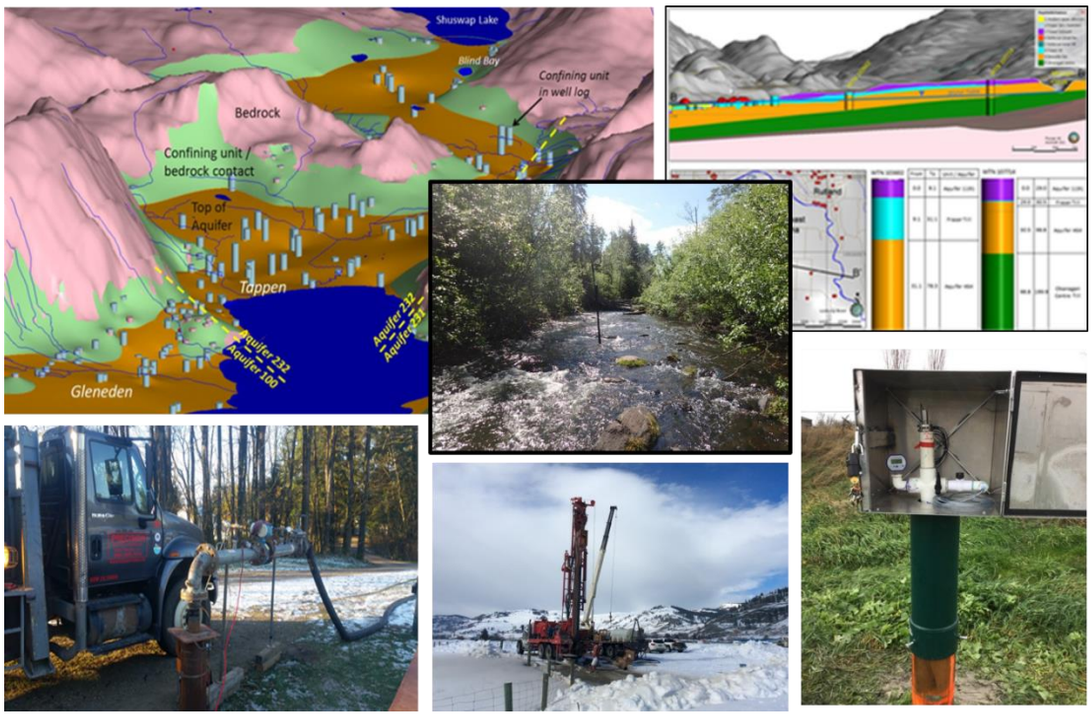
WATER SCIENCE SERIES

Compendium of Provincial Groundwater Science and Monitoring Projects: 2017-18

Compiled by Provincial Groundwater Staff



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Author's Affiliation:
Julie-Ann Ishikawa, M.Sc., P.Geo. (Editor)
Ministry of Environment and Climate Change Strategy
525 Superior Street, Victoria, B.C., V8V 1T7

Cover Photographs:

Middle photo than bottom row left to right
1) In Stream Piezometer and Stillign Well in Stoney Creek, Vanderhoof, B.C. Photo credit: Jun Yin
2) Conducting a pumping test at Steele Park, Langely, B.C. Photo credit: Michele Lepitre
3) Drilling new observation well, Midway, B.C. Photo credit: John Pogson
4) Observation well OW461 showing wellhead modification. Photo credit: Michele Lepitre

Acknowledgements

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EXECUTIVE SUMMARY

The Provincial Groundwater Program originated in 1961 when the *Water Act* was revised to enable the licensing of groundwater. The primary goal of the groundwater program has been to increase the understanding of Provincial groundwater resources, and to ensure the sustainable management and protection of the resource. At this time, as the Province moves forward with the implementation of groundwater licensing under the new *Water Sustainability Act* (WSA), which was brought into force in 2016, there is an even greater need to improve the level of scientific knowledge of aquifers, groundwater availability, and the interactions between surface water and groundwater. This knowledge is critical to support the sustainable management of the groundwater resource and to support science-based decision making. The Ministry of Environment and Climate Change Strategy (ENV) and the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR) share joint responsibility for the Groundwater Program. Currently, groundwater science and monitoring projects are funded out of three main funding envelopes:

- The Strategic Water and Air Monitoring Planning Process (SWAMPP), administered by the Environmental and Climate Monitoring section of the Knowledge Management Branch (KMB) within ENV;
- The Groundwater Science Program, administered by Aquifer and Watershed Science of the Water Protection & Sustainability Branch (WPS) within ENV; and,
- Water Intended Outcome (WIO) research funding, administered by FLNR

In some cases, the province also partners with other agencies such as Geoscience BC, the BC Oil and Gas Commission (OGC), the Geological Survey of Canada (GSC), universities and local governments to fund groundwater related studies.

This compendium is published under the *Water Science Series* to bring together a compilation of short summaries of the groundwater science and monitoring projects that were supported by the province during the 2017-18 fiscal year. The intent is to communicate out to a wider audience the nature of the projects undertaken and to provide a quick overview of the project results. Links to key personnel and additional reporting are provided within the summary for anyone who might require more detailed information.

The projects outlined in this compendium meet some of the goals of FLNR's Ministry's Strategic Roadmap. Specifically, the installation of new groundwater observation wells and remapping of aquifers, provides groundwater staff with the ability to sustainably manage the province's groundwater resources. These projects also support ENV's Service Plan by doing some of the critical work needed to interpret the state of the Province's environmental health so that all British Columbians will continue to benefit from the wise and prudent management of natural resources.

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1. AQUIFER MAPPING

To effectively manage groundwater use and the impacts of land development on groundwater availability and quality, it is essential to understand the existence and characteristics of B.C.'s aquifers. Identifying and mapping aquifers is often the first step in developing this understanding. The British Columbia Aquifer Mapping (BCAM) database is the primary resource of screening level groundwater resource information throughout the Province. The BCAM database is currently utilized for: tracking and managing groundwater rights; prioritizing management; protection and remedial efforts; and, increasing public understanding. It is also used as a resource by several government ministries including ENV, FLNR, Health and Agriculture.

As of June 2018, the database contained nearly 1,200 aquifers. The province continues to conduct new aquifer mapping projects to expand and refine the database. The need for mapping aquifers is ongoing as communities expand or new resource development projects are initiated. In addition, previously mapped aquifers are revisited periodically and updated as new information becomes available or a more detailed level of assessment is required. Aquifer mapping studies are prioritized based on a number of factors, including, but not limited to: (1) the locations of water wells in the provincial Groundwater Wells and Aquifer (GWELLS) database that are not yet associated with a mapped aquifer; (2) the local knowledge of emerging issues that regional offices have identified through their work with communities and in supporting water authorizations; and, (3) the locations of major resource development projects (e.g., mines, oil and gas).

In 2017/18, aquifers were mapped or revised in several areas of the province including the Central and Northern Okanagan, Haida Gwaii, Ucluelet, Salt Spring Island and Hope. This information will be utilized as a reference in implementing groundwater licensing under the *Water Sustainability Act* and is available to the public to inform well protection and land use planning.

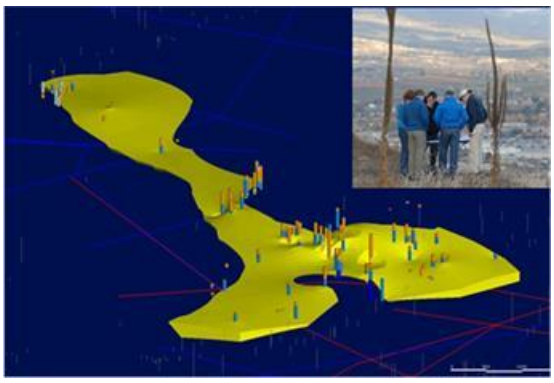
Spatial information about mapped aquifers can be accessed using the following tools, supporting a range of user needs:

- GWELLS – The Provincial database for storing and retrieving water well records and aquifer information
- Groundwater Level Data Interactive Map Portal – a user friendly map-based tool to view and access information from the Provincial Groundwater Observation Network (PGOWN)
- iMapBC - view and analyze mapped aquifers along with hundreds of other data layers compiled from across the B.C. Government and other public-sector agencies

North Okanagan Aquifer Mapping & Geologic Modelling Phase I: Vernon, Salmon Arm and Mara Lake, B.C.

Project Description

This report presents the results of a focused assessment of the hydrostratigraphy of the northern portion of the Okanagan Basin, extending from Vernon, northwest to Salmon Arm, and north to Mara Lake. Groundwater is used predominantly for domestic, agricultural, and municipal water supply in the north Okanagan, and demand is expected to rise. Groundwater is the only available source to meet that growth in demand. This project improves the Province's understanding of the geologic history and the physical hydrogeology of the aquifers which contain most of the accessible groundwater in the region.



