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NICOLA WATERSHED AQUIFER CLASSIFICATION AND MAPPING

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CONTENTS

1. INTRODUCTION

Golder Associates Ltd. (Golder) was retained by the Fraser Basin Council (FBC), in partnership with the British Columbia Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD) to provide aquifer mapping and classification services for 13 British Columbia Geological Survey (BCGS) map sheets in the Nicola Watershed region (the "Study Area"). The purpose of the project is to update previous aquifer mapping completed in the area with newly-obtained subsurface information and to form the framework for development of a conceptual hydrogeological model for the area and potential numerical or analytical groundwater flow modelling. This report presents the geological setting and relevant background studies in the Study Area, the methods used to preprocess, standardize, and interpret the subsurface hydrogeological data, and the resultant aquifer delineations and classification according to British Columbia provincial standards.

2. STUDY AREA LOCATION

The Study Area for the aquifer mapping and classification is defined by 13 BCGS map sheets, roughly corresponding to the following locations (Figure 1):

- Merritt Basin –Nicola Lake Area: 092I017, 092I007
- Lower Nicola – Guichon Creek Area: 092I016, 092I026, 092I036
- Coldwater River Valley Area: 092I006, 092H096, 092H086
- Lower Nicola Valley – Spences Bridge Area: 092I015, 092I025, 092I034, 092I044
- Stump Lake Area: 092I039

The proposed area for development of the conceptual hydrogeological model and numerical groundwater flow model (future phases) is also presented on Figure 1.

3. SCOPE OF WORK

The scope of work for the aquifer mapping included four phases: data gathering and compilation, a two-day study area visit, data processing and 3D hydrostratigraphic modelling, and provision of aquifer mapping deliverables. These phases are described in further detail in the subsections below.

3.1 Data Gathering and Compilation

A literature search was conducted to identify and compile available, relevant geological and hydrogeological data for the study area. Data sources that were searched included the following:

- The British Columbia Ministry of Environment and Climate Change Strategy (ENV) Water Well Database (WELLS Database), including individual water well records and lithological records
- The British Columbia Ecological Reports Catalog (EcoCat)
- Natural Resources Canada's GEOSCAN Database

- The British Columbia Geological Survey's public access databases
- Hydrogeological, geological, and geotechnical reports from previous investigations in the area provided by FLNRORD and Golder
- Previous aquifer mapping and hydrogeological interpretation in the study area
- Topographic data from Natural Resources Canada's Canadian Digital Elevation Model (CDEM)
- Online (Google) search strategies for publically available reports and data

All available hydrogeological data sources and reports were documented, compiled, and reviewed prior to the study area visit. All relevant data and documentation has stored and documented for use in future potential phases.

3.2 Study Area Visit

A two day study area visit was conducted on October 24 and 25, 2017 by Mr. Kevin Bennett, Mr. Nick Gorski, and Ms. Robyn Willis of Golder, together with FLNRORD representative, Ms. Laurie Lyons, to facilitate incorporation of local knowledge into the aquifer mapping and hydrostratigraphic modelling process. The study area visit included a drive-over of the entire area, including discussion and photo-documentation of hydrogeological, geological, and morphological features of interest.

3.3 Data Processing and 3D Hydrostratigraphic Modelling

Well records and relevant hydrogeological information was preprocessed and imported into Leapfrog Hydro (Version 2.7.2) for 3D visualization, geological modelling and interpretation. Methods and workflows for the preprocessing, lithological standardization, 3D visualization, hydrostratigraphic interpretation, and aquifer delineation are presented in greater detail in Section 5.0, below.

3.4 Aquifer Mapping and Classification Deliverables

Aquifer mapping and classification deliverables were prepared in accordance with provincial standards. These deliverables include:

- General geological and hydrostratigraphic interpretation, including visualizations and cross-sections of interpreted data (this report)
- Draft aquifer polygon shape files (provided with this report, attribute fields finalized upon acceptance from provincial authorities)
- Draft aquifer classification worksheets (provided with this report, summary statistics calculated upon acceptance from provincial authorities)
- Well summary spreadsheet file detailing all wells completed in each aquifer, summary statistics, and contacts utilized to delineate the aquifer, where available (generated upon acceptance of aquifers from provincial authorities)
- A Leapfrog 3D visualization of the Study Area provided as a free Viewer file (upon acceptance of report/aquifer delineations)

4. GEOLOGICAL SETTING AND BACKGROUND

The primary reference that defines the framework for the geological setting and background of the Study Area is the Geological Survey of Canada Memoir 380 – Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia, written by Robert J. Fulton (1975). Fulton describes the area as "an area of rolling rocky uplands, only thinly-veneered with Quaternary deposits, and broad deep valleys containing lakes and thick quaternary sediments". The principal groups of Quaternary sediments as resulting from at least two major periods of non-glacial sedimentation and two distinct periods of glaciation. These principal sediment groups, associated age, and type-section subdivisions are described as follows:

- Okanagan Centre Drift (Okanagan Centre Glaciation, before 43,800 B.P)
  - Lower stratified unit
  - Unstratified unit
  - Upper stratified unit
- Bessette Sediments (Olympia Interglaciation, approximately 43,800 – 19,000 B.P.)
- Kamloops Drift (Fraser Glaciation, approximately 19,000 – 10,500 B.P)
  - Lower stratified unit
  - Unstratified unit
  - Upper stratified unit
- Postglacial Deposits (10,500 B.P – current)

The geological setting and framework and how they are expressed within the context of the aquifer mapping and classification activities is further described in the Results and Interpretation section below (Section 6.0). For detailed descriptions of the geological setting, including maps, the reader is directed to the original Fulton reference (1975). More recently, the Study Area has been subject to numerous studies, investigations, and research. In the detailed Data Gathering and Compilation phase described in the Scope of Work (Section 3.1), numerous reports and references were compiled and documented. A complete list of these references is provided in the References section of this report.

5. METHODS

Subsurface geological and hydrogeological data was preprocessed, standardized, and imported into Leapfrog Hydro, a commercially-available 3D hydrostratigraphic modelling software, for interpretation and aquifer delineation. The methods and workflows for the preprocessing, lithological standardization, and 3D visualization and interpretation are described in the subsections below.

5.1 Preprocessing of Well Records and Hydrogeological Data

The primary source of subsurface information for the project was the WELLS database, together with the associated lithological intervals. These data sources contained over 600 well records and over 3700 unique lithological intervals for the study area, representing an amalgamation of all documented wells drilled. Though progress has been made in standardizing the collection and entry of water well data into the provincial database, well information and lithological descriptors remain highly variable in terms of documentation and overall data quality, with substantial variation depending on the age of the well record, drilling company, and database architecture at the time of data entry. As a result, some types of errors are commonly observed in well records throughout the province while other errors tend to be specific to the region of study, and the drillers and operators in that region. Common types of preprocessing and error correction that were conducted as part of this study include:

- Conversion from imperial units (feet, imperial and US gallons per minute) to metric (meters, litres per minute)
- Correction of improper units (i.e. gallons per hour to gallons per minute)
- Removal of duplicate or empty entries
- Correction of overlapping lithology interval data (i.e. from-to intervals of 0-2 m, 0-5 m, 0-9 m became 0-2 m, 2-5 m, 5-9 m)
- Text overruns in a data field would generate multiple lithology entries to accommodate the additional characters in the field. These multiple entries were reduced back to a single entry with the appropriate depth interval range using nested text concatenations.
- Manual supplementation of information into data records based on Ms. Lyons' local expertise and understanding of the wells in the area.
- Correction of intervals with missing depth data

A significant database issue was encountered in the late stages of the project during the hydrostratigraphic interpretation that necessitated a sizable amount of manual data entry to address the resultant data gaps. When performing manual checks on single well records with regards to blank lithology intervals, it was discovered that soil and lithological interval descriptors were often entered into different fields (i.e. raw lithology, material description) in the same well record. This resulted in data gaps as the descriptors entered into the material description field were not standardized and visualized with the rest of the descriptors entered into the lithology field. Furthermore, data entered into the material description field was not included in the download of the WELLS database with lithology from DataBC. As a result, critical individual well records were obtained using the online provincial search tool and manually entered into the database imported into Leapfrog Hydro in order to prevent data loss. This issue is also described in the Data Gaps and Recommendations section (Section 7.0). To address these issues, corrections to the errors identified during this study were accomplished by regional FLNRORD staff for the extent of the study area identified in Figure 1. Furthermore, substantial effort was expended to add well records to the WELLS database where these records were identified to be missing. The efforts of regional FLNRORD staff, in particular Laurie Lyons, are acknowledged and have enabled these improvements to the underlying dataset.

5.2 Lithological Standardization

Similar to the well record data, the availability and data quality of the entries in the lithological interval data were highly variable and dependent on the driller who was recording soil and rock observations from the borehole. As a result, substantial standardization of the lithological dataset was required for effective interpretation of subsurface stratigraphy and conditions. The method of standardization for the lithological intervals associated with this project included a series of nested SQL queries followed by keyword scripts to extract relevant hydrostratigraphic data descriptors from the lithology field. Similar methods were used to extract other information from the lithology and general remarks fields, including well yields, water levels, water bearing zones, and flowing artesian conditions. As drillers in different regions employ their own particular terminologies, nomenclature, and formatting for what they observe while drilling a well, the keyword scripts were iteratively adjusted and checked manually against raw data records until it was determined that the standardization procedure adequately captured the necessary information. Once the relevant lithological descriptors were extracted and standardized, they were grouped into categories that facilitated visualization and interpretation of the subsurface data in 3D. The two common grouping classifications used in this study were based on permeability (i.e. – “permeable”, “non-permeable”, “bedrock”, “undifferentiated”) and soil texture (i.e. – “sand”, “gravel”, “till”, “clay”, “silt”). Table 1, below, presents examples of the lithological descriptor classification using the two classification schemes.

Table 1: Example Lithological Descriptor Classifications

<table>
<tr><th>Example Lithological Descriptor (from Keyword Scripts)</th><th>Soil Textural Classification</th><th>Permeability Classification</th></tr>
<tr><td>Sandy Gravel</td><td rowspan="3">Gravel</td><td rowspan="6">Permeable</td></tr>
<tr><td>Gravel</td></tr>
<tr><td>Silty Gravel</td></tr>
<tr><td>Gravelly Sand</td><td rowspan="3">Sand</td></tr>
<tr><td>Sand (Fine / Medium / Coarse / Clean)</td></tr>
<tr><td>Silty Sand</td></tr>
<tr><td>Silt</td><td rowspan="3">Silt</td><td rowspan="8">Non-Permeable</td></tr>
<tr><td>Sandy Silt</td></tr>
<tr><td>Clayey Silt</td></tr>
<tr><td>Clay</td><td rowspan="2">Clay</td></tr>
<tr><td>Silty Clay</td></tr>
<tr><td>Till</td><td rowspan="3">Till</td></tr>
<tr><td>Hardpan</td></tr>
<tr><td>Multiple Soil Textures</td></tr>
<tr><td>Bedrock / Rock Descriptors</td><td>Bedrock</td><td>Bedrock</td></tr>
<tr><td>Multiple Textures, Unclear Descriptors</td><td>Manually Interpreted / Undifferentiated</td><td>Manually Interpreted / Undifferentiated</td></tr>
</table>

It should be noted that these groupings and classifications are methods used only to facilitate visualization of the data in 3D for the interpreter; the full raw lithologies were still queried by the interpreter during the aquifer mapping and delineation process to ensure that professional judgement was applied throughout the process as opposed to being a strictly an automated process. Challenges with keyword scripting and automated data processing tend to be regionally specific and dependent on the driller or consultant entering the data into the database. For this study, the permeability classification tended to be the most useful as the raw lithological descriptors were highly variable or contained multiple or conflicting textural classes, making classification by soil texture difficult.
In addition, considerable disagreement in stratigraphic elevation correlations between wells was observed in areas of high topographic relief (i.e. – in the Joeyaska area on the outskirts of the Merritt Basin). This is likely due to errors introduced when the collar of a well with poor lateral (XY) accuracy is projected onto the 20 x 20 m digital elevation model (see Section 5.3 below). The visualization and interpretation method as well as guiding principles and criteria for aquifer delineation are described, respectively, in Sections 5.3 and 5.4 below.

5.3 3D Visualization and Interpretation

To conduct the 3D hydrostratigraphic visualization and interpretation, standardized datasets as described in Section 5.2 representing permeability, soil texture, well yield, spatial accuracy, water bearing zones, dry or flowing artesian conditions, and groundwater levels / depths to water were imported into Leapfrog Hydro for rendering. As the vertical accuracy for well records was generally poor, well collars were assigned elevations by projecting them onto the topographic surface at that location, which was defined by the 20 m x 20 m rasterized Canadian Digital Elevation Model (CDEM) provided by Natural Resources Canada. This allowed for vertical referencing of all associated well and lithological data within the 3D space of the hydrostratigraphic model, however, it also meant that vertical elevation errors could be introduced into the model and interpretation if the associated well record had low horizontal accuracy and were in an area of high topographic relief. These inaccuracies were controlled for in the interpretation by visually querying wells that had a documented high spatial accuracy.

Aquifers and hydrostratigraphy were interpreted by the visualizing the associated datasets in 3D, cutting cross-sections, manipulating the model, and then, finally, by manually selecting and assigning various intervals to hydrostratigraphic units and aquifers. This method allowed the interpreter easy access and visualization of many different types of hydrogeological data quickly and efficiently and the ability to easily and continuously cut cross-sections to investigate areas of interest. Subsurface data, existing geological mapping and knowledge, groundwater levels, landform morphology as well as potential uses for the aquifer delineations were all taken into account when delineating the aquifer boundaries with assumptions and notes documented in the associated aquifer classification worksheets.

5.4 Guiding Principles, Criteria, and Assumptions for Aquifer Delineation

The aquifer mapping conducted during this study employed a set of common principles, criteria and assumptions when delineating the aquifers in the Lower Nicola Valley. These include:

- In conformance with provincial guidance, the general area required for a permeable deposit to be mapped as an aquifer was 1.0 km^2. Exceptions to this criteria were used when the aquifer was historically mapped, when revisions to a historically-mapped aquifer resulted in an area of less than 1.0 km^2, or when a permeable unit / aquifer of less than 1.0 km^2 was considered to be hydrogeologically relevant to groundwater movement in the area.
- Bedrock aquifers in the area, in the absence of data to support otherwise and consistent with provincial guidance, were generally mapped on the basis of development, corresponding to areas where bedrock water wells were observed plus a buffer zone.
- Boundaries of delineated aquifers were frequently extended beyond where they were observed in well record data if there was a morphological rationale (i.e. floodplain extent) or if it was considered justified on the basis of the mode of deposition (i.e. continuity of deeper deposits / aquifers to the edges of the Merritt Basin). Where these assumptions were employed, they were discussed in the aquifer classification worksheet of the associated aquifer.
- Areas in major valleys where no subsurface data was available and no existing mapped aquifer was nearby were not mapped as aquifers, though the potential for exploitable groundwater generally exists in the valley fills. Suggestions on how to reconcile this issue are discussed in Section 7.0 and maps of potential areas for additional data collection are included in Appendix B.
- Where uncertainties existed in the continuity and / or interpretation of aquifers or permeable deposits, these were highlighted in the aquifer classification worksheets.

6. RESULTS AND INTERPRETATION

Results of the hydrostratigraphic interpretations and aquifer delineations are presented in the subsections below, first discussing general hydrostratigraphic findings and then discussing specific aquifers.

6.1 Merritt Basin – Nicola Lake Area

The Merritt Basin – Nicola Lake Area has been revised to include seven mapped aquifers in contrast to the four that were previously mapped in the area.

Merritt Basin

The Merritt Basin is the largest depositional basin in the region and, as a result, the stratigraphy underlying the Merritt area is also the most continuous and consistent, with thick, extensive glaciolacustrine deposits and sand and gravel layers that are observed, in general, at similar elevations in the area. The subsurface underlying Merritt has been remapped from being designated as a single unconfined aquifer to include two additional confined sand and gravel aquifers (Figure 2), which given the likely mode of deposition, are assumed to be laterally extensive throughout the basin despite only a limited number of deep wells in the area to support this assumption. Evidence for further aquifers at depth or subdelineation of existing aquifers exists but there is insufficient information at this time to support further delineation.

Upper Merritt Aquifer (Type 1c) – Revised from previous mapping (Merritt Aquifer)

The Upper Merritt Aquifer is an unconfined aquifer comprised of modern alluvial sand and gravel deposits associated with the Nicola and Coldwater Rivers near their confluence in the Merritt area (Figure 2). The aquifer boundary is predominantly based on morphology, whereby the aquifer boundary is coincident with the floodplain limits of the Nicola and Coldwater Rivers and the associated topographic change, as the shallow sand and gravel deposits are generally not observed in the limited wells outside of this boundary. Changes in topography and morphology also mark the assumed limits of the Lower Merritt Aquifer in the valleys to the northwest and south. In the valley to the east, at the outflow of the Nicola River from Merritt, the aquifer boundary is assumed to be where the floodplain deposits become more constrained by the valley walls. Subsurface data in this location is sparse but there is an assumed degree of interconnectivity with permeable deposits as the valley widens to the east.

Middle Merritt Aquifer (Type 4b) – Newly identified aquifer

The Middle Merritt Aquifer is a confined glaciofluvial sand and gravel aquifer located beneath thick fine-grained glaciolacustrine deposits in the Merritt area (Figure 2). Limited wells are completed in the aquifer but the well records where the aquifer is observed are consistent across the basin, typically first intersected between 45 to 65 m below local ground surface. As a result, boundaries are assumed to be laterally extensive in the Merritt area and generally constrained by the surrounding bedrock valley walls; however, the local extent, distribution, and thickness of the aquifer in any given location is expected to be uncertain and needing further definition. Continuity of the aquifer to permeable deposits to the southeast of Merritt, near the Joeyaska Aquifers, is assumed on the basis of the similarity of the deposit elevation and overlying stratigraphies.

Lower Merritt Aquifer (Type 4b) – Newly identified aquifer

The Lower Merritt Aquifer is a confined glaciofluvial sand and gravel aquifer which is the third and deepest known aquifer in the Merritt basin, first intersected typically 75 - 95 m below local ground surface (Figure 2). The aquifer is poorly defined and understood only from the lithologies of five deep wells in the Merritt area in addition to its inferred existence from three other deep wells at similar completion depths but with no lithological information. From the lithology of the deeper wells, intervals of up to 70 meters of coarse material (predominantly gravel) are observed, overlain by 10-25 meters of finer-grained silts and clays. The thickness of the deposit suggests a larger-scale, more regional deposition that would be laterally extensive in the Merritt basin but this is hypothetical and undetermined at this time. As a result, the lateral boundaries are mapped roughly to the margins of the Merritt Basin but these extents are subject to revision and reinterpretation as additional data becomes available. Flowing artesian wells are noted to occur in the Lower Merritt Aquifer.

Cross-sections showing the distribution and extent of the Merritt aquifers relative to each other are presented in Figures 3 and 4.

Joeyaska Area

The Joeyaska area, southwest of the City of Merritt, has been remapped to include two aquifers, a shallow aquifer and a deep aquifer, instead of one previously. The stratigraphy along this hillslope is complex and considerable variation is observed in the well records, however, the delineation of aquifers can be justified on the basis of the presence of a set of generally shallow completions, in contrast to a sizable number of wells that obtain groundwater from much deeper (Figure 5). The boundaries of these aquifers should be considered as somewhat preliminary, subject to further interpretation.

Joeyaska Shallow Aquifer (Type 4a) – Newly identified aquifer

The Joeyaska Shallow Aquifer is an irregularly-distributed shallow sand and gravel aquifer that is located to the south of Merritt, near the Coquihalla Highway (Figure 5). The sand and gravel deposits of the aquifer are variably confined throughout its distribution and, where confined, are capped by a thin veneer of glaciolacustrine material. Lateral boundaries are defined partly on morphological expression and topography between the Iron Mountain highlands and the lowlands of the Merritt basin, but also partly by presence of development on its eastern and western margins. To the east, the aquifer has been mapped to include alluvial fan type deposits, where the presence of shallow coarse grained deposits are expected to be more regular. The distal boundary of the aquifer from the highlands is mapped at the morphological boundary of the Coldwater River floodplain. Though the aquifer is mapped as continuous, the distribution is irregular and presence of viable shallow deposits for groundwater use at any particular location is not assured.

Joeyaska Deep Aquifer (Type 4b) – Revised from previous mapping (Joeyaska Aquifer)

The Joeyaska Deep Aquifer is a deep confined glaciofluvial sand and gravel to shallow bedrock aquifer associated with a dense cluster of wells in a populated area southeast of Merritt (Figure 5X).
The documented stratigraphy from well records in the area is highly variable and complex at depth so the distribution and extent of the permeable deposits and rock may be suitable for further interpretation and sub-delineation. However, in general, wells considered to be completed in the Joeyaska Deep Aquifer tend to be greater than 50 m in depth (with the deepest being up to 200 m) and

generally characterized as having groundwater levels noticeably below ground surface (over 20 m), in comparison to wells completed in the overlying Joeyaska Shallow Aquifer, which typically have groundwater levels close to ground surface. Many wells are completed in deep permeable deposits, basal unconsolidated material, or within the shallow bedrock and tend towards low yields. The presence of permeable materials higher up in the stratigraphic column of the deeper wells often does not influence completion depth, suggesting that these shallower deposits may be dry. Deeper wells at lower elevations closer to the center of the Merritt basin are correlated with the Middle Merritt Aquifer when the stratigraphy becomes more uniform and consistent with permeable deposits underlying the City.

Cross-sections showing the distribution and extent of the Joeyaska Shallow and Joeyaska Deep Aquifers relative to each other are presented in Figure 6. Due to the complexity of the deposits and stratigraphy, 3D volumetric solids were not generated in this area.

Nicola Lake Area

The two aquifers in the Nicola Lake area were slightly revised from their original boundaries to account for updated subsurface information in the area (Figure 7). The shallow Unicola Aquifer has well-defined extents based on the morphology of the alluvial fan deposit near the outlet of Nicola Lake and the associated floodplain of the Nicola River in this area. At greater depths, the confined Conicola Aquifer is observed relatively continuously throughout the valley, with greater uncertainty in areas of fewer deep well records. One deep well midway in the valley between Nicola Lake and Merritt intersected additional permeable deposits at greater depths than the Conicola Aquifer, potentially representing an additional confined aquifer, however insufficient evidence exists at the current time to map this as an aquifer.

Unicola Aquifer (Type 3 / 1c) – Revised from previous mapping

The Unicola Aquifer is a shallow, unconfined sand and gravel aquifer associated with an alluvial fan deposit from the highlands to the north of the Nicola River outflow from Nicola Lake (Figure 8). Greater aquifer thickness is observed near the apex of the fan and distally the aquifer likely interconnects and forms a complex with permeable modern alluvial deposits associated with the Nicola River. The lateral boundaries of the aquifer are delineated to generally coincide with the morphological expression of the fan and the Nicola River floodplain.

Conicola Aquifer (Type 4b) – Revised from previous mapping

The Conicola Aquifer is a confined, glaciofluvial sand and gravel aquifer generally located between in the Nicola River valley between Merritt and Nicola Lake northeast of Merritt (Figure 9). The aquifer is assumed to comprise a complex network of permeable deposits within the valley with formation tops located approximately 35 – 70 meters below local ground surface. The extent and distribution of the aquifer is somewhat variable as a result both of limited available information and the complex glacial history of the area but is generally observed at consistent depths in most well records in the area. Closer to Nicola Lake, available information supports continuity of the deposits whereas further down gradient closer to Merritt the subsurface information is more sparse and the assumed presence of the aquifer in this area has greater uncertainty.

6.2 Lower Nicola – Guichon Creek Area

The aquifer mapping in the Lower Nicola – Guichon Creek Area has been revised from four unconsolidated aquifers to include two additional confined aquifers in the Lower Nicola Area and an additional bedrock aquifer on the eastern side of the Guichon Creek Valley, towards Mamit Lake. As part of this revision, the two previous unconsolidated aquifers in the Lower Nicola area have substantially altered to reflect updated information whereas the two unconsolidated aquifers in the Guichon Creek valley, recently mapped in 2007 by William Hodge, PGeo., remain the same as no additional information has become available

Lower Nicola Area

The Lower Nicola Area, where Guichon Creek meets the Nicola River Valley, has been subject to a complex glacial history. The area was interpreted by Fulton (1975) to have been overridden during the most recent glaciation by glacial ice from the northwest. During glacial retreat, the area was interpreted to have been covered by first stagnant and then dead ice with meltwater flow to Glacial Lake Merritt to the east. As the glaciers retreated further, the area was covered by Glacial Lake Merritt, with meltwater flows continuing from east to the west and input of sediment from the inflowing Guichon Creek valley to the north. This complex history resulted in the formation of the stacked confined and unconfined aquifers in the area, with permeable deposits interpreted to be initial outwash at greater depths and subsequent deposition of alternating permeable and glaciolacustrine deposits on top, with permeable aquifer deposits generally interpreted to prograde distally away from where Guichon Creek enters the Nicola Valley. Water wells completed in aquifers associated with deeper gravel outwash deposits are often characterized by flowing artesian conditions in this area and some evidence for deeper gravel aquifers beneath the currently mapped ones exist with delineation not supported at this time.
The Lower Nicola aquifers are presented in Figure 10.

Stumbles Creek Aquifer (Type 3) – Revised from previous mapping (Stumbles Creek Aquifer)

The Stumbles Creek Aquifer is a shallow, predominantly unconfined, alluvial fan-type sand and gravel aquifer located near the confluence of Guichon Creek and the Nicola River (Figure 10). The fan spreads distally from north to south and is incised to some degree by modern-day Stumbles Creek. The lateral and distal boundaries of the aquifer are the valley sides and the Nicola River, respectively, though the aquifer is less understood at its margins due to limited subsurface information in these areas.

Stumbles Creek Confined Aquifer (Type 4b) – Newly identified aquifer

The Stumbles Creek Confined Aquifer is a relatively limited deposit of confined glaciofluvial silty sand to sand located beneath the Stumbles Creek Aquifer near the confluence of Guichon Creek and the Nicola River (Figure 10). It is a shallow, thinly confined aquifer which appears to be distinct though may harbor some degree of connectivity with the more extensive Lower Nicola Aquifer below.

Lower Nicola Aquifer (Type 4b) – Revised from previous mapping (Lower Nicola Aquifer)

The Lower Nicola Aquifer is a confined predominantly silty sand to sand aquifer located near the confluence of Guichon Creek and the Nicola River (Figure 10). It is the intermediate depth deposit of the three mapped confined aquifers in this area and is likely associated with mass wasting from the Guichon

Creek valley into Glacial Lake Merritt. The silty sand to sand deposits associated with this aquifer are widely observed in wells in the valley and is mapped to extend laterally in close proximity to the valley walls and distally to the Nicola River, though the thickness and distribution of the deposit is expected to be variable. The Lower Nicola Aquifer appears to be a distinct and separate deposit but may have some degree of connection with the overlying Stumbles Creek Confined Aquifer.

Lower Nicola Outwash Aquifer (Type 4b) – Newly identified aquifer

The Lower Nicola Outwash Aquifer is a confined predominantly gravel aquifer located near the confluence of Guichon Creek and the Nicola River (Figure 10). It is the deepest of the mapped confined aquifers in this area and is likely associated with glacial outwash. Similar to overlying aquifers, the gravel deposits associated with this aquifer are widely observed in wells in the valley and is mapped to extend laterally in close proximity to the valley walls and distally to the Nicola River. Additional deeper gravel intercepted in flowing artesian wells closer to the Nicola River may be associated with this aquifer or may comprise a second gravel aquifer at depth.

Cross-sections showing the distribution and extent of the aquifers of the Lower Nicola Area relative to each other are presented in Figures 11 and 12.

Guichon Creek Area

The Guichon Creek Area is a lightly developed valley between the Nicola River and Mamit Lake to the north. The valley infill itself is characterized by hummocky terrain with eskers, and the valley floor is sparsely populated with only minimal subsurface information. Though permeable deposits and exploitable aquifers are likely present in the valley, these have not been mapped as part of this study. This area was previously mapped by Hodge in 2007 and due to limited information, only two unconsolidated aquifers were identified. This area does not require updates as the subsurface understanding has not substantially evolved since that time. An additional bedrock aquifer has been delineated to reflect a local concentration of wells that have been completed in the bedrock along the roadway that runs along the valley. Aquifers in the Guichon Creek Area are presented in Figure 13.

Guichon Creek Aquifer (Type 6b) – Newly identified aquifer

The Guichon Creek Aquifer is a bedrock aquifer located in a sparsely populated area between Lower Nicola and Mamit Lake, north of the confluence of Steffens Creek and Guichon Creek (Figure 14). Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage, and encompasses small communities and properties along the main roads in the area.

Guichon Creek South Of Kamloops Aquifer (Type 3) – No changes to mapping

This small unconsolidated aquifer was previous delineated by Hodge based on topographic relief, well log lithology and Pleistocene geology maps (Figure 14). As the aquifer boundary is not certain, dashed lines are used to represent the aquifer (Hodge 2007).

South Of Mamit Lake Aquifer (Type 4b) – No changes to mapping

This unconsolidated confined aquifer was previously delineated by Hodge based on well log lithology, topography and geographical feature (Mamit Lake, Figure 14) but noted to have high uncertainty.

6.3 Coldwater River Valley Area

The Coldwater River Valley Area comprises the Coldwater River Valley from its outflow to the Merritt Basin, upstream to the just past the community of Kingsvale and also includes Paul's Basin, a lightly-settled valley to the west of the Coldwater River (Figure 15). No previous aquifer mapping had been done in this area. The Coldwater River Valley developed on the regional Coldwater Fault, and remains characterized by predominantly narrow valley walls and tightly constrained unconsolidated valley deposits. Undifferentiated glacial tills and morainal deposits are common on the valley walls, particularly as the valley opens up into the Merritt Basin. With the exception of isolated areas of groundwater developed in unconsolidated deposits in the valley fills or the morainal side slopes, groundwater for domestic and communal purposes tend to be developed in bedrock and are predominantly low yielding. The distribution and extent of permeable materials in the valley is expected to be variable given the valley morphology. However, a deep well in the Coldwater Valley north of Kingsvale intersected two intervals of confined permeable deposits (potential aquifers) underneath the confined Coldwater Valley Aquifer, confirming that deeper unconsolidated deposits can be found in the valley.

Kwinshatin Intertill Aquifer (Type 4b) – Newly identified aquifer

The Kwinshatin Intertill Aquifer is a sand and gravel, intertill aquifer in the Coldwater River Valley near its confluence with Kwinshatin Creek (Figure 16). The aquifer is comprised of layers of water-bearing sand and gravels variably expressed within glacial till and undifferentiated morainal deposits without an obvious continuity between boreholes or at defined elevations. The boundaries are mapped primarily on the basis of observed well records and morphological expression within the valley but permeable deposits are expected to be variable and may exist outside the mapped delineation.

Coldwater Valley Aquifer (Type 4b) – Newly identified aquifer

The Coldwater Valley Aquifer is a confined glaciofluvial sand and gravel aquifer located in the Coldwater Valley just north of Kingsvale (Figure 17). It is delineated laterally based on the Coldwater Valley walls, and upgradient and downgradient based on the limits of observation in well records and the limits of flatter morphological expression of sediments in the valley. The top of the aquifer is commonly observed approximately 15 m below local ground surface in the valley, generally underlying 5 – 10 m of fine grained, glaciolacustrine or glacial till material. Observed aquifer thicknesses are 5 – 10 m thick. Continuity of the aquifer both upgradient in the valley and downgradient in the valley beyond the mapped limits is possible but not observed. One deeper well record in the area observed the potential for two additional underlying aquifers of high yield but these have not been mapped and any connectivity or continuity with the Coldwater Valley Aquifer are undetermined.

Paul's Basin Aquifer (Type 6b) – Newly identified aquifer

The Paul's Basin Aquifer is a bedrock aquifer located in a sparsely populated area in Midday Creek Valley. Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small residences and properties along the main roads in the area. The aquifer is delineated laterally within the basin just below the 920 m elevation, comprising the area where many of the wells are completed (Figure 18).

Kingsvale Aquifer (Type 6b) – Newly identified aquifer

The Kingsvale Aquifer is a bedrock aquifer located in a sparsely populated area of the Coldwater River Valley system near the community of Kingsvale (Figure 19). Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small communities and properties along the main roads in the area.

6.4 Lower Nicola Valley – Spences Bridge Area

The Lower Nicola Valley – Spences Bridge Area comprises the Lower Nicola River Valley from the Lower Nicola Area downstream to Spences Bridge and its confluence with the Thompson River. The valley is notable from a geological standpoint due to its narrower valley walls and relatively small amounts of infill in comparison to other valleys in the area of comparable size. Subsurface data by way of well records exist only in isolated pockets associated with areas of settlement and aquifers are not mapped where data is extremely limited or completely absent, though it is expected that permeable deposits suitable for domestic groundwater development are ubiquitous in the valley infill areas. Previous aquifer mapping in the area had delineated three unconsolidated aquifers and one bedrock aquifer. These previously delineations have been revised based on updated information and one additional unconsolidated aquifer identified.

West of Merritt Aquifer (Type 1c) – Revised from previous mapping (West of Merritt Aquifer)

The West of Merritt Aquifer is a shallow, unconfined sand and gravel aquifer composed of modern alluvium associated with the Nicola River. It is bounded laterally by the valley walls of the Lower Nicola River Valley and upstream by its presence in the shallow well records (Figure 20, 21, 22). Downstream, the aquifer is delineated at the edge of a morphological landform that constrains the Nicola River and the associated alluvium prior to its confluence with Spius Creek. While shallow alluvial deposits are noted on the downstream side of this landform in the floodplains surrounding the confluence, there are few well completions in these materials as well as indications of drier deposits and lower water levels in this area so this region was excluded from the mapped aquifer area. Connectivity and continuity to other shallow modern alluvial deposits closer to Lower Nicola are possible but unable to be proven due to limited data. The thickness of the coarse-grained deposits are variable, but relatively thin (3-10 m).

