

8 June 2016

Document No. 1314750010-004-L-Rev0

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

## **MID-YEAR RESULTS OF 2015 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). Golder conducted the work in accordance with our proposal titled "Work Plan and Cost Estimate for 2015 Groundwater Level Monitoring Program, District of Highlands, BC" (Golder Reference No. 1314350010-003-WP-Rev0) and dated 8 May 2014.

This letter presents a brief summary of the groundwater monitoring that Golder conducted on behalf of the District from January through September of 2015 (i.e., mid-2015). The results of the mid-2015 monitoring event were discussed with the District in October 2015 and are provided in this letter for documentation. A more detailed discussion of the monitoring program through to the end of 2015 is provided in a subsequent letter report (the 2015 Annual Report).

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**

Golder has conducted on-going groundwater monitoring for the District since 2009 to monitor groundwater conditions 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 the conservation and groundwater protection measures, and public education efforts previously identified. 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.



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**Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America**



At present, electronic data loggers (i.e., pressure transducers) are present in six monitoring wells located across the Highlands to collect continuous water-level data, 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-1, 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 representative of groundwater levels in the aquifer in the vicinity of the wells. DOH-03 and DOH-04B are equipped with pumps and operated as supply wells for non-potable uses (i.e. not for drinking water), and therefore, the water levels in these wells may not be representative of the water levels in the aquifer when these wells are in operation.

The objective of the mid-2015 groundwater level monitoring program was to compile and analyse data from the Highlands monitoring programs to provide an assessment of regional groundwater conditions at the end of the dry season in 2015.

## **2.0 METHODS**

The transducers that are installed in the Highlands monitoring wells, including the barologger that is deployed at monitoring location DOH-02A, are programmed to collect data every twelve hours. Golder conducted downloaded pressure transducer data and collected a manual depth-to-water measurement at each monitoring location in the Highlands on 31 March, 8 July and 21 September 2015.

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 four University of Victoria (UVic) School-Based Weather Station Network weather stations, located in various areas of the Highlands (Figure 1).

Data from other stakeholder monitoring programs in the Highlands will be presented in the 2015 Annual Report.

## **3.0 RESULTS AND DISCUSSION**

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 21 September 2015, together with daily precipitation data from nearby weather stations are presented on Figures 2 through 7.

Water levels recorded in the majority of the Highlands monitoring wells in the dry season of 2015 were generally consistent with the patterns observed in previous years, with seasonal responses in 2015 ranging from approximately 15 m in DOH-02A to less than 3 m in DOH-03. The water levels in the Highlands monitoring wells were equal to, or higher than, those observed during the dry season of 2014 and/or 2012. The total precipitation recorded for the West Highlands District Firehall weather station from 1 May through 31 August 2015 was 52.7 mm, compared to values of 44.2 mm and 35.5 mm that were reported for the same period in 2012 and 2014. Precipitation increased beginning in late August of 2015; the wet season began in mid-October in 2012 and late September in 2014.

Highlands monitoring wells DOH-01, DOH-03 and DOH-07B continued to be influenced by pumping of the well (DOH-03) or nearby wells (DOH-01 and DOH-07B); however, less pumping-induced drawdown was observed in these wells, particularly in DOH-01 where the lowest water level of 20.7 m below top of (well) casing (btoc) was higher than the value of 23.6 mbtoc that was observed for this well in July and August 2014.

#### 4.0 CLOSURE

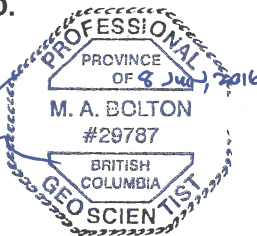
We trust the above information meets your current needs. If you have any questions or require additional information, please do not hesitate to contact the undersigned.

**GOLDER ASSOCIATES LTD.**



Mark Bolton, MSc, PGeo  
Associate, Senior Hydrogeologist

MAB/JPS/lmk



Reviewed by:



Jillian Sacré, MSc, PGeo  
Principal, Senior Hydrogeologist

- 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

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## 5.0 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.