View of water wells within an aquifer.

Summary of Project Outcome

This assessment attempts to provide a coherent regional interpretation of the geometry and hydrogeologic relationships of the various aquifers in the North Okanagan area. Based on analysis of the hydrostratigraphy (i.e., the distribution of aquifer sediments in relation to non-aquifer, or potentially confining soils), the geologic setting of the North Okanagan aquifers is remarkably consistent within valleys of similar size and geometry, despite having an apparently complex geologic history. The consistency and the continuity of the aquifers has important implications for the interpreted hydrogeology of the various aquifers and the approach to water protection and allocation. Three basic valley types have been identified, including MAIN (Okanagan, Lower Salmon River), SECONDARY (O'Keefe, Hullcar and Tuhok) and TERTIARY (Ashton Creek, BX Creek) valleys.

Relevance

An improved understanding of the hydrogeology supports science-based decision making for sustainable water management in the North Okanagan and supports implementation of the *Water Sustainability Act*. In particular, the geologic models can inform groundwater licensing and assist in future assessments on: hydraulic connections with adjacent aquifers and surface waters, aquifer hydraulic properties to inform groundwater development potential, local or regional groundwater budget analyses or development of numerical groundwater models to support holistic groundwater allocation planning.

Learnings & Recommendations

The aquifer assemblages have been sufficiently resolved where the scale of the aquifer extent versus aquifer thickness, and quantity of data permitted. Models of the Okanagan Valley, Lower Salmon River Valley and Tuhok Valley would require additional work to be more inclusive of existing borehole data for smaller scale analysis of discrete portions of the aquifers or other more detailed mapping. In conjunction, stratigraphic relationships could be improved with age dating of organic materials, and within new deeper boreholes drilled in the region. To further refine the understanding of the local hydraulics of the aquifer around individual wells, this assessment should be followed by a detailed field study of water levels in surveyed wells in areas of elevated interest to assess the character of response to seasonal stresses (recharge and evaporation), as well as diurnal stresses (barometric fluctuations).

References

Stewart, M. and R. Allard 2017. *North Okanagan aquifer mapping and geologic modelling: Summary of results and 3D interpretation*. Water Science Series, WSS2017-03. Prov. B.C., Victoria B.C.

Project Contacts

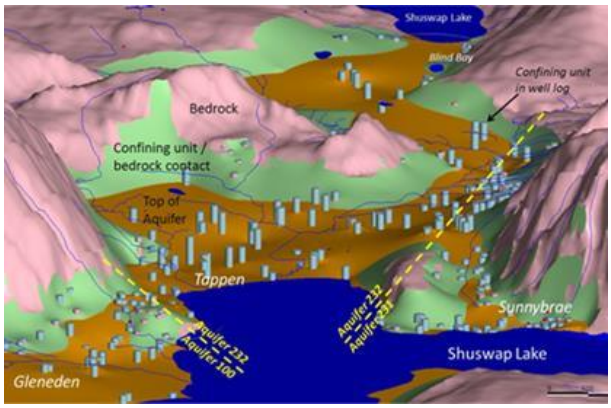
Christine Bieber | e-mail address: Christine.Bieber@gov.bc.ca | Phone number: 778-698-4013
Dave Thomson | e-mail address: David.Thomson@gov.bc.ca | Phone number: 250-260-4641

Acknowledgements:
Groundwater Science Program

North Okanagan Aquifer Mapping & Geologic Modelling Phase II: Tappen, Westwold and Coldstream, B.C.

Project Description

This report presents the results of Phase II of a focused assessment of the hydrostratigraphy of the northern portion of the Northern Okanagan basin. In Phase II, the extent of coverage was expanded to the Upper Salmon River area from Glenemma to Westwold, the Coldstream Valley from Vernon to Cherryville, and the Tappen Area from Salmon Arm to Blind Bay. Groundwater is used for domestic, agricultural, and municipal water supply in the north Okanagan, and demand is expected to rise. This project improves the Province's understanding of the geologic history and the physical hydrogeology of the aquifers in the region.



Aquifer map of the Shuswap lake Area.

Summary of Project Outcome

This assessment provides a coherent regional interpretation of the geometry and hydrogeologic relationships of the various aquifers in the North Okanagan. Modelling in the Upper Salmon River, Coldstream and Tappen areas has allowed refinement of boundaries and clarification of hydraulic relationships between local aquifers. The models inform the possibility of development of deeper groundwater resources, while highlighting the potential risk associated with artesian conditions.

Relevance

An improved understanding of the hydrogeology supports science-based decision making for sustainable water management in the North Okanagan and supports implementation of the *Water Sustainability Act*. The geologic models can inform groundwater licensing and assist in future assessments on: hydraulic connections with adjacent aquifers and surface waters; aquifer hydraulic properties to inform groundwater development; local or regional groundwater budget analyses or development of numerical groundwater models to support holistic groundwater allocation planning.

Learnings & Recommendations

The scale of this study was sufficient to refine aquifer boundaries and improve the understanding of aquifer hydraulics on a regional scale. The results have highlighted the widespread risk of flowing artesian conditions. However, the scale of the study was too regional to provide a clear understanding of why some wells are flowing artesian and some are not, and hence, how to assess the risk for new well construction. The complexity of stratigraphy in the flowing wells at Coldstream Ranch and Westwold could not be captured in a regional groundwater scale geologic model. Additional local scale studies and numerical modelling are recommended to understand the interaction between stratigraphy and geology in generating local artesian conditions.

References

Stewart, M. and R. Allard 2018. *North Okanagan aquifer mapping and geologic modelling Phase II: Tappen, Westwold and Coldstream Areas.* Water Science Series, WSS2018-02. Prov. B.C., Victoria B.C.

Project Contacts

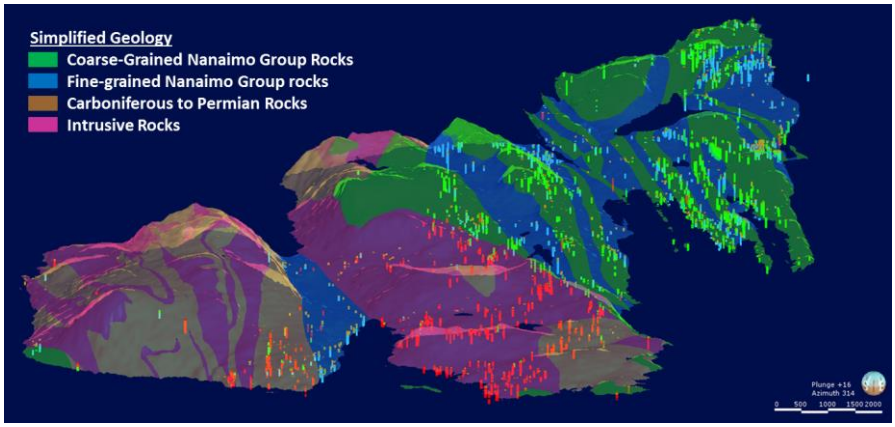
Christine Bieber | e-mail address: Christine.Bieber@gov.bc.ca | Phone number: 778-698-4013
Dave Thomson | e-mail address: David.Thomson@gov.bc.ca | Phone number: 250-260-4641

Acknowledgements:
Groundwater Science Program

Salt Spring Island Aquifer Mapping & Geologic Modelling

Project Description

The province contracted Golder Associates to update aquifer mapping of Salt Spring Island. The goals were to revise outdated mapping by integrating substantial new well log and lithological information and to develop a 3D geological model to visualize and improve interpretation of hydrostratigraphic information.



Standardized Bedrock Lithologies on Salt Spring Island, B.C.

Summary of Project Outcome

Lithological descriptions from over 2600 well records were standardized using an iterative, nested key-word scripting process with manual QA/QC. Three-dimensional geological volumes of the lithologic groupings were constructed in the Leapfrog software using inferred dip and dip direction from geologic mapping and interpreted cross-sections.

Four bedrock aquifers were delineated based on rock type and geologic structures. Two sedimentary bedrock aquifers occur over the northern half of the island, separated by the Ganges thrust fault along topographic lows. Granitic and volcanic rock comprise the bedrock in the southern half of the island, which is delineated into two aquifers separated by the Fulford thrust fault along topographic lows. Unconsolidated aquifers are a minor source of groundwater supply on the island, occurring as small and localized permeable deposits. The extents of three previously mapped unconsolidated aquifers were revised and one new unconsolidated aquifer was delineated in the higher elevations of the Fulford Valley.

