18 October 2022 Reference No. 21476767-002-L-Rev0

Laura Beckett, Municipal Planner, Deputy Approving Officer
District of Highlands
1980 Millstream Road
Victoria, BC V9B 6H1

RESULTS OF 2021 GROUNDWATER LEVEL MONITORING PROGRAM, DISTRICT OF HIGHLANDS, BC

Dear Ms. Beckett,,

As requested by the District of Highlands (the District), Golder Associates Ltd., Member of WSP (WSP Golder) conducted a groundwater level monitoring program in the District of Highlands, BC (the Highlands) for 2021. WSP Golder conducted the groundwater level monitoring program in accordance with our proposal titled "Work Plan and Cost Estimate for 2021 Groundwater Level Monitoring Program, District of Highlands, BC" (WSP Golder Reference No. CX21476767-001-P-Rev0) and dated 2 July 2021.

Our letter should be interpreted and used in accordance with the limitations and considerations set out in WSP Golder's *Study Limitations*, provided at the end of this letter.

1.0 BACKGROUND AND OBJECTIVE

The Highlands is one of the 13-member municipalities of the Capital Regional District (CRD), encompassing approximately 37 square km and located northwest of Victoria, BC. Groundwater supplies within the Highlands are derived primarily from drilled wells completed in the Wark-Colquitz Aquifer. This bedrock aquifer is identified as Aquifer No. 680 by the BC Ministry of Environment and Climate Change Strategy (ENV) and is categorized as class IB under the BC Aquifer Classification System, indicating high demand relative to aquifer productivity and moderate vulnerability of the aquifer to contamination from surface sources. Sewage servicing within the Highlands is primarily by individual septic systems.

The majority of the residential population of 2,482 obtains potable water from private, individual water wells (Statistics Canada, 2022)[1]. Commercial groundwater use is limited to the southern portion of the Highlands. The Hanington Estates subdivision, located along the southern portion of the Highlands, obtains water from a water system ("Hanington Estates Water System") that is supplied by two communal supply wells. Irrigation water for the Bear Mountain Golf Course (Bear Mountain) is sourced from groundwater wells located within the Highlands. Some businesses within the Millstream Industrial Park, located in the Highlands and Langford, had historically

[1] Statistics Canada, 2022. Census Profile, 2021 Census of Population. online database: https://census.gc.ca/census-recensement/index-eng.cfm. accessed June 2022.

used groundwater for commercial purposes; the CRD municipal Regional Water Supply System was extended into this area and may represent the primary water supply for businesses in the industrial park. As per the BC *Water Sustainability Act* (WSA), groundwater use for purposes other than domestic supply must apply for and obtain a groundwater license. Groundwater licensing, which is administered by the Ministry of Forests, establishes rights to groundwater and specifies how much water one can legally use. As of June 2022, no groundwater licences were documented on provincial water rights databases for the Highlands. Three active applications for groundwater licenses (Application Job No. 106990) were identified in the southern portion of the Highlands; these applications were submitted for irrigation at the Bear Mountain Golf Course.

1.1 Groundwater Monitoring and Mapping Programs

On behalf of the District, WSP Golder (formerly Golder Associates Ltd.; herein also referred to as WSP Golder) initiated a groundwater level monitoring program in the Highlands in 2009 in support of the District's Groundwater Protection Study (WSP Golder 2009). To initiate the program, residents in the Highlands were contacted by the District to identify wells that could potentially be used for a monitoring program. Based on feedback from residents, as well as a search of well databases and reports, a list of potential volunteer wells was compiled. In collaboration with the District's Groundwater Task Force, WSP Golder selected candidate wells based on well locations and completion details (i.e., depth). In addition to residential wells, wells located on municipal properties were selected for inclusion in the monitoring program, as it was a requirement that the District have continued access to these wells in the future, if the wells were to be designated for long term monitoring. WSP Golder personnel met with volunteer well owners to assess the suitability of their well for collection of groundwater water-level measurements and water quality samples. Based on the results of the site visits, a total of ten locations were selected for groundwater monitoring. These locations, which are presented on Figure 1, provided spatial coverage throughout Highlands with consideration to areas of development. Monitoring wells were selected in high elevation areas that were predicted to be potentially affected by climate change using a numerical groundwater model that WSP Golder developed, calibrated and used to conduct water balance analyses. Monitoring wells were also selected in groundwater discharge areas near surface water bodies to support assessment of groundwater-surface water interaction.

The water level information from the monitoring program was used to assess seasonal groundwater level variations and, in 2012, to refine a numerical groundwater model that WSP Golder developed, calibrated and used to conduct water balance analyses. At the completion of the Groundwater Protection Study, WSP Golder recommended that the District continue to monitor groundwater conditions at select locations in the Highlands to assess long-term trends. If trends were to be observed, the results would provide the basis for guiding implementation of management strategies including conservation and groundwater protection measures, and public education efforts. The monitoring well locations were selected in discussion with the Groundwater Task Force to support ongoing monitoring at strategic locations across the Highlands, in areas of groundwater recharge and discharge, in a cost-effective manner; the six locations selected are listed in Table 1, and discussed below. Further details are provided in WSP Golder's report titled "Phase 3: Groundwater Protection Study District of Highlands, District of Highlands Victoria, BC" (WSP Golder Report No. 0714140014-501-R-Rev2-3000) and dated 18 December 2012.

The groundwater monitoring program has been continued since 2009 to the present. As of the end of 2021, pressure transducers were deployed in five monitoring wells located across the Highlands to collect continuous water level data at strategic locations, and one additional pressure transducer (a "barologger") was deployed to monitor changes in barometric (i.e., atmospheric) pressure. The locations of monitoring wells DOH-01, DOH-03, DOH-04B, DOH-07B and DOH-09A are presented on attached Figure 1. Monitoring Well DOH-02A, which had been included in the monitoring program since 2009, was removed from the monitoring program in February 2018 at the property owner’s request. The location of DOH-02A is also shown on Figure 1. A summary of the total depths of the Highlands monitoring wells and the Well Tag Numbers (WTNs) that have been assigned by BC ENV is provided in Table 1, below.

Table 1: Summary of Well Tag Numbers for District of Highlands Monitoring Wells

District of Highlands Monitoring Well	Total Depth m bgs (ft bgs)[a]	Well Tag Number[b]
DOH-01	152 (499)	79405
DOH-02A	56 (185)	85719
DOH-03	91 (300)	79581
DOH-04B	53 (175)	48812
DOH-07B	152 (500)	69716
DOH-09A	46 (150)	79583

Notes: a. m bgs = metres below ground surface; ft bgs = feet below ground surface
b. Well Tag Number assigned by the Province and reported on Groundwater Wells and Aquifers (WELLS) database

Monitoring wells DOH-02A, DOH-07B and DOH-09A are unused wells that are not equipped with pumps (i.e., are not in operation). The water levels in these wells are generally considered to be representative of static groundwater levels in the aquifer in the vicinity of the wells. However, groundwater flow within a bedrock aquifer is variable and through discrete fractures. Therefore, water levels at a given location can be influenced by pumping of wells in the area.

DOH-03 and DOH-04B are equipped with pumps and operated as supply wells for non-potable uses (i.e., not for drinking water). Although DOH-01 is an unused well, the water level in this well is influenced by pumping in an adjacent well. Water levels in DOH-01, DOH-03 and DOH-4B are not considered representative of the water levels in the surrounding aquifer during periods of pumping, but the high-water levels are interpreted to represent static (i.e., non-pumping) periods and can provide a basis to assess groundwater conditions in the areas of these wells.

The CRD is currently pursuing a Certificate of Compliance (CoC) from BC ENV for the Millstream Meadows site located in the southern portion of the Highlands at 1965 Millstream Road and adjacent to the District’s office property at 1980 Millstream Road. This has involved drilling and installation of monitoring wells to assess groundwater conditions; one of the monitoring wells was drilled at the District’s office property. In 2021, the CRD provided the District with water level data that were collected in 2020 from multi-level monitoring well MW19-96 that was installed approximately 60 m northeast from the District office.

In 2020, GW Solutions Inc. (GW Solutions) conducted groundwater mapping of the Highlands. This work included delineation of “groundwater regions”, which GW Solutions called community aquifers, and identification of areas of groundwater recharge and areas susceptible to surface contamination (i.e., vulnerable areas). GW Solutions recommended adding more wells to the existing Highlands groundwater level monitoring program and adapting the groundwater level monitoring program to the defined groundwater regions. Further details are provided in the GW Solutions report dated June 2020 and titled “District of Highlands Groundwater Mapping: Recharge of Potential, Community Aquifers and Highly Vulnerable Areas” (referred to herein as the “GW Solutions Mapping Report”).

GW Solutions subsequently refined its groundwater recharge potential mapping, estimated monthly water budgets for each of the 18 groundwater regions and associated estimated groundwater stress. The results are presented in the GW Solutions report dated January 2022 and titled “Water Budget Study for District of Highlands, Groundwater Study – Phase 2” (the “GW Solutions Water Budget Study”).

1.2 Objective

The primary objective of the 2021 groundwater level monitoring program was to continue to implement the Highlands groundwater monitoring program and to compile and analyse data from the Highlands and stakeholder monitoring programs to assess regional groundwater conditions and potential long-term trends. The 2021 program also included a review of the GW Solutions Mapping Report and Water Budget Study with the objective to consider potential refinements to the Highlands groundwater monitoring program; a detailed technical review of the GW Solutions data was not conducted.

2.0 METHODS

2.1 Groundwater Level Monitoring

The transducers that are installed in the Highlands monitoring wells, including the barologger that is deployed at monitoring location DOH-01, are programmed to collect data every twelve hours. Under the current program, WSP Golder downloaded pressure transducer data and collected a manual depth-to-water measurement at each of the monitoring locations in the Highlands on 20 September 2021 and 9 March 2022. WSP Golder also downloaded transducer data and collected water level measurements at the monitoring wells earlier in the year on 4 February 2021 as part of the 2020 monitoring program.

2.2 Data Compilation and Analysis

In addition to the District’s monitoring program, WSP Golder also obtained data from other stakeholder monitoring programs in the Highlands including:

- University of Victoria (UVic) School-Based Weather Station Network: data available on-line for UVic weather stations, located at various areas of the Highlands, as described below
- BC ENV Provincial Groundwater Observation Well Network (PGOWN): water level data available on-line from BC ENV Well No. 372 (WTN 83045), located in the western portion of the Highlands
- Hanington Estates Water System: flow data available from Island Flow Control Water Solutions Ltd. (IFCWS) for the Hanington Estates Water System, in the southern portion of the Highlands

The locations of the monitoring wells and weather stations from the various stakeholder monitoring programs are presented on attached Figure 1.

WSP Golder compiled the raw pressure data from the Highlands monitoring wells and corrected the data for variations in barometric pressure, as recorded by the barologger, to calculate depth to groundwater levels for each Highlands monitoring well. WSP Golder also checked the barometrically corrected transducer data with the manual depth to water measurements that were collected during each monitoring event. As discussed in Section 1.1, water levels in the Highlands monitoring wells are influenced either directly by periodic pumping (i.e., DOH-03 and DOH-4B) or, given the bedrock setting, pumping by adjacent wells, particularly at DOH-01. The water level data are estimated to range from plus or minus 0.01 to 0.02 m relative to manual measurements for DOH-07B and DOH-09A to approximately 0.05 to 0.10 m for DOH-03 and DOH-01. This precision is considered appropriate for a regional water monitoring program that assesses seasonal patterns and long-term trends.

