TECHNICAL MEMORANDUM

DATE 12 March 2021 **Reference No.** 20253005-002-TM-Rev1

TO Mike Simpson, MA, RPF
Fraser Basin Council

CC Laurie Lyons, FLNRORD

FROM Kevin Bennett **EMAIL kabennett@golder.com**

ANALYSIS OF CITY OF MERRITT GROUNDWATER-SURFACE WATER DATA FROM FALL 2020

This technical memorandum provides the results of Task 5 of the "Phase 2 Groundwater-Surface Water Interaction Study" (Study) of the Coldwater River. The Study is an initiative by FLNRORD to better understand the interaction between surface water and groundwater along the Coldwater River. The Study work plan was described in Golder Associates Ltd's. (Golder) proposal to the Fraser Basin Council (FBC) dated 25 September 2020.

This memorandum describes the analysis of groundwater level and water chemistry data that was conducted to find evidence of surface water-groundwater interaction in the Merritt Area and sources of recharge to the Upper Merritt Aquifer. The data were obtained by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) from monitoring wells, municipal production wells, the Coldwater River and the Nicola River within the City of Merritt in Fall 2020.

1.0 OBJECTIVE OF TASK 5

The objective of Task 5 was to evaluate whether the groundwater level data and groundwater and surface water chemistry data provide evidence of groundwater-surface water interaction within the City of Merritt, and specifically to outline where the data indicates or provides evidence of gaining and losing reaches if possible.

2.0 WORK SCOPE

The work scope was to analyse the data set provided by FLNRORD to:

- compare shallow groundwater level elevations with nearby surface water level elevations to evaluate the position of the water table relative to the river level, where possible.
- calculate the direction (upward or downward) and magnitude of the vertical hydraulic gradient between surface water and the nearest shallow groundwater, and at locations with monitoring well nests, to evaluate the vertical direction of groundwater flow in the vicinity of the rivers.

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- prepare graphical plots of the major ion chemistry (i.e., on a Piper Diagram) and stable isotopes (on a δ^2H / $\delta^{18}O$ cross-plot) for the surface water and groundwater samples.
- Based on the data provide recommendations on monitoring locations and parameters for longer term monitoring for the purpose of obtaining more conclusive evidence of groundwater-surface water interaction.

3.0 RESULTS

The City of Merritt groundwater monitoring well network includes 4 nested monitoring wells alongside the Coldwater River and 3 nested monitoring wells alongside the Nicola River. The locations of all groundwater and surface water monitoring and sampling sites are shown on Figure 1 and Figure 2. The mapped aquifers (Gorski et.al. 2018) at and around the City of Merritt are shown on Figure 1. The unconfined Upper Merritt Aquifer is also shown on Figure 2. The well information and water level measurement spreadsheet provided by FLNRORD is provided as Attachment 1. The data set from FLNRORD included survey results (UTM co-ordinates and geodetic elevations) for the monitoring wells and municipal production wells but did not include geodetic elevations for the surface water sampling points.

A summary of the nested monitoring well details is provided in Table 1. Borehole logs for the MW04 and MW07 series monitoring wells are contained in BCGW 2006 and BCGW 2011 respectively.

Table 1: City of Merritt Nested Monitoring Well Summary

Well Name	Depth (mbg)	Screened Formation	Aquifer Name	Approx. Distance to Nearest Surface Water (m)
MW04-1S	4.8	Sand & Gravel	Upper Merritt (unconfined)	Coldwater R (15 m)
MW04-1D	8.5	Gravel	Upper Merritt (unconfined)	Coldwater R (15 m)
MW04-2S	5.5	Silty Gravel	Upper Merritt (unconfined)	Coldwater R (8 m)
MW04-2D	9.2	Clay	Aquitard	Coldwater R (8 m)
MW04-3S	6.2	Gravel	Upper Merritt (unconfined)	Coldwater R (25 m)
MW04-3D	11.2	Gravel	Upper Merritt (unconfined)	Coldwater R (25 m)
MW04-4S	5.3	Silty Gravel	Upper Merritt (unconfined)	Nicola R (35 m)
MW04-4D	9.2	Clay	Aquitard	Nicola R (35 m)

Well Name	Depth (mbg)	Screened Formation	Aquifer Name	Approx. Distance to Nearest Surface Water (m)
MW04-5S	5.4	Sand & Gravel	Upper Merritt (unconfined)	Nicola R (23 m)
MW04-5D	9.9	Gravel	Upper Merritt (unconfined)	Nicola R (23 m)
MW04-6S	4.6	Sand	Upper Merritt (unconfined)	Nicola R (35 m)
MW04-6D	9.4	Clay	Aquitard	Nicola R (35 m)
MW-3S	5.5	Not Detemined[1]	Likely Upper Merritt[2]	Nicola R (185 m) RIB (70 m)
MW-3D	11.0	Not Determined	Likely Upper Merritt	Nicola R (185 m) RIB (70 m)
MW-4S	5.2	Not Determined[1]	Likely Upper Merritt[2]	Coldwater R (17 m)
MW-4D	9.6	Not Determined	Likely Upper Merritt	Coldwater R (17 m)
MW-5S	5.2	Not Determined[1]	Likely Upper Merritt[2]	Coldwater R (210 m)
MW-5D	9.9	Not Determined	Likely Upper Merritt	Coldwater R (210 m)
MW07-1S	57	Sand & Gravel	Middle Merritt (confined)	Nicola R (295 m)
MW07-1M	86	Sand & Gravel	Lower Merritt (confined)	Nicola R (295 m)
MW07-1D	131	Sand & Gravel	Lower Merritt (confined)	Nicola R (295 m)
MW07-2S	30	Sand & Gravel	Upper Merritt (unconfined)	Coldwater R (390 m) Nicola R (285 m)
MW07-2M	58	Sand & Gravel	Middle Merritt (confined)	Coldwater R (390 m) Nicola R (285 m)
MW07-2D	132	Sand & Gravel	Lower Merritt (confined)	Coldwater R (390 m) Nicola R (285 m)

Table Notes:
1- Borehole log is not available to confirm lithology of screened interval.
2- The nearby wastewater rapid infiltration basins would require an underlying highly permeable sand and gravel formation, inferred to be the Upper Merritt Aquifer, to effectively infiltrate treated wastewater.

3.1 Comparison of River Levels to Nearest Water Table Measurement

There are seven paired surface water and shallow groundwater sampling locations, three for the Nicola River and four for the Coldwater River, as shown on Figure 2 (e.g., Coldwater R at Claybanks and MW04-2S/D are one pair). The geodetic river levels at the paired surface water and shallow groundwater sampling locations were not surveyed so it is not possible to compare the elevation of the river surface to the nearest water table elevation measurement provided to Golder. FLNRORD did provide a geodetic benchmark for the Water Survey of Canada (WSC) Coldwater River hydrometric station 08LG010 at Merritt (Figure 2) which was used to estimate the elevation of the Coldwater River adjacent to the Voght Park shallow monitoring well (MW04-1S). Elevations of the Coldwater River adjacent to the Claybanks monitoring well (MW04-2S) and May Street monitoring well (MW04-3S) were estimated from a WSC station 08LG010 river stage correlation developed by FLNRORD in 2008 (MOE 2009). The paired water level elevations for the Coldwater River and the nearest water table are summarized in Table 2. The relative elevation of the water table to the Nicola River could not be determined from the data set provided.

Table 2: Coldwater River and adjacent Water Table Elevations

Location	Date/Time	Est. River Level Elevation (masl)	Shallow Groundwater (Water Table) Elevation (masl)	Net of River Level and Groundwater Level (m) positive value = losing river negative value = gaining river Approx. Uncertainty in Values ± 0.5 m
Voght Park (MW04-1)	21/10/2020:13:40	588.35	587.17	+1.18
Claybanks (MW04-2)	21/10/2020:10:40	592.55	592.57	-0.02
May Street (MW04-3)	29/10/2020:10:40	596.05	594.75	+1.30

The data show that the Coldwater River elevation was higher than the water table at May Street and Voght Park and possibly the same elevation as the water table at Claybanks (located mid-way between the May Street and Voght Park locations), although there is a high degree of uncertainty at Claybanks because of the small difference in the water levels (only 3 cm difference) relative to the potential inaccuracy of the surface water level estimate. The data were indicative of losing river conditions at May Street and Voght Park and inconclusive conditions (i.e., could be losing, gaining or flow-through) for Claybanks. These results are consistent with the year long study in 2007 and 2008 (MOE, 2009) where the Coldwater River at May Street and Voght Park was consistently higher than the adjacent water table throughout the year. MOE (2009) concluded that “Ground water and river temperature and elevation data indicate that the reach of the Coldwater River from the May Street well to Voght Park was a losing reach during the entire monitoring period of April 2007 to April 2008”. MOE also interpreted that the Coldwater River reach though Merritt was a naturally losing reach, i.e., was losing prior to groundwater extraction from the Upper Merritt Aquifer.

Monitoring wells MW04-4S/D and MW-04-6S/D are located adjacent to the Nicola River near the northern margins of the Upper Merritt Aquifer and the surficial aquifer deposits at these two locations are roughly 5 m thick. Conversely the Upper Merritt Aquifer along the Coldwater River is thicker ranging from approximately 12 m thick at the former May Street municipal well (WTN 24105) to 30 m thick at Voght Park (WTN 114668). The thinning of

the Upper Merritt Aquifer beneath the Nicola River likely reduces the potential for drawdown from municipal pumping wells to expand to the Nicola River and induce loss from the river.

3.2 Hydraulic Gradients and Flow Direction - Shallow Groundwater

The direction and magnitude of vertical hydraulic gradients in groundwater calculated at the nested wells (Table 1) are shown on Figure 3. It should be noted that the estimated Coldwater River elevations are not considered in the gradient calculations. For example, although the estimated river elevation was 1.3 m above the groundwater table at May Street (MW04-3S/D) the vertical groundwater gradient between the nested 6 m deep (MW04-3S) and 11 m deep (MW04-3D) monitoring wells was flat. Figure 3 illustrates that in late fall 2020:

- downward groundwater gradients at Voght Park, Merritt's rapid infiltration basins (RIBs), and at Spring Granite (MW04-4S/D) and indicative of potential groundwater recharge conditions by river loss and treated wastewater infiltration.
- upward groundwater gradients at MW-4S/D near the Coldwater-Nicola River confluence and at MW04-5S/D and MW04-6S/D alongside the Nicola River, all completed in the Upper Merritt Aquifer, suggest potential locations of gaining river conditions.
- at Kengard (MW07-1S/M/D), an upward groundwater gradient from the Lower Merritt Aquifer (confined) into the Middle Merritt Aquifer (confined) which suggests that the Middle and Lower Merritt Aquifers are recharged by regional groundwater flow from upland areas around Merritt. Valley aquifers in arid and semi-arid areas (like Merritt) can receive much of their water from an adjacent mountain system. Two recharge mechanisms are typically recognized for these aquifers: mountain front recharge (MFR), which consists of infiltration of overland flow that arrives at the break in slope between the mountain bedrock and the basin fill sediments (including infiltration from streamflow channels); and mountain block recharge (MBR), which consists of diffuse recharge over the mountain block that percolates through the rock and flows laterally as groundwater into the valley/basin sediments (Bresciani et al. 2018).
- at Fairly Park (MW07-2S/M) an upward groundwater gradient from the Middle Merritt Aquifer (confined) into the Upper Merritt Aquifer (unconfined) which suggests that MFR and MBR are providing recharge to the Upper Merritt Aquifer via flow through the deeper valley aquifers.

The piezometric surface and horizontal hydraulic gradient within the Upper Merritt Aquifer calculated from the data set are shown on Figure 4. The data illustrate that the direction of groundwater flow is west-northwesterly from the apex of the alluvial/glaciofluvial fan shaped Upper Merritt Aquifer toward the Coldwater-Nicola River confluence. The average horizontal gradient in late fall 2020 was approximately 0.006 m/m in the south portion of the aquifer along the Coldwater River and 0.004 m/m in the northern portion of the aquifer along the Nicola River. The gradient generally becomes flatter moving from east to west. For comparison, the ground surface slopes at approximately 5 m/km (0.005 m/m) from the fan apex (611 masl) downward to the fan toe (595 masl) along the Nicola River and Coldwater-Nicola River confluence.

3.3 Groundwater Chemistry

3.3.1 Piper Diagram

The table of surface water and groundwater chemistry data provided by FLNRORD is included as Attachment 2. The chemistry data are also plotted on a piper diagram provided on Figure 5. As per verbal and email correspondence with FLNRORD, the following water sample results are suspected of being non-representative and have not been plotted: Kengard Test Well (insufficient purging), MW04-1S (cross contamination) and the 5 November 2020 samples of the Coldwater River at Claybanks and Coldwater River upstream of the Nicola River confluence (flooding event).

