February 7, 2025 Reference No. CA0014383.5087-002-L-Rev0

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

RESULTS OF 2023 GROUNDWATER LEVEL MONITORING PROGRAM, DISTRICT OF HIGHLANDS, BC

Dear Ms. Beckett,

As requested by the District of Highlands (the District), WSP Canada Inc., (WSP) conducted a groundwater level monitoring program in the District of Highlands, BC (the Highlands) for 2023. WSP conducted the groundwater level monitoring program in accordance with our proposal titled "Workplan and Cost Estimate for 2023 Groundwater Level Monitoring Program, District of Highlands, BC" (WSP Reference No. 2023CA95087-001-P-Rev0) and dated October 4, 2023.

Our letter should be interpreted and used in accordance with the limitations and considerations set out in WSP'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. The majority of the residential population of 2,482 obtains potable water from private, individual water wells (Statistics Canada, 2021). 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 used groundwater for commercial purposes; however, the CRD municipal Regional Water Supply System was extended into this area and is understood to represent the primary water supply for businesses in the industrial park.

As per the BC *Water Sustainability Act* (WSA), groundwater uses for purposes other than domestic supply must apply for and obtain a groundwater license. Groundwater licensing, which is administered by the BC Ministry of Water, Land and Resource Stewardship (WLRS), establishes rights to groundwater and specifies how much water one can legally use. As of December 2023, one groundwater licence (License No. 501806) was documented on the provincial Water Rights Databases for the Highlands (Government of British Columbia, 2023). This Conditional Water Licence was issued to Ecoasis Developments LLP for groundwater use in the southern portion of the Highlands for irrigation and land improvements at the Bear Mountain Golf Course; further details are provided in Section 3.4.

1.1 Aquifer Description

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 Province of BC (the Province) and is categorized as class IB under the BC Aquifer Classification System, indicating high demand relative to a moderate aquifer productivity and moderate vulnerability of the aquifer to contamination from surface sources. A copy of the Aquifer Factsheet for Aquifer No. 680 is presented in ATTACHMENT 1.

Sewage servicing within the Highlands is primarily by individual septic systems.

1.2 Groundwater Monitoring and Mapping Programs

On behalf of the District, WSP (formerly Golder Associates Ltd.; work conducted prior to 2021 herein referred to as Golder) initiated a groundwater level monitoring program in the Highlands in 2009 in support of the District's Groundwater Protection Study (Golder 2009). A total of ten monitoring locations were selected and labeled as DOH-01 through DOH-10 (Figure 1). At some locations, two wells were selected for monitoring, with an unused well being used for water level monitoring and a well that was equipped with a pump used for collecting groundwater quality samples. At these locations, the wells were labeled with an A or B (e.g., DOH-02A and DOH-02B).

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 Golder developed, calibrated and used to conduct water balance analyses. At the completion of the Groundwater Protection Study, Golder recommended that the District continue to monitor groundwater conditions at select locations in the Highlands to assess seasonal and 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 District's Groundwater Task Force to support ongoing monitoring at 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 Golder's report titled "Phase 3: Groundwater Protection Study District of Highlands, District of Highlands Victoria, BC" (Report No. 0714140014-501-R-Rev2-3000) and dated December 18, 2012.

The groundwater monitoring program has been continued since 2009 to the present. Six locations were selected for long-term monitoring across the Highlands to collect continuous water level data at strategic locations. As of the end of 2022, pressure transducers were deployed in five monitoring wells, with one additional pressure transducer (a "barologger") 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 request of the property owner at that time. 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 the BC Ministry of Environment and Climate Change Strategy (BC ENV) is provided in Table 1, below.

Table 1: Summary of District of Highlands Long-Term 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.

As part of the 2021 annual groundwater monitoring program, WSP also conducted a review of additional mapping work that had been done by GW Solutions Inc. (GW Solutions). Based on the results of that review, WSP provided recommendations for potential strategic refinements to the Highlands monitoring program, including consideration of additional monitoring locations. It was noted that this could include redeployment of the transducer at DOH-02A and engaging with other stakeholders such as the Province and CRD, the Hanington Estates Water System and owners of private wells on residential properties. Further details are provided in the 2021 annual monitoring report (WSP, 2022).

1.3 Objective

The objective of the 2023 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.

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 downloaded pressure transducer data and collected a manual depth-to-water measurement at each of the active monitoring locations in the Highlands on May 19, 2023, October 20, 2023, and February 22, 2024.

2.2 Data Compilation and Analysis

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

- 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 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 wells. WSP 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 1.2, 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 generally range from plus or minus 0.02 to 0.05 m relative to manual measurements for DOH-07B and DOH-09A, to up to approximately 0.08 to 0.20 m for DOH-03 and DOH-01, respectively. This reported variability for DOH-03 and DOH-01 reflects the influence of pumping at the times of data collection, as described above; water level monitoring that was conducted close to the 12:00 PM transducer reading for DOH-01 in September 2020 and for DOH-03 in May 2023 indicated that the transducer readings were within 0.03 and 0.05 m of the corresponding manual measurements, respectively. This precision is considered appropriate for a regional water monitoring program that assesses seasonal patterns and long-term trends.

WSP also compiled water level data available from BC ENV Well No. 372 and precipitation data from the UVic weather stations that have been analysed during previous years. Limited precipitation data were available for some of the weather stations for periods that extended from a few days to several months; however, the data are considered sufficient for assessing general precipitation patterns. Similar to recent annual monitoring programs, WSP 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 and at a reported elevation of 221 metres above sea level (masl).
- **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, when the station was operational during the following periods: January 2012 to January 2016; and July 2019 to September 2019. For other periods, precipitation data were used from other active stations as follows: Millstream Elementary School Weather Station from February 2016 to July 2019 and September 2019 to December 2021; and the Lakewood Elementary School Station from January 2022 to December 2023. The Millstream Elementary School and Lakewood Elementary School stations are located approximately 2.1 km southeast and 1.8 km south of the District of Highlands Office station, respectively (Figure 1). The elevations at the Millstream Elementary School station (80 masl) and Lakewood Elementary School Station (88 masl) are lower than the District of Highlands Office (104 masl).
- **Western Highlands:** For the periods January 2012 to February 2017 and January 2021 to December 2023, 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 and at an elevation of 154 masl. From March 2017 to December 2020, when there were gaps in the data for the West Highlands District Firehall Station, precipitation data from the Cal Revelle Nature Sanctuary Weather Station, located at an elevation of 221 masl and 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.
- **Eastern Highlands:** Water level data for DOH-09A had been compared to precipitation data for the East Highlands District Firehall weather station (elevation of 101 masl) when data were consistently available during the following periods: January 2012 to May 2014, January 2019 to May 2022 and November 2022 to December 2023. During the other periods, 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.

Data from the Highlands and stakeholder monitoring programs were plotted, and the results analysed to assess seasonal and long-term trends. The CRD provided water quality data related to monitoring wells associated with the Millstream Meadows site, but did not provide groundwater level data. Therefore, water level data for the Millstream Meadows test well that is located on the District's office were not available for review at the time of this letter report.

WSP also reviewed flow data for the Hanington Estates Water System, as provided by IFCWS.

3.0 RESULTS AND DISCUSSION

3.1 District of Highlands Monitoring Program

Detailed water level data for monitoring wells DOH-01, DOH-02A, DOH-03, DOH-04B, DOH-07B and DOH-09A for the period from January 1, 2012 through December 31, 2023, together with daily precipitation data from nearby weather stations, are presented on Figures 2 through 7; the water levels at DOH-02A are provided until February 2018, when the transducer was removed from the well. The precipitation data are provided to illustrate the relationship between precipitation and groundwater levels. As discussed in Section 2.2, data from different weather stations were used based on completeness of the datasets available from the different UVic School-Based Weather Stations to assess precipitation in the Highlands. Although it is expected that there is some variability in precipitation patterns across the Highlands, the precipitation data presented on Figures 2 through 7 are considered suitable for the purposes of assessing general groundwater level patterns and their relationship to precipitation. 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 regional groundwater level conditions.

In 2023 the water levels that were recorded in the majority of the Highlands monitoring wells were generally 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 September before increasing in response to precipitation and groundwater recharge from late October to December. Seasonal responses in 2023 ranged from approximately 3.2 m in DOH-03 to 6.2 m in DOH-07B. As discussed above, the water level in DOH-01 is inferred to be influenced by pumping of an adjacent well, resulting in isolated periods of drawdown. The seasonal response of the static water level in DOH-01 is estimated to be in the range of 2.0 m.

In 2023, the total annual precipitation of 746.1 mm that was recorded at the Calle Revelle Nature Sanctuary weather station was generally low relative to the values from previous years in the Highlands monitoring program (i.e., since 2009) that have ranged from 720 mm in 2020 to 1,483 mm in 2021. In 2023, precipitation during the dry season from May to September at the Calle Revelle station was low, at a value of 60.1 mm. In previous monitoring years, precipitation reported for this station during these summer months has ranged from 80.3 mm in 2018 to 317.8 mm in 2013. Although precipitation was relatively low in summer of 2023, the water levels in the Highlands monitoring wells were relatively consistent with those reported in previous monitoring years, as discussed below.

Southern Highlands

As discussed in Section 1.2, 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 11.2 metres below the top of the casing (mbtoc) that was measured in DOH-01 late in the summer of 2023 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 20.7 mbtoc that was recorded for DOH-01 in September 2023 was within range of previous years and higher than depths that were as low as 25.9 mbtoc during the summers of 2012, 2016 and 2017; this level of 25.9 mbtoc was the level at which the pressure transducer was set, and the water level may have declined below this level during isolated pumping events. The seasonal high-water level of approximately 9.7 mbtoc that was recorded at DOH-01 late in December of 2023 was within the low range of those in recent monitoring years following a seasonal high

of approximately 8.6 mbtoc that was observed in 2012 (Figure 2). The water level may increase into 2024, as it has in some previous years, and on-going monitoring will provide data to assess whether the slight decline in seasonal high-water levels since 2017 reflects a long-term trend or variability. Regardless, as indicated above, the dry season water level for DOH-01 has not exhibited a declining trend.

