FINAL REPORT

Regional District Okanagan-Similkameen

Similkameen Watershed Plan - Phase 2:
Water Supply, Quality, and Groundwater -
Surface Water Interaction Technical Studies




June 2015

SUMMIT
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Public Works Department
101 Martin Street
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Re: FINAL REPORT: PHASE 2 - SIMILKAMEEN WATERSHED PLAN

Dear Ms. Bloomfield:

Summit Environmental Consultants Inc. is pleased to provide the **final report** for Phase 2 of the Similkameen Watershed Plan (SWP).

Phase 2 of the SWP was considered by the Regional District of Okanagan-Similkameen to be the filling of three of the highest-priority information gaps identified during the Phase 1 study. The three highest-priority information gaps were:

1. Assessment of water availability and risk of inadequate supply (Phase 1 study reference WSD-2);
2. Groundwater – surface water interaction (Phase 1 study reference GW-2); and
3. Status and trends analyses of existing water quality data (Phase 1 study reference WQ-1).

This final report includes an extended executive summary and individual reports attached as appendices that address each of the information gaps.

We trust this completes our assignment to your satisfaction. Please call me or Hugh Hamilton if you have any questions.

Yours truly,
Summit Environmental Consultants Inc.

Drew Lejbak, M.Sc., GIT
Hydrologist

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1 Introduction

1.1 PROJECT OVERVIEW

In the Similkameen River watershed, water availability is determined by rain and snowfall and the storage capacity of lakes, wetlands and aquifers. Concerns over future water shortages have been expressed by watershed residents, related to the potential for increased water demands related to climate change and development,. During dry years, the water suppliers in the Similkameen Valley currently impose conservation measures to ensure that human and environmental needs are met. However, water suppliers will likely need to meet higher future demands through additional surface and groundwater withdrawals, reservoir storage, conservation, and other management tools. Increasing water withdrawals could have effects on both ecological and human use values in the Similkameen River and its tributaries, on both sides of the Canada-U.S. border.

There are 16 known water suppliers and 831 active water licences issued by the B.C. provincial government to store or use surface water within the watershed. This translates to approximately 116,000 megalitres (ML)[1] of surface water licensed for off-stream use and approximately 38,000 ML licensed for in-stream (conservation) and other non-consumptive uses. In addition, groundwater has in recent years quickly become the primary or secondary source of water for many of the water suppliers and many private individuals. A total of 1,873 wells are registered within the watershed, with the majority concentrated near the Similkameen River. To balance water availability and use, good planning is fundamental to account for future climate change, manage the role of water in land use and economic development, and protect the ecological functions that rely on water. Such planning depends on the availability of high-quality scientific, socio-economic, and governance information.

Accordingly, in 2010, the Similkameen Valley Planning Society (SVPS) developed a Strategy for a Sustainable Similkameen Valley, 2011-2020 (Glorioso et al. 2010). The strategy included a focus on improving knowledge of water management and developing a water management action plan for the Similkameen Valley.

In 2011, a water planning scoping study was completed for the Similkameen Valley (Summit 2011). Following that study, SVPS and the Regional District of Okanagan-Similkameen (RDOS) secured funding and moved forward with the Similkameen Watershed Plan (SWP). The SWP Terms of Reference was developed with stakeholder input in 2012 and the Phase 1 study was initiated in 2013. The Phase 1 study assembled and catalogued information, identified potential partnerships and funding sources, outlined a SWP communication plan, identified information gaps that would constrain water planning, and made recommendations to fill those gaps (Summit 2014).

Upon review of the Phase 1 study, RDOS decided to move forward to fill three of the high-priority information gaps to continue development of the SWP. The three highest-priority gaps identified were:

[1] One megalitre is one million litres or 1,000 m^3 (or 220,022 Imperial gallons).

1. Assessment of water availability and risk of inadequate supply (Phase 1 study reference WSD-2);
2. Groundwater – surface water interaction (Phase 1 study reference GW-2); and
3. Status and trends analyses of existing water quality data (Phase 1 study reference WQ-1).

This document brings together the results of each study, which are provided as stand-alone reports in appendices A, B, and C.

1.2 PHASE 2 PROJECT OBJECTIVES

The primary objectives and tasks of the three Phase 2 studies are:

1. **Assessment of water availability and risk of inadequate supply (WSD-2)**
   Objective**:** To compare available surface water supply to current and projected future water use.

   The tasks completed to meet this objective included:
   a. Develop estimates of the natural (or naturalized) flow in the Similkameen River watershed for the most recent normal climate period (i.e. 1981-2010) at the outflow locations of the 10 sub-basins identified in the Phase 1 study. The flow estimates are to include median and 1-in-10 year and 1-in-50 year low flow return periods;
   b. Compare the Ministry of Agriculture's Agriculture Water Demand Model results against records of actual water use obtained for the Phase 1 study;
   c. Identify a number of scenarios that incorporate climate change predictions, changes in agricultural land use, and changes in water conservation technology that are realistic for the Similkameen River watershed; and
   d. Use the AWDM to predict the future agricultural water demand for each scenario.

2. **Groundwater – Surface Water Interaction (GW-2)**
   Objective: To review existing hydrometric, water use, and groundwater data to characterize groundwater – surface water interaction and assess whether there is evidence of groundwater withdrawal effects on streamflows.

   The tasks completed to meet this objective included:
   a. Identify the locations along the Similkameen River where groundwater-surface water interactions likely occur and have implications for water management;
      i. Compile hydrometric data for these key locations and standardize the data to a common time period to eliminate climatic variability (if necessary);
      ii. Compute the runoff at each of the key locations on a monthly basis, both for specific years and for an average year;
      iii. Analyze downstream changes in runoff along the river to identify any anomalies and compare to the locations of known wells; and
      iv. Investigate the possible use of shallow groundwater in any areas where runoff results seem anomalous and confirm the potential for a groundwater withdrawal effect on surface water;

  b. Plot the existing B.C. Government observation well groundwater level data against Water Survey of Canada (WSC) level data from the nearest stations to determine if there are any linkages and the nature of the linkages;
  c. Review the available water quality data from the Similkameen River and shallow groundwater wells to assess the potential for a groundwater – surface water linkage; and
  d. Develop recommendations for follow-up studies, as necessary, to quantify groundwater – surface water interaction in areas where there is sufficiently high groundwater use to potentially affect surface water flows.

