

18 May 2018

Reference No. 1771760-001-L-Rev0

**Laura Beckett, Municipal Planner, MURP, MCIP, RPP**

Municipal Planner, Deputy Approving Officer

District of Highlands

1980 Millstream Road

Victoria, BC, V9B 6H1

**RESULTS OF 2017 GROUNDWATER LEVEL MONITORING PROGRAM, DISTRICT OF HIGHLANDS, BC**

Dear Ms. Beckett,

As requested by the District of Highlands (the District), Golder Associates Ltd. (Golder) conducted a groundwater level monitoring program in the District of Highlands, BC (the Highlands) for 2017. Golder conducted the work in accordance with our proposal titled "Work Plan and Cost Estimate for 2017 Groundwater Level Monitoring Program, District of Highlands, BC" (Golder Reference No. P1771760-001-L-Rev0) and dated 11 January 2017.

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

## **1.0 BACKGROUND AND OBJECTIVE**

The Highlands is one of 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 approximately 2,120 obtains potable water from private, individual water wells. 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, also use groundwater for commercial purposes.

### **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 BC Ministry of Environment and Climate Change Strategy (ENV) and is categorized as class IIB under the BC Aquifer Classification System, indicating moderate 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.

## 1.2 Highlands Monitoring Program

On behalf of the District, Golder initiated a groundwater level monitoring program in the Highlands in 2009 in support of the District's Groundwater Protection Study. The water-level information was used to assess seasonal groundwater-level variations and, in 2012, to refine the numerical groundwater model that Golder developed and calibrated. The refined numerical model was then used to develop groundwater conservation and protection measures. 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 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. Further details are provided in Golder's report titled "Phase 3: Groundwater Protection Study District of Highlands, District of Highlands Victoria, BC" (Golder Report No. 0714140014-501-R-Rev2-3000) and dated 18 December 2012.

The groundwater monitoring program has been continued since 2009 through 2017. At the end of 2017, electronic data loggers (i.e., pressure transducers) are deployed in six monitoring wells located across the Highlands to collect continuous water-level data at strategic locations, and one additional pressure transducer (a "barologger") is present to monitor changes in barometric (i.e., atmospheric) pressure. The locations of monitoring wells DOH-01, DOH-02A, DOH-03, DOH-04B, DOH-07B and DOH-09A are presented on attached Figure 1.

Monitoring wells DOH-02A, DOH-07B and DOH-09A are unused wells that are not equipped with pumps (i.e., are not in operation). Therefore, 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. As discussed in Section 3.1, the water level in DOH-07B tends to be influenced by pumping in a nearby well late in the summer period.

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 representative of the water levels in the surrounding aquifer during periods of pumping; however, the high water-levels that represent static (i.e., non-pumping) periods provide a basis to assess groundwater conditions in the areas of these wells.

## 1.3 Objective

The objective of the 2017 groundwater level monitoring program was 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-01A, are programmed to collect data every twelve hours. Under the current program, Golder downloaded pressure transducer data and collected a manual depth-to-water measurement at each monitoring location in the Highlands on 1 September 2017 and 27 February 2018, when the monitoring wells were accessible for monitoring.

## 2.2 Data Compilation and Analysis

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

- ENV Observation Well Network: water-level data available on-line from the ENV for Observation Well No. 372, 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
- Bear Mountain Monitoring Program: water-level and flow data available from Ecoasis Developments LLP for the Bear Mountain Golf and Country Club in the southern portion of the Highlands
- 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

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

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 groundwater levels for each Highlands monitoring well. Golder also compiled data available from ENV Observation Well No. 372. 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 the 2016 annual monitoring program, Golder compiled precipitation data from alternate, nearby weather stations as follows:

- Southern Highlands: In 2016 data for the District of Highlands Office weather station were not available from 15-25 February and from 4 October to the end of the year. Therefore, data from the Millstream Elementary School weather station for the period 1 February 2016 – 31 December 2017 were compiled and compared to the water level data for DOH-01 and DOH-03. The Millstream Elementary School station is located approximately 1,400 m to the south of, and at an elevation 24 m lower than, the District of Highlands Office station (Figure 1).
- Western Highlands: Beginning in March 2017, data were not available for the West Highlands District Firehall weather station. Therefore, data from the Calle Reville 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-02 and DOH-04 for the period 1 March – 31 December 2017.
- Eastern Highlands: Data were not available for the East Highlands District Firehall weather station after 31 May 2014. A UVic weather station is located at Prospect Lake Elementary School, approximately 3 km northeast from the East Highlands District Firehall station. Only intermittent data were available for the Prospect Lake Elementary station. Therefore, data from the Calle Reville Nature Sanctuary Weather Station, located approximately 3.9 km northwest from the East Highlands District Firehall, were compared to water-level data from DOH-09A.

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

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 2016-2017 Annual Groundwater Monitoring Report" (WWAL File No. 16-092-01) and dated 9 March 2018. Golder did not conduct a detailed review of the data presented in WWAL's report. Rather, Golder assessed the results from the Bear Mountain Monitoring Program in the context of the regional groundwater system.

## **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 1 January 2011 through 31 December 2017, together with daily precipitation data from nearby weather stations, are presented on Figures 2 through 7. 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 7 are considered suitable for the purposes of assessing general groundwater level patterns. Furthermore, groundwater recharge into the bedrock aquifer is interpreted to be controlled by the properties of the bedrock and not necessarily the intensity of precipitation. Therefore, it is anticipated that minor changes in precipitation in different areas of the Highlands would not necessarily be reflected in water-level data.

In 2017, the water-levels recorded in the majority of the Highlands monitoring wells were consistent with the seasonal trend observed in previous years, with groundwater elevations highest in the wet winter months of December to April, declining to a seasonal low during the summer months of May to September, and increasing in response to precipitation in October and November. Consistent with previous years, the seasonal responses observed in 2017 were greatest in monitoring wells located at higher elevations, in areas of inferred groundwater recharge. Seasonal responses in 2017 ranged from approximately 17 m in DOH-02A, located in an upland area at an elevation of over 260 m above sea level (asl), to approximately 3 m and 5 m in DOH-03 and DOH-09A, respectively. These wells are located at lower elevations in inferred groundwater discharge areas adjacent to wetlands.

The groundwater levels that were observed in the Highlands monitoring wells at the end of the dry season of 2017 were consistent with precipitation patterns and generally within the range of those observed during previous years. The total precipitation of 110.4 mm that was recorded for the Calle Revelle Nature Sanctuary weather station from 1 May through 30 September 2017 is relatively low when compared to the same period in previous monitoring years. With the exception of 2013, precipitation recorded at the Calle Revelle Nature Sanctuary weather station during the May through September period has ranged from 96.4 mm in 2012 to 174.3 mm in 2009. In 2013, relatively higher precipitation was recorded in May and September, resulting in a total of 317.8 mm

of precipitation being recorded for the May through September period. The seasonal low water levels observed in the Highlands monitoring wells were generally lower in years when precipitation was lower during the summer months.

In mid-October 2017, the seasonal low water level of 31.0 m below top of (well) casing (btoc) that was recorded in DOH-02A was lower than what was observed in previous monitoring years; however, this water level is approximately 25 m above the bottom of the well, which was reported to be approximately 56.4 m below ground surface (bgs) at the time of drilling. Although the seasonal low water levels recorded in DOH-02A exhibit a downward trend from 2013 to 2017, seasonal low water levels of 29.6 and 29.9 mbtoc were observed for this well in 2011 and 2012, respectively. The lower water levels observed in 2011, 2012 and 2017 coincided with longer dry seasons that extended into mid-October. In comparison, higher water levels were observed in DOH-02A during the dry seasons of 2013 and 2014, when relatively more precipitation was recorded in August and September. Similar to previous years, in 2017 the water level in DOH-02A responded rapidly to precipitation in the autumn months. It is anticipated the water level in DOH-02A continued to rise early in 2018 to the range of approximately 13.0 to 14.0 mbtoc that has been observed in previous years. Continued seasonal monitoring would be required to determine if the results from previous monitoring years represent a long term decline in dry season water levels.

