patersongroup **memorandum**

consulting engineers

re: **Sentinel Well Groundwater Monitoring Program**
Kanata North Urban Expansion
Proposed Residential Development
March Road - Ottawa

to: Novatech Engineering Consultants - **Mr. John Riddell -** J.Riddell@novatech-eng.com

date: July 11, 2019

file: PG3975-MEMO.01 Revision 1

Further to your request, Paterson Group (Paterson) conducted a sentinel well groundwater monitoring program at the Kanata North Urban Expansion Area (KNUEA) along March Road at the aforementioned site. A summary of the field program and results have been provided below.

Background Information

Paterson completed a Hydrogeological Existing Conditions Report (PH2223-3R4 dated May 18, 2016) for the KNUEA, as per the scope set out by the KNUEA Environmental Management Plan (EMP) Terms of Reference. Based on Paterson's findings, it was recommended in the Existing Conditions Report, and subsequently, the EMP, that a sentinel well groundwater monitoring program be completed prior to development in order to establish baseline conditions as a basis for evaluating potential impacts once construction commenced.

The field program consisted of the installation of ten monitoring wells at five locations on December 15 to 21, 2016. Each location consisted of a pair of monitoring wells extending to a depth of 6 and 12 m below ground surface (bgs). The wells were distributed in a manner to provide general coverage of the proposed development taking into consideration site features and access.

Field Survey

The locations of all monitoring wells, as well as geodetic elevations of the ground surface elevation at all monitoring well locations, were provided by Novatech Engineering Consultants. The survey was performed using high accuracy (0.02 m) GPS survey equipment. The locations are presented on Drawing PG3975-1 Test Hole Location Plan attached to the current report.

Subsurface Profile

The subsurface profile at the monitoring well locations generally consisted of overburden thickness ranging from 0.7 to 3.0 m followed by poor to excellent quality limestone with some shale partings. Reference should be made to the Soil Profile and Test Data sheets attached to this report for specific details of the overburden and bedrock profile encountered at the monitoring well locations.

Monitoring Well Installation

Typical monitoring well construction details are described below:

- ❏ 1.5 m of slotted 51 mm diameter PVC screen at the base of the aforementioned boreholes.
- ❏ 51 mm diameter PVC riser pipe from the top of the screen to ground surface.
- ❏ No.3 silica sand backfill within annular space around screen.
- ❏ Bentonite hole plug placed directly above PVC slotted screen extending to the existing ground surface.
- ❏ The 51 mm diameter PVC riser extending above the ground surface was covered with a protective steel monitoring well casing.

Specific details of the installation of each monitoring well are further included in the Soil Profile and Test Data Sheets attached to the current report.

Sentinel Well Groundwater Monitoring

On December 22, 2016, each monitoring well at the subject site was equipped with a Van Essen Instrument Mini-Diver Water Level Logger to accurately monitor fluctuations in the groundwater levels. In addition, a Van Essen Instruments Baro-Diver was installed in BH2-DW to monitor the changes in atmospheric pressure. The Mini-Divers were programmed to continuously measure and record groundwater levels throughout the subject site at a fixed rate of 1 reading every 30 minutes for a period of 24 months. The installation depths and Mini-Diver ID for each respective monitoring well is summarized in Table 1 below.

The results of the groundwater fluctuations and correlated precipitation events for each monitoring well location between December 22, 2016 and May 16, 2019 have been summarized in Figure 1 through Figure 5 attached to the current memo.

Table 1 - Water Level Logger Summary - Kanata North		
Monitoring Well	**Mini-Diver ID**	**Depth (m BGS)**
BH1-DW	W0117	9.05
BH1-SW	W0155	5.84
BH2-DW	T2446	9.16
BH2-SW	T2452	5.86
BH3-DW	T2438	10.00
BH3-SW	V3833	5.71
BH4-DW	V3856	9.08
BH4-SW	V3662	5.75
BH5-DW	V3894	9.17
BH5-SW	V3816	5.70

Discussion

The data presented in Figure 1 through Figure 5 show the difference in seasonal groundwater elevation within the shallow wells at each well location vary from 1.1 to 2.3 m bgs, while the deep wells varied from 1.4 to 2.8 m bgs. The seasonal low and high groundwater elevations at each well location have been summarized in Table 2 below.

Table 2 - Seasonal Groundwater Elevations - Kanata North				
Monitoring Well	**Ground Surface Elevation**	**Low Groundwater Elevation**	**High Groundwater Elevation**	**Difference in Groundwater Depth**
BH1-SW	73.08	71.8 m	72.9 m	1.1 m
BH1-DW	73.08	71.9 m	73.3 m	1.4 m
BH2-SW	82.95	81.0 m	83.3 m	2.3 m
BH2-DW	82.95	80.7 m	83.0 m	2.3 m
BH3-SW	88.84	85.4 m	87.7 m	2.3 m
BH3-DW	88.84	83.6 m	86.4 m	2.8 m
BH4-SW	89.34	87.3 m	89.6 m	2.3 m
BH4-DW	89.34	88.2 m	90.5 m	2.3 m
BH5-SW	84.22	82.0 m	84.0 m	2.0 m
BH5-DW	84.22	82.4 m	85.1 m	2.7 m

Conclusions

Based on the results from the sentinel well monitoring program, groundwater levels were measured in both the elevation of the overburden layers and shallow bedrock, illustrating similar fluctuation patterns across the site. This suggests the shallow and deeper bedrock units are considered hydraulically connected. At the majority of the locations, groundwater elevations were within the elevation of the overburden layers, or above ground surface. This suggests that the upper bedrock layer is fully saturated, and that overburden soils are acting as a confining layer. Based on our results from the sentinel well monitoring program and previous investigations, it is our understanding that the long-term groundwater table at the site boundaries are within the overburden and/or shallow bedrock.

