GEOTECHNICAL REPORT

New Water Intake and Huron Street Reconstruction, Blind River, Ontario

June 2024

TULLOCH Project # 23-0821

LICENSED PROFESSIONAL ENGINEER
J. R. MERCER
100515660
2024-06-10
PROVINCE OF ONTARIO

			Laura M		
June 10, 2024	0	Issued for Use	L. Meneghetti	J. Mercer	G. Liang
February 27, 2024	A	Draft	L. Meneghetti	J. Mercer	G. Liang
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**
TULLOCH					

TULLOCH

1100 South Service Rd. Suite 420
Stoney Creek, ON
L8E 0C5

T. 905.481.1678
TF. 800.797.2997
stoneycreek@tulloch.ca

www.TULLOCH.ca

23-0821
June 10, 2024

Town of Blind River
11 Hudson Street
Blind River, Ontario
P0R 1B0

Attention: Kathryn Scott | CAO/Clerk

RE: New Water Intake and Huron Street Reconstruction, Blind River, Ontario

Dear Mrs. Scott,

Please find enclosed our Geotechnical Report for the proposed HDD crossing and reconstruction of approximately 450 linear meters of paved road and municipal services on Huron Avenue, between Causley Street and Woodward Avenue in Blind River, Ontario.

This report outlines the results of the geotechnical investigation and provides geotechnical design recommendations and construction considerations for the HDD crossing and road reconstruction.

We trust the enclosed is adequate for your current needs. If there is anything further that we can assist with, please contact us at your convenience.

Sincerely,

Jackson Mercer, P. Eng.
Geotechnical Engineer

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION AND SCOPE

TULLOCH Engineering Inc. (TULLOCH) was retained by the Town of Blind River (Client) to complete a geotechnical investigation for the proposed HDD crossing utilizing trenchless technology systems for the installation of a 300 mm watermain proposed to be installed below the Huron Central Railway crossing and Causley Street (Highway 17), and the reconstruction of approximately 450 linear meters of paved road and municipal services on Huron Avenue, between Causley Street and Woodward Avenue in Blind River, Ontario.

The purpose of the geotechnical investigation was to evaluate the subsurface conditions within the project site in order to provide recommendations for the trenchless crossing design and the reconstruction of the pavement structure as well as municipal services along Huron Street. A site plan attached in Appendix A outlines the borehole locations completed for the drilling investigation associated with the project.

This report provides the factual geotechnical investigation data and geotechnical design recommendations, which are based on the site investigation data, our understanding of the project scope and engineering experience. Common terminology used in this report can be found in Appendix B and specific terminology is referenced in table notes or in the report body.

2. REGIONAL GEOLOGY AND SITE INFORMATION

Based on review of Bedrock Geology and Northern Ontario Engineering Geology Terrain Study (NOEGTS) (OGS 2005) and Bedrock Geology of Ontario (OGS 2011) mapping as published by the Ontario Geological Survey, the site surficial geology consists of a till material predominantly of sand to silty sand matrix. The bedrock comprised of siltstone, wacke, and argillite, of the McKim Formation belonging to the Elliot Lake Group. The topography of the site is undulating to rolling, with moderate relief and exhibits missed wet and dry drainage conditions.

The project site is located from the shoreline of Lake Huron to the Huron Central Railway and Huron Avenue, between Causley Street and Woodward Avenue in Blind River, Ontario. The roadway proposed for reconstruction consists of a paved two-lane residential road with concrete sidewalks servicing north and south traffic flows. A detailed photo log of the site and investigation is attached in Appendix C.

3. SITE INVESTIGATION AND METHODOLOGY

The field investigation was undertaken from October 30 to November 1, 2023, and consisted of advancing nine (9) geotechnical boreholes referenced as BH-23-01 to BH-23-06, BH-23-09, BH-23-10 and BH-23-12, and three (3) environmental boreholes referenced as BH-23-07, BH-23-08 and BH-23-11. The geotechnical boreholes were advanced to a termination depth between 1.52 m below ground surface (mbgs) to 8.99 mbgs. Shallow auger and spoon refusal were encountered during the advance of BH-23-05 at 0.46 mbgs and BH-23-06 at 2.90 mbgs. The environmental boreholes were advanced to a termination depth of 0.76 mbgs. A supplemental excess soils management investigation was conducted by TULLOCH in accordance with O.Reg. 406/19 concurrently with the geotechnical investigation. Recommendations associated with soil disposal are not included within the scope of this report and are provided in a separate report issued by TULLOCH.

All boreholes were positioned, and field fit to avoid underground utilities present under the direction of a TULLOCH geotechnical representative based on the public and private locate clearances completed prior to the investigation. The following table summarizes the borehole investigation.

Table 3-1: Summary of Borehole Information

Borehole No.	Borehole Type	Easting (m)	Northing (m)	Ground Surface Elevation (m)	Depth of Borehole (mbgs)[1]
BH-23-01	Geotechnical	349 247	5 116 261	178.6	7.12
BH-23-02	Geotechnical	349 299	5 116 307	180.9	5.12
BH-23-03	Geotechnical	349 344	5 116 361	182.7	8.99
BH-23-04	Geotechnical	349 409	5 116 373	182.3	5.90
BH-23-05	Geotechnical	349 454	5 116 455	189.2	0.46
BH-23-06	Geotechnical	349 475	5 116 484	190.3	2.90
BH-23-07	Environmental	349 498	5 116 513	190.4	0.76
BH-23-08	Environmental	349 511	5 116 551	188.5	0.76
BH-23-09	Geotechnical	349 557	5 116 629	185.3	3.05
BH-23-10	Geotechnical	349 578	5 116 660	183.7	1.52
BH-23-11	Environmental	349 592	5 116 674	183.2	0.76
BH-23-12	Geotechnical	349 607	5 116 699	182.9	5.18

Note(s): [1]meters below ground surface.

Boreholes were advanced using a CME 55 truck-mounted drill rig owned and operated by Landcore Drilling in Chelmsford, Ontario. The geotechnical boreholes were advanced using 200 mm OD (outside diameter) continuous flight hollow stem augers and/or using NQ/NWT casing and wash boring. Bedrock cores were retrieved within the NW casing with an NQ2 (76 mm OD) rock core barrel., The environmental boreholes were advanced using continuous flight solid stem augers. The rig was equipped with standard soil sampling equipment including an automatic hammer.

