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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 - Seasona	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								

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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.

Attachments

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

Michael S. Killam, P.Eng.



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Report: PG3975-1



Report: PG3975-1



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154 Colonnade Road South, Ottawa, Ont	ario k	(2E 7J	Eng	ineers	S K O	entinel Mo anata Nor ttawa, Or	onitoring th Comn ntario	Wells nunity Design Plan				
DATUM Ground surface elevations	prov	ided b	y No	vatech	Con	sulting Er	gineering	g Ltd. FILE NO.				
REMARKS Northing 5025679.5; Eastin	ng 34	8531.	2					HOLE NO.				
BORINGS BY CME 55 Power Auger	1			D	ATE	Novembe	er 15, 201	17 BH 1A-16				
SOIL DESCRIPTION	타 SAMPLE					DEPTH	ELEV.	Pen. Resist. Blows/0.3m=● 50 mm Dia. Cone≥				
GROUND SUBFACE	STRATA	ТҮРЕ	TYPE NUMBER © ECOVERY N VALUE				○ Water Content %					
						- 0-	-73.08					
OVERBURDEN						1-	-72.08					
2.21						2-	-71.08					
		RC _	1	100	85	3-	-70.08					
BEDROCK: Good to poor quality,		RC	2	100	40	4-	-69.08					
groy innostone, some shale partings		- RC	3	100	45	5-	-68.08					
End of Borehole						6-	-67.08					
(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, Or	ntario k	(2E 7J	Eng	ineers	Se Ka O	entinel Mo anata Nor ttawa, Or	onitoring th Comr ntario	l Wells nunity Design Plan			
DATUM Ground surface elevation	s provi	ided b	y No	vatech	Con	sulting Er	ngineerin	g Ltd. FILE NO.			
REMARKS Northing 5025679.5; East	ting 34	8531.	2					HOLE NO			
BORINGS BY CME 55 Power Auger				D	ATE	Novembe	er 15, 20 ⁻	17 BH 1B-16			
SOIL DESCRIPTION	гот		SAN	IPLE		DEPTH	ELEV.	Pen. Resist. Blows/0.3m			
SOIL DESCRIPTION	ATA P	ЪE	BER	VERY	ALUE ROD	୍ରି (m) (m) ଚୁନ୍ଦୁ					
GROUND SURFACE	STR	ΤТ	MUN	RECO	N VI OL		72.00	20 40 60 80 ¥C			
						- 0-	-73.08				
OVERBURDEN						1-	-72.08				
2.3	6					2-	-71.08				
		RC -	1	100	75	3-	-70.08				
		RC	2	100	40	4-	-69.08				
						5-	-68.08				
		RC	3	100	60	6-	-67.08				
BEDROCK: Fair to excellent quality,		RC	4	100	95	7-	-66.08				
grey limestone, some shale partings		_				,	00.00				
		RC	5	100	66	8-	-65.08				
		_				9-	-64.08				
		RC	6	100	86	10-	-63.08				
		RC	7	100	100	11-	-62.08				
End of Borehole12.02	2					12-	-61.08				
(GVVL @ 0.70m-Dec. 20, 2016)								20 40 60 80 100 Shear Strength (kPa) ▲ Undisturbed △ Remoulded			

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154 Colonnade Road South, Ottawa, Ont	tario H	(2E 7J	Eng	ineers	S K C	Sentinel Monitoring Wells Kanata North Community Design Plan Ottawa, Ontario						
DATUM Ground surface elevations	prov	ided b	y No	vatech	Cor	sulting Er	ngineerin	g Ltd.	FILE NO.	00075		
REMARKS Northing 5025146.3; Easti	ng 34	8117.	8					-		G3975		
BORINGS BY CME 55 Power Auger				DA	ATE	Novembe	er 16, 20 ⁻	17	B	H 2A-16	;	
SOIL DESCRIPTION	LOT		SAN	IPLE		DEPTH ELEV.		Pen. Res	/0.3m	Well n		
	LA P	M	R	ΞRΥ	Ba	(m)	(m)	• 50			ring ⁻ uctio	
GROUND SURFACE	STRA	ІЛТРІ	NUMBI	RECOVI	N VAL or R(0 Wa	ater Conten 40 60	t %	Monito Constri	
						- 0-	-82.95					
OVERBURDEN						1-	-81.95					
2.51						2-	-80.95				<u>րդդորդի</u>	
		RC	1	100	47	3-	-79.95				<u>լինինինը</u>	
BEDROCK: Poor to fair quality, grey limestone, some shale partings		RC	2	100	80	4-	-78.95					
		RC	3	100	69	5-	-77.95					
6.07		_				6-	76.95					
(GWI @ 0.98m-Dec. 20.2016)												
(GWL @ 0.0011 Dec. 20, 2010)								20	40 60	80 10	00	
								Shear ▲ Undistur	Strength (I	(Pa) noulded		