Additional Monitoring - Water Wells

Subsequent to the sentinel well groundwater monitoring program at the subject site, a baseline well survey program will be implemented to document any changes to existing wells during and after construction for the proposed development area of the KNUEA as recommended in Paterson Report PH2223-3R4 and noted in the Kanata North Community Design Plan dated June 28, 2016.

Based on Paterson Proposal PH3857.PRO.01 dated July 9, 2019, the baseline well survey program is anticipated to be completed approximately 4 to 6 weeks prior to construction for the areas initially proposed to commence work. The overall monitoring area will consist of a 500 m buffer around the KNUEA and will include the majority of lots within adjacent country estate lot subdivisions. The well monitoring program will be comprised of sampling residential wells, for a standard ‘subdivision package’ suite of parameters.

We trust that this information satisfies your requirements.

Best Regards,

Paterson Group Inc.

Nicholas Zulinski, P.Geo., géo.

Michael S. Killam, P.Eng.

Attachments

- ❑ Soil Profile and Test Data Sheets
- ❑ Figure 1 to Figure 5 - Groundwater Monitoring Levels
- ❑ Drawing PG3975-1 - Test Hole Location Plan

Figure 1: BH1 - Groundwater Monitoring Levels vs Precipitation Data

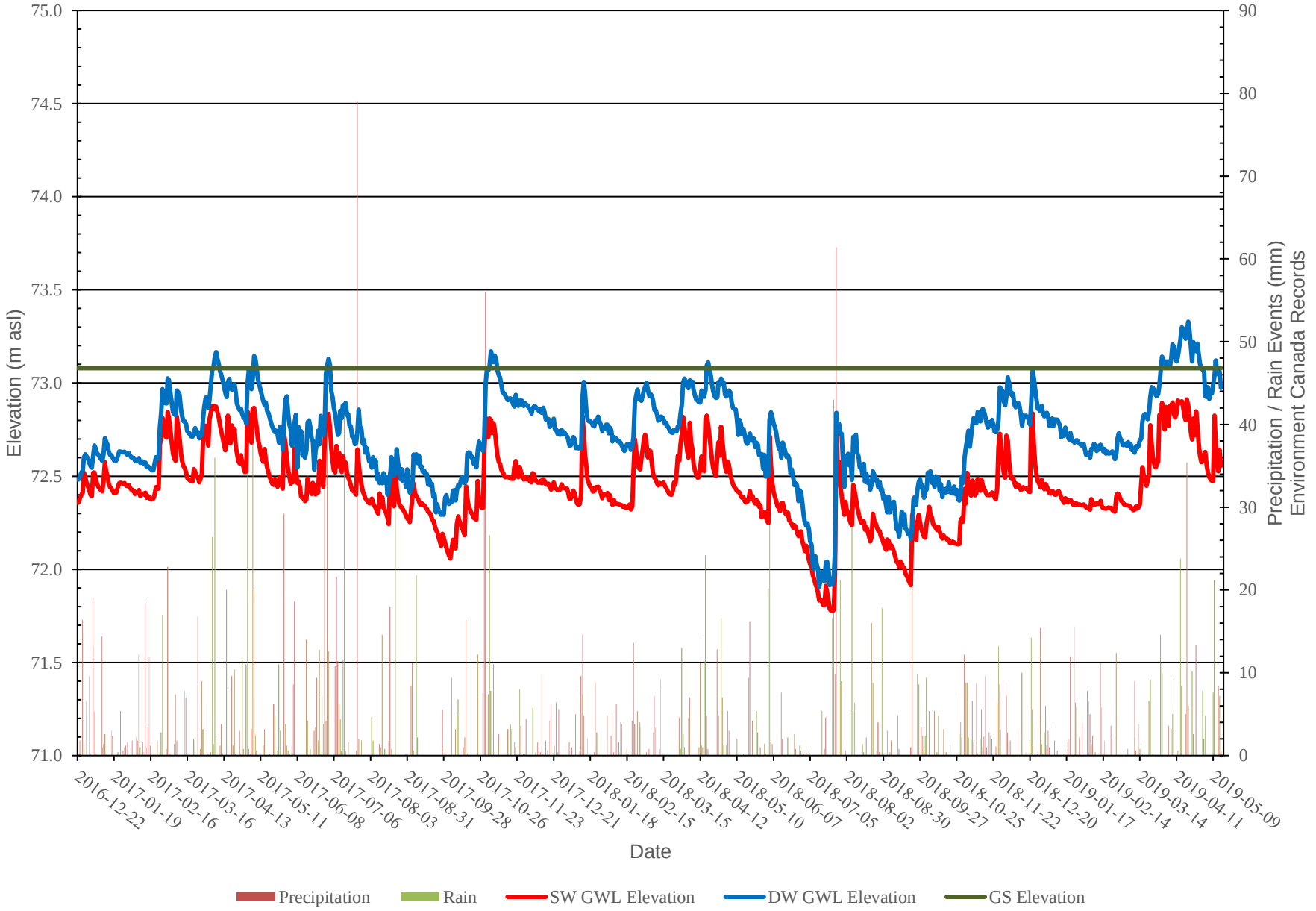


Figure 2: BH2 - Groundwater Monitoring Levels vs Precipitation Data

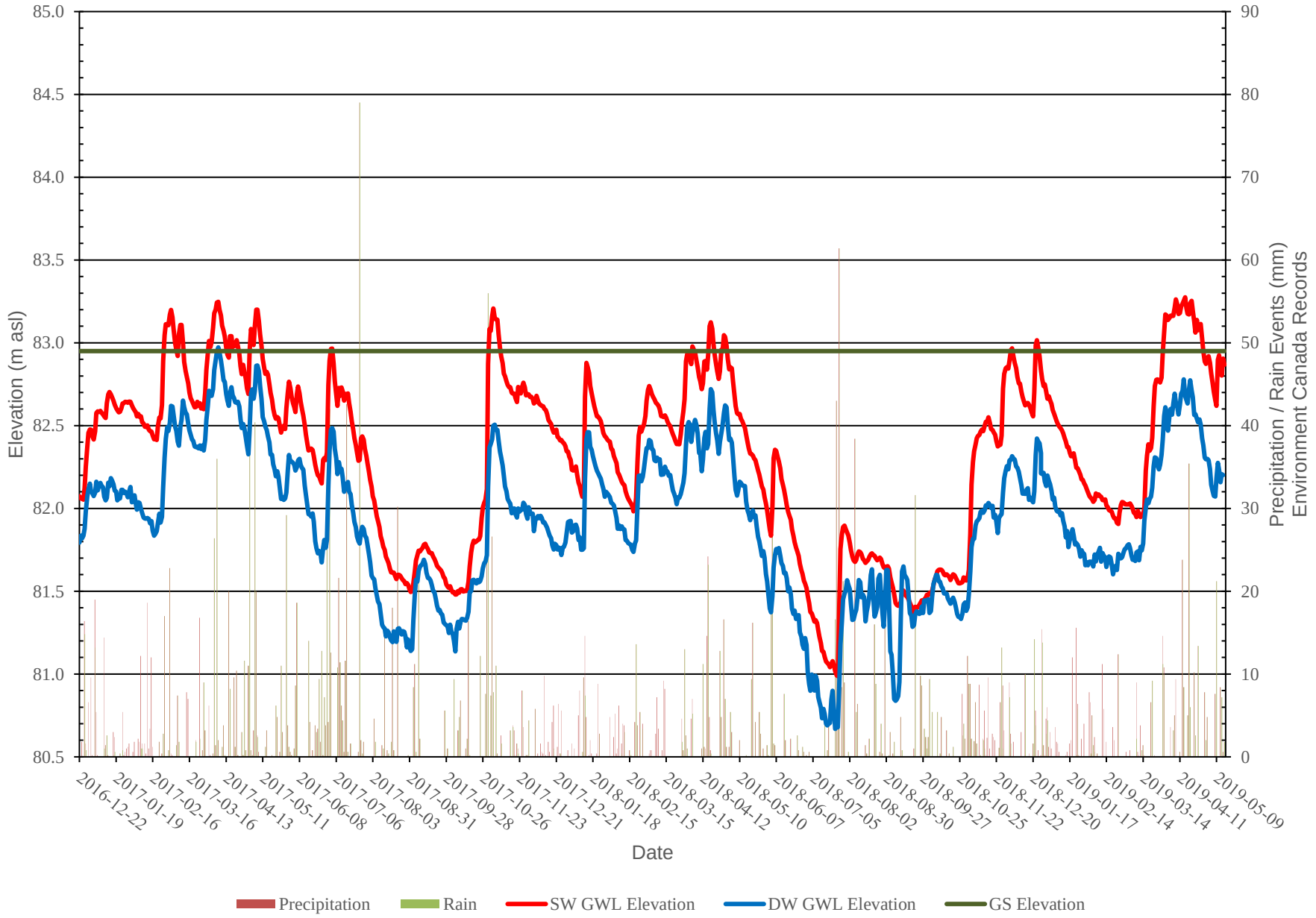


Figure 3: BH3 - Groundwater Monitoring Levels vs Precipitation Data

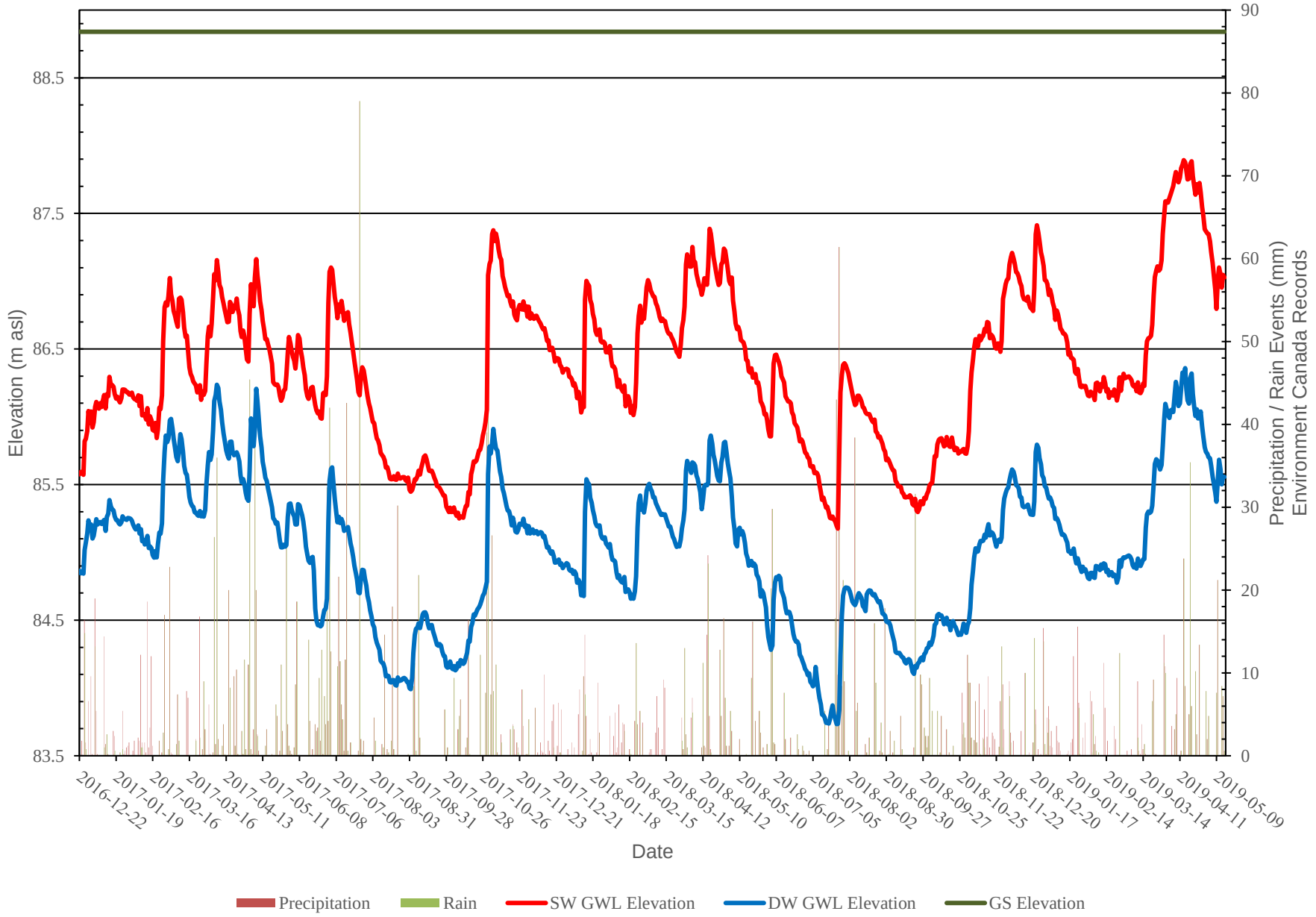


Figure 4: BH4 - Groundwater Monitoring Levels vs Precipitation Data

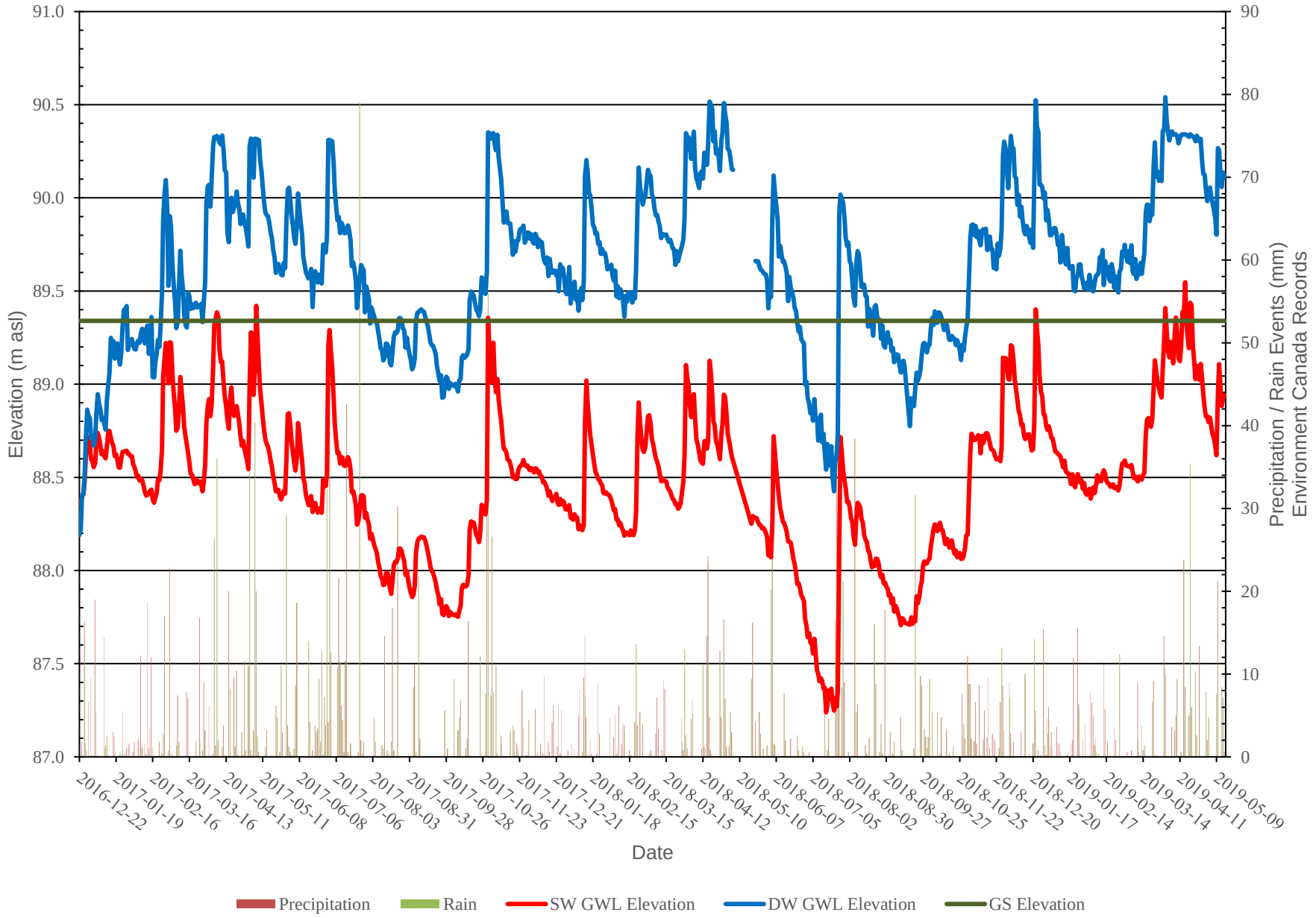
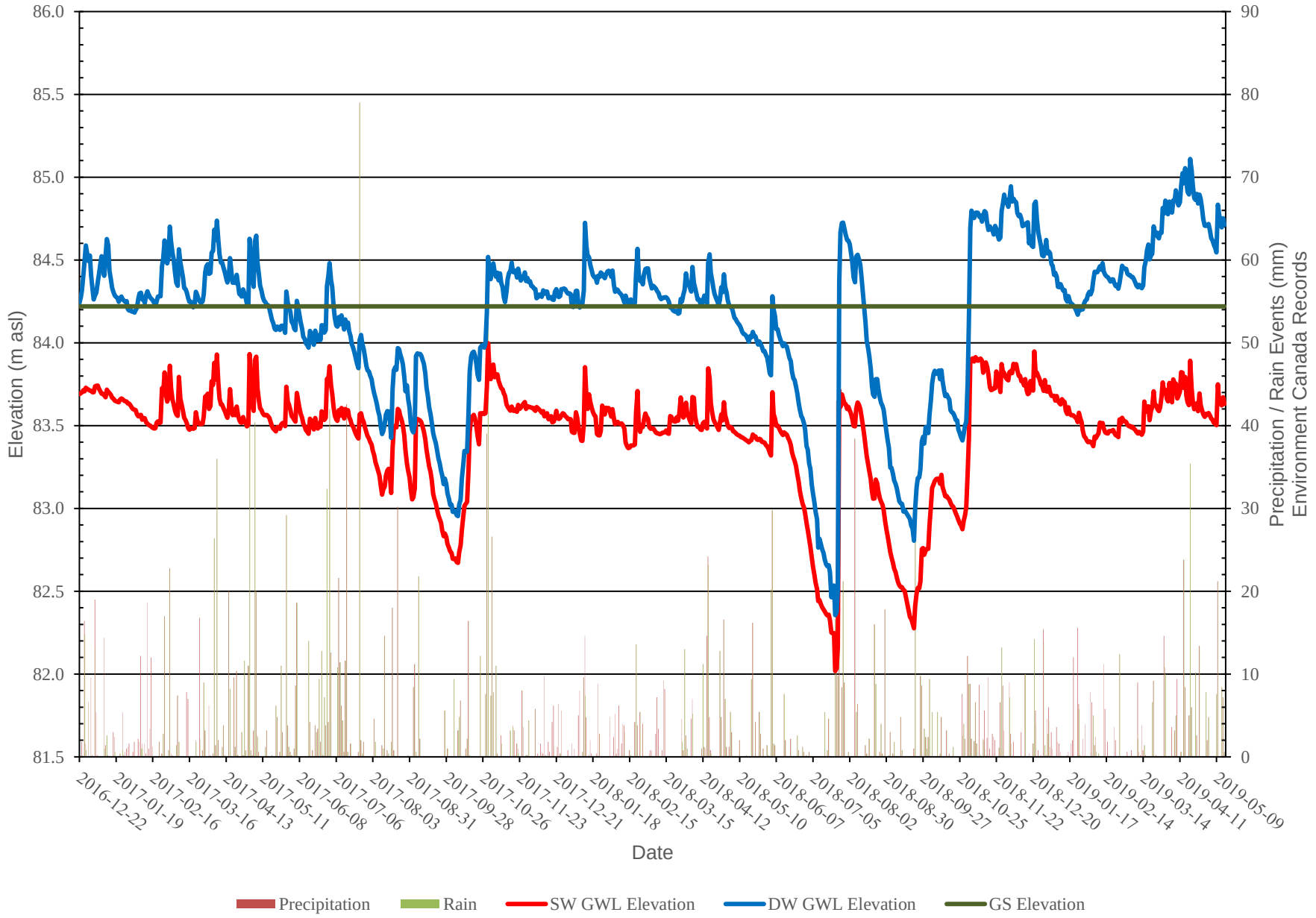


