Appendix A

Regional District Okanagan Similkameen

Similkameen River Watershed: Water Supply and Demand - Available Information

Project: 2013-8017.000.001

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1 Introduction

1.1 BACKGROUND

The Similkameen Valley Planning Society and the Regional District of Okanagan-Similkameen (RDOS) are developing a non-regulatory watershed management plan for the Similkameen River watershed that will be a guidance document for decision making authorities, resource managers, water users and residents to help make more informed and integrated decisions (RDOS and SVPS 2012).

The **Similkameen Watershed Plan** (SWP) will be developed using a phased approach. The main body of this report, titled *Similkameen River Watershed Plan: Phase 1 Report* (the “Phase 1 Report”), describes the outcomes of Phase 1 of the SWP. This Appendix, which is part of the Phase 1 Report, provides a technical summary of available water supply and demand information for the Similkameen River watershed.

1.2 GOALS OF APPENDIX A

The objective of the water supply and demand investigation for the Phase 1 study is to develop a solid understanding of the natural water supply and present and future water demands in the Similkameen River watershed. This information is ultimately to be used as input into a water balance model for the Similkameen River watershed that will allow water managers and planners to assess the effects of a changing population, climate, and land use in the watershed.

The SWP terms of reference further identifies the following objectives for the water supply and demand investigation:

1. Conduct an assessment of water supply and demand in the Similkameen River watershed and determine the key factors affecting water supply, including climate change, and actual/estimated usage by surface water licence holders, potential storage opportunities, groundwater surface water interactions, and groundwater extraction;
2. Develop a water balance model to characterize the watershed and to allow for consideration of population growth, projected water demand, and climate change;
3. Identify relevant legislation, polices, and bylaws, and recommend how available tools, models, and best management practices can be adopted and used in the watershed; and
4. Consider how to develop and use a water use reporting tool in the Similkameen River watershed, similar to the Streamlined Water Use Reporting Tool developed by the Okanagan Basin Water Board. (RDOS and SVPS 2012)

This report addresses the first objective identified above and provides some of the key information needed to meet the other three objectives.

1.3 WATERSHED DESCRIPTION

A detailed description of the Similkameen River watershed is provided in Summit (2011) and in the main body of this Phase 1 Report. The reader is advised to review those documents for supplementary information.

2 Methods

2.1 INFORMATION ASSEMBLY

2.1.1 Library and Database Searches

Much of the water supply and demand information relevant to this investigation was identified and summarized by Summit (2011); therefore, Summit was used as a starting point for data collection. Data was also collected and catalogued from the sources included in Table 2-1. The data collection was split into two parts 1) water supply and 2) water demand and is described further in Section 3. In addition, all literature collected and reviewed was summarized and included in the literature database (see Phase 1 Report).

Table 2-1 Key Information Sources Utilized for Data Collection Requirements.

Data Type	Information Source	Access
Water Supply and Demand Reports	• Hydrology Section Reports • Aquatic Report Catalogue (EcoCat) • Cross-Linked Information Sources (CLIR)	• Available online
Water Supply	• Water Survey of Canada hydrometric information • United States Geological Survey hydrometric information • Ministry of Environment Groundwater Information	• Available online
Water Demand	• Water Licence Information System (WLIS) • Water Licence Database (online query) • Local municipality and purveyor water demand studies • Local municipality and purveyor water use records • Agricultural Census of Canada land base and irrigation information • Ministry of Agriculture and Agriculture and Agri-Foods Canada – Agriculture Water Demand Model Estimates	• Available online, contacting local municipalities and purveyors, and through data sharing agreements
Climate and Climate Change	• Meteorological Service of Canada climatological information • Ministry of Environment River Forecast Centre snow data • United States Geological Survey climatological information • Farmwest climatological information • ClimateBC • Environment Canada and Agriculture and Agri-Foods Canada gridded climate datasets • Climate Related Monitoring Program (CRMP) network • Columbia Basin Climate Change Scenarios Project (Climate Impacts Group, University of Washington)	• Available online and through data sharing agreements
Mapping	• Base mapping and geomatics services mapping • Corporate Watershed Base • GeoBC • GeoBase	• Available online

2.1.2 Contact with Government Agencies and Researchers

In addition to the online and library information searches, representatives of government agencies and researchers who have been active in the watershed were contacted to determine the availability of reports and data files not in the public domain. The contacts were also asked about issues of concern and information regarding studies that are in progress. See the Phase 1 Report for a list of the representatives contacted.

2.1.3 Water Supplier Discussions and Data Collection

The major water suppliers in the Similkameen River watershed were contacted and provided with a questionnaire regarding actual water use and their water supply distribution system. The water suppliers provided water use data, descriptions of historical water use (surface water and/or groundwater), and water supply and demand concerns via telephone and email (no in-person meetings were held). A summary of the water supplier contacts is provided in Table 2-2.

Other water systems in the watershed include the Tower System (Eastgate on north side of Highway 3, Missezula Waterworks District, the Apex Circle Water System, Apex Mountain, Lower Similkameen Indian Band, Rock Ridge Canyon Camp, and The Crossing facility near Keremeos.

Table 2-2 Summary of Water Supplier Contacts in the Similkameen River Watershed.

Water Supplier	Contact	Contact Information
Apex Mountain Water System and Apex Circle Water System	Shawn Witty, Water Operations Manager	Phone: (250) 490-5680 Email: shawn@apexresort.com
Allison Lake Improvement District	Bob Wilson, Chairman	Phone: (250) 295-3135 Email: wilsonmgt@telus.net
Cawston Irrigation District	George Bush, Chairman	Phone: (250) 499-2289 Email: gbush@rdos.bc.ca
Fairview Heights Irrigation District	Brian Mennell	Phone: (250) 499-5303 Email: bmennell@nethop.ca
Hedley Improvement District	Richard Tarnoff, Water Operations Manager	Phone: (250) 442-8633 Email: otootski@gmail.com
Keremeos Irrigation District	Kevin Huey, Water Operations Manager	Phone: (250) 490-7348 Email: khuey@telus.net
Missezula Lake Waterworks District	William Sawchuck, Custodian	Phone: (250) 295-7393 Email: sawch4321@hotmail.com
Olalla Community Water System (operated by RDOS)	Stephen Juch, Subdivision Supervisor, RDOS Engineering Division	Phone: (250) 490-4133 Email: sjuch@rdos.bc.ca
Osprey Lake Waterworks District	Jim Cornish, Board Member	Phone: (604) 266-5883 Email: waterworks@ospreylake.ca
Upper Similkameen Indian Band	Brenda Gould, Administrator	Phone: (250) 292-8733 Email: admin@usib.ca
Village of Keremeos	Jordy Bosscha, Public Works and Parks Foreman	Phone: (250) 499-2711 Email: publicworks@keremeos.ca
Princeton Community Water System (operated by Town of Princeton)	Kevin Huey, Public Works Manager	Phone: (250) 295-3135 Email: khuey@princeton.ca
Similkameen Improvement District	Roger Mayer, Chairman	Phone: (250) 499-2863 Email: rmayer@nethop.net

2.2 SUB-BASIN DELINEATION

To address the water supply and demand investigation at an appropriate scale, it is necessary to divide the Similkameen River watershed into sub-basins. The spatial unit of interest is dependent on the focus of the analysis: 1) watershed/sub-basins for surface water analysis, 2) water supplier distribution areas for water use analysis, and/or 3) aquifer (or portion of) for groundwater use.

The delineation of the sub-basins (Figure 2-1) was determined based on discussions with RDOS and reviews of the watershed that considered the locations of streamflow and water quality monitoring stations and previous studies (e.g. Swain 1985). Using ArcGIS, sub-basin watershed boundaries were mapped to a minimum 1:20,000 scale and geo-referenced.

Ten sub-basins were identified:

- Sub-basin #1 – Similkameen River, Manning Park to Princeton;
- Sub-basin #2 – Tulameen River;
- Sub-basin #3 – Allison Creek;
- Sub-basin #4 – Hayes Creek;
- Sub-basin #5 – Similkameen River, Princeton to Hedley: Residual area contributing to the Similkameen River below the Tulameen River confluence to the Water Survey of Canada (WSC) hydrometric station on the Similkameen River near Hedley, B.C. (WSC Station No. 08NL038), not including Allison and Hayes Creek sub-basins;
- Sub-basin #6 – Hedley Creek;
- Sub-basin #7 – Keremeos Creek;
- Sub-basin #8 – Ashnola River;
- Sub-basin #9 – Similkameen River, Hedley to International Border: Residual area contributing to the Similkameen River below WSC Station No. 08NL083 to the international border, not including Hedley and Keremeos Creek sub-basins; and
- Sub-basin #10 – Similkameen River, International Border to Mouth: Residual area contributing to the Similkameen River below the international border to the confluence with the Okanogan River.

The identified sub-basins formed the basis for the collection and cataloguing of water supply and demand information. Note that the international border is an administrative boundary and does not reflect a watershed divide. Using the international border as a boundary is suitable for this data collection phase of the SWP, but future phases may elect to sub-divide the lower end of the watershed according to watershed divides.

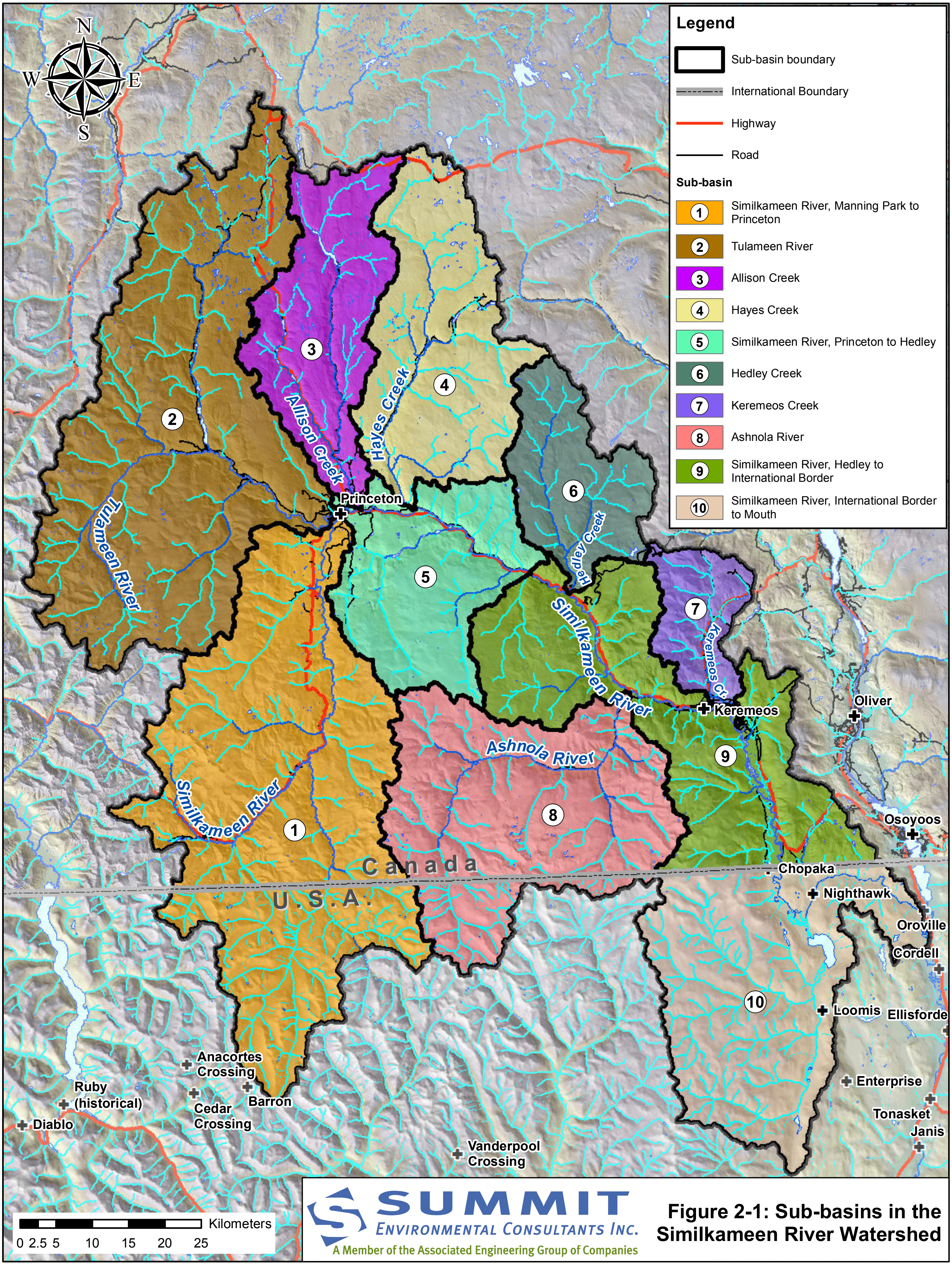


Figure 2-1: Sub-basins in the Similkameen River Watershed

3 Water Quantity - Surface Water

3.1 WATER LICENCES

3.1.1 Summary of Existing Licences

According to Summit (2011) and available water licensing information, a total of 831 current licences (at 690 points of diversion) are issued on streams, springs, and lakes within the entire Canadian portion of the Similkameen River watershed (all points of diversion are shown on Map 1 and summarized in Table 3-1). A summary of individual licences is provided in Summit (2011) and electronically in Attachment 1, while the licences are summarized for each sub-basin in Table A-1 of Appendix A1.

Licences have been issued for off-stream uses, including: domestic, irrigation, waterworks, stock watering, enterprise, mining, and processing purposes, as well as for storage, power, and conservation purposes. For most off-stream use licences (i.e. domestic, waterworks), the period of use is from January to December, while for the majority of irrigation licences, the period of use is from April to the end of September. In addition, for most storage licences, the period of use is from October to June, while for the majority of power and conservation licenses, the period of use is from January to December.

In B.C., the licensed volumes are reported using a variety of units based on their historical application (e.g. imperial gallons per day for domestic). For consistency, this report has converted all units to megalitres per year (ML/yr). One ML is one million litres or 1,000 m^3 (or 220,000 Imperial gallons). The tables and text use ML for simplicity, but readers should be aware that the values are the annual licensed volumes.

Current surface water licensing[1] and water use data for the American portion of the Similkameen River watershed is more challenging to obtain than in B.C. Information is found in several locations and is not organized in a manner that is easy to collect and/or summarize. As such, surface water licensing information for the portion of the Similkameen River watershed in the United States is not included in this report. However, available GIS spatial coverage information on groundwater wells and surface water diversion locations is included electronically in Attachment 1.

On an area basis, the Canadian surface water licences average 15.3 ML/km^2, with the highest allocation of water licence volumes located in Sub-basin #9: Similkameen River, Hedley to International Border.

[1] Surface water licences are referred to as surface water rights in the United States.

Table 3-1 Summary of Current Water Licences in the Canadian Portion of the Similkameen River Watershed.

Sub-basin	No. of Water Licences	No. of Points of Diversion	Licensed Off-stream Volume (ML)	Licensed Storage Volume[1] (ML)	Licensed Conservation Volume[2] (ML)
#1 - Similkameen River, Manning Park to Princeton	52	58	15,792	343	63
#2 - Tulameen River	111	96	6,628	586	1,572
#3 - Allison Creek	158	122	3,588	1,782	1,329
#4 - Hayes Creek	152	120	2,558	436	22,327
#5 - Similkameen River, Princeton to Hedley	74	57	1,484	133	3,947
#6 - Hedley Creek	6	4	1,660	4,194	3,942
#7 - Keremeos Creek	104	73	2,269	0	326
#8 - Ashnola River	20	22	13,826	0	5,001
#9- Similkameen River, Hedley to International Border	154	138	68,125	257	0
Total	**831**	**690**	**115,930**	**7,731**	**38,507**

Notes:
1. Licensed storage supports waterworks and irrigation purposes.
2. Includes the water use purpose “land improvement”, “ponds”, “power-residential”, and “power-commercial”.

3.1.2 Agricultural Licences

A total of 404 water licences have been issued for irrigation purposes in the Canadian portion of the Similkameen River watershed (supported and unsupported by storage), for a total volume of 62,816 ML (Table A1-1 of Appendix A1). The largest licensed off-stream water use sector in each sub-basin is generally irrigation, with the Similkameen River, Hedley to International Border (sub-basin #9) having the highest licensed volume of 39,198 ML (supported and unsupported by storage).

Similkameen Improvement District (SID) is the water purveyor that holds the largest volume of water licensed in the Similkameen River watershed. SID's total licensed volume for irrigation purposes is 15,925 ML from the Similkameen River and Olalla, Allison, and Hayes creeks; with approximately 4,070 ML of the total supported by storage licences on Nickel Plate Lake. Other water purveyors in the Similkameen River watershed with irrigation licences include the Fairview Heights Irrigation District, Keremeos Irrigation District, Lower Similkameen Indian Band, Upper Similkameen Indian Band, Town of Princeton, and RDOS.

In addition to irrigation, a total of 53 stockwatering licences are held in the watershed, totalling 136 ML (Table A1-1 of Appendix A1). Keremeos Creek (sub-basin #7) contains the largest licensed stockwatering volume, which is mainly held by the Ministry of Forests and Range, now Ministry of Forests, Lands and Natural Resource Operations (MFLNRO).

3.1.3 Domestic Licences

A total of 401 domestic water licences have been issued in the watershed for a total volume of 33,822 ML (Table A1-1 of Appendix A1). Of the 401 domestic water licenses, 374 are for domestic purposes (mostly individuals) and the other 23 are issued for waterworks (i.e. water suppliers). However, the total volume licensed for waterworks is much larger than the volume licensed for domestic use (33,313 ML and 509 ML, respectively). The Similkameen River, Hedley to International Border (sub-basin #9) has the largest volume (27,720 ML) licensed for waterworks in the Similkameen River watershed, associated with SID and Fairview Heights Irrigation District (27,675 ML and 45 ML, respectively). Other major water suppliers licensed for waterworks and domestic supply include Allison Lake Irrigation District, Apex Mountain Resort, Keremeos Irrigation District, Lower Similkameen Indian Band, Upper Similkameen Indian Band, Missezula and Osprey Lakes Waterworks Districts, RDOS, and the Town of Princeton.

3.1.4 Industrial and Commercial Licences

Eighteen industrial, commercial, and institutional (ICI) water licences have been issued in the watershed for a total volume of 15,316 ML (Table A1-1 of Appendix A1). Various ICI purposes include enterprise, snowmaking, work camps, dust control, fire protection, mining, and processing. Of these purposes, the largest volume licensed is for mining-processing ore (13,275 ML) for the Copper Mountain Mine property in the Similkameen River, Manning Park to Princeton (sub-basin #1). This licence is held by Copper Mountain Mine Ltd. for the processing of copper ore.

3.1.5 Storage Licences

Forty-seven storage (non-power related) water licences have been issued in the watershed for a total volume of 7,730 ML (Table A1-1 of Appendix A1). The storage licences are generally used to support irrigation and waterworks requirements and of note is that only 6.6 percent of the total licensed off-stream volume in the Similkameen River watershed is supported by storage.

The Hedley Creek watershed (sub-basin #6) has the largest volume (4,194 ML) licensed for storage on Nickel Plate Lake, associated with SID and Apex Mountain Resort (4,070 ML and 124 ML, respectively). Other main water suppliers licensed for storage include Allison Lake Improvement District, Missezula and Osprey Lakes Waterworks Districts, and the Upper Similkameen Indian Band.

3.1.6 Other Licences

Twenty-three non-consumptive water licenses have been issued for conservation, land improvement, ponds, and power purposes for a total volume of 38,444 ML (Table A1-1 of Appendix A1).

Land improvement purposes account for the largest licensed volume for a total of 26,274 ML. RDOS holds the largest land improvement licence in the watershed - a total of 22,327 ML on Shinish Creek (in Hayes Creek watershed - sub-basin #4) for the partial diversion of Shinish Creek into Chain Lake. Young Life of Canada is licensed to divert 3,947 ML of Wolfe Creek for land improvement purposes at Rock Ridge Canyon camp (sub-basin #5).

For conservation purposes (e.g. to retain flows for fish), a total of 2,817 ML has been licensed for storage in the Similkameen River watershed. The Tulameen River watershed (sub-basin #2) contains the largest licensed conversation volume (1,572 ML), which is mainly held by MFLNRO (Fish, Wildlife, and Habitat Management Branch).

Lastly, a total of 9,398 ML has been licensed for power purposes (residential and commercial) in the Similkameen River watershed. The Ashnola River watershed (sub-basin #8) contains the largest residential power licence (4,100 ML), while the Hedley Creek watershed (sub-basin #6) contains the largest commercial power licence (3,942 ML).

3.2 ESTIMATES OF ACTUAL WATER USE

3.2.1 Water Suppliers

Water use information was obtained from the main water suppliers (where available) in the Similkameen River watershed and organized by supplier and source type (surface water or groundwater). Water use data (for each water supplier's period of record) was converted to annual values (in ML). All information collected from the water suppliers (and questionnaires) is included electronically in Attachment 1.

The following section provides a summary of water use information, descriptions of historical water use (surface water or groundwater), and water supply and demand concerns collected for each of the water suppliers.

