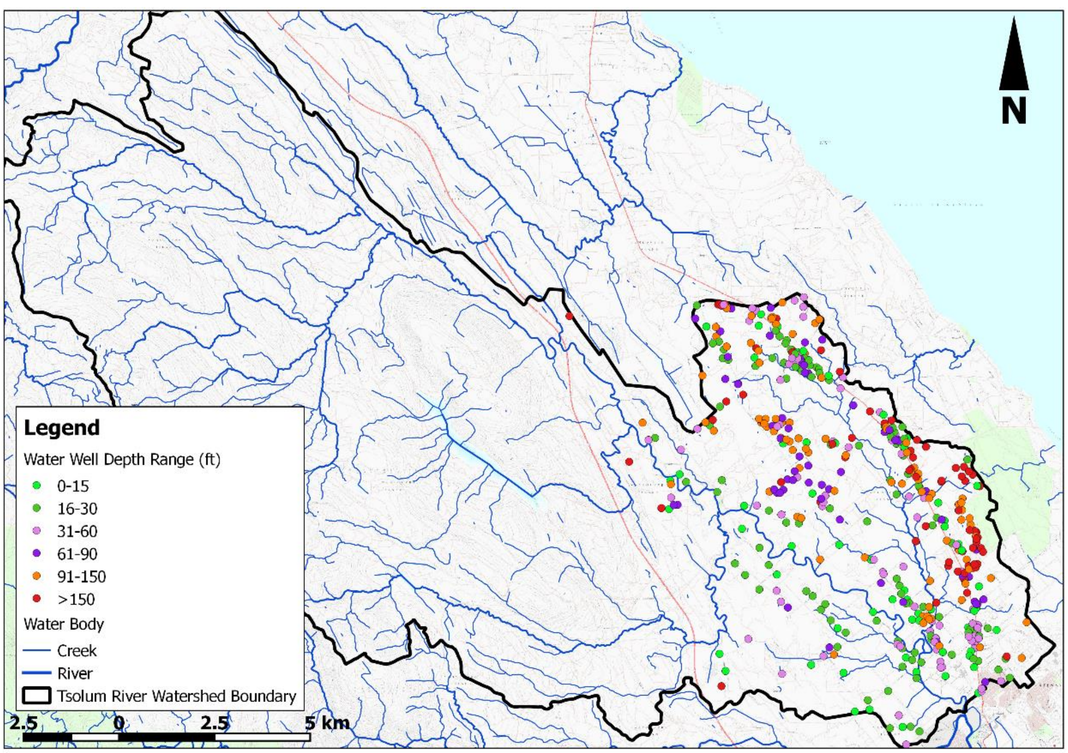

Figure 9: Water wells within Tsolum River watershed categorized by depth

Below are examples of this evidence for salty groundwater occurrence, from driller's descriptions:

- Well Tag # 96395: “shale bedrock | salt water encountered @ 111'”
- Well Tag # 41794: “grey shale - occasional coal stringer|saline water @ 340FT|note: 20GPD of saline |water encountered”

6.2.2 Hydraulic Gradients

When a well is installed in a confined or pressurized aquifer, the groundwater typically rises up the well casing to a certain height, known as the static water level, or piezometric level. If the groundwater rises to the ground surface, this is known as a flowing, or artesian well. The hydraulic or piezometric level is a surface of liquid pressure of groundwater above a datum, e.g. mean sea level. The difference in piezometric levels divided by the distance where these levels are measured defines the hydraulic gradient.

The following assumptions were made about the available data on groundwater elevations in the Tsolum River watershed;

- Static water levels measured in wells at the time of drilling are a reasonable proxy for aquifer piezometric level, given the “watershed scale” of this study.
- Static water levels were classified according to probable aquifer type: bedrock; shallow or deep, confined aquifers.
- Flowing wells and Licensed springs indicate areas where vertical hydraulic gradients are directed upwards and where there is a greater potential for groundwater to contribute to surface water flows.

6.2.3 Results of Aquifer Boundary Assessment

Most of the watershed’s wells draw from surficial (i.e. non-bedrock) units comprising relatively thin intervals of water-bearing sand and gravel. Out of approximately 500 reported wells with lithology information within the watershed:

- 470 are completed in a surficial aquifer, approximately;
- 15 are completed in a bedrock aquifer, approximately.

Integration of standardized WELLS data into a 3-dimensional model resulted in the recognition of two distinct surficial, sand and gravel aquifers present east of the Tsolum River. One is a previously unmapped, confined aquifer that they refer to herein as the Tsolum Aquifer “TS-2”, extending from the Black Creek area south to the lower Tsolum River between the Portuguese Creek and Tsolum River mainstem. GW interprets this as distinct from the mapped Aquifer #408, which extends from Comox Harbour to Black Creek peninsula and is comprised of a Quadra deposit. The Tsolum Aquifer is confined and is characterized by sand and gravel lenses within glacial till. Driller’s note the prevalence of a gravel texture to the aquifer, in contrast to the Quadra deposit and aquifer, which is a more uniform, fine to medium, grey sand. In several areas, this aquifer lays above Aquifer 408.

The wedge of unconsolidated sediment is thickest near the Strait of Georgia, thins considerably west of the Tsolum River and pinches out along the mountain front. Correspondingly, aquifer potential west of the Tsolum River is reduced to localized sand and gravel lenses within till, or within the underlying bedrock.

Figure 10, Figure 11, and Figure 12 present the delineated aquifer of “Tsolum Aquifer TS-2” and the refined boundary of Aquifer #408 with different directions of cross-section, across and along the Tsolum River.

Figure 13 shows a "zoomed in" scene to the groundwater level of available boreholes. The water level within the flowing wells is highlighted by purple.

Observation of flowing wells is important because according to the new Water Sustainability Act, all artesian wells must be under control; "uncontrolled overflow is not permitted".

BC MOE is currently maintaining/managing an aquifer map database. To integrate the new mapped aquifers and modify the extent of Aquifer 408 within the MOE database, certain fields have to be populated/estimated (i.e. vulnerability, productivity).

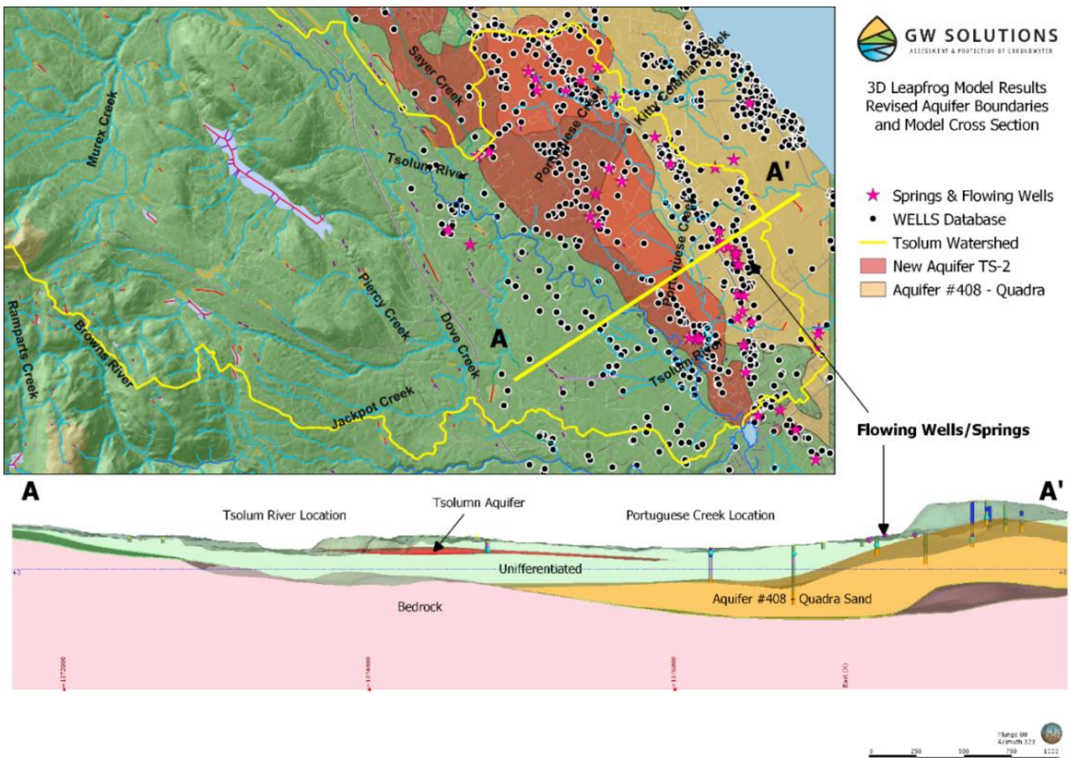

Figure 10: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek and Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions

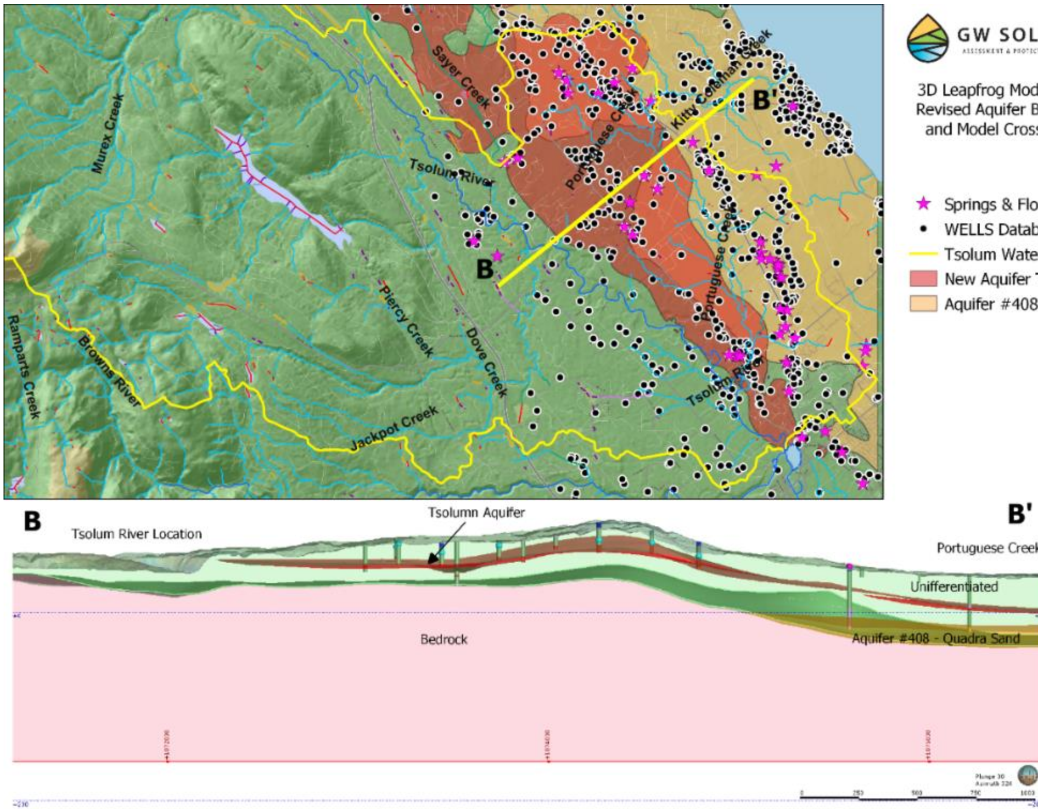

Figure 11: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek and Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions

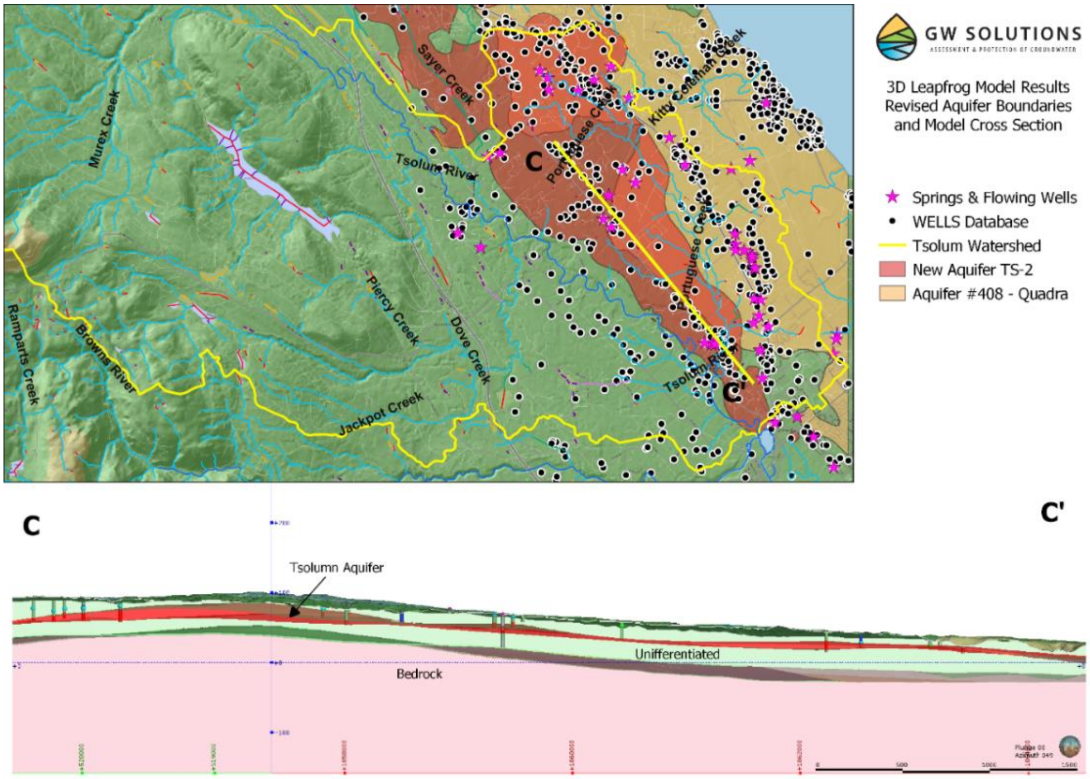

Figure 12: Map of delineated/refined aquifer boundaries and a cross-section along Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions

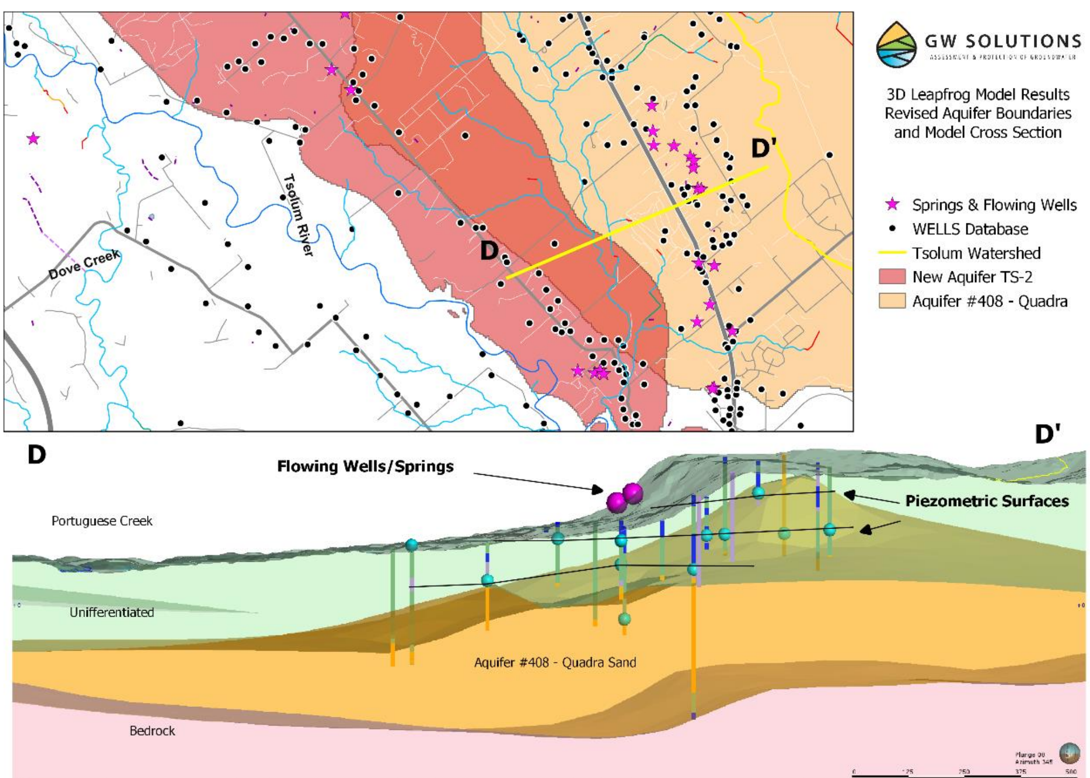

Figure 13: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek, inferred from developed 3D Leapfrog model by GW Solutions - Zooming in the groundwater level of the water wells and water level in artesian condition

6.2.4 Groundwater Movement

The spatial distribution of flowing wells and springs in the Tsolum River watershed illustrate the interaction between aquifers and topography. Results show that the Portuguese Creek sub-watershed has the highest concentration of springs and flowing wells. These findings suggest that groundwater contribution to Portuguese Creek flows is relatively high. Isolated springs and flowing wells occur within the Tsolum River watershed, near the mountain front and along the east bank.

There is also evidence to suggest that in the lower Tsolum there are areas where groundwater contributes to streamflow in dry summer months. In the drought of 2015, provincial government staff were monitoring stream flows and temperatures along the Tsolum and found particularly cool stream temperatures in the lower Tsolum, indicating a likely groundwater contribution (Szczot, 2018). Groundwater is always at a constant temperature equal to the average air temperature; therefore, groundwater has the benefit to warm up surface water during the winter and to cool it during the summer months.

6.3 Groundwater Levels

The provincial government maintains a network of observation wells, used to monitor water levels and quality. Although there is no observation well within the study area, there is one active observation well (OW351) and two abandoned observation wells (OW280 and 285) completed in aquifer 408IIC. The locations of observation wells around the study area is presented in Figure 14.

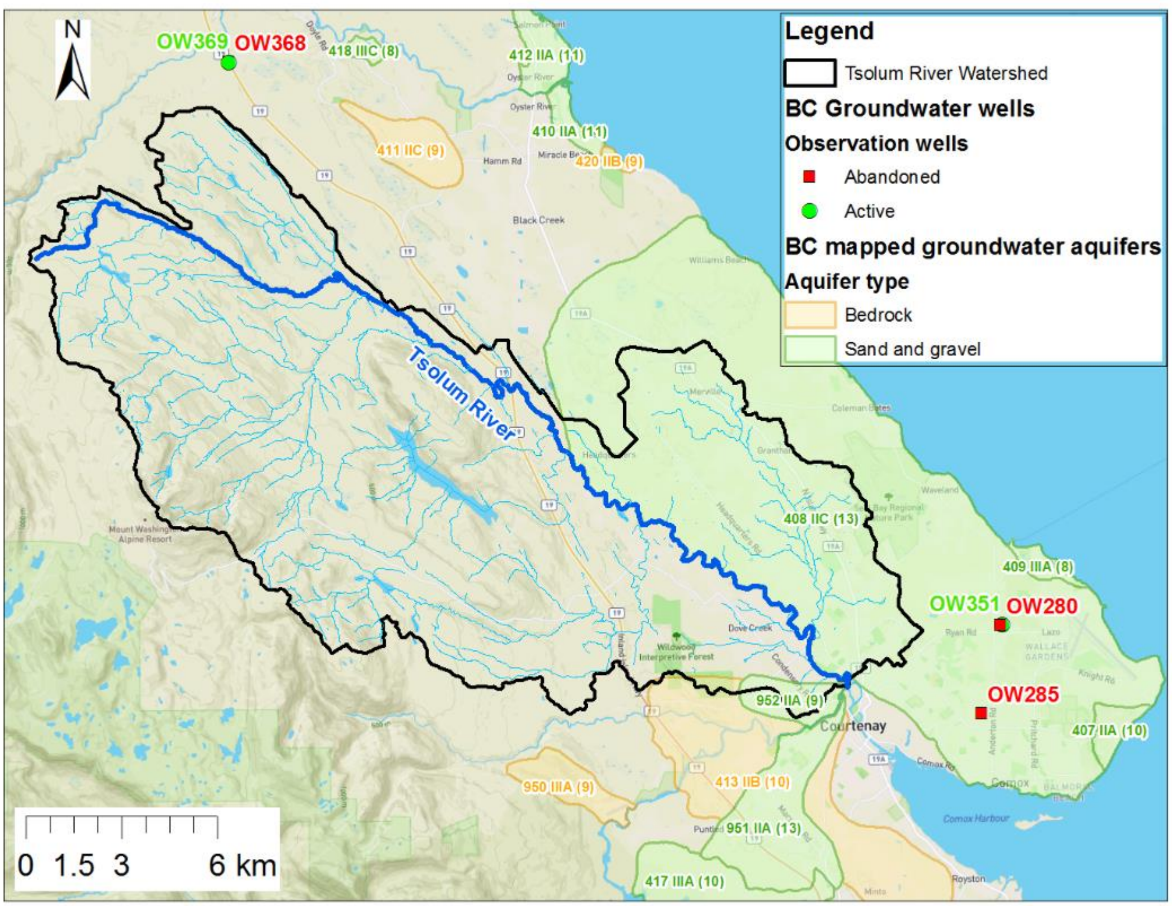

Figure 14: Location of BC observation wells within/around the Tsolum River watershed

The water elevation and depth to water for OW351 is shown in Figure 15. Water level data has been collected since 2001 and this well is active. The water level indicates a slightly increasing trend at a rate of 3.0 cm/year.

