

March 9, 2018

FILE: 16-092-01

Ecoasis Developments LLP  
2050 Country Club Way  
Victoria, BC V9B 6R3  
Attention: Eric Gerlach, P.Eng.

**Re: Bear Mountain 2016-2017 Annual Groundwater Monitoring Report**

Dear Mr. Gerlach:

As requested, Western Water Associates Ltd. (WWAL) provides this report summarizing groundwater monitoring at Bear Mountain golf course in 2016-2017.

This document provides a summary of the groundwater monitoring data collected at Bear Mountain from October 2016 to November 2017. General and background information can be found in the October 2017 Bear Mountain Groundwater Supply Assessment Report (WWAL, 2017a).

## **1. GROUNDWATER EXTRACTION**

### **1.1 Licensing**

The Province of BC passed the Water Sustainability Act (WSA) in 2014, and a series of initial Regulations were enacted on February 29, 2016 requiring non-domestic water users to apply for a water licence and pay annual water rental fees.

In June 2017, Ecoasis submitted an application to the Province for an Existing Use Groundwater Licence. The total annual groundwater diversion amount applied for was 375,000 m<sup>3</sup> from the three existing supply wells (405, 407, and 411). As with most existing use applications, it is still in process with the Province.

### **1.2 Extraction Rates and Volumes**

During the 2016-2017 monitoring period, pumping of wells 407 and 411 for irrigation of both the Mountain and Valley golf courses began on May 4, 2017, and pumping of well 405 began on July 28, 2017. Pumping continued until September 17 for well 405, September 22 for well 407, and October 10, 2017 for well 411 when the production wells were shut off for the winter. Extraction volumes were measured by digital flow meters, which are recorded and maintained by Ecoasis staff.

Ecoasis reported a gross extraction volume of 300,450 m<sup>3</sup> for both golf courses in 2017. Based on the volumes and duration of pumping, the average extraction rates were determined to be approximately 110 USgpm (6.9 L/s) for well 405, 128 USgpm (8.1 L/s) for well 407, and 198 USgpm (12.5 L/s) for well 411. The digital flow meters measured approximately 171,700 m<sup>3</sup> pumped into Osborne Pond (the primary reservoir for the Valley Course) and approximately 128,750 m<sup>3</sup> pumped into the Mountain Pond over the duration of pumping in 2017.

From the water balance work conducted for the golf course by Colquitz Engineering Ltd. (2017), we understand that the net extraction volume for the Valley Golf Course is estimated to be approximately 26% of the measured gross extraction volume, due to leakage of the Osborne Pond. The net groundwater extraction volume removed for the Valley course is therefore estimated to be approximately 44,650 m<sup>3</sup>.

## **2. WATER LEVEL MONITORING**

### **2.1 Methodology**

The location of production and observation wells at Bear Mountain are shown in Figure 1 (from Thurber), attached. Water levels were continuously monitored in pumping wells 405, 407 and 411 during the 2016-2017 monitoring period (October 2016 to November 2017). Continuous monitoring was also conducted in well 412 throughout the monitoring period and in well 414 from the beginning of the monitoring period until July 7 when the monitoring equipment removed as it was malfunctioning. At this time, new monitoring equipment was installed in well 400.

Each of the continuously-monitored wells have dedicated data-logging transducers that are capable of measuring temperature and pressure at set intervals (set to hourly at this site). During downloading of the dataloggers, manual water level measurements were obtained. Periodic water level measurements in the pumping wells were also made by Ecoasis staff.

### **2.2 Results and Discussion**

Figure 2 illustrates groundwater elevations for the selected wells during the 2016-2017 monitoring period. For comparison, water level data from the 2015-2016 monitoring period are also plotted on the same figure using a lighter line weight and a one year shift in the date.

From the data, 2016-2017 groundwater elevations in the bedrock aquifer remained similar to prior years. As in previous years (Thurber, 2012, 2013, 2014, 2015, 2016; WWAL, 2017b), aquifer levels fluctuated seasonally on the order of 2 to 5 m, peaked in the early spring (February to April) and were lowest in the early fall. The groundwater flow direction in the north part of the golf course was inferred to be towards the southeast based on the relative static water levels in the wells 400, 407, 411, 412 and 414.