3.2.1.1 Water Supplier Records

Apex Mountain Resort (Sub-basin #6)

Since 1982, surface water has been used in the daily operations at Apex Mountain Ski Resort near Penticton, B.C. At two intake locations (Nickel Plate Lake and Nickel Plate Creek) water is diverted/pumped into a dry well, a filtered well, and then into a water treatment plant. Water stored in two reservoirs (upper and lower) is gravity fed to users primarily for domestic use. Apex Mountain Ski Resort holds surface water licences for a total of 312.6 ML (82.6 ML for snowmaking, 123.3 ML for storage-non power, and 106.7 ML for waterworks). Annual water use records are available for two periods: (1) 1982 – 2000, when Nickel Plate Creek was the sole water source, and (2) 2001 – 2010, when Nickel Plate Lake and Nickel Plate Creek supplied water. Records for 1982 – 2000 indicate that water use ranged from 8.8 to 48.8 ML, with an average of 24.0 ML, while water use during 2001 – 2010 ranged from 49.7 to 64.6 ML, with an average of 58.0 ML.

A new groundwater well was recently installed at the resort and is anticipated to be active by summer 2013.

A Class One wastewater treatment system treats wastewater from the resort. Treated wastewater is pumped to a primary and secondary retention/settling pond where water is allowed to percolate into the ground.

Apex Circle Water System (Sub-basin #6)

The Apex Circle Water System is a second water system located at and managed by Apex Mountain Ski Resort. The circle system is approximately 40 years old and currently includes 40 connections to residential properties.

The circle system was managed by the RDOS from 2002 to 2012. During this time, water was supplied to the circle system by a deep groundwater well and a subsurface collection gallery, where water was pumped to a 0.02 ML reservoir and gravity fed to domestic users. No chemical treatment (i.e. chlorination or filtration) was administered to the system. No calculated water use records were made available for the circle system for this study; however, RDOS (2012) indicated that consumption volumes for this system were estimated using the kilowatt hours provided from an electrical meter.

In 2012, the circle system was connected to the Apex Mountain Ski Resort water system through a new piping system connected to the upper reservoir. This was completed to ensure water quality consistency and to allow for a greater supply capacity.

Allison Lake Improvement District (Sub-basin #3)

Water is supplied to the Allison Lake Improvement District by groundwater from one well. Water is pumped to a reservoir through a pressurized system and gravity fed to users. End uses include domestic indoor and outdoor. Daily and weekly pumping volumes from the groundwater well are available for 2008 to 2012, with annual ranges of water withdrawal between 18.7 and 67.3 ML, and an average of 38.9 ML.

The Allison Lake Improvement District currently holds surface water licences for a total of 105.5 ML (74.7 ML for waterworks and 30.8 ML for storage-non power); however, surface water has not been used as a water supply for six to eight years (i.e. approximately the time when surface water treatment became mandatory in B.C.). The surface water infrastructure, which includes a small dam on Anderson Creek with a pipe that connects to a holding reservoir, is still in place in the event surface water is required for supply.

Cawston Irrigation District (Sub-basin #9)

The Cawston Irrigation District does not provide water supply services to the Cawston area apart from managing information and maintaining surface water licences. The Cawston Irrigation District holds a surface water licence for a total of 1,480 ML for irrigation; however, the licence is currently not being used. The Fairview Heights Irrigation District provides irrigation service to the Cawston Hall Cemetery and maintains a test well in the Cawston area. In the Cawston area, all water supply requirements are provided by individual private wells.

Community of Tulameen (Sub-basin #2)

The community of Tulameen consists of approximately 250 year round residents and more seasonally (i.e. a total of more than 300 private lots in the community). There is no water distribution system in Tulameen and all individual water supply requirements are provided by private wells (TRUE Consulting Group 2006). No water use information was available for Tulameen.

Fairview Heights Irrigation District (Sub-basin #9)

Water is supplied to the Fairview Heights Irrigation District area by groundwater from five main wells. End uses include domestic, commercial, irrigation, and stockwatering. During the non-irrigation season (i.e. October 15 to April 15), only one well is used for domestic purposes. Water is pumped into a piping system up to a balancing tank and gravity fed to users through a pressurized system.

The Fairview Heights Irrigation District holds surface water licences for a total of 3,264 ML (3,219 ML for irrigation and 45 ML for waterworks); however, surface water has not been used since 1976.

Only four years (2002, 2005-2006, and 2009) of actual annual water use (from groundwater) was available from the Fairview Heights Irrigation District. Water use ranged from 15.6 to 56.9 ML. The District indicated that they have electronic data records from 2006 to 2013; however, they noted that the records will not be available until a water management consultant completes a review of their water supply system (which is currently being organized).

Hedley Improvement District (Sub-basin #6)

Groundwater from two wells provides the main water supply for the Hedley Improvement District. Water is pumped through a distribution system to a reservoir and gravity fed to mostly domestic users (approximately 200 connections) and some commercial properties (approximately 6 connections). Surface water from Hedley Creek was used until 1972 when a flood destroyed some of the surface water infrastructure. As a result, the district decided to drill wells for groundwater. The surface water licence on Hedley Creek was cancelled in 1998.

Monthly water withdrawal records (from groundwater) were available based on the period of record during 1991 to 2012, with annual water use ranging between 118 and 254 ML, and an average of 181 ML. Leakages throughout the system are estimated to be 30 ML annually.

Keremeos Irrigation District (Sub-basin #7)

Groundwater has always been the main water source for the Keremeos Irrigation District. Water is pumped from thirteen wells and distributed for irrigation, stockwatering, waterworks, domestic indoor/outdoor, parks, institutional, commercial, and industrial purposes. Only one well is metered and actual monthly water withdrawal records are available for the period of record during 2003 – 2012; however, water records from 2003 to 2005 are currently under review by the District. Actual annual water withdrawal volumes between 2006 and 2012 ranged from 52.4 to 103.5 ML, with an average of 79.8 ML.

The Keremeos Irrigation District holds surface water licences for a total of 15,040 ML for the purpose of irrigation (15,022 ML) and domestic (18 ML); however, they are not currently being used.

Missezula Lake Waterworks District (Sub-basin #3)

The Missezula Lake Waterworks District uses Missezula Lake as its main water source for recreational and residential properties around the lake. Water is gravity fed from an intake into a 0.4 ML in-ground reservoir as the water level of the lake and inside the reservoir equilibrates. Pumps are used to pressurize water through the distribution system to the residential properties for domestic indoor/outdoor end uses. In October 2013, the District discovered leaks in the distribution system and repaired some of the infrastructure to reduce water losses.

The District holds surface water licences for a total of 699.7 ML (616.7 ML for storage non-power and 83.0 ML for waterworks). Monthly water withdrawal records (from surface water) are available for 2008 to 2012 and water use has ranged annually between 84.3 and 124.4 ML, with an average of 108.8 ML.

Note that volume of water use reported by the District is greater than the licensed amount for waterworks (83.0 ML). The District is aware of this and as such has applied to the regulatory agencies (i.e. MFLNRO) for an increase in their surface water licence. Until the application is approved, the District has made an effort to reduce the amount of water used and actual water withdrawal records available for January to March 2013 indicate that approximately 50 percent less water has been used compared to the same time period in 2012.

Olalla Community Water System (Sub-basin #7)

The Olalla Community Water System is operated by the RDOS. The original water system for the community of Olalla was installed around 1965 and consisted of a dam and intake structure on Olalla Creek that gravity fed water to users. In the early 1980s, the dam and intake structure was partially rebuilt; however, the infrastructure is currently in poor condition. The RDOS holds surface water licences on Olalla Creek for a total of 188 ML (67.6 ML for irrigation and 50.6 ML for waterworks); however, surface water has not been used since the late 1990s.

In the early 1980s, a groundwater well was drilled to help supplement the surface water supply; however, poor water quality resulted in an effort to upgrade the water supply system. Accordingly, in 1998 and 1999, a new deep groundwater well was drilled, a new well supply pump station and reservoir was constructed, and some distribution mains were replaced. Water from the groundwater well is pumped to an elevated concrete storage reservoir and gravity fed to approximately 200 connections of commercial and residential end users.

Seven years (2006 to 2012) of daily and weekly water use records (from groundwater) were available, and showed annual water use ranging from 189 to 214 ML, with an average of 201 ML.

Osprey Lake Waterworks District (Sub-basin #4)

The Osprey Lake Waterworks District manages a seasonal non-potable surface water system that services 87 recreational and residential properties around Osprey Lake. The surface water infrastructure was installed around the mid-1960s and includes a small dam on Lee Creek, which is fed from Westmere Lake. Water is pumped to a balancing reservoir and gravity fed to end users. The Osprey Lake Waterworks District holds surface water licences on Lee Creek for a total of 153.9 ML (5.0 ML for domestic, 49.3 ML for storage-non power, and 99.6 ML for waterworks). Water withdrawal from the system is not metered.

Historically, the Osprey Lake Waterworks District did not treat water to remove pathogens; therefore, boil water notices have been typically issued to the residents. Due to ongoing government demands regarding boil water notices and a recent order by MFLNRO to decommission the dam on Lee Creek, the Osprey Lake Waterworks District is planning to dissolve the district and shut down the system in the summer of 2013.

Similkameen Improvement District (Sub-basin #6)

The Similkameen Irrigation District (SID) operates and maintains the dam and weir structure on Nickel Plate Lake. SID holds a storage licence on Nickel Plate Lake for a total of 4,071 ML and reports that they are currently storing 1,974 ML (1,850 ML for private surface water licence holders and 123 ML for Apex Mountain Ski Resort). During the low flow period between August 1 and October 31, SID gradually releases the 1,974 ML from Nickel Plate Lake into Nickel Plate Creek, which flows into Hedley Creek and eventually into the Similkameen River. The addition of flows from Nickel Plate Lake into the downstream creek system is intended to supplement the amount of water available to private licence holders for irrigation during the low flow period.

Additional water licences held by SID include irrigation (15,925 ML), mining-hydraulic (88.3 ML), waterworks (27,674 ML), and domestic (0.8 ML); however, these licences are not being used. The total licensed volume (including storage non-power) held by the SID is 47,760 ML.

Town of Princeton (Sub-basin #1)

Since 2008, groundwater has been the main source of water for the Town of Princeton. Prior to 2008, a combination of surface water (from the Tulameen River) and groundwater was being used for water supply.

Currently, four wells are managed by the Town of Princeton and provide water for irrigation, waterworks, domestic, parks, institutions, commercial, and industrial end uses. Water from three of the four wells is pumped to two holding reservoirs (North and West Reservoirs), where the water is chlorinated, boosted up to two separate higher elevation reservoirs, and gravity fed to users. The remaining well is located at the campground and supplies only the campground.

The Town of Princeton holds surface water withdrawal licences for a total of 3,538 ML (3.8 ML for domestic, 3.5 ML for exhibition grounds, 47.1 ML for irrigation, and 3,484.6 ML for waterworks).

The Town of Princeton also has a wastewater system; however, there are no return flows.

Daily water use records (for groundwater) were available from June 2011 to April 2013 and indicated that annual water use in 2012 was 1,543 ML. Pumping volumes from groundwater exist prior to 2011; however, the Town of Princeton indicated that additional data processing was required and would not be completed in time for this report.

Village of Keremeos (Sub-basin #7)

The Village of Keremeos does not manage water distribution infrastructure or maintain surface water licences; however, the Village does manage a wastewater system. The wastewater system treats effluent and transfers it into infiltration basins, where the treated effluent slowly percolates into the ground. Treated effluent from the wastewater system is not discharged into any watercourses.

Other Water Users

The Lower and Upper Similkameen Indian Bands were contacted for this study; however, no information was made available at the time of this report. In addition, many individuals hold surface water licences for various purposes throughout the watershed. No information was available on actual water use by these licensees.

3.2.2 Agricultural Census of Canada

The Agricultural Census of Canada provides a statistical picture of Canada's farm sector, based on questionnaires to be completed by any person responsible for operating a farm or agricultural operation

(Statistics Canada 2012). The Agricultural Census of Canada is completed every five years. Information relevant to water planning and use includes total farm area, the areas in crops, and the total area irrigated by crops.

For the Similkameen River watershed, Agricultural Census of Canada information is available for Areas B, G, and H of RDOS (Figure 3-1). Virtually all cropland in the Similkameen Valley depends on irrigation. Areas B, G, and H require irrigation for hay and pasture, field crops, fruits, and vegetables. In Area B, hay/pasture and fruit have similar areas that are irrigated; while in Areas G and H about 80 percent of the irrigated land is hay and pasture (Summit 2011).

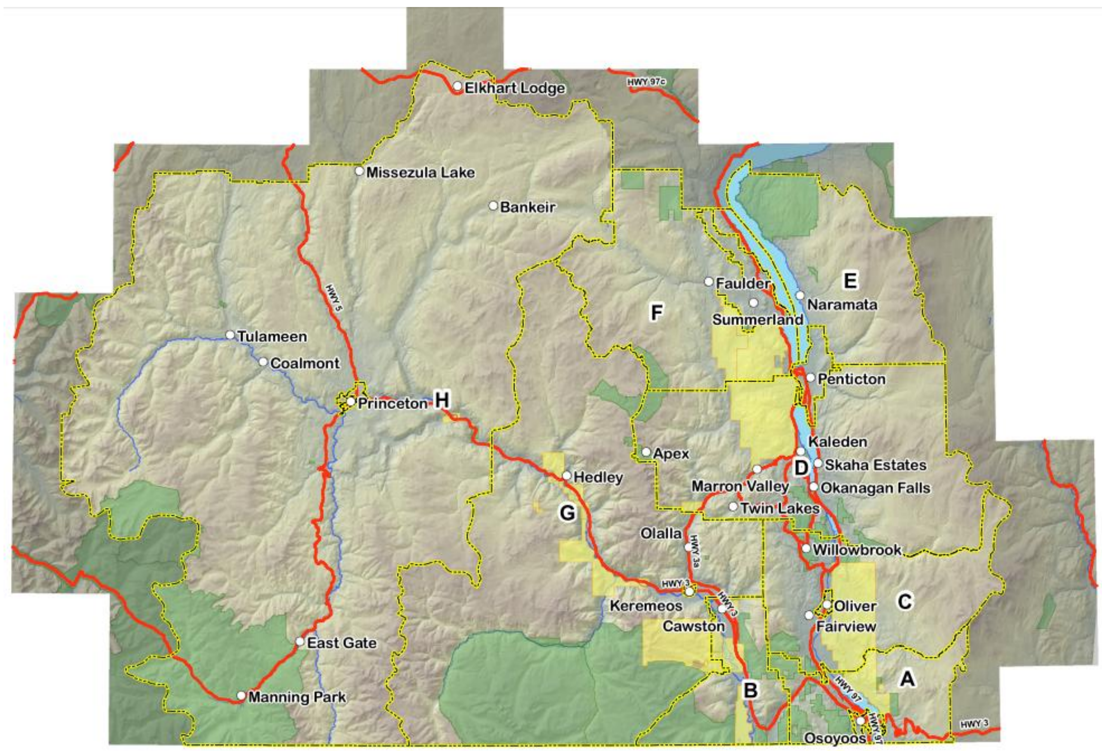


Figure 3-1 Location of RDOS Areas B, G and H in the Similkameen River Watershed (adapted from RDOS 2013).

Since much of the agriculture in the Similkameen River watershed depends on irrigation from surface and groundwater sources, the Agricultural Census of Canada data can be utilized for a preliminary review of agricultural water use. For example, the comparison of total area irrigated to the total crop lands can provide some insight into how actual water use compares to the licensed amount. Information is only available on farm areas for the censuses completed in 2006 and 2011 and on lands irrigated in 2005 and

2010 (provided electronically in Attachment 1). The ratio of areas under irrigation to the reported crop land areas for the total RDOS area is presented in Table 3-2.

Table 3-2 The Ratio of Crop Land Areas under Irrigation to Crop Areas; Agricultural Census of Canada for the Regional District Okanagan Similkameen.

Year	Ratio of area under irrigation to reported crop land area
2006	0.717
2011	0.808

Notes:

1. Calculated from Agricultural Census of Canada statistics assuming that 2005 and 2010 irrigation estimates are representative of 2006 and 2011 conditions, respectively.

3.2.3 Agriculture Water Demand Model – Ministry of Agriculture

Agriculture Water Demand Model - Overview

Recently, the B.C. Ministry of Agriculture and Agriculture and Agri-Foods Canada completed the initial development of an Agriculture Water Demand Model for the Canadian portion of the Similkameen River watershed (van der Gulik et al. 2012). The model was developed to provide current and future agriculture water demands (including both crop irrigation and livestock watering) on a property by property and total basin basis. This is similar to the recent Okanagan Water Demand Model, which estimates agricultural and all indoor and outdoor water demands in the Okanagan Basin (Summit 2010).

The Agriculture Water Demand Model is based on a Geographic Information System (GIS) database that contains cadastre information (showing the boundaries of land ownership), crop type, irrigation system type, soil texture and climatic data (van der Gulik et al. 2012). This information was assembled from background information, high resolution orthophotos, and GIS, and was confirmed by ground surveys in 2009. Land uses (including crop type and method of irrigation) were identified and water demands were estimated at the scale of individual land parcels and finer. Accordingly, the model can provide estimates of water demand for individual crops on a parcel of land, or for an entire watershed, local government jurisdictions, or water supplier distribution areas (e.g. irrigation districts) by summing the demands within those areas.

The Agriculture Water Demand Model calculates the daily evapotranspiration demand for each parcel using a form of the Penman-Monteith equation. It also computes the existing soil moisture and the daily precipitation. The irrigation requirement is the residual demand that cannot be met from these two sources. The climate (dataset) is the key driver of the evapotranspiration calculations. In the Similkameen River watershed, a 1961-2003 gridded dataset consisting of cells measuring 500 m by 500 m was created and temperature (minimum, maximum, and mean) and total precipitation for each day of the year was measured in each cell. A detailed description of how the model calculates agricultural water demands is provided by van der Gulik et al. (2012) and the climate dataset is described further in Section 3.3.4.

It is important to note that the Agriculture Water Demand Model is a mathematical computer model that estimates irrigation water demand (surface and groundwater supplied) based on climate, land use, soils, and the irrigation systems present. By comparison, the estimates of water use in Section 3.2 are based on the water suppliers' records of pumping volumes, thereby providing an estimate of actual use in the area serviced by those suppliers. The records and the model should be used together when determining the range of water use, with the model enabling an understanding of where the irrigation water is applied. Modelled water use approximates actual use if all irrigators watered at optimal rates, leakage was predictable, and users did not over-water or under-water their crops. The model is an improvement over previous estimates, but an inventory of actual use on a sample of farms, ranches and non-farm sites (e.g. golf courses) would be required to extend the data beyond agriculture.

Agriculture Water Demand Model – Summary of Information Collected

At the time of this report, the Agriculture Water Demand Model results for the Similkameen River watershed were only available for 1961-2003. From the available model results, the following information was obtained:

- Agricultural and livestock water demand information (surface and groundwater supplied) for each selected sub-basins in the Similkameen River watershed from 1961-2003;
- Agricultural and livestock water demand information for the available major water suppliers (surface and groundwater supplied) from 1961-2003; and
- Land use information (including crop, irrigation, and soil type breakdown) for each selected sub-basin within the Similkameen River watershed (based on survey information completed in 2009 by the Ministry of Agriculture).

The above information is included electronically in Attachment 1.

The Ministry of Agriculture is currently using the Agriculture Water Demand Model to develop estimates for a range of climate scenarios. Scenarios under different climate conditions and future periods were not obtained for this study; however, additional information can be obtained in the future through a data-sharing agreement with the Ministry of Agriculture.

The types of irrigable lands reported by the Agriculture Water Demand Model for the Similkameen River watershed included alfalfa, grass, fruit, nut, and vegetable crops, turf parks, golf courses, greenhouses, and various others. A summary of the Agriculture Water Demand Model results for each sub-basin is presented in Table 3-3. Reported values are for the total drainage areas of each sub-basin within the Canadian portion of the watershed and include surface and groundwater supplies. The total estimated agricultural use (average over 1961-2003), when converted to ML per square kilometre, is quite different among the sub-basins, with the Hedley Creek and Ashnola River reporting no agricultural demand[2] within each sub-basin, while Keremeos Creek indicating the highest.

The estimates in Table 3-3 are the averages for 1961 to 2003 and may not be representative of current use or use in any given year. Also, note that for all water demand information, the agricultural land base is assumed constant (at 2009 levels) and the variation in water demands is solely a function of variations in climate.

Table 3-3 Selected Results from the Similkameen River Watershed Agriculture Water Demand Model (1961-2003).