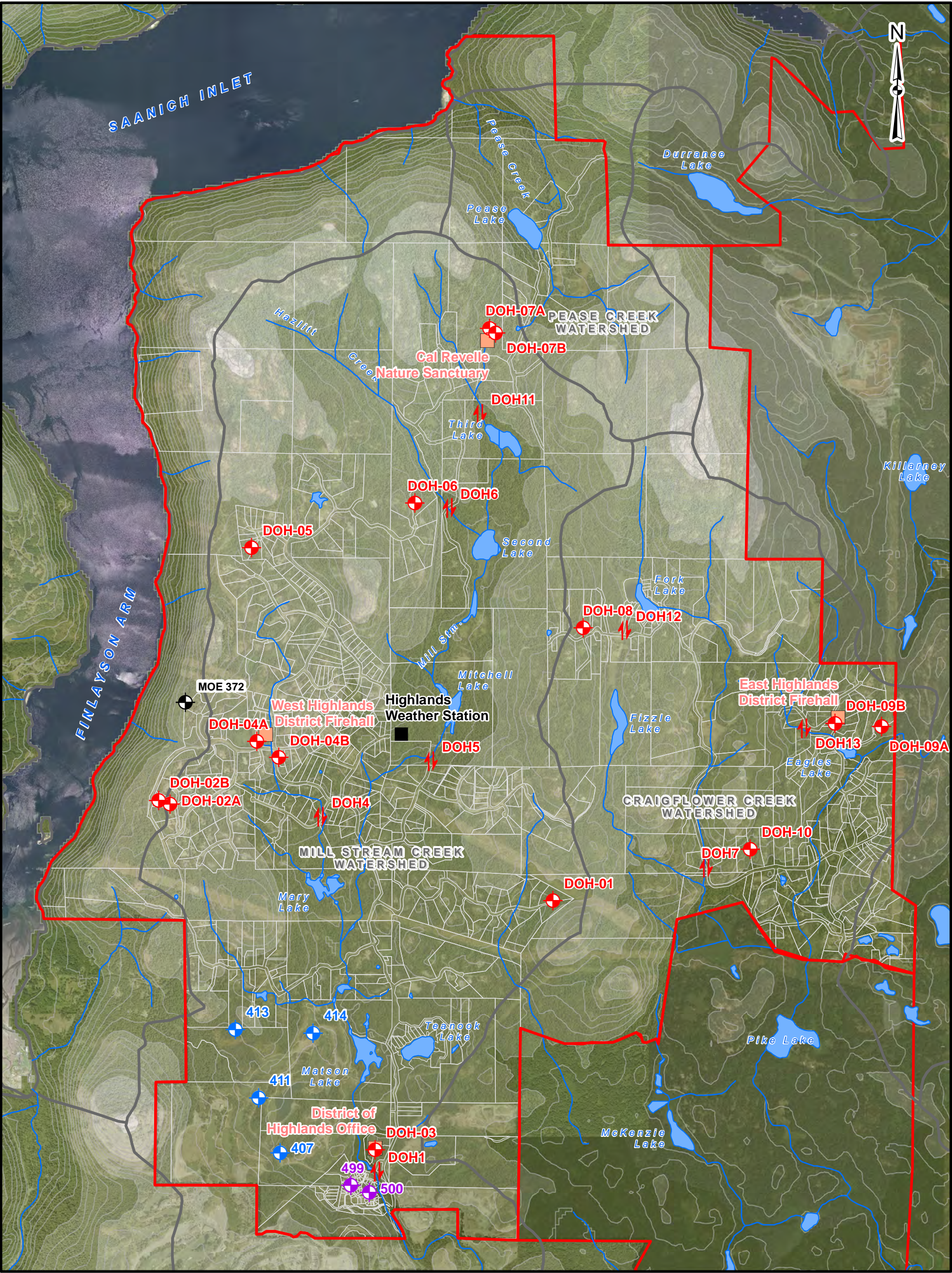
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If new information is discovered in the future, Golder Associates Ltd. should be requested to re-evaluate the content of this letter and provide amendments as required prior to any reliance upon the information presented herein.





LEGEND

- District of Highlands Monitoring Well Location

Stream Flow Measurement Location (2010)