The 2017 seasonal low water level of 7.4 mbtoc that was reported for DOH-04B was relatively higher than the range of 8.0 to 9.4 mbtoc that has been observed for this well in previous monitoring years. The 2017 result may reflect less groundwater use from DOH-04B and/or surrounding wells in the area. The seasonal low water level of 4.7 mbtoc that was reported for DOH-09A in 2017 was also slightly higher than the range of 5.0 to 5.2 mbtoc that has been observed in previous monitoring years.

The water levels in DOH-01, DOH-03 and DOH-07B were also generally consistent with previous years and continued to be influenced by pumping of the well (DOH-03) or nearby well(s) (DOH-01 and DOH-07B). The lowest isolated (i.e., pumping induced) water level of 25.9 mbtoc was observed in DOH-01 in 2012, 2016 and 2017. Similar to previous monitoring years, the static water level in DOH-01 is inferred to have been in the range of 11 mbtoc during the dry season of 2017. Similarly, the seasonal low water level of approximately 7.5 mbtoc that was observed in DOH-03 was also consistent with previous monitoring years.

Similar to previous monitoring years, the lowest water level that was observed in DOH-07B in 2017 (11.0 mbtoc) is inferred to represent a period of pumping in a nearby well late in the summer period. Following recovery of the water level in DOH-07B, the static water level is interpreted to have declined to a seasonal low water level of 10.7 mbtoc in October 2017. This seasonal static low water level observed in DOH-07B in 2017 is within the values that, with the exception of 2016, ranged from 9.6 mbtoc in 2011 to 11.0 mbtoc in 2015. On-going monitoring would be required to determine if the seasonal low water level of 11.7 mbtoc that was observed in DOH-07B in 2016 represents an isolated event or a long term decline in the water level in this well. The seasonal low water levels, which may reflect relatively less precipitation during the dry season in recent years, a change in land use or increased pumping from one or more nearby wells, are approximately 140 m higher than the reported depth of the well (152.4 mbgs).

Similar to previous years, water levels in the Highlands monitoring wells responded rapidly to precipitation following the onset of the wet season, generally increasing from mid-October of 2017. The isolated periods of rapid water level increases observed in monitoring wells are consistent with groundwater recharge during periods of greater precipitation. The seasonal high water levels observed in December 2017 were consistent with previous

years for most Highlands monitoring wells. The seasonal high water level of 5.8 mtoc observed in DOH-07B in April 2017 was consistent with levels observed in 2015 and 2016, and slightly lower than the levels of approximately 5.5 to 5.6 mbtoc observed from 2012 to 2014. On-going monitoring would be required to assess potential long term trends in the static water level of this well during the wet season.

### **3.2 BC Ministry of Environment and Climate Change Strategy Observation Well**

Water-level data for ENV Observation Well No. 372 (ENV Well No. 372) are plotted with precipitation data from the West Highlands District Firehall and Calle Revelle Nature Sanctuary weather stations on Figure 8.

The water level patterns observed in ENV Well No. 372 were generally consistent with those observed in the Highlands monitoring wells; however, the seasonal low water level of 61.1 mbtoc that was reported for the dry season of 2015 and level of 60.1 mbtoc reported for 2016 and 2017 are interpreted to reflect periods when the water level dropped below the pressure transducer that was deployed in the well. Therefore, the seasonal low water level in ENV Well No. 372 is inferred to be lower than 61.1 mbtoc in 2015 and 60.1 mbtoc in 2016 and 2017.

The water level in ENV Well No. 372 increased following the onset of the wet season in October 2017. The high water level of 51.0 mbtoc that was observed in December 2017 is consistent with the levels observed in 2011, 2012 and 2016, suggesting no discernable trend in seasonal high levels for this well over the monitoring period.

### **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 period from 22 December 2016 to 5 February 2018, the total flows from wells 409 and 500 were reported to be 26,668 cubic metres (m<sup>3</sup>) and 5,128 m<sup>3</sup>, respectively, for a combined flow of 31,796 m<sup>3</sup>. The average groundwater use for the Hanington Estates Water System during this period was estimated to be 77.6 m<sup>3</sup>/day, consistent with the value of 77.7 m<sup>3</sup>/day that was estimated for 2016.

Groundwater use is anticipated to be higher during the summer season. 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, the data for the water system suggest that approximately 60% of the annual use in 2017 occurred between May and September, with the demand in the summer months more than double the demand in the winter months. These results, which are inferred to reflect higher irrigation and other outdoor water use during the hotter, drier summer months, are consistent with the data water system data that were reported for 2016.

The population in the Hanington Estates subdivision is reported to have increased from 190 residents in 2016 to 200 residents in 2017<sup>1</sup>. The average per capita water use for the Hanington Estates water system was calculated to be approximately 388 litres per person per day (L/p/d) for the period December 2016 to February 2018, compared to a value of 409 L/p/d that was calculated for the period December 2015 to December 2016. Although

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<sup>1</sup> Population information, as provided by the District of Highlands in file "Estd Pop\_Hanington Creek Estates\_2013-2017.docx", that is based on Occupancy Permits, Stats Canada 2011 Census data and Building Official's observations.

the per capita groundwater use values are anticipated to depend on the monitoring periods reported (e.g., the 2017 value is calculated from a period with relatively more winter [low demand] months compared to 12 month periods), the per capita water use for the Hanington Estates water system is estimated to have decreased each year from the value of 473 L/p/d that was estimated for the period February 2013 to March 2014.

Water level data were not provided for Well 409 and Well 500 for 2017.

### 3.4 Bear Mountain Monitoring Program

For the 2016-2017 Bear Mountain Groundwater Monitoring Program, continuous water level data were collected with dedicated pressure transducers that were deployed in irrigation (i.e., pumping) wells 405, 407 and 411, and monitoring well 412. A transducer was also deployed in monitoring well 414 to record water levels up to 7 July 2017, after which time the transducer was removed from well 414 and a new transducer was placed in well 400. Irrigation wells 405, 407 and 411 are each equipped with a flow meter to measure flow rates.

Bear Mountain pumped a total groundwater volume of approximately 300,450 cubic metres (m<sup>3</sup>) from its irrigation wells in 2017, within the range of values in previous years and less than the total volume of 344,500 m<sup>3</sup> that was pumped from the irrigation wells in 2016. Pumping of wells 407 and 411 began on 4 May 2017, and pumping of well 405 began on 28 July 2017. Pumping continued in 2017 until 17 September (well 405), 22 September (well 407) and 10 October (well 411). The wells were operated at average extraction rates of 6.9 L/s for well 405, 8.1 L/s for well 407 and 12.5 L/s for well 411. Data from flow meters that are located in the water distribution system indicated that approximately 171,700 m<sup>3</sup> of the total groundwater from the irrigation wells in 2017 was pumped into the Osborne Pond (the primary reservoir for the Valley Golf Course) and 128,750 m<sup>3</sup> was pumped into the Mountain Pond. WWAL also noted that a water balance that had been conducted by Colquitz Engineering Ltd. indicated that due to leakage from the Osborne Pond, approximately 74% of the groundwater that is pumped into the pond recharges the aquifer. Based on this information, WWAL estimated the net groundwater extraction from the irrigation wells for the Valley Golf Course to be approximately 44,650 m<sup>3</sup> in 2017. Golder did not review the water balance study that was conducted by Colquitz Engineering Ltd.

Based on the results of a water balance that Colquitz Engineering Ltd. had conducted for Ecoasis, WWAL estimated that the net groundwater extraction (i.e., total volume of groundwater extracted minus the leakage from the primary reservoir of the Valley Golf Course that is inferred to recharge the aquifer) from the irrigation wells in 2017 was approximately 44,650 m<sup>3</sup>, less than the value of 52,000 m<sup>3</sup> that was reported for 2016. Golder did not review the water balance study that was conducted by Colquitz Engineering Ltd.