3. **Status and Trends Analyses of Existing Water Quality Data (WQ-1**)
   Objective: To summarize water quality conditions at monitoring locations throughout the watershed and to determine if water quality is changing over time (i.e. getting better or worse).

   The tasks completed to meet this objective included:
   a. Calculation of descriptive statistics for the two long-term water quality monitoring sites (Princeton and International Border) that are part of the B.C.-Canada Water Quality Monitoring Agreement. The analysis are to include all data up to 2014 and the following (at a minimum):
      i. Comparison of the results to the water quality guidelines for B.C. (for aquatic life protection, drinking water, recreation, and irrigation) and determination of the frequency of guideline exceedances;
      ii. Assessment of trends, including seasonal trends and potential climate change impacts (within the last 10-15 years at a minimum);
      iii. Assessment of the relationships between river flow and water quality; and
      iv. Assessment of variations in dissolved and total metals, including the role of total suspended sediment concentrations on total metal concentrations.
   b. Compilation and summary of water quality data from all other sites within the watershed and comparison to the two long-term water quality monitoring sites; and
   c. Summarize the water quality and aquatic ecosystem information that has been collected in recent years by industrial operators in the valley.

The results for each of these three technical studies are summarized below in Sections 2.1 (Water Supply), 2.2 (Water Supply and Demand), and 2.3 (Water Quality). The detailed reports are provided as appendices:

- Objective 1 – Assessment of Water Supply Availability and Risk (WSD-2) – Appendix A;
- Objective 2 – Groundwater – Surface Water Interaction (GW-2) – Appendix B; and
- Objective 3 – Status and Trends Analyses of Existing Water Quality Data (WQ-1) – Appendix C.

2 Phase 2 Study Summaries

2.1 ASSESSMENT OF WATER SUPPLY AVAILABILITY AND RISK (WSD-2)

This section provides a summary of the results of the assessment of water supply availability and risk for selected sub-basins within the Similkameen River watershed. The complete report is provided in Appendix A.

2.1.1 Sub-basins and Points-of-Interest

In the Phase 1 study, to address water supply and demand investigations at an appropriate scale, the Similkameen River watershed was divided into 10 sub-basins (Figure 2-1). These sub-basins and their downstream points-of-interest (POIs) formed the basis for the assessment of water availability and risk in Phase 2. The POIs were as follows:

- POI #1 – Similkameen River above the Tulameen River Confluence;
- POI #2 – Tulameen River at the Mouth;
- POI #3 – Allison Creek at the Mouth;
- POI #4 – Hayes Creek at the Mouth;
- POI #5 – Similkameen River near Hedley (at Water Survey of Canada Station No. 08NL038);
- POI #6 – Hedley Creek at the Mouth;
- POI #7 – Keremeos Creek at the Mouth;
- POI #8 – Ashnola River at the Mouth;
- POI #9 – Similkameen River at the International Border; and
- POI #10 – Similkameen River at the Mouth (Canada water use only).

At each POI, median annual and monthly values were estimated for the following indicators of water availability and use:

- Net flow;
- Naturalized flow;
- Total licensed quantity for both off-stream and in-stream purposes;
- Licensed quantity for off-stream purposes;
- Licensed quantity for in-stream purposes;
- Licensed quantity for storage;
- Estimated actual off-stream use (not including major suppliers); and
- Estimated actual water purveyor use (including groundwater).

The values were estimated for a standard 30-year period (1981-2010) using available streamflow records, actual water use information, water demand estimates from the Agriculture Water Demand Model (AWDM), and water licences.