The seasonal low static water level of approximately 7.4 mbtoc that was measured in DOH-03 in September 2023 was within the range of previous monitoring years, which have ranged from approximately 7.7 to 7.4 in 2014 and 2021, respectively. Isolated water level measurements that were lower than this range are inferred to reflect isolated pumping of this well to supply the District office (Figure 3). The seasonal high water level of approximately 4.7 mbtoc that was observed in December 2023 was relatively low, but within the range of what has been observed in previous monitoring years. The seasonal high water levels for DOH-03 exhibit short duration responses to precipitation events, demonstrating a strong relationship between this well and infiltration of precipitation. Therefore, depending upon precipitation patterns, the seasonal high-water levels in DOH-03 have been observed later in the wet season (i.e., early months of the year).

Western Highlands

Figure 4 presents water level data for DOH-02A until the well was removed from the Highlands monitoring program in 2017. If this well were to be re-introduced to the Highlands monitoring program, the data that were collected until 2017 would provide a basis for assessment of current conditions in this western portion of the Highlands.

The seasonal low static water level of approximately 7.4 mbtoc that was recorded for DOH-04B in September 2023, and the isolated value of 7.6 mbtoc in July of 2023 that is inferred to reflect isolated pumping, are within the range of values in previous years (Figure 5). Seasonal low water levels have ranged from 6.6 mbtoc in 2019 to 9.4 mbtoc in 2012. The seasonal high water levels in this well have generally been consistent over the duration of the Highlands monitoring program, ranging from 2.3 mbtoc in 2012 to 1.8 mbtoc in 2021. In the fall of 2023, the seasonal high water level was 2.2 mbtoc and may increase later in the wet season, beyond the 2023 monitoring year.

Northern Highlands

In the northern portion of the Highlands, the seasonal low water level in DOH-07B was 12.2 mbtoc in mid-October 2023 (Figure 6). This is the lowest recorded value for this monitoring well and similar to what was reported in 2016, when a period of extended pumping was reported for an adjacent well on the property. The seasonal low water level for DOH-07B may reflect less infiltration of precipitation. As discussed above, the total annual precipitation at the Calle Revelle Nature Sanctuary weather station was relatively lower during the dry season of 2023 compared to previous monitoring years; this weather station is located on the same property as DOH-07B. The seasonal low water level for DOH-07B has been as high as 10.0 mbtoc in 2013.

Similar to previous years, the water level in DOH-07B increased in response to seasonal recharge in the fall of 2023. Although the seasonal high values for DOH-07B exhibited an apparent declining trend from 5.5 mbtoc in 2012 to 5.9 in 2018, seasonal high values since that time have been higher, ranging from 5.6 to 5.8 mbtoc in 2021 and 2019, respectively. The seasonal high water level in DOH-07B at the end of 2023 was 5.7 mbtoc.

Eastern Highlands

In 2023, the seasonal low water level of 4.7 mbtoc that was reported for DOH-09A in 2023 was within the range of 5.2 to 4.4 mbtoc that had been recorded previously in 2012 and 2018, respectively (Figure 7). The seasonal high water level in December 2023 was 0 m relative to 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. This measurement is similar to the seasonal high water levels from previous monitoring years that have ranged from approximately 0.1 mbtoc to 0.5 m above the former top of the casing.

3.2 BC Ministry of Environment and Climate Change Strategy Observation Well

As presented on the Aquifer Factsheet presented in ATTACHMENT 1, based on the water level data from BC ENV Well No. 372, the Province has categorized the groundwater levels in Aquifer No. 680 as Stable.

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 8. The water level pattern observed in BC ENV Well No. 372 continued to be 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 62.4 mbtoc that was reported for BC ENV Well No. 372 in October 2023 was lower than what had been reported during previous years; however, as presented on Figure 8, 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 the levels plotted on Figure 7 and may have been similar to those reported from 2018 onwards. The water level response in the summer of 2023 may reflect less groundwater recharge, as precipitation was lower that year.

The water level in BC ENV Well No. 372 began increasing in late October 2023 in response to seasonal precipitation and was as high as 46.9 mbtoc in December, within the range of what had been recorded for previous winters. It is noted that some of the differences in water levels 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 (WTN 85183) is operated as the primary water supply for the Hanington System and Well 500 (WTN 85184) is operated periodically as a backup supply. During the 297-day period from January 31, 2023 to November 24, 2023, the total flows from Wells 409 and 500 were reported to be 25,199 cubic metres (m^3) and 6,726 m^3, respectively, for a combined flow of 31,975 m^3.

The average groundwater use for the Hanington Estates Water System during this period was estimated to be 107.7 m^3/day. This value is higher than those reported since full buildout of the development in 2017 and ranged from 67.6 m^3/day in 2019 to 86.3 m^3/day in 2021; the population of Hanington Estates is further discussed below.

However, the average rate of daily groundwater use for 2021 was calculated for a period that included relatively fewer days in the winter period compared to some of the previous years. Daily water use is lower in the winter and would result in a lower calculated daily average. Furthermore, greater groundwater use may reflect additional water use during the dry summer and fall months of 2023 when precipitation was relatively low.

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 52% of the annual use in 2023 occurred between May and September, with the highest demand between the months of June through September. These results, which are inferred to reflect higher irrigation and other outdoor water use during the hotter, drier summer months, are consistent with the pattern observed in previous years, with 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 compared to previous years may be due to the increased total precipitation in the summer season that year.

The population in the Hanington Estates subdivision is reported to have been 200 residents in 2023, the same value since 2017, and up from 190 residents in 2016[1]. Based on this information, the average per capita water use for the Hanington Estates water system was calculated to be approximately 538 litres per person per day (L/p/d) for the period from January 31, 2023 to November 24, 2023. The average per capita estimate for 2023 is greater than values of 338 to 432 L/p/d that were calculated for 2019 and 2021, respectively. The results from 2023 may reflect the drier conditions during the summer and fall of that year, or potentially an increase in the population of Hanington Estates and the associated increase in water use.

Water level data were not provided for Well 409 and Well 500 for 2023.

3.4 Bear Mountain Monitoring Program

As discussed in Section 1.2, Conditional Water Licence No. 501806 was issued to Ecoasis for irrigation and land improvements at Bear Mountain. A copy of the Conditional Water Licence and supporting documentation that is publicly available on the provincial Water Rights Database[2] is provided in ATTACHMENT 2. The conditional licence was issued on June 23, 2023 for industrial (lawn, fairway and garden) and land improvement purposes. The conditional licence indicates that the maximum annual quantity of water that can be diverted is 243,180 m^3/year for industrial purposes and 36,520 m^3/year for land improvement purposes. The authorized works include the wells with Well Tag No.s 79523, 81690 and 95749 (Bear Mountain Irrigation Wells 405, 407 and 411; shown on Figure 1).

In previous years, Bear Mountain had retained a professional hydrogeologist to conduct groundwater level and flow monitoring for the irrigation wells (Bear Mountain Wells 405, 407 and 411) and monitoring wells (Bear Mountain Wells 400 and 412) at the golf course. The locations of these wells are presented on Figure 1. Annual reports that documented the results had been made available to the District since the Highlands monitoring program began in 2009, with the most recent Bear Mountain report being provided for 2022. WSP reviewed the Bear Mountain reports and documented the results in the annual reports for the Highlands monitoring program.

An annual groundwater monitoring report for the Bear Mountain was not provided to the District for 2023.

[1] Population information, as provided by the District of Highlands in file “Estd Pop_Hanington Creek Estates_2013-2023.docx”, that is based on Occupancy Permits, Stats Canada 2011, 2016, and 2021 Census data and Building Official’s observations.

[2] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-licences-approvals/water-rights-databases

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Based on the results of the 2023 Highlands groundwater monitoring program, it is concluded that:

- In 2023, groundwater levels in the Highlands monitoring wells were generally consistent with the seasonal patterns reported for previous years and generally within the range of what has been reported for previous monitoring years.
- Relatively low groundwater levels observed in some of the Highlands monitoring wells and provincial observation well BC ENV Well No. 372 during the dry season are inferred to reflect low precipitation that was recorded in the dry summer months and fall of 2023; however, groundwater levels were observed to recover following onset of seasonal precipitation later in the fall, similar to previous years.
- Average water use for the Hanington Estates Water System was estimated to be approximately 107.7 m^3/day for the period January 31, 2023 to November 24, 2023. This is higher than previous values that ranged from 67.6 m^3/day (in 2019) to 86.3 m^3/day (in 2021) since full buildout of the development in 2017.
- Per capital water use for the Hanington Estates Water System was estimated to be 538 L/p/d in 2023. This value is greater than the values of 338 to 432 L/p/d that were calculated for 2019 and 2021, respectively. The results from 2023 may reflect increased water use during the drier than average conditions in 2023 or potentially an increase in the population of Hanington Estates.
- A 2023 annual groundwater monitoring report for the Bear Mountain Golf Course was not available for review for consideration in this report.

WSP provides the following recommendations:

- The Highlands groundwater monitoring program, including review of stakeholder programs, should continue in 2024 to monitor and document groundwater conditions across the Highlands.
- Regarding potential refinements to the current monitoring program, WSP recommends that a pressure transducer be redeployed in DOH-02A to provide additional coverage in the western portion of the Highlands. A survey of residents could also be conducted to identify other potential wells that could be included in the monitoring program. To support this survey, strategic locations in the current monitoring well network should be identified. A plan should also be developed to acquire the necessary equipment (e.g., additional pressure transducers) to refine the program and to replace existing equipment on a regular schedule.
- WSP also recommends that the District consider potential opportunities to collaborate with other parties to share resources and achieve similar objectives in a cost-effective manner. As outlined in the WSP (2022) 2021 annual monitoring report, 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 including: 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, and the groundwater licensing process.