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

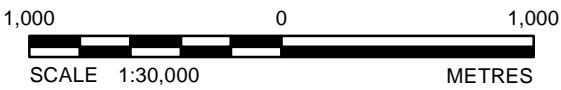
201 - 300

301 - 400

401 - 500

REFERENCE

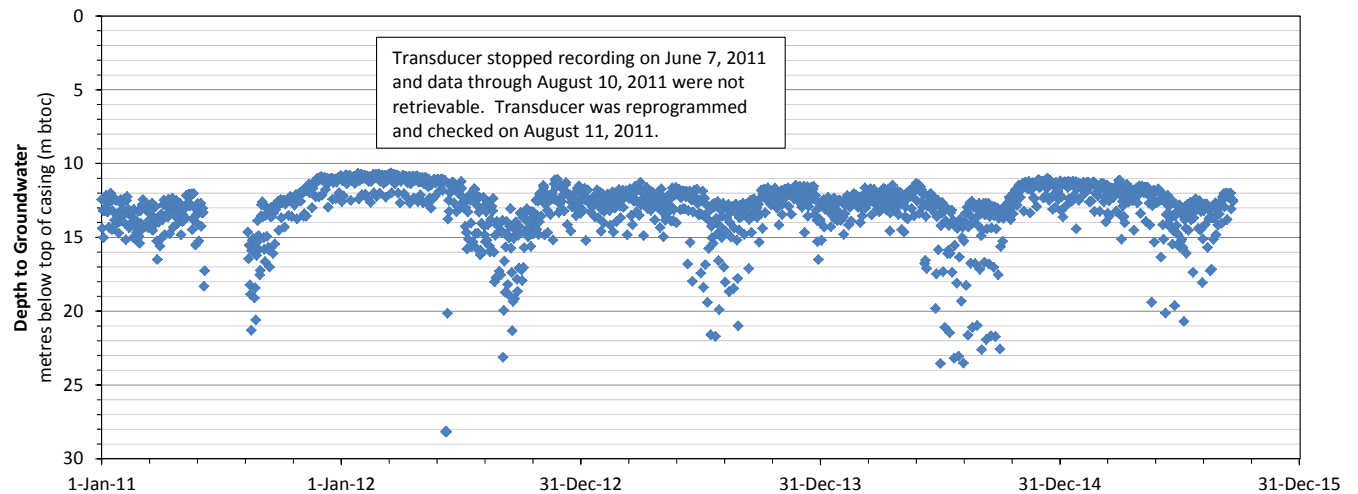
Data provided by the District of Highland and BC ILMB.  
Base data provided by the Ministry of Environment, WMS.  
Hydrology obtained from Canvec© Department of Natural Resources Canada. All Rights Reserved.  
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 10



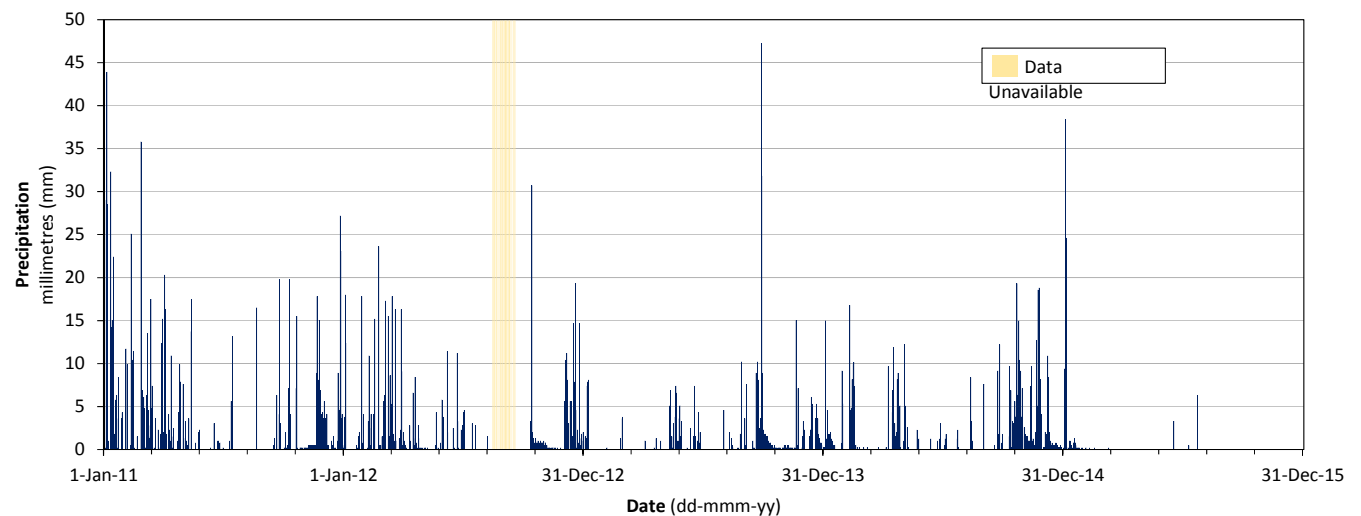
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TITLE		MONITORING LOCATIONS DISTRICT OF HIGHLANDS		
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		DESIGN	MB	24 Apr. 2012
		GIS	DSC/AD	16 May 2016
		CHECK	MAB	5 Nov. 2015
		REVIEW	JPS	5 Nov. 2015
				FIGURE 1