Sub-basin	Drainage Area[1] (km²)	Total Agricultural Lands[2] (km²)	Total Lands Irrigated (km²)	Agricultural Water Use[3] (ML)	Livestock Water Use[3] (ML)	Total Water Use[4] (ML/km²)
#1 - Similkameen River, Manning Park to Princeton	1,811	2.1	0.8	401	0.04	0.2
#2 - Tulameen River	1,778	19.1	3.1	2,092	0.06	1.2
#3 - Allison Creek	600	7.6	2.6	1,339	0.08	2.2
#4 - Hayes Creek	779	4.0	1.1	550	0.03	0.7
#5 - Similkameen River, Princeton to Hedley	601	8.3	4.1	2,669	0.08	4.4
#6 - Hedley Creek	395	0.1	0	0	<0.01	0
#7 - Keremeos Creek	224	10.2	7.9	4,484	0.15	20.0
#8 - Ashnola River	1,060	0	0	0	<0.01	0
#9 - Similkameen River, Hedley to International Border	1,037	50.5	24.0	13,632	0.40	13.1
#10 – Similkameen River, International Border to Mouth	986	n/a	n/a	n/a	n/a	n/a

Note:
1. Total drainage area includes portions of the sub-basin within the United States.
2. Total agricultural lands (both ALR and other active agricultural land) within the Canadian portion of each sub-basin only (based on survey information completed in 2009). Note that based on a review of Google Earth, there does not appear to be any significant agricultural water use in the American portions of sub-basin #1 and #8; however, there is widespread use in sub-basin #10.
3. Average annual water use from 1961-2003.

[2] Note that the Agriculture Water Demand Model indicates no agricultural water demand in the Hedley Creek or Ashnola River sub-basins. Although there are no surface water irrigation licences in the Hedley Creek sub-basin, 1,448 ML of surface water is licensed for irrigation purposes in the Ashnola sub-basin.

4. This includes agricultural and livestock water use for the Canadian portion of the Similkameen River watershed only.

3.3 CLIMATE MONITORING AND MODELLING

3.3.1 Climate Station Monitoring

A wealth of climate data collected by various agencies is available in the Similkameen River watershed. In 2010, an agreement on the management of meteorological networks in B.C. was established under the auspices of the Climate Related Monitoring Program (CRMP). The Ministry of Environment, Ministry of Transportation and Infrastructure, and Ministry of Natural Resource Operations, Forests and Agriculture are working together with BC Hydro and Rio Tinto Alcan under a formal agreement to make long-term meteorological data available for professional users involved in climate change analysis and adaptation through the PCIC (Ministry of Environment 2013a)[3]. The Provincial Climate Data Set (PCDS) compiled as part of the CRMP is accessible under the PCIC Data Portal[4].

For this study, all meteorological stations in the Similkameen River watershed were downloaded from the PCDS and organized by sub-basin and agency (Table 3-4). All available data from these stations was compiled and is available electronically in Attachment 1 and each station is included on Map 1.

In total, 112 meteorological stations from the following six agencies were identified:

- B.C. Ministry of Agriculture and Lands;
- Agricultural and Rural Development Act Network;
- Environment Canada;
- B.C. Ministry of Environment;
- B.C. MFLNRO; and
- B.C. Ministry of Transportation and Infrastructure.

As shown in Table 4-4, the stations are generally well distributed among the sub-basins, with some exceptions. The periods of record and parameters collected do vary widely across the Similkameen River watershed depending on the agency and purpose for the station. The list of parameters collected includes:

- Air Pressure (Point);
- Cloud Cover Fraction;
- Dew Point Temperature (Mean, Point);
- Mean Sea Level;
- Precipitation (Cumulative, Amount);
- Precipitation Climatology;
- Rainfall Amount;
- Relative Humidity (Mean, Point);

[3] Online: http://www.env.gov.bc.ca/epd/wamr/crmp.htm
[4] Online: http://tools.pacificclimate.org/data_portal/pcds_map/

- Snowfall Amount;
- Surface Snow Depth (Point);
- Temperature (Max, Mean, Min, Point);
- Temperature Climatology (Max, Mean, Min);
- Wind Direction (Mean, Point, Standard Deviation);
- Wind Gust (Max);
- Wind Speed (Mean, Point); and
- Short Duration Rainfall Intensity-Duration-Frequency (IDF) Data.

Environment Canada is the primary meteorological data collector, and in the past they have collected information at 27 locations in the Similkameen River watershed. However, Environment Canada is currently actively collecting data only at five locations within the watershed:

- Jellicoe (Station No. 1123721);
- Princeton A (Station No. 1126510);
- Princeton CS (Station No. 112FN0M);
- Hedley N (Station No. 1123370); and
- Hedley NP Mine (Station No. 1123390).

The B.C. Ministry of Transportation and Infrastructure (MOTI) has operated ten stations in the Similkameen River watershed, with three currently in operation:

- Allison Pass (Station No. 15392);
- Red Bluffs (Station No. 24225); and
- Apex Roadside (Station No. 24126).

Two stations are currently in operation by the B.C. Ministry of Agriculture and Lands as part of the Farmwest program:

- Cawston (Station No. SBC24); and
- Keremeos (Station No. SBC25).

The current status of the remaining data monitoring programs, such as those operated by the MFLNRO Wildfire Management Branch and Ministry of Environment Air Quality Network, is unknown. Nevertheless, data from these agencies has been collected for the dates noted in Table 3-4.

Overall there is relatively good characterization of the climate throughout the Similkameen River watershed with the current and discontinued climate monitoring network. This includes both geographically from west to east as well as with elevation, although there is considerable bias towards lower elevation locations where most development is concentrated. To assist future water supply modeling, the most relevant stations with potentially useful information have been identified in Table 3-4. Only two of the sub-basins (#3 – Allison Creek and #6 – Hedley Creek) have limited information available. However, these are small areas, which likely can be characterised by records in adjacent sub-basins.

Table 3-4 Meteorological Stations in the Similkameen River Watershed (organized by sub-basin and agency).

Sub-basin	Agency	Station ID	Station Name	Lon. (deg)	Lat. (deg)	Elev. (m)	Period of record*	Measurement frequency	Parameters																													Potentially useful record
									Air Pressure (Point)	Air Pressure Tendency	Cloud Cover Fraction	Dew Point Temperature (Mean)	Dew Point Temperature (Point)	Mean Sea Level	Precipitation (Cumulative)	Precipitation Amount	Precipitation Climatology	Rainfall Amount	Relative Humidity (Mean)	Relative Humidity (Point)	Snowfall Amount	Surface Snow Depth (Point)	Temperature (Max.)	Temperature (Mean)	Temperature (Min.)	Temperature (Point)	Temperature Climatology (Max.)	Temperature Climatology (Mean)	Temperature Climatology (Min.)	Wind Direction (Mean)	Wind Direction (Point)	Wind Direction (Std Dev)	Wind Gust (Max.)	Wind Speed (Mean)	Wind Speed (Point)	Wind Speed (Max.)	Short Duration Rainfall IDF Data	
#1 – Similkameen River, Manning Park to Princeton	ARDA	112036	NORTH BUNCH	-120.51	49.18	1547	1971-1972	daily							X								X		X													
	ARDA	112037	SOUTH BUNCH	-120.51	49.18	1547	1971-1972	daily															X		X													
	EC	1110350	ALLISON PASS	-120.83	49.13	1341	1958-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1110352	ALLISON PASS DOH	-120.87	49.12	1340	1974-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1124890	MANNING PARK	-120.78	49.07	1198	1952-1961	daily								X		X			X		X		X													
	EC	1126505	PRINCETON	-120.50	49.43	633	1893-1942	daily								X		X			X		X		X													
	EC	1127360	SIMILK. - MINE	-120.55	49.35	940	1974-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	ENV-ASP	2G03P	BLACKWALL PEAK	-120.77	49.10	1940	1967-2008	daily								X	X				X	X	X		X		X	X	X									✓
	FLNRO-WMB	317	ALLISON PASS	-120.77	49.06	1215	1989-2010	1-hourly								X	X		X							X				X				X				
	FLNRO-WMB	979	UPPER PLACER	-120.46	49.18	1674	2007-2007	1-hourly								X			X							X				X				X				
	FLNRO-WMB	293	ZZ MANNING PARK	-120.80	49.00	n/a	1978-2000	daily								X	X		X							X				X				X				✓
	FLNRO-WMB	946	ZZ PASAYTON	-120.56	49.06	1103	2006-2006	1-hourly								X			X							X				X				X				
	FLNRO-WMB	952	ZZ PLACER	-120.50	49.12	1553	2006-2006	1-hourly								X			X							X				X				X				
	FLNRO-WMB	1018	ZZ RED ROCK	-120.48	49.18	1722	2008-2008	1-hourly								X			X							X				X				X				
	MoTIe	15392	ALLISON PASS	-120.87	49.12	1340	2003-2011	1-hourly	X			X			X	X		X	X		X	X	X		X	X				X	X	X		X	X	X		✓
	MoTIe	15322	ALLISON PASS REM	-120.87	49.12	1340	1991-2003	1-hourly	X			X			X	X	X		X		X	X	X		X	X	X	X	X	X		X		X		X		✓
	MoTIm	15301	ALLISON PASS	-120.87	49.12	1340	2002-2004	12-hr								X		X		X	X	X	X		X	X					X				X			
	MoTIm	24003	PRINCETON	-120.51	49.45	660	1988-2001	12-hr								X		X			X	X	X		X	X												✓
#2 - Tulameen River	ARDA	112018	BATES	-120.63	49.87	1053	1971-1972	irregular							X							X																
	ARDA	112027	BLUEY	-120.62	49.85	1030	1971-1972	irregular							X							X																
	ARDA	112012	COALMONT	-120.73	49.54	770	1971-1972	daily							X				X			X	X		X													
	ARDA	112028	GLADSTONE	-120.64	49.78	1058	1971-1972	irregular							X							X																
	ARDA	112019	GROVE	-120.62	49.95	1064	1971-1972	irregular							X							X																
	ARDA	112017	HASTINGS	-120.66	49.83	1107	1971-1972	daily							X							X	X		X													
	ARDA	112013	LOCKIE	-120.77	49.59	780	1971-1972	irregular							X							X																
	ARDA	112011	ROANY	-120.82	49.50	799	1971-1972	irregular							X							X																
	ARDA	112016	SPEARING	-120.73	49.79	969	1971-1972	irregular							X							X																
	ARDA	112015	THALIA	-120.76	49.75	870	1971-1972	irregular							X							X																
	ARDA	112014	THYNNE	-120.78	49.69	832	1971-1972	irregular							X							X																
	EC	1120882	BLAKEBURN	-120.73	49.48	1485	1973-1973	daily								X		X			X		X		X													
	EC	1121090	BROOKMERE	-120.87	49.82	972	1986-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1123280	GRANITE CREEK	-120.73	49.47	1037	1984-1985	daily								X		X			X	X	X		X													
	EC	1118235	TREASURE MTN	-121.05	49.42	1430	1989-1990	daily								X		X			X	X	X		X													
	FLNRO-WMB	302	ASPEN GROVE	-120.62	49.95	1065	1998-2010	1-hourly								X	X		X							X				X				X				✓
	FLNRO-WMB	279	THYNNE	-120.87	49.72	1524	1990-2010	1-hourly								X	X		X							X				X				X				✓
	FLNRO-WMB	278	ZZ LAMONT	-120.80	49.32	1615	1990-2000	1-hourly								X	X		X							X				X				X				✓
	FLNRO-WMB	718	ZZ TULAMEEN	-120.77	49.55	876	2001-2001	1-hourly								X			X							X				X				X				
	MoTIe	24225	RED BLUFFS	-120.62	49.48	830	1997-2011	1-hourly	X			X			X	X		X	X		X	X	X		X	X	X	X	X	X	X	X		X	X	X		✓
	MoTIm	24204	COALMONT	-120.69	49.51	730	1988-1997	12-hr								X		X		X	X	X	X		X	X									X			

Table 3-4 Cont'd.

Parameters

Sub-basin	Agency	Station ID	Station Name	Lon. (deg)	Lat. (deg)	Elev. (m)	Period of record*	Measurement frequency	Air Pressure (Point)	Air Pressure Tendency	Cloud Cover Fraction	Dew Point Temperature (Mean)	Dew Point Temperature (Point)	Mean Sea Level	Precipitation (Cumulative)	Precipitation Amount	Precipitation Climatology	Rainfall Amount	Relative Humidity (Mean)	Relative Humidity (Point)	Snowfall Amount	Surface Snow Depth (Point)	Temperature (Max.)	Temperature (Mean)	Temperature (Min.)	Temperature (Point)	Temperature Climatology (Max.)	Temperature Climatology (Mean)	Temperature Climatology (Min.)	Wind Direction (Mean)	Wind Direction (Point)	Wind Direction (Std Dev)	Wind Gust (Max.)	Wind Speed (Mean)	Wind Speed (Point)	Wind Speed (Max.)	Short Duration Rainfall IDF Data	Potentially useful record
#3 - Allison Creek	ARDA	112029	GULLIFORD	-120.61	49.74	1112	1971-1972	daily							X							X	X		X													
	ARDA	112035	HARDWICK	-120.51	49.53	713	1971-1972	irregular							X							X																
	ARDA	112033	JOHN BURNS	-120.61	49.71	899	1971-1972	irregular							X							X																
	ARDA	112031	KETCHEN	-120.56	49.74	1340	1971-1972	daily							X							X	X		X													
	ARDA	112030	KUMP	-120.59	49.75	1213	1971-1972	daily							X							X	X		X													
	ARDA	112034	LAIRD	-120.60	49.64	831	1971-1972	irregular							X							X																
	FLNRO-WMB	969	OELRICH	-120.54	49.66	1449	2007-2009	1-hourly								X			X							X				X				X				
	FLNRO-WMB	282	ZZ DILLARD	-120.42	49.77	1341	1990-2000	1-hourly								X	X		X							X				X				X				
	FLNRO-WMB	1019	ZZ SIWASH	-120.42	49.78	1483	2008-2008	1-hourly								X			X							X				X				X				
#4 - Hayes Creek	ARDA	112044	FINNEGAN	-120.39	49.51	826	1971-1972	irregular							X							X																
	ARDA	112045	GRANT	-120.34	49.66	899	1971-1972	irregular							X							X																
	ARDA	112043	JURA	-120.44	49.53	960	1971-1972	daily							X				X			X	X		X													
	ARDA	112046	OSPREY LK ASB	-120.23	49.72	1098	1971-1972	daily							X							X	X		X													
	EC	1120630	BANKEIR	-120.23	49.72	1097	1954-1959	daily								X		X			X		X		X													
	EC	1120633	BANKIER CHAIN LK	-120.28	49.70	1020	1974-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1123721	JELLICOE	-120.33	49.67	929	1995-pres.	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1126514	PRINCETON 8NE	-120.43	49.53	975	1971-2000	daily								X	X	X			X	X																✓
	FLNRO-WMB	332	ZZ CHAIN LAKE	-120.30	49.70	n/a	1979-2000	daily								X	X		X							X				X				X				✓
	MoTIm	25003	ELKHART LAKE	-120.30	49.86	1550	1986-1994	12-hr								X	X	X		X	X	X	X		X	X									X			
#5 - Similkameen River, Princeton to Hedley	ARDA	112059	AUGUST	-120.49	49.42	927	1971-1972	daily							X							X	X		X													
	ARDA	112061	BASELY	-120.40	49.46	607	1971-1972	irregular							X							X																
	ARDA	112076	JACOB	-120.31	49.44	582	1971-1972	irregular							X							X																
	ARDA	112042	MT MINER	-120.46	49.49	947	1971-1972	daily							X							X	X		X													
	ARDA	112065	NISSEN	-120.23	49.40	565	1971-1972	irregular							X							X																
	ARDA	112060	SHIRLEY	-120.47	49.46	620	1971-1972	daily							X							X	X		X													
	ARDA	112067	STEMWINDR 27	-120.14	49.39	814	1971-1972	daily							X							X	X		X													
	ARDA	112068	STEMWINDR 40	-120.14	49.40	1197	1971-1972	daily							X							X	X		X													
	ARDA	112062	VORTAC 3200	-120.33	49.42	922	1971-1972	daily							X							X	X		X													
	ARDA	112063	VORTAC 4200	-120.35	49.41	1264	1971-1972	daily							X							X	X		X													
	ARDA	112064	VORTAC 5100	-120.37	49.39	1570	1971-1972	daily							X				X			X	X		X													
	EC	1126510	PRINCETON A	-120.51	49.47	700.4	1936-pres.	daily								X	X	X			X	X	X		X		X	X	X								X	✓
	EC	112FN0M	PRINCETON CS	-120.51	49.47	700.4	1992-pres.	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1127358	SIMILK. COPPER MT	-120.52	49.33	1229	1980-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC_raw	1126510	PRINCETON A	-120.51	49.47	701.7	2011-pres.	1-hourly		X	X		X	X		X				X	X		X		X	X				X			X		X			
	EC_raw	112FN0M	PRINCETON CS	-120.51	49.47	700.4	2011-pres.	1-hourly		X			X	X		X				X	X		X		X	X				X			X		X			
	FLNRO-WMB	836	AUGUST LAKE	-120.46	49.43	855	2003-2010	1-hourly								X			X							X				X				X				
	FLNRO-WMB	325	STEMWINDER	-120.15	49.38	579	1990-2008	1-hourly								X	X		X							X				X				X				✓
#6 - Hedley Cr.	ARDA	112071	NICKLE PLATE	-120.03	49.39	1692	1971-1971	daily							X							X	X		X													

Table 3-4 Cont'd.

Sub-basin	Agency	Station ID	Station Name	Lon. (deg)	Lat. (deg)	Elev. (m)	Period of record*	Measurement frequency	Parameters																													Potentially useful record
									Air Pressure (Point)	Air Pressure Tendency	Cloud Cover Fraction	Dew Point Temperature (Mean)	Dew Point Temperature (Point)	Mean Sea Level	Precipitation (Cumulative)	Precipitation Amount	Precipitation Climatology	Rainfall Amount	Relative Humidity (Mean)	Relative Humidity (Point)	Snowfall Amount	Surface Snow Depth (Point)	Temperature (Max.)	Temperature (Mean)	Temperature (Min.)	Temperature (Point)	Temperature Climatology (Max.)	Temperature Climatology (Mean)	Temperature Climatology (Min.)	Wind Direction (Mean)	Wind Direction (Point)	Wind Direction (Std Dev)	Wind Gust (Max.)	Wind Speed (Mean)	Wind Speed (Point)	Wind Speed (Max.)	Short Duration Rainfall IDF Data	
#7 - Keremeos Creek	ARDA	112082	BARRINGTON	-119.82	49.24	479	1971-1972	irregular							X							X																
	ARDA	112083	MARSEL	-119.79	49.32	623	1971-1972	irregular							X							X																
	EC	1120447	APEX MTN LODGE	-119.92	49.40	1890	1965-2000	daily								X	X	X			X		X		X		X	X	X									✓
	EC	1121459	CAWSTON SIMILK.	-119.77	49.18	398	1979-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1124112	KEREMEOS 2	-119.82	49.22	435	1924-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	ENV-AQN	E272963	KEREMEOS MUNI.	-119.84	49.35	423	2008-2009	1-hourly												X				X							X				X			
	MoTIe	24126	APEX ROADSIDE	-119.90	49.40	1750	1997-2011	1-hourly	X			X			X	X	X		X		X	X	X		X	X	X	X	X	X	X	X		X	X	X		✓
	MoTIm	24106	APEX ALPINE	-119.90	49.40	1750	1992-1997	12-hr								X		X		X	X	X	X		X	X												
	ARDA	112075	ASHNOLA	-120.07	49.15	1460	1971-1972	daily							X				X			X	X		X													
#8 - Ashnola River	ARDA	112077	RIMCO PRISM	-120.39	49.14	2088	1971-1972	daily							X							X	X		X													
	FLNRO-WMB	331	ASHNOLA (MB)	-120.18	49.14	1335	1991-2009	1-hourly								X	X		X							X				X				X				✓
	AGRI	SBC24	CAWSTON	-119.74	49.18	414.1	2004-pres.	daily								X							X		X													✓
	AGRI	SBC25	KEREMEOS	-119.85	49.20	414	2004-pres.	daily								X							X		X													✓
	ARDA	112087	BLIND	-119.74	49.18	433	1971-1972	daily							X							X	X		X													
	ARDA	112072	CAHILL	-120.05	49.33	504	1971-1972	irregular							X							X																
	ARDA	112088	DAWSON	-119.73	49.15	402	1971-1972	daily											X				X	X	X													
	ARDA	112099	HOLT	-119.71	49.09	395	1983-1991	daily															X		X													
	ARDA	112091	KHOLER	-119.70	49.04	381	1971-1972	daily											X				X		X													
#9 - Similkameen River, Hedley to International Border	ARDA	112102	KOBAU 4900	-119.66	49.10	1495	1971-1972	daily							X							X	X		X													
	ARDA	112073	LARCAN	-120.02	49.27	469	1971-1972	irregular							X							X																
	ARDA	112090	MAK SIKKER	-119.71	49.08	381	1971-1972	daily							X							X	X		X													
	ARDA	112089	MANERY	-119.71	49.09	416	1971-1972	daily							X							X	X		X													
	ARDA	112066	MCNULTY	-120.13	49.37	556	1971-1972	irregular							X							X																
	ARDA	112094	NIGHTHAWK	-119.70	49.04	381	1971-1972	irregular							X							X																
	ARDA	112074	OLLALA	-119.95	49.22	463	1971-1972	irregular							X							X																
	ARDA	112092	RICHTER	-119.66	49.02	457	1971-1972	daily							X		X					X	X		X													
	EC	1123360	HEDLEY	-120.08	49.35	517	1904-2005	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1123370	HEDLEY N	-120.07	49.36	542	2007-pres.	daily								X		X			X	X	X	X	X													✓
	EC	1123390	HEDLEY NP MINE	-120.02	49.37	1707	1904-pres.	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1124110	KEREMEOS	-119.82	49.20	415	1891-2000	daily								X	X	X			X	X	X		X		X	X	X									✓
	EC	1124118	KEREMEOS WEST	-119.83	49.22	416	1962-1966	daily								X		X			X																	
	EC	1125223	MT KOBAU OBS.	-119.68	49.12	1862	1966-2000	daily								X	X	X			X	X	X		X		X		X									✓
	FLNRO-WMB	333	ZZ CHOPAKA	-119.70	49.00	n/a	1990-2000	1-hourly								X	X		X							X				X				X				
	FLNRO-WMB	319	ZZ SMITH CREEK	-120.22	49.31	1402	1990-2000	1-hourly								X	X		X							X				X				X				
	MoTIm	24002	KEREMEOS	-119.82	49.21	425	1988-2004	12-hr								X		X		X	X	X		X	X	X												

Notes:

*Additional "preliminary" data beyond indicated dates may be available for active stations
Active Environment Canada stations are in red.
Active B.C. Ministry of Transportation and Infrastructure stations are in blue.
Active B.C. Ministry of Agriculture (Farmwest) stations are in green.