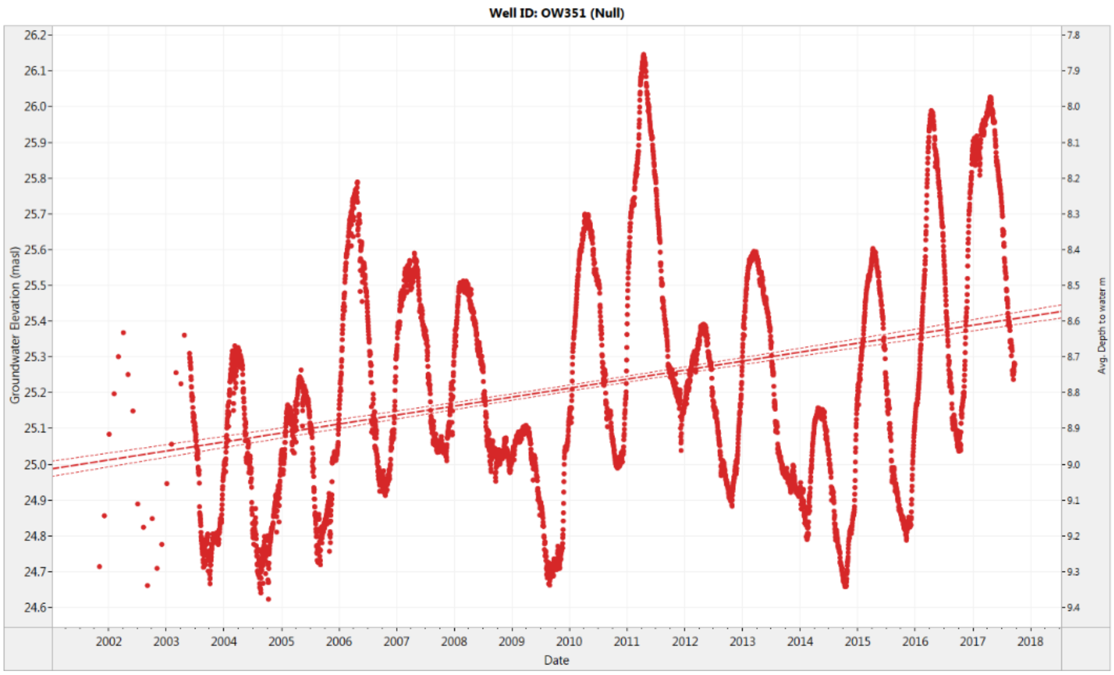

Figure 15: Water level elevation and depth to water for observation well 351

Figure 16 shows the monthly historical water level fluctuation. The lowest water table is observed between August and October and the highest level between February and May with an average amplitude of 0.5 m (from low to max water level).

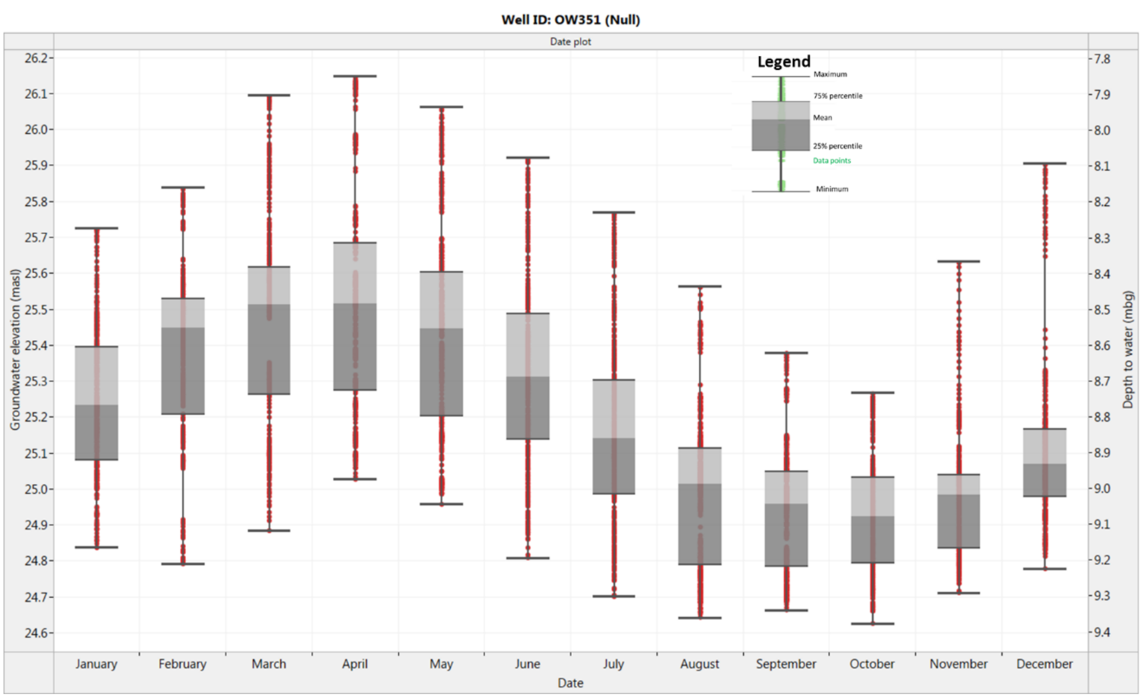

Figure 16: Water level monthly summary for observation well 351

7 Water Uses and Values

In the Tsolum watershed, residents and businesses use surface water and groundwater for a range of purposes. Below is a description of the ways that humans use surface water and groundwater throughout the watershed. This is followed by an in-depth analysis of current and future agricultural water needs.

7.1 Surface Water Use

To use water from surface water and springs in the province of BC, a person is legally required to hold a water license. Figure 17 shows the locations of water licenses for surface water and springs within and near the Tsolum River watershed, classified by source (spring and surface water).

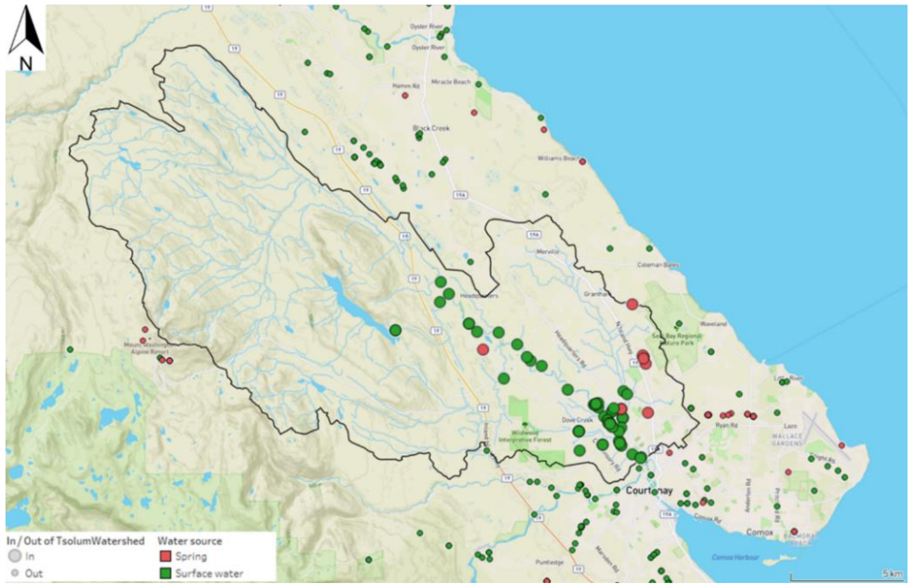

Figure 17: Points of Diversion (POD) within/near the Tsolum Watershed

Some of these licenses are no longer in use. Figure 18 shows the location of the surface water 'points of diversion' (PODs) within the study area classified by license status (current, abandoned licenses, abandoned applications and refused applications).

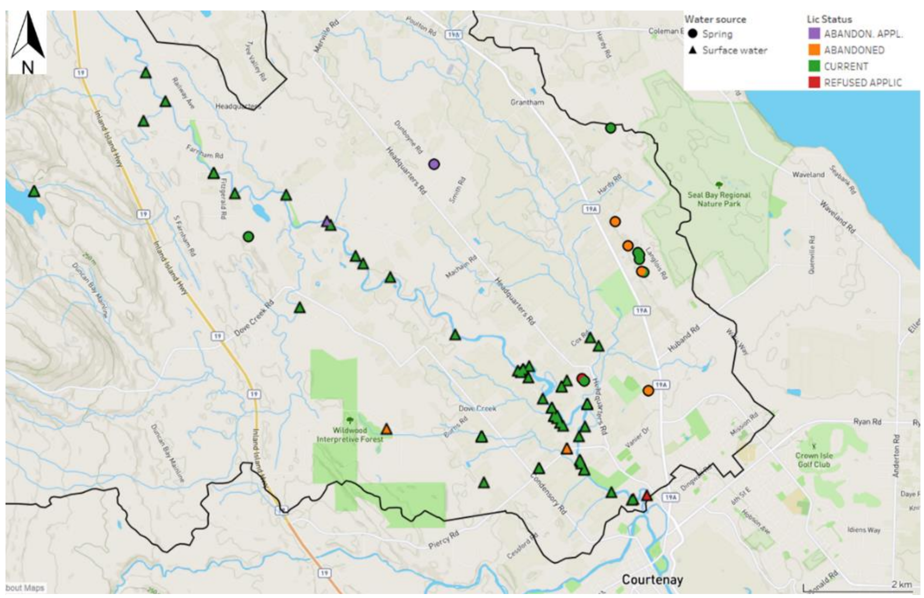

Figure 18: Points of diversion licenses (POD) within the Tsolum Watershed classified by license status

It is important to note that not all water licenses that have a 'current' status may actually be used. Some property owners may not even be aware that there is a surface water license on their property. Others may still have a 'license' but have stopped using the river water because it wasn't a consistent source, the river moved, or they had an issue with the piping and are now actually getting their water from a well. As part of the updates to BC's water laws, under the new Water Sustainability Act (2016), water license holders will now be required to prove that they are using the water, called 'beneficial use', in order to maintain their water license. Beneficial use is described as using the water for the purpose and in the quantity described in the license/approval and using the water efficiently.

Figure 19 shows the number of licenses within the watershed classified by purpose, use and sources. There are 67 current licenses within the study area, of which 56 correspond to surface water and 11 to springs. Within the current surface water licenses, most of them correspond to irrigation (30 licenses) followed by domestic use (18 licenses); whereas, for springs, 80% of the licenses are for domestic use.

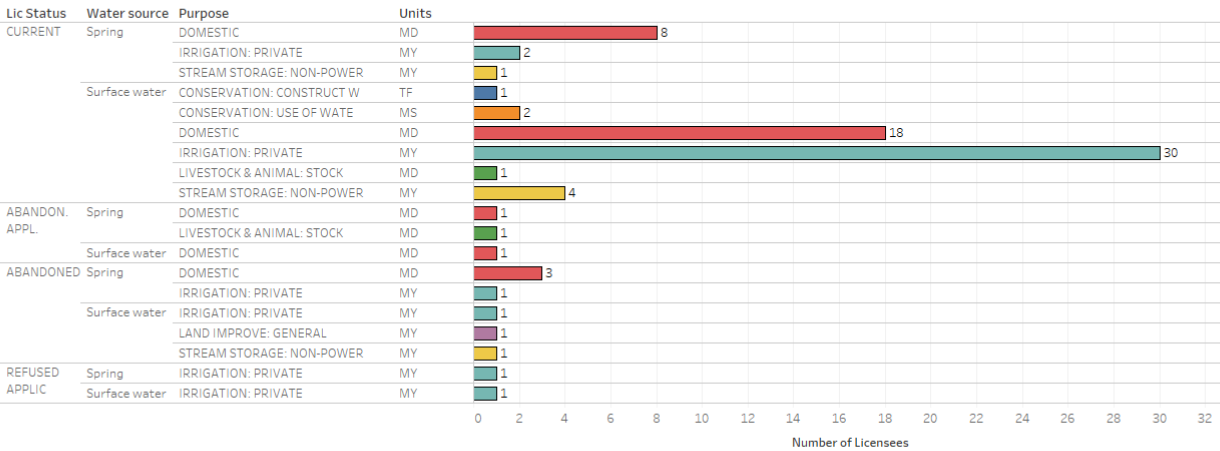

Figure 19. Number of licenses for water extraction (POD) classified by use within Tsolum River Watershed

Table 4 shows the total amount of surface water licensed in the Tsolum River watershed based on the type of water use, or 'licensed purpose'. It identifies whether the water use is consumptive (withdrawn from the river and not entirely returned to the river) or non-consumptive (withdrawn from the river and then returned to the river – much like the water that is stored at the Wolf Lake dam to be released back to the river later in the summer). Overall, 554,521m^3/year of surface water is licensed for consumptive purposes and 285,230,977m^3/year of water is licensed for non-consumptive purposes (almost all of which is for a water licence, held by the Department of Fisheries and Oceans, for Conservation purposes to maintain flows in the Tsolum River in late summer). It is important to note that this only quantifies the amount of surface water used, and does not include the amount of groundwater use (estimated to be approximately 1,882,506m^3/year, as described in 7.2 Groundwater Use). Using these estimates, surface water use accounts for approximately 23% of total water use in the watershed.

Table 4: Amount of Surface Water Licensed (m^3/year) by Purpose/Use

Licensed Purpose	Licensed Amount (m3/year)	Consumptive
CONSERVATION: CONSTRUCT WORKS	0	NO
CONSERVATION: USE OF WATER	281,269,584	NO
DOMESTIC	30,698	YES
IRRIGATION: PRIVATE	520,099	YES
LIVESTOCK & ANIMAL	160	YES
LIVESTOCK & ANIMAL: STOCKWATERING	3,723	YES
STREAM STORAGE: NON-POWER	3,961,393	NO
Total	285,785,659	

Figure 20 shows the Tsolum River consumptive surface water usage by purpose; 94% of the water is used for irrigation, 5.5% is used for domestic and the remaining (<1%) for livestock.

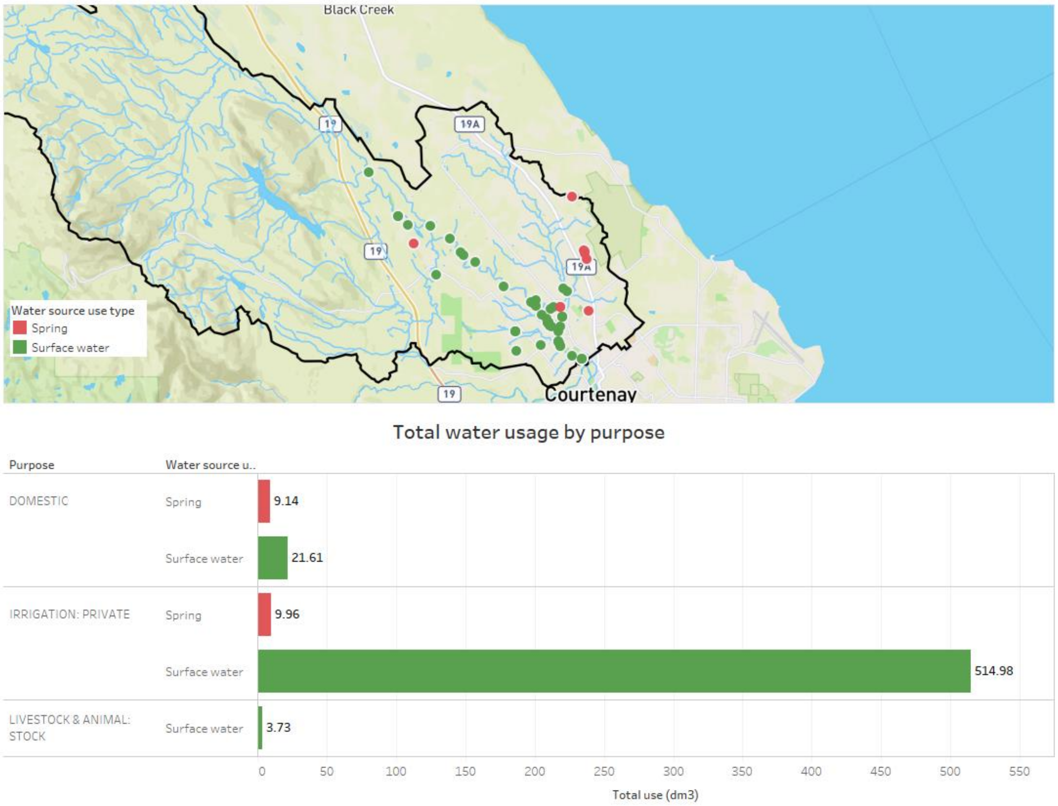

Figure 20: Total monthly licensed volumes by purpose: domestic, irrigation and livestock (total use in cubic decameter-dm3)

7.1.1 Seasonal Variations in Water Use

Much like it is important to understand seasonal variations in streamflow in the Tsolum River watershed, it is also important to understand seasonal variations in water use in the watershed. In the winter there is a large amount of water available, but in the summer there is much less water and many more people and animals wanting to access it.

Currently, there is no metering or measuring of water use in the Tsolum River watershed, so in order to better understand water management concerns in the Tsolum watershed, the team estimated monthly variations in water use, using licensed water volumes as a proxy for actual water use.

To do this, each month was assigned a monthly water use 'coefficient' based on the type of use. For example, an irrigation user would likely use 0% of their yearly water allocation in January, 10% in May, and 30% in August. Table 5 summarizes the monthly coefficients. These coefficients are estimates of monthly variations in water use based on research, consultation with industry experts, and metering data (where available).

Table 5. Monthly allocation coefficients for estimated water usage from PODs

Purpose	Consumptive?	YEAR TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	Source
CONSERVATION: CONSTRUCT W	NO	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
DOMESTIC (WSA01)	YES	12	0.85	0.85	0.85	0.85	0.95	1.00	1.50	1.50	1.10	0.85	0.85	0.85	Domestic usage - Nanaimo
CONSERVATION: USE OF WATE	NO	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
LIVESTOCK & ANIMAL: STOCK	YES	12	0.85	0.85	0.85	0.85	0.95	1.00	1.50	1.50	1.10	0.85	0.85	0.85	Assumed same as domestic
STREAM STORAGE: NON-POWER	NO	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
IRRIGATION: PRIVATE	YES	12	0.00	0.00	0.00	0.00	1.20	2.40	3.60	3.60	1.20	0.00	0.00	0.00	AWDM
DOMESTIC	YES	12	0.85	0.85	0.85	0.85	0.95	1.00	1.50	1.50	1.10	0.85	0.85	0.85	Domestic usage - Nanaimo

The coefficients were then applied to each of the water licenses in the watershed. Figure 21 shows the total monthly licensed volumes in cubic decameters (1dm^3 = 1000m^3) for all the licenses within the Tsolum

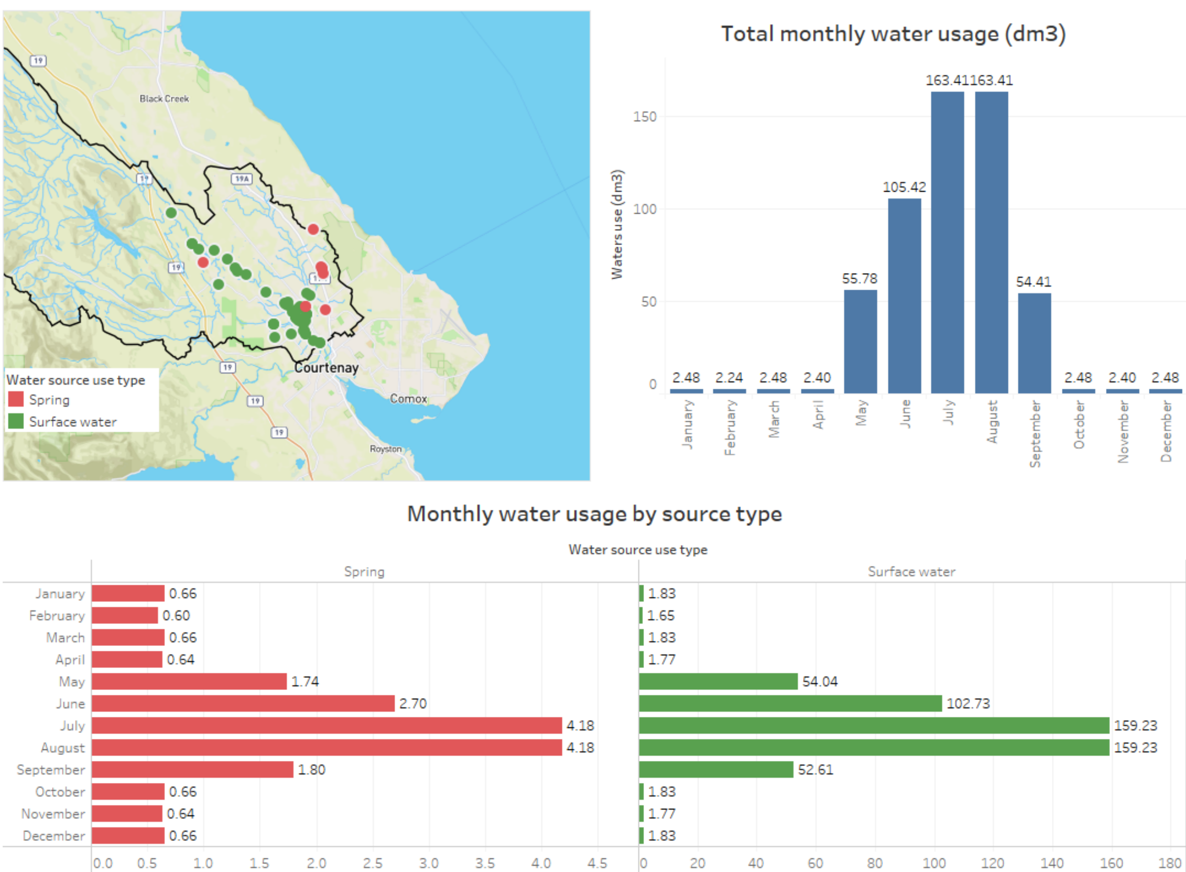

Figure 21: Total monthly licensed volumes by source: spring and surface water

River watershed. As shown in Figure 21, July and August are the months with largest water licensed use. 97% of the licensed use corresponds to surface water bodies, mostly from the Tsolum River, while 3% is from springs.

