



Arnott Brothers Construction Ltd.
36 Highway 511
Perth ON K7H 3C9
Attention: Mike Crain

January 7, 2025

**RE: RESPONSE TO ISSUES, PROPOSED BELOW WATER EXPANSION, MCKINNON PIT
TOWNSHIP OF LANARK HIGHLANDS, LANARK COUNTY**

Dear Mike;

We have reviewed the comments that apply to the geological and hydrogeological study from Ministry of Natural Resources and Forestry (MNRF), Ministry of Northern Development and Mines (MNDM) and Mississippi Valley Conservation Authority (MVCA) and prepared a response.

1 COMMENTS

The comments and a summary of the response as well as location where detailed information is found are in OS Table 1. The questions and comments were organized by topic.

The additional information is provided below.

2 URANIUM

To address the comments about the presence and safety of radioactivity at the site, a gamma-ray spectrometric survey was completed. The results showed that uranium concentrations were nominal, present throughout the pit and around the site in levels that are background and are comparable to or less than concentrations measured at other locations in the region.

2.1 Study Method

On October 27 and November 6, 2023, a Ludlum Model 3 Survey meter with a 44-9 G-M detector meter was used to measure the emission of gamma particles calibrated to uranium at 64 points within the pit, along the pit faces, around the product stockpiles, around the site boundaries and at 11 regional points between the site and the City of Ottawa.

2.2 Results

The most sensitive Ludlum scale factor of 0.1 was used and the counts that were measured barely registered at any point on the site. The results shown in Table 1 and shown in OS Figure 1.



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Table 1: Gamma Ray Survey Results, Site and Surrounding Area

Map Point	CPM*	mR**/hr value	Sv/yr	Location/ Comment
Along pit faces				
1	40	0.013	1.140E-03	east side of pit
2	20	0.009	7.889E-04	base of pit face
3	40	0.015	1.315E-03	base of pit face
4	60	0.020	1.753E-03	base of pit face
5	40	0.015	1.315E-03	base of pit face
6	40	0.015	1.315E-03	base of pit face
7	50	0.020	1.753E-03	base of pit face
8	120	0.038	3.331E-03	low spot on pit floor
9	60	0.020	1.753E-03	base of pit face
10	100	0.031	2.717E-03	base of pit face
11	60	0.020	1.753E-03	base of pit face
12	60	0.020	1.753E-03	base of pit face
13	90	0.030	2.630E-03	base of pit face
14	40	0.015	1.315E-03	base of pit face
15	80	0.025	2.191E-03	base of pit face
16	60	0.020	1.753E-03	base of pit face
17	40	0.015	1.315E-03	base of pit face
18	50	0.020	1.753E-03	base of pit face
19	40	0.015	1.315E-03	base of pit face
20	80	0.025	2.191E-03	base of pit face
21	100	0.031	2.717E-03	base of pit face
22	120	0.038	3.331E-03	topsoil pile
23	100	0.031	2.717E-03	base of pit face
24	140	0.042	3.682E-03	face on 2nd ridge
25	60	0.020	1.753E-03	face on 2nd ridge
26	80	0.025	2.191E-03	face on 2nd ridge
27	80	0.025	2.191E-03	face on 2nd ridge
28	100	0.031	2.717E-03	face on 2nd ridge
29	120	0.038	3.331E-03	face on 2nd ridge
30	120	0.025	2.191E-03	face on 2nd ridge
31	120	0.025	2.191E-03	face on 2nd ridge
32	60	0.020	1.753E-03	face on 2nd ridge
Stockpiles				
33	80	0.025	2.191E-03	sand
34	200	0.060	5.259E-03	topsoil pile
35	80	0.025	2.191E-03	pea gravel
36	80	0.025	2.191E-03	sand
37	140	0.042	3.682E-03	cobble pile



Map Point	CPM*	mR**/hr value	Sv/yr	Location/ Comment
38	80	0.025	2.191E-03	sand
39	90	0.030	2.630E-03	cobble pile
40	100	0.031	2.717E-03	sand
41	80	0.025	2.191E-03	boulders
42	80	0.025	2.191E-03	sand
43	100	0.031	2.717E-03	sand
44	80	0.025	2.191E-03	wood chips
46	60	0.020	1.753E-03	rehabilitated area
Pit and Nearby Surrounding Locations				
45	60	0.020	1.753E-03	TW10
47	100	0.031	2.717E-03	TW2
48	60	0.020	1.753E-03	TW9
49	120	0.038	3.331E-03	undisturbed area
50	60	0.020	1.753E-03	TW6
51	60	0.020	1.753E-03	TW5
52	80	0.025	2.191E-03	TW8
53	80	0.025	2.191E-03	top of hill
54	120	0.038	3.331E-03	top of hill
55	80	0.025	2.191E-03	TW1
56	80	0.025	2.191E-03	TW4
57	80	0.025	2.191E-03	height of land
58	100	0.031	2.717E-03	TW7
59	70	0.022	1.928E-03	property line
60	70	0.022	1.928E-03	rental driveway
61	80	0.025	2.191E-03	wheeler driveway
62	80	0.025	2.191E-03	flats
63	120	0.038	3.331E-03	flats
64	80	0.025	2.191E-03	TW3

The readings are within the concentration that would be considered background. They are similar to the measurements taken at other locations in Lanark and within the City of Ottawa (Table 2, and inset OS Figure 1). The survey shows the aggregate resource on the site does not contain anomalous concentrations of radioactive material. The site is a pit, which will extract granular material. The application will not excavate or process bedrock and will therefore, the operation will not disturb the current bedrock.

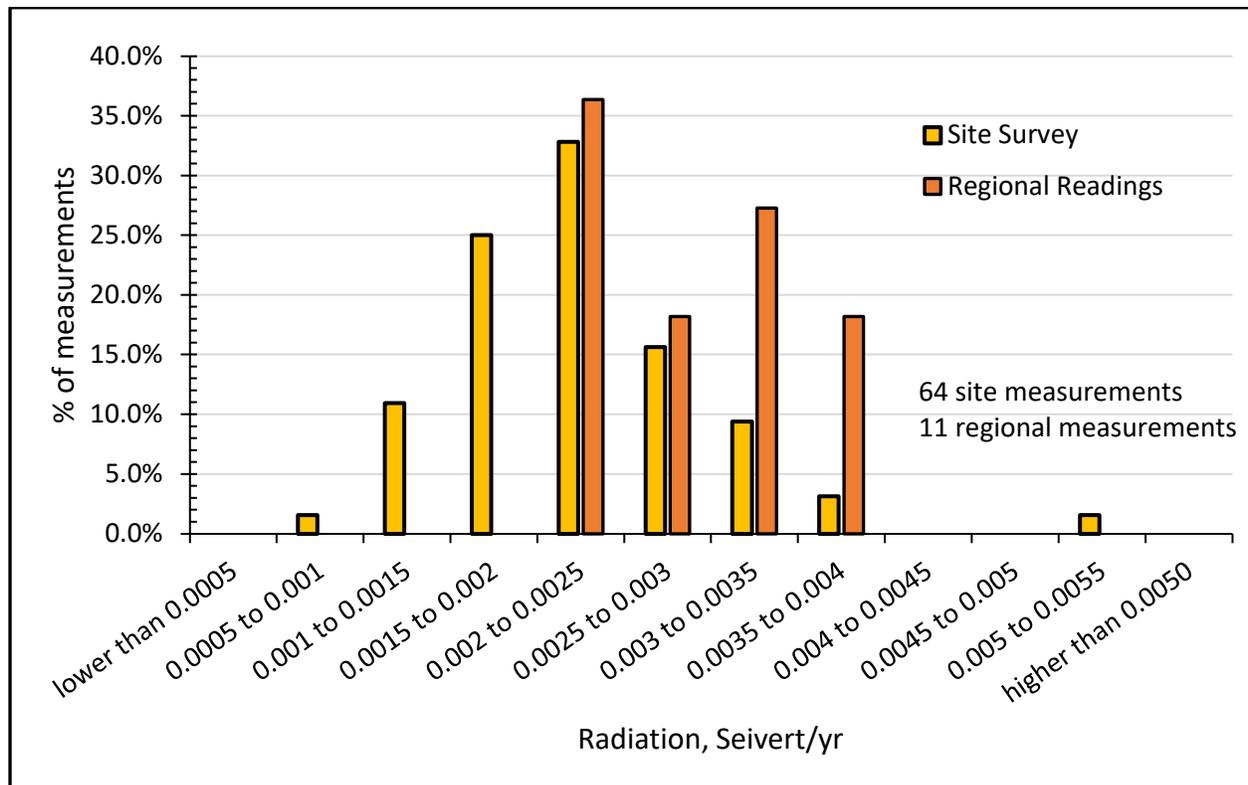
The results of the survey confirm that the aggregate is safe, and there are no concerns of uranium exposure to those attending or working at the site.



Table 2: Comparison Readings at Various Locations

Easting	Northing	CPM* Value	mR/hr** value	Sv/yr	Comment
444658	5021248	125	0.040	3.506E-03	Merivale/Hunt Club area
435973	5017344	80	0.025	2.191E-03	Moodie/ Hunt Club
457542	4973578	80	0.025	2.191E-03	Hope Side Road
415451	5016730	100	0.031	2.717E-03	March Road
415298	5012541	100	0.031	2.717E-03	Burnt Lands
421732	5027274	140	0.042	3.682E-03	Almonte
394816	4496027	80	0.025	2.191E-03	Rosetta Road
394986	4989750	120	0.038	3.331E-03	Lanark Pit
391219	4983749	120	0.038	3.331E-03	West of Lanark Village
411732	4971548	80	0.025	2.191E-03	Station Road
445454	4973128	120	0.038	3.331E-03	Oxford Mills

Figure 1: Analysis of Radiation, Radiation, Sieverts per year (Sv/yr)



3 WATER BALANCE

The Level 1 and Level 2 study (GRI Inc., 2023) provided information on the annual water budget or water balance for the site. However, the specific monthly details were not provided. These details may be found in Appendix A in tables OS Table 2 to OS Table 7. The analysis compared the 1981-2000 Normal data from Environment Canada using the Drummond Centre site, as well as the period around the time of the study (1917 to 2021) to calculate a 5-year average.

This was done to compare the current conditions to Normal, and to facilitate interpretation of groundwater patterns and allow prediction of future impacts. OS Table 2 and OS Table 3, found in Appendix A provide the details on the data used in the GRI (2023) report analysis, presented as monthly and annual water surplus.

To summarize, Normal and daily climate records were taken from the Drummond Climate Station, located approximately 19 km northeast of the site in an area of comparable physiology. The Thornthwaite Method was used to evaluate evaporation (Thornthwaite, 1948). The water surplus was calculated from these components.

In GRI (2023), the infiltration and runoff estimates were based on site data and followed the infiltration factor method using MECP criteria (Ministry of Environment and Energy, 1995). The components of the infiltration factor were a slope factor of 0.1, a soil factor for the site of 0.4 and a vegetation factor of 0.12 for a resultant infiltration factor of 0.62. These were the average conditions over the site, which is appropriate for the method and level of accuracy for the overall analysis. For this additional information, the infiltration factor was refined using a weighted average of the conditions at the two geological units found on the site. The revisions are found in Table 5. The results of the analysis, described below, found the current and post-development water budgets will change very little.

For comparison, the Environment Canada Engineering Climate Services water budget was used. This analysis used daily data from 1985 to 2021 and a modified method based on the methodology of Thornthwaite and Mather (1955) with Canada specific modifications (Johnstone & Louie, 1983). The complete data sheet is found in Appendix A and is summarized in OS Table 4.

Next, the long-term water budget was estimated for the decades of “2020s” and “2050s”, using the predictive model prepared for the Missississipi Watershed (Kunjikutty, 2015). The predicted percent changes in precipitation and temperature found in the report Table 3-7 were accepted as presented. These data were applied to the baseline monthly data in the report to calculate monthly potential evaporation and resultant water surplus. The potential evaporation calculation used Thornthwaite (Thornthwaite, 1948) and assumed that the empirical factors used in the formula will not change in the future. The results are summarized in OS Table 6 and OS Table 7.

Table 3: Drummond Centre Climate Station ID and Location

Climate Station	Drummond Centre
Climate ID	6102j13
Latitude	45°01'56.082" N
Longitude	76°15'10.098" W
Elevation	145.00 m

3.1 Comparison of Water Budgets

The monthly and annual water surplus calculated or predicted from the three methods are compared, along with the data for 2022, in Table 4 and illustrated on Figure 2. Appendix B contains the annual water budgets for each of the assessed methods.

