Preliminary Geotechnical Investigation and Hydrogeological Assessment

600 March Road, Kanata (Ottawa), Ontario

Nokia

April 07, 2022

→ **The Power of Commitment**

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Contents

Table index

Figure index

Appendices

1. Introduction

The technical services of GHD were retained by Nokia (Client) to carry out a preliminary Geotechnical Investigation and preliminary Hydrogeological Assessment for supporting the Zoning By-law Amendment application and Plan of Subdivision application for the redevelopment of the Nokia Campus. The Nokia Property is located at 600 March Road, Kanata (Ottawa), Ontario, hereafter referred to as the Site.

The purpose of the preliminary investigation was to evaluate the soil and bedrock stratigraphy as well as to assess preliminary groundwater conditions at the Site in order to provide preliminary geotechnical and hydrogeological recommendations and comments with respect to the most recent project concept/construction, including:

- Foundation design and geotechnical resistances and reaction values at limit states.
- Subgrade preparation for the building's slab-on-grade and external works.
- Recommendation on excavation and backfilling.
- Site seismic classification in accordance with the National Building Code of Canada (NBCC).
- Control of underground water during and after construction as well as drainage requirements.
- General construction recommendations.

As part of this investigation, ten boreholes were advanced, including installation of five monitoring wells, in situ hydraulic response testing, and laboratory testing to provide interpretation of factual information obtained. This report is accompanied by a series of five appendices including:

- Appendix A | Geotechnical Borehole Logs
- Appendix B | Rock Core Photos
- Appendix C | Results of Geotechnical Laboratory Testing
- Appendix D | Hydrogeological Assessment and Results
- Appendix E | Chemical Laboratory Results

Furthermore, this report has been prepared with limited understanding of the design as described in Section 2 and will be carried out in accordance with all applicable codes and standards. Any changes to the project described herein will require that GHD be retained to assess the impact of the changes on the recommendations provided.

This work was completed in accordance with our proposal reference number 12566614 dated October 27, 2021. This report is subject to a number of limiting conditions due to the inherent nature of geological, geotechnical, and hydrogeological profiles determined by investigative soundings. The applicable limitations of this investigation are explained following the technical section of this report. These limiting conditions are an integral part of this report and the reader is strongly encouraged to inform themselves in order to facilitate their comprehension, interpretation, and use of this document.

2. Site and Project Description

GHD understands that the property owner (Nokia) is looking to improve its existing campus situated on southeast corner of Terry Fox and March Road intersection (600 March Road). The total area of the site including structures, car parking, access roads and landscaped areas is approximately 26 acres. The Site is almost rectangular in shape and currently consists of 538,603 square feet of interconnected buildings on the north being used as Nokia office and lab space, and surface level parking lot on the south. The existing grading of the site is relatively flat with minimal changes in elevation. The site is surrounded by Terry Fox Drive to the north, March Road to the west, Legget Drive to the east and a commercial building to the south. The location of the Site is illustrated on the Site Location Plan attached as Figure 1 at the end of this report.

The plan is to amend the current zoning at this site to add additional density and uses into an integrated live/work/play community. The new Nokia campus will cover 9-acre area at the south end of the site. It will consist of multiple interconnected buildings with few levels of podiums, and an 8-storey and a 5-storey building with at least one level of underground parking covering the total footprint of the buildings.

A retail street bisecting the property east to west connecting March Road to Legget Drive is located adjacent to the Nokia campus at the north end. Retail units are on both sides of the street with eight storeys of residential buildings over top. The balance of the site to the north would be mixed use development in the form of residential towers with a north - south street through the centre of the site connecting the retail street to Terry Fox. The residential towers will consist of 8 to 28 storey buildings with at least one level of underground parking for each building.

The Site is located in the physiographic region of the Ottawa Valley Clay Plains. Surficial geological mapping indicates that the site is underlain by the clay plain consisting of the glaciomarine clay and silt deposits commonly known as the Leda Clay, with lenses of sand. According to the Paleozoic Geology of Southern Ontario map, bedrock at this site consists of interbedded dolomite with sandstone of Beekmantown Group.

3. Field Investigation

The fieldwork program was undertaken between January 28 and February 2, 2022, and consisted of the advancement of ten boreholes, identified as BH01-22 to BH10-22, inclusively, drilled to refusal/bedrock. The boreholes were advanced to depths ranging from 0.9 to 8.6 meters below ground surface (mbgs). Auger refusal was encountered at depths of 0.4 to 3.6 metres (m) in all boreholes. Upon encountering auger refusal, boreholes BH02-22, BH03-22, BH06-22, BH07-22, and BH10-22 were extended an additional 1.6 m to 6.4 m into the bedrock using rotary diamond drilling techniques while retrieving HQ sized core. The locations of the boreholes are illustrated on the Site Location Plan in Figure 1.

The borehole drilling operations were carried out with a rubber-track mounted drill auger rig, supplied, and operated by Aardvark Drilling Inc., under the supervision of GHD field staff. Boreholes were advanced into the overburden using hollow stem augers with Standard Penetration Tests (SPTs) at regular intervals using a 50-millimetre (mm) diameter split spoon sampler and a 63.5-kilogram (kg) hammer, free falling from a distance of 760 mm, to collect soil samples. The number of drops required to drive the sampler 0.3 m recorded on the borehole logs as "N" value.

The drilling procedure involved collection of shear strength data with field vane tests (FVTs) in strata where cohesive overburden was encountered. Sampling procedures were conducted in accordance with American Society for Testing and Materials (ASTM) Standard D 1586.

Wire line techniques using HQ size cores (96 mm outside diameter and 63.5 mm inside diameter) were used to advance the boreholes into the bedrock. A GHD field personnel documented the percentage recovery, thickness and depths of interbedded limestone layers, rock quality designation (RQD), the amount of water loss/return, and presence of voids or cavities in the bedrock. The rock cores were placed in partitioned wooden core boxes to keep each core run separate with depths of recovery clearly marked. Pictures of recovered cores have been provided in Appendix B. The percentage core recovery and RQD values are provided on the borehole logs included in Appendix A.

Boreholes BH01-22, BH02-22, BH03-22, BH06-22, and BH10-22 were fitted with a monitoring well for groundwater level measurement and hydrogeological assessment. Four monitoring wells (BH02-22, BH03-22, BH06-22, and BH10-22) were sealed within the bedrock, while one monitoring well (BH01-22) was sealed in overburden. Measurement for stabilized groundwater level and single well response tests (SWRTs) were completed between February 2 and 6, 2021 by GHD personnel.

All monitoring wells were instrumented with 1.5 (5-foot) and 3 m (10-foot) long, 50 mm (2-inch) inside diameter, No. 10 slot, Schedule 40 PVC screen set in the bedrock, and riser pipe. A fresh commercially available silica sand pack was placed in the annular space between the PVC screen/riser pipe and the borehole, from the bottom of the well screen to at least 0.30 m above the top of the well screen. Bentonite seal was placed above the sand pack to within 0.30 m of the ground surface. A protective casing with a concrete collar was placed around each of the monitoring wells upon completion. The monitoring well installation details are shown on the individual borehole logs included in Appendix A.

The elevations of the boreholes were surveyed using a survey grade GPS equipment referenced to the NAD 83 UTM Zone 18 and geodetic datum.

3.1 Laboratory Testing

All of the recovered geotechnical soil samples were transported to our laboratory where they were logged and visually identified for presentation purposes in this report.

Following the field work, geotechnical laboratory testing was conducted on representative soil and rock samples collected during the field works. The purpose of these laboratory tests was to determine the geotechnical engineering properties of the subsurface soil and rock for use in analysis. The laboratory tests undertaken are shown in Table 1.

Table 1 Laboratory Testing

Laboratory test	Quantity of tests undertaken
Water content testing	9
Atterberg limits tests	3
Sieve analysis	4
Hydrometer testing	3
Corrosivity testing	2*
UCS testing of rock core	5

Notes: UCS = Unconfined compressive strength
* Including one soil and one water samples

The geotechnical laboratory test results, and a summary table are presented in Appendix C. Results of the laboratory testing were used to confirm site soil logging and are discussed in the proceeding relevant subsurface condition section. One soil sample from borehole BH01-22 and one water sample from monitoring well BH04-22 were submitted to Eurofins Environment Testing for corrosivity testing parameters including, chloride, sulphate, pH, sulphide, redox potential, and resistivity. The results of chemical testing carried out on one soil sample and one groundwater sample are included in Appendix D.

The soil and rock samples will be stored for a period of 6 months, after which they will be discarded, unless otherwise requested by the Client.

4. Subsurface Conditions

The detailed subsoil conditions encountered at the locations of drilled boreholes are presented within the borehole reports located in Appendix A of this report. The following table presents an overview of the depth and elevation of each subsoil stratum encountered at the drilling locations:

Table 2 Summary of Subsurface Conditions in Meters

Borehole No.	Ground Surface Elevation	Asphalt/ Topsoil Thickness	Fill Thickness	Silty Clay to Clay		Bedrock		End of Borehole	
				Depth	Elev.	Depth	Elev.	Depth	Elev.
BH01-22	80.2	-	0.6	0.6	79.6	-	-	3.6	76.6

BH02-22	79.7	0.1	0.5	0.6	79.1	2.4	77.3	8.6	71.1
BH03-22	80.7	0.1	0.5	0.6	80.1	1.4	79.3	3.0	77.7
BH04-22	79.8	0.1	0.5	0.6	79.2	-	-	1.7	78.1
BH05-22	81.1	0.1	0.5	0.6	80.5	-	-	0.9	80.2
BH06-22	79.6	0.1	0.3	-	-	0.4	79.2	3.6	76.0
BH07-22	82.5	0.6	-	0.6	81.9	1.0	81.5	4.1	78.4
BH08-22	79.8	0.1	0.5	-	-	-	-	0.6	79.2
BH09-22	82.1	0.9	-	-	-	-	-	0.9	81.2
BH10-22	80.4	0.1	0.8	-	-	0.9	79.5	4.1	76.3

In general, soils encountered at the borehole locations consisted of a surface layer of asphalt or topsoil, overlying a fill material and discontinuous layer of native silty clay to clay, overlying sandstone with dolomite interbeds bedrock. Shallow bedrock ranging in depths of 0.6 to 0.9 mbgs was encountered at the northern site extremity and gradually increased to depths of up to 2.4 to 3.6 mbgs at the southern site boundary.

General descriptions of the subsurface conditions are summarized in the following sections, with a graphical representation of each borehole on the Geotechnical Logs in Appendix A. Notes on borehole logs are provided in Appendix A. Results from the laboratory testing and a summary table of pertinent laboratory results are presented in Appendix C.

4.1 Ground Cover

4.1.1 Topsoil

Topsoil was encountered in two boreholes (BH07-22 and BH09-22) to depths ranging from 0.6 to 0.9 mbgs and generally constituted of organic material with rootlets.

The topsoil descriptions, and thicknesses within this report are for preliminary estimation purposes only and should not be used for quality or quantity assessment. Furthermore, it should be noted that the thickness of topsoil may vary between borehole or test pit locations. Classification of this material was based solely on visual and textural evidence; testing of organic content or other constituents was not carried out as it was not part of the scope of work.

4.1.2 Pavement Structure and Fill

Asphalt layer with thickness of 100 mm was encountered at the ground surface at the location of boreholes BH01-22, BH02-22, BH03-22, BH04-22, BH05-22, BH06-22, BH08-22, and BH10-22. Granular base/subbase (fill material) consisting of sandy sit, sandy gravel to gravelly sand was encountered below the asphalt and extends to depths ranging from 0.4 to 0.9 m. Fill material was also encountered at the surface in borehole BH01-22 and extends to depth of 0.6 m.

Fill material was generally dense and was recovered in moist condition. Water content testing on fill materials returned results ranging from 10 percent to 13 percent. Sieve Analysis tests on two samples of fill returned results of 23 to 45 percent gravel, 29 to 58 percent sand and 19 to 26 percent fines.

4.2 Silty Clay to Clay

Silty clay to clay deposits were encountered below the fill or topsoil in boreholes BH01-22 to BH05-22, and BH07-22 at depth of 0.6 mbgs (Elevations 81.9 m to 79.1 m).

The SPT "N" values recorded within the silty clay to clay deposit range from 4 blows to 13 blows per 0.3 m of penetration. In situ shear vane testing carried out within this deposit measured undrained shear strength values in the range of 68 kilopascal (kPa) to 96 kPa, indicating that the deposit has a stiff consistency. Remolded shear strengths measured in the deposit ranged from about 19 kPa to 69 kPa. The calculated sensitivity ratios in this deposit generally range between 1 and 3, indicating low to medium sensitivity clay.

The water content measured on samples of the silty clay to clay range between 23 percent and 54 percent.

Grain size and Atterberg limits tests were carried out on three samples of the marine clay deposits. The laboratory results are included in Appendix C. A review of the results shows that the samples have 73 to 93 percent fines passing the No. 200 sieve, liquid limits between 57 and 64 percent, plastic limits between 17 and 25 percent, and plasticity indices between 33 and 40 percent, classifying the soil a high plasticity clay. Based on the laboratory test results, the clay deposits can be classified as Organic or Fat Clays (CH) in accordance with ASTM D2487. The fat clays are susceptible to volume change with change in moisture content, i.e., would shrink on drying and swell upon wetting.

4.3 Bedrock

Bedrock (including presumed) was encountered at depths ranging from 0.4 to 3.6 mbgs (Elevations 76.6 to 81.5 m). A summary of the bedrock depths and elevation for each borehole is presented in Table 2.

Upon refusal on the presumed possible bedrock, boreholes BH02-22, BH03-22, BH06-22, BH07-22, and BH10-22 were extended an additional 1.6 m to 6.4 m below the refusal using HQ diamond coring methods to confirm the presence, type, and quality of bedrock.

Based on retrieved rock core and rock exposures, bedrock at the site consists of slightly weathered to fresh, thinly to medium bedded, light grey with yellow bands dolomitic sandstone of the Beekmantown Group per the published Paleozoic geology map.

RQD values measured on the bedrock core samples generally range from 63 to 100 percent, indicating fair to excellent quality rock, except for bedrock at borehole BH10-22 where RQD value of 36 percent indicating poor quality rock is noted at depths of 3.5 to 4.0 mbgs. This low RQD value measured was due to mechanical break that occurred during the last core run of borehole BH10-22 drilling operations, resulting in loss of some of the drilled core sample.

Notes on RQD, solid core recovery (SCR) and total core recovery (TCR) are presented in Appendix A. Bedrock core photographs are presented in Appendix B.

Unconfined compressive strength (UCS) testing of five samples of the sandstone bedrock returned UCS values ranging from 91.1 megapascal (MPa) to 122.5 MPa, resulting in an average value of 106.6 MPa. In accordance with The Canadian Foundation Engineering Manual – 2006 (CFEM) bedrock is classified as strong to very strong. The results of UCS testing are presented in Appendix C and a summary of the UCS results is presented in Table 3 below.

Table 3 Results of Uniaxial Unconfined Compressive Strength Tests on Selected Bedrock

Borehole No.	Run No.	Sample Depth (m)	Compressive Strength (MPa)
BH02-22	5	6.5 - 7.5	122.5
BH03-22	2	2.0 - 3.0	91.1
BH06-22	2	1.9 - 3.6	94.2
BH07-22	3	3.5 - 4.1	111.8
BH10-22	1	0.9 - 2.0	113.3

Using the RQD, uniaxial compressive strength, joint conditions, and groundwater table conditions the bedrock can be rated as Class II "Good rock" in accordance with the Rock Mass Rating criteria as described in ASTM D5878.

5. Hydrogeologic Conditions

5.1 Groundwater Levels and Elevations

Monitoring wells were instrumented into boreholes BH01-22, BH02-22, BH03-22, BH06-22 and BH10-22 to allow for groundwater sampling, hydraulic response testing, and measurements o groundwater levels. The wells were developed on February 3, 2022, to remove all residual drilling fluids and to remove as much silt from the wells as possible. Post development groundwater levels were measured on February 9, 2022, prior to the single well response testing. The measured groundwater levels before and after well development are provided in the Table 4 below.

Table 4 Groundwater Elevations

Well ID	Ground Surface (mAMSL)	Screened Unit	February 03, 2022 (pre-development)		February 09, 2022 (post-development)	
			Depth (mBGS)	Elevation (mAMSL)	Depth (mBGS)	Elevation (mAMSL)
BH01-22	80.175	Overburden	Dry	-	Dry	-
BH02-22	79.717	Bedrock	3.88	75.84	3.88	75.84
BH03-22	80.705	Bedrock	1.55	79.15	Dry	-
BH06-22	79.607	Bedrock	2.86	76.74	3.33	76.28
BH10-22	80.431	Bedrock	3.00	77.43	3.19	77.24

Notes:
mBGS – metres below ground surface
mAMSL – metres above mean sea level

As shown above, the overburden well BH01-22 has been dry since installation. Groundwater levels did not recover in BH03-22 between development and hydraulic response testing.

Bedrock groundwater levels were measured at depths of 3.19 m BGS (BH10-22) to 3.88 m BGS (BH02-22) corresponding to elevations ranging from 75.84 mAMSL (BH02-22) to 77.24 mAMSL (BH10-22). These groundwater levels are based only on wells where the static groundwater levels have stabilized following well development.

It should be noted that the groundwater table is subject to seasonal fluctuations and in response to precipitation and snowmelt events.

5.2 Hydraulic Properties

Single well response testing was completed at all of the bedrock monitoring wells with sufficient water column using recovery testing techniques. A pressure transducer was installed in BH02-22, BH06-22, and BH10-22 to continuously measure water levels in the well during the tests. The wells were purged to induce an initial displacement and the resulting recovery of groundwater levels was monitored between February 9 and February 11, 2022. The water volume in BH06-22 was insufficient to produce an adequate response to be a successful recovery test.

Based on the results from the recovery tests, the horizontal hydraulic conductivity (K_h) of the Beekmantown Group Formation at the Site ranges from 2.073×10^{-6} (BH10-22) to 3.849×10^{-5} centimetre per second (cm/sec) (2.073×10^{-4} to 3.849×10^{-3} [metres per day] m/day) (geometric mean 8.93×10^{-6} cm/sec [8.93×10^{-4} m/day]). The solutions sheet for the recovery test analyses are presented in Appendix D.1.

6. Discussion and Recommendations

According to the information provided by the client, the project will consist of the construction of multiple interconnected buildings with a few levels of podiums and at least one level of underground parking for the south Nokia campus, and construction of multiple residential towers (8 to 28 storey buildings) with a minimum of one level of underground parking at each tower location for the north side of the site.

Structural details were not available at the time this report was prepared; however, it is anticipated that the proposed building foundations will be founded within the underlying bedrock, up to 3 to 4 m below the existing site grade.

Based on the aforementioned information, the geotechnical and hydrogeological findings at the borehole locations and assuming they are representative of the subsurface conditions across the entire Site, the preliminary geotechnical and hydrogeological recommendations and comments are provided in the following subsections. The following recommendations are provided on the basis that the structures will be designed in accordance with Part 4 of the 2012 Ontario Building Code (OBC).

Note that these recommendations are provided for the rezoning application and are solely intended to guide the client during this phase of the project development. We request that the recommendations presented herein be reviewed and re-evaluated as needed once the specific project details are known. Additional testing may be required to complete a detailed final geotechnical and hydrogeological investigation report for the detailed design purposes.

6.1 Site Preparation and Grading

Based on the conditions encountered in the boreholes, the Site is covered by an asphalt layer or surficial topsoil layer overlying earth fill material followed by a discontinuous layer of native silty clay to clay (marine clay) overlying sandstone with dolomite interbeds bedrock.

The site topography is noted to be relatively flat, hence significant grade raises are not anticipated as part of the proposed development plan.

Initial site preparation within the proposed structure footprints would require removal of existing topsoil, fill, deleterious materials, and disturbed native in order to expose the underlying native soils or bedrock. Within the pavement footprint, the existing fill below anticipated subgrade levels may remain in place as long as the material is proven to be competent, stable, and free of any organics and deleterious materials

Prior to site grading activity, the exposed subgrade soils should be visually inspected, compacted, and proof rolled under examination by geotechnical personnel using large axially loaded equipment. Any soft, organic, or unacceptable areas should be removed as directed by the qualified geotechnical personnel and replaced with suitable engineered fill materials compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD). Recommendations regarding placement of engineered fill are provided in Sections 6.10 and 6.12 of this report.

Bedrock excavation will also be required to achieve anticipated founding levels for underground services and underground parking levels. Recommendations regarding bedrock excavations are provided in Section 6.2.2

The granular fill material, free of topsoil/organic and rootlets, encountered at the site might be suitable for reuse as backfill to raise site grades, where required, or as trench backfill during installation of buried services, provided they are free of organic material, and are within the optimum moisture content. The surficial fill at this site should not be used as backfill against the foundation elements. Native soils with high proportions of silt and clays will be difficult to compact and are also susceptible to volume change with change in volume and therefore should not be used for backfilling under or around structure or for raising grades in the proposed pavement areas.

Reclaimed asphalt pavement (RAP) and/or reclaimed concrete material (RCM) may be used on this project as granular as stated in OPSS.MUNI 1010 "Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material" and as amended by City of Ottawa specification F-3142 "Reclaimed Asphalt Pavement (RAP) for Road Base".

It is noted that the proposed development also comprises removal of the existing interconnected Nokia structures. The environmental requirements for removal of existing building materials are not addressed in this report.

6.2 Mass Excavation

Considering one level of underground parking at all building locations, an excavation depth of up to 3 m is assumed for this project. The excavation will be carried out through topsoil or pavement structure fill layers followed by stiff silty clay to clay layer and will penetrate the underlying bedrock. These excavations will extend below the groundwater beyond a depth of approximately 1.5 m to 3.8 m below site grade.

6.2.1 Overburden Excavation

All excavations should be completed and maintained in accordance with the Occupational Health and Safety Act (OHSA) requirements. The following recommendations for excavations should be considered to be a supplement to, not a replacement of, the OHSA requirements.

The Occupational Health and Safety Act (OHSA) regulations require that if workmen must enter an excavation deeper than 1.2 m, the excavation must be suitably sloped and/or braced in accordance with the OHSA requirements. OHSA specifies maximum slope of the excavations for four broad soil types as summarized in the following table:

Table 5 Maximum Slope Inclinations based on Soil Types (OHSA)

Soil Type	Base of Slope	Maximum Slope Inclination
1	Within 1.2 m of bottom	One horizontal to one vertical
2	Within 1.2 m of bottom of trench	One horizontal to one vertical
3	From bottom of excavation	One horizontal to one vertical
4	From bottom of excavation	Three horizontal to one vertical

OHSA Section 226 defines the four soil types as follows:

Type 1 Soil:

1. Hard, very dense, and only able to be penetrated with difficulty by a small sharp object.
2. Has a low natural moisture content and a high degree of internal strength.
3. Has no signs of water seepage.
4. Can be excavated only by mechanical equipment.

Type 2 Soil:

1. Very stiff, dense and can be penetrated with moderate difficulty by a small sharp object.
2. Has a low to medium natural moisture content and a medium degree of internal strength.
3. Has a damp appearance after it is excavated.

Type 3 Soil:

1. Stiff to firm and compact to loose in consistency or is previously excavated soil.
2. Exhibits signs of surface cracking.
3. Exhibits signs of water seepage.
4. If it is dry may run easily into a well-defined conical pile.
5. Has a low degree of internal strength.

Type 4 Soil:

1. Soft to very soft and very loose in consistency, very sensitive and upon disturbance is significantly reduced in natural strength.
2. Runs easily or flows unless it is completely supported before excavating procedures.
3. Has almost no internal strength.
4. Wet or muddy.
5. Exerts substantial fluid pressure on its supporting system. Ontario Regulation (O. Reg.) 213/91, s. 226 (5).

No unusual problems are anticipated in excavating the soil using conventional excavating equipment. The subsoils above the water table can be considered Type 3 soils. Subsoils below the water table should be considered as Type 4 soils unless groundwater levels are lowered in advance of excavation. Furthermore, no vertical unbraced excavations should be performed in the soil.

