Stantec

Memo

To:	Steve Brown Waterloo	From:	Nicole Semper / Lesley Veale Waterloo
File:	161413464	Date:	October 5, 2017

Reference: Hydrogeological Review – Silver Lake EA Addendum, City of Waterloo

The City of Waterloo (the City) is conducting a study to identify and evaluate alternatives to rehabilitate Silver Lake and Laurel Creek within Waterloo Park. Waterloo Park is approximately 48 ha and is generally bounded to the north by Seagram Drive, to the south by Father David Bauer Drive, to the east by Albert Street and Caroline Street, and to the west by University Avenue and Westmount Road (Study Area) (Figure 1, Attachment A).

Stantec Consulting Ltd. (Stantec) has prepared the following technical memorandum to document the results of a hydrogeological review completed to provide a general characterization of hydrogeological conditions within Waterloo Park based on a desktop review of available public documents and field investigation including a summary of groundwater level and surface water level measurements, and vertical hydraulic gradients along the creek and within Silver Lake.

All figures and tables referenced in this technical memorandum are presented in Attachments A and B, respectively.

SITE SETTING

Waterloo Park is situated within the Laurel Creek Watershed within the boundary of the Grand River Conservation Authority (GRCA), with onsite surface water features including Laurel Creek, Clair Creek, Silver Lake, and mapped wetland areas (Figure 1). MTE (2013) indicated that two (2) wetlands were located within Waterloo Park. The wetland boundaries were delineated by MTE in May 2012 and verified by the GRCA, and are shown on Figure 1. MTE (2013) completed a vegetative assessment and indicated that the wetland area (1.9 ha in size) located immediately upstream of Silver Lake is comprised of riparian vegetation and some meadow marsh areas, and the smaller wetland area (0.4 ha in size) located near University Avenue consisted mainly of meadow marsh habitat.

Waterloo Park is located within the physiographic region referred to by Chapman and Putnam (1984) as the Waterloo Moraine or Waterloo Sand Hills. The Waterloo Sand Hills region consists of complex deposits of ice-contact and glacial outwash sands and gravels separated by silt- and clay-rich tills. Surficial geology within Waterloo Park as mapped by the Ontario Geological Survey (OGS; 2010) indicates that ice-contact stratified deposits of sand and gravel with minor silt and clay cover the majority of the Study Area with modern alluvial deposits of clay, silt, sand, and gravel mapped along Laurel Creek. Deposits of sandy silt to silty sand material were mapped at ground surface at the western extent of the Study Area.

Underlying Paleozoic bedrock in the area is mapped as dolostone, shale, and evaporites of the late Silurian and early Devonian Salina Formation (OGS, 1991). Bedrock is located about 60 m below ground surface (BGS) in the vicinity of the Study Area.

A review of the available Ministry of the Environment and Climate Change (MOECC) water well records (WWR) indicates minimal borehole data within Waterloo Park with the exception of the pedestrian bridge at the southern extent. MOECC WWR are available to the south of Waterloo Park, likely a function of the recent construction to the south of Father David Bauer Drive. Based on available data, the following stratigraphy is noted.

- At the western extent of the Study Area near Westmount Road, silty sand material was noted from ground surface up to 3.7 m BGS and underlain by dense silty sand to clayey sand to the base of the borehole at 6.1 m BGS.
- At the southern extent of the Study Area, the boreholes indicated clay to sand material at ground surface but consistently indicated clay material below 4.6 m BGS to the base of the borehole at up to 6.2 m BGS.
- At the southeastern extent of the Study Area, sand and gravel material (potentially fill) was typically noted extending from ground surface up to 4.6 m BGS and underlain by silty clay described as soft to dense depending on location. The clay material extends to the base of the borehole at 7.8 m BGS.

As a general description, shallow overburden conditions are variable throughout the Study Area but typically range from silty material to sand/gravel. The majority of boreholes noted dense clayey material below approximately 5 m BGS and this unit may be continuous across the Study Area. The limited available borehole data within the Study Area limits further evaluation of stratigraphy. Borehole drilling within the Study Area would be required to confirm conditions.

METHODOLOGY

The hydrogeologic field investigations in 2017 included drive-point installation, groundwater and surface water level monitoring and surface water flow monitoring. Details of the methodology are presented below.