Table 4: Summary of Results and Range, Water Surplus Analysis

	1981-2000 Normal	'17 -'21 5-year avg	1985-2021 EC Model*	2022	Predicted**		Range	
					2020s	2050s	Max	Min
January	67.7	73.7	42.0	65.6	74.9	81.9	81.9	42.0
February	51.3	66.8	43.0	93.0	64.1	65.9	93.0	43.0
March	55.1	64.5	101.0	66.0	64.1	69.2	101.0	55.1
April	32.5	81.4	65.0	64.2	39.6	39.0	81.4	32.5
May	-3.0	-5.2	10.0	12.1	-3.6	-5.0	12.1	-5.2
June	-33.7	-7.5	11.0	-3.1	-40.9	-49.6	11.0	-49.6
July	-51.0	-45.2	2.0	-65.5	-50.7	-62.9	2.0	-65.5
August	-41.3	-9.8	2.0	46.0	-42.6	-48.0	46.0	-48.0
September	18.1	10.8	5.0	-11.4	16.4	12.2	18.1	-11.4
October	43.7	83.7	18.0	4.4	37.6	39.9	83.7	4.4
November	78.1	64.7	49.0	63.8	74.4	80.3	80.3	49.0
December	65.9	72.4	42.0	104.8	90.5	96.3	104.8	42.0
Annual	283.4	450.0	390.0	439.9	323.8	319.1	450.0	283.4

* (Johnstone & Louie, 1983)

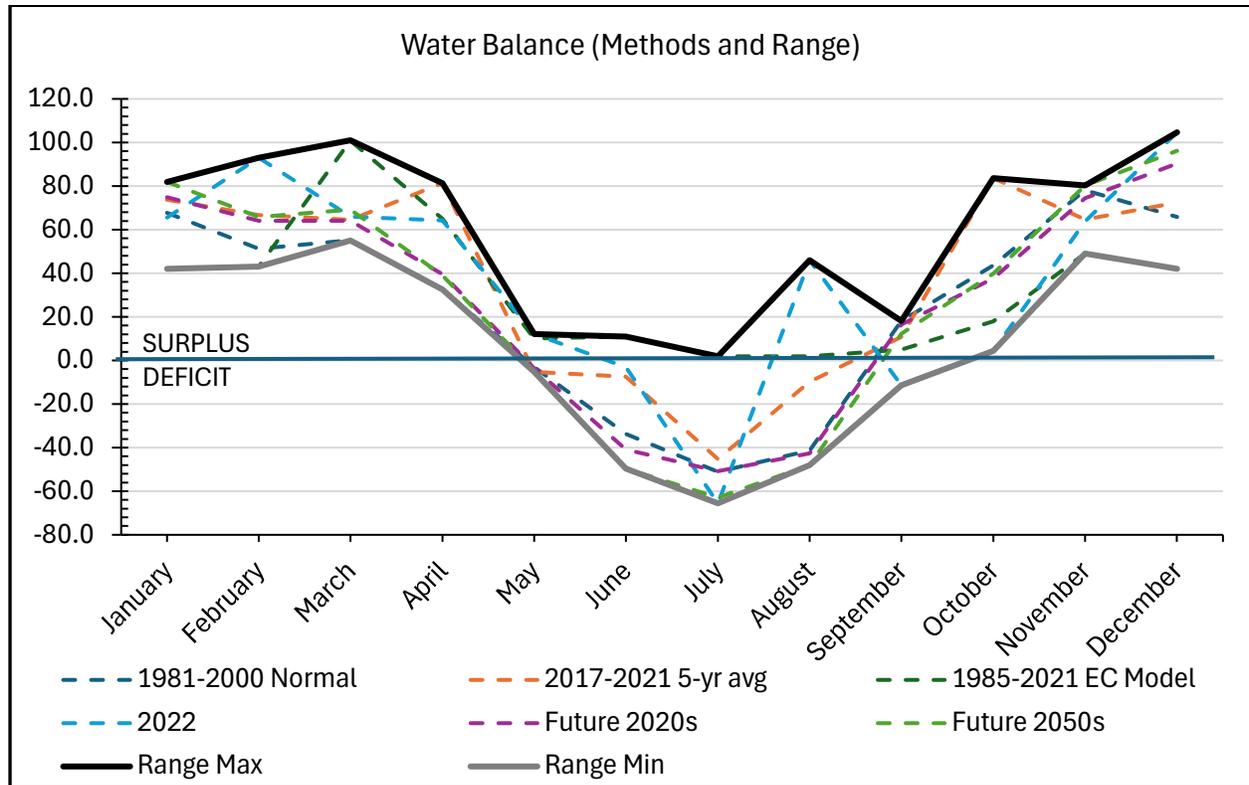
** (Kunjikutty, 2015)

The range of monthly and annual water surplus are also shown in Table 4 and on Figure 2. The monthly maximum and minimums were not consistent with any specific model, for example the greatest water deficit for July was measured in 2022. The maximum and minimum results were used to provide additional information on the range of site recharge and groundwater throughflow that might be expected on the site later in the site life. Therefore, a conservative analysis reveals that the projected water surplus at the site can be expected to vary between 283.4 mm and 479.9 mm annually. Under the maximum surplus scenario, there would be no water deficit, although the water surplus would approach balance in the months from May to July. The monthly deficit would not be less than what has been experienced at the site in the historic record (Figure 2).

There are small differences in the result between the method used in GRI Inc. (2023) and the Johnstone & Louie (1983) calculations. The differences in average precipitation, temperature and resultant water surplus are mainly due to the periods of data used. As noted, the 1981-2000 Normal, which is a standard set of data defined and used by the World Climatological Organization globally. If the 1991 – 2010 Normal data for the Drummond station had been released they might be more similar to the 5-year average data that were calculated and used for the impact assessment in GRI Inc., 2023. The 5-year average data were calculated so that the conditions being measured could be compared to real-time

climate data and short-term trends in order to assess the impact of the proposed operation. These results were higher than the 2020s predicted values in the MVCA model.

Figure 2: Monthly Water Balance (Methods and Range)



The calculated water surplus is distributed through a combination of infiltration and runoff. These components are determined by the geological and geographic conditions that have been identified and measured on the site. The impacts from the proposed operation can be estimated by comparing the changes in the balance between infiltration and runoff that will occur over the life of the operation.

The calculation for site recharge was reassessed using the differences that may result from the predicted water balance components. As with any model, the calculations should be considered an approximation. The calculations are based on the above predictions of a range of conditions for water balance that may occur.

First, the infiltration factor for current and post-development operations was calculated by assessing the infiltration factor components for each geological unit and then applying a weighted average (by unit area) to the catchment:

Table 5: Weighted Infiltration Factor

	Unit Area	IF	Weighted IF
Current Condition			
Till	146,000	0.5	0.72
granular	342,000	0.8	



Post -Development Condition			
till	146,000	0.5	0.47
granular	191,000	0.8	
Open water	151,000	N/A	N/A

In post-development, the area of the granular unit subject to infiltration or runoff will be decreased due to the below water excavation. However, the open water area will receive the undifferentiated water surplus. As such, the recharge under the present and post-development conditions will be distributed as follows:

Table 6: Range of Calculated Recharge from Water Balance Models

Case	Data Set	PPT	PE	Water Surplus	Weighted IF	Infiltration	Runoff	Catchment/ Infiltration Area	Infiltration	Runoff	Recharge	
			m/yr			m/yr		m ²		m ³ /yr		
Current Condition												
1	Normal*	0.876	0.593	0.283	0.72	0.204	0.079	488,941	100,000	39,000	139,000	
2	Maximum	1.054	0.604	0.446	0.72	0.321	0.125	488,941	157,000	61,000	218,000	
3	Minimum	0.876	0.593	0.283	0.72	0.204	0.079	488,000	100,000	39,000	139,000	
Post-Development Condition												
2	Maximum	1.054	0.604	0.446	0.47	0.210	0.237	337,000	71,000	80,000	150,000	
					Open Water			151,000	N/A	N/A	66,000	
											Total Recharge	216,000
3	Minimum	0.876	0.593	0.283	0.47	0.133	0.150	337,000	45,000	51,000	96,000	
					Open Water			151,000	N/A	N/A	96,000	
											Total Recharge	138,000

* From GRI (2023)

The range in estimated current recharge ranges from 139,000 m³/year, based on the climate Normal data, to 218,000 m³/yr which is comparable to the 5-year average analysis. This variation illustrates the natural variation that occurs. The quantities are average analyses, as the calculation cannot account for the many factors that affect the balance between infiltration and runoff.

Post-development, the infiltration over the area that has been extracted below water is reduced when the lake is created, but the water surplus that falls directly on the open water offsets the reduction. To be most conservative, the post-development calculations assumed there would be no infiltration on the lake floor. Under these assumptions, the recharge may be reduced by approximately 1%.

The assumption was made to assess the effect over time, where the floor may seal with fine sediment and organic matter. However, the throughflow of groundwater through the lake was calculated as being on the order of 470,000 m³/yr. Since the rate of sedimentation depends on particle size and flow velocity, the calculated throughflow suggests that sealing of the floor will take an extended period.



The calculations show that the water balance will change minimally from the below water excavation.

4 AQUIFERS AND GROUNDWATER FLOW DIRECTIONS

Ten additional monitoring points have been added to the monitoring network to help delineate the groundwater flow direction on the site. The locations of the monitors are shown on OS Figure 2 and are identified as TW1 to TW3 for the old and TW4 to TW13 for the new monitoring points. From the analysis of the intercepted sediment the sedimentological/physiographic setting the holes were drilled on 1) glaciofluvial assemblage/wetland and 2) Barber Lake bedrock upland.

4.1 Glaciofluvial Assemblage/Wetland

Eight monitoring points were added to the glaciofluvial assemblage (OS Figure 2). New monitoring wells in the deposit, TW5, TW6 and TW8 were drilled by Downing Drilling, Hawkesbury under the supervision of GRI staff on September 29, 2023. The intercepted sediment was logged and sampled, and a piezometer was installed in each well. The logs of the holes are attached as Appendix C. Water levels were measured five times, between November 11, 2023 and November 18, 2024.

Three monitoring points, TW8, TW9 and TW10 were added adjacent to the site at the edge of the wetland. These wells consist of stainless steel well points that were driven by hand 1.4 m below the ground surface. The intent of these installations was to gain monitoring points in the wetland where water levels and temperature readings could be obtained. Data loggers were installed in the sand points and were programmed to take three readings of water levels and temperature levels a day*.

Finally, three monitoring points, TW11, TW12 and TW13, were installed previously by the Arnott Bros. when the pit was first licensed. These were installed to make sure the pit floor remained at least 1 m above the water table (old ARA requirements).

4.2 Barbers Lake Bedrock Upland

The Barber's Lake Upland is located on the southwestern corner of the site. The upland abuts the glaciofluvial assemblage and rises from an approximate elevation of 200 mASL to a high of 220 mASL along Highland Line Road. The material in the upland consists of fine sand over a very dense till over the bedrock surface. East of TW1 the bedrock is exposed just north of the treed area and springs are present (OS Figure 2). The upland has a perched aquifer that is not directly connected to the glaciofluvial assemblage.

TW1 was installed at the contact between the glaciofluvial assemblage and the upland. To further refine the description and characterization of the upland unit, TW4 and TW7 were installed. TW4 was drilled by Downing Drilling under the supervision of GRI staff on September 29, 2023. TW7 is a sand point which was driven by hand 1.4 m into the ground at the top of the hill.

* 1 am, 9 am and 5 pm



4.3 Groundwater Conditions

Elevations were updated from GRI (2023) on May 2, 2024. Precision GNSS data (+/- 0.05 mASL) were collected using a Trimble DA2 receiver. The revised elevation of the monitoring wells is summarized in Table 7.

Table 7: Well Construction (Elevations updated per May 2024 survey)

Well ID	Surface	Total Extent of Drilling	Base Monitoring Well	Base of Screen	Top of Screen	Top of Sand Pack
Elevation (mASL)						
TW 1	202.0	193.14	193.14	194.28	197.38	200.96
TW 2	190.7	172.5	181.91	181.91	185.01	189.80
TW 3	191.9	173.6	182.75	182.75	185.85	190.91
TW 4	207.1	201.51	201.51	201.51	204.61	206.17
TW 5	197.9	186.64	186.64	186.64	186.64	196.92
TW 6	193.1	186.20	186.20	186.20	186.20	192.12
TW7	217.3	215.81	215.81	215.81	217.10	215.63
TW 8	189.9	188.07	188.07	188.07	189.37	N/A
TW 9	189.5	187.63	187.63	187.63	188.92	N/A
TW 10	189.1	187.31	187.31	187.31	188.61	N/A
TW 11	190.3	188.68	188.68	190.25	190.25	N/A
TW 12	190.8	189.16	189.16	190.81	190.81	N/A
TW 13	190.1	188.21	188.21	190.12	190.12	N/A

Key:

	Granular aquifer, pit		Granular aquifer, wetland		Upland perched aquifer
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As discussed in GRI (2023), there were two unconfined aquifers identified on the site, a perched aquifer in the Barbers Lake Upland (upland perched aquifer) and the glaciofluvial assemblage (granular aquifer). The manual water level measurements are summarized in Table 8.

The groundwater elevations for all the site wells are plotted on Figure 3. The groundwater elevations show the nearly 10 m to 15 m separation between the elevation of the perched aquifer and the main granular aquifer. The aquifer character is very different. The perched aquifer has a steep gradient that conforms to the topography of the bedrock, whereas the groundwater elevation in the granular aquifer has a very small variation. Figure 5 narrows into the elevation range of the granular aquifer groundwater levels so the variation in the monitors can be seen more clearly.

Table 8: Groundwater Elevation, mASL

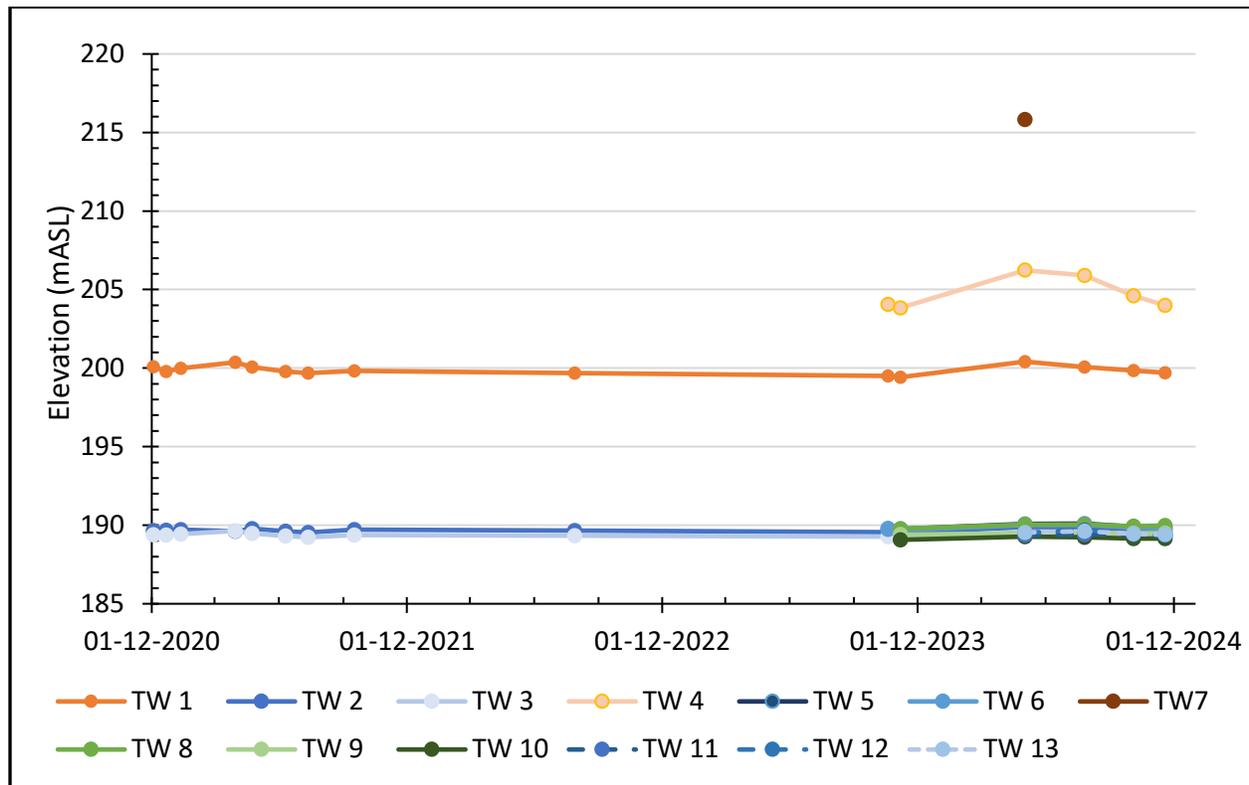
Date	03-12-2020	21-12-2020	11-01-2021	30-03-2021	23-04-2021	10-06-2021	12-07-2021	16-09-2021
TW 1	200.09	199.79	199.99	200.37	200.07	199.78	199.68	199.82
TW 2	189.66	189.68	189.72	189.62	189.77	189.62	189.52	189.72
TW 3	189.38	189.37	189.43	189.64	189.47	189.30	189.23	189.38
TW 4	<-----Wells not installed----->							