If the above recommended excavation side slopes cannot be maintained due to lack of space or any other reason, the excavation side slopes must be supported by an engineered shoring system. The shoring system should be designed in accordance with Canadian Engineering Foundation Manual (4th Edition) and the OHSA Regulations for Construction Projects.

Depending on the climatic conditions and duration of the work, impermeable membranes may be required in order to prevent erosion and the development of local instabilities in the excavation slopes (soils).

During the excavation, excavated material, machinery or equipment should not be placed closer than one meter or the equivalent excavation depth (whichever is larger) from the top of the excavation sidewalls and the safety guidelines provided by OHSA (Section 226) should be strictly adhered to for the open cut excavations.

6.2.2 Bedrock Excavation

Within the bedrock, near-vertical excavations (10V:1H within sound bedrock) can be considered for this project. Bedrock at the site was noted to generally be good to excellent quality and strong to very strong.

Based on our experience with similar projects, the excavation of the upper portion of the fractured rock may potentially be possible with mechanical equipment (jackhammer and hydraulic shovel). Alternatively, the rock mass may be excavated through blasting techniques provided that adequate monitoring is performed by a qualified geotechnical engineer during these works.

To minimize overbreak of bedrock, line-drilling should be completed along the excavation perimeter. This will help maintain the integrity of the rock face throughout the depth of the excavation.

Rock excavation, including vibration control, during these works must be completed in accordance with municipal regulation. Additionally, these works must be monitored by a specialized firm (blasting patterns, protection of adjacent structures, etc.). It should be noted that blasting works can modify the permeability and bearing capacity of the bedrock. Excessive fracturing of bedrock, caused by poorly controlled blasting operations, should thus be avoided. Rigorous control of rock excavation work should therefore be a priority.

All rock excavation faces should be inspected by qualified geotechnical engineer, to detect any possible instabilities. All stabilization works must comply with applicable health and safety regulations and must be validated by a geotechnical engineer.

6.2.3 Temporary Drainage

Surface water seepage is expected in the excavation. Based on the excavation depth of about 3 m, groundwater seepage is expected in the excavated areas. Groundwater levels depend on seasonal conditions and dewatering may need to be reassess especially where any variation in depth of excavations is proposed or where excavations are left open. Conventional construction dewatering techniques should be taken during construction, such as pumping from sumps and or ditches. Additional information on groundwater control during the construction is provided in Section 6.7.

6.3 Foundations

In general, the subsurface conditions in the area of the proposed residential buildings consist of fill/topsoil overlying discontinuous deposit of silty clay to clay, over bedrock. The depth to bedrock is variable across the site, ranging from elevations 76.6 m at the south end to 81.5 m at the north (i.e., 0.4 to 3.6 mbgs). Considering one level of underground parking at all building locations, the foundations of the new buildings should consist of conventional spread and/or strip footings resting on sound bedrock, clean and free of weathering or loose fragments.

Footings placed on sound sandstone bedrock can be designed using a factored bearing capacity value at Ultimate Limit State (ULS) of 3.0 MPa. The factored ULS value includes the geotechnical resistance factor (Φ) of 0.5 for shallow foundations. Serviceability Limit State (SLS) resistance do not apply to footings founded on the bedrock, since the SLS resistance is greater than the factored bearing capacity at ULS.

The bedrock surface should be covered with a minimum 50 mm thick mat of high-slump 0.4 to 1 MPa unshrinkable concrete to provide a smooth working surface and to fill any low depressions and 'nook' and crannies'.

6.4 Frost Protection

All of the exterior building foundations (exterior pile caps, grade beams, footings, etc.) for heated structures should be placed at least 1.5 m beneath the final exterior grade in order to provide adequate frost protection.

Building foundations for unheated structures or isolated exterior foundations (retaining walls, signs, lamp posts, etc.) should be placed at least 1.8 m beneath the final exterior grade in order to provide adequate frost protection.

6.5 Seismic Site Classification

The 2012 Ontario Building Code (OBC) requires the assignment of a seismic site class for calculations of earthquake design forces and the structural design based on a 2 percent probability of exceedance in 50 years. According to the 2012 OBC, the seismic site class is a function of soil profile and is based on the average properties of the subsoil strata to a depth of 30 m below the ground surface. The 2012 OBC provides the following three methods to obtain the average properties for the top 30 m of the subsoil strata:

- Average shear wave velocity.
- Average Standard Penetration Test (SPT) values (uncorrected for overburden).
- Average undrained shear strength.

During the preliminary geotechnical investigation, the depths of boreholes extended to a maximum depth of 8.6 mbgs and terminated within the sandstone bedrock. For the planning purposes, based on the criteria listed in Table 4.1.8.4.A. of the 2012 OBC and our knowledge of the regional geology and borehole data, and in absence of geophysical seismic survey, a **Seismic Site Class 'C'** can be used.

Knowing that the structures will have at least one level of underground parking and will likely be founded on or within bedrock, it is recommended that a site-specific test should be carried out to confirm the seismic site class. The Multi-Channel Analysis of Surface Waves (MASW) is a relatively economical and quick method of determining seismic site class. GHD can provide MASW services, if required.

6.6 Floor Slabs

A conventional slab-on-grade, structurally separated from the columns and foundation walls, can be used for the lowest basement level floor slab of the buildings on the site prepared as discussed in Sections 6.1 and 6.10. Based on the borehole data, the subgrade beneath a slab-on-grade within the investigated area is expected to comprise of either native silty clay to clay strata or sandstone with interbedded dolomite bedrock.

Specifically, the native soils at the site may be suitable to support the slab-on-grade provided unsuitable materials that may be present are removed and the exposed subgrade is proof-rolled, recompacted, and inspected by qualified geotechnical personnel. If grades are to be raised, then suitable engineered fill should be placed as discussed in Section 6.9.

A layer consisting of Granular 'A' at least 200 mm thick and combined with a drainage system as specified in Section 6.7 should be placed immediately below the floor slabs to support the slab-on-grade. This layer should be compacted to 100 percent of its SPMDD and placed on approved subgrade surfaces.

If floor coverings are to be used on slab-on-grades then, a vapour barrier is recommended to be incorporated beneath the slab and should be specified by the architect. Floor toppings may also be impacted by curing and moisture conditions of the concrete. Floor finish manufacturer's specifications and requirements should be consulted, and procedures outlined in the specifications should be followed.

The slabs should not be tied into the foundation walls. Construction and control joints in the concrete should be designed by a suitably qualified and experienced engineer.

6.7 Preliminary Groundwater Control Analysis

6.7.1 Modelling Assumptions

To estimate the volume of water needed to be dewatered for each Site building the following assumptions were used:

- The footprint of each building was measured based on the Conceptual Site Plan shown in Appendix D.2 by using the scale on Figure 1 and matching the size of features around the Site.
- The size of the excavation is assumed to match the footprint of the building and be excavated vertically through the bedrock.
- The shape of the excavations were broken down into simple rectangular areas to allow for simple modelling using shafts and trenches based on the relative lengths of the sides, as shown in the summary table in Appendix D.4.
- The total flow into the excavations were assumed to a sum total of each block of the building even though the shapes have shared edges (conservative assumption).
- A uniform excavation depth for each building was used to 3 m below ground surface.
- A single water elevation measurement event was used.

6.7.2 Water Taking Rate Estimate Methodology

The equation for construction water-taking rate of an unconfined aquifer shaft and trench [Canadian Geotechnical Society/Southern Ontario Section - Toronto Group, International Association of Hydrogeologists/Canadian National Chapter (CGS), 2013], are presented below in Equation 6-1 and 6-2, respectively. These rates are then applied to estimate construction water-taking for each Site building.

$$Q = \frac{\pi K_h (H^2 - h^2)}{\ln\left(\frac{R_0}{r_w}\right)}$$

Equation 6-1
Shaft

$$Q = \frac{\pi K_h (H^2 - h^2)}{\ln\left(\frac{R_0}{r_w}\right)} + 2\left[\frac{x K_h (H^2 - h^2)}{2R_0}\right]$$

Equation 6-2
Trench

Where:

- Q is pumping rate in units of cubic metres per day (m^3/day)
- ln is the natural logarithm
- K_h is the hydraulic conductivity, as defined in Section 5.2, in metres per day (m/day)
- H is the height of groundwater pressure at the excavation in meters above a relevant datum

- h is the height of groundwater near the excavation in meters following water-taking activities and is referenced to a relevant datum
- R_0 is the zero drawdown distance, or zone of influence (ZOI)
- rw the radius of the shaft

To estimate the radius to zero drawdown (R_0), representing the ZOI near the excavations GHD applied the empirical Sichardt relationship expressed as Equation 6-3, below.

$$R_0 = 3000(H-h)\sqrt{K_h \times \frac{1 \text{ day}}{86{,}400 \text{ seconds}}} + r_w$$

Equation 6-3

The height of the aquifer thickness, H, was measured based on static water levels measured in the monitoring wells and the assumed elevation of the bottom of the excavations.

6.7.3 Water Taking Analysis

Groundwater elevations following construction water taking are anticipated to be 76.5 mAMSL. This will be within the Beekmantown Group formation. Prior to construction water taking the static water levels from the unconfined bedrock unit are expected to be approximately 3.19 mBGS (77.24 mAMSL) (based on BH10-22).

It is assumed that water taking will lower the water table to 0.5 m below the base of the excavations, 77.0 mAMSL. A summary of the depths and corresponding elevations is provided below.

Table 6 Summary of Assumed Excavation Elevations

	Depth (mBGS)	Elevation (mAMSL)
Ground	0	80*
Water Table	3.19	77.24^
Base of Excavations	3.00	77*
Water-Taking Level, 0.5 m below deepest part of excavation	3.50	76.5*

Notes: * Uniform site elevation and excavation depths used
^- BH10-22 water elevation used across Northern portion of the Site

The required drawdown is anticipated to be 0.74 m within each excavation area.

The results from the recovery tests were used to estimate the hydraulic properties (hydraulic conductivity) of the bedrock that were then used to estimate groundwater taking rates and area of influence for excavations within the Beekmantown Group formation. The results from the recovery tests completed within BH02-01 and BH10-01 estimate the hydraulic conductivity (K_h) of the bedrock ranging from 2.073×10^{-6} (BH10-22) to 3.849×10^{-5} cm/sec (2.073×10^{-4} to 3.849×10^{-3} m/day) (geometric mean 8.93×10^{-6} cm/sec [8.93×10^{-4} m/day]).

The analytical model input parameters are summarized as follows:

K_h= 8.93×10^{-6} cm/sec (8.93×10^{-4} m/day)
H= 0.736 m height of water table[1]
h_w= 0 m water-taking height (relative to 0.5 m below base of excavation)

The same inputs were used for each of the eight proposed residential buildings north of the northern cross street between March Road and Legget Drive. The conceptual Site plan shown in Appendix D.2 has all of the residential

[1] Height measurements are relative to base of active groundwater flow system and is assumed to be base of dewatering, or 0.5 m below base of excavations (76.5 mAMSL).

buildings numbered for ease of discussion. Residential Buildings 9 and 10, and the office building south of that cross street will not require dewatering based on the February 9th, 2022 groundwater elevations measured in BH06-22 and BH02-22. These conditions may change based on seasonal fluctuations.

Using Equation 6-1 and 6-2, the water-taking rates and radius of influence (R_0) estimated for each excavation are summarized below:

Table 6 Water Taking Estimates

Building	Building Description	Estimated Q (m^3/day)	Estimated Q (L/min)	Estimated R_0 (m)
1	North corner of Terry Fox & Legget dual 16 level unit	1.121	0.778	39.28
2	North Site 13 and 18 level unit	1.144	0.794	37.57
3	Northwest Site northern 28 level twin	0.41	0.285	20.47
4	Northwest Site southern 28 level twin	0.41	0.285	20.47
5	West side 20 level unit	0.62	0.431	30.89
6	West side 14 level unit	0.86	0.597	36.89
7	Mid-west side 10 level unit	0.66	0.458	32.96
8	East side 12 level unit	0.67	0.468	34.18

The water-taking model sheets showing the above inputs are provided in Appendix D.3. Based on the calculations presented in Sections 6.7.2 the water-taking zones of influence are estimated to range between 20.47 to 39.28 m around the building excavations.

During the early stages of water-taking, additional groundwater will be pumped to draw down groundwater in storage. A safety factor of 3x is often applied to allow for a higher water-taking rate during the early stages of groundwater pumping and to account for variability of bedrock fracture conditions. Using a safety factor of 3x, the approximate water-taking rates are summarized below:

Table 7 Estimated Water Taking with 3x Safety Factor

Building	Safety Factored Q (m^3/day)
1	3.36
2	3.43
3	1.23
4	1.23
5	1.86
6	2.58
7	1.98
8	2.02

6.7.4 Summary

The preliminary water-taking rates for all Project excavations are summarized below.

Table 8 Summary of Preliminary Water Taking Rates

Building	Steady State Groundwater Inflow (L/day)	Safety Factor 3x (L/day)
1	1,121	3,363
2	1,144	3,432
3	410	1,230
4	410	1,230
5	620	1,860
6	860	2,580
7	660	1,980
8	674	2,022
9	--	--
10	--	--
Office	--	--

Notes: -- Construction dewatering not required based on February 9, 2022 groundwater elevations

6.7.5 Water Taking Discussion

The water taking analysis presented above is strictly a preliminary hydrogeologic assessment of the proposed Site excavations. Further information is required both with respect to the seasonal fluctuation of groundwater elevations and more accurate site building drawings need to be reviewed in order to increase the accuracy of the models used.

According to O. Reg. 63/16 and O. Reg. 387/04, if the volume of water to be pumped from excavations for the purpose of construction dewatering is greater than 50,000 litre per day (L/day) a Permit to Take Water (PTTW) is required from the Ministry of the Environment, Conservation and Parks (MECP). According to O. Reg. 63.16, if short-term construction site dewatering is greater than 50,000 L/day but less than 400,000 L/day, registry with the Environmental Activity Sector Registry (EASR) is sufficient and PTTW is not required. However, based on the preliminary groundwater inflow estimates provided above, water taking exceeding 400,000 L/day will not be required to dewater groundwater excavations during construction.

Long-term, permanent, dewatering rates of 5,900 L/day are expected to control groundwater after construction. Therefore, the water taking associated with long-term dewatering would not require a PTTW.

It should be noted that the SWRTs used to estimate the hydraulic conductivity of the overburden and bedrock tests the immediate vicinity of the well. SWRTs do not provide an indication of the long-term availability of groundwater to recharge the well. Accordingly, it is possible that the instantaneous recharge to the bedrock wells is extremely fast, but the long-term effects of dewatering may result in progressively lower groundwater intrusion over time.

The estimates presented above used a conservative approach to estimate the groundwater taking at each building. The water level was assumed to be flat based on the largest dewatering level needed in the North of the Site around BH10-22.

Further water elevation measurement events will be needed to establish the seasonal fluctuations and provide a better estimate for the dewatering volumes.

Below sections provide additional recommendations for permanent drainage, perimeter drainage and sub-floor drainage.

6.7.6 Permanent Drainage

6.7.6.1 Underfloor Drainage

Under floor drains are recommended for structures with underground levels. The drains should be connected to a frost-free outlet for year-round drainage. For preliminary purposes, the under-slab drainage system should consist of:

– 300 mm thick clear stone (20-5 mm) having a permeability of 1 cm/s or more, compacted with a heavy compactor. Moreover, a Texel geotextile membrane or equivalent should be placed between the crushed stone and sand deposit fill to avoid clogging of the clean crushed stone and reducing the thickness of the drainage layer.

– 100 mm (4") perforated drainpipes spaced at 4 to 6 m centre to centre, connected to sufficient capacity collectors depending on the area covered by the drainpipes.

– A sump pump of sufficient capacity with an additional half design-capacity pump for uninterrupted service in low discharge periods, with proper backup system.

It is recommended that the underside of the basement floor slab be protected with a waterproofing membrane to prevent water penetration into the basement level.

6.7.6.2 Perimeter Drainage

As groundwater has to be controlled underneath the building slab-on-grade level, backfilling of foundation walls should be carried out mostly using granular materials, such as compacted granular backfill such as an OPSS "Granular BI or BII" type product.

Where foundation walls are present, it is recommended that Composite Drainage Blanket (CDB) or geo-drain be used for the perimeter walls. There are several commercially available product liens available. The CDB should be connected by a collection piping system and drained to a frost-free outlet for year-round drainage.

As the underground portion of the structure is anticipated to be below the water table, it is also recommended that the exterior walls be protected with a waterproofing membrane applied to the wall in addition to the CDB.

6.7.6.3 Elevator Pits

Elevator pits, if present, should have drainage weepers and waterproofing design measures. If drainage weepers are not practical, then the pits will need to be designed to resist hydraulic buoyancy pressures.

If elevator pistons are used, then the designers of these shafts and installations will need to also consider buoyancy issues. Installation of these will also need to consider groundwater control and buoyancy during installation.

6.8 Corrosion Potential of Soils

Analytical testing on one soil sample and one water sample was undertaken to assess the corrosion potential of buried concrete and steel structural elements. The test results are provided in Appendix D and summarized in Table 9.

Table 9 Corrosivity Test Results

Sample ID/Type	Depth Intervals (m)	Chlorides (% for Soil) (mg/L for Water)	Sulphates (% for Soil) (mg/L for Water)	pH	Resistivity (Ohm-cm)	Redox Potential (mV)
BH01-22, SS2	2.3 - 2.7	0.067	0.04	7.79	1180	210
BH02-22	-	820	220	7.54	298	237

Based on the results obtained for the samples submitted, the soil and groundwater at the site are considered to be extremely corrosive to cast iron pipe.

A review of the analytical test results shows the sulphate content in the tested sample is less than 0.1 percent in soil sample and between 150 milligram per litre (mg/L) to 1500 mg/L in water sample. Based upon the test results and Table 3 of the Canadian Standards Association (CSA) document A23.1-04/A23.2-04 'Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete', the degree of exposure of the subsurface concrete structures to sulphate attack is moderate. Therefore, moderate sulphate resistance (MS) cement should be used for the below grade concrete structures.

6.9 Building Backfill

Where it is required to have the placement and compaction of the granular materials and these will support the floor slabs, foundations, pavement, or any interior backfill then these materials must be treated as Engineered Fill.

6.9.1 Engineered Fill

The fill operations for Engineered Fill must satisfy the following criteria:

- Engineered Fill must be placed under the continuous supervision of the Geotechnical Engineer.
- Prior to placing any Engineered Fill, all unsuitable existing fill, topsoil, and deleterious materials must be removed. Following this the subgrade should be proof rolled with any weak/soft areas being over excavated and replaced with engineered fill.
- Prior to the placement of Engineered Fill, the source or borrow areas for the Engineered Fill must be evaluated for its suitability. Samples of proposed fill material must be provided to the Geotechnical Engineer and tested in the geotechnical laboratory for SPMDD and grain size, prior to approval of the material for use as Engineered Fill. The Engineered Fill must consist of environmentally suitable soils (as per industry standard procedures of federal or provincial guidelines/regulations), free of organics and other deleterious material (building debris such as wood, bricks, metal, and the like), compactable, and of suitable moisture content so that it is within -2 percent to +0.5 percent of the Optimum Moisture as determined by the Standard Proctor test. Imported granular soils meeting the requirements of Granular 'A', or 'B' Type II OPSS 1010 criteria would be suitable.
- The Engineered Fill must be placed in maximum loose lift thicknesses appropriate to the compaction equipment utilized. Typical loose thicknesses range from 0.2 m to 0.3 m. Each lift of Engineered Fill must be compacted to 100 percent SPMDD using an appropriately sized roller, suitable for the fill material.
- Field density tests must be taken by the Geotechnical Engineer, on each lift of Engineered Fill. Any Engineered Fill, not meeting compaction specifications, shall be removed or re-compacted and retested.

6.9.2 Exterior Foundation Wall Backfill

Where applicable and/or if necessary, any backfill placed against the foundation walls should be free draining granular materials meeting the grading requirements of OPSS 1010 for Granular 'B' Type I specifications up to within 0.3 m of the ground surface. The upper 0.3 m should be a low permeable soil to reduce surface water infiltration. Foundation backfill should be placed and compacted as outlined below.

- Free-draining granular backfill should be used for the foundation wall.
- Backfill should not be placed in a frozen condition or placed on a frozen subgrade.
- Backfill should be placed and compacted in uniform lift thickness compatible with the selected construction equipment, but not thicker than 0.2 m. Backfill should be placed uniformly on both sides of the foundation walls to avoid build-up of unbalanced lateral pressures.
- At exterior flush door openings, the underside of sidewalks should be insulated, or the sidewalk should be placed on frost walls to prevent heaving. Granular backfill should be used and extended laterally beneath the entire area of the entrance slab. The entrance slab should slope away from the building.
- For backfill that would underlie paved areas, sidewalks, or exterior slabs-on-grade, each lift should be uniformly compacted to at least 98 percent of its SPMDD.

- For backfill on the building exterior that would underlie landscaped areas, each lift should be uniformly compacted to at least 95 percent of its SPMDD.
- In areas on the building exterior where an asphalt or concrete pavement will not be present adjacent to the foundation wall, the upper 0.3 m of the exterior foundation wall backfill should be a low permeable soil to reduce surface water infiltration.
- Exterior grades should be sloped away from the foundation wall, and roof drainage downspouts should be placed so that water flows away from the foundation wall.

6.10 Underground Services

6.10.1 Bedding and Cover

Underground service lines, if any, can be founded on either undisturbed native soils or on bedrock. The suitability of the foundation soils to provide adequate support for buried services must be verified and confirmed on site at the time of construction/installation by qualified geotechnical personnel experienced in such work.

It is recommended that prior to commencing the construction of the site servicing, consideration be given to the excavation of a series of trial excavations along the alignment of the proposed service lines to determine more accurately the soil behavior and whether or not any dewatering works will be required.

The following are recommendations for service trench bedding and cover materials that may be associated with the development.

- Bedding for buried utilities should consist of 150 mm Granular 'A' and placed in accordance with City of Ottawa specifications.
- The cover material, from bedding level to at least 300 mm above the top of pip, should consist of Granular 'A' or Granular B Type I and the dimensions should comply with City of Ottawa standards.
- The bedding material and cover materials should be compacted as per City of Ottawa standards and to at least 95 percent of its SPMDD.
- Compaction equipment should be used in such a way that the utility pipes are not damaged during construction.

6.10.2 Service Trench Backfill

Backfill above the cover for buried utilities should be in accordance with the following recommendation:

- For service trenches under pavement areas, the backfill should be placed and compacted in uniform thickness compatible with the selected compaction equipment and not thicker than 200 mm. Each lift should be compacted to a minimum of 95 percent SPMDD.

6.11 Pavement Design Recommendations

Access driveways and parking areas are expected to be constructed over native stiff silty clay to clay, bedrock or engineered fill. In order to prepare the site for the pavement area, it is necessary that the area be stripped of any existing cover materials such as surficial topsoil or any other deleterious materials deemed unsuitable by geotechnical personnel to expose a suitable subgrade. The exposed subgrade should be proof rolled in the presence of a Geotechnical Engineer. Any areas where "soft spots", rutting, local anomalies, or appreciable deflection are noted should be excavated and replaced with suitable fill. In problematic areas the use of geotextiles may be warranted for strength improvement. The fill placed to repair a subgrade should be compacted to at least 98 percent of its SPMDD.

The preliminary pavement sections described in the table below are recommended for areas subjected to parking lot and access road. GHD could review these preliminary pavement structures should Nokia provide GHD with project traffic design parameters. Pavement materials and workmanship should conform to the appropriate Ontario Provincial Standard Specifications (OPSS).

Table 10 Recommended Pavement Structure - 20 Year Design Life

Pavement Structure Elements	Compaction Requirement	Layer Thicknesses (mm)	
		Standard Duty (Car Parking Areas)	Heavy Duty (Access Roads)
Surface Course OPSS 1150 HL3 Hot Mix	OPSS 310, Table 10	50	40
Base Course OPSS 1150 HL8 HS Hot Mix Asphalt	OPSS 310, Table 10	-	50
Granular A Base (19 mm crusher run limestone)	100% SPMDD	150	150
Granular B Type I Subbase (Sand and Gravel)	100% SPMDD	250	500

In order to accommodate the recommended thicknesses, designers will need to review grades and determine where stripping or filling is necessary. Pavement materials and workmanship should conform to the appropriate OPSS.