DRIVE-POINT PIEZOMETER INSTALLATION

On June 7 and 8, 2017, Stantec installed four (4) drive-point piezometers (DP1-17 to DP4-17) along Laurel Creek and two (2) drive-point piezometers (DP5-17 and DP6-17) along Silver Lake (Figure 1) to evaluate the potential vertical hydraulic connections between these features and the local groundwater system. The drive-point piezometers consisted of a 19 mm diameter, 0.43 m long steel screen, connected to 25 mm diameter steel risers approximately 2.2 m in length. Stantec personnel inserted drive-point piezometers into the substrate of the creek/lake using manual driving techniques. Construction details for the drive-point piezometers are provided in Table 1. The drive-point piezometers were developed following installation to remove water present within the wells and to improve connection with the groundwater system.

GROUNDWATER AND SURFACE WATER LEVEL MONITORING

Groundwater and surface water levels were recorded manually from the top of the well casing (TOC) using a Heron water level meter in June and September 2017. Dataloggers were installed at each piezometer location to record continuous groundwater and surface water level measurements every hour throughout the investigation period. The water level data from the

leveloggers was corrected for atmospheric pressure using data obtained from a barologger installed in DP1-17.

STREAM FLOW MONITORING

In addition to the groundwater and surface water monitoring, manual stream flow measurements were taken at DP1-17 to DP4-17 installed along Laurel Creek on June 8 and September 27, 2017. Measurements at each location were obtained by placing a measuring tape across the width of the stream, perpendicular to flow, and dividing the distance into equal sections. At each section, the depth of the stream was measured and the flow rate recorded using a portable water velocity meter. Total discharge through the section was then calculated using the U.S. Geological Survey approved mid-section method as discussed in Hipolito & Loureiro (1988) and Dingman (1994).

RESULTS

Figures 2 and 3 present the results of the continuous groundwater and surface water monitoring completed from June to September 2017 at the piezometers installed along Laurel Creek (DP1-17 to DP4-17,) and Silver Lake (DP5-17 and DP6-17,), respectively. Surface water data was not available after August 1, 2017 at DP6-17 due to issues with the datalogger battery. The surface water level measured at DP5-17 and DP6-17 are both representative of Silver Lake. The interpreted surface water level based on data from DP5-17 was presented during this time period. The datalogger was replaced at this location in September 2017. The precipitation and temperature data provided in Figures 2 and 3 were obtained from the Environment Canada website for the Region of Waterloo International Airport Climate Station, located approximately 12 km southeast of the Study Area.

LAUREL CREEK

As indicated in the hydrographs presented in Figure 2, overall surface water levels along Laurel Creek remained relatively stable throughout the monitoring period with fluctuations generally corresponding to precipitation events. The following provides a summary of water level data for each drive-point location along the creek:

- **DP1-17**: Groundwater levels showed steady decline throughout the monitoring period with fluctuations generally corresponding to precipitation events, which resulted in a rapid increase in levels followed by a decrease over approximately a 3 day period. Groundwater levels remained lower than the observed surface water levels throughout the monitoring period with vertical downward gradients of 0.3 m/m in June 2017 increasing to 0.6 m/m in September 2017.
- **DP2-17**: Groundwater levels in June and July showed steady recovery with rain events and high surface water levels likely causing the spikes in groundwater levels observed in mid-July and early-August. Following the early August spike, groundwater levels slowly declined to levels slightly above surface water levels by late September 2017. Under stable conditions, it is expected that groundwater levels and surface water levels would be similar with minimal vertical gradients at this location.
- **DP3-17**: There was minimal surface water within the tributary at this location for the majority of the monitoring period, with surface water levels typically noted as 0.2 m or less. Minimal response to precipitation was noted in the surface water levels. Groundwater levels showed a steady increase over the monitoring period approaching potential static conditions by late Fall

2017. The slow increase in groundwater levels suggests low hydraulic conductivity of shallow overburden at this location.

- **DP4-17**: Groundwater levels initially showed a steady increase following drive-point installation and development. A large rain event in late June 2017 resulted in surface waters increasing to 0.98 m above ground surface. This peak surface water level was above top of the drive-point piezometer and rapidly filled the piezometer with surface water. Following the rain event, water levels within the drive-point slowly declined. A similar response was noted following peak surface levels in July and August 2017. The slow decline in groundwater levels following these events suggest low conductivity of the shallow overburden deposits as water slowly infiltrated. By late September 2017, groundwater levels and surface water level were similar, indicating minimal vertical gradient. The stick-up of the piezometer at this location should be increased to avoid future issues during rain events.