Project deliverables include GIS polygons of the mapped aquifer extents, which are publicly available on iMap, updated aquifer classification worksheets that includes summary information from over 2600 well records in the WELLS database, and Leapfrog viewer files of the 3D geologic model.

Relevance

Geologic modelling and aquifer mapping provide a basis for subsequent development of regional aquifer water budgets (Phase II) by compiling information on groundwater use and aquifer yields, improving estimates of aquifer hydraulic properties, and supporting development of conceptual models for groundwater flow across the island. Aquifer water budgets support groundwater resource management by improving knowledge of the availability and pressures on groundwater resources, which can assist and inform allocation staff in groundwater licensing decisions.

Learnings & Recommendations

Hydraulic conductivity of the different Nanaimo Group rocks do not differ substantially and the alternating coarse-grained/fine-grained formations together with complex folding make delineation of bedrock aquifers based solely on lithology impractical. Aquifer yields and groundwater development potential in the bedrock aquifers are highly heterogeneous, controlled largely by the presence of fracture features. Recommendations include geological surveys to identify small-scale lineaments and faults that could act as structural controls on groundwater flow, and field confirmation of high-yielding bedrock wells to establish the potential presence of high-yielding structures.

Project Contacts

Klaus Rathfelder | e-mail address: Klaus.Rathfelder@gov.bc.ca | Phone number: 778-698-3986
Sylvia Barroso | e-mail address: Sylvia.Barroso@gov.bc.ca | Phone number: 250-751-3265

Acknowledgements:
Groundwater Science Program

2. GROUNDWATER MONITORING

The Provincial Groundwater Observation Well Network (PGOWN) monitors groundwater conditions in aquifers across British Columbia through a series of provincially managed groundwater monitoring wells. The water level measurement and water chemistry data collected through the network helps inform water resource management decisions across the province.

The objectives of the network include:

- understanding local and regional hydrogeological processes and characteristics;
- supporting groundwater licensing and sustainable resource management;
- flood forecasting;
- drought monitoring;
- climate change monitoring;
- cumulative effects monitoring; and,
- minimizing groundwater conflicts between users.

The data collected through the PGOWN is made publicly available through a number of Provincial portals:

- *Map tool - Groundwater Level Data Interactive Map*
- *Real-time water level data - Aquarius web portal*
- *Water quality data - Environmental Monitoring Stations (EMS) web reporting*

The PGOWN was formally established in 1961 and the network has changed over the years with new observation wells added and monitoring at other wells discontinued as priorities, staffing levels and funding levels have fluctuated. Currently, there are a total of 204 active PGOWN wells in the network. With the implementation of licensing of groundwater users in 2016, understanding the availability of provincial groundwater resources has been a priority. During the 2017-18 fiscal year, a total of 15 new observation wells were added to the PGOWN. Ten new monitoring wells were drilled in key areas and five existing wells were adopted into the network this year. Summary pages for the new PGOWN wells are available in the following section.

Drilling of New PGOWN Well, Cobble Hill, B.C.

Project Description

A site in Cobble Hill, B.C. was selected to monitor water levels in aquifer #202, the North Shawnigan-Cobble Hill bedrock aquifer as identified in the South Cowichan Water Budget Project (Harris and Usher, 2017). The recharge zone of this aquifer was targeted to obtain a well that would provide a long-term record of climate-related trends without significant pumping interference from neighbouring wells. This project involved site selection, drilling, pumping test, sampling for water quality and instrumentation of the new monitoring well.

Drilling new observation well on Empress Road, Cobble Hill, B.C. Photo credit: Graeme Henderson

Summary of Project Outcome

Observation well OW439 was instrumented with water level monitoring equipment in March 2017 and satellite telemetry functionality in August 2017. Groundwater levels collected hourly are publicly available on the provincial real-time water data website (Province of British Columbia, 2018). Water chemistry samples were collected during an eight-hour pumping test and the results are also publicly available online.

Relevance

This project will result in long-term water level data in aquifer #202 to support water allocation and monitoring during times of water scarcity.

Learnings

Water levels in OW439 ranged from 1.39-9.31 metres below ground surface between March and October, 2017. The deepest groundwater levels were in mid-October and pumping interference appears minimal.

Partners and Linkages

The Cowichan Valley Regional District was involved with seeking a drilling location in one of their parks. The well was drilled on a Ministry of Transportation and Infrastructure road right-of-way.

References

Harris, M. and S. Usher 2017. *Preliminary Groundwater budgets, Cobble Hill / Mill Bay Area, Vancouver Island, B.C.* [Online] Available at https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=52917. [Accessed January 2018]

Project Contact

Graeme Henderson | e-mail address: Graeme.Henderson@gov.bc.ca | Phone number: 250-751-7119

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR West Coast Regional Operations

Drilling of New PGOWN Well, Midway, B.C.

Project Description

A Site was selected to monitor water levels in aquifer #478, located in the Kettle River Valley near Midway, B.C. The aquifer was identified as a high priority aquifer for monitoring (Kohut et. al 2009). The intent of the proposed well was to provide a location for the long-term monitoring of groundwater levels and groundwater chemistry within the aquifer. This project involved site selection, drilling, a pumping test, sampling for water quality and instrumentation of a new monitoring well.

Drilling new observation well, Midway, B.C.
Photo credit: John Pogson

Summary of Project Outcome

Observation well OW444 was installed to a total depth of 23.25 metres below ground surface on February 27, 2018 and was instrumented with interim continuous water level monitoring equipment in April 2018. Full satellite telemetry functionality was achieved in October 2019. Groundwater levels are publicly available through the provincial Groundwater Level Data Interactive Map. Water samples were collected for laboratory analyses during an eight-hour pumping test and the results are also publicly available online.

Relevance

This project will enable the collection of valuable, long-term water level and hydro-chemical for an important aquifer in the Kettle Valley. These data will be used to support: licensing and management decisions; protection and sustainability of the resource; and, consideration of the impact of flood and drought conditions in the area.

Learnings

Water levels in OW444 ranged from 10.10 to 9.65 metres below ground surface between February and April 2018, respectively.

Partners and Linkages

The Village of Midway provided a location on surplus lands on which to install the monitoring well.

References

Kohut, A., Hodge, W., and J. Azar 2009. *Provincial Observation Well Network Review British Columbia.* Prepared for the Water Stewardship Division, BC Ministry of Environment. File No. MOE-OWNR-2008 CWSEN09025

Project Contact

John Pogson | e-mail address: john.pogson@gov.bc.ca | Phone number: 250-490-8220

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Area Regional Operations

Drilling of New PGOWN Well, Osoyoos, B.C.

Project Description

The intention of the project was to provide locations for the long-term monitoring of groundwater levels and groundwater chemistry for aquifers in the Osoyoos area in the South Okanagan, B.C. A location was selected in East Osoyoos to monitor water levels in aquifer #194, a partially confined sand and gravel aquifer. An additional location was selected in West Osoyoos in an attempt to re-establish monitoring in the northern portion of the unconfined sand and gravel aquifer #193.

This project involved site selection, drilling, installation of an observation well, sampling for water quality and interim instrumentation of a new monitoring well.

New observation well, Osoyoos, B.C.
Photo credit: Twyla Lagault

Summary of Project Outcome

Observation well OW467 was installed to a total depth of 14.3 metres below ground surface in Aquifer #194 on March 22, 2018. The monitoring well was instrumented with interim continuous water level monitoring equipment in April 2018. Full satellite telemetry functionality is anticipated in November 2019 when groundwater levels will be publicly available through the provincial Groundwater Level Data Interactive Map. Water samples were subsequently collected for laboratory analyses. Laboratory results are also publicly available online.

A borehole was initiated on the west side of Osoyoos but it did not penetrate any significant water-bearing sediments of Aquifer #193. It was therefore sealed and abandoned.

Relevance

Aquifer #194 was identified as a high priority aquifer for monitoring due to its location and historical quality concerns. The intent of monitoring is to collect long-term water level and groundwater chemistry data. These data will be used to support implementation of the WSA through licensing and inform management decisions that promote protection and sustainability of the resource.

Lithological observations collected from the boring may be used to inform future aquifer mapping refinements.

Learnings

Water levels in OW467 ranged from 10.76 to 10.66 metres below ground surface between March and June 2018, respectively.

The ground surface above Aquifer #193 has considerable development in the form of agriculture, private habitation and infrastructure, which limited the access to suitable locations for a long-term monitoring location. Lithology noted from the borehole in Aquifer #193 demonstrated the lateral variability of sediments in the aquifer. Due to the fine-grained nature of the lithology in the area, future efforts to establish a monitoring location would benefit from a drilling method that allows for increased sample preservation.