To maintain the integrity of the pavement at the Site, filter-cloth wrapped 100 mm diameter PVC perforated subdrains should be installed at all catch basins (3 m stubs in the upgradient direction) and all along the perimeter of the parking lot. The invert of the subdrains should be at least 300 mm below the bottom of the subbase and should be sloped to drain to adjacent catch basins. The subdrains should be installed in a 300 mm by 300 mm trench lined by suitable geotextile and consist of a 100 mm diameter perforated pipe wrapped in a suitable geotextile and surrounded with a minimum thickness of 50 mm of free draining sand such as clear stone wrapped with a filter cloth or concrete sand.

Grading adjacent to pavement areas should be designed so that water is not allowed to pond adjacent to the outside edges of the pavement. Surface runoff should be directed to storm sewers or allowed to flow into ditches.

Annual or regular maintenance will be required to achieve maximum life expectancy. Generally, the asphalt pavement maintenance will involve crack sealing and repair of local distress.

It should be noted that the preliminary pavement sections described within this report represent end-use conditions only, which includes light vehicular traffic and occasional garbage or service trucks. It may be necessary that these sections be temporarily over-built during the construction phase to withstand larger construction loadings such as loaded dump trucks or concrete trucks. Pavement design for the new road dissecting the property into commercial and residential sections can be provided during the detail design when project traffic design parameters are available.

6.12 Construction Field Review

The recommendations provided in this report are based on an adequate level of construction monitoring being conducted during construction phase of the proposed building. GHD requests to be retained to review the drawings and specifications, once complete, to verify that the recommendations within this report have been adhered to, and to look for other geotechnical problems. Due to the nature of the proposed development, an adequate level of construction monitoring is considered to be as follows:

- Prior to construction of footings, the exposed foundation subgrade should be examined by a Geotechnical Engineer or a qualified Technologist acting under the supervision of a Geotechnical Engineer, to assess whether the subgrade conditions correspond to those encountered in the boreholes, and the recommendations provided in this report have been implemented.
- A qualified Technologist acting under the supervision of a Geotechnical Engineer should monitor placement of Engineered Fill underlying floor slabs.
- Backfilling operations should be conducted in the presence of a qualified Technologist on a part time basis, to ensure that proper material is employed, and specified compaction is achieved.
- Placement of concrete should be periodically tested to ensure that job specifications are being achieved.

7. Scope and Limitation

This report has been prepared by GHD for Nokia Inc. and may only be used and relied on by Nokia Inc. for the purpose agreed between GHD and Nokia Inc. as set out in Section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Nokia Inc. arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

The recommendations made in this report are in accordance with our present understanding of the project, the current Site use, ground surface elevations and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of geotechnical engineering professions currently practicing under similar conditions in the same locality.

No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in this report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. We should be retained to review our recommendations when the drawings and specifications are complete. Without this review, GHD will not be liable for any misunderstanding of our recommendations or their application and adaptation into the final design. By issuing this report, GHD is the geotechnical engineer of record. It is recommended that GHD be retained during construction of all foundations and during earth-work operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the test locations only. The subsurface conditions confirmed at the test locations may vary at other locations. The subsurface conditions can also be significantly modified by the construction activities on Site (ex., excavation, dewatering and drainage, blasting, pile driving, etc.). These conditions can also be modified by exposure of soils or bedrock to humidity, dry periods, or frost. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction which could not be detected or anticipated at the time of our investigation. Should any conditions at the Site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD are completed.

Figures

LEGEND

PROPERTY BOUNDARY

PROPOSED BUILDING OUTLINE

BOREHOLE LOCATION

(81.5) ELEVATION OF INTERBEDDED SANDSTONE

(>=81.2) ELEVATION OF AUGER REFUSAL

1 BUILDING NUMBER

0 25 50 75m

1:2500

Coordinate System: UTM with NAD83 datum, Zone 18, Meter;

GHD

NOKIA CAMPUS REZONING
570 and 600 MARCH ROAD
KANATA
(OTTAWA)

BOREHOLE LOCATION PLAN

Project No. 12566614
Date March 2022

FIGURE 1

Filename: \\ghdnet\ghd\CA\Ottawa\Projects\661\12566614\Digital_Design\ACAD\Figures\RPT001\12566614-GHD-0000-RPT-EN-0101_WA-001.DWG
Plot Date: 24 March 2022 10:46 AM

Appendices

Appendix A

Explanatory Notes, Geotechnical Borehole and Test Pit Logs,

Notes on Borehole and Test Pit Reports

Soil description :

Each subsurface stratum is described using the following terminology. The relative density of granular soils is determined by the Standard Penetration Index ("N" value), while the consistency of clayey sols is measured by the value of undrained shear strength (Cu).

Classification (Unified system)

Clay	< 0.002 mm		
Silt	0.002 to 0.075 mm		
Sand	0.075 to 4.75 mm	fine	0.075 to 4.25 mm
		medium	0.425 to 2.0 mm
		coarse	2.0 to 4.75 mm
Gravel	4.75 to 75 mm	fine	4.75 to 19 mm
		coarse	19 to 75 mm
Cobbles	75 to 300 mm		
Boulders	>300 mm		

Terminology

"trace"	1-10%
"some"	10-20%
adjective (silty, sandy)	20-35%
"and"	35-50%

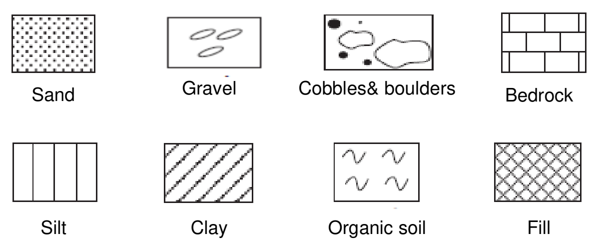
Relative density of granular soils	Standard penetration index "N" value (BLOWS/ft – 300 mm)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Consistency of cohesive soils	Undrained shear strength (Cu) (P.S.F)	(kPa)
Very soft	<250	<12
Soft	250-500	12-25
Firm	500-1000	25-50
Stiff	1000-2000	50-100
Very stiff	2000-4000	100-200
Hard	>4000	>200

Rock quality designation

"RQD" (%) Value	Quality
<25	Very poor
25-50	Poor
50-75	Fair
75-90	Good
>90	Excellent

STRATIGRAPHIC LEGEND



Samples:

Type and Number

The type of sample recovered is shown on the log by the abbreviation listed hereafter. The numbering of samples is sequential for each type of sample.

SS: Split spoon
SSE, GSE, AGE: Environmental sampling
ST: Shelby tube
PS: Piston sample (Osterberg)
AG: Auger
RC: Rock core
GS: Grab sample

Recovery

The recovery, shown as a percentage, is the ratio of length of the sample obtained to the distance the sampler was driven/pushed into the soil

RQD

The "Rock Quality Designation" or "RQD" value, expressed as percentage, is the ratio of the total length of all core fragments of 4 inches (10 cm) or more to the total length of the run.

IN-SITU TESTS:

N: Standard penetration index
R: Refusal to penetration
N_c: Dynamic cone penetration index
Cu: Undrained shear strength
Pr: Pressure meter
k: Permeability
ABS: Absorption (Packer test)

LABORATORY TESTS:

I_p: Plasticity index
W_l: Liquid limit
Wp: Plastic limit
H: Hydrometer analysis
GSA: Grain size analysis
A: Atterberg limits
w: Water content
γ: Unit weight
C: Consolidation
CS: Swedish fall cone
CHEM: Chemical analysis
O.V.: Organic vapor

REFERENCE No.: 12566614

BOREHOLE No.: BH01-22

ELEVATION: 80.2 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash   CHECKED BY: Sahar Soleimani

DATE (START): 28 January 2022   DATE (FINISH): 28 January 2022

LEGEND
- SS - SPLIT SPOON
- ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- WATER LEVEL

NORTHING: 5021740.104   EASTING: 428002.481   ELEVATION: 80.2

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL	Type and Number	Gravel-Sand-Silt-Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/TCR (%)	Moisture Content (%)	Blows per 15cm/RQD (%)	'N' Value SCR (%)
0		GROUND SURFACE							
0–0.6		FILL - Gravelly silty SAND, some clay, greyish brown, moist, dense	GS1	29-37-22-12		--	13	--	--
0.6	79.6	CLAY, greyish brown, moist, very stiff to stiff	SS1			100.0	36	2-4-5-5	9
		grey, moist to wet, stiff	VA			--	--	--	--
			SS2			100.0	54	2-2-2-2	4
			VA			--	--	--	--
3.6	76.6	END OF BOREHOLE (Auger Refusal)							

Vane values: Sensitivity 1.4 (at approx. 1.7 m); Sensitivity 2.3 (at approx. 3.0 m).

Piezometer/Standpipe Installation: Sand and Concrete to 0.3 m; Bentonite 0.3 m to 1.4 m; Sand 1.4 m to 3.6 m; Screen 2.0 m to 3.6 m.

NOTE:
1. Borehole dry upon completion of drilling.
2. Borehole dry on February 3, 2022.

Legend for graph: △ Undisturbed Vane Value (kPa); □ Remoulded Field Vane Value (kPa); Number refer to Sensitivity; ○ Water content (%); Atterberg limits (%) W_p W_l; ● "N" Value (blows / 12 in.-30 cm)

REFERENCE No.: 12566614

BOREHOLE No.: BH02-22
ELEVATION: 79.7 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia
PROJECT: Geotechnical Investigation-Nokia Campus Rezoning
LOCATION: 570 and 600 March Road, Ottawa, Ontario
DESCRIBED BY: Dathon Ash CHECKED BY: Sahar Soleimani
DATE (START): 31 January 2022 DATE (FINISH): 1 February 2022

LEGEND
- ⊠ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- ▼ - WATER LEVEL

NORTHING: 5021805.708 EASTING: 428046.309 ELEVATION: 79.7

- △ Undisturbed Vane Value (kPa)
- □ Remoulded Field Vane Value (kPa)
- $\overset{3}{\triangle}$ Number refer to Sensitivity
- ○ Water content (%)
- W_p W_l Atterberg limits (%)
- ● "N" Value (blows / 12 in.-30 cm)

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/ TCR(%) (%)	Moisture Content (%)	Blows per 15cm/ RQD(%) (%)	'N' Value SCR(%) (%)	PIEZOMETER/ STANDPIPE INSTALLATION
		GROUND SURFACE								
0.1	79.6	ASPHALT								Sand and Concrete; 0.2 m
		FILL - GRAVEL, some sand and silt, grey, moist, dense	GS1			--	--	--	--	
0.6	79.1	CLAY, some silt, trace sand and gravel, greyish brown, moist, stiff	SS1	2-5-48-45		83.3	29	9-6-7-7	13	
						--	--	--	--	
2.4	77.3		SS2			0.0	--	50/102mm	50/102 mm	
		DOLOMITIC SANDSTONE, grey, slightly weathered, excellent to fair qullity								Bentonite
			Run1			100	--	91	100	
		joint, perpendicular to core axis	Run2			100	--	68	89	
										2/3/2022 ▼
		joint, perpendicular to core axis	Run3			95	--	84	92	
										4.9 m

Feet: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
Metres: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

Graph scale: 10 20 30 40 50 60 70 80 90

REFERENCE No.: 12566614

BOREHOLE REPORT

BOREHOLE No.: BH02-22

ELEVATION: 79.7 m (GEODETIC)

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash   CHECKED BY: Sahar Soleimani

DATE (START): 31 January 2022   DATE (FINISH): 1 February 2022

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- ▼ - WATER LEVEL

NORTHING: 5021805.708   EASTING: 428046.309   ELEVATION: 79.7

Chart legend: △ Undisturbed Vane Value (kPa); □ Remoulded Field Vane Value (kPa); △³ Number refer to Sensitivity; ○ Water content (%); W_p W_l Atterberg limits (%); ● "N" Value (blows / 12 in.-30 cm). Scale: 10 20 30 40 50 60 70 80 90

Depth (Metres)	Elevation (m) BGS	Description of Soil	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value SCR(%)	Piezometer/ Standpipe Installation
		GROUND SURFACE								
		joint, approximately 30 degrees to core axis	Run4			100	--	73	94	Sand; 5.5 m
			Run5		122.5	100	--	63	98	Screen
			Run6			83	--	76	83	8.5 m
8.6	71.1	END OF BOREHOLE								8.6 m

Depth scale: Feet 17–32; Metres 5.5–9.5.

NOTE:
1. Water level at a depth of 3.88 m (Elev. 75.84 m) below ground surface on February 3, 2022.

REFERENCE No.: 12566614

GHD

BOREHOLE No.: BH03-22
ELEVATION: 80.7 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia
PROJECT: Geotechnical Investigation-Nokia Campus Rezoning
LOCATION: 570 and 600 March Road, Ottawa, Ontario
DESCRIBED BY: Dathon Ash   CHECKED BY: Sahar Soleimani
DATE (START): 28 January 2022   DATE (FINISH): 31 January 2022

LEGEND
- SS - SPLIT SPOON
- ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- ▼ - WATER LEVEL

NORTHING: 5021800.342   EASTING: 427921.429   ELEVATION: 80.7

Graph legend: △ Undisturbed Vane Value (kPa); □ Remoulded Field Vane Value (kPa); △³ Number refer to Sensitivity; ○ Water content (%); W_p W_l Atterberg limits (%); ● "N" Value (blows / 12 in.-30 cm). Scale: 10 20 30 40 50 60 70 80 90

Depth (m)	Elevation (m) BGS	Description of Soil	Type and Number	Gravel-Sand-Silt-Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/TCR (%)	Moisture Content (%)	Blows per 15cm/RQD (%)	'N' Value/SCR (%)
0		GROUND SURFACE							
0.1	80.6	ASHPHALT							
0.1–0.6		FILL - Sandy GRAVEL, some silt, trace clay, greyish brown, moist, dense	GS1	45-29-18-8		--	10	--	--
0.6–1.4	80.1	Silty CLAY, some sand, trace gravel, greyish brown, moist, stiff	SS1	1-28-(71)		95.8	30	4-5-5-5	10
1.4–3.0	79.3	DOLOMITIC SANDSTONE, light grey with yellow bands, slightly weathered, excellent quality	Run1			100	--	100	100
			Run2		91.1	100	--	100	100
3.0	77.7	END OF BOREHOLE							

NOTE:
1. Water level at a depth of 1.55 m (Elev. 79.15 m) below ground surface on February 3, 2022.

PIEZOMETER/STANDPIPE INSTALLATION: Sand and Concrete (0–0.2 m); Bentonite (0.2–1.2 m); Sand (1.2–3.0 m); Screen (1.5–3.0 m); water level 2/3/2022.

REFERENCE No.: 12566614

GHD	BOREHOLE No.: BH04-22 ELEVATION: 79.8 m (GEODETIC)	BOREHOLE REPORT Page 1 of 1

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash CHECKED BY: Sahar Soleimani

DATE (START): 28 January 2022 DATE (FINISH): 28 January 2022

LEGEND

- ☒ SS - SPLIT SPOON
- ◩ ST - SHELBY TUBE
- ◫ VA - VANE SHEAR
- ◨ AU - AUGER PROBE
- ⧅ GS - GRAB SAMPLE
- ▼ - WATER LEVEL

NORTHING: 5021867.201 EASTING: 427996.294 ELEVATION: 79.8

△ Undisturbed Vane Value (kPa)
□ Remoulded Field Vane Value (kPa)
△³ Number refer to Sensitivity
○ Water content (%)
W_p ├┤ W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL	State	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value SCR(%)	Plot (10 20 30 40 50 60 70 80 90)	PIEZOMETER/ STANDPIPE INSTALLATION
		GROUND SURFACE										
0.1	79.7	ASPHALT										
0.6	79.2	FILL - Gravelly SAND, some silt and clay, grey, moist, dense	GS	GS1	23-58-(19)		--	--	--	--		
1.7	78.1	Silty CLAY, some sand, greyish brown, moist, stiff	SS	SS1	0-10-44-46		77.0	29	5-6-7-7	13	● ○	
			VA				--	--	--	--	□ △4.0	
		END OF BOREHOLE (Auger Refusal)										

Depth scale: Feet 0–16; Metres 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

REFERENCE No.: 12566614

BOREHOLE No.: BH05-22

ELEVATION: 81.1 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash CHECKED BY: Sahar Soleimani

DATE (START): 1 February 2022 DATE (FINISH): 1 February 2022

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- WATER LEVEL

NORTHING: 5021890.495 EASTING: 427830.004 ELEVATION: 81.1

△ Undisturbed Vane Value (kPa)
□ Remoulded Field Vane Value (kPa)
Number refer to Sensitivity
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL	State	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value SCR(%)	PIEZOMETER/ STANDPIPE INSTALLATION
0		GROUND SURFACE									
0.1	81.0	ASPHALT									
0.6	80.5	FILL - Sandy SILT, some gravel, greyish brown, moist, dense	GS	GS1			--	--	--	--	
0.9	80.2	CLAY, some silt and sand, trace gravel, greyish brown, moist, firm to stiff	SS	SS1	1-15-50-34		100.0	23	13-50/76mm	50/76 mm	
		END OF BOREHOLE (Auger Refusal)									

Feet: 0–16; Metres: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

Plot scale: 10 20 30 40 50 60 70 80 90

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REFERENCE No.: 12566614

GHD

BOREHOLE No.: BH06-22

ELEVATION: 79.6 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash CHECKED BY: Sahar Soleimani

DATE (START): 2 February 2022 DATE (FINISH): 2 February 2022

LEGEND

- ⊠ SS - SPLIT SPOON
- ◪ ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- ▼ - WATER LEVEL

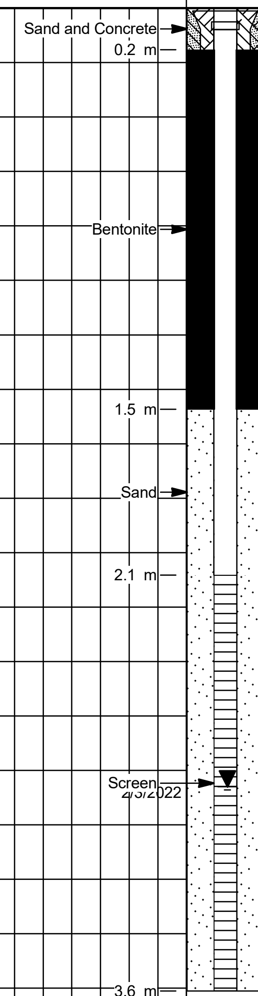
NORTHING: 5021952.611 EASTING: 427924.443 ELEVATION: 79.6

△ Undisturbed Vane Value (kPa)
□ Remoulded Field Vane Value (kPa)
Number refer to Sensitivity
○ Water content (%)
Atterberg limits (%) W_p W_l
● "N" Value (blows / 12 in.-30 cm)

Depth (Feet)	Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL	State	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value SCR(%)
				GROUND SURFACE								
0				ASPHALT								
	0.1	79.5		FILL - Sandy SILT, some gravel, brown, moist, dense		GS1			--	--	--	--
1												
	0.4	79.2		DOLOMITIC SANDSTONE, light grey with yellow bands, fresh, good quality								
	0.5											
2												
3	1.0											
4						Run1			97	--	87	97
5	1.5											
6												
7	2.0											
8	2.5											
9						Run2		94.2	90	--	75	90
10	3.0											
11	3.5											
	3.6	76.0		END OF BOREHOLE								
12				NOTE: 1. Water level at a depth of 2.86 m (Elev. 79.15 m) below ground surface on February 3, 2022.								
13	4.0											
14												
15	4.5											
16												

10 20 30 40 50 60 70 80 90

PIEZOMETER/ STANDPIPE INSTALLATION



REFERENCE No.: 12566614

GHD

BOREHOLE No.: BH07-22
ELEVATION: 82.5 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash CHECKED BY: Sahar Soleimani

DATE (START): 31 January 2022 DATE (FINISH): 31 January 2022

LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- ▼ - WATER LEVEL

NORTHING: 5022030.466 EASTING: 427695.319 ELEVATION: 82.5

△ Undisturbed Vane Value (kPa)
□ Remoulded Field Vane Value (kPa)
△ Number refer to Sensitivity
○ Water content (%)
Atterberg limits (%) W_p W_l
● "N" Value (blows / 12 in.-30 cm)

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value SCR(%)	PIEZOMETER/ STANDPIPE INSTALLATION
0		GROUND SURFACE								
0.0–0.6	81.9	TOPSOIL - Clayey SILT, contains rootlets and organic matter, dark brown, moist	GS1			--	--	--	--	
0.6–1.0	81.5	Silty CLAY to Clayey SILT, some sand and gravel, dark brown, moist, soft, organics matter	SS1			41.7	--	3-5-50/0	>50	
1.0–4.1	78.4	DOLOMITIC SANDSTONE, slightly weathered, light grey to grey with yellow bands, fair to good quality	Run1			100	--	66	100	
			Run2			96	--	89	96	
			Run3		111.8	100	--	88	88	
4.1		END OF BOREHOLE								

REFERENCE No.: 12566614

GHD

BOREHOLE No.: **BH08-22**

ELEVATION: 79.8 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash   CHECKED BY: Sahar Soleimani

DATE (START): 2 February 2022   DATE (FINISH): 2 February 2022

LEGEND

- ☒ SS - SPLIT SPOON
- ◩ ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- ▼ - WATER LEVEL

NORTHING: 5022071.843   EASTING: 427843.613   ELEVATION: 79.8

Depth (Feet)	Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL	State	Type and Number	Gravel Sand Silt Clay	Unconfined Compressive Strength	Recovery/ TCR(%)	Moisture Content	Blows per 15cm/ RQD(%)	'N' Value SCR(%)	△ Undisturbed Vane Value (kPa) □ Remoulded Field Vane Value (kPa) △³ Number refer to Sensitivity ○ Water content (%) Atterberg limits (%) W_p W_l ● "N" Value (blows / 12 in.-30 cm)	PIEZOMETER/ STANDPIPE INSTALLATION
				GROUND SURFACE			%	MPa	%	%	%	%	10 20 30 40 50 60 70 80 90	
0	0.1	79.7		ASPHALT										
1				FILL - Sandy SILT, trace gravel, greyish brown, moist, dense		GS1			--	--	--	--		
2	0.5 0.6	79.2		END OF BOREHOLE (Auger Refusal)										
3	1.0													
4														
5	1.5													
6														
7	2.0													
8	2.5													
9														
10	3.0													
11														
12	3.5													
13	4.0													
14														
15	4.5													
16														

REFERENCE No.: 12566614

BOREHOLE REPORT

BOREHOLE No.: **BH09-22**

ELEVATION: 82.1 m (GEODETIC)

Page 1 of 1

CLIENT: Nokia

PROJECT: Geotechnical Investigation-Nokia Campus Rezoning

LOCATION: 570 and 600 March Road, Ottawa, Ontario

DESCRIBED BY: Dathon Ash CHECKED BY: Sahar Soleimani

DATE (START): 31 January 2022 DATE (FINISH): 31 January 2022

LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- ▼ - WATER LEVEL

NORTHING: 5022131.544 EASTING: 427632.69 ELEVATION: 82.1

Depth (Feet)	Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL	State	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value SCR(%)	△ Undisturbed Vane Value (kPa) □ Remoulded Field Vane Value (kPa) Number refer to Sensitivity ○ Water content (%) Atterberg limits (%) W_p W_l ● "N" Value (blows / 12 in.-30 cm) 10 20 30 40 50 60 70 80 90	PIEZOMETER/ STANDPIPE INSTALLATION
0				GROUND SURFACE										
0–3	0–0.9			TOPSOIL- SILT, trace sand and gravel, contains rootlets and organic matter, dark brown, moist		GS1			--	--	--	--		
						SS1			25.0	--	2-50/0mm	>50		
3	0.9	81.2		END OF BOREHOLE (Auger Refusal)										

Depth scale: Feet 0–16; Metres 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

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GHD

BOREHOLE No.: BH10-22
ELEVATION: 80.4 m (GEODETIC)

BOREHOLE REPORT

CLIENT: Nokia
PROJECT: Geotechnical Investigation-Nokia Campus Rezoning
LOCATION: 570 and 600 March Road, Ottawa, Ontario
DESCRIBED BY: Dathon Ash CHECKED BY: Sahar Soleimani
DATE (START): 2 February 2022 DATE (FINISH): 2 February 2022

LEGEND
- SS - SPLIT SPOON
- ST - SHELBY TUBE
- VA - VANE SHEAR
- AU - AUGER PROBE
- GS - GRAB SAMPLE
- WATER LEVEL

NORTHING: 5022166.631 EASTING: 427726.321 ELEVATION: 80.4

△ Undisturbed Vane Value (kPa)
□ Remoulded Field Vane Value (kPa)
Number refer to Sensitivity
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)
10 20 30 40 50 60 70 80 90

Depth (m)	Elevation (m) BGS	Description of Soil	Type and Number	Gravel Sand Silt Clay (%)	Unconfined Compressive Strength (MPa)	Recovery/TCR (%)	Moisture Content (%)	Blows per 15cm/RQD (%)	'N' Value SCR (%)	Piezometer/Standpipe Installation
0		GROUND SURFACE								
0.1	80.3	ASPHALT								Sand and Concrete (to 0.2 m)
		FILL - Sandy SILT, some gravel, brown, moist, dense	GS1			--	--	--	--	
			SS1			0.0	--	50/152mm	50/152 mm	Bentonite (0.2 m to 1.9 m)
0.9	79.5	DOLOMITIC SANDSTONE, slightly weathered, excellent to fair quality								
		joint, perpendicular to core axis	Run1		113.3	100	--	81	100	
			Run2			100	--	95	100	Sand (1.9 m to 4.1 m); Screen (2.5 m to 4.1 m); water level 2/3/2022
			Run3			50	--	36	50	
4.1	76.3	END OF BOREHOLE								4.1 m

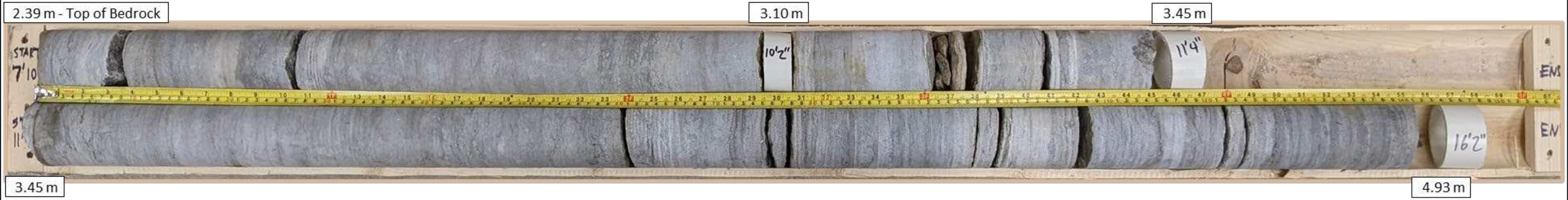
NOTE:
1. Water level at a depth of 3.00 m (Elev. 77.43 m) below ground surface on February 3, 2022.