Water levels in the pumping wells showed a similar fluctuation to the observation wells in the winter and early spring when they were not being pumped. During the 2017 irrigation season, water levels in the irrigation wells were drawn down due to pumping by a maximum of approximately 35 m in well 405, 43 m in well 407 and 86 m in well 411 (compared to 50, 43, and 80 m, respectively during the previous year). Water level drawdown in the pumping wells showed a relatively rapid decline when extraction was initiated and then a gradual flattening after prolonged pumping. When pumping was stopped, the water levels in the wells recovered relatively quickly following the first significant precipitation events. In 2017, this occurred around the middle of October.

Following shutdown of the pump in well 411 for the winter on October 10, water levels in the pumping wells recovered to 100% of the pre-pumping groundwater levels after approximately 5 weeks. This can be compared to a full recovery after ~4 weeks in 2016 (WWAL, 2017b), ~5 weeks in 2015 (Thurber, 2016), ~6 weeks in 2014

(Thurber, 2015), ~10 days in 2013 (Thurber, 2014), and ~2 weeks in 2012 (Thurber, 2013). From this information, we can conclude that the time to full recovery varies from year to year, depending on the timing of the onset of the rainy season, which is typically within one to two months after the end of the irrigation season.

As observed in previous years, extraction pumping of irrigation wells did not appear to impact the water levels in the observation wells (413 and 414 in the past, and 400 and 412 currently). This is consistent with the conceptual understanding of the aquifer described in previous reports that the observation wells are considered hydraulically separate from the permeable fault/fracture zone that provides the source of water for the irrigation wells.

### 3. CONCLUSIONS AND RECOMMENDATIONS

Groundwater extraction and level monitoring data at Bear Mountain in 2016-2017 are provided in this report. The results confirm the patterns observed in previous years. Seasonal fluctuations in monitoring wells were on the order of 2 to 5 m. Complete recovery of water table drawdown in the aquifer due to pumping occurred after approximately 5 weeks. There were no indications of groundwater quantity issues. Consistent year-over-year recovery in the extraction wells suggests that existing local demands on the aquifer do not exceed its supply capacity.

It is recommended that the annual groundwater monitoring and reporting program be maintained in 2017-2018. The dataloggers should be downloaded at the start and the end of the irrigation season, or approximately in May and November.

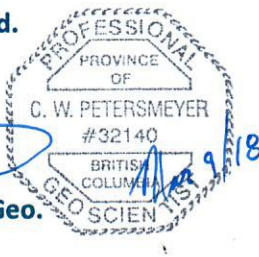
### 4. CLOSURE

We trust this letter provides the information you require. If you have any questions, please contact us.

**Western Water Associates Ltd.**

  
**Chad Petersmeyer, M.Sc., P.Geo.**

**Senior Hydrogeologist**



Attachments:

Thurber Figure 1

Figure 2

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## 5. REFERENCES

Colquitz Engineering Ltd., Bear Mountain Golf Courses Golf Irrigation Water Balance Study, December 28, 2017.

Thurber Engineering Ltd., Bear Mountain 2014-2015 Annual Groundwater Monitoring Report, Ecoasis Developments LLP, August, 2016.

Thurber Engineering Ltd., Bear Mountain 2013-2014 Annual Groundwater Monitoring, Ecoasis Developments LLP, October, 2015.

Thurber Engineering Ltd., 2012-2013 Annual Groundwater Monitoring, Bear Mountain Development, January, 2014.

Thurber Engineering Ltd., 2011-2012 Annual Groundwater Monitoring, Bear Mountain Development, February, 2013.