Figure 22 summarizes water usage by waterbody. Most of the water is extracted from the Tsolum River (92% of the total water usage) followed by Carwithen Swamp (2.8%), Mattoon Spring (1.6%) and Forsyth Creek (1.4%). The water usage from the other waterbodies is recorded at less than 1% of the total water usage.

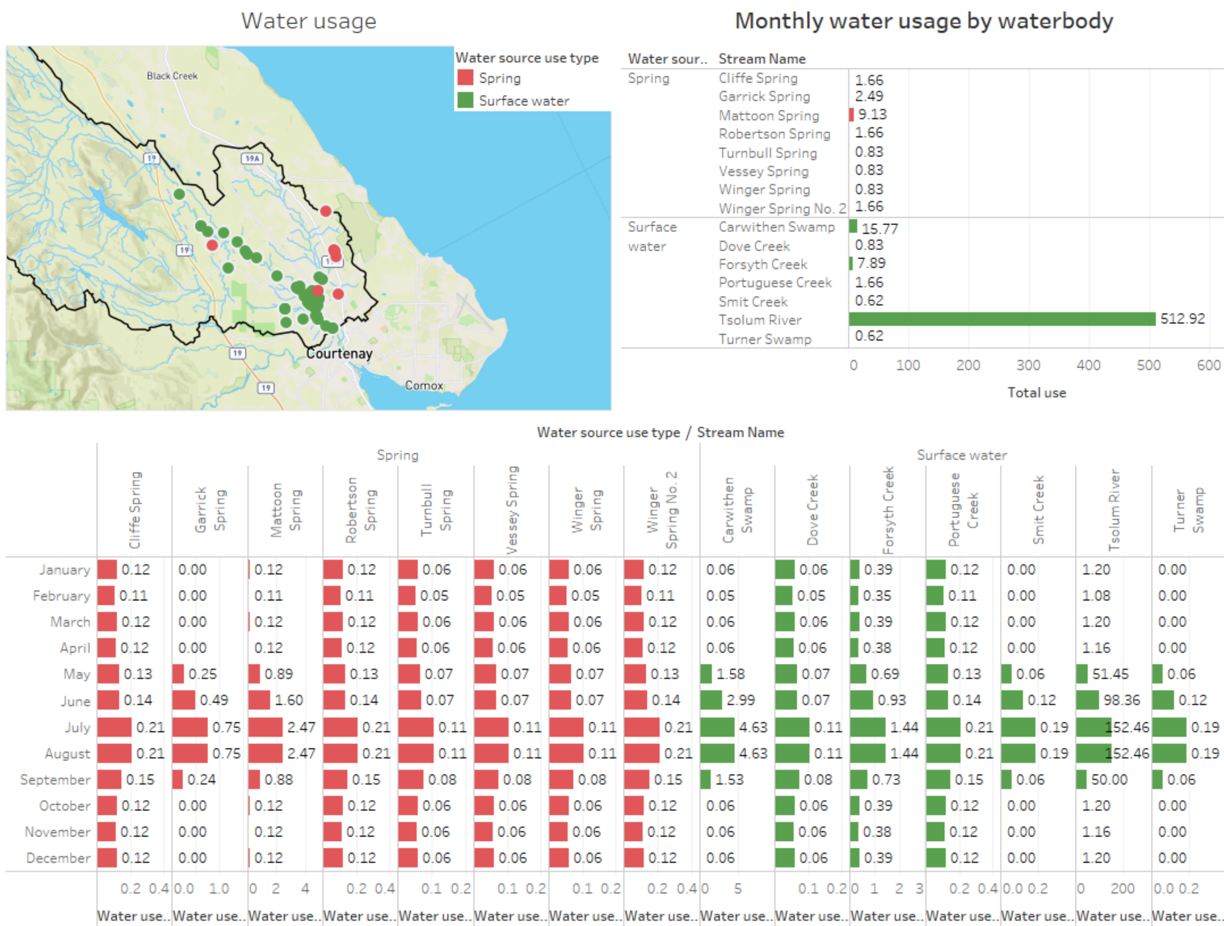

Figure 22: Total monthly usage by waterbody

7.1.2 Future Surface Water Use

The Provincial government has set restrictions on how much water can be taken out of the Tsolum River. In 1953 a Water Allocation Restriction was placed on the Tsolum River (Ministry of Forests, Lands, and Natural Resource Operations, 2016). A water allocation restriction is a water management tool that Ministry of Forests, Lands and Natural Resource Operations (FLNRO) staff may use on a stream or an aquifer to alert other staff to current or potential water allocation concerns, ranging from a possible water shortage to fully recorded with limitations on further licensing.

Because flows are so low in the summer, surface water is only available to be taken out of the watershed during the months of October through May when the mean monthly discharge is above 60% MAD (Riddell & Bryden, 1996). The watershed is fully recorded with the exception of domestic users or if a license application is supported by storage.

If someone is interested in obtaining a surface water license in the Tsolum River watershed, they must create storage to capture the water in the winter if they want to use it in the summer. If an existing user is interested in withdrawing more water from the river, they are required to develop storage to store the water during the rainy season.

There is considerable flow available in winter months which is allowed to be stored to support water demands during summer months.

Several local watersheds also have periods of low flow in which water is not allowed to be extracted. Although the Tsolum River has a 4-month low flow period, several local watersheds have longer low flow periods and have even greater restrictions on use.

7.2 Groundwater Use

Many water users in the Tsolum River watershed obtain their water from groundwater wells. Although the provincial government has a database containing information on wells, it does not identify how much water is pumped from these wells. The wells database is also limited in that it does not identify all wells in the province, because until 2016, well drillers were not required to submit well records.

To estimate groundwater use for domestic and industrial, institutional, and commercial users, GW Solutions combined information from the Cadastral data-BC Assessment and the wells database. Groundwater usage was estimated based on the location of the well, property use, and size of property. To estimate groundwater use for agricultural users, the Agricultural Water Demand Model results were used (as described in 7.3 Agricultural Water Use).

Groundwater use for water supply system wells was calculated separately because the water usage of these wells depends on the number of connections. To estimate groundwater use for water supply wells, GW used data from groundwater source approvals available in a Vancouver Island Health Authority database.

Figure 23 below shows the location of wells with the study area classified by use and status type. Water wells have been classified by use in seven groups based on cadastral information: Water Supply System, Recreational, Irrigation, Institutional, Industrial, Domestic, and Commercial. This figure also shows the number of water wells considered for each type of use. Most of the active water wells are used for domestic or irrigation purposes (278 and 171 water wells, respectively).

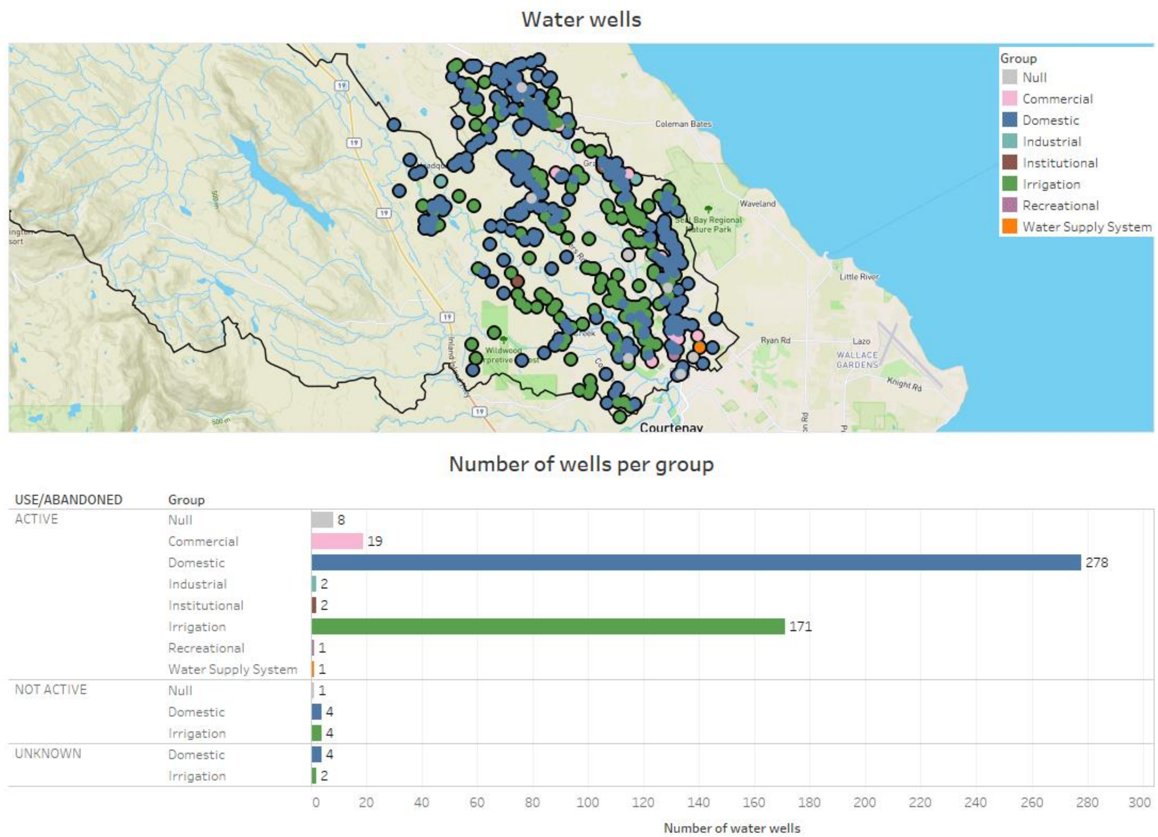

Figure 23. Number of water wells by status and use

To estimate water use from non-agricultural wells, only active wells were considered. The full methodology for this work is described in Appendix A.

Figure 24 summarizes the total estimated groundwater use classified by use type. Most of the groundwater wells within the Tsolum River watershed are used for irrigation purposes with 84% of the total groundwater use going to irrigation, followed by domestic and industrial use with 1.6% and 1.8%, respectively.

According to the Vancouver Island Health Authority (VIHA) data, there are seven water supply systems wells within the study area totalling a groundwater usage of 2.7 dm^3. These well locations and usage information are also shown Figure 24.

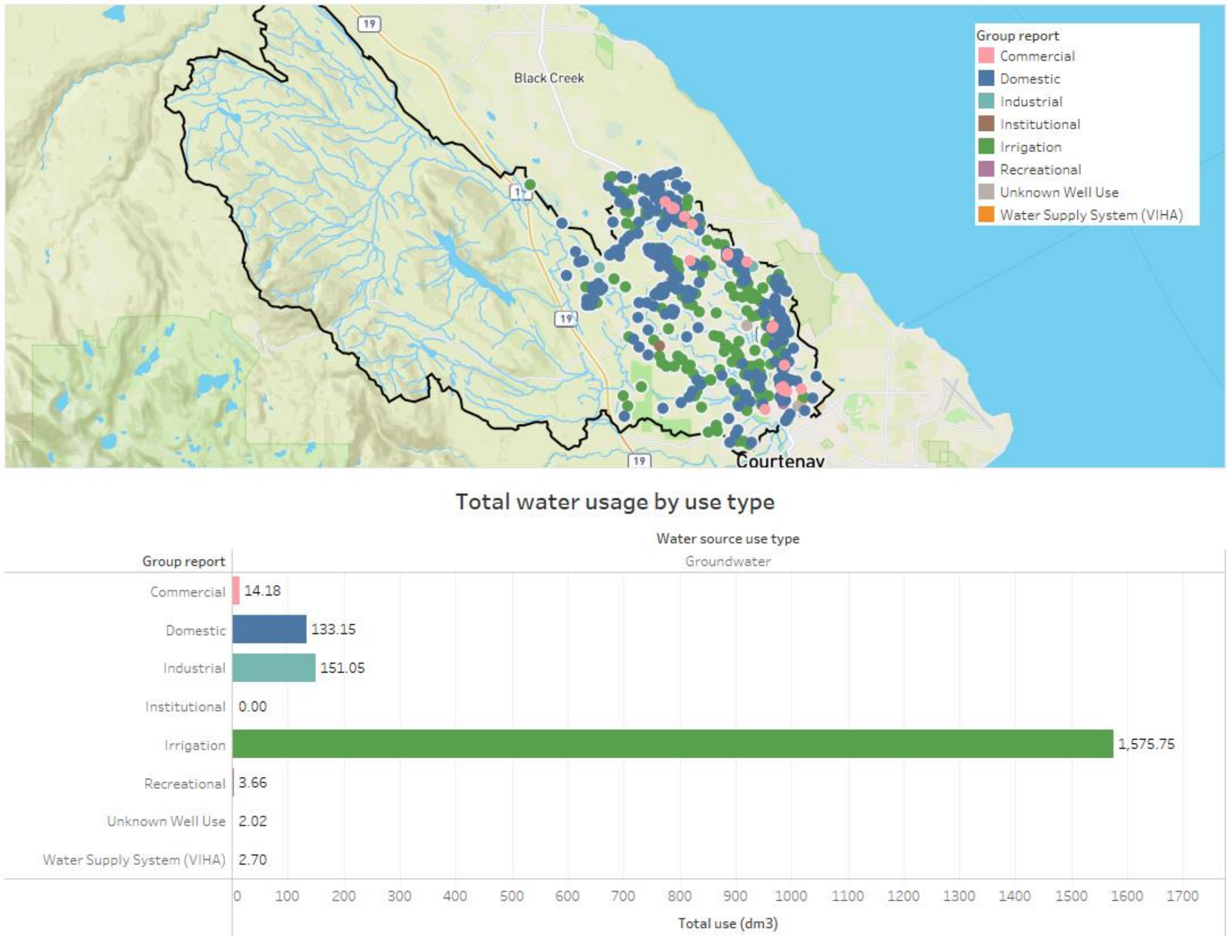

Figure 24: Total groundwater usage classified by type of use (total use in cubic decameter-dm³)

7.2.1 Future Groundwater Use

The K'omok's First Nation (KFN) is currently in treaty negotiations with the Government of Canada and British Columbia. To date, the KFN has negotiated an agreement for access to surface water on the nearby Puntledge River. Access to freshwater is a very important part of treaty negotiations as access to water impacts the KFN's economic future. A reliable supply of clean, fresh drinking water will allow the KFN to develop their lands and build businesses, housing and infrastructure. The KFN has not yet negotiated an agreement for access to surface water but may be interested in obtaining access to groundwater in the Tsolum River watershed (M. Horton, personal communication, January 9, 2019).

In the future, water license applicants may be required to show that their groundwater license application does not reduce instream flows needed for aquatic life (J. Szczot, personal communication, June 11, 2018).

7.3 Agricultural Water Use

As noted earlier, agriculture is a major user of water in the Tsolum River watershed. It is likely that agricultural water needs will increase in the future with climate change and increased agricultural activity. To better understand current and future agricultural water needs, the CVRD partnered with the Ministry of Agriculture in 2014 to conduct a detailed assessment of agricultural water demand in the CVRD (Gulik, Neilsen, Fretwell, & Tam, 2014).

The assessment of agricultural water use was conducted using the Agricultural Water Demand Model (AWDM). This is a tool developed by the Ministry of Agriculture with the Partnership for Water Sustainability of BC. The Model calculates irrigation and livestock watering needs on a property-by-property basis and sums each property to obtain an estimate of the following for the entire basin:

1. Total surface water used for irrigation
2. Total groundwater used for irrigation
3. Total livestock watering needs.

The CVRD and Ministry of Agriculture began this work by conducting an Agricultural Land Use Inventory (ALUI). This inventory, completed in 2013, identified the type of crop grown and type of irrigation system used (if any) on all farmed and ALR parcels in the CVRD (Ministry of Agriculture, 2013).

Next, the Agricultural Water Demand Model was used to estimate current and future water needs. The AWDM combines information from the Agricultural Land Use Inventory with data on soil texture and climate to calculate daily water demand on each parcel. It estimates daily water demand for both a typical hot and dry year (similar to 2003) and a wet and cool year (similar to 1997). The AWDM then sums the water use by watershed, aquifer, and area. A full description of the technical work and detailed calculations can be found in the online report "Agriculture Water Demand Model: Report for the Comox Valley Regional District" (Gulik, Neilsen, Fretwell, & Tam, 2014).

The CVRD and Ministry of Agriculture used the AWDM to identify agricultural water needs under four different scenarios:

- Scenario '0': Current conditions (current climate, current amount of farming)
- Scenario 1: Climate Change
- Scenario 2: Increased Agriculture Activity ('Buildout')
- Scenario 3: Increased Agriculture Activity AND Climate Change

To support the Tsolum River watershed planning process, in 2017 the CVRD requested that these scenarios be run specifically on the Tsolum River watershed. This section provides an overview and analysis of the results for the Tsolum River watershed.

7.3.1 Scenario '0': Current Conditions

Currently, relatively little of the agricultural land in the Tsolum River watershed is irrigated. Only 423 ha, or 20% of the 2158 ha of farmed land in the watershed is described as having an irrigation system in place. The predominant crop type in the watershed is forage and the predominant irrigation system used (74%) is travelling guns.

Table 6 below shows that the estimated annual irrigation demand for the watershed using historic climate data for 1997 (a relatively cool, wet year) and 2003 (hot and dry). The AWDM estimates that under current conditions, producers use an average of 2,321,812 m^3 of water per year for irrigation and stockwatering. In dry years, the model estimates that producers may use as much as 3,170,941m^3 of water.

During a wet year like 1997 irrigation use is only 46% of the amount of water that may be used in a hot dry year like 2003.

Table 6: Estimate of Current Agricultural Water Demand from AWDM (m^3/year)

Year	Irrigation Water Use by Sub-watershed (m3/year)			Livestock Demand	Average Irrigation demand (surface water)	Average Irrigation demand (groundwater)	Average Total Demand (inc livestock)	Max Demand (inc livestock)
	Sub-watershed	Surface water	Groundwater					
1997	Portuguese Creek		772,778	51,713				
	Tsolum River Mainstem	419,423	228,769					
	TOTAL	419,423	1,001,547					
2003	Portuguese Creek		1,703,986					
	Tsolum River Mainstem	969,283	445,959					
	TOTAL	969,283	2,149,945					
Average					694,353	1,575,746	2,321,812	3,170,941

It is important to note that these numbers are estimates and the actual water demand supplied by an irrigation system may be less or more than the numbers shown above.

One of the reasons that the actual water use may be slightly lower is that the Model does not have an adjustment for water supplied to crops grown in low lying areas with a high water table. In portions of the Tsolum River watershed, farms located in the lowland regions have high water tables during portions of the growing season. The high water tables will reduce irrigation demand which is not accounted for in the Model outputs. The Model numbers should therefore be considered the higher estimate of demand.

The model also assumes that producers are using average irrigation practices. If farmers are over-watering, than water demands may actually be higher. Similarly, if farmers are using highly efficient irrigation practices, then water use may actually be lower.

7.3.2 Scenario 1: Climate Change

In the coming years, climate change will impact the agricultural sector in BC. Although producers are accustomed to adjusting their practices to manage through changing weather and difficult conditions, the scope and scale of climate change is anticipated to exceed anything previously experienced (Crawford & McNair, 2012).

7.3.2.1 Predicted Climate Change Impacts

Scientists are predicting that we will see the following changes on Vancouver Island in the coming years (Crawford & McNair, 2012):

- Overall, higher temperatures

- Increased winter precipitation and decreased summer precipitation (with a decrease in snowfall and increase in rainfall in the winter)
- Increased extreme conditions:
  - Increased magnitude, frequency, and intensity of extreme events (flooding, drought)
  - Increased risk of wildfires
  - Drier conditions in summer and more hot summer days

As winter snowpack levels in the headwater mountains decrease and winter rains increase, the Tsolum River system is likely to shift to a more rain-driven streamflow pattern. This will make stream flows less predictable, and likely lead to earlier and greater spring flows and potentially higher winter flows (Crawford & McNair, 2012). Increased wet season precipitation may positively impact groundwater recharge in the region, but lower summer precipitation, coupled with warmer temperatures (and increasing evaporation rates for surface water), mean that summer streamflow levels may become lower and flows less reliable (Crawford & McNair, 2012).

Figure 25 summarizes the expected changes to conditions, as described by the Plan2Adapt, a tool developed by the Pacific Climate Impacts Consortium, to help local governments assess climate impacts in their region (Pacific Climate Impacts Consortium, 2018).