Appendix B

Rock Core Photos

BH 2-22 (Dry)
Box 1 of 3

Run No.	Run Start/End (m)
1	2.39 - 3.10
2	3.10 - 3.45
3	3.45 - 4.93



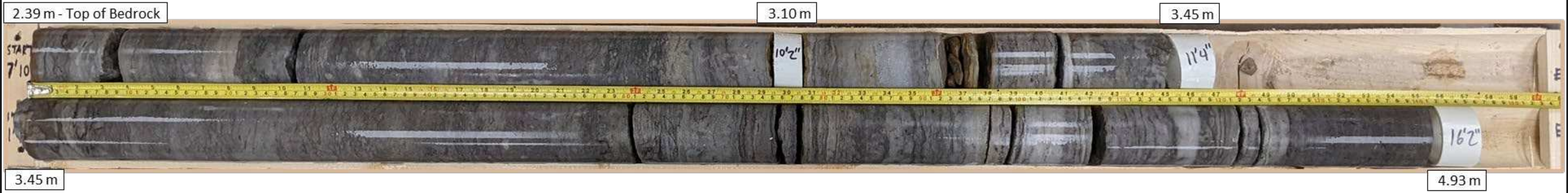
Client :	Colliers
Project :	Geotechnical Investigation
Reference N°. :	12566614
Location:	600 March Road, Kanata, Ontario

Prepared by : Kenneth O. Omenogor

Revised by : Sahar Soleimani, **P.Eng.**

BH 2-22 (Wet)
Box 1 of 3

Run No.	Run Start/End (m)
1	2.39 - 3.10
2	3.10 - 3.45
3	3.45 - 4.93



Client :	Colliers
Project :	Geotechnical Investigation
Reference N^{o.} :	12566614
Location:	600 March Road, Kanata, Ontario

Prepared by : Kenneth O. Omenogor

Revised by : Sahar Soleimani, **P.Eng.**

BH 2-22 (Dry)
Box 2 of 3

Run No.	Run Start/End (m)
4	4.93 - 6.50
5	6.50 - 7.49

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference N°. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 2-22 (Wet)
Box 2 of 3

Run No.	Run Start/End (m)
4	4.93 - 6.50
5	6.50 - 7.49

Client :	Colliers
Project :	Geotechnical Investigation
Reference N°. :	12566614
Location:	600 March Road, Kanata, Ontario

Prepared by : Kenneth O. Omenogor

Revised by : Sahar Soleimani, **P.Eng.**

BH 2-22 (Dry)
Box 3 of 3

Run No.	Run Start/End (m)
5	7.49 - 8.03
6	8.03 - 8.61

Client :	Colliers
Project :	Geotechnical Investigation
Reference N°. :	12566614
Location:	600 March Road, Kanata, Ontario

Prepared by :	Kenneth O. Omenogor
Revised by :	Sahar Soleimani, **P.Eng.**

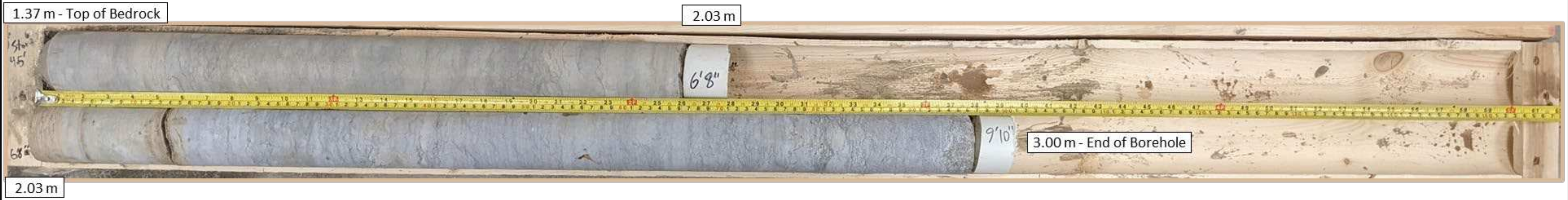
BH 2-22 (Wet)
Box 3 of 3

Run No.	Run Start/End (m)
5	7.49 - 8.03
6	8.03 - 8.61

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference No. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 3-22 (Dry)
Box 1 of 1

Run No.	Run Start/End (m)
1	1.37 - 2.03
2	2.03 - 3.00



Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference No. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 3-22 (Wet)
Box 1 of 1

Run No.	Run Start/End (m)
1	1.37 - 2.03
2	2.03 - 3.00

Client :	Colliers
Project :	Geotechnical Investigation
Reference No. :	12566614
Location:	600 March Road, Kanata, Ontario

Prepared by :	Kenneth O. Omenogor
Revised by :	Sahar Soleimani, **P.Eng.**

BH 6-22 (Dry)
Box 1 of 1

Run No.	Run Start/End (m)
1	0.41 - 1.88
2	1.88 - 3.61

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference No. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 6-22 (Wet)
Box 1 of 1

Run No.	Run Start/End (m)
1	0.41 - 1.88
2	1.88 - 3.61

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference N°. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 7-22 (Dry)
Box 1 of 2

Run No.	Run Start/End (m)
1	1.02 - 1.83
2	1.83 - 3.45

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference N°. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 7-22 (Wet)
Box 1 of 2

Run No.	Run Start/End (m)
1	1.02 - 1.83
2	1.83 - 3.45

1.02 m - Top of Bedrock

1.83 m

2.33 m

2.33 m

3.45 m

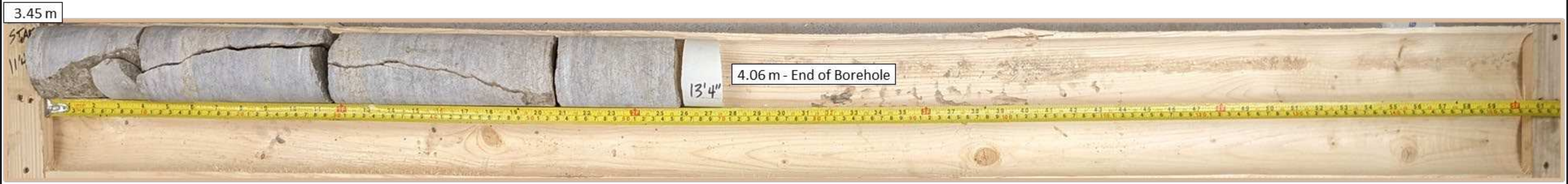
Client :	Colliers
Project :	Geotechnical Investigation
Reference No. :	12566614
Location:	600 March Road, Kanata, Ontario

Prepared by : Kenneth O. Omenogor

Revised by : Sahar Soleimani, **P.Eng.**

BH 7-22 (Dry)
Box 2 of 2

Run No.	Run Start/End (m)
3	3.45 - 4.06



Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference Nº. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 7-22 (Wet)
Box 2 of 2

Run No.	Run Start/End (m)
3	3.45 - 4.06

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference No. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 10-22 (Dry)
Box 1 of 1

Run No.	Run Start/End (m)
1	0.91 - 1.98
2	1.98 - 3.50
3	3.50 - 3.78

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference N°. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

BH 10-22 (Wet)
Box 1 of 1

Run No.	Run Start/End (m)
1	0.91 - 1.98
2	1.98 - 3.50
3	3.50 - 3.78

Client :	Colliers	**Prepared by :**	Kenneth O. Omenogor
Project :	Geotechnical Investigation		
Reference N°. :	12566614	**Revised by :**	Sahar Soleimani, **P.Eng.**
Location:	600 March Road, Kanata, Ontario		

Appendix C

Summary Table and Laboratory Results

Table C1 Summary of Geotechnical Laboratory Test Results

Borehole	Sample No.	Depth (m)	Material	WC (%)	LL (%)	PL (%)	PI (%)	Grain Size Distribution				UCS (MPa)
								Gravel (%)	Sand (%)	Silt (%)	Clay (%)	
BH01-22	GS1	0 – 0.6	Gravelly silty sand	13	-	-	-	29	37	22	12	-
BH01-22	SS1	0.8 – 1.4	Clay	36	-	-	-	-	-	-	-	-
BH01-22	SS2	2.3 – 2.9	Clay	54	64	24	40	-	-	-	-	-
BH02-22	SS1	0.8 – 1.4	Clay	29	58	25	33	2	5	48	45	-
BH02-22	R5	7.3 – 8.3	Sandstone bedrock	-	-	-	-	-	-	-	-	122.5
BH03-22	GS1	0.1 – 0.6	Sandy gravel	10	-	-	-	45	29	18	8	-
BH03-22	SS1	0.8 – 1.4	Silty clay	30	-	-	-	1	28	71		-
BH03-22	R2	2.4 – 3.4	Sandstone bedrock	-	-	-	-	-	-	-	-	91.1
BH04-22	GS1	0.1 – 0.6	Gravelly sand	-	-	-	-	23	58	19		-
BH04-22	SS1	0.8 – 1.4	Silty clay	29	-	-	-	0	10	44	46	-
BH05-22	SS1	0.8 – 1.4	Clay	23	57	17	40	1	15	50	34	-
BH06-22	R2	2.0 – 3.0	Sandstone bedrock	-	-	-	-	-	-	-	-	94.2
BH07-22	R3	4.0 – 5.0	Sandstone bedrock	-	-	-	-	-	-	-	-	111.8
BH10-22	R1	0.9 – 1.9	Sandstone bedrock	-	-	-	-	-	-	-	-	113.3

Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D4318)

Client:	Nokia	**Lab no.:**	G-22-01
Project/Site:	600 March Road, Kanata, Ontario	**Project no.:**	12566614

Borehole no.:	BH-01-22	Sample no.:	SS-2	Depth:	2,29 - 2,90 m
Soil Description:	Organic Clay (OH)-PI plots on or above "A" line.			Date sampled:	January 28, 2022

Apparatus:	Hand Crank	Balance no.:	8033031049	Porcelain bowl no.:	1
Liquid limit device no.:	1	Oven no.:	B23-04645	Spatula no.:	1
Sieve no.:	0155690	Glass plate no.:	1		

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	38	24	17
Water Content:			
Tare no.	37	2	44
Wet soil+tare, g	31.60	36.00	41.60
Dry soil+tare, g	23.90	26.20	29.60
Mass of water, g	7.70	9.80	12.00
Tare, g	11.30	11.00	11.30
Mass of soil, g	12.60	15.20	18.30
Water content %	61.1%	64.5%	65.6%

Plastic Limit (PL) - Water Content:

Tare no.	21	12
Wet soil+tare, g	18.20	18.60
Dry soil+tare, g	16.90	17.20
Mass of water, g	1.30	1.40
Tare, g	11.30	11.50
Mass of soil, g	5.60	5.70
Water content %	23.2%	24.6%
Average water content %	23.9%	

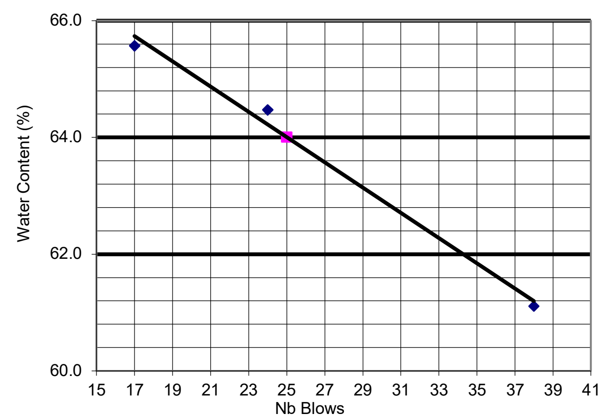
Natural Water Content (W^n):

Tare no.	S32	S43
Wet soil+tare, g	58.30	60.40
Dry soil+tare, g	43.20	44.10
Mass of water, g	15.10	16.30
Tare, g	14.30	14.80
Mass of soil, g	28.90	29.30
Water content %	52.2%	55.6%

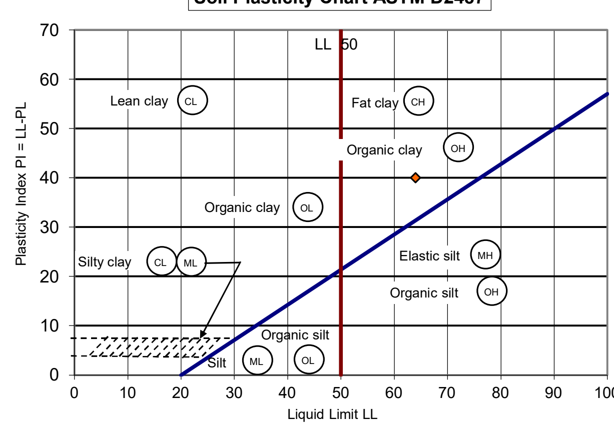
Soil Preparation:

- ☑ Cohesive <425 µm
- ☐ Cohesive >425 µm
- ☐ Non-cohesive
- ☐ Dry preparation
- ☑ Wet preparation

Results



Soil Plasticity Chart ASTM D2487



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
64	24	40	53.9

Remarks:

Performed by:	J. Lalonde	**Date:**	February 18, 2022
Verified by:		**Date:**	February 23, 2022
Laboratory Location:	179 Colonnade Rd. Suite 400, Ottawa, Ontario		

Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D4318)

Client:	Nokia	**Lab no.:**	G-22-01
Project/Site:	600 March Road, Kanata, Ontario	**Project no.:**	12566614

Borehole no.:	BH-02-22	Sample no.:	SS-1	Depth:	0,76 - 1,37 m
Soil Description:				Date sampled:	January 31, 2022

Apparatus:	Hand Crank	Balance no.:	8033031049	Porcelain bowl no.:	1
Liquid limit device no.:	1	Oven no.:	B23-04645	Spatula no.:	1
Sieve no.:	0155690	Glass plate no.:	1		

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	38	28	15
Water Content:			
Tare no.	42	48	39
Wet soil+tare, g	25.20	27.10	29.80
Dry soil+tare, g	20.30	21.40	22.90
Mass of water, g	4.90	5.70	6.90
Tare, g	11.40	11.40	11.40
Mass of soil, g	8.90	10.00	11.50
Water content %	55.1%	57.0%	60.0%

Plastic Limit (PL) - Water Content:

Tare no.	S19	15
Wet soil+tare, g	22.10	18.30
Dry soil+tare, g	20.60	16.90
Mass of water, g	1.50	1.40
Tare, g	14.80	11.30
Mass of soil, g	5.80	5.60
Water content %	25.9%	25.0%
Average water content %	25.4%	

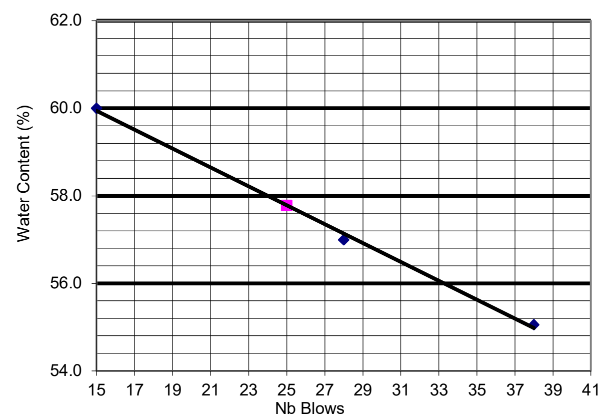
Natural Water Content (W^n):

Tare no.	32	38
Wet soil+tare, g	35.60	36.60
Dry soil+tare, g	30.20	30.90
Mass of water, g	5.40	5.70
Tare, g	11.40	11.30
Mass of soil, g	18.80	19.60
Water content %	28.7%	29.1%

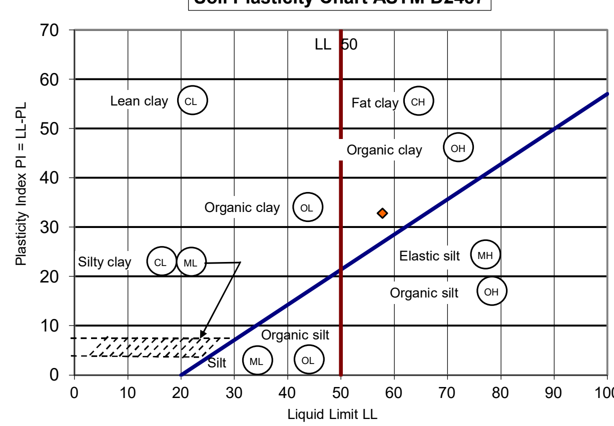
Soil Preparation:

- ☑ Cohesive <425 µm
- ☐ Cohesive >425 µm
- ☐ Non-cohesive
- ☐ Dry preparation
- ☑ Wet preparation

Results



Soil Plasticity Chart ASTM D2487



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
58	25	33	28.9

Remarks:

Performed by:	J. Lalonde	**Date:**	February 18, 2022
Verified by:		**Date:**	February 23, 2022
Laboratory Location:	179 Colonnade Rd. Suite 400, Ottawa, Ontario		

Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D4318)

Client:	Nokia	**Lab no.:**	G-22-01
Project/Site:	600 March Road, Kanata, Ontario	**Project no.:**	12566614

Borehole no.:	BH-05-22	Sample no.:	SS-1	Depth:	0,76 - 1,37 m
Soil Description:	Organic Clay (OL)- PI > 4 and plots on or above "A" line.			Date sampled:	February 1, 2022

Apparatus:	Hand Crank	Balance no.:	8033031049	Porcelain bowl no.:	1
Liquid limit device no.:	1	Oven no.:	B23-04645	Spatula no.:	1
Sieve no.:	0155690	Glass plate no.:	1		

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	42	15	30
Water Content:			
Tare no.	15	37	12
Wet soil+tare, g	28.10	29.00	29.80
Dry soil+tare, g	22.20	22.40	23.30
Mass of water, g	5.90	6.60	6.50
Tare, g	11.30	11.30	11.50
Mass of soil, g	10.90	11.10	11.80
Water content %	54.1%	59.5%	55.1%

Plastic Limit (PL) - Water Content:

Tare no.	48	
Wet soil+tare, g	14.20	
Dry soil+tare, g	13.80	
Mass of water, g	0.40	
Tare, g	11.40	
Mass of soil, g	2.40	
Water content %	16.7%	
Average water content %	16.7%	

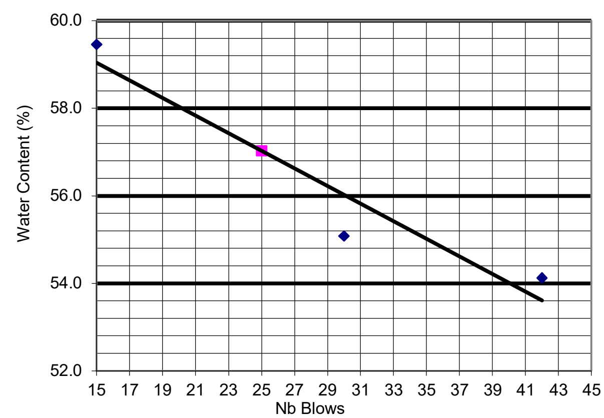
Natural Water Content (W^n):

Tare no.	43	
Wet soil+tare, g	29.60	
Dry soil+tare, g	26.80	
Mass of water, g	2.80	
Tare, g	14.80	
Mass of soil, g	12.00	
Water content %	23.3%	

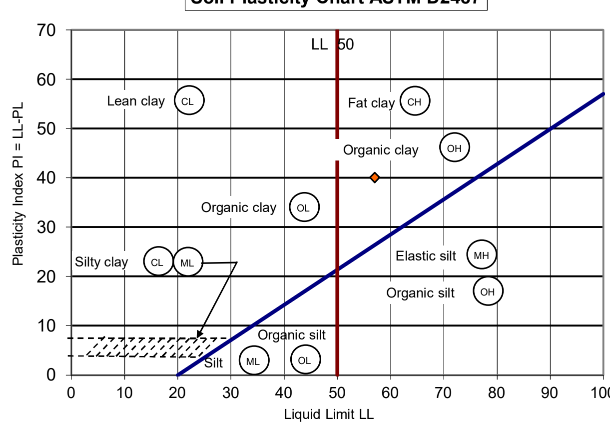
Soil Preparation:

- ☐ Cohesive <425 µm
- ☑ Cohesive >425 µm
- ☐ Non-cohesive
- ☐ Dry preparation
- ☑ Wet preparation

Results



Soil Plasticity Chart ASTM D2487



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
57	17	40	23.3

Remarks:

Performed by:	J. Lalonde	**Date:**	February 23, 2022
Verified by:		**Date:**	February 23, 2022
Laboratory Location:	179 Colonnade Rd. Suite 400, Ottawa, Ontario		

Moisture Content of Soils
(ASTM D 2216)

Client:	Nokia	**Lab No.:**	G-22-01
Project/Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614