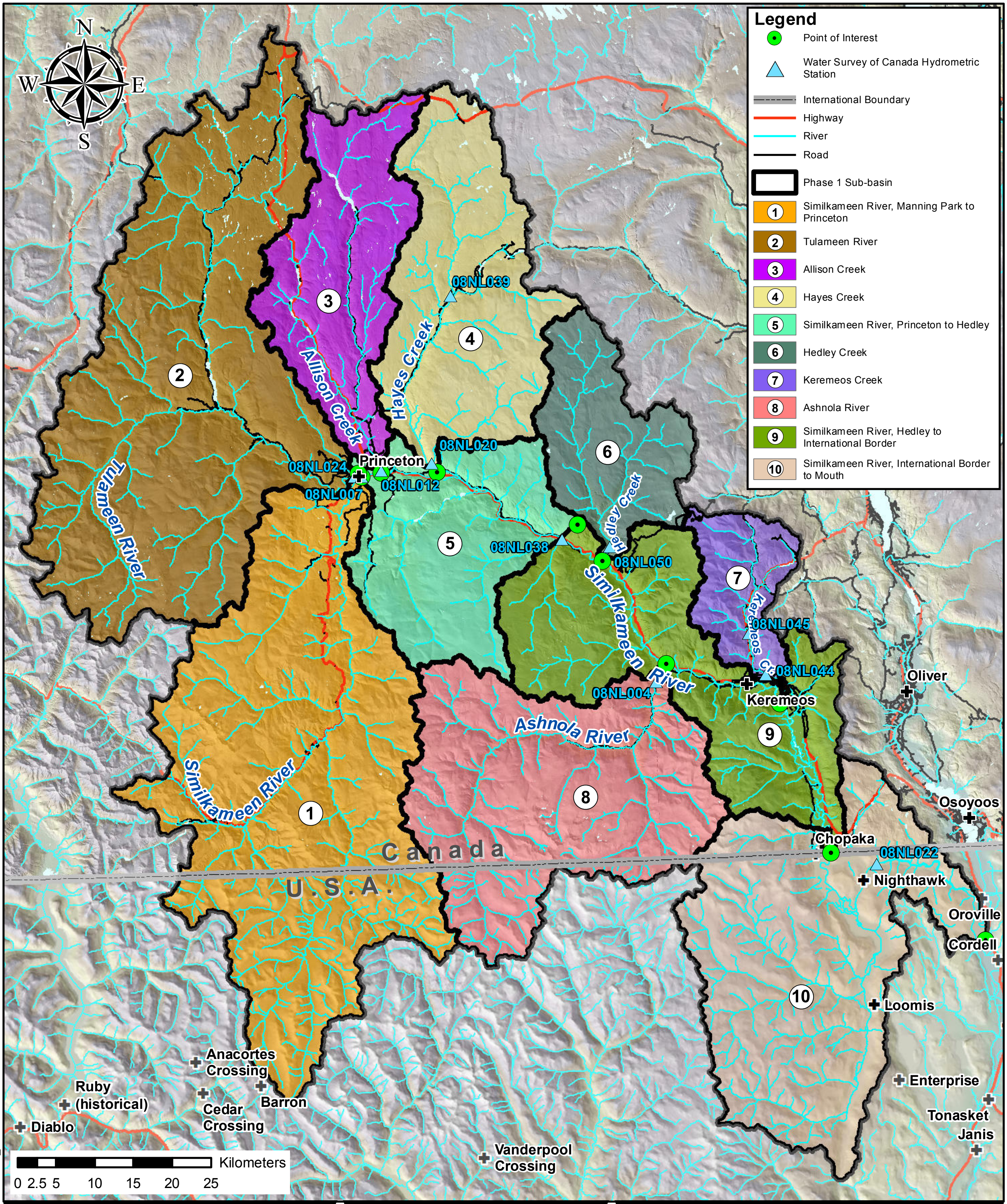

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FIGURE 2-1: SUB-BASINS AND POINTS OF INTEREST IN THE SIMILKAMEEN WATERSHED

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Similkameen Watershed Plan - Phase 2

2.1.2 Water Supply Availability Assessment

Once water availability and use information was estimated for each sub-basin, a water supply availability risk review was completed. Risk is defined here as the inability of a surface water resource to provide the necessary volume of water to meet human requirements under median conditions for the standard period (using a monthly timescale). Risk ratings of low, medium, and high were assigned to each sub-basin based on water use and licensing compared with naturalized flows. The risk ratings are:

- *Low* for Similkameen River above the Tulameen River Confluence, Tulameen River, Hayes Creek, Similkameen River near Hedley, Hedley Creek, and Ashnola River;
- *Moderate* for Similkameen River at the International Border; and
- *High* for Keremeos Creek and Allison Creek.

In addition to the water supply risk review for <u>current</u> conditions, three scenarios were selected to investigate <u>future</u> water demands within the Similkameen River watershed using three climate models and the Agriculture Water Demand Model. The scenarios were selected to assess how different combinations of future climate conditions and potential land use and crop type changes could influence water demands from 2011-2070 in comparison with the 1981-2010 standard period. Scenario comparison results were completed for the Canadian portion of the Similkameen River watershed and for the Keremeos Creek sub-basin to provide a total watershed and sub-basin perspective, respectively. The scenarios are:

1. Scenario A – No change to existing agricultural land base and irrigation type and considering climate change influences only;
2. Scenario B – Add irrigation to all existing and non-irrigated lands, plus potential agricultural lands and consider climate change influences to the existing and expanded irrigation areas; and
3. Scenario C – Maintain existing agricultural land base and irrigation type, except that 2% of the currently irrigated non-grape land base in the Keremeos Creek and Similkameen River – Hedley to International Border sub-basins are assumed to be converted to grape crops for three consecutive years (i.e. 6% increase in total) and is then maintained at constant levels. This scenario is intended to illustrate how climate change would interact with a change in agricultural use (i.e. an increase in grape production) to affect water demand. It is provided only as an example of what could happen if agricultural land-use changes, and is not an actual prediction.

The results are summarized as follows:

- There is trend towards increasing water demand and variability of supply in the future;
- Under climate change only (Scenario A), the annual agricultural water demand is predicted to increase by approximately 16-28% for the entire watershed and 12-20% for the Keremeos Creek sub-basin between the period 2011-2070;
- Under climate change and expanded irrigated area (Scenario B), the annual agricultural water demand is predicted to be 16% greater for the entire watershed and 5% greater for the Keremeos Creek sub-basin in comparison to climate change alone; and
- Under climate change and an increase in grape crops (Scenario C), the annual agricultural water demands are predicted to be less than the two other scenarios.

2.1.3 Summary of Results and Recommendations

Based on the results, increase water demands are predicted for the future. This could impact water availability in the Canadian portion of the Similkameen River watershed and corresponding sub-basins. In particular, with increased water demand in the future and warmer, dry summers, water supply availability could decrease and result in water shortages occurring more frequently than what are already being observed.

Note that there is a reasonable degree of confidence in the median annual and monthly streamflow values for the 10 POIs, though limitations (or absence) of sub-basin information dictated that certain estimates and a number of assumptions were required. Therefore, the following recommendations are provided to improve the understanding of water supply availability and risk within the Similkameen River watershed:

- Meet with the Water Survey of Canada to determine their long-term plans for hydrometric monitoring in the watershed. RDOS and SVPS should work cooperatively with WSC to ensure that hydrometric monitoring continues at the existing stations in the watershed, given their importance in informing water management plans.
- Complete a detailed groundwater-surface water interaction assessment within the Keremeos Creek sub-basin to determine whether observed low flows were related to water use (surface and groundwater) or due to losing stream conditions (i.e. streamflows lost to the channel bed). This recommendation is consistent with the results from Section 2.2 (below).
- Update the water availability and risk review results presented in this investigation with new water use information (as it becomes available) from other sources (e.g. Lower and Upper Similkameen Indian Bands, United States).
- Develop future water demand scenarios to support long-term growth strategies for the SWP, building on the three initial scenarios used here. The scenarios should consider at a minimum population growth, economic development, and climate.
- Complete an environmental flow needs[2] (EFN) assessment to provide a complete assessment of water availability and risk within the Similkameen River watershed. EFN is defined in the *Water Sustainability Act* as “the volume and timing of water flow required for the proper functioning of the aquatic ecosystem of the stream”. This report has helped to clarify potential water demand and total supply, but an EFN study is needed to determine how that demand compares to supply when environmental needs are factored in.