As part of the surface water monitoring, surface water flow measurements were recorded to document changes along Laurel Creek to suggest sections of gaining or losing stream flow.

- In June 2017, calculated stream flows were approximately 235 L/s at DP1-17, 222 L/s at DP2-17, and 208 L/s at DP4-17, with minimal input of 1.5 L/s from the adjacent tributary at DP3-17. The flow rates decreased approximately 6-7% along the flow path (i.e. DP1-17 to DP-2-17 to DP4-17) suggesting the surface water flow measurements were relatively similar in magnitude.
- In September 2017, streams flow measurements were approximately 93 L/s at DP1-17, 126 L/s at DP2-17, and 130 L/s at DP4-17. Again, minimal flow of 0.2 L/s was noted at DP3-17. There was a notable 35% increase in flow rate from DP1-17 to DP2-17 in September 2017 suggesting the potential for surface water recharging conditions in this section of Laurel Creek.

No clear indications of groundwater discharge or groundwater recharge were noted within the section of Laurel Creek within the Study Area. Water level data at DP1-17 suggested downward vertical gradients throughout the monitoring period, with minimal gradients interpreted at the remaining drive-point locations. While available surface water flow data indicated either no change in flow or potential groundwater discharge conditions between DP1-17 and DP2-17.

SILVER LAKE

The surface water levels within Silver Lake remained relatively stable over the monitoring period at both DP5-17 and DP6-17 with increases corresponding to precipitation events (Figure 3). At DP5-07, groundwater levels showed a steady increase over the monitoring period and steady state conditions had not been reached by September 2017. At DP6-17, groundwater levels recovered following initial drive-point installation and development with levels gently fluctuating over the monitoring period. Precipitation events resulted in minor increases in groundwater levels and not the spikes as seen in surface water. Upward vertical gradients were generally observed at this location of up to 0.1 m/m.

CONCLUSIONS AND RECOMMENDATIONS

The results of the current preliminary hydrogeological investigation indicate that there is potential for groundwater recharging conditions to be present in some reaches of Laurel Creek and Silver Lake and groundwater discharging conditions in other reaches. In general, vertical gradients appear to be minimal. These observations are consistent with the findings from MTE (2013).

Reference: Hydrogeological Review – Silver Lake EA Addendum, City of Waterloo

The following recommendations are presented:

- The stick-up at DP4-17 should be increased in Fall 2017 to avoid overflow of the piezometer during large rain events.
- The dataloggers should be removed from all locations in Fall 2017 as the monitoring program is compete.
- A final round of manual water level measurements and surface water flow measurements should be completed in Spring 2018 to document high water level conditions. An addendum letter should be prepared to document observations.

STATEMENT OF LIMITATIONS

This document entitled Hydrogeological Review - Silver Lake EA Addendum, City of Waterloo was prepared by Stantec Consulting Ltd. ("Stantec") for the account of City of Waterloo (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Regards,

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Attachments: A Figures
B Table

REFERENCES

Chapman, L.J. and D.F. Putnum. 1984. The Physiography of Southern Ontario: Third Edition. Ontario Geological Survey, Special Volume 2.

Dingman, S. (1994). Physical Hydrology. New Jersey, USA: Prentice-Hall.

Grand River Conservation Authority (GRCA), 1993. Laurel Creek Watershed Study.

Grand River Conservation Authority (GRCA) Web-GIS Application (https://maps.grandriver.ca/web-gis/public/?theme=General&bbox=407843,4726420,720099,4913102).

Hipolito, J., & Loureiro, J. (1988). Analysis of some velocity-area methods for calculating open-channel flow. Hydrological Sciences Journal, 33, 311-320.

MTE, 2013. Baseline Inventory Summary Report, Final Silver lake/Laurel Creek Rehabilitation Assessment. Prepared for City of Waterloo. June 13, 2013.

Ontario Geological Survey (OGS), 2010. Surficial Geology of Southern Ontario.

Ontario Geological Survey (OGS), 1991. Bedrock Geology of Ontario, Southern Sheet; Ontario Geological Survey Map 2544, scale 1:1,000,000.