Summary of Climate Change for Comox Valley in the 2050s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+1.5 °C	+0.9 °C to +2.3 °C
Precipitation (%)	Annual	+6%	-2% to +11%
	Summer	-17%	-26% to +2%
	Winter	+5%	-4% to +14%
Snowfall* (%)	Winter	-36%	-55% to -19%
	Spring	-52%	-71% to -17%
Growing Degree Days* (degree days)	Annual	+342 degree days	+210 to +532 degree days
Heating Degree Days* (degree days)	Annual	-516 degree days	-786 to -321 degree days
Frost-Free Days* (days)	Annual	+23 days	+13 to +34 days

Figure 25: Climate Impacts in the Comox Valley: Source - Pacific Climate Impacts Consortium (http://www.plan2adapt.ca/)

7.3.2.2 Estimated Changes to Agricultural Water Demand

With anticipated climate change, drier summer conditions will mean that more water is required. To predict potential increased irrigation needs under climate change, the AWDM was run using future climate scenarios. The model was run using 3 predictive climate model datasets provided by Pacific Climate Impacts Consortium for the years 2053, 2056 and 2059. Three climate models were chosen because it is difficult to know what the future will bring and using these three different models can give a better estimate. The years 2053, 2059, and 2056 were chosen because they are predicted to be the three driest years in the 2050's and should give a good indication of increased water needs. Three climate models were used so that an average could be created to get a more reliable trend. Table 7 shows potential agricultural water demand under changing climate.

Table 7: Estimate of Agricultural Water Demand with Climate Change from AWDM (m3/year)

Year	Irrigation Water Use by Subwatershed (m3/year)			Livestock Demand	Average Irrigation Demand (surface water)	Average Irrigation Demand (groundwater)	Average Total Demand (inc livestock)	Max Demand (inc livestock)
	Subwatershed	Surface water	Groundwater					
Climate Model #1: access1_rcp85								
2053	Portugese Creek		1,914,787	51,713				
	Tsolum River Main	1,203,250	637,430					
	TOTAL	1,203,250	2,552,217					
2056	Portuguese Creek		2,338,383	51,855				
	Tsolum River Main	1,234,581	687,188					
	TOTAL	1,234,581	3,025,571					
2059	Portuguese Creek		1,698,147	51,713				
	Tsolum River Main	908,542	503,233					
	TOTAL	908,542	2,201,379					
Average of Climate Model #1					1,115,458	2,593,056	3,760,274	4,312,007
Climate Model #2: canesm2_rcp85								
2053	Portugese Creek		2,332,604	51,713				
	Tsolum River Main	1,233,674	687,495					
	TOTAL	1,233,674	3,020,098					
2056	Portuguese Creek		1,349,536	51,855				
	Tsolum River Mai	724,799	405,421					
	TOTAL	724,799	1,754,957					
2059	Portuguese Creek		2,188,766	51,713				
	Tsolum River Main	1,163,364	628,365					
	TOTAL	1,163,364	2,817,131					
Average of Climate Model #2					1,040,612	2,530,729	3,623,101	4,305,627
Climate Model #3: cnrm-cm5_rcp45								
2053	Portugese Creek		1,364,916	51713				
	Tsolum River Main	746,502	411,699					
	TOTAL	746,502	1,776,615					
2056	Portuguese Creek		965,873	51855				
	Tsolum River Main	525,047	295,994					
	TOTAL	525,047	1,261,868					
2059	Portuguese Creek		1,304,912	51713				
	Tsolum River Main	704,006	391,723					
	TOTAL	704,006	1,696,635					
Average of Climate Model #3					658,518	1,578,373	2,288,651	2,574,972
Average of All Scenarios					938,196	2,234,052	3,224,009	3,730,869

The AWDM results indicate that without changing crops and irrigation systems, climate change may significantly increase agricultural water demands. The scenarios indicate that future agricultural demand on existing farms with climate change is likely to be an average of 3,224,009m^3/year and up to 4,312,007 m^3/year.

This means that existing farms will need anywhere from 50-200% more water in the future as the climate changes.

7.3.3 Scenario 2: Increased Agricultural Activity ('Buildout')

In the future, it is likely that more land will be placed in agricultural production. There are approximately 72km^2 of Agricultural Land Reserve (ALR) in the Tsolum River watershed and only 28% of it is currently used for farming. If this land is developed for agriculture, there would be an increase in agricultural water demand. To understand how much water may be needed, a 'buildout' scenario was created. In this scenario, scientists attempted to be realistic about agricultural activities and only stated that the land would be used if it met the following criteria:

- within 1,000 m of water supply (lake)
- within 1,000 m of water supply (water course)
- within 1,000 m of water supply (wetland)
- within 1,000 m of high productivity aquifer
- within 1,000 m of water purveyor
- with Ag Capability class 1-4 only where available
- must be within the ALR
- below 250 m average elevation

They then estimated the type of crops and irrigation systems that would be used. They predicted that farming would occur in a relatively similar manner to the current situation (e.g. a relatively similar distribution of crops and irrigation systems, with a slight decrease in forage crops and increase in 'grapes' or berry type crops):

- Forage crops: 50% of buildout area with sprinkler irrigation
- Pasture: 10% of buildout area with sprinkler irrigation
- Grapes: 20% of buildout area with drip irrigation
- Vegetables: 20% of buildout area with drip irrigation

Using these criteria, the scientists estimated that it would be possible to farm and irrigate approximately 2,090ha of land, if sufficient water was available. This is approximately five times more land than is currently irrigated (423ha).

Table 8 shows the potential water demands if there was increased agricultural activity in the Tsolum River watershed. This table is not considering climate change impacts. In this scenario, on average it is expected that agricultural water demand would go up to 9,071,118 m^3/year on average, and potentially up to 12,414,687m^3/year in dry years. That is approximately three times as much water as is currently used.

Table 8: Agricultural Water Demand with Increased Agricultural Activity (m³/year)

Year	Irrigation Water Use by Subwatershed (m3/year)			Livestock Demand	Average Irrigation Demand (surface water)	Average Irrigation Demand (groundwater)	Average Total Demand (inc livestock)	Max Demand (inc livestock)
	Subwatershed	Surface water	Groundwater					
1997	Dove Creek	416,369		51,713				
	Headquarters Creek	46,950						
	Jackpot Creek	257639						
	Piercy Creek	49,432						
	Portuguese Creek	2,005,834	772,778					
	Tsolum River Main	1,898,066	228,769					
	TOTAL	4674289	1001547					
2003	Dove Creek	801,338		51,713				
	Headquarters Creek	90,833						
	Jackpot Creek	483414						
	Piercy Creek	97,247						
	Portuguese Creek	4,755,713	1,703,986					
	Tsolum River Main	3,984,484	445,959					
	TOTAL	10213029	2149945					
Average					7,443,659	1,575,746	9,071,118	12,414,687

It is important to consider that the 'agricultural buildout scenario' considers maximum possible agricultural activity, while it is likely that the actual increase in agricultural activity will be less.

7.3.4 Scenario 3: Increased Agricultural Activity AND Climate Change

Finally, the AWDM was used to estimate the impact of both climate change and increased agricultural activity. The results of the scenario are in Table 9. The Scenario results are displayed for the whole Tsolum River rather than by subwatershed, for ease of viewing.

The AWDM results for this scenario show that if the Tsolum River watershed experiences both climate change and increased agricultural activity, it is possible that average water demands could go up as much as 463%.

Table 9: Estimate of agricultural water demand with increased agricultural activity and climate change from AWDM (m³/year)

Year	Surface water	Groundwater	Livestock water demand (m3/year)	Average Irrigation Demand (surface water)	Average Irrigation Demand (groundwater)	Average Total Demand (inc livestock)	Max Demand (inc livestock)
Climate Model #1: access1_rcp85							
2053	12,206,623	2,552,217	51,713				
2056	14,816,488	3,025,571	51,855				
2059	10,752,506	2,201,379	51,713				
Average of Climate Model #1				12,591,872	2,593,056	15,236,688	17,893,914
Climate Model #2: canesm2_rcp85							
2053	14,904,278	3,020,098	51,713				
2056	8,536,903	1,754,957	51,855				
2059	13209047	2817131	51,713				
Average of Climate Model #2				12,216,743	2,530,729	14,799,232	17,976,231
Climate Model #3: cnrm-cm5_rcp45							
2053	8,479,118	1,776,615	51,713				
2056	6,057,357	1,261,868	51,855				
2059	8,046,401	1,696,635	51,713				
Average of Climate Model #3				7,527,625	1,578,373	9,157,758	10,307,588
Average of all Climate Models				10,778,747	2,234,052	13,064,559	15,392,578

7.3.5 Analysis

Table 10 summarizes the results of the AWDM work. The results suggest that it is likely that agricultural water needs will significantly increase in years to come.

Under climate change, with existing levels of farming alone, it is estimated that water needs will increase from an average of 2,321,812m³/year to an average of 3,224,009m³/year. This represents an increase in agricultural water demands of 39%. If all the ALR land that has access to water was developed and used for farming (using similar crops and irrigation systems as currently exist), it is estimated that water consumption would go up to an average of 9,071,118m³/year. This represents an increase in agricultural water demands of 291%. Finally, if both climate change impacts occur and there is an increase in agricultural activity, it is possible that agricultural water demand could go up to an average of 13,064,559m³/year, or even a maximum of 15,392,578m³/year. On average, this would represent an increase water use of 463%.

Although it is difficult to estimate the exact amount of water used and needed by agriculture, this work indicates that it is likely that agricultural water needs will increase substantially in coming years. Given the potential for agriculture in the Tsolum and the fact that water supplies are already limited it will be important to carefully plan for future water needs.

Table 10: Summary of estimated current and future agricultural water demand according to AWDM (m^3/year)

Scenario	Average Modelled Irrigation SW Demand (m^3/year)	Average Modelled Irrigation GW Demand (m^3/year)	Average Modelled SW + GW + Livestock Demand (m^3/year)	Max Total Modelled Demand inc. Livestock (m^3/year)	Average Percent Increase
Scenario '0': Current Use	694,353	1,575,746	2,321,812	3,170,941	
Scenario 1: Climate Change (no Increase in Farming)	938,196	2,234,052	3,224,009	3,730,869	39%
Scenario 2: Current Climate, More Farming	7,443,659	1,575,746	9,071,118	12,414,687	291%
Scenario 3: Climate Change, Increased Farming	10,778,747	2,234,052	13,064,559	15,392,578	463%

7.4 Validation of Water Use

It is difficult to know how much water is used because there are no users in the watershed that are required to report their water use. Farmers generally don't meter their water use and although research was conducted to identify additional sources of information on water use, no additional measurements of water consumption were found.

The earlier description of surface water use is based on water license information and only shows what is legally allowed to be used, which may differ from what is actually used. The information on groundwater use is based on estimates based on size of property, using coefficients developed from metering in other jurisdictions (e.g. the Nanaimo, Gabriola). While this metered data from other areas is useful, it may not be applicable to the Tsolum watershed.

The AWDM, described above, estimates water use based on the type of crops grown, type of irrigation system, weather, soil types, etc. However, the AWDM estimates that more surface water is used in the Tsolum River watershed than is actually licensed. The AWDM estimates that currently an average of 694,353m^3/year of surface water is used, which is approximately 25% greater than what is licensed for use (523,982m^3/year). It is difficult to assess which water use value is most realistic.

Without measurement it is difficult to know how much water is actually used. Voluntary metering or measurement of water use would be helpful to better quantify water use. Further work is required to better understand surface and groundwater extractions in this watershed. However, there are limits to the quality of information that can be obtained, as described in further detail in the recommendations section. At the moment, the amount of water available is unknown and identifying that also high priority.

8 Water Quality

The Tsolum River has received a significant amount of attention with regards to water quality. The provincial Environmental Monitoring System (EMS) contains nearly 5,000 water quality samples for the Tsolum River watershed.

This attention is partially due to water contamination issues caused by the Mount Washington Copper mine. This open pit copper mine, active from 1964 to 1967, was a source of copper contamination for the aquatic life in the waterbodies downstream. Many remediation efforts were attempted over the years to adequately close the mine. In 2006 the Tsolum River Partnership was formed and undertook a 10-year, multi-phased, multi-partnered solution to reverse the environmental damage. The pollution was drastically reduced in 2010 due to effective mine remediation. In 2015, 129,000 salmon returned to the river, indicating water quality is improving.

Of the 5,000 samples in the watershed, approximately 97% of the samples were collected prior to 2012 and the sampling frequency has decreased since 2013 to an average of over 20 samples per year as shown in Figure 26.

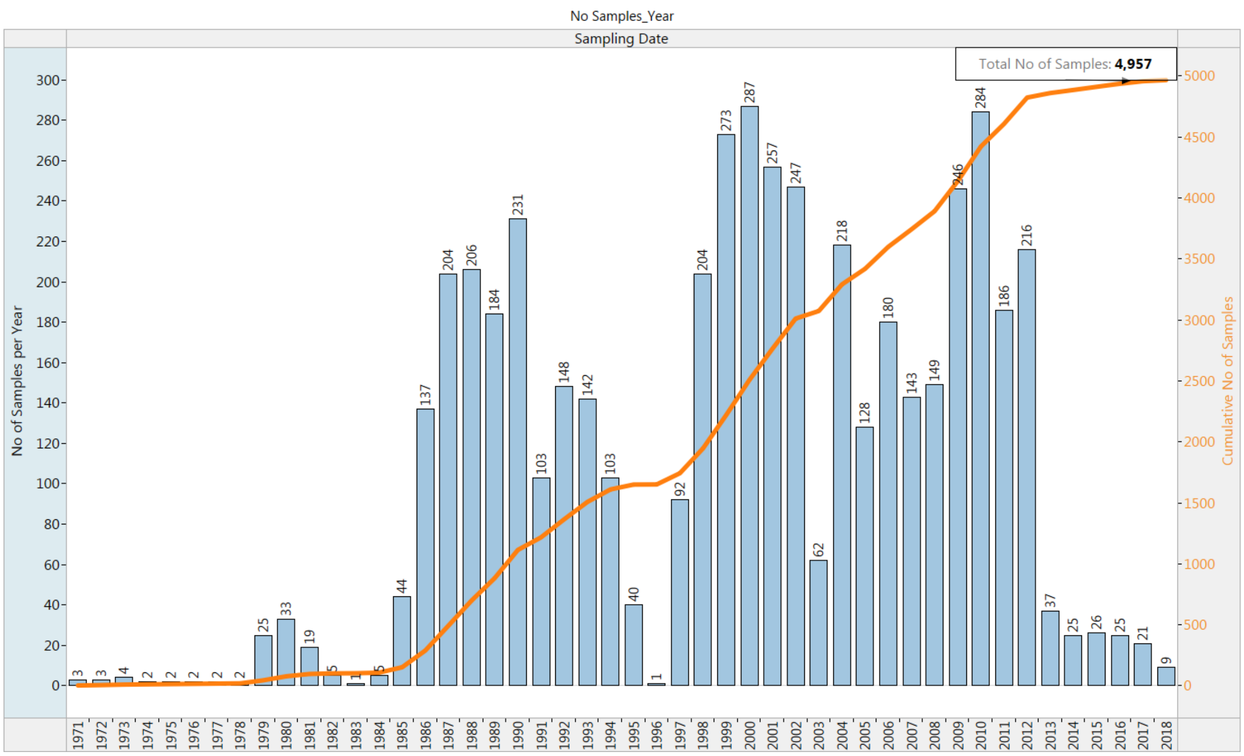

Figure 26. Number of samples per year compiled for the water quality analysis

Table 11 summarizes the number of samples and tests including the date range and location type. Approximately 97% of the data corresponds to surface water and the remaining to groundwater and other with percentages of less than 1% and 2.7%, respectively.

Table 11: Compiled water quality data

Location type group	Location type	Date monitoring from	Date monitoring to	No of monitoring stations	Number of tests	No of samples
Groundwater	OBSERVATION WELL (GROUNDWATER)	8/27/1987	9/20/2017	3	547	9
Other	DITCH OR CULVERT	10/16/1979	9/10/1996	3	472	37
	SEEPAGE OR SEEPAGE POOLS	10/16/1979	11/6/2012	5	3,508	101
Surface water	LAKE OR POND	3/16/1993	8/23/2016	3	57	3
	RIVER, STREAM OR CREEK	5/20/1971	5/15/2018	25	165,201	4,816
			Total	39	169,785	4,966

Figure 27 shows the locations of the water quality monitoring stations. The location type group "Other" corresponds to samples taken within the Mount Washington Copper Mine.

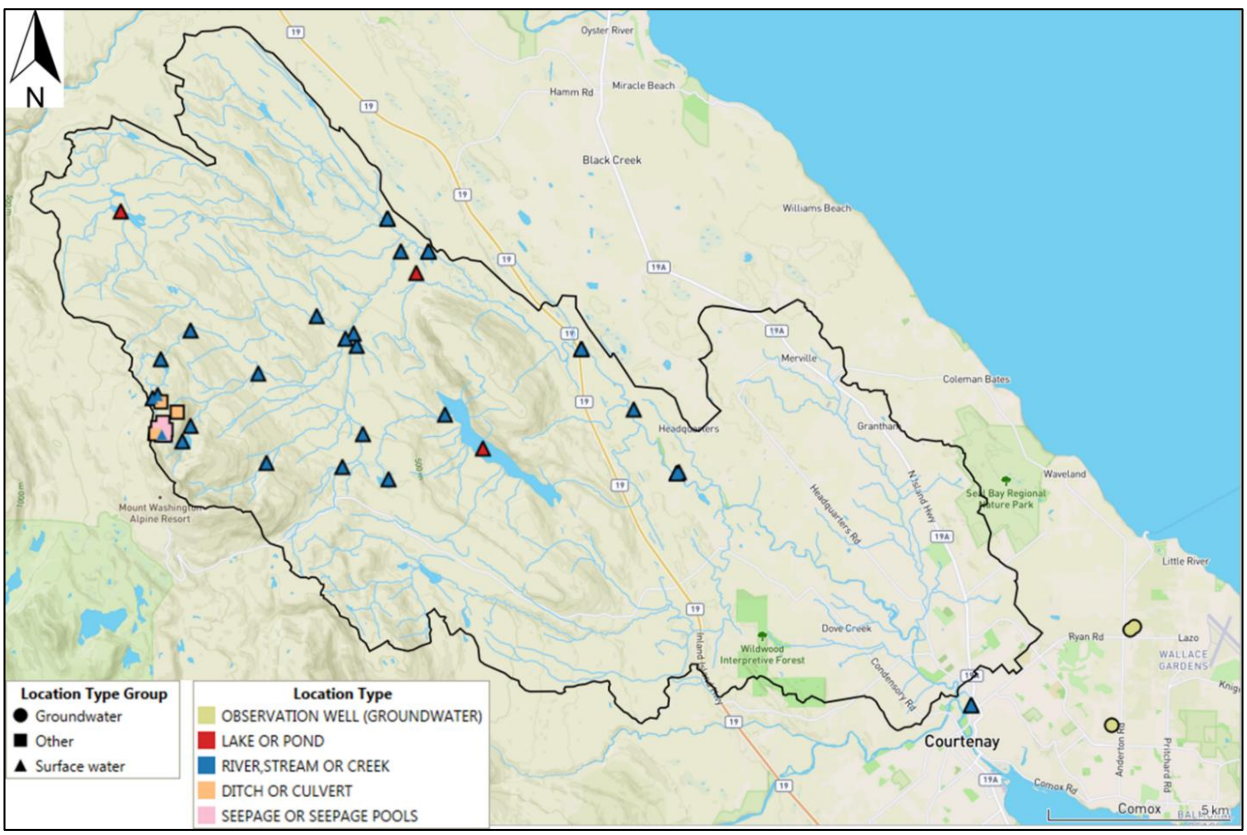

Figure 27. Location of water quality monitoring stations within/near Tsolum River watershed

8.1.1 Water quality data integration

GW Solutions has developed a management and visualisation tool for data integration, interpretation and display. The water quality data has been updated, cleaned-up, and standardized using this tool. In addition, they have built a series of queries to link data to watersheds, sample type, and sample results.

The federal Drinking Water Quality Guidelines, the provincial Acute Fresh Water Aquatic Life and Agriculture Irrigation and Livestock Guidelines were used to identify the parameters and locations where these guidelines were exceeded.

The water quality interactive analysis platform was used to explore the test results for the monitoring stations. One of the outputs of the platform is a display composed of the following windows:

- Map: It shows the location of the monitoring stations. In addition, it displays information regarding the station such as ID, water body name, location (latitude, longitude) and sample type.
- Water quality summary: It provides the baseline for the selected stations. For instance, it shows the number of tests, minimum, maximum and average results for each parameter group including the sampling year range.
- Water quality data: It shows the scatter plot for water quality results over time for all the tested parameters.

An example of the output is shown in Figure 28 for the station located at the mouth of the Tsolum River prior to discharging to Courtenay River.