Date	03-12-2020	21-12-2020	11-01-2021	30-03-2021	23-04-2021	10-06-2021	12-07-2021	16-09-2021
TW 5	<-----Wells not installed----->							
TW 6								
TW 7								
TW 8								
TW 9								
TW 10								
TW 11								
TW 12								
TW 13								
Date	28-07-2022	19-10-2023	06-11-2023	02-05-2024	26-07-2024	04-10-2024	18-11-2024	
TW 1	199.68	199.49	199.43	200.42	200.07	199.84	199.70	
TW 2	189.66	189.55	189.52	189.88	189.88	189.68	189.62	
TW 3	189.32	189.27	189.23	189.56	189.56	189.41	189.34	
TW 4		204.05	203.84	206.24	205.90	204.61	203.99	
TW 5		189.80	189.77	190.08	190.10	189.90	189.85	
TW 6		189.73	189.69	190.00	190.04	189.83	189.78	
TW 7				215.82	DRY	DRY		
TW 8			189.79	190.04	190.05	189.93	189.98	
TW 9			189.41	189.50	189.51	189.49	189.49	
TW 10			189.08	189.28	189.24	189.16	189.16	
TW 11				189.37	189.42	189.41	189.37	
TW 12				189.52	189.70	189.43	189.37	
TW 13				189.54	189.62	189.46	189.41	



Figure 3: Groundwater Elevation, Site Wells



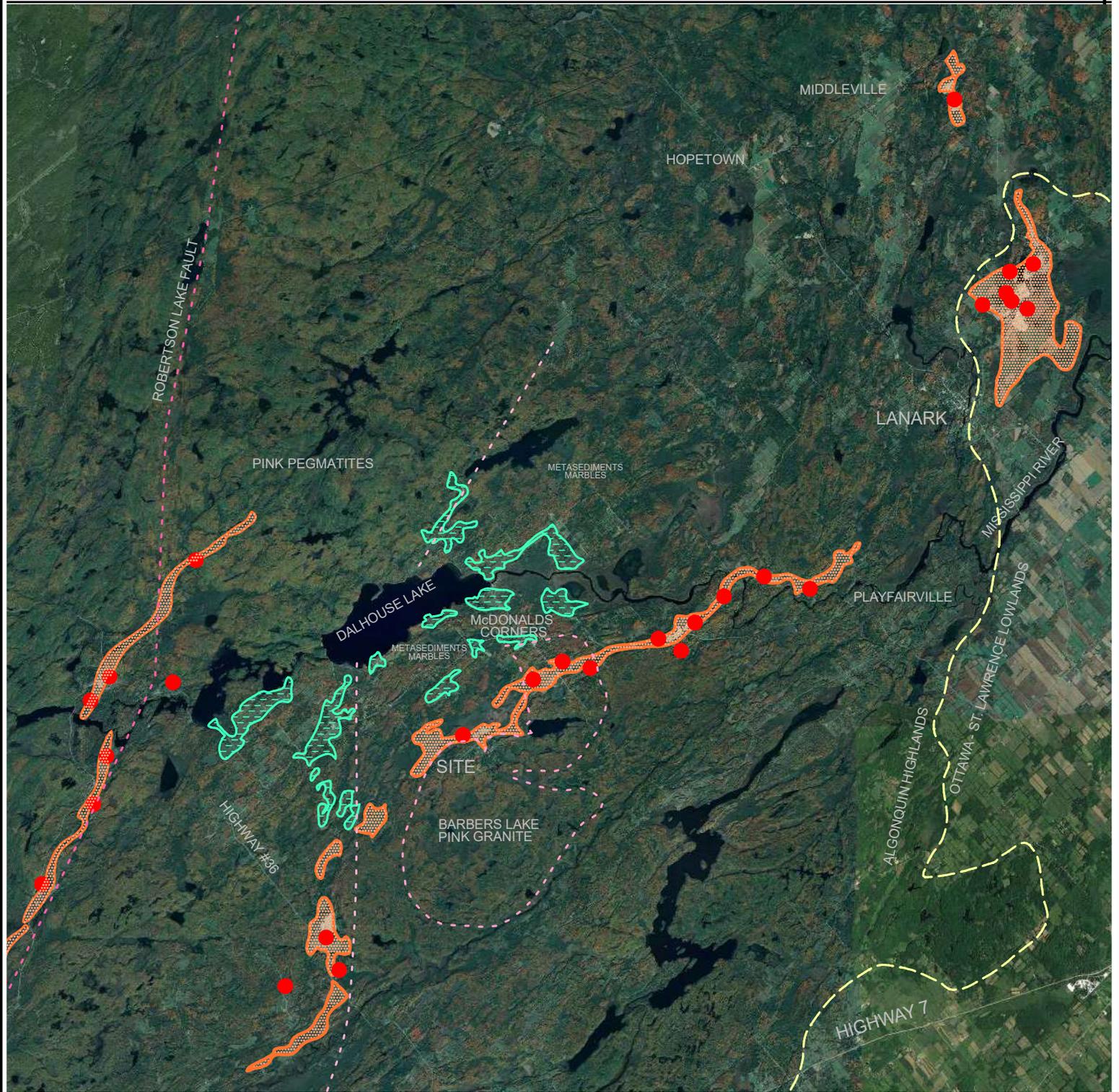
4.3.1 Granular Aquifer

This aquifer consists of the glaciofluvial assemblage that extends from beyond the Frontenac/Lanark County border to east of Playfairville. The aquifer on the site is part of the Lanark-McDonalds Corners glaciofluvial assemblage (Figure 4). The groundwater levels in the granular aquifer for the study period are shown in Figure 5.

The groundwater flow direction is eastward through the deposit towards Barbers Lake. On the site, the deposit extends beneath the wetland along the northern boundary of the site. The area of the wetland that is underlain by the aquifer is represented by TW8 to TW10.

The groundwater flow through volume of flow for the glaciofluvial system was estimated in GRI (2023) to be on the order of 470,000 m³/yr.

The extent of the glaciofluvial system is immense and, just in the portion of the system extending from Playfairville to the Frontenac/Lanark County border is on the order of 1,000 ha. The 41 ha Arnott represents 4.1 % of the system. The proposed changes will not change the groundwater flow direction, gradient or discharge through the system.



LEGEND

-  GLACIOFLUVIAL ASSEMBLAGES
-  GLACIOLACUSTRINE DEPOSITS
-  GEOLOGICAL BOUNDARY
-  ARA-LICENSED SITE

FIGURE 4

LANARK-McDONALDS CORNERS GLACIOFLUVIAL ASSEMBLAGE AND BEDROCK GEOLOGY

CLIENT ARNOTT BROS CONSTRUCTION LTD.

PROJECT NO. 21-022

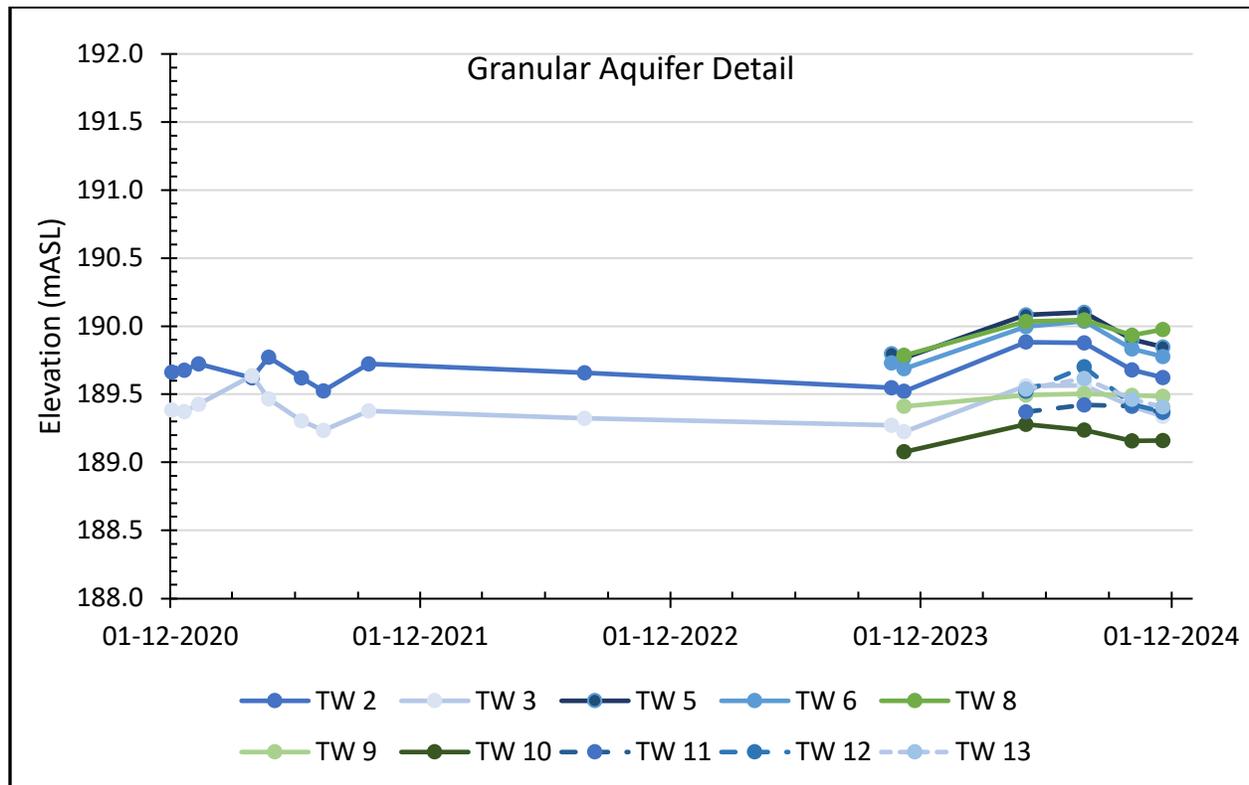
DATE: JULY, 2022



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Figure 5: Groundwater Elevations, Granular Aquifer



4.3.2 Barbers Lake Upland Perched Aquifer

In addition to being present in the south-west corner of the site, based on the geological mapping and Provincial well record data, the aquifer in the Barbers Lake Upland also extends westward towards the Frontenac/Lanark County border. The purpose of the new installations was to address the request by reviewers to provide more detail in support of the groundwater flow interpretation.

The flow was evaluated from TW1, TW4 and TW7 and the springs zone. The aquifer intersects the ground surface on the north-facing slope along the south-west part of the site. The perched water table emerges as springs in a zone that was documented to be between approximately 195.6 to 197.6 mASL. The discharge from the springs infiltrates into the glaciofluvial deposit within approximately 70 m.

The groundwater elevations are shown in Figure 6.

Groundwater flow in the upland perched aquifer is northward from the topographic high along Highland Line Road to the pit. The area where the springs were mapped is shown on OS Figure 2. As shown on the schematic profile in Figure 7, the water from this system exits along the bedrock/till interface at the base of the hill. Water from these springs flows overland for less than 70 m along the bedrock surface before infiltrating into the glaciofluvial system.

