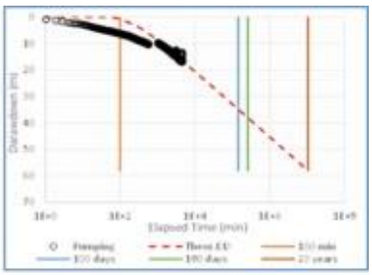
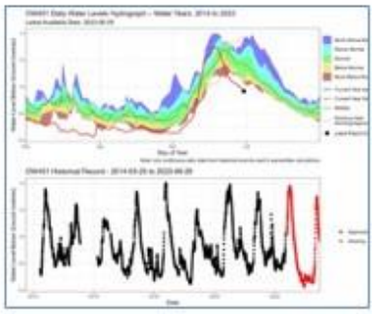
WATER SCIENCE SERIES

Compendium of Provincial Groundwater Science and Monitoring Projects: 2022-23





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Clockwise from left:
Drilling of observation well # 508, Tulameen, B.C. Photo: J. Pogson
Semi-log plot of Cooper-Jacob extrapolated drawdown. Graphic provided by D. van Everdingen
Observation well #511, Savary Island, B.C. Photo: B. Jackson
Annual groundwater hydrograph with historic water level percentiles. Graphic provided by J. Goetz

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PREFACE

The B.C. Provincial Groundwater Program originated in 1961 when the *Water Act* was revised to enable the licensing of groundwater. The primary goals of the Groundwater Program are to increase the understanding of groundwater resources in British Columbia, and to promote the sustainable management and protection of groundwater resources. To advance these goals, there is an ongoing need to improve scientific knowledge and monitoring of aquifer characteristics, groundwater availability, and groundwater interactions with surface water. This knowledge is central to the review of groundwater license applications in accordance with the 2016 *Water Sustainability Act* (*WSA*) and supports the goals of sustainable allocation and use of groundwater resources and science-based policy development.

The Groundwater Program is jointly administered by the Ministry of Water, Land and Resource Stewardship (WLRS), the Ministry of Environment and Climate Change Strategy (ENV) and the Ministry of Forests (FOR). Currently, groundwater science and monitoring projects are primarily supported through three main funding envelopes:

- the Groundwater Science Program, administered by the Water Protection & Sustainability Branch (WPS) in WLRS;
- dedicated funding in ENV to support the expansion, management and maintenance of the Provincial Groundwater Observation Well Network; and,
- the Water Research Portfolio, administered by FOR.

The Groundwater Program also partners with other ministries and agencies in support of groundwater related studies, including: the Ministry of Agriculture and Food (AF), the Ministry of Energy, Mines and Low Carbon Innovation (EMLI), Geoscience BC, the BC Energy Regulator (BCER), universities, local governments, and First Nations.

This compendium is published under the *Water Science Series* to bring together a compilation of short summaries of the groundwater science and monitoring projects supported by the Province during the 2022-23 fiscal year. The intent is to communicate to a wide audience about the nature of the projects undertaken and to provide an overview of the project results. Linkages to key institutions, personnel and supporting references are provided within each summary.

CONTENTS

1. AQUIFER MAPPING

To effectively manage groundwater resources 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 Groundwater Wells and Aquifers (GWELLS) application is a primary source of groundwater information and data across the Province. The GWELLS database is used to: i) support and inform groundwater allocation and water rights; ii) prioritize groundwater management initiatives; iii) support the protection of groundwater quality and groundwater remediation efforts; and iv) serve as a public resource for groundwater information, education, and data.

As of August 2023, the GWELLS database contained over 1,290 aquifers. The Province continues to conduct new aquifer mapping projects to expand and refine the database. The demand for mapping aquifers is ongoing as communities expand and 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 several factors including: (i) local knowledge of emerging issues identified through regional work with communities; (ii) the location of water wells in the provincial GWELLS database that are not yet associated with a mapped aquifer; and (iii) the location of major resource development projects (e.g., mines, oil and gas).

In 2022/23, aquifers were primarily mapped or revised in northeast B.C. within the Kiskatinaw-Peace area, south of the Peace River, between the Pine River and the British Columbia-Alberta provincial border. This aquifer mapping information is used in groundwater allocation and licensing decisions under the *Water Sustainability Act* and is available to the public to inform groundwater well protection and land use planning.

Spatial information about mapped aquifers can be accessed using the following tools:

- GWELLS – The Provincial database for storing, visualizing and retrieving water well records and aquifer information; and,
- iMapBC – view, visualize and analyze mapped aquifers along with hundreds of other data layers compiled from across the BC Government and other agencies. The provincial aquifer layer is named "Aquifers" and is found under the heading "Fresh Water and Marine."

Aquifer Mapping Studies, Northeast Region

Project Description

Phase 2 of the Northeast region aquifer mapping project focused on the Kiskatinaw and Pouce Coupe watersheds in proximity to the communities of Groundbirch, Dawson Creek and others. Due to climate changes in precipitation patterns, irrigation will be increasingly required for agriculture in northeast B.C. Most agricultural land in the region is located well above the floors of river valleys. As a result, groundwater development is expected to increase.

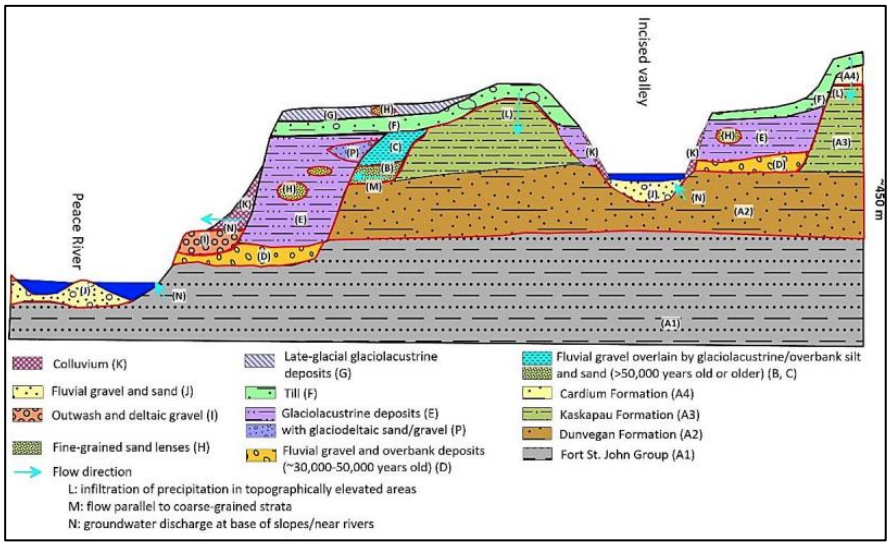

Figure 1 Conceptual model of the geology and hydrogeology of the Study Area (Source: Lengyel et al., 2023).

Through identification and mapping of freshwater aquifers, this study provides a foundation for sustainable management of groundwater resources. This project integrated water well records from the GWELLS database with information from previous hydrogeologic studies and mapping of geology, topography, streams and springs to map new and update existing aquifers.

Project Outcomes

Twelve existing aquifers were updated, and one additional aquifer was mapped as an outcome of this study.

Relevance

The results will inform groundwater licensing under the *Water Sustainability Act*. The results may also be used to inform priorities for groundwater protection, studies of hydraulic connections with surface waters, and groundwater availability analyses.

Learnings and Recommendations

This study provides a foundation that can inform the direction of future work. Further studies could be conducted to improve understanding of groundwater-surface water interactions, surficial geologic mapping, collection of data from existing water wells, or expansion of the Provincial Groundwater Monitoring Well Network.

References

Lengyel, T., J. Deri-Takacs, A.C. Hinnell, and J.J Clague, 2023. Kiskatinaw-Peace Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2023-04. Province of British Columbia, Victoria.

Project Contacts

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Funding Acknowledgements:
Groundwater Science

2. WATER MONITORING

Groundwater Monitoring

The Provincial Groundwater Observation Well Network (PGOWN) monitors groundwater conditions in aquifers across British Columbia through provincially managed groundwater monitoring wells. The groundwater level measurements collected through the network helps inform water stewardship decisions across the Province. Two main objectives of the network are:

1. Understanding local and regional hydrogeological processes; and,
2. Supporting the sustainable use of groundwater.

Information collected through the PGOWN is publicly available through several Provincial portals:

- The Interactive Map – includes all PGOWN information including the location of active and inactive monitoring wells; links to monitoring well construction reports; and groundwater level data and charts for real-time data and historical data.
- The Real-time Water Data Tool – is a browser-based information and data presentation system for access to continuous (time-series) surface, groundwater, snow monitoring data.
- The Environmental Monitoring System (EMS) Web Reporting – is an on-line search tool for surface and groundwater quality information stored in the EMS database.

The PGOWN was formally established in 1961 and the network has evolved with new observation wells added over time while others have been discontinued as priorities, staffing levels and funding levels have fluctuated. As of August 2023, there were 233 active observation wells in the PGOWN with several more wells to be added. During the 2022-23 fiscal year, ten new observation wells were drilled and added to the network. The new observation wells are described in the following project summaries.

In addition to the expansion of the PGOWN, another major project for this monitoring program currently underway is the development of an operations manual for our field technicians. This manual will help to ensure standardized operations are followed across the network and is being written jointly by staff from the Ministry of Environment and Climate Change Strategy, and the Ministry of Forests, and by Hatfield Consultants. While this project was started during the 2022-23 fiscal year, it will be completed in the 2023-24 fiscal year due to the complexity of developing or updating the necessary standard operating procedures and guidance.