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			Eng	ineers	S	Sentinel Monitoring Wells Kanata North Community Design Plan							
154 Colonnade Road South, Ottawa, On		(2E /J	5	(ataab	0	Ottawa, Ontario							
DATUM Ground surface elevations	s prov		0 INON	alech	Con	sulling Er	igineerin						
REMARKS INOILINING 5025140.3, Easu	ng 34	0117.	0	D		Novombo	vr 16 201	HOLE NO. BH 2B-16					
BURINGS BY CIVIL 33 FOWER Auger			SAN		AIE		110,20	Pon Posist Ployo/0.2m —					
SOIL DESCRIPTION	A PLOI		SAIV «		Но	DEPTH (m)	EPTH ELEV. (m) (m)	● 50 mm Dia. Cone					
	STRAT	TYPE NUMBER % ECOVER			N VALU or RQI			○ Water Content %					
						- 0-	82.95						
						1-	-81.95						
OVERBURDEN						2-	-80.95						
3.02		=RC	1	100		3-	-79.95						
		RC	2	100	67	4-	-78.95						
		_ RC	3	100	66	5-	-77.95						
						6-	-76.95						
BEDROCK: Fair to excellent quality, grey limestone, some shale partings		RC	4	100	61	7-	-75.95						
		RC	5	100	93	8-	-74.95						
						9-	-73.95						
		RC	6	100	95	10-	-72.95						
		RC	7	100	90	11-	-71.95						
End of Borehole <u>12.17</u>						12-	-70.95						
(20 40 60 80 100 Shear Strength (kPa) ▲ Undisturbed △ Remoulded					

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154 Colonnade Road South, Ottawa, Ont	ario k	(2E 7J	Eng	ineers	S K C	Sentinel Mo Canata Noi Ottawa, Or	onitoring rth Comn ntario	Wells nunity Des	ign Plan				
DATUM Ground surface elevations	prov	ided b	y Nov	vatech	Cor	nsulting Er	ngineerin	g Ltd.	FILE NO.	DC 2075	,		
REMARKS Northing 5025257.5; Eastin	ng 34	7719.	.2							PG3975)		
BORINGS BY CME 55 Power Auger				D	ATE	Novembe	er 18, 201	7		^{^{′′} BH 3A-1}	6		
SOIL DESCRIPTION	PLOT		SAN	IPLE		DEPTH	ELEV.	Pen. Re ● 50	esist. Blo 0 mm Dia	Well			
	RATA I	(PE	(BER	°° SVERY	ALUE	(m)	(m)		/ater Cor	/ater Content %			
GROUND SURFACE	STI	E	NUN	REC	N C	х о 0-	-88 84	20	40 6	io 80	Mon Con		
							00.04				<u>իրիրի</u> դերել		
OVERBURDEN						1.	-87.84		· · · · · · · · · · · · · · · · · · ·				
<u>1.73</u>			4	100	67	2-	-86.84						
		-		100	07	3-	-85.84						
		RC	2	100	86		04.04				10000000000000000000000000000000000000		
BEDROCK: Fair to good qualtiy, grey limestone, some shale partings						4-	-04.04			· · · · · · · · · · · · · · · · · · ·			
		RC	3	100	68	5-	-83.84						
6.02 End of Borehole						6-	-82.84						
(GWL @ 3.27m-Dec. 20, 2016)													
								20 Shea ▲ Undistr	40 6 ar Streng urbed △	60 80 1 th (kPa) Remoulded	⊣ 00		