- 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, if available. 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 continuous water level monitoring data from the production wells, and potentially from an observation well if present, in addition to the flow meter data that are currently collected. It is anticipated that water level monitoring may be required by the Province to support groundwater licensing.
- 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,

WSP Canada Inc.

Mark Bolton, MSc, P.Geo.
Senior Principal Hydrogeologist

Arianna Piazza, MASc, P.Eng.
Principal Hydrogeologist

MB/AP/cdg

WSP Canada Inc.
Engineers & Geoscientists BC
Permit #1000200

Attachments: Figures 1 – 8
Attachment 1 – Aquifer Factsheet: Aquifer 680 Wark-Colquitz
Attachment 2 – Conditional Groundwater Licence for Bear Mountain Golf Course

https://wsponlinecan.sharepoint.com/sites/ca-2023ca95087/shared documents/06. deliverables/3.0_issued/ca0014383.5087-002-l-rev0/ca0014383.5087-002-l-rev0-final report-07feb_25.docx

6.0 REFERENCES

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FINLAYSON ARM
Pease Creek
Pease Lake
Durrance Lake
Hazlitt Creek
Cal Revelle Nature Sanctuary
DOH-07A
DOH-07B
PEASE CREEK WATERSHED
Third Lake
Killarney Lake
DOH-06
DOH-05
Second Lake
Fork Lake
DISTRICT OF HIGHLANDS
THE CORPORATION OF THE DISTRICT OF SAANICH
Mill Stm.
Mitchell Lake
MOE 372
West Highlands District Firehall
Highlands Weather Station
East Highlands District Firehall
DOH-09A
DOH-09B
Fizzle Lake
Eagles Lake
DOH-04A
DOH-04B
DOH-02B
DOH-02A
CRAIGFLOWER CREEK WATERSHED
MILL STREAM CREEK WATERSHED
DOH-01
Mary Lake
413
414
412
411
Teanook Lake
Pike Lake
Matson Lake
GOLDSTREAM 13
400
407
405
409
500
District of Highlands Office
DOH-03
McKenzie Lake
TOWN OF VIEW ROYAL
CITY OF LANGFORD
Lakewood Elementary School
Millstream Elementary School
INSET
0 3,000 6,000
1:300,000 METRES
460000 462000 464000 466000
5378000 5376000 5374000 5372000 5370000 5368000

LEGEND

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

Elevation - metres above sea level (masl)

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

0 640 1,280
1:32,000 METRES

REFERENCES

1. DATA PROVIDED BY THE DISTRICT OF HIGHLAND AND BC ILMB.
2. WEATHER STATIONS OBTAINED FROM ENVIRONMENT CANADA AND THE UNIVERSITY OF VICTORIA SCHOOL-BASED WEATHER STATION NETWORK.
3. PARCEL FABRIC, MUNICIPAL BOUNDARY, INDIAN RESERVE, WATERBODY AND WATERCOURSE DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.
4. IMAGERY COPYRIGHT © 20230214 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 MONITORING PROGRAM
DISTRICT OF HIGHLANDS, BC

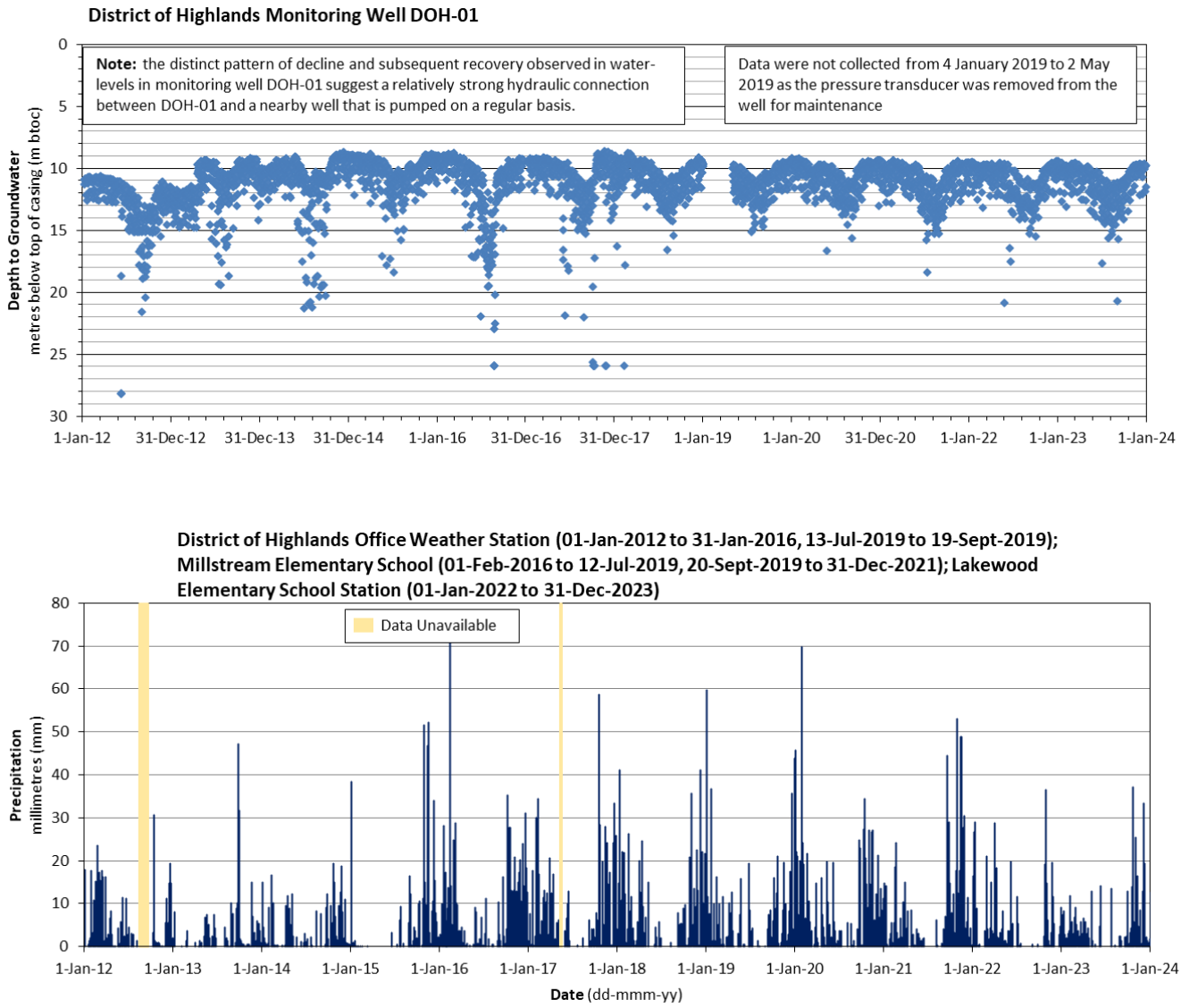
TITLE
MONITORING LOCATIONS

CONSULTANT
wsp

YYYY-MM-DD	2025-01-28
DESIGNED	AU
PREPARED	LH
REVIEWED	AU
APPROVED	MAB

PROJECT NO. CA0014383.5087
REV. 1
FIGURE 1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
0