ATTACHMENT A
FIGURES

Stantec

Legend

- Approximate Study Area Limit
- Drive-Point Piezometer
- Road
- Railway
- Watercourse
- Waterbody
- Wetland (MTE, 2013)

0 100 200 metres

1:4,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2016.
3. Orthoimagery © First Base Solutions, 2016.

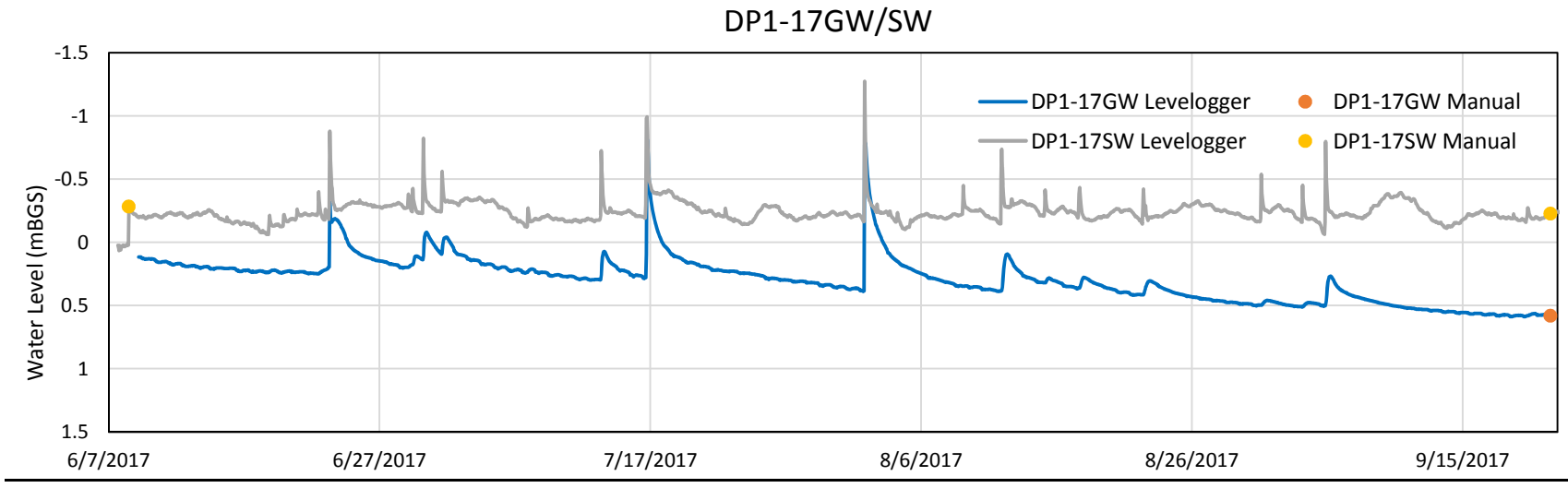
Project Location
Waterloo, Ontario

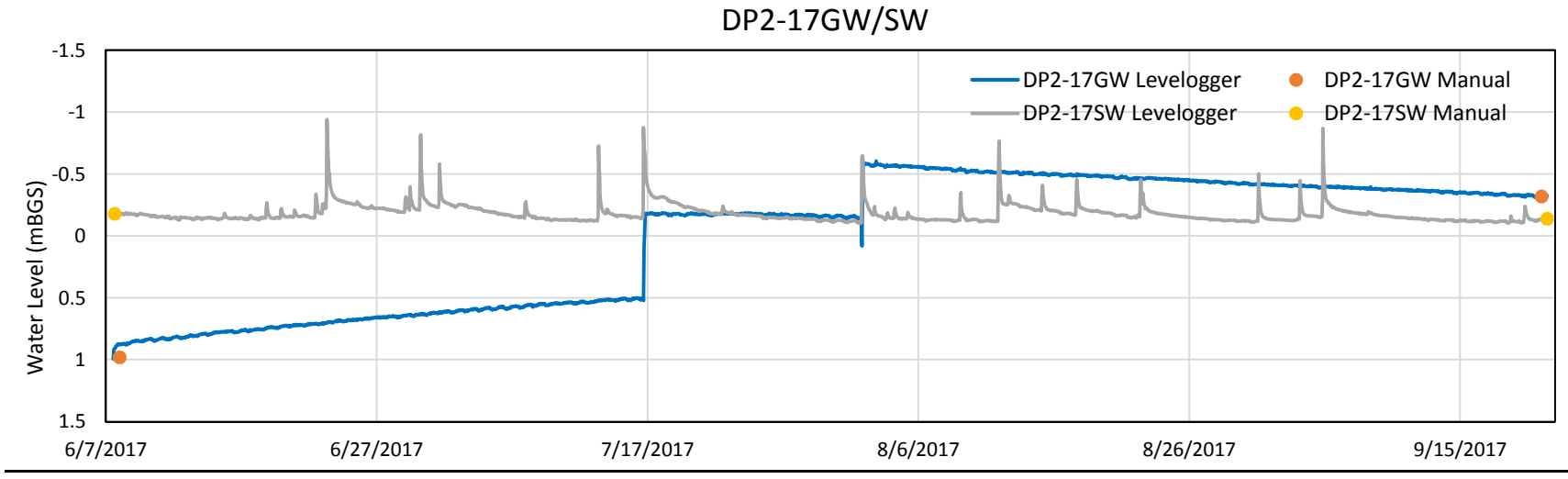
161413464 REVA
Prepared by PRM on 2017-10-04
Technical Review by NS on 2017-10-04