Project Contact

John Pogson | e-mail address: john.pogson@gov.bc.ca | Phone number: 250-490-8220

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Area Regional Operations

Drilling of New PGOWN Well, Cranbrook, B.C.

Project Description

A monitoring location was selected to monitor water levels in aquifer #525, a confined sand and gravel aquifer located at the City of Cranbrook, B.C. The intent of the proposed well was to provide a location for the long-term monitoring of groundwater levels and groundwater chemistry within the aquifer. This project involved site selection, drilling, a pumping test, sampling for water quality and interim instrumentation of a new monitoring well.

New observation well at Pop Price Park, Cranbrook, B.C.
Photo credit: Kristina Anderson

Summary of Project Outcome

Observation well OW468 was installed to a total depth of 27.7 metres below ground surface on March 6, 2018, and instrumented with interim continuous water level monitoring equipment in April 2018. Full satellite telemetry functionality was achieved in October 2018. Groundwater levels are publicly available through the provincial Groundwater Level Data Interactive Map. Water samples were collected during an eight-hour pumping test for laboratory analyses. Laboratory results are also publicly available online.

Relevance

Aquifer #525 was identified as a high priority aquifer for monitoring due to its location and the anticipated increased demand on the aquifer in the future. The intent of monitoring is to collect long-term water level and groundwater chemistry data. These data will be used to support implementation of the *WSA* through licensing and inform management decisions that promote protection and sustainability of the resource.

Learnings

Water levels in OW468 ranged from 1.83 to 1.17 metres below ground surface between March and July 2018, respectively.

Partners and Linkages

The City of Cranbrook provided a location on surplus lands for the installation of the monitoring well.

Project Contact

John Pogson | e-mail address: john.pogson@gov.bc.ca | Phone number: 250-490-8220

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Area Regional Operations

Drilling of New PGOWN Well, Sooke, B.C.

Project Description

A monitoring site in Sooke, B.C. was selected to obtain a better understanding of layered aquifers in the area and to obtain baseline data in previously unmonitored aquifers. A shallow well was drilled to observe water levels in the upper sand and gravel aquifer #599. The deeper well was drilled to monitor the lower bedrock aquifer #606. The area residents rely on groundwater from both aquifers for domestic and agricultural purposes and the new observation wells will help facilitate groundwater protection and regulation. This project involved site selection, drilling, pumping test, sampling for water quality and instrumentation of two new monitoring wells.

Drilling observation well on Phillips Road, Sooke, B.C.
Photo credit: Graeme Henderson

Summary of Project Outcome

Observation wells OW443 (deep) and OW469 (shallow) were instrumented with water level monitoring equipment in April 2018. Groundwater levels collected hourly are publicly available on the provincial real-time water data website. Water chemistry samples were collected from OW443 during an eight-hour pumping test and the results are publicly available online through the Environmental Monitoring System (EMS) web reporting tool. OW469 had no pumping test or samples collected at the time this summary was written.

Relevance

This project will result in long-term water level data in aquifer #599 and #606 to support water authorizations of groundwater, particularly during times of water scarcity. The project will also provide the opportunity to research how water moves through layered aquifer systems.

Learnings

Water levels in OW443 ranged from 3.29-10.81 metres below ground surface between April and June 2018. Water levels in OW469 ranged from 5.5-6.1 metres below ground surface between April and June. Water levels are anticipated to continue dropping through the summer months. Both wells appear to have approximately 10-20 cm of pumping interference, likely from neighbouring wells.

Partners and Linkages

Staff members from the Capital Region District and the Ministry of Transportation and Infrastructure were also involved in deciding on a final location for these wells. A permit from the District of Sooke was required to drill the wells in the road right-of-way.

Project Contact

Graeme Henderson | e-mail address: Graeme.Henderson@gov.bc.ca | Phone number: 250-751-7119

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR West Coast Regional Operations

Drilling of New PGOWN Well, Surrey, B.C.

Project Description

A monitoring location was selected to monitor water levels in aquifer #58 (Nicomekl-Serpentine aquifer), which is a confined sand and gravel aquifer located in Surrey and Langley in the Fraser Lowlands, B.C. The intention of this well was to provide a location for the long-term monitoring of groundwater levels and groundwater chemistry within this aquifer. This project involved researching and selecting a site, drilling the monitoring well, developing a specialized wellhead design for an artesian well, sampling for water quality and adding monitoring instrumentation to the well.

OW461 showing wellhead modification.
Photo credit: Michele Lepitre

Summary of Project Outcome

Observation well OW461 was drilled to a total depth of 90 metres below ground surface (m bgs) on August 21-25, 2017. The well screen was installed at a depth of 71-74 m bgs. Wellhead modifications to allow for both groundwater level monitoring and water quality sampling were completed in November 2017. Full satellite telemetry functionality is not available for this well due to the artesian conditions. Data will be periodically manually downloaded; following which groundwater levels will be publicly available through the provincial Groundwater Level Data Interactive Map. Note that groundwater level values for this well are 'negative' to reflect artesian conditions (i.e., the groundwater levels are measured above the ground surface). Water samples were subsequently collected for laboratory analyses, and the results are also publicly available online.

Relevance

Aquifer #58 was identified as a high priority aquifer for monitoring because of its large size (>200 km^2), demand pressures and the high number of potentially flowing artesian wells installed in this aquifer. The intent of monitoring is to collect long-term water level and groundwater chemistry data. The data will be used to support implementation of the *WSA* through licensing and inform management decisions that promote protection and sustainability of the resource.

Lithological observations collected from the well will be used to inform future aquifer mapping refinements planned for this area.

Learnings

Water levels in OW461 ranged from a minimum of 2.98 m above ground surface (m ags) to a maximum of 3.55 m ags between November 2017 and June 2018.

Partners and Linkages

The City of Surrey provided a location on park lands for the installation of the monitoring well.

Project Contacts

Michele Lepitre | e-mail address: Michele.Lepitre@gov.bc.ca | Phone number: 604-586-2821
Bryan Jackson | e-mail address: Bryan.Jackson@gov.bc.ca | Phone number: 604-586-2801

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Coast Regional Operations

Drilling of New PGOWN Well, Maple Ridge, B.C.

Project Description

A monitoring location was selected to monitor water levels in aquifer #19 (Grant Hill aquifer), which is a partially confined bedrock aquifer located in Maple Ridge, B.C. The intention of this well was to provide a location for the long-term monitoring of groundwater levels and groundwater chemistry within the aquifer. This project involved researching and selecting a site, drilling the monitoring well, sampling for water quality and adding telemetry and monitoring instrumentation to the well.

Drilling OW462 with dual rotary method.
Photo credit: Bryan Jackson

Summary of Project Outcome

Observation well OW462 was drilled to a total depth of 151.5 metres below ground surface (m bgs) on February 28 to March 2, 2018. The well was cased to 6 m bgs, with the remainder left as an open-hole bedrock well. Full satellite telemetry was added to this well. All groundwater level data will be publicly available through the provincial Groundwater Level Data Interactive Map. Water samples were subsequently collected for laboratory analyses, and the results are also publicly available online.

Relevance

Aquifer #19 was identified as a high priority aquifer for monitoring due to the dependence of the local community on this aquifer, primarily for domestic and agricultural needs, as well as ongoing complaints from this area regarding potentially falling groundwater levels. The intent of monitoring is to collect long-term water level and groundwater chemistry data. These data will be used to support implementation of the WSA through licensing and inform management decisions that promote protection and sustainability of the resource.

Learnings

Water levels in OW462 ranged from 30.22 to 36.57 m bgs between March and September 2018.

Partners and Linkages

The District of Maple Ridge provided a location on park lands for the installation of the monitoring well.

Project Contacts

Michele Lepitre | e-mail address: Michele.Lepitre@gov.bc.ca | Phone number: 604-586-2821
Bryan Jackson | e-mail address: Bryan.Jackson@gov.bc.ca | Phone number: 604-586-2801

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Coast Regional Operations

Drilling of New PGOWN Well, Mission, B.C.

Project Description

A monitoring location was selected in the Stave Falls area, north-west of Mission, B.C. to monitor groundwater levels in aquifer #884, a confined sand and gravel aquifer. The intention of this well was to provide a location for the long-term monitoring of groundwater levels within this aquifer. This project involved researching and selecting a site, drilling the monitoring well and adding telemetry and monitoring instrumentation to the well.