Canford Aquifer (Type 4b) – Revised from previous mapping (Spius Creek West of Canford Aquifer)

The Canford Aquifer is a shallow, confined, glaciofluvial sand and gravel aquifer located within the Lower Nicola River Valley in the Canford area (Figures 20, 21, 22). The aquifer is bounded laterally by local valley walls, downstream past the confluence of the Nicola River with Spius Creek, and upstream at the limits of its observation in well records. The aquifer is considered to be relatively continuous in the valley and may extend further upstream and downstream than its current mapped boundaries. The top of the aquifer is most commonly intersected approximately 25 to 50 m below local ground surface with the notable exception of several wells near Canford where permeable deposits considered to be part of the Canford Aquifer are intersected at approximately 15 m below local ground surface. As the Canford Aquifer is reasonably productive, whereby wells are usually completed in the aquifer as soon as appreciable water is found. As such, the underlying deposits are unknown and the total thickness of the aquifer is unknown and open at depth.

Spius Creek West of Canford Aquifer (Type 6b) – Revised from previous mapping (Spius Creek West of Canford Aquifer)

The Spius Creek West of Canford Aquifer is a bedrock aquifer located west of Canford, BC where the Spius Creek valley meets the Lower Nicola Valley (Figures 20, 23). Due to limited lithological information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small communities and properties along the main roads in the area.

Agate Aquifer (Type 4b) – Newly identified aquifer

The Agate Aquifer is a shallow, confined, glaciofluvial sand and gravel aquifer within the Lower Nicola River Valley observed in wells drilled between near the communities of Dot and Agate (Figure 24, 25). The aquifer is bounded by the tight valley walls of the Nicola Valley along its lateral boundaries and delineated on its upstream and downstream margins by the limits of development though the aquifer may extend beyond this. The aquifer is commonly intersected from 25-60 m below local ground surface underneath an overlying silt and fine-grained deposit and, despite limited wells across its extent, is assumed to be relatively continuous based on the likely mode of deposition. Unconfined shallow modern alluvial deposits are infrequently exploited for groundwater within the aquifer boundaries but these materials are not considered part of the Agate Aquifer.

Spences Bridge Aquifer (Type 1b)

The Spences Bridge Aquifer is a shallow, unconfined sand and gravel aquifer associated with permeable deposits from the Thompson River and the Nicola River (Figure 26). The aquifer is of limited size and is constrained by a small depression associated with the confluence of the Nicola River.

6.5 Stump Lake Area

Though relatively undeveloped with limited subsurface information, the Stump Lake Area has been subject to a complex glacial history during the most recent glaciation. The ice advance was interpreted to have come originally from the north (Fulton 1975). During the subsequent glacial retreat back to the north, the valley that modern day Stump Lake resides in received meltwater outflows from the north and was on the boundary of stagnant ice and the then-Glacial Lake Hamilton. As the glaciers retreated further, the influx of meltwater from the north also subsided and the Stump Lake area then became the northern boundary of Glacial Lake Merritt, receiving meltwater from the west and outflowing to the northeast along the valley in the direction of what is now Napier Lake. During this time, sediment was likely supplied to the northeast boundary of Glacial Lake Merritt (now Stump Lake) via several watercourses including Stumplake Creek and Frisken Creek, resulting in a complex stratigraphy and bounded by bedrock between Glacial Lake Merritt and Napier Lake. Generally, exposed bedrock outcrops are common in the Stump Lake area and outside of the northeastern portion of the lake, where the aforementioned thicker unconsolidated deposits are observed, most domestic groundwater is supplied by bedrock wells. No previous aquifer mapping was previously completed in this area.

Stump Lake Aquifer (Type 4b)

The Stump Lake Aquifer is a confined sand and gravel aquifer located at the northeastern shore of Stump Lake (Figure 27, 28). The area is characterized by a complex stratigraphy owing to the complicated glacial history and there is considerable disagreement in the associated well records due to both the complexity of the subsurface and the spatial accuracy of the well records. As such, the aquifer can be considered a loose aggregation of permeable deposits, generally confined by a 5 – 15 m layer of till or fine-grained deposits and subject to further definition when information becomes available.
The shore of Stump Lake forms the southwestern boundary of the aquifer with bedrock forming the remainder of the boundaries. Flowing artesian conditions are commonly observed in wells completed in permeable deposits below the confining till layer.

Stump Lake Bedrock Aquifer (Type 6b)

The Stump Lake Bedrock Aquifer is a bedrock aquifer located in a sparsely populated area northeast of Stump Lake (Figure 27, 29). Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small communities and properties along the main roads in the area and with close proximity to the lake.

7. DATA GAPS AND RECOMMENDATIONS

Data gaps in the conceptual understanding of the Study Area were documented during the project so that future hydrogeological work in the area can be tailored to address data needs and gaps in understanding. Quality assurance and quality control recommendations with respect to the provincial databases and data management of those databases are also highlighted and discussed. In addition, implications of various aquifer delineation strategies on water allocation and implementation of the Water Sustainability Act are also presented in the following list of data gaps and recommendations:

- Within the provincial WELLS database with lithology, data QA/QC checks should be considered by the relevant provincial authorities to ensure that lithological descriptors are properly entered in the relevant columns, as well as to ensure that this information is carried over to the database that is downloadable via the provincial data portal, DataBC. These updates have already been completed manually for important stratigraphic wells in the study area but this should also be generally considered for other areas and, moving forward, ensuring that data is properly captured in eWELLS in the first place.
- In accordance with provincial guidance and general practice in the province, in the absence of suitable lithological and structural data, bedrock aquifers were delineated based on the limits of development. While this is a reasonable procedure in the absence of detailed bedrock hydrostructural information, there are implications from this approach to provincial water allocation initiatives. Many measures of groundwater availability treat an aquifer as a self-contained unit, where groundwater inputs and throughput (and, implicitly, "sustainable yield")

is highly sensitive to the aquifer area. Due to the often complex dynamics of groundwater flow and availability within bedrock units, this conceptualization of bedrock aquifers could lead to inaccurate estimates of available water. It is recommended that provincial authorities consider how various parameters generated from aquifer maps affect water allocation initiatives. Alternatives to delineating based on development in data sparse areas include delineating based on contributing catchment area on one side of the spectrum or acknowledgement (supported by some recent studies in bedrock aquifers) that quantity concerns within individual wells are a result of "hydrogeological drought", or the inability of the bedrock to bring adequate amounts of usable water to the well. In this case, estimation of available water in terms of a bedrock aquifer balance or budget may not be valid.

- Assumptions concerning the extrapolation of aquifer boundaries using geological rationale to areas where there is limited to no subsurface lithological data are explicitly stated in Section 5.4. The implications of these assumptions should be considered within the context of the Ministry's goals for provincial aquifer mapping and water allocation. For example, is it more desirable to have a situation where an aquifer is intersected where no aquifer is mapped as a result of conservative delineation or to have a situation where an aquifer is not intersected in an area where it is anticipated to be as a result of hydrostratigraphic extrapolation? Another consideration would be to evaluate how the aquifer mapping is most-commonly utilized and employ aquifer delineation strategies that support that use.
- Reduction in spatial uncertainty and errors associated with the well records could be accomplished with LIDAR (LIght Detection and Ranging) topography or a high resolution well survey. LIDAR topography would improve the resolution of the digital elevation model, which the well collars are projected upon, increasing confidence in the vertical (Z) dimension. Accurate well survey data of important stratigraphic wells would also increase confidence in the horizontal (XY) dimension as well as the vertical (Z) dimension, providing stratigraphic control on the interpretation. Natural Resources Canada has begun publishing a High Resolution Canadian Digital Elevation Model (HRCDEM) with 1 x 1 m and 2 x 2 m resolution in limited areas of the country, but this type of data is not available for the Nicola Watershed yet.
- Wells with improper coordinates were identified during the course of this study and manually corrected by regional FLNRORD staff within the study area. The province could consider conducting a QA/QC screening on the entire WELLS database cross-referencing the UTM coordinates with the region or district in the well record to flag potential wells where the UTM coordinates are erroneous.
- Areas with limited subsurface information are candidate locations where surficial geophysical methods (electric resistivity imaging, electromagnetic methods, or seismic surveys) could be employed to better understand stratigraphy. However, to interpret the geophysical data with passable accuracy, the data need to be calibrated to the stratigraphy logged from a test borehole or at the very least a competent water well log. Areas of particular interest include valleys in the study area where limited well records and subsurface information exists (i.e. – Coldwater Valley) and/or where the bedrock surface in the valley bottom has not been proven (i.e. – Lower Nicola area). As these valleys represent pathways for historical glacial meltwater flow all have the potential for glaciofluvially deposited permeable materials at greater depth. Similarly, geophysical methods could also be employed in the Merritt Basin, to confirm the extent, distribution and thickness of the deeper confined aquifers in this area. Test drilling could also be performed in the above areas to provide high quality point information. Areas for potential additional data collection are provided in Appendix B.

- Uncertainties with respect to items such as potential deeper aquifers, lateral extents of aquifer borders, spatial uncertainty and interconnectivity of permeable units are highlighted both in this report and in the aquifer classification worksheets. Subsurface data continues to be generated that can address gaps in the current conceptual understanding. Consideration should be given to mechanisms whereby newly-generated data that has the potential to improve the current interpretation of the subsurface is integrated and disseminated to the public in a timely manner.

8. CLOSING

We trust that this report, together with the associated draft GIS aquifer polygons and aquifer classification worksheets meets your needs at this time. Should you have any questions, please do not hesitate to contact the undersigned.

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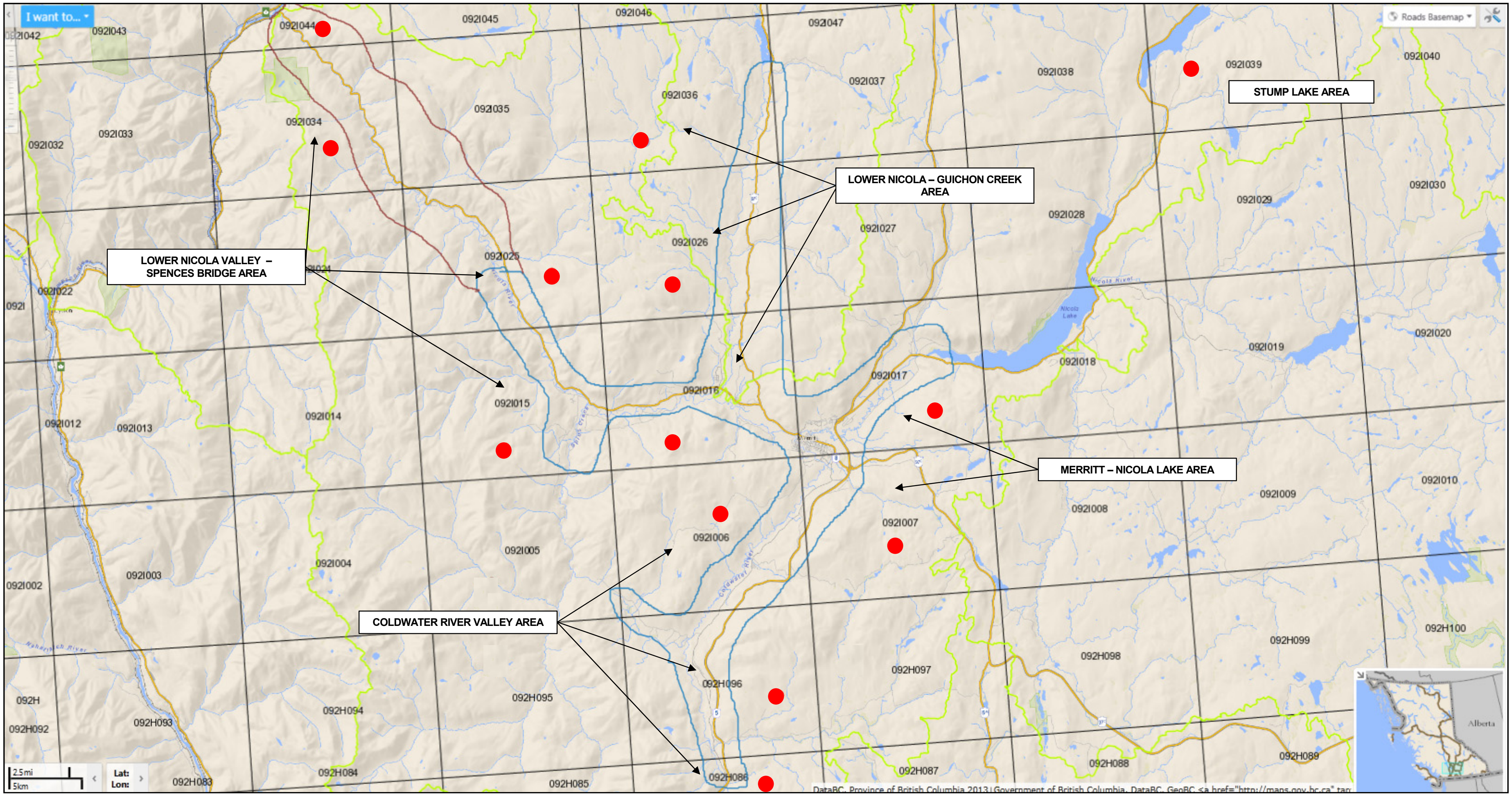

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●	SELECTED MAP SHEET FOR AQUIFER MAPPING
(blue outline)	NUMERICAL GROUNDWATER FLOW MODEL BOUNDARY
(red outline)	EXTENSION TO NUMERICAL GROUNDWATER FLOW MODEL BOUNDARY

CLIENT
FRASER BASIN COUNCIL AND
BRITISH COLUMBIA MINISTRY OF FOREST LAND AND
NATURAL RESOURCE OPERATIONS

BRITISH COLUMBIA Ministry of Environment
GOLDER

YYYY-MM-DD	2017-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	JAS
APPROVED	KB

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
AQUIFER MAPPING AND CLASSIFICATION STUDY AREA AND FUTURE POTENTIAL GROUNDWATER FLOW MODEL BOUNDARIES

PROJECT NO.	PHASE	REV.	FIGURE
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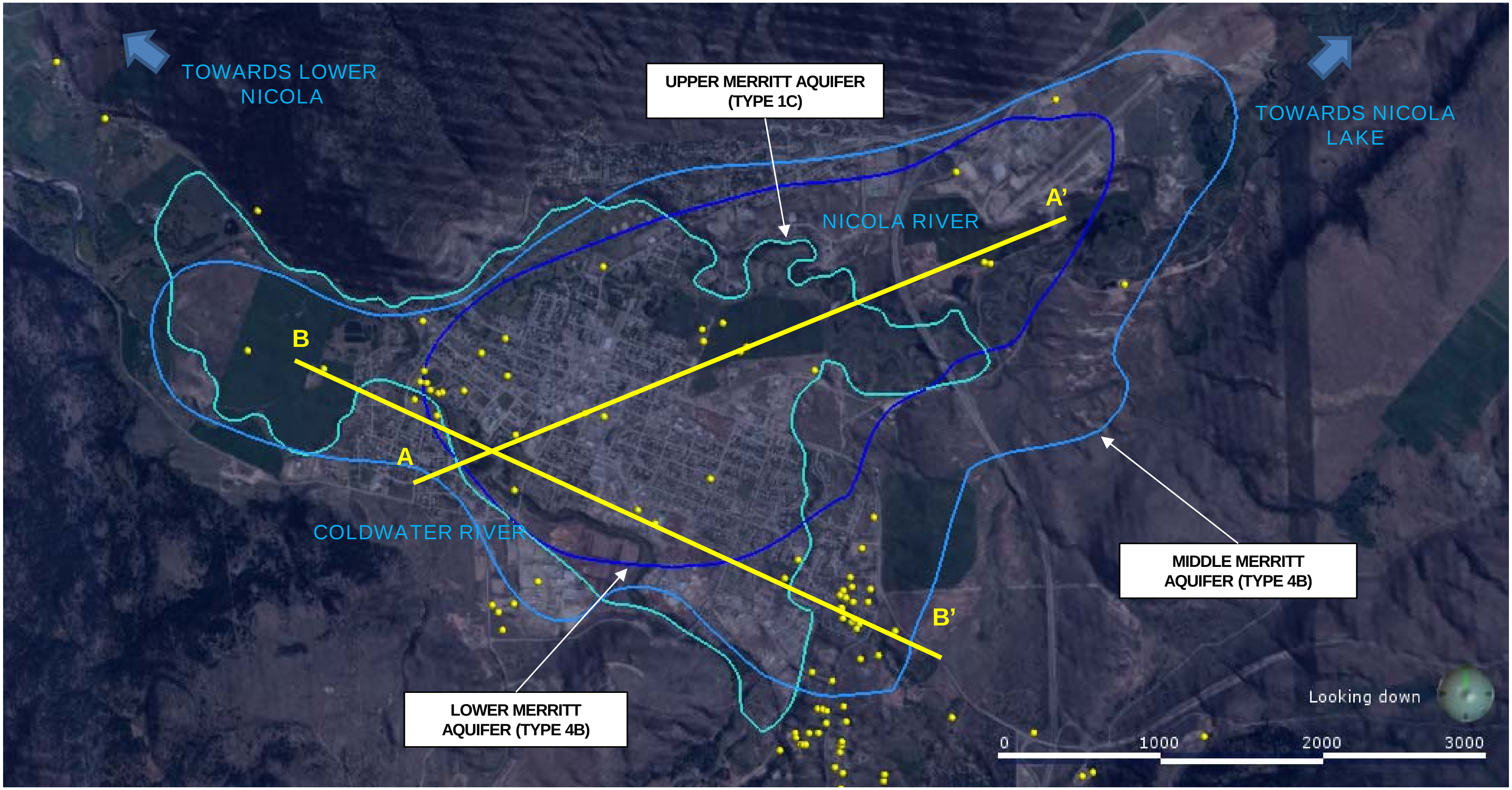

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

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Ministry of Environment

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PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
MERRITT – NICOLA LAKE AQUIFERS
MERRITT BASIN – PLAN VIEW

PROJECT NO.	PHASE	REV.	FIGURE
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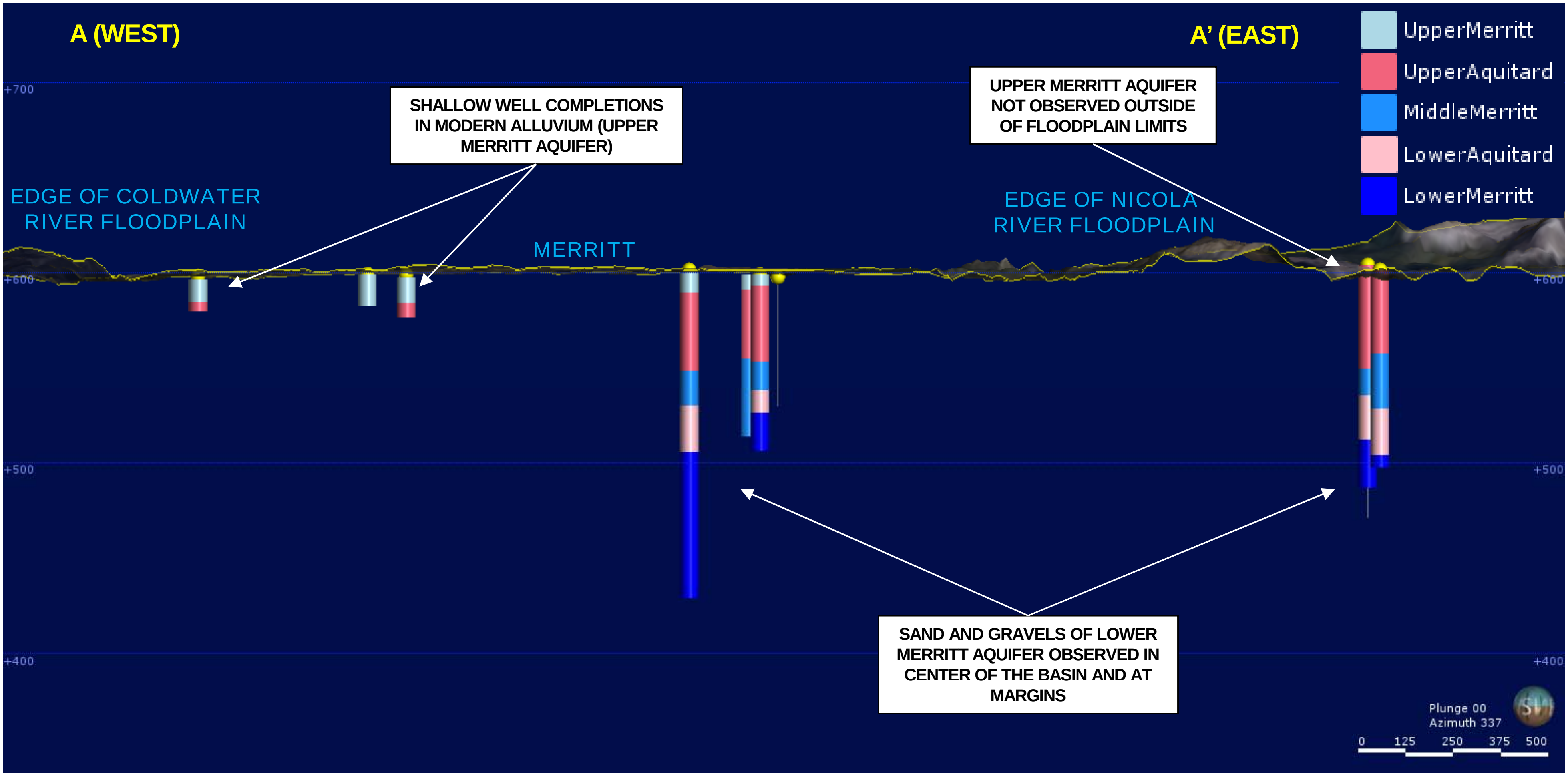

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BRITISH COLUMBIA
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YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
MERRITT BASIN
CROSS-SECTION A-A' (400 m SLICE WIDTH)

PROJECT NO.	PHASE	REV.	FIGURE
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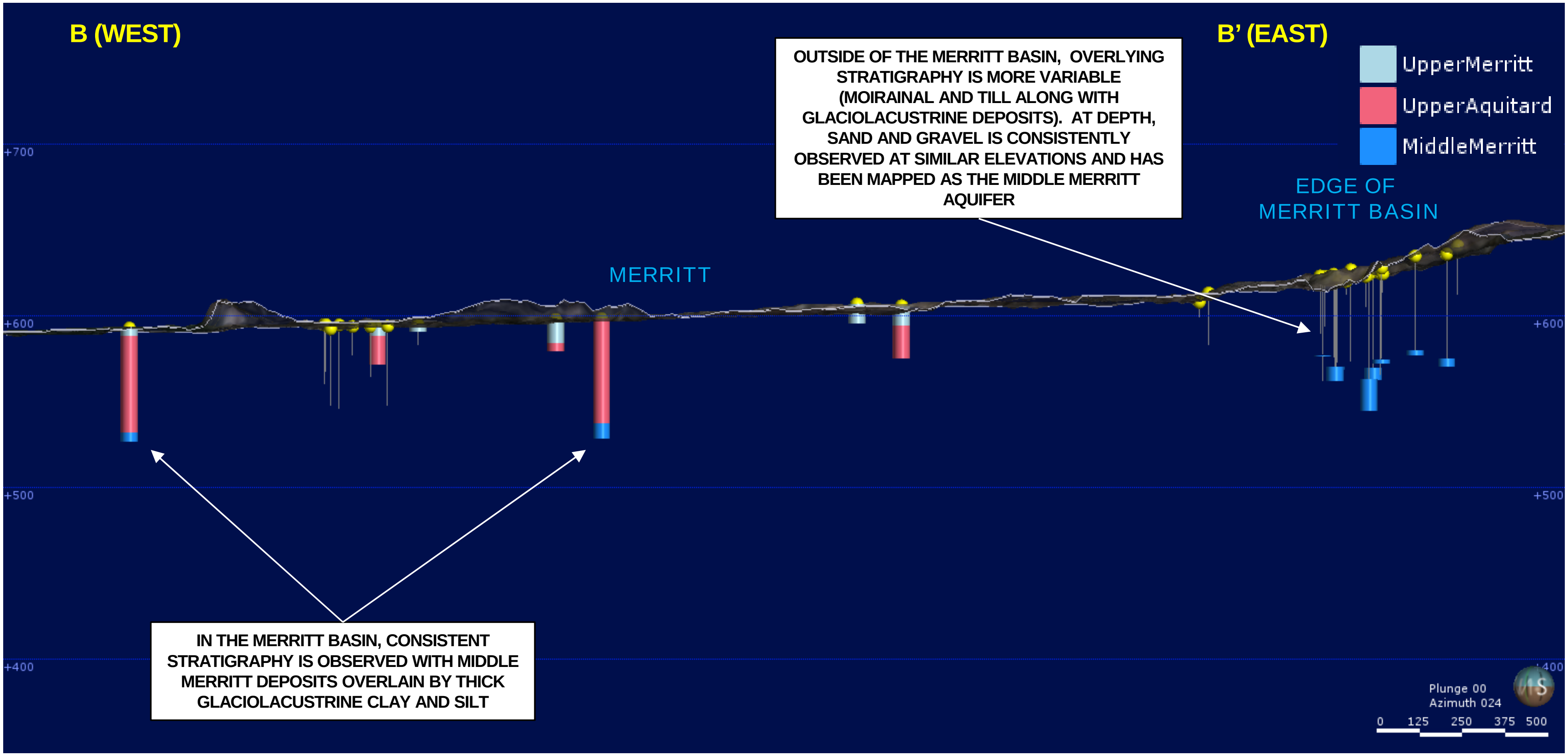

VERTICAL EXAGGERATION: 5x

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YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
MERRITT BASIN
CROSS-SECTION B-B' (500 m WIDTH)

PROJECT NO.	PHASE	REV.	FIGURE
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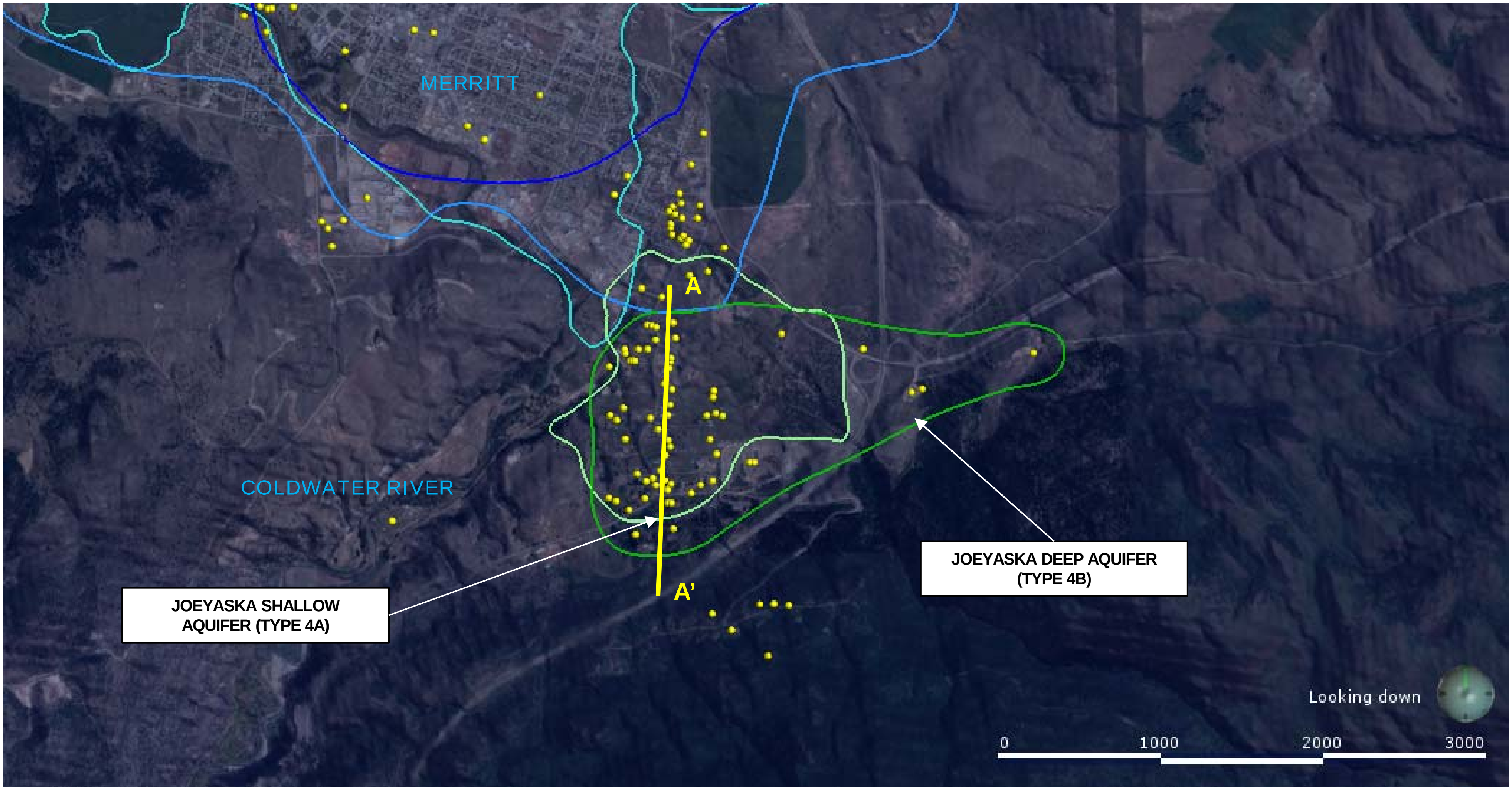

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YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
JOEYASKA AREA
PLAN VIEW – JOEYASKA SHALLOW AND JOEYASKA DEEP AQUIFERS

PROJECT NO.	PHASE	REV.	FIGURE
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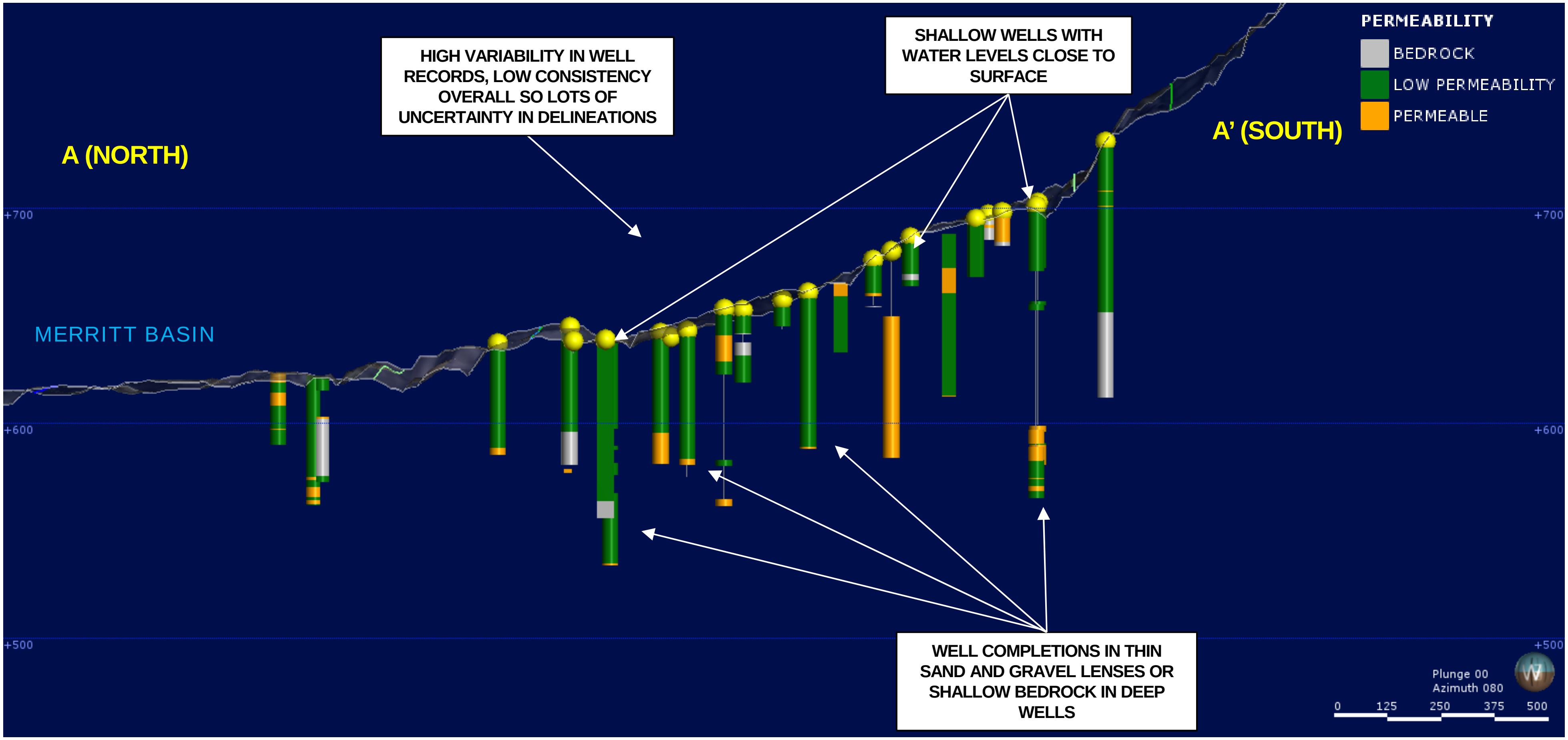

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FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
JOEYASKA AREA
CROSS-SECTION A-A' (120 m SLICE WIDTH)