In the overburden, soil samples were obtained using standard split spoon equipment in conjunction with Standard Penetration Tests (SPT) performed in accordance with ASTM D1586. SPT sampling generally occurred at 0.76 m intervals in the upper approximately 1.5 m of the boreholes, and at 1.5 m intervals thereafter and was conducted using an automatic hammer.

The drilling and soil/rock sampling program were directed by a TULLOCH representative, who logged the drilling operations and identified the soil samples and rock cores as they were retrieved. Detailed borehole logs for the proposed site can be found in Appendix D. Detailed bedrock core photos of the retrieved runs are attached in Appendix E.

The recovered soil/rock samples were transported to TULLOCH's CCIL-Certified Laboratory in Sault Ste. Marie for detailed examination and testing. A select number of soil samples were also submitted to Testmark Laboratories in Garson, ON for soil corrosivity analysis. All samples will be stored at the laboratory for three (3) months and then disposed of unless directed otherwise.

4. LABORATORY TESTING PROGRAM

A geotechnical laboratory testing program was performed on representative samples in accordance with ASTM standards. Table 4-1 provides a list of the testing program. Detailed laboratory reports for particle size distribution curves, moisture content, and corrosivity testing can be found in Appendix F.

Table 4-1: Summary of Soil Laboratory Testing Program

Item No.	Test	Number of Tests	ASTM Standard
1	Sieve/Hydrometer Analysis	14	ASTM D422/ D7928
2	Moisture Content	16	ASTM D2216
3	Corrosivity Analysis	2	Various
4	Unconfined Compression Test	4	ASTM D7012

5. SUBSURFACE CONDITIONS

5.1 General

Subsurface conditions encountered within the boreholes during the geotechnical investigation are summarized below. Detailed borehole and associated laboratory testing reports are provided in Appendix D and F, respectively. It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The soil encountered on the project site consisted of the main deposits outlined below and are described as they were encountered from ground surface.

5.1.1 TOPSOIL

Surficial topsoil was encountered in boreholes BH-23-01 to BH-23-03. The encountered topsoil was found to be approximately 0.2 to 0.4 m thick and was mainly comprised of fine to coarse grained sand with some fine to coarse grained gravel and non-plastic fines, rootlets, and organics. The material was typically dark brown in colour, non-cohesive, and field moisture observations on retrieved split spoon samples indicated the material was moist.

Laboratory testing on a representative sample yielded a moisture content of 17.6%.

Gradation testing was conducted on one (1) of the recovered samples of the topsoil. The laboratory sieve analysis yielded the grain size distributions shown in Table 5-1.

Table 5-1: Grain Size Distribution Summary – Topsoil

Borehole No.	Sample No.	Size Fraction (%)		
		Gravel	Sand	Silt/Clay
BH-23-02	SS01A	7	77	16

5.1.2 COBBLES and BOULDERS

Cobbles and boulders were encountered in BH-23-01 underlying the surficial topsoil. The cobbles and boulders were advanced by utilizing NW/NQ coring techniques from approximately 0.4 to 3.1 mbgs and recorded as Run 1 to Run 3 in the Record of Rockcore No. BH-23-01, found in Appendix D and shown in Appendix E.

5.1.3 (SP) SAND

A sand deposit was encountered below the topsoil layer in BH-23-02. This material was found to be approximately 0.7 m in thickness. The generally the sand deposit was found to be fine to medium grained sand with some fine-grained gravel and some non-plastic fines. The material was brown in colour, non-cohesive, and field moisture observations on retrieved split spoon samples indicated the material was moist. The sand deposit was found to overlie the soil to bedrock contact and exhibited a high SPT ‘N’ value of 60 blows for 30 cm of sampling advancement indicating a very dense material density and inferred to be caused by interference with the bedrock contact.

5.1.4 ASPHALT

Asphalt from the existing pavement structures was encountered in borehole BH-23-04 to BH-23-12. The encountered asphalt thickness was found between 75 mm to 50 mm across the site, with an average thickness of 53 mm across all boreholes advanced during the investigation. Generally, based on visual observation the pavement condition was generally fair to poor. Alligator, transverse, and longitudinal cracking were observed with patching throughout the project area.

5.1.5 Existing FILL - (SW) SAND to Gravelly SAND

Existing road base/sub-base fills were encountered directly below the topsoil in borehole BH-23-03 and the asphalt in boreholes BH-23-04 to BH-23-12. The walls of each borehole were scratched, and auger cuttings were examined in the field to determine road base and sub-base material thicknesses below the pavement. Distinction between the existing road base and sub-base fills was not possible during the investigation as the fill was found to contain variably mixed sands and gravels and due to the age of the pavement structure, may not exist. The material contained fine to coarse grained sand and gravel and trace to some amounts of non-plastic fines. The material was typically brown to dark brown and black in colour, non-cohesive, and field moisture observations on retrieved split spoon samples indicated the material was moist. Asphalt debris was encountered in samples of the existing fill material obtained from BH-23-03 and BH-23-10.

The SPT ‘N’ value in this deposit ranged from 2 to 83 blows per 30 cm of sampler advancement in all boreholes, typically the material was observed to be compact to very dense.

Laboratory testing on representative samples yielded moisture contents ranging from 2.6% to 30.1% with an average of 9.9%.

Gradation testing was conducted on nine (9) of the recovered samples of the existing fill. The laboratory sieve analysis yielded the grain size distributions shown in Table 5-2.

Table 5-2: Grain Size Distribution Summary – Existing Fill

Borehole No.	Sample No.	Size Fraction (%)			
		Gravel	Sand	Silt	Clay
BH-23-03	SS03	26	60	14	
BH-23-04	SS01	28	62	10	
BH-23-04	SS02	23	71	6	
BH-23-05	SS01	25	67	8	
BH-23-06	SS01	17	75	8	
BH-23-06	SS02	19	74	7	
BH-23-06	SS05	44	51	5	
BH-23-09	SS02	38	50	12	
BH-23-10	SS01	5	70	22	3

5.1.6 (SM) SILTY SAND

A silty sand deposit was encountered in BH-23-09, BH-23-10, and BH-23-12 below the existing fill. The material was found to range from approximately 1.1 m to 1.6 m thick. The material contained fine to coarse grained sand with trace fine grained gravel. The silty sand was found to be non-plastic, brownish grey to greyish brown in colour with field moisture observations on retrieved split spoon samples indicating the material was moist. The SPT ‘N’ value in this deposit ranged from 5 to 12 blows per 30 cm of sampler advancement in all boreholes indicating material density of loose to compact. High blow count values of 72 to 121 blows per 30 cm of sampler advancement were encountered in BH-23-09 and are inferred to be caused by interference with cobbles to boulders that resulted in auger and spoon refusal at 2.29 mbgs. BH-23-09 was moved approximately 1.0 m and was continued to 3.05 m.