Drilling OW463 with sonic drilling method.
Photo credit: Bryan Jackson

Summary of Project Outcome

Observation well OW463 was drilled to a total depth of 36.6 metres below ground surface (m bgs) on December 4-6, 2017. The well screen was installed at a depth of 11-14 m bgs. Full satellite telemetry was added to this well. All groundwater level data will be publicly available through the provincial Groundwater Level Data Interactive Map.

Relevance

Aquifer #884 was identified as a high priority aquifer for monitoring due to the dependence of the local community on this aquifer, primarily for domestic and water supply system wells. The intent of monitoring is to collect long-term water level data. The data will be used to support implementation of the *WSA* through licensing and inform management decisions that promote protection and sustainability of the resource.

Learnings

Water levels in OW463 ranged from 4.61 to 6.35 m bgs between December 2017 and September 2018.

Partners and Linkages

The District of Mission provided a location at a fire hall for the installation of the monitoring well.

Project Contacts

Michele Lepitre | e-mail address: Michele.Lepitre@gov.bc.ca | Phone number: 604-586-2821
Bryan Jackson | e-mail address: Bryan.Jackson@gov.bc.ca | Phone number: 604-586-2801

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Coast Regional Operations

Drilling of New PGOWN Well, Columbia Valley, B.C.

Project Description

A monitoring location was selected to monitor water levels in aquifer #20, which is an unconfined sand and gravel aquifer located in the Columbia Valley. The intention of this well was to provide a location for the long-term monitoring of groundwater levels and groundwater chemistry within this aquifer. This aquifer was historically monitored by former Observation well OW335. Monitoring at OW335 was discontinued due to significant pumping interference and because the well was on private property. This project involved researching and selecting a site, drilling the monitoring well, sampling for water quality and adding telemetry and monitoring instrumentation to the well.

OW465, showing well construction.
Photo credit: Bryan Jackson

Summary of Project Outcome

Observation well OW465 was drilled to a total depth of 82 metres below ground surface (m bgs) on January 16 to 19, 2018. The well screen was installed at a depth of 79-82 m bgs. Full satellite telemetry was added to this well. All groundwater level data will be publicly available through the provincial Groundwater Level Data Interactive Map. Water samples were subsequently collected for laboratory analyses, and the results are also publicly available online.

Relevance

Aquifer #20 was identified as a high priority aquifer for monitoring due to the dependence of the local community on this aquifer, primarily for domestic and agricultural needs. The intent of monitoring is to collect long-term water level and groundwater chemistry data. These data will be used to support implementation of the *WSA* through licensing and inform management decisions that promote protection and sustainability of the resource.

Learnings

Groundwater levels in OW465 ranged from 54.86 to 56.44 m bgs between May 2018 and September 2018, respectively.

Partners and Linkages

A permit was obtained from the Ministry of Transportation and Infrastructure to drill on the road right-of way.

Project Contacts

Michele Lepitre | e-mail address: Michele.Lepitre@gov.bc.ca | Phone number: 604-586-2821
Bryan Jackson | e-mail address: Bryan.Jackson@gov.bc.ca | Phone number: 604-586-2801

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Coast Regional Operations

Drilling of New PGOWN Well, Mill Bay, B.C.

Project Description

This project involved site selection, drilling, pumping test, sampling for water quality and instrumentation of a new monitoring well in Mill Bay, B.C. The site in Mill Bay was selected to obtain water level data in an aquifer that was previously monitored by OW350 from 2001-2006. Monitoring at OW350 was discontinued due to gravel extraction drastically changing the surface topography around the well. Aquifer #206 is a sand and gravel aquifer that supports community water systems and domestic wells.

Drilling observation well on Deloume Road, Mill Bay, B.C. Photo credit: Graeme Henderson

Summary of Project Outcome

Observation well OW470 was instrumented with water level monitoring equipment in April 2018. Groundwater levels collected hourly are publicly available on the provincial real-time water data website. OW470 had no pumping test or samples collected at the time this summary was written. When completed, water quality results will be publicly available online through the Environmental Monitoring System (EMS) web reporting tool.

Relevance

This project will result in long-term water level data in aquifer #206 to support water allocation decisions especially during times of water scarcity. OW470 was completed with a screen at the bedrock-surficial sediments boundary. The level and chemistry data will be useful for monitoring precipitation behaviour as it recharges the aquifer.

Learnings

Water levels in OW470 were 14.28-17.92 metres below ground surface between April and August 2018. It was anticipated that the water level would continue to drop over the summer with little or no precipitation. The well may become seasonally dry over the summer, but it appears that the water level responds quickly with the onset of the wet season.

Partners and Linkages

A permit was obtained from the Ministry of Transportation and Infrastructure to drill on the road right-of way. The Director of Operations at Brentwood College was contacted because the sports field beside the well is owned by the college. They had a positive response to the aquifer being monitored and plan to use the monitoring data for their water management planning.

Project Contact

Graeme Henderson | e-mail address: Graeme.Henderson@gov.bc.ca | Phone number: 250-751-7119

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR West Coast Regional Operations

Five New PGOWN Wells Obtained through Adoption of Existing Wells, South Coast Region, B.C.

Project Description

This project involved collaborating with partners to identify previously drilled monitoring wells that could be incorporated into the PGOWN, evaluating the wells, making third party agreements for the selected wells, water quality sampling and adding telemetry and monitoring instrumentation to the selected wells, where feasible.

The intention of the project was to provide locations for the long-term monitoring of groundwater levels and groundwater chemistry within these aquifers.

OW459 in Chilliwack (top) and OW473 on Bowen Island (inset).
Photo credits: Bryan Jackson

Summary of Project Outcome

The following previously drilled wells were adopted into the PGOWN Network as a result of this project in 2017-2018: OW440 (in aquifer #52, Langley, near former OW004), OW441 (in aquifer #15, Abbotsford-Sumas aquifer, Abbotsford), OW459 (in aquifer #8, Vedder River Fan aquifer, Chilliwack), OW471 (in aquifer #960, Lund) and OW473 (in aquifer #747, on Bowen Island). All of these wells had telemetry installed, except the one on Bowen Island. Groundwater Level data will be manually downloaded periodically from this well. All groundwater level data will be publicly available through the provincial Groundwater Level Data Interactive Map. Water samples were collected from all the wells and submitted for baseline laboratory analyses, and the results are also publicly available online.

Relevance

The intent of adopting these monitoring wells is to collect long-term water levels and groundwater chemistry data in key lower mainland locations. These data will be used to support implementation of the WSA through licensing and inform management decisions that promote protection and sustainability of the resource.

Learnings

Groundwater levels in OW440 ranged from 35.55 to 37.83 metres below ground surface (m bgs) between November 2017 and September 2018. Groundwater levels in OW441 ranged from 12.92 to 16.58 m bgs between October 2017 and September 2018. Groundwater levels in OW459 ranged from 1.60 to 2.78 m bgs between December 2017 and September 2018. Groundwater levels in OW471 ranged from 1.77 to 3.37 m bgs between March and September 2018. Groundwater levels in OW473 ranged from 0.70 to 8.24 m bgs between December 2017 and May 2018 (no telemetry).

Partners and Linkages

Partners for this project included: the Township of Langley; the City of Abbotsford; the City of Chilliwack; the Powell River Regional District (Lund); and, the Bowen Island Municipality.

Project Contacts

Michele Lepitre | e-mail address: Michele.Lepitre@gov.bc.ca | Phone number: 604-586-2821
Bryan Jackson | e-mail address: Bryan.Jackson@gov.bc.ca | Phone number: 604-586-2801

Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNR South Coast Regional Operations

3. GROUNDWATER RESEARCH AND SCIENCE PROJECTS

The projects in the following section highlight the wide variety of groundwater science and research projects undertaken by the Province in 2017-18. They demonstrate the technical ability and expertise of provincial groundwater staff and also demonstrate the challenges and complexities of assessing and sustainably managing the groundwater resources of the province.