Figure 5: BH5 - Groundwater Monitoring Levels vs Precipitation Data



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5025679.5; Easting 348531.2

HOLE NO. BH 1A-16

BORINGS BY CME 55 Power Auger **DATE** November 15, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	73.08	20 40 60 80	
OVERBURDEN						1	72.08		
2.21						2	71.08		
		RC	1	100	85	3	70.08		
BEDROCK: Good to poor quality, grey limestone, some shale partings		RC	2	100	40	4	69.08		
		RC	3	100	45	5	68.08		
6.12						6	67.08		
End of Borehole									
(GWL @ 0.85m-Dec. 20, 2016)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

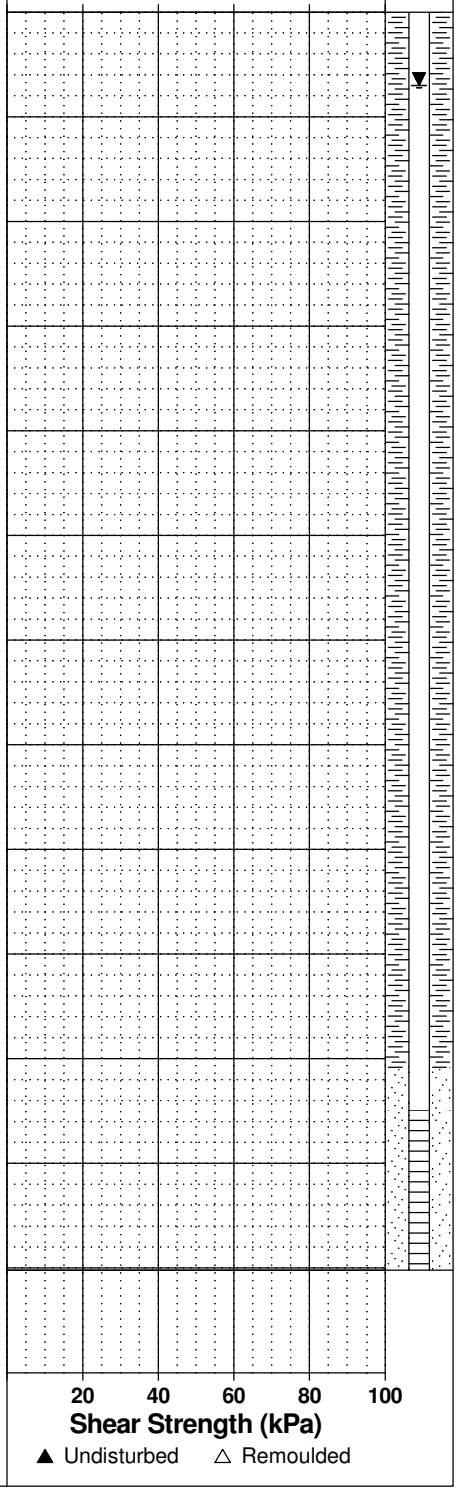
FILE NO. PG3975

REMARKS Northing 5025679.5; Easting 348531.2

HOLE NO. BH 1B-16

BORINGS BY CME 55 Power Auger **DATE** November 15, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	73.08		
OVERBURDEN						1	72.08		
						2	71.08		
2.36									
		RC	1	100	75	3	70.08		
		RC	2	100	40	4	69.08		
		RC	3	100	60	5	68.08		
						6	67.08		
BEDROCK: Fair to excellent quality, grey limestone, some shale partings		RC	4	100	95	7	66.08		
		RC	5	100	66	8	65.08		
						9	64.08		
		RC	6	100	86	10	63.08		
		RC	7	100	100	11	62.08		
12.02						12	61.08		
End of Borehole									
(GWL @ 0.70m-Dec. 20, 2016)									