Laboratory testing on representative samples yielded moisture contents ranging from 7% to 7.5% with an average of 7.3%.

Gradation testing was conducted on two (2) of the recovered samples of the silty sand. The laboratory sieve analysis yielded the grain size distributions shown in Table 5-3.

Table 5-3: Grain Size Distribution Summary – Silty Sand

Borehole No.	Sample No.	Size Fraction (%)			
		Gravel	Sand	Silt	Clay
BH-23-09	SS04	7	61	32	
BH-23-12	SS04	0	65	27	8

5.1.7 (ML) SILT and (SP) SAND

A silt and sand deposit was encountered below the silty sand deposit in BH-23-12. The material was encountered between 2.21 mbgs and 5.18 mbgs. The material contained fine grained sand and trace amounts of clay. The silt & sand was found to be non-plastic, greyish brown in colour with field moisture observations on retrieved split spoon samples indicating the material was moist to wet. The SPT ‘N’ value in this deposit ranged from 3 to 9 blows per 30 cm of sampler advancement indicating material density of very loose to loose.

Laboratory testing on representative samples yielded moisture contents ranging from 17.8% to 20.1% with an average of 19%.

Gradation testing was conducted on one (1) recovered sample of the silt and sand. The laboratory sieve analysis yielded the grain size distributions shown in Table 5-4.

Table 5-4: Grain Size Distribution Summary – Silt and Sand

Borehole No.	Sample No.	Size Fraction (%)			
		Gravel	Sand	Silt	Clay
BH-23-12	SS04	0	44	54	2

5.1.8 Bedrock

Bedrock was cored in BH-23-01 to BH-23-04 and inferred in BH-23-05 from auger and split spoon sampler refusal at approximately 0.5 m. Based on visual observations of the bedrock coring, the bedrock on the project site generally consisted of greywacke bedrock that was dark grey in colour, fine to medium grained and fresh to faintly weathered.

The RQD values of the retrieved core samples ranged from 0% to 95% indicating a very poor to excellent quality rock with an averaging of 48%. Generally, very poor to poor quality bedrock based on RQD values was recorded in the upper slightly to faintly weathered bedrock which increased to good to excellent quality fresh bedrock with depth.

The core recovery was fair to excellent, with recovery rates ranging from 47% to 100% with an average of 52%. Generally, poorer core recovery was experienced within the upper weathered zone and increased as the bedrock transitioned to slightly weathered to fresh rock.

Solid core recovery ranged from 8% to 92% with an average value of 89% and appears to generally increase with depth. The SCR index was generally influenced by the orientations of the fractures. The values of the Fracture Index range between 0 and 7 fractures per 300 mm of intact core recovered.

Unconfined compression testing was conducted on representative samples of the bedrock encountered throughout BH-23-01 to BH-23-04 and ranged from 45.8 MPa to 135.5 MPa with an average of 75.6 MPa.

5.2 Groundwater Conditions

Groundwater level measurements were taken down open boreholes upon completion of the drilling. Groundwater was not encountered in any of the boreholes advanced during this investigation.

It is noted that the proposed project is close to Lake Huron, for design purposes, the groundwater table can be assumed as the same as the lake level.

The groundwater levels encountered during the investigation may not represent stabilized conditions at the time of measurement, furthermore, it should be noted that groundwater level is subject to seasonal fluctuations with high levels occurring during wet weather conditions in the spring and fall and lower levels during dry weather conditions. As such additional precautions should be taken for groundwater management if necessary.

6. GEOTECHNICAL RECOMMENDATIONS

6.1 General

The following section will discuss trenchless crossing and pavement recommendations and construction considerations for the reconstruction of Huron Avenue. This section will provide our interpretation of the available geotechnical data and geotechnical recommendations and it is intended for the guidance of the design engineer. Where comments are made regarding construction, they are provided only to highlight any aspects that could affect the design of the project. Contractors bidding on or undertaking the construction should make their own interpretation of the provided subsurface information with respect to their planned construction methods, equipment selection, scheduling, and the like.

6.2 Trenchless Crossing

Based on the available information, the following factors should be considered:

- At the time of writing this report, the crossing design was not available to TULLOCH. TULLOCH understands that the proposed trenchless crossing alignment is to cross below the Huron Central Railway owned by Canadian Pacific Railway and Causley Street (Highway 17). From review of the borehole logs it is recommended that the crossing be targeted to go through the greywacke bedrock encountered in BH-23-02 south of Martin Street which will transition from good to excellent quality bedrock and good to fair quality bedrock encountered in BH-23-04 on the east side of Huron Street.

The installation of the trenchless crossing under the Huron Central Railway and Causley Street (Highway 17) must conform to the following standards and guidelines.

- Ontario Provincial Standard Specification (OPSS) 450 Construction Specification for Pipeline and Utility Installation by Horizontal Directional Drilling.
- American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway Engineering (2018)
- Transport Canada TC E-10 Standards Respecting to Pipeline Crossing Under Railways
- Transportation Association of Canada (TAC). Guidelines for Underground Utility Installations Crossing Highway Rights-of-Way. March 2013

6.2.1 Installation Depth

It is understood that the proposed crossing pipeline will consist of a twin HDPE pipe watermain with an outside diameter of 12” (300 mm). At this time the proposed bore length is estimated at approximately 70 m.