Surface Water Monitoring

The Province co-manages the Federal-Provincial Hydrometric Network with the Water Survey of Canada, which includes 460+ hydrometric stations across the province. Network operation costs are shared between the provincial and federal governments and 3rd parties. The majority of the stations are operated on larger river systems for a variety of objectives such as public safety, trans-boundary water management, and utility, transportation and resource management. The network focuses on the primary hydrometric parameters of stage and discharge with auxiliary parameters at select locations. Stations are operated in both real-time (telemetry) and non-real-time. Data are published through the federal Water Office website (https://wateroffice.ec.gc.ca/).

Some Provincial Regions conduct additional local hydrometric measurements to fill data gaps on smaller stream systems to support licensing decisions. Monitoring of surface water helps to provide insight into the interactions between aquifer-stream systems and provides a more complete picture of the water exchanges between the surface and sub-surface required for assessing water resources.

Provincial Groundwater Observation Well #504, Langley, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) is intended to monitor groundwater conditions in selected aquifers throughout B.C. to support water management. In partnership with the Township of Langley, Provincial Observation Well 504 (OW504) was installed to monitor groundwater level trends in Provincial Aquifer 1192 (Aldergrove CD), a confined sand and gravel aquifer that is a significant water resource to the nearby community.

Observation Well 504 – Langley B.C.
Photo: Kumar KC

Project Outcomes

OW504 was drilled in December 2022 to a depth of 68.6 metres below the ground surface and screened within Aquifer 1192. Telemetry was added during the summer of 2023 to provide real-time monitoring of the groundwater levels. Hourly water level monitoring data is publicly available through the B.C. Groundwater Level Data Interactive Map and the provincial Aquarius time-series database. Water quality information is publicly available through the Environmental Monitoring System (EMS ID E332112).

Relevance

Aquifer 1192 is located in an area with significant reliance on groundwater extraction. OW504 is the first observation well installed in Aquifer 1192 and will provide insights on groundwater level trends within the aquifer. Data collected from OW504 will support water allocation and inform groundwater licensing and water management decisions.

Learnings and Recommendations

Groundwater level monitoring and water quality data for OW504 will provide important baseline information to support water management decisions for this area.

Partners and Linkages

The Township of Langley partnered with the Province to install OW504. The Township contributed $10,000 towards the drilling cost of completing this observation well and allowed the observation well to be drilled on their property.

References

Province of British Columbia. 2023. Well Record for Observation Well 504. GWELLS, Well Tag Number 128157.

Project Contacts

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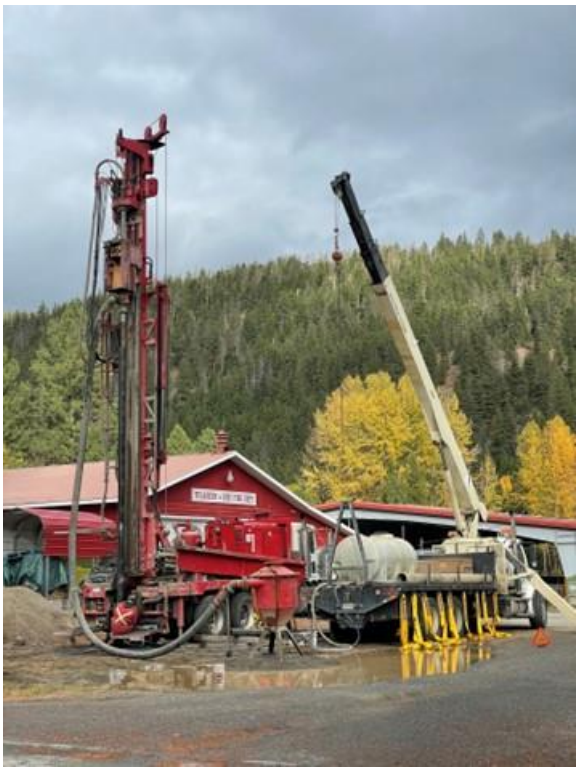
Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, Coast Area Regional Operations
Township of Langley

Provincial Groundwater Observation Well #508, Tulameen, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors water levels and water quality in aquifers across B.C. to support effective and sustainable water management and to protect valuable groundwater resources.

Provincial Observation Well 508 (OW508) was installed in Tulameen, B.C. – a location with regular water scarcity concerns. The purpose of the well is to provide baseline groundwater monitoring and characterization of the aquifer.



Drilling of Observation Well 508 – Tulameen B.C.
Photo: J. Pogson

Project Outcomes

OW508 was installed in Provincial Aquifer 1010 at a depth of 29.95 metres below ground surface (mbgs). The static water level in OW508 at the time of installation was 4.19 mbgs. A stepped rate pumping test and 8-hour constant rate pumping test were conducted. Water quality information from water samples collected after the pumping test is available through the B.C. Environmental Monitoring System (EMS ID E329792). Hourly water level monitoring data has been collected since July 4, 2023, and will be publicly available through the B.C. Groundwater Level Data Interactive Map.

Relevance

The drilling and installation of OW508 provides water level, lithology, and water chemistry data that can be used to: support licensing and management decisions; assist protection and sustainable use of the resource; and inform flood and drought emergency response in the area.

Learnings and Recommendations

Groundwater quality data and groundwater level monitoring at OW508 will provide important baseline and ongoing groundwater level information that may inform future water allocation and management decision-making in the area. The drilling, installation and pumping test at OW508 provides detailed lithological information and valuable insight into aquifer properties.

References

Province of British Columbia. 2023. Well Record for Observation Well 508. GWELLS, Well Tag Number: 128408.

Project Contacts

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Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, South Area Regional Operations

Provincial Groundwater Observation Well #509, Canyon, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors water levels and water quality in aquifers across B.C. to support effective and sustainable water management and to protect valuable groundwater resources.

Observation Well 509 (OW509) was installed in Provincial Aquifer 489. This monitoring location will provide long-term groundwater level monitoring in a location with regular water scarcity concerns; help assess the likelihood of hydraulic connection to the Goat River; and, increase hydrogeologic understanding of an area with significant agricultural value.

Drilling of Observation Well 509 – Canyon B.C.
Photo: N.Pyett

Project Outcomes

OW509 was installed in an unconfined alluvial fan aquifer (Aquifer 489) to a depth of 57.6 metres below ground surface (mbgs). The static water level in OW 509 was measured at 23.90 mbgs on June 06, 2023. Water quality and isotope information will be available through the B.C. Environmental Monitoring System (EMS ID E329791). Hourly groundwater level monitoring data has been collected since June 06, 2023, and is publicly available through the B.C. Groundwater Level Data Interactive Map.

Relevance

Groundwater level monitoring in OW509 will inform water management decision-making in an area of known water scarcity. Drilling and sampling of OW509 provides valuable subsurface information related to geology, the likelihood of hydraulic connectivity to surface water, and groundwater quality in Provincial Aquifer 489.

Learnings and Recommendations

Groundwater levels are well below ground surface at this location. Groundwater level and chemistry data from OW 509 will provide important baseline information that may inform future research on groundwater/surface water interactions in the area.

References

Province of British Columbia. 2023. Well Record for Observation Well 509. GWELLS, Well Tag Number 126644.

Project Contacts

Nicole Pyett | e-mail: Nicole.Pyett@gov.bc.ca | Phone: 778-622-6974

Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, South Area Regional Operations

Provincial Groundwater Observation Well #510, near Armstrong, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors water levels and water quality in aquifers across B.C. to support effective and sustainable water management and to protect valuable groundwater resources.

This project results from a desire to resume monitoring of Provincial Aquifer 1153, which was discontinued in 2010. Provincial Observation Well 510 (OW510) was installed in fine sand, beneath approximately 60 m of fine-grained clay and silty clay. This observation well will provide long-term groundwater level monitoring in a location of increasing water scarcity concerns.

Drilling of Provincial Observation Well 510
Photo: D. Thomson

Project Outcomes

OW510 was installed in Provincial Aquifer 1153 at a depth of 72.6 metres below ground surface (mbgs). The static water level in OW510 at the time of installation was ~2.5 mbgs.

Water quality and isotope information is available through the B.C. Environmental Monitoring System (EMS ID E330711). Hourly groundwater level monitoring data has been collected since February 21, 2023, and is publicly available through the B.C. Groundwater Level Data Interactive Map.

Relevance

Groundwater level monitoring in OW510 will inform water management decision-making in an area of known water scarcity. Drilling and sampling of OW510 provides valuable subsurface information related to geology and groundwater quality in Provincial Aquifer 1153.

Learnings and Recommendations

Groundwater levels are near ground surface at this location and indicate an upward vertical hydraulic gradient. Laboratory analyses of groundwater samples reported concentrations of manganese above the Maximum Acceptable Concentration (MAC) for Canadian Drinking Water Quality Guidelines (CDWQG, 2023), and hardness was reported above the Aesthetic Objective (AO). Groundwater level, and chemistry and isotope data from OW510 will provide important baseline and ongoing groundwater level monitoring to inform future research on groundwater level trends and groundwater/surface water interactions in the area.

References

Province of British Columbia. 2023. Well Record for Observation Well 510. GWELLS, Well Tag Number 128403.