AGRI B.C. Ministry of Agriculture and Lands
ARDA Agricultural and Rural Development Act Network
EC Environment Canada (Canadian Daily Climate Data 2007)
EC_raw Environment Canada (raw observations from ""Climate Data Online"")
ENV-AQN B.C. Ministry of Environment - Air Quality Network
ENV-ASP B.C. Ministry of Environment - Automated Snow Pillow Network
MFLNRO-WMB B.C. Ministry of Forests, Lands, and Natural Resource Operations - Wild Fire Management Branch
MoTIe / MOTIm B.C. Ministry of Transportation and Infrastructure (electronic/manual)

3.3.2 Snowpack Monitoring and Data

The water supply for the Similkameen River watershed is highly dependent on the volume of water contained in the snowpack each year. In order to gauge the depth of snow and its water content, the BC Ministry of Environment River Forecast Centre operates a network of snow survey sites throughout the province. Eleven stations have been established in the Similkameen River watershed, although only six remain in operation (Table 3-5). In addition, four active stations are located outside of the Similkameen River watershed, but are generally representative of conditions within the watershed. Furthermore, one station in the U.S. portion of the watershed (Harts Pass) is operated by the Northwest River Forecast Center in Washington State. Two of the active stations (Blackwall Peak and Harts Pass) contain equipment (e.g. snow pillow) to automatically gauge and transmit the information in near real-time. All other stations are manually operated. All available data from these stations was compiled and is available electronically in Attachment 1, and each station location is included on Map 1.

All stations are located on the eastern side of the Cascade Mountains, and the southernmost part of the Thompson Plateau. The records of snow accumulation and melt assist with modelling runoff and tracking peak flows, and with low flow prediction and management.

The data from the snow survey sites generally show a decrease in total snowpack from west to east at high elevation in the rain shadow area east of the Cascade Mountains (see Table 3-5). Valley bottom locations report much less snow during winter. As is typical for southern B.C., the range of snow accumulation is large, dependant on El Nino/La Nina climate patterns and storm tracks.

Table 3-5 Similkameen River Watershed Snow Survey Sites.

Sub-basin[1]	Station ID	Station Name (ID)	Status		Elevation (m)	Period of Record
			A[2]	D[3]		
#1 – Similkameen River, Manning Park to Princeton	2G03P	Blackwall Peak Snow Pillow	✓		1,934	1967-present
	WA09	Harts Pass	✓		1,980	2003-present
	3D02	Lightening Lake[4]	✓		1,254	1947-present
	2G03	Blackwall Peak		✓	1,934	1959-1994
	2G01	Copper Mountain		✓	1,310	1949-1971
	2G01A	Sunday Summit		✓	1,310	1959-1996
#2 – Tulameen River	1C01	Brookmere	✓		994	1945-present
	2G06	Hamilton Hill	✓		1,477	1960-present
	1C29	Shovelnose Mountain	✓		1,456	1979-present

Table 3-5 Cont'd.

Sub-basin[1]	Station ID	Station Name (ID)	Status		Elevation (m	Period of Record
			A[2]	D[3]		
#3 – Allison Creek	2G05	Missezula Mountain	✓		1,602	1960-present
#4 – Hayes Creek	2F01	Trout Creek[4]	✓		1,428	1935-present
#6 – Hedley Creek	2F11	Isintok Lake[4]	✓		1,651	1965-present
	2G02	Nickel Plate		✓	1,890	1949-1986
	2G02A	Nickel Plate		✓	1,890	1986-1986
#9 – Similkameen River, Hedley to International Border	2G04	Lost Horse Mountain	✓		1,988	1960-present
	2F12	Mount Kobau[4]	✓		1,817	1966-present

Notes:
1. No snow survey sites are located in sub-basins #5, #7, #8.
2. A = Active
3. D = Discontinued
4. Station is outside the Similkameen River watershed; however, it is nearby and may be representative of conditions within the watershed.

3.3.3 Climate Model (ClimateBC)

The University of British Columbia Faculty of Forestry Centre for Forest Conservation Genetics along with partners from the MFLNRO have developed an easy-to-use online and desktop software tool (ClimateBC) that provides estimates of precipitation, temperature, and other climate variables for any location by simply inputting the latitude, longitude, and elevation (Wang et al. 2006). This tool is useful to estimate climate parameters at ungauged locations. It includes over 20,000 surfaces of monthly, seasonal, and annual climate variables from 1901 to 2009; several climate normal periods; and climate projections for the 2020s, 2050s, and 2080s (Wang et al. 2012).

The online version of this tool is located at http://www.genetics.forestry.ubc.ca/cfcg/climate-models.html. Since the data is contingent on the specific points of interest entered, no data was downloaded specifically for this phase of the study.

3.3.4 Climate Model (Gridded GIS Dataset)

As part of the development of the Agriculture Water Demand Model for the Similkameen watershed (van der Gulik et al. 2012), the B.C. Ministry of Agriculture and Agriculture and Agri-Food Canada developed spatial datasets to represent the climate of the Similkameen River watershed at a 500 m grid resolution. As described in Neilsen et al. (2010), each grid cell contains daily climate data, maximum and minimum temperature (Tmax and Tmin), and precipitation as well as a calculated daily reference evapotranspiration rate (ETo). The climate dataset was developed using existing data from climate stations (and Global Circulation Models (GCMs) (i.e. CanESM2 and CGCM3/T47 SREA2 models)) within and near the Similkameen River watershed from 1961-2003. This data was then interpolated (and downscaled from the available GCMs) to provide data for the entire watershed at a 500 m grid resolution.

For this study, a GIS climate dataset (average of values for 1961-2003 for each grid cell) was obtained from Agriculture and Agri-Foods Canada for air temperature, total precipitation, and calculated evapotranspiration for the entire Similkameen River watershed. The spatial coverages are presented visually in Figure 3-1 and are included electronically in Attachment 1.

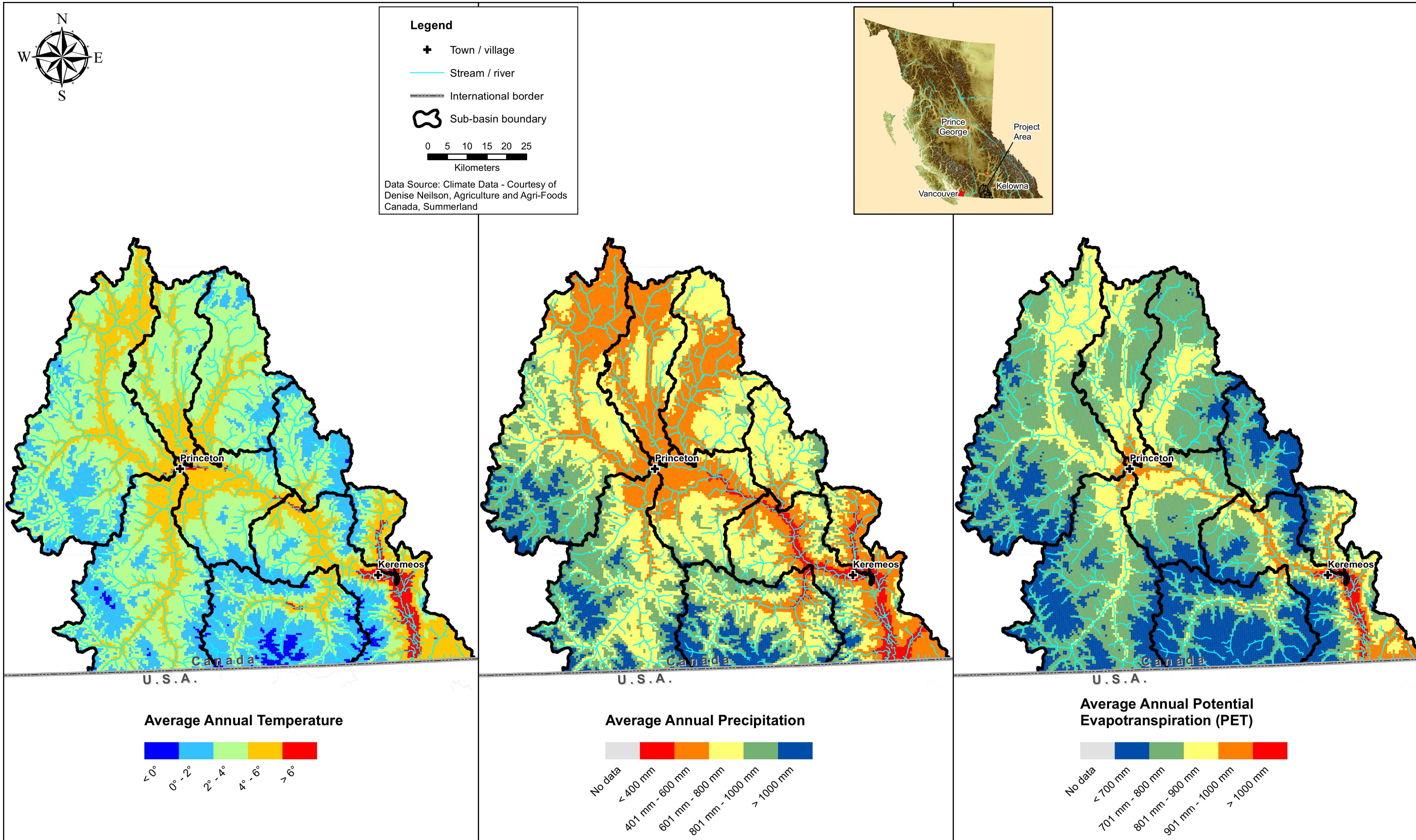
Specific water supply and demand scenarios (and water balance modeling) for the Similkameen River watershed were not completed for this phase of the study; therefore the complete climate dataset (i.e. historical periods and future scenarios) was not obtained from Agriculture and Agri-Foods Canada. The dataset can be obtained in the future through a data-sharing agreement.

3.3.5 Climate Change Hydrologic Modelling

Recent work at the University of Victoria's Pacific Climate Impacts Consortium (PCIC) and the University of Washington's Climate Impacts Group is directly applicable to the Similkameen River watershed. PCIC has developed the 'Plan2Adapt' tool, which provides estimates of future primary climate variables such as temperature and precipitation, as well as more complex parameters derived from these primary variables, for specified geographic areas. The University of Washington has also recently completed a major study of climate change in the Columbia River Basin.

The PCIC Plan2Adapt tool and the University of Washington's study use an ensemble of recent (i.e. AR4) climate models. Inconsistencies in model outputs between the tool and the study may exist due to a number of factors. The models used are not the same, and the modelled areas selected for the simulations are not identical. In addition, the baseline periods are different (PCIC uses 1961-1990 while University of Washington uses 1970-1999). Also, although they both use the B1 emission scenario (i.e. the one with the lowest amount of global surface warming) PCIC uses the A2 emission scenario while University of Washington uses the A1B emission scenario (the A2 scenario is slightly warmer on average and has a larger range of temperatures than the A1B scenario). Also, the middle period of future predictions centres on the 2050s for the PCIC data, while University of Washington centres on the 2040s. Nevertheless, the general trends for both temperature and precipitation are consistent, and most of the hydrological implications of the predicted changes in climate are similar.

The available climate change information from PCIC and the University of Washington relevant to the Okanagan-Similkameen River region is summarized by Summit (2011) and in the following sections.



SUMMIT ENVIRONMENTAL CONSULTANTS INC.
A Member of the Associated Engineering Group of Companies

Figure 3-2: Modelled Average Annual Air Temperature, Precipitation, and Potential Evapotranspiration of the Similkameen River Watershed (1961 - 2003)

University of Victoria, Pacific Climate Impact Consortium – Plan2Adapt Tool

The University of Victoria's PCIC Plan2Adapt tool[5] provides outputs for the Okanagan-Similkameen region, which are presented in Figures A2-1 to A2-4 of Appendix A2. In addition, Table 3-6 identifies the median and ranges of values expected for the 2020s, 2050s and 2080s compared to the baseline period of 1961-90. These values are derived from a 15 GCM ensemble, under the A2 and B1 CO_2 emission scenarios.

Table 3-6 Climate Change for the South Okanagan-Similkameen Region.

Climate Variable	Time of Year	Projected Change (from 1961-90 baseline)					
		2020s		2050s		2080s	
		Median	Range	Median	Range	Median	Range
Mean Temp. (ºC)	Annual	+1.1ºC	+0.6ºC to +1.4ºC	+1.9ºC	+1.2ºC to +2.7ºC	+3.0ºC	+1.7ºC to +4.4ºC
Precip.	Annual Summer Winter	+4% -9% +2%	-1% to +7% -15% to +10% -3% to +10%	+6% -14% +6%	-2% to +10% -31% to 0% -2% to +15%	+8% -16% +10%	+1% to +17% -38% to -4% +3% to +24%
Snow Depth[1]	Winter Spring	-6% -33%	-16% to 0% -58% to -4%	-14% -57%	-25% to -3% -73% to -20%	-22% -78%	-41% to -9% -88% to -24%
GDD[1,2]	Annual	+175	+89 to +275	+379	+217 to +547	+571	+380 to +972
HDD[1,3]	Annual	-379	-521 to -234	-680	-961 to -422	-1056	-1560 to -609
FFD[1,4]	Annual	+15	+8 to +20	+26	+14 to +37	+39	+23 to +62

Notes:
1. These values are derived from temperature and precipitation
2. GDD: Growing Degree Days (given in degree days)
3. HDD: Heating Degree Days (given in degree days)
4. FFD: Frost-Free Days

The potential hydrological impacts to the Similkameen River watershed according to PCIC (2011) include:

- Warmer annual temperature:
  - Changes in seasonality of streamflow; and
  - Increased evaporation.
- Winter warming:
  - Mid-winter thaw events may cause ice jams and flooding.
- Wetter conditions projected in winter:
  - Higher winter streamflows and extreme precipitation events may cause flooding, or increase the risks of more severe or more frequent floods and landslides; and

[5] Online at: http://plan2adapt.ca/plan2adapt.php

  - o Increase in storm events.
- Warmer, drier summers:
  - o Possibility of more prolonged and intense droughts with lower water supply during periods of peak demand;
  - o Reduced soil moisture and increased evaporation, increasing irrigation needs at the same time of year that streamflows are expected to decline; and
  - o Possible declines in recharge rates for groundwater sources.

Overall, the region is predicted to warm, and annual precipitation is predicted to increase. Summer precipitation is likely to decrease and winter precipitation is likely to increase. The number of Growing Degree Days (i.e. days >5ºC) and the number of Frost-Free Days (i.e. days >0ºC) are expected to increase, while the number of Heating Degree Days (i.e. days <18ºC) is expected to decrease.

Columbia Basin Climate Change Scenarios Project, University of Washington

The Columbia Basin Climate Change Scenarios Project (CBCCSP) is documented in Hamlet et al. (2010) and project report and data are accessible online through the University of Washington's Climate Impacts Group[6]. The CBCCSP includes future projections for a selection of hydro-climatic parameters including:

- Temperature;
- Precipitation;
- Potential and actual evapotranspiration;
- Soil moisture;
- Snow water equivalent (SWE);
- Streamflow (runoff);
- Peak flow; and
- Low flow.

Projections are provided for many locations in the Columbia River Basin including seven sites in the Similkameen River watershed that correspond to WSC hydrometric station locations, as follows:

- Pasayten River above Calcite Creek;
- Similkameen River at Princeton;
- Tulameen River at Princeton;
- Similkameen River near Hedley;
- Ashnola River near Keremeos;
- Similkameen River near Nighthawk; and
- Similkameen River at Oroville.

These data are highly relevant to this study so all relevant digital summary data for these seven sites was compiled and is provided electronically in Attachment 1. An example of the model projections for Similkameen River near Nighthawk is provided in Tables A2-1 to A2-4 of Appendix A2 for the following four

[6] Online at: http://www.hydro.washington.edu/2860/products/sites/

parameters: total streamflow (dam^3), peak flows (m^3/s), low flows (m^3/s), and snow water equivalent (mm). These outputs are derived from a 10 GCM model ensemble, under the A1B and B1 emission scenarios for the periods centering on the 2020s, 2040s, and 2080s. They are compared to the baseline period of 1970-1999.

The following points summarize the general trends predicted for the Okanagan-Similkameen region:

Streamflow:

- Late fall, winter and early spring flows are forecast to be greater; while late spring, summer and early fall flows will be smaller;
- Shift in hydrograph to earlier in the year; and
- Total flows for the year increase.

Daily Peak Flows:

- Similkameen River near Nighthawk - average peak flows decrease under both scenarios, except under A1B where they are predicted to increase by the 2080s; and
- Range of daily peak flow projections is considerable (i.e. ranges from less to greater than simulated baseline flows (1970-1999).

Low Flows:

- Late summer/early fall low flows decrease, winter low flow flows increase.

Snow Water Equivalent (SWE):

- Average SWE predicted to decrease in all periods under both scenarios.

3.4 HYDROMETRIC MONITORING

Table 3-7 lists all hydrometric stations that have been established in the Similkameen River watershed either by the WSC or United States Geological Survey (USGS). The stations are included on Map 1 and all available data from these stations was compiled and is provided electronically in Attachment 1. To assist with future water modelling, each station has been organized by sub-basin and classified as to whether the flow regime is natural or regulated. Stations are also classified as active, active with real-time data available, or discontinued.

Twelve hydrometric stations are active in the Similkameen River watershed, with four of these recording streamflows on the mainstem of the Similkameen River. Two active stations are on the Tulameen River, and one is operating on each of the Ashnola River, Ewart Creek, Hedley Creek, Keremeos Creek, Pasayten Creek, and Siwash Creek (see Map 1 for locations). With the exception of Ewart Creek, the active stations have more than 35 years of data and four have more than 60 years of data.

The discontinued stations (Table 3-7) operated from less than a year up to more than 80 years. The discontinued stations that have more than 20 years of data are indicated with an asterisk in Table 3-7.

These are the stations that although discontinued, have enough data to support a number of hydrologic analyses. However, even sites with only a few years of data are useful for assessing variations in flow when compared to longer term records at other sites.

WSC operates a number of “real-time” hydrometric stations in B.C. where the water levels and flows can be viewed online[7] (Table 3-7). Four are in the Similkameen River watershed – the two Tulameen River stations and the Similkameen River stations at Princeton and Hedley. These stations allow users to see flow conditions in near real-time. The real time stations are very useful for situations where water management decisions need to be made based on the river discharge.

The main goal of a hydrometric network is to support management of water and related resources and to provide the spatial distribution of natural streamflow for past, present, and future (i.e. climate change) conditions (Okanagan Hydrometric Network Working Group 2008). Within the Similkameen River watershed, the current (and discontinued) hydrometric network is generally well equipped to monitor (and summarize) the spatial variation of streamflow and water supply throughout the watershed and on the mainstem river. For water supply/water balance calculations, the four active stations present on the mainstem river and the eight active stations present on major tributary creeks (within both wetter and drier climates) should provide adequate natural and regulated streamflow information. Some 20 stations (identified in Table 3-7) are considered to provide potentially useful hydrometric data for characterizing the sub-basin specific and overall watershed hydrology. Note however, that some of these represent regulated flow regimes; therefore, it is necessary to account for flow regulation and withdrawals in order to estimate natural flow conditions.

Although the hydrometric network is well suited for regional studies, for specific investigations (i.e. groundwater-surface water interaction, investigations and aquatic resource assessments) some additional monitoring at site specific locations may be necessary.

[7] Online: http://www.wateroffice.ec.gc.ca/index_e.html

Table 3-7 Hydrometric Stations in the Similkameen River Watershed (organized by sub-basin).