In accordance with AREMA (2018), under-track bores are to be installed at a minimum depth of 1.68 m below the base of the railway rail and with TAC (2013), the service is to be installed at a minimum depth of 3.0 m under highways unless approved by the road authority. Based on the site geotechnical conditions, TULLOCH recommends installing the utility conduit to be within the good quality bedrock at the site. The target burial depth should be between 4.0 m to 6.0 m depth below the existing ground surface at the crossing location. In accordance with the AREMA guidelines, pipelines under railway tracks are required to be encased in a larger diameter steel casing pipe and extend a minimum distance of 25 m of the railway centerline. The outside diameter of the casing pipe should be at least 100 mm greater than the carrier pipe. If the casing pipe is installed without protective coating or cathodically protected, the wall thickness of the casing pipe should be increased to the nearest standard size which is a minimum of 1.6 mm greater than the thickness required. The steel casing pipe should also have a specified minimum yield strength of 241 MPa or greater.

For Horizontal Directional Drilling installations, the burial depth will vary adjacent to the entry and receiving pits. At these locations, the cover depth should be at least 3D to maintain the bore stability, where D is the diameter of the conduit. Installing the conduit within the geological settings recommended above (i.e. the good-quality bedrock) will reduce the risk of unacceptable track settlement during the installation.

Section 6.2.4 below summarizes the parameters required to estimate settlement and stresses acting on the conduit.

6.2.2 Installation Method

Three (3) trenchless technologies were considered for the gas pipeline installation given the site geology and replacement pipeline alignment. These include:

- **Jack and Bore**: A horizontal solid auger is used to advance a steel casing from an entry pit to a receiving pit constructed on either side of the crossing. The entry and receiving pits must be excavated to a depth that is below the invert of the conduit since the bore path is straight. A bore machine is erected within the entry pit; this pit must be sized to accommodate the jacking and boring machine, steel casing segments, operators, soil cuttings and shoring system. The auger, which is situated inside the casing is advanced either slightly ahead of or behind the leading edge of the casing depending on the ground conditions. The casing is advanced with the auger using hydraulic jacks. Based on the need for a curved bore path to provide increased pipeline cover at the proposed crossing, this straight path method is considered feasible but likely uneconomical.

- **Horizontal Direction Drilling (HDD)**: HDD involves the boring and enlargement of an uncased borehole, which is kept open using a bentonite-water or bentonite-polymer-water slurry referred to as drill fluid. A relatively small diameter pilot hole is typically bored from an entry pit to a receiving pit along the proposed installation alignment. The drill bit or cutting head at the lead end of the drill string is used to steer the hole along the designed bore path. Accordingly, the bore path can be curved for this type of installation to provide sufficient soil cover between the pipeline and the surface of the proposed crossing alignment. After executing the pilot hole, the borehole is then enlarged using a reamer until the desired bore diameter is achieved, typically slightly larger than the conduit, and the conduit is pulled through the borehole on the final reaming pass.

- **Micro-tunnelling**: Micro-tunneling involves the use of a Micro-tunnel Boring Machine (MTBM) to advance a small tunnel heading through the ground along the proposed bore path. The MTBM is typically placed in a launch pit and the MTBM and conduit, situated behind the MTBM, are advanced by pipe jacking. The cutting head of the MTBM is often lubricated with a bentonite slurry that is designed based on the sub-surface soil conditions. The MTBM cutter head excavates a tunnel of a slightly larger diameter than the conduit to reduce the friction on the conduit during advancement. Dewatering is necessary during construction to facilitate bore pit operations and prevent workplace flooding. MTBM operations tend to be used for larger-scale operations and often have a higher associated cost. Given the size and length of the bore path planned for this application, it is not considered economical.

Table 6-1 summarizes TULLOCH’s assessment of the applicable trenchless technologies for the proposed crossing site. Based on Table 6-1, HDD is the recommended method for the proposed installation due to the small size of the pipe installation, the length of installation required between the sending and receiving pits, no dewatering requirement, the presence of shallow medium to high strength bedrock, lower installation stresses on the conduit from the geological deposits encountered at the project sites, satisfactory settlement control, and relatively low cost. Considering the constructability and economics, HDD is the preferred option when installed by an experienced contractor with adequate experience.

HDD borings are typically done from the ground surface without the use of deep staging excavations, reducing the extent of groundwater control required. HDD also has the ability to control the movement of the reamer to allow for steering of the bore path safely under the Huron Central Railway and Causley Street (Highway 17) crossing. The maximum pressure of the drilling fluid must be controlled to prevent the drilling fluid from migrating into the groundwater system during construction. Preventing and mitigating inadvertent drilling fluid returns should be part of the planning and construction of an HDD installation.

It is the contractor’s responsibility for the slurry design and tooling systems for the HDD installation based on the specific site geotechnical conditions as presented in the borehole logs in this report.

The Jack and Bore methodology while feasible, is likely uneconomical and may be more difficult from an installation perspective due to the limited steering ability during advancement. This would require significantly deeper entry and exit pits than other methods and would require larger ground disturbance (e.g. bedrock excavation), resulting in significantly more impact on the roadway. Given the size of the pipe proposed for the trenchless crossing, Jack and Bore technology is likely uneconomical for this application.

It is assumed that more expensive options such as micro-tunnelling are likely not economically feasible in this area. The final choice of equipment and the method of tunnelling should be the Contractor’s responsibility.

Successful completion of any trenchless technology or tunnelling project largely depends on an appropriate selection of equipment and methods and the skills and experience of the Contractor. The final selection of the trenchless crossing technique should be made by the Contractor based on their experience and equipment capabilities in addition to their assessment of the subsurface conditions. The soil deposits and groundwater conditions described above may pose several constraints to trenchless installations.

Table 6-1: Trenchless Method Evaluation

Trenchless Technology	Constructability	Cost	Installation Stresses on the Watermain	Ground Surface Settlement Control
Jack and Bore	• Requires deep entry and receiving pits plus shoring. Dewatering may be required to facilitate bore pit operations and prevent workplace flooding, for excavations that exceed the groundwater table. • A Permit to Take Water (PTTW) from the MOE may be required if the dewatering discharge is greater than 50,000 L/day. • Ground settlement may be caused by construction dewatering at the site. • The groundwater table is assumed the same as the adjacent lake level, however, a seasonal higher groundwater table may be encountered during construction. • Not feasible if hard bedrock is present. • Not feasible where curved bore path is needed due to limited steering ability.	• Normally very economical except when executed below the groundwater table. • Increased expense for sending and receiving pits at this site. • Increased expense of equipment for the size of the proposed trenchless installation	• Low to moderate jacking stresses during installation	• Very good settlement control provided the casing is advanced ahead of the auger. • Ground settlement may be caused by dewatering at the site during construction.
HDD	• Entry and receiving pits can be minimized or not required depending on the design and bore path required. • A workspace should be provided at both ends for storage and equipment. • Feasible in medium strength rock • Locally, the rock may be susceptible to raveling for large diameter bores. • No to minimal dewatering is anticipated during construction. • Sufficient installation accuracy over long distances	• Normally very economic	• Typically, lower than Jack and Bore; and much lower in stiff ground.	• Satisfactory settlement control provided the proper design of drill fluid mix and pressure.
Micro-Tunneling	• Requires large entry and exit pits. • Dewatering is required in entry and exit pits. • Micro-tunneling work can be extremely accurate.	• Highest cost option.	• Typically, lower than Jack and Bore; and much lower in stiff ground.	• Satisfactory settlement control can be achieved. • Ground settlement may be caused by dewatering at the entry and exit pits.