During the pumping period in 2017, maximum drawdown in the irrigation wells was reported to be approximately 35 m, 43 m and 86 m in wells 405, 407 and 411, respectively (compared to values of 50, 43 and 80 m in 2016, respectively). WWAL reported that in the fall of 2017, the water levels in the irrigation wells recovered to 100% of the pre-pumping groundwater levels within approximately 5 weeks compared to recovery periods of approximately 6 weeks in 2014 to 10 days in 2013. WWAL attributed the variation in recovery periods to the lengths of the dry seasons in these years.

In 2017, the static water levels in observation wells 400 and 412 were reported to be similar to those observed in wells 413 and 414 in previous years, exhibiting a seasonal fluctuation of approximately 2 to 5 m. WWAL interpreted these results as indicating that the observation wells are hydraulically separate from the lineament (i.e., fault/fracture zone) in which the irrigation wells are completed.

WWAL noted that the application that Ecoasis had submitted to the Province of British Columbia for an Existing Use Groundwater License for an annual diversion of 375,000 m<sup>3</sup> of groundwater from its three irrigation wells (405, 407 and 411) was in progress with the Province.

## **4.0 CONCLUSIONS AND RECOMMENDATIONS**

### **4.1 Conclusions**

The results from the 2017 groundwater monitoring program were generally consistent with the seasonal patterns reported for previous years. Water levels in the Highlands monitoring wells during the dry season of 2017 were within the range of those observed in previously monitored years (i.e., since 2010). The seasonal low water level observed in monitoring well DOH-07B was higher than what was reported in 2016. The water level in DOH-07B, which is interpreted to have typically been influenced by pumping of an adjacent well late in the dry season, may reflect a change in land use or increased pumping from one or more nearby wells. Further monitoring is required to determine if the declining water levels that were observed for this well from 2011 to 2016 represents a long term decline in dry and wet season water levels at this location. It should be noted that the lowest water level that has been observed in DOH-07B is still approximately 140 m higher than the reported depth of the well (152.4 mbgs).

The average water use at Hanington Estates was estimated to be approximately 77.6 m<sup>3</sup>/day for the period December 2016 to February 2018, within the range of values that have been reported since annual well flow data were provided in 2013. When the population of the Hanington Estates subdivision, which has been increasing, is considered, the per capita water use for the Hanington Estates water system is estimated to have decreased from 473 L/p/d in 2013 to 388 L/p/d in 2017. Approximately 60% of the annual water use in 2017 occurred between May and September, reflecting increased irrigation and outdoor water use during the dry summer months.

A total volume of 300,450 cubic metres (m<sup>3</sup>) of groundwater was reported to have been pumped from Bear Mountain irrigation wells 405, 407 and 411 during the dry season of 2017, within the range of volumes reported for previous years and less than the volume of 344,500 m<sup>3</sup> that was extracted from these wells in 2016. The pumping-induced drawdown levels that were observed in the irrigation wells in 2017 were also within the range of levels that have been reported in previous monitoring years. In 2017, the water levels in the irrigation wells recovered to 100% of the pre-pumping levels within approximately 5 weeks, compared to the range of 10 days to 6 weeks that were observed in 2013 and 2014, respectively.

### **4.2 Recommendations**

Golder recommends that the groundwater monitoring program continue in 2018 to document water levels and provide the basis to assess seasonal patterns and long term trends in groundwater levels across the Highlands. The results of stakeholder programs should also continue to be reviewed on an annual basis to monitor groundwater conditions in the southern portion of the Highlands where production wells are operated.


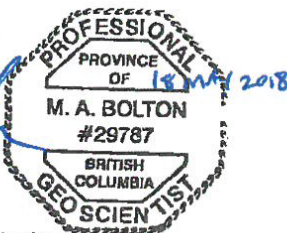
We also recommend that the water balance study that was prepared by Colquitz Engineering for Bear Mountain be reviewed to understand groundwater extraction and water use at the golf course.


## 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 truly,

**Golder Associates Ltd.**

  
  
**Mark Bolton, MSc, PGeo**  
*Associate, Senior Hydrogeologist*

  
**Jillian Sacré, MSc, PGeo**  
*Principal, Senior Hydrogeologist*

MAB/nnv

- 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-02A and Precipitation in Western Highlands
  - Figure 4: Depth to Groundwater Monitoring Well DOH-03 and Precipitation in Southern Highlands
  - Figure 5: Depth to Groundwater Monitoring Well DOH-04B and Precipitation in Western Highlands
  - Figure 6: Depth to Groundwater Monitoring Well DOH-07B and Precipitation in Northern Highlands
  - Figure 7: Depth to Groundwater Monitoring Well DOH-09A and Precipitation in Eastern Highlands
  - Figure 8: Depth to Groundwater Monitoring Well MoE Observation Well 372 and Precipitation in Western Highlands

[https://golderassociates.sharepoint.com/sites/16979g/deliverables/issued to client/1771760-001-l-rev0/1771760-001-l-rev0-2017-doh gwmon-report-18may\\_18.docx](https://golderassociates.sharepoint.com/sites/16979g/deliverables/issued%20to%20client/1771760-001-l-rev0/1771760-001-l-rev0-2017-doh%20gwmon-report-18may_18.docx)

## 6.0 STUDY LIMITATIONS

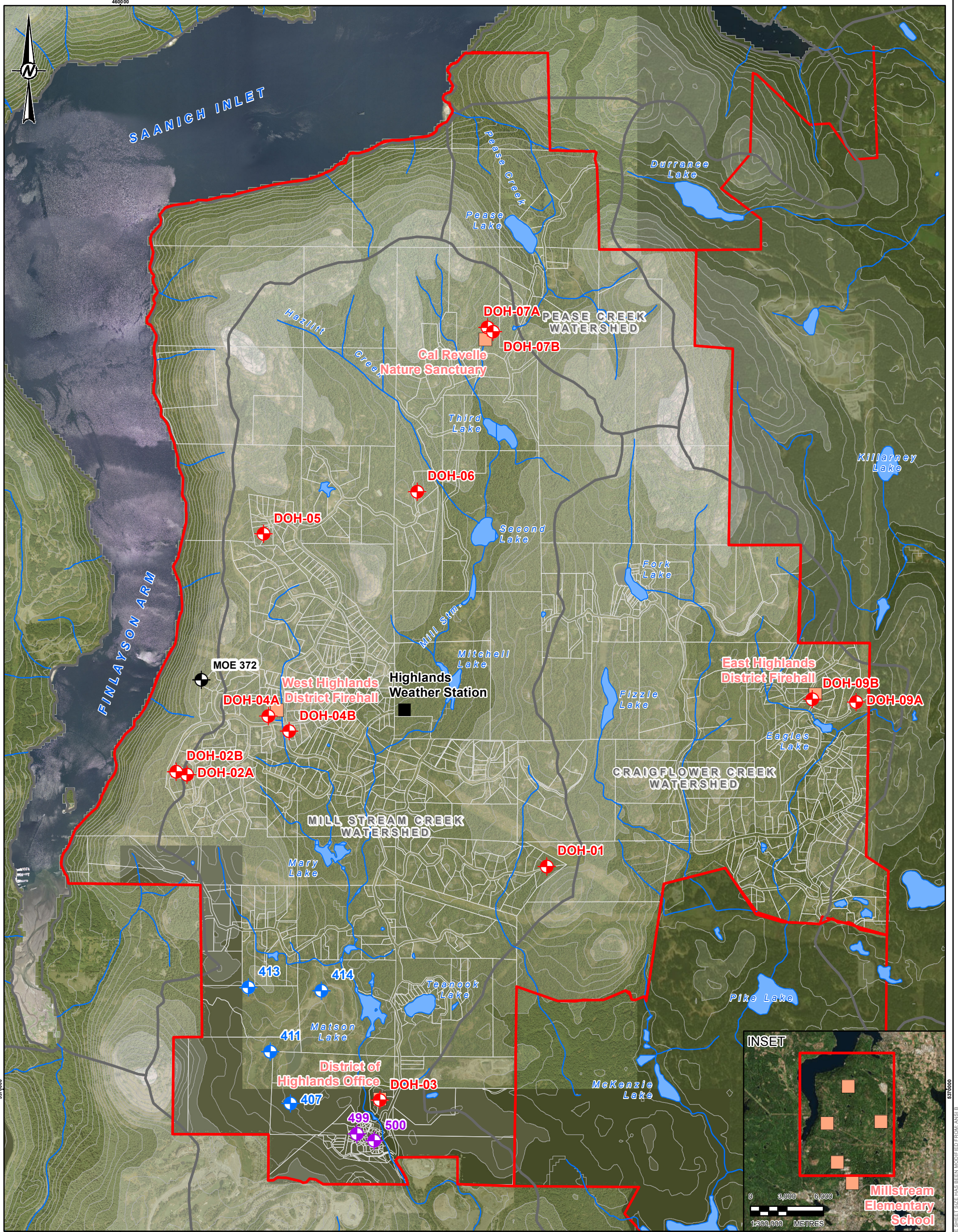
Golder Associates Ltd. (Golder) has prepared this letter in a manner consistent with that level of care and skill ordinarily exercised by members of the landfill engineering and science professions currently practicing in British Columbia, subject to the time limits and physical constraints applicable 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 Golder by the Client, communications between Golder and the Client, and to any other letters prepared by 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. 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 Golder and the Client.