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 2023 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC**				
TITLE	**DEPTH TO GROUNDWATER MONITORING WELL DOH-01 AND PRECIPITATION IN SOUTHERN HIGHLANDS**				
	PROJ. NO. CA0014383.5087			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
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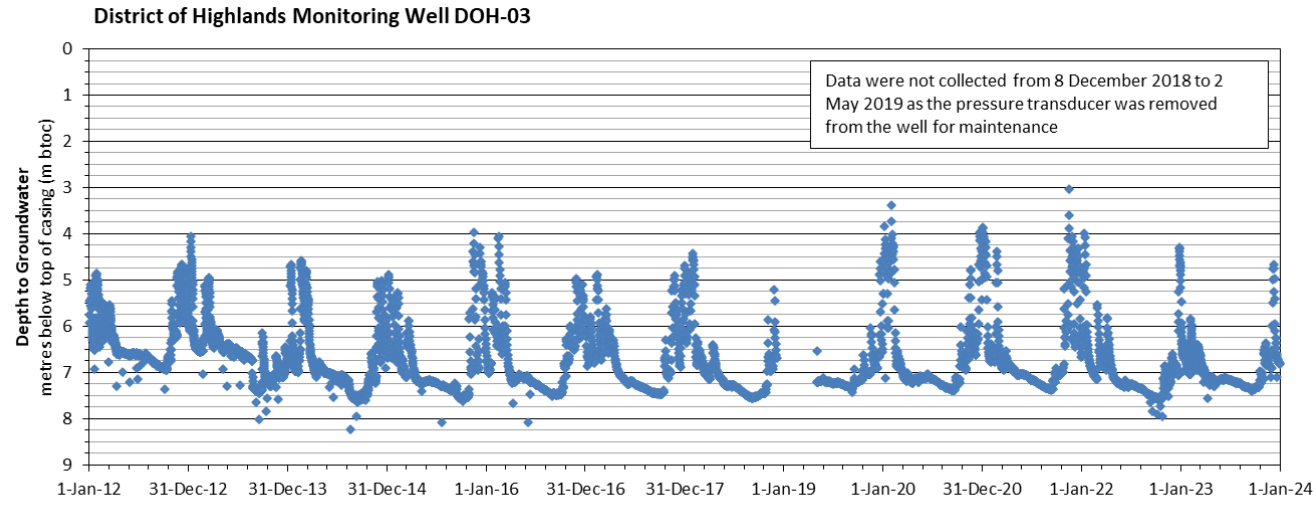
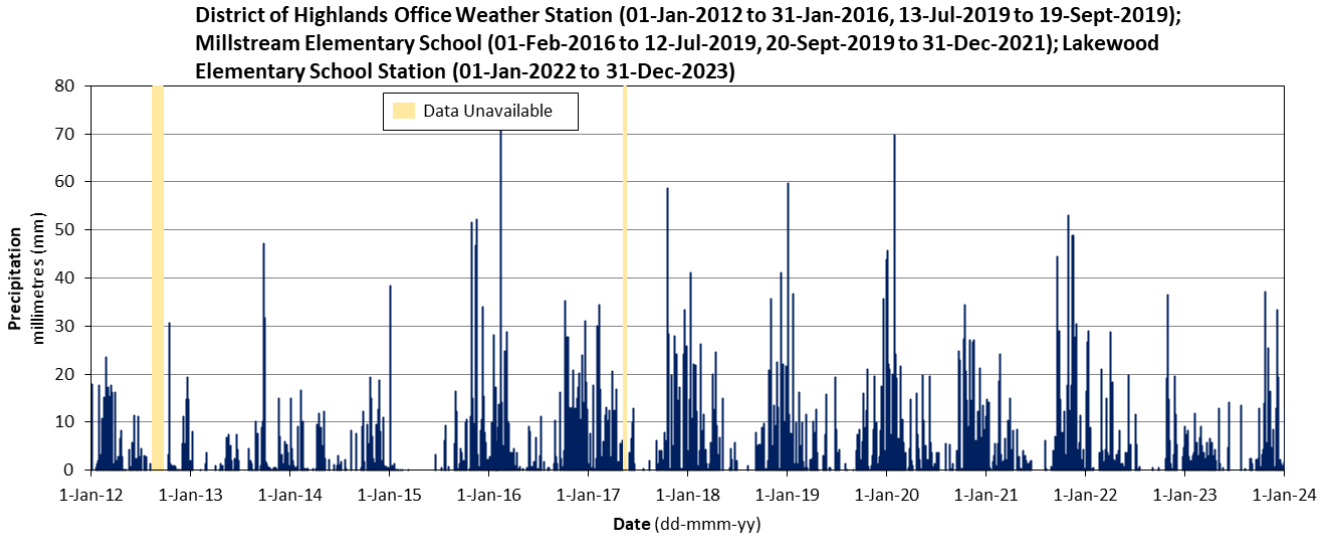
	CHECK	MB	15JAN25		
	REVIEW	AP	30JAN25		





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 2023 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC**				
TITLE	**DEPTH TO GROUNDWATER MONITORING WELL DOH-03 AND PRECIPITATION IN SOUTHERN HIGHLANDS**				
	PROJ. NO. CA0014383.5087			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
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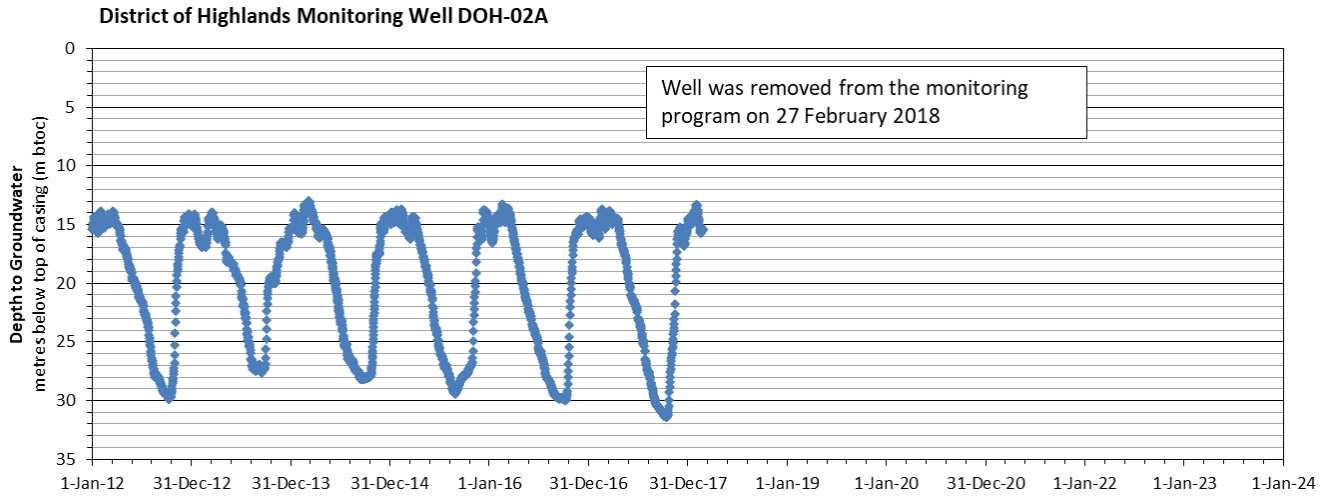
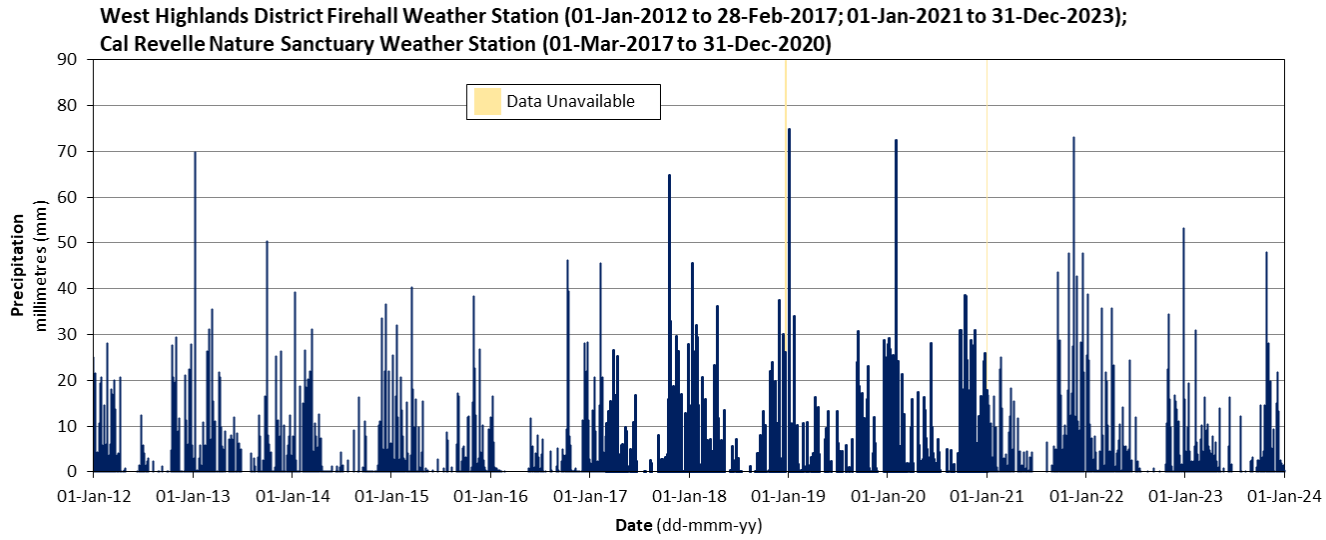
	CHECK	MB	15JAN25		
	REVIEW	AP	30JAN25		





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 2023 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC				
TITLE	DEPTH TO GROUNDWATER MONITORING WELL DOH-02A AND PRECIPITATION IN WESTERN HIGHLANDS				
wsp	PROJ. NO. CA0014383.5087			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
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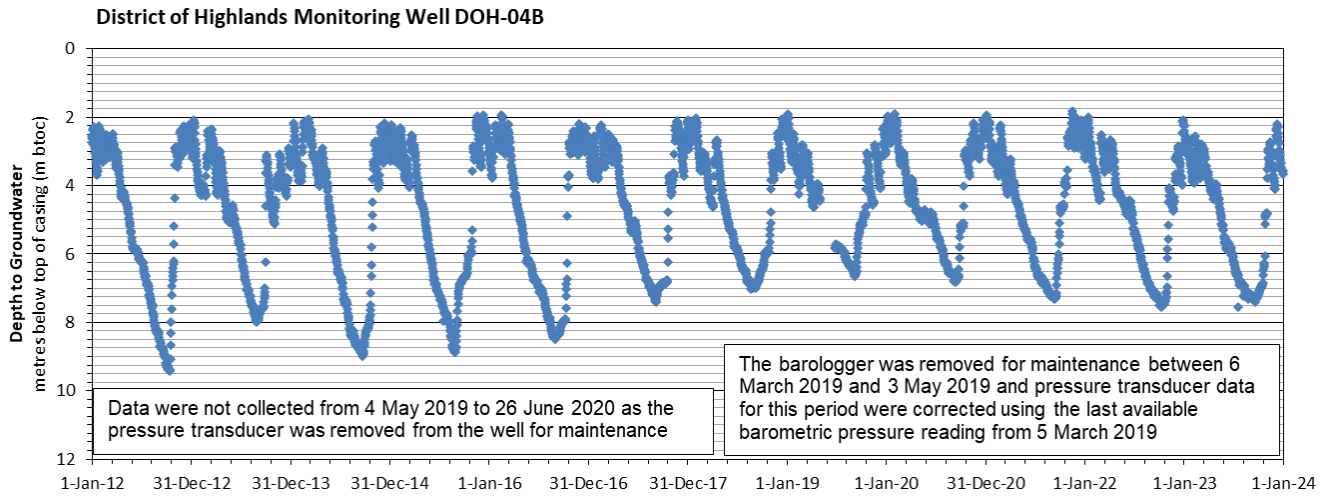
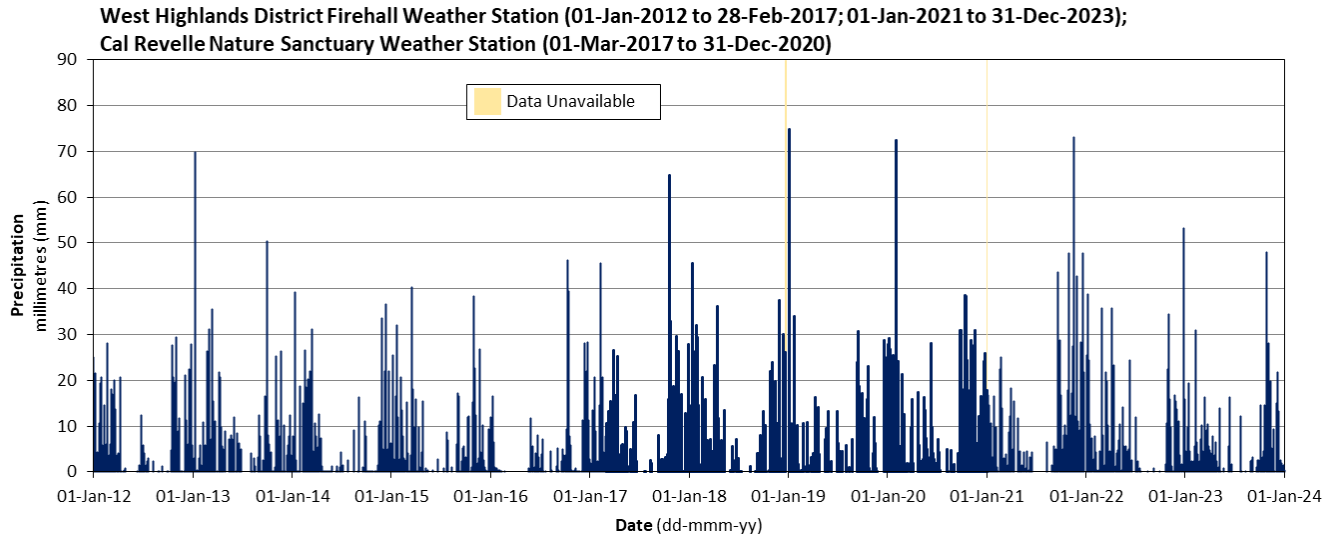
	REVIEW	AP	30JAN25		