A piper diagram is a graphical method to represent the distribution of major ions and plots the percentage of cations and anions (cations: calcium, sodium, magnesium and potassium; and anions: chloride, bicarbonate alkalinity and sulphate) for all the samples. It should be noted that because relative percentages are plotted, waters with much different total ion concentrations may plot similarly on the piper diagram. The regions of different water types are shown on the piper diagram as calcium-sulphate type (Ca-SO4), calcium-carbonate type (Ca-HCO3), sodium-bicarbonate type (Na-HCO3) and sodium-chloride type (NaCl). Surface water and groundwater samples are colour grouped based origin, aquifer type or purpose. Figure 5 illustrates the following water classifications within the Merritt sampling area:

- **Calcium-bicarbonate type water**: Surface waters from the Coldwater River and Nicola River, all of the unconfined Upper Merritt Aquifer groundwater samples, including the Voght Park and Fairly Park municipal wells, MW07-1M completed in the confined Middle Merritt Aquifer at Kengard and the bedrock well on Fox Farm Road east and upslope of Merritt.
- **Calcium-sulphate type water**: Groundwater from the Kengard municipal well (2016 and October 2020 samples), the deep Kengard monitoring well MW07-1D which is completed at the same depth in the confined Lower Merritt Aquifer as the Kengard well, MW04-6D which is completed in shallow clay alongside the Nicola River, the mid-level Fairly Park monitoring well MW07-2M screened in the confined Middle Merritt Aquifer and MW-3S in the Upper Merritt Aquifer near the Merritt RIBs. It is possible the treated wastewater is altering the groundwater quality at MW-3S causing this to be an outlier. The mineralogy of the clay could be influencing the other outlier, MW04-6D (completed in shallow clay).
- **Sodium-bicarbonate and sodium-chloride type waters**: None of the surface water or groundwater samples were sodium-bicarbonate or sodium-chloride type waters.

Groundwater is typically found to chemically evolve from bicarbonate- to sulphate- to chloride-type waters with increasing flow path lengths in the subsurface. The bicarbonate-type groundwaters in the unconfined Upper Merritt Aquifer suggests shorter groundwater flow paths (residences times) than the calcium-sulphate type waters in the Lower Merritt Aquifer where longer flow paths and residence times represent MFR and MBR through the valley sides into the deep valley sediments.

Piper diagrams can provide an indication of water mixing, where differing mixtures of two different waters will plot along a straight line between end members representative of each individual water type. For example, the calcium-bicarbonate type surface waters from the Coldwater and Nicola Rivers could be considered one end member representative of river loss recharge to the Upper Merritt Aquifer. Groundwater from the Lower Merritt

Aquifer forms an end member representative of waters that reflect longer residence times in the subsurface. The groundwater samples from the four Merritt Municipal Wells drawing from the Upper Merritt Aquifer group midway between these two end members, with their water compositions being a blend of each water type. This supports a concept that the Upper Merritt Aquifer is recharged by river loss, and by MFR and MBR through lateral recharge from the valley sides and upward groundwater flow from the Middle and Lower Merritt Aquifers into the Upper Merritt Aquifer.

3.3.2 Isotopes Analysis

Within the water molecule, there are two stable isotopes of hydrogen: ^{2}H and ^{1}H, and three stable isotopes of oxygen: ^{16}O, ^{17}O and ^{18}O. These stable isotopes serve as conservative groundwater tracers and often carry a signature that indicates the source of groundwater recharge and relative residence times of groundwater in the subsurface.

The stable isotopes of hydrogen and oxygen are measured as the ratio of the two most abundant isotopes of a given element (for oxygen, these are ^{16}O and ^{18}O) (Clark and Fritz 1997). Water isotope results are reported relative to Vienna Standard Mean Ocean Water (VSMOW)-Standard Light Antarctic Precipitation (SLAP), and expressed in the δ (‰) (“del”) notation (Clark and Fritz 1997), as follows for $\delta^{18}O$:

$$\partial^{18}O = \left(\frac{(^{18}O/^{16}O)_{sample} - (^{18}O/^{16}O)_{smow}}{(^{18}O/^{16}O)_{smow}} \right) x1000$$

where:

$(^{18}O/^{16}O)_{sample}$ is the light to heavy isotope ratio for the oxygen in the sample.

$(^{18}O/^{16}O)_{smow}$ is the light to heavy isotope ratio for the oxygen in a standard.

Similarly, the value of δD is calculated by replacing the ratio of $^{18}O/^{16}O$ with $^{2}H/^{1}H$ in the above equation.

The δ2H and δ18O values of groundwater samples collected by FLNRORD are shown on the δ2H δ18O cross-plot on Figure 6. The δ2H and δ18O values of these samples are shown relative to the Global Meteoric Water Line (GMWL; Craig 1961). The GMWL is based on unevaporated precipitation data from locations around the globe and shows the linear relationship between δ2H and δ18O values of precipitation. The GWML has an equation of δ2H = 8 δ18O + 10. Although the slope of the GMWL is nearly constant globally, both the slope and the intercept of local waters can vary considerably, reflecting local meteorological, topographic and seasonal conditions (i.e., resulting in local meteoric water lines).

In general, natural groundwaters that are recharged by the infiltration of precipitation originating at higher elevations and colder temperatures (i.e., snow and/or early spring or late fall rains), where little to no evaporation of the precipitation occurs before infiltration into the ground, will have a more-depleted isotopic signature (i.e., more negative $\delta^{2}H$ and $\delta^{18}O$ values) and will plot at the bottom left-hand corner of a $\delta^{2}H$ $\delta^{18}O$ plot. Groundwaters with a more-enriched isotopic signature (i.e., more positive $\delta^{2}H$ and $\delta^{18}O$ values) are generally

indicative of a source of recharge that is either different or lower in elevation, that has been altered through evaporation and/or that mixing of different sources of water has occurred. The following interpretation of the isotope data is provided below:

- The δ^2H and $\delta^{18}O$ values of the Nicola River, Coldwater River and the shallow Nicola River monitoring well MW04-6S plot in the top right corner of the δ^2H-$\delta^{18}O$ plot and exhibit the most isotopically enriched signature relative to other waters, likely due to the high rates of evaporation in surface water. The Coldwater River sample collected on 3 November 2020 was less enriched than the three Coldwater River samples collected on 9 November 2020.
- The δ^2H and $\delta^{18}O$ values of groundwater samples from the Lower and Middle Merritt Aquifers generally plot in the bottom left corner of the δ^2H-$\delta^{18}O$ plot and exhibit the most isotopically depleted signature relative to other waters. The isotopic signature of the groundwater samples from the confined aquifer suggests recharge from a more distant, higher elevation, regional water source, and is typical of deep (regional) MBR.
- The groundwater sample from the Fairly Park monitoring well MW07-02M screened in the Middle Merritt Aquifer is an outlier; it is much more enriched than the other confined aquifer samples, which is not well understood at this time. This groundwater sample plots as a calcium-sulphate type water and is a “near” end member on the piper diagram (Figure 5) and not characteristic of recharge from a surface water source as implied by the isotope plot.
- The δ^2H and $\delta^{18}O$ values of the municipal wells pumping from the Upper Merritt Aquifer cluster midway between the confined aquifer samples end member (Middle/Lower Merritt Aquifers) and the Coldwater River end member. This suggests that the Upper Merritt Aquifer may be recharged by both surface water infiltration and by upward flowing groundwater from the underlying confined Middle Merritt Aquifer.
- The shallow and deep monitoring wells at May Street (MW04-3S/D) had similar isotopic signatures to the Coldwater River sample at May Street were indicative of recharge by the river; both groundwater and river samples were collected on 3 November 2020.
- The assembly of monitoring wells screened in the Upper Aquifer generally group closer to the Coldwater River than the Nicola River except for the deep monitoring well MW04-1D at Voght Park which plots closer to the Nicola River. The MW04-1D sample is also different from the nearby Voght Park municipal wells that are near the base of the Upper Merritt Aquifer. These results suggest recharge from the Coldwater River losses, except at MW04-1D.

4.0 CONCLUSIONS

This technical memorandum provides a qualitative analysis of potential surface water-groundwater interaction within the City of Merritt and sources of recharge to the Upper Merritt Aquifer. Based on the review of groundwater level and water chemistry data from the Merritt area collected and provided to Golder by FLNRORD, it is Golder’s assessment that:

- The Coldwater River from May Street to Voght Park was at or above the elevation of the water table in October 2020 (Table 2) and reflects losing conditions (i.e., surface water providing recharge to the shallow groundwater system).

- Upward hydraulic gradients were present at monitoring wells MW04-5S/D and MW04-6S/D completed in the Upper Merritt Aquifer and located along side the Nicola River suggesting potential locations for gaining river conditions at the time of monitoring i.e., late fall 2020. However, the elevation of the nearest water table relative to the Nicola River level could not be determined from the data set provided to confirm this.
- The thinner extent of the Upper Merritt Aquifer near the Nicola River (roughly 5 m thick at the aquifer's northern margin) relative to its thicker extent along the Coldwater River (approximately 12 m thick at the former May Street municipal well to 30 m thick at Voght Park) suggests that there is a reduced potential for drawdown from municipal well pumping to expand to the Nicola River and induce losses from this river.
- The inferred direction of groundwater flow in the Upper Merritt Aquifer is west-northwesterly, from the apex of the alluvial/glaciofluvial fan-shaped Upper Merritt Aquifer toward the Coldwater-Nicola River confluence. The horizontal hydraulic gradient ranges from 0.004 to 0.006 m/m and generally decreases moving from east to west.
- An upward vertical hydraulic gradient at Kengard (MW07-1S/M/D), from the Lower Merritt Aquifer (confined) into the Middle Merritt Aquifer (confined), and at Fairly Park (MW07-2S/M), from the Middle Merritt Aquifer (confined) into the Upper Merritt Aquifer (unconfined), suggests aquifer recharge from regional groundwater flow from upland areas (mountain block recharge) around Merritt.
- The results of the isotope analyses are consistent with the interpretations made with respect to the major ion chemistry of waters that recharge to the Upper Merritt Aquifer reflects a combination of river loss primarily from the Coldwater River, potential MFR via valley side contact with the Upper Merritt Aquifer and MBR through upward hydraulic gradients from the Middle and Lower Merritt Aquifers into the Upper Merritt Aquifer.

The results of this analysis of the City of Merritt wells improves the understanding of the groundwater flow regime and the interaction of shallow groundwater and surface water within the Merritt Basin, thus refining the conceptual hydrogeological model for the Merritt Area. The updated conceptual model together with the water level dataset from the monitoring wells and the vertical gradients observed in these wells could be used to update the existing numerical groundwater flow model for the Nicola Valley and improve the calibration of this model in the Merritt area. Furthermore, the results from this analysis could be used to improve the development of an integrated groundwater-surface water flow model of the Coldwater Study area using HydroGeoSphere (HGS) that was proposed previously by Golder (Phase 3 Groundwater-Surface Water Interaction Study, Coldwater River; proposal dated 20 November 2019).

5.0 RECOMMENDATIONS

Based on the data analysis Golder recommends that FBC consider:

- Completing a second isotope sampling event during the summer low flow/peak groundwater usage period to confirm the outliers and to assess if the data shows a shift in the mixing line towards the Nicola River or Coldwater River, or towards the confined aquifer signature. A shift may qualitatively indicate whether increased recharge by river loss or alternately by mountain block recharge is occurring to sustain groundwater withdrawals. Sampling points should include Nicola Lake, the Coldwater River, Nicola River, the six nested monitoring wells along both rivers, the Merritt observation well 296, the municipal wells completed

in the Upper Merritt Aquifer, the Fairly Park monitoring well MW07-02M screened in the Middle Merritt Aquifer and the Kengard municipal well completed in the Lower Merritt Aquifer. The sampling event should also include measuring groundwater levels to assess vertical gradients within the Upper Merritt Aquifer and between the Middle and Lower Merritt Aquifer, and the Upper Merritt Aquifer.

- Using the provincial hydrometric station on the Nicola River near Norgaard Ready Mix (Figure 2 - location ID "Nicola R U/S of Coldwater") to estimate the Nicola River geodetic elevation adjacent to the three nested monitoring wells MW04-4S/D, MW04-5S/D and MW04-6S/D followed by measurement of river level and groundwater level elevations at least monthly for a one-year period. Alternately, stilling wells could be installed in the Nicola River near each nested monitoring well to monitor the river elevation. This data can be used to assess the elevation differences between the Nicola River and the water table at these three monitoring well locations to determine whether the river is gaining or losing and whether these conditions are seasonally influenced.
- Instrumenting the Nicola River with a temperature sensor(s) and MW04-4S/D, MW04-5S/D and MW04-6S/D with pressure/temperature sensors to monitor for changes in groundwater temperature that would be indicative of river loss. Corresponding temperature/pressure data from the Merritt provincial observation well 296 could also be used to benchmark the monitoring well data.
- Whether a quantitative study is warranted to assess if and how river losses may change seasonally considering factors of river flow and groundwater pumping. A quantitative study may inform methods to schedule groundwater extraction and support environmental flow needs. The study would require additional river flow monitoring, groundwater extraction data and developing a numerical flow model to simulate the surface water and groundwater flow systems (previously recommended as Phase 3 of the Groundwater-Surface Water Interaction Study).

6.0 LIMITATIONS

This report was prepared for the exclusive use of the Fraser Basin Council and the Ministry of Forests, Lands, Natural Resource Operations & Rural Development. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Golder Associates Ltd. (Golder) accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The report is based on data and information collected during investigations conducted by Golder and is based solely on the condition of the Site at the time of the investigations as described in this report, supplemented by historical data provided to Golder as described in this report. Golder has relied in good faith on information provided by third parties. We accept no responsibility for any deficiency, misstatements, or inaccuracies contained in this report as a result of omissions, misinterpretations, or fraudulent or negligent acts of others.