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5025146.3; Easting 348117.8

HOLE NO. BH 2A-16

BORINGS BY CME 55 Power Auger **DATE** November 16, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	82.95	20 40 60 80	
OVERBURDEN						1	81.95		
						2	80.95		
2.51									
		RC	1	100	47	3	79.95		
		RC	2	100	80	4	78.95		
BEDROCK: Poor to fair quality, grey limestone, some shale partings									
		RC	3	100	69	5	77.95		
6.07						6	76.95		
End of Borehole									
(GWL @ 0.98m-Dec. 20, 2016)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5025146.3; Easting 348117.8

HOLE NO. BH 2B-16

BORINGS BY CME 55 Power Auger **DATE** November 16, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	82.95		
OVERBURDEN						1	81.95		
						2	80.95		
3.02						3	79.95		
		RC	1	100					
		RC	2	100	67	4	78.95		
						5	77.95		
		RC	3	100	66				
						6	76.95		
BEDROCK: Fair to excellent quality, grey limestone, some shale partings		RC	4	100	61	7	75.95		
						8	74.95		
		RC	5	100	93				
						9	73.95		
		RC	6	100	95	10	72.95		
						11	71.95		
		RC	7	100	90				
12.17						12	70.95		
End of Borehole									
(GWL @ 1.12m-Dec. 20, 2016)									

Pen. Resist. Blows/0.3m: 20 40 60 80
Water Content %: 20 40 60 80
Shear Strength (kPa): 20 40 60 80 100
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5025257.5; Easting 347719.2

HOLE NO. BH 3A-16

BORINGS BY CME 55 Power Auger **DATE** November 18, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	88.84	20 40 60 80	
OVERBURDEN						1	87.84		
1.73						2	86.84		
		RC	1	100	67	3	85.84		
		RC	2	100	86	4	84.84		
BEDROCK: Fair to good qualtiy, grey limestone, some shale partings		RC	3	100	68	5	83.84		
6.02						6	82.84		
End of Borehole									
(GWL @ 3.27m-Dec. 20, 2016)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5025257.5; Easting 347719.2

HOLE NO. BH 3B-16

BORINGS BY CME 55 Power Auger **DATE** November 18, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	88.84	20 40 60 80	
OVERBURDEN						1	87.84		
1.73						2	86.84		
		RC	1	100	81	3	85.84		
		RC	2	95	41	4	84.84		
BEDROCK: Good to fair quality, grey limestone, some shale partings		RC	3	100	58	5	83.84		
		RC	4	100	58	6	82.84		
- excellent to good quality by 7.5m depth		RC	5	100	100	7	81.84		
		RC	6	100	93	8	80.84		
		RC	7	100	81	9	79.84		
						10	78.84		
						11	77.84		
12.02						12	76.84		
End of Borehole									
(GWL @ 4.01m-Dec. 20, 2016)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5024849.7; Easting 347680.5

HOLE NO. BH 4A-16

BORINGS BY CME 55 Power Auger **DATE** November 18, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	89.34	20 40 60 80	
OVERBURDEN						1	88.34		
2.03						2	87.34		
		RC	1	100	88				
BEDROCK: Good to excellent qualtiy, grey limestone, some shale partings						3	86.34		
		RC	2	100	97	4	85.34		
		RC	3	95	90	5	84.34		
6.07						6	83.34		
End of Borehole									
(GWL @ 0.49m-Dec. 20, 2016)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5024849.7; Easting 347680.5

HOLE NO. BH 4B-16

BORINGS BY CME 55 Power Auger **DATE** November 16, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE						0	89.34		
OVERBURDEN						1	88.34		
						2	87.34		
2.26									
		RC	1	100	91	3	86.34		
		RC	2	100	97	4	85.34		
		RC	3	100	98	5	84.34		
		RC	4	100	100	6	83.34		
BEDROCK: Excellent qualtiy, grey limestone, some shale partings		RC	5	100	81	7	82.34		
		RC	6	100	88	8	81.34		
		RC	7	100	93	9	80.34		
						10	79.34		
						11	78.34		
12.19						12	77.34		
End of Borehole (MW blocked at 0.35m depth - Dec. 20, 2016)									

Pen. Resist. Blows/0.3m: 20 40 60 80

Water Content %: 20 40 60 80

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

REMARKS Northing 5024538.9; Easting 348324.3

HOLE NO. BH 5A-16

BORINGS BY CME 55 Power Auger **DATE** November 21, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	84.22
OVERBURDEN							
0.76							
		RC	1	100	75	1	83.22
		RC	2	100	85	2	82.22
BEDROCK: Good to excellent quality, grey limestone, some shale partings		RC	3	100	81	3	81.22
		RC	4	97	95	4	80.22
						5	79.22
6.10						6	78.22
End of Borehole							
(GWL @ 0.54m-Dec. 20, 2016)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone
○ Water Content %
20 40 60 80