[2] “Environmental Flow Needs” (EFN) has replaced the old term In-stream Flow Needs (IFN). Under Section 15 of the draft *Water Sustainability Act*, “the decision maker must consider the environmental flow needs of a stream in deciding an application in relation to the stream or an aquifer the decision maker considers is reasonably likely to be hydraulically connected to that stream”.

2.2 GROUNDWATER - SURFACE WATER INTERACTION (GW-2)

This section provides a summary of the results of the groundwater – surface water (GW-SW) interaction investigation within the Similkameen River watershed. The complete report is provided in Appendix B.

2.2.1 Background

Prior to 2014, little work had been undertaken on groundwater – surface water (GW-SW) interaction in the Similkameen River watershed. As part of groundwater protection planning for the Keremeos Irrigation District, Golder (2008) used a numerical model to estimate 100-day and one-year travel time capture zones[3] from three well fields located 200 m, 850 m, and 1,000 m from the Similkameen River. The results indicated that the pumping of large water supply wells located some distance from the Similkameen River can draw water from the river into the aquifer. A more recent study (Golder [2012]) was not publically available at this time of this report, so a summary of results could not be provided.

2.2.2 Methods

2.2.2.1 Identification of Key Groundwater – Surface Water Locations

Given the Golder (2008) results and the limited amount of GW-SW interaction information available for the Similkameen River watershed, an initial screening exercise was completed to identify key locations where surface water could be influenced by groundwater withdrawals. This screening assessment involved two tasks:

1. Mapping groundwater wells within watershed boundaries and screening by interaction potential. All wells that were ≤6-inch diameter and located more than 100 m from a stream, and all wells >6-inch diameter located more than 300 m from a stream were eliminated from further study. The remaining wells were judged to be those with the greater potential to interact with surface water.
2. Identifying areas with potentially high groundwater extraction rates. Based on the results of the screening, the Similkameen sub-basins (Figure 2-1) were sorted by the number of wells that met both criteria, with particular emphasis on the >6-inch diameter criteria.

Following the above methods, two key GW-SW interaction locations were identified:

- Key GW-SW Interaction Location 1 – Similkameen River near Keremeos and Cawston; and
- Key GW-SW Interaction Location 2 – Keremeos Creek Valley.

For each of these locations, to assess whether groundwater withdrawals were affecting streamflows at or near the key locations, net[4] and naturalized[5] streamflow estimates at selected points-of-interest within the

[3] A capture zone is defined as the spatial region surrounding a water supply well, in which water will flow into a well within a period of time (Toews and Allen 2007).

[4] Net streamflows are streamflows that include water extractions and storage effects upstream.

[5] Naturalized streamflows are streamflows that are estimates of natural flows adjusting net flows for the effects of water withdrawals and storage.

Similkameen River watershed (Figure 2-1) (from Section 2.1) were compiled. The flow estimates for upstream and downstream of the two key locations were then assessed for evidence of GW-SW interaction. An increase in flow would mean that the stream is a “gaining stream” and a reduction in flow would mean that it is a “losing stream”.

Following this, an assessment of the net groundwater flow contribution to surface water at each of the key GW-SW interaction locations was also completed to review groundwater withdrawals in comparison to groundwater recharge. This assessment assumed that all groundwater recharge by upgradient aquifer contribution and direct precipitation was naturally discharged to a stream/river and was equal to natural baseflow (i.e. groundwater component of streamflow). Because natural losing streamflow conditions are not uncommon for streams flowing across alluvial deposits in certain hydrogeological settings, this alternative approach was used to assess whether groundwater withdrawals have the potential to affect streamflows at the key GW-SW interaction locations.