### District of Highlands Monitoring Well DOH-01



### District of Highlands Office Weather Station




### Notes

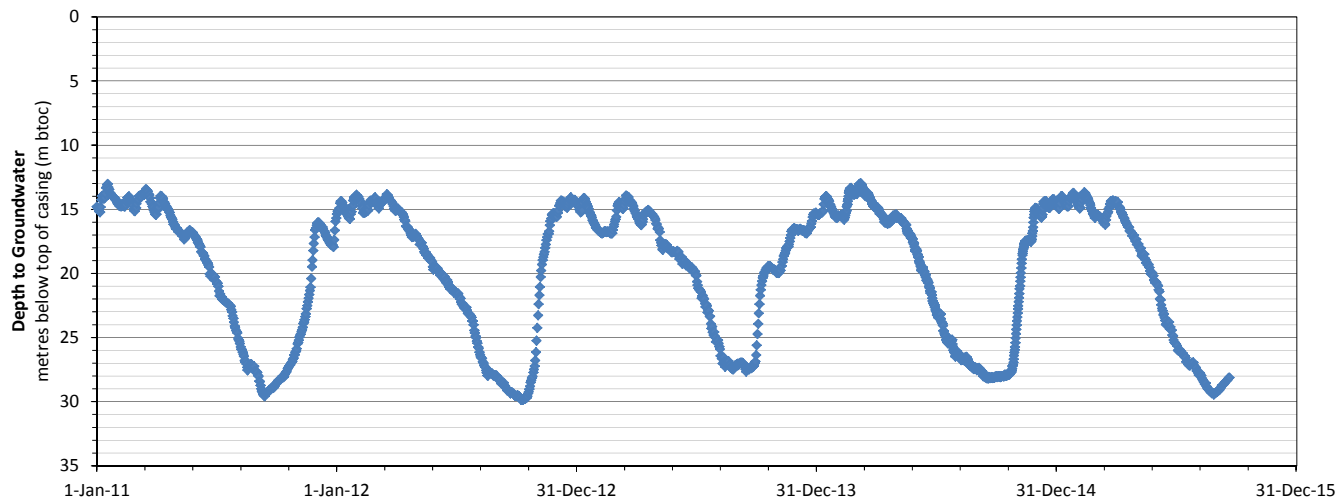
Water level data collected under the District of Highlands Groundwater Monitoring Program.

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

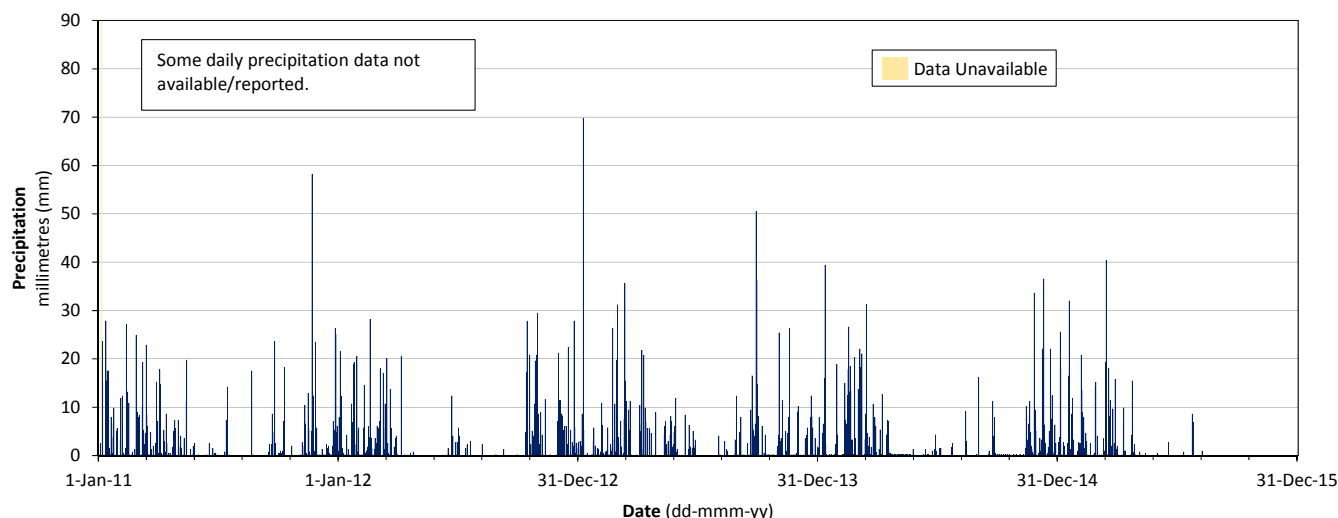
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TITLE		<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-01 AND PRECIPITATION IN SOUTHERN HIGHLANDS</b>			
		PROJECT No. 13-1435-0010		FILE No. ----	
		DESIGN	CB	14NOV06	SCALE NTS
		CADD	CB	15JAN16	REV.
		CHECK	MAB	15OCT28	<b>FIGURE 2</b>
		REVIEW	JPS	15OCT28	