WSP Golder also compiled water level data available from BC ENV Well No. 372. WSP Golder compiled data from the UVic weather stations that have been analysed during previous years; however, limited precipitation data were available for some of the weather stations. Therefore, similar to recent annual monitoring programs, WSP Golder compiled precipitation data from weather stations with available data as follows:

- **Northern Highlands:** Water level data for DOH-07B were compared to precipitation data for the Cal Revelle Nature Sanctuary Weather Station, located approximately 20 m north from DOH-7B.
- **Southern Highlands:** Water level data for DOH-01 and DOH-03 had been compared to precipitation data for the District of Highlands Office Weather Station, adjacent to DOH-03, for the period of 1 January 2012 to 31 January 2016. For the period 1 February 2016 to 31 December 2021, precipitation data from the Millstream Elementary School Weather Station were primarily used.[2] The Millstream Elementary School station is located approximately 1.4 km to the south of, and at an elevation 24 m lower than, the District of Highlands Office station (Figure 1).
- **Western Highlands:** For the period 1 January 2012 to 28 February 2017, water level data for DOH-04B and BC ENV Well No. 372 were compared to precipitation data from the West Highlands District Firehall weather station, located approximately 200 m northwest from DOH-04B. Beginning in March 2017, data for the West Highlands District Firehall Station were only available for certain periods. Therefore, data from the Cal Revelle Nature Sanctuary Weather Station, located approximately 3.5 km northeast of the West Highlands District Firehall station were compared to water level data from DOH-04B and BC ENV Well No. 372 for the period 1 March 2017 to 31 December 2021.
- **Eastern Highlands:** Water level data for DOH-09A had been compared to precipitation data for the East Highlands District Firehall weather station from 1 January 2012 until 31 May 2014, after which data were no longer available for the station. For the period 1 June 2014 to 31 December 2021, water level data from DOH-09A were compared to precipitation data from the Cal Revelle Nature Sanctuary Weather Station, located approximately 4 km northwest from DOH-09A.

[2] Data from Millstream Elementary School Weather Station were not available from 13 July 2019 to 19 September 2019. Therefore, data from the District of Highlands Office was used for this time period

Data from the Highlands and stakeholder monitoring programs were plotted, and the results analysed to assess seasonal and long-term trends.

WSP Golder also reviewed flow data for the Hanington Estates Water System, as provided by IFCWS, and the results from the Bear Mountain Monitoring Program presented in the report prepared by Western Water Associates Ltd. (WWAL) titled “Bear Mountain 2021 Annual Groundwater Monitoring Report” (WWAL File No. 16-092-01) and dated 31 May 2022. WSP Golder did not conduct a detailed review of the data presented in WWAL’s report. Rather, WSP Golder assessed the results from the Bear Mountain Monitoring Program in the context of the regional groundwater system. The District advised that in 2021 the CRD did not monitor groundwater levels in the Millstream Meadows test well that is located on the District’s office property. Therefore, data from this well were not available for review at the time of this letter report.

In addition to the information described above, WSP Golder also reviewed the GW Solutions Mapping Report and the Water Budget Study.

3.0 RESULTS AND DISCUSSION

3.1 District of Highlands Monitoring Program

Detailed water level data for monitoring wells DOH-01, DOH-03, DOH-04B, DOH-07B and DOH-09A for the period from 1 January 2012 through 31 December 2021, together with daily precipitation data from nearby weather stations, are presented on Figures 2 through 6. The precipitation data are provided to illustrate the relationship between precipitation and groundwater levels. As discussed in Section 2.2, data from the District of Highlands Office and East Highlands District Firehall weather stations, which had been used during previous monitoring years to assess precipitation in the southern and eastern portions of the Highlands, respectively, were supplemented with precipitation data from nearby stations within the UVic School-Based Weather Station Network. Although it is expected that there is some variability in precipitation patterns across the Highlands, the precipitation data presented on Figures 2 through 6 are considered suitable for the purposes of assessing general groundwater level patterns across the Highlands. Furthermore, groundwater recharge into the bedrock aquifer is interpreted to be in part controlled by the properties of the bedrock and not necessarily the intensity of specific precipitation events. Therefore, it is anticipated that minor changes in precipitation in different areas of the Highlands would not necessarily be reflected in significant variations in groundwater level data.

Similar to previous years, in 2021 the water levels that were recorded in the majority of the Highlands monitoring wells were consistent with seasonal precipitation patterns that were observed in previous years. Groundwater elevations were highest in the wet winter months of December to April, declining to a seasonal low during the dry summer period from May to early September before increasing in response to precipitation between September and December. Seasonal responses in 2021 ranged from approximately 9.1 m in DOH-01 to approximately 4.4 m in DOH-03.

In 2021, the precipitation recorded during the summer was less than what had been observed in previous monitoring years and temperatures were particularly high in late June to early July. The precipitation recorded during the fall and early winter of 2021 was greater than what had been observed in previous monitoring years. The total precipitation of 44.6 mm that was reported for the Cal Revelle Nature Sanctuary weather station from May through August 2021 was generally less than typical values for this station that have ranged from 36.8 mm in

2018 to 148.9 mm in 2020 over the duration of the Highlands monitoring program. Although water levels in the Highlands monitoring wells during the dry season of 2021 were relatively low compared to previous monitoring years, consistent with less recharge from precipitation, the water levels in the monitoring wells recharged during the wet season in 2021 and were relatively consistent with previous monitoring years. The total precipitation of 972.1 mm that was reported for the Cal Revelle Nature Sanctuary weather station from September through December 2021 was greater than values for this station that ranged from 370.5 mm in 2019 to 720.11 mm in 2020.

As discussed in Section 1.1, the water level in monitoring well DOH-01 is influenced by pumping in one or more nearby wells. The inferred static groundwater level of approximately 11.0 metres below the top of the casing (mbtoc) that was measured in DOH-01 late in the summer of 2021 was similar to values reported for most of the previous monitoring years (Figure 2). The lowest isolated (i.e., pumping induced) water level of approximately 18.4 mbtoc that was recorded for DOH-01 during the summer of 2021 was higher than those that were below 25.9 mbtoc during the summers of 2012, 2016 and 2017; the level of 25.9 mbtoc was the level at which the pressure transducer was set, and the water level is inferred to have declined below this level during isolated pumping events. The patterns observed in the summers of 2018, 2019, 2020, and 2021 could potentially reflect less sustained pumping from nearby wells. The seasonal high water level of approximately 9.3 mbtoc that was recorded at DOH-01 late in February of 2021 was generally within the low range of those in previous monitoring years with a seasonal high of approximately 8.5 mbtoc observed in 2012 (Figure 2).

The seasonal low water level of approximately 7.4 mbtoc that was measured in DOH-03 in September 2021 was high relative to previous monitoring years, with the exception of the summer of 2012 when a low of approximately 6.9 mbtoc was recorded (Figure 3). The seasonal high water level of approximately 3.0 mbtoc that was observed in November 2021 was also higher than what had been observed in previous monitoring years; the isolated water levels above 4 mbtoc are inferred to reflect short duration responses to precipitation events.

The seasonal low water levels observed in 2021 in DOH-04B and DOH-09A were also relatively lower than the levels in 2018 to 2020, but similar to previous monitoring years (Figures 4 and 6). The seasonal low water levels in DOH-04B and DOH-09A were as low as 9.5 mbtoc and 5.2 mbtoc, respectively in 2012, compared to the 2021 the seasonal low water levels were 7.3 mbtoc in DOH-04B and 4.7 mbtoc in DOH-09A. The seasonal high water levels in these wells have generally been consistent over the duration of the Highlands monitoring program. The seasonal high in DOH-04B has been in the range of approximately 1.9 to 2.2 mbtoc. The seasonal high in DOH-09A increased slightly between 2012 and 2021 from approximately 0.1 m below to 0.5 m above the former top of the casing of DOH-09A, prior to the casing for this well being extended by approximately 1.24 m in October 2011.

As presented on Figure 5, the seasonal low water level of 12.0 mbtoc that was recorded in DOH-07B in mid September 2021 was lower than values that had previously ranged from 9.8 mbtoc in 2013 to 11.7 mbtoc in 2016; the isolated period of drawdown to 12.1 mbtoc observed on 30 August 2016 corresponded with a period of extended pumping in an adjacent well on the property. The seasonal low water level observed at DOH-07B during 2021 may reflect the relatively hot and dry summer conditions that occurred. Although the seasonal high values for DOH-07B exhibited an apparent declining trend from 5.5 mbtoc in 2012 to 5.9 in 2018, a seasonal high value of 5.6 mbtoc was observed in January 2021, reflecting seasonal recharge that was consistent with recent years. As reported in previous annual reports, the lowest water level recorded in DOH-07B is approximately 140 m higher than the reported depth of the well (152.4 m below ground surface; bgs).

3.2 BC Ministry of Environment and Climate Change Strategy Observation Well

Water level data for BC ENV Well No. 372 are plotted with precipitation data from the West Highlands District Firehall and Cal Revelle Nature Sanctuary weather stations on Figure 7. The water level pattern observed in BC ENV Well No. 372 was generally consistent with those observed in the Highlands monitoring wells, declining through the spring and summer months and then increasing in response to seasonal precipitation in the fall and winter.

The seasonal low water level of 61.4 mbtoc that was reported for BC ENV Well No. 372 in mid October 2021 was consistent with the low water levels of 61.8 mbtoc that were reported in mid October of both 2019 and 2020. As presented on Figure 7, periods of consistent low water levels that were reported in the dry seasons of 2015, 2016 and 2017 are inferred to reflect periods when the water level dropped below the pressure transducer that was deployed in the well. Therefore, the low water levels in monitoring years prior to 2018 were lower than what are plotted on Figure 7 and may have been similar to those reported for 2018 to 2021.

The water level in BC ENV Well No. 372 began increasing in late October 2021 in response to seasonal precipitation. In late 2021, when the water level in the well reflected the seasonal high for the winter, the water level was as high as 45.6 mbtoc. This level is similar to what had been generally recorded for previous winters in 2020 and from 2014; variable water levels that were reported for this monitoring well during the period of the Highlands monitoring program may reflect movement of the transducer and potentially placement at different depths that may have affected the data.

3.3 Hanington Estates Water System

Water supply for the Hanington Estates Water System is sourced from two groundwater supply wells. Well 409 (Well Tag No. 85183) is operated as the primary water supply for the Hanington System and Well 500 (Well Tag No. 85184) is operated periodically as a backup supply. During the 204-day period from 10 May 2021 to 30 November 2021, the total flows from Wells 409 and 500 were reported to be 13,958 cubic metres (m^3) and 3,651 m^3, respectively, for a combined flow of 17,609 m^3. Based on these numbers, the average groundwater use for the Hanington Estates Water System during this period was estimated to be 86.32 m^3/day. This value is higher than the value of 81.23 m^3/day that was estimated for 2020; however, the average rate of daily groundwater use for 2020 was calculated for the 233-day period from 25 February 2020 to 15 October 2020 which included relatively more days in the winter period when daily water use is lower and would result in a lower calculated daily average.

IFCWS also provided flow monitoring data for the overall water system. Although considered to be less accurate than the flow data for the individual wells (Well 409 and Well 500), the data for the water system suggest that approximately 51% of the annual use in 2021 occurred between May and September, with the highest demand in the summer months of June through August. These results, which are inferred to reflect higher irrigation and other outdoor water use during the hotter, drier summer months, are consistent with values of 49% (2020) to 60% (2017) of the annual use occurring between May and September. The lower percentage of water used during May to September of 2019 and 2020 compared to previous years may be due to the increased total precipitation in the summer seasons of those years. As discussed in Section 3.1, precipitation was relatively lower during the summer of 2021 compared to most years over the duration of the Highlands monitoring program.

The population in the Hanington Estates subdivision is reported to have been 200 residents in 2021, the same value since 2017, and up from 190 residents in 2016[3]. Based on this information, the average per capita water use for the Hanington Estates water system was calculated to be approximately 432 litres per person per day (L/p/d) for the period from 10 May 2021 to 30 November 2021. The average per capita estimate for 2021 is slightly higher than the value of 406 L/p/d that was calculated for 2020; as discussed above, the average for 2020 was calculated from water usage during a period that included a relatively greater proportion of winter months when water use is typically lower.

Water level data were not provided for Well 409 and Well 500 for 2021.