In preparing this letter, 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.

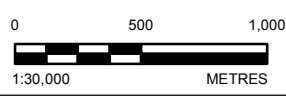
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If new information is discovered in the future, Golder Associates Ltd. should be requested to re-evaluate the content of this letter and provide amendments as required prior to any reliance upon the information presented herein.



- 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
  - Waterbody

- Cadastre Information
  - Major Watershed Boundary
  - Municipality Boundary
- Elevation - metres above sea level (masl)**
- 0 - 100
  - 101 - 200
  - 201 - 300
  - 301 - 400
  - 401 - 500



**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 © 20130727 AND 20180401. ESRI AND ITS LICENSORS. SOURCE: CNES/AIRBUS DS AND DIGITALGLOBE. USED UNDER LICENSE, ALL RIGHTS RESERVED.

COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT  
**DISTRICT OF HIGHLANDS**

PROJECT  
**GROUNDWATER PROTECTION STUDY  
HIGHLANDS, B.C.**

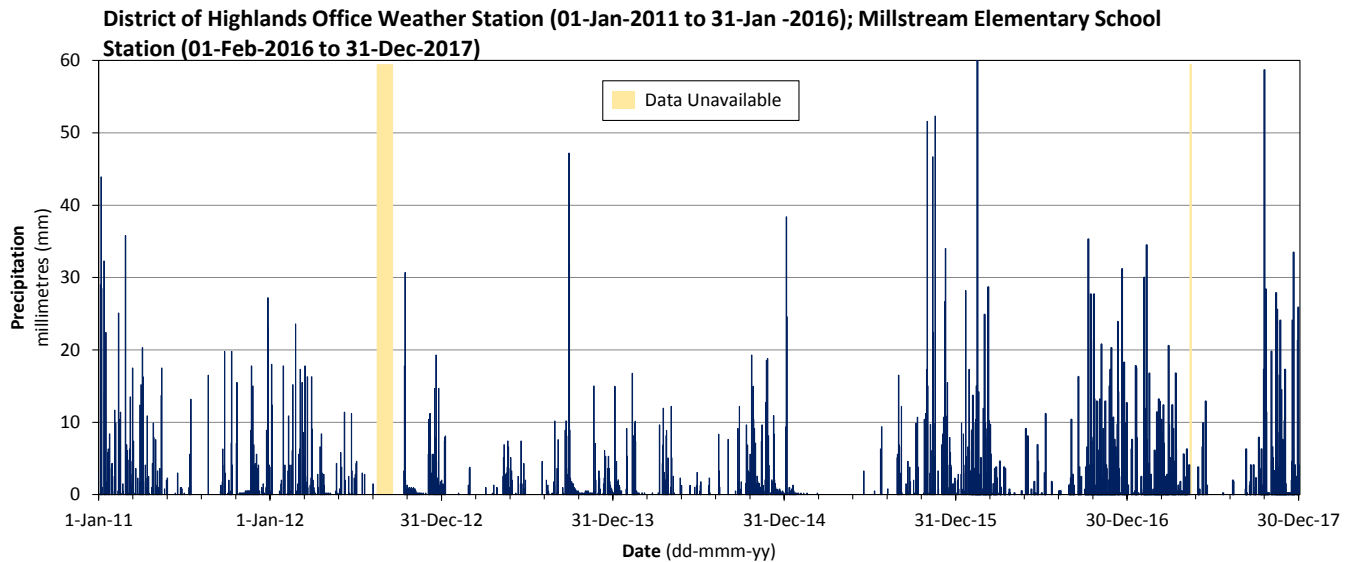
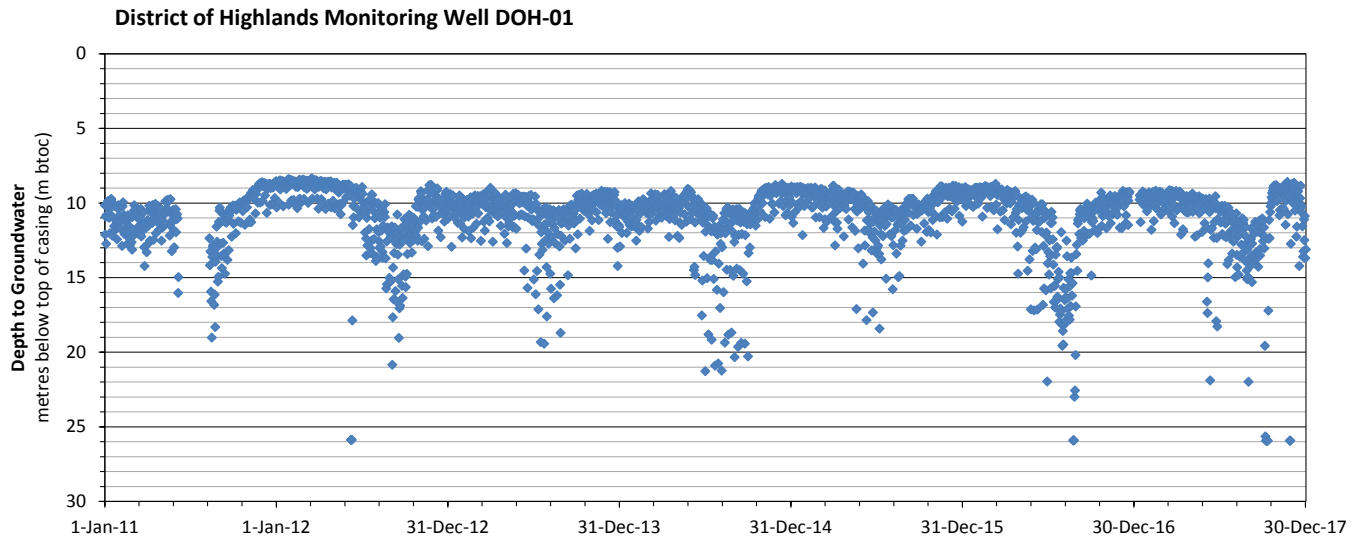
TITLE  
**MONITORING LOCATIONS**

CONSULTANT	YYYY-MM-DD	2018-05-14
	DESIGNED	MB
	PREPARED	DSC/AD
	REVIEWED	MB
	APPROVED	JS

PROJECT NO. CONTROL REV. FIGURE  
**1658853 0 1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM A4 (815x1155mm) TO A3 (841x1189mm)