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 2023 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC				
TITLE	DEPTH TO GROUNDWATER MONITORING WELL DOH-04B AND PRECIPITATION IN WESTERN HIGHLANDS				
wsp	PROJ. NO. CA0014383.5087			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
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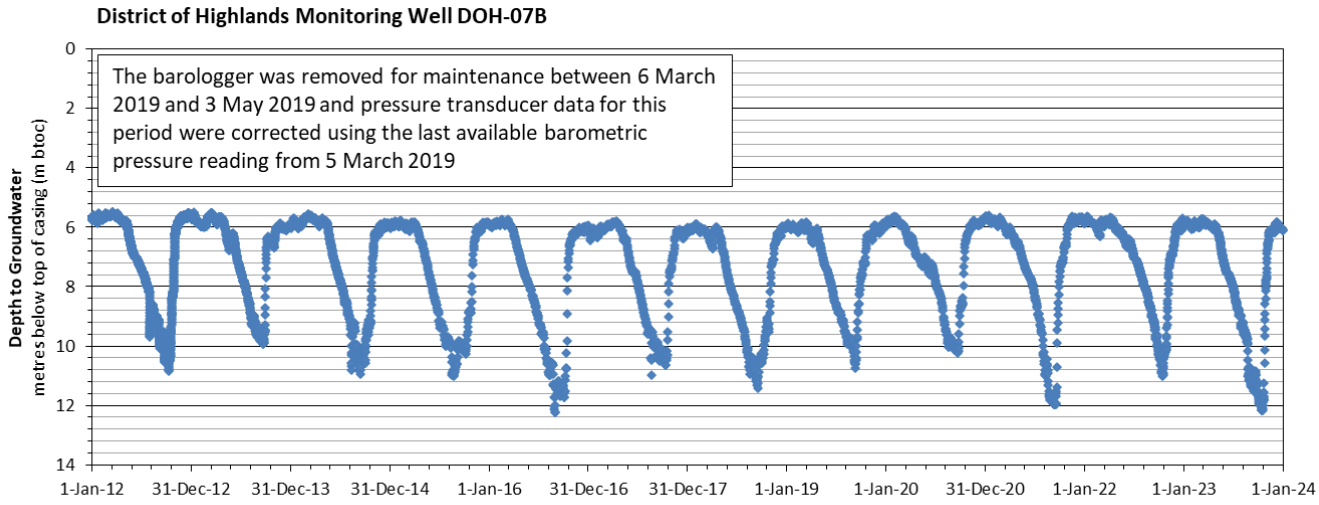
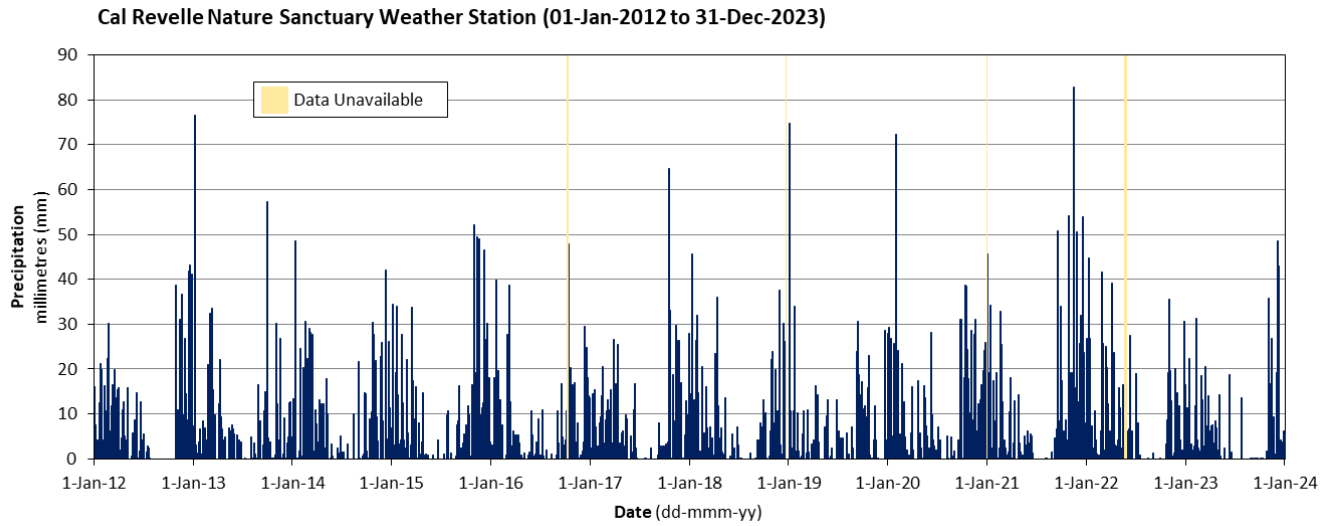
	REVIEW	AP	30JAN25		





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 2023 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC				
TITLE	DEPTH TO GROUNDWATER MONITORING WELL DOH-07B AND PRECIPITATION IN NORTHERN HIGHLANDS				
wsp	PROJ. NO. CA0014383.5087			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
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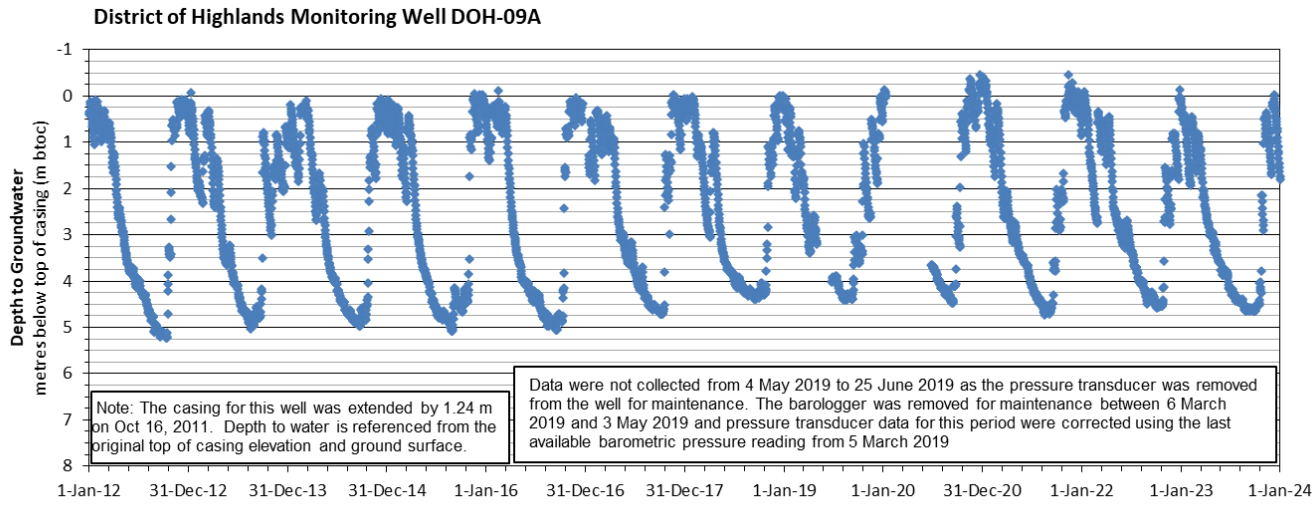
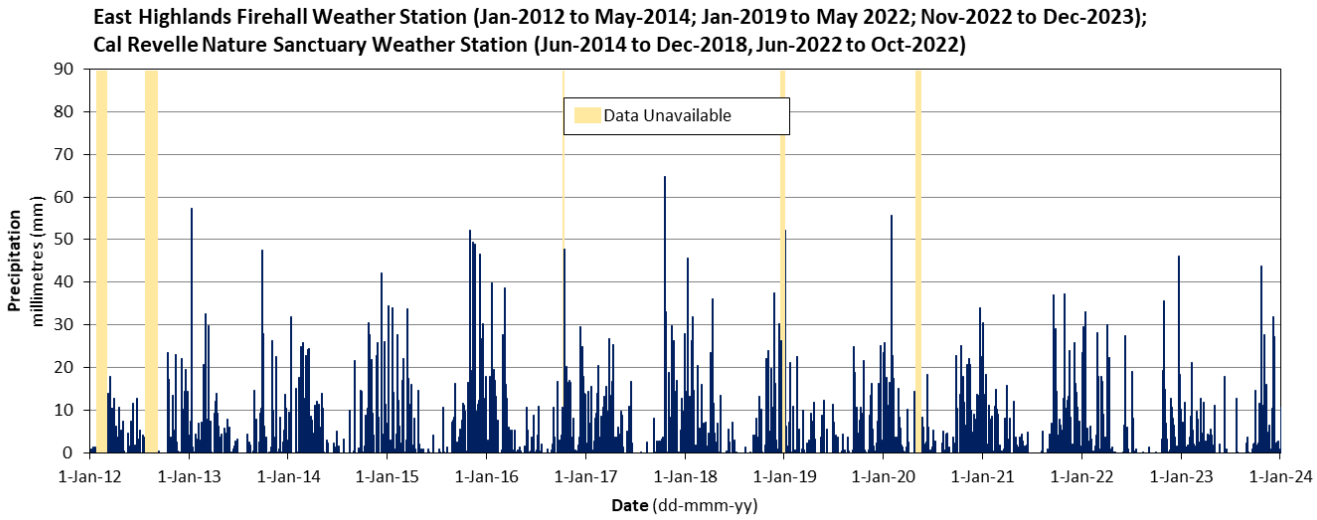
	CHECK	MB	15JAN25		
	REVIEW	AP	30JAN25		