PROJECT NO.	PHASE	REV.	FIGURE
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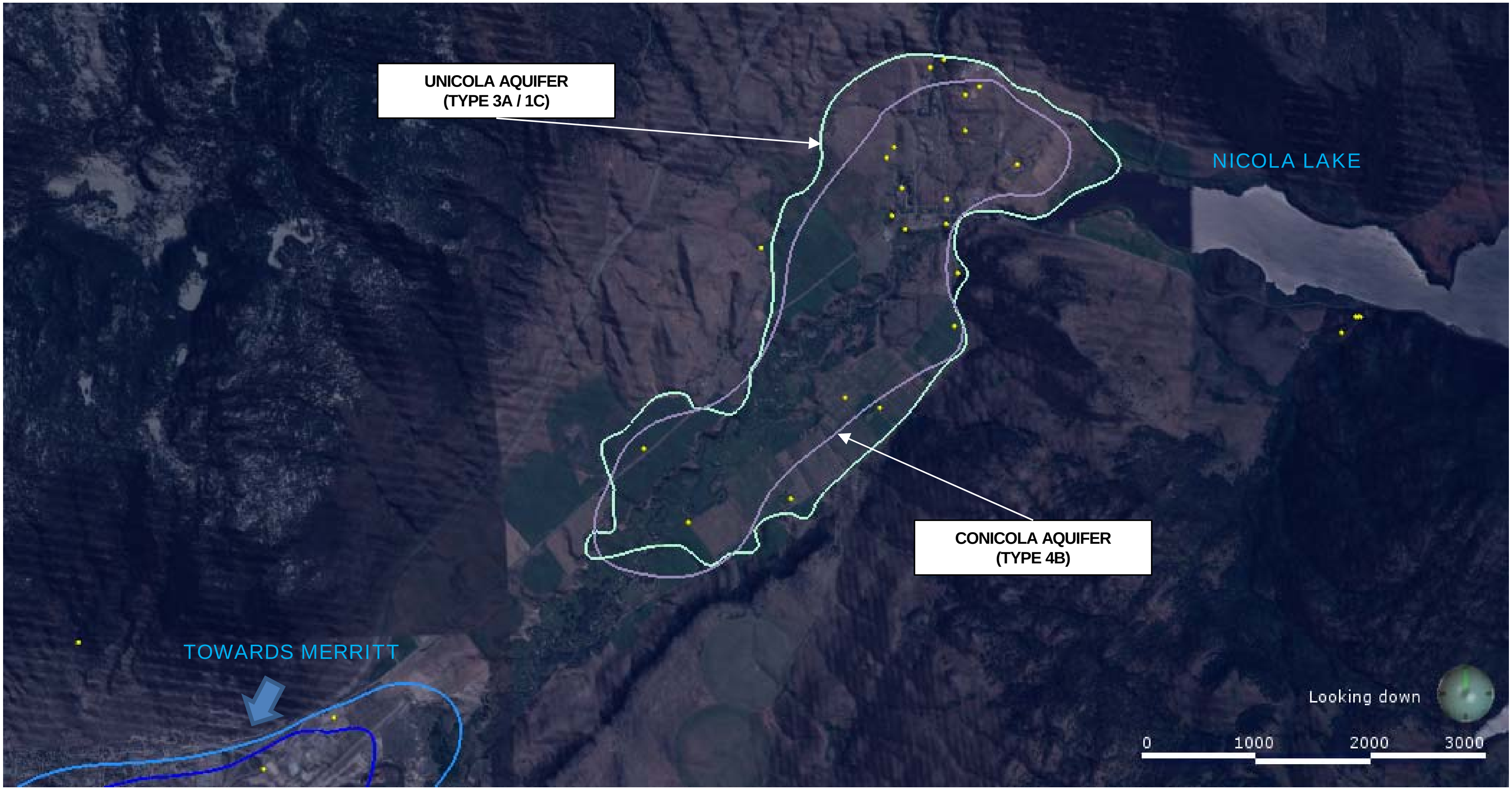

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YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
NICOLA LAKE AREA
PLAN VIEW – UNICOLA AND CONICOLA AQUIFERS

PROJECT NO.	PHASE	REV.	FIGURE
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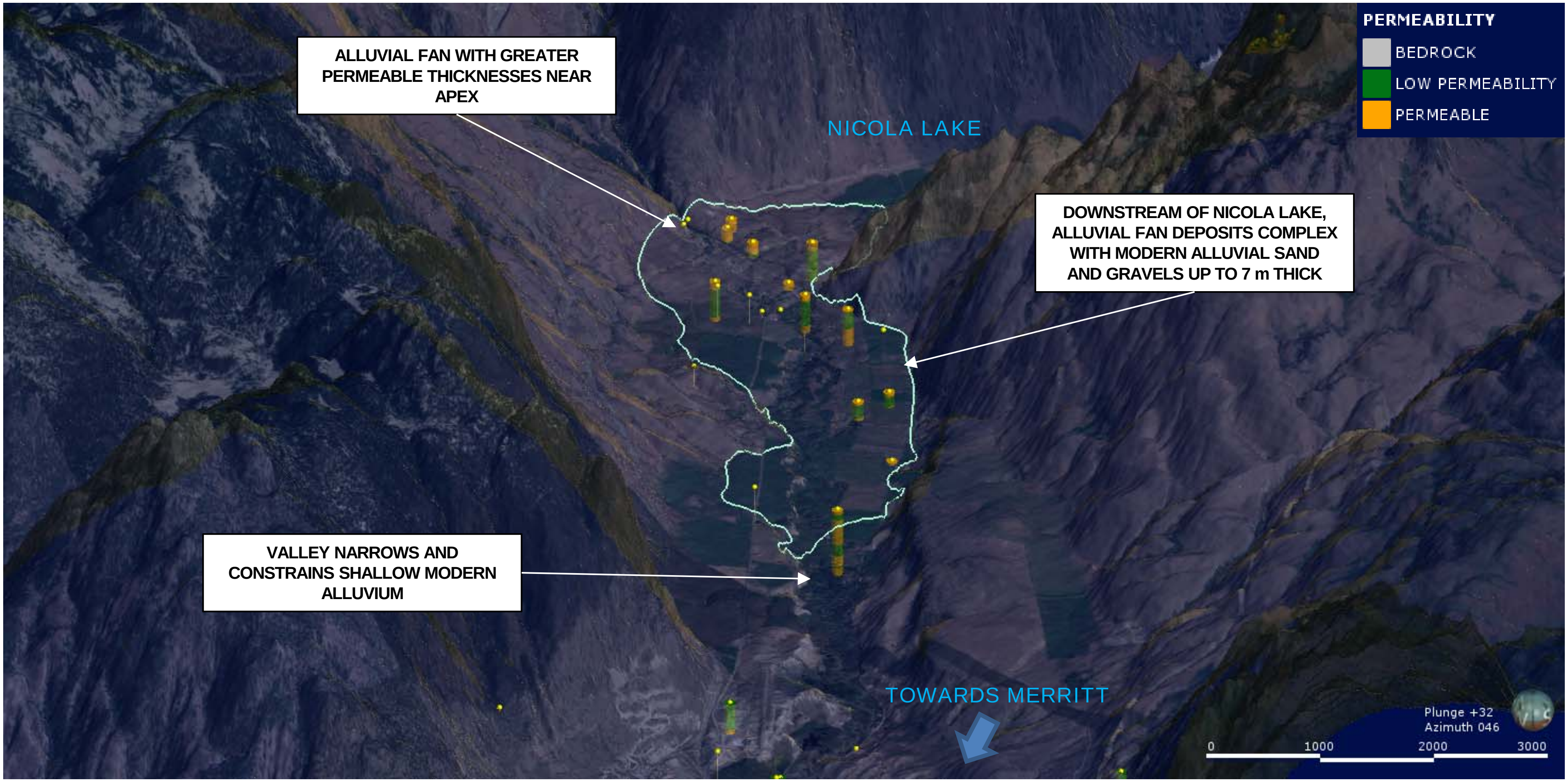

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FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

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GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
NICOLA LAKE AREA
UPDATED UNICOLA AQUIFER (TYPE 3 / 1C)
LOOKING NORTHEAST FROM MERRITT TO NICOLA LAKE

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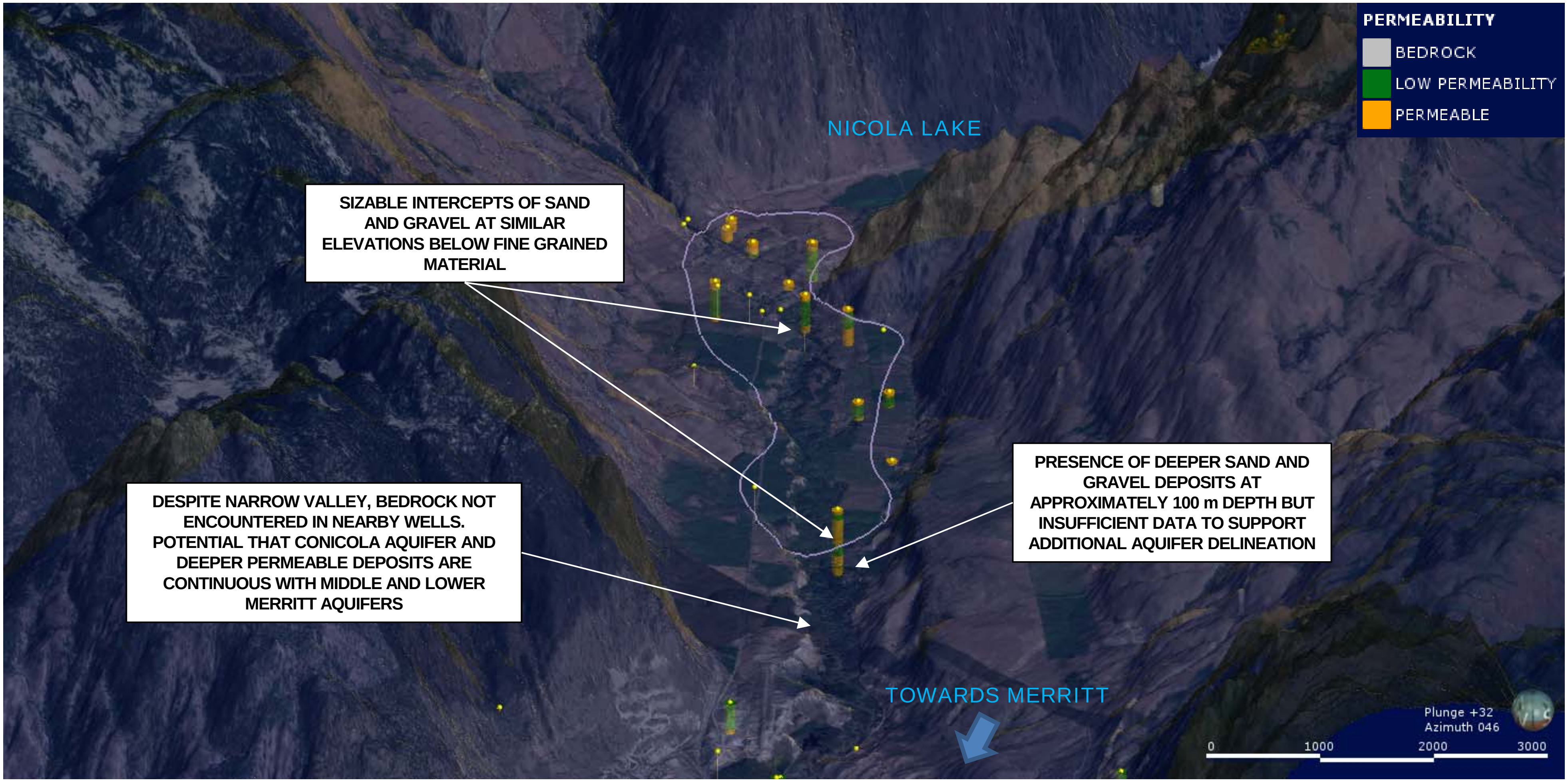

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FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

BRITISH COLUMBIA
Ministry of Environment

GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

TITLE
NICOLA LAKE AREA
UPDATED CONICOLA AQUIFER (TYPE 4B)
LOOKING NORTHEAST FROM MERRITT TO NICOLA LAKE

PROJECT NO.	PHASE	REV.	FIGURE
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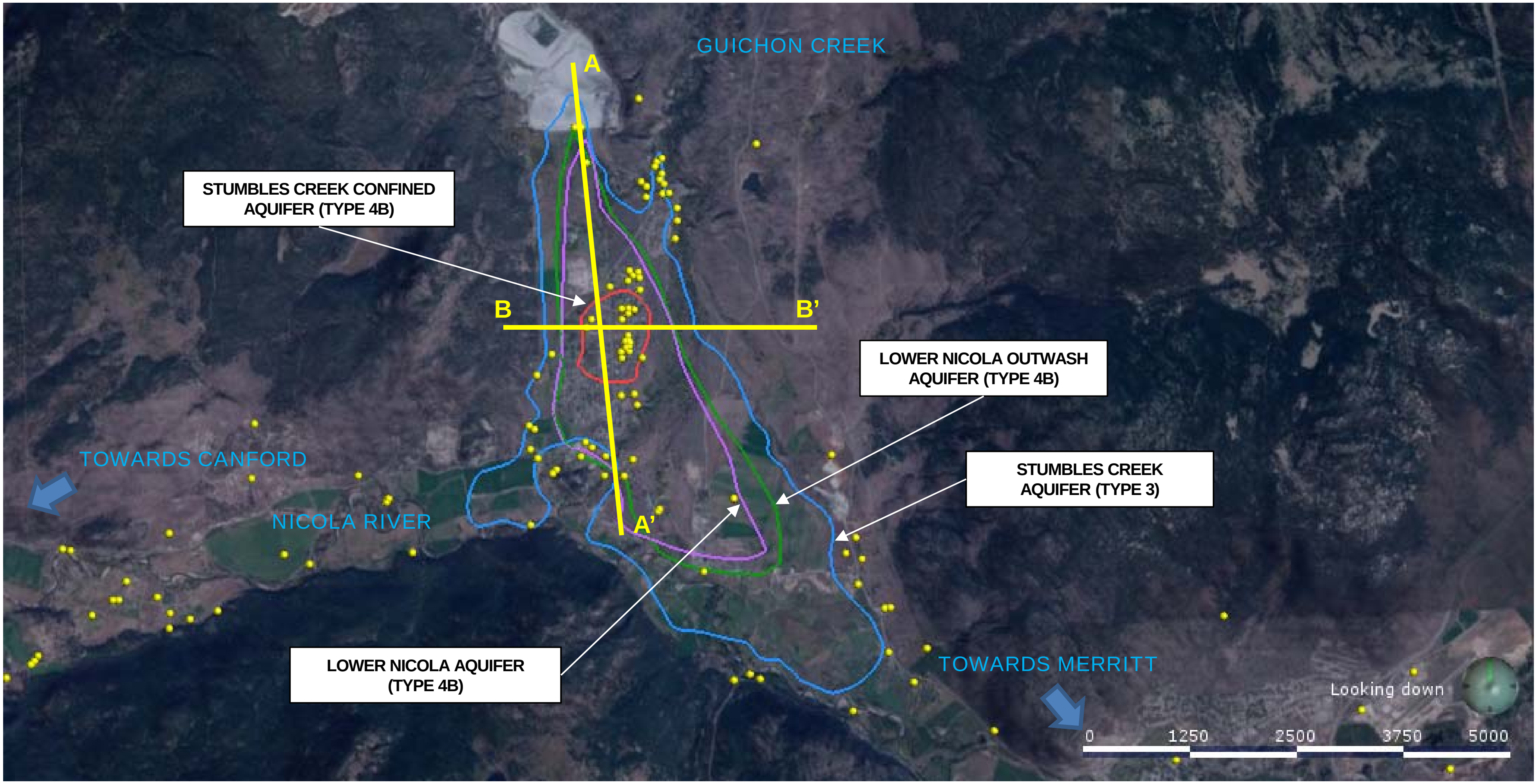


FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

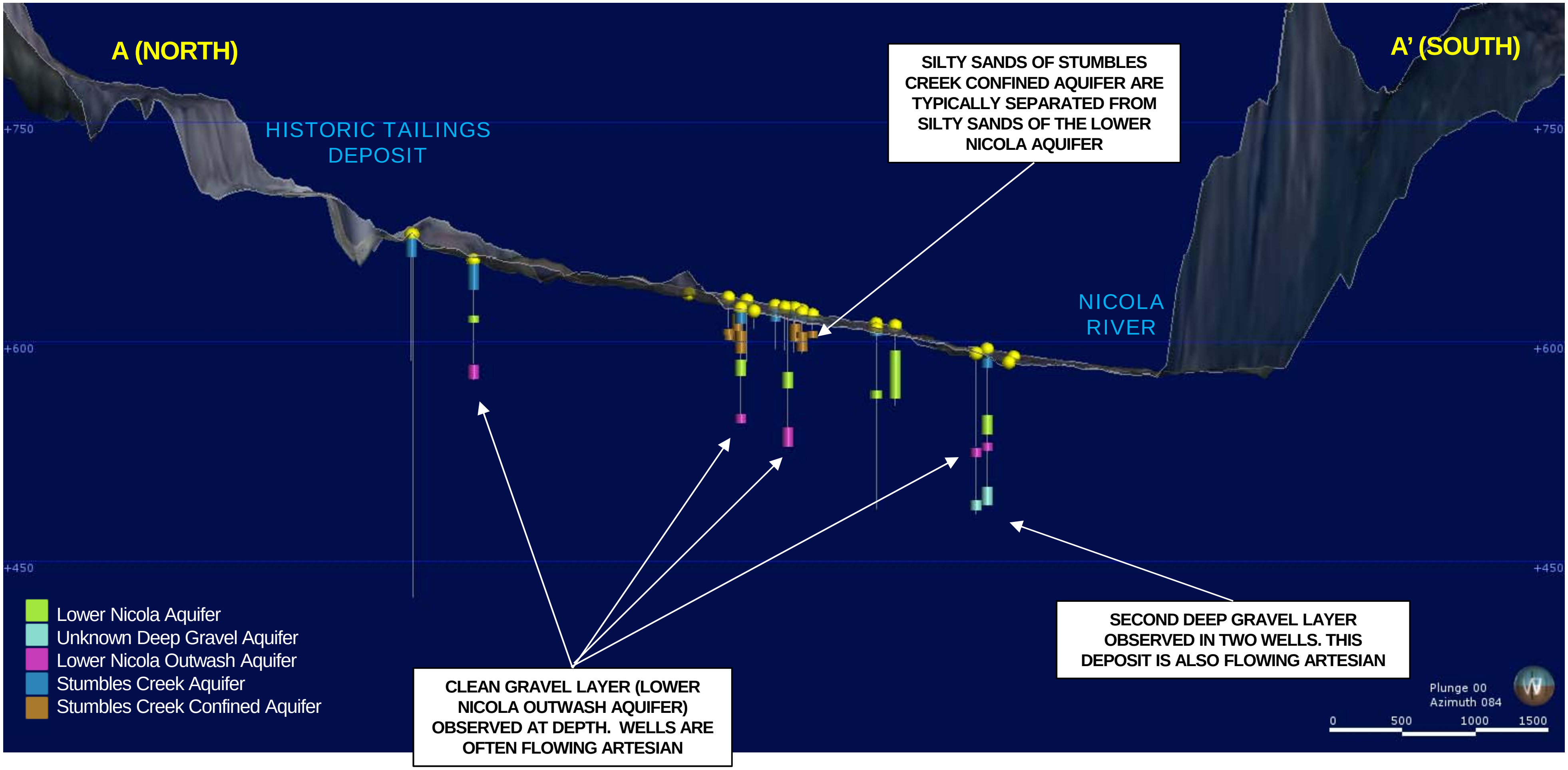
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
LOWER NICOLA AREA
PLAN VIEW SHOWING AQUIFERS

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	10



VERTICAL EXAGGERATION: 10x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

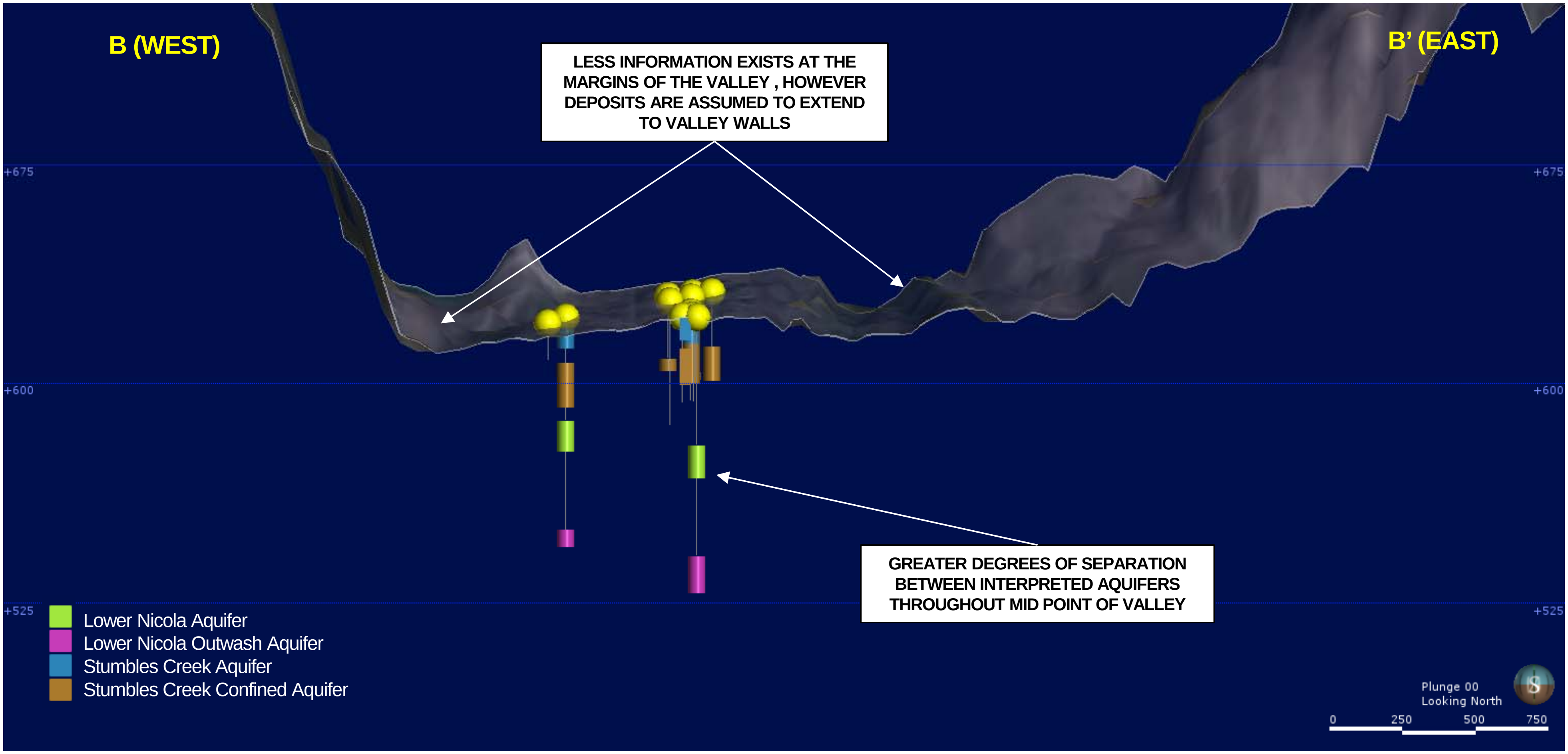
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
LOWER NICOLA AREA
CROSS-SECTION A-A' (500 m SLICE WIDTH)

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	11



VERTICAL EXAGGERATION: 10x

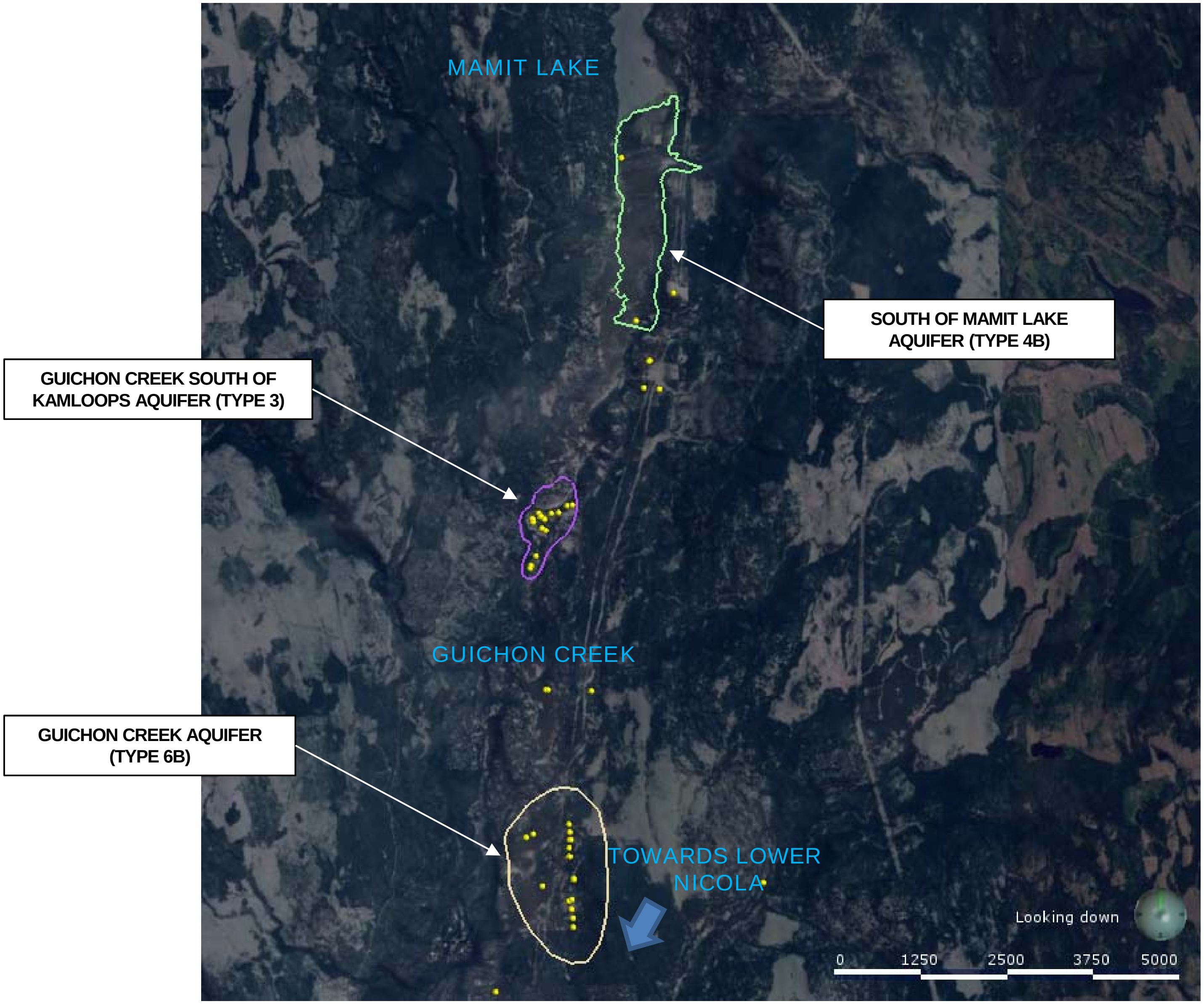
FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
LOWER NICOLA AREA
CROSS-SECTION B-B' (600 m SLICE WIDTH)

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	12



FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

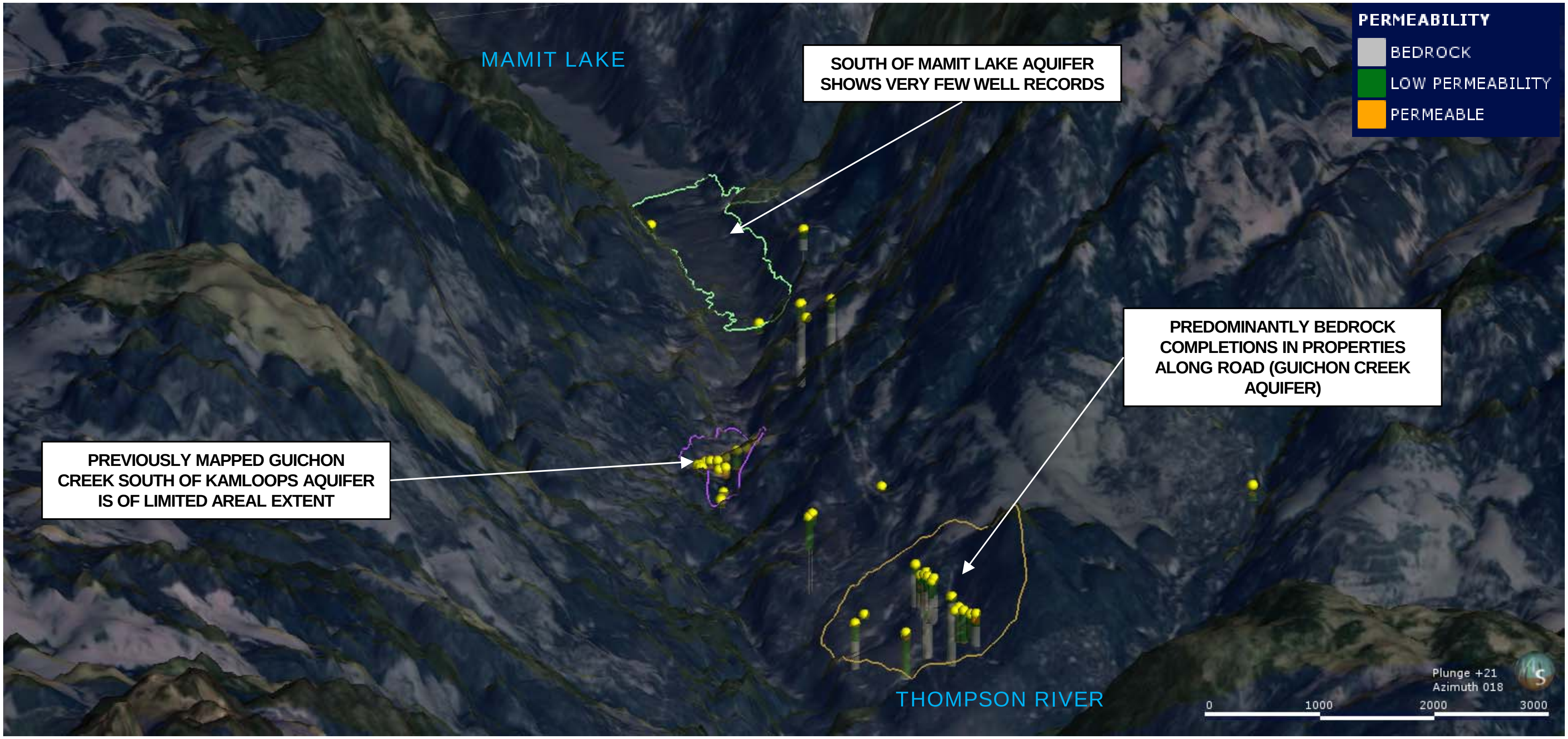
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
GUICHON CREEK AREA
PLAN VIEW SHOWING AQUIFERS

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	13



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

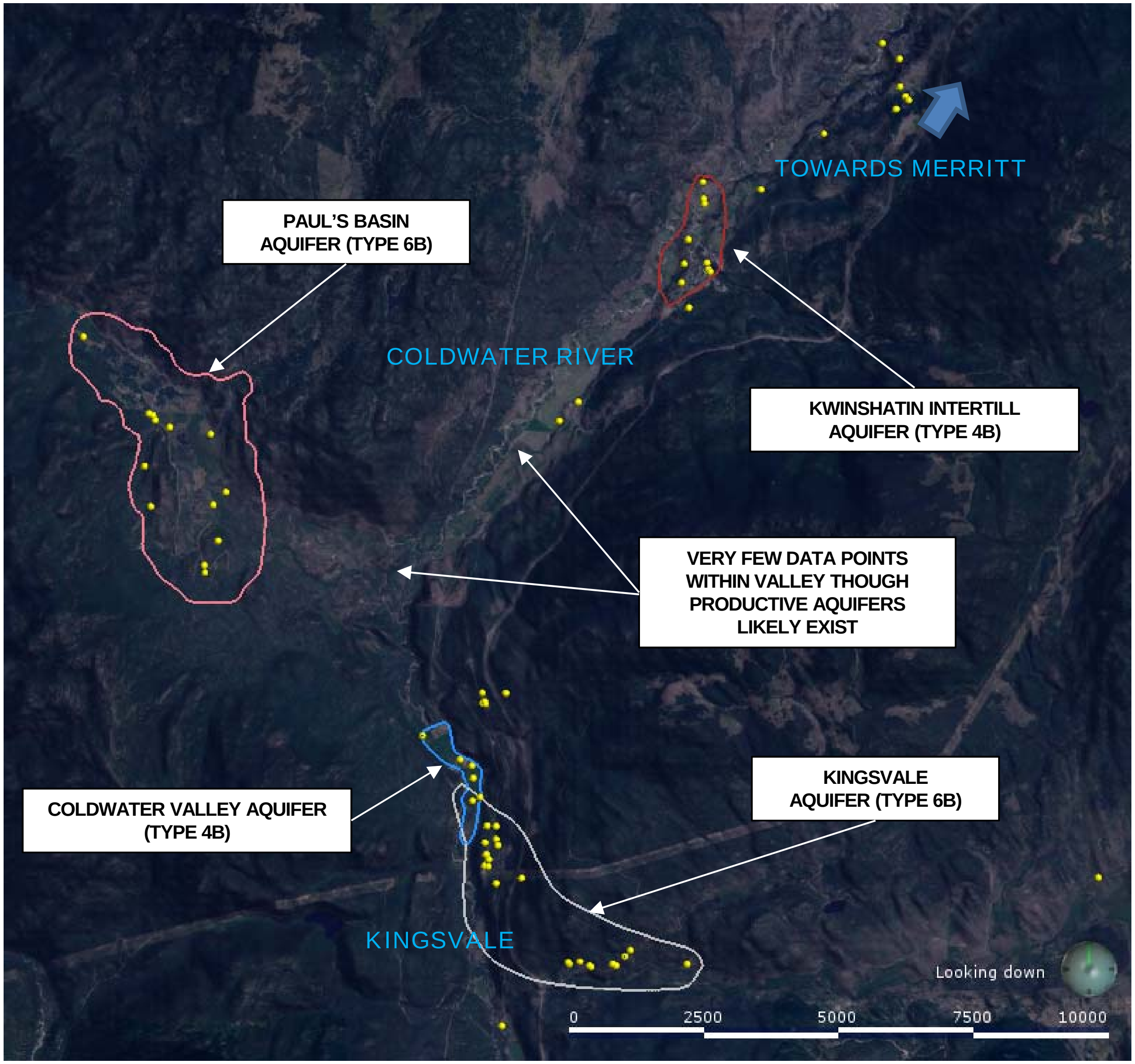
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
GUICHON CREEK AREA AQUIFERS LOOKING NORTH-NORTHEAST ALONG GUICHON CREEK VALLEY