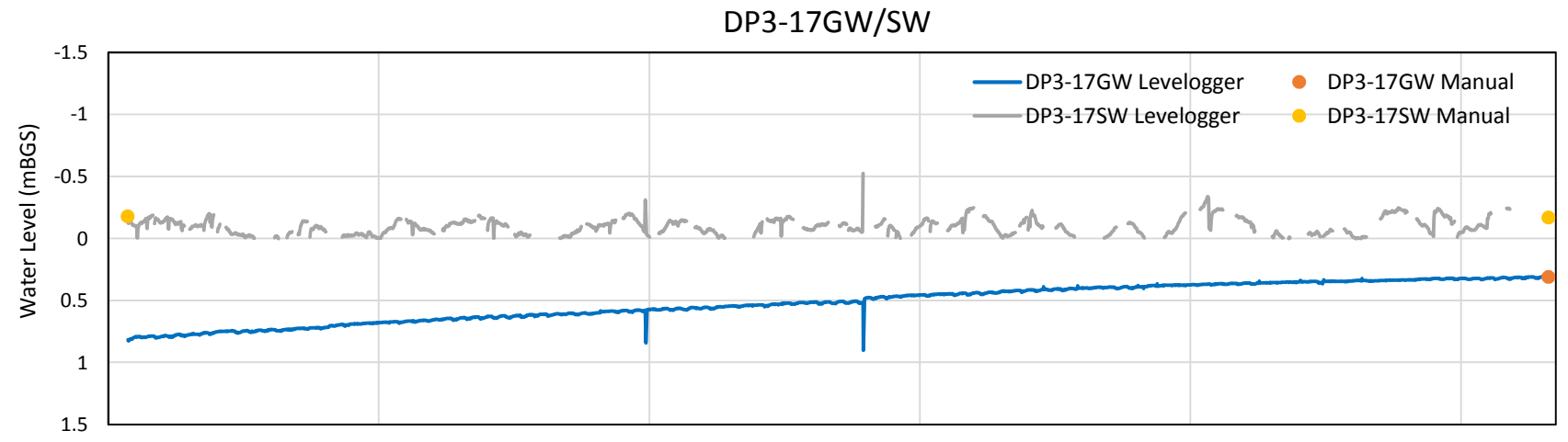
Client/Project
CITY OF WATERLOO
HYDROGEOLOGICAL REVIEW,
SILVER LAKE EA ADDENDUM, WATERLOO PARK