Golder makes no warranty, expressed or implied, and assumes no liability with respect to the use of the information contained in this report at the subject Site, or any other site, for other than its intended purpose. If new information is discovered during future work, including excavations, borings or other studies, Golder should be requested to re-evaluate the conclusions of this report and provide amendments as required prior to any reliance upon the information presented herein.

The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

7.0 CLOSURE

We trust this information is sufficient for your needs at this time. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Golder Associates Ltd.

Kevin Bennett, PEng
Senior Groundwater Engineer

Connie Romano, MSc, PGeo
Associate, Senior Hydrogeologist

KB/CR/asd/lmk

Attachments: Figure 1: Study Area and Local Aquifers
Figure 2: Monitoring and Sampling Locations
Figure 3: Vertical Hydraulic Gradients
Figure 4: Shallow Groundwater Level Elevations
Figure 5: Geochemical Analysis – Piper Plot
Figure 6: H_2O Isotope Fractionation Analysis
Attachment 1: Well Data from FLNRORD
Attachment 2: Water Quality Data from FLNRORD

https://golderassociates.sharepoint.com/sites/131172/project files/6 deliverables/issued to client_for wp/20253005-002-tm-rev1/20253005-002-tm-rev1-task 5-12mar_21.docx

8.0 REFERENCES

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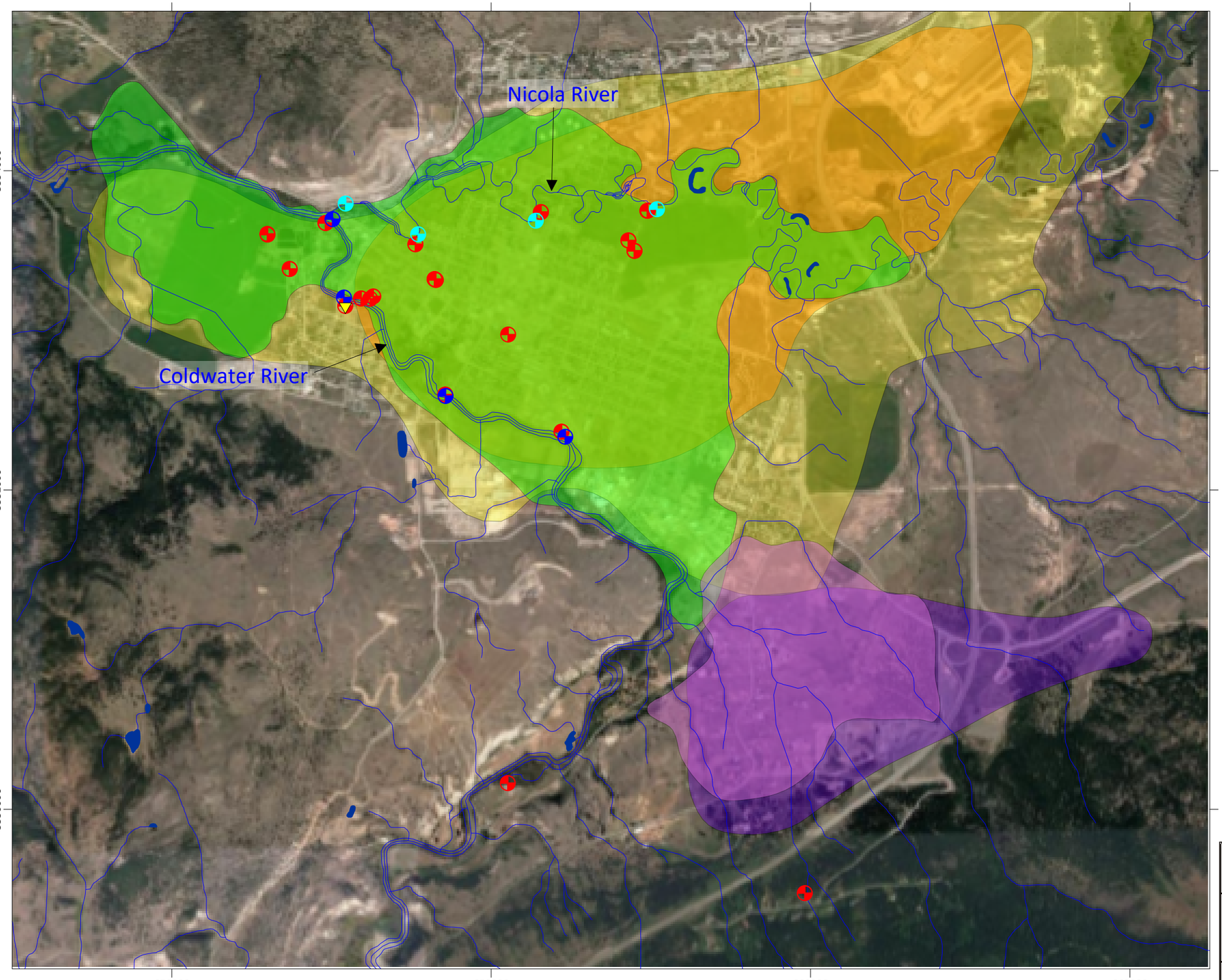


LEGEND

- GROUNDWATER SAMPLE LOCATION
- SURFACE WATER SAMPLE LOCATION (COLDWATER RIVER)
- SURFACE WATER SAMPLE LOCATION (NICOLA RIVER)
- WSC HYDROMETRIC STATION
- UPPER MERRITT AQUIFER
- MIDDLE MERRITT AQUIFER
- LOWER MERRITT AQUIFER
- SHALLOW JOEYASKA AQUIFER
- DEEP JOEYASKA AQUIFER
- SURFACE WATER (STREAMS, RIVERS, LAKES)

SCALE [m]

0 500 1000 1500 2000

NOTES

1. WSC (WATER SURVEY OF CANADA) HYDROMETRIC STATION DATA

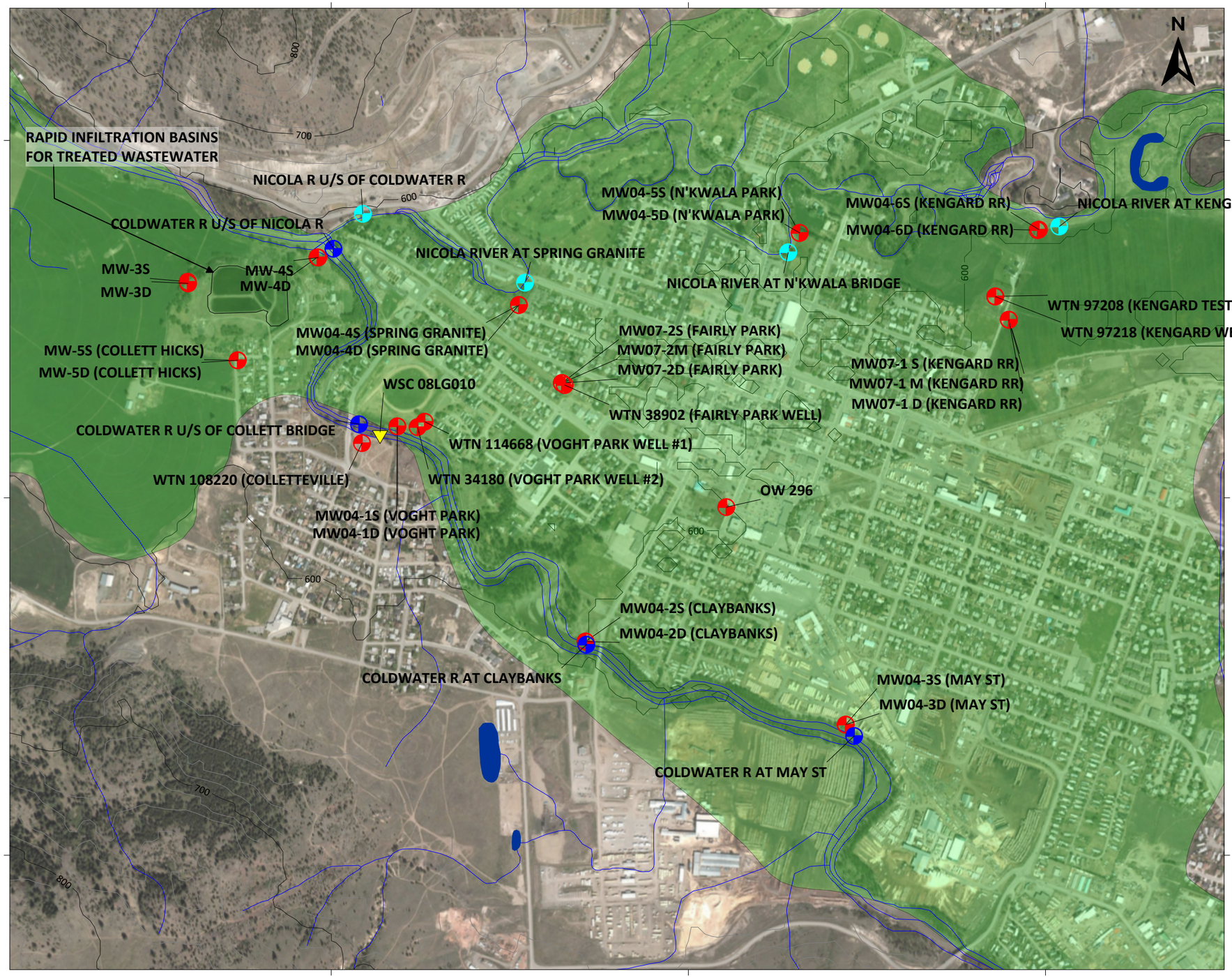
PROJECT
COLDWATER RIVER GROUNDWATER-SURFACE WATER INTERACTION STUDY

TITLE
STUDY AREA AND LOCAL AQUIFERS

GOLDER

PROJECT No. 20253005			PHASE No. 5000	
DESIGN	SI	2021-01-15	SCALE AS SHOWN	REV. 0
PREP.	SI	2021-01-15		
CHECK	KB	2021-01-27	1	
REVIEW	CR	2021-01-27		

REVISION DATE: 23APR19 BY: BM SURFER FILE: https://golderassociates.sharepoint.com/:b:/r/sites/22510g/Technical%20Work/Figures/Surfer/Bin-Surfer%20files/Dec%202018.pdf?csf=1&e=2tq9PB



LEGEND

- GROUNDWATER SAMPLE LOCATION
- SURFACE WATER SAMPLE LOCATION (COLDWATER RIVER)
- SURFACE WATER SAMPLE LOCATION (NICOLA RIVER)
- WSC HYDROMETRIC STATION
- UPPER MERRITT AQUIFER
- SURFACE WATER (STREAMS, RIVERS, LAKES)
- 590 SURFACE ELEVATION CONTOURS [MASL]

Aquifer	Well Name
Upper Merritt Aquifer	MW04-6S (KENGARD RR) MW04-5 S/D (N'KWALA PARK) MW04-4S (SPRING GRANITE) MW04-3 S/D (MAY ST) MW04-2 S/D (CLAYBANKS) MW04-1 S/D (VOGHT PARK) WTN 108220 (COLLETTEVILLE) MW-5 S/D (COLLETT HICKS) * MW-4 S/D * MW-3 S/D * MW07-2S (FAIRLY PARK) WTN 38902 (FAIRLY PARK WELL) OW 296 WTN 34180 (VOGHT PARK WELL #2) WTN 114668 (VOGHT PARK WELL #1)
Aquitard	MW04-6D (KENGARD RR) MW04-4D (SPRING GRANITE)
Middle Merritt Aquifer	MW07-1 S (KENGARD RR) MW07-2M (FAIRLY PARK)
Lower Merritt Aquifer	MW07-1 M/D (KENGARD RR) WTN 97208 (KENGARD TEST WELL) WTN 97218 (KENGARD WELL) MW07-2D (FAIRLY PARK)

* Completion in aquifer was assumed. Well log not available for some wells.