3.4 Bear Mountain Monitoring Program

In 2021, continuous water level data were collected with dedicated pressure transducers that were deployed in Irrigation (i.e., pumping) Wells 405, 407 and 411, and Observation Wells 400 and 412. Although in previous years flow rates had been measured with digital flow meters, in 2021 the digital flow meter which measures flow and volume into Osborne Pond (the primary reservoir for the Valley Golf Course) malfunctioned and data were not available. Therefore, WWAL calculated the gross groundwater extraction from the irrigation wells in 2021 based on past extraction and groundwater usage volumes from previous years. With this method, WWAL estimated the total groundwater extraction from the irrigation wells to be 271,449 m^3 in 2021, with 127,457 m^3 estimated to have been pumped into the Mountain Pond and 143,991 m^3 pumped into the Osborne Pond. The estimated groundwater extraction of 271,449 m^3 is within the range of values that have been reported since flow monitoring began in 2013. During this time, volumes were reported to range from 196,650 m^3 in 2013 to 344,500 m^3 in 2016.

Based on a water balance that was conducted by Colquitz Engineering Ltd. (CQZ) and estimated that approximately 74% of the groundwater that is pumped into Osborne Pond recharges the aquifer, WWAL estimated that net groundwater extraction from the irrigation wells for the Valley Golf Course to be approximately 37,438 m^3 in 2021. WSP Golder notes that there is uncertainty regarding the recharge estimate provided by CQZ and what proportions of leakage from Osborne Pond discharge to downgradient surface water bodies (i.e., streams and wetlands) and to the deeper bedrock aquifer.

In 2021, pumping of Wells 405, 407 and 411 began on 27 May and continued until 16 September. Extraction rates for the individual wells were not reported. During this pumping period, maximum drawdown in the irrigation wells was reported to be approximately 44 m, 43 m and 82 m in Wells 405, 407 and 411, respectively; these values are within the range of those reported in previous monitoring years. WWAL reported that in the fall of 2021, the water levels in Wells 407 and 411 recovered to 100% of the pre-pumping groundwater levels within approximately three weeks, but also reported that recovery occurred by late October following pump shutdown on 16 September. Full recovery of water levels in Wells 407 and 411 has ranged from approximately 10 days (2013) to 7 weeks (2018) in previous years, with WWAL attributing this variation in recovery periods to the timing of the start of the rainy season in different years; the total volume of groundwater extracted each year did not exhibit a strong relationship to length of recovery periods.

[3] Population information, as provided by the District of Highlands in file “Estd Pop_Hanington Creek Estates_2013-2021.docx”, that is based on Occupancy Permits, Stats Canada 2011, 2016, and 2021 Census data and Building Official’s observations.

The recovery data for Well 405 in the fall of 2021 were considered suspect and, therefore, recovery of the water level in this well could not be confirmed. Consistent with observations in previous monitoring years, WWAL also reported that in 2021 the static water levels in Observation Wells 400 and 412 did not appear to be significantly impacted by pumping of the irrigation wells. WWAL has interpreted these results to indicate that the observation wells are hydraulically separate from the lineament (i.e., fault/fracture zone) in which the irrigation wells are completed.

WWAL also noted that in June 2017 Ecoasis had submitted an application to the Province of British Columbia for an Existing Use Groundwater License for an annual diversion of 375,000 m^3 of groundwater from its three Irrigation Wells 405, 407 and 411. This application has since been amended to an annual diversion of 279,700 m^3. This application was under review by the Province at the time of WWAL's report. At the time of this report, the Province had sent a referral to the District regarding the Ecoasis application and the District was in the process of preparing a response with input from WSP Golder and GW Solutions.

3.5 GW Solutions Groundwater Mapping and Water Budgets

3.5.1 Groundwater Mapping and Water Budget Results

GW Solutions (2020) delineated a total of 18 groundwater regions within six watersheds within the Highlands. The extents of the groundwater regions, which were based on a number of criteria including topographic, bedrock characteristics, surface water and groundwater data, are subsets of the mapped watersheds within the Highlands. The extents of the delineated groundwater regions and watersheds within the Highlands, as presented in the GW Solutions Mapping Report, are provided on Figures 8 and 9, respectively in Attachment 1.

Using a GIS-based approach, GW Solutions also estimated recharge potential across the Highlands, with relatively higher recharge potential predicted in areas of higher elevation, generally in the northern and central portion of the Highlands. The potential for recharge in areas of higher elevation was identified in WSP Golder's Phase 1 Groundwater Protection Study (2009) report and is consistent with seasonal recharge that is observed in the wells in the Highlands groundwater level monitoring program. WSP Golder notes that recharge to, and groundwater flow patterns within, the aquifer is controlled by the properties of the bedrock. Therefore, recharge to the aquifer is inferred to be variable and may not reflect the resolution (i.e., 10 m × 10 m grid) presented in the GW Solutions Mapping Report. Using the estimated recharge as an indication of groundwater vulnerability, GW Solutions identified potential sources of contamination that were primarily located in the southern portion of the Highlands, particularly activities in the Millstream Industrial Park and golf course, as well as sources across the region, including septic systems, borehole leakage, and the use, storage and disposal of hazardous materials associated with rural residential properties. The results of GW Solutions' assessment were consistent with the contaminant inventory and groundwater protection analysis that WSP Golder (2009) presented in Phase 2 of the Groundwater Protection Study. WSP Golder's Phase 2 (2009) and Phase 3 (2012) reports provided recommendations for conservation and groundwater protection measures, and public education efforts.

GW Solutions subsequently refined the groundwater recharge potential mapping and developed a GIS-based water balance model that was used to estimate the water surplus or deficit for each of the groundwater regions. GW Solutions utilized a method, which was developed by Dyer (2019) and correlated to sites in eastern U.S.A., that compares estimates of potential evapotranspiration to actual evapotranspiration to predict areas where soil moisture deficits (i.e., evapotranspiration is greater than the available water in the soil) and surpluses (i.e., the soil moisture capacity is reached and excess water results in runoff and/or groundwater recharge) occur. The results from GW Solutions provide a more refined estimate of recharge that varies across the Highlands based on a number of factors including climatic, topographic, geologic and land cover variables. Based on the results of sensitivity analyses, GW Solutions indicated that recharge estimates were most sensitive to precipitation.

Noting that the refined recharge estimates presented by GW Solutions is regional in scale, it is anticipated that some variability to the results presented by GW Solutions may be observed at the local (i.e., site-specific) scale. For example, the method assumes that soil moisture surpluses that are not reflected in surface water runoff result in groundwater recharge and may not account for standing water that accumulates in depressions and low-lying areas, as observed in some locations of the Highlands. WSP Golder also notes that due to the complexity of the fractured bedrock aquifer, the hydraulic connection between the overburden deposits (soil) and the underlying bedrock is not necessarily uniform across the Highlands. As discussed in Section 3.1 and illustrated on attached Figure 2, the seasonal high groundwater level in Highlands monitoring well DOH-01 is over 9 m bgs; this monitoring well is adjacent to an ephemeral stream that consistently flows during the wet season. These results, as well as the flashy responses of surface water bodies in the Highlands to precipitation events (i.e., rapid increase in surface water discharge over a short period of time during and immediately after precipitation events), are consistent with WSP Golder's interpretation discussed above that recharge to the aquifer is also controlled by the properties of the bedrock during the majority of the wet season.

GW Solutions estimated groundwater usage for various groundwater users and compared usage to groundwater recharge to estimate annual and monthly water budgets for each of the groundwater regions. GW Solutions then categorized groundwater regions based on groundwater usage that was estimated to be <5%, 5 to 10% and >10% of the estimated recharge to identify areas where usage is relatively high. The results of this analysis provide a technical basis to identify areas where groundwater use is relatively high compared to recharge from precipitation. WSP Golder notes that this water budget method does not account for groundwater flow into and out of the groundwater regions, a process that has a significant influence on groundwater flow patterns, particularly from areas of higher elevation. The regional-scale 3D flow model that WSP Golder developed and calibrated for the Groundwater Protection Study simulates groundwater conditions across the Highlands and accounts for flow between different subregions, such as the "groundwater regions". WSP Golder then used the model to conduct water balance analyses to assess the sustainability of current and future groundwater withdrawals, together with the potential impacts of climate change. The groundwater level responses predicted by the model, which were consistent with the observations from the Highlands groundwater monitoring program, reflect a dynamic system where groundwater flows from areas of greater recharge and elevation to areas of groundwater discharge.[4] Therefore, the numerical model also provides the District with a strong technical basis to identify areas of relatively high groundwater use for the protection and management of groundwater.

In summary, the work conducted by GW Solutions and WSP Golder provide the District with technical tools to assess and understand groundwater conditions within the Highlands. The results from these tools also provide a basis to assess potential refinements to the current monitoring program to support the District in managing and protecting its groundwater resources.

[4] As discussed with the District's Groundwater Task Force, while the WSP Golder (2012) Phase 3 report did not present figures that illustrated these results due to potential sensitivities regarding inferred water supply and property values, the results were described in the text of the report.

3.5.2 GW Solutions Recommendations for Monitoring Program

Based on the results of the groundwater mapping and water budget activities, GW Solutions recommended that a community-based monitoring program be initiated, including increased groundwater monitoring and implementation of water metering, hydrometric stations and climate stations. GW Solutions identified seven groundwater regions where the percentage of groundwater usage was estimated to be more than 5% of the recharge: 1-2, 1-3, 1-4, 1-5, 4-2, 3-2 and 5-1.

The locations of the monitoring wells that are currently in the Highlands monitoring program, compared to the groundwater regions as presented by GW Solutions (2020), are provided on Figure 18 in Attachment 1. Highlands monitoring wells are currently located in groundwater regions 1-2, 1-4, 4-2 and 3-2. As noted by GW Solutions, some of these wells are within the vicinity of a surface water body; however, these wells provide data to support assessment of groundwater-surface water interaction and potential changes in groundwater contributions to baseflow over time. Within groundwater region 1-4, water levels in three production wells and two observation wells at the Bear Mountain Golf Course are also monitored and reported on an annual basis; it is noted that the observation wells that are currently monitored are inferred to have a weak hydraulic connection to the production wells (see Section 3.4). The Millstream Meadows property is located within groundwater region 1-5. As discussed in Section 2.2, the CRD has conducted groundwater monitoring at this property. The District could also consider options to engage with operators of other commercial/industrial (C/I) properties in the southern portion of the Highlands to establish additional monitoring wells; further details regarding recommended groundwater protection measures for C/I properties are provided in the WSP Golder (2012) Phase 3 Groundwater Protection Study report.

WSP Golder agrees that water metering data would help refine estimates of groundwater usage. As outlined in WSP Golder's (2012) Phase 3 report, in addition to requesting metering data for non-domestic water users, the District could consider installation of flow meters on volunteer residential wells. The resulting data could assist in refining groundwater demand estimates as well as providing well owners with an opportunity to assess their water use behaviours and the influence of groundwater conservation measures.

GW Solutions recommended that hydrometric stations be established to monitor surface water level and discharge at a total of ten locations within the Highlands, with four stations on Millstream Creek, four on Hazlitt Creek and two stations on Craigflower Creek. WSP Golder conducted surface water level and discharge monitoring at ten locations across the Highlands; one event was conducted during the dry season of 2007 and discussed in the Phase 1 report (2009) and one event was conducted during the wet season of 2010 and discussed in the Phase 3 (2012) report. Due to the flashy responses of surface water bodies to precipitation events, it is anticipated that monitoring stations would have to be automated to collect continuous water level and discharge measurements in order to provide a dataset with sufficient detail to support a refined assessment of water resources in the Highlands. WSP Golder notes that there may be opportunities for the District to collaborate with other parties such as the Province to establish hydrometric stations at strategic locations. In particular, hydrometric monitoring may be required to support assessment of environmental flow needs (EFNs) to support groundwater licensing.