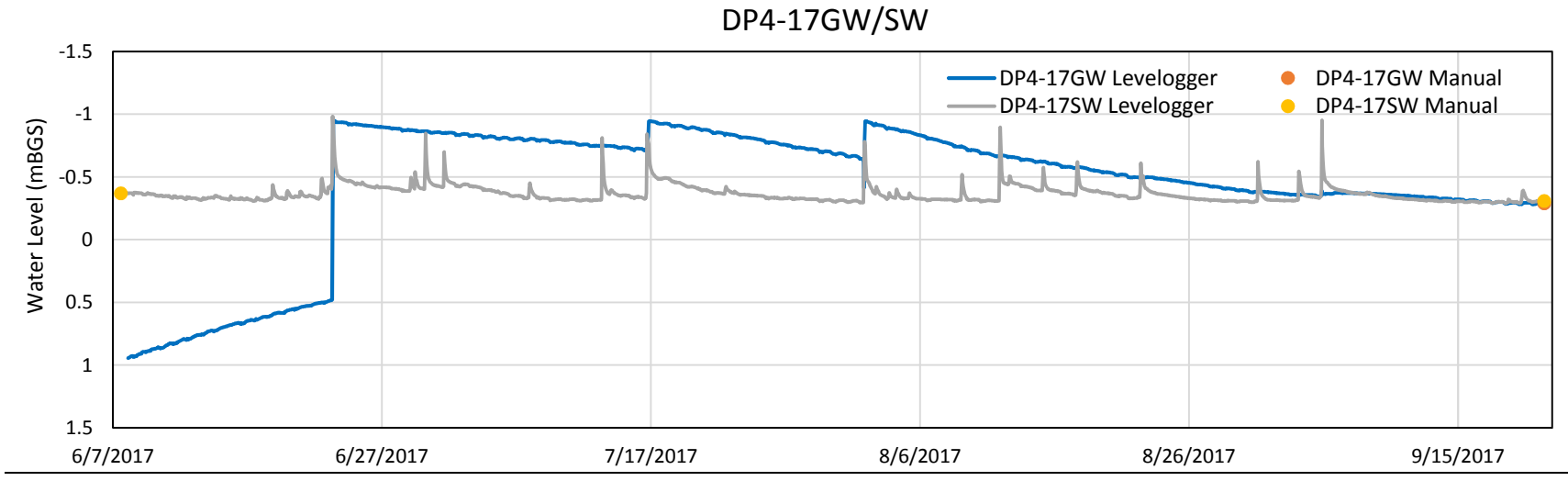
Figure No.
1

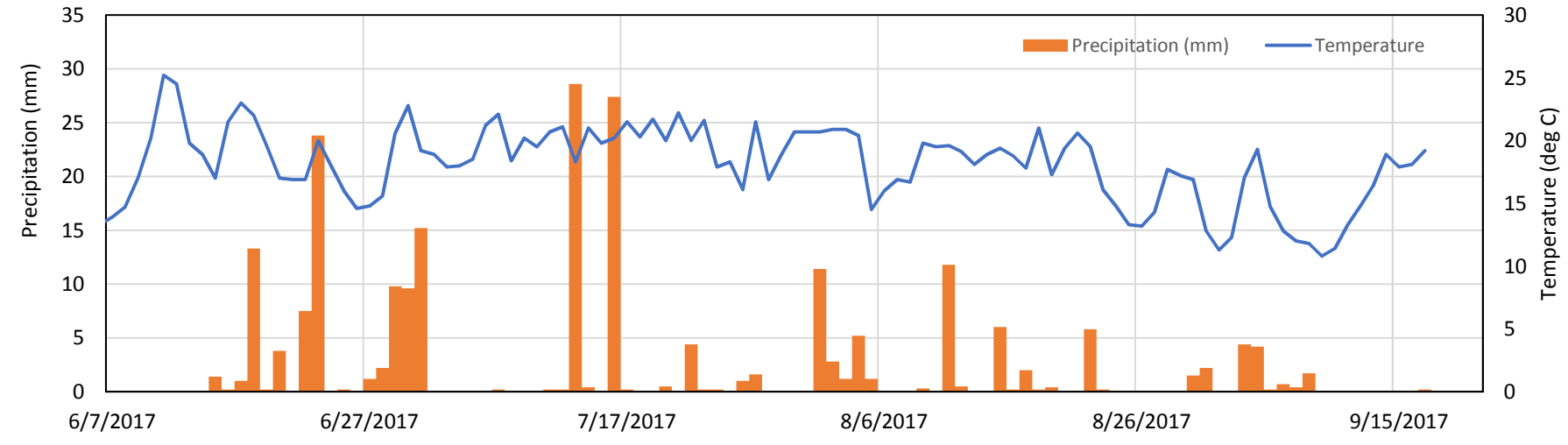
Title
Site Plan











Notes:

1. Data are shown in metres below ground surface
2. Climate data obtained from the Kitchener/Waterloo climate station located at the Waterloo International Airport

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Silver Lake EA Addendum
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Figure No.