Project Contacts

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Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, South Area Regional Operations

Provincial Groundwater Observation Well #511, Savary Island, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) is intended to monitor groundwater conditions in selected aquifers throughout B.C. to support water management. Provincial Observation Well 511 (OW511) was installed to monitor groundwater level trends in Provincial Aquifer 834 (Savary Island), a mostly confined sand and gravel aquifer that is an essential water resource to the nearby community.

Observation Well 511 – Savary Island B.C.
Photo: B. Jackson

Project Outcomes

OW511 was drilled in November 2022 to a depth of 9.14 metres below the ground surface, and screened within Aquifer 834. Telemetry will be added during the summer of 2023 to monitor the groundwater levels of this confined sand and gravel aquifer. Water samples will be collected to analyze for groundwater chemistry.

Relevance

OW511 is the second observation well installed in Aquifer 834, and will provide insight on groundwater level trends in the western portion of the aquifer, which is an area with a significant number of domestic wells. Water supply on the eastern portion of Savary Island is mostly supplied by the Savary Shores Improvement District and is monitored by OW408. Data collected from OW511 will support water allocation and inform groundwater licensing and water management decisions.

Learnings and Recommendations

Groundwater level and chemistry data for OW511 will be made available through the Groundwater Level Data Interactive Map, the provincial Aquarius time-series database, and the Environmental Monitoring System once monitoring and telemetry equipment are installed.

Partners and Linkages

The Ministry of Transportation and Infrastructure allowed the installation of OW511 on their road right-of-way.

References

Province of British Columbia. 2023. Well Record for Observation Well 511. GWELLS, Well Tag Number 128292.

Project Contacts

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Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, Coast Area Regional Operations

Provincial Groundwater Observation Well #512, South Okanagan Grassland Protected Area near Osoyoos, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors water levels and water quality in aquifers across B.C. to support effective and sustainable water management and to protect valuable groundwater resources.

This project is the result of collaboration between Osoyoos Indian Band (OIB), BC Parks and the Ministry of Forests. The South Okanagan Grassland Protected Area (SOGPA) Provincial Observation Well 512 (OW512) was installed in bedrock, overlain by a thin veneer of unconsolidated overburden materials ranging from silts to sand and gravel. A shallow piezometer was installed adjacent to OW512 at the overburden-bedrock interface to establish the vertical gradient of groundwater flow. OW512 will provide long-term groundwater level monitoring in a location with regular water scarcity concerns.

Drilling of Observation Well 512
Photo: J. Pogson

Project Outcomes

OW512 was installed in Provincial Aquifer 238 at a depth of 36.6 metres below ground surface (mbgs). The static water level in OW512 at the time of installation was 0.61 metres above ground surface (mags) and lowered to 0.52 mbgs by May 30, 2023. The shallow piezometer was dry at the time of drilling and measured 1.7 mbgs on May 30, 2023. Water quality and isotope information is available through the B.C. Environmental Monitoring System (EMS ID E330911). Hourly groundwater level monitoring data has been collected since February 21, 2023, and is publicly available through the B.C. Groundwater Level Data Interactive Map.

Relevance

Groundwater level monitoring in OW512 will inform water management decision-making in an area of known water scarcity. Drilling, installation and sampling of OW512 provides valuable subsurface information related to geology and the vertical hydraulic gradient in addition to groundwater quality parameters within Provincial Aquifer 238.

Learnings and Recommendations

Groundwater levels were near ground surface. An upward vertical hydraulic gradient was calculated. Laboratory analyses of groundwater samples reported elevated concentrations of sulphate, chloride, sodium, and manganese among others. Groundwater level and chemistry data from OW512 will provide important baseline and ongoing water level information that may inform future research on groundwater/surface water interactions in the area.

Partners and Linkages

Osoyoos Indian Band and BC Parks

References

Province of British Columbia. 2023. Well Record for Observation Well 512. GWELLS, Well Tag Number 128380

Project Contacts

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Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, South Area Regional Operations

Provincial Groundwater Observation Wells #514 (shallow) and #515 (deep), Salmon River at Falkland, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors water levels and water quality in aquifers across B.C. to support effective and sustainable water management and to protect valuable groundwater resources.

Provincial Observation Well 514 (OW514) is a shallow well completed in Provincial Aquifer 97- Salmon River Upper, and Observation well 515 (OW515) is a deep well completed in Provincial Aquifer 98 - Salmon River Lower. These wells are located near Water Survey of Canada (WSC) stream hydrograph station 08LE020 – Salmon River at Falkland. OW514 and OW515 will provide long-term groundwater level monitoring in a location with regular water scarcity concerns and improve understanding of the groundwater-surface water interactions in this area.

Drilling of Observation Wells 514 & 515
Photo: M. Wade

Project Outcomes

OW514 was installed Aquifer 97 at a depth of 11.9 metres below ground surface (mbgs). The static water level in OW514 at the time of installation was 3.05 mbgs. OW515 was installed in deeper Aquifer 98 at a depth of 35.7 mbgs. The static water level in OW515 at the time of installation was 2.28 mbgs. Hourly water level monitoring data has been collected since May 4, 2023, and is publicly available through the B.C. Groundwater Level Data Interactive Map. Water quality information is available through the B.C. Environmental Monitoring System (EMS IDs E331412 for OW514 and E331411 for OW515)

Relevance

The drilling and installation of these wells provides water level, lithology, and water chemistry data that can be used to support licensing and management decisions, protection and sustainability of the resource, and inform flood and drought emergency response in the area. These wells satisfy recommendations to include PGOWN locations paired with a hydrometric station to improve groundwater-surface water interactions and support Environmental Flow Needs (EFN) assessments. These wells also allow assessment of municipal pumping wells on river flow and groundwater levels.

Learnings and Recommendations

Groundwater level and chemistry data from OW514 and OW515 will provide important baseline and ongoing level information that may inform future research on groundwater/surface water interactions in the area.

References

Province of British Columbia. 2023. Well Record for Observation Well 514. GWELLS, Well Tag Number 128015.
Province of British Columbia. 2023. Well Record for Observation Well 515. GWELLS, Well Tag Number 128014.

Project Contacts

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Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, South Area Regional Operations

Provincial Groundwater Observation Wells #516 & #517, Vanderhoof, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) is intended to monitor groundwater quantity and quality in aquifers across British Columbia. To fill data gaps identified in a recent aquifer mapping study (Hinnell et al., 2020), two observation wells were constructed in Provincial Aquifers 242 and 246 near Vanderhoof, B.C. These glacial fluvial aquifers are important sources of groundwater supply to municipal and agricultural users. Pressure on these aquifers is expected to increase as streams in the area are already experiencing limitations in their ability to meet a growing demand. Additionally, information collected from these two wells will be used to support the ongoing Stoney Creek numerical modelling project (see separate project summary below.

Drilling of Observation Well 516 – Vanderhoof B.C.

Project Outcomes

Provincial Observation Wells 516 (OW516) and 517 (OW517) were drilled in March 2023. OW516 was drilled to 97.5 metres below ground surface (mbgs) into Aquifer 242 and completed with a 3 m stainless steel screen. OW517 was drilled to 48.8 mbgs and completed in Aquifer 246 with a 3 m stainless steel screen. Water samples were collected in June 2023 and continuous water level monitoring equipment was installed in each well. Water level monitoring data is publicly available through the B.C. Groundwater Level Data Interactive Map.

Relevance

The Nechako Valley consists of the second largest agriculture belt in the Province, and water demand has been increasing in recent years due to domestic and agricultural needs. This project adds second and third observation wells in the valley to monitor two major unconsolidated aquifers. These aquifers are expected to be in close connection with the underlying bedrock aquifers. Information obtained from both wells can be used to support allocation decisions.

Learnings and Recommendations

Both wells were completed in glacial fluvial aquifers with relatively fresh groundwater. Pumping tests and seasonal water chemistry analysis can be used to assess the hydraulic connectivity between the wells and nearby streams. Winter drilling incurs extra costs related to snow removal and fuel consumption for heating.

Partners and Linkages

This project is co-funded by the Climate Action Plan administered by the Forest Carbon & Climate Sciences Branch within the Ministry of Forests.

References

- Hinnell, A.C., T. Lengyel, S. Funk, J.J Clague and Z.M. Hammond, 2020. Vanderhoof and Houston Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2020-07, Province of B.C.
- Province of British Columbia, 2023. Well Record for Observation Well 516, Well Tag Number 128282
- Province of British Columbia, 2023. Well Record for Observation Well 517, Well Tag Number 128283

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Funding Acknowledgements:
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, North Area Regional Operations

South Coast Natural Resource Region Hydrometric Network

Project Description

The South Coast Hydrometric Network was established between 2019 to 2020 by regional Ministry of Forest (FOR) staff and initially consisted of 14 manual stations. The network currently has 11 stations. Two stations were lost during the atmospheric river event in 2021 and one was decommissioned due to performance issues. Additional stations, including real-time stations, are planned for areas in the South Coast Region not covered under the Canada-British Columbia Hydrometric Program. The goal of the network is to provide authorization staff with quality non-integrated hydrometric data collected and graded using the Manual of British Columbia Hydrometric Standards (RISC). Data will aid with water licensing and approval decisions, drought response, and sustainable resource planning.

Google Earth Imagery of South Coast Hydrometric Network.