Apparatus Used for Testing

Oven No.: B23-04645 **Scale No.:** 8033031049

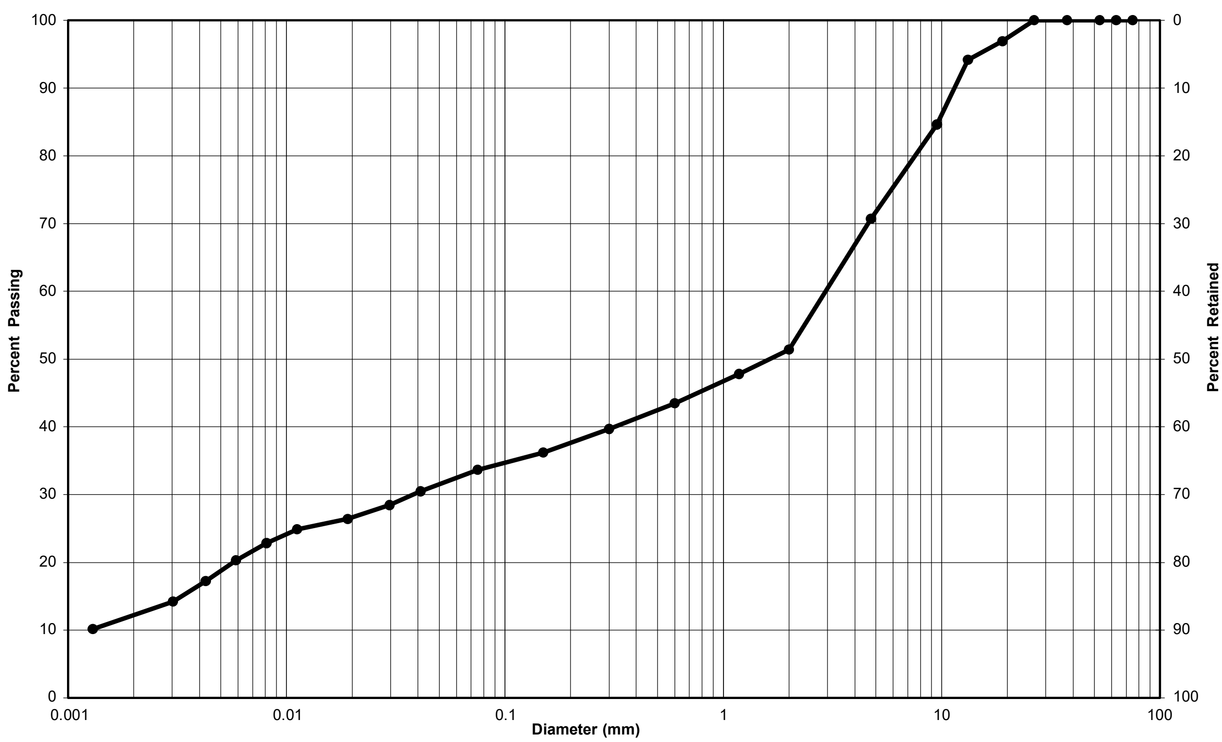
BH No.:	BH-01-22	BH-01-22	BH-03-22	BH-03-22	BH-04-22			
Sample No.:	GS-1	SS-1	GS-1	SS-1	SS-1			
Depth:	0,0-0,6 m	0,8-1,4m	0,0-0,6 m	0,8-1,4 m	0,0-0,6 m			
Container no.	54	19	68	59	64			
Mass of container + wet soil (g)	914.40	68.40	1040.20	634.00	765.20			
Mass of container + dry soil (g)	873.20	55.20	996.30	576.60	715.70			
Mass of container (g)	543.20	18.30	546.40	386.30	543.10			
Mass of dry soil (g)	330.0	36.9	449.9	190.3	172.6			
Mass of water (g)	41.2	13.2	43.9	57.4	49.5			
Moisture content (%)	12.5	35.8	9.8	30.2	28.7			
BH No.:								
Sample No.:								
Depth:								
Container no.								
Mass of container + wet soil (g)								
Mass of container + dry soil (g)								
Mass of container (g)								
Mass of dry soil (g)								
Mass of water (g)								
Moisture content (%)								

Remarks:

Performed By:	J. Lalonde	**Date:**	February 22, 2022
Verified by :		**Date:**	February 23, 2022

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Nokia	**Lab No.:**	G-22-01
Project, Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614
Borehole No.:	BH-01-22	Sample No.:	GS-1
Depth:	0,00 - 0,61 m	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

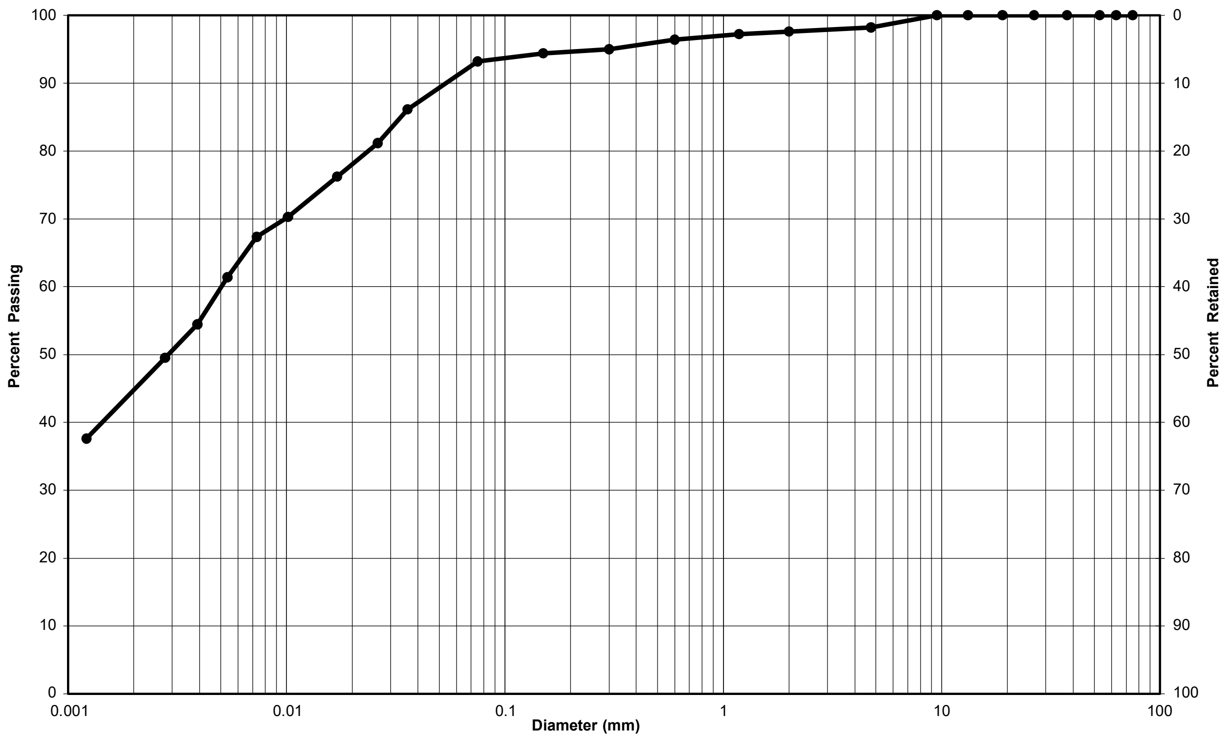
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
	29	37	34
Silt-size particles (%) :	22		
Clay-size particles (%) (<0.002 mm):	12		

Remarks: More information is available upon request.

Performed by:	J. Lalonde	**Date:**	February 17, 2022
Verified by:		**Date:**	February 23, 2022

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Nokia	**Lab No.:**	G-22-01
Project, Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614
Borehole No.:	BH-02-22	Sample No.:	SS-1
Depth:	0,76 - 1,37 m	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

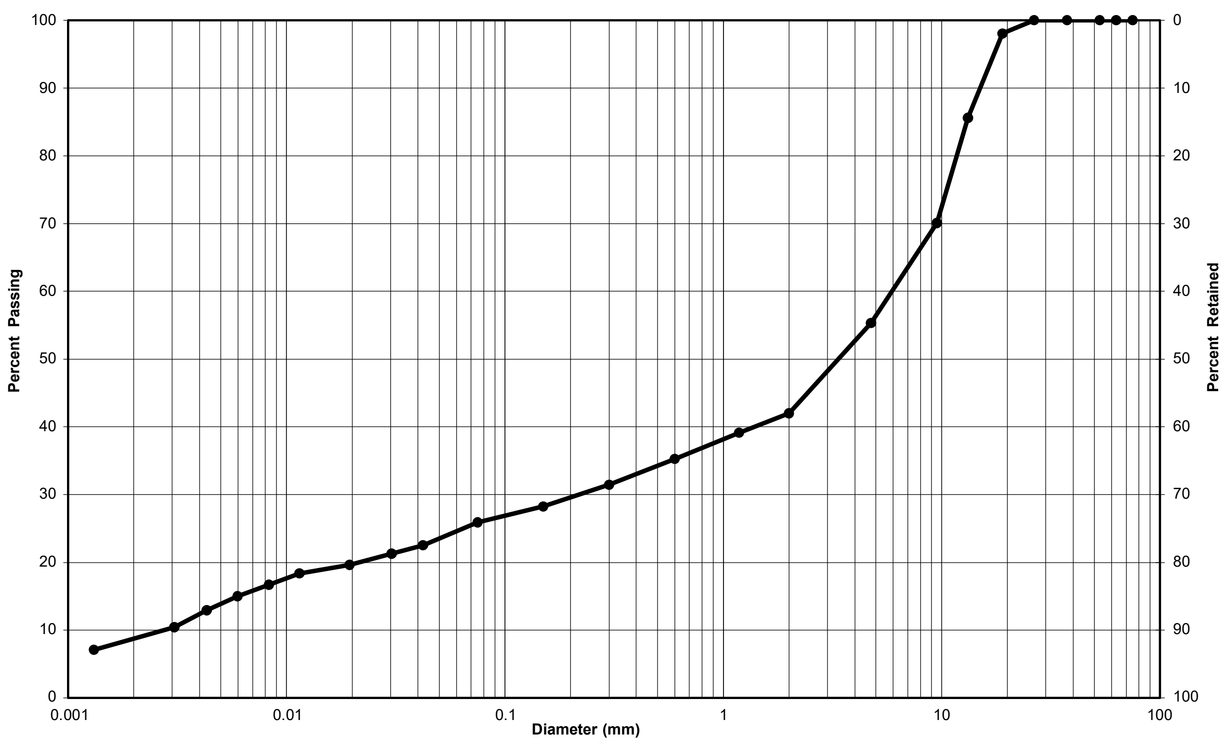
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
	2	5	93
Silt-size particles (%) :	48		
Clay-size particles (%) (<0.002 mm):	45		

Remarks: More information is available upon request.

Performed by:	J. Lalonde	**Date:**	February 17, 2022
Verified by:		**Date:**	February 23, 2022

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Nokia	**Lab No.:**	G-22-01
Project, Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614
Borehole No.:	BH-03-22	Sample No.:	GS-1
Depth:	0,00 - 0,61 m	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

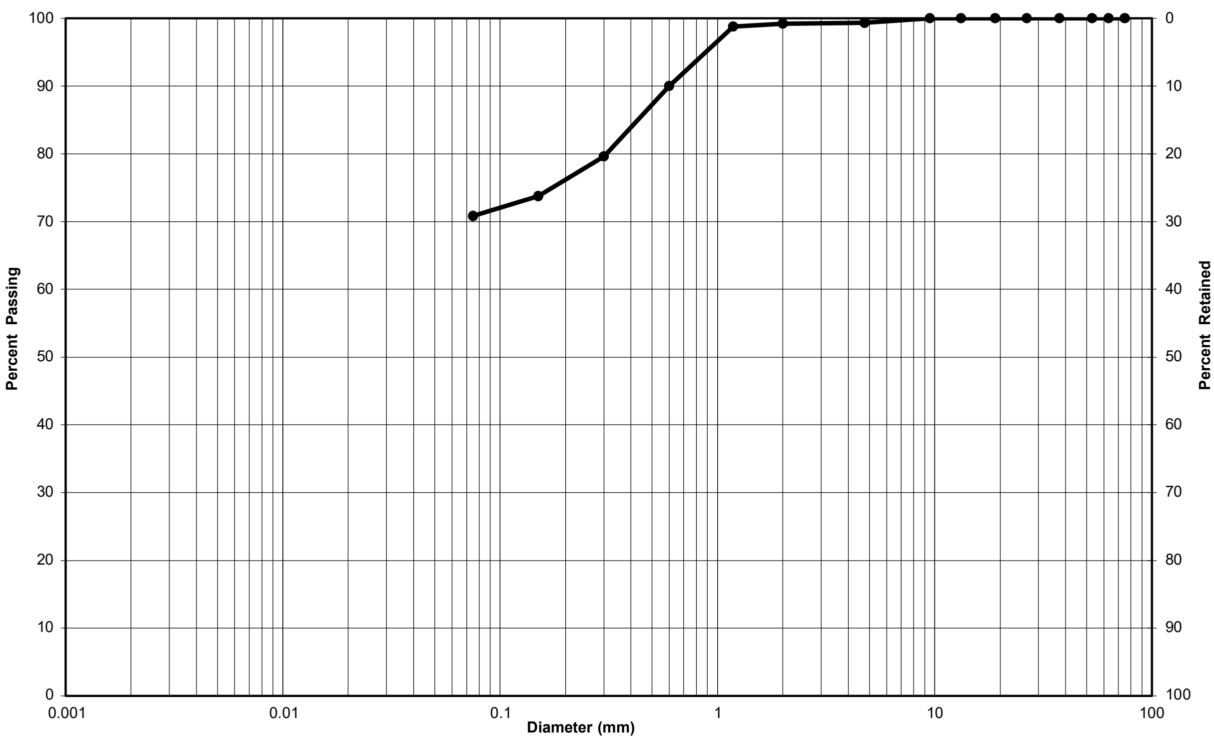
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
	45	29	26
Silt-size particles (%) :	18		
Clay-size particles (%) (<0.002 mm):	8		

Remarks: More information is available upon request.

Performed by:	J. Lalonde	**Date:**	February 17, 2022
Verified by:		**Date:**	February 23, 2022

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Nokia	**Lab No.:**	G-22-01
Project, Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614
Borehole No.:	BH-03-22	Sample No.:	SS-1
Depth:	0,76 - 1,37 m	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

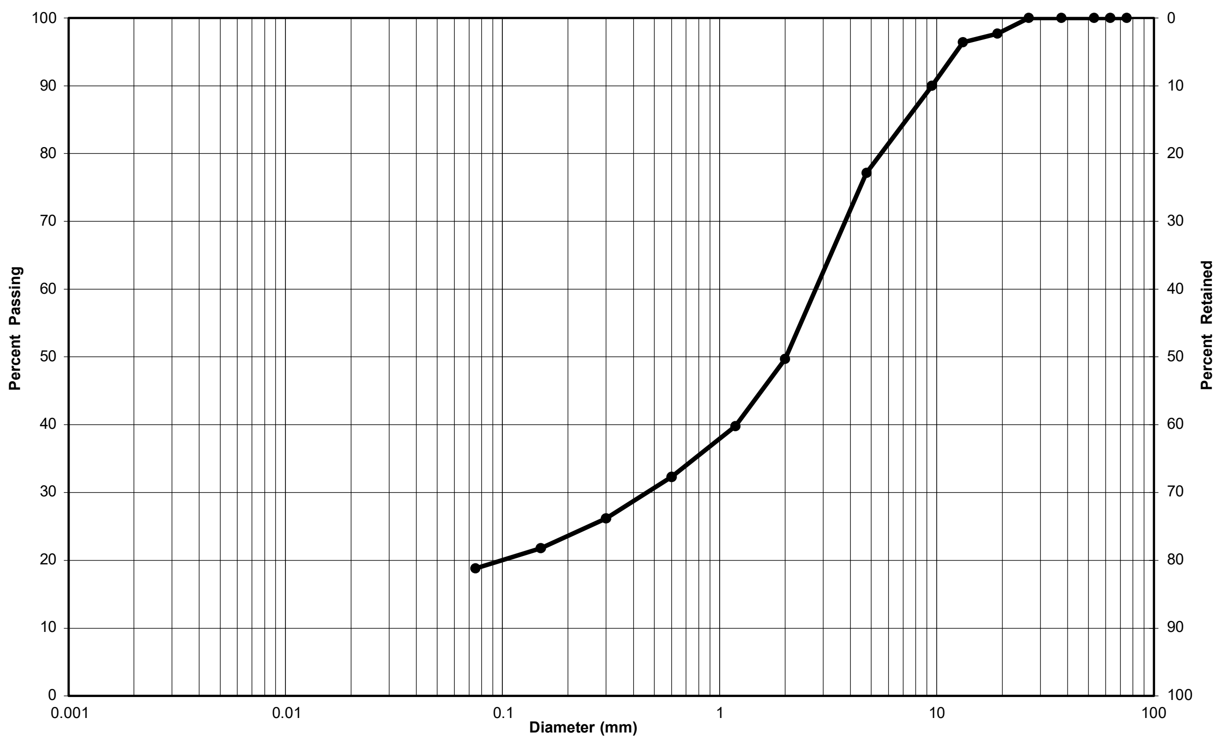
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
	1	28	71
Silt-size particles (%) :			
Clay-size particles (%) (<0.002 mm):			

Remarks: More information is available upon request.

Performed by:	J. Lalonde	**Date:**	February 18, 2022
Verified by:		**Date:**	February 23, 2022

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Nokia	**Lab No.:**	G-22-01
Project, Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614
Borehole No.:	BH-04-22	Sample No.:	GS-1
Depth:	0,0 - 0,61 m	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

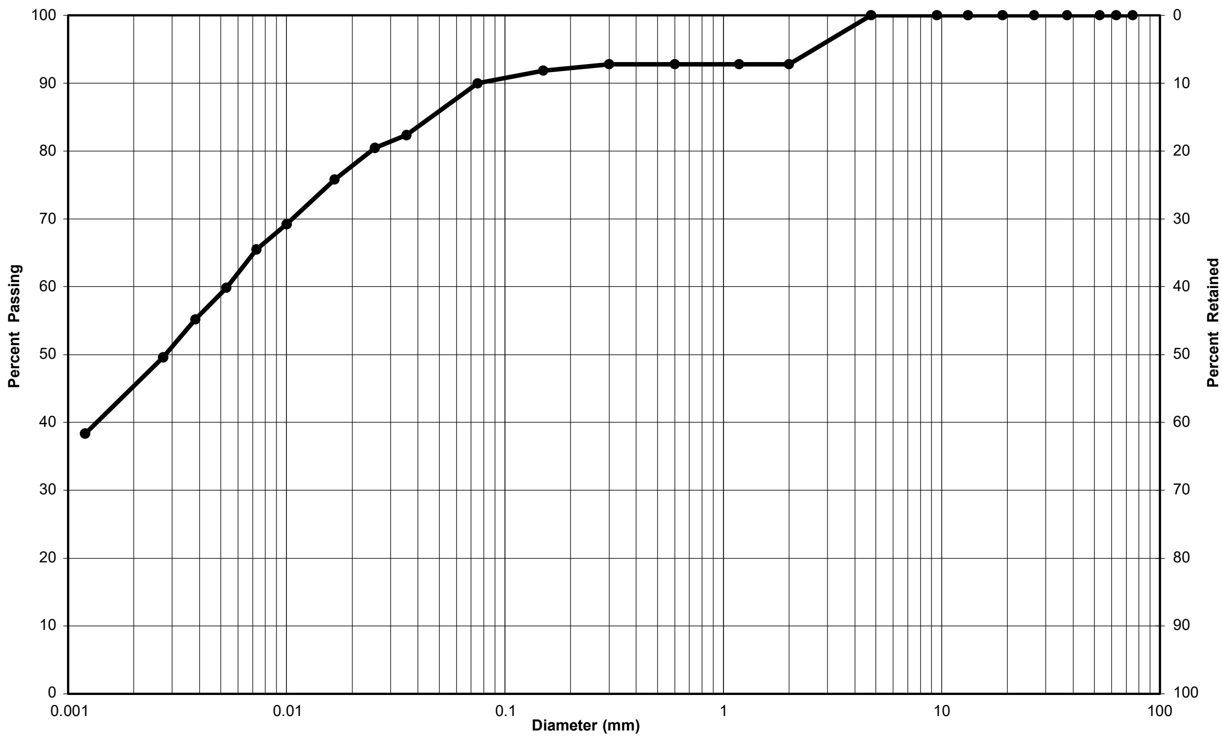
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
	23	58	19
Silt-size particles (%) :			
Clay-size particles (%) (<0.002 mm):			

Remarks: More information is available upon request.

Performed by:	J. Lalonde / G. Beauchamp	**Date:**	February 24, 2022
Verified by:		**Date:**	February 24, 2022

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Nokia	**Lab No.:**	G-22-01
Project, Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614
Borehole No.:	BH-04-22	Sample No.:	SS-1
Depth:	0,00 - 0,61 m	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

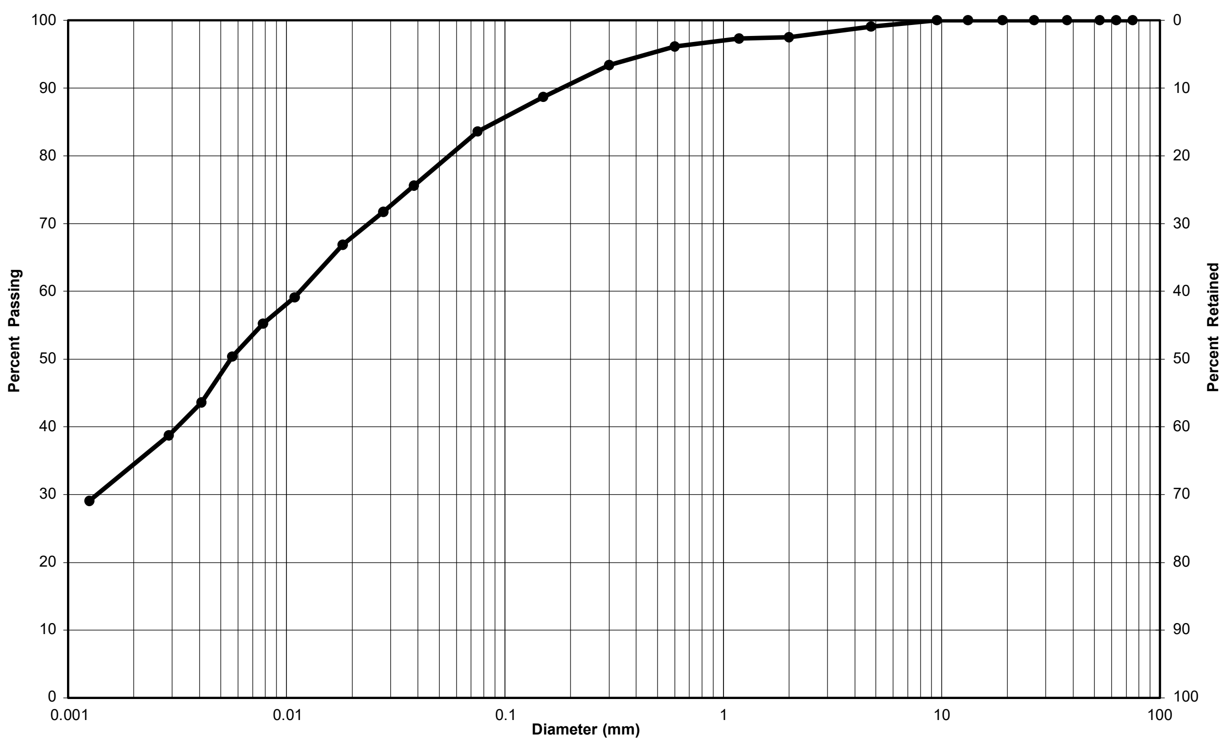
Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
	0	10	90
Silt-size particles (%) :	44		
Clay-size particles (%) (<0.002 mm):	46		

Remarks: More information is available upon request.

Performed by:	J. Lalonde	**Date:**	February 17, 2022
Verified by:		**Date:**	February 23, 2022

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Nokia	**Lab No.:**	G-22-01
Project, Site:	600 March Road, Kanata, Ontario	**Project No.:**	12566614
Borehole No.:	BH-05-22	Sample No.:	SS-1
Depth:	0,76 - 1,37 m	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
	1	15	84
Silt-size particles (%) :	50		
Clay-size particles (%) (<0.002 mm):	34		

Remarks: More information is available upon request.