6.2.3 Ground Settlement

Invariably there is almost always some ground movement, deformation and settlement associated with tunneling regardless of the method used. It is anticipated that the replacement pipeline invert level will result in an earth cover above the bores of at least 4.0 m to 6.0 m under the Huron Central Railway and Causley Street (Highway 17) crossing. This would correspond to approximately 10 to 15 times the casing diameter of 16” (400 mm), which is considered to be adequate. Assuming a bore size of 16” (400 mm) and a maximum 1% ground loss during tunnelling through the greywacke bedrock, the maximum settlement at ground surface above the center line of the tunnel was estimated to be less than 1 mm at a minimum of 4.0 m relative depth under the Huron Central Railway and Causley Street (Highway 17) crossing, which is negligible. This assumes the bore is conducted exclusively through the medium to high strength greywacke bedrock with reasonably good slurry control and maintenance of appropriate slurry processes and pipe advancement rates.

Once the crossing design has been determined, calculations to determine the allowable ground loss to satisfy the required settlement criteria and Tunnel Induced Surface Settlement should be completed to develop a performance specification for the contractor placing the responsibility to manage the ground loss to the prescribed criteria.

6.2.4 Crossing Design Parameters

Based on the geotechnical investigations at the crossing location, Table 6-2 summarizes the recommended geotechnical parameters for the crossing design within the bedrock at the crossing location. The following summarizes TULLOCH’s guidance for the crossing design:

- Based on the borehole data obtained from BH-23-03, the HDD may cross through a very poor to poor quality rock zone between the Huron Central Railway and Causley Street (Highway 17) when advanced with a minimum installation depth of 4.0 m. The contractor should ensure that the equipment performing the work can advance through the bedrock conditions presented in Appendix D and meet the settlement criteria developed for the project.

- The crossing pipeline should be designed for the *in-situ* earth pressures for subsurface conditions encountered at the site plus any additional earth pressure imposed by surface surcharge loads due to train and traffic loading caused by the Huron Central Railway and Causley Street (Highway 17).

- The *in-situ* earth pressures in the rock can be determined using the parameters in Tables 6-4 and 6-5 by the sum of the unit weight of each material times its thickness overlying the conduit centerline. For example, at BH-23-04 and a depth of 4 m, the material zones encountered are a Sand Fill overlying Greywacke bedrock, therefore, the vertical, P_V, and horizontal, P_H, earth pressures on the conduit are:

$$P_V = 0.9\,m \times 20\frac{kN}{m3} + 3.1m \times 25\frac{kN}{m3} = 95.5\,kPa;\;\; P_H = 2 \times P_v = 191\,kPa$$

- The design of the conduit should account for the *in-situ* stress and additional stresses due to installation and surcharge loads at the ground surface during the crossing design life.

- Boussinesq's equation (1985), i.e. for calculating ground stresses due to point load or line load at the surface, can be used to estimate the vertical and horizontal stress acting at the conduit centerline due to train wheel loads.

- The ground settlement caused by train loads can be estimated using elastic solutions and the elastic parameters, referred to as deformation modulus, listed in Tables 6-2 and 6-3.

- Pullback forces on the conduit can be estimated using methods such as PRCI Publication PR-277-144507-Z01 or equivalent using the friction factors listed in Tables 6-2 and 6-3 and assuming a drilling fluid specific gravity of 1.1.

Table 6-2: Overburden (Sand) Properties

Soil Property	Symbol	Unit	Value
Effective Internal Friction Angle	ϕ'	degree	32
Unit Weight	γ	kN/m^3	20
Earth Pressure Coefficient at Rest	K_0	Unitless	0.5
Passive Lateral Earth Pressure Coefficient	K_p	Unitless	3.2
Active Lateral Earth Pressure Coefficient	K_a	Unitless	0.3
Vertical Modulus of Subgrade Reaction	K	kN/m^3	50,000
Deformation Modulus	E'	MPa	80
Friction Coefficient, for HDD Pullback Forces	μ	Unitless	0.5

Table 6-3: Rock (Greywacke) Mass Properties

Rock Property	Symbol	Unit	Value
Unit Weight of Rock Mass	γ	kN/m³	25
Earth Pressure Coefficient at Rest	K_0	Unitless	0.44
Intact Rock Strength[1]	σ_{ci}	MPa	75.6
Geological Strength Index	GSI	Unitless	50
Rock Mass Compressive Strength[2]	σ_{cm}	MPa	13.2
Deformation Modulus[3]	E_m	MPa	8700
Poisson's Ratio	v	–	0.2
Friction Angle (Residual)	ϕ'	degree	40

Note(s): [1] The intact rock strength is estimated from the average unconfined compression testing values on retrieved rock cores on site. [2] σcm=(0.0034m_i^0.8) σc [1.029+0.025e^((-0.1m_i))]^GSI (Eberhardt, 2003); [3] Given by Em= √(σc/100)*10^((GSI-10)/40) (Hoek and Brown, 1998).