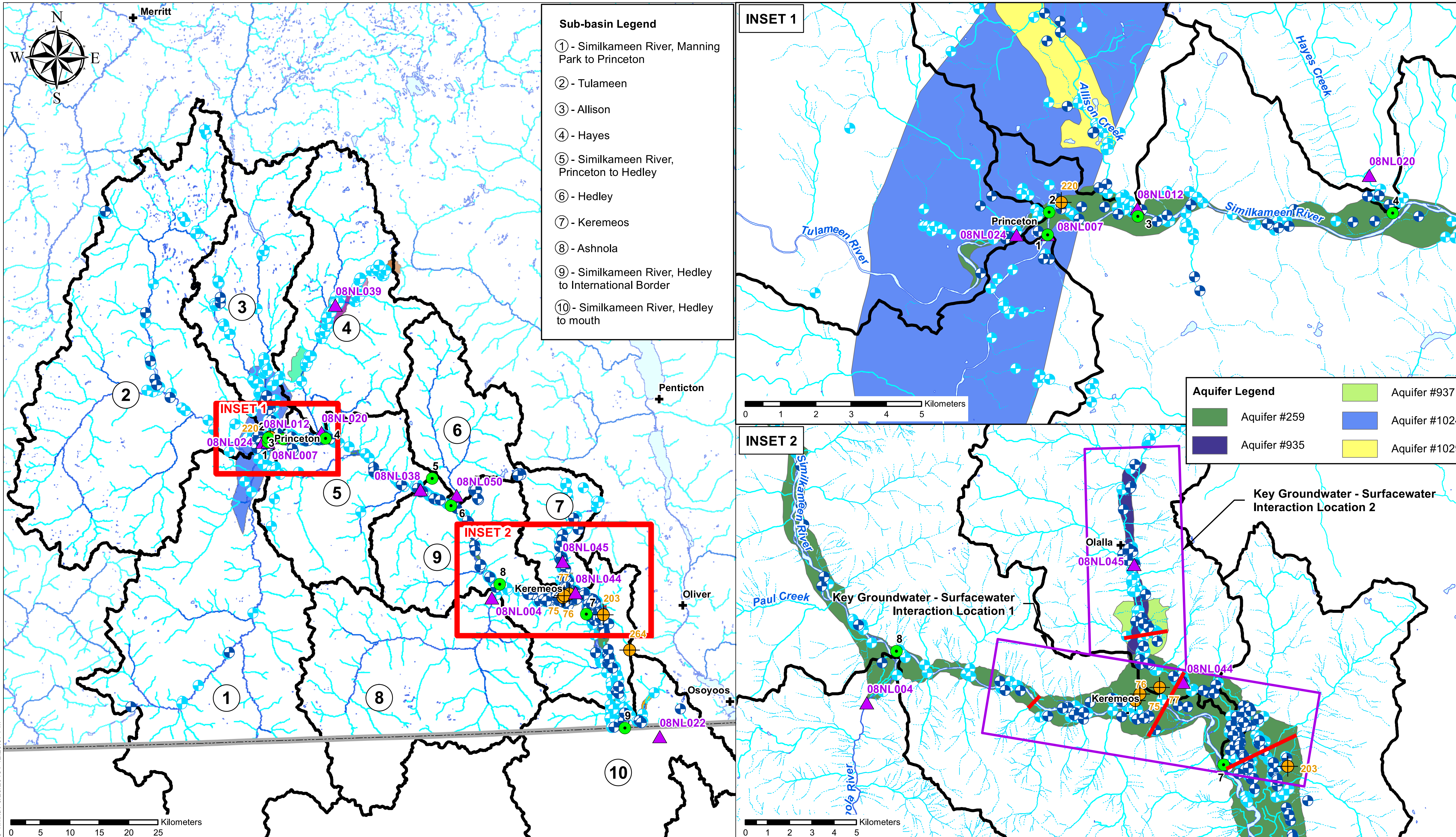
2.2.2.2 Observation Well Assessment

Another way to investigate the linkages between groundwater and surface water within in the Similkameen River watershed was to compare groundwater levels or quality data to nearby streamflow levels or quality data, respectively, to evaluate for apparent relationships. In the Similkameen River watershed, there are three active and three inactive observation wells for which groundwater level data was available (Figure 2-2). The observation wells are the responsibility of B.C. Ministry of Forests, Lands, and Natural Resource Operations.

The locations of the observation wells were assessed relative to the locations of nearby WSC hydrometric stations to determine whether any wells and hydrometric stations were within close proximity of each other and had overlapping datasets:

- Active Observation Wells 75 (Keremeos) and 203 (Cawston) are of particular interest because they are installed within the mapped sand and gravel aquifer along the river valley; however, no WSC hydrometric station(s) on the Similkameen River were located in close proximity for comparison purposes. However, data from a discontinued station on Keremeos Creek includes a period of overlapping records with Well 75 (Keremeos);
- Observation Well 220 (Princeton) has been inactive since 1999; however, two WSC hydrometric stations were located in close proximity to but upstream of the well location; and
- Observation Well 264 (active) was not considered further because it is installed in bedrock above the Similkameen River valley.

For the identified observation wells, a statistical trend analysis was completed for all available groundwater level datasets for the observation wells in Keremeos (Well 75), Cawston (Well 203), and Princeton (Well 220). The purpose of trend analysis was to determine whether there was a statistically significant change (i.e. increase or decrease) in the groundwater level over time.



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Ground water wells > 6 inch (within 300 m of a stream)

Ground water wells ≤ 6 inch (within 100 m of a stream)

Point of Interest (Summit 2015)

Water Survey of Canada Hydrometric Station

FLNRO observation well

Sub-basin boundary

International Boundary

Selected locations of groundwater & surface flux calculations

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FIGURE 2-2: SIMILKAMEEN WATERSHED & INSETS SHOWING WELLS THAT MEET INITIAL SCREENING CRITERIA

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In addition to the groundwater and streamflow level review and trend analysis, water chemistry at available surface water quality sites was compared to the water chemistry at groundwater sites to yield information about residence times, source water type, and whether groundwater is under the influence of surface water. A review of the provincial Environmental Monitoring System database identified two locations within the Similkameen River watershed where registered wells with water quality data were located in close proximity to surface water quality sites. The two locations were as follows:

- Hedley – Groundwater samples were previously collected in 1998, 2001, and 2002 from a registered well. The well is located approximately 500 m downstream of the Similkameen River at 20 Mile Creek surface water quality site (see Section 2.3).
- Princeton – Groundwater samples were collected in 1987, 1997, and 2001 from Princeton Observation Well 220, which is located approximately 700 m downstream of the Similkameen River at Princeton surface water monitoring site (see Section 2.3).

2.2.3 Summary of Results

The main results of the GW-SW interaction investigation are summarized as follows:

- The Similkameen watershed is made up of mountainous terrain with steep valley walls and narrow u-shaped valley bottoms. The valley bottoms are made up of high permeability sand and gravel aquifers. The sand and gravel aquifers beneath the valley streams are hydraulically connected to those streams. Evidence to support this is as follows:
    a. Water levels in groundwater near Keremeos and in the nearby Similkameen River have been compared and are close to each other (Golder 2008).
    b. Measured groundwater flow is both towards the Similkameen River and parallel to river. In addition, streamflow losses have been documented between upstream and downstream locations in Similkameen River and Keremeos Creek near Keremeos (Golder 2008). Modelling results show that a large portion of groundwater was being recharged by natural streamflow losses from both these surface water bodies.
    c. Keremeos Creek was identified to be a losing stream between upstream and downstream WSC hydrometric stations during at least one month of each of the seven years (1971-1977) both stations were recording data.
    d. At two key locations of GW-SW interaction, Location 1 – Similkameen River near Keremeos and Cawston and Location 2 – Keremeos Creek Valley (Figure 2-2), a simple water balance model showed that without the natural inflow of water from the stream beds, the groundwater pumping would exceed the aquifer recharge from other sources.
    e. Water levels in observation wells go up and down at similar times as river levels at nearby WSC hydrometric stations, with only slight lags between peaks (Figure 2-3).