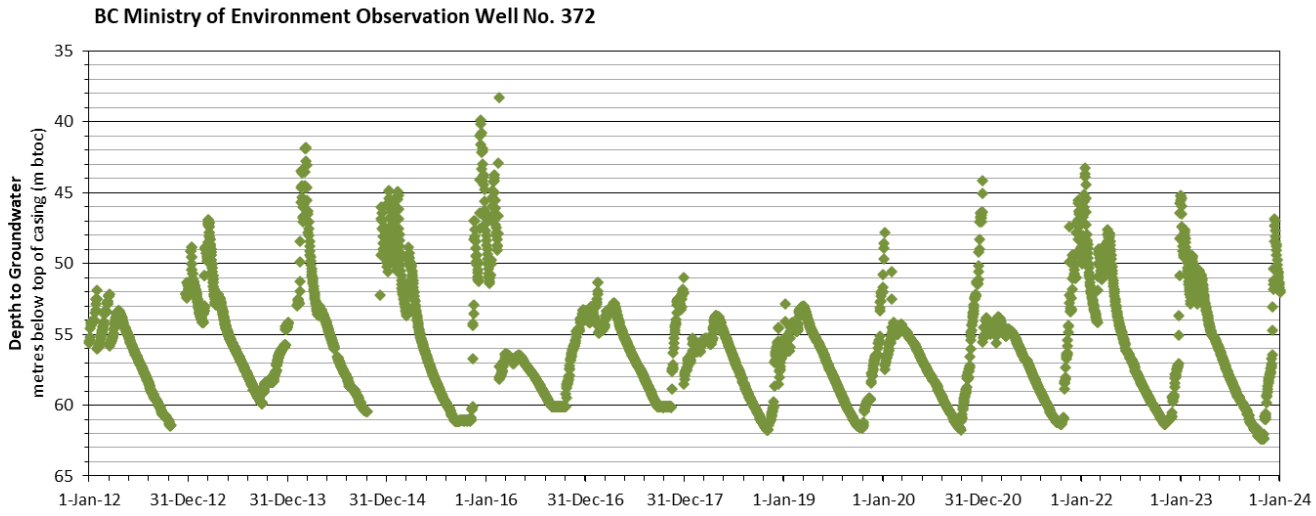


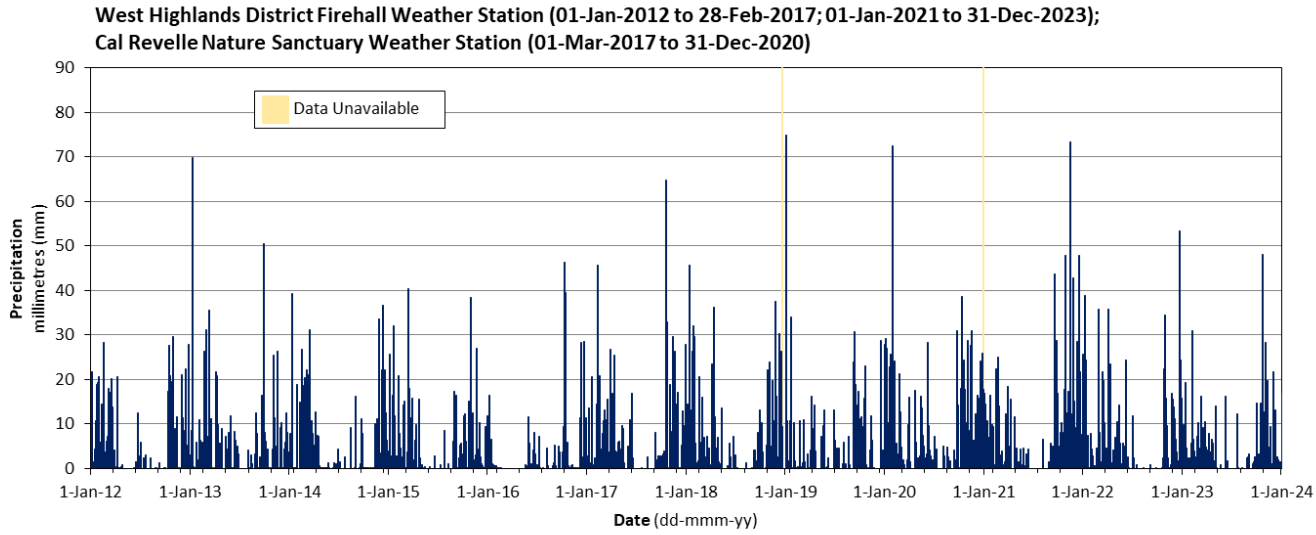
Notes

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 2023 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC**				
TITLE	**DEPTH TO GROUNDWATER MONITORING WELL DOH-09A AND PRECIPITATION IN EASTERN HIGHLANDS**				
	PROJ. NO. CA0014383.5087			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
	CADD	MB	15JAN23	**FIGURE 7**	
	CHECK	MB	15JAN25		
	REVIEW	AP	30JAN25		





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

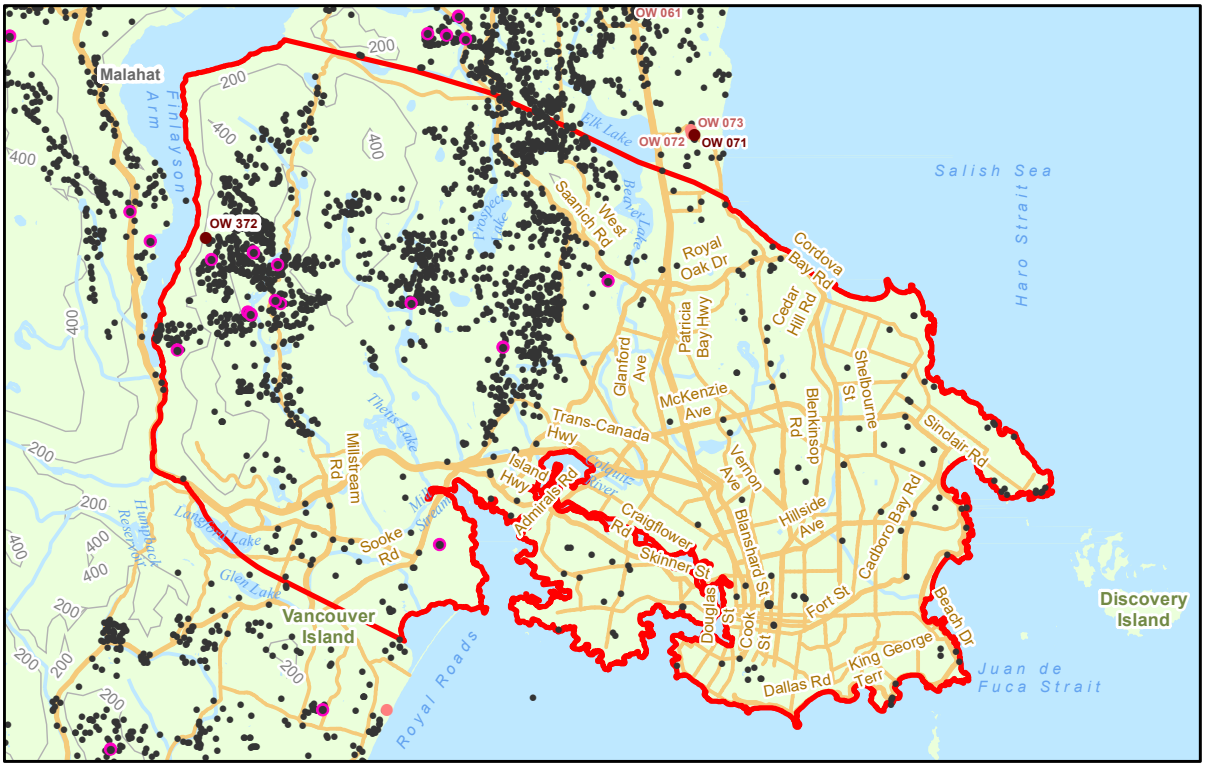
Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.
http://www.victoriaweather.ca/