Sub-basin	Station ID	Station Name[1]	Flow[2]		Status[3]			Period of Record	Drainage area[4]	Potentially useful record
			N	R	A	RT	D			
#1 – Similkameen River, Manning Park to Princeton	08NL069	PASAYTEN RIVER ABOVE CALCITE CREEK	✓		✓			1974- present	566 km^2	✓
	08NL070	SIMILKAMEEN RIVER ABOVE GOODFELLOW CREEK	✓		✓			1973-present	408 km^2	✓
	08NL033	LITTLE MUDDY CREEK NEAR MANNING PARK		✓			✓	1960-1964, 1967-1970	25.9 km^2	
	08NL036	WHIPSAW CREEK BELOW LAMONT CREEK*	✓				✓	1964-1999	185 km^2	✓
	08NL062	SIMILKAMEEN RIVER BELOW CHUWANTEN CREEK	✓				✓	1973-1975	355 km^2	
	08NL074	LITTLE MUDDY CREEK BELOW LIGHTNING LAKE		✓			✓	1973 to 1977	n/a	
	08NL075	SIMILKAMEEN RIVER ABOVE MEMALOOSE CREEK	✓				✓	1978-1980, 1985-1986	n/a	
	08PA010	LIGHTNING LAKE NEAR MANNING PARK		✓			✓	1973-1979	n/a	
#2 – Tulameen River	08NL024	TULAMEEN RIVER AT PRINCETON	✓		✓	✓		1950-present	1,780 km^2	✓
	08NL071	TULAMEEN RIVER BELOW VUICH CREEK	✓		✓	✓		1974-present	253 km^2	✓
	08NL005	TULAMEEN RIVER NEAR PRINCETON	✓				✓	1919-1920	n/a	
	08NL008	TULAMEEN RIVER AT COALMONT*	✓				✓	1914-1918, 1947- 1954	1,370 km^2	✓
	08NL015	ASP CREEK NEAR PRINCETON*	✓				✓	1912-1912, 1919-1920, 1960-1969	51.8 km^2	✓
	08NL021	GRANITE CREEK AT THE MOUTH*	✓				✓	1914-1915, 1973-1979	264 km^2	
	08NL023	OTTER CREEK AT TULAMEEN*		✓			✓	1912-1912, 1915-1916, 1947-1985	673 km^2	✓

Table 3-7 Cont'd.

Sub-basin	Station ID	Station Name[1]	Flow[2]		Status[3]			Period of Record	Drainage area[4]	Potentially useful record
			N	R	A	RT	D			
#2 – Tulameen River	08NL059	OTTER LAKE NEAR TULAMEEN		✓			✓	1973-1985	n/a	
	08NL060	OTTER CREEK BELOW SPEARING CREEK	✓				✓	1973-1982	409 km^2	
	08NL061	DAVIS LAKE NEAR THALIA		✓			✓	1973-1976	n/a	
	08NL067	TULAMEEN RIVER NEAR TULAMEEN	✓				✓	1973-1979	619 km^2	
#3 – Allison Creek	08NL012	ALLISON CREEK NEAR PRINCETON*		✓			✓	1912-1912, 1919-1927, 1943-1954, 1971-1983	593 km^2	✓
	08NL013	SUMMERS CREEK AT THE MOUTH*	✓				✓	1912-1912, 1919-1921, 1960-1966	n/a	✓
	08NL019	SUMMERS CREEK NEAR PRINCETON	✓				✓	1922-1927	n/a	
	08NL043	SUMMERS CREEK AT OUTLET OF MISSEZULA LAKE		✓			✓	1970-1980	123 km^2	
	08NL046	MISSEZULA LAKE NEAR PRINCETON		✓			✓	1971-1971, 1973-1982	n/a	
	08NL053	SUMMERS CREEK NEAR THE MOUTH		✓			✓	1973-1985	n/a	
	08NL054	SUMMERS CREEK BELOW DILLARD CREEK		✓			✓	1973-1976, 1981-1981	123 km^2	
	08NL055	DILLARD CREEK NEAR THE MOUTH[ND]	✓				✓	1973-1974	n/a	
	08NL056	ALLISON CREEK ABOVE SUMMERS CREEK		✓			✓	1973-1981	207 km^2	
	08NL057	ALLISON CREEK AT OUTLET OF ALLISON LAKE		✓			✓	1974-1977, 1979-1981	76.1 km^2	
	08NL058	ALLISON LAKE NEAR PRINCETON		✓			✓	1974-1976, 1980-1981	n/a	

Table 3-7 Cont'd.

Sub-basin	Station ID	Station Name[1]	Flow[2]		Status[3]			Period of Record	Drainage area[4]	Potentially useful record
			N	R	A	RT	D			
#4 – Hayes Creek	08NL039	SIWASH CREEK NEAR PRINCETON		✓	✓			1967-present	263 km^2	✓
	08NL018	HAYES CREEK NEAR JURA		✓			✓	1924-1927	n/a	
	08NL020	HAYES CREEK NEAR PRINCETON	✓				✓	1924-1926, 1943-1949	751 km^2	
	08NL037	TREHEARNE CREEK NEAR PRINCETON	✓				✓	1964-1979	16.1 km^2	
	08NL048	SHINISH CREEK NEAR PRINCETON[ND]	✓				✓	1973-1973	n/a	
	08NL051	HAYES CREEK BELOW SHINISH CREEK		✓			✓	1973-1981, 1984-1984, 1986-1986	112 km^2	
	08NL052	CHAIN LAKE AT THE OUTLET		✓			✓	1973-1979, 1984-1984, 1986-1986	n/a	
#5 – Similkameen River, Princeton to Hedley	08NL007	SIMILKAMEEN RIVER AT PRINCETON	✓		✓	✓		1914-1917, 1939-present	1,810 km^2	✓
	08NL038	SIMILKAMEEN RIVER NEAR HEDLEY	✓		✓	✓		1965-present	5,580 km^2	✓
	08NL025	WOLFE CREEK NEAR PRINCETON*	✓				✓	1912-1912, 1952-1956, 1966-1967	227 km^2	✓
	08NL034	SMITH CREEK NEAR HEDLEY*		✓			✓	1964-1987	127 km^2	✓
	08NL035	SOUKUP CREEK NEAR HEDLEY	✓				✓	1964-1979	22.3 km^2	
	08NL041	WOLFE CREEK AT OUTLET OF ISSITZ LAKE	✓				✓	1968-1981	215 km^2	
	08NL042	ISSITZ LAKE NEAR PRINCETON	✓				✓	1968-1981	n/a	
	08NL064	LORNE LAKE NEAR PRINCETON	✓				✓	1973-1975	n/a	

Table 3-7 Cont'd.

Sub-basin	Station ID	Station Name[1]	Flow[2]		Status[3]			Period of Record	Drainage area[4]	Potentially useful record
			N	R	A	RT	D			
#6 – Hedley Creek	08NL050	HEDLEY CREEK NEAR THE MOUTH	✓		✓			1973-present	388 km^2	✓
	08NL009	HEDLEY CREEK NEAR HEDLEY	✓				✓	1913-1916	n/a	
	08NL065	NICKEL PLATE LAKE NEAR HEDLEY		✓			✓	1975-1975, 1977-1979	n/a	
	08NL068	NICKEL PLATE RESERVOIR OUTFLOW		✓			✓	1975-1976	6.73 km^2	
#7 – Keremeos Creek	08NL045	KEREMEOS CREEK BELOW WILLIS INTAKE		✓	✓			1971-present	181 km^2	✓
	08NL010	KEREMEOS CREEK NEAR OLALLA		✓			✓	1919-1927, 1947-1971	n/a	
	08NL011	OLALLA CREEK AT OLALLA	✓				✓	1912-1913, 1919-1921	n/a	
	08NL014	KEREMEOS CREEK ABOVE MARSEL CREEK	✓				✓	1912-1913, 1920-1928	68.6 km^2	
	08NL044	KEREMEOS CREEK AT MIDDLE BENCH ROAD		✓			✓	1971-1977	221 km^2	
	08NL047	YELLOW LAKE NEAR KEREMEOS		✓			✓	1973-1981	n/a	
#8 – Ashnola River	08NL004	ASHNOLA RIVER NEAR KEREMEOS	✓		✓			1912-1912, 1914-1918, 1920-1920, 1947- present	1,050 km^2	✓
	08NL076	EWART CREEK NEAR CATHEDRAL PARK	✓		✓			1998-present	n/a	✓
	08NL049	ASHNOLA RIVER BELOW YOUNG CREEK	✓				✓	1973-1975	469 km^2	
	08NL072	ASHNOLA RIVER ABOVE YOUNG CREEK	✓				✓	1975-1979	n/a	
	08NL073	YOUNG CREEK NEAR THE MOUTH[ND]	✓				✓	1974-1978	n/a	

Table 3-7 Cont'd.

Sub-basin	Station ID	Station Name[1]	Flow[2]		Status[3]			Period of Record	Drainage area[4]	Potentially useful record
			N	R	A	RT	D			
#9 – Similkameen River, Hedley to International Border	08NL006	SIMILKAMEEN RIVER NEAR KEREMEOS*	✓				✓	1911-1912, 1914-1932	5,960 km^2	
	08NL040	RICHTER CREEK NEAR OSOYOOS	✓				✓	1966-1974, 1977-1977	15.3 km^2	
#10 – Similkameen River, International Border to Mouth	08NL022 (USGS 12442500)	SIMILKAMEEN RIVER NEAR NIGHTHAWK		✓	✓			1928-present	9,190 km^2	✓
	USGS 12440000	SINLAHEKIN CREEK ABOVE BLUE LAKE NEAR LOOMIS, WA		✓			✓	1924-1930	108 km^2 (41.7 mi^2)	
	USGS 12440500	SINLAEKIN CREEK AT MILE 22.3 NEAR LOOMIS, WA		✓			✓	1920-1929	n/a	
	USGS 12441000	SINLAHEKIN CREEK AT TWIN BRIDGE NEAR LOOMIS, WA		✓			✓	1921-1923	195 km^2 (75.5 mi^2)	
	USGS 12441500	SINLAHEKIN CREEK NEAR LOOMIS, WA		✓			✓	1903-1905, 1958-1958	223 km^2 (86.0 mi^2)	
	USGS 12441700	MIDDLE FORK TOATS COULEE CREEK NEAR LOOMIS, WA		✓			✓	1958-1970	n/a	
	USGS 12441800	OLIE CREEK NEAR LOOMIS, WA		✓			✓	1972-1975	n/a	
	USGS 12442000	TOATS COULEE CREEK NEAR LOOMIS, WA		✓			✓	1920-1970	n/a	
	USGS 12442200	WHITESTONE IRRIGATION CANAL NEAR LOOMIS, WA		✓			✓	1957-1970	n/a	
	USGS 12442300	SINLAHEKIN CREEK AB CHOPAKA CREEK NEAR LOOMIS, WA		✓			✓	1957-1965	663 km^2 (256 mi^2)	
	USGS 12442310	CHOPAKA LAKE NEAR NIGHTHAWK, WA		✓			✓	1975-1975	n/a	
	USGS 12442400	PALMER LAKE NEAR NIGHTHAWK, WA		✓			✓	1975-1975	759 km^2 (293 mi^2)	

Table 3-7 Cont'd.

Sub-basin	Station ID	Station Name[1]	Flow[2]		Status[3]			Period of Record	Drainage area[4]	Potentially useful record
			N	R	A	RT	D			
#10 – Similkameen River, International Border to Mouth	USGS 12443000	OROVILLE TONASKET I.D. CANAL NR OROVILLE, WA		✓			✓	1922-1928	n/a	
	USGS 12443500	SIMILKAMEEN RIVER NEAR OROVILLE, WA		✓			✓	1911-1928	9,272 km^2 (3,580 mi^2)	
	USGS 12443600	SIMILKAMEEN RIVER AT OROVILLE, WA		✓			✓	1929-2000	9,194 km^2 (3,550 mi^2)	

Notes:
1. "*" = Over 20 years of data is available; ND = No data is available.
2. N = Natural; R = Regulated
3. A = Active; RT = Real-time; D = Discontinued
4. n/a = Not available

3.5 DAMS AND WATER STORAGE

There are no major dams along the Canadian portion of the Similkameen River; however, the Enloe Dam is located on the Similkameen River downstream of the international border (near Nighthawk, WA), but it ceased operations in 1958. A search of the provincial dam database found that there are 45 dams (earthfill and concrete) on record in the watershed. Of these, 25 are classified as a "regulated" dam, which is:

a) A dam 1 metre or more in height that is capable of impounding a volume of water greater than 1,000,000 m^3;
b) A dam 2.5 metres or more in height that is capable of impounding a volume of water greater than 30,000 m^3;
c) A dam 7.5 metres or more in height; and
d) A dam that does not meet the criteria under paragraph (a), (b) or (c) but has a safety risk classification of significant, high, very high or extreme.

The remaining 20 dams in the Similkameen River watershed do not meet these criteria and are considered "unregulated". Table 3-8 lists the dams on file with MFLNRO by sub-basin. The dams are identified on Map 1 and summary information for each dam is included electronically in Attachment 1.

There are proposals in the United States to both reactivate the Enloe Dam and to build a new dam about 1.6 km upstream at Shanker's Bend. The Shanker's Bend dam would provide significant storage capacity. Detailed hydrological, environmental, and climate studies have been prepared to assess the feasibility of these projects (Okanogan PUD No. 1 2009, 2011). These most recent studies build on studies that began in the 1920s when a dam with significant storage was first proposed. Given their proximity to the Canadian border, the analyses for these sites provide valuable information for the understanding of water resources in the Similkameen River watershed.

Lastly, FortisBC holds power generation and storage licences on the Similkameen River at Similkameen Falls. It is understood that FortisBC has begun feasibility studies on this project, but reports and data are not yet available.

Table 3-8 Summary of Dams in the Similkameen River Watershed.

Sub-basin	Name of Dam	Regulation Status	Dam Status	Type	Owner
#1 – Similkameen River, Manning Park to Princeton	Lightning Lake Dam	Regulated	Active	Earthfill	MFLRNO
	Stevenson Lake Dam	Regulated	Active	Earthfill	Individual
	Willis Lake	Regulated	Active	Earthfill	Individual
	Watkins Lake Dam	Regulated	Breached	Earthfill	Individual
#2 – Tulameen River	Batstone Lake Dam	Regulated	Active	Earthfill	Ducks Unlimited
	Kidd Lake Dam	Regulated	Active	Earthfill	Ducks Unlimited
	Otter Lake Dam	Non-Regulated	Breached	Concrete	Individual
	Schubert Pond Dam	Non-Regulated	Active	Earthfill	Individual
	Jacks Lake Dam	Regulated	Active	Earthfill	Individual
	Batstone Marsh Dam	Non-Regulated	Active	Earthfill	Ducks Unlimited
	Batstone Pond Dam	Non-Regulated	Active	Earthfill	Ducks Unlimited
	Biely Lake Dam	Regulated	Active	Earthfill	Ducks Unlimited
	Davis Lake Dam	Regulated	Active	Earthfill	Ducks Unlimited
	Davis Marsh Dam	Non-Regulated	Active	Earthfill	Ducks Unlimited
	Hall Lake Dam	Non-Regulated	Breached	Earthfill	Individual
	Harvey Hall Lake Dam	Regulated	Active	Earthfill	Ducks Unlimited
	Harvey Hall Marsh Dam	Non-Regulated	Active	Earthfill	MFLRNO
	Myren Lake Dam	Regulated	Active	Earthfill	Ducks Unlimited

Table 3-8 Cont'd.

Sub-basin	Name of Dam	Regulation Status	Dam Status	Type	Owner
#2 – Tulameen River	Otter Creek Dam	Non-Regulated	Active	Earthfill	Individual
	Tommy Lee Lake Dam	Regulated	Active	Earthfill	Individual
	Dodds Lake Dam	Non-Regulated	Conversion	Earthfill	MFLRNO
#3 – Allison Creek	Allison Lake Dam	Non-Regulated	Active	Concrete	Allison Lake Improvement District
	Gould Lake Dam	Non-Regulated	Active	Earthfill	Individual
	John Burns Lake Dam	Regulated	Active	Earthfill	Individual
	Missezula Lake Dam	Regulated	Active	Concrete	Missezula Lake Waterworks District
	Seperation Lake Dam	Non-Regulated	Active	Earthfill	Individual
	Oelrich Creek Reservoir Dam	Non-Regulated	Active	Earthfill	Individual
	Christian Lake #1 Dam	Regulated	Active	Earthfill	Individual
	Christian Lake #2 (Lower) Dam	Non-Regulated	Active	Earthfill	Individual
	Christian Lake #3 (Upper) Dam	Non-Regulated	Active	Earthfill	Individual
	Hardwick Creek Reservoir Dam	Non-Regulated	Active	Earthfill	Individual
	Rampart Lake Dam	Regulated	Active	Earthfill	MFLNRO
	Wayne Lake Dam	Non-Regulated	Active	Earthfill	Individual
	Vinson Lake Dam	Regulated	Active	Earthfill	Missezula Lake Waterworks District

Table 3-8 Cont'd.

Sub-basin	Name of Dam	Regulation Status	Dam Status	Type	Owner
#4 – Hayes Creek	Chain Lake Dam	Regulated	Active	Earthfill	Individual
	Lee Creek Diversion Dam	Regulated	Active	Earthfill	Osprey Lake Waterworks District
	William Creek Reservoir Dam	Regulated	Active	Earthfill	Individual
	Harvey Creek Reservoir Dam	Non-Regulated	Active	Dugout/Pond	Individual
	Agur Lake Dam	Non-Regulated	Active	Earthfill	Individual
#5 – Similkameen River, Princeton to Hedley	Lorne Lake Dam	Regulated	Active	Earthfill	Individual
	Basely Lake Dam	Regulated	Active	Earthfill	Individual
#6 – Hedley Creek	Nickel Plate Lake Dam	Regulated	Active	Earthfill	Similkameen Improvement District
#7 – Keremeos Creek	Ford Lake Dam	Regulated	Active	Earthfill	Individual
	Yellow Lake Dam	Regulated	Active	Earthfill	MFLNRO
#8 – Ashnola River	Red Bridge Lake Dam	Non-Regulated	Active	Earthfill	MFLNRO

4 Water Quantity - Groundwater

The majority of groundwater information available for the Similkameen River watershed was identified and summarized by Summit (2011). The following sections provide a brief summary of the available information.

4.1 SIMILKAMEEN RIVER WATERSHED AQUIFER MAPPING

MFLNRO identifies and maps groundwater aquifers in the province. To date, eighteen aquifers have been mapped within the Similkameen River watershed (Table 4-1 and Map 2).

It is important to note that current aquifer mapping is based on priorities for management; and that other aquifers exist in the watershed beyond those that are currently mapped. However, no information is available at this time. Finally, the physical characteristics of Aquifer 259 exhibit considerable spatial variation; therefore, to better facilitate water supply and demand management, the aquifer could be sub-divided into a number of smaller units based on physical properties and demand.

The Ministry of Environment (2013b) reports that the nature of the surficial deposits filling the Similkameen River valley is known mostly from water wells that have been constructed in the near-surface aquifer. In particular, the well record from a 126 m deep test well shows two other gravelly sand aquifers separated by till below the upper gravel aquifer. The upper aquifer, which extends from near surface to 43 m, is very productive, so it is the only one being used. The Ministry of Environment (2013b) reports that recharge is mostly from the Similkameen River, which has a coarse gravel bottom and an average gradient of approximately 0.3%.

4.2 OBSERVATION WELL NETWORK

The MFLNRO groundwater program currently performs trend monitoring, largely related to groundwater levels and groundwater quality characterization in high priority water basins (e.g. with high levels of contaminants such as nitrate). The data are stored in the Observation Well Network[8] database.

There are three active and four inactive MFLNRO observation wells in the Similkameen River watershed (Map 2). The three active wells are located in Keremeos (#75) and near Cawston (#203 and #264), while the inactive wells were located in Keremeos (#76 and #77) and near Princeton (#220 and #221). Table 4-2 lists available well information, with the detailed well records available from the B.C. Water Resources Atlas (including well depths and date of installation).

Water level information from the observation wells was collected manually until 2007 when dataloggers were installed. Since then, the data is collected hourly. All available water level information for each of the observation wells is provided electronically in Attachment 1.

[8] Online at: http://www.env.gov.bc.ca/wsd/data_searches/obswell/

Table 4-1 Aquifers in the Similkameen River Watershed Mapped by MFLNRO.