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	14



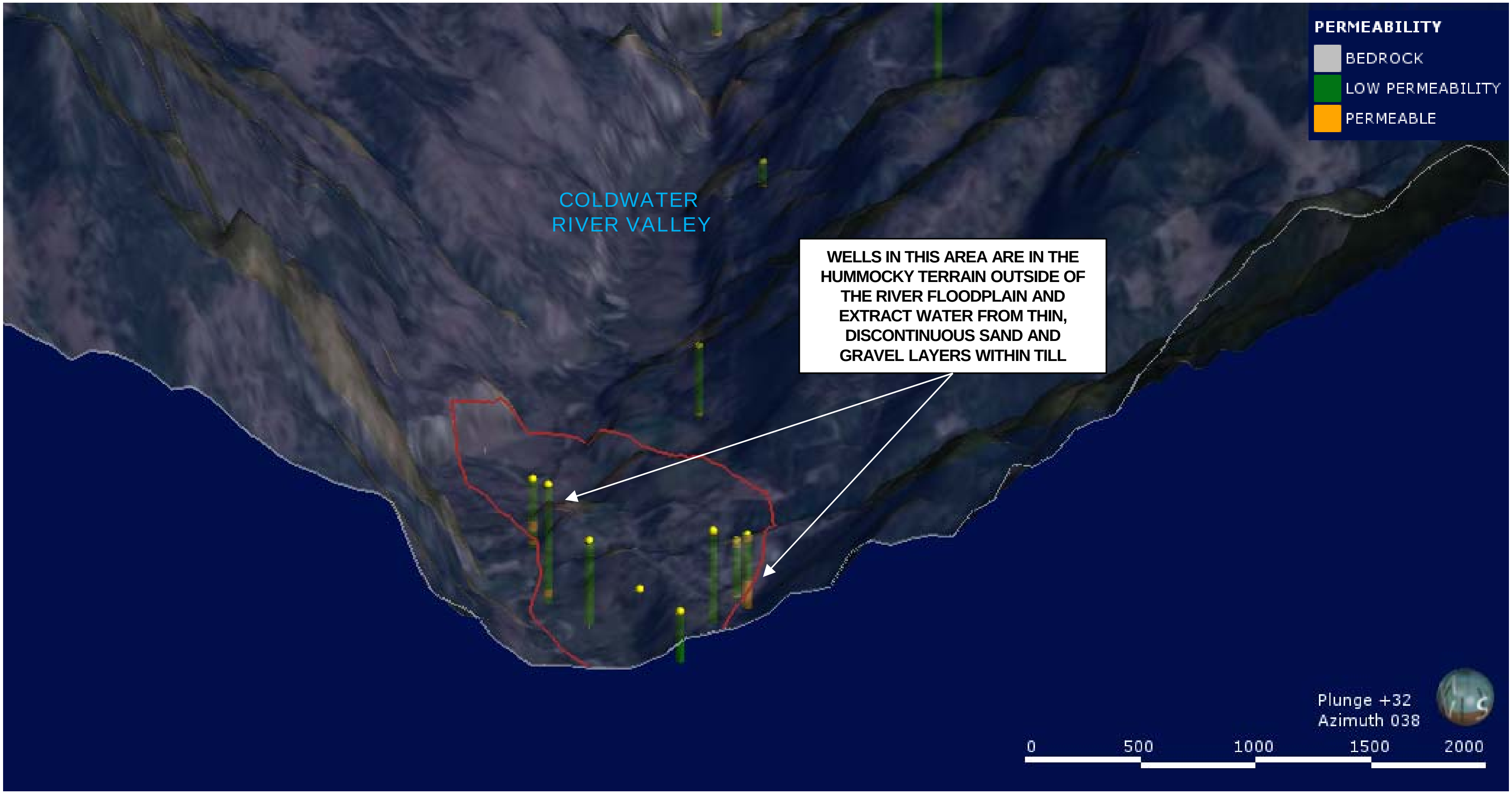
FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

TITLE
COLDWATER RIVER VALLEY AREA PLAN VIEW SHOWING AQUIFERS

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	15



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

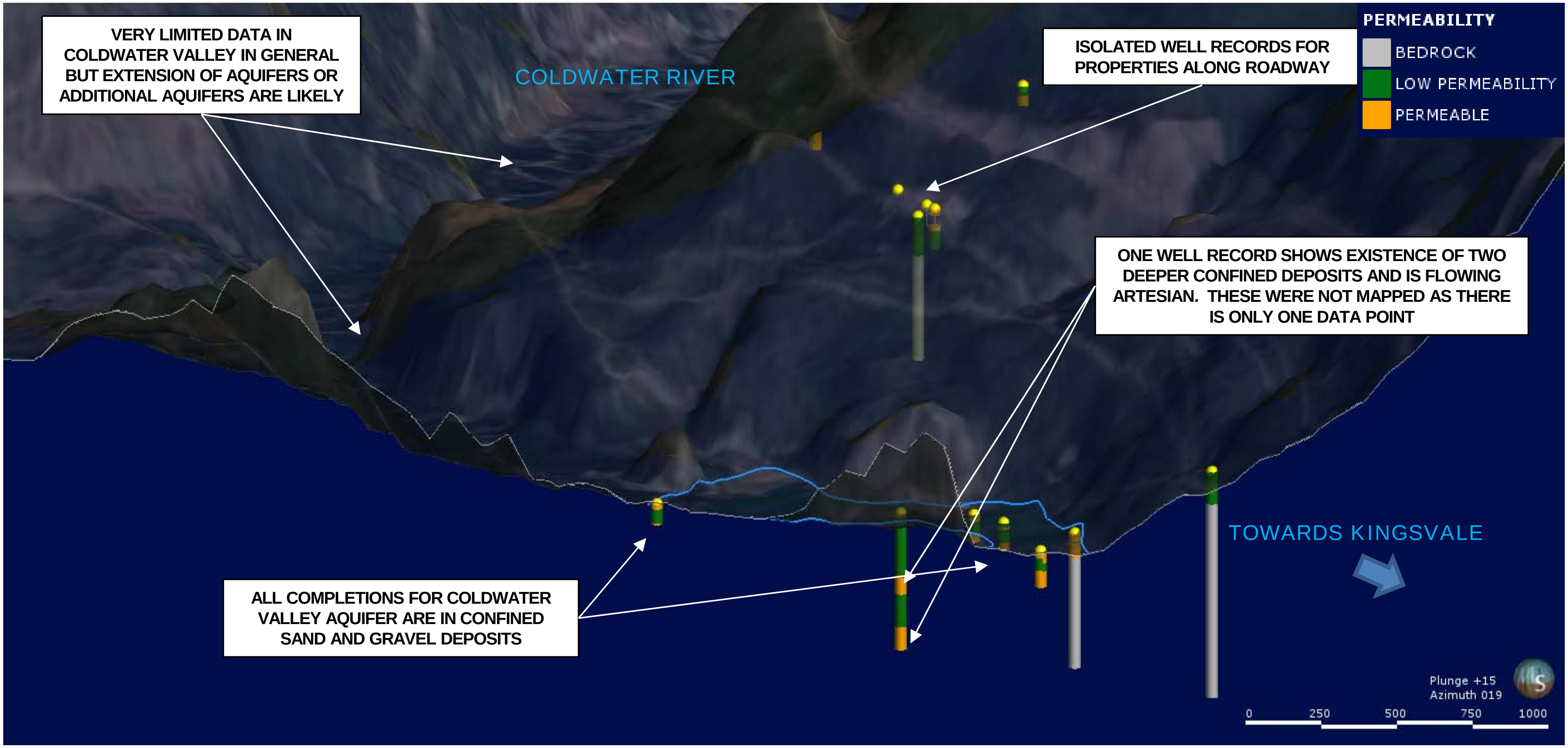
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
CUT AWAY SHOWING KWINSHATIN INTERTILL AQUIFER LOOKING NORTH-NORTHEAST

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	16



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

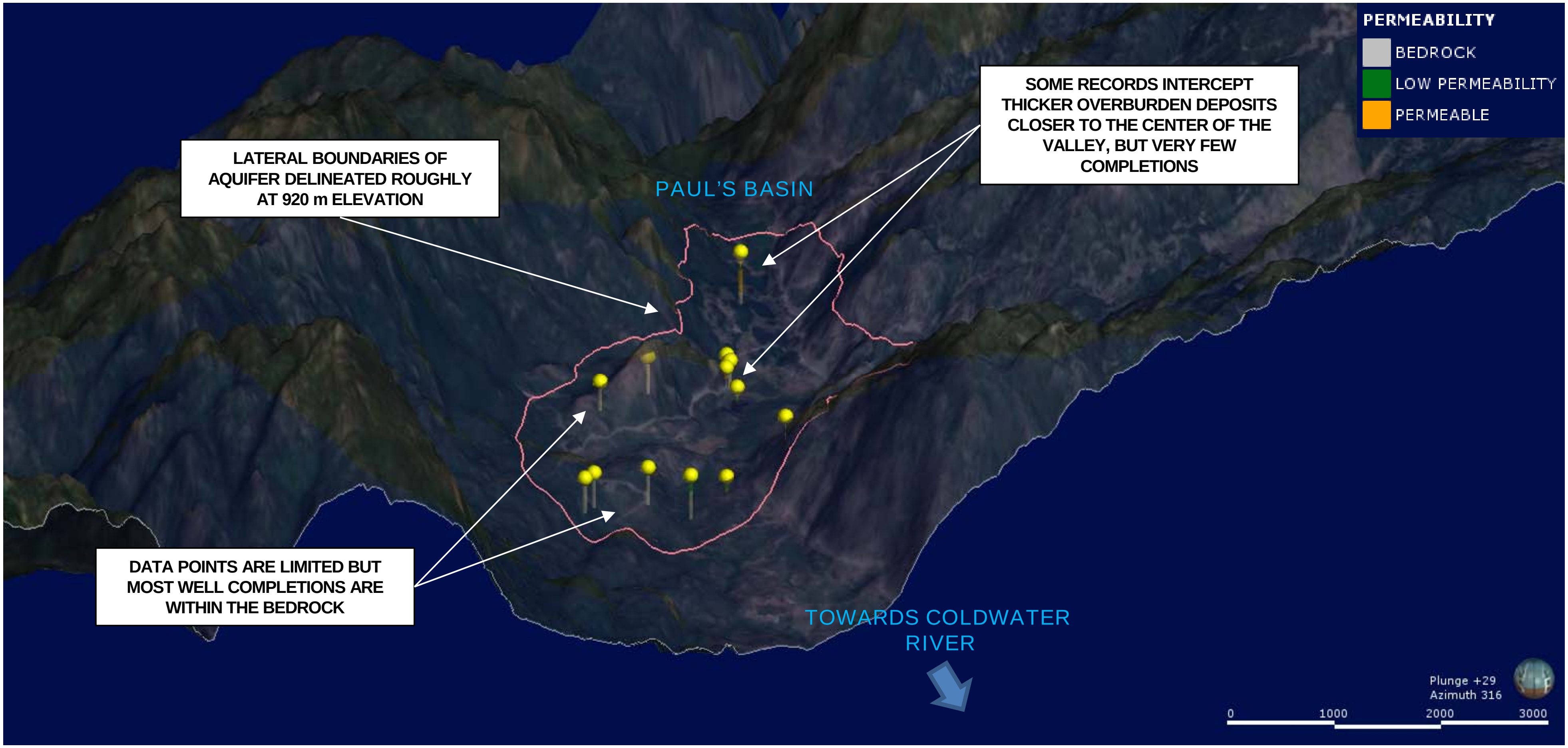
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
CUT AWAY SHOWING COLDWATER VALLEY AQUIFER LOOKING NORTH-NORTHEAST

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	17



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

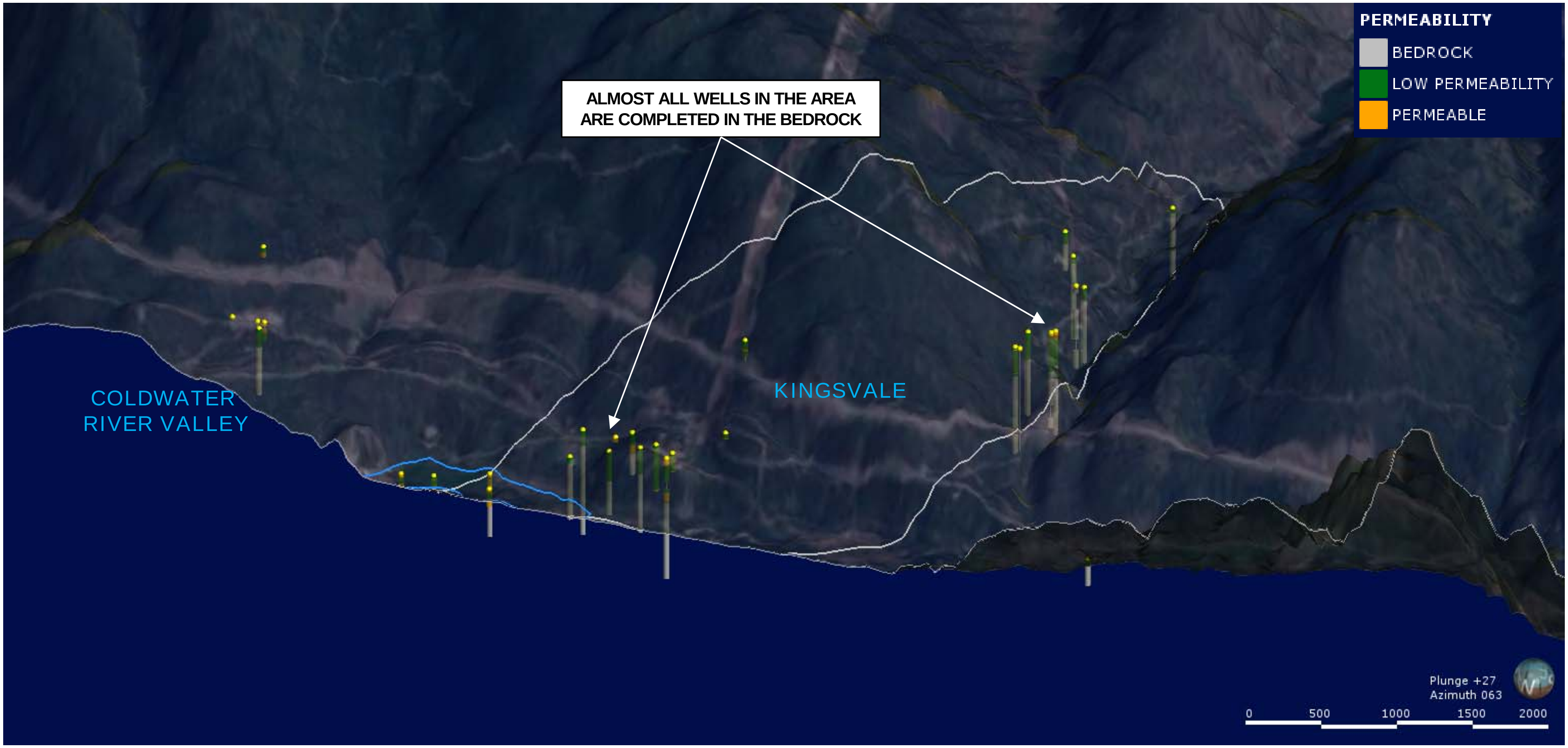
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
CUT AWAY SHOWING PAUL'S BASIN AQUIFER LOOKING NORTHWEST ALONG BASIN

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	18



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

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Ministry of Environment

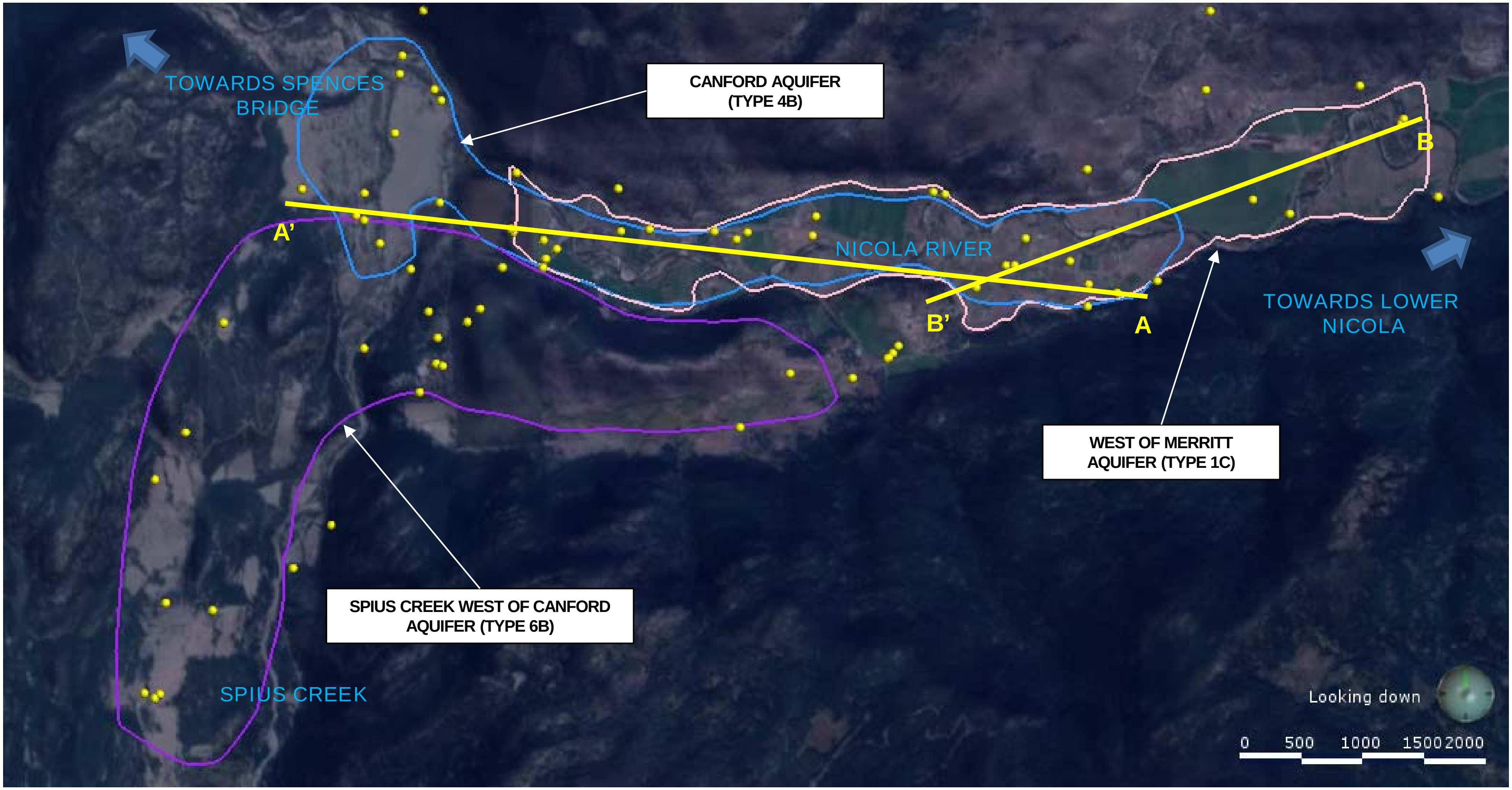
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
CUT AWAY SHOWING KINGSVALE AQUIFER LOOKING NORTH-NORTHEAST

PROJECT NO.	PHASE	REV.	FIGURE
1772201	**4000**	**1**	**19**



FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

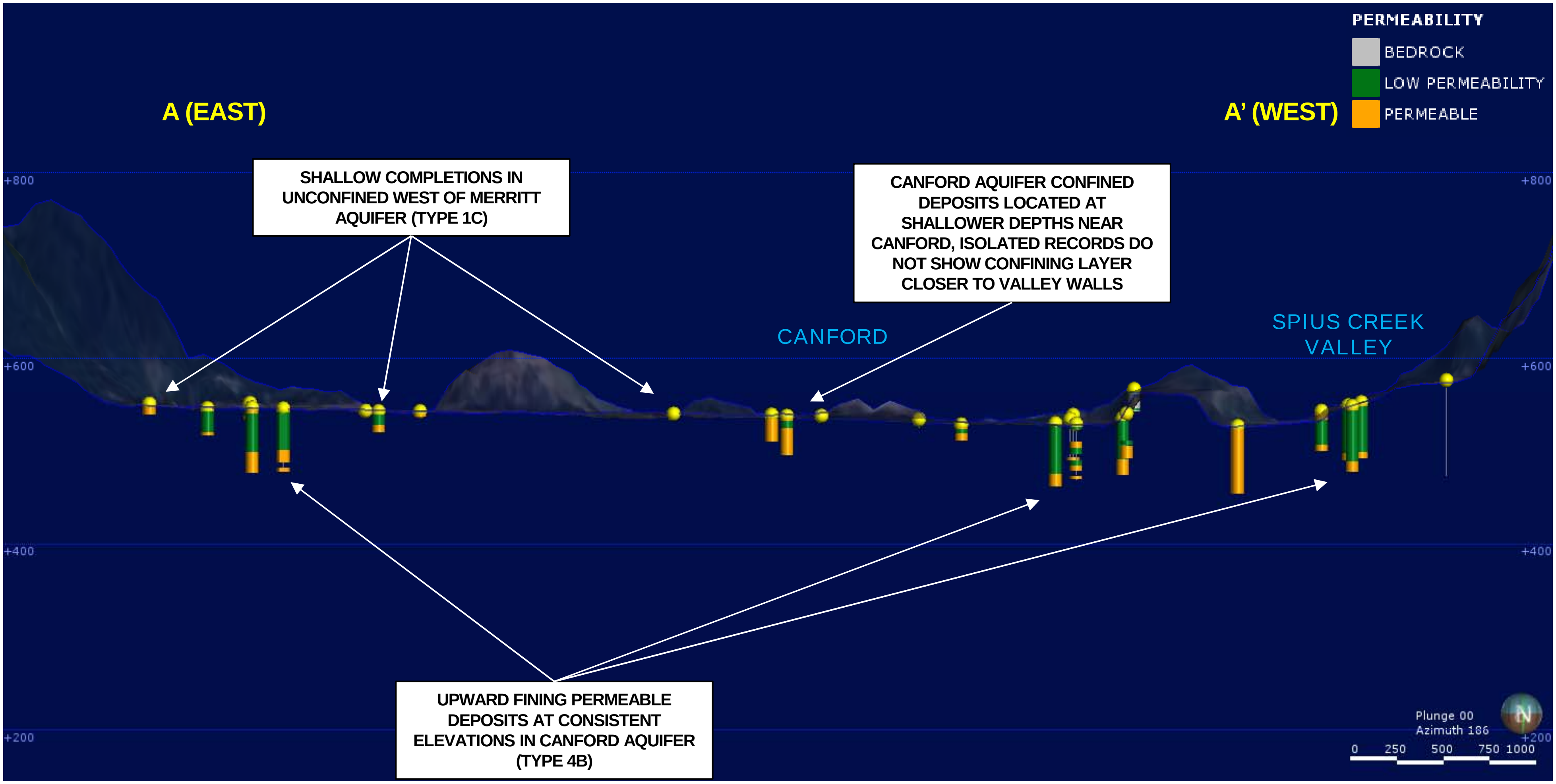
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
LOWER NICOLA VALLEY AQUIFERS – CANFORD AREA PLAN VIEW

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	20



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

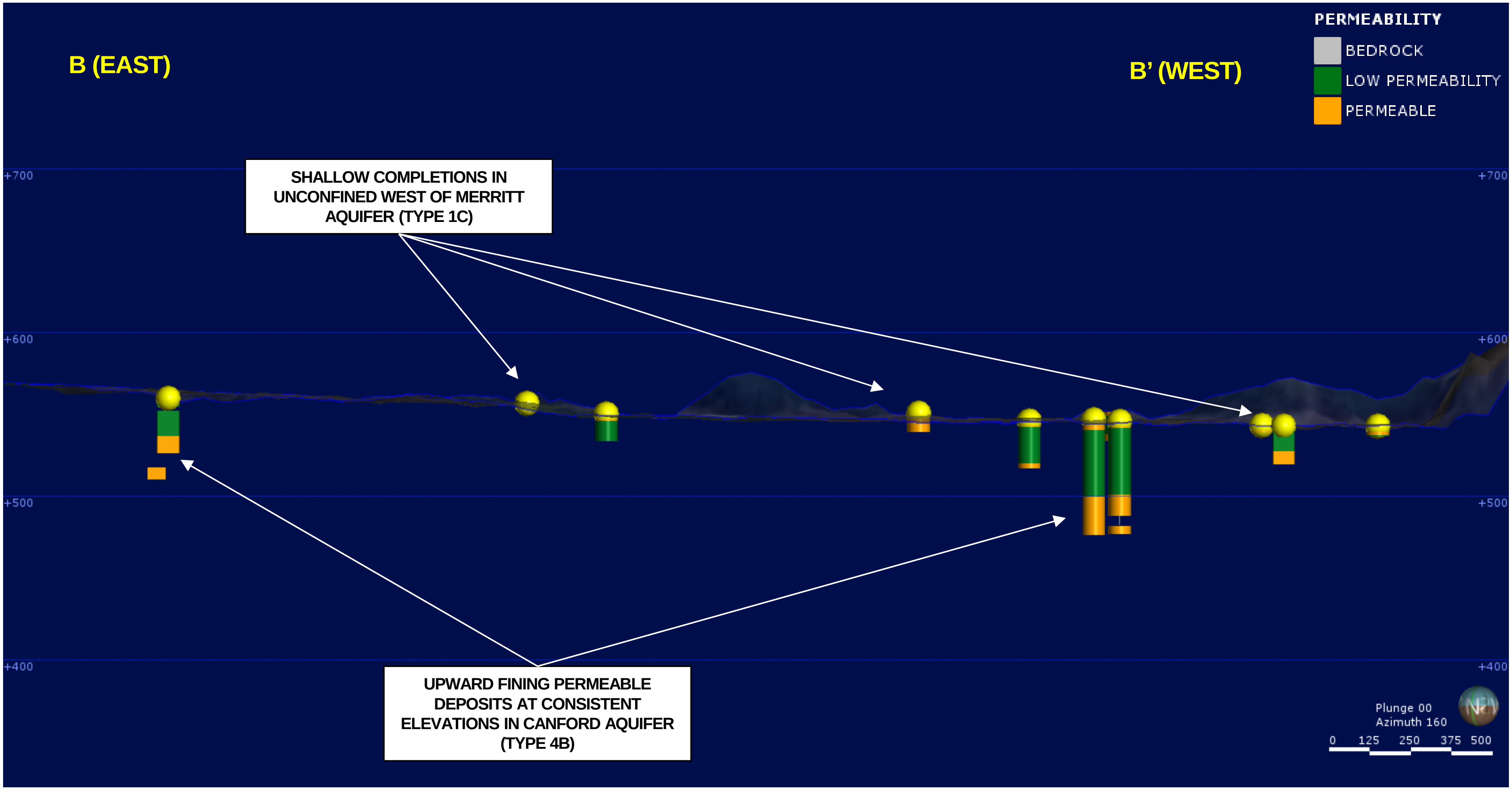
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
UNCONSOLIDATED LOWER NICOLA VALLEY AQUIFERS CROSS-SECTION A – A'
CANFORD AREA–LOOKING SOUTH (SLICE WIDTH = 500 m)

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	21



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

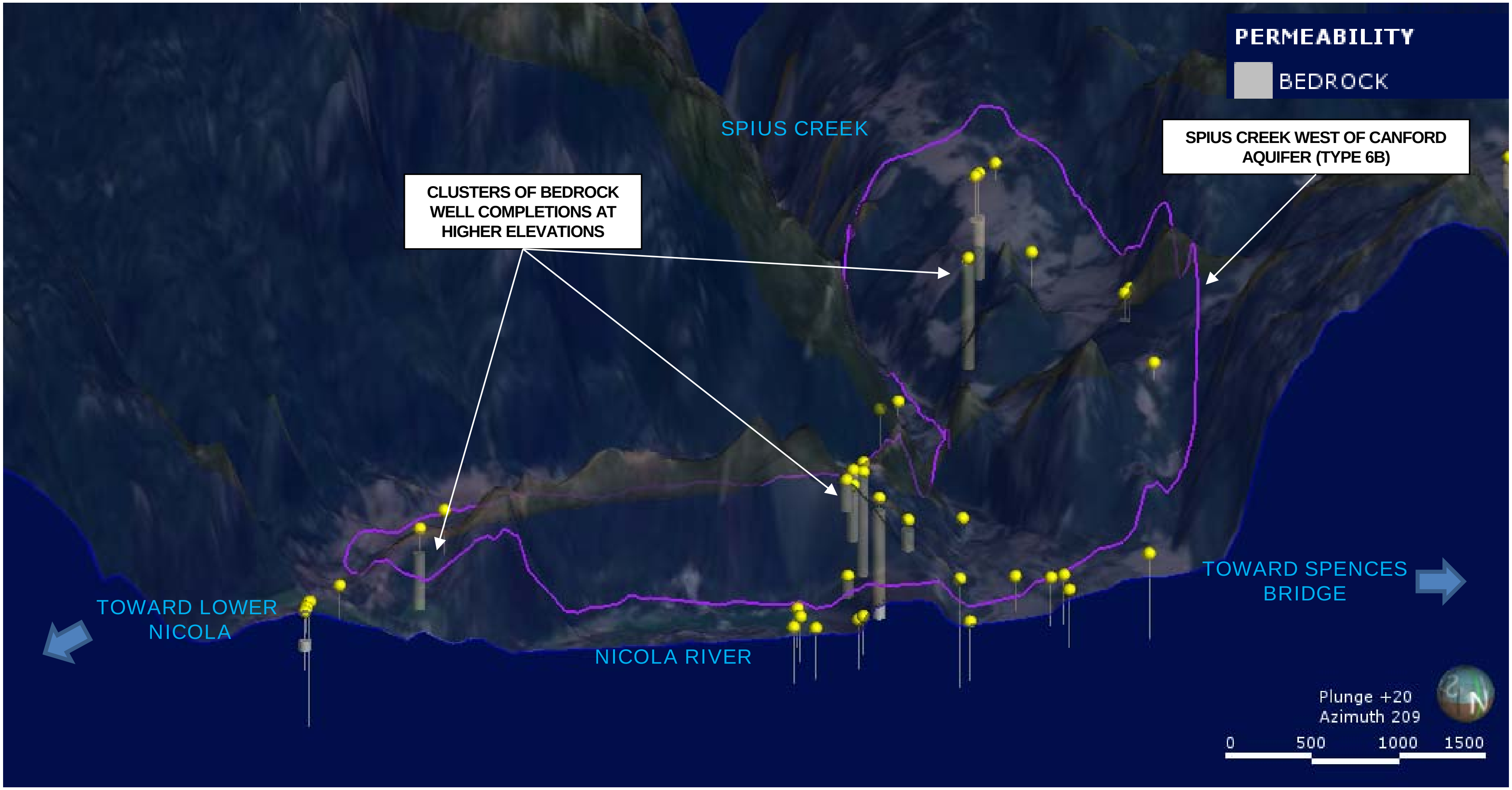
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
UNCONSOLIDATED LOWER NICOLA VALLEY AQUIFERS CROSS-SECTION B – B' CANFORD AREA–LOOKING SOUTH (SLICE WIDTH = 500 m)

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	22



VERTICAL EXAGGERATION: 3x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
SPIUS CREEK WEST OF CANFORD AQUIFER (TYPE 6B) CUT-AWAY VIEW LOOKING SOUTH-SOUTHWEST