Figure 6: Groundwater Elevations, Upland Perched Aquifer

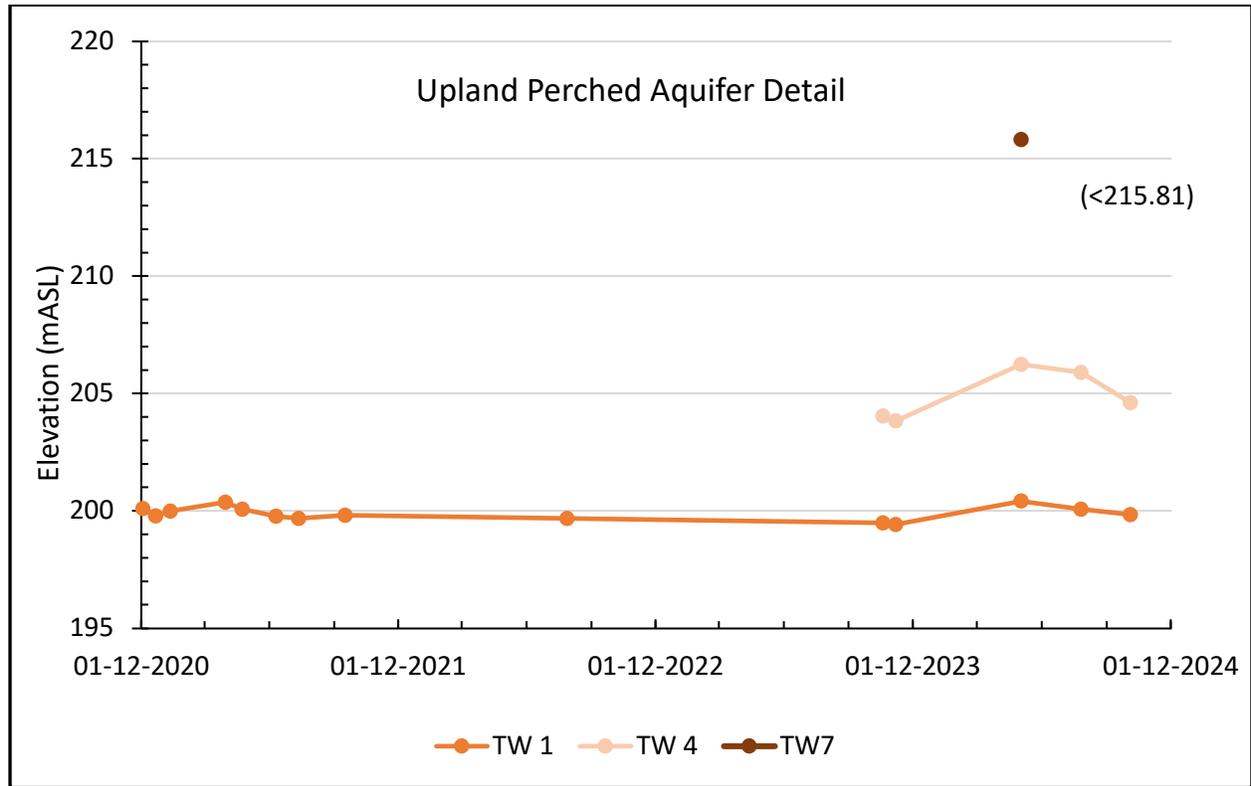
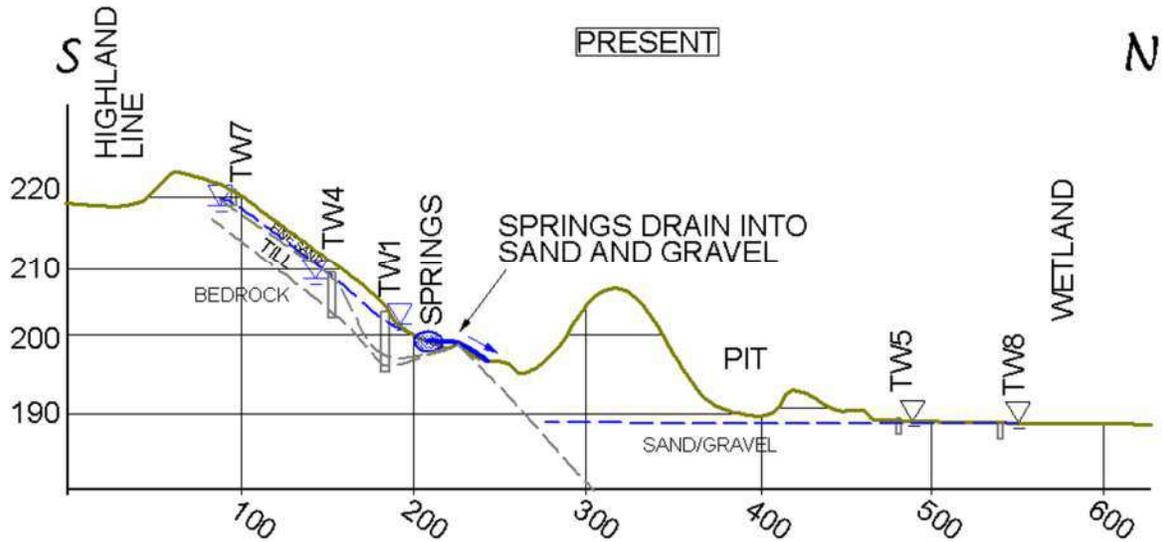


Figure 7: Schematic Cross-Section, Present Setting Aquifer Interaction



The volume of groundwater flow from the perched upland aquifer through the site was also estimated.

$$Q = k i A$$

Where:

Q = groundwater flow, m^3/yr

k = hydraulic conductivity, m/yr

i = hydraulic gradient in the direction of flow,

= d_v/d_h **15** d_v =change in groundwater level across the site

195 d_h =distance over which the change occurs

$$i = 0.07692$$

A = Cross-sectional area,

= $D \times W$ 2.7 D = average depth of aquifer, m

 580 W = width of cross section, m

$$A = 970 \quad m^2$$

k = $3.15E+01$ m/yr (for till, assumed $1e-6$ m/s)

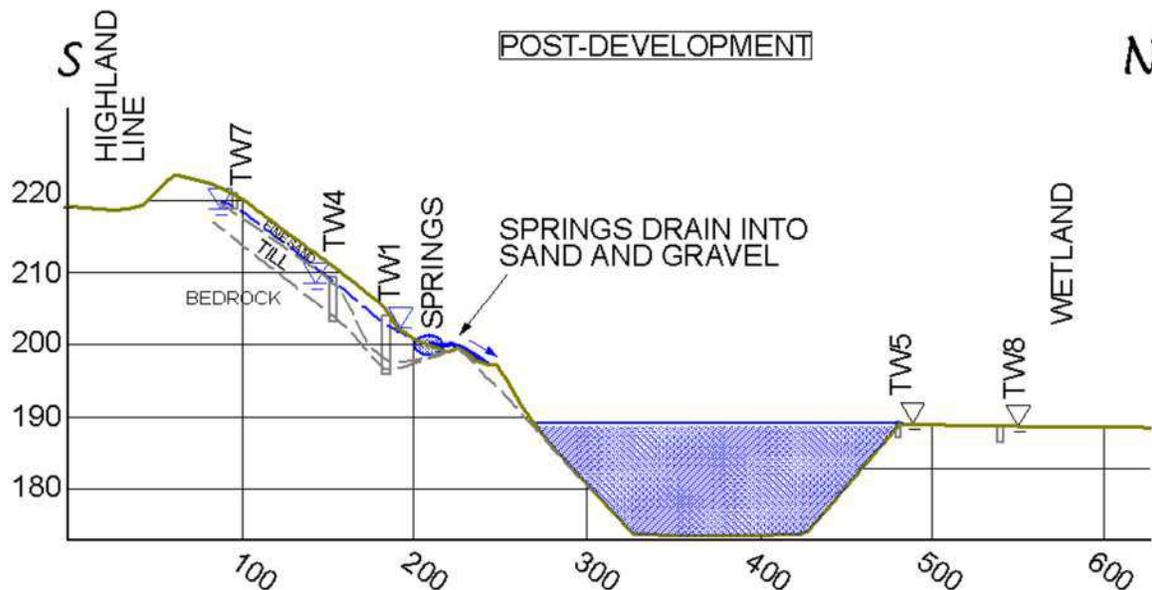
Therefore,

$$Q = 3,760.1 \quad m^3/yr$$

The flow contribution of the perched aquifer to the granular aquifer is on the order of $3,800$ $m^3/year$, which is less than 1% of the flow in the granular aquifer.

During and after the excavation of the deposit below the water table, the perched aquifer will not change. The aquifer currently emerges from the south slope of the property from between 195.6 and 197.6 $mASL$. The current pit floor is currently at approximately 190 $mASL$, currently 5 to 7 m below the zone where the springs emerge. The groundwater elevation in the glacialfluvial aquifer is an average of 189.5 $mASL$, 6 to 8 m below the springs zone where the upland aquifer exits on the slope.

Figure 8: Schematic Cross-Section, Post-Development Aquifer Interaction



As the pit is excavated below the water table, the discharge from the springs will continue to drain to the pit area just as they do now (Figure 8). The excavation below the water table in the granular aquifer will have no impact on the perched upland aquifer.

5 SURFACE WATER CHARACTERIZATION

Fisheries water is classified according to the water temperature. By definition, the temperature of a cold water system does not rise above 19°C. Cool water systems range in temperature from 19 to 25 °C in the summer, and the temperature in warm water systems can be greater than 25 °C.

To characterize the thermal character of the surface water features around the Arnott site, some background information was collected in collaboration with the natural heritage scientists at Ecological Services. The data were collected from the closest defined channel to the license boundary to assist with the impact assessment of the proposed below water excavation. The readings were recorded by qualified staff using portable meters consisting of a Hanna HI 991300 pH/EC/TDS meter, a Hach 2100Q turbidity meter and a YSI 95 portable dissolved oxygen meter. The stream velocity was measured with a CNYST FRM 500 flow rate meter. The equipment was calibrated according to the manufacturers' manual within 24 hours prior to the field visit.

The fish habitat north of the existing and proposed pit expansion area exists in a wetland that has an aquatic connection to Long Sault Creek. Potential fish habitat originates from a wetland more than 2 km (as the fish swims) west of the pit expansion area, and south of Highland Line. From here, water moves north and crosses near the corner of Highland Line and 12th Concession Line. From that corner, prospective fish habitat continues as a meandering watercourse and areas of non-channelled wetland. Fish movement within the more than 3.5 km distance (as the fish swims) from 12th Concession Line, north of the pit area, and east towards the Highland Line crossing, would be hindered by dry areas during the summer and several beaver dams. After crossing south of Highland Line (~1.2 km east of the Arnott Pit site) the watercourse continues in an easterly direction for ~1 km to 9A Concession Line ~ 550 m south of the intersection of Highland Line and 9A Concession Line. Fish movement barriers also exist in this ~ 1 section of the tributary. From 9A Concession Line the tributary continues another ~ 1 km east and connects with the main channel of Long Sault Creek. The provincial mapping of watercourses shows the closest location of Long Sault Creek to the proposed license boundary (OS Figure 2) is about 700 m to the south with no direct intervening surface water connection. It is separated from the site by bedrock, which means it is not directly affected by site operations. This section of Long Sault Creek drains into Barber Lake. The creek begins again at the eastern end of Barber Lake where it continues eastward and discharges into the Mississippi River approximately 6.5 km downstream.

Portions of Long Sault Creek have been known to support cold water species, such as Brook Trout. It has also been historically stocked with Brook Trout. Past fish sampling that recorded Brook Trout was done at two locations along 9th Concession Road.

- Fish sampling undertaken by Muncaster Environmental Planning Inc (2006) approximately 120 m north of the pit licence area in open water areas found on either side of a snowmobile trail reported fish species that are representative of cool water thermal regimes. Their tolerance to

environmental and/or anthropogenic stresses, including temperature, are indicated as intermediate to tolerant as based on the Ontario Freshwater Fishes Life History Database.

- At the crossing by the main body of Long Sault creek more than 2 km downstream of the proposed pit area, MNRF indicates a variety of cool and warm water species have been caught here, but also Brook Trout, which is a cold-water species.

The 2023 EIS noted that the adjacent wetland put limits on the value of fish habitat due to the density of wetland vegetation, confining it to a few channels and some ponding areas (shown on GRI OS Figure 2). Several beaver dams and periods of dry during the summer months would also put limits on the value of the fish habitat in the adjacent wetland (Rob Snetsinger pers. comm.)

Ecological Services, who conducted the 2023 EIS did not find cold water fish habitat features in the wetland adjacent to the site. The EIS discussed a ponded area behind a beaver dam (SW1) near the north-west corner of the pit expansion area. Initially, GRI was asked to collect field measurements at three locations, which are identified on OS Figure 2 as SWES1 (upstream), SW1 and SW4 (downstream). After the initial readings were collected, further discussions were undertaken to choose additional stations around the site that will provide data for ongoing impact analysis through the site operation life. Permission will be required from adjacent landowners for the data collection to continue at SW1, SW2 and SW3. Although the data collection began at a late stage of GRI's supplementary investigation, the surface water monitoring will continue as part of the recommended monitoring, as discussed below.

Table 9: Surface Water Field Measurements

	SW-ES1	SW1		SW4	
	2024-10-01	2024-10-01	2024-11-18	2024-10-01	2024-11-18
pH	7.04	7.34	7.78	7.13	7.4
TDS (mg/L)	169	118	103	139	148
Conductivity (µs)	330	232	202	273	289
Water Temp (°C)	17.3	17.7	6.4	17.4	6.2
Air Temp (°C)	18	18	5	18	5
DO (mg/L)	8.85	8.94	11.18	8.86	11.36
Turbidity (NTU)	2.94	2.94	11.7	2.26	3.12
Redox (mv)	1	-16	-36	-4	-17
Width (m)	2.65	1.25	1.4	1 to >5	>5
Depth (m)	0.58	0.05 to 0.57	0.15	.1 to 0.61	0.18
Flow	0.15	0.32	N/A	not measurable	

SW-ES1 is located east side of the Dalhousie 12th Concession from the channel on the north side of Highland Line. SW1 is in the channel that flows through a large established beaver dam. The readings and measurements were taken from the channel immediately downstream of the dam. SW4 is the downstream location from the site, at the point where the tributary crosses Dalhousie 9th Concession.

The field data (Table 9) and fish species suggest cool water fish habitat, not cold water fish habitat conditions, in the surface water north of the site. If the system was cold water, more cooling would have been expected by October when the sampling was undertaken (R. Snetsinger, pers. comm.).



Two additional surface water monitoring stations are proposed adjacent to the north license boundary, but as noted above, permission to monitor the locations will be required from the landowners.

5.1 Surface Water Monitoring

The field monitoring of the surface water stations should continue at the same frequency as the groundwater monitoring. If permission is granted, stations SW1, SW2 and SW3 should be included in the program. If permission is not granted, monitoring should continue at SW-ES1 along with SW4, although the impact will not be as easy to assess. The results and assessment should be part of the previously recommended reporting.

6 COUNTY OF LANARK SIGNIFICANT GROUNDWATER RECHARGE AREA DESIGNATION

GRI (2023) reported that the County of Lanark designates the area around the site as a significant groundwater recharge area. Part of the purpose of the report was to assess impacts by the proposal and the significant groundwater designation was considered as part of the overall impact assessment. However, a conclusion specific to the designation was not included in the report. This section provides additional information.

The significant groundwater recharge area is shown as an overlay in the County of Lanark Official Plan. The source of the information is not referenced but is believed to originate from the Renfrew County-Mississippi-Rideau Groundwater Study (Golder Associates Ltd. , 2003). A snapshot of the overlay captured for this review is shown in comparison of the significant groundwater recharge areas to the surficial geology mapping shows that most of these areas consist of deposits that were formed by glaciofluvial or glaciolacustrine processes, including at the application site.

Figure 9: Significant Groundwater Recharge Areas around Study Site (Source: Lanark County, Source Water Protection, [CommunityPAL \(cgis.com\)](https://communitypal.com) accessed September, 2024)



GRI (2023) and the additional data and analysis in this addendum report provide information on the deposit and aquifer that is shown as significant groundwater recharge area. The assessment determined at the local level that the proposed amendment to permit below water excavation of material will have a minimal impact on the granular aquifer. Groundwater quality and quantity were considered and are addressed in the ARA site plan. Consequently, we believe that the significant groundwater recharge area was considered in the study and the impacts on it have also been addressed. The analyses found;

- There may be a small shift in balance between infiltration and runoff that results from the creation of a lake. The water surplus will not change from the operation.
- The removal of the aggregate will be done without dewatering will not change the groundwater levels or flow through the aquifer.
- While there are potential impacts to groundwater quality from the operation, they can be mitigated through adhering to the pertinent legislation and regulations and by operating the site according to industry best practices. These requirements have been implemented on the ARA site plan that will govern the operation of the site, and they are legally enforceable.
- Finally, monitoring of groundwater levels and quality will be a part of the operation of the site. The collection and regular analysis of the data will be used to assess the operation in real time as it develops. These data will be a continual assessment and will be used to further refine the predictions. Qualified professionals will advise on changes to the operation that may be needed to minimize impacts.