Project Outcomes

Hydrometric stations include benchmarks, staff gauge, and instrumentation to collect discharge and real-time water level data. Data are downloaded bi-monthly with more frequent site visits during peak flow and low flow (drought) periods. Hydrographs, rating curves, water temperature charts, and discharge plots are prepared for each station. The data are available on the Real-time Water Data Tool. Some of the data are preliminary as quality assurance/quality control of data is conducted to ensure the data is graded to RISC standards.

Relevance

The South Coast Hydrometric Network complements the Canada-British Columbia Hydrometric Program by focusing on small urban streams that may be impacted by extraction, land use change, and may be hydraulically connected to important groundwater sources. The collected data provides the Region with a better understanding of the GW-SW interactions in high priority watersheds, supports WSA authorizations and informs drought response during times of water scarcity.

Learnings and Recommendations

Lessons learned from this regional project have helped shape the new Provincial Hydrology Program, complementing the Canada-British Columbia Hydrometric Program and supports development of similar networks in other regions. Hydrometrics is labour and capital intensive, thus, it is recommended to continue a cooperative approach to collect quality hydrometric data where limited or no data are available. Pursuing Local Government data sharing is also a priority to further fill data gaps and reduce monitoring redundancy.

Partners and Linkages

08MH0041 is on private property within the Little Campbell River watershed at A Rocha. 08MH0060 is installed on Blaney Creek within the Malcom Knapp Research Forest (access granted by UBC Forestry). Data from 08MH0048 and 08MH0049 (in Bertrand Creek) have been used by SFU Earth Science students. In addition, various local governments have provided support by permitting FOR staff to install hydrometric equipment on or near their infrastructure. This project is funded by using Regional Ministry of Forests budget and with financial and in-kind support from the Environmental Monitoring and Analysis Branch in Ministry of Environment and Climate Change Strategy.

Project Contacts

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Funding Acknowledgements:
FOR South Coast Regional budget
ENV Climate Preparedness and Adaptation Strategy
ENV Environment and Climate Monitoring Section

3. GROUNDWATER CHARACTERIZATION AND RESEARCH

The Provincial Groundwater Program supports ongoing groundwater science and research projects to promote effective groundwater resource stewardship and to provide a technical basis for groundwater policy development.

In 2022-23, groundwater-surface water interactions continued to be an important area of focus. Under the *Water Sustainability Act*, water is managed as one, interconnected resource and understanding groundwater- surface water (GW-SW) interactions remains a high priority for resource managers and licensing staff. Research projects included both field-based studies and desktop studies, which encompassed a variety of objectives and focus areas.

- Studies to characterize the location and dynamics of GW-SW interactions included:
  - Assessment of GW-SW interactions on the Vaseux Creek Alluvial Fan, Oliver, B.C
  - Groundwater- surface water exchange dynamics in low gradient and tidally influenced streams in the Lower Fraser Valley
  - Upper Bulkley River GW-SW interaction project, Houston, B.C.
  - Prediction of freshwater spring locations using random forest machine learning, Doig River, B.C.
  - Development of an integrated hydrological model for Windermere Creek watershed, Upper Columbia River Basin
  - Impacts of cumulative groundwater withdrawal on surface water and groundwater interactions in Stoney Creek watershed
  - Groundwater monitoring to support authorizations pilot project, Averill Creek watershed
- Studies to characterize the ecological importance of GW-SW interactions:
  - Groundwater flow patterns in shorespawning Kokanee salmon habitat, Western Kootenay Lake
- Studies that focus on the role of groundwater and drought:
  - Drought and deluge: Informed water allocation decision making in a world of intensifying hydrologic extremes, South Alouette Watershed
  - Groundwater and drought - Implementation of groundwater level percentiles to support British Columbia's drought response

Other groundwater science and research projects undertaken in 2022-23 focused on improving knowledge and understanding of groundwater resources and groundwater use to directly inform resource management. These projects included:

- Comparison of sustainable yield determination methods
- Updates to the GWELLS application and database enhancements
- Predictive surficial geology mapping to support groundwater management
- Assessing groundwater allocation limits in B.C.

Assessment of Groundwater-Surface Water Interactions on the Vaseux Creek Alluvial Fan, Oliver, B.C.

Project Description

The Vaseux Creek Groundwater/Surface Water Interactions Study is a three-year project jointly managed by the Ministry of Forests and the Okanagan Nation Alliance (ONA) on the traditional lands of the Osoyoos Indian Band (OIB). snʕaxəlqaxʷiyaʔ (Vaseux Creek) is a site of regular water scarcity-based conflict related to flow requirements for culturally significant fish species, anthropogenic water use demands, and the current hydrological regime. Analysis of data from installed hydrometric and groundwater monitoring equipment will inform our understanding of the dynamics between groundwater and surface water to support effective water management on this site.

snʕaxəlqaxʷiyaʔ (*Vaseux Creek)*
Photo: J. Pogson

Summary of Project Outcome

Year 2 of 3 included refinement of the site conceptual model, on-going maintenance of six hydrometric stations, eight groundwater level monitoring locations, one Okanagan River level monitoring location, and the collection of water level and water quality data throughout the hydrologic year.

Relevance

Pressure on water availability is increasing in many locations across the Province due to expanding development, land use changes, and climate change effects. This study will develop an understanding of the relationship between snʕaxəlqaxʷiyaʔ (Vaseux Creek) and the underlying aquifer and will attempt to assess the impacts of water use on the system to inform aquatic ecosystem recovery efforts and water management activities such as water licensing and drought response.

Learnings & Recommendations

Year 2 data analysis indicated that overall snʕaxəlqaxʷiyaʔ (Vaseux Creek) consistently lost water to the underlying aquifer; however some gains were reported during low flows in the distal portion of the fan. Environmental tracer analysis indicated three distinct water sources recharge the aquifer and control flow direction. Ongoing data collection will develop understanding of inter-annual variability in groundwater/surface water interactions. Development of hydrogeological cross-sections, mapping changes in water levels over time, and more clearly defining the hyporheic zone will inform further evaluation of groundwater/surface water flow dynamics.

Partners and Linkages

Project partners include the Okanagan Nation Alliance; the Osoyoos Indian Band; the Nature Trust of British Columbia; the University of British Columbia (Okanagan); Okanagan Basin Water Board; and the Department of Fisheries and Oceans Habitat Stewardship Program.

References

Province of British Columbia. 2023. Well Record for Observation Well 506. GWELLS, Well Tag Number 125206 and Water levels.

Project Contacts

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Acknowledgements:
All project partners
Groundwater Science Funding
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, South Area Regional Operations

Groundwater-Surface Water Exchange Dynamics in Low-Gradient and Tidally Influenced Streams in the Lower Fraser Valley

Project Description

This study is focused on groundwater-surface water exchanges in tidally-influenced and low-gradient streams in the Lower Fraser Valley of the South Coast Natural Resource Region (South Coast Region). These stream types have unique flow patterns (e.g., tidal oscillations, flow cessation, and flow reversals), which preclude the use of standard methods used to assess Environmental Flow Needs (EFN). Currently there are no established methodologies in B.C. that support implementation of the *Water Sustainability Act* (WSA) for these stream types. The goal of this project is to evaluate whether groundwater-surface water exchange and stream habitat dynamics vary between stream types.

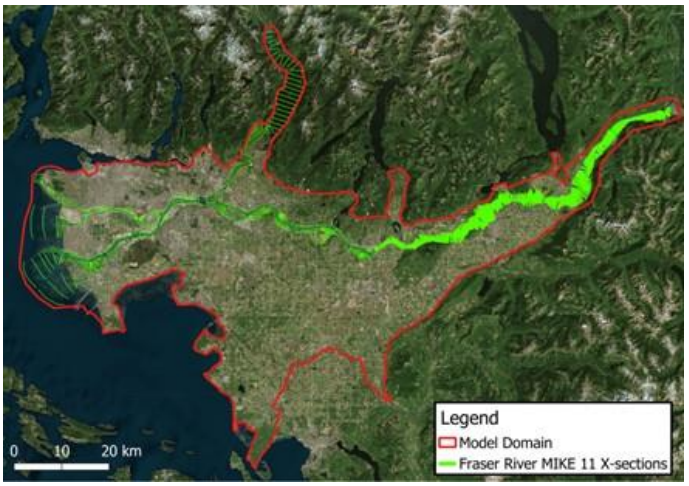

Figure 2. MIKE model domain and MIKE 11 River cross-sections.

A three-dimensional groundwater and surface water model is being built using "MIKE" suite of water modeling software (DHI, 2023). "MIKE SHE" is a fully integrated surface and groundwater modeling package that allows for the simulation of complex hydrological processes such as infiltration, evapotranspiration, surface water flow, recharge, and groundwater-surface water exchange. MIKE SHE is being coupled with a "MIKE 11" River model to characterize both stream and groundwater flow regimes, and groundwater-surface water exchanges for different stream types, primarily tidally influenced and intermittent streams. Paired analysis of model output and empirical hydrometric data will be used to relate stream-type hydrological regimes to patterns of habitat availability and connectivity, which will help inform the evaluation of ecological impacts due to water withdrawals.

Summary of Project Outcome

A baseline MIKE SHE model was successfully built. The geological model developed by Simpson (2012) will be expanded to encompass an area that spans from Delta, westward to Chilliwack and also includes areas North of the Fraser River. A MIKE 11 River model of the Fraser River and Pitt Lake, provided by the River Forecast Centre, is being expanded to include all streams.

Relevance

Results will inform groundwater licensing under the WSA. This project will be a significant contribution toward the completion of actions outlined in the South Coast Region's 5-year water management plan.