6.2.5 Construction Considerations

The following considerations should be accounted for during the crossing design:

- Due to the very poor to poor rock quality found in BH-23-03, the conduit should be pulled into place as soon as practical after the initial pilot bore. TULLOCH recommends requiring the contractor to install the conduit during the 1st reaming pass after the initial pilot bore. The initial pilot bore should be as small as practical.
- The contractor should be equipped with appropriate tooling systems that should be selected to handle the possibility of cobbles and boulders as well as advancement through the medium to high strength bedrock encountered throughout the site. The selected contractor should have a contingency plan to handle boulders/cobbles if encountered at the site.
- The amount of surface settlement during construction will depend on the contractor's skill and the care taken to limit ground loss during the conduit installation. As noted above, during the crossing design, the design engineers should determine the allowable ground loss required to satisfy the appropriate settlement criteria and then develop a performance specification for the installation that informs the contractor of these limits and places the responsibility to comply with these limits on the contractor.

6.2.6 Temporary Excavations

As bedrock was encountered within 1.0 m below ground surface in BH-23-02 and BH-23-04, where the presumed sending and receiving pits would be located, the use of temporary excavation and support systems are unlikely. Should open excavations for the entry and receiving pits be adopted, they must be carried out in a manner that complies with the Occupational Health and Safety Act (OHSA), Ontario Regulation 213/91.

6.3 Pavement Design

6.3.1 Existing Pavement Condition

The existing asphalt was found to range between approximately 75 mm to 50 mm thick across BH-23-04 to BH-23-12. The subgrade conditions consisted of an existing gravelly sand to sand fill overlaying native silty sand. During the investigation, granular base and sub-base measurement attempts were made, however, due to the variability of existing fill, the distinguishment between base and sub-base was not possible at the time of investigation and may not exist beneath the asphalt.

Photographs of the asphalt surface of the road were taken during the investigation on October 30 and November 1, 2023, at the borehole locations. Selected representative photos can be found in Appendix C. Visual inspection of the pavement surface noted that it was in fair to poor condition. Most stretches of paved surfaces are visibly distressed, with frequent raveling, longitudinal and transverse cracking noted throughout the site. The depressions and frequent cracking are indications of inadequate or poorly constructed granular base/sub-base not sufficient to support the current traffic loading or future increased traffic volume and may be caused by consolidation or lateral movement of the materials due to traffic loading. No catch basins or manholes were observed along the southern half of Huron Street during the investigation which indicates that there is no existing storm sewer network to provide proper drainage to this portion of the project site. Poor existing fill grading which does not promote natural drainage and the lack of an adequate drainage network could also be leading to increased pavement degradation.

Table 6-4 summarizes the road conditions including asphalt, granular road base and groundwater depth.

Table 6-4: Existing Road Condition Summary Based on Borehole Data

Borehole	Asphalt Thickness (mm)	Existing Road Fill Thickness (mm)	Groundwater Depth (m)[1]
BH-23-01	-	-	N/E[2]
BH-23-02	-	-	N/E[2]
BH-23-03	-	-	N/E[2]
BH-23-04	75	835	N/E[2]
BH-23-05	50	410	N/E[2]
BH-23-06	50	710	N/E[2]
BH-23-07	50	710	N/E[2]
BH-23-08	50	710	N/E[2]
BH-23-09	50	710	N/E[2]
BH-23-10	50	400	N/E[2]
BH-23-11	50	710	N/E[2]
BH-23-12	50	710	N/E[2]

Note(s): [1] Field observation taken upon completion of borehole. Note that the groundwater level from this observation may not represent the stabilized groundwater level [2] N/E = Not Encountered.

6.3.2 Pavement Design

The following section will discuss pavement recommendations for the stretch of roadway. Table 6-2 presented below shows the minimum recommended specifications for a flexible asphaltic concrete pavement structure constructed on the native silty sand. Shallow bedrock was encountered along the southern portion of Huron Street between BH-23-04 and BH-23-05; therefore, recommendations are also provided for pavement structures constructed on exposed competent bedrock. The Client has not provided TULLOCH with the expected daily traffic volume and TULLOCH understands that there is no available traffic data or any published traffic studies for the project site. As such, pavement design has been conducted in accordance with the Routine (Empirical) Method – Experience-Based Standard Section design method as presented in the Pavement Design and Rehabilitation Manual (PDRM) (MTO 2013). The pavement structure design has been conducted to provide a Granular Base Equivalency in accordance with the PDRM and from our previous experience for similar pavement structures in the Blind River, Ontario area.

The reuse of the existing granular fill material has been deemed acceptable based on the gradation results of the existing fill and will be discussed further in Section 6.3.2. Therefore two (2) options have been presented for the Client’s consideration. Option 1 is to partially reuse the existing granular fill as granular sub-base with the Granular Base Equivalency (GBE) factor adjusted accordingly. Alternatively, Option 2 is to reinstate the pavement structure with new imported granular fills.

The recommended pavement options are shown below in Table 6-5.

Table 6-5: Pavement Design Parameters

Pavement Layer	Compaction Requirements	Option 1: Partial Reuse of Existing Fill		Option 2: New Imported Granular Fill	
		Silty Sand (mm)	Competent Bedrock (mm)	Silty Sand (mm)	Competent Bedrock (mm)
Surface Asphalt: HL3 (OPSS.MUNI 1150)	HMA (OPSS.MUNI 310)	40	40	40	40
Binder Asphalt: HL-8 (OPSS.MUNI 1150)	Same as above	50	50	50	50
Base Course: Granular "A" (OPSS 1010)	100% Standard Proctor Maximum Dry Density (ASTM-D698)	150	150	150	150
Sub-base Course: Granular "B" Type I (OPSS 1010)	100% Standard Proctor Maximum Dry Density (ASTM D698)	-	-	300	-
Sub-base Course: Reused Existing Granular Fill[1]	100% Standard Proctor Maximum Dry Density (ASTM D698)	500	-	-	-
Geogrid[2]	-	Yes	-	Yes	-
Non-woven Geotextile[3]	-	Yes	-	Yes	-
Minimum Total Thickness		650 mm	300 mm		

Note(s): [1] It is assumed that the existing sand fill material will be reused as granular subbase. [2] The geogrid should be TBX2500 from Terrafix Geosynthetics Inc. or approved equivalent. [3] Geotextile should be non-woven LP 8 from Layfield or approved equivalent with the grab tensile strength not less than 800 N and AOS (Apparent Opening Size) not larger than 0.3 mm.

Pavement design cases have been based on an estimated design life of 15 years prior to major rehab or reinstatement assuming adequate maintenance is conducted throughout its design life. Higher maintenance costs may be associated with the partial reuse of existing fills given the loose and highly frost susceptible nature of the native subgrade.