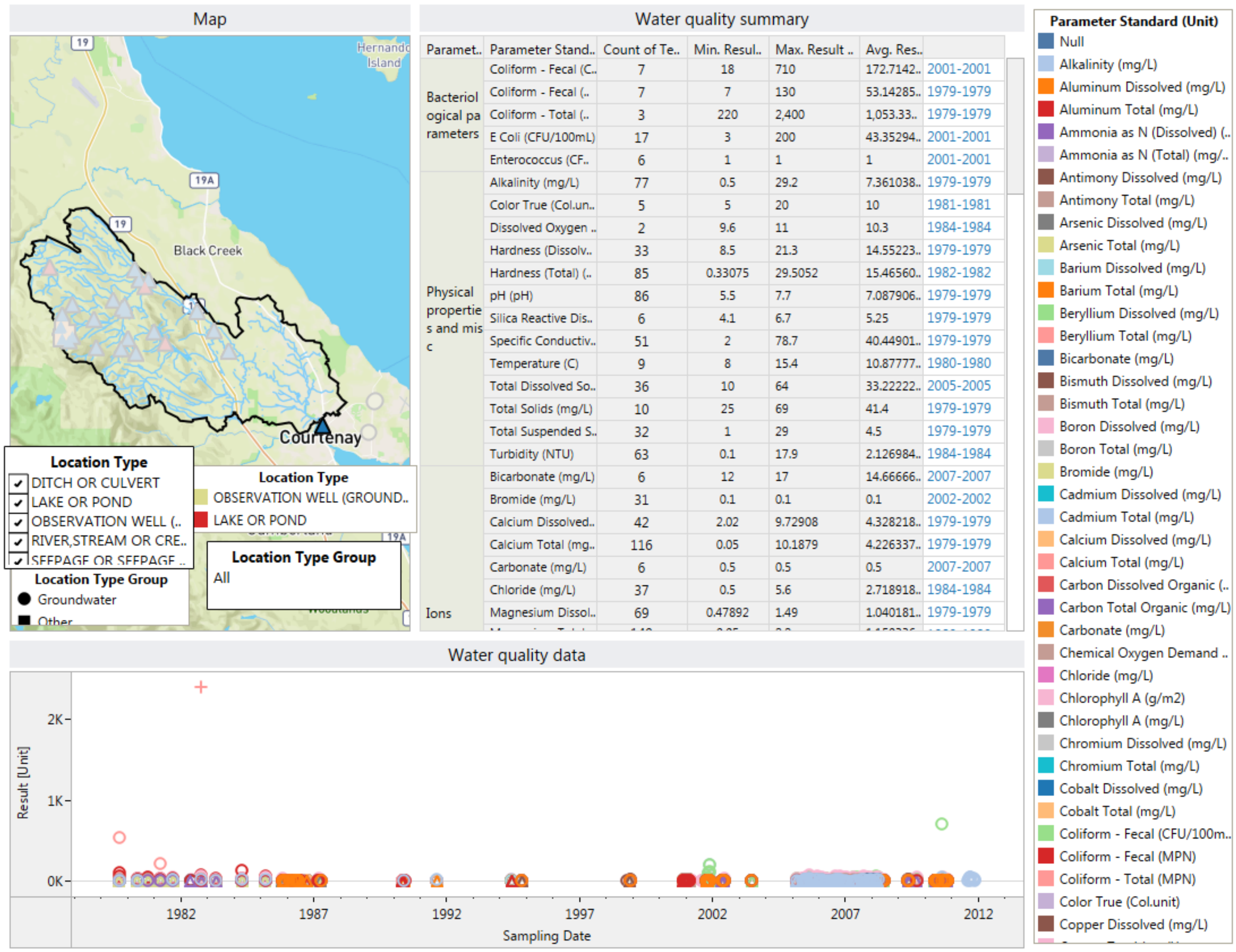

Figure 28: Water quality results for station: TSOLUM RIVER U/S PUNTLEDGE RIVER (EMS ID: 0127621)

8.1.2 Comparison of water quality data with guidelines

The exceedance analysis presented in this report includes all the water quality results collected after 2010 coinciding with Phase 2 of the rehabilitation of the Mount Washington mine.

Figure 29 shows the locations of the stations for which samples have been taken from 2010 to 2018 and Figure 30 displays the number of samples included per year in the exceedance analysis. The year 2010 is chosen as a starting year because it is more representative of current conditions (years prior to 2010 show extremely high copper contamination levels because the copper mine had not yet been closed).

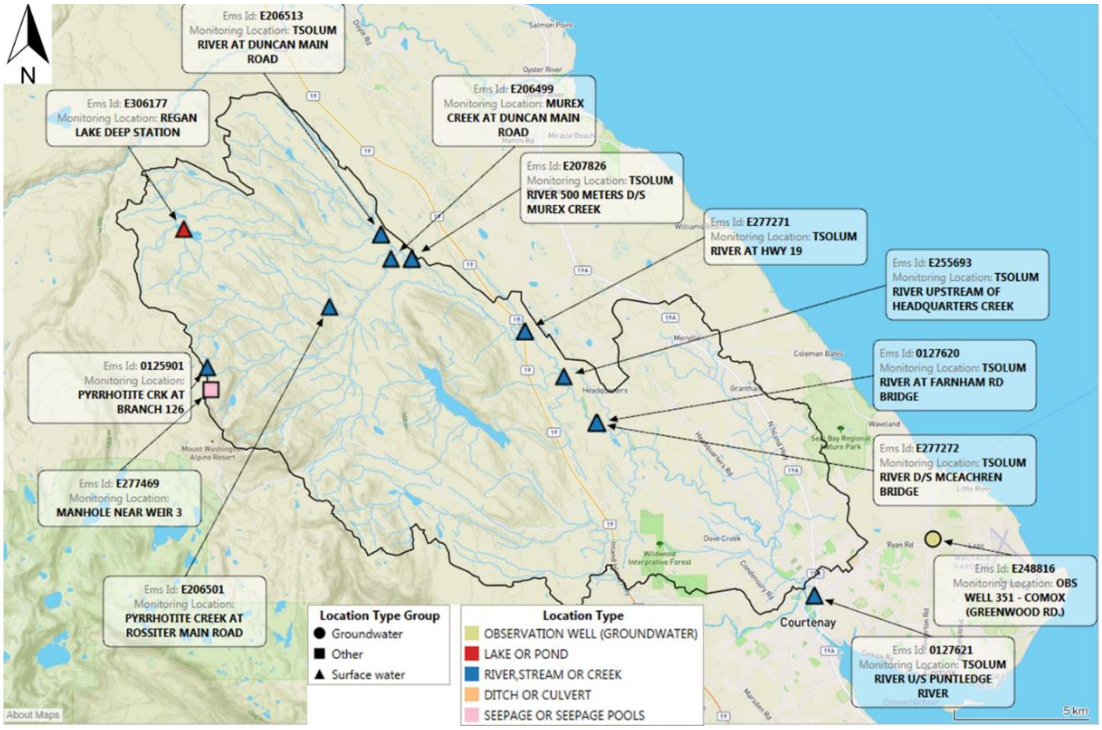

Figure 29. Location of water quality monitoring stations with data from 2010 to 2018

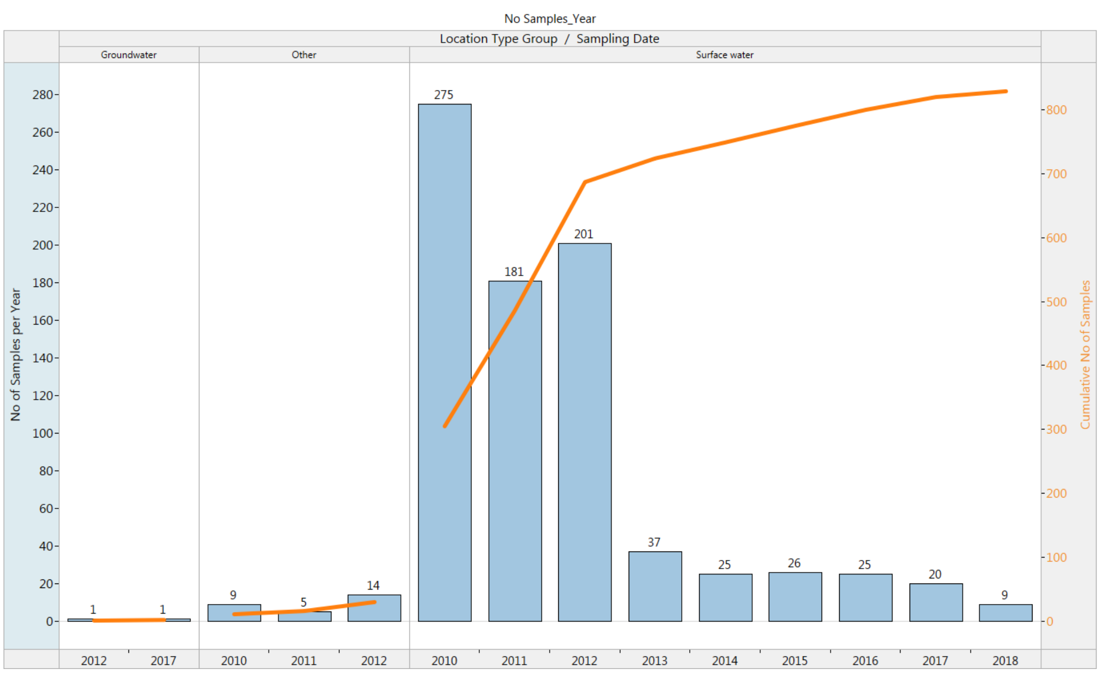

Figure 30 Number of samples per year included in the exceedance analysis summarized by location type group

8.1.2.1 Concentrations above drinking water quality standards

Figure 31 and Figure 32 show the exceedance analysis results for groundwater and surface water samples, respectively when comparing to the Federal Drinking Water Quality Guideline. The results include water quality comparison for bacteriological, ions, metals, nutrients and physical properties. The diagram shows two summary plots: number of tests and percentage of exceedance. There are no exceedances recorded for groundwater samples; however, surface water samples present some exceedances:

- Bacteriological parameters: 87% of the Fecal coliforms tests exceeded the guideline
- Metals: Three parameters exceed the guideline Aluminum total (20% of the samples exceeded the guideline), Iron total (7%), and Manganese (1%)
- Physical properties: pH, color, and temperature present exceedances of 31%, 36%, and 12%, respectively.

Fecal coliform exceedances in samples tend to increase moving downstream (Phippen, 2012).

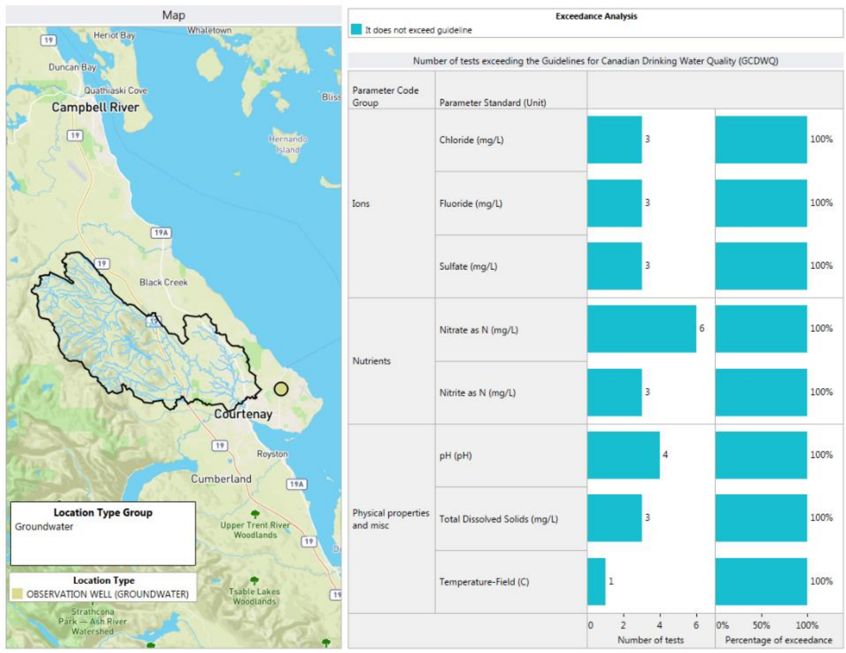

Figure 31: Exceedance analysis for groundwater samples considering the Federal Drinking Water Quality Guideline

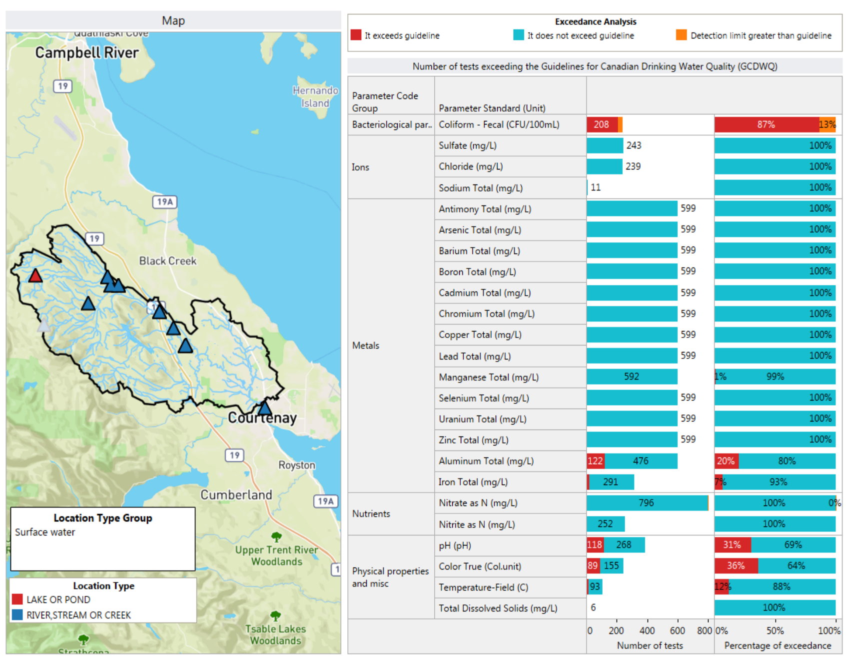

Figure 32. Exceedance analysis for surface water samples considering the Federal Drinking Water Quality Guideline

8.1.2.2 Concentrations above BC acute aquatic life guidelines

Figure 33 shows the exceedance analysis results for surface water samples when comparing to the BC Aquatic Life Acute Guideline. Total copper exceeded the most the aquatic life guideline with 60% of the samples exceeding the guidelines followed by aluminum dissolved (7%), cadmium dissolved (3%) and zinc and iron (1%). Further research (outside of the scope of this project) is needed to understand the current conditions and their impact on aquatic life.

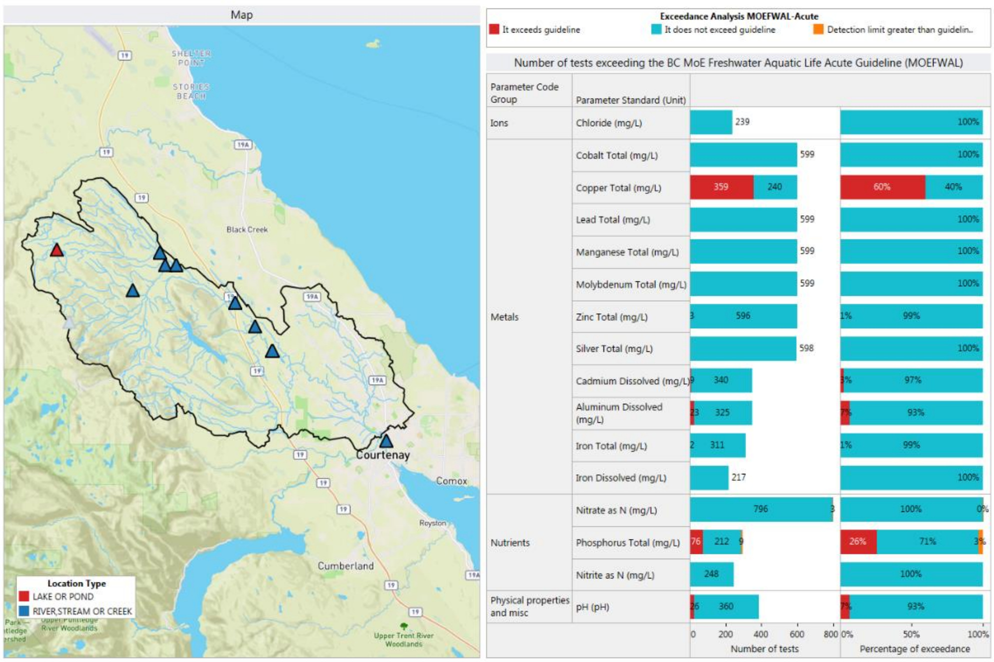

Figure 33. Exceedance analysis for surface water samples considering the Aquatic Life Acute Guideline

8.1.2.3 Concentrations above BC agriculture-irrigation guidelines

Figure 34 and Figure 35 show the exceedance analysis result for groundwater and surface water samples, respectively, when comparing to the BC guidelines applying to agricultural irrigation. There are no exceedances recorded for groundwater samples; however, surface water samples presented some exceedances of less than 1% for pH and copper.

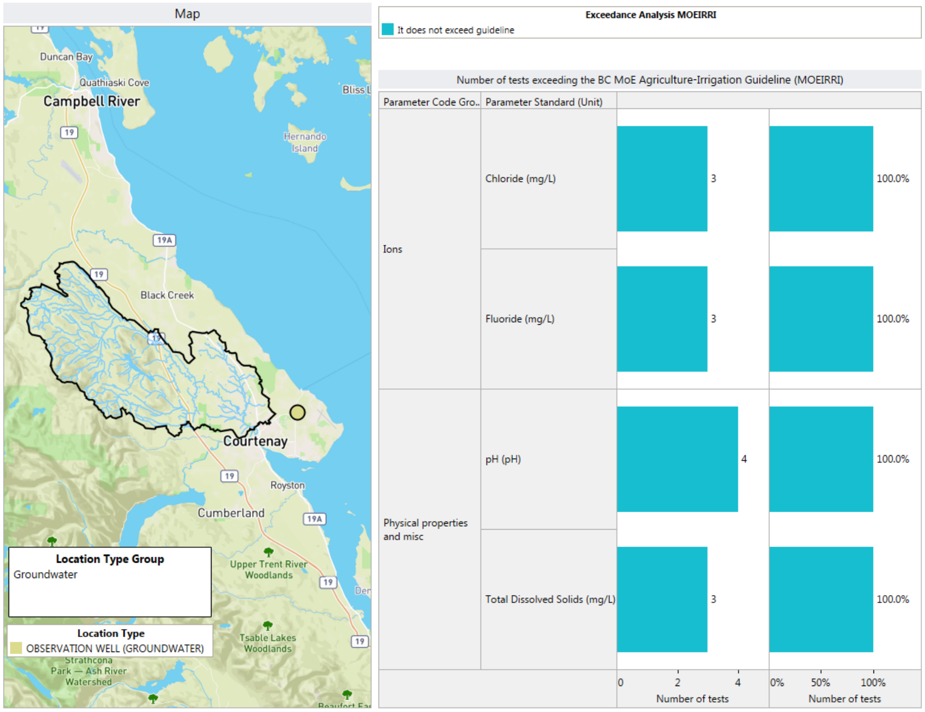

Figure 34: Exceedance analysis for groundwater samples considering the BC Agriculture-Irrigation Water Quality Guideline

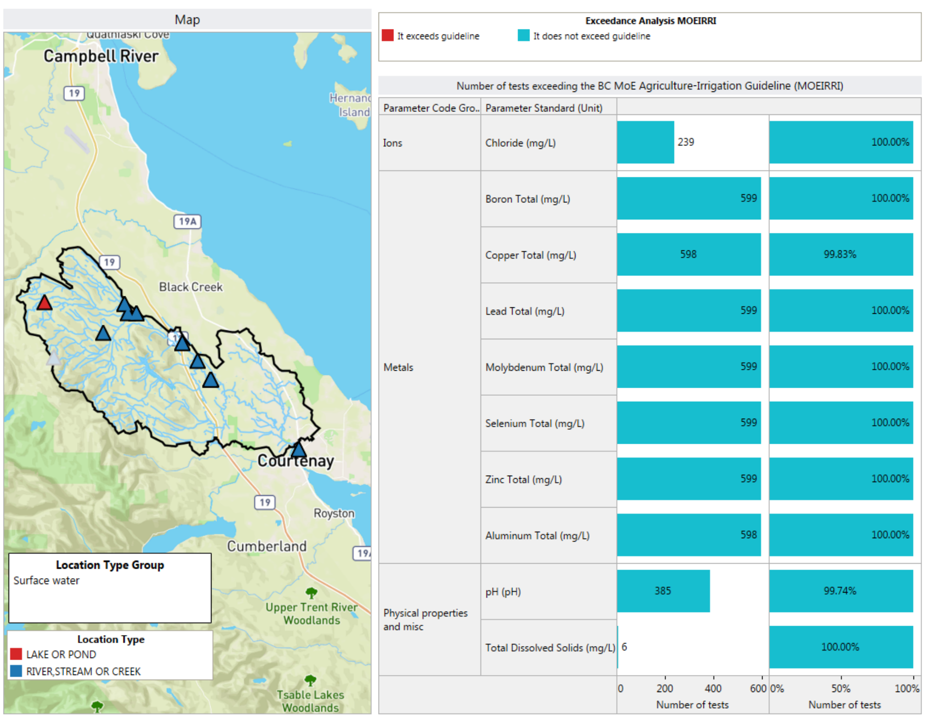

Figure 35. Exceedance analysis for surface water samples considering the BC Agriculture-Irrigation Water Quality Guideline

8.1.2.4 Concentrations above BC agriculture-livestock guidelines

Figure 36 and Figure 37 show the exceedance analysis result for groundwater and surface water samples, respectively, when comparing to the BC agricultural-livestock guidelines. There are no exceedances recorded for groundwater samples. Nevertheless, surface water samples presented some exceedances of less than 1% for pH, copper and nitrate.