GW Solutions reported that the four UVic weather stations located in the Highlands are active and recommended that additional climate stations also be established at elevations of 250, 300, 350, 400 and 450 m above sea level (asl). This recommendation was based on GW Solution's observation that the water balance approach they utilized was most sensitive to precipitation as an input parameter; however, as discussed in the preceding section, WSP Golder notes that the properties of the bedrock are also inferred to control seasonal recharge to the aquifer and flow within the aquifer affects the water balance within the Highlands. As discussed in Section 2.2, data from the District of Highlands Office, Western Highlands District Firehall and the East Highlands District Firehall weather stations have only been available for certain periods in recent years. The District may be able to coordinate with the UVic School-Based Weather Station Network to consistently maintain these stations and develop a more comprehensive dataset with coverage across the Highlands. If additional climate stations are considered, it is recommended that the potential value of the data be considered in the context of the broader monitoring program and objectives.

GW Solutions also recommended that the effects of climate change on aquifer recharge and groundwater availability be estimated and modeled. WSP Golder notes that the numerical model that was developed and calibrated for the Groundwater Protection Study was used to assess the potential impacts of climate change. The numerical model provides a strong technical tool to identify areas for targeted implementation of groundwater management and protection measures.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The results from the 2021 Highlands groundwater monitoring program were generally consistent with the seasonal patterns reported for previous years. In 2021 the total precipitation during the summer months was higher than the total precipitation in the summers of 2019 and 2020, but similar to summer months in previously monitored years. Consistent with less precipitation during the summer, the seasonal low groundwater levels observed in Highlands monitoring wells in the summer of 2021 were generally slightly lower than those reported in previous monitoring years. Groundwater levels reported for stakeholder monitoring wells were also consistent with the results of the Highlands wells.

The results from stakeholder monitoring programs were also generally consistent with previous years. Average water use at Hanington Estates that was estimated to be approximately 86.3 m^3/day for the period May 2021 to November 2021, was within the range of values that have been reported since annual well flow data have been provided (2013). When the population of the Hanington Estates subdivision is considered, the per capita water use for the Hanington Estates water system has declined steadily from an estimated value of 473 L/p/d in 2013 to 338 L/p/d in 2019. In 2020 and 2021 the per capita water use increased relative to the 2019 use to 406 L/p/d and 432 L/p/d, respectively. The 2019 value was calculated from a period which included relatively more days in the winter period when daily water use is lower and would result in a lower calculated daily average.

During the dry season of 2021, the total volume of groundwater that was pumped from Bear Mountain Irrigation Wells 405, 407 and 411 was not measured due to a malfunction with the digital flow meter. Pumping from the three irrigation wells began on 27 May and continued until 16 September; this start date is generally later than in previous years, but the end date was similar to previous years. The pumping-induced drawdown levels that were observed in the irrigation wells in 2021, at values of approximately 44 m (Well 405), 43 m (Well 407) and 82 m (Well 411), were also within the range of levels that have been reported in previous monitoring years. The water levels in Wells 407 and 411 recovered to 100% of the pre-pumping levels within approximately three weeks, compared to the range of 10 days to 7 weeks that were observed in 2013 and 2018, respectively. The recovery data for Well 405 in the fall of 2021 could not be confirmed.

Using a GIS-based approach to groundwater recharge mapping, GW Solutions delineated 18 groundwater regions within the Highlands and estimated water budgets for each region. Based on the results of the groundwater mapping and water budget activities, GW Solutions identified seven groundwater regions where, using the water budget method that compared estimated groundwater use to estimated recharge to the water region from precipitation, the percentage of groundwater usage was estimated to be more than 5% of the recharge. These regions, numbered as 1-2, 1-3, 1-4, 1-5, 4-2, 3-2 and 5-1 are located primarily in the southern portion of the Highlands. However, in addition to recharge from precipitation, groundwater flow into and out of the groundwater regions has a significant influence on groundwater levels and regional groundwater flow patterns.

GW Solutions recommended that a community-based monitoring program be initiated, including water metering, and collection of data from groundwater monitoring wells, hydrometric stations and climate stations. Water metering, which was proposed in WSP Golder (2012) Phase 3 report and the GW Solutions Water Budget Study (2022), would provide data to help refine estimates of groundwater usage in the Highlands. The Highlands groundwater monitoring program currently includes five active monitoring wells that are located across the Highlands, with a well located in four (1-2, 1-4, 4-2 and 3-2) of the seven regions identified by GW Solutions with relatively high groundwater usage relative to estimated recharge. Within groundwater region 1-4, a groundwater monitoring program is conducted for the Bear Mountain Golf Course, although it is noted that the observation wells that are monitored are inferred to have a weak hydraulic connection to the wells that are pumped during the summer months for irrigation. Within groundwater region 1-5, groundwater monitoring has been conducted at the Millstream Meadows site by the CRD; to date, the CRD has provided the District with quarterly water level data that were collected from multi-level monitoring well MW19-96 from December 2019 to September 2020. Climate and hydrometric monitoring would also provide data to support assessment of water resources in the Highlands. Of the four climate stations that were established in the Highlands by the UVic School-Based Weather Station Network, one has been consistently maintained. Within the Highlands, there are currently no active hydrometric stations.

4.2 Recommendations

WSP Golder recommends that the Highlands groundwater monitoring program, including review of stakeholder programs, continue in 2022 to continue to document conditions and assess groundwater levels across the Highlands.

Regarding potential refinements to the current monitoring program, WSP Golder recommends that the District consider the value of additional monitoring and utility of the data relative to the objectives of the District’s overall Groundwater Protection Work Plan. It is recommended that the District consider the objectives of the monitoring program, the associated costs and how the data will be used both with the tools that the District currently has including the groundwater flow model that was developed by WSP Golder and the refined mapping and water budgets that were developed by GW Solutions. Importantly, the District should also consider how the output from the monitoring program will inform the measures that the District will implement to support conservation, management and protection of water resources in the Highlands.

If the District wishes to proceed with refinement of the current Highlands groundwater monitoring program at strategic locations, it is recommended that it consider potential opportunities to collaborate with other parties to share resources and achieve similar objectives in a cost-effective manner. Potential options include the following:

- The District may be able to team with the Province to establish additional monitoring locations through a number of programs. In addition to the observation wells that the Province currently monitors through the PGOWN program, a network of hydrometric stations is also maintained under the Canada-British Columbia Hydrometric Program that is co-managed by the Province and the Federal Government, with the costs shared between the two governments and third-parties. The groundwater licensing process may also provide an opportunity to establish hydrometric stations in certain areas to assess EFNs.
- Through the referral process, the District could request that the Province require refinements to the Bear Mountain Monitoring Program, such as establishing observation wells that have a hydraulic connection to the irrigation wells; as discussed in Section 3.4, the District is currently in the process of preparing a response regarding the application that Ecoasis has submitted for an Existing Use Groundwater License.
- The District could contact the CRD to discuss the potential to maintain one or more of the monitoring wells at the Millstream Meadows site for long term monitoring. The District could also consider options to engage with operators of other C/I properties in the southern portion of the Highlands to establish additional monitoring wells. These programs could include monitoring of both groundwater levels and groundwater quality.
- There may be an opportunity to work with the operator of the Hanington Estates Water System to include collection of continual water level monitoring data from the production wells, and potentially an observation well if present, in addition to the flow meter data that are currently collected.
- There may also be opportunities for the District to work with community-based programs, including stewardship groups and residents who are interested in citizen science initiatives to expand monitoring network in the Highlands. These programs could include groundwater and hydrometric monitoring.
- The District could also engage with owners of wells on residential properties. The District could conduct a survey of well owners to update its database and identify residents who would be interested to volunteer use of a well on their property and to participate in a pilot water metering program. Based on the responses, the District could assess whether there are opportunities to expand the monitoring network in key areas of the Highlands.

5.0 CLOSURE

We trust the above information meets your current needs. If you have any questions or require additional information, please do not hesitate to contact the undersigned.

Yours very truly,

Golder Associates Ltd.

PROFESSIONAL GEOSCIENTIST
PROVINCE OF BRITISH COLUMBIA
M. A. BOLTON
#29787
18 Oct 2022

Alanna Umphrey, AScT
Applied Science Technologist

Mark Bolton, MSc, PGeo
Associate, Senior Hydrogeologist

Jillian Sacré, MSc, PGeo
Principal, Senior Hydrogeologist

PERMIT TO PRACTICE #1003064
Engineers & Geoscientists BC

AU/MB/lih

Attachments: Figure 1: Monitoring Locations District of Highlands
Figure 2: Depth to Groundwater Monitoring Well DOH-01 and Precipitation in Southern Highlands
Figure 3: Depth to Groundwater Monitoring Well DOH-03 and Precipitation in Southern Highlands
Figure 4: Depth to Groundwater Monitoring Well DOH-04B and Precipitation in Western Highlands
Figure 5: Depth to Groundwater Monitoring Well DOH-07B and Precipitation in Northern Highlands
Figure 6: Depth to Groundwater Monitoring Well DOH-09A and Precipitation in Eastern Highlands
Figure 7: Depth to Groundwater Monitoring Well MoE Observation Well 372 and Precipitation in Western Highlands
Attachment 1 – Mapped extents of watersheds within the Highlands, and delineated groundwater regions (community aquifer), as presented in GW Solutions Mapping Report

https://golderassociates.sharepoint.com/sites/149068/project files/6 deliverables/3.0_issued/21476767-002-l-rev0/21476767-002-l-rev0-2021 gw level monitoring prog 18oct_22.docx

6.0 REFERENCES

Dyer, J.M., 2019. A GIS-Based Water Balance Approach Using a LiDAR-Derived DEM Captures Fine-Scale Vegetation Patterns. Remote Sensing. 2019. 11(20), 2385

Golder Associates Ltd., (WSP Golder) 2008. Phase 1: Groundwater Protection Study District of Highlands. Golder Report No. 07-1414-0014. September 2008.

Golder Associates Ltd., (WSP Golder) 2009. Phase 2: Groundwater Protection Study District of Highlands. Golder Report No. 07-1414-0014-2000. December 2009.

Golder Associates Ltd., (WSP Golder) 2012. Phase 3: Groundwater Protection Study District of Highlands. Golder Report No. 0714140014-501-R-Rev2-3000. December 2012.

GW Solutions Inc. (GW Solutions), 2020. District of Highlands Groundwater Mapping: Recharge Potential, Community Aquifers and Highly Vulnerable Areas. June 2020.

GW Solutions Inc. (GW Solutions), 2022. Water Budget Study for District of Highlands, Groundwater Study Phase 2. January 2022.

7.0 STUDY LIMITATIONS

Golder Associates Ltd. Member of WSP (WSP Golder) has prepared this letter in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and geoscience professions currently practicing in British Columbia, subject to the time limits and physical constraints applicable to this letter. No other warranty, express or implied is made.

The letter is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP Golder by the Client, communications between WSP Golder and the Client, and to any other letters prepared by WSP Golder for the Client relative to the specific site described in the letter. In order to properly understand the suggestions, recommendations and opinions expressed in this letter, reference must be made to the whole of the letter.

WSP Golder cannot be responsible for use by any party of portions of the letter without reference to the entire letter and other relevant communications between WSP Golder and the Client.

In preparing this letter, WSP Golder has relied in good faith on information provided by the individuals and agencies noted in this letter. We accept no responsibility for any deficiency or inaccuracy contained in this letter as a result of errors, omissions, misinterpretations or fraudulent acts of the persons or agencies contacted.