Aquifer Number	258	259	935	937	1010	1011	1012	1013	1024
Sub-Basin	#9	#1, #5, and #9	#7	#7	#2	#2	#2	#2	#1, #2, #3, and #5
Descriptive Location	Richter Pass	International Border to Princeton	Keremeos Creek Valley	Keremeos Creek Valley	Tulameen	Coalmont, 5 km SE of Tulameen	Riddle Mountain, SE Slope	Otter Lake, NW Shoreline	Princeton
Aquifer Materials	Sand and Gravel	Sand and Gravel	Sand and Gravel	Bedrock	Sand and Gravel	Sand and Gravel	Bedrock	Gravel	Bedrock
Area (km^2)	7.6	119.8	5.2	4.7	0.9	0.9	1.2	0.6	122.3
Aquifer Classification	IIC	IIA	IIB	IIB	IA	IIA	IIA	IIA	IIB
Demand	Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate	Moderate	Low
Productivity	Moderate	High	High	Low	Moderate	Moderate	Moderate	Moderate	Moderate
Vulnerability	Low	High	Moderate	Moderate	High	High	High	High	Moderate
Aquifer Ranking Value	10	14	12	9	11	10	10	10	13
Adjoining Map sheet	No	Yes	No	Yes	No	No	No	No	Yes
Litho Stratigraphic Unit	Recent Fraser Glaciation – Alluvial Fan deposits	Recent Fraser Glaciation	n/a	Sedimentary Rock	Sand and Gravel	Sand and Gravel	Intrusive and Volcanic Rock	Gravel	Princeton Group – Sedimentary Rock
Type of Water Use	Multiple	Multiple	Multiple	Multiple	Domestic	Domestic	Domestic	Domestic	Multiple

Aquifer Number	1025	1026	1027	1028	1029	1030	1031	1032	1033
Sub-Basin	#3	#4	#4	#4	#3	#3	#4	#4	#4
Descriptive Location	Allison Lake	Hayes Creek, North of Finnegan Creek	Chain Lake	Confluence of Hayes and Siwash Creeks	North of Princeton	12 km North of Princeton	Hayes Creek South of Trehearne Creek	Osprey Lake	Chain Lake
Aquifer Materials	Sand and Gravel	Bedrock	Bedrock	Gravel	Gravel	Sand and Gravel	Bedrock	Bedrock	Sand and Gravel
Area (km^2)	0.9	22.5	1.8	7	8.2	0.8	14.3	5.9	0.4
Aquifer Classification	IIIB	IIB	IIC	IIA	IIA	IIB	IIB	IIB	IIC
Demand	High	Low	Low	Moderate	Moderate	Moderate	Low	Moderate	High
Productivity	Moderate	Low	Moderate	Moderate	High	Moderate	Low	Low	Moderate
Vulnerability	Moderate	Moderate	Low	High	High	Moderate	Moderate	Moderate	Low
Aquifer Ranking Value	10	8	7	12	13	10	9	9	9
Adjoining Map sheet	No	No	No	No	Yes	No	No	No	No
Litho Stratigraphic Unit	Glaciofluvial Deposits	Primarily Granitic Intrusive Rocks	Primarily Granitic Intrusive Rocks	Glaciofluvial Deposits	Glaciofluvial Deposits	Likely Glaciofluvial deposits	Primarily Granitic Intrusive Rocks	Igneous Intrusive or Metamorphic Rocks	Likely Glaciofluvial Deposits
Type of Water Use	Domestic	Domestic	Domestic	Multiple	Multiple	Multiple	Domestic	Domestic	Domestic

Table 4-2 MFLNRO Observation Wells in the Similkameen River Watershed.

Observation Well No.	203	75	264	76	77	220	221
Sub-basin	#9 - Similkameen River, Hedley to International Border	#7 - Keremeos Creek	#9 - Similkameen River, Hedley to International Border	#7 - Keremeos Creek	#7 - Keremeos Creek	#5 – Similkameen River, Princeton to Hedley	#1 – Similkameen River, Princeton to Manning Park
Location	Cawston – 1943 Barcelo Road	Keremeos – 6th Ave. & 5th St.	n/a	Keremeos – 9th Ave. & 3rd St.	Keremeos – Morrison Road	n/a	n/a
Owner	Fairview Heights Irrigation District	Village of Keremeos	MFLNRO	Keremeos Irrigation District	Village of Keremeos	Roy Thomas Well 2	Town of Princeton
Status	Active	Active	Active	Inactive	Inactive	Inactive	Inactive
Well Tag no.	33378	20533	62733	22585	22625	20313	34031
Depth (m)	60.7	28.0	76.2	22.6	34.1	9.8	11.6
Static Water Level (m)	24.4	3.4	29.9	3.0	24.1	3.7	2.7
Elevation (m GSC)	417	n/a	1,832	415	429	n/a	639
Year started	1977	1963	1980	1963	1972	1977	n/a
Completed in	Fine Sand	Fine Silty Sand	Bedrock	Sand & Gravel	Pea Gravel	Gravel	Sand & Gravel

4.3 WELL RECORDS

As identified in Section 3.2, groundwater is the primary or secondary source of water used by water suppliers and private individuals for domestic, irrigation, and other purposes in the Similkameen River watershed. A review of the available well information indicated that there are 1,873 groundwater wells on record in the watershed. Table 4-3 summarizes the information on well depth and well yields based on the drillers' records for each sub-basin. All wells are identified on Map 2 and summarized for each sub-basin electronically in Attachment 1.

Approximately 40% of the registered wells in the Similkameen River watershed are relatively shallow (less than 50 m deep) and about a third of the wells are more than 100 m deep. The capacity data in Table 4-3 is based on the initial tests completed by the well driller and therefore is only an estimate of actual yield. About a quarter of the wells on record have no yield data and those that do have yield data show wide variation.

4.4 GROUNDWATER PROTECTION PLANNING AND INVESTIGATIONS

The Village of Keremeos and the Keremeos Irrigation District have combined resources to develop a groundwater protection plan, which was prepared by Golder Associates Ltd. (Golder) (2008, 2009). Other communities that have either begun or completed groundwater protection plans include Olalla and Princeton[9]. Collectively, these plan areas include a significant portion of the valley population that obtains its drinking water from groundwater. The plans provide good information on potential sources of contamination and recommended steps to reduce risk.

In addition, based on a review of information collected in the literature database (see Phase 1 Report), an assessment completed by Golder (2012) on the hydraulic connection between Keremeos Irrigation District wells and the Similkameen River represents the only surface-groundwater interaction investigation that has been completed within the Similkameen River watershed.

[9] The plans and supporting documents are available in the literature database (see Phase 1 Report).

Table 4-3 Summary of Groundwater Well Depths and Yields for the Canadian Portion of the Similkameen River Watershed.

	#1 - Similkameen River, Manning Park to Princeton		#2 - Tulameen River		#3 – Allison Creek		#4 – Hayes Creek		#5 - Similkameen River, Princeton to Hedley		#6 – Hedley Creek		#7 - Keremeos Creek		#8 - Ashnola River		#9 - Similkameen River, Hedley to International Border	
Number of Wells	**79**		**225**		**210**		**221**		**212**		**9**		**256**		**6**		**655**	
Well Depth (m)	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Unspecified	3	3.8%	4	1.8%	6	2.9%	10	4.5%	6	2.8%	1	11.1%	5	2.0%	0	0.0%	30	4.6%
<20	12	15.2%	111	49.3%	96	45.7%	65	29.4%	93	43.9%	1	11.1%	101	39.5%	1	16.7%	429	65.5%
20-40	15	19.0%	22	9.8%	49	23.3%	58	26.2%	62	29.2%	2	22.2%	66	25.8%	5	83.3%	105	16.0%
40-60	14	17.7%	22	9.8%	10	4.8%	24	10.9%	24	11.3%	2	22.2%	24	9.4%	0	0.0%	46	7.0%
60-80	11	13.9%	25	11.1%	13	6.2%	18	8.1%	11	5.2%	1	11.1%	14	5.5%	0	0.0%	18	2.7%
80-100	4	5.1%	13	5.8%	10	4.8%	16	7.2%	10	4.7%	0	0.0%	14	5.5%	0	0.0%	9	1.4%
100-200	20	25.3%	28	12.4%	25	11.9%	28	12.7%	6	2.8%	2	22.2%	30	11.7%	0	0.0%	16	2.4%
200-300	0	0.0%	0	0.0%	1	0.5%	2	0.9%	0	0.0%	0	0.0%	2	0.8%	0	0.0%	1	0.2%
>300	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%		0.0%	0	0.0%	1	0.2%
Average Depth	64		43		40		50		31		61		44		26		22	
Well Yield (L/min)	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Unspecified	14	17.7%	49	21.8%	39	18.6%	26	11.8%	31	14.6%	3	33.3%	69	27.0%	2	33.3%	213	32.5%
<19	19	24.1%	29	12.9%	29	13.8%	70	31.7%	10	4.7%	0	0.0%	37	14.5%	0	0.0%	7	1.1%
19 to 38	14	17.7%	26	11.6%	13	6.2%	27	12.2%	10	4.7%	0	0.0%	13	5.1%	0	0.0%	13	2.0%
38 to 76	13	16.5%	30	13.3%	20	9.5%	25	11.3%	24	11.3%	0	0.0%	19	7.4%	0	0.0%	48	7.3%
76 to 151	8	10.1%	52	23.1%	43	20.5%	48	21.7%	44	20.8%	2	22.2%	30	11.7%	0	0.0%	111	16.9%
151 to 227	3	3.8%	16	7.1%	27	12.9%	14	6.3%	50	23.6%	0	0.0%	21	8.2%	1	16.7%	71	10.8%
227 to 379	5	6.3%	10	4.4%	23	11.0%	8	3.6%	17	8.0%	1	11.1%	19	7.4%	2	33.3%	70	10.7%
379 to 1,136	3	3.8%	10	4.4%	8	3.8%	1	0.5%	12	5.7%	2	22.2%	15	5.9%	0	0.0%	70	10.7%
1,136 to 1,893	0	0.0%	0	0.0%	1	0.5%	1	0.5%	5	2.4%	0	0.0%	6	2.3%	0	0.0%	10	1.5%
1,893 to 3,785	0	0.0%	2	0.9%	5	2.4%	0	0.0%	9	4.2%	0	0.0%	15	5.9%	1	16.7%	27	4.1%
3,785 to 5,678	0	0.0%	0	0.0%	1	0.5%	0	0.0%	0	0.0%	1	11.1%	6	2.3%	0	0.0%	9	1.4%
5,678 to 7,570	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	4	1.6%	0	0.0%	2	0.3%
>7,570	0	0.0%	1	0.4%	1	0.5%	1	0.5%	0	0.0%	0	0.0%	2	0.8%	0	0.0%	4	0.6%
Average Well Yield	76		208		322		182		280		901		814		942		602	

5 Information Summary and Data Gaps

5.1 DATA AVAILABILITY AND SPATIAL COVERAGE

Despite the relatively low population of the Similkameen River watershed compared to other parts of southern B.C., the watershed has a solid information base on which water resource management decisions can be made.

The number of streamflow monitoring stations (hydrometric) is above average for B.C. and the stations are spatially diverse throughout the watershed. Although the hydrometric network is well suited for regional studies, for specific investigations (i.e. groundwater-surface water interaction, investigations and aquatic resource assessments) some additional monitoring at site specific locations may be necessary.

Overall there is relatively good characterization of the climate throughout (and outside of) the Similkameen River watershed with the current and discontinued climate and snowpack monitoring network. This includes both geographically from west to east as well as with elevation, although there is considerable bias towards lower elevations locations where most development is concentrated. Only two of the sub-basins (#3 – Allison Creek and #6 – Hedley Creek) have limited information available. However, these are small areas, which likely can be characterized by records in adjacent sub-basins.

In addition, with the recent development of gridded climate datasets by Agriculture and Agri-Foods Canada, a better understanding of climate variation throughout the watershed is available. Building on the available climate datasets, the Ministry of Agriculture's Agriculture Water Demand Model allows for an estimation of surface and groundwater uses throughout the watershed. This model is an improvement over previous estimates, but an inventory of actual use on a sample of farms, ranches and non-farm sites (e.g. golf courses) would be required to extend the data beyond agriculture.

Recent climate change modeling by the University of Victoria's PCIC and the University of Washington's Climate Impacts Group is directly applicable to the Similkameen River watershed. In addition, datasets available from ClimateBC and Agriculture and Agri-Foods Canada are also directly applicable. Accordingly, climate change predictions and future scenario modeling to the 2100s is currently available for the watershed, which provides a solid information base for water supply and demand investigations under current and future conditions.

Relative to other watersheds in southern B.C., groundwater makes up a significant proportion of agricultural and domestic water use in the Similkameen River watershed. Almost all of the major water suppliers within the Similkameen River watershed were contacted and water system and water use information was obtained. According to water supplier records, most suppliers had abandoned their surface water supply infrastructure and water supplies were largely dependent on groundwater wells.

MFLNRO has mapped two aquifers in the watershed; located along or in proximity to the valley bottoms where agricultural activities and communities are concentrated. The mapped aquifers are in sand and gravel deposits and are ranked as having moderate to high productivity and low to high vulnerability to contamination from surface activities. A search of the provincial water well database found more than 1,800 wells. Registration of drilled wells is not mandatory, so there may be 2,000 wells or more in the watershed, although it is not known how many are not in use or have been decommissioned. The demand on these aquifers is estimated as either low or moderate at this time. Overall, with respect to groundwater, there is information on some of the aquifers throughout the watershed; however, little is known on surface-groundwater interaction, which is a key data gap that should be addressed (see Section 5.2).

5.2 DATA GAPS

There are enough available water resources data, analyses, and reports to move into subsequent phases of the SWP without delay. However, there are several information gaps that should be addressed before completion of a water supply and demand investigation. The first group listed below are directly related to water supply and demand investigations, while the second group are longer-term initiatives that will help address expected on-going water management information needs. Note that recommendations for technical studies to fill the data gaps are provided in the Phase 1 Report.

5.2.1 Information Needs to Support the Watershed Management Plan

- Within the Similkameen River watershed, the current (and discontinued) hydrometric network is generally well equipped to monitor (and summarize) the spatial variation of streamflow and water supply throughout the watershed and on the mainstem river. However, estimates of natural (or naturalized flow) under current normal and 1-in-10-year return period low flows and under projected (e.g. 2050) normal and 1-in-10-year low flows should be developed (at a sub-basin level or smaller) to help assess available surface water supplies.
- To date, the only investigation on surface-groundwater interaction has focussed on the Similkameen River valley aquifer near Keremeos. Less is known about these processes elsewhere in the watershed. In addition, no estimates on the contribution of groundwater flows from upper elevation areas to the lower elevation aquifers are available.
- With a moderate number of storage dams (i.e. 45) located within the Similkameen River watershed, an overview identification of storage options is necessary for surface water management. The review should include an assessment on the status of the existing dams and whether any dam is being decommissioned or is included in applications for the raising of dam levels.
- There is limited information on how much irrigation water returns to underlying aquifers or to nearby streams. This may be significant in some areas (e.g. with sandy soils), and estimates of actual water use by irrigation would be improved by better estimates of return flow.
- The Ministry of Agriculture's Agriculture Water Demand Model estimates agricultural and livestock use from 1961-2003, but water use estimates for a range of climate scenarios are not yet available and the model has not yet been checked against actual use in the Similkameen River watershed,

as has been done elsewhere in B.C. The checking of actual water use (surface and groundwater) against the model predictions should begin with a number of the larger individual irrigation licenses, but also include some assessment of users across the range of licensed volumes.

- The Agriculture Water Demand Model also suggests that no agricultural water use is occurring within the Hedley Creek and Ashnola River sub-basins. As such, the checking of actual water use within these sub-basins against model predictions should be completed to confirm model results.

5.2.2 Longer-term Assessment, Monitoring and Adaptive Management

- The aquifers mapped to date by MFLNRO cover the most populated and agriculturally intensive parts of the watershed where groundwater was being utilized at the time when the mapping program was active. A review of the existing geologic and aquifer mapping should be completed to set priorities for delineating and characterizing aquifers outside the boundaries of the provincially mapped aquifers.
- There are no active hydrometric monitoring stations on Allison or Hayes creeks. For specific investigations on these creeks, synthetic records would need to be developed using regional and/or discontinued stations.
- Due to the large dependence on groundwater for water supply near the Town of Keremeos, the re-implementation of hydrometric monitoring on the Similkameen River at Keremeos (WSC Station No. 08NL006) could contribute to future surface-groundwater interaction investigations and/or provide information on water level trends during periods of intense irrigation and groundwater pumping.
- Limited information is available on water use within the American portion of the Similkameen River watershed. Accordingly, if water supply and demand modeling is desired in the future, this information will need to be obtained or estimated.
- There is no hydrometric station on the Similkameen River near the international border. At this time, scaling of hydrometric records at Nighthawk, WA, (WSC Station 08NL022) would likely provide a suitable surrogate, since natural inflow between the international border and Nighthawk, WA, are small. However, as water use between the international border and Nighthawk, WA, may be significant, consideration should be given for the implementation of a station near the international border to monitor cross border flows. This would ensure that if any trans-border water supply treaties were developed or implemented in the future, flow monitoring would be available.
- There are three active groundwater Observation Wells (in Keremeos (#75) and near Cawston (#203 and #264)); however, there are large areas of the watershed that lack information on variations in groundwater levels.
- Consideration should be given to the addition of domestic indoor/outdoor, institutional, commercial, industrial, and other water use purposes to the Agriculture Water Demand Model for the Similkameen River watershed. This addition would allow for a complete estimate of all water uses throughout the watershed under current and future climate conditions.

- Due to the large variation in water use information available by water suppliers within the Similkameen River watershed, reporting to the B.C. Water Use Reporting Centre would allow for consistency of records between water suppliers and for more accurate and up-to-date information.
- Once the major data gaps are filled, the next logical step in developing the SWP would be to develop a water balance model. The model framework is contingent upon the requirements of the RDOS and could range from a relatively straightforward spreadsheet model to a distributed hydrologic/water balance model. As such, a user's needs assessment would be recommended prior to any model development.

References

Golder Associates Ltd. (Golder). 2008. Phase Three Groundwater Protection Planning, Keremeos, B.C. Report prepared for Keremeos Irrigation District. May 8, 2008.

Golder Associates Ltd. (Golder). 2009. Phase Four Groundwater Protection Plan – Long-Term Action Planning and Preliminary Contaminant Inventory Update, Village of Keremeos and Keremeos Irrigation District. April 16, 2009.

Golder Associates Ltd. (Golder). 2012. Groundwater Under the Direct Influence of Surface Water Assessment, Keremeos, B.C. Prepared for the Keremeos Irrigation District, January 2012.

Hamlet, A.F., Carrasco, P., Deems, J., Elsner, M.M., Kamstra, T., Lee, C., Lee, S., Mauger, G.S., Salathe, E.P., Tohver, I. and Binder, L.W. 2010. Final Report for the Columbia Basin Climate Change Scenarios Project. http://www.hydro.washington.edu/2860/report/

Ministry of Environment. 2013a. Climate Related Monitoring Program (CRMP). On-line at: http://www.env.gov.bc.ca/epd/wamr/crmp.htm

Ministry of Environment. 2013b. Groundwater Water Resources in British Columbia. On-line at: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/gwbc/C131_Agriculture.html

Neilsen, D., Duke, G., Taylor, B., Byrne, J. M., and van der Gulik, T. (2010). Development and Verification of Daily Gridded Climate Surfaces in the Okanagan Basin of British Columbia. Canadian Water Resources Journal. 35(2): 131-154.

Okanagan Hydrometric Network Working Group. 2008. Hydrometric network requirements for the Okanagan Basin. Prepared for the Okanagan Basin Water Board and Water Stewardship Division, August 2008.

Okanogan Public Utility District (PUD) No. 1. 2009. Similkameen River Appraisal Level Study. April 2009. On-line at http://www.okanoganpud.org/Similkameen/SimilkameenStudy.htm

Okanogan Public Utility District (PUD) No. 1. 2011. Enloe Hydroelectric Project (FERC project no. 12569) United States Fish and Wildlife Service Biological Evaluation. June 2011. On-line at: http://www.okanoganpud.org/enloe/Enloe%20DEA/DRAFTBA.pdf

Regional District Okanagan Similkameen (RDOS). 2012. Apex Circle Water System: 2011 Annual Water Quality Monitoring Report. Prepared for Interior Health Authority, January 2011.

Regional District Okanagan Similkameen (RDOS). 2013. Map and General Information. On-line at: http://www.rdos.bc.ca/regional-government/map-general-info/

Statistics Canada, 2006 Census of Agriculture, Farm Data and Farm Operator Data, catalogue no. 95-629-XWE.

Summit Environmental Consultants Inc. 2010b. Okanagan Water Supply and Demand Project: Appendix A1 – Okanagan Water Demand Model Summary Report. Prepared for the Ministry of Agriculture and Lands and Agriculture and Agri-Foods Canada for the Okanagan Basin Water Board, April 2010.

Summit Environmental Consultants Inc. (Summit). 2011. Similkameen River Water Management Plan: Part 1 – Scoping Study. Prepared for Similkmeen Valley Planning Society, September 2011.

Swain, L.G. 1985. Okanagan Area – Similkameen River Sub-Basin Water Quality Assessment and Objectives. Ministry of Environment, Resource Quality Section. November 1985.

TRUE Consulting Group. 2006. Tulameen Community Water System Study Update. Draft Report. Prepared for Regional District Okanagan Similkameen, May 2006.

van der Gulik, T., Neilsen, D., Fretwell, R., and A. Petersen. 2012. Agricultural Water Demand Model: Report for the Similkameen Watershed. Funded by Canada-British Columbia Water Supply Extension Program, April 2012.

Wang, T., Hamann, A., Spittlehouse, D., and Aitken, S. N. 2006. Development of Scale-Free Climate Data for Western Canada and Use in Resource Management. International Journal of Climatology. 26(3): 383-397.

Wang, T., Hamann, A., Spittlehouse, D., and T. N. Murdock. 2012. ClimateWNA – High-Resolution Spatial Climate Data for Western North America. Journal of Applied Meteorology and Climatology. 61: 16-29.