Partners and Linkages

Project partners include the Department of Earth Sciences, Simon Fraser University; South Coast Region, B.C. Ministry of Forests; and the B.C. River Forecast Centre.

References

DHI. (2023). MIKE SHE User Manual.

Simpson, M. 2012. Assessing Risk to Groundwater Quality Using an integrated framework. M.Sc. thesis, Department of Sciences, Simon Fraser University.

Project Contacts

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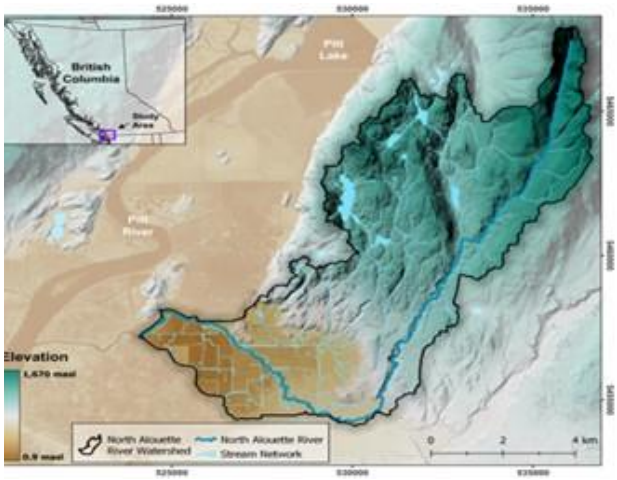
Funding Acknowledgements:
Groundwater Science Funding

Drought and Deluge: Informed Water Allocation Decision Making in a World of Intensifying Hydrologic Extremes, South Alouette Watershed

Project Description

Climate change is resulting in shifts in hydrologic regimes that are increasingly accompanied by intensified extremes, including heavy rain events and prolonged drought periods. This project supported throught the Pacific Institute for Climate Solutions (PICS) focuses on developing solutions for adaptating to climate change. Specifically, this projects seeks a strategy for building resilience in the face of climate extremes for water resources by supporting water allocation decision making.



Model output for South Alouette Watershed.

Summary of Project Outcome

Simon Fraser University hydrologists have partnered with Ministry of Forests staff in the South Coast Region to 1) determine the extent to which the headwater catchments and the different land use types in the lower catchments (forest, bog, agricultural, urban-rural) buffer water resources from an increasingly variable climate and 2) map the sensitivity of valley-bottom stream reaches to climate extremes in areas representing different land-use types.

Relevance

Currently, water licences are issued in perpetuity; however, under s.23 of the WSA a Water Manager may direct a licensee to submit to a review of the terms and conditions of their licence. However, there is currently no guidance on when, where (e.g., focus on selected areas) or how to do this review. The review offers a window of opportunity to introduce new terms and conditions for the water licence (e.g., monitoring, or a reduction in the water licence volume). In this regard, the Province is seeking input on what to consider when water licences are reviewed and what new terms and conditions could be introduced.

Learnings and Recommendations

Phase 1 of this project involved a series of field studies focused on collecting data during extreme weather conditions (e.g., the atmospheric rivers in 2021-22 and summer drought conditions in 2022). Data include: 1) stream temperature (from in situ loggers, a drone mounted thermal infrared (TIR) sensor, and a LandSat TIR sensor); nitrate concentrations; stable isotopes of precipitation, stream and groundwater; streambed permeability. An integrated hydrological model of the watershed is also being developed to explore hydrological responses during extreme weather events.

Partners and Linkages

The partners on this project include: the Pacific Institute for Climate Solutions (PICS) – project funding; Diana Allen (Earth Sciences) and Jesse Hahm (Geography), Simon Fraser University: Shirley Wang, Jacquelyn Shrimer and Michele Lepitre, B.C. Ministry of Forests; Marc Porter with Pacific Salmon Foundation; and, Eric Saczuk of the British Columbia Institute of Technology

Project Contacts

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Funding Acknowledgements:
Pacific Institute for Climate Solutions

Groundwater Monitoring Supporting Authorizations Pilot, Averill Creek Watershed

Project Description

This three-year pilot project aims to enhance the understanding of surface-groundwater interactions within the lower Averill Creek watershed to support water authorizations and the adjudication of water rights. A new groundwater monitoring site will be established to address groundwater data deficiencies, quantify impacts of existing groundwater use, establish baseline data for the purpose of forecasting drought and to set low flow management criteria.

Installation of project monitoring well.
Photo source: Ministry of Forests

Project Outcomes

The first year of the project focused on siting and installing a new monitoring well in the Averill Creek watershed. Site selection targeted an apparent zone of hydraulic connection between Averill Creek and the underlaying aquifer. The selected site is also in the vicinity of a hydrometric monitoring station currently operated by the West Coast water authorizations team. The outcomes of the project include the establishment of a new observation well and collection of groundwater data. Low flow prevented a pumping test from being conducted. A down-hole camera survey highlighted fracture locations where groundwater flows into the well.

Relevance

There are several values to be derived from improved groundwater monitoring in the Averill Creek watershed including a refined assessment of groundwater availability, a better understanding of the potential effects of groundwater demand on streamflow and measuring potential changes to Indigenous water values of the watershed. These objectives not only meet the provincial mandate of sustainable resource management, but also provide potential mitigation options for impacts to aboriginal rights in terms of licensing existing groundwater use, while also furthering reconciliation. In short, monitoring groundwater in the watershed will facilitate better decision making in adjudicating groundwater licences, enhanced resource stewardship and provide a means of mitigating impacts of water withdrawal. Monitoring will also provide data to inform drought forecasting and management response.

Learnings and Recommendations

Averill Creek watershed is an example of an area of considerable water demand contrasted by a deficiency of water data, particularly groundwater, that hinders water authorizations from processing existing groundwater use licence applications. Success of the pilot will lead to an expanded monitoring program, led by water authorizations, to better answer questions and address water management issues.

Partners and Linkages

This project was coordinated in partnership with Cowichan Tribes and the Cowichan Valley Regional District (CVRD). The partnership with the CVRD created an opportunity for the establishment of a groundwater monitoring site on municipal lands and the program design was aligned to also address data gaps of the CVRD's Drinking Water and Watershed Protection Program.

Project Contacts

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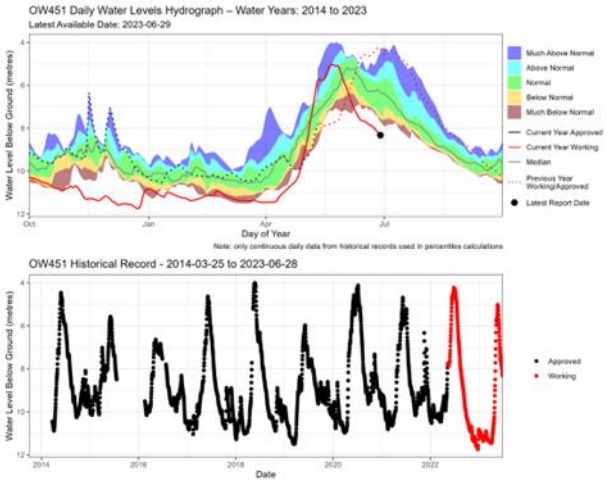
Funding Acknowledgements:
Groundwater Science Program

Groundwater and Drought – Implementation of Groundwater Level Percentiles to Support British Columbia's Drought Response

Project Description

In hydraulically connected groundwater-surface water systems, groundwater levels can potentially be used as an indicator to supplement and support drought monitoring. As part of a recent SFU report titled "Identifying Drought Susceptible and Drought Resilient Aquifer-Stream Systems in British Columbia" (Gullacher et al, 2023), historical groundwater levels from provincial water wells were summarized into percentiles to produce a set of baseline groundwater level graphs for comparing current water level conditions and classifying them as either above, below or comparable to historic levels. The main purpose of this project was to operationalize the use of groundwater level percentiles by developing tools and automated reports to inform decision makers and the public on groundwater level conditions in B.C. throughout the drought season.



Annual hydrograph of groundwater levels with historical water level percentiles and current year levels (top); and historic daily water levels records (bottom). Examples of figured used in groundwater level percentiles reporting.

Project Outcomes

Several different tools have been developed using water level data from the 200+ wells in the Provincial Groundwater Observation Well Network (PGOWN). These products maintained by the River Forecast Center, include:

- static and interactive plots of recent groundwater levels compared to historical percentiles;
- automated regional groundwater drought reports which summarize the number of wells with water levels below normal; and,
- a map product on the B.C. Drought Information Portal to view well groundwater level percentiles across B.C.

Relevance

These products provide accessible groundwater level information to help decision makers and the public understand how drought can affect our groundwater resources. This information can also be used to understand groundwater availability for water allocation, source water protection, and other provincial water protection strategies.

Partners and Linkages

This project was an extension of an SFU study led by Dr. Diana Allen of the Department of Earth Sciences at Simon Fraser University. Project support was provided by the BC River Forecast Centre (FOR), Water Protection and Sustainability Branch (WLRS), Environmental Monitoring and Analysis Branch (ENV), and various staff within the Ministry of Forests.

References

B.C. Ministry of Water, Land, and Resource Stewardship (WLRS). 2023. British Columbia Drought and Water Scarcity Response Plan, Government of British Columbia (Accessed 29 June 2023).