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**Notes**

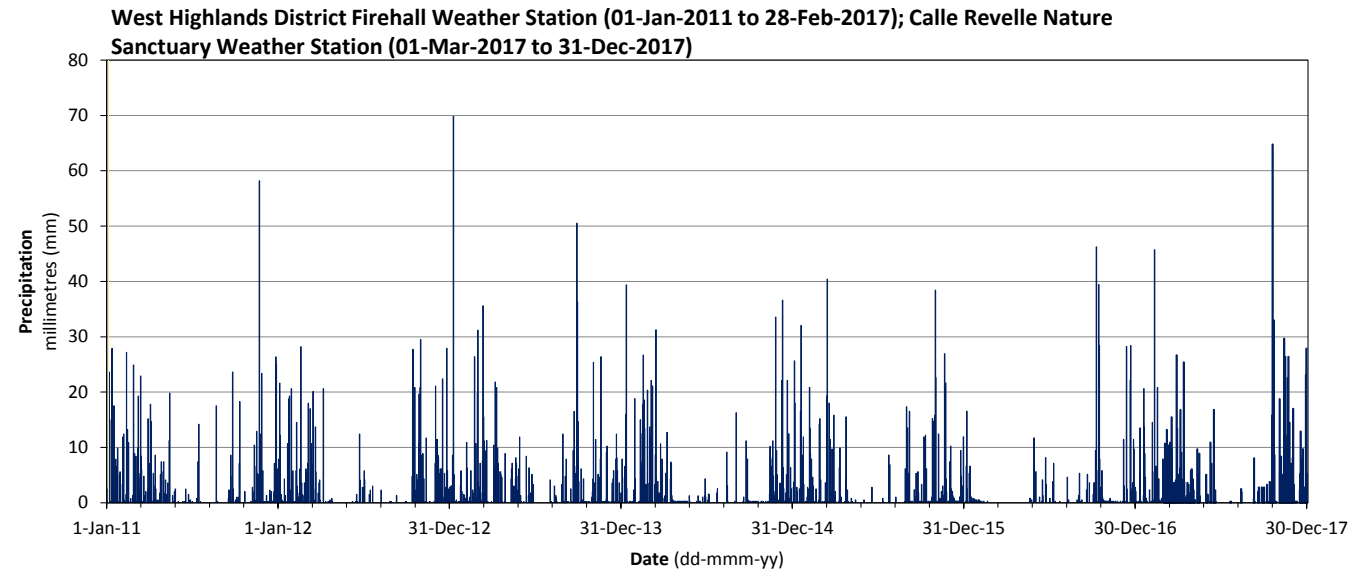
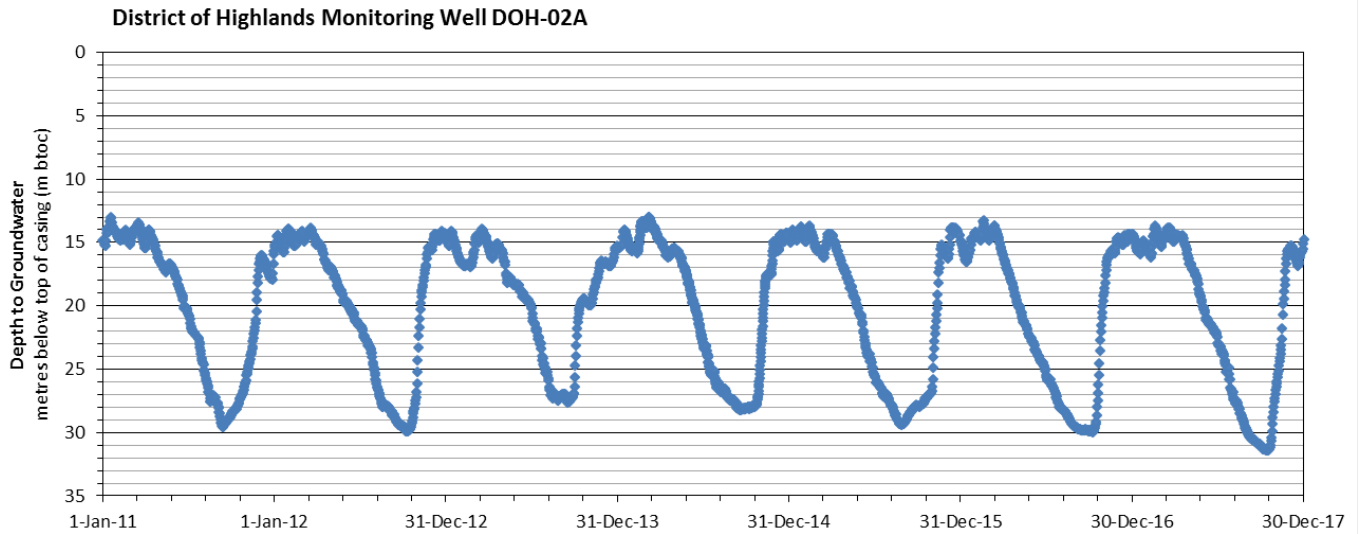
Water level data collected under the District of Highlands Groundwater Monitoring Program.

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

PROJECT					<b>DISTRICT OF HIGHLANDS 2017 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>				
TITLE					<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-01 AND PRECIPITATION IN SOUTHERN HIGHLANDS</b>				
PROJECT No. 1771760				FILE No. ----					
DESIGN		CB	14NOV06	SCALE		NTS	REV.		
CADD		CB	15JAN16						
CHECK		MAB	23APR18			<b>FIGURE 2</b>			
REVIEW		JPS	23APR18						




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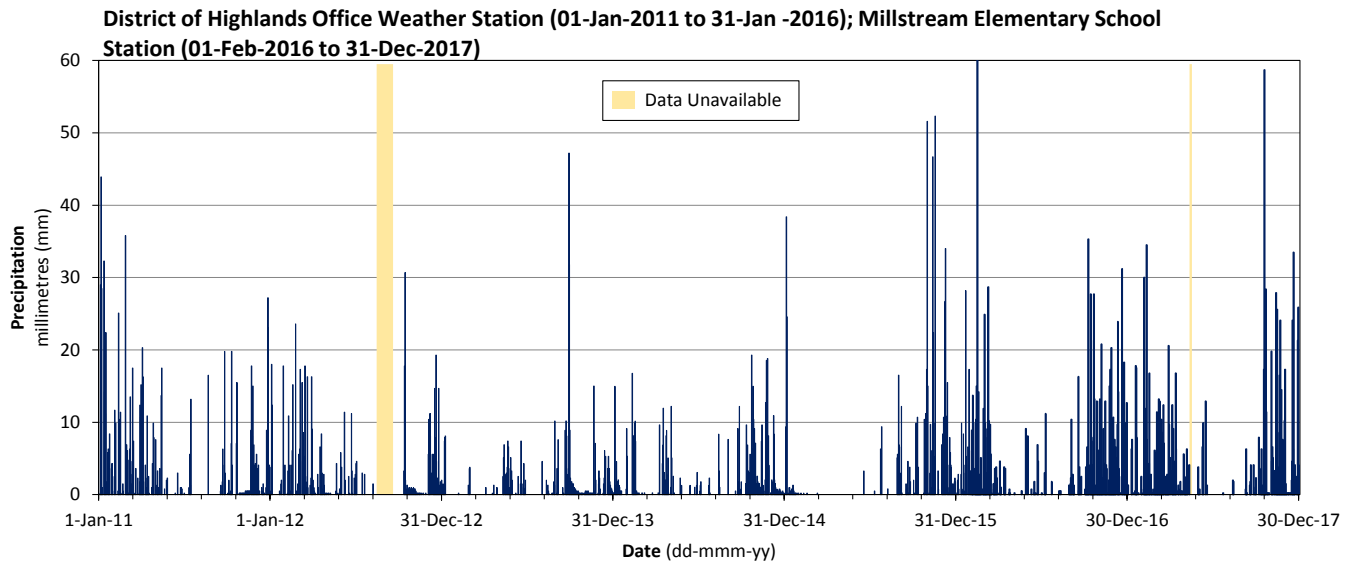
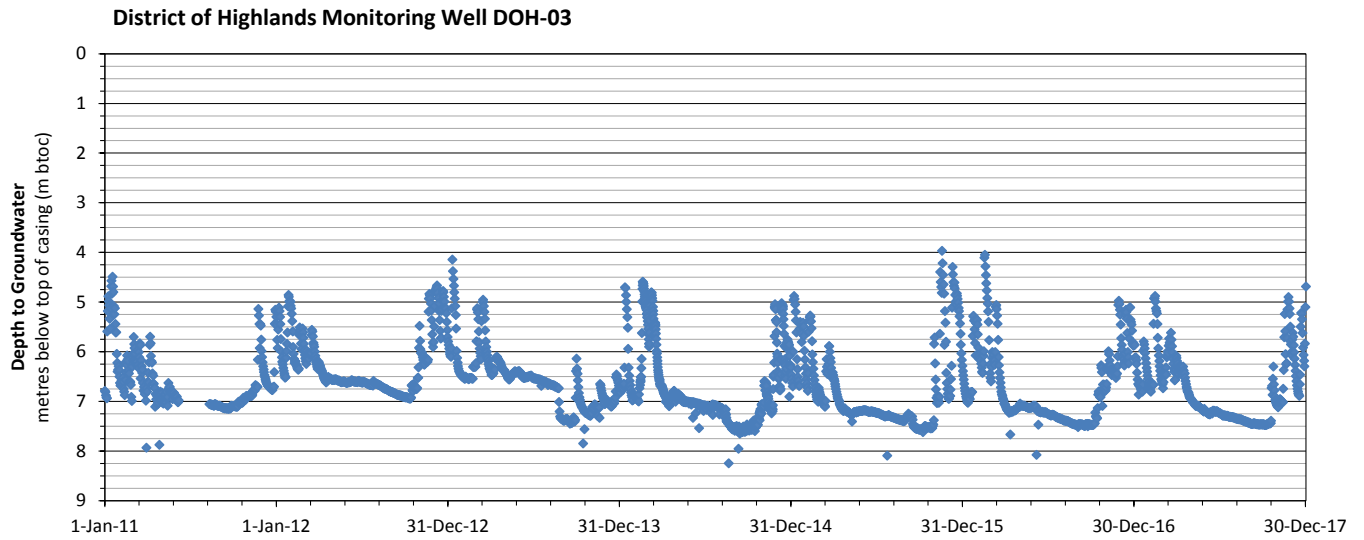
**Notes**