A1 Appendix A1 - Summary of Water Licences

Table A1-1 Water Licence Summary: Similkameen River Watershed Sub-basins

Sub-basin	License Type	Purpose	No. Water Licenses	Licensed Volume (ML)	Major License Holder(s)
#1 – Similkameen River, Manning Park to Princeton	Agricultural	Irrigation	23	1,484.1	Individuals
		Stockwatering	2	10.8	Individuals
	Domestic	Domestic	24	28.6	Individuals
		Waterworks	4	157.6	Bonnevier Water Co. Ltd. (49.8 ML); HML Mining Inc. (82.9 ML); BC Parks (24.9 ML)
	Industrial, Commercial, and Institutions (ICI)	Enterprise	2	10.8	Individuals
		Cooling	1	36.5	HML Mining Inc.
		Fire Protection	1	0.8	Individuals
		Mining – Hydraulic	1	788.4	Individuals
		Mining – Processing Ore	1	13,275	Copper Mountain Mine (BC) Ltd.
	Other	Storage – Non-Power	4	343	Individuals
		Power – Residential	1	63.1	Individuals
		Land Improvement	1	Total Flow	BC Parks
#2 – Tulameen River	Agricultural	Irrigation	38	3,048.3	Town of Princeton (34.8 ML); Individuals (3013.5 ML)
		Stockwatering	7	12.4	MFLNRO (10.7 ML); Ministry of Transportation and Infrastructure (1.7 ML)
	Domestic	Domestic	57	61.9	Town of Princeton (3.8 ML); Individuals (58.1 ML)
		Waterworks	1	3,484.6	Town of Princeton
	Industrial, Commercial, and Institutions (ICI)	Dust Control	1	3.7	Huldra Silver Inc.
		Mining Equipment	1	10.2	Huldra Silver Inc.
		Work Camps	1	6.6	Huldra Silver Inc.
	Other	Storage – Non-Power	8	585.9	Individuals
		Conservation – Stored Water	10	1,571.5	Ducks Unlimited (Canada) (166.5 ML); MFLNRO (1405 ML)

Table A1-1 cont'd Water Licence Summary: Similkameen River Watershed Sub-basins

Sub-basin	License Type	Purpose	No. Water Licenses	Licensed Volume (ML)	Major License Holder(s)
#3 – Allison Creek	Agricultural	Irrigation	71	3,338.5	SID (118.4 ML); Individuals (3,220.1 ML)
		Stockwatering	1	1.7	MFLNRO
	Domestic	Domestic	76	77.7	Individuals
		Waterworks	3	157.6	Allison Lake Improvement District (74.7 ML); Missezula Lake Waterworks District (82.9 ML)
	Industrial, Commercial, and Institutions (ICI)	Enterprise	1	10.0	Individuals
		Exhibition Grounds	1	2.5	Town of Princeton
	Other	Storage – Non-Power	13	1,718.8	Missezula Lake Waterworks District (616.7 ML); Individuals (1,102.1 ML)
		Power – Residential	2	410.0	Individuals
		Conservation – Stored Water	3	918.9	Ducks Unlimited (Canada) (203.5 ML); MFLNRO (715.4 ML)
		Conservation – Constr. Works	3	Total Flow	MFLNRO
#4 – Hayes Creek	Agricultural	Irrigation	68	2,369.7	SID (3.7 ML); Individuals (2,364.2 ML)
		Stockwatering	8	8.8	Individuals
	Domestic	Domestic	81	80.4	Individuals
		Incidental - Domestic	1	0.8	SID
		Waterworks	1	99.6	Osprey Lakes Waterworks District
	Other	Storage – Non-Power	14	435.7	Osprey Lakes Waterworks District (49.3 ML); Individuals (386.7 ML)
		Land Improvement	1	22,327	RDOS
		Conservation – Constr. Works	2	Total Flow	MFLNRO

Table A1-1 cont'd Water Licence Summary: Similkameen River Watershed Sub-basins

Sub-basin	License Type	Purpose	No. Water Licenses	Licensed Volume (ML)	Major License Holder(s)
#5 – Similkameen River, Princeton to Hedley	Agricultural	Irrigation	35	1,401.3	SID (3.7 ML); Town of Princeton (12.3 ML); USIB (540.3 ML); Individuals (845 ML)
		Stockwatering	8	18.6	MLFNRO (6.6 ML); Individuals (12.0 ML)
	Domestic	Domestic	38	44.0	USIB (3.3 ML); Individuals (40.7 ML)
	Industrial, Commercial, and Institutions (ICI)	Processing	1	19.9	Individual
	Other	Storage – Non-Power	3	133.2	USIB (9.9 ML); Individuals (123.3 ML)
		Land Improvement	1	3,947.1	Young Life of Canada
#6 – Hedley Creek	Domestic	Waterworks	2	1,577.8	USIB (1537.1 ML); Apex Mountain Resort Ltd. (40.7 ML)
	Industrial, Commercial, and Institutions (ICI)	Snowmaking	1	82.6	Apex Mountain Resort Ltd.
	Other	Storage – Non-Power	2	4,193.8	SID (4070.5 ML); Apex Mountain Resort Ltd. (123.3 ML)
		Power – Commercial	1	3,942.0	Ministry of Social Development
#7 – Keremeos Creek	Agricultural	Irrigation	45	2,033.7	RDOS (24.2 ML); Keremeos Irrigation District (1,128.1 ML); SID (72.8 ML); LSIB (28.4 ML); Individuals (780.2 ML)
		Stockwatering	18	46.5	MFLNRO (39.9 ML); Individuals (6.6 ML)
	Domestic	Domestic	40	54.8	LSIB (1.7 ML); Individuals (53.1 ML)
		Incidental – Domestic	3	17.4	Keremeos Irrigation District
		Waterworks	10	116.6	RDOS (50.6 ML); Apex Mountain Resort Ltd. (66.0 ML)
	Other	Ponds	1	18.0	Individual
		Conservation – Stored Water	1	308.4	MFLNRO

Table A1-1 cont'd Water Licence Summary: Similkameen River Watershed Sub-basins

Sub-basin	License Type	Purpose	No. Water Licenses	Licensed Volume (ML)	Major License Holder(s)
#8 – Ashnola River	Agricultural	Irrigation	8	13,783.2	Keremeos Irrigation District (12,335 ML); LSIB (1,380.3 ML); Individuals (67.9 ML)
		Stockwatering	3	14.9	MLFNRO
	Domestic	Domestic	8	21.6	LSIB (13.3 ML); Individuals (8.3 ML)
	Industrial, Commercial, and Institutions (ICI)	Enterprise	1	6.6	Cathedral Lakes Lodge Ltd.
	Other	Power – Residential	1	4,099.7	Individual
		Power - Commerical	1	883	Cathedral Lakes Lodge Ltd.
		Conservation – Constr. Works	1	18.5	MFLNRO
#9 – Similkameen River, Hedley to International Border	Agricultural	Irrigation	121	39,198	SID (15,726.7 ML); Keremeos Irrigation District (1,559.1 ML); Fairview Heights Irrigation Districts (3,219.4 ML); Cawston Irrigation District (1,480.2 ML); LSIB (7,230.7 ML); USIB (2,786.4 ML); RDOS (43.4 ML); Individuals (7,152.1 ML)
		Stockwatering	6	22.4	Individuals
	Domestic	Domestic	52	122.1	LSIB (40.7 ML); USIB (16.6 ML); RDOS (0.8 ML); Keremeos Irrigation District (0.8 ML); Individuals (63.2 ML)
		Waterworks	2	27,720	SID (27,675 ML); Fairview Heights Irrigation District (45 ML)
	Industrial, Commercial, and Institutions (ICI)	Mining - Hydraulic	1	883.0	SID
		Mining – Processing Ore	3	179.8	Barrick Gold Inc.
	Other	Storage – Non-Power	3	256.6	Individual

A2 Appendix A2 - Examples of Available Climate Change Information

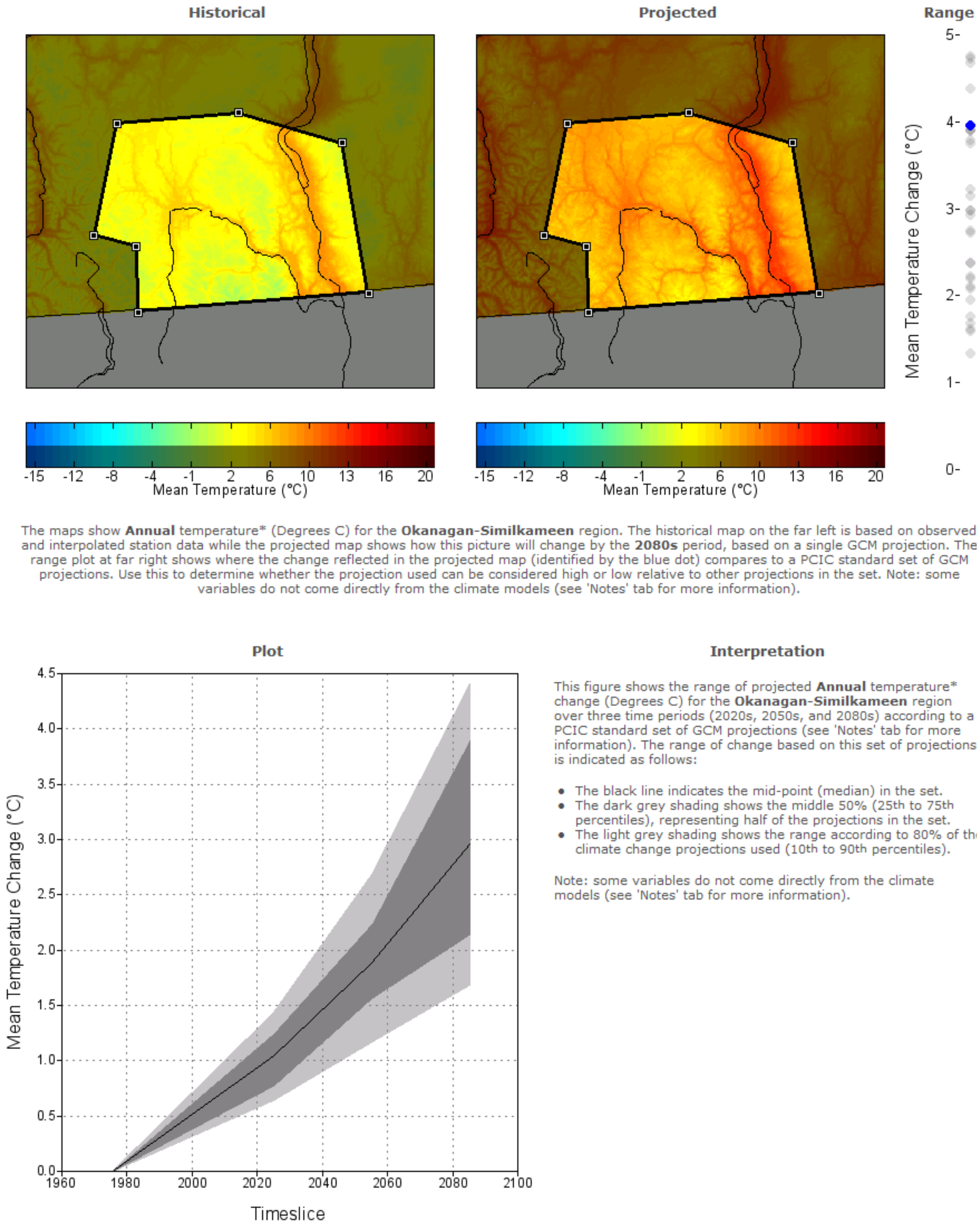
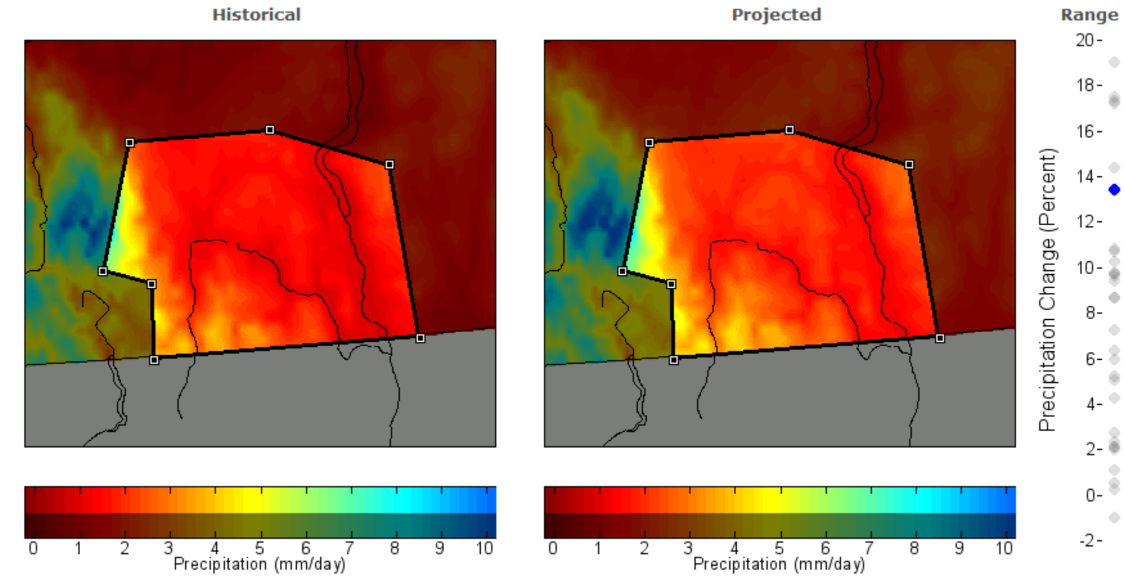
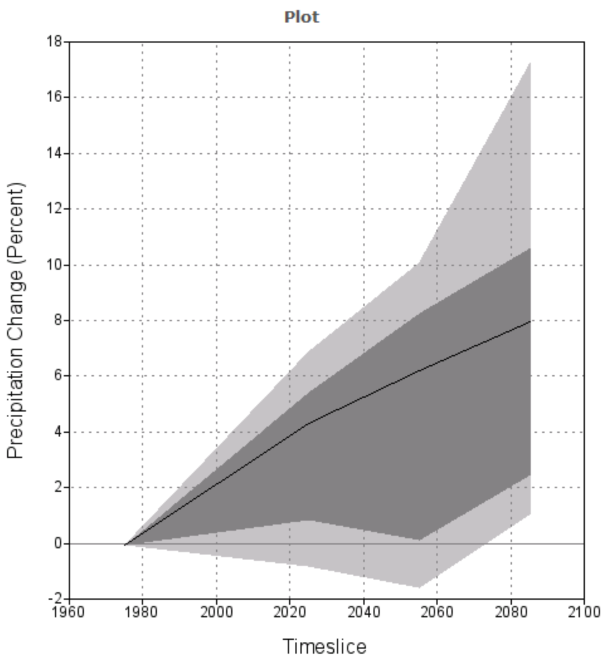


Figure A2-1. Projections for mean temperature in the Okanagan-Similkameen region based on the PCIC Plan2Adapt tool.



The maps show **Annual** precipitation* (rain plus snow) (mm per day) for the **Okanagan-Similkameen** region. The historical map on the far left is based on observed and interpolated station data while the projected map shows how this picture will change by the **2080s** period, based on a single GCM projection. The range plot at far right shows where the change reflected in the projected map (identified by the blue dot) compares to a PCIC standard set of GCM projections. Use this to determine whether the projection used can be considered high or low relative to other projections in the set. Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).



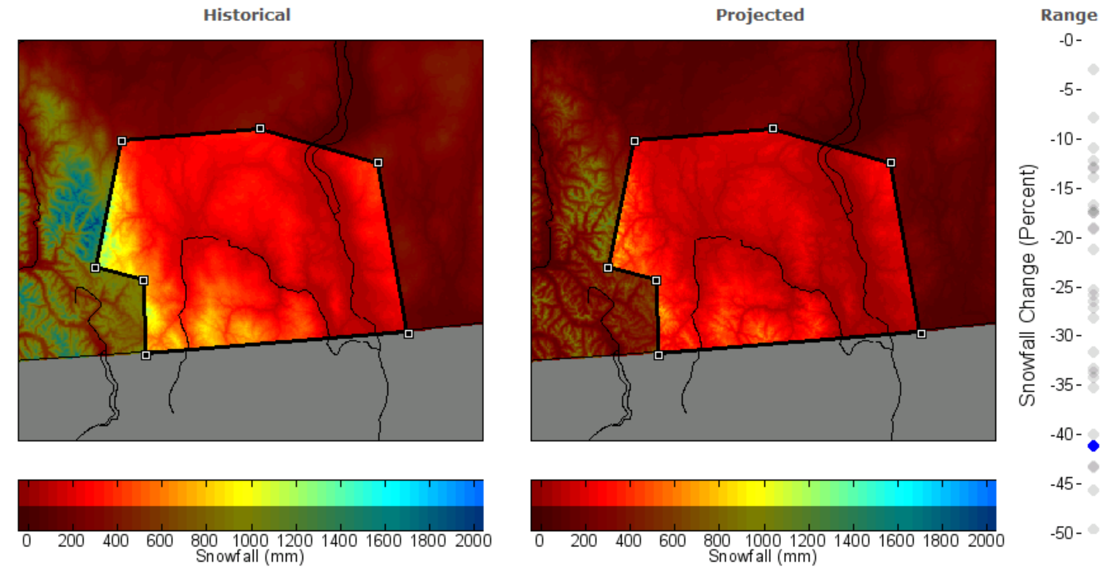
Interpretation

This figure shows the range of projected **Annual** precipitation* (rain plus snow) change (percent) for the **Okanagan-Similkameen** region over three time periods (2020s, 2050s, and 2080s) according to a PCIC standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

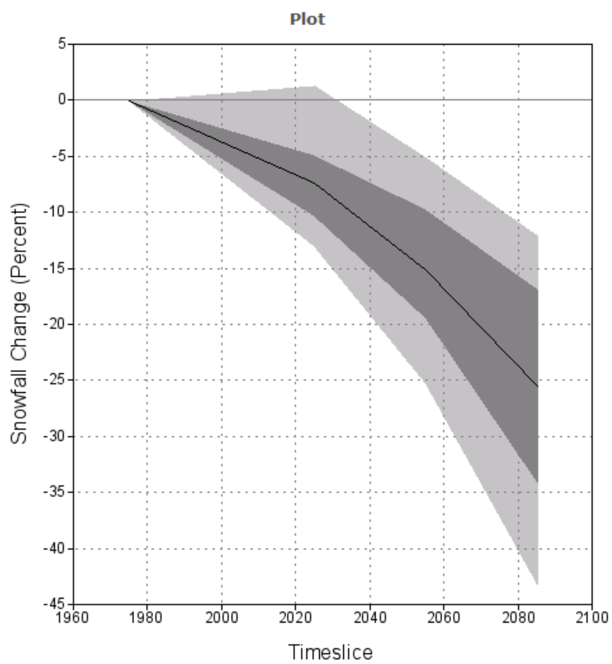
- The black line indicates the mid-point (median) in the set.
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).

Figure A2-2. Projections for mean precipitation in the Okanagan-Similkameen region based on the PCIC Plan2Adapt tool.



The maps show **Annual** precipitation as snow* (mm) for the **Okanagan-Similkameen** region. The historical map on the far left is based on observed and interpolated station data while the projected map shows how this picture will change by the **2080s** period, based on a single GCM projection. The range plot at far right shows where the change reflected in the projected map (identified by the blue dot) compares to a PCIC standard set of GCM projections. Use this to determine whether the projection used can be considered high or low relative to other projections in the set. Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).