SCALE [m]

0 250 500 750 1000

NOTES
1. WSC (WATER SURVEY OF CANADA) HYDROMETRIC STATION DATA
2. LOCATION COORDINATES OF WSC 08LG010 MODIFIED (50m EAST, 20m NORTH) SO HYDROMETRIC STATION LIES WITHIN MAPPED RIVER PATH

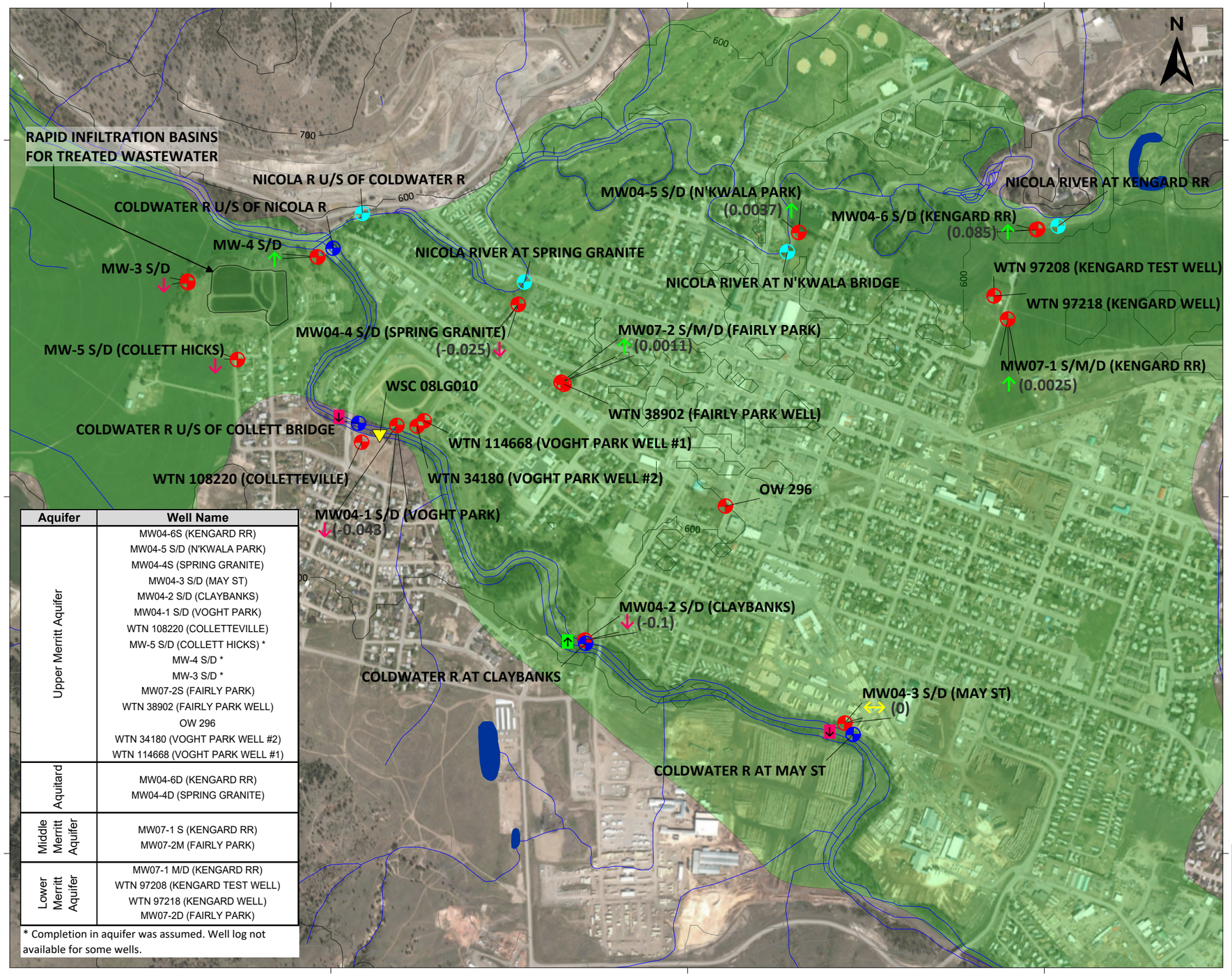
PROJECT
COLDWATER RIVER GROUNDWATER-SURFACE WATER INTERRACTION STUDY

TITLE
MONITORING AND SAMPLING LOCATIONS

GOLDER

PROJECT No. 20253005			PHASE No. 5000	
DESIGN	SI	2020-01-15	SCALE AS SHOWN	REV. 0
PREP.	SI	2020-01-15		
CHECK	KB	2020-01-27	2	
REVIEW	CR	2020-01-27		

REVISION DATE: 23APR19 BY: BM SURFER FILE: https://golderassociates.sharepoint.com/:b:/r/sites/22510g/Technical%20Work/Figures/Surfer/Bin-Surfer%20files/Dec%202018.pdf?csf=1&e=2tq9PB



Aquifer	Well Name
Upper Merritt Aquifer	MW04-6S (KENGARD RR)
	MW04-5 S/D (N'KWALA PARK)
	MW04-4S (SPRING GRANITE)
	MW04-3 S/D (MAY ST)
	MW04-2 S/D (CLAYBANKS)
	MW04-1 S/D (VOGHT PARK)
	WTN 108220 (COLLETTEVILLE)
	MW-5 S/D (COLLETT HICKS) *
	MW-4 S/D *
	MW-3 S/D *
	MW07-2S (FAIRLY PARK)
	WTN 38902 (FAIRLY PARK WELL)
	OW 296
	WTN 34180 (VOGHT PARK WELL #2)
	WTN 114668 (VOGHT PARK WELL #1)
Aquitard	MW04-6D (KENGARD RR)
	MW04-4D (SPRING GRANITE)
Middle Merritt Aquifer	MW07-1 S (KENGARD RR)
	MW07-2M (FAIRLY PARK)
Lower Merritt Aquifer	MW07-1 M/D (KENGARD RR)
	WTN 97208 (KENGARD TEST WELL)
	WTN 97218 (KENGARD WELL)
	MW07-2D (FAIRLY PARK)

* Completion in aquifer was assumed. Well log not available for some wells.

LEGEND

- GROUNDWATER SAMPLE LOCATION
- SURFACE WATER SAMPLE LOCATION (COLDWATER RIVER)
- SURFACE WATER SAMPLE LOCATION (NICOLA RIVER)
- WSC HYDROMETRIC STATION
- UPWARD HYDRAULIC GRADIENT
- DOWNWARD HYDRAULIC GRADIENT
- NEGLIGIBLE VERTICAL HYDRAULIC GRADIENT
- (0.085) HYDRAULIC GRADIENT [M/M]
- GAINING RIVER (BASED ON PAIRED GW/SW LEVELS)
- LOSING RIVER (BASED ON PAIRED GW/SW LEVELS)
- UPPER MERRITT AQUIFER
- SURFACE WATER (STREAMS, RIVERS, LAKES)
- 590 SURFACE ELEVATION CONTOURS [MASL]

SCALE [m]

0 250 500 750 1000

NOTES

1. WSC (WATER SURVEY OF CANADA) HYDROMETRIC STATION DATA
2. LOCATION COORDINATES OF WSC 08LG010 MODIFIED (50m EAST, 20m NORTH) SO HYDROMETRIC STATION LIES WITHIN MAPPED RIVER PATH

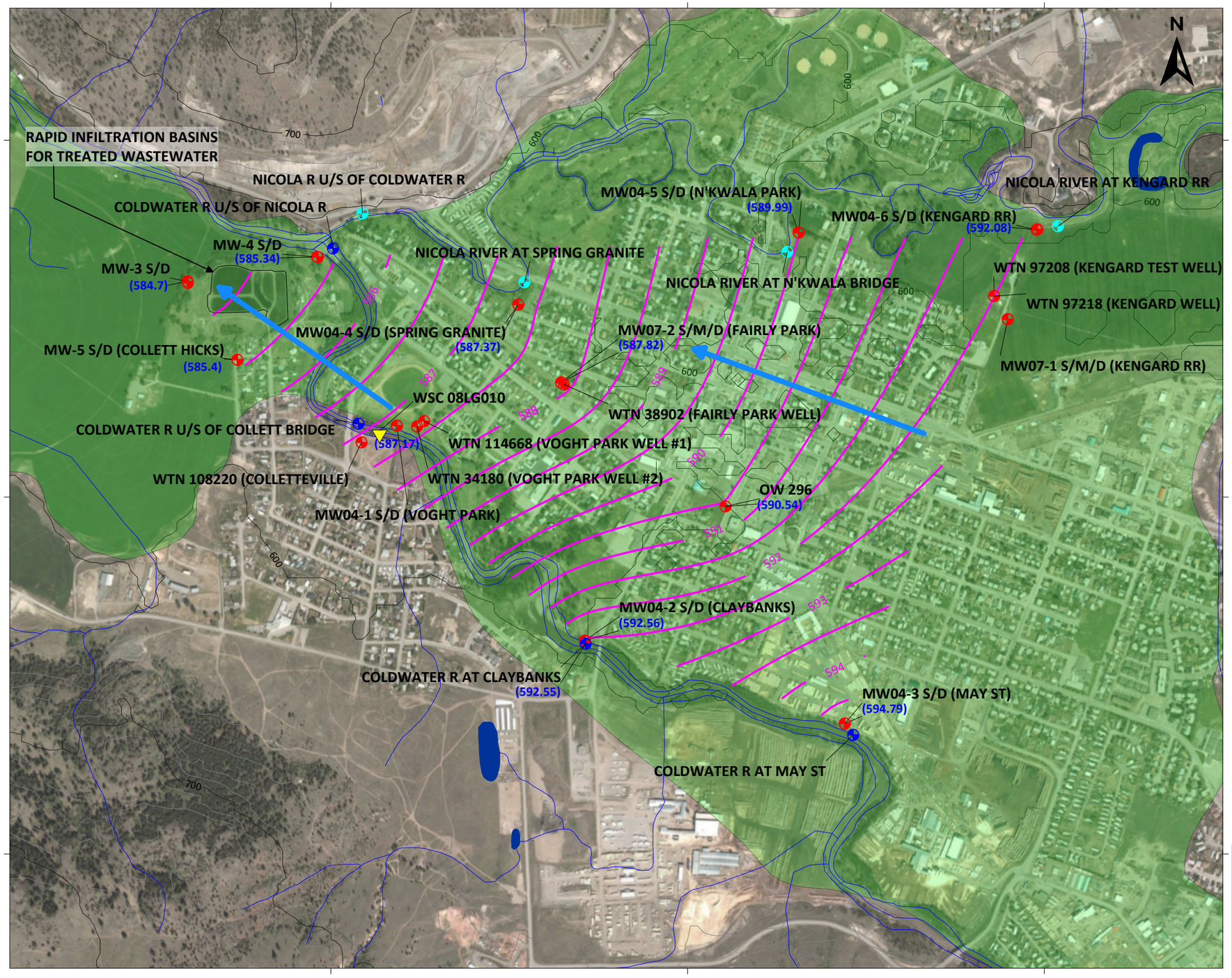
PROJECT
COLDWATER RIVER GROUNDWATER-SURFACE WATER INTERACTION STUDY

TITLE
VERTICAL HYDRAULIC GRADIENTS

GOLDER

PROJECT No.	20253005		PHASE No.	5000	
DESIGN	SI	2020-01-15	SCALE	AS SHOWN	REV. 0
PREP.	SI	2020-01-15	3		
CHECK	KB	2020-01-27			
REVIEW	CR	2020-01-27			

REVISION DATE: 23APR19 BY: BM SURFER FILE: https://golderassociates.sharepoint.com/:b:/r/sites/22510g/Technical%20Work/Figures/Surfer/Bin-Surfer%20files/Dec%202018.pdf?csf=1&e=2tqPPB



LEGEND

- GROUNDWATER SAMPLE LOCATION
- SURFACE WATER SAMPLE LOCATION (COLDWATER RIVER)
- SURFACE WATER SAMPLE LOCATION (NICOLA RIVER)
- WSC HYDROMETRIC STATION
- 590 GROUNDWATER ELEVATION CONTOURS [MASL]
- (0.085) GROUNDWATER ELEVATION [MASL]
- GROUNDWATER FLOW DIRECTION
- UPPER MERRITT AQUIFER
- SURFACE WATER (STREAMS, RIVERS, LAKES)

Aquifer	Well Name
Upper Merritt Aquifer	MW04-6S (KENGARD RR)
	MW04-5 S/D (N'KWALA PARK)
	MW04-4S (SPRING GRANITE)
	MW04-3 S/D (MAY ST)
	MW04-2 S/D (CLAYBANKS)
	MW04-1 S/D (VOGHT PARK)
	WTN 108220 (COLLETTEVILLE)
	MW-5 S/D (COLLETT HICKS) *
	MW-4 S/D *
	MW-3 S/D *
	MW07-2S (FAIRLY PARK)
	WTN 38902 (FAIRLY PARK WELL)
	OW 296
	WTN 34180 (VOGHT PARK WELL #2)
	WTN 114668 (VOGHT PARK WELL #1)
Aquitard	MW04-6D (KENGARD RR)
	MW04-4D (SPRING GRANITE)
Middle Merritt Aquifer	MW07-1 S (KENGARD RR)
	MW07-2M (FAIRLY PARK)
Lower Merritt Aquifer	MW07-1 M/D (KENGARD RR)
	WTN 97208 (KENGARD TEST WELL)
	WTN 97218 (KENGARD WELL)
	MW07-2D (FAIRLY PARK)

* Completion in aquifer was assumed. Well log not available for some wells.