Performed by:	J. Lalonde	**Date:**	February 17, 2022
Verified by:		**Date:**	February 23, 2022

Unconfined Compressive Strength of Intact Rock Core Specimen
ASTM D 7012, ASTM D 4543

Client : Nokia

Project N° : 12566614

Project : 600 March Road, Kanata, Ontario

Sample N° : BH-02-22 r.5

Depth : 7,26 - 7,38 m

Sampling Date : 2022-01-31

Testing Apparatus Used : **Loading device N°** _9130____ **Caliper N°** _1__________

Technical Data

				Average	
Diameter :	63.02	63.10	63.16	**63.09**	(mm)
Length :	124.08	124.12	124.12	**124.11**	(mm)
Straightness (0.5mm maximum) (S1) :	0.0	0.0	0.0	**0.0**	(mm)
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	**Ok**	(µm)
Parallelism (0.25 ° maximum) (FP2) :	0.00	0.00	0.00	**0.00**	(°)

Mass : 973.5 (g) Volume: 388018 (mm^3)

Density : 2509 (kg/m^3)

Moisture Conditions : Dry

Loading Rate (0.5 to 1.0 MPa / sec) : 0.59 (MPa/sec)

Type of Fracture : Axial Splitting

Test Duration (2-15 Minutes) : 208 (seconds)

Maximum Applied Load : 383.12 (kN)

Compressive Strength : 122.5 (MPa)

View of Specimen

Before Test :

After Test :

Macroscopic Description

Remarks :

Analysed by : J. Lalonde **Date :** 2022-02-15

Verified by : **Date :** 2022-02-23

Unconfined Compressive Strength of Intact Rock Core Specimen
ASTM D 7012, ASTM D 4543

Client :	Nokia	**Project N° :**	12566614
Project :	600 March Road, Kanata, Ontario	**Sample N° :**	BH-03-22 r.2
		Depth :	2,36 - 2,48 m
		Sampling Date :	2022-01-31

Testing Apparatus Used : **Loading device N°_9130____** **Caliper N° _1__________**

Technical Data

				Average	
Diameter :	62.96	62.92	62.94	**62.94**	(mm)
Length :	123.96	123.86	124.02	**123.95**	(mm)
Straightness (0.5mm maximum) (S1) :	0.0	0.1	0.0	**0.0**	(mm)
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	**Ok**	(µm)
Parallelism (0.25 ° maximum) (FP2) :	0.01	0.10	0.07	**0.06**	(°)

Mass : 1017.5 (g) Volume: 385637 (mm^3)

Density : 2638 (kg/m^3)

Moisture Conditions : Dry

Loading Rate (0.5 to 1.0 MPa / sec) : 0.51 (MPa/sec)

Type of Fracture : Axial Splitting

Test Duration (2-15 Minutes) : 178 (seconds)

Maximum Applied Load : 283.42 (kN)

Compressive Strength : 91.1 (MPa)

View of Specimen

Before Test :

After Test :

Macroscopic Description

Remarks :

Analysed by :	J. Lalonde	**Date :**	2022-02-15
Verified by :		**Date :**	2022-02-23

Unconfined Compressive Strength of Intact Rock Core Specimen
ASTM D 7012, ASTM D 4543

Client : Nokia

Project : 600 March Road, Kanata, Ontario

Project N° : 12566614

Sample N° : BH-06-22 r.2

Depth : 1,97 - 2,09 m

Sampling Date : 2022-02-02

Testing Apparatus Used : **Loading device N°_9130____** **Caliper N° _1__________**

Technical Data

				Average	
Diameter :	63.08	63.16	63.00	**63.08**	(mm)
Length :	120.70	120.58	120.42	**120.57**	(mm)
Straightness (0.5mm maximum) (S1) :	0.1	0.0	0.1	**0.1**	(mm)
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	**Ok**	(µm)
Parallelism (0.25 ° maximum) (FP2) :	0.11	0.01	0.13	**0.08**	(°)

Mass : 991.7 (g) Volume: 376791 (mm^3)

Density : 2632 (kg/m^3)

Moisture Conditions : Dry

Loading Rate (0.5 to 1.0 MPa / sec) : 0.51 (MPa/sec)

Type of Fracture : Axial Splitting

Test Duration (2-15 Minutes) : 186 (seconds)

Maximum Applied Load : 294.47 (kN)

Compressive Strength : 94.2 (MPa)

View of Specimen

Before Test :

After Test :

Macroscopic Description

Remarks :

Analysed by : J. Lalonde **Date :** 2022-02-15

Verified by : **Date :** 2022-02-23

Unconfined Compressive Strength of Intact Rock Core Specimen
ASTM D 7012, ASTM D 4543

Client : Nokia

Project : 600 March Road, Kanata, Ontario

Project N° : 12566614

Sample N° : BH-07-22 r.3

Depth : 3,96 - 4,07 m

Sampling Date : 2022-01-31

Testing Apparatus Used : **Loading device N°_9130____** **Caliper N° _1__________**

Technical Data

				Average	
Diameter :	63.14	63.10	63.14	**63.13**	(mm)
Length :	107.94	107.84	108.02	**107.93**	(mm)
Straightness (0.5mm maximum) (S1) :	0.1	0.0	0.0	**0.0**	(mm)
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	**Ok**	(µm)
Parallelism (0.25 ° maximum) (FP2) :	0.01	0.10	0.08	**0.06**	(°)

Mass : 877.9 (g) Volume: 337809 (mm^3)

Density : 2599 (kg/m^3)

Moisture Conditions : Dry

Loading Rate (0.5 to 1.0 MPa / sec) : 0.56 (MPa/sec)

Type of Fracture : Multiple Fracture

Test Duration (2-15 Minutes) : 198 (seconds)

Maximum Applied Load : 350.01 (kN)

Compressive Strength : 111.8 (MPa)

View of Specimen

Before Test :

After Test :

Macroscopic Description

Remarks :

Analysed by : J. Lalonde **Date :** 2022-02-15

Verified by : **Date :** 2022-02-23

Unconfined Compressive Strength of Intact Rock Core Specimen
ASTM D 7012, ASTM D 4543

Client : Nokia

Project : 600 March Road, Kanata, Ontario

Project N° : 12566614

Sample N° : BH-10-22 r.1

Depth : 0,94 - 1,07 m

Sampling Date : 2022-02-02

Testing Apparatus Used : **Loading device N° _9130____** **Caliper N° _1__________**

Technical Data

				Average	
Diameter :	63.12	63.10	63.10	**63.11**	(mm)
Length :	123.94	123.78	123.86	**123.86**	(mm)
Straightness (0.5mm maximum) (S1) :	0.1	0.1	0.0	**0.1**	(mm)
Flatness (25µm maximum) (FP2) :	Ok	Ok	Ok	**Ok**	(µm)
Parallelism (0.25 ° maximum) (FP2) :	0.07	0.09	0.00	**0.05**	(°)

Mass : 1024.9 (g) Volume: 387411 (mm^3)

Density : 2646 (kg/m^3)

Moisture Conditions : Dry

Loading Rate (0.5 to 1.0 MPa / sec) : 0.58 (MPa/sec)

Type of Fracture : Axial Splitting

Test Duration (2-15 Minutes) : 197 (seconds)

Maximum Applied Load : 354.38 (kN)

Compressive Strength : 113.3 (MPa)

View of Specimen

Before Test :

After Test :

Macroscopic Description

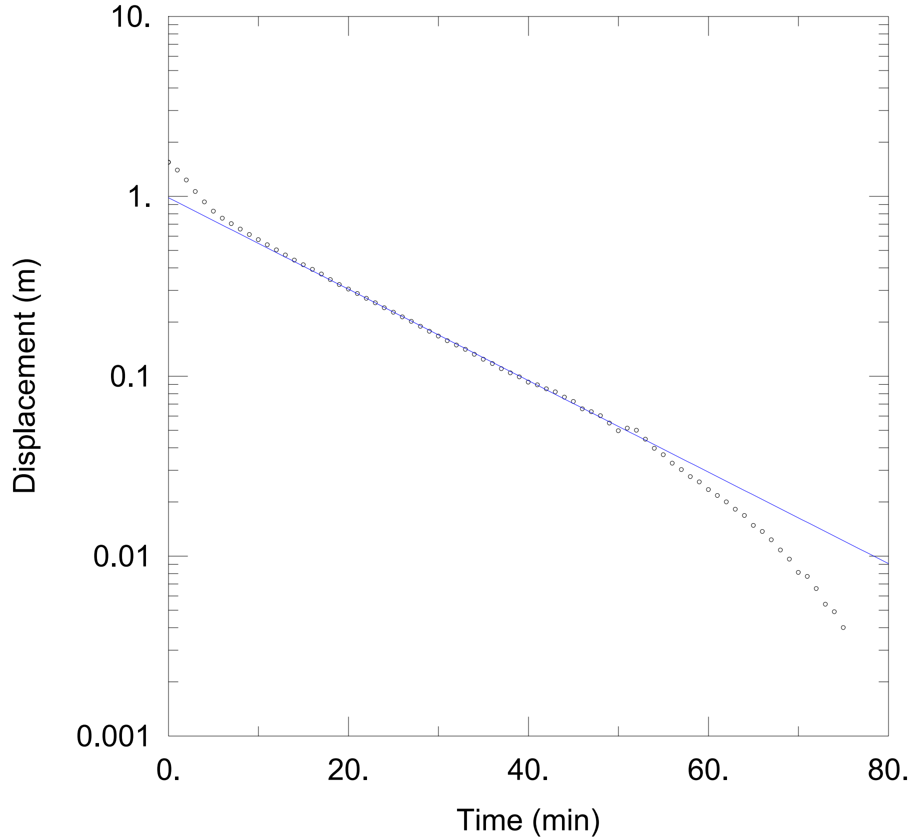
Remarks :

Analysed by : J. Lalonde **Date :** 2022-02-15

Verified by : **Date :** 2022-02-23

Appendix D

Hydrogeological Assessment and Results



BH02-22 - RECOVERY TEST

Data Set: N:\...\BH02-22 - Recovery Test.aqt
Date: 02/24/22 Time: 09:38:46

PROJECT INFORMATION

Company: GHD Ltd.
Client: Nokia
Project: 12566614
Location: Kanata, Ontario
Test Well: BH02-22
Test Date: February 9, 2022

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

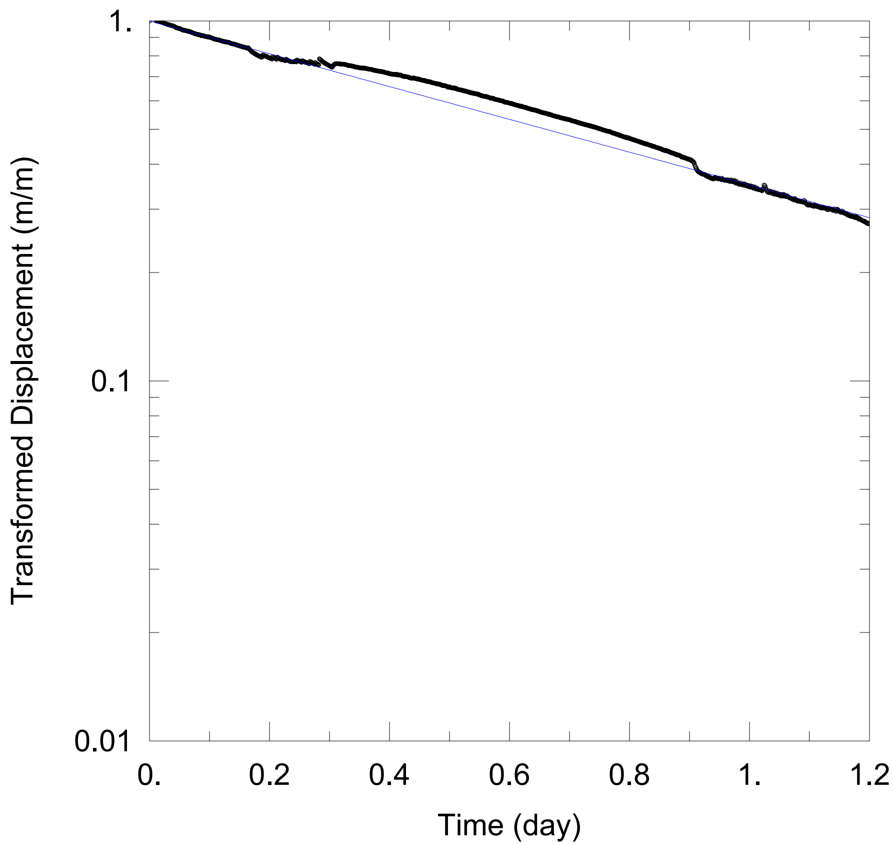
K = 3.849E-5 cm/sec
y0 = 0.9815 m

AQUIFER DATA

Saturated Thickness: 4.61 m
Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (BH10-22)

Initial Displacement: 1.545 m
Total Well Penetration Depth: 4.66 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.65 m
Screen Length: 3.05 m
Well Radius: 0.048 m



BH10-22 - RECOVERY TEST

Data Set: \...\BH10-22 - Recovery Test.aqt
Date: 02/24/22 Time: 09:37:55

PROJECT INFORMATION

Company: GHD Ltd.
Client: Nokia
Project: 12566614
Location: Kanata, Ontario
Test Well: BH10-22
Test Date: February 9, 2022

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan

K = 2.073E-6 cm/sec
y0 = 0.6348 m

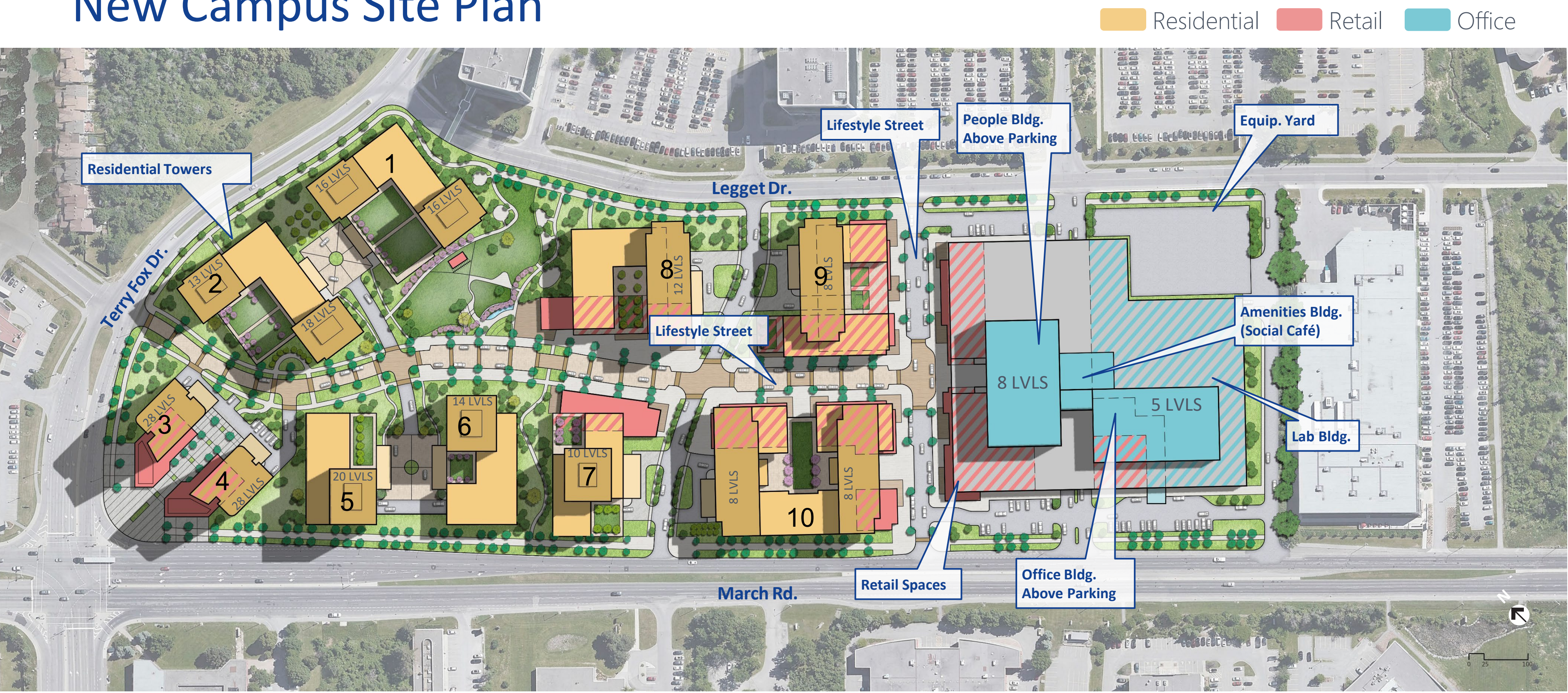
AQUIFER DATA

Saturated Thickness: 0.87 m
Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (BH10-22)

Initial Displacement: 0.635 m
Total Well Penetration Depth: 0.87 m
Casing Radius: 0.0254 m
Static Water Column Height: 0.87 m
Screen Length: 0.87 m
Well Radius: 0.048 m
Gravel Pack Porosity: 0.3

New Campus Site Plan



  February 10, 2022

Gensler NOKIA

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 1- Block 1

NOKIA CAMPUS
KANATA, ON

Flow to a Shaft in an *Unconfined Aquifer*

Information

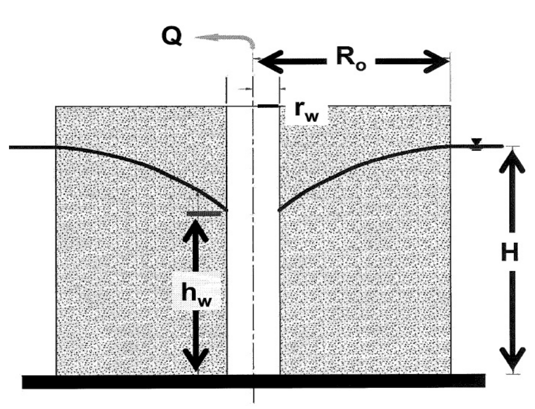
Steady State flow to a shaft within an unconfined aquifer.
Use this equation when a/b < 1.5.
Equation 1.0

$$Q = \frac{\pi K\left(H^2 - h_w^2\right)}{\ln R_0 / r_w}$$

Equation 1.1

$$r_w = \sqrt{\frac{ab}{\pi}}$$

Ro is determined by the Siechardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s



Enter Parameters

Shaft or Trench Eq'n Check: **1.348387097** This number **must be less than 1.5**; if not, then use a Trench equation.

K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	0.00771769	m/day	Hydraulic Conductivity converted to m/d
H=	**0.736**	m	Input height of groundwater
hw=	**0**	m	Input dewatering height
a=	**67.716**	m	Input length of excavation
b=	**50.22**	m	Input width of excavation
rw=	**32.90**	m	Input/calculate radius of shaft
π=	3.141592654		Pi

Note: Height measurements are relative to base of active groundwater

Calculating Ro using: $R_o = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	30	days	Input pumping duration in days
S=	0.3		Input storage coefficient
Ro=	1.13	m	Radius of Influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_o = 1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days.** R_o will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	1.00E-06	cm/s	K2=	0.000864	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 1.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
Ro=	**33.56**	**m**	**Q=**	**0.661**	**m³/day**	**Q=**	**0.459**	**L/min**	**Q=**	**0.101**	**gal/min**
Ro2=	33.12	m	Q2=	0.22	m³/day	Q2=	0.15	L/min	Q2=	0.03	gal/min
Ro3=	33.60	m	Q3=	0.70	m³/day	Q3=	0.49	L/min	Q3=	0.11	gal/min
Ro4=	35.11	m	Q4=	2.26	m³/day	Q4=	1.57	L/min	Q4=	0.35	gal/min
Ro5=	6.98	m	Q5=	-0.95	m³/day	Q5=	-0.66	L/min	Q5=	-0.14	gal/min
Ro6=	54.98	m	Q6=	28.63	m³/day	Q6=	19.88	L/min	Q6=	4.37	gal/min
Ro7=	102.72	m	Q7=	129.14	m³/day	Q7=	89.68	L/min	Q7=	19.73	gal/min
Ro8=	253.70	m	Q8=	719.82	m³/day	Q8=	499.84	L/min	Q8=	109.95	gal/min
Ro9=	731.13	m	Q9=	4741.38	m³/day	Q9=	3292.41	L/min	Q9=	724.23	gal/min
R10=	2240.90	m	Q10=	34832.97	m³/day	Q10=	24188.01	L/min	Q10=	5320.61	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 1- Block 2

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.

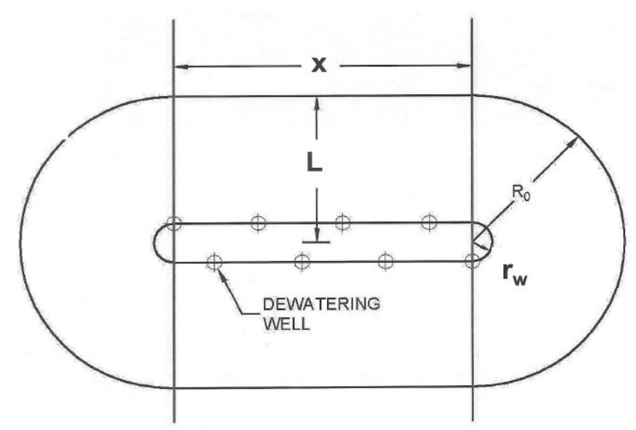
Equation 4.0

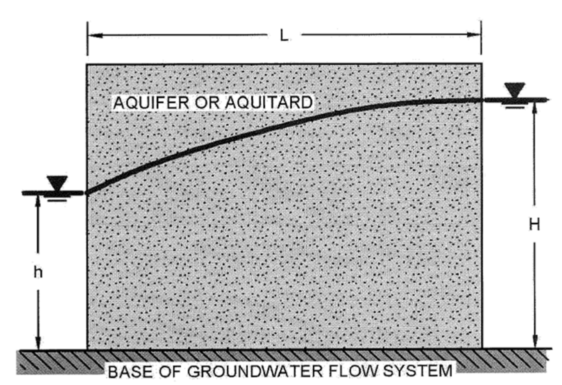
$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0/r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check: **2.9** This number **must be greater than 1.5**; if not, then use a Shaft equation.