**District of Highlands Monitoring Well DOH-02A**




**West Highlands District Firehall Weather Station**



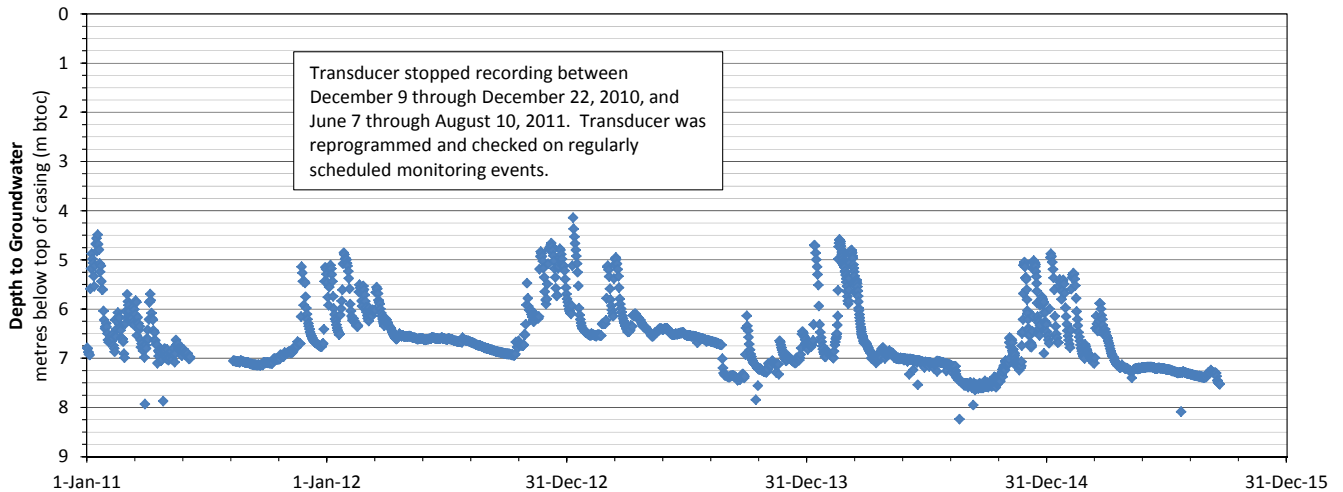
#### Notes

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

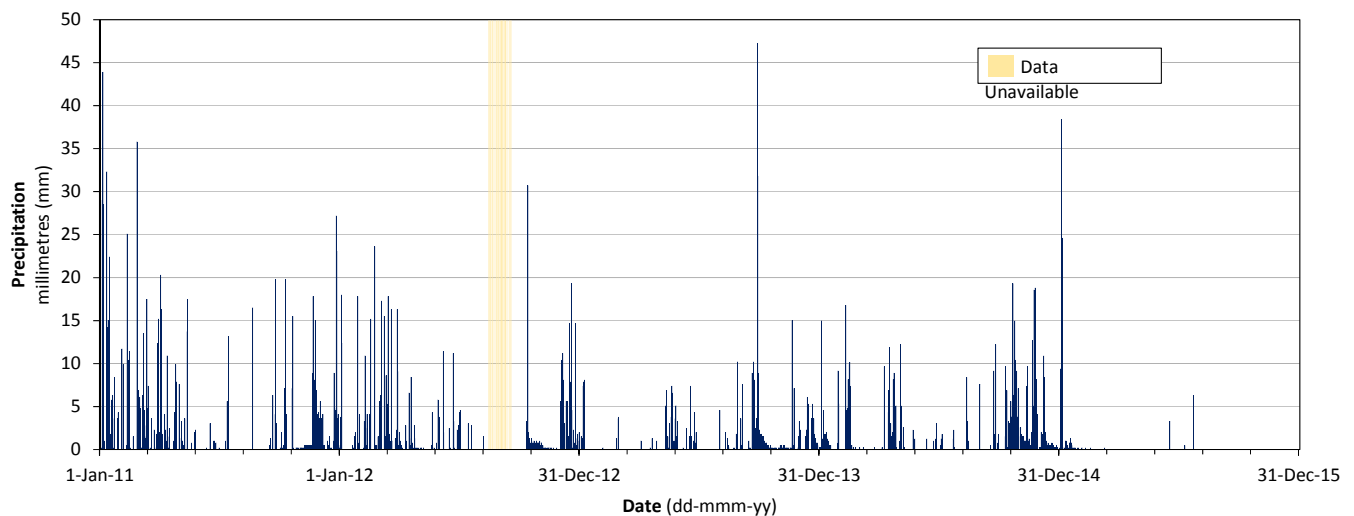
Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.  
<http://www.victoriaweather.ca/>

PROJECT		<b>DISTRICT OF HIGHLANDS 2015 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC</b>			
TITLE		<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-02A AND PRECIPITATION IN WESTERN HIGHLANDS</b>			
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### District of Highlands Monitoring Well DOH-03