SCALE [m]

0 250 500 750 1000

NOTES
1. WSC (WATER SURVEY OF CANADA) HYDROMETRIC STATION DATA
2. LOCATION COORDINATES OF WSC 08LG010 MODIFIED (50m EAST, 20m NORTH) SO HYDROMETRIC STATION LIES WITHIN MAPPED RIVER PATH

PROJECT
COLDWATER RIVER GROUNDWATER-SURFACE WATER INTERACTION STUDY

TITLE
GROUNDWATER ELEVATION CONTOURS

GOLDER

PROJECT No.	20253005		PHASE No.	5000	
DESIGN	SI	2020-01-15	SCALE	AS SHOWN	REV. 0
PREP.	SI	2020-01-15	4		
CHECK	KB	2020-01-27			
REVIEW	CR	2020-01-27			

Coldwater R.
- COLDWATER RIVER AT KINGSVALE
- COLDWATER RIVER U/S OF COLLETTE BRIDGE
- COLDWATER RIVER AT VOGHT PARK
- COLDWATER RIVER AT MAY ST.
- COLDWATER RIVER AT HOUSTON

Nicola R.
- NICOLA RIVER AT KENGARD RR
- NICOLA RIVER AT N'KWALA BRIDGE
- NICOLA RIVER AT SPRING GRANITE

Nicola R. MWs
- MW04–4S (SPRING GRANITE)
- MW04–4D (SPRING GRANITE)
- MW04–5S (N'KWALA PARK)
- MW04–5D (N'KWALA PARK)
- MW04–6S (KENGARD RR)
- MW04–6D (KENGARD RR)

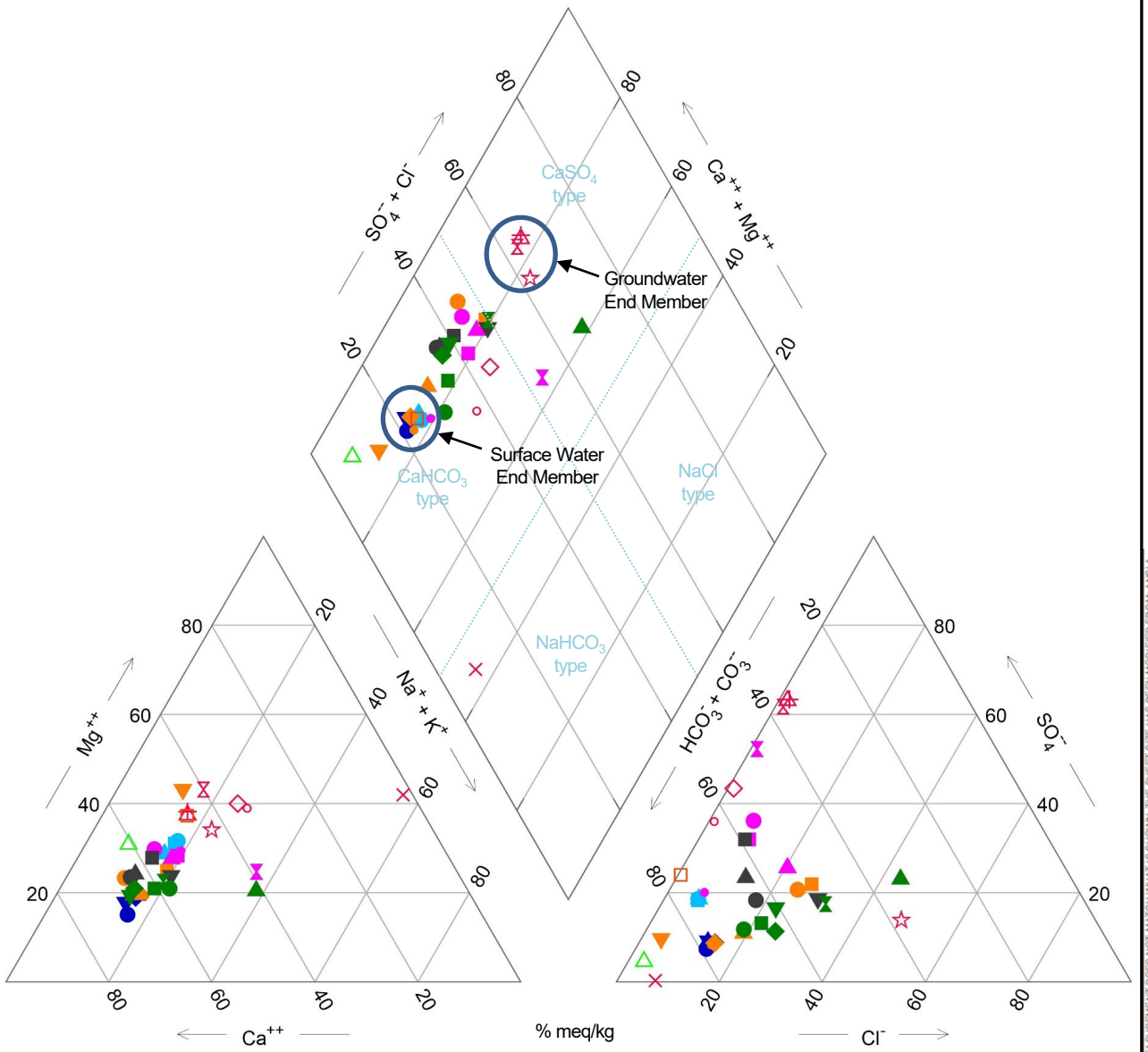
Coldwater R. MWs
- MW–4S
- MW–4D
- MW04–1D (VOGHT PARK)
- MW04–2D (CLAYBANKS)
- MW04–3S (MAY ST)
- MW04–3D (MAY ST)

Municipal Wells
- WTN 108220 (COLETTEVILLE)
- WTN114668 (VOGHT PARK WELL #1)
- WTN 34180 (VOGHT PARK WELL #2)
- WTN 38902 (FAIRLY PARK WELL)

Merritt aquifer MWs
- MW–5S (COLLETTE HICKS)
- MW–5D (COLLETTE HICKS)
- MW–3S
- MW–3D
- WTN 56918 (OBS WELL 296)
- MW07–2S (FAIRLY PARK)

Confined Aquifer Wells
- WTN 97218 (KENGARD WELL) 2016
- WTN 97208 (KENGARD WELL) NOV 2020
- WTN 97218 (KENGARD WELL) OCT 2020
- MW07–1S (KENGARD RR)
- MW07–1M (KENGARD RR)
- MW07–1D (KENGARD RR)
- MW07–2M (FAIRLY PARK)

Bedrock Well
- WTN 83868 (MT MUSIC)
- WTN 83959 (FOX FARM/MURRAY)



CLIENT
FRASER BASIN COUNCIL

CONSULTANT
GOLDER

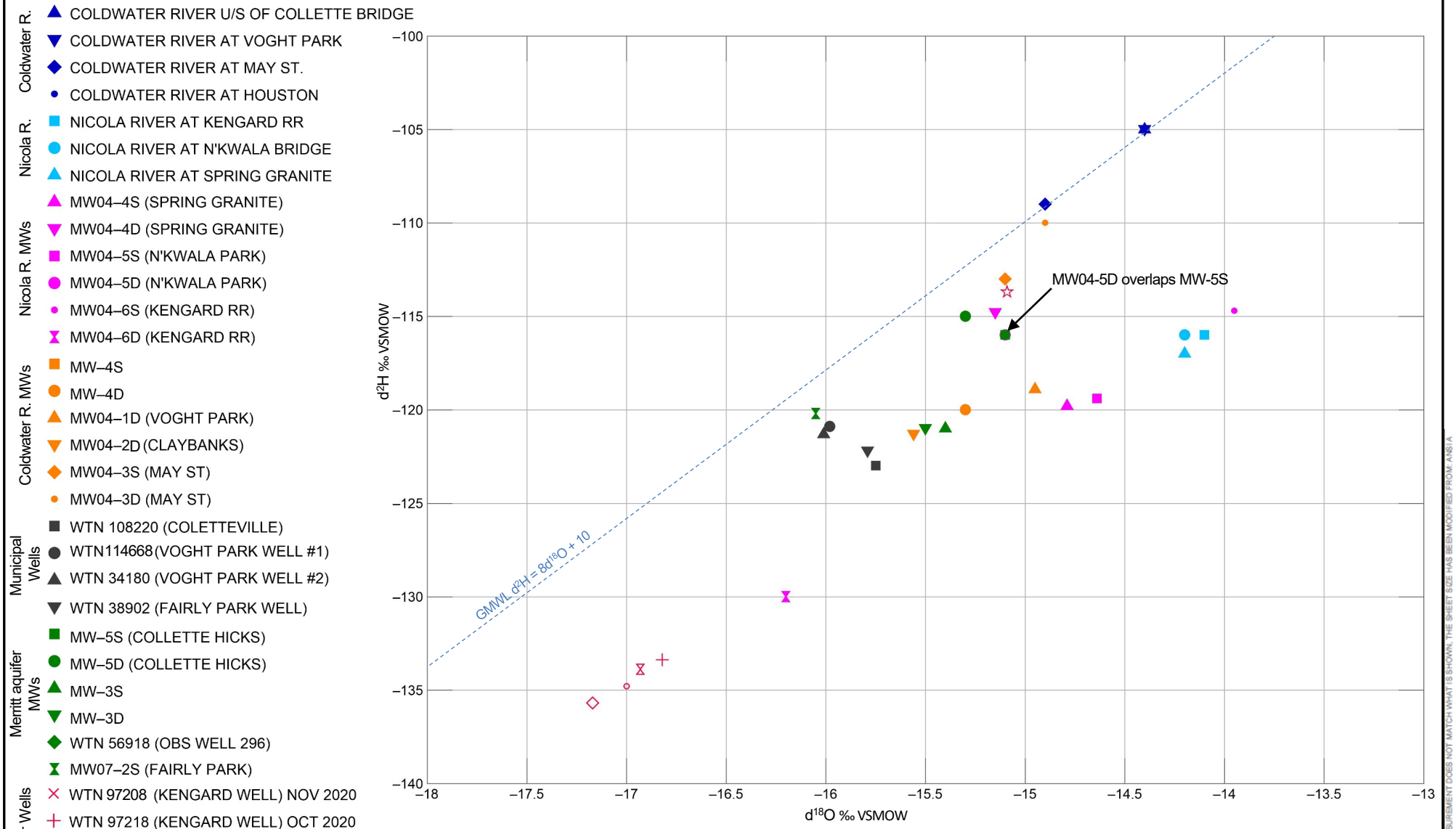
YYYY-MM-DD	2020-02-26
PREPARED	SI
DESIGNED	SI
REVIEWED	
APPROVED	

PROJECT
COLDWATER RIVER GROUNDWATER – SURFACE WATER INTERACTION STUDY

TITLE
GEOCHEMICAL ANALYSIS – PIPER PLOT

PROJECT NO.	PHASE	REV.	FIGURE
20253005	**5000**	**0**	**5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



CLIENT
FRASER BASIN COUNCIL

PROJECT
COLDWATER RIVER GROUNDWATER – SURFACE WATER INTERACTION STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	20201-01-19
PREPARED	SI
DESIGNED	KB
REVIEWED	KB
APPROVED	CR

TITLE
H_2O ISOTOPE FRACTIONATION ANALYSIS

PROJECT NO.	PHASE	REV.
20253005	**5000**	**0**

6

ATTACHMENT 1

Well Data from FLNRORD

Site Name		MW-5S Collett Hicks	MW-5D Collett Hicks	MW-3S	MW-3D	MW-4S	MW-4D	Colletteville 12727	Voght 1 GE 12729	Voght 2 VPD 12728	MW04-1S Voght Park	MW04-1D Voght Park	MW04-2S Claybanks	MW04-2D Claybanks	MW04-3S May St	MW04-3D May St	MW04-4S Spring Granite	MW04-4D Spring Granite	Fairly Park 12730	MW07-2S Fairly Park	MW07-2M Fairly Park	MW07-2D Fairly Park	MW04-5S N'Kwala Park	MW04-5D N'Kwala Park	MW04-6S Kengard RR	MW04-6D Kengard RR
Well Tag Number								40069	114668	34180	122251	122252	122255	122254	122257	122258	122262	122261	WTN 38902	122277	122276	122275	122264	122265	122267	122268
Well ID Plate								12727	12729	12728									12730							
Construction date								1978-07-08	1970	1976	2004-12-07	2004-12-07	2004-12-08	2004-12-08	2004-12-08	2004-12-08	2004-12-07	2004-12-07	1966-01-25	2007-06-22	2007-06-22	2007-06-22	2004-12-07	2004-12-07	2004-12-07	2004-12-07
well depth		5.243	9.85	5.49	10.97	5.24	9.61	49.07	30	34.75	5	9.2	6	9.2	6.5	11.2	5.6	9.3	29.87	30	57.9	132	5.5	9.9	4.8	9.4
bottom of screen								45.11		34.14	4.8	8.5	5.5	9.2	6.2	11.2	5.3	9.2	25.3	29.9	56.9	131	5.4	9.9	4.56	9.42
top of screen								39		24.69	3.3	7	4.2	6.7	4.6	9.7	4	7.7	19.2	25	53.9	128	3.6	8.2	3	7.8
well record casing stick-up		0.63	0.63	1.22	1.22	0.83	0.82				0.52	0.52	0.56	0.56	0.84	0.84	0.25	0.25		0.3	0.03	0.03	0.67	0.67	0.48	0.62
																						artesian with well packer				
Lat		50.112001	50.112001	50.114012	50.113969	50.114525	50.114531	50.109826	50.110317	50.110193	50.110221	50.110221	50.104671	50.104671	50.102388	50.102388	50.113182	50.113182	50.111135	50.111188	50.111188	50.111188	50.114785	50.114785	50.114690	50.114677
Long		120.807770	120.807770	120.809641	120.809628	120.804506	120.804537	120.803009	120.800532	120.800813	120.801606	120.801606	120.794491	120.794491	120.784409	120.784409	120.796712	120.796712	120.795010	120.795119	120.795119	120.795119	120.785641	120.785641	120.776276	120.776329
UTM 10U Easting		656738.17	656738.17	656598.32	656599.43	656961.50	656961.50	657086.16	657261.62	657241.92	657185.13	657185.13	657712.10	657712.10	658440.47	658440.47	657525.35	657525.35	657653.72	657645.78	657645.78	657645.78	658311.51	658311.51	658981.29	658977.57
Northing		5553384.84	5553384.84	5553604.50	5553599.83	5553672.98	5553672.98	5553153.15	5553212.93	5553198.49	5553199.97	5553199.97	5552597.99	5552597.99	5552365.48	5552365.48	5553539.50	5553539.50	5553315.46	5553321.11	5553321.11	5553321.11	5553741.13	5553741.13	5553750.45	5553748.93
TOC @ mASL by KABLAL											590.186	590.186	594.617	594.617	599.619	599.619										
ground at mASL by KABLAL																										
Top of Pipe ELEV (GCM) by Underhill Geomatics		588.480	588.480	587.542	587.540	588.110	588.094		590.765	590.822	590.157	590.157	594.654	594.654	598.681	598.681	589.651	589.651		591.945	591.946	591.752	593.180	593.180	594.547	594.379
Top of Cement ELEV (GCM) by Underhill Geomatics								591.481	590.765	590.822									591.310							
surface casing stick-up.																										
Production casing stick-up from top of cement pad																				0.870	0.870	0.630				
SWL (m BTOC)																										
2020-10-15 9:00													2.12	2.445												
2020-10-15 11:25																	2.33	2.42								
2020-10-19 11:45														2.35												
2020-10-20 13:20																							3.187	3.17		
2020-10-20 13:42																							3.187			
2020-10-20 14:25																	2.29	2.385								
2020-10-21 9:50																	2.28	2.374								
2020-10-21 10:30																	2.28	7.94								
2020-10-21 10:40													2.08	2.38												
2020-10-21 15:15													2.09	2.4												
2020-10-21 11:10																					4.1					
2020-10-21 12:30																				4.13						
2020-10-21 13:40												3.15														
2020-10-21 14:05											2.99															
2020-10-26 11:35																										
2020-10-26 13:05																										1.89
2020-10-26 12:35																										
2020-10-26 14:30																									2.47	
2020-10-27 10:00																										
2020-10-27 13:30																										
2020-10-28 9:50																										3.913
2020-10-28 9:45				2.84																						
2020-10-28 11:00					2.945																					
2020-10-28 10:35		3.195																								
2020-10-29 14:35															3.89	3.89										
2020-11-02 8:45																										
2020-11-02 13:06		3.08																								
2020-11-02 13:30			3.09																							
2020-11-03 9:40															3.897	3.897										
2020-11-03 10:10															3.897											
2020-11-03 12:15							2.678																			
2020-11-03 12:45						2.775																				
2020-12-09 9:40																				3.46	4.035					
2020-12-09 15:05																	2.2	2.32								
2020-12-09 10:00											3.575	3.7														
2020-12-09 12:20				1.22	1.22	1.2																				
2020-12-09 12:40		3.175	3.18																							
2020-12-09 13:00						2.815	2.725																			
2020-12-09 14:20													2.124	2.495												
2020-12-09 15:05																	2.2	2.32								
2020-12-10 9:40																							3.035	3.07		
2020-12-10 10:15																										
2020-12-10 10:50																									2.07	1.9
2020-12-10 11:20																										
2020-12-10 12:10															3.942	3.87										