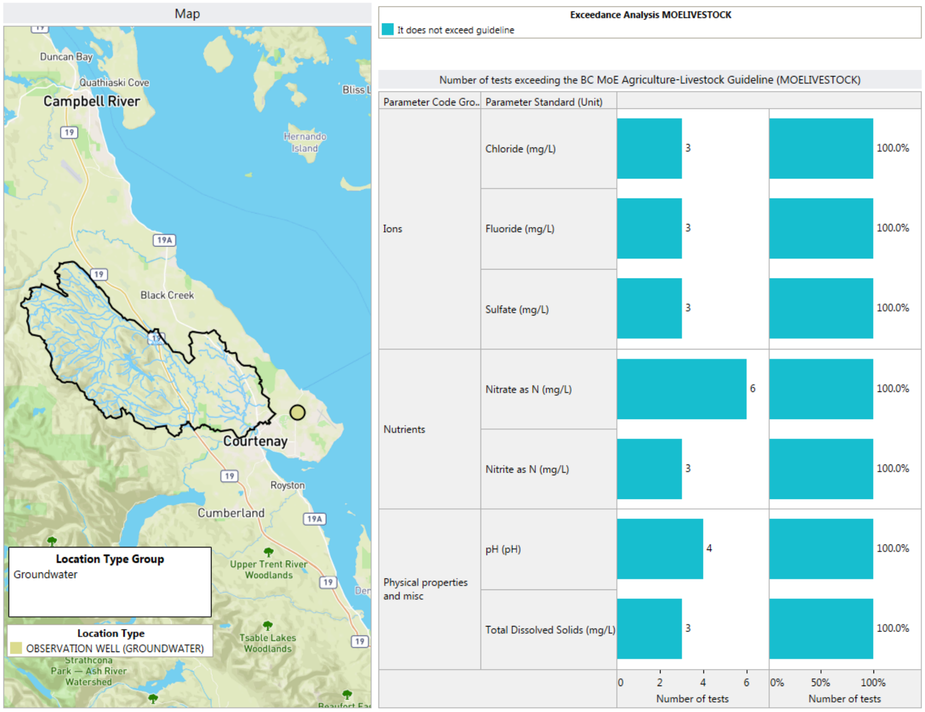

Figure 36. Exceedance analysis for groundwater samples considering the BC Agriculture-Livestock Water Quality Guideline

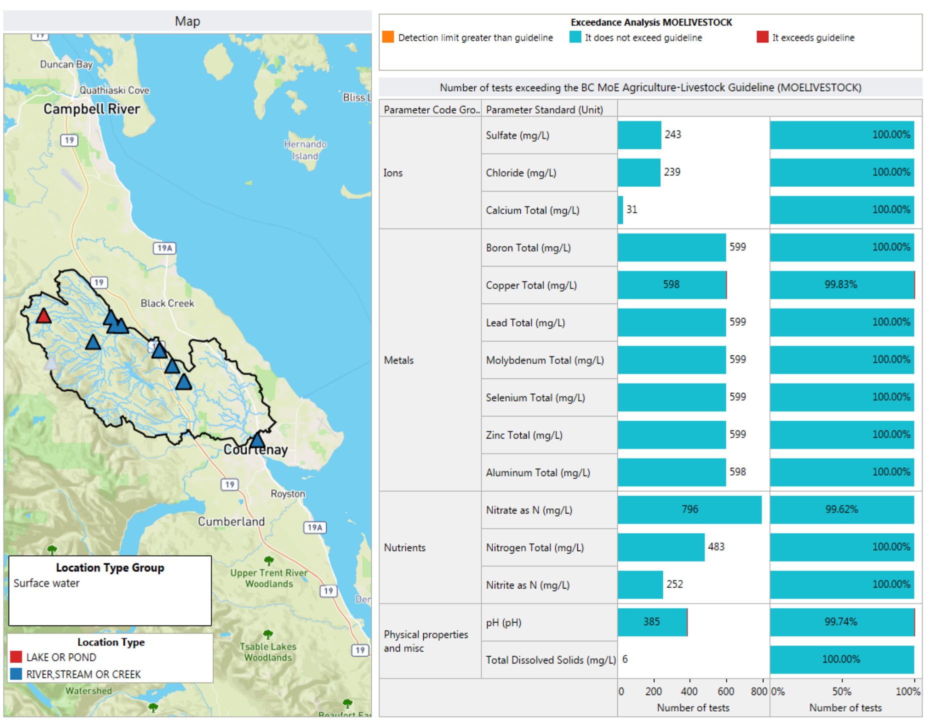

Figure 37. Exceedance analysis for surface water samples considering the BC Agriculture-Livestock Water Quality Guideline

8.1.3 Analysis

There have been substantial improvements in water quality in the Tsolum River watershed, due to the efforts of the Tsolum River Partnership. However, there are still some exceedances with surface water samples. There are exceedances of Cadmium, Copper, Aluminum, and Phosphorus, particularly with regards to Acute Aquatic Life Guidelines. Moving forward it would be useful to plot the concentrations of these parameters over time to assess whether there are increasing or decreasing trends. There are also a relatively high number of coliforms in surface water samples.

9 Environmental Flow Needs

The Tsolum River watershed is home to many aquatic animals, including, Pink, Coho, Chum, and Chinook Salmon, Cutthroat and Rainbow Trout, and lamprey and freshwater mussels. Although these species were some of the original inhabitants of the stream, fish and aquatic life don't 'hold' official water licenses on the creek.

However, under the new Water Sustainability Act, the provincial government has stated that "Environmental Flow Needs" (EFNs) must be considered in any new decisions about water use on a stream. EFNs are defined as the volume and timing of water flow required for proper functioning of the aquatic ecosystem (*Water Sustainability Act*, Section 1).

As of 2016, EFNs must be considered in decisions about water licences or use approvals on a stream - or an aquifer that is hydraulically connected to a stream.

The amount of water needed in a river for a healthy functioning ecosystem varies from one river to the next. The Provincial government has created an "Environmental Flow Needs Policy" to guide this decision-making (Government of British Columbia, 2018). Based on the Environmental Flow Needs Policy, in the Tsolum River, the flow sensitivity is high in August and moderate in July and September for the river, (considering flow data from 1977 to 2017 at WSC 08HB011) (Government of British Columbia, 2018). However, there is no clear information on how much water needs to remain in the stream to support ecological health in the Tsolum River watershed.

9.1 Summary of Available Information on Environmental Flow Needs in the Tsolum

The Courtenay Water Allocation Plan (Figure 38) uses the Modified Tennant (Montana) Method to recommend that an estimated minimum of 10% of MAD is maintained in the Tsolum to support aquatic life (Riddell & Bryden, 1996). In the Tsolum River, MAD is $10m^3/s$, and August flows are often well below $1m^3/s$.

However, more recently, Provincial scientists have decided that maintaining flows of 10% MAD in Vancouver Island streams may not be realistic. Many streams on the east coast of Vancouver Island have highly variable flow regimes and may not have had flows above 10% MAD in the summer prior to human disturbance (Szczot, 2018). The regional Senior Aquatic Ecologist stated that a more appropriate target may to be maintain $0.5m^3/s$ in the Tsolum River watershed during low flows (Szczot, 2018).

A prior study (Wolf Lake Study, 1976) stated that at a minimum, in the Tsolum River, $0.42m^3/s$ is required for fish attraction purposes prior to spawning during the period of Aug 15-Sept 15.

Modified Tennant (Montana) Method Instream Flow Requirements	
Flows	**Description**
30-60% MAD	Excellent spawning/rearing
20-30% MAD	Good spawning/rearing
10-20% MAD	Fair spawning/rearing
5-10% MAD	Poor spawning/rearing
>5% MAD	Severely degraded spawning/rearing

Figure 38: Flow needs. Source: Courtenay River Water Allocation Plan

Except during the irrigation months and occasionally in the winter, the minimum suggested environmental flows are met by the natural flow of the river in the Tsolum watershed. However, in August and early September, flows can become extremely low. A review of flow records shows that flows are often less than 5% MAD, and occasionally under 1% MAD in these critical months. Augmentation from Wolf Lake reservoir attempts to provide flows of 10% MAD in the lower 18 km of the Tsolum River. But in recent drought years, even with augmentation, August flows have dropped well below 5% MAD.

9.2 Critical Environmental Flow Thresholds

In addition, to EFNs, the Provincial government has developed criteria called “Critical Environmental Flow Thresholds”. A critical environmental flow threshold is a short-term flow threshold, below which significant or irreversible harm to the aquatic ecosystem of the stream is likely to occur (*Water Sustainability Act*, Section 1). On Vancouver Island, the provincial government has identified 2-3% MAD as a ‘critical environmental flow threshold’ (Szczot, 2018). If flows in the river get this low, the provincial government can step in with a ‘Critical Environmental Flow Protection Order’ or a ‘Fish Population Protection Order’. This can limit water license holders from taking water from the stream. It is better for all users of the river if the conditions don’t get to this point, so when flows become very low, provincial staff may begin asking users to modify their use. For instance, they may ask producers to water 24 hours/day at a lower flow rate, rather than 8 hours/day at a higher rate, so that the river flows don’t drop suddenly when the ‘taps are turned on’ (Szczot, 2018).

9.3 Determining Environmental Flow Needs for the Tsolum River Watershed

In several watersheds in BC, scientists are conducting research to identify the river’s unique Environmental Flow Needs (Okanagan Basin Water Board, 2018). This research has not yet been done on the Tsolum.

Provincial government staff have noted that managing rivers for environmental health may be more complex than simply managing for a certain flow threshold. For example, some research has found that it may be more valuable to manage the stream to keep water temperature below a certain threshold and maintain high value habitat areas (Neil Goeller, AWPAC meeting, September 26, 2018).

Further work is needed to quantify the flows and conditions required to maintain ecosystem health so that everyone can better manage their water use in the Tsolum River watershed. It is recommended that Phase 2 of the Agricultural Watershed Planning work begins with an assessment of Environmental Flow Needs.

10 Significance of Agriculture with Respect to Economic Activities

Agriculture plays an important role in the economy of the Comox Valley Regional District and the Tsolum River watershed. In the CVRD, there are 416 farm businesses, managed by 640 farm operators, representing approximately $531 million in farm capital. Although there is a tendency to view farming as merely the growing of food and pastoral landscapes, the reality is that farms play an important role in a much larger supply chain in which the farmer is both a consumer and producer of goods and services (Fraser Valley Regional District, 2017). In BC, it is estimated that agriculture and the agri-food system account for over 13% of BC's employment. Nationwide, producers spend approximately $50 billion in operating expenses which flows back in the broader economy (Fraser Valley Regional District, 2017).

In the Tsolum River watershed, agriculture plays a role in the four main areas of economic activity: production of commodities, consumption of goods, employment, and the provision of services. In this section, we use Statistics Canada Census of Agriculture data to identify the current significance of agriculture in the watershed with respect to economic activities. Then, we use information on trends in agriculture in the Comox Valley to demonstrate the potential economic significance of agriculture in the watershed.

10.1 Background

Every five years, Statistics Canada gathers data on the Canadian agricultural industry and farm operators as part of the Census of Agriculture. This data is then summarized and reported for each electoral area and Regional District across the country. Although information on agriculture is not summarized for the Tsolum River watershed specifically, it is possible to roughly estimate the contribution of agriculture to the economy in the watershed using existing data. Approximately half of the agriculture in the CVRD occurs in the Tsolum River watershed[1] so it could be very roughly estimated that approximately 50% of the economic activities related to agriculture in the CVRD are in the Tsolum River watershed.

10.2 Production

In the last Census of Agriculture (Statistics Canada, 2016), farmers in the CVRD reported that they received approximately $34 million ($33,662,551) in funds for off-farm sales, according to total gross farm receipts. In addition, many farmers produce their own inputs (e.g. dairy farmers produce hay to feed cattle), so the actual value of goods produced on farm is likely higher. In general, local production consumed or used by the producer is estimated at 10% of the value of agri-food products, so the value of goods produced by farmers in the CVRD is likely closer to $37 million.

If agriculture in the Tsolum River watershed accounts for approximately 50% of agricultural activities in the CVRD (British Columbia Assessment data) it is possible to estimate that the value of goods produced by agriculture in the Tsolum River watershed is approximately $18.5 million.

10.3 Consumption

As a primary industry, agriculture not only provides inputs to the economy, it is also a consumer of goods and services from other local businesses. In the CVRD, farm businesses spent $29 million ($29,490,823) in operating costs in 2016 and much of this was input into the local economy. At a rate of approximately

[1] 54% of the CVRD's farm properties[1] are in the Tsolum watershed and 42% of the farmed land cover in the CVRD is in the Tsolum River watershed.

50%, one could estimate that farm business operating expenses were approximately $14 million for producers in the Tsolum River watershed and that agriculture in the Tsolum River contributed approximately $14 million to the local economy through consumption.

10.4 Employment

Within the CVRD, 1,975 people are reported to be employed in agriculture in 2016. This means that 6.3% of all employment in the CVRD for those over the age of 15 is on farm or related to agri-food processing. In 2011[2], approximately $7 million dollars was paid to employees on farms in the CVRD. If it is estimated that half of the farm activities in the CVRD are in the Tsolum River watershed, one would estimate that there are approximately 800 people employed on-farm in the Tsolum River watershed, and that agricultural employment accounts for approximately $3.5 million worth of wages earned in the watershed.

Those employed by the agricultural industry (farm operators and employees) also contribute to the broader economy by spending the wages earned from farming consuming good and services in the community (food, entertainment, household items, personal services, etc.).

10.5 Good and Services

Farms also play a role in providing services in the watershed through agritourism, direct sales, and food processing. These services contribute to the overall quality of life, economy and tourism industry in the greater CVRD.

Agritourism is a growing way in which farms contribute to the economy. Agritourism promotes visits to the farm (and surrounding area) for the purposes of recreation and includes services such as corn mazes, petting zoos, bed and breakfasts, campsites, winery and orchard tours, horse rentals for trail riding, pumpkin patches, etc. Increasingly, tourists are coming to the Comox Valley to experience local cuisine, attend farmer's markets, stay at on-farm bed and breakfasts, and participate in the growing agritourism industry. These visitors will have far-reaching contributions to the Comox Valley economy.

In addition, many farms sell directly to the public through permanent or temporary stores such as fruit-stands, u-pick, or restaurant/take out services (Statistics Canada Census of Agriculture, 2016). Small farms and direct marketing play a large role in BC, and this is particularly a trend in the Comox Valley. Almost half of farms in the CVRD sell directly to consumers, with the primary venue being through sales of unprocessed products, and secondarily through farm gate, stands, kiosks, and u-pick (Statistics Canada Census of Agriculture, 2016).

Finally, farms provide extended services to the community through food and agri-food product processing. This includes fruit canning, wine and cider making, meat processing, etc.

10.6 Future Significance

It is likely that the economic significance of agriculture in the Tsolum River watershed will increase. The demand for locally grown agricultural products is anticipated to grow as the population grows and there are a number of consumer trends that suggest that there will be increasing demand for local foods: the 100-mile diet, slow food, real food, organic food, etc. Increasingly, consumers are becoming aware of the

[2] This data was not gathered in 2016

benefits of eating locally and are making choices at supermarkets and markets to eat more locally produced food. Increasing fuel costs have already pushed the price of food up and climate change will likely make importing food from other areas (e.g. California) less reliable. It is likely that local food production will become more profitable and local foods more in demand.

The Comox Valley has significant potential to expand for its agricultural base, related employment and businesses. The Tsolum River watershed has the potential to generate a much higher level of agricultural production, if there is sufficient water available. The valley's favorable climate, available land, and access to local markets make it well-poised for future growth. The Comox Valley has one of the most favorable growing climates in the country (a very high number of frost-free days and growing degree days) and while many areas of the province have exhausted their available agricultural land, there is still a large reservoir of land available to build a strong and viable agriculture sector into the future. In the Tsolum River watershed, only 28% of the ALR land is currently used for farming and with drainage and irrigation improvements, the productivity of some of that land could be greatly increased. However, much of the unused ALR is currently uncleared and the quality of the soils may be low.

The Comox has an active local farming community and local support. The Comox Valley Farmers' Market operates twice a week from April to December with 50 to 60 vendors and several grocery stores in the Valley sell local products. The fact that the Farmer's market has grown from 6 to 60 vendors in just 10 years as a sign of the increasing popularity of agriculture (Penfold, Rolston, & Guiton, 2002).

Looking forwards, agricultural development is a viable and desirable economic development option for the Comox Valley. Expanding the agriculture base in the Comox Valley would be a wise choice for investment in the future health of the CVRD in terms of economic potential, food security, and community development (Penfold, Rolston, & Guiton, 2002). Agriculture growth would also be an asset to the local economy because agriculture is a relatively stable industry. Although farm operators definitely experience their share of 'ups and downs', the industry has generally maintained itself. The agriculture sector in the CVRD has remained relatively stable when sectors such as fisheries, mining, forestry, construction, and manufacturing sectors have faltered.

11 Data Gaps

As part of this report, the consultants were asked to identify key data gaps in the Tsolum River watershed. The following is a list of data gaps in the watershed. Although it would be helpful to address many of these in the future, much of this work would be outside the scope of the agricultural watershed planning process.

11.1 Water Quantity

- **Water usage data for groundwater and surface water:** There is currently no actual information on water use. All water use values in this report are estimates. It would be helpful to have information on water use, monthly, particularly in low flow months (July to September) so flows in the river can be compared with water usage. Ideally it would be better to work with the seven-day low flows, however, daily or weekly water usage scales are not feasible at this point because of too many assumption and unknowns. With the available information, only monthly water usage could be estimated.
- **Environmental flow needs:** Information on environmental flow needs should be developed.
- **Groundwater and surface water data:** There are no observation wells within the aquifers in the watershed. Designing a groundwater and surface water monitoring program for water quantity analysis is recommended: To study whether dropping groundwater levels is a concern in the study area, implementing observation wells and a monitoring program is essential. In addition, there are only two active hydrometric stations for the whole watershed. It would be helpful to have information on flows (gauges) above the confluences of Pyrrhotite Creek, McKay Creek, Murex-Creek, Headquarters Creek, Piercy Creek, Jackpot Creek and Portuguese Creek. More stations along Tsolum River will provide a better insight to surface water-groundwater interconnection as well as water availability along the river.
- **Surface water and groundwater interaction along Tsolum River and Portuguese Creek:** The current hydrogeological study shows that there are artesian conditions within the Portuguese Creek sub watershed suggesting upward groundwater flow (discharge to the River). Information on hydraulic connectivity is required for Portuguese Creek and the Tsolum River.
- **Aquifer mapping and characterization:** Information on potential mapped and characterized aquifers should be continuously refined as new data is collected. Drilling of observation/test wells may be necessary to validate the existence and characteristics of the aquifers.
- **Assessment of landscape-scale flow augmentation opportunities:** Although there have been studies looking at the potential for flow augmentation, using large-scale regional storage such as Wolf Lake, there has been no work done to investigate the potential of smaller-scale distributed storage in the watershed (e.g. by adding water storage ponds, dugouts, wetlands, etc.). There has also been no assessment of opportunities to augment flow by retaining water in landscape (e.g. through different land use management strategies that increase vegetation and forest retention).

11.2 Water Quality

- **Groundwater quality data:** There is no groundwater quality data available for the Tsolum River watershed. Voluntary sharing of private well test data (as is done in the Regional District of Nanaimo) would be useful. A groundwater monitoring program should be designed and implemented. It would be helpful for VIHA data and private sampling analysis to be available in the water quality database. Currently, the water quality database only includes EMS sources.

- **Water quality data for tributaries:** There is currently no water quality data for Portuguese Creek and Dove Creek.
- **Chronic guideline analysis:** Characterize waterbodies for chronic guideline analysis as there is a lack of chronic data for the whole watershed. In BC there are two sets of aquatic life guidelines: chronic and acute. Acute guidelines refer to concentration at any time; however, the 30-day average or (chronic) concentration is based on five weekly samples collected within a 30-day period. Thresholds for chronic exposure are stricter (lower) than for acute exposure; however, concentrations describing the chronic conditions are more representative of the long-term exposure of fish and fish habitat to water. Therefore, the chronic concentration is a better representation of the conditions of the water quality of a water body.
- **Water Quality Objective attainment monitoring:** The Province has established water quality objectives for the Tsolum River watershed and suggests monitoring for compliance every 5 years (Five sites on the mainstem Tsolum).

12 Public and Stakeholder Consultation and Engagement

Informed and inclusive public consultation is a critical part of watershed plan development and helps ensure that the final agricultural watershed plan reflects the aspirations and ideas of agricultural producers and the wider community within the watershed. Community engagement is also important as an engaged community can help support the implementation of Phase Two.