K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**24.624**	m	Input length of trench
a=	**24.624**	m	Input length of excavation
b=	**8.424**	m	Input width of excavation
rw=	**10.52**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0=1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_o=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days. R_o** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)				Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**11.18**	**m**	**Q=**	**0.23**	**m³/day**	**Q=**	**0.16**	**L/min**	**Q=**	**0.03**	**gal/min**
L2= Ro2=	15.93	m	Q2=	2.56	m³/day	Q2=	1.78	L/min	Q2=	0.39	gal/min
L3= Ro3=	11.22	m	Q3=	0.24	m³/day	Q3=	0.17	L/min	Q3=	0.04	gal/min
L4= Ro4=	12.73	m	Q4=	0.86	m³/day	Q4=	0.60	L/min	Q4=	0.13	gal/min
L5= Ro5=	6.98	m	Q5=	-1.93	m³/day	Q5=	-1.34	L/min	Q5=	-0.30	gal/min
L6= Ro6=	32.60	m	Q6=	16.54	m³/day	Q6=	11.48	L/min	Q6=	2.53	gal/min
L7= Ro7=	80.35	m	Q7=	86.68	m³/day	Q7=	60.19	L/min	Q7=	13.24	gal/min
L8= Ro8=	231.32	m	Q8=	525.65	m³/day	Q8=	365.01	L/min	Q8=	80.29	gal/min
L9= Ro9=	708.76	m	Q9=	3,655.30	m³/day	Q9=	2,538.24	L/min	Q9=	558.33	gal/min
L10= R10=	2218.52	m	Q10=	27,998.14	m³/day	Q10=	19,441.91	L/min	Q10=	4,276.62	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 1- Block 3

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

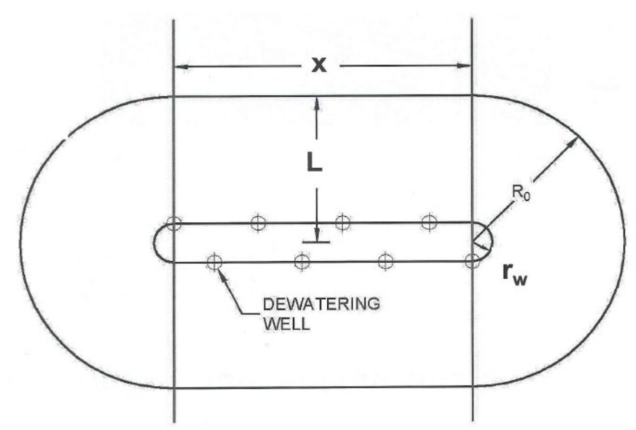
Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.
Equation 4.0

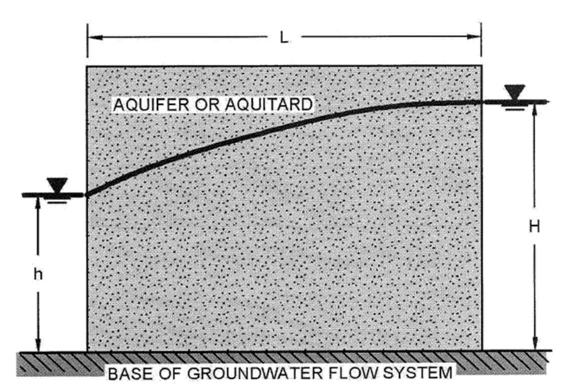
$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0 / r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check:	**2.3**		This number **must be greater than 1.5**; if not, then use a Shaft equation.
K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**24.3**	m	Input length of trench
a=	**24.3**	m	Input length of excavation
b=	**10.368**	m	Input width of excavation
rw=	**11.04**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0 = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_0=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days. R_0** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**11.70**	**m**	**Q=**	**0.23**	**m³/day**	**Q=**	**0.16**	**L/min**	**Q=**	**0.04**	**gal/min**
L2= Ro2=	16.45	m	Q2=	2.63	m³/day	Q2=	1.82	L/min	Q2=	0.40	gal/min
L3= Ro3=	11.74	m	Q3=	0.25	m³/day	Q3=	0.17	L/min	Q3=	0.04	gal/min
L4= Ro4=	13.25	m	Q4=	0.89	m³/day	Q4=	0.62	L/min	Q4=	0.14	gal/min
L5= Ro5=	6.98	m	Q5=	-1.58	m³/day	Q5=	-1.10	L/min	Q5=	-0.24	gal/min
L6= Ro6=	33.12	m	Q6=	16.82	m³/day	Q6=	11.68	L/min	Q6=	2.57	gal/min
L7= Ro7=	80.86	m	Q7=	87.91	m³/day	Q7=	61.04	L/min	Q7=	13.43	gal/min
L8= Ro8=	231.84	m	Q8=	532.01	m³/day	Q8=	369.43	L/min	Q8=	81.26	gal/min
L9= Ro9=	709.27	m	Q9=	3,692.59	m³/day	Q9=	2,564.13	L/min	Q9=	564.03	gal/min
L10= R10=	2219.04	m	Q10=	28,237.95	m³/day	Q10=	19,608.43	L/min	Q10=	4,313.25	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 2- Block 1

NOKIA CAMPUS
KANATA, ON

Flow to a Shaft in an *Unconfined Aquifer*

Information

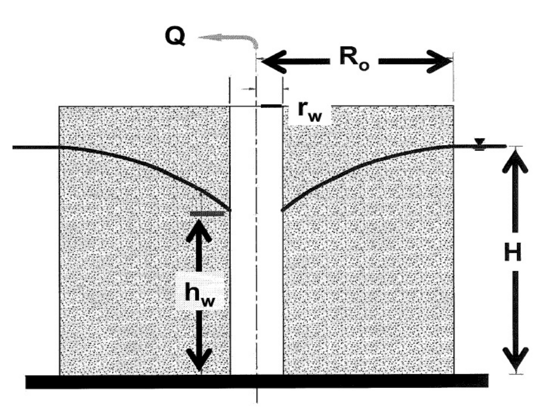
Steady State flow to a shaft within an unconfined aquifer.
Use this equation when a/b < 1.5.
Equation 1.0

$$Q = \frac{\pi K \left(H^2 - h_w^2\right)}{\ln R_0 / r_w}$$

Equation 1.1

$$r_w = \sqrt{\frac{ab}{\pi}}$$

Ro is determined by the Siechardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s



Enter Parameters

Shaft or Trench Eq'n Check: **1.171052632** This number **must be less than 1.5**; if not, then use a Trench equation.

K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	0.00771769	m/day	Hydraulic Conductivity converted to m/d
H=	**0.736**	m	Input height of groundwater
hw=	**0**	m	Input dewatering height
a=	**57.672**	m	Input length of excavation
b=	**49.248**	m	Input width of excavation
rw=	**30.07**	m	Input/calculate radius of shaft
π=	3.141592654		Pi

Note: Height measurements are relative to base of active groundwater

Calculating Ro using: $R_o = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	30	days	Input pumping duration in days
S=	0.3		Input storage coefficient
Ro=	1.13	m	Radius of Influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_o=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days.** R_o will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	1.00E-06	cm/s	K2=	0.000864	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 1.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
Ro=	**30.73**	**m**	**Q=**	**0.605**	**m³/day**	**Q=**	**0.420**	**L/min**	**Q=**	**0.092**	**gal/min**
Ro2=	30.29	m	Q2=	0.20	m³/day	Q2=	0.14	L/min	Q2=	0.03	gal/min
Ro3=	30.77	m	Q3=	0.64	m³/day	Q3=	0.44	L/min	Q3=	0.10	gal/min
Ro4=	32.28	m	Q4=	2.07	m³/day	Q4=	1.44	L/min	Q4=	0.32	gal/min
Ro5=	6.98	m	Q5=	-1.01	m³/day	Q5=	-0.70	L/min	Q5=	-0.15	gal/min
Ro6=	52.15	m	Q6=	26.70	m³/day	Q6=	18.54	L/min	Q6=	4.08	gal/min
Ro7=	99.89	m	Q7=	122.47	m³/day	Q7=	85.04	L/min	Q7=	18.71	gal/min
Ro8=	250.87	m	Q8=	693.08	m³/day	Q8=	481.27	L/min	Q8=	105.87	gal/min
Ro9=	728.30	m	Q9=	4613.20	m³/day	Q9=	3203.41	L/min	Q9=	704.65	gal/min
R10=	2238.07	m	Q10=	34115.42	m³/day	Q10=	23689.75	L/min	Q10=	5211.01	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 2- Block 2

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

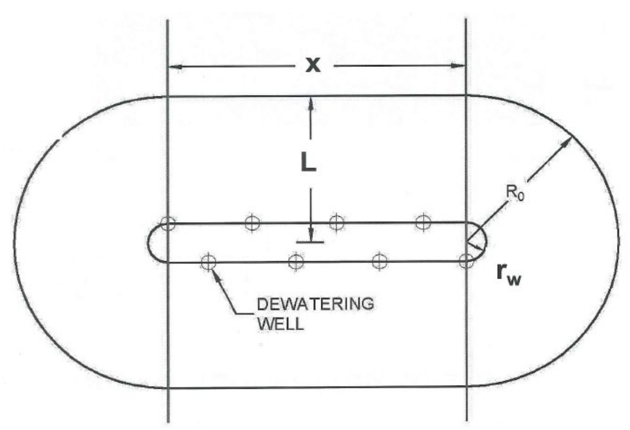
Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.
Equation 4.0

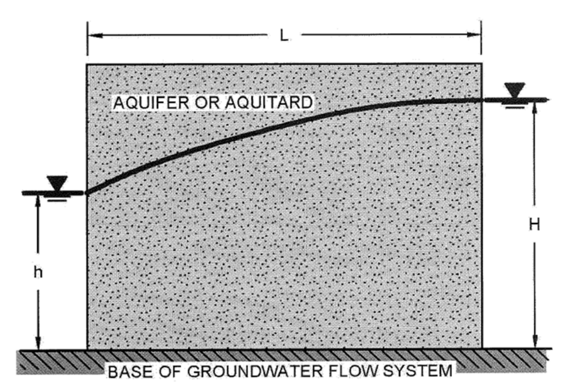
$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0 / r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check: **2.6** This number **must be greater than 1.5**; if not, then use a Shaft equation.

K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**24.624**	m	Input length of trench
a=	**24.624**	m	Input length of excavation
b=	**9.396**	m	Input width of excavation
rw=	**10.83**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0 = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_0=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days. R_0** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**11.49**	**m**	**Q=**	**0.23**	**m³/day**	**Q=**	**0.16**	**L/min**	**Q=**	**0.04**	**gal/min**
L2= Ro2=	16.24	m	Q2=	2.60	m³/day	Q2=	1.81	L/min	Q2=	0.40	gal/min
L3= Ro3=	11.53	m	Q3=	0.25	m³/day	Q3=	0.17	L/min	Q3=	0.04	gal/min
L4= Ro4=	13.04	m	Q4=	0.88	m³/day	Q4=	0.61	L/min	Q4=	0.13	gal/min
L5= Ro5=	6.98	m	Q5=	-1.70	m³/day	Q5=	-1.18	L/min	Q5=	-0.26	gal/min
L6= Ro6=	32.91	m	Q6=	16.73	m³/day	Q6=	11.62	L/min	Q6=	2.56	gal/min
L7= Ro7=	80.66	m	Q7=	87.53	m³/day	Q7=	60.78	L/min	Q7=	13.37	gal/min
L8= Ro8=	231.63	m	Q8=	529.88	m³/day	Q8=	367.95	L/min	Q8=	80.94	gal/min
L9= Ro9=	709.07	m	Q9=	3,679.08	m³/day	Q9=	2,554.75	L/min	Q9=	561.97	gal/min
L10= R10=	2218.83	m	Q10=	28,147.02	m³/day	Q10=	19,545.29	L/min	Q10=	4,299.36	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 2- Block 3

NOKIA CAMPUS
KANATA, ON

Flow to a Shaft in an *Unconfined Aquifer*

Information

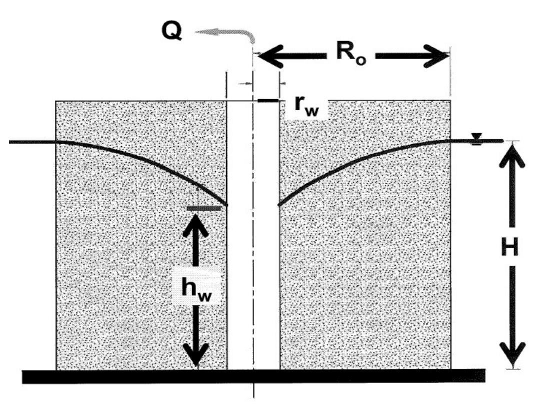
Steady State flow to a shaft within an unconfined aquifer.
Use this equation when a/b < 1.5.
Equation 1.0

$$Q = \frac{\pi K \left(H^2 - h_w^2\right)}{\ln R_0 / r_w}$$

Equation 1.1

$$r_w = \sqrt{\frac{ab}{\pi}}$$

Ro is determined by the Siechardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s



Enter Parameters

Shaft or Trench Eq'n Check: **1.168831169** This number **must be less than 1.5**; if not, then use a Trench equation.

K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	0.00771769	m/day	Hydraulic Conductivity converted to m/d
H=	**0.736**	m	Input height of groundwater
hw=	**0**	m	Input dewatering height
a=	**29.16**	m	Input length of excavation
b=	**24.948**	m	Input width of excavation
rw=	**15.22**	m	Input/calculate radius of shaft
π=	3.141592654		Pi

Note: Height measurements are relative to base of active groundwater

Calculating Ro using: $R_o = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	30	days	Input pumping duration in days
S=	0.3		Input storage coefficient
Ro=	1.13	m	Radius of Influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) R_o=1.5(Tt/S)$^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days. R_o** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	1.00E-06	cm/s	K2=	0.000864	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 1.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
Ro=	**15.88**	**m**	**Q=**	**0.309**	**m³/day**	**Q=**	**0.215**	**L/min**	**Q=**	**0.047**	**gal/min**
Ro2=	15.44	m	Q2=	0.10	m³/day	Q2=	0.07	L/min	Q2=	0.02	gal/min
Ro3=	15.92	m	Q3=	0.33	m³/day	Q3=	0.23	L/min	Q3=	0.05	gal/min
Ro4=	17.43	m	Q4=	1.09	m³/day	Q4=	0.75	L/min	Q4=	0.17	gal/min
Ro5=	6.98	m	Q5=	-1.89	m³/day	Q5=	-1.31	L/min	Q5=	-0.29	gal/min
Ro6=	37.30	m	Q6=	16.40	m³/day	Q6=	11.39	L/min	Q6=	2.51	gal/min
Ro7=	85.04	m	Q7=	85.45	m³/day	Q7=	59.34	L/min	Q7=	13.05	gal/min
Ro8=	236.02	m	Q8=	536.33	m³/day	Q8=	372.43	L/min	Q8=	81.92	gal/min
Ro9=	713.45	m	Q9=	3821.38	m³/day	Q9=	2653.57	L/min	Q9=	583.70	gal/min
R10=	2223.22	m	Q10=	29499.65	m³/day	Q10=	20484.56	L/min	Q10=	4505.97	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 3

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

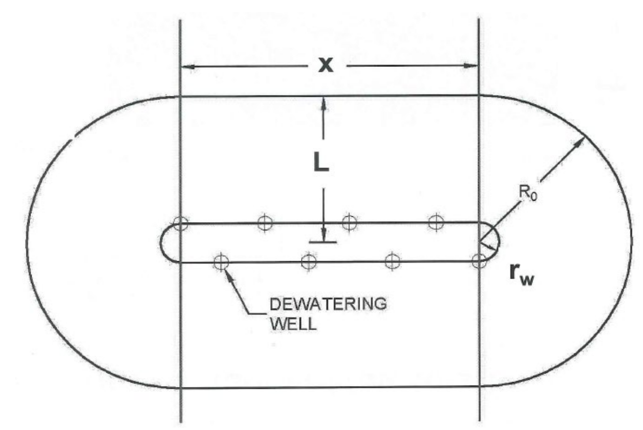
Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.
Equation 4.0

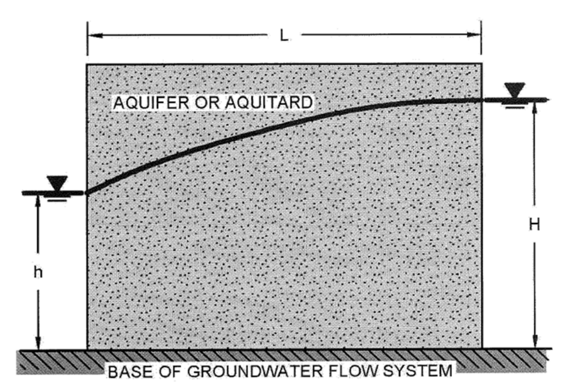
$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0 / r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a + b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check:	**1.5**		This number **must be greater than 1.5**; if not, then use a Shaft equation.
K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**37.584**	m	Input length of trench
a=	**37.584**	m	Input length of excavation
b=	**24.624**	m	Input width of excavation
rw=	**19.81**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0 = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_0 = 1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days. R_0** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)				Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**20.47**	**m**	**Q=**	**0.41**	**m³/day**	**Q=**	**0.28**	**L/min**	**Q=**	**0.06**	**gal/min**
L2= Ro2=	25.22	m	Q2=	4.07	m³/day	Q2=	2.83	L/min	Q2=	0.62	gal/min
L3= Ro3=	20.51	m	Q3=	0.43	m³/day	Q3=	0.30	L/min	Q3=	0.07	gal/min
L4= Ro4=	22.02	m	Q4=	1.47	m³/day	Q4=	1.02	L/min	Q4=	0.22	gal/min
L5= Ro5=	6.98	m	Q5=	1.11	m³/day	Q5=	0.77	L/min	Q5=	0.17	gal/min
L6= Ro6=	41.89	m	Q6=	23.83	m³/day	Q6=	16.55	L/min	Q6=	3.64	gal/min
L7= Ro7=	89.63	m	Q7=	117.03	m³/day	Q7=	81.27	L/min	Q7=	17.88	gal/min
L8= Ro8=	240.61	m	Q8=	661.97	m³/day	Q8=	459.67	L/min	Q8=	101.11	gal/min
L9= Ro9=	718.04	m	Q9=	4,340.34	m³/day	Q9=	3,013.93	L/min	Q9=	662.97	gal/min
L10= R10=	2227.81	m	Q10=	31,924.37	m³/day	Q10=	22,168.28	L/min	Q10=	4,876.33	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 4

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

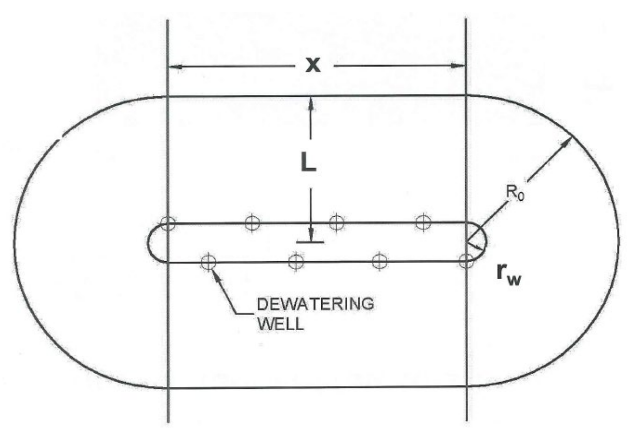
Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.
Equation 4.0

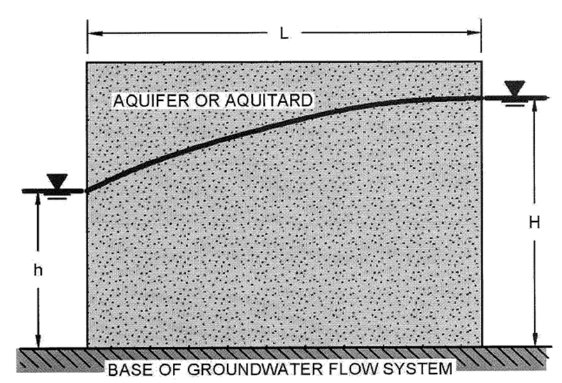
$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0/r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check:	1.5		This number **must be greater than 1.5**; if not, then use a Shaft equation.
K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**37.584**	m	Input length of trench
a=	**37.584**	m	Input length of excavation
b=	**24.624**	m	Input width of excavation
rw=	**19.81**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: R_0=1.5(Tt/S)$^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) R_0=1.5(Tt/S)$^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days.** $\mathbf{R_0}$ will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)				Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**20.47**	**m**	**Q=**	**0.41**	**m³/day**	**Q=**	**0.28**	**L/min**	**Q=**	**0.06**	**gal/min**
L2= Ro2=	25.22	m	Q2=	4.07	m³/day	Q2=	2.83	L/min	Q2=	0.62	gal/min
L3= Ro3=	20.51	m	Q3=	0.43	m³/day	Q3=	0.30	L/min	Q3=	0.07	gal/min
L4= Ro4=	22.02	m	Q4=	1.47	m³/day	Q4=	1.02	L/min	Q4=	0.22	gal/min
L5= Ro5=	6.98	m	Q5=	1.11	m³/day	Q5=	0.77	L/min	Q5=	0.17	gal/min
L6= Ro6=	41.89	m	Q6=	23.83	m³/day	Q6=	16.55	L/min	Q6=	3.64	gal/min
L7= Ro7=	89.63	m	Q7=	117.03	m³/day	Q7=	81.27	L/min	Q7=	17.88	gal/min
L8= Ro8=	240.61	m	Q8=	661.97	m³/day	Q8=	459.67	L/min	Q8=	101.11	gal/min
L9= Ro9=	718.04	m	Q9=	4,340.34	m³/day	Q9=	3,013.93	L/min	Q9=	662.97	gal/min
L10= R10=	2227.81	m	Q10=	31,924.37	m³/day	Q10=	22,168.28	L/min	Q10=	4,876.33	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 5

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

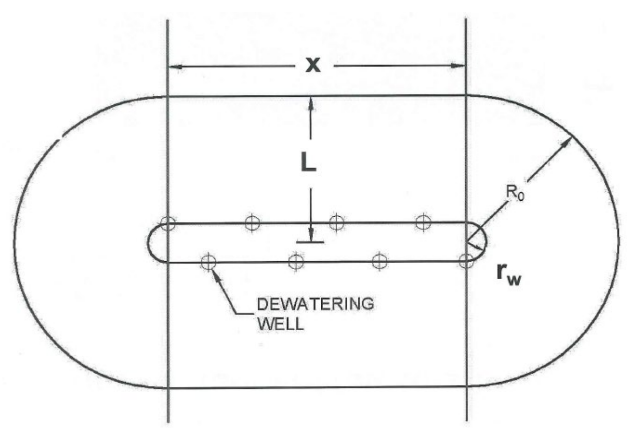
Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.
Equation 4.0

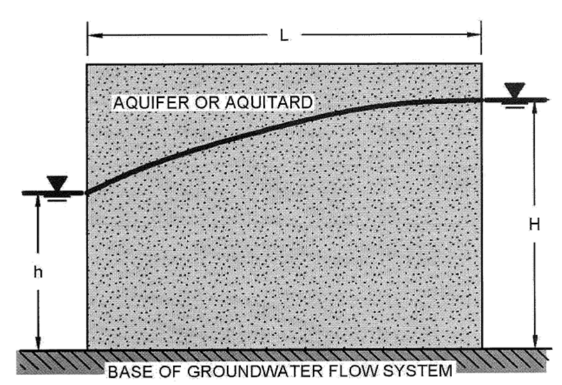
$$Q=\frac{\pi K\left(H^2-h^2\right)}{\ln R_0/r_w}+2\left[\frac{xK\left(H^2-h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w=\frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check:	**1.6**		This number **must be greater than 1.5**; if not, then use a Shaft equation.
K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**58.32**	m	Input length of trench
a=	**58.32**	m	Input length of excavation
b=	**36.612**	m	Input width of excavation
rw=	**30.23**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0=1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_0=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days. R_o** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**30.89**	**m**	**Q=**	**0.62**	**m³/day**	**Q=**	**0.43**	**L/min**	**Q=**	**0.09**	**gal/min**
L2= Ro2=	35.64	m	Q2=	5.82	m³/day	Q2=	4.04	L/min	Q2=	0.89	gal/min
L3= Ro3=	30.93	m	Q3=	0.65	m³/day	Q3=	0.45	L/min	Q3=	0.10	gal/min
L4= Ro4=	32.44	m	Q4=	2.17	m³/day	Q4=	1.51	L/min	Q4=	0.33	gal/min
L5= Ro5=	6.98	m	Q5=	2.91	m³/day	Q5=	2.02	L/min	Q5=	0.44	gal/min
L6= Ro6=	52.31	m	Q6=	32.03	m³/day	Q6=	22.24	L/min	Q6=	4.89	gal/min
L7= Ro7=	100.06	m	Q7=	150.14	m³/day	Q7=	104.26	L/min	Q7=	22.93	gal/min
L8= Ro8=	251.03	m	Q8=	803.39	m³/day	Q8=	557.87	L/min	Q8=	122.71	gal/min
L9= Ro9=	728.46	m	Q9=	4,995.52	m³/day	Q9=	3,468.89	L/min	Q9=	763.05	gal/min
L10= R10=	2238.23	m	Q10=	35,377.79	m³/day	Q10=	24,566.34	L/min	Q10=	5,403.83	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 6- Block 1

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.