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154 Colonnade Road South, Ottawa, On	tario ł	K2E 7J	Eng	ineers	Se Ka Ot	entinel Mo anata Noi ttawa, Oi	onitoring rth Comn ntario	g Wells munity Design Plan					
DATUM Ground surface elevations	prov	ided b	y No	vatech	Con	sulting Er	ngineerin	ng Ltd. FILE NO.					
REMARKS Northing 5025257.5; Easti	ng 34	17719.	2					HOLE NO					
BORINGS BY CME 55 Power Auger				D	ATE	Novembe	er 18, 20 ⁻	17 BH 3B-16					
SOIL DESCRIPTION	LOT		SAN	/IPLE		DEPTH	ELEV.	Pen. Resist. Blows/0.3m $=$ 50 mm Dia. Cone					
GROUND SURFACE	STRATA I	ТҮРЕ	NUMBER	% RECOVERY	N VALUE or RQD	(m)	(m)	O Water Content % 0 20 40 60 80 V					
						- 0-	-88.84						
OVERBURDEN						1-	-87.84						
1.13		RC	1	100	81	2-	-86.84						
		-				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						
			4	100	50	6-	-82.84						
- excellent to good quality by 7.5m			4	100	28	7-	-81.84						
depth		RC	5	100	100	8-	-80.84						
		- BC	6	100	93	9-	-79.84						
		_				10-	-78.84						
10.00		RC	7	100	81	11-	-77.84						
End of Borehole (GWL @ 4.01m-Dec. 20, 2016)						12-	+76.84						
								20 40 60 80 100 Shear Strength (kPa) ▲ Undisturbed △ Remoulded					

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154 Colonnade Road South, Ottawa, Or	ntario k	(2E 7J	Eng	gineers	So Ka O	entinel Mo anata Noi ttawa, Oi	onitoring rth Comr ntario	g Wells nunity Design Plan				
DATUM Ground surface elevation	s prov	ided b	by No	vatech	Con	sulting Er	ngineerin	ig Ltd. FILE NO.				
REMARKS Northing 5024849.7; East	ting 34	7680.	.5					HOLE NO				
BORINGS BY CME 55 Power Auger				D	ATE	Novembe	er 18, 20 [°]	17 BH 4A-16				
SOIL DESCRIPTION	LOT		SAI	MPLE		DEPTH ELEV.	ELEV.	Pen. Resist. Blows/0.3m $=$ 50 mm Dia Cone				
	RATA P	VATA P) (PE (BER % VERY NTTE				(m)	(m)	• Water Content %				
GROUND SURFACE	STI	Ţ.	NUN	RECO	N OR N	0-	-80.34	20 40 60 80 Z C				
							09.04					
OVERBURDEN						1-	-88.34					
2.0	3					2-	-87.34					
		RC	1	100	88							
BEDROCK: Good to excellent quality, grey limestone, some shale						3-	+86.34					
partings		RC	2	100	97	4-	-85.34					
		RC	3	95	90	5-	-84.34					
6.0	$7^{\frac{1}{1}\frac{1}{1}\frac{1}{1}\frac{1}{1}}_{\frac{1}{1}\frac{1}{1}\frac{1}{1}}$					6-	-83.34					
(GWI @ 0.49m-Dec. 20. 2016)												
(GWL @ 0.4011 Dec. 20, 2010)												
								20 40 60 80 100 Shear Strength (kPa) ▲ Undisturbed △ Remoulded				

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154 Colonnade Road South, Ottawa, On	tario ł	(2E 7J	Se Ka	Sentinel Monitoring Wells Kanata North Community Design Plan Ottawa, Ontario							
DATUM Ground surface elevations	s prov	ided b	y No	vatech	Con	sulting Er	gineerin	g Ltd. FILE NO.			
REMARKS Northing 5024849.7; Easti	ing 34	7680.	5					PG3975			
BORINGS BY CME 55 Power Auger				D	ATE	Novembe	er 16, 20 ⁻	17 BH 4B-16			
	LOT		SAN	IPLE		DEPTH	ELEV.	Pen. Resist. Blows/0.3m			
SOIL DESCRIPTION	ATA P	Э.Е.	BER	ÆRY	LUE	(m)	(m)				
GROUND SURFACE	STRI	алт	INUME	RECOV	N VA of F	or		○ Water Content % 11 ts 20 40 60 80 ≥0			
						- 0-	-89.34				
OVERBURDEN						1-	-88.34				
OVERBORDEN											
2.26)	-				2-	-87.34				
		RC	1	100	91	3-	-86.34				
		RC	2	100	97		95.24				
						4	-05.54				
		RC	3	100	98	5-	-84.34				
						6-	-83.34				
BEDROCK: Excellent quality, grey		RC	4	100	100	7-	-82.34				
limestone, some shale partings		_				8-	-81 3/				
		RC	5	100	81		01.04				
		_				9-	-80.34				
		RC	6	100	88	10-	-79.34				
						11-	-78.34				
10 10		RC	7	100	93	12-	-77.34				
End of Borehole (MW blocked at 0.35m depth - Dec. 20, 2016)											
-,,								20 40 60 80 100 Shear Strength (kPa) ▲ Undisturbed △ Remoulded			