There are several organizations and agencies involved in the Tsolum River watershed. These include:

- Stewardship Groups: Tsolum River Restoration Society, Comox Valley Land Trust, Project Watershed, Comox Valley Naturalists Society
- Agricultural Organizations: Mid Island Farmer's Institute, Comox Valley Farmer's Institute
- First Nations: K'ómoks First Nation, Kwakiutl Territorial Fisheries Commission
- Provincial Government: Ministry of Agriculture, Ministry of Environment, Ministry of Forests, Lands, Natural Resource Operations, & Rural Development, Ministry of Energy & Mines
- Federal: Department of Fisheries and Oceans, Environment Canada
- Commercial/Industrial/Institutional: Businesses, schools, meeting venues, exhibition grounds
- Large industry: Timberwest (also, large landowner), Canadian Pacific Railway
- Recreational User Groups: Courtenay Fish and Game Club, Golf Courses, Mt. Washington Ski Resort, etc.
- Local Government: CVRD, City of Courtenay

Between September 2018 and February of 2019, the public and watershed stakeholders were invited to share their water quantity and quality concerns, provide feedback on the information gathered to-date, and discuss future water management solutions. This was done through a series of activities including: targeted interviews, a public open house event, public survey, a booth at the Comox Valley Farmer's Market, social media posts, news releases, engagement with the Comox Valley Farmer's Institute and Mid-Island Farmer's Institutes at their Annual General Meetings, and interview and meetings with the K'òmoks First Nation, and Advisory Committee engagement.

The goal of these activities was to:

- Share information about the Tsolum River Agricultural Watershed Planning process
- Share information on the Tsolum River watershed (results of Deliverable #1)
- Obtain feedback on the information gathered to date and next steps
- Obtain local information to be included and considered in plan development
- Develop an increased understanding of water supply and demand challenges in the watershed
- Identify levels of community support for different water management solutions
- Increase support for a planning process to reduce current and future water use conflicts.

The community engagement and consultation work resulted in the following:

- 170 survey responses (exact number to be confirmed)
- 60+ people reached at October 13th Farmer's Market
- 37+ people reached at October 29th Public Open House event
- 35+ reached via the Comox Valley Farmer's Institute and Mid-Island Farmer's Institutes Annual General Meetings, September 18th and 19th

- 15 local or subject matter experts reached through targeted stakeholder interviews
- Numerous people reached via posters and brochures distributed at 14 busy locations in the community
- Numerous people reached through two media releases
- Up to 5,500 'followers' reached via social media (CVRD site, Comox Valley Farmer's Institute sites, Mid-Island Farmer's Institute site)

12.1 Potential Solutions

During the engagement process, participants were asked to provide feedback on several proposed solutions for addressing agricultural water supply issues in the Tsolum River watershed. The following provides an overview of the proposed solutions.

Overall, participants showed significant support for the development of water storage infrastructure, with a preference for on-farm storage. Several participants recommended supporting producers in developing storage on-farm by providing financial support in the form of incentives and/or interest-free loans. Participants were also supportive of demand management and pursuing legal approaches to water management, with the caveat that these are considered in partnership with steps to address the obvious water supply concerns. The following provides a brief description of several of the proposed solutions.

12.1.1 On-farm storage

On-farm water storage, in the form of dugouts, ponds, or cisterns, can be used to hold rainwater, groundwater, or surface water from a river/stream/creek or overland flow. On-farm storage can be used to store water from rainy months to be used in dry summer months. It can also be used to modulate flow from marginal groundwater wells.

On-farm storage has been used in agriculture for hundreds of years and is already in place in many parts of the watershed. Distributed on-farm storage is beneficial from an environmental perspective because it increases retention of water throughout the watershed and provides wildlife habitat. There is potential for on-farm storage to help modulate high flows and possibly increase low flows in the river. It may also be useful for firefighting.

Figure 39: Irrigation Pond at Cherry Point Vineyards (Cowichan)

Although, on-farm storage can have benefits for both producers, the broader community, and the environment, it comes at a significant cost that is borne exclusively by the producers.

Dugouts cost a substantial amount of money. A dugout may cost a producer $60,000-$150,000, and as most producers would be taking out a loan to finance this infrastructure, the ultimate cost of the dugout may be even 30% greater after paying accumulated interest. If a producer is able to obtain a loan of this size and invest in on-farm storage, they do so at the expense of other on-farm (and household/family) investments. However, it is likely that on a regional level, dugouts would be less costly than large-scale storage such as a dam.

On-farm storage also requires a substantial area of land and can take a great deal of farmland out of production. For example, to store enough water to irrigate a 153-acre forage field in the Comox Valley, a producer would be required to construct a dugout approximately 10 feet deep and covering approximately 20 acres, or 13% of their field. (The amount of water required to irrigate in the Comox Valley is higher than in other areas of Vancouver Island or in the Fraser Valley (Agriculture, 2005)). The dugout area would no longer be available for crop production. The remaining 87% of the land would need to be 15% more productive to account for the land lost to the dugout area, or else the producer would lose income. Because of this, on-farm storage is more suitable for operations with high efficiency water use like fruit and vegetable operations and greenhouses. For example, in the Comox Valley, a local intensive vegetable farm experienced a doubling of productivity using only 2% of the farm's productive area for their dugout and buffer area (Mid Island Farmers Institute Board, 2018). But it is important to note that not every farm has the space or landscape for water storage infrastructure.

Once a dugout is constructed, the dugout requires maintenance and has a lifespan. Depending on how a dugout is constructed, it may be considered a dam, which requires additional engineering and construction costs, as well as permitting, inspection, and maintenance. Dams also increase farm liability.

On-farm storage can be beneficial for producers because it provides a water supply source that can be managed independently and may add value to their farm. A dugout can have additional indirect farm and watershed benefits, because it may provide an incentive for investment in water conservation practices. On-farm storage can take advantage of the plentiful winter rains without drawing down the aquifers. It is also likely that water retention in dugouts may contribute to local groundwater recharge.

However, the costs to producers and potential barriers to implementation need to be addressed when considering dugouts as a water supply solution.

12.1.2 Regional storage

Large-scale, regional water storage could also be created to enhance local agricultural water supplies. Water would be collected during the rainy season and stored for release in dry summer months. In 2007 a study was conducted to identify the best options for large-scale storage and found that Wolf Lake was the most suitable location (Gooding, Flow Augmentation in the Tsolum Watershed, 2007). The study found that if the Wolf Lake dam height was increased by one meter, the additional flows in the Tsolum would only be half of what was needed for fish. Hover, the study raised concerns about impacts of a dam on wetland habitat. There were also issues related to land ownership in the area. In 1976 a study was conducted to estimate the cost of increasing storage in Wolf Lake (Associated Engineering Services Ltd, 1976), however those cost estimates are now out-of-date.

Developing storage at Wolf Lake would require a significant amount of money. In order to ensure that this large investment benefited multiple members of the community, a distribution system would be required to share the water supplies with producers throughout the watershed. Currently, it is unclear whether it is feasible to develop such a large-scale water storage reservoir and distribution network and who might own, manage, and take responsibility for such a system.

Although some producers are attracted to the idea of large-scale storage because it requires less producer investment, initially (ideally the producer would be charged a monthly bill) and leaves land available for farming, it is likely that if additional water was added to the Tsolum River, this water would not be available for additional irrigation. Several stakeholders including stewardship groups, the K'òmoks First Nation, and the Mid-Island Farmers Institute were opposed to the idea of using Wolf Lake as an agricultural water supply, because they think that the storage in the lake should be used in support of Environmental Flow Needs.

In the public engagement process, two producers suggested investigating aquifer storage and recovery, however there are currently no local examples of successful use of this technology.

12.1.3 Collective dugouts

It may be possible for producers to share water storage areas, by developing storage at the corners of fields, where machinery may not easily reach. This would require substantial long-term collaboration by multiple property owners and received limited interest from producers and other stakeholders.

12.1.4 On-farm integration of drainage and storage

Currently, in the Tsolum watershed and other areas of BC, some producers integrate drainage and irrigation through sub-irrigation (see Figure 41) and/or by storing drainage water for later use in irrigation. This is beneficial because it meets drainage and irrigation objectives, increases water retention in the watershed, reduces environmental impacts of drainage, reduces flood impacts, provides wildlife habitat, 'shortens' the water cycle, and helps retain soil and nutrients. However, this sort of solution is very costly, management intensive, reduces available farmland, and will not be possible on all properties.

Figure 40: Pendray Farms (Saanich, BC): Using tile drainage to supply irrigation ponds (also replenished with wells)

12.1.5 Demand management

There are several ways in which the amount of water required by agriculture can be reduced. Irrigation system improvements such as inspecting and fixing irrigation system components, upgrading the type of irrigation system, and/or using improved irrigation practices (e.g. soil moisture sensors, irrigation scheduling tools) to only water as much as needed can help reduce water needs.

One producer noted that it is common in the Tsolum watershed to irrigate forage fields using an inch of water per week, rather than as prescribed by the B.C. Irrigation Management Guide (Agriculture, 2005). With this approach, producers may be over-watering at certain times of the year and there is likely room to reduce water needs.

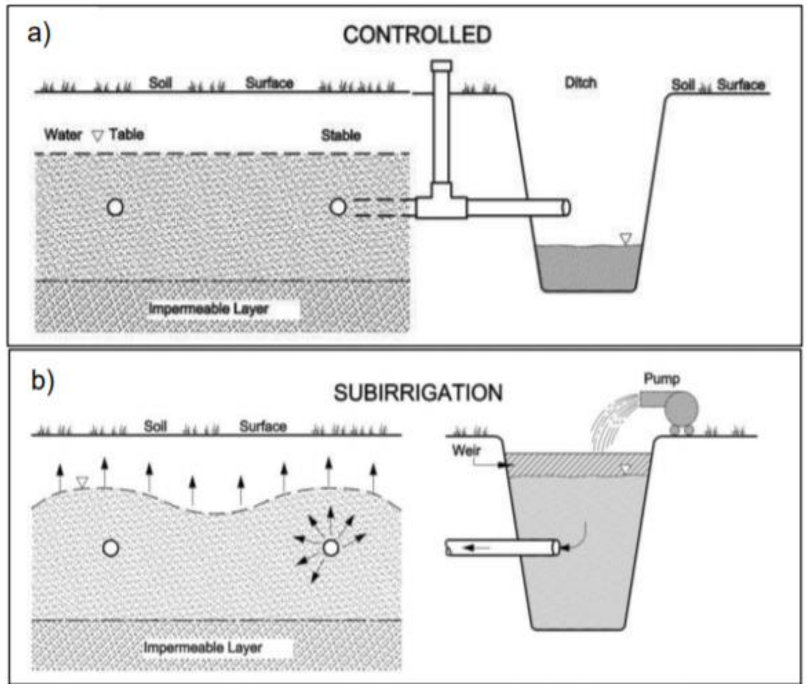

Figure 41: Combining drainage and sub-surface irrigation (Delta, BC)

There may also be ways in which other farm practices can be adjusted to reduce water demand such as through the use of more drought crop tolerant varieties, weed control, limited/no tillage, soil amendments to increase soil moisture, and varied cropping strategies. Demand management is an important consideration for the future but should not be viewed as the primary solution to water management in the Tsolum, as many producers who have water supply concerns are already using the most efficient form of irrigation possible. Demand management approaches should be paired with suitable water supply solutions.

12.1.6 Legal options

There are a variety of legal options that may be used to support agricultural water management.

12.1.6.1 Agricultural Water Reserve

The CVRD could apply for an Agricultural Water Reserve (AWR), which is a new mechanism available under the Water Sustainability Act (2016). Much like the ALR, which reserves land for future agricultural use, an AWR reserves water for future use on ALR and agricultural-zoned lands. An AWR would include existing allocations to agricultural properties as well as reserves for lands in the ALR that do not now have water rights. Unlike a water license, where a producer must use the water or lose rights to it (to prevent speculative water licensing), an AWR reserves water for the future. This is useful because it provides an incentive for conservation (if water demand is reduced through water conservation, the water saved will be available for agriculture in the future).

12.1.6.2 Water Sustainability Plan

The Water Sustainability Act (WSA) enables the creation of Water Sustainability Plans, which are powerful tools which may allow for the development of regulations which can restrict or limit users of land and water and delegate or share watershed decision-making. The province has not yet created guidelines for Water Sustainability Planning, so it is unclear what the criteria and process is for this work.

12.2 Consultation and Engagement: Group Highlights

In the consultation and engagement process, there were a few notable differences between participant groups.

- Participants at the Farmer's Institute AGMs were concerned about water quantity and many emphasized that water supplies were becoming an increasingly limiting factor on farms. Several producers at these meetings had already carefully evaluated various water supply and storage options and proposed potential solutions.
- The K'òmoks First Nation representatives stated that fish are a big priority. Fish are a main life source for the community and KFN community members have observed that fish are being cumulatively impacted by the many activities in the watershed, including historical mine contamination, irrigation extractions in summer months, and forestry. KFN Guardian Watchmen, Cory Frank, stated that after a lifetime spent fishing, hunting, gathering plants, and recreating in the watershed, he found that increased forestry activities in recent years has decreased water retention in watershed, causing greater and more frequent floods, more gravel and sediment transport, more channel alteration, increased bedload (filling in salmon habitat, covering eggs, making low flows effectively lower and causing river temperatures to rise to dangerous levels for fish). He also noticed that forestry reduced connectivity in the forest, which reduced wildlife health and populations. Cory observed reduced soil moisture and groundwater levels and found that increases flood flows were impacting historical sites in the estuary. With the river flowing much higher than historical averages, and significantly increased gravel transport, there has been a lot of erosion in the estuary, which is filling in old channels and creating new paths for water. These changes have far surpassed historical conditions and ancient fish traps are being carried away. KFN representatives also noted that while land use is already "wreaking havoc" on watershed, climate change will make everything worse. They recommended more tree planting in the watershed, increased vegetation retention, and no more extractions without storage.

> ***"The Tsolum is where I go to get my mint every year and I didn't get half of it this year. Even at the lower end of the river, the salmon berries aren't as prevalent as they used to be***" Cory Frank, K'òmoks First Nation Guardian Watchmen Manager

- Public survey respondents had concerns about both water quality and quantity. Survey respondents who had concerns about water quantity were often already taking steps on their property to manage water efficiently (drip-irrigation systems, soil moisture sensors, irrigation scheduling). Many noted wanting to invest in water storage but not being able to cover the up-front costs. Some producers in the Tsolum who responded to the survey did not have quantity concerns, which demonstrates the variability of groundwater in the area.
- Participants at the public open house event focused on water supply issues on farm, stream health, and water governance. This event was well-attended by the stewardship community (approximately 37 participants in total) and there were approximately 6 producers in attendance. Many expressed concerns about impacts of forest practices on hydrology. There was a strong interest in solutions that focused on shared governance, demand management, and funding mechanisms (interest-free loans, funding assistance), to support development of on-farm storage.
- Several key stakeholders stated that they did not support the use of Wolf Lake as an irrigation water supply source (KFN, MIFI) due to its potential to be used for flow augmentation for EFNs. They stated that until EFNs are understood, this option should not be considered. Several also

thought it shouldn't be considered due to the substantial costs of construction of a dam and distribution system and challenges of establishing a new water service authority.

- Several people suggested that it may be possible to use reclaimed water from the wastewater treatment plant for watering in some cases (e.g. sub-surface irrigation, forage)
- Many stakeholder groups and individuals and the K'òmoks First Nation were interested in the development of a Water Sustainability Plan.

12.3 Key Themes

A few core ideas emerged from all the feedback received:

- **Water supply is variable and is a real limiting factor on many farms and residential properties:** While some producers in the Tsolum watershed have sufficient water supply, there are many that don't. In the community engagement process, over 81 comments were provided from producers and residents in the Tsolum River watershed, stating that they did not have enough water to run their farming operations and/or homes. Many producers mentioned not having enough water to utilize large portions of their property, even when using advanced water efficient technology and irrigation systems. Several residents described not having enough water for basic household needs and described ordering water deliveries by truck, storing water in bathtubs, using outhouses to save water, showering at friend's houses, and doing laundry in town.
- **Water supply is becoming an increasing concern:** Many producers described declining water availability and noted that they were able to grow less and less food on their property in recent years due to decreased water supplies. These comments were provided by both dryland farmers and irrigators. Many were concerned that water supply issues will become even greater with climate change and increased population.

  Most water quantity issues in the feedback were related to groundwater supplies, as groundwater is the primary source of water in this watershed.
- **Groundwater quality is variable:** Several residents and producers described groundwater quality concern, primarily related to naturally occurring iron, manganese, turbidity, and salinity.

> ***"Water supply is definitely an issue. There isn't enough water to go around by a long shot. Most people with water licenses aren't drawing their full allotments. I'm not sure what would happen to the river if everyone drew what they're licensed for."*** *Tsolum producer, 20 years*

- **We don't know how much water is available:** Many noted that it is difficult to plan for the future without knowing how much water is available. Given that there are already significant water supply limitations in the watershed, and a strong likelihood that water demands will grow, many suggested limiting future use approvals until we better understand how much water is available in local aquifers. Several noted that although we do not know exactly how much water is available, we *DO* know that there is a lot of water available in the winter, which supports the idea of using water storage in future plans.
- **Need to better understand groundwater/surface water interaction and aquifer recharge:** It is also important to understand how these aquifers are recharged and how much water can be used from them sustainability. It will also be important tto understand how much water that is being stored in Wolf Lake and released during low flow periods is going from the river into the local

aquifers. Understanding groundwater/surface water interaction also has a role in pollution control.

- **Prioritize water for agriculture, aquatic health, and existing domestic users:** There is a strong desire to see future water allocations prioritized for agriculture, aquatic health, and domestic purposes.
- **There is an interest in exploring water storage options but more information is needed to understand which option is best:** Over 50 participants suggested developing water storage to capture the plentiful water in rainy winter months for use in dry summer months. Participants were interested in both on-farm and regional-scale storage, with a preference for on-farm storage. It is important to note that the overall preference for on-farm storage reflects feedback from both producers and the broader public. Among producers, alone, there was a slightly greater interest in regional storage, due to the loss of land and financial barriers to on-farm storage. There are still many questions to be answered to assess the feasibility of each. For example, for regional storage, how much would it cost, how would it be distributed, who could benefit? For on-farm storage, are there ways to help producers make this large infrastructure investment?

> ***"Better water management is the cornerstone of food security, the protection of the environment, and our local economy. We are all concerned about a water deficit and the need to plan for the future. Our community needs to ensure that farmers are supported in creating food security."*** *Mid-Island Farmer's Institute Board*

- **Concerns about the impact of land clearing:** Many participants noted concerns about land clearing throughout the watershed and the impacts on flows. These comments were provided from stewardship groups, producers, and the K'òmoks First Nation. Several stated that over the past 25-30 years they had noticed flows become 'flashier' and a reduced holding capacity in the watershed. Most of these concerns were related to forest harvesting, and some were related to agriculture. Several were also concerned about the increased potential for groundwater contamination due to land clearing.
- **Local water governance:** Many, including stewardship groups, the K'òmoks First Nation, and some producers, were interested in watershed planning and/or developing a watershed roundtable, where various interests in the watershed were represented and could help make decisions about water management, particularly related to licenses and water use in times of scarcity.

- **Demand management is important but cannot be considered alone:** As water is a scarce resource in the summer, it will be important for producers to reduce demand, where possible. This can be done by assessing irrigation systems, improving irrigation systems were possible through maintenance and/or technology upgrades. However, this cannot be considered alone, as many of the producers who noted water supply issues in the survey were already using water efficient drip irrigation systems with soil moisture sensors and irrigation scheduling. In addition, many dryland farmers who are currently not irrigating will need to install irrigation systems in coming years, as climate change results in less summer precipitation.
- **Climate change brings uncertainty. A precautionary approach is wise.** Given that historical climate and flow data may not be an accurate predictor of future flows and climate patterns, it will be important to take a precautionary approach to ensure that the ecological health of the watershed is protected until we better understand climate impacts and both current and future water availability.

> ***"We are living in an era where 1-in-100 year climatic events are happening somewhere on this continent, even this province, every 2 to 5 years. This means that reliance on historical measurements may not be enough…. I would like to see reserves for fish double, not to 5% MAD but 20%. If we are (happily) wrong we can go back and allocate more water elsewhere later, but we need to safeguard the ecological basis of the coast before it is too late."*** *Conservation Partnership*

12.4 Summary of Public Engagement

The following is a summary of what was heard from participants:

- Prioritize access to water for agriculture, stream health, and residential needs
- Support water storage to increase agricultural water supply and reduce demand on local watercourses and aquifers in dry summer months.
- Quantify how much water is available in watershed aquifers and characterize these aquifers to understand aquifer recharge so they can be sustainably managed
- Support water conservation
- Take a watershed-scale approach, that considers the impacts of various land uses and users on water supply

Overall, one thing is clear from the many people who participated in Phase One; Tsolum River producers, residents, and the stewardship community care greatly about the watershed and are genuinely concerned about agricultural water needs and watershed health. A summary of public engagement activities can be found in Appendix C.

13 Recommendations and Next Steps

In order to develop recommendations for the next phase of Tsolum River agricultural watershed planning, the following actions were taken:

- Review of relevant policy and legislation and consultation with provincial staff
- Review of IAFBC Phase Two goals and objectives, including consultation with IAFBC
- Review of data gaps and assessment of their relationship to Phase Two work
- Review of all recommendations provided in the public engagement process
- Research into costs of recommended actions to assess their feasibility within the Phase Two budget
- Review of other local government watershed management programs and best practices

The following provides:

- An overview of the provincial water management context
- Recommendations for next steps in Phase Two of the Agricultural Watershed Planning process
- Recommendations for long term water management in the Tsolum watershed (if a suitable funding source or partnerships were established).