Gullacher, A., D.M. Allen, and J.D. Goetz. 2023. Indicators of Groundwater Drought in British Columbia. Water Science Series, WSS2023-01. Prov. B.C., Victoria.

Project Contacts

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Funding Acknowledgements:
Groundwater Science Funding

Upper Bulkley River Groundwater – Surface Water Interaction Project, Houston, B.C.

Project Description

Located near Houston B.C., the Upper Bulkley River watershed system has both a shallow valley fill aquifer with strong connections to surface water, and a separate deeper aquifer for which surface water connectivity is less well understood. It is intended that data collected from this project will provide insight on how these water sources interact to guide resource management in the area.

Initiated in 2018, the four-year project uses drone collected imagery to guide traditional groundwater level and flow monitoring. At potential seepage locations, seepage meters and piezometers are placed in cross sections to monitor the flux of groundwater into the stream. Additionally, volunteer domestic wells have been monitored to understand seasonal variability in the aquifer system. Currently we are removing long term stations and interpreting the collected data.

Stream instrumentation.
Photo: J. Wick

Summary of Project Outcome

This project has strategically collected data to inform management of the water resources in the Upper Bulkley River watershed. Data collection has included continuous aquifer water level monitoring, imagery from drone flights, and groundwater discharge (seepage) rates at select stream sites. In 2022, eight piezometers, two stilling wells, and two seepage meters were installed at two locations on the Upper Bulkley River. Aquifer water level measurements continued to be collected at the five private wells. Interpretation of the collected data aims to fill current knowledge gaps, particularly where there are implications for Environmental Flow Needs (EFNs).

Relevance

The Upper Bulkley River watershed serves as a critical spawning and rearing area for pacific salmon and steelhead trout, and as a source of water for a variety of users. The watershed's natural propensity for low water conditions and high water temperatures raises considerations for water management in the area. The impact that groundwater withdrawals can have on stream flow has led to an interest in assessing hydraulic connectivity and its relationship to EFNs in the Upper Bulkley River watershed.

Learnings & Recommendations

There have been extensive learnings on the technical aspects of installing and monitoring seepage meters and piezometers, as well as using drone-based imagery. Unfortunately, seepage meter installation constraints do not always allow installation at desired locations, therefore additional methods may be required to target these sites.

Partners and Linkages

Project development and data sharing partners 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; local residents who volunteered wells and the BC Ministry of Forests.

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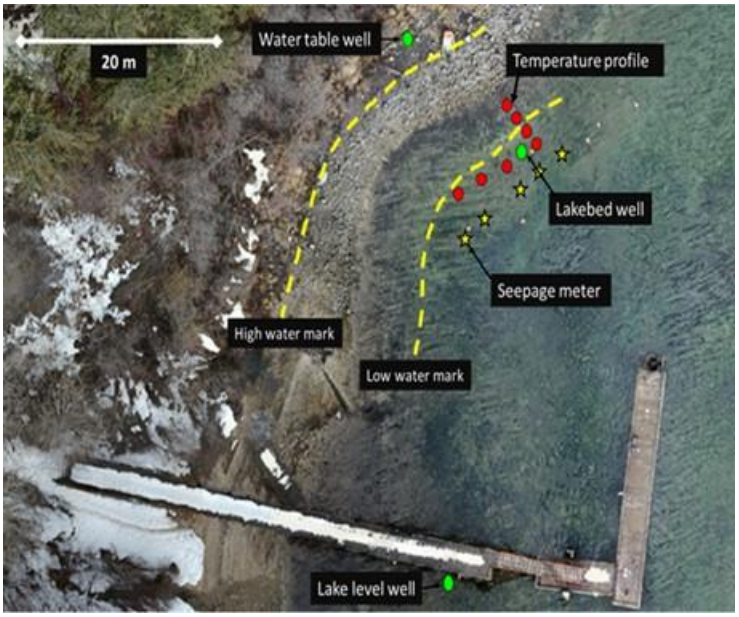
Funding Acknowledgements:
Water Research Portfolio

Groundwater Flow Patterns in Shorespawning Kokanee Salmon Habitat, West Arm of Kootenay Lake

Project Description

This study was conducted on the unceded traditional territories of the Sinixt, Ktunaxa and Syilx peoples.

A small but important population of Kokanee Salmon spawn in areas of upwelling groundwater along the shoreline of Kootenay Lake. Lake drawdown occurs over the winter egg development period for hydroelectric power generation, stranding fry and reducing the number that successfully emerge from the gravels. Efforts are underway to enhance spawning habitat lower in the water column to avoid egg dewatering over the winter. However, little is known about how groundwater upwelling rates change with lake level. In this project, multiple methods were used to assess groundwater upwelling rates and patterns, changes over the winter egg development period and the effects of changing water level on groundwater flow patterns.



The study area at McDonalds Landing Reginal Park on Kootenay Lake.

Project Outcomes

Two field seasons have been completed, and MSc Candidate Cameron Spooner is currently writing his thesis at UBC Okanagan. Groundwater flow rates into the lake were measured over two winter egg development periods using seepage meters, lakebed temperature profiles and natural tracers. Lake level and the local water table were also monitored.

Relevance

The results of this project will be used to improve the efficacy of physical habitat enhancement projects (e.g., gravel placement).

Learnings and Recommendations

Natural tracers such as Radon-222 and oxygen and hydrogen isotopes showed that the lakebed pore water chemistry is similar to the local groundwater. Modelled groundwater upwelling increases as the lake level drops over the winter.

Partners and Linkages

This project complements a habitat enhancement project undertaken by the Friends of Kootenay Lake Stewardship Society, who are a major partner in this study. The Regional District of Central Kootenay manages McDonalds Landing Regional Park, where the study takes place, and they have provided groundwater samples from their drinking supply well at Six Mile.

Project Contacts

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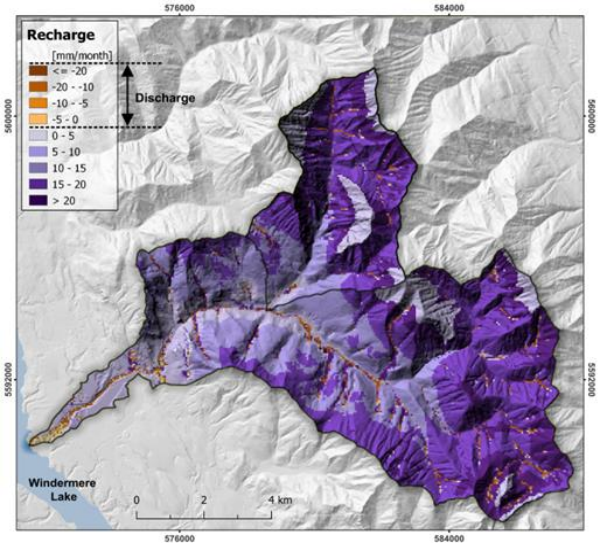
Funding Acknowledgements:
Water Research portfolio

Integrated Hydrological Model for Windermere Creek Watershed, Upper Columbia River Basin

Project Description

Windermere Creek is in the unceded traditional territories of the ?Akisq'nuk (A-kiss-qe-nuk) First Nation and the Shuswap peoples. A three-dimensional integrated hydrological/hydrogeological model (MIKE SHE) was developed for Windermere Creek basin to quantify the water balance, identify recharge and discharge areas where surface water and groundwater exchange occurs, and to explore the seasonal/interannual variability in these processes. The project builds on an existing 3D hydrostratigraphic model of the alluvial fan developed by GW Solutions for Living Lakes Canada.



Model output for Windermere Creek watershed

Project Outcomes

The model indicates that at the watershed scale, the majority of groundwater recharge occurs during the snowmelt and spring rainy seasons (May-June), and that snowmelt at mid and high elevations is an important component of the water balance. On an annual basis, 50% of the precipitation that falls on the watershed makes its way to the aquifer system, becoming available to the creek as baseflow, supporting wetland ecosystems, emerging as springs and flowing underground to Windermere Lake, as well as providing water to well users. The model also suggests that Windermere Creek is consistently gaining water from groundwater along its length, and that the deeply incised nature of the channel over much of the alluvial fan explains the strong connection to the aquifer. Complex bedrock topography under the aquifer limits the influence of Windermere Creek on groundwater levels south of the creek.

Relevance

Communities in B.C. are concentrated in valley bottoms where alluvial fan aquifers are under conflicting pressures between human use (i.e., domestic and irrigation water supply) and ecosystems (i.e., flows for fish). Information on groundwater recharge and discharge in alluvial fan aquifers is critical for long term planning and management in southern B.C.

Learnings and Recommendations

There were numerous challenges in model development. First, a novel workflow was required to represent the geology of the alluvial fan using lenses. Second, the study area is very data scarce; therefore, model calibration involved adjusting parameters to best simulate snow accumulation and melt and streamflow based on sparse nearby or near-in-time datasets. Third, the approach had to be adapted multiple times to address model instabilities.

Partners and Linkages

- The MIKE SHE model was developed by Alexandre Nott and Diana Allen at Simon Fraser University.
- Living Lakes Canada provided the digital geological model files prepared by GW Solutions as part of the study "Windermere Preliminary Hydrogeological Characterization".