PROJECT	**DISTRICT OF HIGHLANDS 2023 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC**				
TITLE	**DEPTH TO GROUNDWATER MOE OBSERVATION WELL 372 AND PRECIPITATION IN WESTERN HIGHLANDS**				
wsp	PROJ. NO. CA0014383.5087			FILE No. ----	
	DESIGN	CB	06NOV14	SCALE NTS	REV. 0
	CADD	MB	15JAN23	**FIGURE 8**	
	CHECK	MB	15JAN25		
	REVIEW	AP	30JAN25		

ATTACHMENT 1

Aquifer Factsheet: Aquifer 680 Wark-Colquitz

Aquifer #680
Wark-Colquitz



Legend

- Registered Water Well - Artesian
- Registered Water Well
- Active Observation Well
- Inactive Observation Well
- Aquifer Boundary

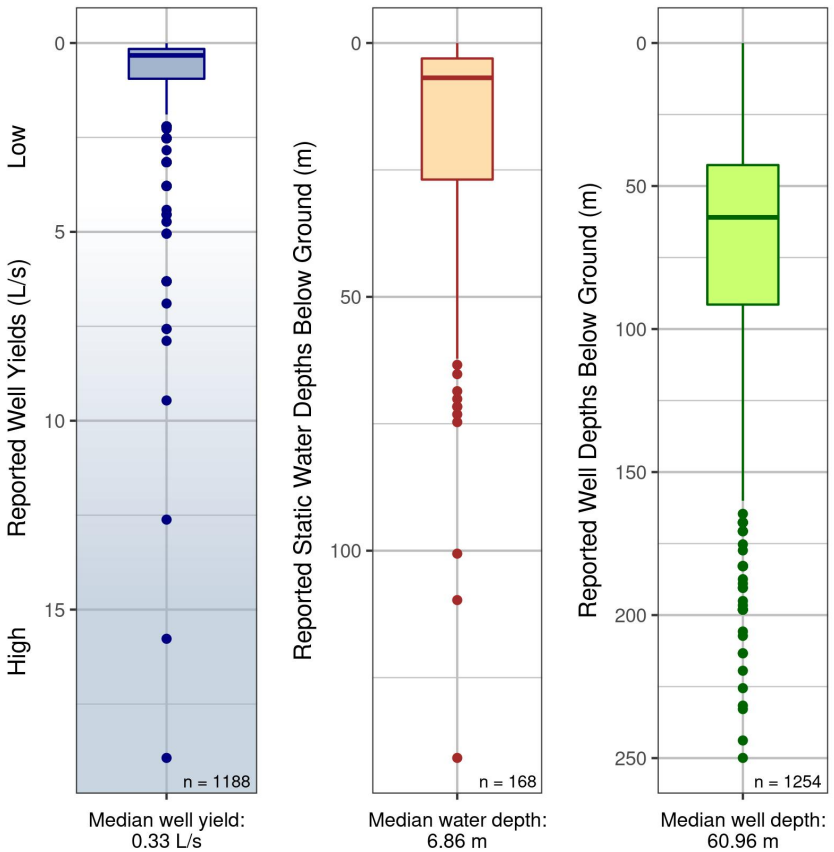
0 2 4 km

N

Aquifer Description (Mapping Report - 2012): Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic, volcanic) rock aquifer (subtype = 6b).

Aquifer Details	
Region	West Coast
Water District	Victoria
Aquifer Area	209 km^2
No. Wells Correlated	1258
Vulnerability to Contamination	Moderate
Productivity	Moderate
Aquifer Classification	IB
Hydraulic Conductivity *	Unknown
Transmissivity *	Unknown
Storativity *	Unknown
No. Water Licences Issued to Wells	Unknown
Observation Wells (**Active**, Inactive)	**372**

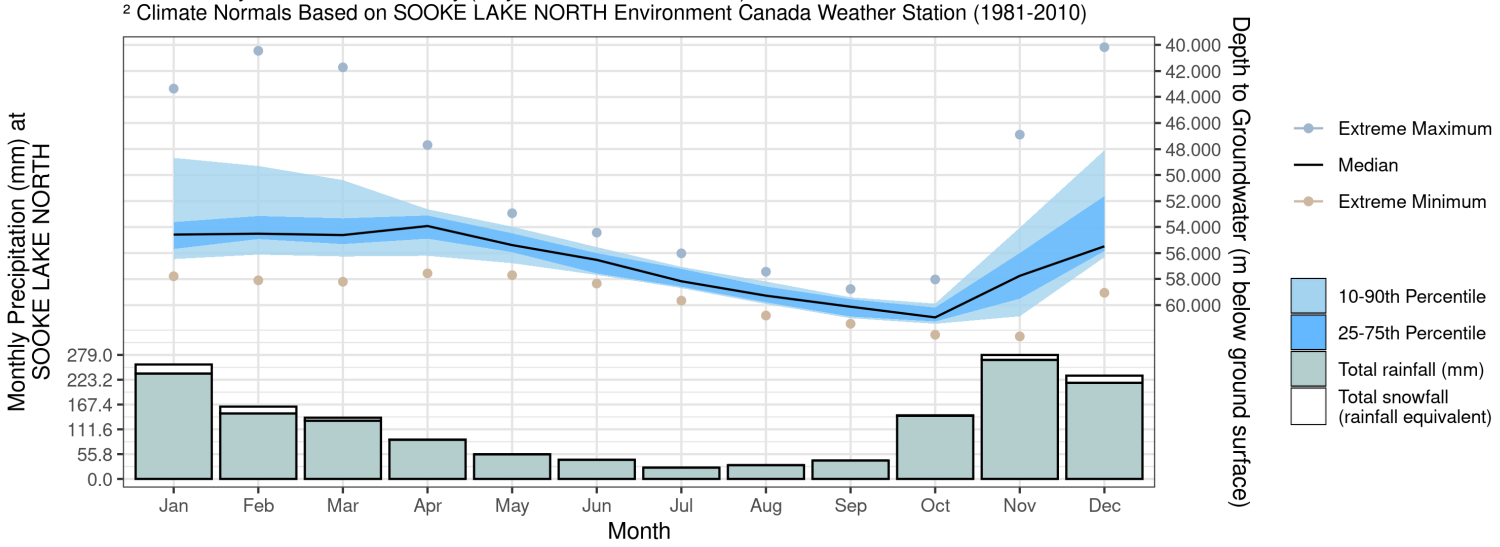
* min - max
For Hydraulic Connection see guidance document



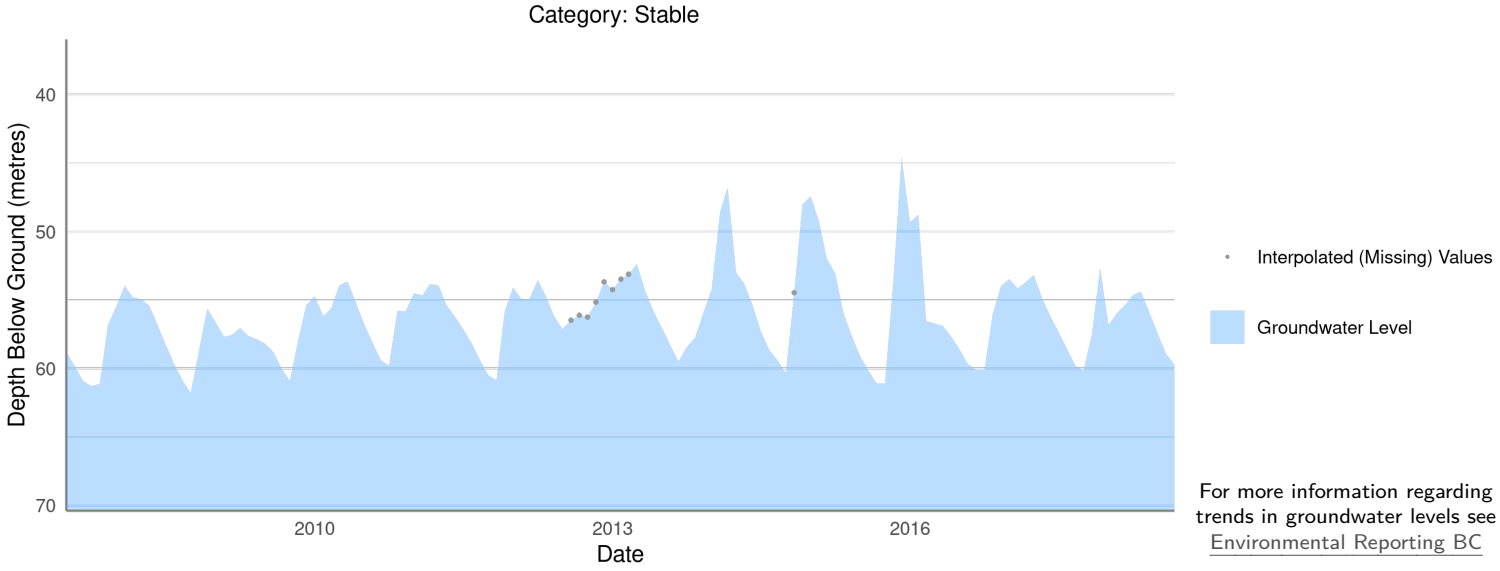
Detailed methods for all figures are described in the companion document (Aquifer Factsheet - Companion Document.pdf).
Factsheet generated: 2022-07-27. Aquifers online: https://apps.nrs.gov.bc.ca/gwells/aquifers.