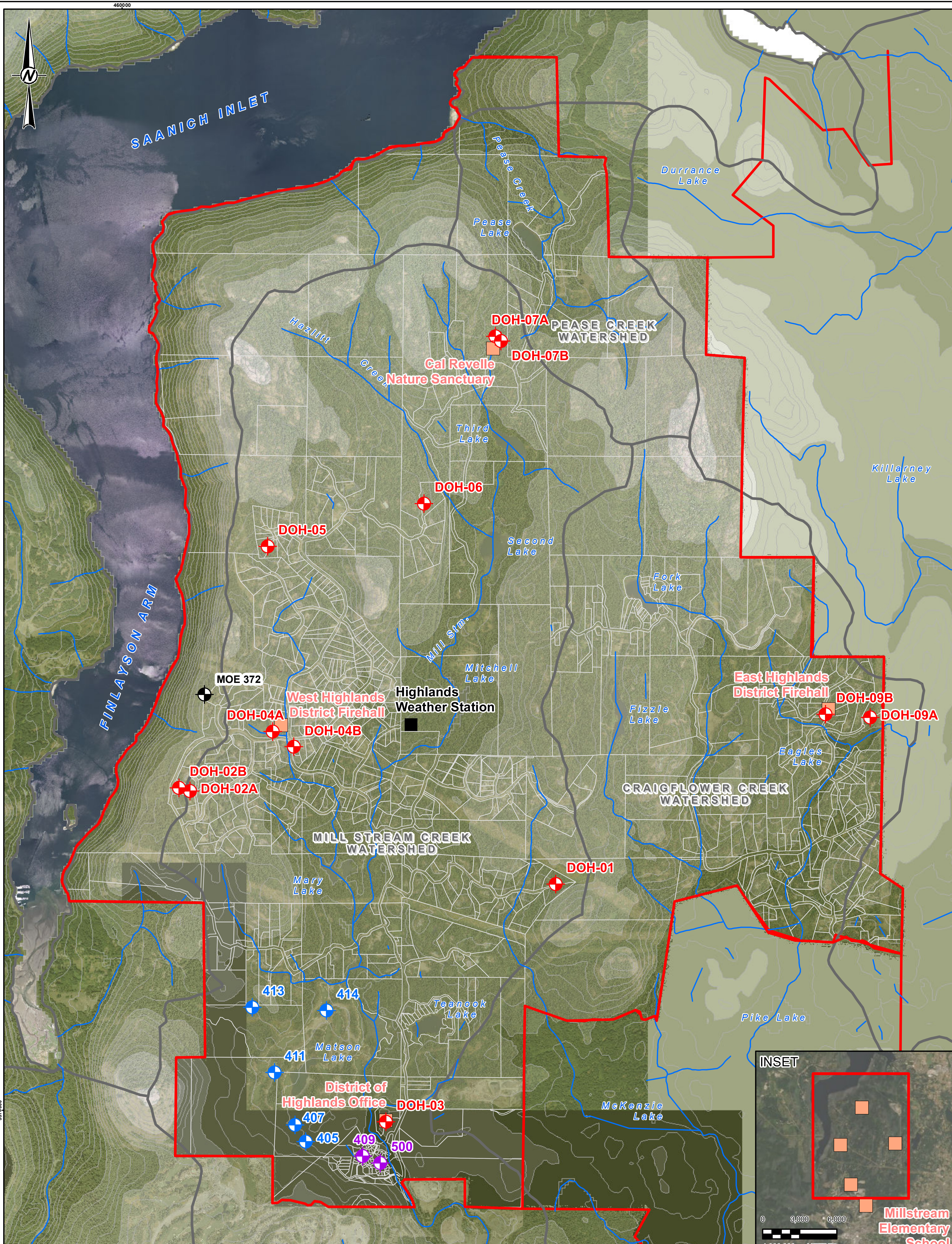
The information, recommendations and opinions expressed in this letter are for the sole benefit of the Client.

No other party may use or rely on this letter or any portion thereof without WSP Golder's express written consent.

The letter, all plans, data, drawings and other documents as well as all electronic media prepared by WSP Golder are considered its professional work product and shall remain the copyright property of WSP Golder, who authorizes only the Client to make copies of the letter, and only in such quantities as are reasonably necessary for the use of the letter by those parties. The Client may not give, lend, sell, or otherwise make available the letter or any portion thereof to any other party without the express written permission of WSP Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of WSP Golder's letter or other work products.

If new information is discovered in the future, WSP Golder should be requested to re-evaluate the content of this letter and provide amendments as required prior to any reliance upon the information presented herein.

PATH: Y:\burnaby\CAD-GIS\Client\District_of_Highlands\DoH_GW_Monitoring\99_PROJECTS\21476767\4000\02_PRODUCTION\MXD\Report\FIG_1_21476767_4000_Monitoring_Locations.mxd PRINTED ON: 2022-10-17 AT: 1:00:49 PM



LEGEND

- District of Highlands Monitoring Well Location
- Hanington Creek Estates Well
- Bear Mountain Monitoring Well
- Ministry of Environment Observation Well No. 372
- Environment Canada Weather Station
- University of Victoria Weather Station
- Contour (20m Interval)
- Watercourse
- Watercourse
- Waterbody
- Cadastre Information
- Major Watershed Boundary
- Municipality Boundary

Elevation - metres above sea level (masl)

- 0 - 100
- 101 - 200
- 201 - 300
- 301 - 400
- 401 - 500

0 500 1,000

1:30,000 METRES

REFERENCES

1. DATA PROVIDED BY THE DISTRICT OF HIGHLAND AND BC ILMB.
2. BASE DATA CONTAIN INFORMATION LICENCED UNDER THE OPEN GOVERNMENT LICENCE – BRITISH COLUMBIA/CANADA.
3. WEATHER STATIONS OBTAINED FROM ENVIRONMENT CANADA AND THE UNIVERSITY OF VICTORIA SCHOOL-BASED WEATHER STATION NETWORK.
4. IMAGERY COPYRIGHT © 20201201 ESRI AND ITS LICENSORS. SOURCE: MAXAR. USED UNDER LICENSE, ALL RIGHTS RESERVED..

COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
DISTRICT OF HIGHLANDS

PROJECT
GROUNDWATER PROTECTION STUDY
HIGHLANDS, B.C.

TITLE
MONITORING LOCATIONS

CONSULTANT
WSP GOLDER

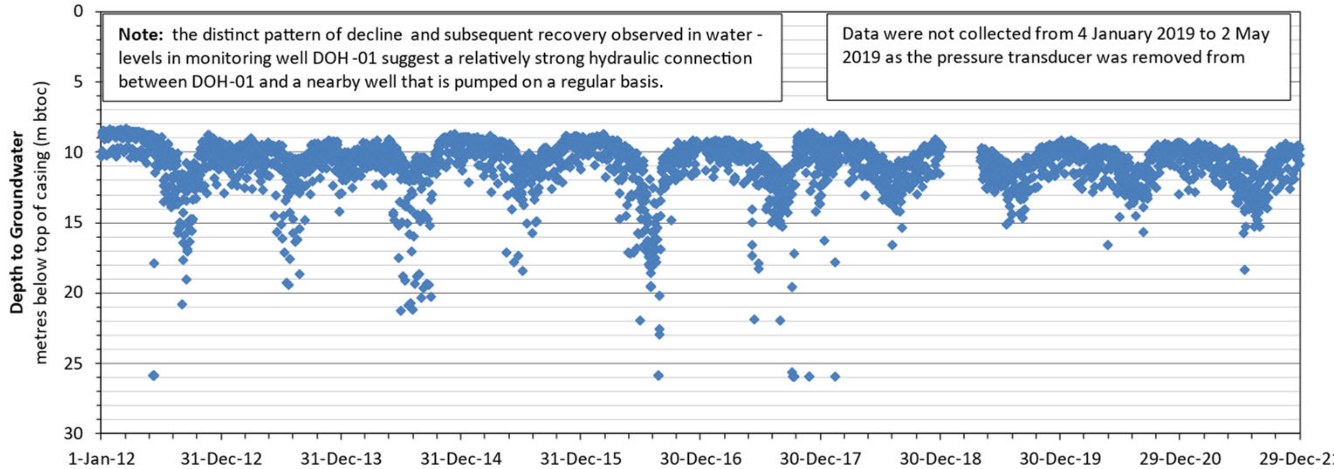
YYYY-MM-DD	2022-10-17
DESIGNED	AU
PREPARED	LH
REVIEWED	AU
APPROVED	MAB

PROJECT NO.	CONTROL	REV.	FIGURE
21476767	4000	0	1

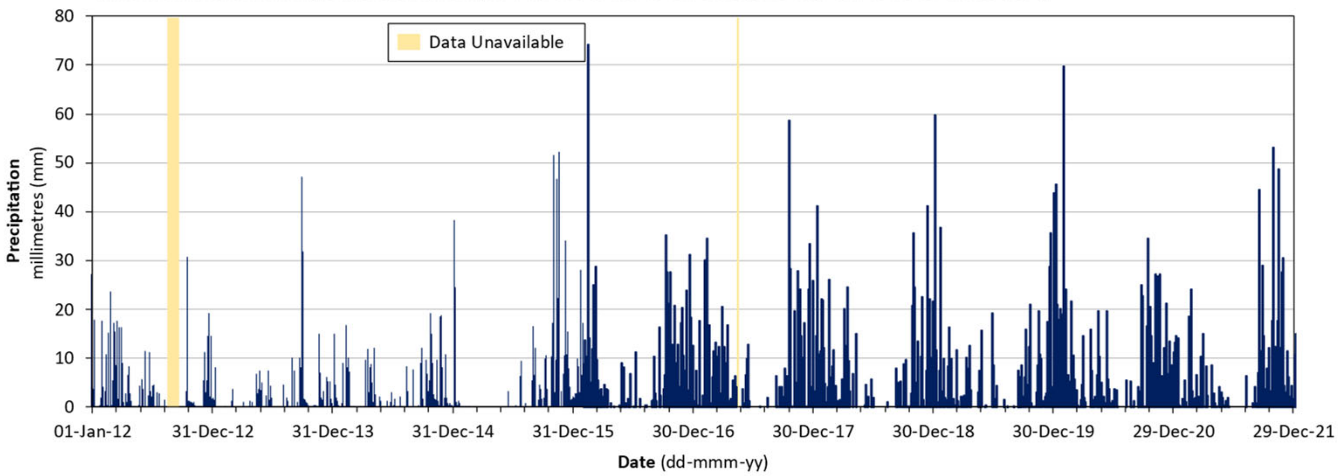
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

District of Highlands Monitoring Well DOH-01



District of Highlands Office Weather Station (01-Jan-2012 to 31-Jan-2016; 13-Jul-2019 to 19-Sep-2019); Millstream Elementary School Station (01-Feb-2016 to 12-Jul-2019; 20-Sep-2019 to 31-Dec-2021)



Notes

Water level data collected under the District of Highlands Groundwater Monitoring Program.

Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.
http://www.victoriaweather.ca/