6.3.3 Subgrade Preparation

All topsoil, organics, soft soil, asphalt, and construction debris (if any) must be sub-excavated within the proposed subgrade areas below the pavement structure. The site should be graded to the target subgrade profile as per the final pavement profile and the total pavement thickness. Unless the Client elects to proceed with an option that includes the reuse of existing fills, all road base and sub-base material should be comprised of imported and approved engineered fill materials for this site. Given the fine-grained nature of the encountered subgrade, a non-woven geotextile (Layfield LP8 or approved equivalent) should be placed between the native subsoil material and any imported fill material to act as a separation medium and to promote drainage.

The exposed subgrade should be inspected and approved by the geotechnical engineer, or their representative during construction to ensure the encountered subgrade conditions are consistent with the design assumptions used to prepare this report. Proof rolling should be carried out as directed by the geotechnical engineer or their representative to spot and delineate soft areas and may not be required where the subgrade soil is deemed very sensitive. If a soft spot/area is identified, it should be sub-excavated and subsequently replaced with compacted engineered fill such as Granular B or as approved by the geotechnical engineer. If deemed necessary by the engineer, the density of the subgrade should be tested and recorded during backfill inspection. The native fine grained silty sand subgrade may easily become disturbed or degraded when exposed to weather or heavy vibration, as such caution should be taken when compacting the initial lift of fill not to leave the subgrade exposed and should be backfilled immediately upon exposure and inspection.

Should the subgrade soils become disturbed during construction or pockets of unstable or unsuitable areas be encountered, TULLOCH can provide recommendations at the time, which may include but not be limited to the following:

- Compaction of the subgrade soil
- Removal of subgrade material and subsequent replacement with engineered fill
- Stabilization with a non-woven geotextile or geogrid

Post compaction settlement of fine-grained soils can be expected, even when placed to compaction specifications. As such, fill material should be installed as far in advance as possible before finishing the parking lot and roadway for best grade integrity.

Imported granular fill material is to be placed in maximum 200 mm thick lifts compacted to minimum 100% SPMDD within ±2% of optimum moisture content.

Where existing fill is to be re-used it should be recompacted in-situ to 100% of the materials SPMDD and proof-rolled and certified by a geotechnical engineer prior to placement of imported fills.

Quality control will be of utmost importance when selecting the material. The selection of the material should be done as early in the contract as possible to allow sufficient time for gradation and proctor testing on representative samples to ensure it meets project specifications. This material may also be used for general landscaping purposes where compaction is not critical.

The final subgrade crossfall should be at least 2% to drain and be free of depressions. Grading should be completed to promote positive drainage to existing ditches and as required.

6.3.4 Reuse of Existing Granular Fill

Excavated existing granular fills may be re-used assuming sufficient testing and inspection have been conducted to confirm their general conformance with OPSS 1010 standards. While still usable, given the unknown age and construction history of Huron Street, the material may contain greater than 10% fines content causing increased frost susceptibility and decreased strength over time. However, the largely granular fill will likely still be suitable for general re-use on site given the above understanding of risk associated with the re-use of the existing fill and based on inspection and certification by a qualified geotechnical engineer, or their representative.

The native silty sand soils on site may be re-used as general landscaping fills but given high fines contents are frost susceptible and should not be used within the pavement structure reconstruction areas where settlement and/or movement are a concern.

6.3.5 Pavement Materials, Placement and Compaction

The asphalt, base and subbase granular fill should be placed and compacted as per the requirement in this section.

6.3.5.1 Asphalt

The mix design should follow the specifications in OPSS 1150 for HL3. Table 6-6 summarizes the specifications regarding asphalt. The mix designs can use Traffic Category “B” as per the expected traffic volume. The mix design should be submitted and approved by a geotechnical engineer prior to use.

6.3.5.2 Base and Sub-base Fill

Table 6-6 below summarizes the specifications regarding base and sub-base fills.

Table 6-6: Requirement for Asphalt, Base and Sub-base Materials

Materials	Notes
Asphalt HMA (OPSS 1150)	- PGAC: Zone 1 52-34 with up to 15% RAP - Performance graded asphalt should conform to OPSS 1101 - Asphalt construction and QA/QC as per OPSS 310 - Mix properties in accordance with AASHTO M323
Base Course: Granular “A” (OPSS 1010)	- 100% Standard Proctor Maximum Dry Density (ASTMD698) at ± 2% of Optimum Moist Content (OMC) - Placement in maximum 200 mm lifts, or as accepted by the engineer in writing
Sub-base Course: Granular “B” Type I, Type II or Approved Fill (OPSS 1010)	- 100% Standard Proctor Maximum Dry Density (ASTMD698) at ± 2% of Optimum Moist Content (OMC) - Placement in maximum 200 mm lifts, or as accepted by the engineer in writing

6.3.5.3 Inspection and Testing

During construction, subgrade inspection and in-situ density tests should be conducted, by the field geotechnical engineer, or their representative, to confirm that the conditions exposed are consistent with those encountered in boreholes and to verify the conformance to the design specifications.

6.3.6 Pavement End Treatment

Joints between new and existing asphalt should be stepped and constructed according to the requirements of OPSS.PROV 313.07.09 regarding Longitudinal and Transverse joints. The step should be constructed with a width of 300 mm and height equal to half the existing surface course of asphalt, (average step height 25 mm). Tack coating should be applied to any milled surface, including the vertical joint surface.

6.3.7 Horizontal Transition

Horizontal transition treatment is required where pavement structure changes occur. The following recommendations should be considered:

- The frost tapers for the transition zone between fine-grained native soil and granular fill should be designed at least 10H:1V to mitigate abrupt differential frost heave.

- Horizontal transition from backfill and native soil should follow OPSD 803.010, OPSD 803.030, and OPSD 803.031.
- To ensure a good tie-in from new to old asphalt, the joints along both longitudinal and transverse direction should be designed as per Section 310.07.11 in OPSS 310.

6.3.8 Pavement Over Underground Utilities

After installation of underground service, the pavement should be constructed as per the recommended pavement structure. Appropriate frost tapers should be implemented in the backfill geometry for the underground service utilities such as culverts as per the OPSD 803 series (e.g., 803.030 and 803.031).

The backfill should be placed in a maximum 200 mm loose lifts and compacted to minimum 95% SPMDD, except the top 1 m of the pavement subgrade which should be compacted to at least 100%.