Monthly Groundwater Level[1] with Precipitation from Climate Normals[2]

[1] Full Monthly Water Level Summary (15 years of data; 2007-2022)
[2] Climate Normals Based on SOOKE LAKE NORTH Environment Canada Weather Station (1981-2010)

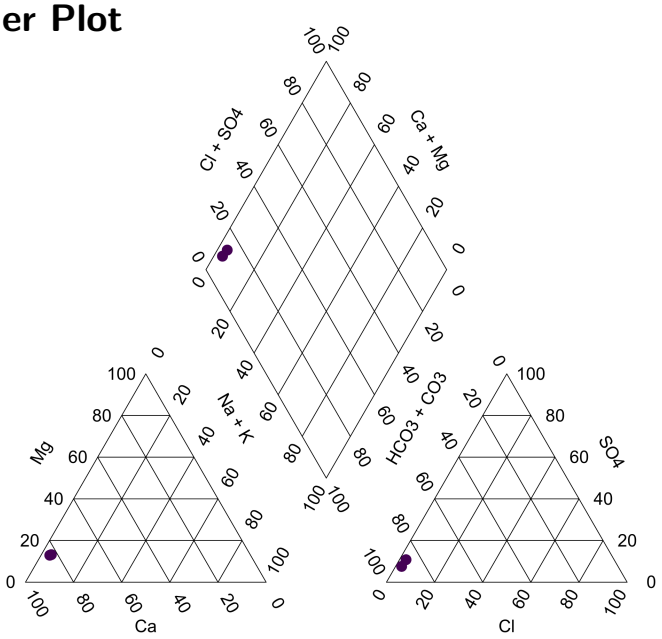


Groundwater Levels and Long-term Trend



For more information regarding trends in groundwater levels see Environmental Reporting BC

Piper Plot



The groundwater samples are typically of the Ca-HCO3 type. Ca is the dominant cations, which indicates a less evolved/short flow path recharge area type of groundwater. The fact that HCO3 is the dominant anion shows the source is primarily recent precipitation in the bedrock aquifer #680. For EMS water chemistry data, see EMS ID E267282.

ATTACHMENT 2

Conditional Groundwater Licence for Bear Mountain Golf Course

Province of British Columbia
Water Sustainability Act

CONDITIONAL WATER LICENCE

The owner(s) of the land to which this licence is appurtenant is hereby authorized to divert and use water as follows:

a) The aquifer on which the rights are granted is comprised of bedrock materials within the Millstream Watershed (VICT – Millstream) located at approximately 67 metres (220 feet), 84 metres (275 feet), and 116 metres (380 feet) depth below ground surface.

b) The points of well diversions (WTN 79523, WTN 81690, and WTN 95749) are located as shown on the attached plan.

c) The date from which this licence shall have precedence is February 2, 2007.

d) The purposes for which this licence is issued are industrial (lawn, fairway & garden) and land improvement.

e) The maximum quantity of water which may be diverted for industrial (lawn, fairway & garden) purpose is 243,180 cubic metres per year, and for land improvement purpose is 36,520 cubic metres per year.

f) The period of the year during which the water may be used is May 1 to October 31.

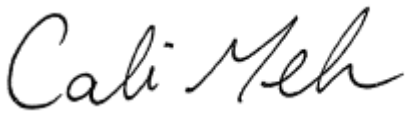
g) The land upon which the water is to be used and to which this licence is appurtenant is Section 5, Range 4 West, Except Parts in Plans VIP60675, VIP67875 & VIP75584; the South 60 acres of Section 6, Range 4 West, Except Part in Plan VIP67875; Section 12, Except Parts in Plans 10853, 11134 & 45402; Section 16, Except that Part in Plan VIP72555; Block B, Section 75; Lot 1, Sections 81, 82 and 84, Plan VIP75509, Except Plans VIP76365, VIP79028, VIP82848, VIP82851, VIP85324, EPP19660, EPP63084, EPP72419, EPP80460 & EPP70640; and Lot 2, Sections 81, 82, 83 and 84, Plan VIP75509, Except Parts in Plans VIP76365, VIP78873, VIP81135, VIP81958, VIP82040, VIP89370, EPP42751, EPP46993, EPP80460, EPP68922 & EPP111201, all within Highland District.

h) The authorized works are three wells, three meters, two ponds, two pumphouses, pipe, and irrigation system, which shall be located approximately as shown on the attached plan.

i) The construction of the said works has been completed and the water is being beneficially used. The licensee shall continue to make regular beneficial use of the water in a manner authorized herein.

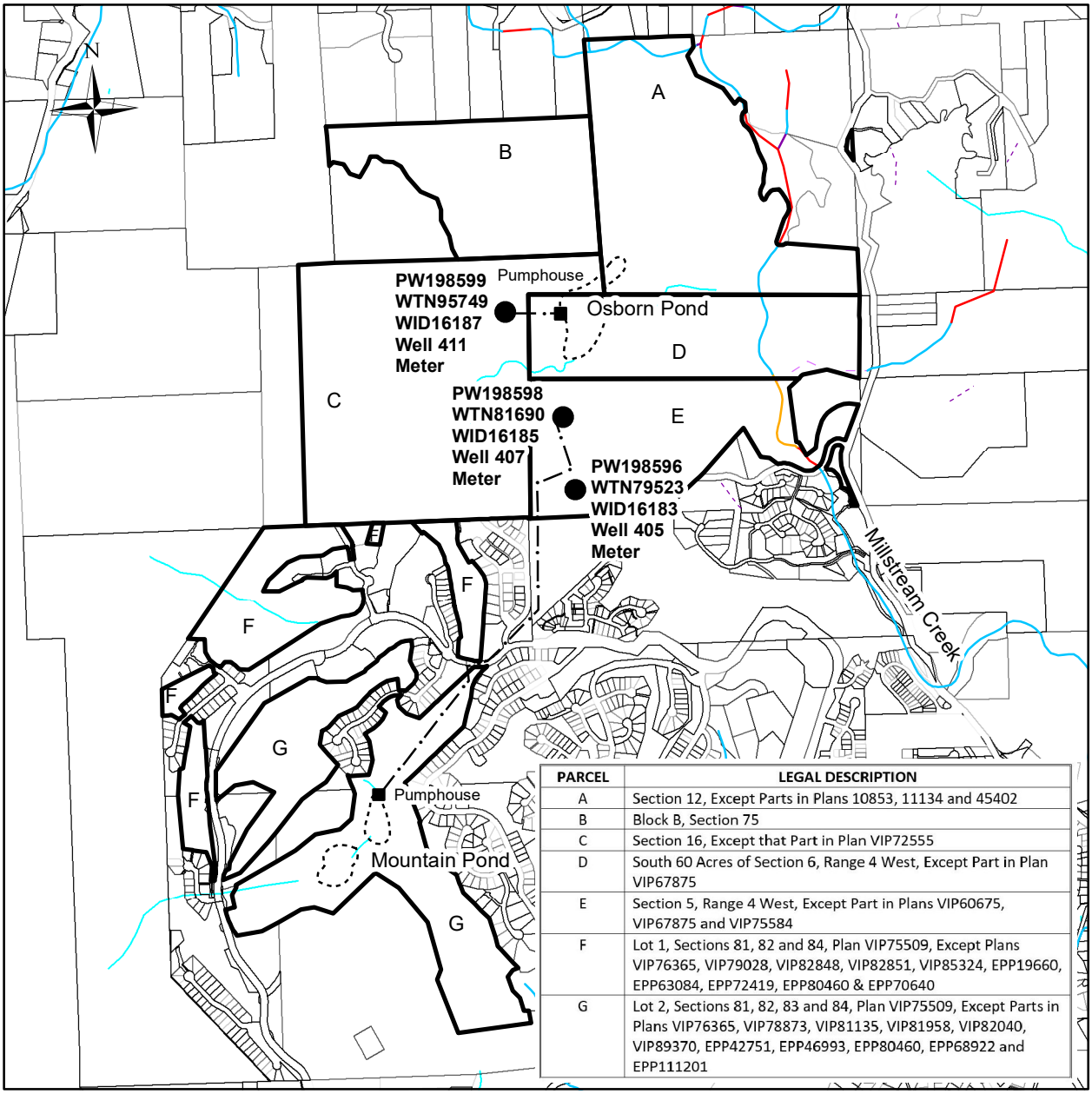
j) The licensee shall install a flow measuring device to the satisfaction of an Engineer under the *Water Sustainability Act*.

k) The licensee shall retain flow meter records for inspection upon request by an Engineer under the *Water Sustainability Act*.



Cali Melnechenko
Water Manager

BRITISH COLUMBIA



PARCEL	LEGAL DESCRIPTION
A	Section 12, Except Parts in Plans 10853, 11134 and 45402
B	Block B, Section 75
C	Section 16, Except that Part in Plan VIP72555
D	South 60 Acres of Section 6, Range 4 West, Except Part in Plan VIP67875
E	Section 5, Range 4 West, Except Part in Plans VIP60675, VIP67875 and VIP75584
F	Lot 1, Sections 81, 82 and 84, Plan VIP75509, Except Plans VIP76365, VIP79028, VIP82848, VIP82851, VIP85324, EPP19660, EPP63084, EPP72419, EPP80460 & EPP70640
G	Lot 2, Sections 81, 82, 83 and 84, Plan VIP75509, Except Parts in Plans VIP76365, VIP78873, VIP81135, VIP81958, VIP82040, VIP89370, EPP42751, EPP46993, EPP80460, EPP68922 and EPP111201

WATER DISTRICT: VICTORIA
PRECINCT: VICTORIA
LAND DISTRICT: HIGHLAND
WATERSHED: VICT - Millstream

Signature: Cali Meh
Date: June 23, 2023

LEGEND:

Scale: 1:20,000
Point of Diversion: ●
Map Number: 92B.043.3
Pipe: ·—·—·—·–

C.L.: 501806
FILE: 20006990

The boundaries of the land to which this licence is appurtenant are shown thus: ——————