It is important to note that watershed management is both a multi-phase and multi-year process. Recommendations in this report are for Phase Two only. Partial funding for Phase Two is available from the IAFBC, and the recommendations for this work follow the IAFBC guidelines. Additional work is suggested at the end of Phase Two to identify next steps and potential funding sources. For the long-term recommendations, the CVRD would need to establish an appropriate funding source, water management service area, or complete work in partnership with other agencies.

13.1 Provincial Context

Provincial government staff were consulted to obtain information on the next steps required to initiate a Water Sustainability Plan (under the Water Sustainability Act) or alternative planning process, and the steps to prepare an Agricultural Water Reserve.

They shared that the Provincial government is in a place of transition as it begins implementing the Water Sustainability Act (2016). The Province is taking a phased approach to implementation, and at this point, has not yet developed clear guidance on the process for developing Water Sustainability Plans (WSPs) and/or Agricultural Water Reserves (AWRs). In addition, it has not clearly identified how it will be prioritizing watersheds or regions for plan development (Vigano, 2018).

The Province has stated that the only way to dedicate water to agriculture in the future is to establish an Agricultural Water Reserve, and to do that, a community must enter a Water Sustainability Planning process. This planning process is required because there are serious implications to establishing an Agricultural Water Reserve. It is essential that there is a rigorous process involved to ensure there is community support and a suitable scientific basis for a reserve (Vigano, 2018).

At this point, the Province has limited financial resources and capacity available for Water Sustainability Planning and there are many communities interested in this watershed planning process. Because of this, the Province is focusing water sustainability planning in a few select watersheds where there are high priority needs, existing impacts, and available information.

The Province is maintaining an informal list of communities and watersheds in which Water Sustainability Plans are of interest. Although the Province does not have clear criteria on how it will assess applications to establish Water Sustainability Plans, there is an interest in knowing which communities are interested in the planning process and where background data is being collected (P. Lapcevic, personal communication, November 13, 2018), (J. Vigano, personal communication, November 13, 2018).

13.2 Phase Two Recommendations

Phase Two of the watershed planning process is intended to include: hydrology modeling, scenario evaluations, and plan development.

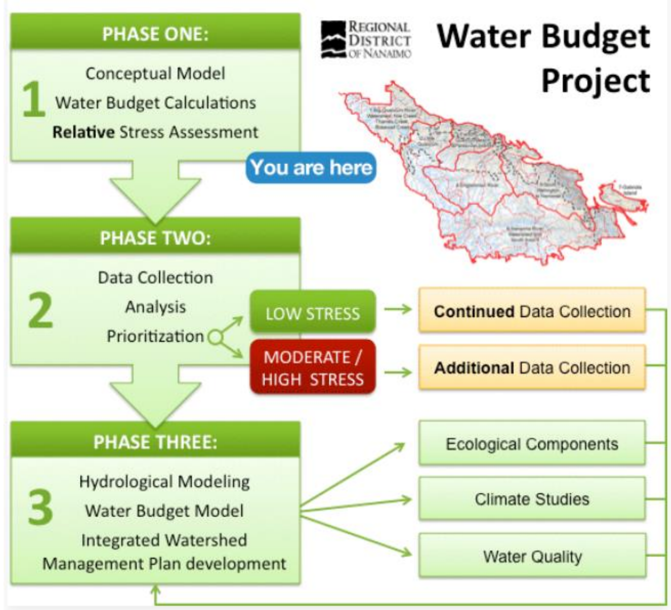

Figure 42: Regional District of Nanaimo Water Budget Project Model

Based on the feedback received from the community, guidance from IAFBC advisors (S. Tam, personal communication, December 14, 2018), and the existing information gaps, it is suggested that Phase 2 efforts focus on understanding:

- How much water is moving through the system (and how water moves through the system)
- How much of that needs to stay in the system (e.g. Environmental Flow Needs)
- And, how much water could be made available for producers (including where this water could be obtained from and how it could be stored).

If approved, up to $70,000 may be available for Phase Two work.

13.2.1 Hydrology Modelling

Recommendation #1a): Develop a water budget, identifying the volume of surface water and groundwater available in the watershed.

To support management of the watershed and the potential establishment of an Agricultural Water Reserve, the CVRD should develop a water budget, estimating the amount of water available in local aquifers and surface water and comparing this to the amount of water used. The assessment of water used should include the identification of how much water is needed by the natural environment, or Environmental Flow Needs, as described in Recommendation #2.

Given that groundwater use accounts for approximately 77% of water use in the region, particular care should be taken to quantifying how much water is available in local aquifers, groundwater/surface water interactions, and groundwater recharge.

Water budgets should be completed on a sub-watershed basis.

Approach

Before this project is initiated, the CVRD should meet with the KFN to identify opportunities for collaboration. The KFN may also be completing a groundwater budget in the Tsolum River watershed as part of their research and it would be beneficial to collaborate where possible to reduce duplication of efforts and combine resources to create a greater understanding of local aquifers.

Given the volume of groundwater use, attention should be paid to the groundwater component of the water budget, identifying areas of groundwater-surface water interactions and groundwater recharge. It will be important to assess the hydraulic connectivity of groundwater and surface water, to the greatest extent possible within the given budget. When developing an Agricultural Water Reserve it is essential to understand how much of the water in the stream (which is needed for aquatic life), comes from aquifers. The Provincial Water Science Series Report - "Determining the Likelihood of Hydraulic Connection" should be used when assessing hydraulic connectivity of the watershed (Lapcevic, 2018).

In order to ensure that the information that is gathered is of a suitable nature and quality, the CVRD and their consultant should meet with Regional staff (e.g. Section Head, Water Protection and Section Head, Water Authorizations) to obtain guidance (J. Vigano, personal communication, November 13, 2018). The MFLNRORD is developing an approach to estimating groundwater availability and conducting water budgets for the purpose of establishing water reserves. This will be described in a provincial 'Water Science Series" report in early 2019 (Lapcevic, 2018). The CVRD should ensure that the estimates of groundwater availability and water budget assessments meet the minimum standards outlined in this document. A more sophisticated and robust approach would be preferable if budget permits.

Provincial staff have advised that the information on water use developed through the AWDM and used in Phase One is of a suitable quality for estimating agricultural water demand for this initial water budget (Lapcevic, 2018).

Given that there is currently limited information available on several components of the water budget, the work conducted in Phase Two will be a preliminary water budget. As more information on different components of the water budget becomes available, the water budget can be refined. Figure 42 shows how a preliminary water budget can fit into the broader picture of long-term watershed management.

Recommendation #1b): Develop an understanding of Environmental Flow Needs and the Critical Environmental Flow Threshold.

Legally, the environment is the highest priority user of water, so Environmental Flow Needs and the Critical Environmental Flow Threshold must first be determined in order to identify how much water is available for agriculture and other users.

Environmental Flow Needs of the Tsolum Watershed should be developed on a sub-watershed basis and include consideration of stream temperature, instream habitats, proper functioning condition of riparian areas, and climate change. The KFN and TRRS (at a minimum) should be involved in this process.

Approach:

The following approach is suggested:

1. Project initiation meeting with representatives from organizations that understand local aquatic ecosystems including the EFN consultants, CVRD, DFO, a Provincial Aquatic Ecosystems Specialist, K'òmoks First Nation, the Tsolum River Restoration Society, and the consultant engaged to complete the Phase Two Agricultural Watershed Planning work.
2. Desktop screening assessment: Apply Provincial EFN Risk Management Framework to determine the risk management level in the Tsolum River under the current and potential future allocations, in consideration of the natural sensitivity of the stream. This screening assessment will identify potential measures to assess or mitigate effects of water use (e.g., field studies).
3. Background review to identify previous studies that may be useful and gather key information about the ecology of the Tsolum River. Includes review of AWP Phase 1 report and relevant studies that have been conducted to date (e.g., 2010 Biophysical Assessment, 2014 Fish Habitat Assessment Procedure Report (FHAP), 2007 Flow Augmentation Feasibility Study)
4. Instream Flow Study (IFS) field study and habitat modelling to develop relationships between habitat and flow
5. Additional Fish Habitat Assessment Studies (if required, depends on the outcome of 3. above)
6. Preparation of a report describing impact on flow-sensitive environmental values should all future allocations be applied, including potential mitigation options.

Items 1-3, a portion of 6, and a portion of 5, should be included in the Phase Two work (dependent upon whether additional FHAP field work is required to support the IFS work). Actions 4 and much of 5 may need to be completed outside of Phase Two funding.

Where possible, it is suggested that the approach used in the Okanagan Basin is followed (recognizing that the OBWB has significantly greater resources to conduct the work).

EFNs have recently been developed for the Puntledge River. Some of the information used in the development of these may be of use and this report should be shared with the consultant working on EFNs for the Tsolum.

13.2.2 Scenario Evaluations

Recommendation #2: Assess water storage options and alternate supplies

Phase One of the Tsolum River Agricultural Watershed Planning process has identified that water storage capacity will need to be increased in the Tsolum River watershed to meet the joint challenges of agricultural production growth, environmental protection, and climate change. In Phase Two, the CVRD should evaluate options to improve access to irrigation water through increased water storage and alternate supplies.

This work should be carefully coordinated with the water budget work so that there is a sufficient understanding of available water volumes from the different water supply sources. Any numerical values that are identified in the scenario development should be reported on a sub-watershed basis, where possible.

Approach

It is suggested that the following water management scenarios are evaluated:

1) On-farm water storage: identify using GIS tools approximately how much land could be used for water storage on farm properties and how much water could be made available through storage. This should include a consideration of available land for on-farm storage (based on lot sizes, cleared land, etc.), as well as feasibility of (e.g. would it be possible to store and distribute the amount of water required?). The storage volumes should be compared to the estimated future water needs under AWDM scenarios. Where appropriate, integrated drainage and water supply systems should be considered, as these will have multiple benefits for producers and aquatic life.
2) Alternate water supply sources and distribution options: assess the potential to use alternate water supply sources (e.g. reclaimed water) for irrigation. Reclaimed water is not appropriate in many agricultural contexts but may be appropriate for watering forage or in some cases for sub-surface irrigation. Currently there is no water supply service area or irrigation district to take on the responsibility for large-scale regional storage, so this would need to be considered.
3) Demand management: estimate approximately how much water could be saved through the use of demand management (e.g. irrigation system upgrades, beneficial management practices). Much of this information should be available from the AWDM study.

The water management scenario work should include:

- An assessment of the long-term and short-term costs of the different scenarios
- Potential funding mechanisms;
- A preliminary assessment of the potential impact of each option on other users and aquatic health.

This work should be done on a sub-watershed basis and integrated with the water budget work to the greatest extent possible.

Recommendation #3: Community and Advisory Committee engagement.

Once the CVRD has gathered information on the amount of water available and has completed an assessment of water storage and distribution options, they should consult with producers to obtain feedback on the various possible water management scenarios. The CVRD should also consult with the broader community including stewardship groups and other watershed stakeholders to ensure diverse interests are considered. Throughout the work, the CVRD should consult with the local representatives through the Advisory Committee.

Approach

According to feedback from survey the best way to reach producers is through local Farmer's Institutes, Internet/Social media, and the Country Life in BC publication.

13.2.3 Plan Development

Recommendation #4: Communicate with the Province to identify an interest in Water Sustainability Planning.

The final deliverable for Phase Two will be a plan for the watershed that is intended to be endorsed and/or adopted by the CVRD. The following provides an overview of Phase Two.

It is recommended that the CVRD communicate with the Provincial government regional staff at the onset of Phase Two work to ensure that the work, where possible, aligns with the guidelines required by the Province for the establishment of an Agricultural Water Reserve.

Given the historic, current, and future concerns regarding water supplies, and the substantial amount of agricultural land available, regardless of how current and future agricultural water needs are met, it would be valuable to support a portion of the water in the watershed being reserved for agriculture now and in the future. Although the CVRD has not committed to developing a Water Sustainability Plan, or an Agricultural Watershed Reserve, understanding the potential planning process and its information requirements will be a proactive measure.

Approach

When communicating with the Province, it is advised that the CVRD develop a "Problem Statement", identifying historical, current, and anticipated water supply issues, projected climate impacts and future water needs. It should note that an AWR could help ensure there is enough water available for agricultural users, the environment, and domestic needs now and in the future. This "Problem Statement" should be provided to Regional Staff so that they are aware of the watersheds in the province that are potential future candidates.

In engagement for this work, the KFN may also have a desire to provide a letter of support to the Province for this process and should be reached out to early on in the process.

Recommendation #6: Develop plan for next steps

Once the community and Advisory Committee has provided input on the preferred approaches for water management scenarios in the watershed, a plan should be developed, identifying next steps and actors. This plan will not be a watershed plan but provide the information to support the CVRD in taking next steps with the development of a Water Sustainability Plan, if desired. This plan should also summarize the work completed in Recommendations #1-4.

13.2.4 Cost and Implications of Phase Two Recommendations

The following is a summary of the estimated costs associated with Phase Two recommendations.

Phase 2 Component	Recommendation	Estimated Cost
Hydrology modelling	#1a: Develop water budget	$25,000[3]
Hydrology modelling	#1b: Identify Environmental Flow Needs	$21,000
Scenario evaluations	#2: Assess water storage options	$12,000
Scenario evaluations	#3: Community engagement: assess scenarios with producers, broader community, and Advisory Committee	$7,000
Watershed plan	#4: Communications with Province	-
Watershed plan	#5: Development of report and plan for next steps	$4,000
Total Cost		**$70,000**

These actions will support the CVRD in meeting the goals identified in the Regional Growth Strategy, including:

- 2C-8 Support increased water availability for agriculture while ensuring natural systems remain healthy and functioning.
- 3C1 - Work with the Ministry of Agriculture and Lands and the Agricultural Land Commission to develop strategies and actions to increase the amount of actively farmed agricultural lands and reduce barriers to agricultural viability in Agricultural Areas.
- 3C-2 - Encourage the development of infrastructure to help increase agricultural production such as irrigation water and regional drainage improvements.
- 6-A: Protect land for existing and future agriculture and associated activities and allow for the growth and expansion of such activities.
- 6C-1 Local governments and farmers should work together to increase irrigation water supply to support agricultural activities
- 6C-2 Local governments, agricultural stakeholder groups and farmers should work together to increase non-potable irrigation water to farmland.

13.3 Long Term Recommendations

Based on the completed data gathering and public engagement process we have identified several recommendations for the Tsolum River watershed that are beyond the scope of Phase Two of the Agricultural Watershed Planning process. These general recommendations for watershed management are not eligible for IAFBC funding under Phase Two and would require an additional funding source such as grant funding, partnership with other organizations, or establishment of a watershed management service area, similar to the Drinking Water and Watershed Protection Program at the Regional District of Nanaimo.

If a watershed protection service area was established, further work should be done to develop long-term recommendations for management that incorporate all watershed interests and objectives.

These additional recommendations are described in further detail below.

Additional Recommendation #1: Pilot on-farm water storage and/or demand management actions

While the best way to address long-term agricultural water supply needs may require significant planning and study, it would be ideal to balance long-term planning efforts with actions 'on the ground' for on-farm water management actions. This will help maintain the engagement and support of the agricultural community and demonstrate a commitment to action.

There are many 'low' or 'no-regrets' actions that could be taken immediately which would have immediate value and multiple benefits, such as demonstration or piloting of beneficial practices in the area of demand management or on-farm water storage.

During the engagement process, several participants described several potential 'early actions' that could provide concrete, immediate benefits. Examples included incentives for producers to develop on-farm storage (highest ranked) and a forage trial testing the effectiveness of various watering practices (e.g. comparing forage yields when watering an inch/week compared to watering using the provincial irrigation guidelines). The MIFI and other participants suggested support sharing information on other methods of farming that focus on water conservation. Many of these methods involve storing water in the soil and vegetation, as well as capturing seasonal rains, with the added benefit of potentially recharging aquifers. Such an initiative could likely be delivered for a low administrative cost through one of the local farmer's institutes.

If possible, it would be ideal to work with a local Farmer's Institute to apply for top-up funding from other initiatives (e.g. Growing Forward, Group Environmental Farm Plan, or Farm Adaptation Innovator funding).

This approach (providing funding for 'early actions', while developing a long-term plan) was used with great success among agricultural and rural residential communities in the development of the Ontario Source Water Protection program and is an excellent way to maintain community relationships and forward momentum during long-term plan development.

Potential Partners: Local farmer's institutes, Environmental Farm Planning program, funding sources listed above.

Additional Recommendation #2: Increase understanding of groundwater and surface water resources and aquatic needs

If funds were available and/or partnerships could be established, there are many ways in which an improved understanding of the groundwater and surface water sources in the watershed could help support watershed management.

Table 12 provides information on steps that could be taken to address data gaps in the Tsolum River watershed, if funding sources were available. This table identifies potential next steps to fill data gaps, as well as potential partners, funding sources, and costs (where possible).

Table 12: Recommendations to address data gaps (beyond Phase Two)

Data Gap	Discussion/Approach	Term	Leadership	Potential partners	Phase 2?	Approximate Cost
WATER QUANTITY						
1) Environmental Flow Needs	If the Phase Two EFN work discovers that a instream flow study is required, to quantify EFNs, this work should be completed, to help provide a clearer picture of how much water should remain in the watershed and how much water is available for agriculture and other users.	Short Term	CVRD	TRRS, KFN	Partially	$65,000-$70,000
1) Water usage data for groundwater and surface water	It would be very helpful to better understand water use in the watershed, but it is difficult to know how to best address this data gap. Generally, metering water use causes a user to conserve water, so metered data is not the best representation of use for unmetered users. Also, given that 85% of the water use in the watershed is for irrigation, and irrigation demand is very dependent on individual producer's practices, land, irrigation systems, crop type, etc. a large amount of data would be required to refine irrigation use estimates. Although the Provincial government staff have stated that AWDM values are sufficiently accurate at this time to be used in provincial decision making, it may be helpful at a later date to monitor a few farms to test the AWDM estimations.	Longer Term	CVRD	MIFI, CVFI	No	Unknown
2) Groundwater data	Currently there is no monitoring of groundwater levels in the Tsolum River watershed. It is recommended that the CVRD work with private well owners (similar work is done at the RDN) to monitor groundwater levels by installing water level loggers in one or more volunteer unused/private domestic wells. The information collected would be of value in the longer term (after 10-15 years). This would likely be led by the CVRD as other organizations have limited authority/funding for this sort of work. The Provincial Government (MFLNRORD) has developed a tool to store and share water data, called the Real-time Water Data Tool. This should be used if possible. (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/real-time-water-data-reporting).	Medium Term	CVRD, MFLNRORD	Private well owners, expertise from MFLNRORD with regards to equipment and monitoring plan	No	$10,000-$15,000/year (higher costs in first year to establish program)
3) Surface Water Data	Flow monitoring would provide information that is useful in the medium term for calculating water budget values and in the long term for identifying trends. This data could be stored in the Real-time Water Data Tool (above). The MFLNRORD is also working to develop its own hydrometric network, and should be conducted to identify partnership potential. It would be ideal to store and share surface water data via the Real-time Water Data Tool (link above).	Medium and Long Term	MFLNRORD, Water Survey of Canada	TRRS, BCCF	No	Unknown

4) Surface water/ groundwater interaction along Tsolum River and Portuguese Creek	Suggested: use guidance documents from MFLNRORD on assessing hydraulic connectivity. This work would likely be partially considered in the development of a water budget.	Short Term	CVRD	TRRS, grant funding?	Partially: with water budget	Unknown
5) Aquifer mapping and characterization	Requires technical work and potentially drilling of observation/test wells to validate the characteristics of the aquifers. Some of this work may be addressed with the development of the water budget. The aquifer mapping and characterization should continue to be refined as new information is gathered.	Medium Term			Potentially: with groundwater budget.	Unknown
6) Land Use Management	Residential and (non-agricultural) Industrial/Commercial development on agricultural lands in the watershed should be limited. If this development is allowed to occur, strict water conservation practices should be required.	Short-term	CVRD		No	None
WATER QUALITY						
7) Groundwater quality data	Voluntary sharing of private well test data (as is done in the Regional District of Nanaimo in partnership with North Island Labs/Maxxam Analytics) would likely require little staff investment and little to no funding from the CVRD.	Short Term	CVRD	Maxxam Analytics	No	Limited ($3,000 to launch program with rebates for completing water analysis)
8) Water quality data for tributaries	Currently, there is no water quality information from tributaries. TRRS is willing to assist with sample collection provided there is funding available for analysis	Medium Term	MOE	CVRD, TRRS	No	Depends on parameters and partnership with stream keepers groups
9) Chronic guideline analysis	This would help provide a better understanding of water quality impacts on aquatic life.	Long term	MOE	CVRD, TRRS	NO	Unknown
10) Water Quality Objective attainment monitoring	The MOE has established water quality objectives (1995, 2012) for the watershed and suggests monitoring for compliance every 5 years. Therefore it is timely to revisit whether objectives are met and/or adequate and whether they should be updated to the present understanding of watershed.	Medium Term	MOE	CVRD, TRRS	NO	Unknown

14 Conclusions

Access to water is a current and increasing concern for producers and residents in the Tsolum River watershed. In coming years, it is likely that water supply challenges will increase as climate changes, agricultural land is developed, and population increases. The Tsolum River Agricultural Watershed Planning process can help reduce conflicts for water users, reduce the environmental impact of the extreme high and low flows, and support local agricultural producers in securing access to reliable water supplies. The information gathered in this report and the proposed recommendations will help ensure that there is a sufficient amount of water available in the Tsolum River watershed for agriculture, fisheries, and watershed residents, now and in the future.

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