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	23

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

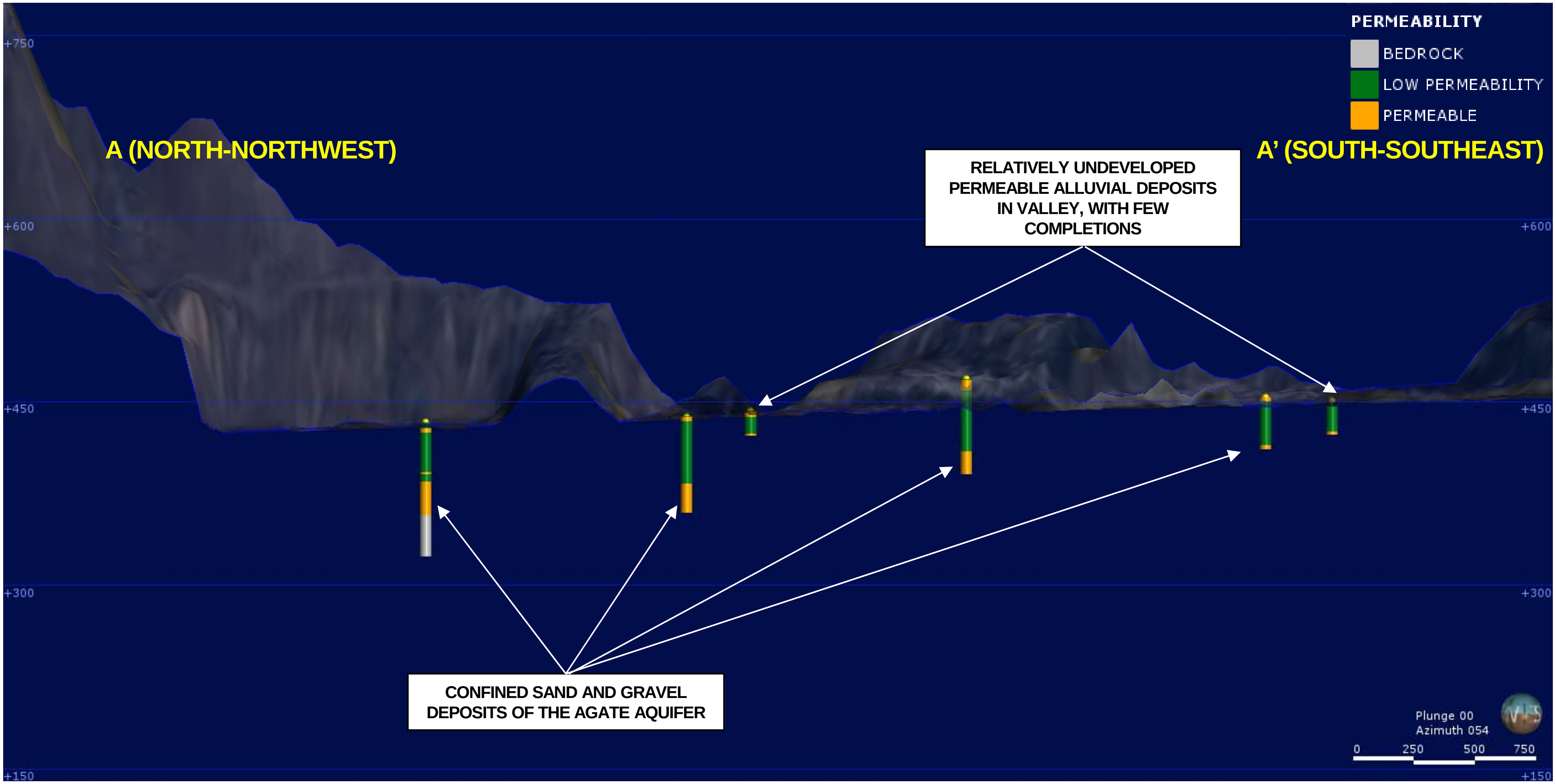
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
AGATE AQUIFER (TYPE 4B)
PLAN VIEW

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	24



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
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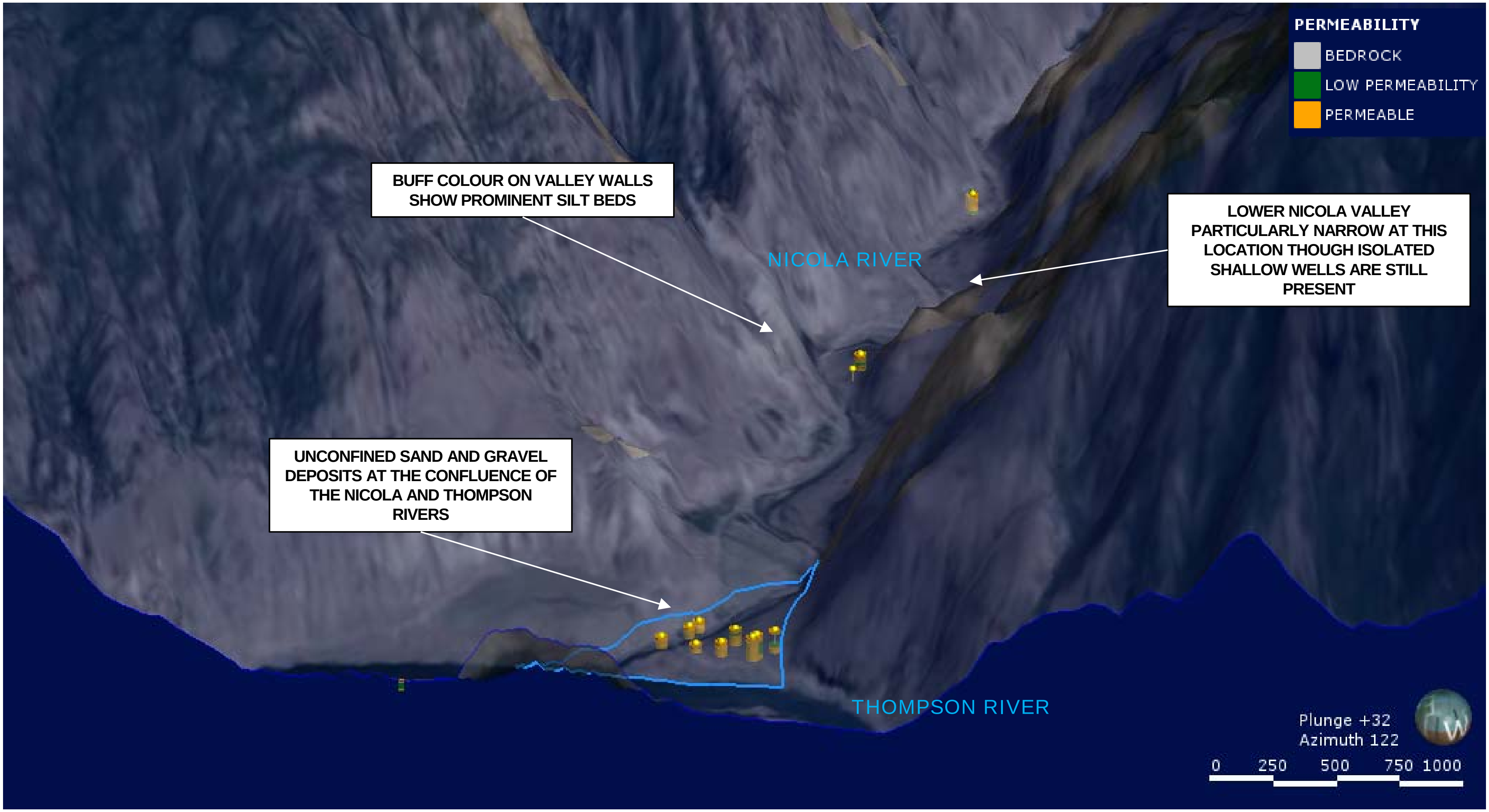
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
AGATE AQUIFER (TYPE 4B)
CROSS-SECTION A-A' (600 m WIDTH)

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	25



VERTICAL EXAGGERATION: 3x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA Ministry of Environment

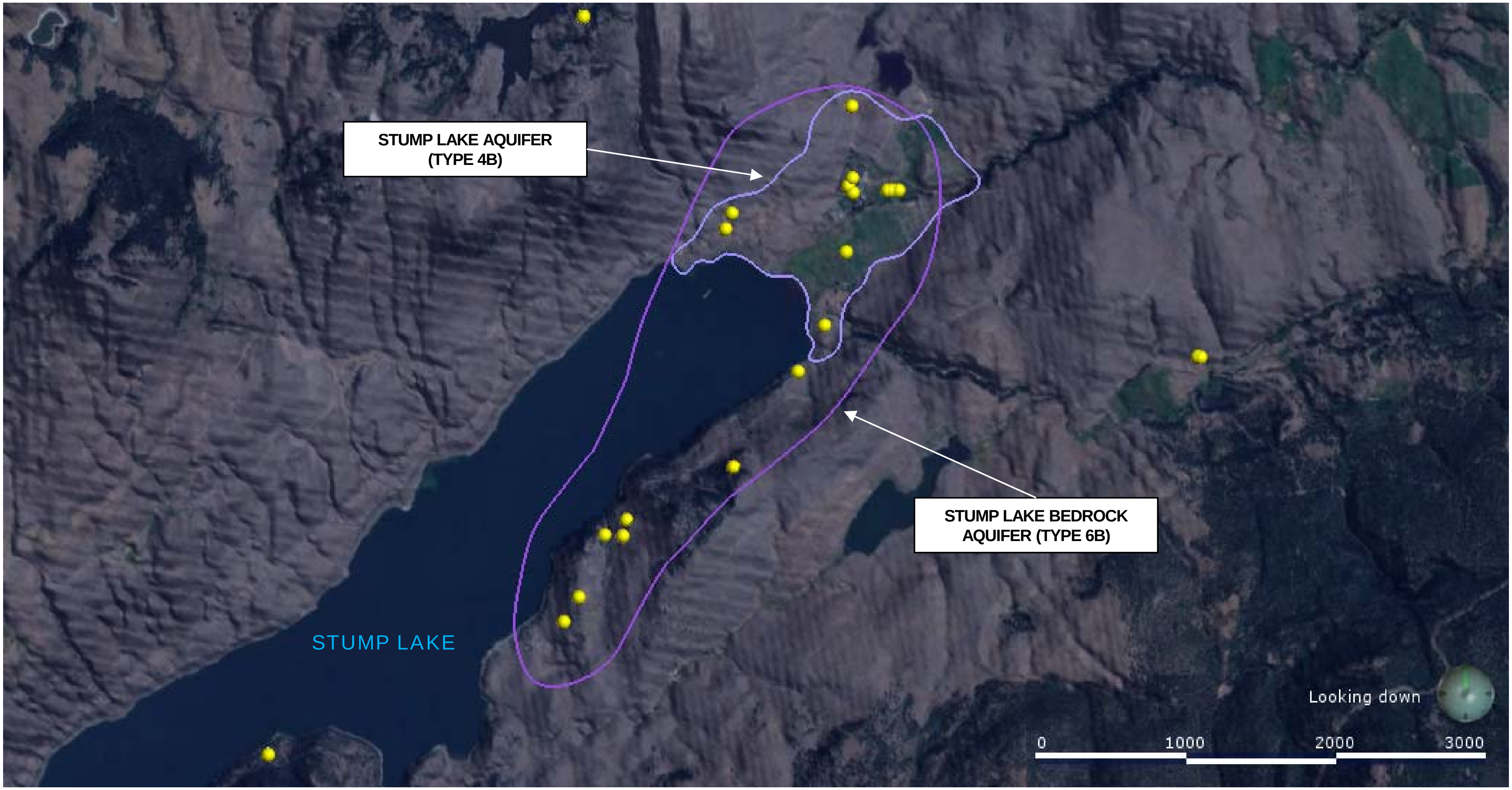
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
UPDATED SPENCES BRIDGE AQUIFER (TYPE 1B) LOOKING SOUTHEAST EAST FROM THE THOMPSON RIVER

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	26



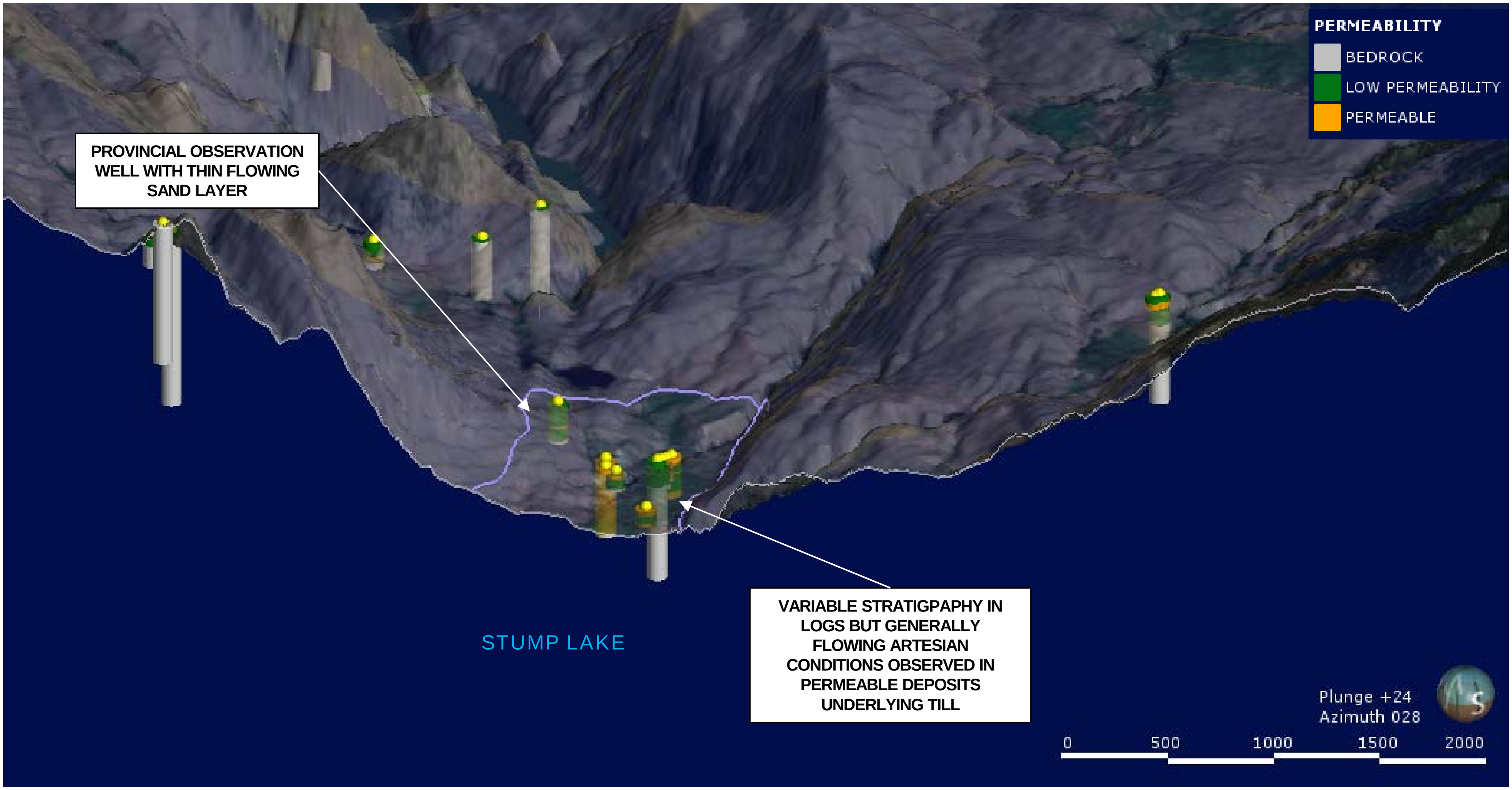
FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
STUMP LAKE AREA
PLAN VIEW – STUMP LAKE AND STUMP LAKE BEDROCK AQUIFERS

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	27



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

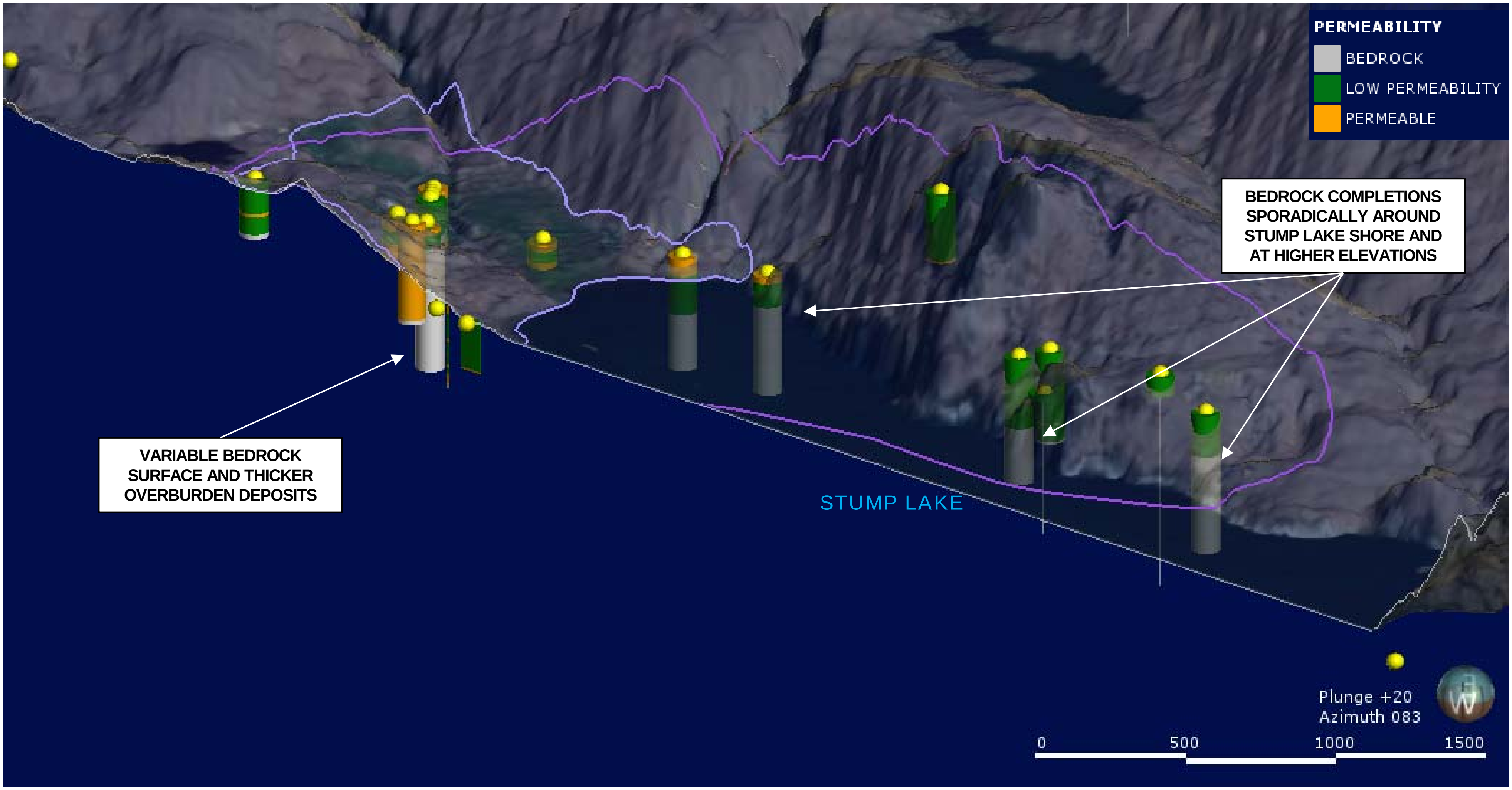
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
STUMP LAKE AREA
CUT AWAY SHOWING STUMP LAKE AQUIFER
LOOKING NORTH-NORTHEAST

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	28



VERTICAL EXAGGERATION: 5x

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
STUMP LAKE AREA
CUT AWAY SHOWING STUMP LAKE BEDROCK AQUIFER
LOOKING EAST

PROJECT NO.	PHASE	REV.	FIGURE
1772201	4000	1	29

APPENDIX A: Aquifer Classification Worksheets

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1163

DESCRIPTIVE LOCATION OF AQUIFER: Agate Aquifer

NTS MAP SHEET: 092I025

BCGS MAP SHEET: 92I.025.3.3.3, 092.025.3.3.4, 092.025.3.32, 092I.025.3.4.1, 092I.025.3.2.3, 092I.025.3.2.4, 092I.025.3.2.2, 092I.025.1.4.4, 092I.025.1.4.2, 092I.025.2.3.3, 092I.025.2.3.1

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: III C **RANKING: 9**

Aquifer Size: 4.9 km^2

Aquifer Boundaries: The Agate Aquifer is a shallow, confined, glaciofluvial sand and gravel aquifer within the Lower Nicola River Valley observed in wells drilled between near the communities of Dot and Agate. The aquifer is bounded by the tight valley walls of the Nicola Valley along its lateral boundaries and delineated on its upstream and downstream margins by the limits of development though the aquifer may extend beyond this. The aquifer is commonly intersected from 25-60 m below local ground surface underneath an overlying silt and fine-grained deposit and, despite limited wells across its extent, is assumed to be relatively continuous based on the likely glaciofluvial mode of deposition. Unconfined shallow modern alluvial deposits are infrequently exploited for groundwater within the aquifer boundaries but these materials are not considered part of the Agate Aquifer.

Aquifer Sub-type: 4b - Confined glaciofluvial sand and gravel aquifer

Observation Wells: None

Geologic Formation (overlying materials): 25 to 50 m of silt and other fine-grained glaciolacustrine material

Geologic Formation (aquifer): Glaciofluvial sand and gravel deposits located in the Lower Nicola River Valley, between 25 – 70 m below local ground surface. Where more detailed well records are available, an upward-fining sequence is often described.

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Low. The aquifer is confined by thick layer of low permeability material that is expected to be laterally extensive with no windows observed. The top of the aquifer is generally located at a moderately deep depth (30-60 m) below the ground surface.

Productivity: High (Geomean – 3.1 L/s). Wells in the confined Agate aquifer are comprised of sand and gravel and are generally high producing with some moderate producing wells.

Depth to Water: Shallow. Hydraulic head levels are artesian and predominantly 5-10 meters below ground surface - (Average – 9.9 m bgs). Flowing artesian conditions are known to exist at one well in the aquifer.

Direction of Groundwater Flow: Data is sparse but groundwater flow direction is assumed to be from nearby topographic highs and then ultimately upwards towards the topographic lows and surface water features in the valley, mediated by overlying deposits.

Recharge: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic), community water supply (Shacken Indian Band), irrigation.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

Golder Associates Ltd. 2005. Hydrogeology Assessment of the Lower Nicola Valley, Lower Nicola, British Columbia. Prepared for Associate Engineering (BC) Ltd.

Golder Associates Ltd., 2016. Lower Nicola Valley Groundwater Budget. Ministry of Environment, Groundwater Science Study.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	1
Size:	1
Demand:	1
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**9**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 12

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	12	8	11	12
Minimum	NA	20.1	4.3	1.0	11.3
Maximum	NA	84.9	33.5	12.6	71.6
Median	NA	48.5	5.5	2.5	33.8
Average	NA	51.7	9.9	4.0	30.7
Geometric Mean	NA	46.9	7.3	3.1	26.8

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0726

DESCRIPTIVE LOCATION OF AQUIFER: Canford Aquifer

NTS MAP SHEET: 092I015 & 092I016

BCGS MAP SHEET: 092I.015.4.2.1, 092I.015.2.4.3, 092I.015.2.4.4, 092I.016.1.3.3, 092I.016.1.3.1, 092I.016.1.3.4, 092I.016.1.3.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: **II B** **RANKING:** **12**

Aquifer Size: 5.4 km^2

Aquifer Boundaries: The Canford Aquifer is a shallow, confined, glaciofluvial sand and gravel aquifer located within the Lower Nicola River Valley in the Canford area. The aquifer is bounded laterally by local valley walls, on the downstream side just past the confluence of the Nicola River with Spius Creek, and on the upstream side at the limits of its observation in well records. The aquifer is considered to be relatively continuous in the valley and may extend further upstream and downstream than it current mapped boundaries. The top of the aquifer is most commonly intersected approximately 25 to 50 m below local ground surface with the notable exception of several wells near Canford where permeable deposits considered to be part of the Canford Aquifer are intersected at shallower depths approximately 15 m below local ground surface. As the Canford Aquifer is reasonably productive, wells are usually completed in the aquifer as soon as appreciable water is found. As such, the underlying deposits are unknown and the total thickness of the aquifer is unknown and open at depth.

Aquifer Sub-type: 4b - Confined glaciofluvial sand and gravel aquifer

Observation Wells: None

Geologic Formation (overlying materials): Generally, 15 to 50 m of silt and other fine-grained glaciolacustrine material

Geologic Formation (aquifer): Glaciofluvial sand and gravel deposits located in the Lower Nicola River Valley near Canford, most commonly between 15 – 50 m below local ground surface. Many well records in the aquifer exhibit a classic upward fining sequence, with coarser, more permeable materials at greater depths.

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Moderate. In general, the top of the Canford aquifer is moderately deep (30-60m) below 25-50 m of fine grained, low permeability material, however, in the middle of the aquifer near Canford the deposit becomes more shallow and confinement is not observed in all well records.

Productivity: Moderate to High (Geomean 2.7 L/s). Generally wells in Canford Aquifer are moderate producing (0.3 – 3.0 L/s), however the aquifer is comprised of sand and gravel and there are several high producing wells (> 3.0 L/s) primarily used for irrigation. One irrigation well located in the eastern portion of the aquifer is known to have flowing artesian conditions.

Depth to Water: Hydraulic head levels are artesian and close to surface (Average 14.4 m bgs) in the eastern portion of the Canford Aquifer. One flowing artesian well is known to exist in the eastern portion of the Canford Aquifer. On the western side of the aquifer near the Spius Creek, hydraulic head levels are notably lower, approximately 15-30 m below ground surface.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs and then ultimately upwards towards the topographic lows and surface water features in the valley, mediated by overlying deposits. Upward groundwater flow from the confined Canford Aquifer provides recharge for the overlying West of Merritt Aquifer and ultimately the Nicola River which is a gaining reach in the region.

Recharge: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic), irrigation.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Golder Associates Ltd., 2016. Lower Nicola Valley Groundwater Budget. Ministry of Environment, Groundwater Science Study.

Henderson Environmental Consulting Ltd., 1999. Hydrologic Assessment of the Spius Creek Watershed. Prepared for Aspen Planers Ltd. Merritt Division.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	2
Size:	2
Demand:	2
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**12**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 23

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	23	22	16	20
Minimum	NA	11.6	1.2	0.5	4.3
Maximum	NA	70.7	57.3	44.2	59.4
Median	NA	53.0	6.3	3.0	24.8
Average	NA	47.1	14.4	5.9	30.0
Geometric Mean	NA	42.4	8.7	2.7	22.9

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1164

DESCRIPTIVE LOCATION OF AQUIFER: Coldwater Valley Aquifer

NTS MAP SHEET: 092H096

BCGS MAP SHEET: 092H.096.3.2.1, 092H.096.1.4.3, 092H.096.1.4.4, 092H.096.1.4.2, 092H.096.3.2.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: III B **RANKING: 8**

Aquifer Size: 0.8 km^2

Aquifer Boundaries: The Coldwater Valley Aquifer is a confined glaciofluvial sand and gravel aquifer located in the Coldwater Valley just north of Kingsvale. It is delineated laterally based on the Coldwater Valley walls, and upgradient and downgradient based on the limits of observation in well records and the limits of flatter morphological expression of sediments in the valley. The top of the aquifer is commonly observed approximately 15 m below local ground surface in the valley, generally underlying 5 – 10 m of fine grained, glaciolacustrine or glacial till material. Observed aquifer thicknesses are 5 – 10 m thick. Continuity of the aquifer both upgradient in the valley and downgradient in the valley beyond the mapped limits is possible but not observed. One deeper well record in the area observed the potential for two additional underlying aquifers of high yield but these have not been mapped and any connectivity or continuity with the Coldwater Valley Aquifer are undetermined.

Aquifer Sub-type: 4b - Confined glaciofluvial sand and gravel aquifer

Observation Wells: None

Geologic Formation (overlying materials): The aquifer is overlain by up to 10 m of silts, clays and till with 0-5 m of modern alluvial deposits associated with the Coldwater River.

Geologic Formation (aquifer): Glaciofluvial sand and gravel deposits located in the Coldwater River Valley north of Kingvale, most commonly observed between 15 – 30 m below local ground surface.

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Moderate. Data is sparse in the area, but the aquifer is generally confined by up to 10 m of fine grained, low permeability material.

Productivity: Moderate (Geomean 1.9 L/s). Wells in the Coldwater aquifer are generally moderately yielding (0.3 to 3.0 L/s).

Depth to Water: Groundwater levels in wells are commonly near ground surface, with flowing artesian conditions commonly observed in several of the wells completed in this aquifer. (Average – 1.8 m bgs)

<u>Direction of Groundwater Flow</u>: Groundwater flow direction is assumed to be from nearby topographic highs and then ultimately upwards towards the topographic lows and surface water features in the valley, mediated by overlying deposits.

<u>Recharge</u>: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands. Whether the Coldwater River is losing or gaining in this area is unknown.

<u>Domestic Well Density</u>: Moderate – 4-20 wells/km^2.

<u>Type of Known Water Use:</u> Drinking water (domestic), irrigation.

<u>Reliance on Source</u>: Primary.

<u>Conflicts between Users</u>: No documented conflicts.

<u>Quantity Concerns</u>: No documented concerns.

<u>Quality Concerns</u>: No documented concerns.

<u>Comments</u>: None.

<u>Water Budget:</u> None.

<u>Groundwater Model(s):</u> None.

<u>References</u>:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	2
Vulnerability:	2
Size:	1
Demand:	1
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	0
Total:	**8**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 5

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	5	2	4	5
Minimum	NA	13.9	1.2	1.9	5.5
Maximum	NA	24.4	2.4	1.9	9.5
Median	NA	18.3	1.8	1.9	7.9
Average	NA	18.6	1.8	1.9	7.7
Geometric Mean	NA	18.3	1.7	1.9	7.6

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0080

DESCRIPTIVE LOCATION OF AQUIFER: Conicola Aquifer

NTS MAP SHEET: 092I017

BCGS MAP SHEET: 092I.017.1.4.4, 092I.017.2.3.3, 092I.017.4.1.1, 092I.017.4.1.2, 092.017.4.13, 092I.017.4.1.4, 092I.017.1.4.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: III C **RANKING: 9**

Aquifer Size: 6.3 km^2

Aquifer Boundaries: The Conicola Aquifer is a confined, glaciofluvial sand and gravel aquifer generally located in the Nicola Valley between Merritt and Nicola Lake located northeast of Merritt. The aquifer is assumed to comprise a complex network of permeable deposits within the valley with formation tops located approximately 35 – 70 meters below local ground surface. The extent and distribution of the aquifer is somewhat variable as a result both of limited available information and the complex glacial history of the area but is generally observed at consistent depths in most well records in the area. Closer to Nicola Lake, available information supports continuity of the deposits whereas further down gradient closer to Merritt the subsurface information is more sparse and the assumed presence of the aquifer in this area is more uncertain.

Aquifer Sub-type: 4b – Confined glaciofluvial sand and gravel aquifer.

Observation Wells: None

Geologic Formation (overlying materials): Variably, 30 – 70 m of fine grained glaciolacustrine material.

Geologic Formation (aquifer): Glaciofluvial sand and gravel deposits from the Fraser Glaciation.

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Low. The permeable sand and gravel deposits of the Conicola Aquifer is overlain by 30-70 m of fine-grained, low permeability glaciolacustrine material.

Productivity: Moderate (Geomean – 1.4 L/s). Wells completed in the Conicola Aquifer are generally moderate yielding, with one very high yielding well located near the outlet of Nicola Lake.

Depth to Water: Shallow (Average – 10.4 m bgs). In general, groundwater levels are shallow (0-15 m) with reported water levels generally occurring above the top of the confining layer. One moderately shallow groundwater level (15-30m) is reported. No flowing artesian conditions are reported in the aquifer.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs towards the topographic lows and surface water features in the valley, namely the Nicola River.

Recharge: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic), irrigation.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

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Hender Environmental Consulting Ltd. 1999. Hydrologic Assessments of the Merritt District Sub-basins. Prepared for Weyerhaeuser Canada Ltd.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

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Summit Environmental Consultant Ltd. 2007. Nicola River Watershed, Present and Future Water Demand Study. Presented for the Nicola Watershed Community Round Table.

Rathfelder, K.M. 2016. Modelling Tools for Estimating Effects of Groundwater Pumping on Surface Waters. Province of B.C., Ministry of Environment, Water Science Series WSS2016-09.

Nicola WUMP Multi-Stakeholder Committee. 2010. Nicola Water Use Management Plan (A water use management plan for the Nicola watershed). Prepared on the behalf of the Citizens of the Nicola watershed.

Kosakiski G.T. and Hamilton, R.E. 1982. Water Requirements for the Fisheries Resource of the Nicola River, B.C. Department of Fisheries and Oceans. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1680.

Water Management Consultants Inc. 2008. Surface and Groundwater Supply and Interaction Study – Phase 1 and Phase 2 WUMP-2006-S02. Prepared for the Nicola Watershed Community Round Table.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	2
Vulnerability:	1
Size:	2
Demand:	1
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**9**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 8

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	8	4	5	5
Minimum	NA	35.7	0.3	0.4	20.4
Maximum	NA	132.3	21.0	9.5	57.9
Median	NA	75.7	10.1	1.6	27.4
Average	NA	79.8	10.4	2.8	35.9
Geometric Mean	NA	74.2	3.8	1.4	33.0

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1172

DESCRIPTIVE LOCATION OF AQUIFER: Guichon Creek Aquifer

NTS MAP SHEET: 092I026

BCGS MAP SHEET: 092I.026.4.4.1, 092I.026.4.2.3, 092I.026.4.2.1, 092I.026.4.2.2, 092I.026.4.2.4, 092I.026.4.4.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 8**

Aquifer Size: 2.9 km^2

Aquifer Boundaries: The Guichon Creek Aquifer is a bedrock aquifer located in a sparsely populated area between Lower Nicola and Mamit Lake, north of the confluence of Steffens Creek and Guichon Creek. Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage, and encompasses small communities and properties along the main roads in the area.

Aquifer Sub-type: 6b – Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic volcanic) rock aquifer

Observation Wells: None

Geologic Formation (overlying materials): The Guichon Creek Aquifer is overlain primarily by gravelly till with some occurrences of clay, sand and gravel deposits. The area represents a complex surficial geology with raised terrace and kettle terrace deposits of sandy gravel bordering Guichon Creek and a glaciolacustrine veneer of silt and clayey gravel further upstream in the Steffen Creek Valley (Fulton, 1975). Undifferentiated moirainal deposits of granular and clay till occur in the upland area which likely represent the overburden in the northern portion of the aquifer.

Geologic Formation (aquifer): Primarily silty sandstone with indication of granite bedrock in one well log in the southern portion of the aquifer. The Guichon Creek Aquifer is located near the boundary between the Coastal Intrusions Group to the south and the Nicola Group deposits to the north. Nicola Group deposits vary spatially and temporarily from Pleistocene Valley Basalts to Upper Triassic volcanic and sedimentary deposits (Bulletin 69, 1979).