Project Contacts

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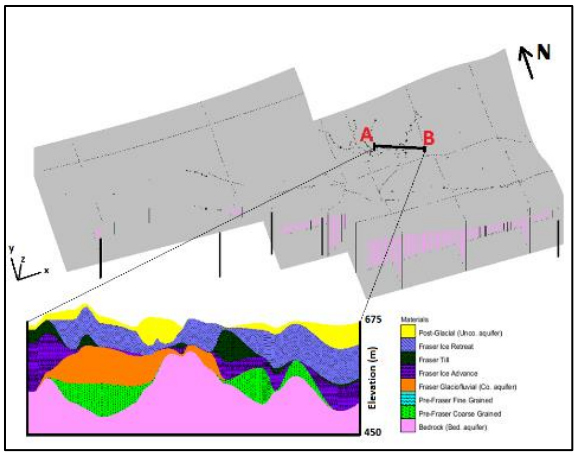
Funding Acknowledgements:
Water Research Portfolio

Impact of Cumulative Groundwater Withdrawal on Surface Water and Groundwater Interaction in Stoney Creek Watershed

Project Description

Groundwater and surface water interactions are one of the key considerations when making groundwater allocation decisions. Typically, hydraulic connectivity is assessed by pumping one or several wells for a short period of time, however the impact of cumulative groundwater withdrawal is not fully known, especially over longer time frames. This project will build off an existing numerical model developed for the Stoney Creek watershed to simulate groundwater-surface water connectivity and the impacts of cumulative groundwater withdrawal.



Cross section showing the complex aquifer system underlaying the Stoney Creek

Project Outcomes

2022-2023 was the first year of this multi-year project. To date, an information inventory has been compiled of all available data sources, and a literature review of groundwater and surface water interaction simulations has been completed. A field investigation has been designed and implemented with the purpose of reducing knowledge gaps in available hydrological and hydrogeological data. A field monitoring program has also been proposed for the study area. In addition, three-dimensional modelling of the stratigraphy of the study area has been developed and verified based on available data and reports. In the next phase of the project, the scope of modelling and the numerical model boundary conditions will be determined, and the variables and parameters of the 3D numerical model will be developed.

Relevance

Compared to the previous model developed for the project area (Aghbelagh et al., 2018), the current domain has been refined based on the newly available lithology data and the Vanderhoof mapping report (Hinnell et al., 2020). The model will be calibrated against both historical and newly collected water level and stream discharge data. This model will help to assist with water allocation and water resources management under different water use and climate change scenarios.

Learnings and Recommendations

The locations and degree of hydraulic connectivity between the surface water and the confined aquifers poses a challenge to the model calibration. A rigorous monitoring network must be established to validate the model further.

Partners and Linkages

This is a joint project between the University of Northern British Columbia and the Ministry of Forests.

References

Aghbelagh Y.B., J. Li, and J, Yin, 2018. Surface water and groundwater interactions in the Stoney Creek watershed: Insights from numerical groundwater flow modeling, EcoCat Report ID: 58104

Hinnell, A.C., T. Lengyel, S. Funk, J.J Clague and Z.M. Hammond, 2020. Vanderhoof and Houston Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2020-07. Province of British Columbia.

Project Contacts

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Funding Acknowledgements:
Groundwater Science
BC Real Estate Foundation Partner fund
NSERC Alliance fund

Prediction of Fresh Water Spring Locations Using Random Forest Machine Learning, Doig River Watershed, B.C.

Project Description

This project leverages random forest machine learning to predict the locations of freshwater springs, a significant step forward from traditional regression analysis methods. Freshwater springs hold high environmental, cultural, and economic significance, host unique species and provide crucial microhabitats. However, their locations are influenced by various environmental and geological factors, making their prediction complex. While classic regression methods are invaluable in identifying linear relationships, they often struggle with complex patterns found in environmental and geological datasets. In contrast, random forests can effectively model these intricate relationships, constructing multiple decision trees to produce more accurate and robust predictions.

Fresh water springs predicted for 1.7% of total area.

Project Outcomes

The output from the random forest machine learning process offers an array of accuracy statistics, providing a detailed understanding of the model's predictive performance and the impact of each variable. This enables the model to continuously improve as more data is accumulated. As field validation is added to the process the model will be optimized to provide a valuable tool to identify areas for potential habitat protection.

Relevance

Predicting the location of freshwater springs is of immense relevance due to their environmental, cultural, and economic importance. With changing climatic conditions and anthropogenic disturbances, springs are under increasing pressure. Understanding their potential locations will contribute to their conservation and sustainable use, benefiting both ecosystems and human communities.

Learnings and Recommendations

This project has demonstrated the power and utility of machine learning in environmental science. Machine learning can capture complex relationships between multiple variables, making it an invaluable tool in predictive environmental studies. Moving forward, we recommend integrating more data, both spatial and temporal, into the model. As more spring locations are added, the model's accuracy and precision will increase. Additionally, including a temporal analysis could provide insight into changes in spring conditions and locations over time. This approach will make the prediction process more efficient and accurate, leading to better conservation and management strategies for freshwater springs.

Partners and Linkages

Partners on this project include Landen Matechuk, Dirk Kirste, Ismena Bystron, Brynje Johson, Doig River First Nation, UNBC GIS lab. This project has strong linkages with Source Water Protection and Rural Water Security.

References

Bystron, I. 2018. GIS-based analysis of spring occurrence and spring source areas in Peace River Regional District, British Columbia. [Date created: 2018-04-12].

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Funding Acknowledgements:
Water Research Portfolio

Assessing Groundwater Allocation Limits in B.C.

Project Description

A two-year study was undertaken to develop and test potential methods for setting groundwater allocation limits. In year 1, a literature review and survey of more than 20 Canadian and international jurisdictions informed the development of a methodological framework for setting allocation limits. In year 2, the technical procedures for establishing allocation limits were tested through application to five aquifer types in B.C.

Proposed aquifer management area for groundwater allocation. Source: Hatfield Consultants

Project Outcomes

A tiered framework for establishing groundwater allocation limits was developed. A Tier 1 screening level assessment was conducted for all aquifers in B.C. to establish an initial list of aquifers for potential allocation limits. Tier 2 is the quantification of preliminary allocation limits based on simplistic desktop evaluations using available data. Tier 2 case studies were conducted for five aquifer types in four locations in B.C. Tier 3 is the refinement of preliminary allocation limits through field data collection to reduce uncertainty. Tier 4 comprises the development of a fully calibrated transient numerical model to support management of high priority aquifers where pumping and allocation poses significant operational or environmental consequences.

Relevance

This project may inform the development of provincial policy on setting science-based groundwater allocation limits consistent with the goals of the *Water Sustainability Act*.

Learnings and Recommendations

- Groundwater pumping impacts on streamflow in hydraulically connected systems and the protection of streamflow is a primary groundwater allocation constraint for many aquifers in B.C. Identifying the location of hydraulic connection and establishing streamflow thresholds is crucial for setting aquifer allocation limits.
- Tier 2 assessments were completed on five aquifers in four locations in B.C. Four of the aquifers were divided into sub-areas (i.e., management areas) for the purpose of estimating groundwater extraction limits.
- Adequately characterizing the hydrogeology of aquifers is central to developing and applying groundwater allocation limits. Continual review of allocation limits, data gathering and monitoring allows limits to be refined over time. Tier 2 assessments can help identify data gaps and licence conditions.
- Allocation limits are meaningful only if they reflect reality and are implemented in tandem with other operational regulatory activities.

Partners and Linkages

The study was conducted by a consultant team comprised of Western Water Ltd, HydroGeoLogic Consulting, HyGeo Consulting, and Hatfield Consultants.

References

Sivak,T., M. Wei, A. Kohut, and D. Geller, 2023. Setting Groundwater Allocation Extraction Limits and Improving Understanding of Hydraulic Connection in B.C. Report submitted to the Government of B.C., Ministry of Forests.

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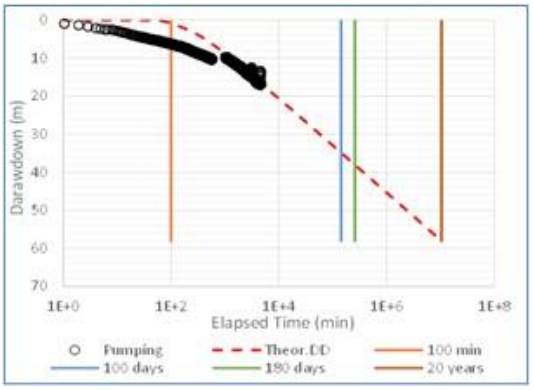
Funding Acknowledgements:
Ministry of Agriculture and Food
Groundwater Science Program
Ministry of Forest, South Area Regional Operations

Sustainable Yield Determination: Q_{20} and 100-Day Methods

Project Description

Well performance and aquifer capabilities must be assessed to Provincial standards when providing supplementary information for groundwater licence applications (Todd et al., 2020). The two acceptable standards in B.C. for evaluating long-term capacities for water supply wells, include the 100-day (Ministry of Environment, 1999) and the modified Moell Q_{20} (Maathuis and van der Kamp, 2006) methods. A review of these methods was undertaken.



Seim-log plot of Cooper-Jacob extrapolated drawdown to 20 years.

Summary of Project Outcome

The 100-day method is the safe available drawdown multiplied by the specific capacity (SC) of the well. SC is the pumping rate divided by the projected drawdown at 100 days using the Cooper-Jacob straight line semi-log plot. This assumes Theis (1935) assumptions are valid. The 100-days of pumping represent a period where no recharge occurs (e.g., typically summer months in coastal regions and winter months in the interior) (MoE, 1999). Although the 100-day method was developed based on the Theis model, it is feasible to apply another model that allows the calculation of projected drawdown at 100 days.