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					<b>DISTRICT OF HIGHLANDS 2017 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>				
TITLE					<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-02A AND PRECIPITATION IN WESTERN HIGHLANDS</b>				
PROJECT No. 1771760				FILE No. ----					
DESIGN		CB	14NOV06	SCALE		NTS		REV.	
CADD		CB	15JAN16	<b>FIGURE 3</b>					
CHECK		MAB	23APR18						
REVIEW		JPS	23APR18						
									


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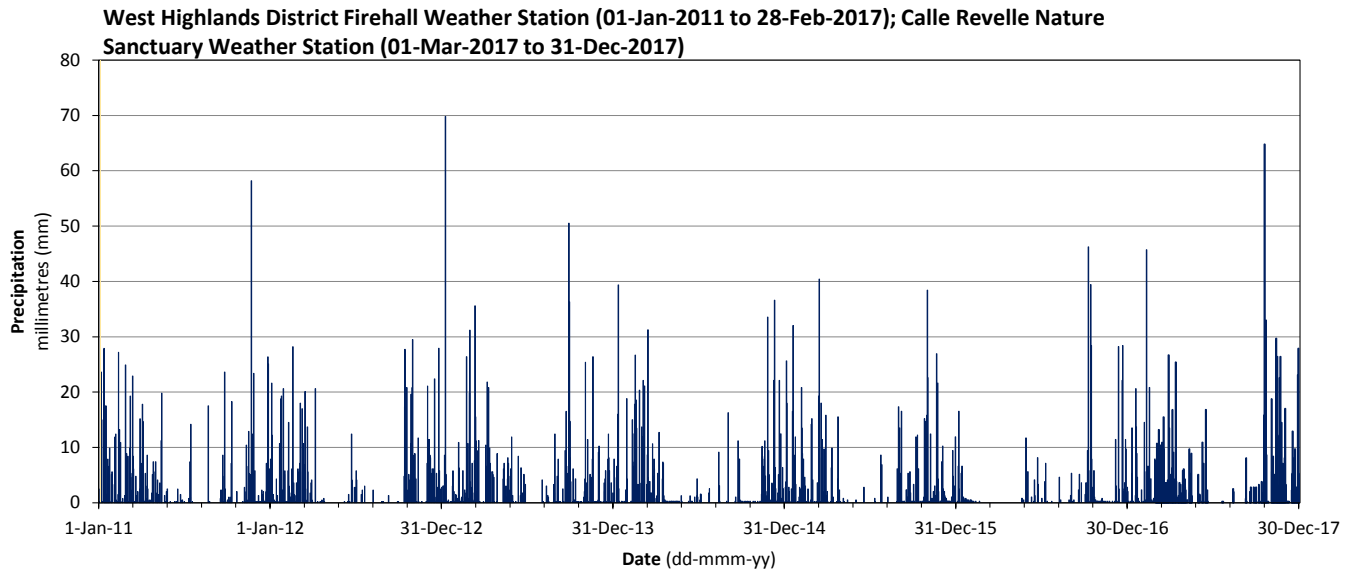
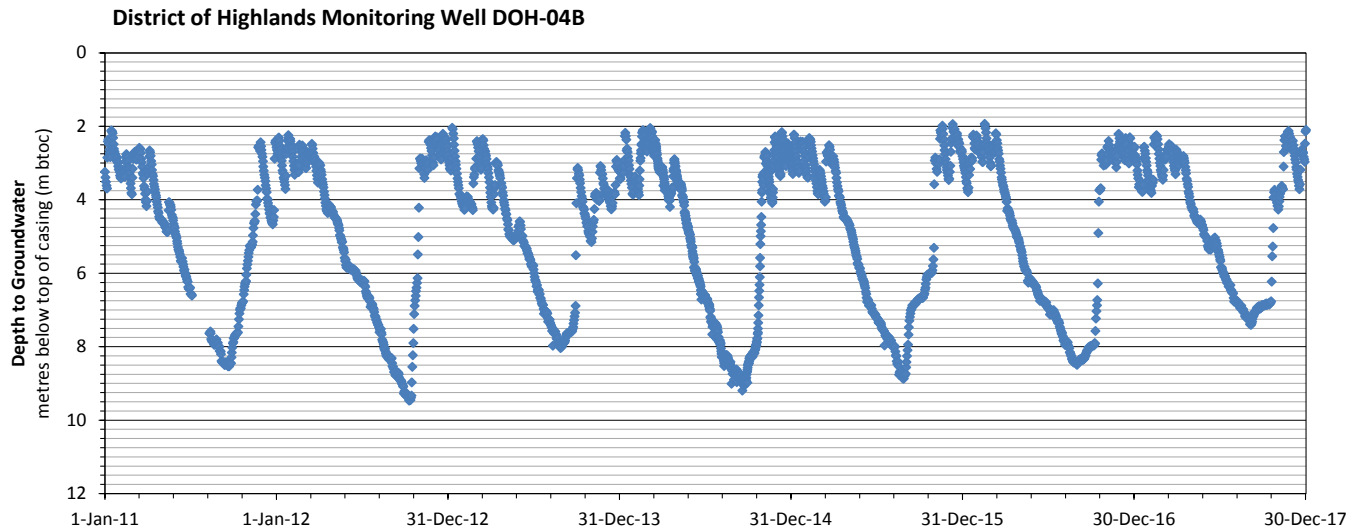
**Notes**

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					<b>DISTRICT OF HIGHLANDS 2017 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>				
TITLE					<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-03 AND PRECIPITATION IN SOUTHERN HIGHLANDS</b>				
PROJECT No. 1771760				FILE No. ----					
DESIGN		CB	14NOV06	SCALE		NTS	REV.		
CADD		CB	15JAN16	<b>FIGURE 4</b>					
CHECK		MAB	23APR18						
REVIEW		JPS	23APR18						
									