Site Name	MW07-1S Kengard RR	MW07-1M Kengard RR	MW07-1D Kengard RR	Kengard Test	Kengard 29680	Nicola River Kengard RR	Nicola River N'Kwala Bridge	Nicola River Spring Granite	Coldwater R US Nicola R	Coldwater R US Collett Bridge	Coldwater R Voght Park	Coldwater R Claybanks	Coldwater R May St	Coldwater R Houston	OW 296	OW 494
Well Tag Number	122270	122274	122273	WTN 97208	WTN 97218										WTN 56918	WTN 61559
Well ID Plate					29680										21152	18704
Construction date	2007-06-23	2007-06-23	2007-06-23	2007-09-02	2007-12-10											
well depth	57	86	131.1	172.21	166.12											
bottom of screen	56.4	85	123		139.51											
top of screen	48.7	72	118.9		89.58											
well record casing stick-up	0.3	0.3	0.3													
				0.765												
Lat	50.112447	50.112447	50.112447	50.112884	50.113045	50.114753	50.114308	50.113740	50.114734	50.110303	50.109800	50.104592	50.102096	50.095782	50.107991	50.125478
Long	120.777555	120.777555	120.777555	120.777805	120.778056	120.547500	120.786109	120.796445	120.803901	120.803104	120.800718	120.794465	120.784092	120.777609	120.788610	120.746775
UTM 10U Easting	658897.28	658897.28	658897.28	658877.96	658859.47	659038.33	658279.63	657542.62	657006.30	657077.83	657250.01	657714.22	658464.09	658948.59	658103.68	661054.89
Northing	5553498.31	5553498.31	5553498.31	5553546.38	5553563.80	5553759.16	5553687.04	5553602.03	5553696.84	5553205.95	5553155.04	5552589.19	5552333.69	5551645.60	5552978.94	5555013.29
TOC @ mASL by KABLAL																
ground at mASL by KABLAL															594.910	
Top of Pipe ELEV (GCM) by Underhill Geomatics	596.923	596.923	596.923	596.895	596.039										596.183	630.337
Top of Cement ELEV (GCM) by Underhill Geomatics																
surface casing stick-up.																
Production casing stick-up from top of cement pad																
SWL (m BTOC)																
2020-10-15 9:00																
2020-10-15 11:25																
2020-10-19 11:45																
2020-10-20 13:20																
2020-10-20 13:42																
2020-10-20 14:25																
2020-10-21 9:50																
2020-10-21 10:30																
2020-10-21 10:40																
2020-10-21 15:15																
2020-10-21 11:10																
2020-10-21 12:30																
2020-10-21 13:40																
2020-10-21 14:05																
2020-10-26 11:35	4.256															
2020-10-26 13:05																
2020-10-26 12:35		4.113														
2020-10-26 14:30																
2020-10-27 10:00			4.145													
2020-10-27 13:30	4.285	4.22														
2020-10-28 9:50																
2020-10-28 9:45																
2020-10-28 11:00																
2020-10-28 10:35																
2020-10-29 14:35																
2020-11-02 8:45				4.08												
2020-11-02 13:06																
2020-11-02 13:30																
2020-11-03 9:40																
2020-11-03 10:10																
2020-11-03 12:15																
2020-11-03 12:45																
2020-12-09 9:40																
2020-12-09 15:05																
2020-12-09 10:00																
2020-12-09 12:20																
2020-12-09 12:40																
2020-12-09 13:00																
2020-12-09 14:20																
2020-12-09 15:05																
2020-12-10 9:40																
2020-12-10 10:15	4.135	4.215	4.175													
2020-12-10 10:50																
2020-12-10 11:20				4.14												
2020-12-10 12:10																

ATTACHMENT 2

Water Quality data from FLNRORD

Site Name		MW 5 S Collett Hicks	MW 5 D Collett Hicks	MW 3 S	MW 3 D	MW 4 S	MW 4 D	Colletteville 12727	Voght 1 GE 12729	Voght 2 VPD 12728	MW04-1 S Voght Park	MW04-1 D Voght Park	MW04-2 D Claybanks	MW04-3 S May St	MW04-3 D May St	MW04-4 S Spring Granite	MW04-4 D Spring Granite	Fairly Park 12730	MW07-2 S Fairly Park	MW07-2 M Fairly Park	MW04-5 S N'Kwala Park
Client REQ ID		50251456	50251109	50251459	50251151	50251460	50251138	50251147	50251146	50251143	20251110	20251113	20251106	20251126	20251127	50251122	20251123	50251139	50251134	50251118	20251130
Client Sample ID		E321933_REG	E321762_REG	E321932_REG	E206590_REG	E321931_REG	E206592_REG	E250649_REG	E250652_REG	E250653_REG	E321761_REG	E321760_REG	E321763_REG	E321751_REG	E321752_REG	E321756_REG	E321763_REG	E250650_REG	E321732_REG	E321757_REG	E321754_REG
Date Sampled		02-Nov-2020	02-Nov-2020	28-Oct-2020	28-Oct-2020	03-Nov-2020	03-Nov-2020	19-Oct-2020	19-Oct-2020	19-Oct-2020	21-Oct-2020	21-Oct-2020	21-Oct-2020	03-Nov-2020	03-Nov-2020	15-Oct-2020	21-Oct-2020	19-Oct-2020	21-Oct-2020	21-Oct-2020	20-Oct-2020
Time Sampled		13:10	13:40	10:45	11:05	12:40	12:23	11:30	11:15	11:05	14:10	13:55	15:55	10:15	09:53	11:45	15:55	10:40	12:50	12:10	13:47
ALS Sample ID		VA20B9869-001	VA20B9870-001	VA20B9436-001	VA20B9443-001	VA20B9949-001	VA20B9963-001	VA20B8526-001	VA20B8522-001	VA20B8518-001	VA20B8846-001	VA20B8853-001	VA20B8845-001	VA20B9968-001	VA20B9970-001	VA20B8260-001	VA20B8845-001	VA20B8532-001	VA20B8852-001	VA20B8847-001	VA20B8675-001
Analyte	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
Field Tests (Matrix: Water)																					
conductivity, field	µS/cm	206.4	169.4	649	481.0	438.6	541.3	414.6	274.7	280.4	231.4	190.6	200.0	153.8	105.7	578.3	200.0	544.5	307.0	195.5	688
oxygen, dissolved, field	mg/L	4.52	4.09	3.65	5.57	12.9	1.22	2.68	3.7	1.75	6.65	4.69	8.21	6.73	8.44	2.57	8.21	11.54	7.62	7.77	4.27
pH, field	pH units	7.04	7.19	6.17	7.62	6.97	7.35	7.45	6.96	6.98	7.64	6.79	8.23	7.00	7.48	7.13	8.23	7.68	8.16	10.8	6.96
redox potential, field	mV	191.0	210.1	292.7	272.5	282.3	254.4	71.7	187.8	202.2	24.6	236.2	21.7	306.8	287.5	147.4	21.7	244.2	-209.1	-369.0	46.2
temperature, field	°C	11.0	9.1	16.9	14.7	12.9	10.7	9.8	10.1	10.2	10.5	12.6	8.7	12.9	13.0	12.3	8.7	10.7	11.0	11.0	11.7
Physical Tests (Matrix: Water)																					
conductivity	µS/cm	249	206	835	501	538	666	473	312	316	258	258	233	188	135	677	233	626	699	191	799
alkalinity, total (as CaCO3)	mg/L	84.9	74.9	149	177	154	208	166	113	115	82.2	92.1	118	74.5	54.1	202	118	189	200	55.1	271
hardness (as CaCO3), dissolved	mg/L	105	83.9	252	218	235	334	209	140	143	85.3	105	104	87.3	58.1	298	104	256	285	246	341
pH	pH units	7.37	7.45	7.62	8.03	7.57	8.00	7.98	7.58	7.65	7.91	7.41	8.18	7.25	7.74	7.66	8.18	8.11	7.93	9.83	7.16
solids, total dissolved [TDS]	mg/L	146	112	503	321	331	400	304	196	197	181	160	173	121	88	375	173	406	438	116	501
turbidity	NTU	1.54	0.68	0.95	0.83	0.21	168	0.36	<0.10	<0.10	>4000	<0.10	1220	345	<0.10	0.86	1220	<0.10	18.1	1.52	8.10
alkalinity, phenolphthalein (as CaCO3)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	16.3	<1.0
alkalinity, hydroxide (as CaCO3)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
alkalinity, carbonate (as CaCO3)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	32.6	<1.0
alkalinity, bicarbonate (as CaCO3)	mg/L	84.9	74.9	149	177	154	208	166	113	115	82.2	92.1	118	74.5	54.1	202	118	189	200	22.5	271
Anions and Nutrients (Matrix: Water)																					
Kjeldahl nitrogen, dissolved [DKN]	mg/L	0.088	0.059	1.30	0.153	1.15	0.387	<0.050	0.068	<0.050	0.055	<0.050	0.109	0.064	<0.050	0.278	0.109	0.269	0.290	0.289	0.206
ammonia, total dissolved (as N)	mg/L	<0.0050	<0.0050	0.928	<0.0050	<0.0050	0.137	<0.0050	<0.0050	<0.0050	0.0386	<0.0050	0.0807	<0.0050	<0.0050	0.0066	0.0807	<0.0050	0.0151	<0.0050	0.0067
chloride	mg/L	16.4	11.9	114	38.7	47.5	55.4	14.9	18.6	14.3	9.56	14.8	3.21	8.38	5.87	44.7	3.21	63.9	73.6	16.8	26.8
fluoride	mg/L	0.050	0.049	0.120	0.048	0.078	<0.100	0.091	0.043	0.050	0.075	0.046	0.152	0.102	0.060	0.099	0.152	0.057	<0.100	0.083	<0.100
nitrate (as N)	mg/L	0.466	0.197	1.25	0.985	1.31	1.72	0.150	0.391	0.264	0.0693	0.517	0.0045	0.0288	0.0293	2.51	0.0045	1.79	1.18	<0.0030	0.147
nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0050	<0.0010	<0.0010	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	<0.0050
nitrogen, total dissolved	mg/L	0.522	0.222	2.48	0.910	2.21	2.16	0.178	0.410	0.295	0.130	1.46	0.122	0.081	0.089	2.68	0.122	1.85	1.32	0.210	0.396
phosphorus, total dissolved	mg/L	0.0092	0.0046	0.270	0.0029	0.0039	0.0217	0.0050	<0.0020	0.0023	0.0237	0.0046	0.0989	0.0064	0.0030	0.0064	0.0989	0.0031	0.0027	0.0119	0.0105
sulfate (as SO4)	mg/L	13.4	9.97	81.5	37.6	51.8	62.1	70.6	25.5	33.6	7.91	11.4	10.2	6.63	4.55	75.6	10.2	53.1	54.3	6.48	117
Ion Balance (Matrix: Water)																					
anion sum	meq/L	2.47	2.06	8.00	5.49	5.60	7.14	5.23	3.35	3.43	2.09	2.54	2.68	1.87	1.35	7.06	2.68	6.81	7.30	1.72	8.64
cation sum	meq/L	2.57	2.13	8.26	5.10	5.79	7.57	4.90	3.19	3.29	2.02	2.48	2.41	2.06	1.41	7.30	2.41	6.42	7.09	6.40	8.45
ion balance (cation-anion difference)	%	1.98	1.67	1.60	3.68	1.67	2.92	3.26	2.45	2.08	1.70	1.20	5.30	4.83	2.17	1.67	5.30	2.95	1.46	57.6	1.11