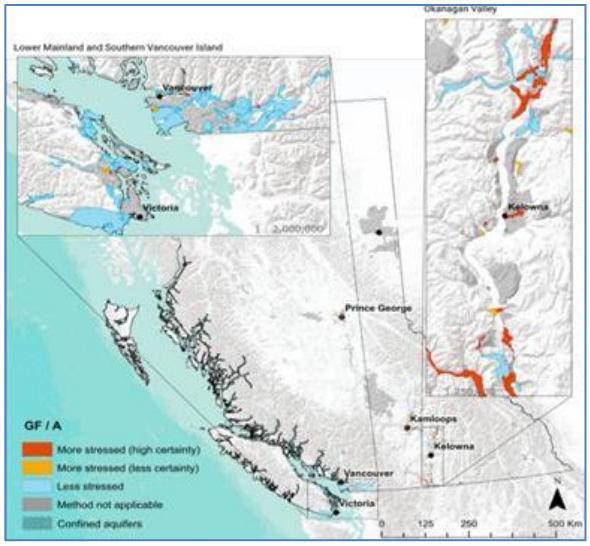
The interaction between surface water and groundwater is still poorly understood and has emerged as an overarching theme in many of the projects undertaken in 2017-18. Under the *Water Sustainability Act*, water is to be managed as one interconnected resource and a number of the studies included in this section seek to understand and characterize the interaction between aquifers and hydraulically connected streams and to assess the implications of groundwater pumping on the Environmental Flow Needs (EFN) of connected streams. The range and type of studies undertaken to understand these interactions have included; water budget assessments and numerical modeling of specific watersheds; field studies near sensitive streams involving pumping tests; and a high level provincial screening of aquifer stress. Other projects have included a groundwater resource assessment in a transboundary watershed, a water chemistry sampling program and development of automated tools to analyse and share existing groundwater data.

Many of the following projects are relatively large in scope and are being conducted over multiple years. In cases where the projects are ongoing, an update summary has been provided to report out on progress and any results or learnings achieved to date.

Aquifer Stress, Groundwater Recharge, Groundwater Use, and the Contribution of Groundwater to Environmental Flows for Unconfined Aquifers across British Columbia

Project Description

This project focused on the synthesis, spatial analysis and modelling of existing data to map stress for unconfined aquifers across the province and developed an aquifer-scale decision support tool to assist water managers in decision making. The project identified potentially high risk aquifers and promotes awareness of groundwater resources across the province in order to encourage the protection and management of this valuable freshwater resource. The scope of the project was to derive aquifer-scale estimates of annual volumes for groundwater withdrawal, recharge, and groundwater's contribution to environmental flows as a means to provide screening level estimates of aquifer-scale stress using the groundwater footprint (GF). A GF greater than 1 means that more water is being withdrawn from the aquifer than the estimated annual recharge and the aquifer is therefore considered "stressed". The groundwater footprint was calculated for four combinations of input parameters. Where the stress index was greater than 1 based on at least one set of data, the aquifer was considered "stressed (less certainty)". Where the stress index was greater than 1 for all combinations of data, the aquifer was considered "stressed (high certainty)". If the index was less than 1 for all sets of calculations, the aquifer was considered to be "less stressed".



Aquifer stress for the Lower Mainland and Vancouver Island.

Summary of Project Outcome

The groundwater footprint methodology was applied to 404 of the 1130 mapped aquifers in B.C. Although groundwater withdrawal was derived for most aquifers, the components of recharge and groundwater's contribution to environmental flows could only be derived for unconfined aquifers and the GF could only therefore be applied to provincially mapped unconfined aquifers. The results of the 404 aquifers for which the methodology was applicable, indicate that 43 aquifers (11%) are stressed with high certainty, 32 aquifers (8%) are stressed with low certainty, 296 aquifers (70%) are less stressed, and 29 aquifers (11%) were not included due to missing parameters or issues where modelled recharge was less than environmental flows.

An interactive web tool was developed to communicate the results of the aquifer stress analysis.

Learnings

The GF calculation is based on regional data and the results are limited by uncertainties. The first province-wide calculations of groundwater stress using the groundwater footprint are estimates. In order to increase the accuracy of the groundwater footprint, the parameters within the equation should be locally refined.

Partners and Linkages:

The University of Victoria's Groundwater Science and Sustainability research group, in collaboration with ENV, completed a research project to estimate relative aquifer stress throughout the province.

References

Forstner, T., Gleeson, T., Borrett, L., Allen, D.M., Wei, M., and A. Baye, A 2018. *Mapping aquifer stress, groundwater recharge, groundwater use, and the contribution of groundwater to environmental flows for unconfined aquifers across British Columbia*. Water Science Series, WSS2018-04. Prov. B.C., Victoria B.C.

Project Contact

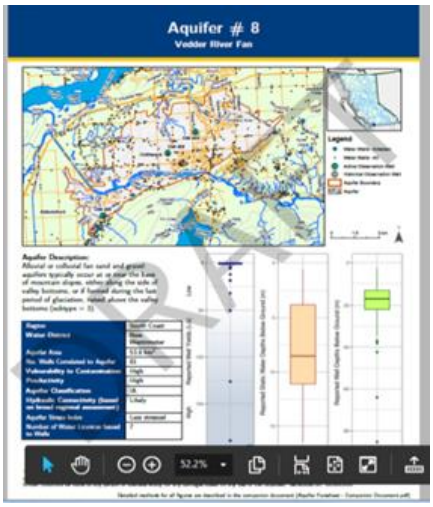
Andarge Baye | e-mail address: Andarge.Baye@gov.bc.ca | Phone number: 778-698-4079

Acknowledgements:
Groundwater Science Program

Aquifer Dashboard Project

Project Description

The purpose of the Aquifer Dashboard project is to "know what we know" about groundwater and aquifers in the province and to be able to quickly and easily access the available information from a centralized location. Currently groundwater information is stored in several different databases across a number of different ministries and programs. The objective of the Aquifer Dashboard project is to identify and bring together key groundwater information through the development of an interactive groundwater map tool. The Aquifer Dashboard includes the production of aquifer factsheets (with hyperlinks to source data) to help to tell the "Aquifer Story" for the nearly 1200 mapped aquifers across the province. This is a large endeavour being worked on by a team of hydrogeologists from the Ministry of Environment & Climate Change Strategy (ENV) and Forests Lands Natural Resource Operations and Rural Development (FLNRORD).



Aquifer Factsheet for Aquifer #8.

Summary of Project Outcome

This is a multi-year endeavour. Work completed to the end of March 2018 has included the development of a template to automate the production of aquifer factsheets. The template was created using the scripting languages R and R-markdown to retrieve, clean, analyze and display groundwater data from a number of different databases. Support from the Groundwater Science Program made it possible to hire a contractor to assist with the scripting, and to assemble the various components into a formatted 1 to 2 page factsheet. Approximately 100 auto-generated aquifer factsheets were produced during the 2017/18 fiscal year. In addition, a "pilot dashboard" was developed using ArcGIS online. The pilot incorporated information from several data sources on an interactive map base and serves as a proof of concept for the Aquifer Dashboard tool. The pilot dashboard will be used to consult with regional staff regarding top priority functionalities and will be key in informing the direction of the dashboard tool.

Relevance

Having quick and easy access to groundwater information is more important than ever with the implementation of licensing of groundwater users under the *Water Sustainability Act*. Authorization staff are expected to be transitioning approximately 20,000 existing groundwater users into the licensing scheme and adjudicating all new license applications. The streamlined access to information will be crucial to processing licenses efficiently and in making consistent, informed decision related to sustainable water management. The results of this project are expected to save staff time and effort.

Learnings

This project has demonstrated the tremendous value of using scripts to work with large data sets in a manner that is reproducible, easily updateable and can done in an automated fashion. This is of particular importance when working with nearly 1200 aquifers. One of the main limitations of the aquifer factsheets is that they do not capture information from areas outside of mapped aquifers, (which makes up a large portion of the province). This gap should be addressed through the development of the interactive map tool, which will be designed to accommodate all groundwater data whether it is linked to a mapped aquifer or not.

Partners and Linkages

GWELLS: The development of the interactive Aquifer Dashboard is envisioned to be an integrated component of the GWELLS application, which will help ensure that groundwater data and information is accessible through a central location.
Geological Survey of Canada (GSC): We are also partnering with the GSC to ensure that the products are compatible with the National Groundwater Information Network (GIN) portal.

Project Contact

Julie-Ann Ishikawa | e-mail address: JulieAnn.Ishikawa@gov.bc.ca | Phone number: 778-698-4024

Acknowledgements:
Groundwater Science Program

Assessment of Aquifer-Stream Connectivity Related to Groundwater Abstraction in the Lower Fraser Valley

Project Description

Pumping groundwater from a well beside a stream can result in depletion of streamflow. Evaluation of hydraulic connectivity is required for water licensing decisions in B.C. under the *Water Sustainability Act* (WSA). The purpose of this study was to build an understanding of the interaction between groundwater and surface water to identify streams that are vulnerable to stream depletion due to pumping. The study consisted of a field investigation to determine the impacts of pumping on aquifer-stream interactions, and a stream vulnerability assessment in the Fraser Valley to determine the vulnerability of similar stream-aquifer systems in order to identify streams that may be similarly impacted by pumping.