7 IMPACT OF CHANGE TO LAKE SURFACE ON GROUNDWATER FLOW

As has been previously noted, large volumes of groundwater now flow and will continue to flow through the site through the granular aquifer. The groundwater level in the granular aquifer was a maximum of 189.95 mASL at the west end of the site and minimum 189.39 mASL at the east end of the site.

An assumption has been made that the final lake will have a flat surface. However, the lake that will be constructed will remain part of the groundwater system. Groundwater will enter the lake from the west side and will exit into the system along the east end. For flow to be generated, a gradient is required, and therefore, it is unlikely that the lake surface will be level.

However, the most conservative analysis assumes the lake surface will be flat. The change of the average groundwater elevation from data collected over the study using the average change in groundwater elevation from TW5 and TW8 (west) to TW10 and TW13 (east) is,

$$\frac{189.94 + 189.96}{2} - \frac{189.20 + 189.58}{2} = 0.56 \text{ m}$$

If the final surface was flat, the change across the surface would be half the change in groundwater elevation may be around 0.28 m or a final lake level of around 189.7 mASL (Wrobel, 1980), and the groundwater surface would exhibit as a decrease in water level at the west end of the lake, and an increase in the open water level at the east end of the lake.

The resultant groundwater surface was estimated using MODFLOW6. A 2-dimensional model was created but the use of the numerical model permitted a more complex geology of the site to be considered. The model examined the granular deposit and considered recharge and the wetland. The



groundwater flow was first calibrated to the average water levels collected over the study, and subsequently the final lake was added. The results are shown on OS Figure 4. The results show that the effect of the lake decreases quickly with distance, as would be expected. Within about 30 m from the lake edge, the post-development water level would be restored from the initial 0.28 m to about 0.10 m.

The result is consistent with the available literature.

Given the size and characteristics of the granular aquifer, if it occurs, this change will have minimal effect. Nevertheless, the effects of below water excavation will be monitored for confirmation of the analysis and predictions. The additional analysis results in no changes to the recommended groundwater monitoring program in GRI 2023.

If unexpected changes are observed during monitoring, there will be sufficient time to amend or in the worst case discontinue the operation before off-site impacts occur.

7.1 Temperature, Groundwater, Wetland and Streams

Data loggers were installed in TW2, TW8, TW9 and TW10 to provide continuous measurement of groundwater level fluctuations and groundwater temperature. The data loggers gather readings three times a day, at 1 am, 9 am and 5 pm.

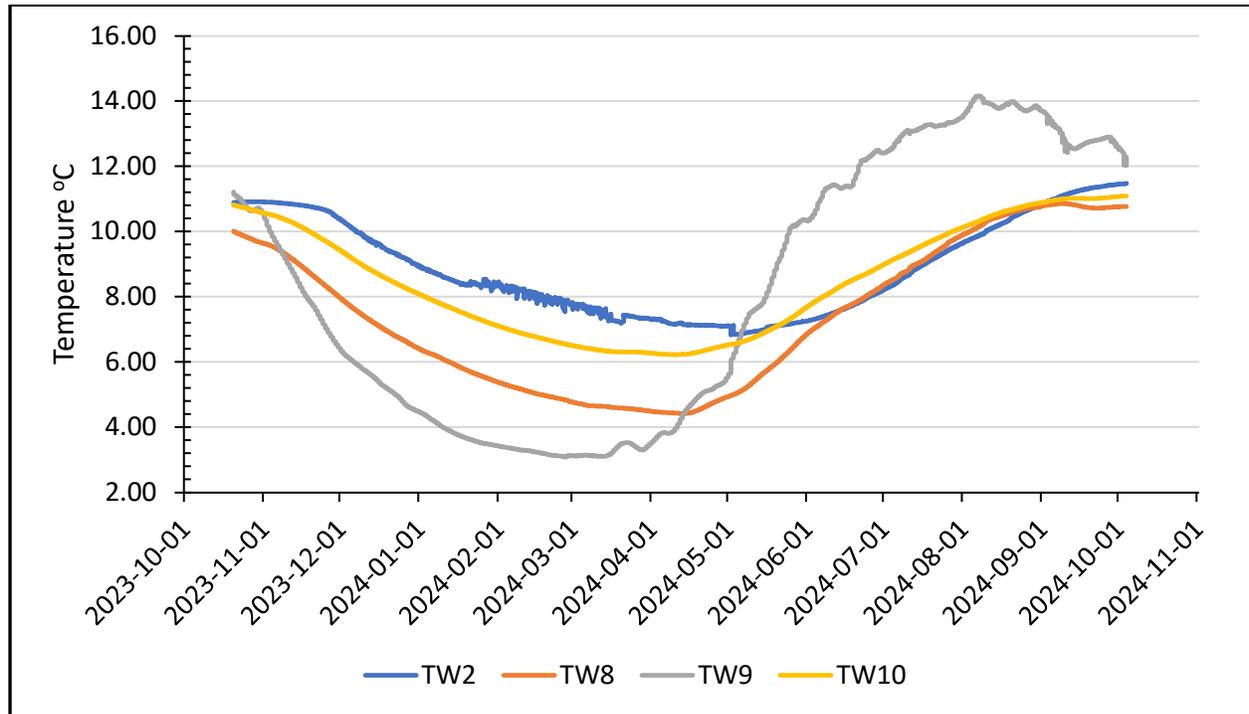
Figure 10 shows the temperature measured for the four stations over the period from October 2023 through July 2024. TW2 is in the pit floor along the northern periphery of the extraction limit. TW8 and TW10 are shaded by a tree canopy and are in the wetland on the McKinnon property boundary. TW9 is in the open within a depression adjacent to the snow mobile trail that crosses the wetland.

At TW8 the water temperature decreased from approximately 10 °C in October to a minimum of 4.29 °C in April before increasing to 8.83 °C in late July. The temperature in July at TW8 was slightly higher than the temperature of the groundwater in TW2 (8.41 °C).

At TW9, which is in the open area showed the greatest range in temperature, from a maximum of 14.10 °C in August (2024), to a minimum 3.08 °C in March (2023). The rate of temperature increase and decrease was the steepest of the four monitored wells, and was about twice the rate as TW8 and TW10 and had the highest temperature of any in August at 14.10 °C.



Figure 10: Groundwater Temperature, Granular Aquifer



At TW10, the temperature trend was similar to TW8, although the absolute temperature was on average 2 degrees higher. The temperature decreased from 10.78 °C in October to 6.25 °C in April then increased to 9.53 °C in July. The temperature was higher than in the pit at TW2 from late May through the summer.

The temperature in the pit, at TW2 decreased from 10.78 °C comparable to in TW10, to a minimum of 6.83 °C in April. The rate of decrease in temperature over the winter was comparable to TW8 and TW10, but the increase in temperature in the spring was slower than at the wells in the wetland.

As would be expected, the seasonal temperature response at the stations relate to the sun exposure as well as to the depth to the groundwater. For TW2 the static water level is 2 m or more below ground surface and the water is never in direct sunlight. The water levels for the wells in the wetland where the water level is at and periodically above ground surface absorbs more heat from sunlight more rapidly. TW9 has no overhead cover, and the water level tends to be closer to the surface than the other wetland stations.

Studies of changes to groundwater temperature due to creation of lakes have shown that the temperatures fluctuate seasonally. The published studies indicate that the effects of temperature change due to the introduction of an open water feature are limited to a short distance. Based on the available research, no significant changes to the groundwater is predicted.

One limitation of research on aggregate sites noted by the authors was that many (most) of the case study sites did not have pre-development data. There is data collection ongoing for this operation which will continue to be collected and interpreted in real time. The site data suggests that the open water will have similar behaviour to the wetland monitors, which would have the effect of complimenting the existing setting.

The best practice would be to continue to monitor the groundwater temperature in the pit and wetland. The data can be used to observe how the open water changes the local environment both by measuring absolute changes and observing the distance required to restore the temperature to background.

The below water extraction should begin at the most distant point from the wetland that is reasonable for the site operation. As the site progresses, the monitoring data will be interpreted so that if impacts are predicted, measures can be implemented that may include reducing excavation depth or proximity to the natural feature. This assessment should be based on the above monitoring data.

7.1.1 Monitoring Recommendations

The temperature in TW2, TW8, TW9 and TW10 should continue to be measured using dataloggers. The data should be downloaded when seasonal field measurements are taken, and the data should be checked for trends and potential concerns. TW2 will be a sentry to monitor changes to the groundwater in the pit from the open water.

It is important to also continue the monitoring up to the commencement of the below water excavation to establish a baseline record. This data can be evaluated regularly as part of the monitoring and assessment to identify patterns as the site develops and subsequently discern if the creation of the lake would impact the water temperature of the wetland.

GRI (2023) recommended a formal review of all the monitoring data at the end of two years. Although not clearly stated, the intention was for the review to occur two years after below-water excavation begins.

8 SUPPLEMENTARY RECOMMENDATIONS

1. The below water extraction should begin at the most distant point from the wetland that is reasonable for the site operation. As the site progresses, the monitoring data will be interpreted so that if impacts are predicted, measures can be implemented that may include reducing excavation depth or proximity to the natural feature. This assessment should be based on the above monitoring data.
2. The temperature in TW2, TW8, TW9 and TW10 should continue to be measured using dataloggers. The data should be downloaded when seasonal field measurements are taken, and the data should be checked for trends and potential concerns. TW2 will be a sentry to monitor changes to the groundwater in the pit from the open water.
3. Field monitoring of the surface water stations should continue at the same frequency as the groundwater monitoring. If permission is granted, stations SW1, SW2 and SW3 should be included in the program. If permission is not granted, monitoring should continue at SW-ES1 along with SW4, although the impact will not be as easy to assess. The results and assessment should be part of the previously recommended reporting.



We hope that the additional information found within this auxiliary report addresses the concerns of the review agencies. If there are further questions, we would be happy to discuss them.

Sincerely;



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The services performed, as described in this letter, were conducted in a manner consistent with the current level of care and skill normally exercised by members of the engineering and science professions practicing under similar conditions, under comparable time limits and financial and physical constraints applicable to the services.

The assessment of conditions and possible hazards at this site has been made using the method outlined in the project Scope, which may include results of physical measurements and chemical analyses of samples from identified monitoring locations. The conditions between locations have been inferred and may vary from the sample location(s).

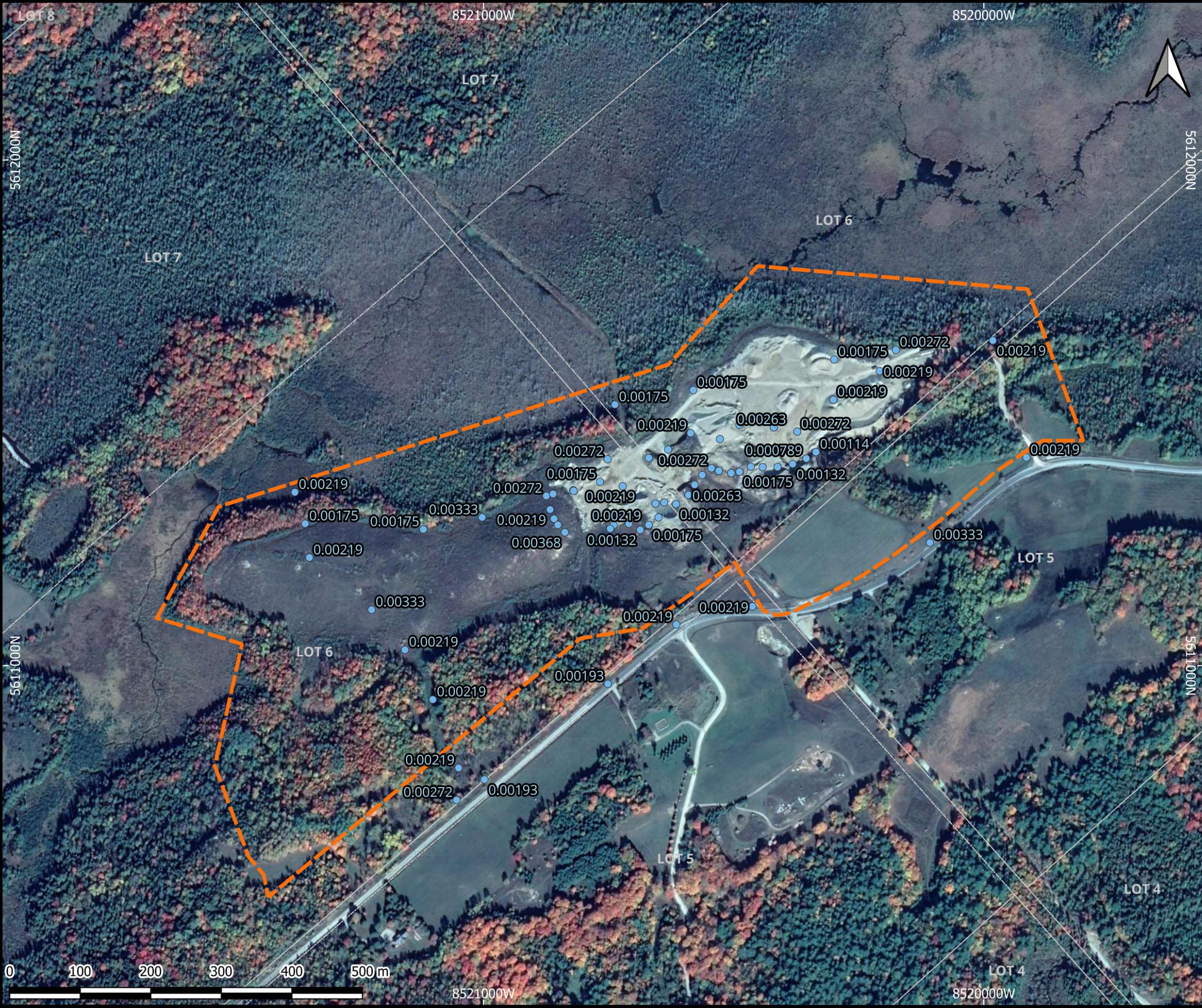
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Oversize Figures