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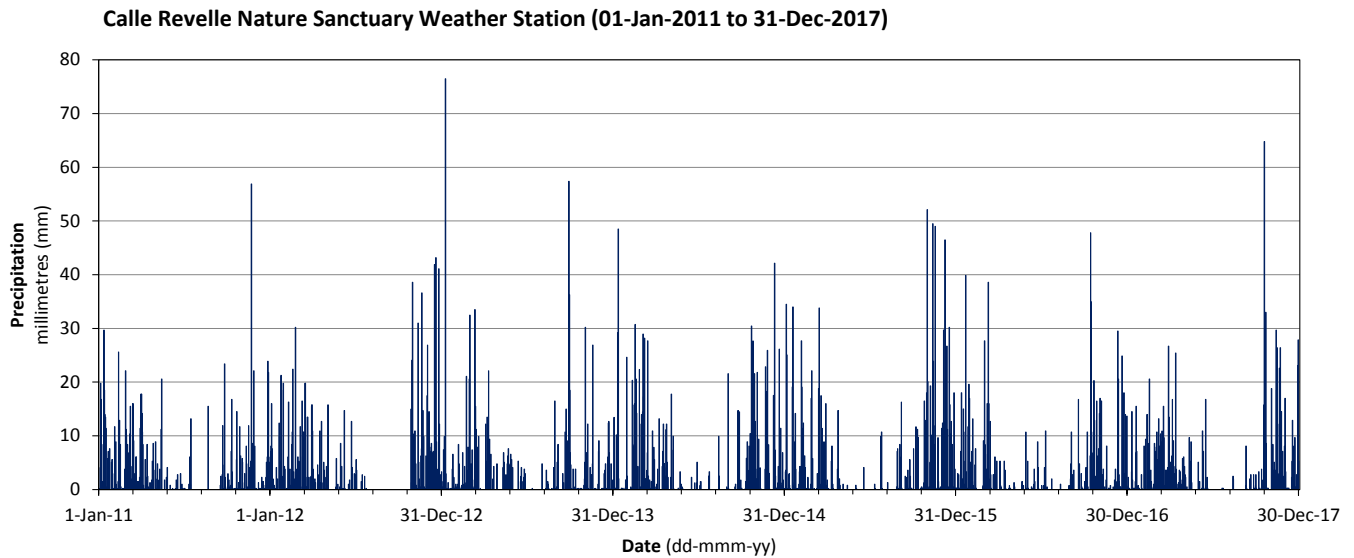
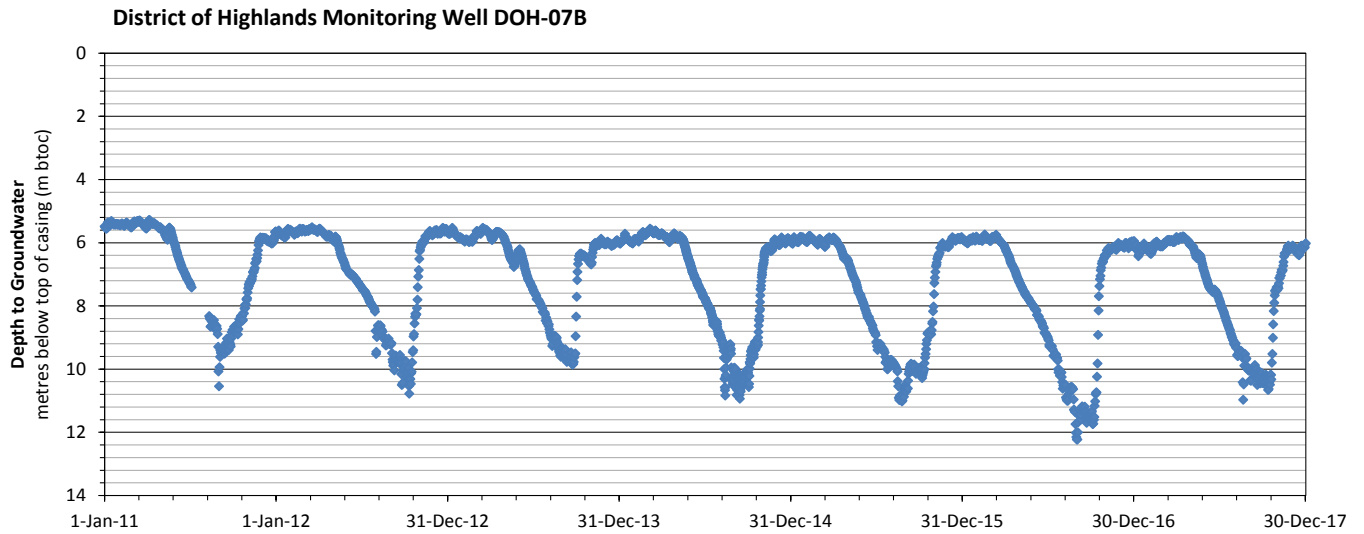
**Notes**

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					<b>DISTRICT OF HIGHLANDS 2017 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>				
TITLE					<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-04B AND PRECIPITATION IN WESTERN HIGHLANDS</b>				
PROJECT No. 1771760				FILE No. ----					
DESIGN		CB	14NOV06	SCALE		NTS	REV.		
CADD		CB	15JAN16	<b>FIGURE 5</b>					
CHECK		MAB	23APR18						
REVIEW		JPS	23APR18						

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**Notes**

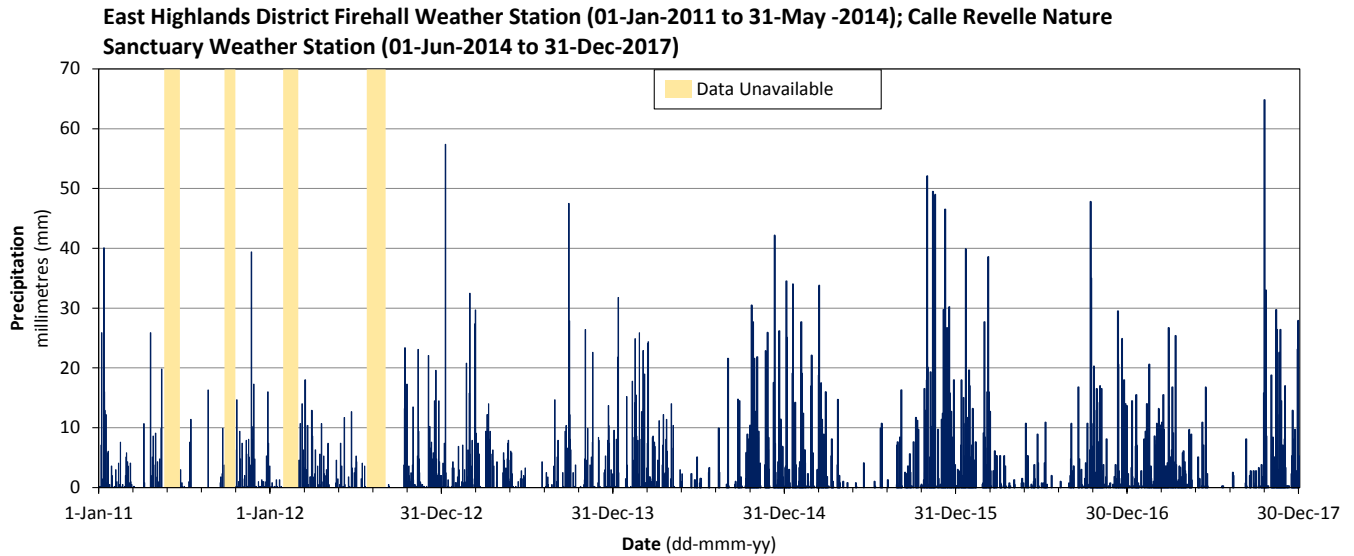
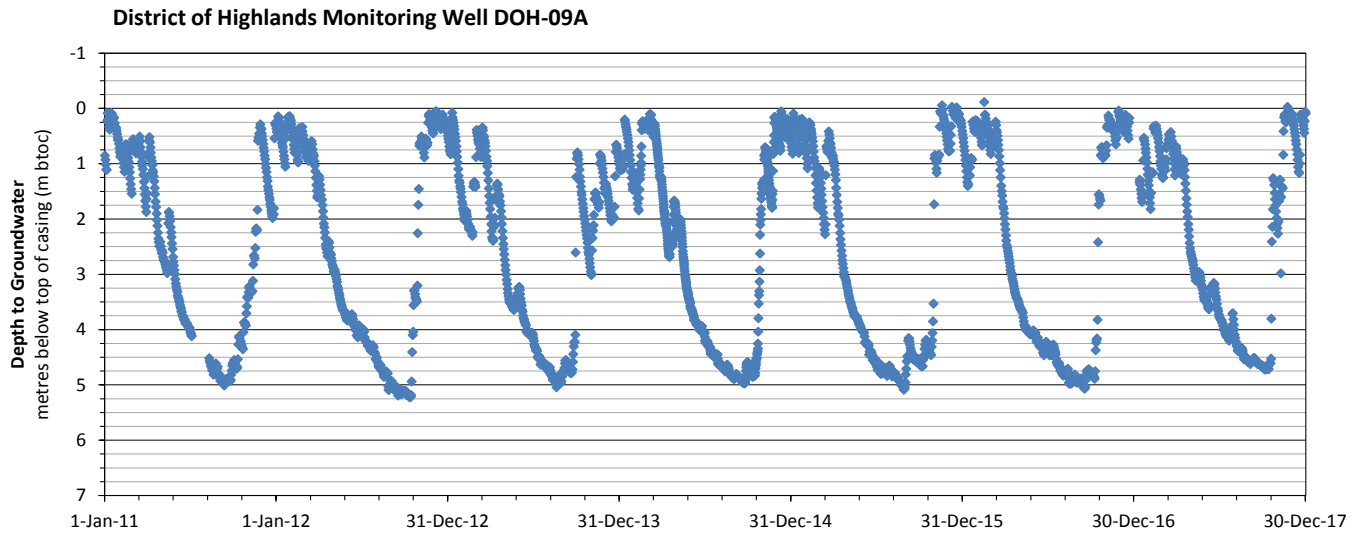
Water level data collected under the District of Highlands Groundwater Monitoring Program.