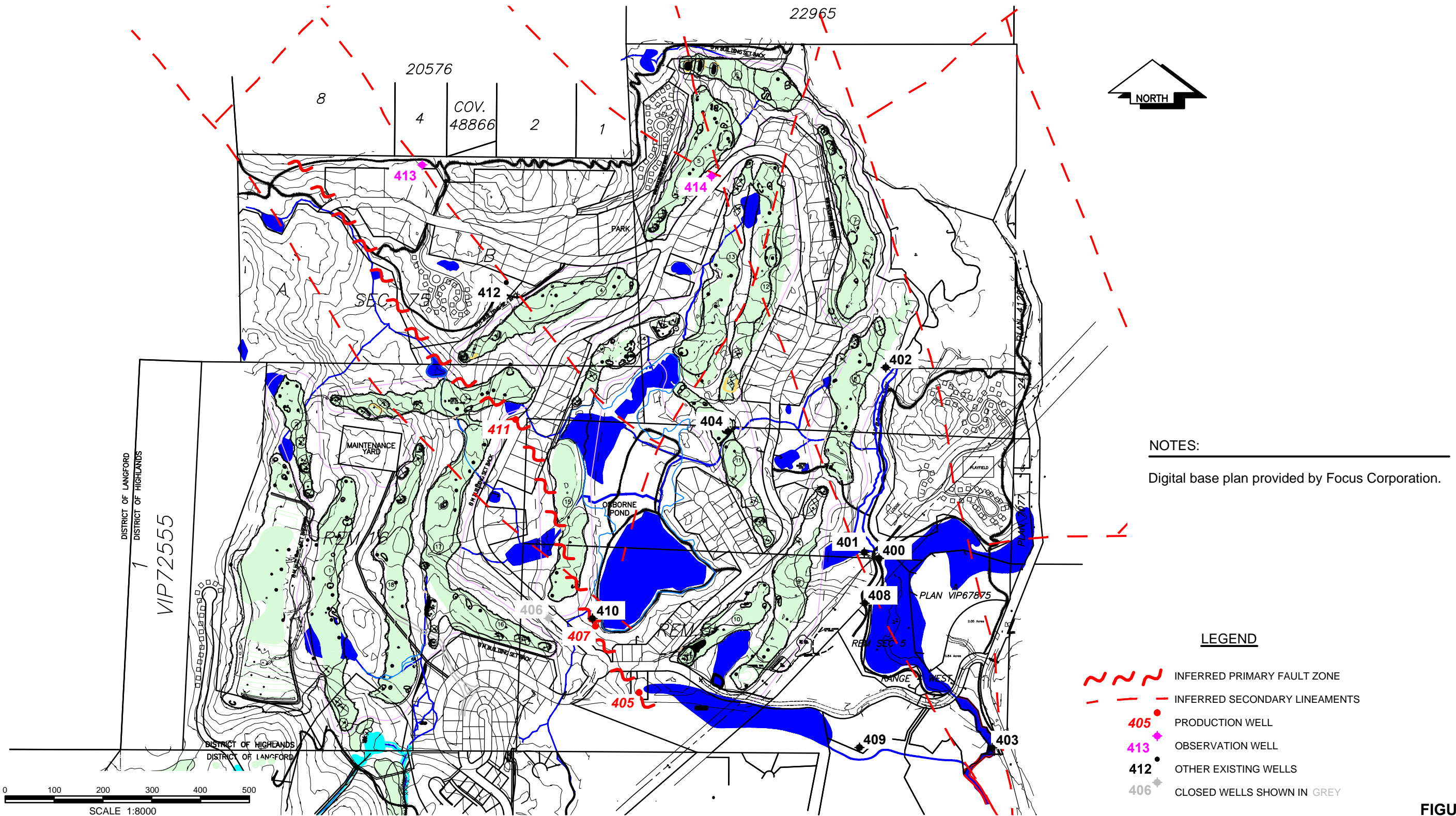
Thurber Engineering Ltd., Bear Mountain Development, 2010-2011 Annual Groundwater Monitoring Report, January, 2012.

Western Water Associates Ltd., Bear Mountain Groundwater Supply Assessment Report, October 19, 2017a.