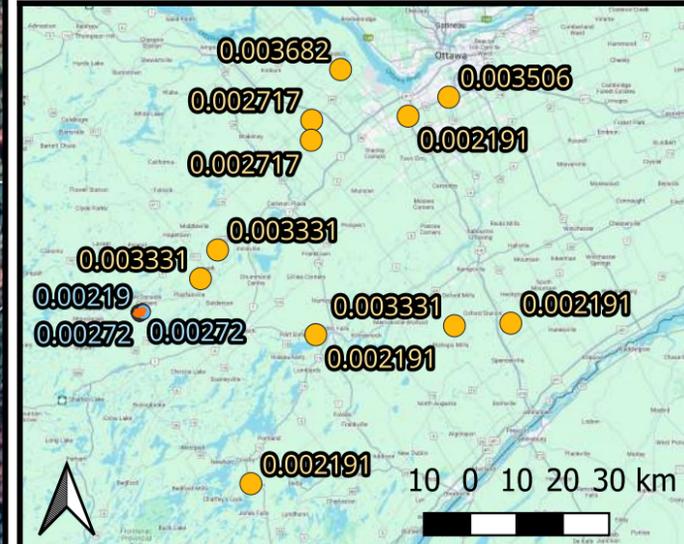




LEGEND

-  Property Boundary
 -  Lot, Conc.
 -  Gamma Survey, Nov 6, 2023
- Google Image 10.10.19

REGIONAL GAMMA RAY READINGS, NOV 6, 2023



OS FIGURE 1
GAMMA RAY SURVEY
URANIUM, NOV 6, 2023

CLIENT: ARNOTT BROS CONST.
 PROJECT NO: 21-022-1
 DATE: OCTOBER 2024

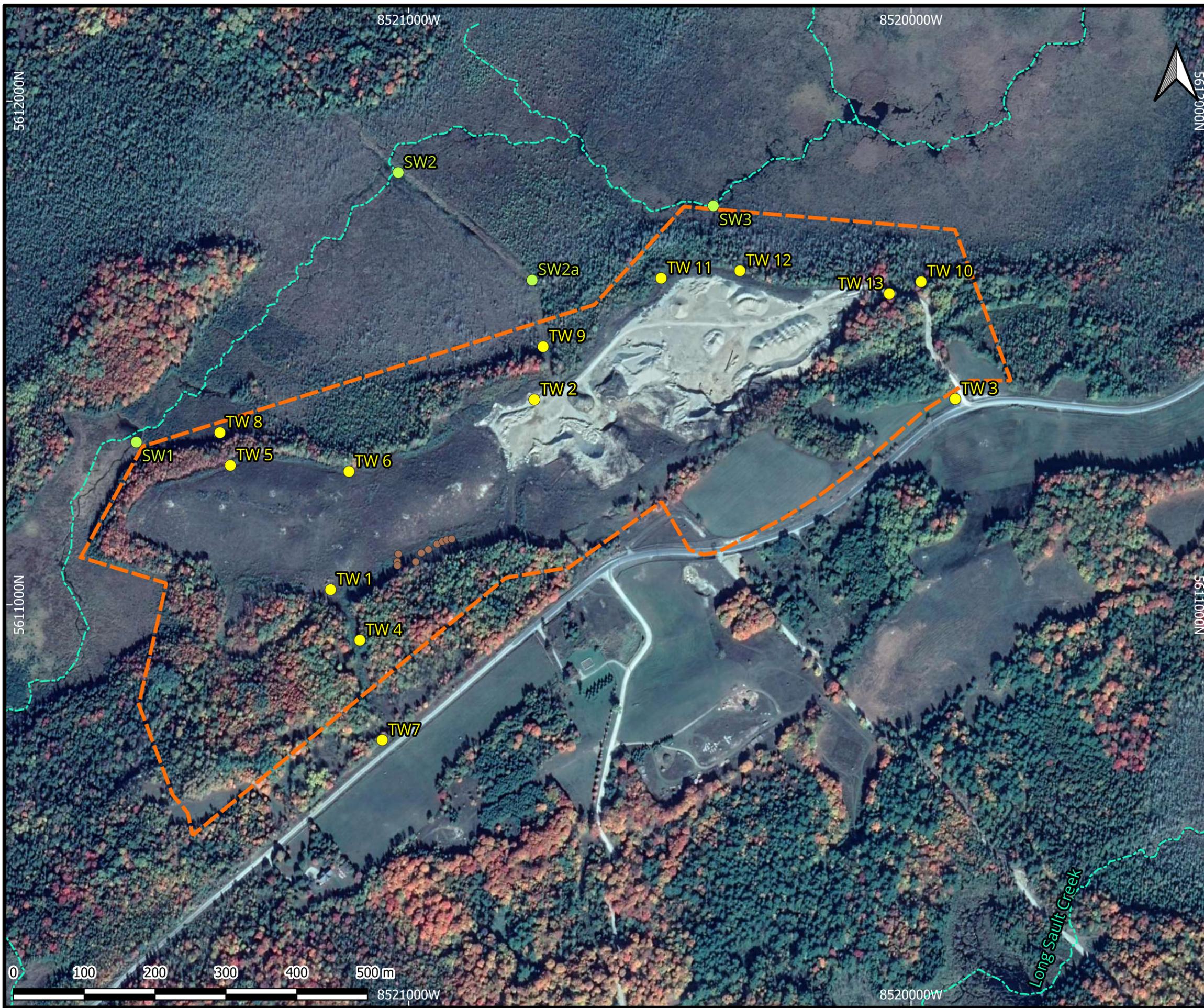


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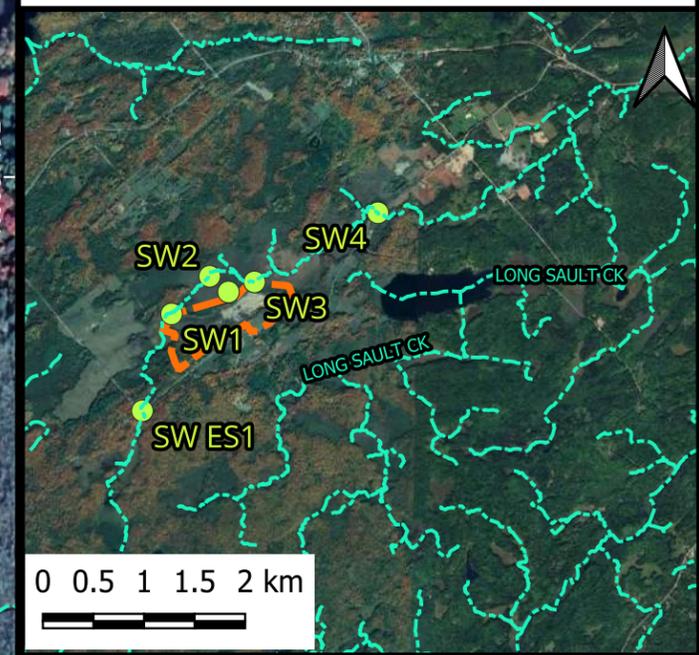


LEGEND

-  Property Boundary
-  Test Wells
-  new SW stations
-  Springs, Elev.

Google Image 10.10.19

INSET SHOWING AREA WATERCOURSES

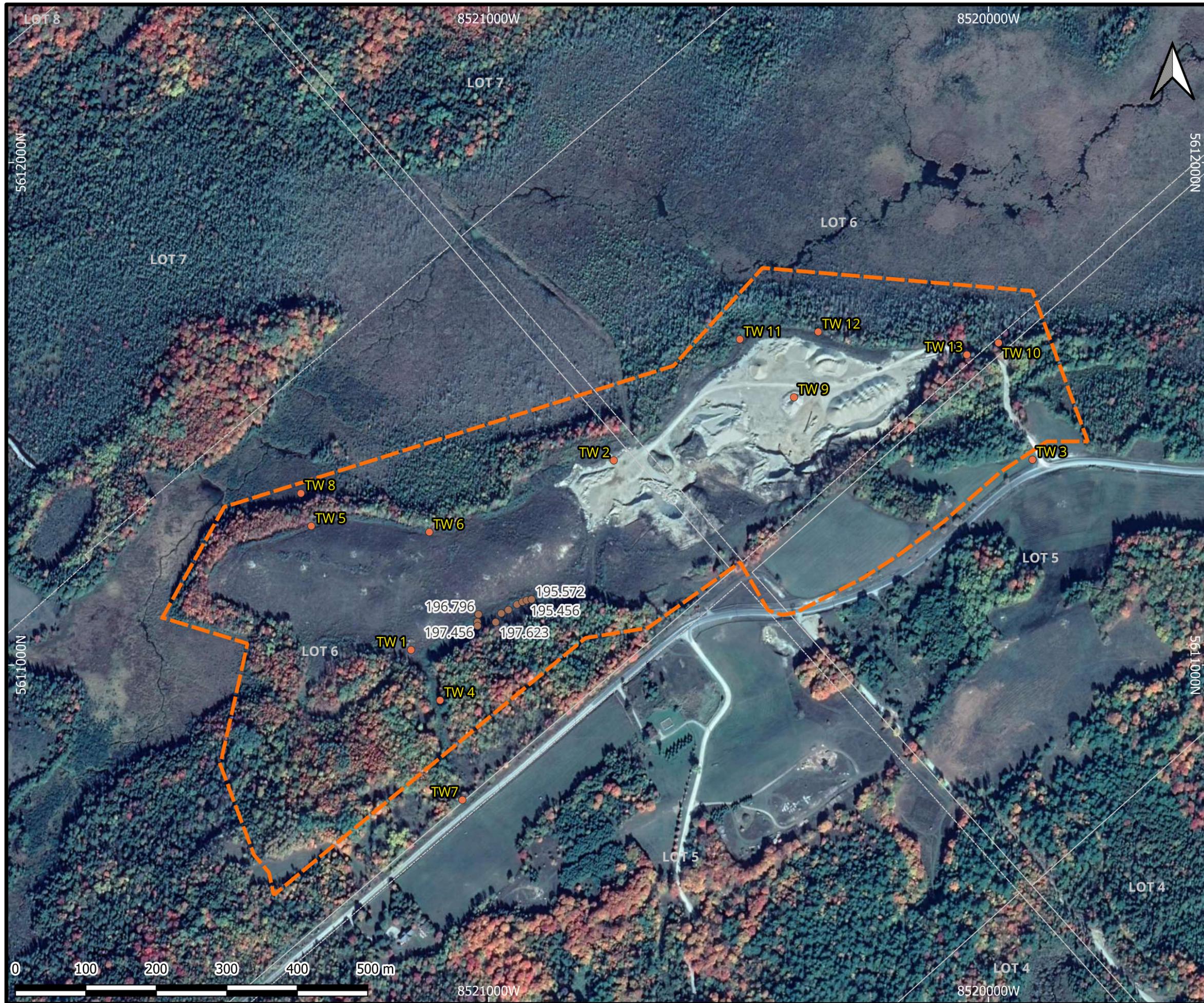


OS FIGURE 2
**TEST WELL AND
 SPRINGS LOCATION**

CLIENT: ARNOTT BROS CONST.
 PROJECT NO: 21-022-1
 DATE: OCTOBER 2024



2024-11-29



LEGEND

-  Property Boundary
-  Lot, Conc.
-  Monitoring Well
-  Springs, Elev.