Confined / Partially Confined / Unconfined: Confined / Partially Confined. Groundwater levels for wells completed in the Guichon Creek Aquifer are variable, with some reported water levels above the bedrock – overburden interface and some groundwater levels within the bedrock. The rock is generally directly overlain by thicker layers of low permeability material that can act as a confining layer.

Vulnerability: Low. The bedrock of the Guichon Creek Aquifer is generally directly overlain by 10-30 meters of till and fine-grained, low permeability material.

Productivity: Low (Geomean 0.1 L/s). Wells completed in the Guichon Creek Aquifer are generally very low yielding, with well yields dependent on the degree of fracturing within the rock mass intersected by each individual well. Some dry boreholes or relatively productive wells are observed depending on the permeability of local rock intersected.

Depth to Water: Moderate to Moderately Deep (Average 31.6 m bgs). In general, groundwater levels are moderate (15-30 m) to moderately deep (30-60m) within the rock. However, isolated occurrences of moderately shallow groundwater levels above the bedrock – overburden interface are present. No flowing artesian conditions are reported in the aquifer but the potential for flowing artesian conditions exists due to the presence of steep topographic relief.

Direction of Groundwater Flow: The general direction of groundwater flow is interpreted to be from local topographic highs in the aquifer area to local valley features / topographic lows, namely the Guichon Creek Valley. Local scale groundwater flow direction within the bedrock is expected to be controlled by the presence and distribution of permeable features and structures within the rock.

Recharge: The major likely source of recharge to the aquifer is via precipitation to local topographic highs and subsequent infiltration into the bedrock.

Domestic Well Density: Moderate– 4-10 wells/km^2. The average well density for the Guichon Creek Aquifer area is moderate, with most wells concentrated along roadways in the area.

Type of Known Water Use: Drinking water (domestic).

Reliance on Source: Primary. Domestic wells completed in the Guichon Creek Aquifer are the sole primary domestic water source for associated users.

Conflicts between Users: No documented conflicts.

Quantity Concerns: Isolated concerns. No water quantity concerns are documented, however, the aquifer yield is very low, with several noted dry holes.

Quality Concerns: No known concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

AGRA Earth & Environmental, 1999. Groundwater Potential Study Guichon Creek, Lower Nicola, BC. Prepared for Fisheries and Oceans Canada habitat & Enhancement Branch.

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

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Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

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AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	1
Vulnerability:	1
Size:	1
Demand:	2
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	1
Total:	**8**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 10

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	10	10	7	8	9
Minimum	9.1	59.4	12.2	0.1	4.6
Maximum	81.4	150.9	71.9	0.3	61.6
Median	28.3	80.8	21.6	0.1	16.5
Average	33.8	88.5	31.6	0.1	22.5
Geometric Mean	27.1	84.9	25.5	0.1	17.1

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0075

DESCRIPTIVE LOCATION OF AQUIFER: Joeyaska Deep Aquifer

NTS MAP SHEET: 092I007 & 092I017

BCGS MAP SHEET: 092I.007.3.3.2, 092I.007.3.3.4, 092I.007.3.4.3

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 7**

Aquifer Size: 2.7 km^2

Aquifer Boundaries: The Joeyaska Deep Aquifer is a deep confined glaciofluvial sand and gravel to shallow bedrock aquifer located associated with a dense cluster of wells in a populated area southeast of Merritt. The documented stratigraphy from well records in the area are highly variable and complex at depth so the distribution and extent of the permeable deposits and rock may be applicable for further interpretation and sub-delineation. However, in general, wells considered to be completed in the Joeyaska Deep Aquifer tend to be greater than 50 m in depth (with the deepest being up to 200 m) and generally characterized as having groundwater levels noticeably below ground surface (over 20 m), in comparison to wells completed in the overlying Joeyaska Shallow Aquifer, which typically have groundwater levels close to ground surface. Many wells are completed in deep permeable deposits, basal unconsolidated material, or within the shallow bedrock and tend towards low yields. The presence of permeable materials higher up in the stratigraphic column of the deeper wells often does not influence completion depth, suggesting that these deposits may be dry. Deeper wells at lower elevations closer to the center of the Merritt basin, are correlated with the Middle Merritt Aquifer when the stratigraphy become more uniform and consistent with permeable deposits underlying the city.

Aquifer Sub-type: 4b / 5a – Confined glaciofluvial sand and gravel / shallow sedimentary bedrock aquifer

Observation Wells: None

Geologic Formation (overlying materials): The aquifer is overlain by a thick glaciolacustrine and glacial till sequence up to 80 m in thickness.

Geologic Formation (aquifer): Deep glaciofluvial sand and gravel deposits or shallow sedimentary bedrock associated with the Coldwater Beds.

Confined / Partially Confined / Unconfined: Confined.

Vulnerability: Low. Deposits are overlain by thick glaciolacustrine and till deposits.

Productivity: Moderate (Geomean – 0.4 L/s). Well yields are typically moderate, but exhibit variability.

Depth to Water: Moderately Deep to Deep (Average – 35.9 m bgs). Flowing artesian wells are observed in this aquifer.

Direction of Groundwater Flow: The general direction of groundwater flow is interpreted to be from local topographic highs near Iron Mountain to the Coldwater River valley and Merritt basin to the north / northwest.

Recharge: The major likely source of recharge to the aquifer is via influx from nearby highland and mountainous areas as well as precipitation / recharge via overlying deposits.

Domestic Well Density: Moderate (4 – 20 wells/km^2).

Type of Known Water Use: Drinking water (community / domestic).

Reliance on Source: Domestic wells completed in the aquifer are the sole primary domestic water source for associated users. Community wells are present in the aquifer which supply water for the Cook's Ferry Indian Band and the Lower Nicola Indian Band.

Conflicts between Users: No documented conflicts.

Quantity Concerns: Isolated concerns. No water quantity concerns are documented, however, the aquifer yield is very low, with several noted dry holes and wells that have been hydraulically fractured to improve productivity.

Quality Concerns: No known concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

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Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Preto, V.A. 1979. Bulletin 69: Geology of the Nicola Group Between Merritt and Princeton. Ministry of Energy, Mines and Petroleum Resources.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component: ***Ranking Value***

Productivity: 2

Vulnerability: 1

Size: 1

Demand: 1

Type of Use: 2

Quality Concerns: 0

Quantity Concerns: 0

Total: **7**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 33

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	10	33	21	22	21
Minimum	12.2	33.5	0.6	0.0	29.6
Maximum	134.1	196.6	88.7	4.7	192.0
Median	78.5	102.7	31.4	0.5	68.0
Average	80.2	102.6	35.9	0.9	72.3
Geometric Mean	68.5	96.6	24.6	0.4	65.3

Note: Provide a statistical summary of the wells in the aquifer. If it is not possible to provide values for a specific parameter due to lack of information (e.g. depth to bedrock), provide an explanation in the table note.

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1169

DESCRIPTIVE LOCATION OF AQUIFER: Joeyaska Shallow Aquifer

NTS MAP SHEET: 092I007 & 092I017

BCGS MAP SHEET: 092I.007.3.3.4, 092I.007.3.3.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II B **RANKING: 9**

Aquifer Size: 1.9 km^2

Aquifer Boundaries: The Joeyaska Shallow Aquifer is an irregularly-distributed shallow sand and gravel aquifer that is located to the south of Merritt, near the Coquihalla Highway. The sand and gravel deposits of the aquifer are variably confined throughout its distribution and, where confined, are capped by a thin veneer of glaciolacustrine or moirainal material. Lateral boundaries are defined partly on morphological expression and topography between the Iron Mountain highlands and the lowlands of the Merritt basin, but also partly by presence of development on its eastern and western margins. To the east, the aquifer has been mapped to include alluvial fan type deposits, where the presence of shallow coarse grained deposits are expected to be more regular. The distal boundary of the aquifer from the highlands is mapped at the morphological boundary of the Coldwater River floodplain. Though the aquifer is mapped as continuous, the distribution is irregular and presence of viable shallow deposits for groundwater use at any particular location is not assured.

Aquifer Sub-type: 4a /4b – Semi-confined glaciofluvial sand and gravel aquifer

Observation Wells: None

Geologic Formation (overlying materials): The aquifer is irregularly and variably confined by a thin veneer of fine-grained glaciolacustrine material, likely Late Kamloops Drift.

Geologic Formation (aquifer): Shallow, irregularly distributed sand and gravel deposits.

Confined / Partially Confined / Unconfined: Partially Confined – The Joeyaska Shallow Aquifer is partially confined by a spatially variable thin glaciolacustrine veneer. The permeable sand and gravel deposits are exposed at surface in some locations.

Vulnerability: Moderate. The confining layer is irregularly and discontinuously distributed with over the aquifer. Groundwater levels are located below confining layer and are generally shallow to moderately shallow (0-30 m).

Productivity: Moderate (Geomean 1.3 L/s). Well yields are typically moderate, but exhibit variability.

Depth to Water: Shallow to Moderately Shallow (Average - 6.8 m bgs)

<u>Direction of Groundwater Flow</u>: The general direction of groundwater flow is interpreted to be from local topographic highs near Iron Mountain to the Coldwater River valley and Merritt basin to the north.

<u>Recharge</u>: The major likely source of recharge to the aquifer is via precipitation.

<u>Domestic Well Density</u>: Moderate (4 – 20 wells/km^2)

<u>Type of Known Water Use:</u> Drinking water (domestic)

<u>Reliance on Source</u>: Domestic wells completed in the aquifer are the sole primary domestic water source for associated users.

<u>Conflicts between Users</u>: No documented conflicts.

<u>Quantity Concerns</u>: Isolated concerns. No water quantity concerns are documented, however, the irregular distribution of the aquifer suggests that overall groundwater availability may be limited.

<u>Quality Concerns</u>: No known concerns.

<u>Comments</u>: None.

<u>Water Budget:</u> None.

<u>Groundwater Model(s):</u> None.

<u>References</u>:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

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Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

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Preto, V.A. 1979. Bulletin 69: Geology of the Nicola Group between Merritt and Princeton. Ministry of Energy, Mines and Petroleum Resources.

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AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	2
Vulnerability:	1
Size:	1
Demand:	2
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	1
Total:	**9**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 26

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	25	10	4	14
Minimum	NA	1.5	0.6	0.5	4.3
Maximum	NA	36.6	20.7	2.2	26.8
Median	NA	11.9	6.4	1.6	13.6
Average	NA	13.1	6.8	1.5	14.4
Geometric Mean	NA	9.6	4.5	1.3	12.8

Note: Provide a statistical summary of the wells in the aquifer. If it is not possible to provide values for a specific parameter due to lack of information (e.g. depth to bedrock), provide an explanation in the table note.

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1165

DESCRIPTIVE LOCATION OF AQUIFER: Kingsvale Aquifer

NTS MAP SHEET: 092H096

BCGS MAP SHEET: 092H.096.1.4.2, 092H.096.1.2.4, 092H.096.2.1.3

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 8**

Aquifer Size: 7.4 km^2

Aquifer Boundaries: The Kingsvale Aquifer is a bedrock aquifer located in a sparsely populated area of the Coldwater River Valley system near the community of Kingsvale. Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small communities and properties along the main roads in the area.

Aquifer Sub-type: 6b – Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic volcanic) rock aquifer

Observation Wells: None

Geologic Formation (overlying materials): The Kingsvale Aquifer is overlain by undifferentiated morainal deposits of granular and clay till. The surficial expression of these glacial drift deposits generally reflects the smooth underlying bedrock and lacks the drumlinoid or rigid surficial expression seen elsewhere in the Nicola region. Well logs indicate a stony and clayey nature of the overburden till material that overlies the bedrock aquifer.

Geologic Formation (aquifer): Triassic aged fractured granitic intrusion of the Coastal Intrusions Group. Fulton (1975) noted the common occurrence of granitic intrusions within the Nicola Group volcanic throughout the region. Evidence of the metamorphism is suggested by the argillite strings noted in a well record to at the northern portion of the development.

Confined / Partially Confined / Unconfined: Confined / Partially Confined. Groundwater levels for wells completed in the Kingsvale Aquifer are variable, with some reported water levels above the bedrock – overburden interface and some groundwater levels within the bedrock. The rock is generally directly overlain by thicker layers of low permeability material that can act as a confining layer.

Vulnerability: Low. The bedrock of the Kingsvale Aquifer is generally directly overlain by 10-50 meters of till and fine-grained, low permeability material.

Productivity: Low – (Geomean – 0.2 L/s). Wells completed in the Kingsvale Aquifer are generally very low yielding, with well yields dependent on the degree of fracturing within the rock mass intersected by each individual well. Some dry boreholes or relatively productive wells are observed depending on the permeability of local rock intersected.

Depth to Water: Moderately Deep to Deep (Average 49.3 m bgs). In general, groundwater levels are moderately deep (30 – 60m) to deep (> 60m) within the rock. However, isolated occurrences of moderately shallow groundwater levels above the bedrock – overburden interface are present. No flowing artesian conditions are reported in the aquifer but the potential for flowing artesian conditions exists due to the presence of steep topographic relief.

Direction of Groundwater Flow: The general direction of groundwater flow is interpreted to be from local topographic highs in the aquifer area to local valley features / topographic lows, with outflows ultimately reporting to the Coldwater River. Local scale groundwater flow direction within the bedrock is expected to be controlled by the presence and distribution of permeable features and structures within the rock.

Recharge: The major likely source of recharge to the aquifer is via precipitation to local topographic highs and subsequent infiltration into the bedrock.

Domestic Well Density: Light – < 4 wells/km^2. The average well density for the Kingsvale Aquifer area is low, with most wells concentrated in Kingsvale and along roadways in the area.

Type of Known Water Use: Drinking water (domestic).

Reliance on Source: Domestic wells completed in the Kingsvale Aquifer are the sole primary domestic water source for associated users.

Conflicts between Users: No documented conflicts.

Quantity Concerns: Isolated concerns. No water quantity concerns are documented, however, the aquifer yield is very low, with several noted dry holes and wells that have been hydraulically fractured to improve productivity.

Quality Concerns: No known concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Cockfield, W.E. 1961. Geology and Mineral Deposits of Nicola Map-Area. British Columbia, Geological Survey of Canada, Department of Mines and Technical Surveys, Memoir 249.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Preto, V.A. 1979. Bulletin 69: Geology of the Nicola Group Between Merritt and Princeton. Ministry of Energy, Mines and Petroleum Resources.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	1
Vulnerability:	1
Size:	2
Demand:	1
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	1
Total:	**8**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 17

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	17	17	7	9	15
Minimum	3.4	56.08	6.1	0.1	5.5
Maximum	64.0	176.78	79.3	1.9	55.8
Median	25.3	121.92	61.0	0.1	29.1
Average	28.7	119.32	49.3	0.4	28.0
Geometric Mean	21.6	114.14	36.8	0.2	22.9

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1173

DESCRIPTIVE LOCATION OF AQUIFER: Kwinshatin Intertill Aquifer

NTS MAP SHEET: 092I006

BCGS MAP SHEET: 092I.006.2.4.3, 092I.006.2.4.1

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 8**

Aquifer Size: 1.8 km^2

Aquifer Boundaries: The Kwinshatin Intertill Aquifer is a sand and gravel, intertill aquifer in the Coldwater River Valley near its confluence with Kwinshatin Creek. The aquifer is comprised of layers of water bearing sand and gravels variably expressed within glacial till and undifferentiated moirainal deposits without an obvious continuity between boreholes or at defined elevations. The boundaries are mapped primarily on the basis of observed well records and morphological expression within the valley but permeable deposits are expected to be variable and may exist outside the mapped delineation.

Aquifer Sub-type: 4b – Confined glaciofluvial sand and gravel aquifer

Observation Wells: None

Geologic Formation (overlying materials): The sand and gravels of the aquifer are variably confined by 40 – 80 m of glacial till.

Geologic Formation (aquifer): Irregularly distributed intertill sand and gravel deposits.

Confined / Partially Confined / Unconfined: Confined.

Vulnerability: Low. The top of the aquifer is generally located 40- 80 m below the ground surface and is overlain by a thick layer of low permeability till.

Productivity: Moderate – High (Geomean – 3.4 L/s). The wells in the Kwinshatin Intertill Aquifer generally range moderate to very high yielding. Several wells with reported yields >30 L/s are present in the aquifer.

Depth to Water: Moderately Shallow (Average 19.5 m bgs).

Direction of Groundwater Flow: The general direction of groundwater flow is interpreted to be from local topographic highs to the Coldwater River valley.

Recharge: The major likely source of recharge to the aquifer is via bedrock valley walls and overlying / underlying tills.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (community / domestic).

Reliance on Source: Domestic wells completed in the aquifer are the sole primary domestic water source for associated users. Several of the Coldwater Indian Band wells are completed in this aquifer.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No known concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	2
Vulnerability:	1
Size:	1
Demand:	2
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	0
Total:	**8**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 6

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	6	5	5	6
Minimum	NA	56.4	3.1	0.3	35.1
Maximum	NA	119.8	61.6	37.9	101.2
Median	NA	82.3	12.8	2.5	53.6
Average	NA	83.7	19.5	14.6	60.9
Geometric Mean	NA	81.2	11.6	3.4	56.7

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1167

DESCRIPTIVE LOCATION OF AQUIFER: Lower Merritt Aquifer

NTS MAP SHEET: 092I017

BCGS MAP SHEET: 092I.017.1.1.1, 092I.017.1.1.3, 092.017.1.1.4, 092.017.1.1.2, 092.017.1.2.3

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 11**

Aquifer Size: 6.8 km^2

Aquifer Boundaries: The Lower Merritt Aquifer is a confined glaciofluvial sand and gravel aquifer which is the third and deepest known aquifer in the Merritt basin, first observed between 75 to 95 meters below local ground surface. The aquifer is poorly defined and understood only from the lithology of five deep wells in the Merritt area in addition to its inferred existence from three other deep wells at similar completion depths but with no lithological information. From these deep wells, intervals of up to 70 meters of coarse material (predominantly gravel) are observed, overlain by and separated from the Middle Merritt Aquifer by 10-25 meters of finer-grained silts and clays. The thickness of the deposit suggests a larger-scale, more regional deposition that would be laterally extensive in the Merritt basin but this is hypothetical and undetermined at this time. As a result, the lateral boundaries are mapped roughly to the margins of the Merritt Basin but these extents are subject to revision and reinterpretation as additional data becomes available. Flowing artesian wells are noted to occur in the Lower Merritt Aquifer.

Aquifer Sub-type: 4b - Confined glaciofluvial sand and gravel aquifers underneath till, in between till layers, or underlying glacio-lacustrine deposits.

Observation Wells: None

Geologic Formation (overlying materials): Directly overlain by 0 to 25 meters of fine-grained glaciolacustrine deposits.

Geologic Formation (aquifer): Glaciofluvial sand and gravel deposits either associated with the early stratified unit of the Kamloops Drift or with earlier Okanagan Center Drift

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Low. The Lower Merritt Aquifer is directly overlain and separated from the Middle Merritt Aquifer by 10-25 m of fine grained, low permeability material.

Productivity: High – (Geomean – 3.0 L/s) Wells completed in the confined Lower Merritt Aquifer are highly productive. The Kengard municipal well is rated to pump at 50 L/sec (City of Merritt, 2015). An irrigation well in the vicinity of the Kengard Municipal well has head pressures above local ground surface.

Depth to Water: Shallow (Average – 11.7 m bgs). Hydraulic heads are within close proximity to surface and an irrigation well in the vicinity of the Kengard production well has measured hydraulic head pressure above ground surface (flowing artesian). No other flowing artesian conditions are reported, however the potential exists in the aquifer and have been historically documented.

Direction of Groundwater Flow: Data is sparse but groundwater flow direction is assumed to be from nearby topographic highs and then ultimately upwards towards the topographic lows and surface water features in the basin, mediated by overlying deposits.

Recharge: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (municipal), irrigation. The Kengard production well for the City if Merritt is completed in the confined Lower Merritt Aquifer.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: Isolated. Manganese and total dissolved solids have been reported to exceed the aesthetic objectives at the Kengard production well (Western Water, 2012).

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Bennett K. and Caverly, A. 2009. Review of Ground Water/Surface Water Interaction within the City of Merritt. Province of B.C, Ministry of the Environment, Water Stewardship and Bio. Environmental Stewardship.

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

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Water Management Consultants Inc. 2008. *Surface and Groundwater Supply and Interaction Study – Phase 1 and Phase 2 WUMP-2006-S02*. Prepared for the Nicola Watershed Community Round Table.

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Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

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Kosakiski G.T. and Hamilton, R.E. 1982. Water Requirements for the Fisheries Resource of the Nicola River, B.C. Department of Fisheries and Oceans. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1680.

Nicola WUMP Multi-Stakeholder Committee. 2010. Nicola Water Use Management Plan. Prepared on Behalf of the Citizens of the Nicola Watershed.

Opus DaytonKnight. 2012. Merritt Water Utility Master Plan. Prepared for the City of Merritt.

Pacific Hydrology Consultants Ltd. 1978. Well Constructing and Testing – Coldwater Improvement District. Report prepared for the Colderwater Improvement District.

Pacific Hydrology Consultants Ltd. 1984. Construction and Testing Production Well No. 2. Prepared for Lower Nicola Waterworks District.

Rathfelder, K.M. 2016. *Modelling Tools for Estimating Effects of Groundwater Pumping on Surface Waters*. Province of B.C., Ministry of Environment, Water Science Series WSS2016-09.

Summit Environmental Consultant Ltd. 2007. Nicola River Watershed, Present and Future Water Demand Study. Presented for the Nicola Watershed Community Round Table.

Van der Gulik, T., Neilsen, D., Fretwell, R., Petersen, A. and Tam, S. 2013. Agriculture Water Demand Model - Report for the Nicola Watershed. Prepared for the B.C. Ministry of Agriculture and B.C. Agricultural Council.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Western Water Associates Ltd. 2012. Well Assessment and Asset Evaluation: City of Merritt, B.C. Prepared for the City of Merritt.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	1
Size:	2
Demand:	2
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**11**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 5

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	5	4	5	5
Minimum	NA	93.0	1.8	0.3	12.2
Maximum	NA	166.1	19.8	31.5	24.4
Median	NA	109.7	12.6	4.7	23.2
Average	NA	121.1	11.7	10.5	20.9
Geometric Mean	NA	118.5	7.9	3.0	20.3

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0077

DESCRIPTIVE LOCATION OF AQUIFER: Lower Nicola Aquifer

NTS MAP SHEET: 09I016

BCGS MAP SHEET: 092I.016.4.3.1, 092I.016.4.1.3, 092I.016.4.1.4, 092I.016.4.1.1, 092I.016.4.1.2, 092I.016.2.3.4

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II B **RANKING: 11**

Aquifer Size: 5.5 km^2

Aquifer Boundaries: The Lower Nicola Aquifer is a confined predominantly silty sand to sand aquifer located near the confluence of Guichon Creek and the Nicola River. It is the intermediate depth deposit of the three mapped confined aquifers in this area and is likely associated with mass wasting from the Guichon Creek valley into Glacial Lake Merritt. The silty sand to sand deposits associated with this aquifer are widely observed in wells in the valley and is mapped to extend laterally in close proximity to the valley walls and distally to the Nicola River, though the thickness and distribution of the deposit is expected to be variable. The Lower Nicola Aquifer appears to be a distinct and separate deposit but may have some degree of connection with the overlying Stumbles Creek Unconfined and Confined Aquifers.

Aquifer Sub-type: 4b - Confined glaciofluvial sand aquifer

Observation Wells: None

Geologic Formation (overlying materials): 10-20 meters of glaciolacustrine deposits

Geologic Formation (aquifer): Glaciofluvial / glaciolacustrine silty sand to sand deposits

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Moderate. The confined the Lower Nicola Outwash Aquifer is overlain by 10-20 m of fine grained, low permeability glaciolacustrine deposits. Depth to the top of the aquifer is generally moderately deep (30-60 m).

Productivity: Moderate to High (Geomean - 2.8 L/s) The wells in Lower Nicola Aquifer generally are moderately yield with some flowing artesian conditions noted near topographic lows of the Nicola River.

Depth to Water: Shallow. (Average – 11.9 m bgs). In general, the groundwater level in wells is shallow (0-15m) and located within the overlying glaciolacustrine deposits. Flowing artesian conditions appear to be topographically controlled, occurring in the southern portion of the aquifer in the vicinity of the topographic lows of the Nicola River.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs from the valley ultimately towards the Nicola River (Golder, 2016).

Recharge: Recharge is assumed to be from topographic highs via valley walls.

Domestic Well Density: Light – < 4 wells/km^2. The average well density for the area is low, with many of the wells in the area drawing water from the other three aquifers in the Lower Nicola.

Type of Known Water Use: Drinking water (community / domestic).

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: A water budget was developed for Lower Nicola between Merritt and Spius Creek by Golder (2016) as part of the Lower Nicola Valley Groundwater Budget.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

Golder Associates Ltd. 2005. Hydrogeology Assessment of the Lower Nicola Valley, Lower Nicola, British Columbia. Prepared for Associate Engineering (BC) Ltd.

Golder Associates Ltd. 2016. Lower Nicola Valley Groundwater Budget. Ministry of Environment, Groundwater Science Study.

Henderson Environmental Consulting Ltd., 1999. Hydrologic Assessment of the Spius Creek Watershed. Prepared for Aspen Planers Ltd. Merritt Division.

Hender Environmental Consulting Ltd. 1999. Hydrologic Assessments of the Merritt District Sub-basins. Prepared for Weyerhaeuser Canada Ltd.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

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Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	2
Size:	2
Demand:	1
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**11**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 5

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	5	2	4	3
Minimum	NA	36.0	11.9	0.3	14.3
Maximum	NA	62.8	11.9	18.9	29.0
Median	NA	54.9	11.9	3.9	16.8
Average	NA	53.5	11.9	6.8	20.0
Geometric Mean	NA	52.6	11.9	2.8	19.1

Note: Provide a statistical summary of the wells in the aquifer. If it is not possible to provide values for a specific parameter due to lack of information (e.g. depth to bedrock), provide an explanation in the table note.

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1171

DESCRIPTIVE LOCATION OF AQUIFER: Lower Nicola Outwash Aquifer

NTS MAP SHEET: 092I016

BCGS MAP SHEET: 092I.016.4.3.1, 092I.016.4.1.3, 092I.016.4.1.4, 092I.016.4.1.1, 092I.016.4.1.2, 092I.016.2.3.4

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 11**

Aquifer Size: 6.4 km^2

Aquifer Boundaries: The Lower Nicola Outwash Aquifer is a confined predominantly gravel aquifer located near the confluence of Guichon Creek and the Nicola River. It is the deepest of the mapped confined aquifers in this area and is likely associated with glacial outwash. Similar to overlying aquifers, the gravel deposits associated with this aquifer are widely observed in wells in the valley and is mapped to extend laterally in close proximity to the valley walls and distally to the Nicola River. Additional deeper gravel intercepts in flowing artesian wells closer to the Nicola River may be associated with this aquifer or may comprise a separate deeper gravel aquifer at depth.

Aquifer Sub-type: 4b - Confined glaciofluvial sand and gravel aquifers underneath till, in between till layers, or underlying glacio-lacustrine deposits.

Observation Wells: None

Geologic Formation (overlying materials): 15 – 25 metres of glaciolacustrine and glacial till deposits

Geologic Formation (aquifer): Well sorted, clean sand and gravel deposits (likely outwash)

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Low. The confined the Lower Nicola Outwash Aquifer is directly overlain by 15-25 m of fine grained, low permeability glaciolacustrine deposits separating it from the overlying Lower Nicola Aquifer. Depth to the top of the aquifer is generally deep, greater that 60 m below the ground surface.

Productivity: High. Estimated hydraulic conductivity values range from 2 x 10-5 m/s to 6 x 10-4 m/s (Golder, 2005) but the productivity is classified as high based on the gravel composition. The Lower Nicola Waterworks District (LNWDF) services the community of the Lower Nicola with water from three flowing artesian wells completed in the aquifer, though two of these wells are in a deeper gravel deposit that may comprise a separate aquifer. Well 3-99, completed is reported to have a shut in pressure of 38 psi at the time of construction (Golder, 2005).

<u>Depth to Water</u>: Shallow. Strong flowing artesian conditions are observed in some wells completed in this aquifer and the potential for flowing artesian conditions is high for wells drilled into this aquifer.

<u>Direction of Groundwater Flow</u>: Groundwater flow direction is assumed to be from nearby topographic highs upwards ultimately towards the Nicola River.

<u>Recharge</u>: Recharge is assumed to be from nearby highlands / mountain to the valley deposits.

<u>Domestic Well Density</u>: Light – < 4 wells/km^2.

<u>Type of Known Water Use:</u> Drinking water (municipal / community well / domestic). The Lower Nicola Waterworks District (LNWDF) services the community of the Lower Nicola with water from three flowing artesian wells. Two of these wells are completed in a deeper gravel deposit which may comprise a separate aquifer.

<u>Reliance on Source</u>: Primary.

<u>Conflicts between Users</u>: No documented conflicts.

<u>Quantity Concerns</u>: No documented concerns.

<u>Quality Concerns</u>: No documented concerns.

<u>Comments</u>: None.

<u>Water Budget:</u> None.

<u>Groundwater Model(s):</u> None.

<u>References</u>:

AGRA Earth & Environmental, 1999. Groundwater Potential Study Guichon Creek, Lower Nicola, BC. Prepared for Fisheries and Oceans Canada habitat & Enhancement Branch.

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AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	1
Size:	2
Demand:	2
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**11**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 3

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	3	0	1	3
Minimum	NA	78.6	NA	1.3	26.5
Maximum	NA	94.5	NA	1.3	27.4
Median	NA	82.3	NA	1.3	26.5
Average	NA	85.1	NA	1.3	26.8
Geometric Mean	NA	84.9	NA	1.3	26.8

Note: Provide a statistical summary of the wells in the aquifer. If it is not possible to provide values for a specific parameter due to lack of information (e.g. depth to bedrock), provide an explanation in the table note.

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1168

DESCRIPTIVE LOCATION OF AQUIFER: Middle Merritt Aquifer

NTS MAP SHEET: 092I017

BCGS MAP SHEET: 092I016.2.2.4, 092I.016.2.2.2, 092I.017.1.1.3, 092.017.1.1.1, 092.007.3.3.3, 092.007.3.3.4, 092I.017.1.1.2, 092I.017.1.1.4, 092.I.017.1.2.3, 092.017.1.2.1

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 10**

Aquifer Size: 13.0 km^2

Aquifer Boundaries: The Middle Merritt Aquifer is a confined glaciofluvial sand and gravel aquifer located beneath thick fine-grained glaciolacustrine deposits in the Merritt area. Limited wells are completed in the aquifer but the well records where the aquifer is observed are generally consistent in elevations across the basin, typically intersected between 45 – 65 m below local ground surface. As a result, boundaries are assumed to be laterally extensive in the Merritt area and generally constrained by the surrounding bedrock valley walls however, the local extent, distribution, and thickness of the aquifer in any given location is expected to be uncertain and needing further definition. Continuity of the aquifer to permeable deposits to the southeast of Merritt, near the Joeyaska Aquifers is assumed on the basis of the similarity of the deposit elevation and overlying stratigraphies.

Aquifer Sub-type: 4b - Confined glaciofluvial sand and gravel aquifer

Observation Wells: None

Geologic Formation (overlying materials): Thick (30 – 60m) fine-grained glaciolacustrine deposits.

Geologic Formation (aquifer): Early Fraser Glaciation glaciofluvial sand and gravel deposits.

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Low. The Middle Merritt Aquifer is overlain by 30-60 m of fine grained, low permeability material.

Productivity: High (Geomean 1.2 L/s)

Depth to Water: Moderately shallow (Average – 20.3 m bgs). Flowing artesian wells are observed in this aquifer and the potential for flowing artesian conditions in this aquifer exist.

Direction of Groundwater Flow: Data is sparse but groundwater flow direction is assumed to be from nearby topographic highs towards the topographic lows and surface water features in the valley.

Recharge: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic), irrigation.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Bennett K. and Caverly, A. 2009. Review of Ground Water/Surface Water Interaction within the City of Merritt. Province of B.C, Ministry of the Environment, Water Stewardship and Bio. Environmental Stewardship.

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Opus DaytonKnight. 2012. Merritt Water Utility Master Plan. Prepared for the City of Merritt.

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Van der Gulik, T., Neilsen, D., Fretwell, R., Petersen, A. and Tam, S. 2013. Agriculture Water Demand Model - Report for the Nicola Watershed. Prepared for the B.C. Ministry of Agriculture and B.C. Agricultural Council.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Western Water Associates Ltd. 2012. Well Assessment and Asset Evaluation: City of Merritt, B.C. Prepared for the City of Merritt.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	1
Size:	2
Demand:	2
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**10**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 24

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	24	15	18	11
Minimum	NA	44.2	3.4	0.1	26.8
Maximum	NA	92.4	37.2	63.1	61.0
Median	NA	58.7	18.3	0.7	51.8
Average	NA	60.1	20.3	6.3	50.3
Geometric Mean	NA	59.0	17.2	1.2	49.1

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1166

DESCRIPTIVE LOCATION OF AQUIFER: Paul's Basin Aquifer

NTS MAP SHEET: 092I005, 092I006, 092H095 & 092H096

BCGS MAP SHEET: 092I.005.2.2.4, 092I.005.2.2.2, 092I.006.1.1.3, 092I.006.1.1.1, 092H.095.4.4.4, 092H.096.3.3.3, 092H.096.3.3.1

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II B **RANKING: 10**

Aquifer Size: 11.0 km^2

Aquifer Boundaries: The Paul's Basin Aquifer is a bedrock aquifer located in a sparsely populated area in Midday Creek Valley. Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small residences and properties along the main roads in the area. The aquifer is delineated laterally within the basin just below the 920 m elevation, comprising the area where many of the wells are completed.