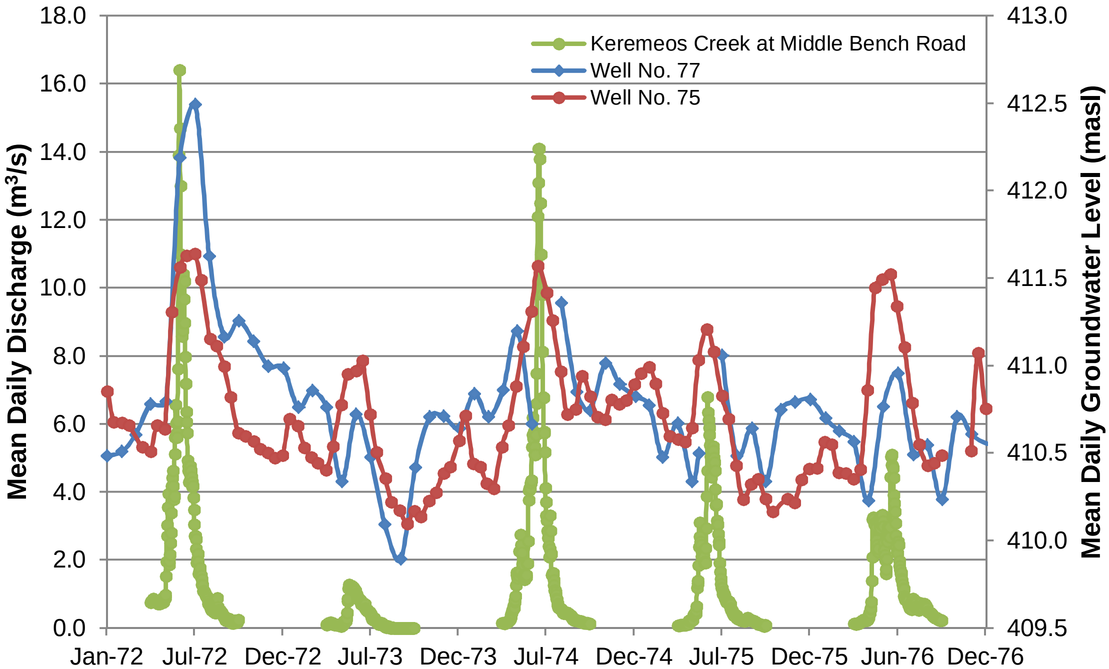

Figure 2-3 Streamflow and groundwater level comparison for Sub-basin #7 (Keremeos Creek), 1971-1977

- Even though the aquifers and streams/rivers in the Similkameen River watershed are closely linked, and the losing streams are recharge sources for groundwater in the valley bottom, the magnitude of the total streamflow compared to total water withdrawals were assessed as a first step in determining whether groundwater use would significantly affect streamflows. The results indicate that in the Similkameen watershed, groundwater use is small compared to flow in the main streams in nine of the ten sub-basins.
    a. Comparisons of streamflows during the month with the lowest flow (typically September) to the groundwater withdrawals during the month with the highest extraction (typically July) show that groundwater withdrawals are currently less than 10% of the streamflows in all but one sub-basin (i.e. Keremeos Creek sub-basin).
    b. Even when comparing groundwater withdrawals to a 1 in 50-year return period low flow, groundwater withdrawals are currently less than 20% of streamflows in all but one sub-basin (i.e. Keremeos Creek sub-basin).

- Statistical trend analysis indicated that groundwater levels decreased slightly over the period of record in the three observation wells: Well 75 (Keremeos) (since 1963), Well 203 (Cawston) (since 1977), and Well 220 (Princeton) (between 1977 and 2000). During the same periods, precipitation did not decrease, suggesting that the slight decrease in groundwater levels was likely not related to climatic influences and may have been a result of groundwater withdrawals exceeding the rate of groundwater recharge. However, the groundwater level records since 2000 indicate flat to slight increasing water level trends, which suggests that groundwater withdrawals may be reaching more sustainable rates reflecting more efficient irrigation methods, crop changes to those that use less water, or land use changes.

- Despite the indication of sustainable rates of groundwater use since 2000, the overall data record indicates that the aquifers in this part of the watershed are sensitive to groundwater use, and that an increase in use from current conditions could again cause a decline. Additional investigations are needed to confirm this and to develop quantitative estimates of changes in groundwater levels.

2.2.4 Recommendations

Management recommendations for the SWP

- Generally consider groundwater and surface water to be a single source of water in the valley bottom portions of the Similkameen watershed where there is agricultural land use and where most people reside
- The SWP should include requirements for proposals for new groundwater or surface water withdrawals to be supported by assessments of potential effects on both surface water and groundwater, recognizing their connected nature.
- As recommended in the Water Availability study (Section 2.1), develop environmental flow needs for each sub-basin, starting with Keremeos Creek and Similkameen River near Keremeos/Cawston. This will assist developers with determining how much groundwater or surface water withdrawals are reasonable for each area.
- The SWP should consider a requirement to monitor water levels in any new well that is 6 inches in diameter or larger. In addition to adding to the database of water levels, it will enable the water user to make management decisions based local information.
- In Sub-basin #7 (Keremeos Creek), consider limiting additional groundwater use until there is evidence that streamflow levels are stable. Installation of a new observation well and hydrometric station in the lower portion of the Keremeos Creek sub-basin is recommended to enable monitoring of this sensitive area.
- New groundwater withdrawals in Sub-basin #9 should also be limited until a detailed study of GW-SW interaction is complete. The can make use of the existing observation wells, but would likely require additional field investigations (see below).

Research, Planning Studies, and Monitoring Network Recommendations

- Currently Aquifer 259 is a mapped aquifer in the main Similkameen River valley bottom extending from the U.S. border to Princeton. It is mapped as one single unit of sands and gravels, but it unlikely homogeneous for the entire mapped spatial extent. As a result, updated mapping and creation of unique numbered system of aquifers underlying all lands in the watershed is recommended to support management decisions throughout the watershed. This will enable groundwater management to be tailored specifically to aquifer characteristics and the demand on that aquifer.