Conducting a pumping test at Steele Park.
Photo credit: Michele Lepitre

Summary of Project Outcome

The degree of hydraulic connectivity was determined by conducting a pumping test, while measuring: water levels (in wells and instream piezometers), seepage, stream stage and streamflow. Streamflow depletion during the pumping test was modeled using a suite of available analytical solutions. The models all showed similar results, which indicated that at around 750 days 95% of normalized streamflow depletion is attained (meaning that 95% of water extracted from the well is sourced from the stream). However, small changes in the streambed leakance parameter used in the models resulted in significant changes in the estimated rate of streamflow depletion in all streamflow impedance models. The stream vulnerability assessment carried out throughout the Lower Fraser Valley ranked streams that might be variably impacted by groundwater abstraction.

Relevance

This research resulted in a better understanding of the effect of pumping on streamflow depletion. A series of tools were used to evaluate hydraulic connectivity to support decisions on water allocation and actions taken during times of water scarcity. The approaches can be extrapolated to different regions.

Learnings

Analysis of the field data highlighted the importance of; (1) accurately characterizing the hydraulic properties of the streambed sediments, and; (2) properly designing and implementing field tests, including examining seasonal variation in hydraulic connectivity, conducting pumping tests during baseflow and measuring streamflows outside the pumping well's radius of influence.

Partners and Linkages

Dr. Diana Allen of Simon Fraser University's Department of Earth Sciences supervised an honours undergraduate student and a post-doctoral student undertaking this research. The Township of Langley provided the study location on their park lands.

References

Hall, G. Allen, D.M., Simpson, M., Tolera, H., Jackson, B., Middleton, M.E., and M. Lepitre 2017. *Assessment of hydraulic connectivity related to groundwater extraction on selected sensitive steams: Phase 1 Field Investigation*. Water Science Series, WSS2017-02. Prov. B.C., Victoria B.C.

Middleton, M.A., and D.M. Allen 2017. *Assessment of hydraulic connectivity related to groundwater extraction on selected sensitive steams: Stream Vulnerability Mapping.* Water Science Series, WSS2017-04. Prov. B.C., Victoria B.C.

Project Contact

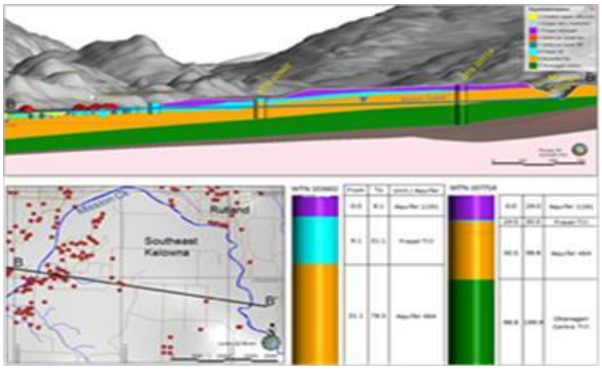
Michele Lepitre | e-mail address: Michele.Lepitre@gov.bc.ca | Phone number: 604-586-2821

Acknowledgements:
Groundwater Science Program

A Revised Geological Model and Hydrostratigraphic Framework for the Kelowna-Mission Aquifers

Project Description

The Kelowna-Mission aquifer re-delineation project was started in 2017 with the objective of building a comprehensive regional hydrostratigraphic model of the Kelowna area. The objective was to provide a comprehensive study that synthesizes the hydrostratigraphic information available for the Kelowna-Mission area to produce a rigorous, defensible and updateable geologic model. This geologic model is intended to provide a foundation both for future groundwater allocation decisions and for regional or site specific hydrogeologic studies.



Cross section showing the Rutland Section of the Greater Kelowna Aquifer (464) below Southeast Kelowna.

Summary of Project Outcome

A three-dimensional (3D) modelling approach was utilized to generate digital representations of aquifers and their confining units, to add aquifer information to the wells database and to summarize the regional hydrostratigraphy of the local overburden. The model extends from Ellison lake, south to bedrock, and from Lake Okanagan, east to where Mission Creek enters the Okanagan valley upstream of Gallaghers Canyon. Three main aquifers in the Kelowna area have been defined based on results of the modelling, in order from shallowest to deepest

- The Mission Creek Aquifer, a shallow unconfined aquifer comprising alluvium and flood deposits associated with the meandering channel of Mission Creek and Mill Creek;
- The Central Kelowna Aquifer, a semi-confined aquifer comprising proglacial outwash sediments overlying Fraser-age till, but predating deposition of late glacial lacustrine sediments; and
- The Greater Kelowna Aquifer, a deep confined aquifer comprising highly productive alluvial sediments (Bessette Sediments) from the non-glacial period between the Okanagan Centre glaciation and Fraser glaciation.

Relevance

Understanding the character of aquifers in priority areas such as Kelowna is an important component of groundwater resource and risk assessment in the province and provides critical support for resource management.

Learnings

The thickness and characteristics of the overburden underlying the Greater Kelowna Aquifer is poorly understood. Additional work is needed to reconcile aquifer geometry, hydraulic gradients and implications for recharge and discharge to/from the aquifers documented in this report.

Partners and Linkages

The project was completed in collaboration with the Okanagan Basin Water Board.

References

Stewart, M. and R. Allard 2018. *A revised geological model and hydrostratigraphic framework for the Kelowna-Mission Aquifers.* British Columbia Water Science Series, WSS2018-03, Victoria B.C.

Project Contact

Andarge Baye | e-mail address: andarge.baye@gov.bc.ca | Phone number: 778-698-4079

Nicole Pyett | e-mail address: nicole.pyett@gov.bc.ca | Phone number: 250-490-2285

Acknowledgements:
Groundwater Science Program

Surface Water and Groundwater Interactions in the Stoney Creek Watershed: Insights from Numerical Groundwater Flow Modelling

Project Description

The interaction between surface water and groundwater in the Stoney Creek watershed in Vanderhoof, B.C. was investigated using numerical groundwater flow modeling. The model estimates the annual water budget and simulates the groundwater table throughout the year in the watershed. The model was calibrated using stream levels and shallow groundwater levels that were collected from 2015 to 2017 at seven transects along the creek below Tachick Lake. The results from this study will support decision-makers who require a more detailed understanding of surface water-groundwater interactions to inform water allocation decisions.

In stream piezometer and stilling well in the creek.
Photo credit: Jun Yin

Summary of Project Outcome

A calibrated numerical model was developed to simulate the groundwater flow in aquifers underlying the Stoney Creek watershed. Through simulation, Stoney Creek was determined to be a gaining stream that receives water from groundwater throughout the year. The present work shows that groundwater is a major contributor to streamflow in Stoney Creek and Nechako River, during both wet and dry seasons. Precipitation contributes to the groundwater recharge through infiltration, with the highest contributions between April-May and August-September. Tachick Lake also interacts with the groundwater system by gaining groundwater in the region but losing water to Stoney Creek. The net water budget is gaining.

Relevance

This project studies the seasonal surface water and groundwater connectivity in the watershed. The calibrated model is a tool to understand the interactions between surface water and groundwater and will assist with water allocation and water resource management in different scenarios.

Learnings

Surface water and groundwater interactions play an important role in determining the regional water budget. The contribution of groundwater to streamflow varies significantly throughout the year. When making allocation decisions in areas with water scarcity and groundwater use near sensitive or fully allocated streams, factors that control the surface water groundwater connectivity (e.g., river bed connectivity) need to be considered.

Partners and Linkages

The project was a joint project between the University of Northern British Columbia (UNBC) and FLNR.

References

Aghbelagh, Y.B., Li, J., and J.Yin 2018. Surface Water and Groundwater Interactions in the Stoney Creek Watershed: Insights from Numerical Groundwater Flow Modeling (in progress).

Project Contact:

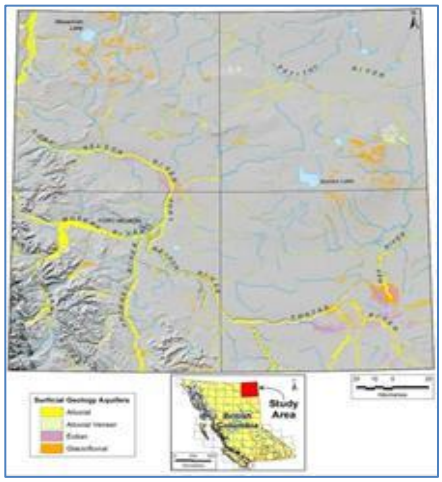
Jun Yin | e-mail address: jun.yin@gov.bc.ca | Phone number: 778-693-3015

Acknowledgements:
Groundwater Science Program

Liard and Petitot Sub Basins Transboundary Groundwater Resources Assessment, Northeast British Columbia

Project Description

Limited knowledge on aquifers in the region is a major impediment to the sustainable management of transboundary groundwater resources. The Liard-Petitot project is designed to provide geological and hydrogeological data to aid in groundwater resource assessments in the Liard and Petitot sub-basins trans-boundary water management areas. The purpose of the project is to compile, synthesize and analyze groundwater related information from NTS map sheets 94I, 94J, 94O and 94P including surficial geology maps, water well records, geology, hydrology, current development activities and groundwater use to infer and prioritize potential transboundary aquifers/groundwater areas for future aquifer mapping and characterization.



