



Memorandum

October 5, 2017

To: Maureen Bilawchuk (BC MOE) Ref. No.: 11149336

From: Ben Kempel – Senior Hydrogeologist/sdz/01 Tel: 604-214-0510

cc: James Reid (GHD)

**Subject: Review of Monitoring well MW-6
Cobble Hill Landfill
460 Stebbings Road, South Shawinigan Lake Area, BC**

As requested, GHD Limited (GHD) has prepared this memorandum to provide the BC Ministry of Environment and Climate Change Strategy (MOE) with an expert opinion concerning the location of monitoring well MW-6 at a quarry/landfill site located at 460 Stebbings Road in the South Shawinigan Lake area, BC (Site). The MOE specifically requested GHD's opinion on the following:

1. Is MW-6 upstream of the landfill?
2. Is MW-6 being impacted by the landfill?
3. Is MW-6 suitable as a control well for the site (landfill, pond and other discharge points)?

The opinion presented in this memorandum is based on GHD's review of the following documentation:

- October 22, 2013 – Letter from Active Earth Engineering Ltd. to MOE summarizing the core drilling and testing at MW13-4 and MW13-5
- January 27, 2016 - Letter from SIMS to MOE describing intention to replace MW-4 with MW-6.
- March 23, 2016 – Technical memorandum from Stantec on replacement of MW-4 with MW-6 (Stantec Memo).
- March 31, 2016 – Letter from SIMS to MOE describing installation, development and sampling of MW-6 by Stantec.
- Stratigraphic and monitoring well instrumentation logs for MW-1, MW-2, MW-5 and MW-6.
- Groundwater sampling information summary for September 2013 monitoring event

MW-6 Installation and Groundwater Elevations

MW-6 was installed as a replacement background monitoring well for MW-4. MW-6 was installed with a screen interval from 295.5 to 301.5 metres above mean sea level (m AMSL), which is slightly higher in elevation than the screen interval for MW-4 (292 to 298 m AMSL). The screen interval was selected based on evidence of water-bearing fractures in this interval during drilling. A water-bearing fracture zone was encountered at 297 m AMSL in MW-4. The screen interval for MW-6 overlaps this elevation and the



observations of small fractures during drilling MW-6 are reasonably consistent with the fracture zone elevation noted at MW-4.

Based on the information provided, ground surface at MW-6 is approximately 342.5 m AMSL. Accordingly, the groundwater elevation measured prior to sampling was approximately 326.23 m AMSL. Although no current static groundwater elevations were provided for other monitoring wells, this elevation is significantly higher (>5 m) than those measured at monitoring wells located closer to the western site boundary during a monitoring event in 2013. In the October 22, 2013 letter, Active Earth Engineering Ltd. provided an interpretation of groundwater flow direction, based on static groundwater elevations measured in September 2013. Based on the measured elevations and the horizontal hydraulic gradients, Active Earth Engineering Ltd. concluded that the groundwater flow direction at the Site was to the north-northwest (as presented on Figure 2 from the October 22, 2013 letter). Based on GHD's review of the static groundwater elevations presented, GHD concurs with Active Earth Engineering Ltd.'s interpretation of groundwater flow direction.

Based on the measured static groundwater elevation at MW-6 and the historical documented groundwater flow direction, MW-6 is located in an area that is hydraulically elevated compared to the northwestern portion of the Site. This provides evidence that the monitoring well is in an upgradient position relative to the bulk of the Site, including MW-4 and the Permanent Encapsulation Area and the nearby settling pond. It should be noted that because of the spatial configuration of the monitoring well network, there could be some minor variation in the actual groundwater flow direction compared to the interpretation based on the available data.

It is noted that the static water level in MW-6 measured prior to sampling was several metres lower than static water levels measured prior to extensive purging. Due to the observed slow recharge of this well, the true static groundwater elevation at MW-6 may be higher than 326.23 m AMSL. The following table summarizes the available measurements of static groundwater levels at MW-6.

Date	Static Level (m BGS)	Elevation (m AMSL)	Comments
February 24, 2016	9.23	333.27	Following well installation
February 26, 2016	10.21	332.29	36 hours following installation
March 8, 2016	16.27	326.23	Following purging of 300 L

Water Quality

Samples were collected from MW-4 and MW-6 on March 8, 2016. Each well was reportedly purged of an entire well casing volume several days prior to sample collection to remove potentially stagnant groundwater from the well casing. Based on observations made during purging, MW-4 and MW-6 have similar recharge characteristics.

Based on the water quality reported in the samples collected from MW-4 and MW6 on March 8, 2016, water quality at the two monitoring locations is largely similar. The sample and its duplicate collected from MW-6



exhibited slightly greater concentrations of primary water quality indicators including conductivity, hardness, TDS, alkalinity, sulphate and chloride. Dissolved metals concentrations were in general slightly greater at MW-6 than at MW-4, although less than BC Contaminated Sites Regulation (CSR) standards. There were no volatile organic compounds (VOCs), polyaromatic hydrocarbons (PAHs) or other hydrocarbon parameters detected in samples collected from either well.

With respect to MW-6 being a replacement for MW-4, the differences in water quality reported between MW-4 and MW-6 are relatively minor. Considering the nature of the formation in which these wells are screened (low conductivity metamorphic bedrock, few fractures), it is not unexpected that water quality would differ slightly from one location to the next. The analytical results from MW-6 do not on their own suggest a landfill-related water quality impact at this location.

Conclusion

On the basis of the limited data provided, GHD offers the following opinions with respect to the specific questions provided by the MOE:

1. Is MW-6 upstream of the landfill?
 - Although the exact groundwater flow direction cannot be determined from the data provided, the data indicates that MW-6 is located in an area of higher groundwater hydraulic head than the northwestern portion of the Site. Based on this fact, MW-6 is located in an upgradient position relative to the Permanent Encapsulation Area.
2. Is MW-6 being impacted by the landfill?
 - There is no definitive evidence of landfill-related water quality impairments at MW-6 based on the data provided.
3. Is MW-6 suitable as a control well for the site (landfill, pond and other discharge points)?
 - Based on the data reviewed, the construction details and limited groundwater quality and hydraulic data suggest that MW-6 is a suitable location for representing background groundwater quality at the Site.