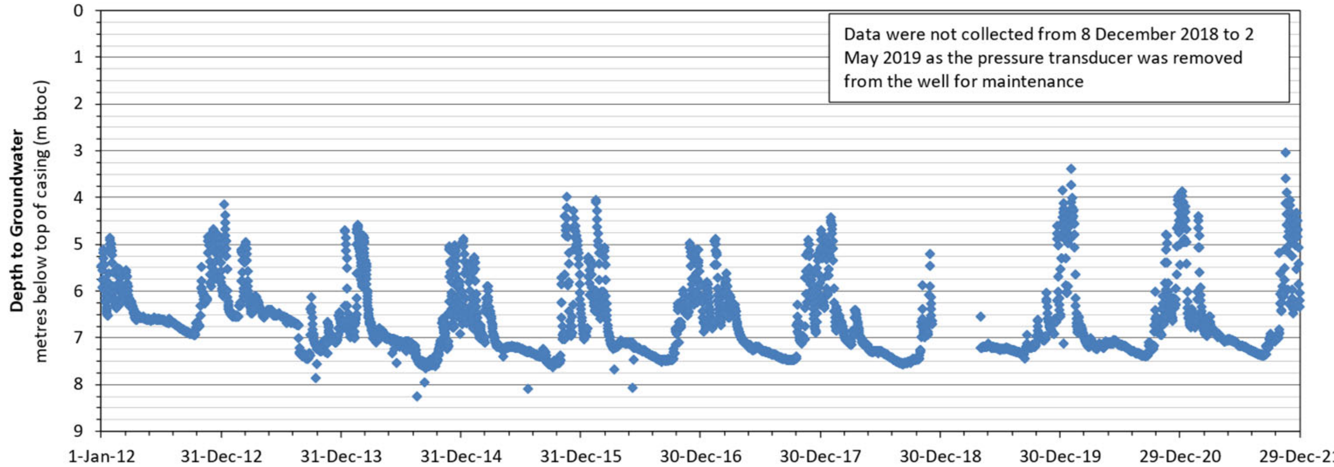
PROJECT
DISTRICT OF HIGHLANDS
2021 GROUNDWATER MONITORING PROGRAM
HIGHLANDS, BC

TITLE
DEPTH TO GROUNDWATER MONITORING WELL DOH-01 AND PRECIPITATION IN SOUTHERN HIGHLANDS

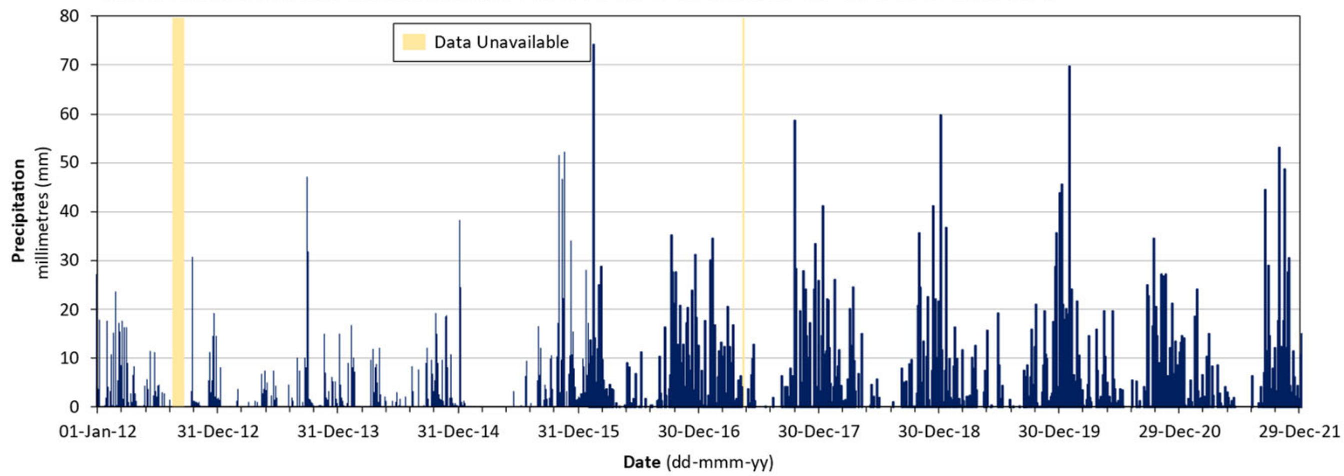
WSP GOLDER

PROJECT No.	21476767		FILE No. ----	
DESIGN	CB	06NOV14	SCALE NTS	REV. 0
CADD	AU	04APR22	**FIGURE 2**	
CHECK	AU	04APR22		
REVIEW	MB	17JUN22		

District of Highlands Monitoring Well DOH-03



District of Highlands Office Weather Station (01-Jan-2012 to 31-Jan-2016; 13-Jul-2019 to 19-Sep-2019);
Millstream Elementary School Station (01-Feb-2016 to 12-Jul-2019; 20-Sep-2019 to 31-Dec-2021)

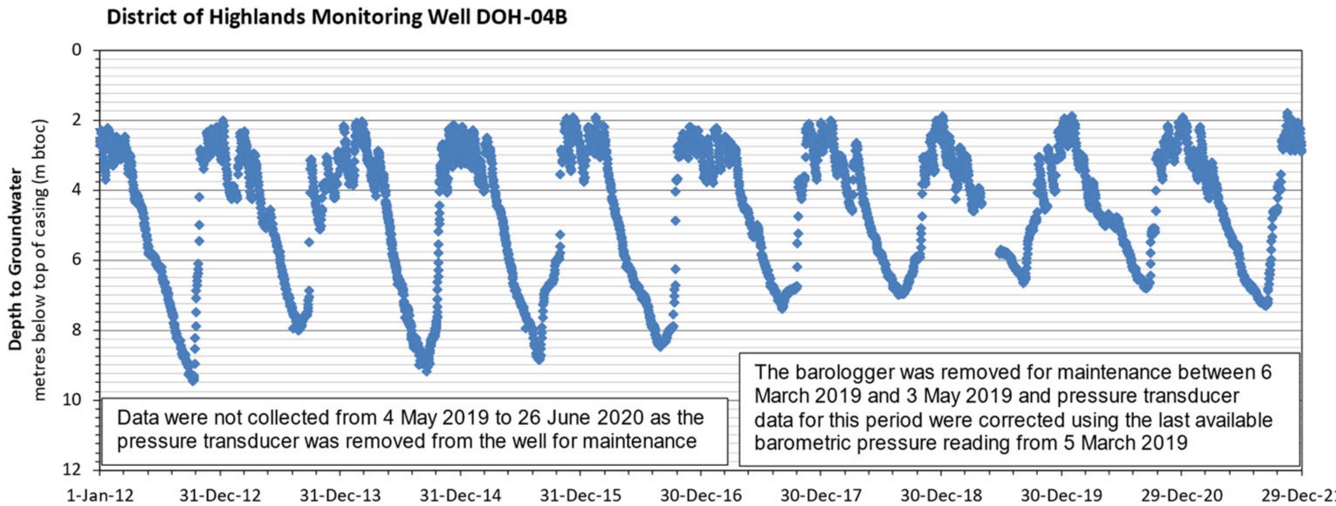


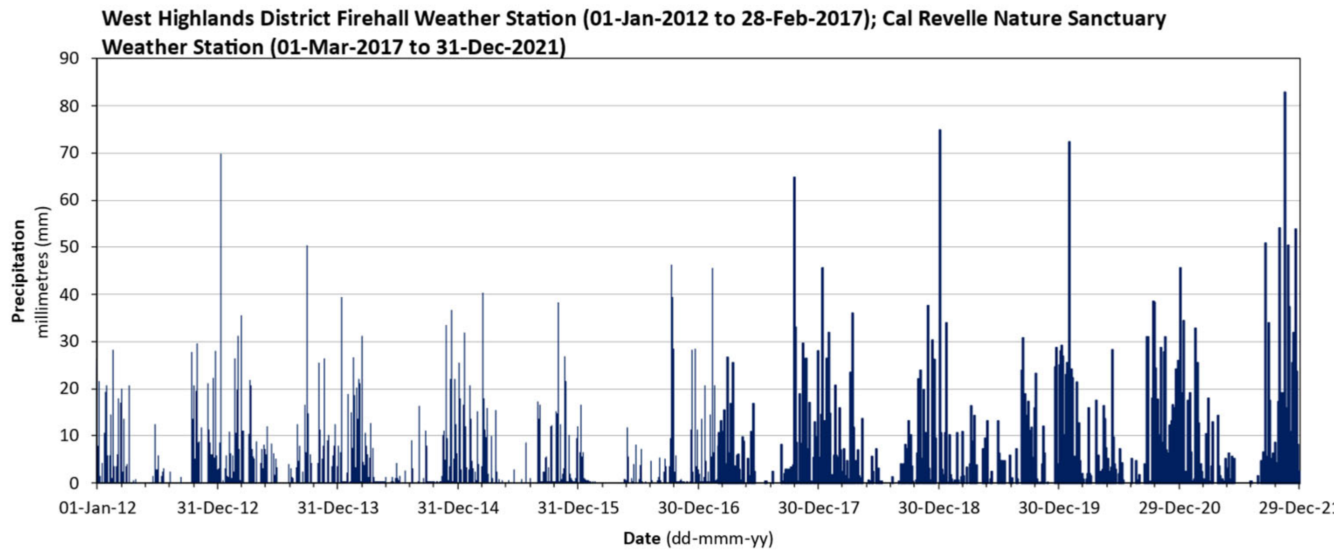
Notes

Water level data collected under the District of Highlands Groundwater Monitoring Program.

Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.
http://www.victoriaweather.ca/

PROJECT	DISTRICT OF HIGHLANDS 2021 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC				
TITLE	DEPTH TO GROUNDWATER MONITORING WELL DOH-03 AND PRECIPITATION IN SOUTHERN HIGHLANDS				
WSP GOLDER	PROJECT No. 21476767			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
	CADD	AU	04APR22	FIGURE 3	
	CHECK	AU	04APR22		
	REVIEW	MB	17JUN22		



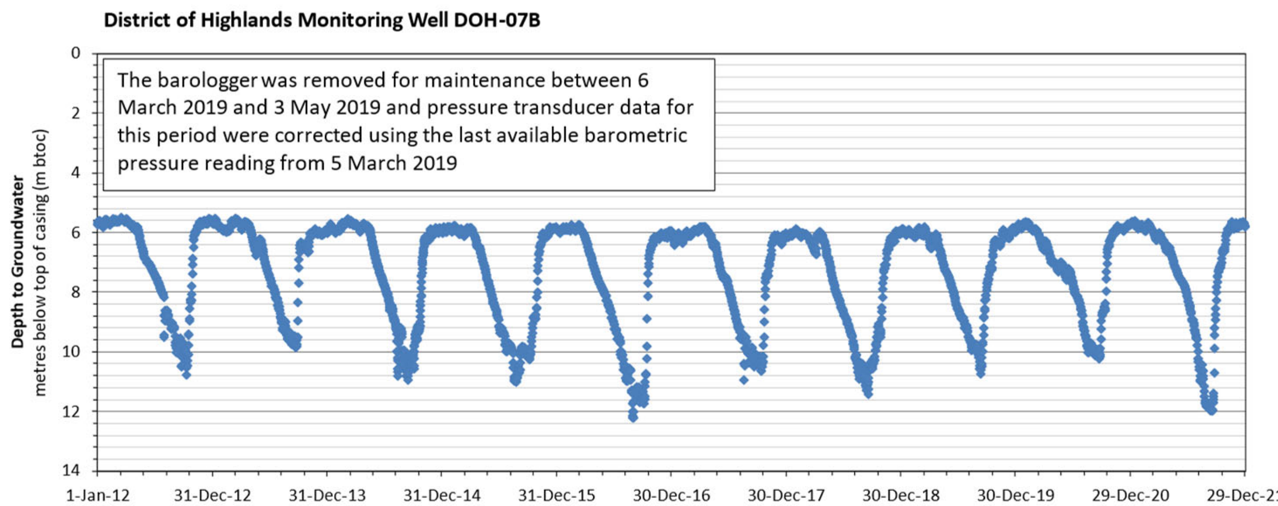


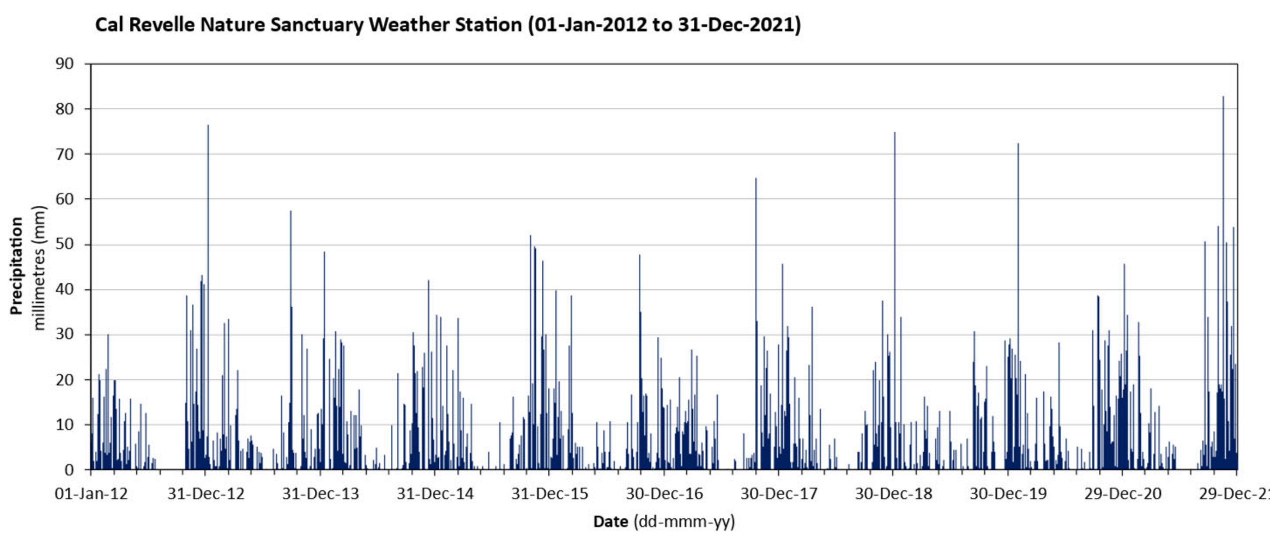
Notes

Water level data collected under the District of Highlands Groundwater Monitoring Program.