Google Image 10.10.19

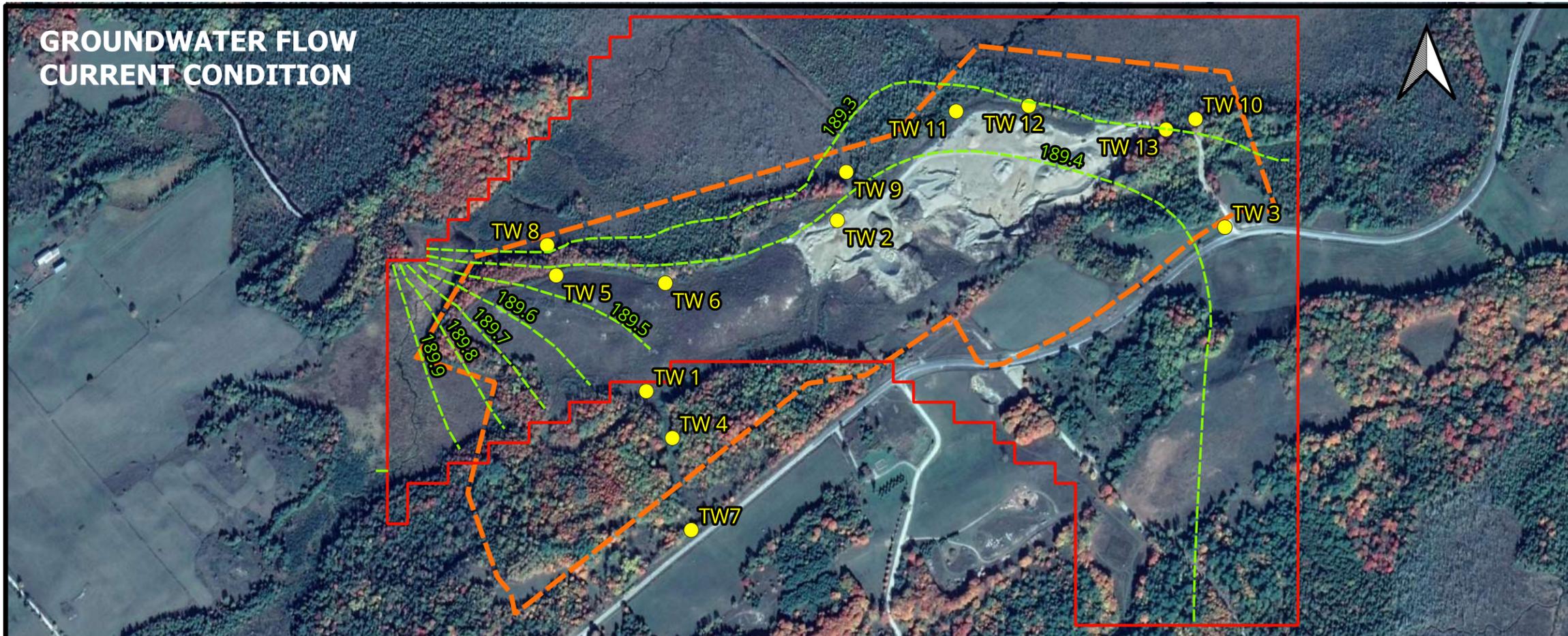
OS FIGURE 3
GROUNDWATER FLOW
MAY 2024

CLIENT: ARNOTT BROS CONST.
 PROJECT NO: 21-022-1
 DATE: OCTOBER 2024



2024-09-24

**GROUNDWATER FLOW
CURRENT CONDITION**



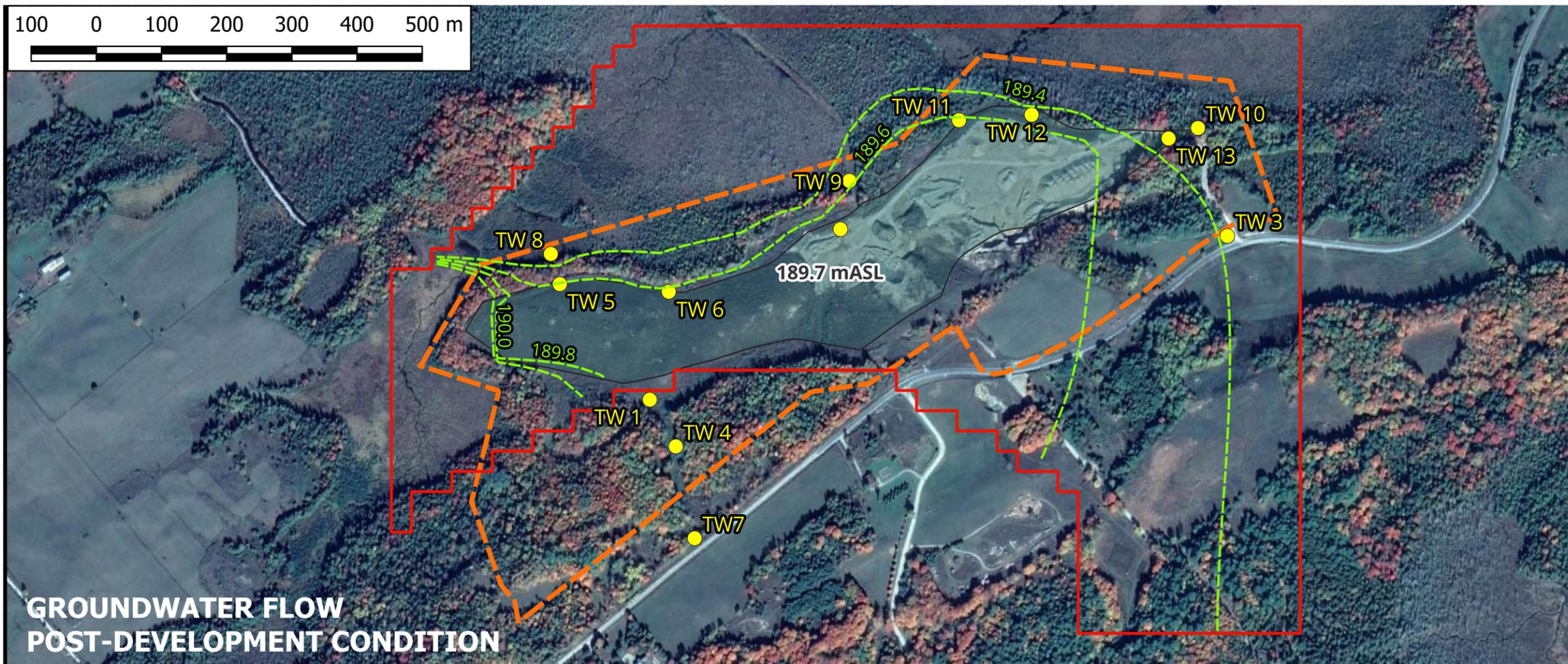
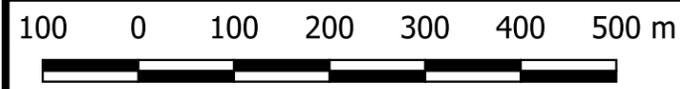
LEGEND

- Property Boundary
- Test Wells

GROUNDWATER MODEL

- Active Cells Grid

Google Image 10.10.19



**GROUNDWATER FLOW
POST-DEVELOPMENT CONDITION**

OS FIGURE 4

**THEORETICAL RADIUS OF
INFLUENCE, FINAL LAKE**

CLIENT: ARNOTT BROS CONST.

PROJECT NO: 21-022-1

DATE: OCTOBER 2024



Oversize Tables



OS Table 1: Summary of Agency Comments and Response Index

Topic, Comment	Agency	Location of Response, Summary
Radioactivity/ Health and Safety		
Barbers Lake Granite contains uranium and thorium, and the proponent should determine the risk of excavating the material will have on Arnott staff.	MNDM	See Section 2 The gamma-ray spectrometric survey did not find radioactive concentrations on or near the site that were anomalous or above what would be considered normal natural concentration at an inert location. Comparable concentrations were measured at other locations in Lanark and at locations in Ottawa.
Water Balance/ Water Budget		
A monthly, annual and long-term water budget and hydrologic analysis is recommended.	MVCA	See Section 3 Additional details on annual, monthly and future water budgets are provided.
Groundwater		
Identify and show that there are indeed two aquifers on the site that have a 5+ m difference in heads.	MNRF (AUG 22/23)	See Section 4 This section provides additional field details to differentiate the two aquifers
16. Ensuring the protection of natural heritage features like wetlands, streams, and springs from impacts related to aggregate extraction activities is important. While the report indicates that there are two distinct aquifers represented by TW1 and TW Nos. 2 and 3, the evidence supporting this claim seems inconclusive. The provided information reveals considerable variability in both subsurface conditions and groundwater level elevations as measured in the monitoring wells. The groundwater levels from the three monitoring wells on the property may not comprehensively represent the aquifer(s) and/or the groundwater levels across the site. Consequently, it would be prudent to obtain groundwater level data from additional locations, especially in the site's western portion.	MNRF (OCT 28/24)	
18. The recorded water level difference between the monitoring wells located upstream and downstream (considering the interpreted groundwater flow direction) is approximately 10 metres. It's anticipated that the extraction of aggregate material will result in a "water leveling" effect. It's crucial to assess how a potential 5-metre decrease in the water table on the western side, and a corresponding 5-metre increase on the eastern side,	MNRF (OCT 28/24)	

Topic, Comment	Agency	Location of Response, Summary
will influence the adjacent wetlands and streams. Data from additional monitoring wells might provide a more comprehensive understanding of the final elevation of the rehabilitated pond level across the site, aiding in the assessment of possible impacts.		
Show seasonal variation in water levels in pit and adjacent wetlands and cold streams	MNRF (AUG 22/23)	Section 4.3 Contains additional seasonal monitoring data, with additional monitoring points in the wetland adjacent to the pit. Field measurements taken from the closest watercourse with locations chosen in consultation with Ecological Services.
17. Please determine the seasonal relationship between the groundwater table and the water levels of nearby wetlands and cold streams. This correlation is vital for gauging potential impacts.	MNRF (OCT 28/24)	
Show the difference between the water levels and gradient across the site. More monitoring wells might provide a more comprehensive understanding of the final elevation.	MNRF (AUG 22/23)	Section 4.3 New monitors were added to confirm the assessment, and the results are consistent with the data originally presented in GRI (2023)
Expand on the potential thermal impact on the cold streams using site-specific data	MNRF (AUG 22/23)	Section 4.5 New monitors were added to provide temperature data for the pit and wetland. The seasonal variations are described. A continued monitoring program is recommended.
19. Please provide evaluation of the potential thermal impacts on the cold streams using site-specific data.	MNRF (OCT 28/24)	
Update the monitoring program with any wells and other monitoring points completed to address the points above.	MNRF (AUG 22/23)	Section 4.3 Additional groundwater monitoring data is provided.
20. Given the above comments 16 to 19, please update the monitoring program, triggers, and mitigation measures to account for the presented data, any new findings, and the functions of the natural heritage features.	MNRF (OCT 28/24)	The addendum recommendations have been added to the site plan. Landowner permission is required to access recommended surface water monitoring stations SW1, SW2 and SW3.
The area is designated by the County of Lanark as significant groundwater. This needs to be addressed further in the report	MVCA	Section 6 provides further discussion about the significant groundwater recharge area.
More data on the perched aquifer is required.	MVCA	Section 4.2 Additional data on the perched upland aquifer and the relationship to the primary granular aquifer is provided.
Additional details on the perched unconfined, unconfined and confined aquifers such as locations, elevations, interactions and	MVCA	Section 4 Additional data on the perched upland aquifer and the relationship to the primary granular aquifer is provided.

Topic, Comment	Agency	Location of Response, Summary
connectivity/discharge to the wetlands/ creek should be provided.		
Wetlands		
Significant Wetlands - reduction of groundwater flow impacting the adjacent significant wetlands.	MNRF (AUG 22/23)	Section 7 As stated in GRI (2023), and as analysed further in Sections 3 and 4, there will be no significant reduction in groundwater flow or resultant impact to adjacent wetlands
What are the potential impacts to the adjacent wetland's hydrologic functions, on the east side of the site, during below water excavation phase.	MVCA	Section 7 There will be minimal changes to the groundwater levels due to the operation, and consequently no change to hydrologic function in the wetland. There is no dewatering, water in excavated material drains to the aquifer on the site. Groundwater flow will continue as it now does as the excavation below water proceeds with no change to conditions downflow.
The potential impact to the adjacent wetland needs to discuss or analyse the proposed extraction impact on the wetland, fish and significant wildlife habitats. The impact of the reduction in surface runoff on the hydraulic function of the adjacent wetlands needs to be discussed.	MVCA	Section 7 The assumption that there will be a reduction in runoff because of the below water excavation is confusing. There will be no net change to the contribution by the site to the hydrologic function. Section 4.4 estimates the open water surface will be 0.28 m lower than the groundwater elevation at the west end of the lake, and similarly higher at the east, downflow end of the lake. The lake has an outlet, so recharge from the water surplus will continue to be delivered downflow either through infiltration or runoff to the wetland downgradient. The Arnott Bros site comprises less than 1% of the area of the granular aquifer and local catchment.
Discuss further how the extraction below the water table affects flow to the wetland	MVCA	Section 7
Detail the potential impacts to the MCVA wetlands that will be close to the edge of the created lake.	MVCA	Section 5, 7 The information provided by Ecological Services on the potential impact to the wetland adjacent to the lake (provided by e-mail, September 25, 2024, was; <ul style="list-style-type: none"> - Cold water conditions/species were not indicated for the channels and wetland areas next to the pit. Fish sampling to date has not caught any cold water species such as brook trout. - There are impediments to upstream trout movement for the section of creek downstream of the wetland next to the Arnott Pit. - The closest area of confirmed Brook Trout (cold water habitat) use is where Long Sault Creek meets 9A Concession Dalhousie. The Long Sault Creek system has two crossings of 9A. the wetland area next to the Arnott Pit may not connect directly to the trout stream that MVCA noted. The tributary crosses Highland Line at 9A Concession Line, approximately 2 km east. MVCA appears to show the habitat in association with the main creek crossing of 9A south and downstream of Barbers Lake approximately 2.5 km away. The impacts from the below water operation at the pit will be limited to a few hundred meters from the lake. Given the distance of separation to a known brook trout area, there is little chance of thermal changes from the Arnott Pit affecting the known trout stream area as it is so far downstream.

Topic, Comment	Agency	Location of Response, Summary
		The groundwater elevation adjacent to the open water was found to return to normal before the tributary is intercepted due to the highly permeable nature of the aquifer. Additionally, the lake will continue to recharge the wetland downgradient as drainage from the site continues as it does now (OS Figure 4)
Miscellaneous Comments		
Is the maximum depth 173 or 171 mASL	MVCA	As indicated by the Operations Page of the proposed Site Plan, the base of the excavation will be 173 mASL.
Show locations of profiles A-A', B-B' and C-C'.	MVCA	The attached OS Figure 2 shows the locations of the Cross Sections that were missing from OS Figure 2 in GRI, 2023

Appendix A

Water Budget Tables



OS Table 2: Monthly and Annual Water Budget, 1981-2000 Normal

	Mean Monthly T °C	Monthly PPT	PE* mm	Water Surplus
January	-9.8	67.7	0.0	67.7
February	-8.5	51.3	0.0	51.3
March	-2.0	55.1	0.0	55.1
April	6.0	64.2	31.7	32.5
May	12.7	77	80.0	-3.0
June	17.8	82.4	116.1	-33.7
July	20.3	83.5	134.5	-51.0
August	19.1	75.3	116.6	-41.3
September	14.4	91.8	73.7	18.1
October	7.8	78.5	34.8	43.7
November	1.6	83.6	5.5	78.1
December	-5.8	65.9	0.0	65.9
Annual	6.1	876.3	592.9	283.4

* Potential Evaporation, Thornthwaite (1936)

OS Table 3: Monthly and Annual Water Budget, 2017-2021 (5 Year Average)

	Mean Monthly T °C	Monthly PPT	PE mm	Water Surplus
January	-7.3	73.72	0.0	73.7
February	-6.3	66.76	0.0	66.8
March	-1.7	65.52	1.0	64.5
April	5.7	108.12	26.8	81.4
May	13.0	71.04	76.3	-5.2
June	18.1	105.96	113.5	-7.5
July	21.4	95.2	140.4	-45.2
August	20.0	111.84	121.7	-9.8
September	15.5	90.08	79.3	10.8
October	9.3	124.64	41.0	83.7
November	0.7	68.56	3.9	64.7
December	-5.1	72.36	0.0	72.4
Annual	7.0	1053.8	603.8	479.9