2

Title

Hydrographs
DP1-17 - DP4-17

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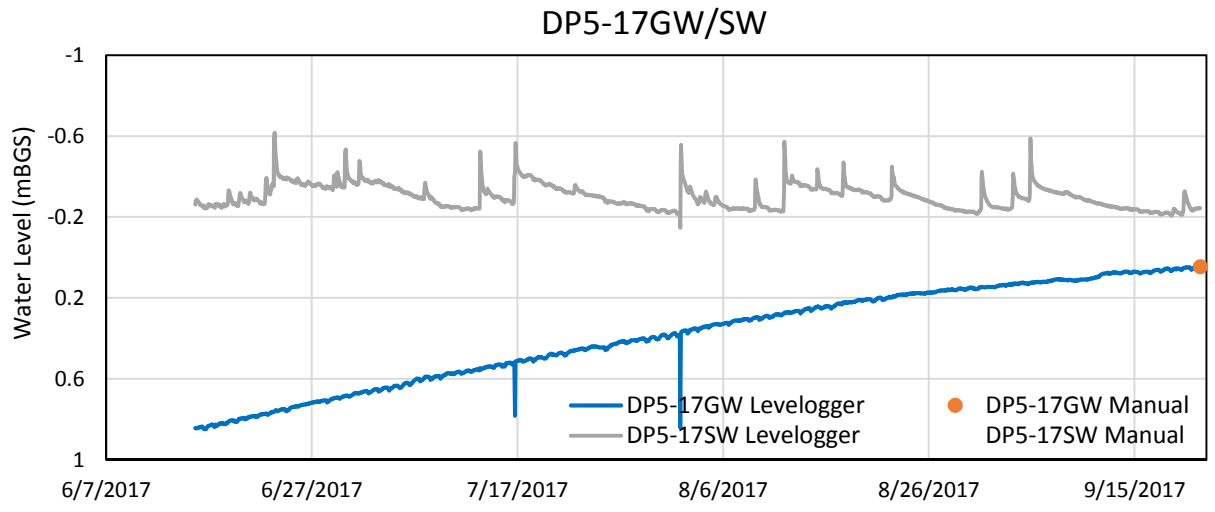