### District of Highlands Office Weather Station



### Notes

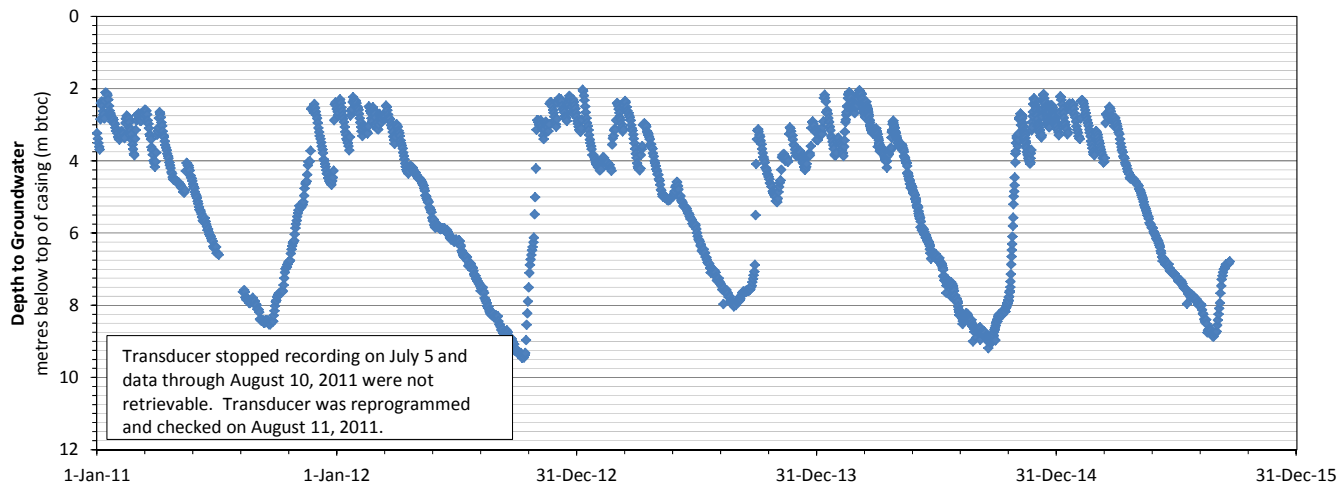
Water level data collected under the District of Highlands Groundwater Monitoring Program.

Precipitation data obtained online from the University of Victoria School-Based Weather Station Network.  
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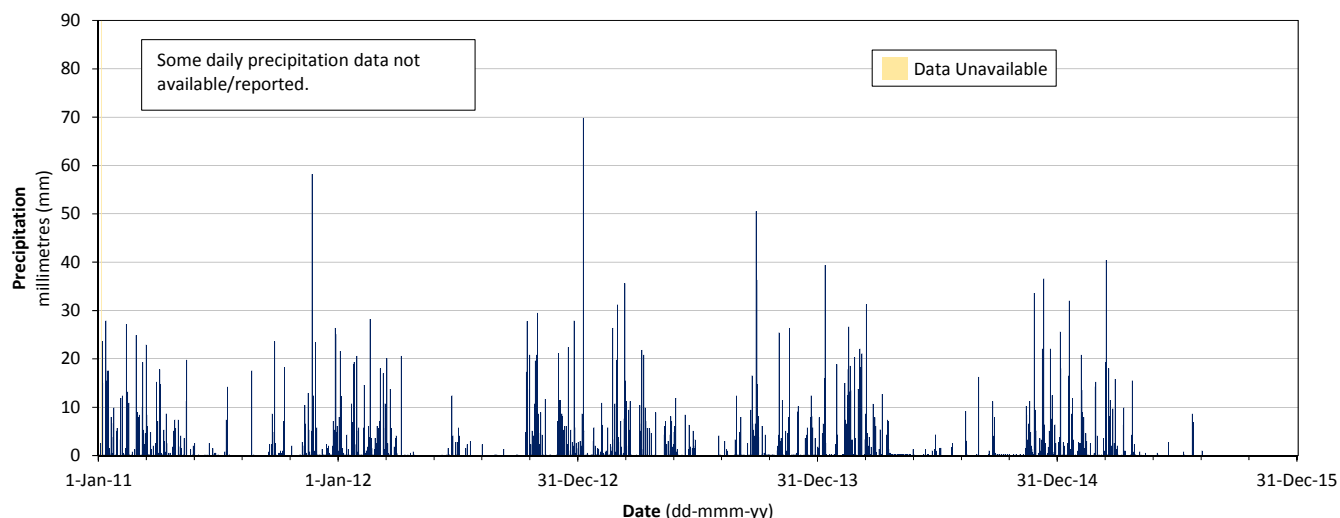
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					<b>FIGURE 4</b>