Aquifers mapped from surficial geology.

Summary of Project Outcome

To determine priority areas for future study, two land use indices were generated, and then combined to make a third. First, general land surface impacts were quantified by considering data on the area of land use impact, land use type and general surficial hydrogeology type. This index is mainly a proxy of land use impacts on groundwater quality. Secondly, an index of water well density was generated by considering the density of wells. This index is a proxy for land use impacts on groundwater quantity. Finally, the two indices were normalized and combined to create a total index of land disturbance and well density, and then ranked for each of 28 drainage basins in the study area. Disturbance indices were determined by evaluating disturbance in the entire basin as well as disturbance only within aquifers. The top ranked (high priority) basins as a proportion of the entire basin area are the Lower Prophet (1), Middle Fort Nelson (2), Lower Muskwa (3), Lower Fort Nelson (4), Lower Liard (5) and Upper Muskwa (6) river basins. As a proportion of only aquifer area, they are the Lower Fort Nelson (1), Middle Fort Nelson (2), Lower Muskwa (3), Lower Prophet (4), Upper Fort Nelson (5) and Lower Liard (6) river basins.

Relevance

The assessment is intended to support the implementation of the Mackenzie River Basin Bilateral Water Management Agreements as well as to provide key information for the implementation of the *Water Sustainability Act* (WSA) and the Northeast Water Strategy (NEWS).

Learnings

Three major types of aquifer systems were identified in the area: alluvial (mainly fluvial) aquifers, where the potential for hydraulic connectivity with a river is high, upland (mainly glaciofluvial) aquifers that may or may not be hydraulically connected to modern surface water bodies and bedrock aquifers.

References

Levson, V.M., H. Blyth, T. Johnsen and M. Fournier. 2018. Liard and Petitot Sub Basins Transboundary Groundwater Resources Assessment. Water Science Series, WSS2018-01. Prov. B.C., Victoria B.C.

Project Contact

Andarge Baye | e-mail address: andarge.baye@gov.bc.ca | Phone number: 778-698-4079

Acknowledgements:
Groundwater Science Program
Water Intended Outcome

Bulkley Groundwater Interaction Project, Houston, B.C.

Project Description

Groundwater and surface water are a single system and when groundwater is withdrawn there can be implications for streamflow. The Upper Bulkley River watershed near Houston, BC, is a classic valley fill aquifer consisting of sand and gravel with strong connections between groundwater and surface water. There is considerable interest around hydraulic connectivity and Environmental Flow Needs (EFN) in the Upper Bulkley River watershed. This interest is due, in part, to the watershed's natural propensity for drought and low flow conditions, high water temperatures, its importance as a critical spawning and rearing area for pacific salmon and steelhead trout, and its importance as a source of water for a variety of users. This project began in 2018 and is intended to be a 3-year study that includes: a desktop and scoping exercise (Phase 1), field data collection which involves a drone overflight with infrared instrumentation, the monitoring and recording of discharge, water levels, the analysis of water for a range of parameters (Phase 2) and report writing and data sharing with stakeholders, First Nations and Water Management staff (Phase 3).

A view of the Upper Bulkley River.
Photo Credit: Samuel Pittman

Summary of Project Outcome

The intended outcome of this Project is to increase the understanding, at all levels of government (Federal, Provincial, Regional and First Nations), of the interaction between surface water and groundwater resources in the Upper Bulkley River watershed through strategic collection and synthesis of both groundwater and surface water data.

This Project will contribute to a more thorough understanding of groundwater resources, existing allocation pressures, the interplay between groundwater and surface water, and Environmental Flow Needs (EFN) which must now be understood by Water Managers in order to make informed and durable water allocation decisions under the *Water Sustainability Act.*

Relevance

This project will support not only water management decisions in the Upper Bulkley River watershed but will provide critical water information to a multi-year, multi-stakeholder fisheries research project.

Partners and Linkages

Project development and data sharing partners will include: The Office of the Wet'suwet'en; The Wet'suwet'en First Nation; The Upper Bulkley River Streamkeepers; The District of Houston; The Regional District of Bulkley-Nechako; Fisheries and Oceans Canada; and FLNR staff.

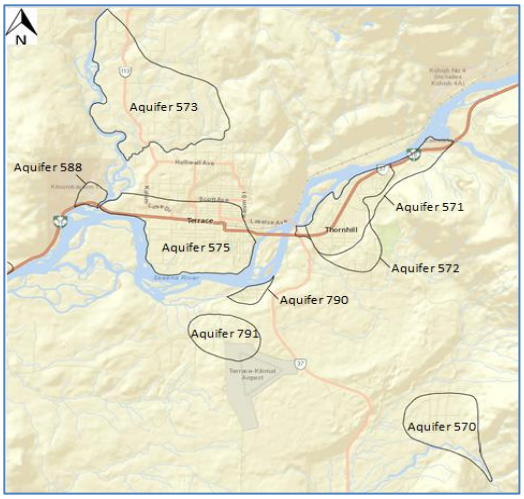
Project Contact

Samuel R. Pittman| E-mail address: Samuel.Pittman@gov.bc.ca | Phone number: 250-847-7493

Terrace Aquifer Characterization Project, Terrace, B.C.

Project Description

The purpose of this study is to identify approaches to characterize aquifers using water chemistry as a primary information source and to improve the understanding of local aquifers and groundwater resources in the Terrace and Thornhill area. A sampling program was developed to evaluate groundwater and surface water quality in order to provide insight into groundwater recharge zones, interactions between surface water and groundwater, and to aid in estimating the mean groundwater recharge.



Mapped aquifers in the Terrace.

Summary of Project Outcome

The project is in its final year (2018) of data collection. Three rounds of private well sampling (28 sites) and surface water collection (15 sites) have been completed. Sample analysis included metals, isotopes, and general parameters. In addition, a total of 16 groundwater sites were selected for tritium analysis during the summer 2017 sampling event. Data analysis is underway; outcomes of the final project are expected in the fall of 2018.

Relevance

There is a lack of hydrogeological knowledge/understanding in regards to the recharge areas for the aquifers in Terrace and the interactions between groundwater and surface water bodies (i.e., Skeena River). Due to an increase in industrial activities and the potential for future development around Terrace, the groundwater resources need to be better understood to ensure groundwater protection and sustainability. In addition, this research will support effective allocation and management of the groundwater resource. The methods developed as part of this project (i.e., natural isotopic tracer) can be extrapolated to different regions.

Learnings

1) Water chemistry can be used as a tool to better define aquifer boundaries and was used to assess groundwater surface water interactions in the Terrace area;
2) Analysis of water samples for tritium isotopes can provide useful information related to aquifer recharge zones but local meteoric water chemistry needs to be established.

Partners and Linkages

Sampling occurs from volunteer wells across the region, volunteer wells are from the City of Terrace, the Regional District of Kitimat-Stikine, First Nations (Kitselas and Kitsumkalum), and private home owners.

References

A final report will be produced documenting the results of the research.

Project Contact

Johanna Wick | E-mail address: Johanna.wick@gov.bc.ca | Phone number: 778-693-2671

Acknowledgements:
Water Intended Outcome

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- Brentwood College
- Fisheries and Oceans Canada
- Geological Survey of Canada
- Ministry of Energy, Mines and Petroleum Resources
- Ministry of Environment and Climate Change Strategy
- Ministry of Transportation and Infrastructure
- The Kitselas First Nation
- The Kitsumkalum First Nation
- The Wet'suwet'en First Nation
- The Office of the Wet'suwet'en
- The Okanagan Basin Water Board
- The Upper Bulkley River Streamkeepers
- The District of Houston
- The District of Sooke
- The District of Maple Ridge
- The District of Mission
- The Bowen Island Municipality
- The Village of Midway
- The Township of Langley
- The City of Surrey
- The City of Abbotsford
- The City of Chilliwack
- The City of Terrace
- The City of Cranbrook
- The Cowichan Valley Regional District
- The Regional District of Bulkley-Nechako
- The Regional District of Kitimat-Stikine
- The Capital Regional District
- The Powell River Regional District
- The GWELLS development team