Aquifer Sub-type: 6b – Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic volcanic) rock aquifer

Observation Wells: None

Geologic Formation (overlying materials): The Paul's Basin Aquifer is overlain by undifferentiated morainal deposits of granular and clay material, including some permeable glaciofluvial / fluvial sediments associated with Midday Creek.

Geologic Formation (aquifer): Nicola Group volcanics.

Confined / Partially Confined / Unconfined: Confined.

Vulnerability: Moderate. The bedrock of the Paul's Basin Aquifer is generally directly overlain by 10-30 meters of fine-grained, low permeability material but is likely to not be confined throughout due to permeable sediments associated with Midday Creek. The top of the aquifer is generally shallow to moderately shallow (0-30 m).

Productivity: Moderate – (Geomean – 1.3 L/s)). Wells completed in the Paul's Basin Aquifer are generally moderate yielding, with well yields dependent on the degree of fracturing within the rock mass intersected by each individual well. Some dry boreholes or relatively productive wells are observed depending on the permeability of local rock intersected.

<u>Depth to Water</u>: Shallow (Average 19.9 m gbs). In general, groundwater levels are shallow (0-15m) with groundwater levels generally present above the bedrock – overburden interface. Flowing artesian conditions is reported in the aquifer at a Coldwater Indian Band well.

<u>Direction of Groundwater Flow</u>: The general direction of groundwater flow is interpreted to be from local topographic highs in the aquifer area to local valley features / topographic lows, namely the Midday Creek. Local scale groundwater flow direction within the bedrock is expected to be controlled by the presence and distribution of permeable features and structures within the rock.

<u>Recharge</u>: The major likely source of recharge to the aquifer is via precipitation to local topographic highs and subsequent infiltration into the bedrock.

<u>Domestic Well Density</u>: Light – < 4 wells/km^2. The average well density for the Paul's Basin Aquifer area is low, with most wells concentrated along roadways in the area.

<u>Type of Known Water Use:</u> Drinking water (community well / domestic).

<u>Reliance on Source</u>: Domestic wells completed in the Paul's Basin Aquifer are the sole primary domestic water source for associated users.

<u>Conflicts between Users</u>: No documented conflicts.

<u>Quantity Concerns</u>: No known concerns.

<u>Quality Concerns</u>: No known concerns.

<u>Comments</u>: None.

<u>Water Budget:</u> None.

<u>Groundwater Model(s):</u> None.

<u>References</u>:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

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Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

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AQUIFER CLASSIFICATION AND RANKING

Ranking Component: ***Ranking Value***

Productivity: 2

Vulnerability: 2

Size: 2

Demand: 2

Type of Use: 2

Quality Concerns: 0

Quantity Concerns: 0

Total: **10**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 9

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	9	9	9	9	9
Minimum	0.3	61.0	5.2	0.1	0
Maximum	86.3	109.7	81.7	37.9	32.6
Median	10.1	73.2	14.0	0.6	10.1
Average	19.2	77.9	19.9	8.9	10.8
Geometric Mean	7.1	76.7	13.6	1.3	6.0

AQUIFER CLASSIFICATION WORK SHEET

DATE: February 11, 2007.

AQUIFER MAPPER: William S. Hodge, P. Geo.

AQUIFER LOCATION: South of Mamit Lake / between Logan Lake and Merritt.

AQUIFER NUMBER: 827.

NTS MAP SHEET: 92I/7.

BCGS TRIM MAP: 092I.036.2.4.4., 4.2.4 and 092I,037.1.3 and 3.1.

CLASSIFICATION: III C **RANKING VALUE: 8**

Aquifer Size: 2.0 km^2.

Aquifer Boundaries: This unconsolidated confined aquifer was delineated based on well log lithology, topography and geographical feature (Mamit Lake). Because the aquifer extent is not certain, a dashed line has been used to outline the aquifer.

Geologic Formation (overlying): Well records indicate that this unconsolidated aquifer is confined by clay or till (gravel and clay intermixed).

Geologic Formation (aquifer): Likely Outwash Terrace / stratified drift of fine sand to coarse gravel and deposited by melting glacial ice.

Major Aquifer System Type: Unconsolidated 4b. Confined sand and gravel aquifers of glacial or pre-glacial origin (glaciofluvial).

Confined / Partially Confined / Unconfined: Confined by clay and till.

Vulnerability: Low. The vulnerability of this confined unconsolidated aquifer is considered low. Well records show the presence of water-bearing zones below confining layer of clay (and gravel or rocks). Confining thickness ranges between 3.6 and 15.2 m (12.0 and 50.0 ft). There are only two well records available. One well record shows 3.3 m (11.0 ft) of unconfined gravel and cobbles overlies the confining layer.

Productivity: Moderate. Based on the two well records available, the productivity of this confined unconsolidated aquifer is considered moderate. Well records indicate that the aquifer is fine to coarse sand and gravel existing below layer of confining clay (and gravel or rocks). Only one well yield has been reported (1.3 L/s or 20 USgpm). The well yield reported was estimated only, based on a short-term bail test.

Depth to Water Table: Shallow. Only one depth to groundwater was reported at 5.5 m or 18.0 ft. As groundwater levels vary seasonally, this measurement likely does not represent local water table conditions throughout the year.

Direction of Groundwater Flow: There is insufficient data to determine the direction of groundwater flow. Groundwater is anticipated to follow the topographic gradient from high elevation to low elevation.

Recharge: Wells are recharged from the direct infiltration of precipitation (rain and snow).

Domestic Well Density: Low.

Type of Well Use: Domestic Use.

Reliance on Source: Well water is the only known source of water for domestic use. Mamit Lake may also be utilized as a water supply.

Conflicts Between Users: None documented.

Quantity Concerns (type, source, level of concern): None documented.

Quality Concerns (type, source, level of concern): None documented.

Comments: For the purpose of standardization and to achieve all objectives of the aquifer mapping program, the document *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater* (Berardinucci and Ronneseth, 2002) was referenced in the preparation of this worksheet. There is likely more domestic groundwater development than indicated.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water, Air and Climate Change Branch, Water Protection Section.

AQUIFER CLASSIFICATION AND RANKING

AQUIFER LOCATION: South of Mamit Lake / between Logan Lake and Merritt.
.
AQUIFER NUMBER: 827.

CLASSIFICATION: III C **RANKING VALUE: 8**

Classification Component:

Level of Development: Low. Low level of demand in relation to moderate aquifer productivity.

Level of Vulnerability: Low level of vulnerability to surface contamination.

Ranking Component:	**Ranking Value**
Productivity:	2
Vulnerability:	1
Size:	1
Demand:	2*
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	0
Total =	8

*Demand is moderate and has been assessed subjectively. Demand is based on domestic well density, number and type of wells, and general knowledge of well use and land use in the area. Demand assumes that the reported well capacity is the amount of water used, which can be misleading. The reported well capacity can be higher than actual use.

Number of water wells = 2

Statistical Analyses of Well Data for Aquifer 827

	Well Depth		Depth to Water		Depth to Bedrock		Reported Est. Well Yield		Est. Thickness of Confining Materials	
	m	ft	m	ft	m	ft	L/s	USgpm	m	ft
Number of Wells	2	2	2	2	2	2	2	2	2	2
Maximum	17.1	56.0	unk	unk	unk	unk	1.3	20.0	15.2	50.0
Minimum	14.3	47.0	5.5	18	unk	unk	unk	unk	3.6	12.0
Average	-	-	-	-	-	-	-	-	-	-
Median	-	-	-	-	-	-	-	-	-	-
Geometric Mean	-	-	-	-	-	-	-	-	-	-

unk = unknown or not reported
- = insufficient data to determine

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0716

DESCRIPTIVE LOCATION OF AQUIFER: Spences Bridge Aquifer

NTS MAP SHEET: 092I044

BCGS MAP SHEET: 092I.044.1.2.4 and 092I.044.1.4.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II A **RANKING: 12**

Aquifer Size: 0.4 km^2

Aquifer Boundaries: The Spences Bridge Aquifer is a shallow, unconfined sand and gravel aquifer associated with permeable deposits of the Thompson River and Nicola River. The aquifer is of limited size and is constrained by a small depression associated with the confluence of the Nicola River.

Aquifer Sub-type: 1b – Fluvial or glaciofluvial sand and gravel aquifer found along a rivers of moderate stream order with the potential to be hydraulically influenced by the river.

Observation Wells: None

Geologic Formation (overlying materials): None.

Geologic Formation (aquifer): Sand and gravel

Confined / Partially Confined / Unconfined: Unconfined

Vulnerability: High. The aquifer is largely unconfined, with no significant zone of low permeability noted in the drill logs. Permeable deposits are present at the surface and are continuous below the water table. Depth to the water table is generally shallow (0-15 m).

Productivity: High (Geomean – 8.4 L/s). Wells in the Spences Bridge Aquifer are generally high yielding (>3.0 L/s), with one very high producing irrigation well located in the eastern portion of the aquifer.

Depth to Water: Shallow (Average – 7.1 m bgs). The depth to water is shallow (0-15m) with reported depths between 4-11 m in close proximity to the Nicola River.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs towards the Thompson River.

Recharge: Recharge may be influenced by water levels in the Thompson River and Nicola River and by precipitation.

Domestic Well Density: High.

Type of Known Water Use: Drinking water (community water supply / domestic). Three community water supply wells are completed in the Spences Bridge Aquifer, which supply water for the Cook's Ferry Indian Band and the Lytton First Nation.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

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Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	3
Size:	1
Demand:	2
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**12**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 9

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	9	6	7	NA
Minimum	NA	11.9	4.3	3.0	NA
Maximum	NA	36.6	11.9	44.2	NA
Median	NA	20.7	5.0	4.7	NA
Average	NA	23.6	7.1	14.7	NA
Geometric Mean	NA	22.0	6.4	8.4	NA

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0725

DESCRIPTIVE LOCATION OF AQUIFER: Spius Creek West of Canford

NTS MAP SHEET: 092I015 and 092I016

BCGS MAP SHEET: 092I.015.2.1.2, 092.015.2.1.4, 092.015.2.2.3, 092.015.2.3.2, 092.015.2.2.1, 092.015.2.4.1, 092.015.2.4.3, 092.015.2.4.4, 092.015.2.4.2, 092.016.1.3.3,

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: III B **RANKING: 9**

Aquifer Size: 9.8 km^2

Aquifer Boundaries: The Spius Creek West of Canford Aquifer is a bedrock aquifer located west of Canford, BC where the Spius Creek valley meets the Lower Nicola Valley. Due to limited lithological information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small communities and properties along the main roads in the area.

Aquifer Sub-type: 6b – Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic volcanic) rock aquifer

Observation Wells: None

Geologic Formation (overlying materials): Discontinuous layer of mixed clay and gravel, generally 0-15 m thick directly overlying bedrock.

Geologic Formation (aquifer): Volcanic bedrock of the Kingsvale group (Cockfield, 1961).

Confined / Partially Confined / Unconfined: Partially Confined. Groundwater levels for wells completed in the Spius Creek West of Canford Aquifer are generally located within the bedrock. The bedrock outcrops at surface in some location and is directly overlain by thicker layers of low permeability material that can act as a confining layer in other locations.

Vulnerability: Moderate. The bedrock of the Spius Creek West of Canford Aquifer is overlain by variable thickness of fine grained material ranging from 0-15 m in thickness. Exposed bedrock occurs in some locations.

Productivity: Low (Geomean – 0.6 L/s). Wells completed in the Spius Creek West of Canford Aquifer generally have moderate well yields (0.3 - 3.0 L/s) but is classified as low productivity because signficant intervals of rock are required to obtain those yields. Well yields are dependent on the degree of fracturing within the rock mass intersected by each individual well. One well has a reported yield of 6.3 L/s, which is significantly higher than other wells completed in the aquifer. Some dry boreholes or relatively productive wells are observed depending on the permeability of local rock intersected.

Depth to Water: Moderate to Moderately Deep (Average – 31.1 m bgs). In general, groundwater levels are moderate (15 – 30m) to moderately deep (30-60m) within the rock. No flowing artesian conditions are reported in the aquifer but the potential for flowing artesian conditions exists due to the presence of steep topographic relief.

Direction of Groundwater Flow: The general direction of groundwater flow is interpreted to be from local topographic highs in the aquifer area to local valley features / topographic lows, namely the Spius Creek valley and Lower Nicola valley, with outflows ultimately reporting to the Nicola River. Local scale groundwater flow direction within the bedrock is expected to be controlled by the presence and distribution of permeable features and structures within the rock.

Recharge: The major likely source of recharge to the aquifer is via precipitation to local topographic highs and subsequent infiltration into the bedrock.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic) and irrigation.

Reliance on Source: Domestic wells completed in the Spius Creek West of Canford Aquifer are the sole primary domestic water source for associated users.

Conflicts between Users: No documented conflicts.

Quantity Concerns: Isolated concerns. No water quantity concerns are documented, however, the aquifer yield is generally low with the exception of one high producing well

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: A water budget was developed for Lower Nicola between Merritt and Spius Creek by Golder (2016) as part of the Lower Nicola Valley Groundwater Budget.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

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Golder Associates Ltd., 2016. Lower Nicola Valley Groundwater Budget. Ministry of Environment, Groundwater Science Study.

Golder Associates Ltd. 2005. Hydrogeology Assessment of the Lower Nicola Valley, Lower Nicola, British Columbia. Prepared for Associate Engineering (BC) Ltd.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	1
Vulnerability:	2
Size:	1
Demand:	1
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	1
Total:	**9**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 12

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	10	12	8	8	10
Minimum	0.0	24.7	12.2	0.1	0.0
Maximum	52.4	146.3	54.9	6.3	42.7
Median	8.8	106.7	24.4	0.7	4.3
Average	17.5	93.5	31.1	1.3	13.8
Geometric Mean	9.6	80.8	27.3	0.6	6.4

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0076

DESCRIPTIVE LOCATION OF AQUIFER: Stumbles Creek Aquifer

NTS MAP SHEET: 092I016

BCGS MAP SHEET: 092I.016.4.3.1, 092I.016.4.1.3, 092I.016.4.1.2, 092I.016.4.1.1, 092I.016.4.1.4, 092I.016.4.1.2, 092I.016.2.3.3, 092I.016.2.3.4, 092I.016.2.4.3, 092I.016.2.3.2, 092I.016.2.4.1

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II A RANKING: 12

Aquifer Size: 12.9 km^2

Aquifer Boundaries: The Stumbles Creek Aquifer is a shallow, predominantly unconfined, alluvial fan-type sand and gravel aquifer located near the confluence of Guichon Creek and the Nicola River. The fan spreads distally from north to south and is incised to some degree by modern-day Stumbles Creek. The lateral and distal boundaries of the aquifer are the valley sides and the Nicola River, respectively, though the aquifer is less understood at its margins due to limited subsurface information in these areas.

Aquifer Sub-type: 3 – Post-glacial alluvial fan-type aquifer

Observation Wells: None.

Geologic Formation (overlying materials): None.

Geologic Formation (aquifer): Post-glacial alluvial sands and gravels, poorly sorted

Confined / Partially Confined / Unconfined: Unconfined

Vulnerability: High. The Stumbles Creek Aquifer is unconfined, with high permeability sand and gravel deposits extending from surface to below reported static water levels. Groundwater is generally shallow with several locations of reported groundwater levels less than 5 m below ground surface.

Productivity: Moderate (Geomean – 0.9 L/s). Estimated hydraulic conductivity of 0.001 m/s for the fan deposits (Golder, 2016).

Depth to Water: Shallow (Average – 4.6 m bgs). Groundwater is generally shallow (0-15m) with several locations of reported groundwater levels less than 5 m below ground surface near the northern extend of the aquifer.

Direction of Groundwater Flow: The general direction of groundwater flow is interpreted to be from local topographic highs in the aquifer area to topographic lows. Groundwater flow is inferred to be in the southwards direction towards the Nicola River (Golder, 2016). The Nicola River is a gaining reach in the Lower Nicola. The Stumbles Creek Aquifer is inferred to be the primary source of recharge to the Nicola River in the area.

Recharge: The primary source of recharge is precipitation and inflows from adjacent formations (Golder, 2016).

Domestic Well Density: Low – < 4 wells/km^2.

Type of Known Water Use: Drinking water (water supply, community wells, domestic), irrigation. The Shullus subdivision and the Rocky Pines subdivisions are supplied by two water systems operated by the Lower Nicola Indian Band on the Nicola-Mameet Indian Reserve (Golder, 2016).

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: A water budget was developed for Lower Nicola between Merritt and Spius Creek by Golder (2016) as part of the Lower Nicola Valley Groundwater Budget.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

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Golder Associates Ltd. 2016. Lower Nicola Valley Groundwater Budget. Ministry of Environment, Groundwater Science Study.

Henderson Environmental Consulting Ltd., 1999. Hydrologic Assessment of the Spius Creek Watershed. Prepared for Aspen Planers Ltd. Merritt Division.

Hender Environmental Consulting Ltd. 1999. Hydrologic Assessments of the Merritt District Sub-basins. Prepared for Weyerhaeuser Canada Ltd.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Pacific Hydrology Consultants Ltd. 1984. Construction and Testing Production Well No. 2. Prepared for Lower Nicola Waterworks District.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	2
Vulnerability:	3
Size:	2
Demand:	2
Type of Use:	3
Quality Concerns:	0
Quantity Concerns:	0
Total:	**12**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 24

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	24	13	10	NA
Minimum	NA	1.8	0.6	0.2	NA
Maximum	NA	54.9	9.1	1.9	NA
Median	NA	12.2	3.7	1.3	NA
Average	NA	14.5	4.6	1.1	NA
Geometric Mean	NA	10.3	3.8	0.9	NA

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1170

DESCRIPTIVE LOCATION OF AQUIFER: Stumbles Creek Confined Aquifer

NTS MAP SHEET: 092I016

BCGS MAP SHEET: 092I.016.4.1.3, 092I.016.4.1.4, 092I.016.4.1.1, 092I.016.4.1.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: III B **RANKING: 8**

Aquifer Size: 0.7 km^2

Aquifer Boundaries: The Stumbles Creek Confined Aquifer is a relatively limited deposit of confined glaciofluvial silty sand to sand located beneath the Stumbles Creek Aquifer near the confluence of Guichon Creek and the Nicola River. It is a shallow, thinly confined aquifer which appears to be distinct though may harbor some degree of connection with the more laterally extensive Lower Nicola Aquifer below.

Aquifer Sub-type: 4b - Confined glaciofluvial sand aquifer

Observation Wells: None

Geologic Formation (overlying materials): 5 – 10 meters of glaciolacustrine deposits

Geologic Formation (aquifer): Glaciofluvial / glaciolacustrine silty sand to sand deposits

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Moderate. The Stumble Creek Aquifer is overlain by laterally extensive layer of fine grained, low permeability material. The depth to the base of the confining galciolacustrine deposits is generally shallow (0-15 m).

Productivity: Moderate (Geomean – 0.9 L/s).

Depth to Water: Shallow (Average – 6.4 m bgs). In general, groundwater levels are shallow (0-15 m) and reported groundwater levels are located within the glaciolacustrine deposits between Stumbles Creek Confined Aquifer and the overlying Stumble Creek Aquifer. No flowing artesian conditions are reported in the aquifer.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs to the north towards the Stumbles / Guichon Creek and ultimately the Nicola River.

Recharge: Recharge is assumed to be from precipitation and from surrounding unconsolidated material.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic).

Reliance on Source: Primary. Domestic wells completed in the Stumbles Creek Confined Aquifer are the primary domestic water source for associated users.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: A water budget was developed for Lower Nicola between Merritt and Spius Creek by Golder (2016) as part of the Lower Nicola Valley Groundwater Budget.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

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Golder Associates Ltd. 2016. Lower Nicola Valley Groundwater Budget. Ministry of Environment, Groundwater Science Study.

Henderson Environmental Consulting Ltd., 1999. Hydrologic Assessment of the Spius Creek Watershed. Prepared for Aspen Planers Ltd. Merritt Division.

Hender Environmental Consulting Ltd. 1999. Hydrologic Assessments of the Merritt District Sub-basins. Prepared for Weyerhaeuser Canada Ltd.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

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AQUIFER CLASSIFICATION AND RANKING

Ranking Component: ***Ranking Value***

Productivity: 2

Vulnerability: 2

Size: 1

Demand: 1

Type of Use: 2

Quality Concerns: 0

Quantity Concerns: 0

Total: **8**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 11

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	11	8	9	8
Minimum	NA	15.7	4.3	0.4	3.0
Maximum	NA	30.5	7.6	4.4	25.0
Median	NA	29.6	6.4	0.5	12.6
Average	NA	26.5	6.4	1.3	13.2
Geometric Mean	NA	25.9	6.3	0.9	10.8

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1174

DESCRIPTIVE LOCATION OF AQUIFER: Stump Lake Aquifer

NTS MAP SHEET: 092I039

BCGS MAP SHEET: 092I.039.3.4.3, 092I.039.3.4.1, 092I.039.3.4.4, 092I.039.3.4.2

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II B **RANKING: 9**

Aquifer Size: 1.5 km^2

Aquifer Boundaries: The Stump Lake Aquifer is a confined sand and gravel aquifer located at the northeastern shore of Stump Lake. The area is characterized by a complex stratigraphy owing to a complicated glacial history and there is considerable disagreement in the associated well records due to both the complexity of the subsurface and the spatial accuracy of the well records. As such, the aquifer can be considered a loose aggregation of permeable deposits, generally confined by a 5 – 15 m layer of till or fine-grained deposits and subject to further definition when information becomes available. The shore of Stump Lake forms the southwestern boundary of the aquifer with bedrock forming the remainder of the boundaries. Flowing artesian conditions are commonly observed in wells completed in permeable deposits below the confining till layer.

Aquifer Sub-type: 4b – Confined glaciofluvial sand and gravel aquifer.

Observation Wells: Observation Well #035 – Stump Lake (Hwy 5a and Old Kamloops Road)

Geologic Formation (overlying materials): Variably, 5-45 m of till and fine-grained material

Geologic Formation (aquifer): Glaciofluvial sand and gravel deposits, delta terrace deposits,

Confined / Partially Confined / Unconfined: Confined

Vulnerability: Moderate. The depth to the top of aquifer is generally moderately shallow (15-30 m) and is generally confined by 5-30 m of fine grained, low permeability till material.

Productivity: Moderate (Geomean – 1.4 L/s). Reported well yields are generally moderate (0.3-3.0 L/s). One higher yielding water supply well is reported near the south eastern portion of the aquifer.

Depth to Water: Shallow (Average 1.8 m bgs). Reported water levels are shallow (0-15m). Flowing artesian conditions are commonly observed in this aquifer.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs towards Stump Lake.

Recharge: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic).

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

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<u>AQUIFER CLASSIFICATION AND RANKING</u>

Ranking Component:	***Ranking Value***
Productivity:	2
Vulnerability:	2
Size:	1
Demand:	2
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	0
Total:	**9**

<u>Statistical Summary of Well Data for Aquifer</u>

Total number of wells available for statistical analysis: 5

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	5	1	4	5
Minimum	NA	18.3	1.8	0.5	7.6
Maximum	NA	47.9	1.8	3.2	46.0
Median	NA	35.1	1.8	1.3	18.3
Average	NA	34.4	1.8	1.4	22.9
Geometric Mean	NA	32.7	1.8	1.4	18.4

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 1175

DESCRIPTIVE LOCATION OF AQUIFER: Stump Lake Bedrock Aquifer

NTS MAP SHEET: 092I039

BCGS MAP SHEET: 092I.039.3.4.3, 092I.039.3.4.4, 092I.039.3.4.1, 092I.039.3.4.2, 092I.039.3.1.4, 092I.039.3.2.3, 092I.039.3.1.2.

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II C **RANKING: 8**

Aquifer Size: 5.1 km^2

Aquifer Boundaries: The Stump Lake Bedrock Aquifer is a bedrock aquifer located in a sparsely populated area north east of Stump Lake. Due to limited information and sparse local population, the aquifer is delineated based on the area of development and usage and encompasses small communities and properties along the main roads in the area and with close proximity to the lake.

Aquifer Sub-type: 6b – Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic volcanic) rock aquifer

Observation Wells: None

Geologic Formation (overlying materials): Undifferentiated morainal deposits (Fulton 1975). Basal till deposits of mixed clay to gravel sized particles. Increased sand and gravel content towards the north of the lake inferred to be associated with fluvial deposits (Fulton, 1975).

Geologic Formation (aquifer): The area surrounding Stump Lake is dominated by Upper Triassic Nicola Group volcanics which vary spatially and temporarily from Pleistocene Valley Basalts to Upper Triassic volcanic and sedimentary deposits (Preto, 1979). Wells logs indicate a primarily volcanic nature of the bedrock along the north western portion of Stump Lake and occurrences of sedimentary and intrusive bedrock along the eastern edge of Stump Lake.

Confined / Partially Confined / Unconfined: Confined. Groundwater levels for wells completed in the Stump Lake Aquifer are generally above the bedrock – overburden interface. The rock is generally directly overlain by thicker layers of low permeability material that can act as a confining layer.

Vulnerability: Low. The bedrock of the Stump Lake Aquifer is generally directly overlain by 20-35 meters of till and fine-grained, low permeability material.

Productivity: Low. (Geomean - 0.7 L/s). Wells completed in the Stump Lake Aquifer are generally very low yielding, with well yields dependent on the degree of fracturing within the rock mass intersected by each individual well. Some dry boreholes or relatively productive wells are observed depending on the permeability of local rock intersected.

Depth to Water: Shallow to Moderately Shallow. (Average – 18.9 m bgs) In general, groundwater levels are shallow (0-15 m) to moderately shallow (15-30m) above the overburden-bedrock interface. No flowing artesian conditions are reported in the aquifer but the potential for flowing artesian conditions exists due to the presence of steep topographic relief.

Direction of Groundwater Flow: The general direction of groundwater flow is interpreted to be from local topographic highs in the aquifer area to local valley features / topographic lows, namely Stump Lake. Local scale groundwater flow direction within the bedrock is expected to be controlled by the presence and distribution of permeable features and structures within the rock.

Recharge: The major likely source of recharge to the aquifer is via precipitation to local topographic highs and subsequent infiltration into the bedrock.

Domestic Well Density: Light – < 4 wells/km^2. The average well density for the Stump Lake Aquifer area is low, with most wells concentrated along Stump Lake and along roadways in the area.

Type of Known Water Use: Drinking water (domestic), irrigation.

Reliance on Source: Domestic wells completed in the Stump Lake Aquifer are the sole primary domestic water source for associated users.

Conflicts between Users: No documented conflicts.

Quantity Concerns: Isolated concerns. No water quantity concerns are documented, however, the aquifer yield is very low, with several noted dry holes.

Quality Concerns: No known concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

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Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

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<u>AQUIFER CLASSIFICATION AND RANKING</u>

Ranking Component:	***Ranking Value***
Productivity:	1
Vulnerability:	1
Size:	2
Demand:	1
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	1
Total:	**8**

<u>Statistical Summary of Well Data for Aquifer</u>

Total number of wells available for statistical analysis: 14

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	12	14	7	11	7
Minimum	16.2	18.3	1.2	0.1	10.7
Maximum	67.1	150.6	45.1	9.5	50.3
Median	32.9	74.7	15.5	0.3	27.4
Average	36.9	73.1	18.9	1.6	28.7
Geometric Mean	33.1	62.0	12.9	0.7	26.3

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0079

DESCRIPTIVE LOCATION OF AQUIFER: Unicola Aquifer

NTS MAP SHEET: 092I017

BCGS MAP SHEET: 092I.017.1.4.4, 092I.017.2.3.3, 092I.017.4.1.1, 092I.017.4.1.2, 092.017.4.13, 092I.017.4.1.4

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: III A **RANKING: 10**

Aquifer Size: 8.1 km^2

Aquifer Boundaries: The Unicola Aquifer is a shallow, unconfined sand and gravel aquifer associated with a alluvial fan deposit from the highlands to the north of the Nicola River outflow from Nicola Lake. Greater aquifer thickness is observed near the apex of the fan and distally the aquifer likely interconnects and forms a complex with permeable modern alluvial deposits associated with the Nicola River. The lateral boundaries of the aquifer are delineated to generally coincide with the morphological expression of the fan and the Nicola River floodplain.

Aquifer Sub-type: 3 / 1c – Alluvial fan – modern alluvium aquifer

Observation Wells: None

Geologic Formation (overlying materials): None.

Geologic Formation (aquifer): Primarily sand and gravel alluvial fan type deposit interconnected distally with modern alluvium.

Confined / Partially Confined / Unconfined: Unconfined

Vulnerability: High. Unconfined high permeable sand and gravels extend from surface to below reported static water levels. Reported depth to the water table is generally shallow (0-15 m).

Productivity: Moderate (Geomean – 0.9 L/s). Yield data is sparse, however, wells completed in the Unicola Aquifer are generally moderate yielding.

Depth to Water: Shallow to Moderately Shallow. (Average – 13.1 m bgs). In general, groundwater levels are shallow (0-15 m) to moderately shallow (15-30 m). Many of the wells in the area are screened in the underlying confined Conicola Aquifer. No flowing artesian conditions are reported in the aquifer.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs towards the topographic lows and surface water features in the valley, namely the Nicola River.

Recharge: Recharge is assumed to be predominantly via mountain block recharge from the surrounding highlands.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic), irrigation.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: None.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Hender Environmental Consulting Ltd. 1999. Hydrologic Assessments of the Merritt District Sub-basins. Prepared for Weyerhaeuser Canada Ltd.

Van der Gulik, T., Neilsen, D., Fretwell, R., Petersen, A. and Tam, S. 2013. Agriculture Water Demand Model - Report for the Nicola Watershed. Prepared for the B.C. Ministry of Agriculture and B.C. Agricultural Council.

Summit Environmental Consultant Ltd. 2007. Nicola River Watershed, Present and Future Water Demand Study. Presented for the Nicola Watershed Community Round Table.

Rathfelder, K.M. 2016. *Modelling Tools for Estimating Effects of Groundwater Pumping on Surface Waters*. Province of B.C., Ministry of Environment, Water Science Series WSS2016-09.

Nicola WUMP Multi-Stakeholder Committee. 2010. Nicola Water Use Management Plan (A water use management plan for the Nicola watershed). Prepared on the behalf of the Citizens of the Nicola watershed.

Kosakiski G.T. and Hamilton, R.E. 1982. Water Requirements for the Fisheries Resource of the Nicola River, B.C. Department of Fisheries and Oceans. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1680.

CDN Water Management Consultants Inc. 2008. *Surface and Groundwater Supply and Interaction Study – Phase 1 and Phase 2 WUMP-2006-S02*. Prepared for the Nicola Watershed Community Round Table.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	2
Vulnerability:	3
Size:	2
Demand:	1
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	0
Total:	**10**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 7

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	7	4	3	NA
Minimum	NA	1.2	3.0	0.3	NA
Maximum	NA	36.3	27.4	2.2	NA
Median	NA	14.5	11.0	1.1	NA
Average	NA	17.7	13.1	1.2	NA
Geometric Mean	NA	11.6	9.5	0.9	NA

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0074

DESCRIPTIVE LOCATION OF AQUIFER: Upper Merritt Aquifer

NTS MAP SHEET: 092I017

BCGS MAP SHEET: 092I016.2.2.4, 092I.016.2.2.2, 092I.017.1.1.3, 092.017.1.1.1, 092.007.3.3.3, 092.007.3.3.4, 092I.017.1.1.2, 092I.017.1.1.4

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: IA **RANKING: 15**

Aquifer Size: 7.0 km^2

Aquifer Boundaries: The Upper Merritt Aquifer is an unconfined aquifer comprised of modern alluvial sand and gravel deposits associated with the Nicola and Coldwater Rivers near their confluence in the Merritt area. The aquifer boundary is predominantly based on morphology, whereby the aquifer boundary is coincident with the floodplain limits of the Nicola and Coldwater Rivers and the associated topographic change, as the shallow sand and gravel deposits are generally not observed in the limited wells outside of this boundary. Changes in topography and morphology also mark the assumed limits of the Lower Merritt Aquifer in the valleys to the northwest and south. In the valley to the east, at the outflow of the Nicola River from Merritt, the aquifer boundary is assumed to be where the floodplain deposits become more constrained by the valley walls. Subsurface data in this location is sparse but there is an assumed degree of interconnectivity with permeable deposits as the valley widens to the east.

Aquifer Sub-type: 1c - Predominantly unconfined fluvial or glacio-fluvial sand and gravel aquifers found along lower order (< 3-4) streams in confined valleys with relatively undeveloped floodplains, where aquifer thickness and lateral extent are more limited.

Observation Wells: Observation Well #296 – Merritt (Garcia Road at Library)

Geologic Formation (overlying materials): None.

Geologic Formation (aquifer): Modern alluvial sand and gravel deposits.

Confined / Partially Confined / Unconfined: Unconfined

Vulnerability: High. Largely unconfined, high permeability sand and gravel deposits and depth to static water level is generally shallow (0-15m). Based on this, the vulnerability of the aquifer is considered high.

Productivity: High (Geomean – 5.4 L/s). Wells completed in the Upper Merritt Aquifer generally have high yields. Estimated hydraulic conductivity is on the order of 0.001 m/sec to 0.002 m/sec (Bennett K. and Caverly, 2009). Four municipal supply wells with rated capacities between 60 to 125 L/s are completed in the unconfined aquifer (Merritt, 2015). Pumping tests completed in 2012 at the Collettville and Vought Park #2 wells indicated specific capacities of 27.1 L/s/m and 9.22 L/s/m, respectively (Western Water, 2012).

Depth to Water: Shallow (Average – 4.0 m bgs). Depth to water ranges from 2.1 to 5.6 m below ground surface. Water levels were reported to be approximately 4.5 m below ground surface at OBS Well # 296 in 2016.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs towards the topographic lows and surface water features in the valley, namely the Nicola River and Coldwater River. The Coldwater River is a losing reach as it flows through Merritt (Bennett and Caverly, 2009). The Nicola River is inferred to be gaining reach between Nicola Lake and the confluence with the Coldwater River (Golder, 2015). Natural river losses from the Nicola River to underlying aquifers is inferred to be zero in Merritt (Golder 2015).