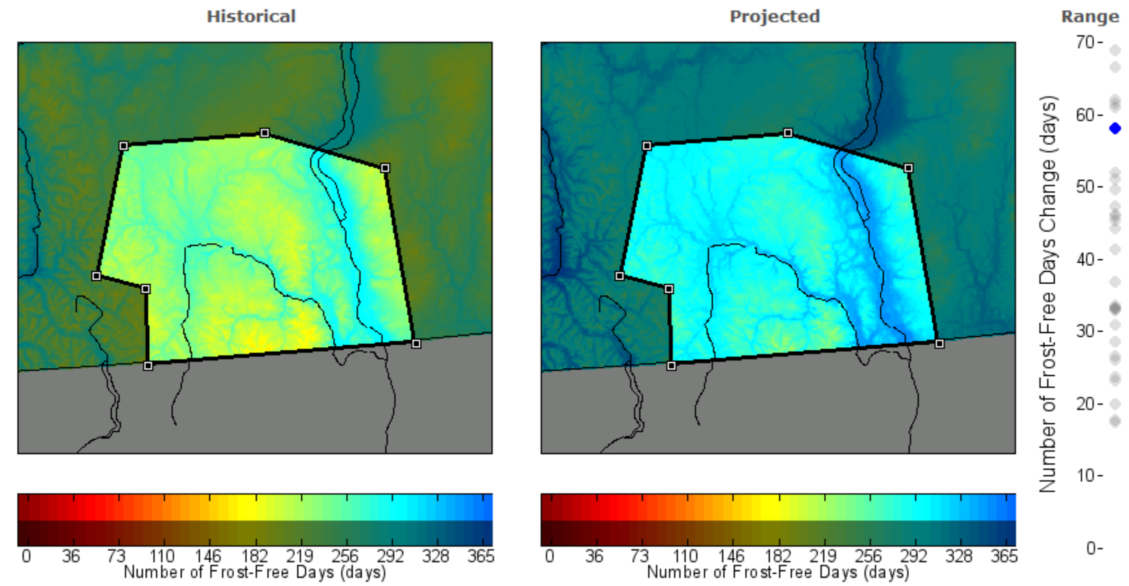
Interpretation

This figure shows the range of projected **Annual** precipitation as snow* change (percent) for the **Okanagan-Similkameen** region over three time periods (2020s, 2050s, and 2080s) according to a PCIC standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

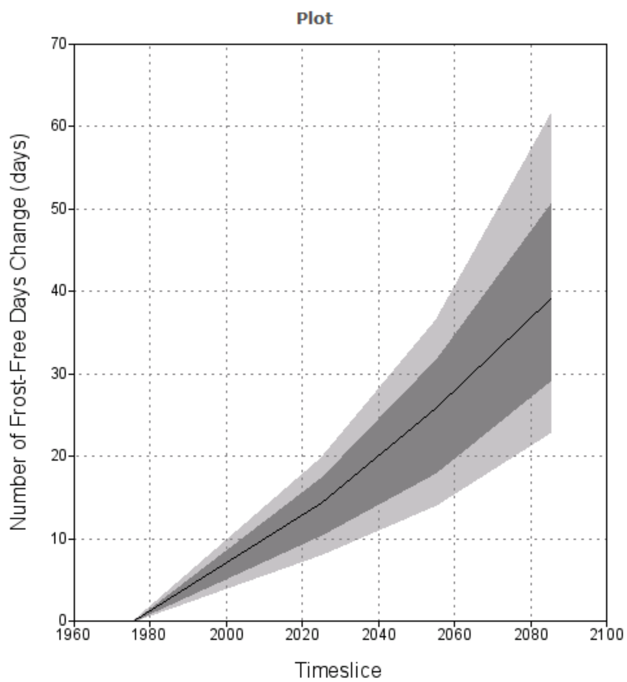
- The black line indicates the mid-point (median) in the set.
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).

Figure A2-3. **Projections for snowfall in the Okanagan-Similkameen region based on the PCIC Plan2Adapt tool.**



The maps show **Annual** frost free days* (days) for the **Okanagan-Similkameen** region. The historical map on the far left is based on observed and interpolated station data while the projected map shows how this picture will change by the **2080s** period, based on a single GCM projection. The range plot at far right shows where the change reflected in the projected map (identified by the blue dot) compares to a PCIC standard set of GCM projections. Use this to determine whether the projection used can be considered high or low relative to other projections in the set. Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).



Interpretation

This figure shows the range of projected **Annual** frost free days* change (days) for the **Okanagan-Similkameen** region over three time periods (2020s, 2050s, and 2080s) according to a PCIC standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

- The black line indicates the mid-point (median) in the set.
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).

Figure A2-4. Projections for number of frost-free days in the Okanagan-Similkameen region based on the PCIC Plan2Adapt tool.

Table A2-1 Similkameen River near Nighthawk: Projected Future Average Monthly Runoff (Source: Hamlet et al. 2010).

Emission Scenario		A1B									B1								
Month	Historical Simulated Volumes (1970-99)	2020s			2040s			2080s			2020s			2040s			2080s		
		Ratio			Ratio			Ratio			Ratio			Ratio			Ratio		
	Dam^3	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Oct	179,593	0.996	0.805	1.143	1.029	0.850	1.315	1.051	0.799	1.392	0.983	0.872	1.045	0.999	0.738	1.151	1.013	0.861	1.205
Nov	178,995	1.115	0.866	1.316	1.299	1.075	1.737	1.593	1.017	2.247	1.111	0.915	1.300	1.185	0.924	1.619	1.420	1.062	1.876
Dec	126,961	1.180	0.899	1.448	1.448	1.120	1.809	2.118	1.423	3.026	1.133	0.975	1.399	1.274	0.888	1.649	1.705	1.281	2.275
Jan	111,230	1.207	0.911	1.609	1.531	1.094	2.200	2.436	1.437	4.062	1.144	0.976	1.336	1.317	0.924	1.669	1.785	1.224	2.758
Feb	97,774	1.243	0.964	1.538	1.576	1.157	2.050	2.472	1.493	3.739	1.236	0.993	1.814	1.371	0.967	1.733	1.994	1.205	3.040
Mar	160,484	1.281	1.021	1.591	1.542	1.139	1.939	2.287	1.403	3.025	1.261	1.055	1.577	1.379	1.015	1.680	1.898	1.186	2.669
Apr	357,207	1.303	1.019	1.665	1.490	1.187	1.929	1.743	1.455	2.225	1.296	1.018	1.466	1.396	1.139	1.892	1.662	1.207	2.431
May	703,940	1.123	1.032	1.253	1.167	1.007	1.406	1.018	0.589	1.440	1.109	1.014	1.397	1.124	1.002	1.393	1.115	0.969	1.255
Jun	802,865	0.913	0.681	1.031	0.815	0.467	1.008	0.543	0.221	0.994	0.914	0.755	1.046	0.852	0.683	1.020	0.695	0.397	0.976
Jul	441,685	0.682	0.444	0.810	0.529	0.304	0.696	0.352	0.240	0.453	0.711	0.562	0.830	0.618	0.445	0.837	0.451	0.340	0.602
Aug	150,261	0.782	0.738	0.871	0.719	0.613	0.863	0.627	0.533	0.805	0.818	0.684	0.937	0.753	0.655	0.882	0.689	0.626	0.799
Sep	126,295	0.902	0.780	1.085	0.847	0.692	1.020	0.831	0.654	1.150	0.910	0.754	1.078	0.871	0.694	1.030	0.850	0.726	1.033
Total (Year)		1.022	0.819	1.204	1.056	0.793	1.335	1.092	0.703	1.575	1.018	0.858	1.212	1.026	0.819	1.291	1.076	0.791	1.433
Total (Apr-Jul)		0.993	0.795	1.155	0.972	0.712	1.213	0.837	0.528	1.218	0.994	0.838	1.177	0.974	0.805	1.234	0.926	0.686	1.215

Notes:

1. April to July cells are shaded grey;
2. ‘Blue’ values = more water forecasted and ‘Red’ values = less water forecasted;
3. Note that under both scenarios, the total average runoff volume for the year is predicted to increase for all periods and decrease during April to July.

Table A2-2 Similkameen River near Nighthawk: Projected Daily Flood Statistics (Source: Hamlet et al. 2010).

Emission Scenario		A1B									B1								
Recurrence Interval (years)	Historical Simulated Peak Flow (1970-99)	2020s			2040s			2080s			2020s			2040s			2080s		
		Ratio			Ratio			Ratio			Ratio			Ratio			Ratio		
	m^3/s	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
20	760	0.981	0.895	1.049	0.991	0.890	1.163	1.040	0.878	1.328	0.967	0.868	1.081	0.966	0.834	1.089	0.983	0.884	1.105
50	832	0.976	0.889	1.038	0.987	0.898	1.159	1.055	0.878	1.352	0.966	0.860	1.079	0.964	0.829	1.079	0.986	0.878	1.101
100	879	0.972	0.876	1.037	0.986	0.904	1.157	1.068	0.877	1.370	0.966	0.853	1.101	0.963	0.827	1.073	0.989	0.873	1.099

Notes:

1. Note that under both scenarios, the average peak flows are not expected to change significantly, but the change in peak flow is considerable.

Table A2-3 Similkameen River near Nighthawk: Projected 7Q10 Low Flow Statistics (Source: Hamlet et al. 2010).

Emission Scenarios		A1B									B1								
Recurrence Interval (years)	Historical Simulated Low Flow (1970-99)	2020s			2040s			2080s			2020s			2040s			2080s		
		Ratio			Ratio			Ratio			Ratio			Ratio			Ratio		
	m^3/s	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
7Q10	24	0.994	0.932	1.068	0.992	0.916	1.053	0.962	0.878	1.033	1.012	0.949	1.096	0.998	0.887	1.090	0.992	0.919	1.094

Notes:

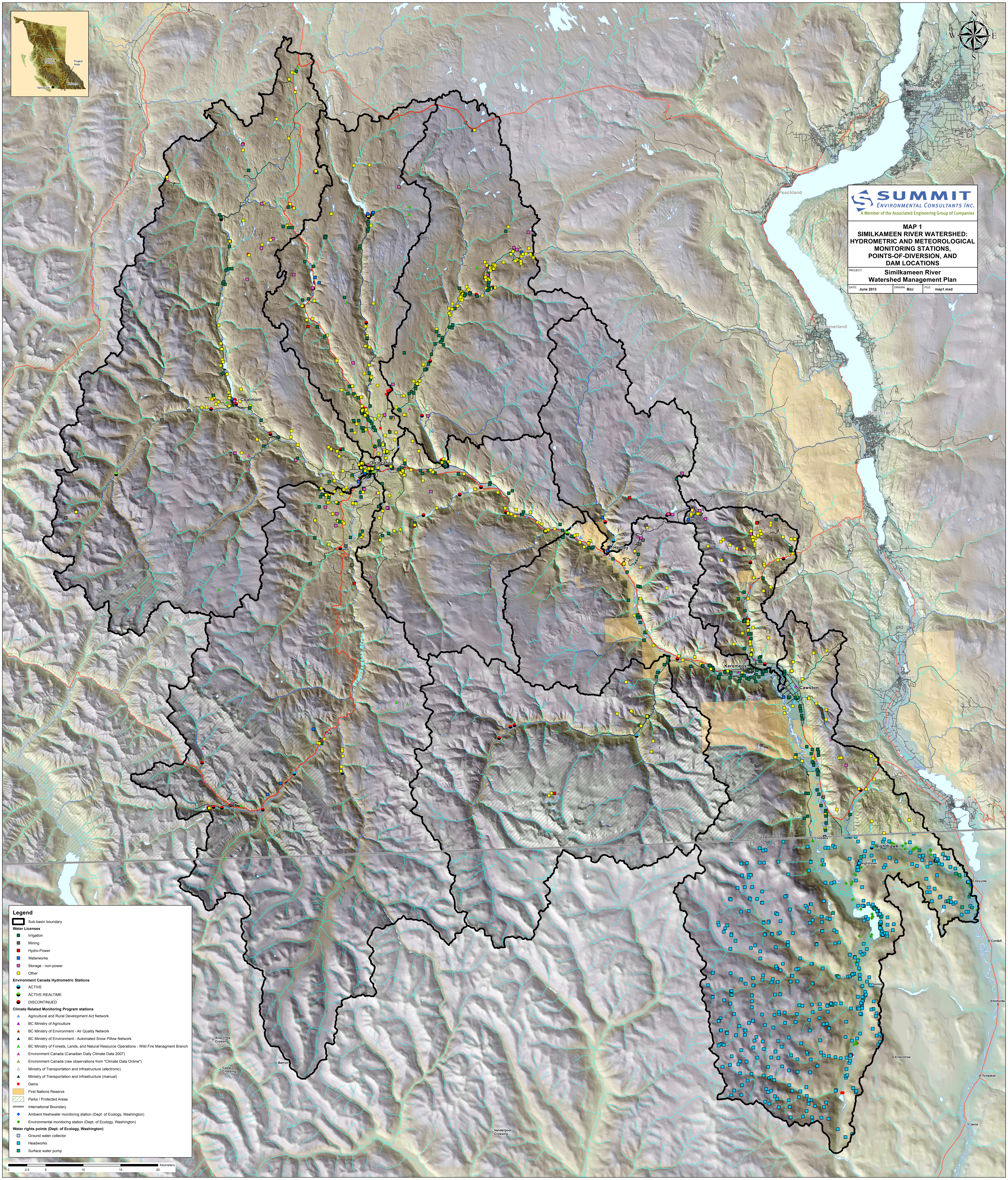
1. Note that under both scenarios, the average monthly flows in the winter are expected to increase, but the 7Q10 flows are not expected to change significantly. However, the range of low flows is considerable.

Table A2-4 Similkameen River near Nighthawk: Project First Day of Month Total Snow Water Equivalent Averaged over the Entire Basin.

Emission Scenario		A1B									B1								
Month	Historical SWE (1970-99)	2020s			2040s			2080s			2020s			2040s			2080s		
		Ratio			Ratio			Ratio			Ratio			Ratio			Ratio		
	mm	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Oct	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nov	4.4	0.685	0.499	0.860	0.439	0.289	0.621	0.249	0.111	0.530	0.642	0.440	0.869	0.535	0.233	0.822	0.395	0.174	0.801
Dec	53.5	0.946	0.693	1.312	0.821	0.636	1.245	0.597	0.372	1.155	0.966	0.667	1.433	0.881	0.610	1.201	0.700	0.407	0.954
Jan	144.3	0.972	0.796	1.175	0.863	0.671	1.089	0.690	0.486	1.078	0.962	0.819	1.283	0.900	0.767	1.091	0.780	0.622	0.930
Feb	231.6	0.970	0.805	1.084	0.877	0.662	0.982	0.693	0.539	1.044	0.946	0.809	1.158	0.897	0.806	0.995	0.823	0.729	0.918
Mar	279.8	0.960	0.815	1.038	0.866	0.686	1.014	0.680	0.486	1.027	0.934	0.806	1.097	0.887	0.796	0.999	0.803	0.667	0.927
Apr	288.4	0.928	0.790	1.027	0.832	0.654	1.018	0.600	0.362	1.014	0.903	0.740	1.062	0.862	0.773	0.991	0.746	0.566	0.933
May	213.7	0.836	0.616	0.990	0.702	0.398	0.943	0.437	0.225	0.954	0.802	0.668	0.935	0.725	0.614	0.933	0.603	0.418	0.908
Jun	95.5	0.695	0.324	0.931	0.501	0.143	0.762	0.229	0.056	0.625	0.661	0.471	0.853	0.545	0.307	0.774	0.404	0.254	0.666
Jul	20.8	0.477	0.107	0.704	0.238	0.013	0.492	0.048	0.004	0.161	0.449	0.242	0.622	0.301	0.126	0.484	0.145	0.053	0.287
Aug	0.7	0.219	0.014	0.507	0.048	0.000	0.246	0.000	0.000	0.000	0.205	0.055	0.370	0.079	0.000	0.219	0.023	0.000	0.109
Sep	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes:

1. April to July cells are shaded grey;
2. ‘Blue’ values = more water forecasted and ‘Red’ values = less water forecasted;
3. Note that during this time frame, the average SWE is predicted to decrease for all periods under both scenarios. In addition, the range is expected to be less than the simulated historical SWE values by the 2080s under the B1 scenario, and for all periods and both scenarios from the months of May to July.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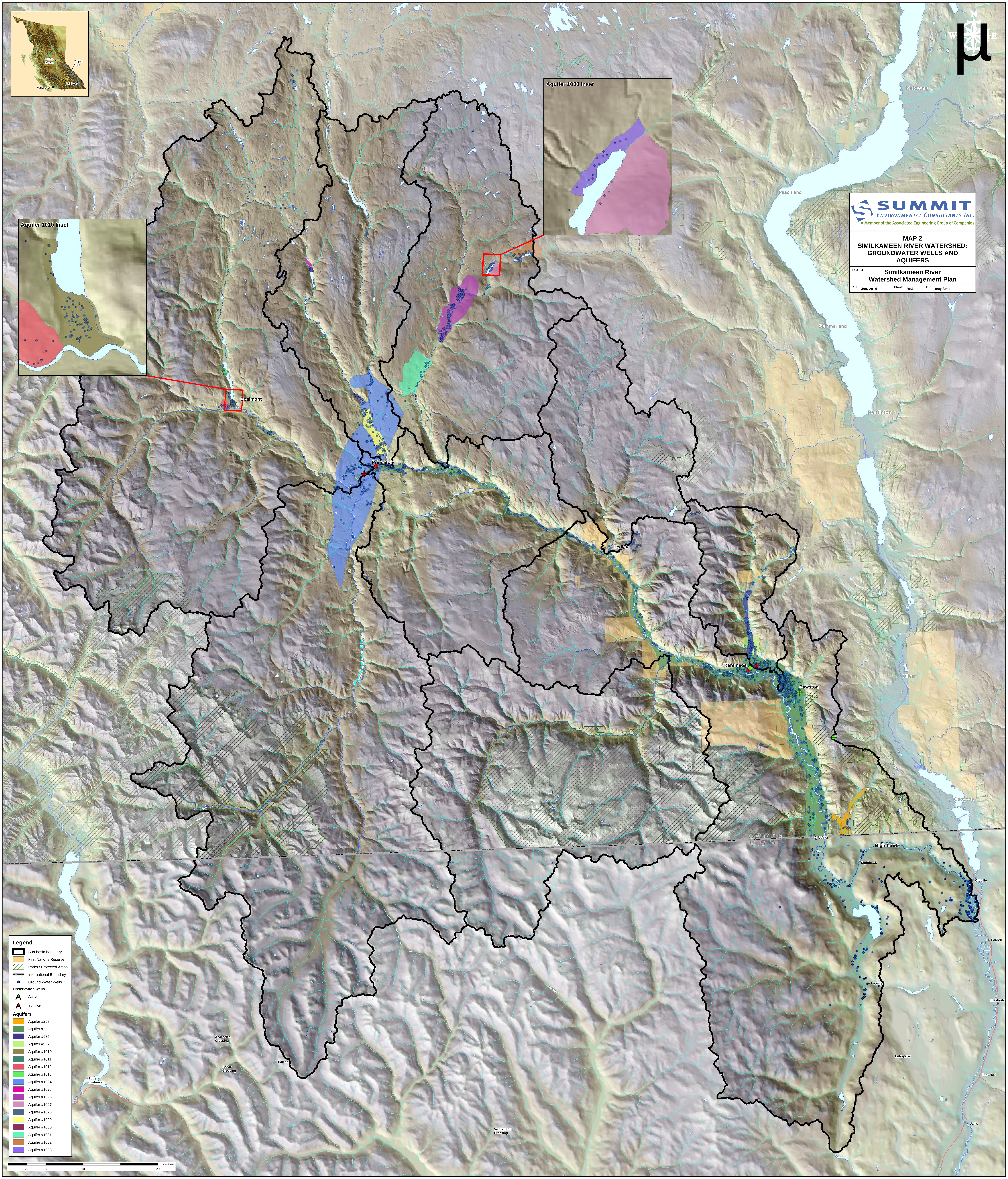
MAP 1
SIMILKAMEEN RIVER WATERSHED:
HYDROMETRIC AND METEOROLOGICAL
MONITORING STATIONS,
POINTS-OF-DIVERSION, AND
DAM LOCATIONS
PROJECT:
Similkameen River
Watershed Management Plan
DATE: June 2013
DRAWN: BdJ
FILE: map1.mxd
Legend
Sub-basin boundary
Water Licenses
Irrigation
Mining
Hydro-Power
Waterworks
Storage - non-power
Other
Environment Canada Hydrometric Stations
ACTIVE
ACTIVE-REALTIME
DISCONTINUED
Climate Related Monitoring Program stations
Agricultural and Rural Development Act Network
BC Ministry of Agriculture
BC Ministry of Environment - Air Quality Network
BC Ministry of Environment - Automated Snow Pillow Network
BC Ministry of Forests, Lands, and Natural Resource Operations - Wild Fire Managment Branch
Environment Canada (Canadian Daily Climate Data 2007)
Environment Canada (raw observations from "Climate Data Online")
Ministry of Transportation and Infrastructure (electronic)
Ministry of Transportation and Infrastructure (manual)
Dams
First Nations Reserve
Parks / Protected Areas
International Boundary
Ambient freshwater monitoring station (Dept. of Ecology, Washington)
Environmental monitoring station (Dept. of Ecology, Washington)
Water rights points (Dept. of Ecology, Washington)
Ground water collector
Headworks
Surface water pump
Kilometers
0 2.5 5 10 15 20
Coalmont
Keremeos
Cawston
Peachland
Nighthawk
Oroville


Aquifer 1033 Inset
Aquifer 1010 Inset
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MAP 2
SIMILKAMEEN RIVER WATERSHED: GROUNDWATER WELLS AND AQUIFERS
PROJECT:
Similkameen River Watershed Management Plan
DATE: Jan. 2014
DRAWN: BdJ
FILE: map2.mxd
Peachland
Summerland
Penticton
Kelowna
Coalmont
Princeton
Hedley
Keremeos
Cawston
Nighthawk
Oroville
Legend
Sub-basin boundary
First Nations Reserve
Parks / Protected Areas
International Boundary
Ground Water Wells
Observation wells
Active
Inactive
Aquifers
Aquifer #258
Aquifer #259
Aquifer #935
Aquifer #937
Aquifer #1010
Aquifer #1011
Aquifer #1012
Aquifer #1013
Aquifer #1024
Aquifer #1025
Aquifer #1026
Aquifer #1027
Aquifer #1028
Aquifer #1029
Aquifer #1030
Aquifer #1031
Aquifer #1032
Aquifer #1033
0
2.5
5
10
15
20
Kilometers