Site Name		MW 5 S Collett Hicks	MW 5 D Collett Hicks	MW 3 S	MW 3 D	MW 4 S	MW 4 D	Colletteville 12727	Voght 1 GE 12729	Voght 2 VPD 12728	MW04-1 S Voght Park	MW04-1 D Voght Park	MW04-2 D Claybanks	MW04-3 S May St	MW04-3 D May St	MW04-4 S Spring Granite	MW04-4 D Spring Granite	Fairly Park 12730	MW07-2 S Fairly Park	MW07-2 M Fairly Park	MW04-5 S N'Kwala Park
Client REQ ID		50251456	50251109	50251459	50251151	50251460	50251138	50251147	50251146	50251143	20251110	20251113	20251106	20251126	20251127	50251122	20251123	50251139	50251134	50251118	20251130
Client Sample ID		E321933_REG	E321762_REG	E321932_REG	E206590_REG	E321931_REG	E206592_REG	E250649_REG	E250652_REG	E250653_REG	E321761_REG	E321760_REG	E321763_REG	E321751_REG	E321752_REG	E321756_REG	E321763_REG	E250650_REG	E321732_REG	E321757_REG	E321754_REG
Date Sampled		02-Nov-2020	02-Nov-2020	28-Oct-2020	28-Oct-2020	03-Nov-2020	03-Nov-2020	19-Oct-2020	19-Oct-2020	19-Oct-2020	21-Oct-2020	21-Oct-2020	21-Oct-2020	03-Nov-2020	03-Nov-2020	15-Oct-2020	21-Oct-2020	19-Oct-2020	21-Oct-2020	21-Oct-2020	20-Oct-2020
Time Sampled		13:10	13:40	10:45	11:05	12:40	12:23	11:30	11:15	11:05	14:10	13:55	15:55	10:15	09:53	11:45	15:55	10:40	12:50	12:10	13:47
ALS Sample ID		VA20B9869-001	VA20B9870-001	VA20B9436-001	VA20B9443-001	VA20B9949-001	VA20B9963-001	VA20B8526-001	VA20B8522-001	VA20B8518-001	VA20B8846-001	VA20B8853-001	VA20B8845-001	VA20B9968-001	VA20B9970-001	VA20B8260-001	VA20B8845-001	VA20B8532-001	VA20B8852-001	VA20B8847-001	VA20B8675-001
Dissolved Metals (Matrix: Water)																					
aluminum, dissolved	mg/L	0.0045	0.0010	0.0015	0.0262	0.0387	0.139	<0.0010	<0.0010	<0.0010	0.113	0.0012	0.0064	0.0020	0.0039	<0.0010	0.0064	<0.0010	<0.0010	0.0020	0.0020
antimony, dissolved	mg/L	<0.00010	<0.00010	0.00019	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00017	<0.00010	<0.00010	0.00027	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00015
arsenic, dissolved	mg/L	0.00017	0.00013	0.00116	<0.00010	0.00018	0.00023	0.00052	<0.00010	<0.00010	0.00042	0.00012	0.00404	0.00016	0.00022	0.00021	0.00404	0.00011	0.00031	0.00126	0.00034
barium, dissolved	mg/L	0.0545	0.0404	0.192	0.111	0.137	0.0789	0.0658	0.0660	0.0627	0.110	0.0741	0.0251	0.0544	0.0318	0.157	0.0251	0.151	0.116	0.0362	0.145
beryllium, dissolved	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
bismuth, dissolved	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, dissolved	mg/L	0.021	0.020	0.173	0.029	0.023	0.027	0.018	0.013	0.014	<0.010	<0.010	0.013	<0.010	<0.010	0.031	0.013	0.019	0.017	0.042	0.036
cadmium, dissolved	mg/L	0.0000297	0.0000056	0.000213	0.0000129	0.0000134	0.0000300	<0.0000100	<0.0000050	<0.0000050	0.0000286	0.0000083	<0.0000050	0.0000506	<0.0000050	0.0000072	<0.0000050	0.0000199	<0.0000050	<0.0000050	0.0000213
calcium, dissolved	mg/L	31.3	24.7	67.4	67.5	65.2	98.5	56.6	40.9	41.4	26.4	32.4	21.1	26.6	17.8	78.9	21.1	72.0	82.4	55.0	88.7
chromium, dissolved	mg/L	0.00012	0.00011	<0.00010	0.00022	<0.00010	0.00015	<0.00010	<0.00010	0.00012	0.00017	<0.00010	<0.00010	<0.00010	<0.00010	0.00018	<0.00010	0.00016	0.00029	<0.00010	0.00017
cobalt, dissolved	mg/L	<0.00010	<0.00010	0.00252	0.00011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00010
copper, dissolved	mg/L	0.00123	0.00085	0.0150	0.00151	0.00092	0.00072	0.00050	0.00122	0.00176	0.00154	0.00062	<0.00020	0.00114	0.00120	0.00147	<0.00020	0.00130	0.00020	<0.00020	0.00248
iron, dissolved	mg/L	<0.0050	<0.0050	0.0271	0.0360	<0.0050	0.0120	<0.0050	<0.0050	<0.0050	0.118	<0.0050	0.0874	<0.0050	0.0069	0.0077	0.0874	<0.0050	0.347	0.114	0.0543
lead, dissolved	mg/L	<0.000050	<0.000050	0.000115	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000118	0.000169	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
magnesium, dissolved	mg/L	6.55	5.42	20.3	11.9	17.5	21.3	16.5	9.07	9.68	4.68	5.89	12.5	5.09	3.30	24.5	12.5	18.5	19.2	26.5	29.0
manganese, dissolved	mg/L	0.00116	<0.00010	0.223	0.00358	0.00019	0.103	0.00296	0.00094	<0.00010	0.00789	<0.00010	0.292	0.00019	0.00012	0.00087	0.292	0.00020	0.0962	0.0821	0.0644
molybdenum, dissolved	mg/L	0.000472	0.000415	0.00340	0.000456	0.000813	0.000563	0.00216	0.000453	0.000569	0.000745	0.000375	0.00265	0.000800	0.000705	0.00121	0.00265	0.000540	0.000669	0.00597	0.00119
nickel, dissolved	mg/L	<0.00050	<0.00050	0.00646	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00050	0.00095	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00190
phosphorus, dissolved	mg/L	0.016	0.010	0.279	<0.010	0.010	0.022	<0.010	<0.010	<0.010	0.032	<0.010	0.085	0.019	<0.010	<0.010	0.085	<0.010	<0.010	0.017	<0.010
potassium, dissolved	mg/L	1.41	1.39	16.4	2.13	1.66	2.57	2.30	1.26	1.41	1.07	0.851	1.76	1.09	0.760	2.47	1.76	2.24	2.49	5.44	3.52
selenium, dissolved	mg/L	0.000114	0.000072	0.000177	0.000143	0.000441	0.000405	<0.000050	0.000079	<0.000050	0.000054	0.000103	<0.000050	<0.000050	<0.000050	0.000483	<0.000050	0.000441	0.000392	0.000143	0.000136
silicon, dissolved	mg/L	4.76	4.16	7.20	6.07	5.64	7.24	7.10	6.28	6.49	4.97	5.18	7.71	5.22	4.11	6.68	7.71	6.66	6.31	7.21	8.44
silver, dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000070	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, dissolved	mg/L	10.1	9.68	62.7	15.8	24.1	18.4	15.0	8.46	9.07	6.17	8.15	6.06	6.59	5.18	29.4	6.06	28.6	30.2	30.6	35.5
strontium, dissolved	mg/L	0.192	0.153	0.469	0.384	0.452	0.522	0.345	0.248	0.256	0.153	0.198	0.137	0.163	0.113	0.544	0.137	0.547	0.548	0.406	0.525
sulfur, dissolved	mg/L	4.32	3.26	28.0	12.1	16.7	20.7	23.4	8.03	11.0	2.39	4.26	3.55	2.14	1.60	26.2	3.55	18.2	21.5	53.8	44.5
thallium, dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
tin, dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
titanium, dissolved	mg/L	<0.00030	<0.00030	<0.00030	0.00135	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	0.00415	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
uranium, dissolved	mg/L	0.000160	0.000132	0.000377	0.000666	0.00138	0.00147	0.00164	0.000359	0.000496	0.000219	0.000145	0.00122	0.000102	0.000117	0.00204	0.00122	0.00119	0.00108	0.00252	0.00199
vanadium, dissolved	mg/L	0.00060	0.00053	0.00471	<0.00050	0.00080	0.00085	0.00099	<0.00050	<0.00050	0.00081	<0.00050	<0.00050	0.00061	0.00094	0.00087	<0.00050	0.00060	<0.00050	<0.00050	0.00090
zinc, dissolved	mg/L	0.0012	<0.0010	0.0029	<0.0010	0.0011	0.0025	<0.0010	0.0017	0.0032	0.0029	<0.0010	0.0015	0.0026	<0.0010	<0.0010	0.0015	0.0017	0.0359	<0.0010	0.0013
dissolved metals filtration location		Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field

$\delta^{18}O$	‰ VSMOW	-15.1	-15.3	-15.4	-15.5	-15.10	-15.30	-15.75	-15.98	-16.01	-16.76	-14.95	-15.56	-15.10	-14.90	-14.79	-15.15	-15.79	-16.05	-15.09	-14.64
	±1σ	0.10	0.13	0.08	0.06	0.08	0.03	0.02	0.09	0.06	0.03	0.03	0.02	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.02
$\delta^{2}H$	‰ VSMOW	-116	-115	-121	-121	-116.00	-120.00	-123.0	-120.9	-121.3	-133.0	-118.9	-121.3	-113.0	-110.00	-119.8	-114.8	-122.2	-120.2	-113.7	-119.4
	±1σ	0.48	1.06	0.31	0.62	0.21	0.05	0.07	0.20	0.13	0.05	0.09	0.08	0.45	0.12	0.04	0.07	0.07	0.02	0.12	0.08