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

PROJECT					<b>DISTRICT OF HIGHLANDS 2017 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>		
TITLE					<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-07B AND PRECIPITATION IN NORTHERN HIGHLANDS</b>		
PROJECT No. 1771760				FILE No. ----			
DESIGN		CB	14NOV06	SCALE NTS		REV.	
CADD		CB	15JAN16				
CHECK		MAB	23APR18			<b>FIGURE 6</b>	
REVIEW		JPS	23APR18				



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**Notes**

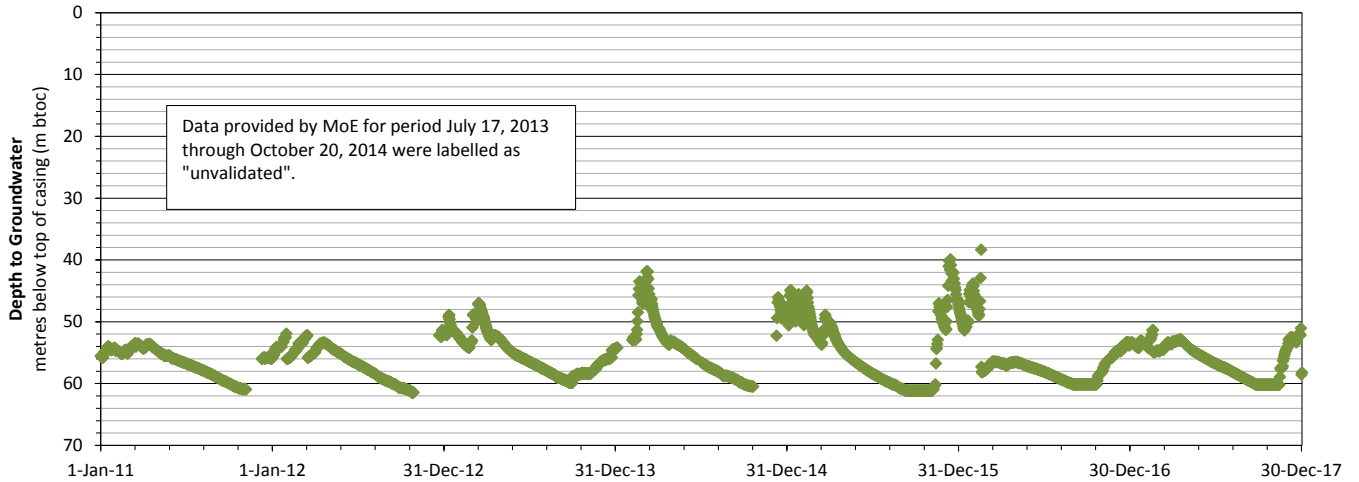
Water level data collected under the District of Highlands Groundwater Monitoring Program.

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

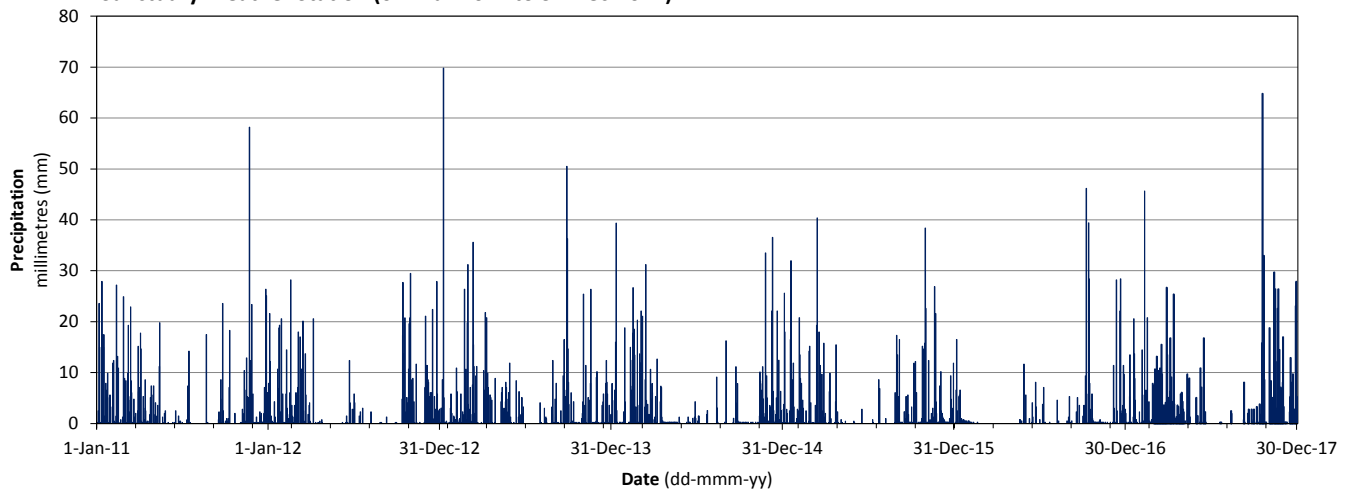
PROJECT					<b>DISTRICT OF HIGHLANDS 2017 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>				
TITLE					<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-09A AND PRECIPITATION IN EASTERN HIGHLANDS</b>				
PROJECT No. 1771760				FILE No. ----					
DESIGN		CB	14NOV06	SCALE		NTS	REV.		
CADD		CB	15JAN16	<b>FIGURE 7</b>					
CHECK		MAB	23APR18						
REVIEW		JPS	23APR18						
		GOLDER							

FILE: https://goldeassociates.sharepoint.com/sites/16979g/Technical%20Work/Forms/AllItems.aspx?viewpath=%2Fsites%2F16979g%2FTechnical%20Work%2FForms%2FAllItems%2Easpx

**BC Ministry of Environment Observation Well No. 372**



**West Highlands District Firehall Weather Station (01-Jan-2011 to 28-Feb-2017); Calle Reville Nature Sanctuary Weather Station (01-Mar-2017 to 31-Dec-2017)**



**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](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					<b>DISTRICT OF HIGHLANDS 2017 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>				
TITLE					<b>DEPTH TO GROUNDWATER MOE OBSERVATION WELL 372 AND PRECIPITATION IN WESTERN HIGHLANDS</b>				
PROJECT No. 1771760				FILE No. ----					
DESIGN		CB	14NOV06		SCALE		NTS		REV.
CADD		CB	15JAN16		<b>FIGURE 8</b>				
CHECK		MAB	23APR18						
REVIEW		JPS	23APR18						