### District of Highlands Monitoring Well DOH-04B



### West Highlands District Firehall Weather Station




### Notes

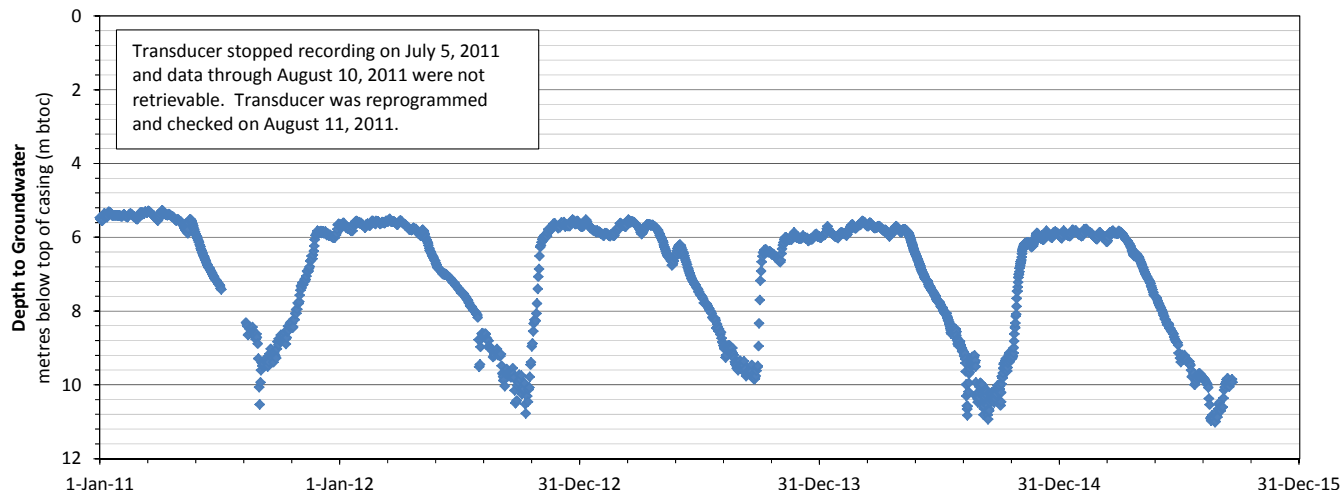
Water level data collected under the District of Highlands Groundwater Monitoring Program.

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

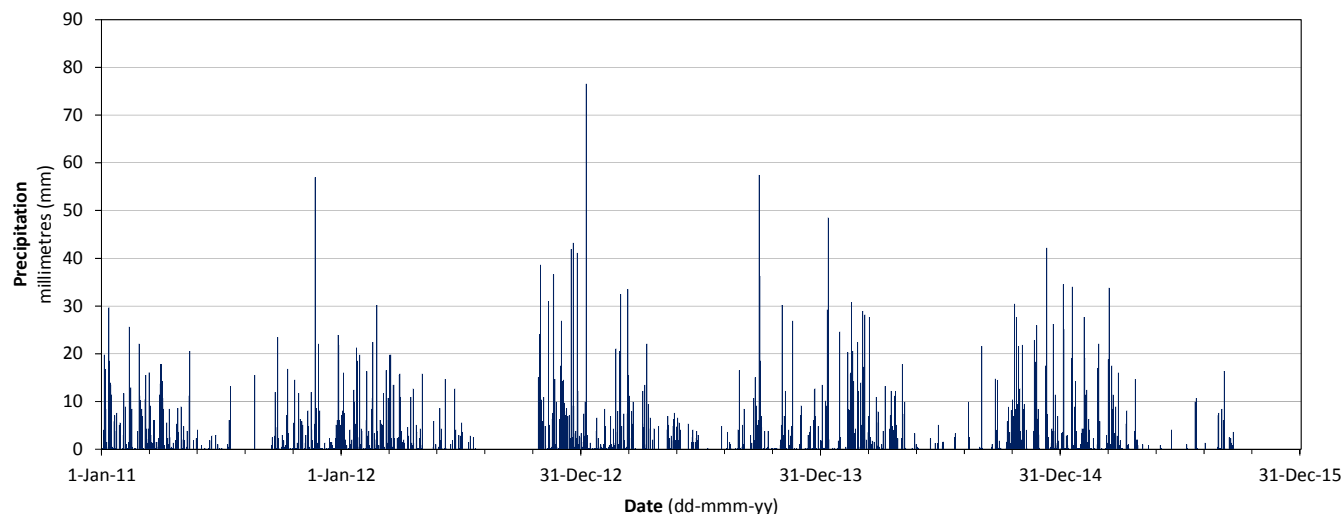
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TITLE		<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-04B AND PRECIPITATION IN WESTERN HIGHLANDS</b>			
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		CHECK	MAB	15OCT28	<b>FIGURE 5</b>
		REVIEW	JPS	15OCT28	