- The current FLNRO observation well program includes three active monitoring wells within the Similkameen River watershed. This number of observation wells should be considered as the minimum number to enable a basic program of monitoring of groundwater levels within the watershed. To provide additional groundwater monitoring support and to provide additional GW-SW interaction information, consider augmenting the FLNRO observation well network as follows:

  - Keremeos Creek was identified to lose streamflows through the Keremeos Creek valley. To support GW-SW interaction investigations, hold discussions with the WSC and FLNRO to consider reactivating WSC hydrometric station 08NL044 on Keremeos Creek and to install an observation well next to the station;
  - Work with the FLNRO to reactivate the discontinued observation well in Princeton (Well 220). This well showed a downward trend in groundwater levels prior to being discontinued.
  - In future, if large groundwater withdrawals are planned for aquifers where an observation well is not located, meet with FLNRO to discuss installing an observation well.

- Although the available data and previous studies provide some understanding about the nature of groundwater-surface water interaction in the Similkameen watershed, the topic has not been studied in detail. As a result, only estimates exist for many of the key fluxes of the groundwater component of the hydrologic cycle. There would be value in addressing this lack of quantitative information by carrying out a detailed investigation of the alluvial aquifers in the Keremeos-Cawston area to obtain a better understanding of aquifer recharge processes and the effects of groundwater pumping on flows in tributary streams and the Similkameen River. This would involve a combination of field studies (i.e. additional streamflow monitoring, pumping tests, and possibly well installation) and modelling. Keremeos-Cawston is the suggested location because it is the area most likely to see an increase in water demand, but also because information obtained there is applicable to other areas in the valley where tributary stream have created an alluvial fan in the valley bottom. The recharge processes that would be examined include stream losses (tributaries and main stem), mountain block recharge, and direct precipitation.

  Completion of the Similkameen Watershed Plan can proceed without the information that would be obtained from the recommended GW-SW study. However, given the importance of groundwater in the valley, the detailed assessment should be considered for the next three to five years. SVPS and RDOS may wish to consider forming partnerships with other levels of government (including LSIB and USIB) and the university research community to carry out the work.

2.3 WATER QUALITY: STATUS AND TRENDS ANALYSES OF AVAILABLE DATA (WQ-1)

This section provides a summary of the results of the status and trends analyses of existing water quality data within the Similkameen River watershed. The complete report is provided in Appendix C.

2.3.1 Water Quality Monitoring Locations

The 2011 scoping study and the Phase 1 study summarized the results of the information search that was completed to determine how much surface water quality data was in the public domain. The results showed that there was a number of surface water quality monitoring sites in the Similkameen watershed with a significant amount of data. Of particular interest were the two active long-term water quality monitoring sites along the Similkameen River that have a significant amount of data: one near Princeton, and the other near the U.S. border (Figure 2-4). These two sites are monitored as part of the B.C.-Canada Water Quality Monitoring Agreement and water quality testing is on-going (i.e. water sampling every two weeks).[6]

Because of the significant amount of available data and importance of the B.C.-Canada sites, the two active monitoring sites (i.e. Similkameen at Princeton and Similkameen at International Border) were selected for detailed analysis (including trend analysis). Select analyses were also completed for a third long-term monitoring site (decommissioned in 1996) at Hedley (Similkameen River at 20 Mile Creek).

In addition to the B.C.-Canada data, water quality data from the provincial Environmental Monitoring System (EMS) Web Reporting database was analyzed for the following key locations in the Similkameen River watershed (Figure 2-4):

- Similkameen River near Princeton (upstream and downstream of the wastewater treatment facility outfall);
- Similkameen River near Keremeos (upstream and downstream of the wastewater treatment facility outfall); and
- Hedley Creek downstream of the Nickel Plate Mine.

These sites were selected because they have at least five years of data, they were sampled for parameters of interest given the water uses, and they are indicative of water quality either in important tributaries to the Similkameen River or at locations that provide information on the potential effects of land use, water use, and/or industrial activity.

[6] The B.C.-Canada Water Quality Monitoring Agreement is an agreement signed in 1985 with the purpose of coordinating and integrating water quality monitoring by Environment Canada and the B.C. Ministry of Environment.