Precipitation data obtained online from the University of Victoria School-Based Weather Station Network. http://www.victoriaweather.ca/

PROJECT	DISTRICT OF HIGHLANDS 2021 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC				
TITLE	DEPTH TO GROUNDWATER MONITORING WELL DOH-04B AND PRECIPITATION IN WESTERN HIGHLANDS				
WSP GOLDER	PROJECT No. 21476767			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
	CADD	AU	04APR22	FIGURE 4	
	CHECK	AU	04APR22		
	REVIEW	MB	17JUN22		





Notes

Water level data collected under the District of Highlands Groundwater Monitoring Program.

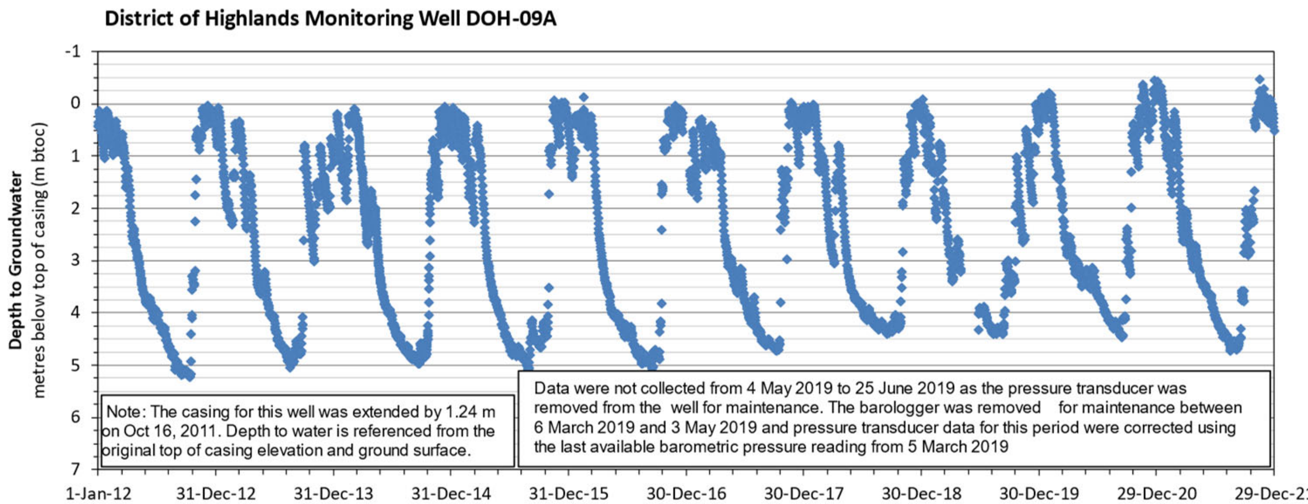
Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.
http://www.victoriaweather.ca/

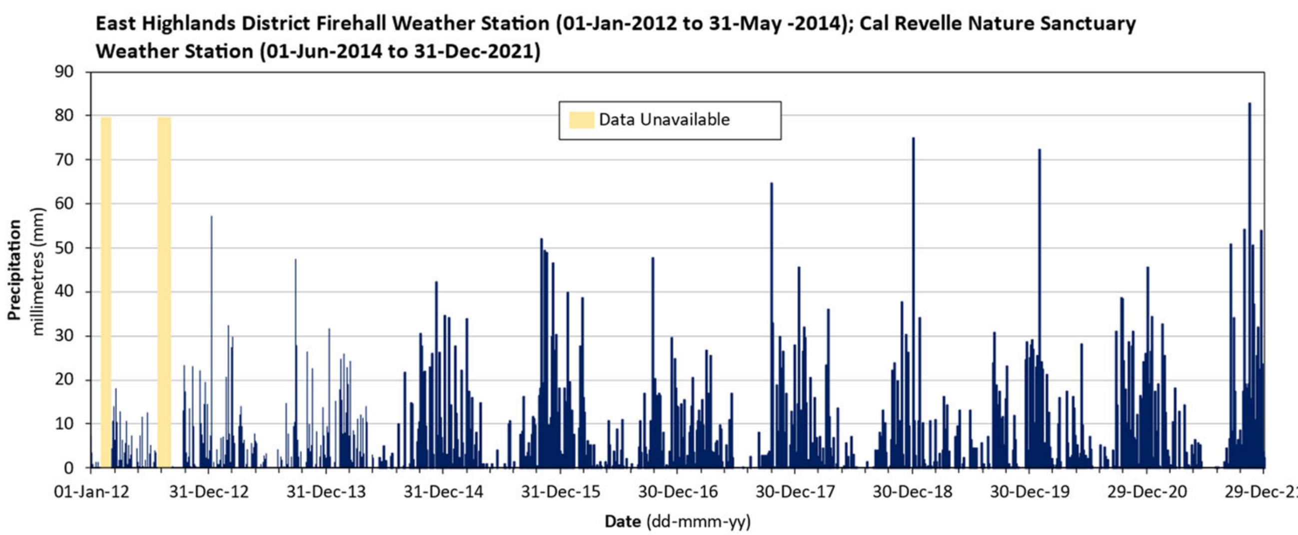
PROJECT
DISTRICT OF HIGHLANDS
2021 GROUNDWATER MONITORING PROGRAM
HIGHLANDS, BC

TITLE
DEPTH TO GROUNDWATER MONITORING WELL DOH-07B AND PRECIPITATION IN NORTHERN HIGHLANDS

WSP GOLDER

PROJECT No.	21476767		FILE No. ----	
DESIGN	CB	06NOV14	SCALE NTS	REV. 0
CADD	AU	04APR22	FIGURE 5	
CHECK	AU	04APR22		
REVIEW	MB	17JUN22		





Notes

Water level data collected under the District of Highlands Groundwater Monitoring Program.

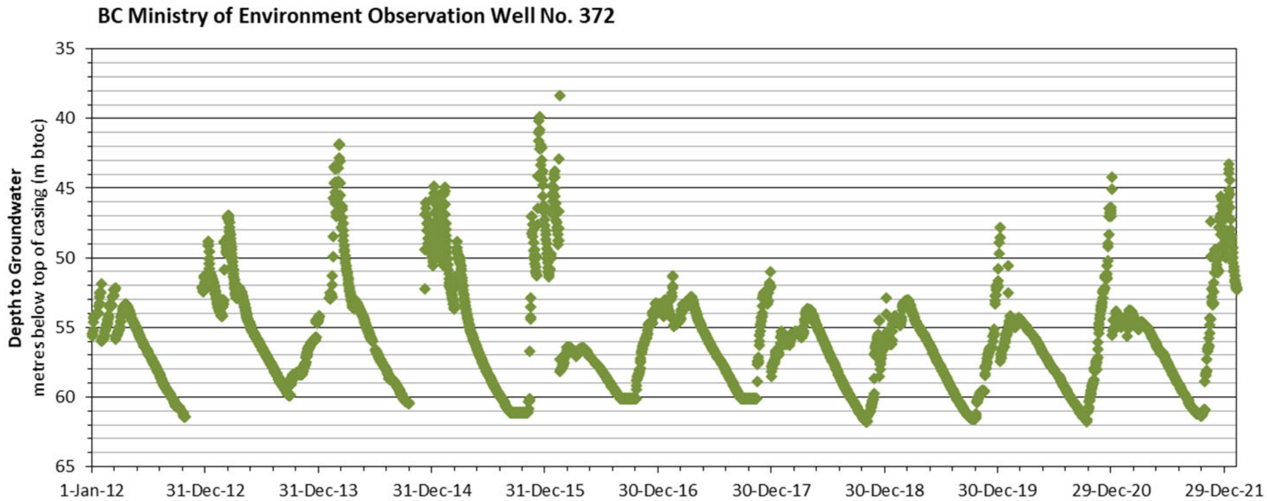
Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.
http://www.victoriaweather.ca/

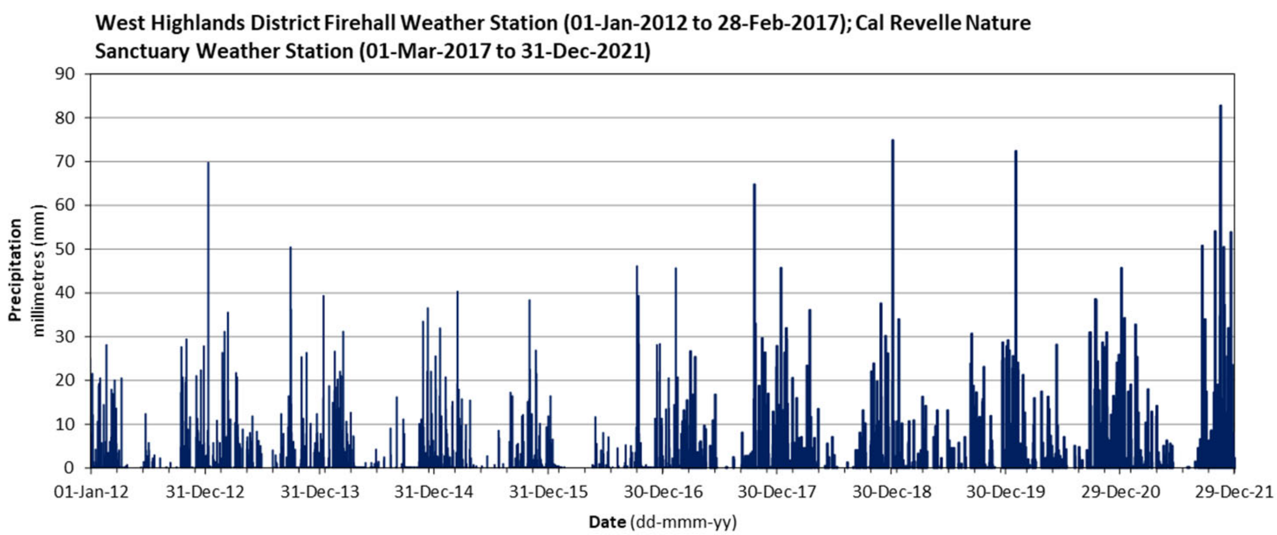
PROJECT
DISTRICT OF HIGHLANDS
2021 GROUNDWATER MONITORING PROGRAM
HIGHLANDS, BC

TITLE
DEPTH TO GROUNDWATER MONITORING WELL DOH-09A AND PRECIPITATION IN EASTERN HIGHLANDS

WSP GOLDER

PROJECT No.	21476767		FILE No. ----	
DESIGN	CB	06NOV14	SCALE NTS	REV. 0
CADD	AU	04APR22	**FIGURE 6**	
CHECK	AU	04APR22		
REVIEW	MB	17JUN22		





Notes

Water level data obtained online from the Ministry of Environment British Columbia Groundwater Observation Network.
http://www.env.gov.bc.ca/wsd/data_searches/obswell/map/obsWells.html

Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.
http://www.victoriaweather.ca/

PROJECT **DISTRICT OF HIGHLANDS**
2021 GROUNDWATER MONITORING PROGRAM
HIGHLANDS, BC

TITLE **DEPTH TO GROUNDWATER**
MOE OBSERVATION WELL 372 AND
PRECIPITATION IN WESTERN HIGHLANDS

WSP GOLDER

PROJECT No.	21476767		FILE No. ----	
DESIGN	CB	06NOV14	SCALE NTS	REV. 0
CADD	AU	04APR22	FIGURE 7	
CHECK	AU	04APR22		
REVIEW	MB	17JUN22		