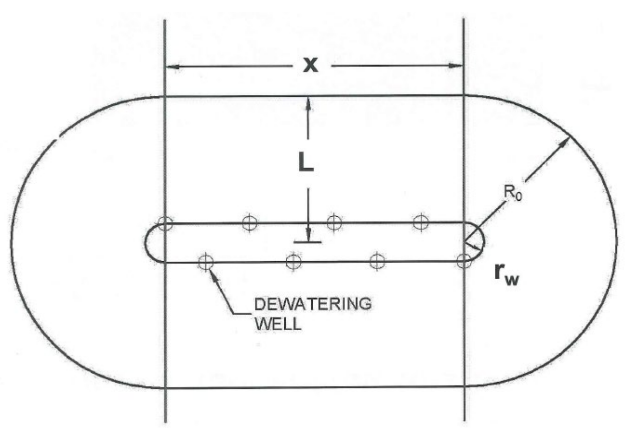
Equation 4.0

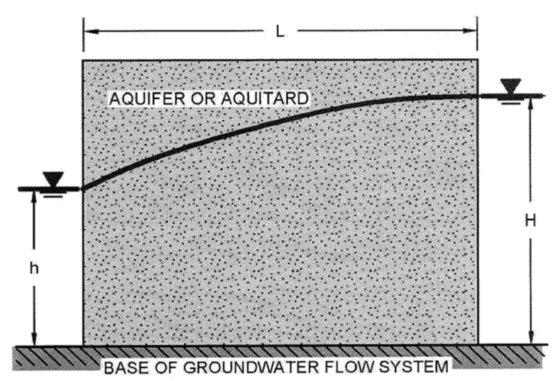
$$Q=\frac{\pi K\left(H^2-h^2\right)}{\ln R_0/r_w}+2\left[\frac{xK\left(H^2-h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w=\frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check: **1.6** — This number **must be greater than 1.5**; if not, then use a Shaft equation.

K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**58.32**	m	Input length of trench
a=	**58.32**	m	Input length of excavation
b=	**36.612**	m	Input width of excavation
rw=	**30.23**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0=1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_0=1.5(Tt/S)^{0.5}$ where T is transmissivity in **m²/day**, **t** is pumping duration in **days. R_0** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)				Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**30.89**	**m**	**Q=**	**0.62**	**m³/day**	**Q=**	**0.43**	**L/min**	**Q=**	**0.09**	**gal/min**
L2= Ro2=	35.64	m	Q2=	5.82	m³/day	Q2=	4.04	L/min	Q2=	0.89	gal/min
L3= Ro3=	30.93	m	Q3=	0.65	m³/day	Q3=	0.45	L/min	Q3=	0.10	gal/min
L4= Ro4=	32.44	m	Q4=	2.17	m³/day	Q4=	1.51	L/min	Q4=	0.33	gal/min
L5= Ro5=	6.98	m	Q5=	2.91	m³/day	Q5=	2.02	L/min	Q5=	0.44	gal/min
L6= Ro6=	52.31	m	Q6=	32.03	m³/day	Q6=	22.24	L/min	Q6=	4.89	gal/min
L7= Ro7=	100.06	m	Q7=	150.14	m³/day	Q7=	104.26	L/min	Q7=	22.93	gal/min
L8= Ro8=	251.03	m	Q8=	803.39	m³/day	Q8=	557.87	L/min	Q8=	122.71	gal/min
L9= Ro9=	728.46	m	Q9=	4,995.52	m³/day	Q9=	3,468.89	L/min	Q9=	763.05	gal/min
L10= R10=	2238.23	m	Q10=	35,377.79	m³/day	Q10=	24,566.34	L/min	Q10=	5,403.83	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 6- Block 2

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.

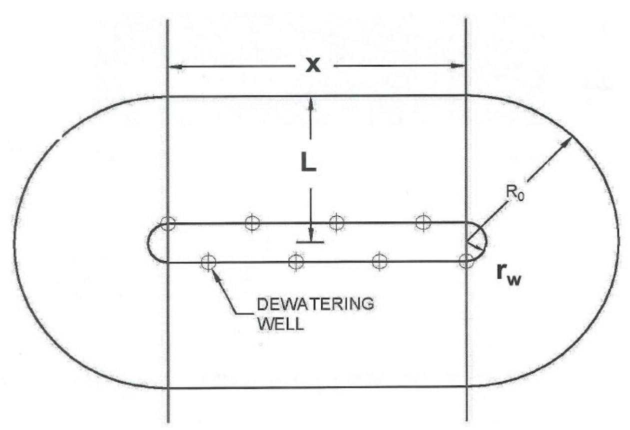
Equation 4.0

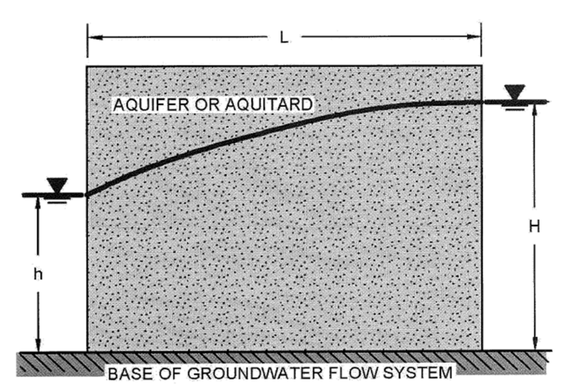
$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0/r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check:	**2.8**		This number **must be greater than 1.5**; if not, then use a Shaft equation.
K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**26.244**	m	Input length of trench
a=	**26.244**	m	Input length of excavation
b=	**9.396**	m	Input width of excavation
rw=	**11.35**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0 = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_0=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days. R_0** will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**12.01**	**m**	**Q=**	**0.24**	**m³/day**	**Q=**	**0.17**	**L/min**	**Q=**	**0.04**	**gal/min**
L2= Ro2=	16.76	m	Q2=	2.70	m³/day	Q2=	1.88	L/min	Q2=	0.41	gal/min
L3= Ro3=	12.05	m	Q3=	0.26	m³/day	Q3=	0.18	L/min	Q3=	0.04	gal/min
L4= Ro4=	13.56	m	Q4=	0.92	m³/day	Q4=	0.64	L/min	Q4=	0.14	gal/min
L5= Ro5=	6.98	m	Q5=	-1.27	m³/day	Q5=	-0.88	L/min	Q5=	-0.19	gal/min
L6= Ro6=	33.43	m	Q6=	17.29	m³/day	Q6=	12.00	L/min	Q6=	2.64	gal/min
L7= Ro7=	81.17	m	Q7=	89.87	m³/day	Q7=	62.41	L/min	Q7=	13.73	gal/min
L8= Ro8=	232.15	m	Q8=	540.08	m³/day	Q8=	375.03	L/min	Q8=	82.50	gal/min
L9= Ro9=	709.58	m	Q9=	3,728.58	m³/day	Q9=	2,589.13	L/min	Q9=	569.53	gal/min
L10= R10=	2219.35	m	Q10=	28,423.46	m³/day	Q10=	19,737.25	L/min	Q10=	4,341.58	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 7

NOKIA CAMPUS
KANATA, ON

Flow to a Trench for a *Unconfined Aquifer*

Information

Steady State flow to a trench for an unconfined aquifer.
Use this equation when a/b > 1.5.

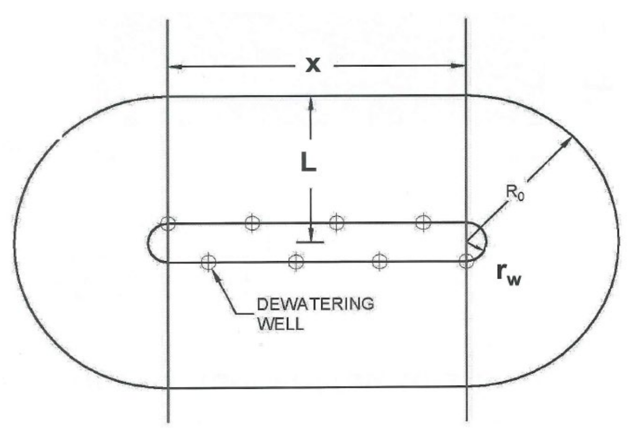
Equation 4.0

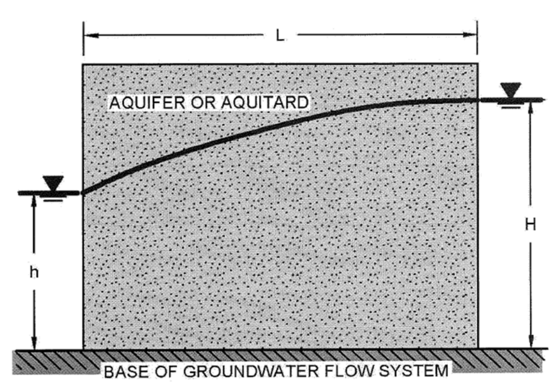
$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0/r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a+b}{\pi}$$

Ro is determined by the Sichardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s





Enter Parameters

Shaft or Trench Eq'n Check:	**1.7**		This number **must be greater than 1.5**; if not, then use a Shaft equation.
K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	7.72E-03	m/day	Hydraulic Conductivity converted to m/day
H=	**0.736**	m	Input height of groundwater pressure
h=	**0**	m	Input dewatering height
x=	**64.476**	m	Input length of trench
a=	**64.476**	m	Input length of excavation
b=	**36.936**	m	Input width of excavation
rw=	**32.30**	m	Input/calculate radius of trench
π=	3.141592654		Pi

Note: L and Ro are the same distance
*Note: Height measurements are relative to base of active groundwater

Calculating L and Ro using: $R_0 = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	365	days	Input pumping duration in days
S=	0.21		Input storage coefficient
L=Ro=	4.71	m	Line source distance; distance of influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_0=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days**. R_0 will be in **metres.**

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	6.00E-04	cm/s	K2=	0.5184	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 4.0

Results for Ro (radius of influence)				Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
L= Ro=	**32.96**	**m**	**Q=**	**0.66**	**m³/day**	**Q=**	**0.46**	**L/min**	**Q=**	**0.10**	**gal/min**
L2= Ro2=	37.71	m	Q2=	6.18	m³/day	Q2=	4.29	L/min	Q2=	0.94	gal/min
L3= Ro3=	33.00	m	Q3=	0.70	m³/day	Q3=	0.48	L/min	Q3=	0.11	gal/min
L4= Ro4=	34.50	m	Q4=	2.31	m³/day	Q4=	1.60	L/min	Q4=	0.35	gal/min
L5= Ro5=	6.98	m	Q5=	3.36	m³/day	Q5=	2.33	L/min	Q5=	0.51	gal/min
L6= Ro6=	54.38	m	Q6=	33.77	m³/day	Q6=	23.45	L/min	Q6=	5.16	gal/min
L7= Ro7=	102.12	m	Q7=	157.28	m³/day	Q7=	109.21	L/min	Q7=	24.02	gal/min
L8= Ro8=	253.10	m	Q8=	833.40	m³/day	Q8=	578.72	L/min	Q8=	127.30	gal/min
L9= Ro9=	730.53	m	Q9=	5,127.54	m³/day	Q9=	3,560.56	L/min	Q9=	783.21	gal/min
L10= R10=	2240.30	m	Q10=	36,029.88	m³/day	Q10=	25,019.15	L/min	Q10=	5,503.44	gal/min

PRELIMINARY ESTIMATED WATER TAKING AND AREA OF INFLUENCE
Building 8

NOKIA CAMPUS
KANATA, ON

Flow to a Shaft in an *Unconfined Aquifer*

Information

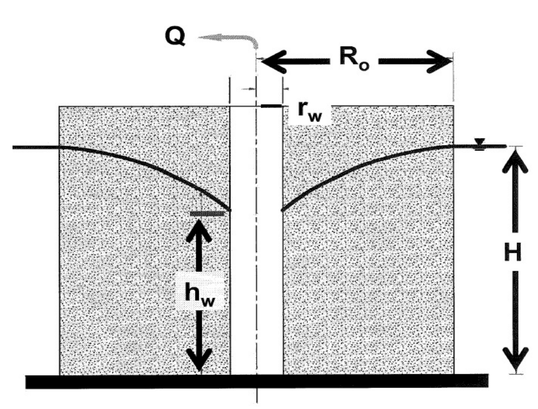
Steady State flow to a shaft within an unconfined aquifer.
Use this equation when a/b < 1.5.
Equation 1.0

$$Q = \frac{\pi K \left(H^2 - h_w^2\right)}{\ln R_0 / r_w}$$

Equation 1.1

$$r_w = \sqrt{\frac{ab}{\pi}}$$

Ro is determined by the Siechardt Equation: Ro = 3000(H-hw)K^0.5 when K is in m/s



Enter Parameters

Shaft or Trench Eq'n Check: **1.085227273** This number **must be less than 1.5**; if not, then use a Trench equation.

K=	**8.93E-06**	cm/s	Input Hydraulic Conductivity in cm/s
=>	0.00771769	m/day	Hydraulic Conductivity converted to m/d
H=	**0.736**	m	Input height of groundwater
hw=	**0**	m	Input dewatering height
a=	**61.884**	m	Input length of excavation
b=	**57.024**	m	Input width of excavation
rw=	**33.52**	m	Input/calculate radius of shaft
π=	3.141592654		Pi

Note: Height measurements are relative to base of active groundwater

Calculating Ro using: $R_o = 1.5(Tt/S)^{0.5}$

T=	0.00568022	m²/day	Input transmissivity in m²/day
t=	30	days	Input pumping duration in days
S=	0.3		Input storage coefficient
Ro=	1.13	m	Radius of Influence

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_o=1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m²/day**, **t** is pumping duration in **days**. **R_o** will be in **metres**.

*Note: The above Ro is for comparison. It is not the Ro used to calculate Q below.

Enter additional K values (optional)

K=	**8.93E-06**	**cm/s**	**K=**	**0.00771769**	**m/day**
K2=	1.00E-06	cm/s	K2=	0.000864	m/day
K3=	1.00E-05	cm/s	K3=	0.00864	m/day
K4=	1.00E-04	cm/s	K4=	0.0864	m/day
K5=	1.00E-03	cm/s	K5=	0.864	m/day
K6=	1.00E-02	cm/s	K6=	8.64	m/day
K7=	1.00E-01	cm/s	K7=	86.4	m/day
K8=	1.00E+00	cm/s	K8=	864	m/day
K9=	1.00E+01	cm/s	K9=	8640	m/day
K10=	1.00E+02	cm/s	K10=	86400	m/day

Calculated flow rate using Equation 1.0

Results for Ro (radius of influence)			Flow Results in m³/day			Flow Results in L/min			Flow Results in gal/min		
Ro=	**34.18**	**m**	**Q=**	**0.674**	**m³/day**	**Q=**	**0.468**	**L/min**	**Q=**	**0.103**	**gal/min**
Ro2=	33.74	m	Q2=	0.22	m³/day	Q2=	0.16	L/min	Q2=	0.03	gal/min
Ro3=	34.21	m	Q3=	0.71	m³/day	Q3=	0.50	L/min	Q3=	0.11	gal/min
Ro4=	35.72	m	Q4=	2.30	m³/day	Q4=	1.60	L/min	Q4=	0.35	gal/min
Ro5=	6.98	m	Q5=	-0.94	m³/day	Q5=	-0.65	L/min	Q5=	-0.14	gal/min
Ro6=	55.60	m	Q6=	29.05	m³/day	Q6=	20.17	L/min	Q6=	4.44	gal/min
Ro7=	103.34	m	Q7=	130.58	m³/day	Q7=	90.68	L/min	Q7=	19.95	gal/min
Ro8=	254.32	m	Q8=	725.53	m³/day	Q8=	503.81	L/min	Q8=	110.82	gal/min
Ro9=	731.75	m	Q9=	4768.53	m³/day	Q9=	3311.27	L/min	Q9=	728.38	gal/min
R10=	2241.52	m	Q10=	34984.01	m³/day	Q10=	24292.90	L/min	Q10=	5343.68	gal/min

APPENDIX D.4
PRELIMINARY WATER TAKING MODEL INPUTS AND OUTPUTS
NOKIA CAMPUS
KANATA, ON

BUILDING	DESCRIPTION	RECTANGULAR BLOCK SEGMENTS OF EACH PROPOSED BUILDING									
		BLOCK 1		BLOCK 2		BLOCK 3		BLOCK 4		BLOCK 5	
		a	b	a	b	a	b	a	b	a	b
1	North corner of Terry Fox & Legget (dual 16 levels)	67.716	50.22	24.624	8.424	24.3	10.368				
		SHAFT		TRENCH		TRENCH					
2	North site (13 & 18 levels)	57.672	49.248	24.624	9.396	29.16	24.948				
		SHAFT		TRENCH		SHAFT					
3	NW Site (28 level twin North)	37.584	24.624								
		TRENCH									
4	NW Site (28 level twin South)	37.584	24.624								
		TRENCH									
5	West side (20 levels)	58.32	36.612								
		TRENCH									
6	West side (14 levels)	58.32	36.612	26.244	9.396						
		TRENCH		TRENCH							
7	Mid west side (10 levels)	64.476	36.936								
		TRENCH									
8	East side (12 levels)	61.884	57.024								
		SHAFT									
NO DEWATERING											
9	East side (8 levels)	72.252	46.008	21.06	9.072						
10	South (dual 8 levels)	38.88	24.948	39.852	24.948	42.444	22.68	42.444	21.384	41.796	22.68
OFFICE	OFFICE	153.9	100.116	93.96	31.104						

NOTES
All proposed building measurements measured off conceptual site plan
All measurements are in metres

APPENDIX D.4
PRELIMINARY WATER TAKING MODEL INPUTS AND OUTPUTS
NOKIA CAMPUS
KANATA, ON

BUILDING	**DEWATERING MODELLING OUTPUTS**										**3x SAFETY FACTOR**	
	BLOCK 1		BLOCK 2		BLOCK 3		TOTALS					
	Q (m^3/day)	R_0 (m)	Q (m^3/day)	R_0 (m)	Q (m^3/day)	R_0 (m)	Q (m^3/day)	R_0 (m)	Q (L/min)	Q (L/day)	Q (m^3/day)	Q (L/day)
1	0.661	33.56	0.23	11.18	0.23	11.7	1.121	39.28	0.778	1,121	3.363	3,363
2	0.605	30.73	0.23	11.49	0.309	15.88	1.144	37.5725	0.794	1,144	3.432	3,432
3	0.41	20.47					0.41	20.47	0.285	410	1.23	1,230
4	0.41	20.47					0.41	20.47	0.285	410	1.23	1,230
5	0.62	30.89					0.62	30.89	0.431	620	1.86	1,860
6	0.62	30.89	0.24	12.01			0.86	36.895	0.597	860	2.58	2,580
7	0.66	32.96					0.66	32.96	0.458	660	1.98	1,980
8	0.674	34.18					0.674	34.18	0.468	674	2.022	2,022
NO DEWATERING									Total Combined	5,899	Total Combined	17,697
9	-	-										
10	-	-										
OFFICE	-	-										

NOTES
Q = Flow rate
R_0 = radius of influence

Appendix E

Chemical Laboratory Results

Certificate of Analysis

Eurofins Environment Testing

Client:	GHD Limited (Ottawa) 400-179 Colonnade Rd. Ottawa, ON K2E 7J4	Report Number:	1971489
Attention:	Mr. Kenneth Omenogor	Date Submitted:	2022-02-09
PO#:	735-002201	Date Reported:	2022-02-17
Invoice to:	GHD Limited (Ottawa)	Project:	12566614 - Nokia
		COC #:	886034

Dear Kenneth Omenogor:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: Addrine Thomas 2022.02.17 14:49:49 -05'00'

Addrine Thomas, Inorganics Supervisor

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: http://www.cala.ca/scopes/2602.pdf.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

eurofins | Environment Testing

Client: GHD Limited (Ottawa)
400-179 Colonnade Rd.
Ottawa, ON
K2E 7J4
Attention: Mr. Kenneth Omenogor
PO#: 735-002201
Invoice to: GHD Limited (Ottawa)

Report Number: 1971489
Date Submitted: 2022-02-09
Date Reported: 2022-02-17
Project: 12566614 - Nokia
COC #: 886034

Group	Analyte	MRL	Units	Guideline	Lab I.D.: 1609628 Sample Matrix: Soil Sample Type: Sampling Date: 2022-01-28 Sample I.D.: BH 01-22 SS2 (7.5ft - 9.5ft)
Anions	SO4	0.01	%		0.04
Cl in Concrete	Cl	0.002	%		0.067
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.86
	pH	2.00			7.79
	Resistivity	1	ohm-cm		1180
Redox Potential	REDOX Potential		mV		210
Subcontract	Moisture-Humidite	0.25	%		33.2
	S2-	0.2	ug/g		<0.20

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Environment Testing

Client:	GHD Limited (Ottawa) 400-179 Colonnade Rd. Ottawa, ON K2E 7J4
Attention:	Mr. Kenneth Omenogor
PO#:	735-002201
Invoice to:	GHD Limited (Ottawa)

Report Number:	1971489
Date Submitted:	2022-02-09
Date Reported:	2022-02-17
Project:	12566614 - Nokia
COC #:	886034

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 416967 **Analysis/Extraction Date** 2022-02-10 **Analyst** MW **Method** C SM2580B			
REDOX Potential	191 mV	100	
Run No 416987 **Analysis/Extraction Date** 2022-02-11 **Analyst** AA **Method** C CSA A23.2-4B			
Chloride	<0.002 %		80-120
Run No 417077 **Analysis/Extraction Date** 2022-02-14 **Analyst** MW **Method** Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	97	90-110
pH	8.68	101	90-110
Resistivity			
SO4	<0.01 %	98	70-130
Run No 417237 **Analysis/Extraction Date** 2022-02-16 **Analyst** AET **Method** SUBCONTRACT-A			
Moisture-Humidite	<0.25 %	100	
S2-	<0.20 ug/g	86	

Guideline = *** = Guideline Exceedence**

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Certificate of Analysis

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Client:	GHD Limited (Ottawa) 400-179 Colonnade Rd. Ottawa, ON K2E 7J4	Report Number:	1971490
Attention:	Mr. Kenneth Omenogor	Date Submitted:	2022-02-09
PO#:	735-002201	Date Reported:	2022-02-17
Invoice to:	GHD Limited (Ottawa)	Project:	12566614 - Nokia
		COC #:	886034

Dear Kenneth Omenogor:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL:

Addrine Thomas
2022.02.17
07:29:51 -05'00'

Addrine Thomas, Inorganics Supervisor

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Certificate of Analysis

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PO#:	735-002201	Date Reported:	2022-02-17
Invoice to:	GHD Limited (Ottawa)	Project:	12566614 - Nokia
		COC #:	886034

				Lab I.D.	1609629
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2022-02-09
				Sample I.D.	BH 02-22
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L		820
	SO4	1	mg/L		220
General Chemistry	Conductivity	5	uS/cm		3360
	pH	1.00			7.54
	Resistivity	0.2	Mohm-cm		298
	S2-	2	mg/L		<2
Redox Potential	REDOX Potential		mV		237

Guideline = *** = Guideline Exceedence**

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Certificate of Analysis

eurofins Environment Testing

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Attention: Mr. Kenneth Omenogor
PO#: 735-002201
Invoice to: GHD Limited (Ottawa)

Report Number: 1971490
Date Submitted: 2022-02-09
Date Reported: 2022-02-17
Project: 12566614 - Nokia
COC #: 886034

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 416967 **Analysis/Extraction Date** 2022-02-10 **Analyst** MW **Method** C SM2580B			
REDOX Potential	191 mV	100	
Run No 416968 **Analysis/Extraction Date** 2022-02-10 **Analyst** AsA **Method** SM2320,2510,4500H/F			
Conductivity	<5 uS/cm	99	90-110
pH		99	90-110
Run No 416971 **Analysis/Extraction Date** 2022-02-11 **Analyst** AaN **Method** SM 4110			
Chloride	<20 mg/L		90-110
SO4	<20 mg/L	100	90-110
Run No 417051 **Analysis/Extraction Date** 2022-02-14 **Analyst** AsA **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	86	80-120
Run No 417218 **Analysis/Extraction Date** 2022-02-17 **Analyst** AET **Method** Resistivity - water			
Resistivity			

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
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Certificate of Analysis

Environment Testing

Client:	GHD Limited (Ottawa) 400-179 Colonnade Rd. Ottawa, ON K2E 7J4		Report Number:	1971490
			Date Submitted:	2022-02-09
			Date Reported:	2022-02-17
			Project:	12566614 - Nokia
Attention:	Mr. Kenneth Omenogor		COC #:	886034
PO#:	735-002201			
Invoice to:	GHD Limited (Ottawa)			

Sample Comment Summary

Sample ID: 1609629 BH 02-22 Cl, S2- & SO4 MRL elevated due to matrix interference (dilution was done).

Guideline = *** = Guideline Exceedence**

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Methods references and/or additional QA/QC information available on request.

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