### District of Highlands Monitoring Well DOH-07B



### Calle Reville Nature Sanctuary Weather Station




#### Notes

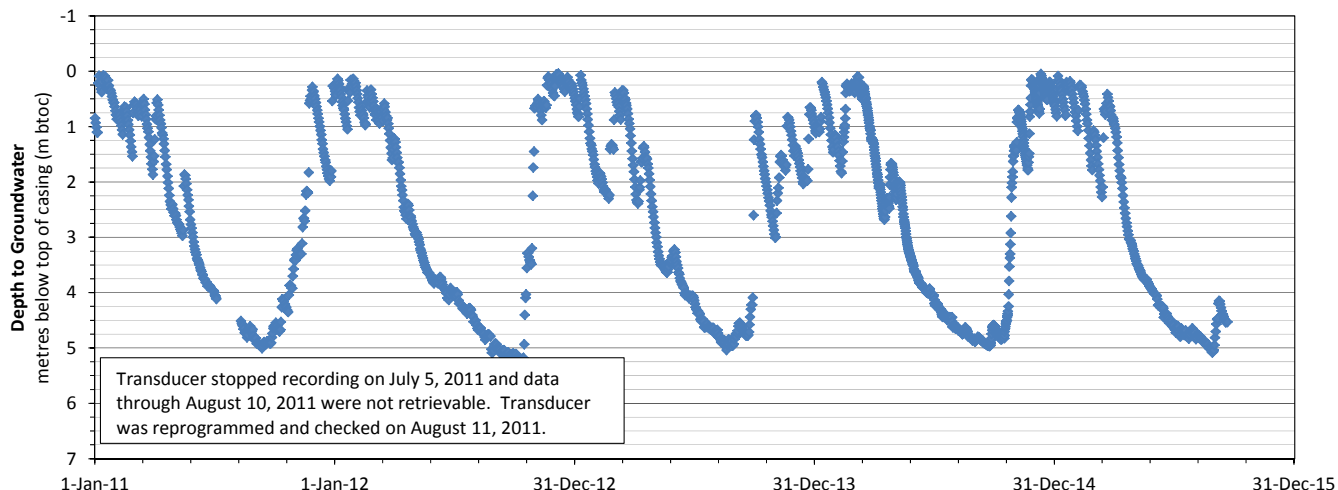
Water level data collected under the District of Highlands Groundwater Monitoring Program.

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

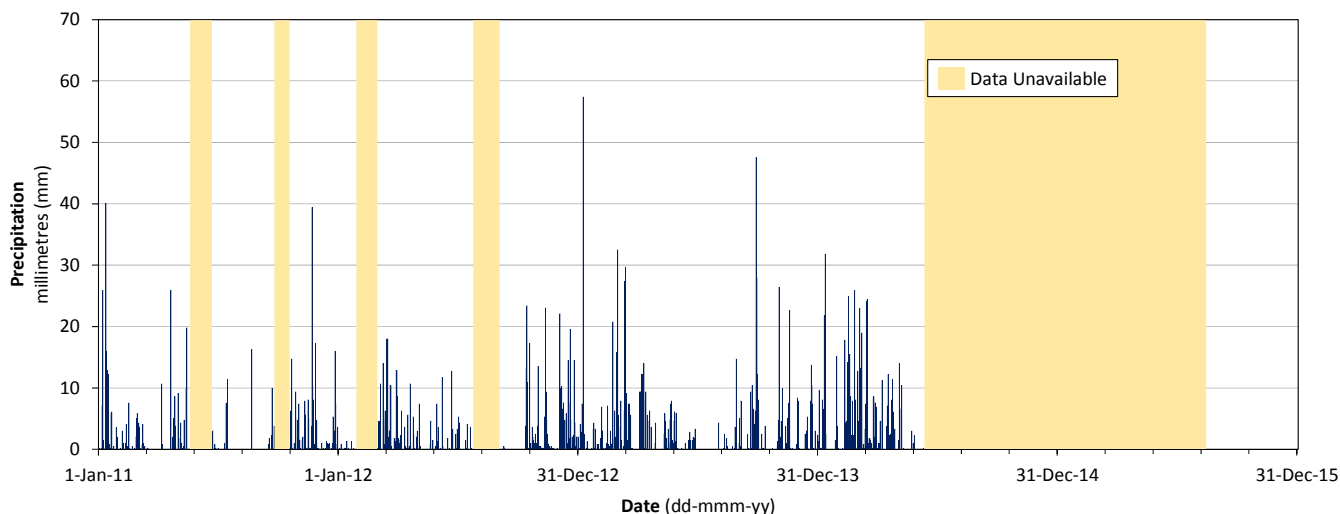
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TITLE		<b>DEPTH TO GROUNDWATER MONITORING WELL DOH-07B AND PRECIPITATION IN NORTHERN HIGHLANDS</b>		
		PROJECT No.	13-1435-0010	FILE No. ----
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		CHECK	MAB	15OCT28
		REVIEW	JPS	15OCT28
		SCALE	NTS	REV.
		<b>FIGURE 6</b>		

District of Highlands Monitoring Well DOH-09A



East Highlands District Firehall Weather Station




#### 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/>

REVISION DATE: BY: FILE:

PROJECT		DISTRICT OF HIGHLANDS 2015 GROUNDWATER MONITORING PROGRAM HIGHLANDS, BC			
TITLE		DEPTH TO GROUNDWATER MONITORING WELL DOH-09A AND PRECIPITATION IN EASTERN HIGHLANDS			
		PROJECT No. 13-1435-0010		FILE No. ----	
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		REVIEW	JPS	15OCT28	