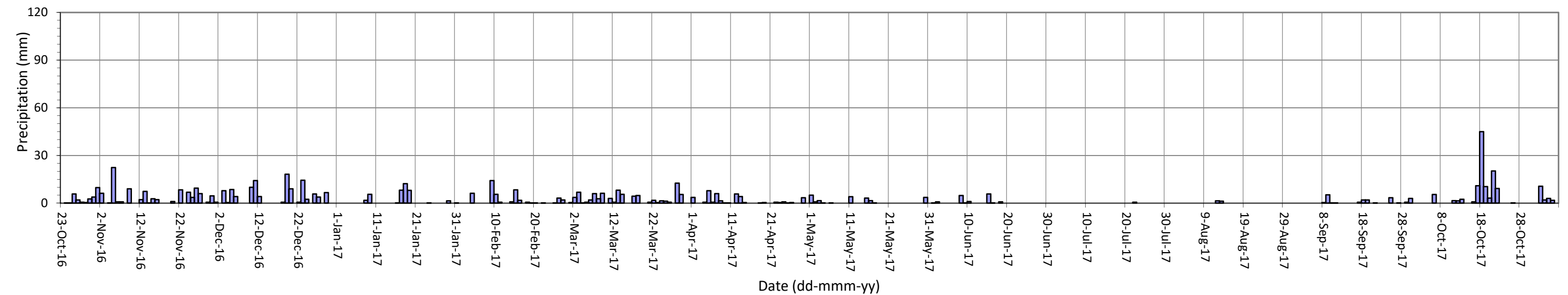
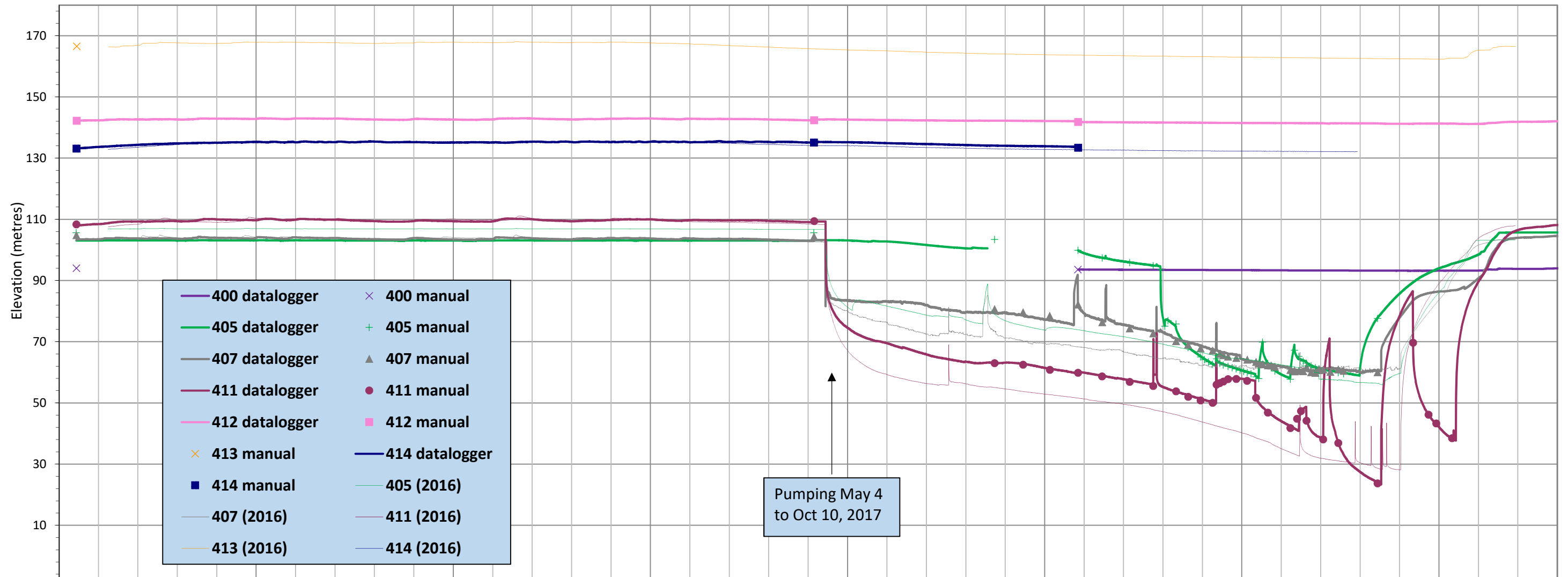
Western Water Associates Ltd., Bear Mountain 2015-2016 Annual Groundwater Monitoring Report, October 19, 2017b.

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**FIGURE 1**



**Figure 2: Bear Mountain Golf Course 2016-2017 Groundwater Levels**

TITLE			
<b>Figure 2: Bear Mountain Golf Course 2016-2017 Groundwater Levels</b>			
DRAWN	CWP	DATE	March 7, 2018
CHECKED		SCALE	
REVIEWED		FILE NO.	
		PROJECT NO.	16-092-01
		DWG. NO.	N/A
		FIGURE VERSION NO.	