The Q_{20} modified Moell method (Maathuis and van der Kamp, 2006) is used to calculate the sustainable yield of the well based on the projected drawdown after 20 years using a proven mathematical model (e.g., Theis but can also use any other model), assuming continuous pumping for the duration. The sustainable well yield (Q_{20}) equation is essentially the same as the 100-day equation, except that SC equals test pumping rate divided by the projected drawdown after 20 years modified by the well loss during the first 100 minutes of pumping. This method was developed for aquifers in the prairie provinces where recharge is likely much lower.

Relevance

When estimating the sustainable yield of a water well, it is important to understand which method of analysis is most suitable based on the intended use of the well and the physical properties of the site.

Learnings and Recommendations

The selection of one method should be dictated by the intended duration of pumping, aquifer characteristics and climatic conditions; which precludes the concurrent use of the other method. Selecting an inappropriate method can result in over-estimation of the well yield potentially leading to excessive drawdown in the well. Method selection should be justified by the qualified professional.

References

Maathuis, H. and van der Kamp, G. 2006. The Q_{20} Concept: Sustainable Well Yield and Sustainable Aquifer Yield. Saskatchewan Research Council. Saskatoon, SK. 55p.

Ministry of Environment (MoE), Lands and Parks. 1999. Evaluating Long-term Well Capacity for a Certificate of Public Convenience and Necessity. Water Management Branch, Groundwater Section, 16p.

Todd, J., Lepitre, M., Thomson, D., Ishikawa, J-A., Wade, M. and Beebe, C. 2020. Guidance for Technical Assessments in Support of an Application for Groundwater Use in British Columbia, Version 2. Water Science Series 2020-01, Province of B.C.

Project Contacts

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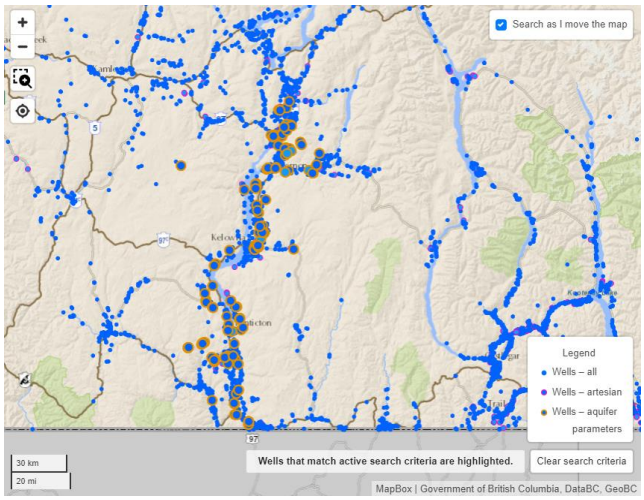
Funding Acknowledgements:
Ministry of Forest, West Coast Regional Operations

GWELLS Application and Database Enhancements

Project Description

The Groundwater Wells and Aquifers (GWELLS) application is a geospatial database for locating, visualizing and accessing groundwater related information, including Provincial well records, aquifer and hydrogeologic information, and the registry of certified well drillers and well pump installers (WD/WPI). This project is a continuation of ongoing work to maintain, update, and enhance features and functionality of GWELLS.



Wells in interior British Columbia that have pumping test data available in GWELLS.

Project Outcomes

Over the last two years the following enhancements have been incorporated into GWELLS:

- New capabilities to add, search, and view pumping test data, as well as calculated aquifer parameters, such as transmissivity, hydraulic conductivity, storativity, and specific capacity. For wells with available pumping tests the data can be accessed and visualized on the Well Summary Page, as well as within the "Download all wells" in either .xlsx or .csv format. A flag for wells with pumping test data is visible in map view on the Well Search page.
- New functionality to search and view Aquifers Notations within GWELLS. Aquifer notations are water allocation notations assigned by natural resource staff to aquifers that have current or potential water allocation concerns or potential water quality concerns such as saltwater intrusion. Aquifer notations have been added to the advanced search function on the Aquifer Search Page, and each aquifer now has a section under Knowledge Indicators on the Aquifer Summary Page that describes the type of aquifer notation that has been assigned to that aquifer, if any.
- New search functionality has been added to be able to search registered WD/WPI by a map, as well as the ability to search all WD/WPI who work in a specific region of the Province.
- The addition of "Tool Tips" on the Aquifer Summary Pages to provide additional context on each of the fields provided, accessed by hovering over the blue circle with a question mark (?).
- The addition of a "Drinking Water Area Indicator" on the Well Summary Page to let users know if a well has a capture zone delineated around the well.
- The addition of a "Technical Report" flag on the Well Summary Page to let users know if a well has a Technical Assessment Report available for request.

Relevance

Locating and accessing groundwater information is essential to informing groundwater licensing under the *Water Sustainability Act*, as well as to groundwater resource management in general. GWELLS is intended to simplify groundwater data compilation and is useful to both proponents who are preparing groundwater license applications and to allocation staff who are evaluating the applications.

Partners and Linkages

GWELLS enhancements were completed under contract with oversight from partners in WLRS, ENV and FOR.

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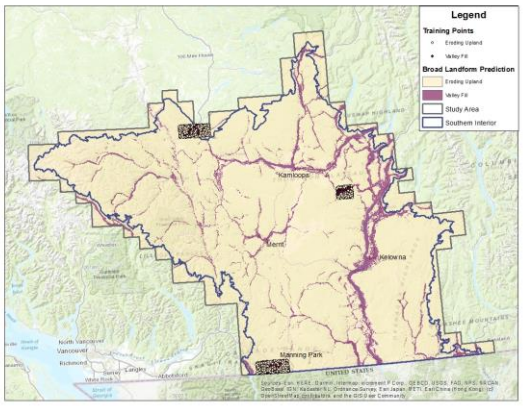
Funding Acknowledgements:
GroundWater Science

Predictive Surficial Geology Mapping to Support Groundwater Management

Project Description

The goal of this muti-year project is to increase the utility of surficial geology and landform information with a focus on identifying unconsolidated sediments with high aquifer potential, such as in valley bottoms. A simple and categorical classification that finds the "common ground" among existing geomorphology related datasets was developed. During Phase 2 of this project (2020 to 2022) a machine learning approach to mapping the surficial materials was piloted in the Southern Interior EcoProvince study area.



Study area for assessing surficial material mapping approaches.

Summary of Project Outcome

The surficial materials classification includes a new *Broad Landform* class which first divides the landscape into two categories; upland areas dominated by erosional landforms and lowland areas dominated by depositional landforms. The lowland areas, identified as *Valley Fill,* represent areas in the landscape where sediments accumulate and where there is high potential for unconsolidated aquifers. Secondly, areas of *Valley Fill* are further subdivided into landform groupings of surficial materials and surface expressions. As training data for the machine learning model, 2,500 points were attributed with the surficial material classification and predictive maps of each class were generated.

Learnings and Recommendations

During Phase 2 of the project several key learnings were noted. These learnings will guide development of Phase 3.

- The surficial materials classification was successfully mapped using a machine learning approach which produced maps with reasonable distribution of landforms and over 90% internal accuracy.
- The variable occurrence of different landforms led to an imbalanced training data set. Minority classes which are captured by a small sample of training points are difficult for models to interpret. Strategically capturing minority features during future training point development would benefit predictive modelling.
- Within the Okanagan-Thompson Plateau the division of the landscape into eroding upland and valley fill is less clear. A third broad landform category could be explored to capture large areas of glacial scour and thicker glacial deposits such as kame/esker, drumlins, and kame/kettle topography.

Relevance

Understanding of B.C.'s complex surficial geology is crucial to the understanding of groundwater and surface water resources. Surficial materials make up approximately seventy percent of the mapped aquifers in B.C. Despite extensive work in aquifer mapping, there are still many unmapped surficial aquifers. These reconnaissance level maps can be used to support decision making and guide detailed mapping efforts.

Partners and Linkages

Madrone Environmental Services provided support and expertise throughout this project. Dr. Brandon Heung, Dalhousie University and Jin Zhang, Simon Fraser University provided expertise and analytical support with predictive mapping methodology.

Project Contacts

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GroundWater Science

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- Ministry of Agriculture and Food
- Ministry of Energy, Mines and Low Carbon Innovation
- Ministry of Environment and Climate Change Strategy
- Ministry of Forests
- Ministry of Transportation and Infrastructure
- Ministry of Water, Land and Resource Stewardship
- B.C. River Forecast Centre
- Friends of Kootenay Lake Stewardship Society
- BC Parks
- Department of Fisheries and Oceans Canada
- The District of Houston
- A Rocha
- Living Lakes Canada
- The Nature Trust of British Columbia
- The Township of Langley
- The Regional District of Central Kootenay
- Okanagan Basin Water Board
- The Okanagan Nation Alliance
- Osoyoos Indian Band
- Cowichan Tribes
- Cowichan Valley Regional District
- Doig River First Nation
- The Wet'suwet'en First Nation
- The Office of the Wet'suwet'en
- University of British Columbia (Okanagan)
- University of Northern British Columbia
- Simon Fraser University – Department of Earth Sciences
- Dalhousie University
- British Columbia Institute of Technology
- Pacific Institute for Climate Solutions
- Pacific Salmon Foundation
- The Upper Bulkley River Streamkeepers
- The Regional District of Bulkley-Nechako