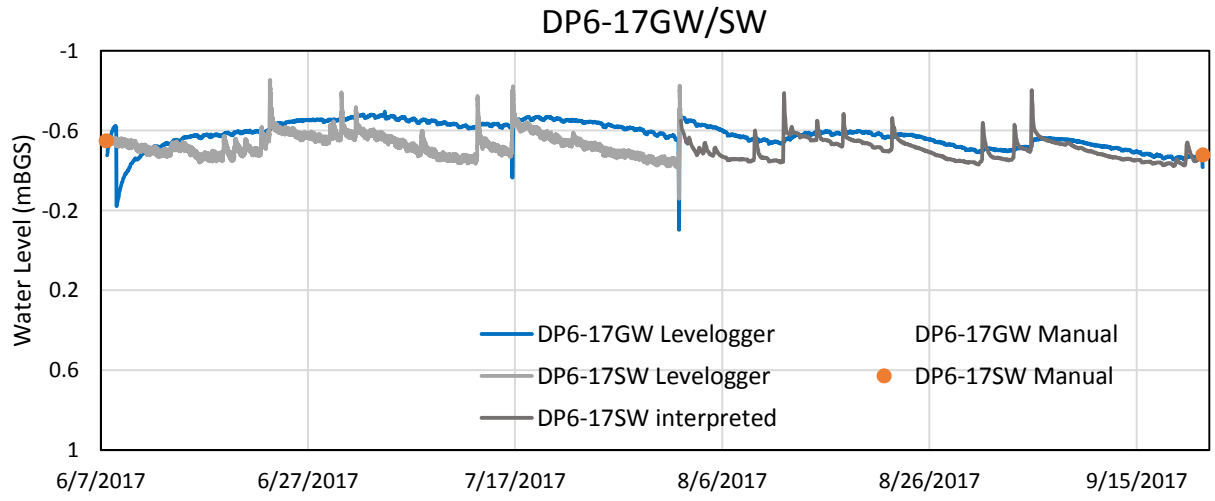

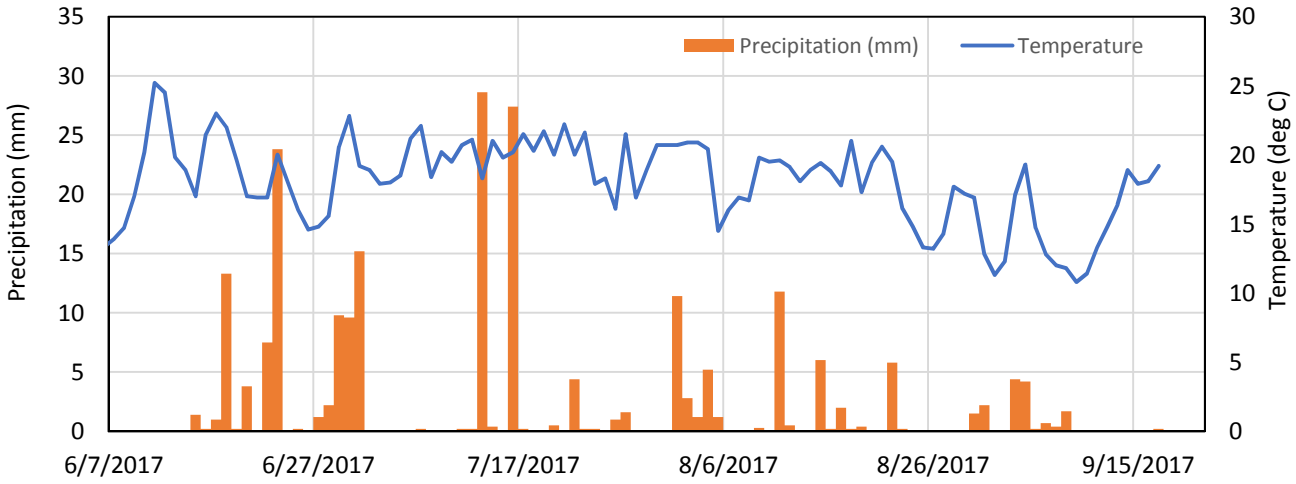

Notes:

1. Data are shown in metres below ground surface
2. Climate data obtained from the Kitchener/Waterloo climate station located at the Waterloo International Airport

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Figure No. **3**

Title

Hydrographs
DP5-17 - DP6-17

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ATTACHMENT B
TABLE

Table 1
Drive-Point Piezometer Construction Details and Water Levels
Hydrogeological Review
Silver Lake EA Addendum, City of Waterloo

Well ID	Northing	Easting	Well Stick-up	Well Depth		Screened Interval		Monitoring Date	Surface Water Levels		Groundwater Levels	
			(m)	(m BTOC)	(m BGS)	(m BTOC)	(m BGS)		(m BTOC)	m BGS	(m BTOC)	m BGS
DP1-17	4812596.2	537246.1	1.03	2.65	1.62	2.2 - 2.6	1.2 - 1.6	8-Jun-17	0.75	-0.29	0.89	-0.14
								21-Sep-17	0.80	-0.23	1.61	0.58
DP2-17	4812794.7	537651	1.03	2.65	1.62	2.2 - 2.6	1.2 - 1.6	7-Jun-17	0.85	-0.18	2.01*	0.98
								21-Sep-17	0.89	-0.14	0.71	-0.32
DP3-17	4812841.1	537681.5	0.92	2.65	1.73	2.2 - 2.6	1.3 - 1.7	8-Jun-17	0.75	-0.17	1.88	0.96
								21-Sep-17	0.76	-0.16	1.24	0.32
DP4-17	4812693.9	537838.7	0.91	2.65	1.74	2.2 - 2.6	1.3 - 1.7	7-Jun-17	0.54	-0.37	1.96*	1.05
								21-Sep-17	0.60	-0.31	0.62	-0.29
DP5-17	4812762.6	538211.8	0.90	2.65	1.75	2.2 - 2.6	1.3 - 1.7	7-Jun-17	0.58	-0.32	-	-
								21-Sep-17	0.66	-0.25	0.95	0.04
DP6-17	4812661.4	538322.8	0.92	2.65	1.73	2.2 - 2.6	1.3 - 1.7	7-Jun-17	0.37	-0.55	-	-
								21-Sep-17	0.44	-0.48	0.45	-0.47

Notes:

m = metres
m BTOC = metres below top of pipe
m BGS = metres below ground surface
- = not measured
* = water level taken June 8, 2017