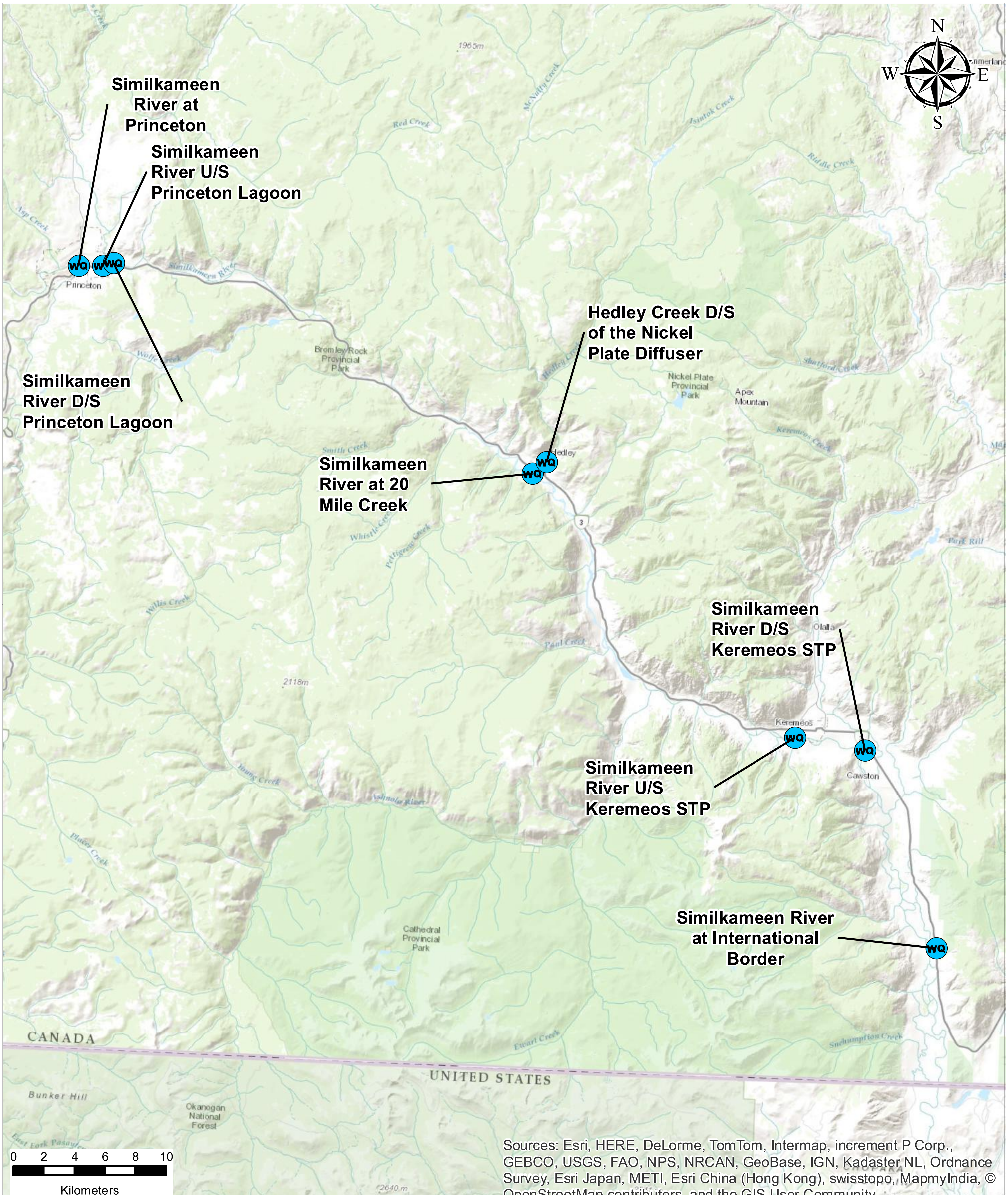

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FIGURE 2-4: WATER QUALITY MONITORING SITES

Regional District of Okanagan Similkameen

Similkameen Valley Watershed Plan Phase 2

2.3.2 Methods

Once the data for the sites were obtained and formatted, analyses were conducted to assess the current state of water quality in the Similkameen watershed. The analysis included:

- Data screening and normality testing (all sites);
- Calculation of descriptive statistics to provide a summary of the available water quality data (all sites);
- Comparison of water quality results to applicable provincial guidelines and Similkameen River and Hedley Creek water quality objectives to identify parameters of concern and narrow the focus of additional analysis (all sites);
- Comparison of differences between upstream and downstream water quality to see if effluent discharges from wastewater treatment plants are affecting water quality (at select sites);
- Trend analysis to determine whether water quality and quantity of the Similkameen River is changing over time (at select sites); and
- Assessment of the relationship between river flow and water quality results to identify times of the year when water quality may be of greater concern (at select sites).

2.3.3 Summary of Results

The main results of the water quality assessment are summarized as follows:

- The findings of the water quality guideline comparison of the B.C.-Canada sites were similar to those found when the B.C. and federal governments last reviewed the data (Swain 2007a; 2007b). When the 95^{th} percentile concentrations were compared to guideline and objective levels, relatively few exceedances were found. The parameters that did exceed guidelines at one or more sites included water temperature, pH, fecal coliforms, colour, dissolved oxygen, several total metals (aluminum, chromium, copper, iron, and manganese), and strong acid dissociable cyanide.

- The water quality is generally similar between the three B.C.-Canada sites. The main difference noted was the International Border site, which had higher average concentrations of a number of metals.

- Statistically significant upward trends (i.e. increasing concentration over time) were found for total nitrogen, total dissolved nitrogen, and turbidity at both the Princeton site and International Border site, pH at the International Border site, and arsenic at the Princeton site. However, the magnitude of the trends was small and the results may be affected by the lack of consistent sampling interval. Conversely, statistically significant decreasing trends (i.e. decreasing concentration over time) were found for a number of metals including arsenic (International Border site only), aluminum, copper, iron, and zinc.

- Mean monthly streamflows do not appear to be changing at the International Border site. At the Princeton site, a very slight downward trend was found; however, downward trends were not observed during the late summer months when water demand is at its highest and in-stream flow needs for fish are most likely to be constrained.

- As expected, there is a relatively strong relationship between river flow and water quality. Turbidity and total metals generally follow river flow, while pH and hardness show an inverse relationship. Because dissolved metals have only been sampled for during select months, the relationship between total and dissolved metals is not well understood.

- The water quality upstream and downstream of the wastewater treatment facility outfalls in Princeton and Keremeos is similar, indicating these operations are not affecting water quality after mixing. The only parameter showing a statistically significant downstream change was nitrate+nitrite-N at Keremeos.

- The water quality of Hedley Creek at the monitoring point downstream of the Nickel Plate mine is also generally good. The 95th percentile concentrations of analyzed parameters were generally within guideline levels with the exception of strong acid dissociable cyanide, which exceeded the Hedley Creek Water Quality Objective and the B.C. drinking water guideline, and aluminum, which exceeded the Hedley Creek objective and B.C. aquatic life guidelines.

Overall, given the large amount of available surface water quality data, and the overall finding that water quality is generally good within the Similkameen River, the results of this assessment noted that the SVPS and RDOS can proceed with the water quality components of the SWP. However, to continue to improve the understanding of water quality and trends within the Similkameen River watershed, a reconnaissance survey of water quality in selected tributaries and lakes is recommended (identified as project WQ-2 in the Part 1 report). The results of this Part 2 study confirmed that there is a good amount of water quality data for the Similkameen River mainstem, but less is known about water quality in tributaries (other than Hedley Creek and, to a lesser extent, the Tulameen River) and in lakes.

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