Monitoring Well Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

FILE NO. PG3975

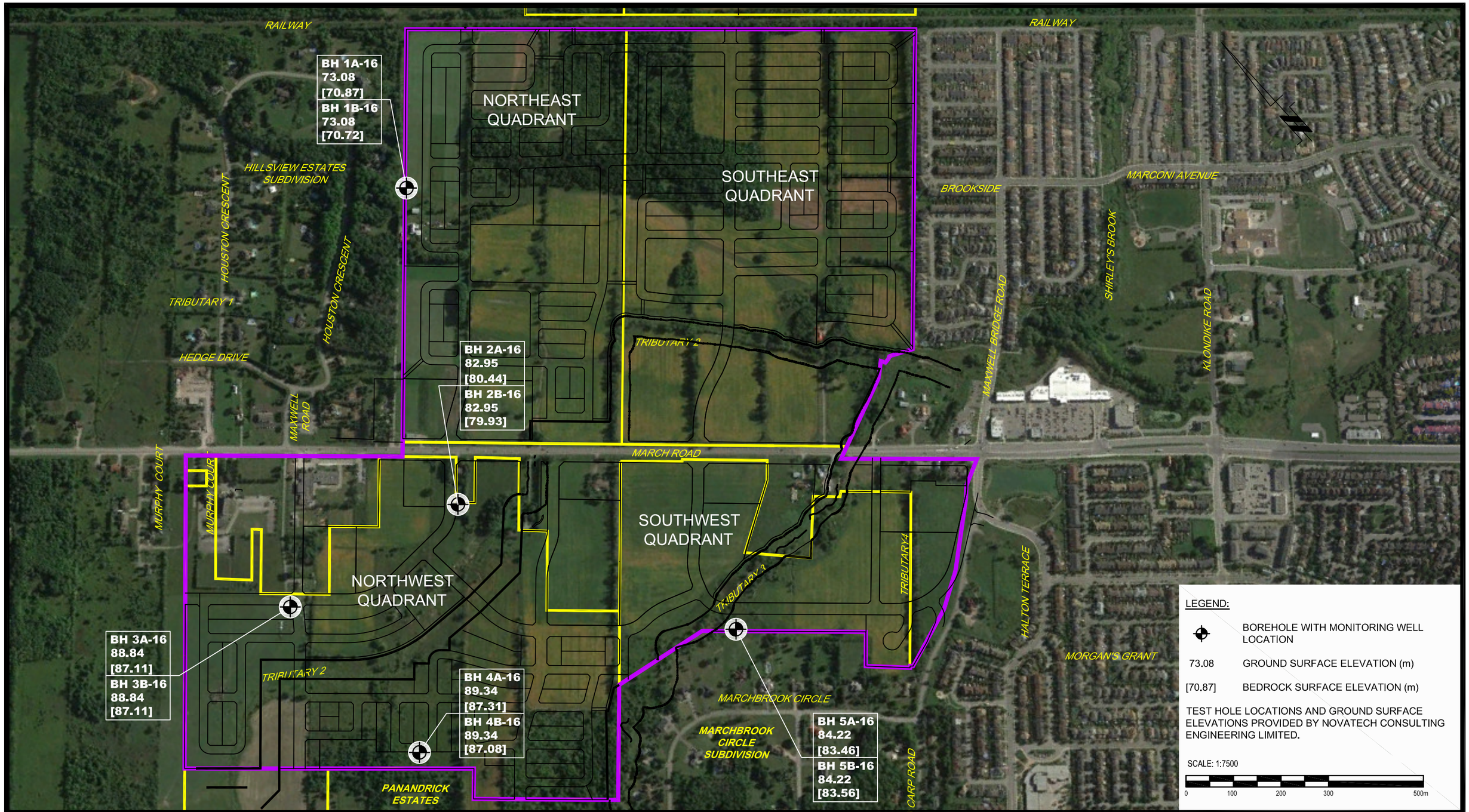
REMARKS Northing 5024538.9; Easting 348324.3

HOLE NO. BH 5B-16

BORINGS BY CME 55 Power Auger **DATE** November 21, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Monitoring Well Construction
GROUND SURFACE									
OVERBURDEN						0	84.22		
0.66									
		RC	1	100	71	1	83.22		
		RC	2	100	95	2	82.22		
		RC	3	100	100	3	81.22		
		RC	4	100	97	4	80.22		
BEDROCK: Fair to excellent quality, grey limestone,some shale partings		RC	5	100	100	5	79.22		
		RC	6	100	95	6	78.22		
		RC	7	100	97	7	77.22		
		RC	8	100	98	8	76.22		
						9	75.22		
						10	74.22		
						11	73.22		
12.02						12	72.22		
End of Borehole (MW blocked at 0.60m depth - Dec. 20, 2016)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded



LEGEND:

⊕	BOREHOLE WITH MONITORING WELL LOCATION
73.08	GROUND SURFACE ELEVATION (m)
[70.87]	BEDROCK SURFACE ELEVATION (m)

TEST HOLE LOCATIONS AND GROUND SURFACE ELEVATIONS PROVIDED BY NOVATECH CONSULTING ENGINEERING LIMITED.

SCALE: 1:7500

0 100 200 300 500m

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL
0			

NOVATECH CONSULTING ENGINEERING LIMITED

SENTINEL MONITORING WELLS
KANATA NORTH COMMUNITY DESIGN PLAN

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:7500	Date: 01/2017
Drawn by: MPG	Report No.: PG3975-1
Checked by: MK	Dwg. No.: PG3975-1
Approved by: MK	Revision No.: 0

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