FILE: https://golderassociates.sharepoint.com/sites/25417g/SitePages/Home.aspx

ATTACHMENT 1

Mapped extents of watersheds within the Highlands, and delineated groundwater regions (community aquifer), as presented in GW Solutions Mapping Report

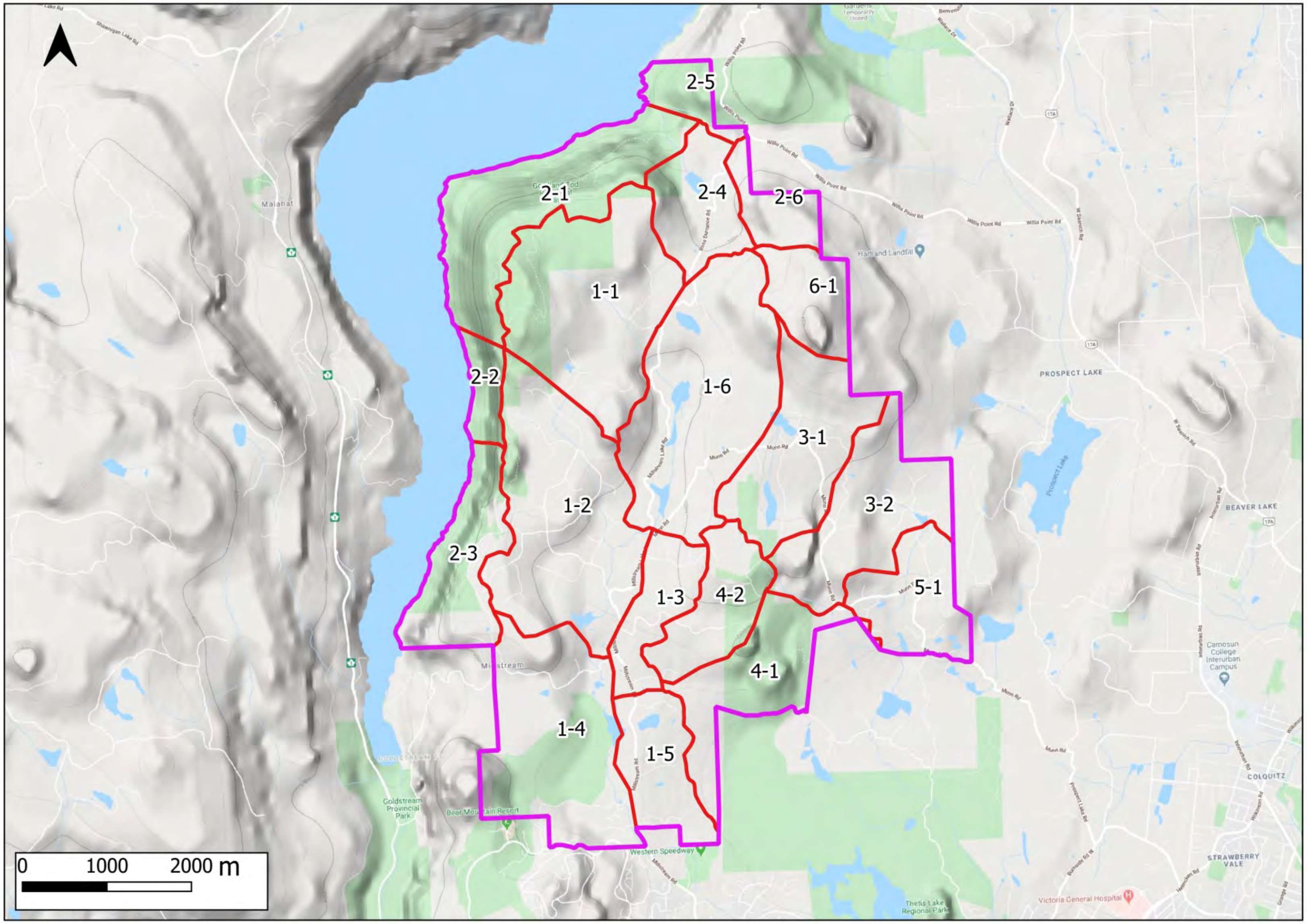


Figure 8. Groundwater regions/community aquifers

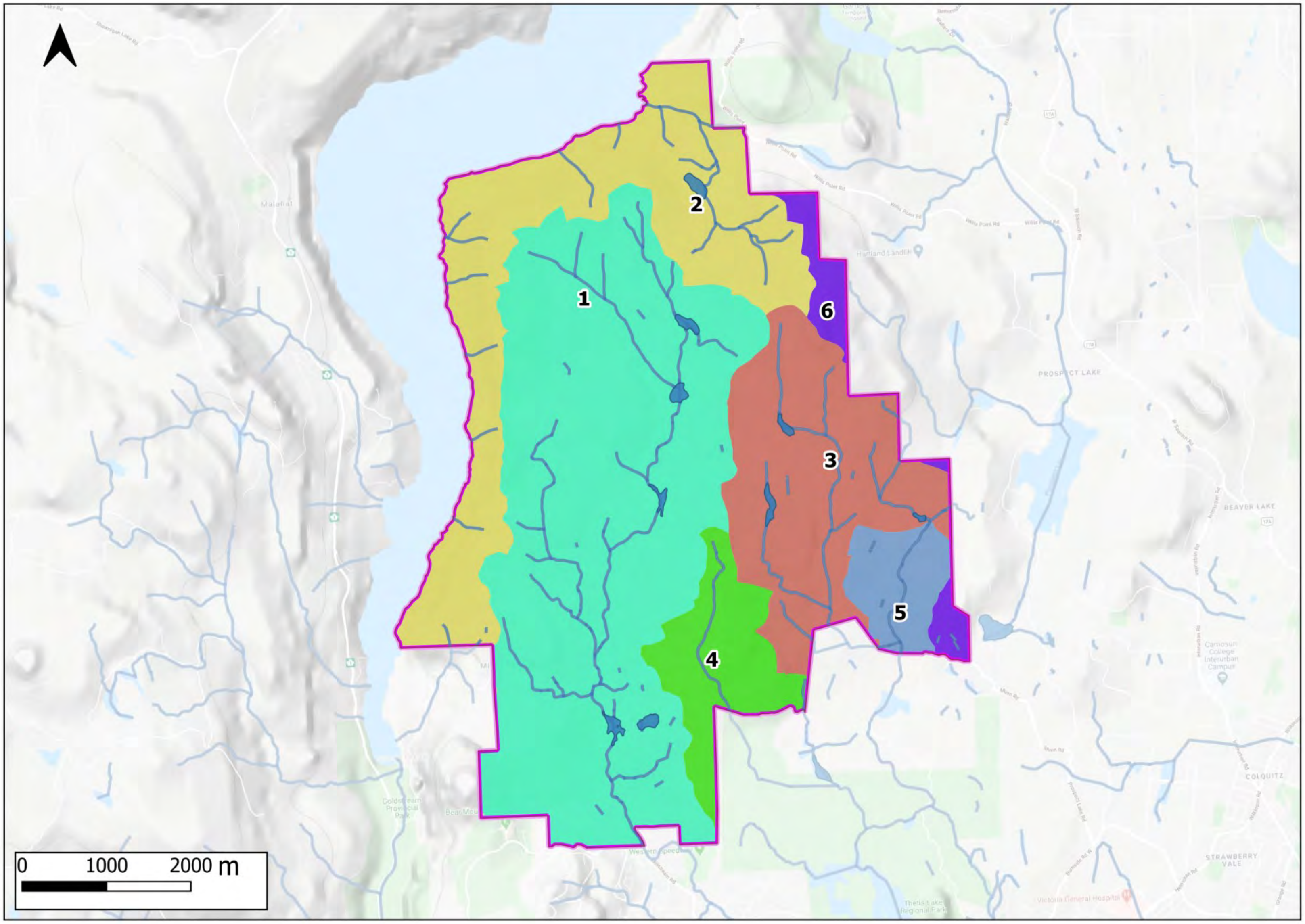


Figure 9: Watersheds' extents within DoH

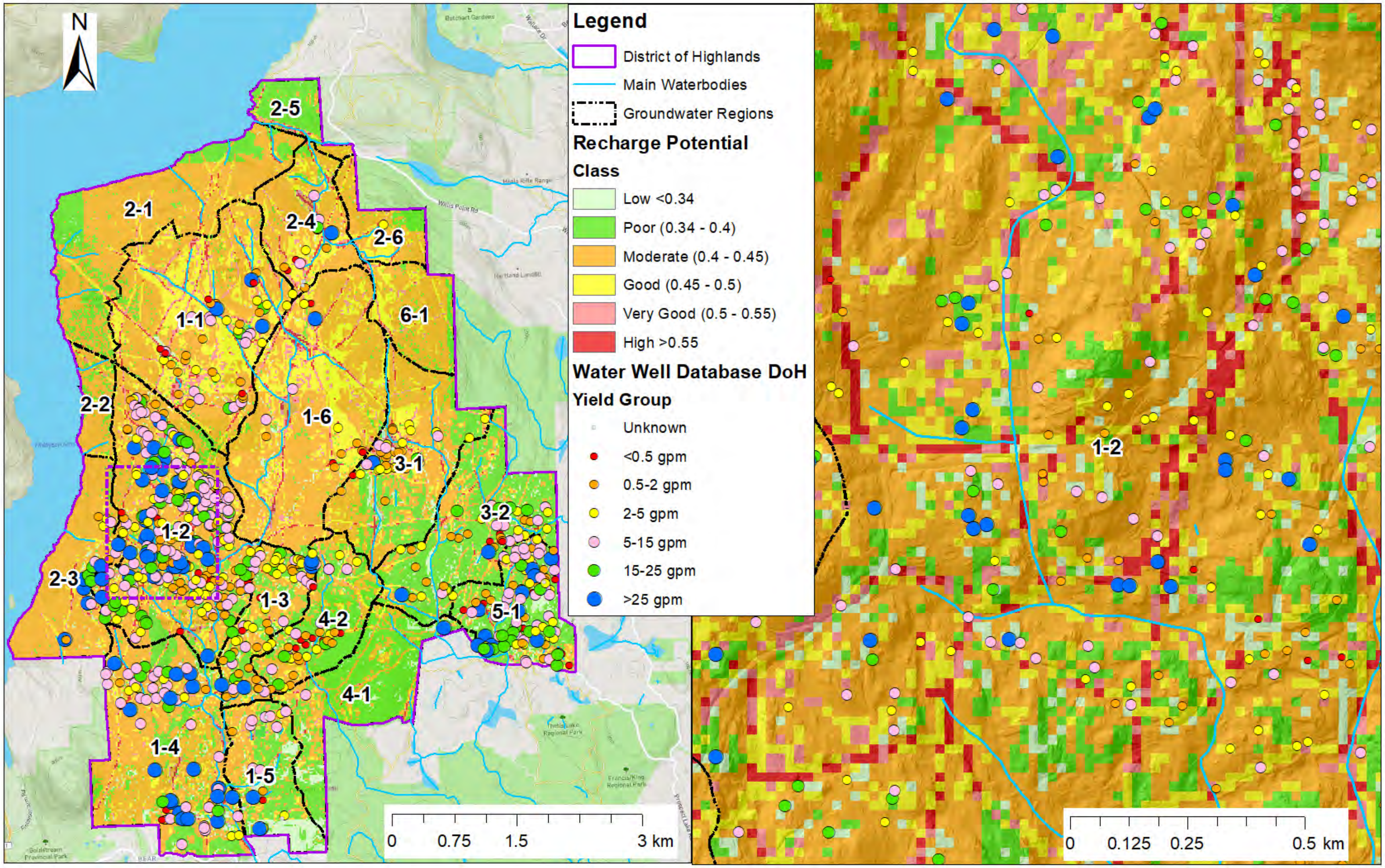


Figure 18. Recharge potential map, groundwater regions and water wells