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154 Colonnade Road South, Ottawa, Ont	tario k	/ 1 (2E 7J	Eng 5	ineers	́S К О	entinel Mo anata Nor ttawa, Or	onitoring th Comn ntario	y Wells nunity Des	sign Plar	1	
DATUM Ground surface elevations	prov	ided b	y Nov	vatech	Con	sulting Er	gineerin	g Ltd.	FILE NC	DC2075	
REMARKS Northing 5024538.9; Easti	ng 34	8324.	3							- FG3973	
BORINGS BY CME 55 Power Auger				DA	ATE	Novembe	er 21, 201	17		^{••} BH 5A-1	6
SOIL DESCRIPTION	PLOT		SAN	/IPLE		DEPTH	ELEV.	Pen. R ● 5	esist. B 0 mm Di	lows/0.3m a. Cone	Nell on
	[RATA	LYPE	JMBER	°° SOVERY	VALUE ROD	(11)	(11)	• V	Vater Co	ntent %	nitoring
GROUND SURFACE	S.		N	REC	zö	0	04.00	20	40	60 80	CON
OVERBURDEN						_ 0-	-84.22				<u>IIIIIII</u> IIIIIIIIIIII
		RC	1	100	75	1-	-83.22				
		RC	2	100	85	2-	-82.22				<u>իդիդիդի</u> Սդիդիդիդի
BEDROCK: Good to excellent						3-	-81.22				
quality, grey limestone, some shale partings		RC	3	100	81	4-	-80.22				
		RC	4	97	95	5-	-79.22				
End of Borehole						6-	-78.22				
(GWL @ 0.54m-Dec. 20, 2016)											
								20	40	60 80 1	00
								Shea	ar Streng turbed 2	jth (kPa) ∆ Remoulded	-

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154 Colonnade Road South, Ottawa, Oni	tario ł	(2E 7J	Eng 5	ineers	S K C	Sentinel Monitoring Wells Kanata North Community Design Plan Ottawa, Ontario								
DATUM Ground surface elevations	prov	ided b	y Nov	/atech	Cor	sulting Er	ngineerin	g Ltd.	FILE NO). DC207	F			
REMARKS Northing 5024538.9; Easti	ng 34	8324.	3							PG39/3	2			
BORINGS BY CME 55 Power Auger				D	ATE	Novembe	er 21, 20 [.]	17		BH 5B-	16			
SOIL DESCRIPTION	PLOT		SAN	IPLE			ELEV.	Pen. R	. Resist. Blows/0.3m					
	STRATA	TYPE AUMBER % COVERY VALUE				(11)	(11)	• Water Content %			 onitoring onstructi			
GROUND SURFACE			-	8	Z *	- 0-	-84.22	20	40	60 80				
OVERBURDEN 0.66														
		RC	1	100	71	1-	-83.22							
		RC	2	100	95	2-	-82.22							
						3-	-81.22							
		RC	3	100	100	4-	-80.22							
		_ RC	4	100	97	5-	-79.22							
BEDROCK: Fair to excellent quality, grey limestone.some shale partings		_				6-	-78.22							
		RC	5	100	100	7-	-77.22							
		RC	6	100	95	8-	-76.22							
						9-	-75.22							
		RC	7	100	97	10-	-74.22							
		_ RC	8	100	98	11-	-73.22							
End of Borehole (MW blocked at 0.60m depth - Dec. 20, 2016)						12-	-72.22							
								20 She ▲ Undis	40 ar Stren turbed	60 80 gth (kPa) △ Remoulded	100			



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

No.	0 100	200	300	500m
	Scale:		Date:	
		1:7500	01/2017	
	Drawn by:		Report No.:	
		MPG	PC	G3975-1
)	Checked by:		Dwg. No.:	
		MK	DC30	75_1
	Approved by:		FG3973-1	
		МК	Revision No.:	0

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