OS Table 4: EC Water Budget Analysis

Drummond Centre		WATER BUDGET MEANS FOR THE PERIOD 1985-2021									DC20492
LAT.... 45.03		WATER HOLDING CAPACITY... 75 MM					HEAT INDEX... 36.49				
LONG... 76.25		LOWER ZONE..... 45 MM					A..... 1.076				
DATE	TEMP (C)	PCPN	RAIN	MELT	PE	AE	DEF	SURP	SNOW	SOIL	ACC P
31- 1	-9.2	69	19	24	1	1	0	42	58	74	303
28- 2	-8.0	55	15	29	1	1	0	43	68	75	358
31- 3	-2.0	61	33	76	8	8	0	101	21	75	418
30- 4	6.1	75	71	26	33	33	0	65	0	74	495
31- 5	13.2	75	75	0	81	81	0	10	0	57	570
30- 6	18.0	95	95	0	114	104	-10	11	0	37	666
31- 7	20.5	88	88	0	133	107	-27	2	0	17	755
31- 8	19.4	83	83	0	116	82	-34	2	0	15	838
30- 9	15.0	92	92	0	76	71	-5	5	0	31	930
31-10	8.3	88	87	1	37	37	0	18	0	64	88
30-11	1.5	75	60	10	10	10	0	49	5	74	163
31-12	-5.5	72	27	18	2	2	0	42	32	75	235
AVE	6.5 TTL	927	745	184	612	537	-76	390			
Drummond Centre		STANDARD DEVIATIONS FOR THE PERIOD 1985-2021									DC20492
DATE	TEMP (C)	PCPN	RAIN	MELT	PE	AE	DEF	SURP	SNOW	SOIL	ACC P
31- 1	3.1	27	24	23	1	1	0	39	32	5	53
28- 2	2.7	21	15	26	1	1	0	34	43	0	59
31- 3	2.4	29	22	31	5	5	0	35	43	0	68
30- 4	1.6	40	40	44	8	8	0	56	0	4	89
31- 5	1.6	30	30	0	10	10	0	17	0	23	98
30- 6	1.2	47	47	0	8	20	20	24	0	31	116
31- 7	1.4	35	35	0	9	30	33	9	0	23	128
31- 8	1.2	44	44	0	8	28	31	10	0	26	140
30- 9	1.4	40	40	0	8	13	12	17	0	27	134
31-10	1.5	34	35	4	7	7	2	26	0	18	34
30-11	1.9	29	27	10	4	4	0	33	10	3	46
31-12	3.1	26	20	14	2	2	0	25	29	0	47



OS Table 5: Monthly and Annual Water Budget (Summary), Environment Canada Climatic Water
Balance Model 1985-2021

	Mean Monthly T °C	Monthly PPT	PE mm	Water Surplus
January	-9.2	69	1.0	42.0
February	-8.3	55	1.0	43.0
March	-2.0	61	8.0	101.0
April	6.1	75	33.0	65.0
May	13.2	75	81.0	10.0
June	18.0	95	114.0	11.0
July	20.5	88	133.0	2.0
August	19.4	83	116.0	2.0
September	15.0	92	76.0	5.0
October	8.3	88	37.0	18.0
November	1.5	75	10.0	49.0
December	-5.5	72	2.0	42.0
Annual	6.5	927	612.0	390.0

OS Table 6: 2020s Monthly and Annual Water Budget (derived from data from (Kunjikutty, 2015))

	Mean Monthly T °C	Monthly PPT	PE* mm	Water Surplus
January	-8.9	74.9	0.0	74.9
February	-7.5	64.1	0.0	64.1
March	-0.9	64.1	0.0	64.1
April	6.6	70.9	31.2	39.6
May	14.1	79.5	83.1	-3.6
June	18.5	74.9	115.8	-40.9
July	21.3	88.7	139.4	-50.7
August	20.2	80.2	122.8	-42.6
September	14.7	91.1	74.6	16.4
October	8.5	74.5	36.8	37.6
November	1.8	80.0	5.6	74.4
December	-5.3	90.5	0.0	90.5
Annual	6.9	1000.9	609.4	323.8

OS Table 7: 2050s Monthly and Annual Water Budget (derived from data from (Kunjikutty, 2015))

	Mean Monthly T °C	Monthly PPT	PE* mm	Water Surplus
January	-7.1	81.9	0.0	81.9
February	-6.1	65.9	0.0	65.9
March	0.4	70.2	0.9	69.2
April	8.3	76.1	37.1	39.0
May	15.3	82.5	87.5	-5.0
June	19.4	69.8	119.4	-49.6
July	22.6	84.4	147.3	-62.9
August	21.4	81.0	129.0	-48.0
September	15.8	90.2	78.0	12.2
October	9.7	79.6	39.7	39.9
November	2.8	88.0	7.7	80.3
December	-3.7	96.3	0.0	96.3
Annual	6.9	1016.0	646.6	319.1

Appendix B: Recharge Calculations, Water Balance Models

Appendix B

Recharge Calculations, Water Balance Models



Water Budget from Normal			Runoff and Infiltration Areas		
Precipitation	0.876	m/yr	Catchment Area:	488,941	m ²
Evaporation	0.593	m/yr	Infiltration Area	488,941	m ²
Seepage					
Water Surplus	0.283	m/yr	Infiltration	85,790	m ³
Infiltrate	0.1755	m/yr	Runoff	52,581	m ³
Runoff	0.1075	m/yr	Total (Water Surplus)	138,566	m³

Water Budget from 2017 to 2021 5-year average			Runoff and Infiltration Areas		
Precipitation	1.053	m/yr	Catchment Area:	488,941	m ²
Evaporation	0.604	m/yr	Infiltration Area	488,941	m ²
Seepage					
Water Surplus	0.5	m/yr	Infiltration	151,572	m ³
Infiltrate	0.3100	m/yr	Runoff	92,899	m ³
Runoff	0.1900	m/yr	Total (Water Surplus)	138,566	m³

Water Budget from 2018 to 2022 5-year average			Runoff and Infiltration Areas		
Precipitation	1.001	m/yr	Catchment Area:	488,941	m ²
Evaporation	0.603	m/yr	Infiltration Area	488,941	m ²
Seepage					
Water Surplus	0.398	m/yr	Infiltration	120,651	m ³
Infiltrate	0.2468	m/yr	Runoff	73,947	m ³
Runoff	0.1512	m/yr	Total (Water Surplus)	138,566	m³



Water Budget from 2019 to 2023 5-year Average			Runoff and Infiltration Areas		
Precipitation	0.977	m/yr	Catchment Area:	488,941	m ²
Evaporation	0.604	m/yr	Infiltration Area	488,941	m ²
Seepage					
Water Surplus	0.373	m/yr	Infiltration	113,039	m ³
Infiltrate	0.2312	m/yr	Runoff	69,282	m ³
Runoff	0.1417	m/yr	Total (Water Surplus)	138,566	m³

Water Budget from 2023			Runoff and Infiltration Areas		
Precipitation	0.859	m/yr	Catchment Area:	488,941	m ²
Evaporation	0.613	m/yr	Infiltration Area	488,941	m ²
Seepage					
Water Surplus	0.247	m/yr	Infiltration	74,876	m ³
Infiltrate	0.1531	m/yr	Runoff	45,892	m ³
Runoff	0.0939	m/yr	Total (Water Surplus)	138,566	m³



Appendix C

Monitoring Well Logs



ELEVATION (mASL)	SCALE (m)	LITHOLOGY	MUD SANDGRAVEL	NOTES	SAMPLE NO.	INSTALLATION
202.0	1 2 3			layered, layers of medium to medium coarse sand layers of pebbles and stones, sets 20 to 60 cm thick		
199.3	4			stone layer		
197.7	5 6 7			medium to medium fine sand, occasional stone layer, ALCS <5 cm, layered, sets 10 to 20 cm thick, sample 1 at 6.10 mbgs. Calculated hydraulic conductivity was 2.3E-5 m/s	1 60-28-73	
195.0				Till, dense sandy silt, stone layers		
194.9				weathered/broken bedrock		
194.4				Precambrian bedrock, Pink Granite EOH 7.92 mBGS	Sa.72	

MUD SANDGRAVEL

- clay
- silt
- vf
- mvc
- gran
- pebb
- cobb
- boul

NOTES

SAMPLE NO.

INSTALLATION

1
2
3
4
5
6
7

layered, layers of medium to medium coarse sand layers of pebbles and stones, sets 20 to 60 cm thick

stone layer

medium to medium fine sand, occasional stone layer, ALCS <5 cm, layered, sets 10 to 20 cm thick, sample 1 at 6.10 mbgs. Calculated hydraulic conductivity was 2.3E-5 m/s

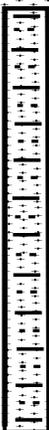
Till, dense sandy silt, stone layers

weathered/broken bedrock

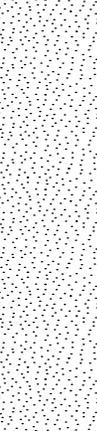
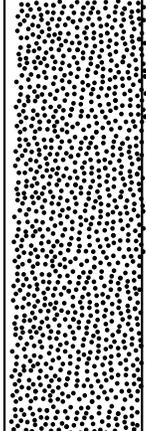
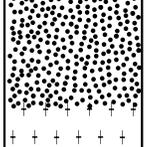
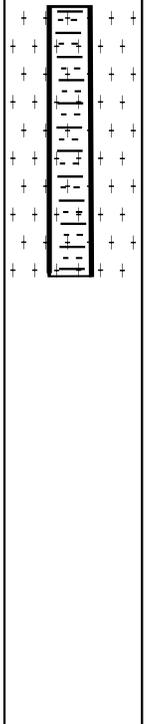
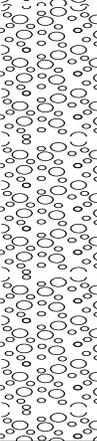
Precambrian bedrock, Pink Granite EOH 7.92 mBGS

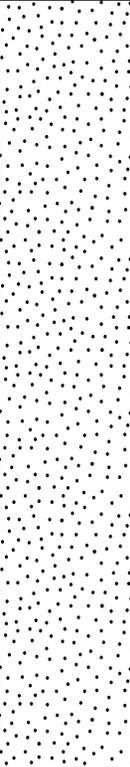
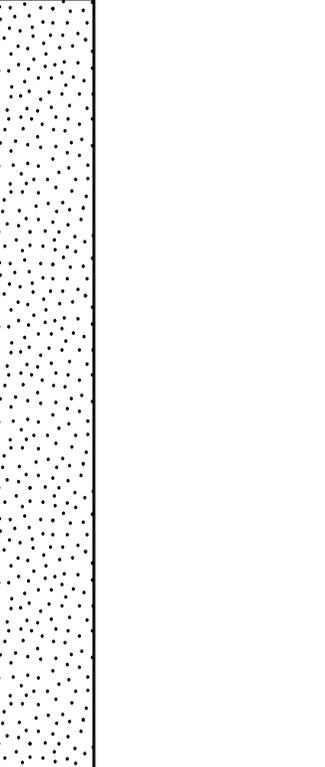
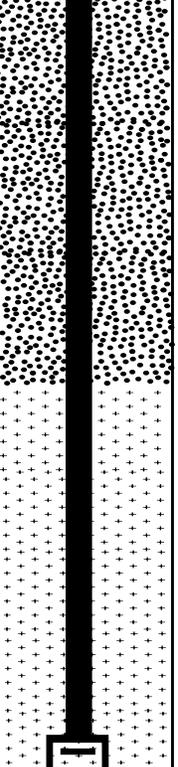
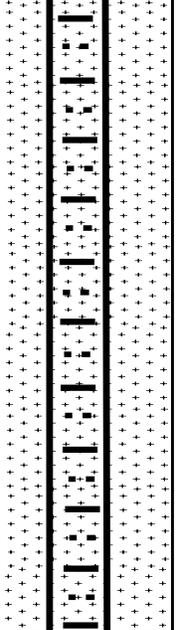
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60-28-73

Sa.72



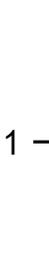
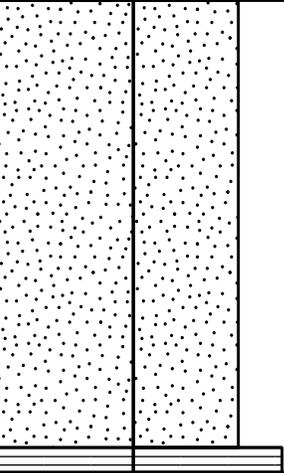
ELEVATION (mAASL)	SCALE (m)	LITHOLOGY	MUD SANDGRAVEL	NOTES	SAMPLE NO.	INSTALLATION
			-clay -silt -vf -m -vc -f -c -gran -pebb -cobb -boul			
190.7	1 2 3 4 5			layers of medium to medium coarse sand and to very coarse gravel, ALCS <5 cm		
181.6	6 7 8 9 10 11 12 13 14			layers of medium coarse to very coarse sand, ALCS 0.5 to 2 cm, Likely <25% stone, calculated hydraulic conductivity 4.1E-5 ms		
184.6	15 16 17 18			layers of medium coarse to very coarse sand, ALCS 0.5 to 2 cm, likely <25% stone; SA 2 medium coarse to very coarse sand, pebbles, ALCS <2 cm Stopped at 18.29 mBGS, sand coming up augers		

ELEVATION (mASL)	SCALE (m)	LITHOLOGY	MUD SANDGRAVEL -clay -silt -vf_mvc -gran -pebb -cobb -boul	NOTES	SAMPLE NO.	INSTALLATION
191.9	1 2 3 4			loose silty sand		
187.3	5 6			medium coarse to very coarse sand, pea gravel, ALCS 1 to 2 cm, FM 3 to 3.5		
185.8	7 8 9 10 11 12			medium coarse to very coarse sand, pea gravel, ALCS 1 to 2 cm, FM 3 to 3.5. Calculated hydraulic conductivity was 5.8E-05 m/s	sa3 1-2-18-16	
178.2	14 15 16 17 18			layered, 10 to 20 cm layers, medium coarse to coarse sand to silty fine sand layers Overall, medium to medium coarse. FM 2 to 2.5. Less than 10% stone.		
173.6				EOHat 18.29mBGS. No refusal, just stopped due to augers filling with sand		

ELEVATION (mASL)	SCALE (m)	LITHOLOGY	MUD SANDGRAVEL	NOTES	SAMPLE NO.	INSTALLATION
207.1				fine silty sand	Sa 1 and Sa 2	
204.1				grey, dense sandy silty to silty sand till ALCS <4cm	sa 3	
201.5				Bedrock - Granite		

-clay
 -silt
 -vf
 -m
 -vc
 -gran
 -pebb
 -cobb
 -boul

ELEVATION (mASL)	SCALE (m)	LITHOLOGY	MUD SANDGRAVEL	NOTES	SAMPLE NO.	INSTALLATION
197.9			<p>clay silt vf f c m vc gran pebb cobb boul</p>	<p>layers of medium to medium coarse sand and to very coarse gravel, ALCS <5cm</p> <p>Stopped at 8.23 mBGS, sand coming up augers, below water table</p>		
186.64						

ELEVATION (mASL)	SCALE (m)	LITHOLOGY	MUD SANDGRAVEL	NOTES	SAMPLE NO.	INSTALLATION
190.3			<ul style="list-style-type: none"> - clay - silt - vf - mvc - gran - pebb - cobb - boul 	<p>Unknown, but assumed to be sand, Installed by Arnett Bros to identify that the pit floor is at least 1 mBS. Base of installs at 1.89 mBGS. Installed 5.1 cm slotted pipe.</p>		

188.68