Site Name		MW04-5 D N'Kwala Park	MW04-6 S Kengard RR	MW04-6 D Kengard RR	MW07-1 S Kengard RR	MW07-1 M Kengard RR	MW07-1 D Kengard RR	Kengard Test	Kengard 29680	Nicola River Kengard RR	Nicola River N'Kwala Bridge	Nicola River Spring Granite	Coldwater R US Nicola R	Coldwater R US Collett Bridge	Coldwater R Voght Park	Coldwater R Claybanks	Coldwater R May St	Coldwater R Houston
Client REQ ID		20251131	20251360	20251099	50251356	50251359	50251117	50251096	50251154	50251656	50251658	50251659	50251660	50251657	50251661	50251258	50251262	50251265
Client Sample ID		E321753_REG	E321851_REG	E321766_REG	E321853_REG	E321852_REG	E321758_REG	E321765_REG	E307146_REG	E322351_REG	E322352_REG	E322353_REG	E322354_REG	E279294_REG	E322355_REG	E206272_REG	E321832_REG	E321831_REG
Date Sampled		20-Oct-2020	26-Oct-2020	28-Oct-2020	26-Oct-2020	26-Oct-2020	27-Oct-2020	02-Nov-2020	27-Oct-2020	05-Nov-2020	05-Nov-2020	05-Nov-2020	05-Nov-2020	09-Nov-2020	09-Nov-2020	05-Nov-2020	03-Nov-2020	09-Nov-2020
Time Sampled		13:35	14:30	09:58	11:55	14:15	13:30	12:00	11:00	09:25	08:40	12:10	11:00	12:00	12:25	10:15	10:55	14:15
ALS Sample ID		VA20B8674-001	VA20B9161-001	VA20B9453-001	VA20B9154-001	VA20B9153-001	VA20B9335-001	VA20B9828-001	VA20B9331-001	VA20C0278-001	VA20C0279-001	VA20C0280-001	VA20C0215-001	VA20C0411-001	VA20C0414-001	VA20C0220-001	VA20B9940-001	VA20C0410-001
Analyte	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
Field Tests (Matrix: Water)																		
conductivity, field	µS/cm	621.9	252.9	459.1	577.8	497.9	705	218.5	824	213.3	213.2	214.3	39.6	71.1	71.3	39.4	84.4	70.2
oxygen, dissolved, field	mg/L	2.2	3.34	9.33	0.15	0.09	3.13	0.95	2.63	11.17	11.0	11.57	12.14	14.59	14.17	11.43	13.2	14.14
pH, field	pH units	7.08	7.36	8.05	8.47	8.21	8.23	10.1	7.9	8.12	8.13	8.28	7.84	7.96	7.82	7.88	7.99	7.23
redox potential, field	mV	126.5	213.3	267.8	-220.7	-234.7	-116.1	-42.7	89.3	273.7	222.3	313.9	295.6	267.2	281.8	290.8	262.9	278.3
temperature, field	°C	11.0	12.2	8.4	10.2	10.7	10.6	10.4	12.9	7.7	7.5	7.9	6.2	0.0	0.1	6.2	4.4	0.1
Physical Tests (Matrix: Water)																		
conductivity	µS/cm	775	299	521	581	506	821	265	962	265	265	265	49.5	87.8	86.0	49.8	104	85.3
alkalinity, total (as CaCO3)	mg/L	249	118	152	201	187	191	141	219	115	114	115	21.0	35.8	35.7	21.5	40.3	35.5
hardness (as CaCO3), dissolved	mg/L	350	132	180	244	193	385	70.0	459	122	116	131	20.6	40.8	38.2	20.4	45.8	37.5
pH	pH units	7.32	7.82	7.96	8.48	8.40	8.25	9.63	8.17	8.20	8.20	8.15	7.36	7.69	7.71	7.39	7.79	7.67
solids, total dissolved [TDS]	mg/L	509	192	340	366	315	592	126	700	158	170	173	58	61	61	48	70	61
turbidity	NTU	0.58	26.0	1770	6.12	0.70	2.72	0.95	0.23	5.22	8.06	4.66	177	1.34	1.65	198	0.84	1.26
alkalinity, phenolphthalein (as CaCO3)	mg/L	<1.0	<1.0	<1.0	4.8	3.0	<1.0	30.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
alkalinity, hydroxide (as CaCO3)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
alkalinity, carbonate (as CaCO3)	mg/L	<1.0	<1.0	<1.0	9.6	6.0	<1.0	61.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
alkalinity, bicarbonate (as CaCO3)	mg/L	249	118	152	192	181	191	79.8	219	115	114	115	21.0	35.8	35.7	21.5	40.3	35.5
Anions and Nutrients (Matrix: Water)																		
Kjeldahl nitrogen, dissolved [DKN]	mg/L	0.272	0.231	0.316	0.077	0.071	0.080	0.076	0.067	0.354	0.341	0.357	0.139	0.093	0.196	0.133	0.082	0.080
ammonia, total dissolved (as N)	mg/L	0.0314	0.0083	0.0656	0.0368	0.0502	0.0353	<0.0050	0.0334	0.0213	0.0243	0.0127	0.0092	<0.0050	<0.0050	0.0104	<0.0050	<0.0050
chloride	mg/L	22.6	6.80	2.52	2.42	1.82	4.84	3.78	7.36	6.01	5.95	6.08	1.38	3.59	3.59	1.34	4.56	3.61
fluoride	mg/L	<0.100	0.136	0.260	0.187	0.193	0.128	0.152	0.130	0.100	0.102	0.100	0.039	0.036	0.036	0.029	0.041	0.036
nitrate (as N)	mg/L	<0.0150	<0.0030	0.190	<0.0030	<0.0030	<0.0150	<0.0030	<0.0150	0.0783	0.0738	0.0646	<0.0030	0.0111	0.0104	<0.0030	<0.0030	0.0115
nitrite (as N)	mg/L	<0.0050	<0.0010	0.0024	<0.0010	<0.0010	<0.0050	<0.0010	<0.0050	0.0013	0.0014	0.0020	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
nitrogen, total dissolved	mg/L	0.298	0.254	0.491	0.075	0.085	0.078	0.065	0.075	0.429	0.447	0.443	0.141	0.097	0.206	0.132	0.065	0.093
phosphorus, total dissolved	mg/L	0.0084	0.0151	0.0707	0.0256	0.0408	0.0102	0.0033	0.0107	0.0204	0.0207	0.0228	0.0061	<0.0020	<0.0020	0.0064	<0.0020	<0.0020
sulfate (as SO4)	mg/L	128	25.5	134	118	81.3	253	<0.30	314	22.1	22.2	22.6	1.55	3.26	3.26	1.42	3.62	3.26
nitrate + nitrite (as N)	mg/L	<0.0158	<0.0050	0.193	<0.0050	<0.0050	<0.0158	<0.0050	<0.0158	0.0796	0.0752	0.0666	<0.0050	0.0116	0.0108	<0.0050	<0.0050	0.0119
Ion Balance (Matrix: Water)																		
anion sum	meq/L	8.29	3.08	5.93	6.56	5.50	9.23	2.93	11.1	2.93	2.93	2.96	0.49	0.89	0.88	0.50	1.01	0.88
cation sum	meq/L	8.17	3.29	6.10	6.51	5.32	9.28	3.19	11.0	2.96	2.82	3.14	0.50	0.98	0.90	0.49	1.09	0.89
ion balance (cation-anion difference)	%	0.729	3.30	1.41	0.382	1.66	0.270	4.25	0.452	0.509	1.91	2.95	1.01	4.81	1.12	1.01	3.81	0.565

Site Name		MW04-5 D N'Kwala Park	MW04-6 S Kengard RR	MW04-6 D Kengard RR	MW07-1 S Kengard RR	MW07-1 M Kengard RR	MW07-1 D Kengard RR	Kengard Test	Kengard 29680	Nicola River Kengard RR	Nicola River N'Kwala Bridge	Nicola River Spring Granite	Coldwater R US Nicola R	Coldwater R US Collett Bridge	Coldwater R Voght Park	Coldwater R Claybanks	Coldwater R May St	Coldwater R Houston
Client REQ ID		20251131	20251360	20251099	50251356	50251359	50251117	50251096	50251154	50251656	50251658	50251659	50251660	50251657	50251661	50251258	50251262	50251265
Client Sample ID		E321753_REG	E321851_REG	E321766_REG	E321853_REG	E321852_REG	E321758_REG	E321765_REG	E307146_REG	E322351_REG	E322352_REG	E322353_REG	E322354_REG	E279294_REG	E322355_REG	E206272_REG	E321832_REG	E321831_REG
Date Sampled		20-Oct-2020	26-Oct-2020	28-Oct-2020	26-Oct-2020	26-Oct-2020	27-Oct-2020	02-Nov-2020	27-Oct-2020	05-Nov-2020	05-Nov-2020	05-Nov-2020	05-Nov-2020	09-Nov-2020	09-Nov-2020	05-Nov-2020	03-Nov-2020	09-Nov-2020
Time Sampled		13:35	14:30	09:58	11:55	14:15	13:30	12:00	11:00	09:25	08:40	12:10	11:00	12:00	12:25	10:15	10:55	14:15
ALS Sample ID		VA20B8674-001	VA20B9161-001	VA20B9453-001	VA20B9154-001	VA20B9153-001	VA20B9335-001	VA20B9828-001	VA20B9331-001	VA20C0278-001	VA20C0279-001	VA20C0280-001	VA20C0215-001	VA20C0411-001	VA20C0414-001	VA20C0220-001	VA20B9940-001	VA20C0410-001
Dissolved Metals (Matrix: Water)																		
aluminum, dissolved	mg/L	0.0040	0.0020	1.93	0.0013	0.0017	0.0031	<0.0010	0.0010	0.0022	0.0035	0.0130	0.0525	0.0350	0.0268	0.0627	0.0153	0.0321
antimony, dissolved	mg/L	0.00011	0.00012	0.00057	<0.00010	<0.00010	<0.00010	0.00014	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
arsenic, dissolved	mg/L	0.00044	0.00060	0.00286	0.00135	0.00245	0.00358	0.00015	0.00248	0.00119	0.00117	0.00113	0.00017	0.00021	0.00011	0.00017	0.00012	0.00012
barium, dissolved	mg/L	0.136	0.0511	0.0520	0.0547	0.0469	0.0459	0.00131	0.0660	0.0273	0.0277	0.0282	0.0136	0.0322	0.0261	0.0150	0.0318	0.0277
beryllium, dissolved	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
bismuth, dissolved	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, dissolved	mg/L	0.019	0.012	0.089	0.050	0.058	0.044	0.036	0.054	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
cadmium, dissolved	mg/L	0.0000851	0.0000224	0.000726	<0.0000050	<0.0000050	<0.0000100	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000074	0.0000080	0.0000056	<0.0000050	<0.0000050
calcium, dissolved	mg/L	91.7	33.7	44.2	45.5	35.8	74.2	1.23	100	30.6	28.7	34.5	6.60	12.6	12.1	6.55	14.2	11.7
chromium, dissolved	mg/L	0.00028	0.00011	0.00310	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00011	0.00010	0.00012	<0.00010	0.00011	<0.00010	<0.00010	<0.00010	0.00011
cobalt, dissolved	mg/L	0.00056	<0.00010	0.00120	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
copper, dissolved	mg/L	0.00335	0.00457	0.0149	<0.00020	<0.00020	<0.00020	<0.00020	0.00034	0.00197	0.00191	0.00185	0.00121	0.00083	0.00131	0.00106	0.00052	0.00069
iron, dissolved	mg/L	0.0128	<0.0050	3.66	0.0681	0.0645	0.310	0.0214	0.0594	0.0178	0.0178	0.0266	0.0408	0.0220	0.0181	0.0540	0.0150	0.0200
lead, dissolved	mg/L	<0.000050	<0.000050	0.0959	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
magnesium, dissolved	mg/L	29.4	11.7	17.0	31.5	25.1	48.5	16.2	50.6	11.1	10.8	11.0	1.01	2.30	1.91	0.994	2.49	2.01
manganese, dissolved	mg/L	0.783	0.0482	0.0976	0.0677	0.0526	0.0445	0.0118	0.112	0.0258	0.0240	0.0244	0.00590	0.00512	0.00454	0.00639	0.00328	0.00452
molybdenum, dissolved	mg/L	0.00162	0.00403	0.167	0.00720	0.00798	0.00484	0.00477	0.00511	0.00200	0.00210	0.00196	0.000220	0.000397	0.000364	0.000217	0.000382	0.000359
nickel, dissolved	mg/L	0.00198	0.00103	0.00273	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00067	0.00060	0.00091	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
phosphorus, dissolved	mg/L	<0.010	0.021	0.194	0.027	0.042	<0.020	<0.010	0.013	0.015	0.018	0.022	0.018	<0.010	<0.010	<0.010	<0.010	<0.010
potassium, dissolved	mg/L	3.08	4.28	3.19	6.99	6.12	5.91	6.81	6.07	3.11	3.07	3.05	0.468	0.465	0.406	0.478	0.501	0.419
selenium, dissolved	mg/L	0.000064	0.000256	<0.000050	0.000302	<0.000050	<0.000050	<0.000050	<0.000050	0.000155	0.000166	0.000176	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
silicon, dissolved	mg/L	7.70	4.60	8.38	9.84	10.5	9.27	0.113	9.51	3.97	3.76	3.80	2.10	3.23	3.17	2.11	3.17	3.28
silver, dissolved	mg/L	<0.000010	<0.000010	0.000011	<0.000010	<0.000010	<0.000020	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, dissolved	mg/L	24.5	12.1	45.6	33.4	30.0	32.5	37.2	37.5	9.93	9.68	10.1	1.46	3.26	2.73	1.45	3.66	2.97
strontium, dissolved	mg/L	0.581	0.214	0.296	0.434	0.292	0.573	0.00594	0.751	0.177	0.179	0.181	0.0452	0.0855	0.0812	0.0458	0.0962	0.0824
sulfur, dissolved	mg/L	46.9	8.95	41.5	42.9	28.9	92.5	<0.50	115	7.36	6.78	7.01	0.57	1.55	0.58	<0.50	1.38	0.62
thallium, dissolved	mg/L	<0.000010	<0.000010	0.000020	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
tin, dissolved	mg/L	<0.00010	<0.00010	0.00103	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
titanium, dissolved	mg/L	<0.00030	<0.00030	0.171	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	0.00058	0.00079	0.00052	<0.00030	0.00186	<0.00030	0.00046
uranium, dissolved	mg/L	0.00168	0.000470	0.00585	0.00306	0.00345	0.00233	<0.000010	0.00449	0.000648	0.000679	0.000676	0.000078	0.000103	0.000099	0.000075	0.000107	0.000098
vanadium, dissolved	mg/L	0.00075	0.00100	0.0115	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00140	0.00131	0.00121	0.00053	<0.00050	<0.00050	0.00059	<0.00050	<0.00050
zinc, dissolved	mg/L	0.0054	0.0013	2.47	0.0015	0.0014	<0.0010	<0.0010	0.0017	0.0020	0.0013	<0.0010	<0.0010	<0.0010	0.0025	<0.0010	<0.0010	<0.0010
dissolved metals filtration location		Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field

$\delta^{18}O$	‰ VSMOW	-15.1	-13.95	-16.2	-17.17	-17.00	-16.93	-16.6	-16.82	-14.10	-14.20	-14.20	-13.80	-14.40	-14.40	-13.90	-14.90	-14.40
	±1σ	0.10	0.02	0.05	0.05	0.01	0.03	0.04	0.02	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.01
$\delta^{2}H$	‰ VSMOW	-116	-114.7	-130	-135.7	-134.8	-133.9	-133	-133.4	-116.00	-116.00	-117.00	-99.00	-105.00	-105.00	-100.00	-109.00	-105.00
	±1σ	0.48	0.09	0.98	0.11	0.12	0.12	1.31	0.08	0.12	0.05	0.17	0.06	0.08	0.05	0.10	0.12	0.09