Recharge: The major source of recharge to the aquifer is infiltration from river loss from the Coldwater River as it flows through Merritt (Bennett and Caverly, 2009). Other sources of recharge likely include infiltration of precipitation and inflows from upstream aquifers in the alluvial sediments.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (municipal water supply/domestic), irrigation.

Reliance on Source: Primary. The Vought Park #1 and #2, Fairley Park and Colletville municipal wells are completed in the Upper Merritt Aquifer.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: Isolated. The municipal water supply wells are rated as Groundwater Under Direct Influence from Surface Water (GWUDI). Isolated occurrences of detectable total coliforms were reported between 2006-2012 (Western Water, 2012). In general, quality of water is high with no documented water quality concerns in recent years.

Comments: None.

Water Budget: None. Groundwater budgets are currently planned (as of 2018).

Groundwater Model(s): None. Numerical or analytical groundwater modelling is currently planned for 2018.

References:

Bennett K. and Caverly, A. 2009. Review of Ground Water/Surface Water Interaction within the City of Merritt. Province of B.C, Ministry of the Environment, Water Stewardship and Bio. Environmental Stewardship.

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

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Kalyn, D. 1988. Construction and Testing of Observation Well No. 296 Merritt, British Columbia. B.C. MoE Water Management Branch. Contract No. 84.

Kosakiski G.T. and Hamilton, R.E. 1982. Water Requirements for the Fisheries Resource of the Nicola River, B.C. Department of Fisheries and Oceans. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1680.

Nicola WUMP Multi-Stakeholder Committee. 2010. Nicola Water Use Management Plan (A water use management plan for the Nicola watershed). Prepared on the behalf of the Citizens of the Nicola watershed.

Opus DaytonKnight. 2012. Merritt Water Utility Master Plan. Prepared for the City of Merritt.

Pacific Hydrology Consultants Ltd. 1984. Construction and Testing Production Well No. 2. Prepared for Lower Nicola Waterworks District.

Rathfelder, K.M. 2016. *Modelling Tools for Estimating Effects of Groundwater Pumping on Surface Waters*. Province of B.C., Ministry of Environment, Water Science Series WSS2016-09.

Summit Environmental Consultant Ltd. 2007. Nicola River Watershed, Present and Future Water Demand Study. Presented for the Nicola Watershed Community Round Table.

Van der Gulik, T., Neilsen, D., Fretwell, R., Petersen, A. and Tam, S. 2013. Agriculture Water Demand Model - Report for the Nicola Watershed. Prepared for the B.C. Ministry of Agriculture and B.C. Agricultural Council.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Western Water Associates Ltd. 2012. Well Assessment and Asset Evaluation: City of Merritt, B.C. Prepared for the City of Merritt.

AQUIFER CLASSIFICATION AND RANKING

Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	3
Size:	2
Demand:	3
Type of Use:	3
Quality Concerns:	1
Quantity Concerns:	0
Total:	**15**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 10

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	10	7	4	NA
Minimum	NA	11.6	2.1	2.2	NA
Maximum	NA	30.5	5.8	25.2	NA
Median	NA	18.3	4.0	4.0	NA
Average	NA	20.1	4.0	8.9	NA
Geometric Mean	NA	19.2	3.8	5.4	NA

AQUIFER CLASSIFICATION WORKSHEET

DATE: March 2018

AQUIFER REFERENCE NUMBER: 0724

DESCRIPTIVE LOCATION OF AQUIFER: West of Merritt Aquifer

NTS MAP SHEET: 092I015 & 092I016

BCGS MAP SHEET: 092I.015.2.4.4, 092I.015.2.4.2, 092I.016.1.3.3, 092I.016.1.3.1, 092I.016.1.3.4, 092I.016.1.3.2, 092I.016.1.4.3, 092I.016.1.4.1, 092I.016.1.4.4

AUTHOR: Golder Associates Ltd. - Nick Gorski, MSc / Kevin Bennett, PEng

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CLASSIFICATION: II A **RANKING: 12**

Aquifer Size: 5.6 km^2

Aquifer Boundaries: The West of Merritt Aquifer is a shallow, unconfined sand and gravel aquifer composed of modern alluvium associated with the Nicola River. It is bounded laterally by the valley walls of the Lower Nicola River Valley and upstream by its presence in the shallow well records. Downstream, the aquifer is delineated at the edge of a morphological landform that constrains the Nicola River and the associated alluvium prior to its confluence with Spius Creek. While shallow alluvial deposits are noted on the downstream side of this landform in the floodplains surrounding the confluence, there are few well completions in these materials as well as indications of drier deposits and lower water levels in this area so this region was excluded. Connectivity and continuity to other shallow modern alluvial deposits closer to Lower Nicola are possible but unable to be proven due to limited data. The thickness of the coarse-grained deposits are variable, but relatively thin (3-10 m).

Aquifer Sub-type: 1c - Predominantly unconfined fluvial or glacio-fluvial sand and gravel aquifers found along lower order (< 3-4) streams in confined valleys with relatively undeveloped floodplains, where aquifer thickness and lateral extent are more limited.

Observation Wells: None.

Geologic Formation (overlying materials): None.

Geologic Formation (aquifer): Post-glacial alluvial sands and gravels, poorly sorted and variably distributed.

Confined / Partially Confined / Unconfined: Unconfined

Vulnerability: High. The aquifer is largely unconfined, with no significant zone of low permeability noted in the drill logs. Permeable deposits are present at the surface and are continuous below the water table. Depth to the water table is generally shallow (0-15 m).

Productivity: Moderate/ High (Geomean 0.8 L/s). Reported yields for wells in the West Merritt Aquifer are generally moderate with occasional high producing wells.

Depth to Water: Shallow (Average 7.1 m bgs). The depth to water shallow (0-15 m) in the West of Merritt Aquifer.

Direction of Groundwater Flow: Groundwater flow direction is assumed to be from nearby topographic highs from the valley ultimately towards the Nicola River (Golder, 2016).

Recharge: Upward groundwater flow from the confined Canford Aquifer and lateral recharge from the fan deposits of the unconfined Stumble Creek Aquifer.

Domestic Well Density: Light – < 4 wells/km^2.

Type of Known Water Use: Drinking water (domestic) and irrigation.

Reliance on Source: Primary.

Conflicts between Users: No documented conflicts.

Quantity Concerns: No documented concerns.

Quality Concerns: No documented concerns.

Comments: None.

Water Budget: A water budget was developed for Lower Nicola between Merritt and Spius Creek by Golder (2016) as part of the Lower Nicola Valley Groundwater Budget.

Groundwater Model(s): None.

References:

Berardinucci J. and K. Ronneseth, 2002. *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater*. BC Ministry of Water, Land and Air Protection, Water Air and Climate Change Branch, Water Protection Section.

Hy-Geo Consulting, Hodge Hydrogeology Consulting, and Azar & Associates. 2009. Provincial Observation Well Network Review British Columbia. Prepared for the BC Ministry of Environment Water Stewardship Division.

Wei, M., D. M. Allen, A. P. Kohut, S. Grasby, K. Ronneseth, and B. Turner. 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. Streamline Watershed Management Bulletin, FORREX Forum for Research and Extension in Natural Resources.

Bobrowsky P., Cathro, M. and Paulen, R. 2001. Quaternary Geology Reconnaissance Studies 92I/2 and 7. British Columbia Geological Survey, Geological Fieldwork 2001. Paper 2002-1.

Fulton, R.J. 1975. Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia. Geological Survey of Canada, Memoir 380.

Henderson Environmental Consulting Ltd., 1999. Hydrologic Assessment of the Spius Creek Watershed. Prepared for Aspen Planers Ltd. Merritt Division.

Hender Environmental Consulting Ltd. 1999. Hydrologic Assessments of the Merritt District Sub-basins. Prepared for Weyerhaeuser Canada Ltd.

Golder Associates Ltd., 2016. Lower Nicola Valley Groundwater Budget. Ministry of Environment, Groundwater Science Study.

Golder Associates Ltd. 2005. Hydrogeology Assessment of the Lower Nicola Valley, Lower Nicola, British Columbia. Prepared for Associate Engineering (BC) Ltd.

Pacific Hydrology Consultants Ltd. 1984. Construction and Testing Production Well No. 2. Prepared for Lower Nicola Waterworks District.

AQUIFER CLASSIFICATION AND RANKING

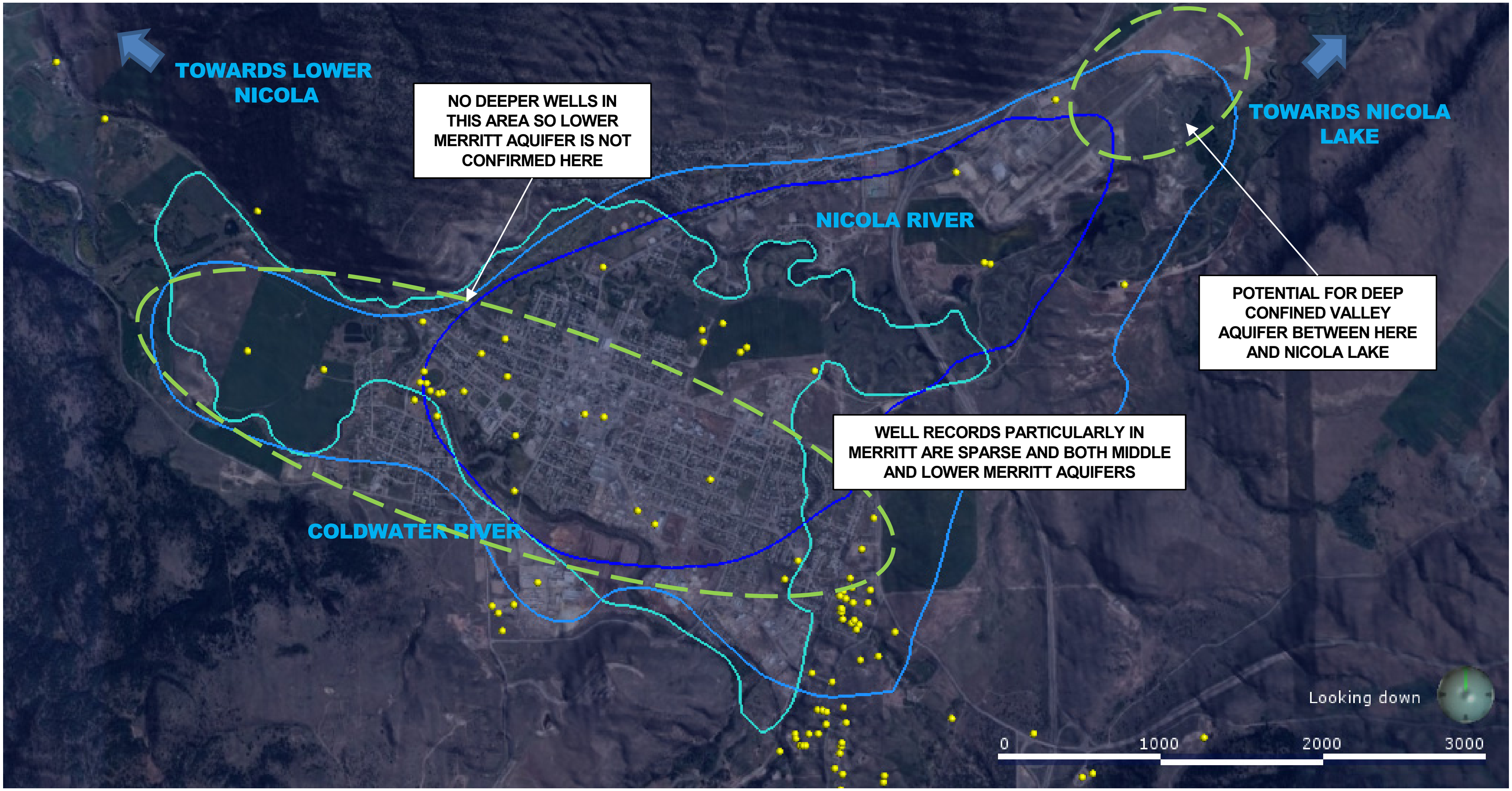
Ranking Component:	***Ranking Value***
Productivity:	3
Vulnerability:	3
Size:	2
Demand:	2
Type of Use:	2
Quality Concerns:	0
Quantity Concerns:	0
Total:	**12**

Statistical Summary of Well Data for Aquifer

Total number of wells available for statistical analysis: 11

	Depth to Bedrock (m bgs)	Well Depth (m bgs)	Depth to Water (m bgs)	Reported Est. Well Yield (L/s)	Est. Thickness of Confining Materials (m)
Number of Wells	NA	11	10	5	NA
Minimum	NA	1.8	1.2	0.5	NA
Maximum	NA	19.8	16.5	1.3	NA
Median	NA	4.9	5.2	0.6	NA
Average	NA	6.7	7.1	0.8	NA
Geometric Mean	NA	5.5	5.0	0.8	NA

APPENDIX B: Potential Areas for Future Investigation



FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

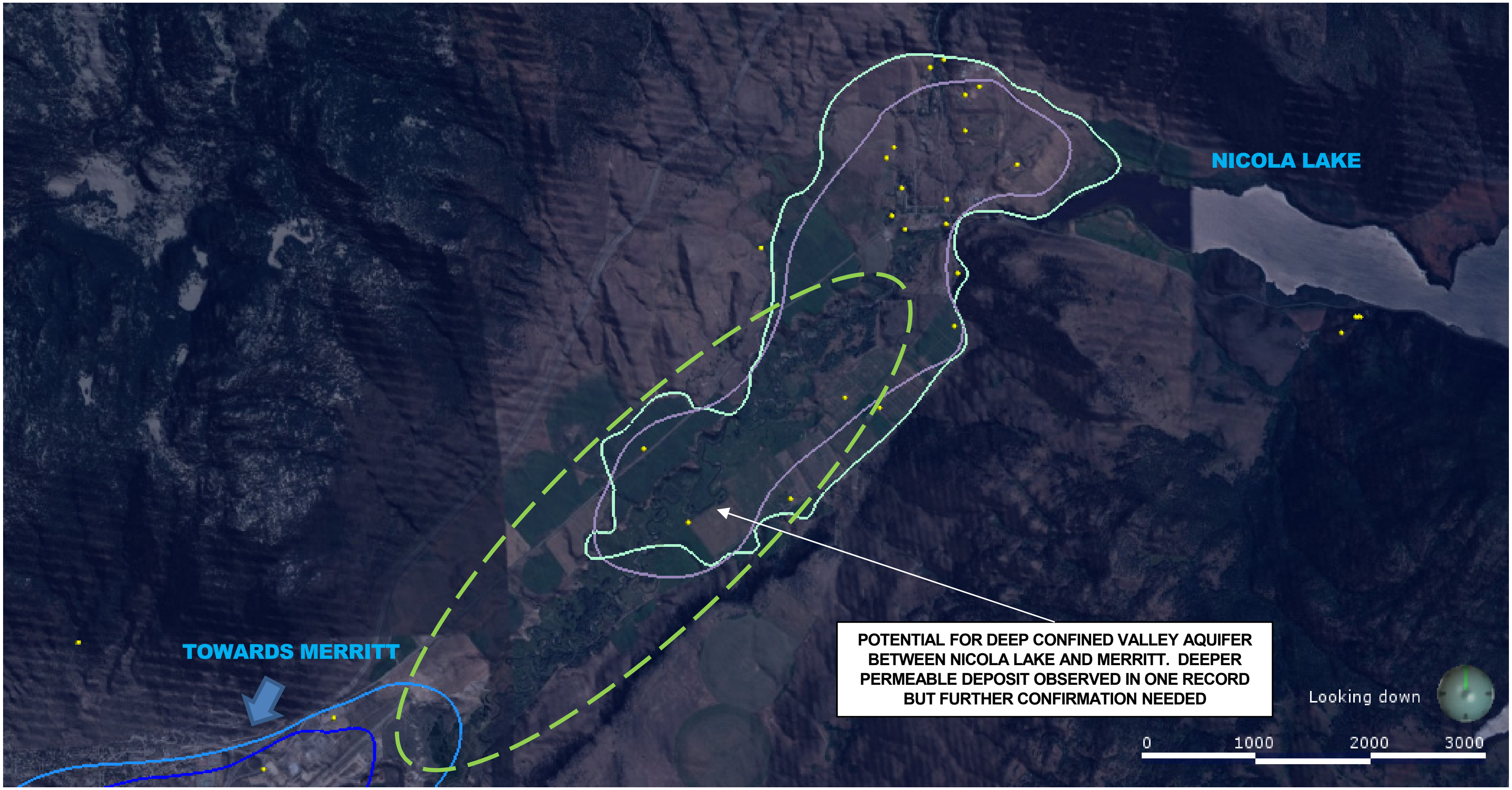
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
MERRITT – NICOLA LAKE AQUIFERS
MERRITT BASIN – PLAN VIEW
POTENTIAL AREAS FOR FURTHER INVESTIGATION

PROJECT NO.	PHASE	REV.	
1772201	4000	1	B1



FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
NICOLA LAKE AREA
PLAN VIEW – UNICOLA AND CONICOLA AQUIFERS
POTENTIAL AREAS FOR FURTHER INVESTIGATION

PROJECT NO.	PHASE	REV.	
1772201	4000	1	B2

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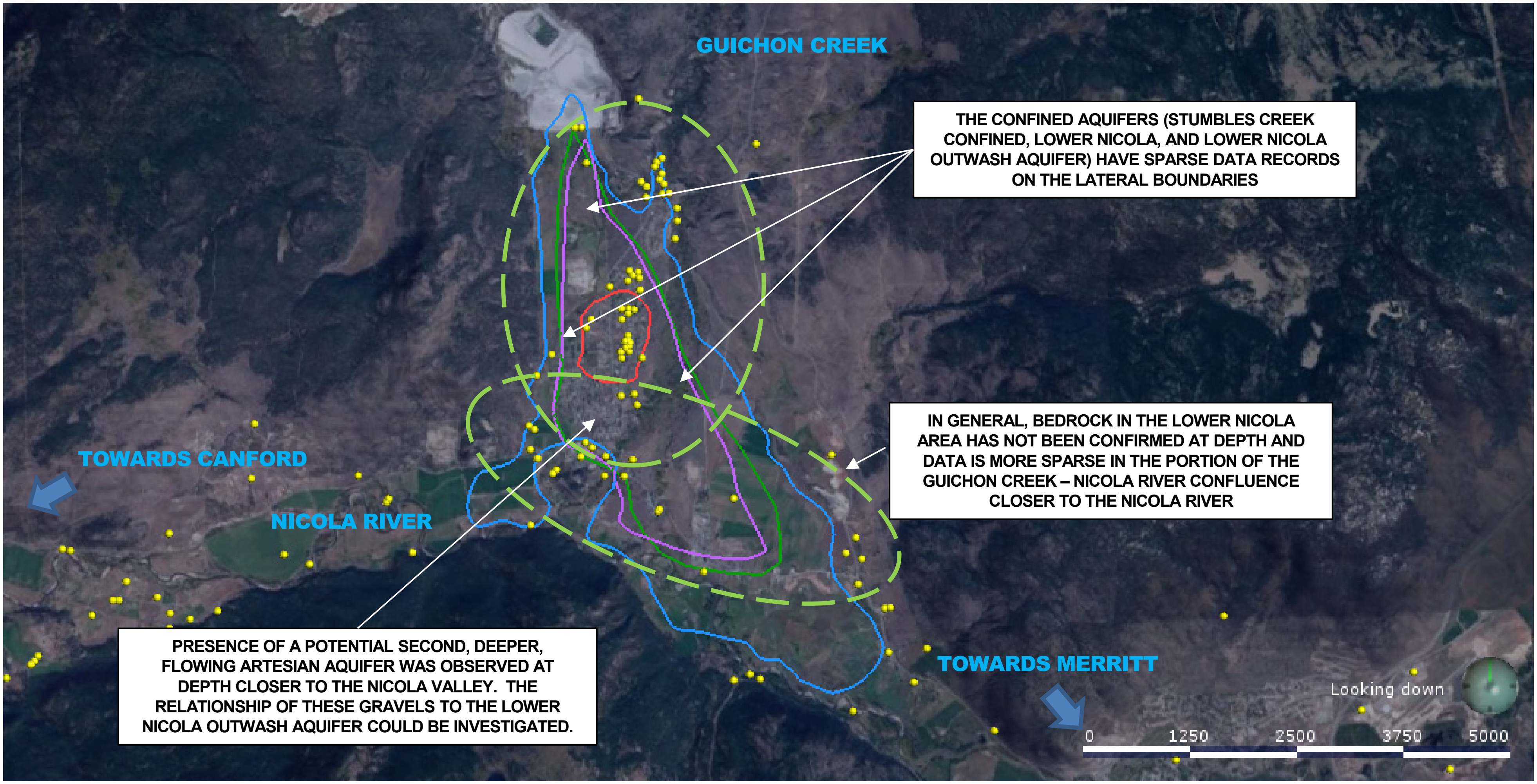

FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
LOWER NICOLA AREA
PLAN VIEW SHOWING AQUIFERS
POTENTIAL AREAS FOR FURTHER INVESTIGATION

PROJECT NO.	PHASE	REV.	
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1 in
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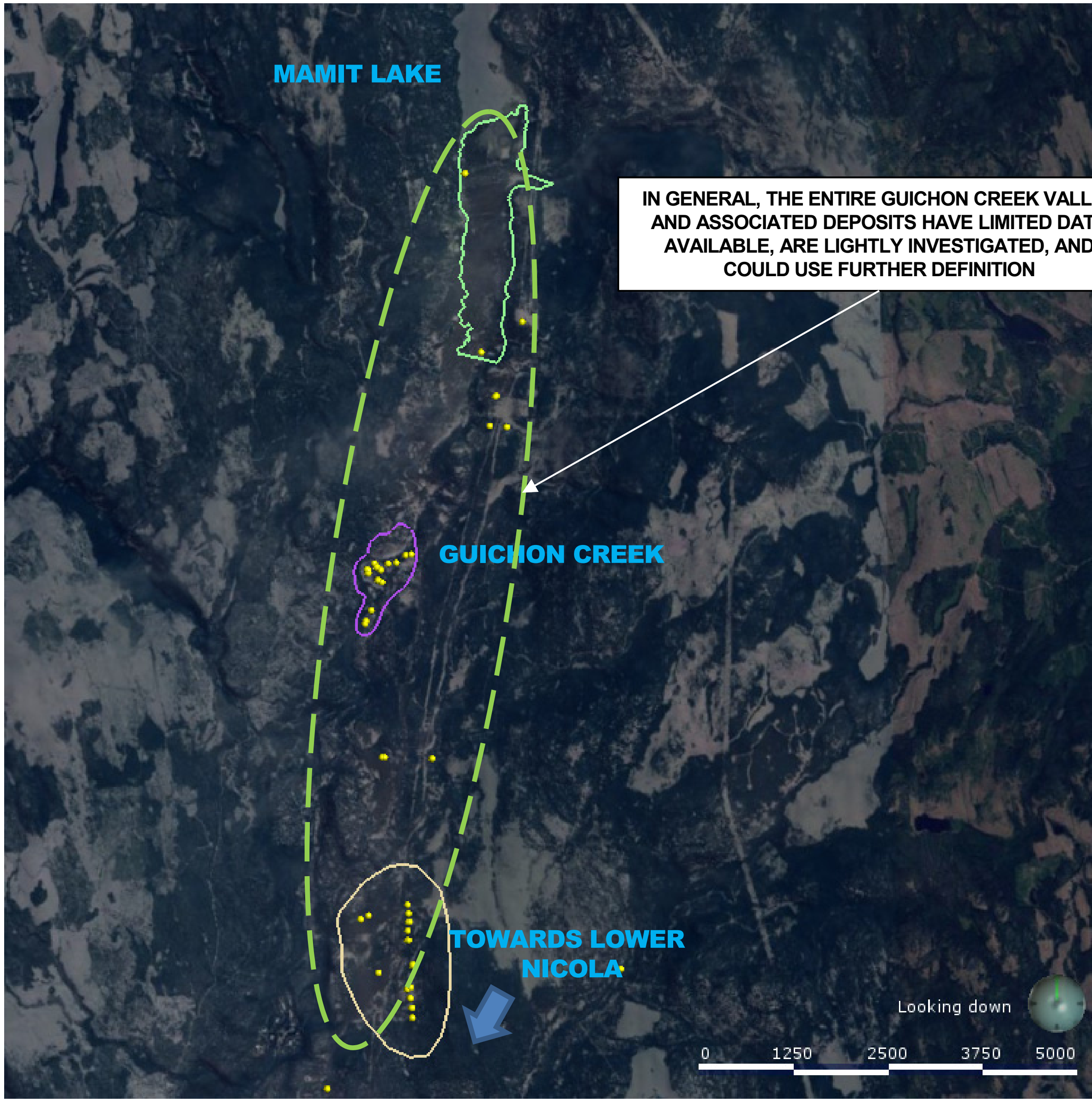


FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA
Ministry of Environment

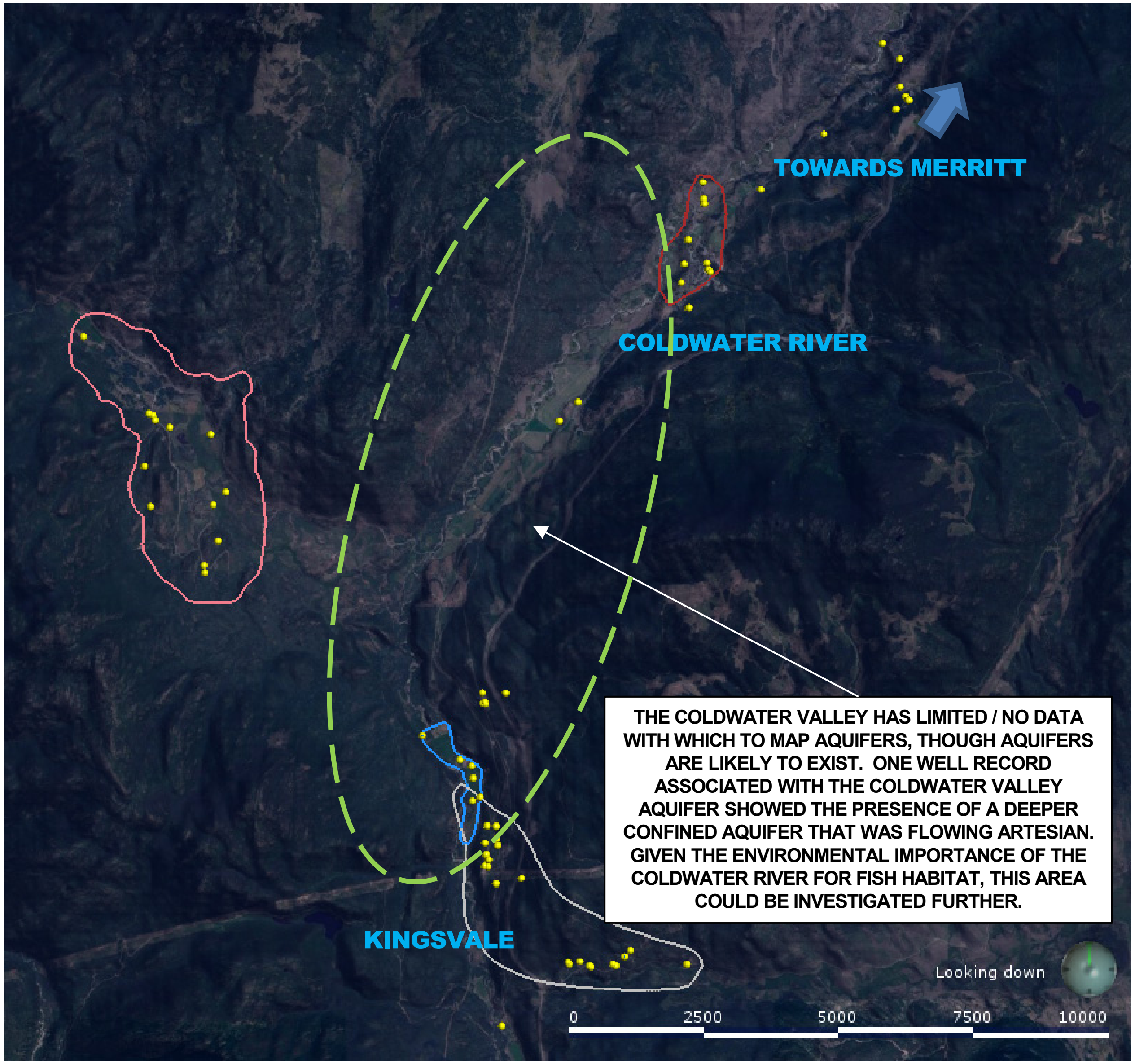
GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
GUICHON CREEK AREA
PLAN VIEW WITH AQUIFERS
POTENTIAL AREAS FOR FURTHER INVESTIGATION

PROJECT NO.	PHASE	REV.	
1772201	4000	1	B4



FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

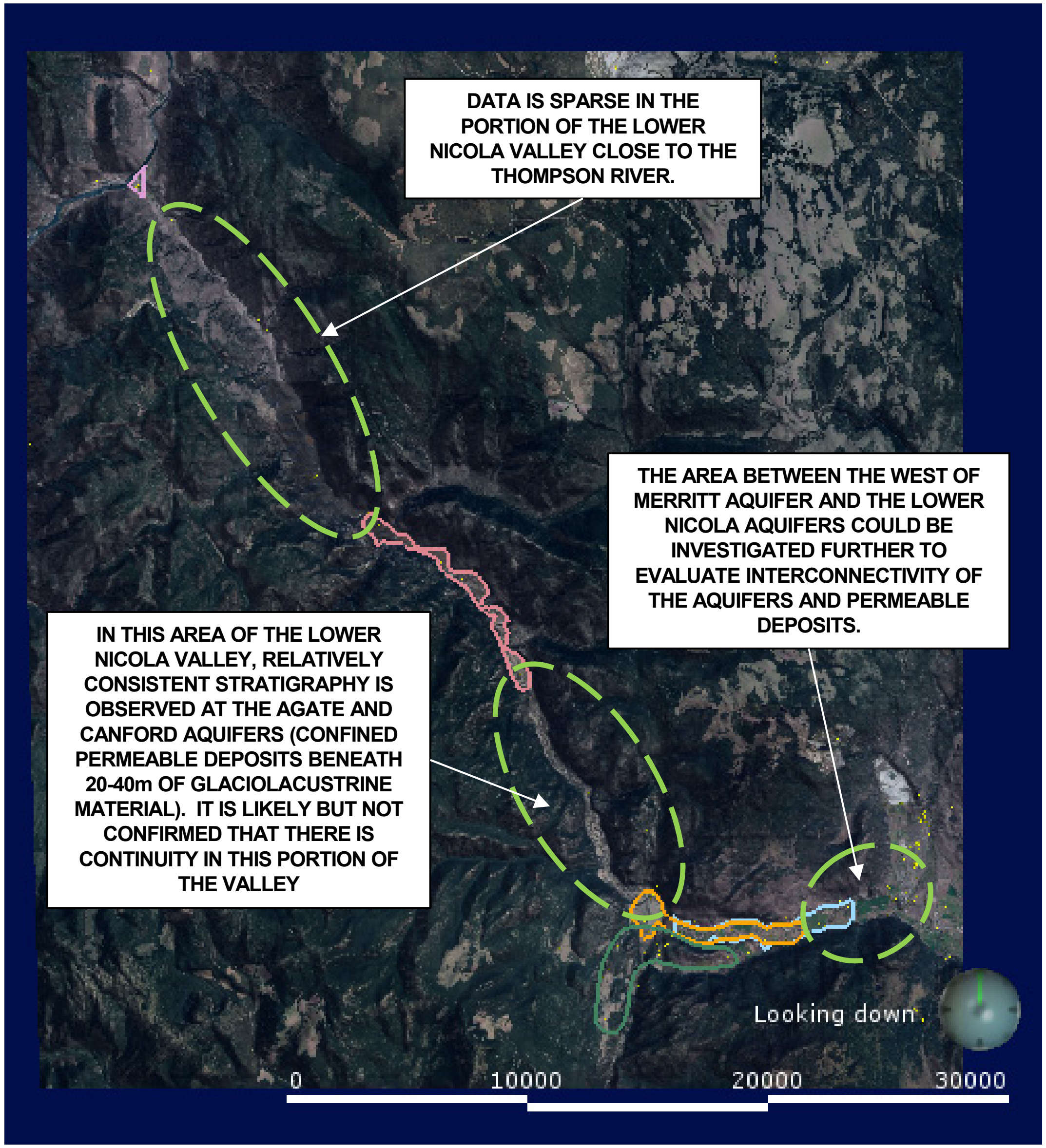
YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT
NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE
COLDWATER RIVER VALLEY AREA
PLAN VIEW WITH AQUIFERS
POTENTIAL AREAS FOR FURTHER INVESTIGATION

PROJECT NO.	PHASE	REV.	
1772201	4000	1	B5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



FRASER BASIN COUNCIL AND MINISTRY OF FOREST LAND AND NATURAL RESOURCE OPERATIONS AND RURAL DEVELOPMENT

BRITISH COLUMBIA Ministry of Environment

GOLDER

YYYY-MM-DD	2018-05-22
PREPARED	NGG
DESIGNED	NGG
REVIEWED	KB
APPROVED	JAS

PROJECT

NICOLA WATERSHED AQUIFER MAPPING AND CLASSIFICATION

TITLE

LOWER NICOLA VALLEY AQUIFERS
PLAN VIEW
POTENTIAL AREAS FOR FURTHER INVESTIGATION

PROJECT NO.	PHASE	REV.	
1772201	4000	1	**B6**