6.3.9 Pavement Drainage

The surface of the subgrade, subbase and base should be graded with a suitable slope to ensure satisfactory drainage performance.

6.4 Site Utility Servicing – Bedding and Backfilling

Bedding for utilities should be placed as per the pipe design. It is recommended to place a minimum of 150 mm to 200 mm OPSS Granular A below the pipe invert as bedding material. A minimum 300 mm thick cover consisting of Granular A should be placed above and along the sides of the pipe.

In areas where a relatively high groundwater table is encountered during construction, 19 mm clear stone pipe bedding may need to be used as an alternative to Granular A where compaction of the bedding materials may not be possible. A non-woven geotextile such as Layfield LP8 or equivalent should be placed to completely encapsulate the clear stone pipe bedding and act as a filter to prevent fines migration into the bedding material.

Trench backfilling may be completed as per Section 6.7.

If backfilling against slopes, fills should be benched into native slopes per OPSD 208.010.

6.5 Frost Protection

The estimated frost penetration depth at the site is 1.8 m, as such, all servicing shall be situated at least 1.8 m below ground surface to provide adequate soil cover against frost heaving. Alternatively, insulation equivalent to a soil cover can be used to raise the frost line. If shallower embedment is needed, Expanded Polystyrene (EPS) insulation or equivalent can be designed to prevent frost action. A demonstration of a typical methodology can be seen in OPSD 1109.030. Installing insulation does not alter conventional utility line construction practices to an appreciable extent. It should be noted that a wider trench may be required to accommodate frost tapering if backfill soils differ from the surrounding native soils to prevent differential frost heaving and subsequent thaw settlement. A preliminary estimate for cost evaluation can be made assuming that 25 mm of rigid insulation designed for below grade installation is equivalent to approximately 0.3 m soil cover. It should also be noted that as per OPSD 1109.030, the minimum recommended insulation thickness is 50 mm.

If construction is undertaken during the winter months, road subgrade must be protected from freezing.

6.6 Excavation and Groundwater Control

All excavation should be carried out in accordance with Occupational Health and Safety Act (OHSA), Ontario Regulation 213/9, Construction Projects, January 1, 2010, and OPSS 902. Based on the OHSA, the soils are classified as Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavation side slopes in Type 3 soils should remain stable at a slope of 1H:1V. Temporary excavation side slopes in Type 4 soils should remain stable at a slope of 3H:1V. As the native materials are of a glacial origin, there is the possibility of encountering boulders and cobbles during excavation that were not identified in the geotechnical investigation for the proposed road rehabilitation. Therefore, the contractor undertaking the work should supply equipment capable of removing such material. Excavation safety and the stability of temporary construction slopes and lateral support systems are the contractor’s responsibility.

Groundwater control may be required during construction to maintain dry excavations. The contractor should direct any surface water and runoff generated from the excavation area. The groundwater level was lower than the expected pavement structure of the boreholes during the investigation. However, seasonal variations in the water table should be expected. Pumping from filtered sumps will likely be sufficient to control groundwater unless deeper excavations are required for such things as servicing where excavation depth extends 0.5 m below the groundwater table, in which case active de-watering may be required. The temporary groundwater control measures for excavation are the contractor's responsibility.

An application under the Environmental Activity Sector Registry (EASR) of the Ministry of the Environment and Climate Change should be submitted in the event that the dewatering pumping volumes exceed 50,000 L/day.

6.7 Excavated Soil and Trench Backfill

Typical practice in Northern Ontario is to reuse a portion of the in-situ excavated material as fill within utility service trenches, especially where these trenches interrupt travelled sections of a roadway. This is to ensure compatibility with adjacent subgrade soils to minimize differential frost heaving. Maintaining compatibility with adjacent subgrade conditions is crucial to minimize the annual differential frost heaving. This is usually accomplished by backfilling the service trenches with excavated materials. If dissimilar materials are used for trench backfilling, frost tapers should be incorporated in the backfill trench geometry as discussed in Section 6.3.7.

The non-organic material from the service trench excavation may be re-used as backfill above the top of the pipe cover material to the underside of the pavement structure subbase materials. Prior to re-use, all fill materials should be inspected and certified by a qualified geotechnical engineer. All re-used materials must be placed in lifts not exceeding 200 mm and be compacted to 95% of the SPMDD within 2% of the optimum moisture content. Subgrade materials within 1.0m of the road base should be compacted to 100% SPMDD.

TULLOCH cautions that any native material below the groundwater level may not meet the above compaction requirements without reworking (drying) prior to placement. If stockpiling of trench excavated material for re-use is required, it is recommended that it be covered to prevent exposure to rain, and it cannot be allowed to freeze. Furthermore, stockpiles should be kept at a safe distance (distance at least equal to the depth of the excavation) away from open excavations. All unsuitable materials (construction rubble, organics, etc.) from the trench excavation must be disposed of off-site in an environmentally compliant method. Any excavated material contaminated with organics must not be re-used as backfill material. It is recommended that the excavated native soils be inspected and certified by a geotechnical engineer prior to re-use.

6.8 Soil Corrosivity

Testing was completed for soil corrosivity and sulphate concentrations on recovered samples from the borehole investigation. The results of the testing are shown below in Table 6-7. Samples were tested at TESTMARK Laboratories based in Garson, Ontario. The detailed results can be found in Appendix E.

Table 6-7: Soil Corrosivity Results

Borehole No. / Sample No.	Depth (m)	Resistivity (Ω cm)	pH	Redox Potential (mV)	Chloride (µg/g)	Sulfide (µg/g)	Sulphate (µg/g)
BH-23-06 SS04	1.83	21300	6.48	350	4.3	<0.2[1]	11.2
BH-23-12 SS03	1.52	4650	6.26	383	89.8	<0.3[1]	15.7

Note(s): [1]Sulfide testing detection limit.

The results of the chemical testing were assessed in reference to the AWWA C-105 Standard from ANSI/AWWA Corrosivity Rating System. A score greater than 10 indicates the requirement of corrosion protective measures for buried cast iron alloys. The tested samples analyzed for the boreholes referenced in Table 6-4 above scored a ranking of 1, which is below the threshold.

In addition, chloride ions can lead to corrosion of steel. Typically, soils with chloride concentrations greater than 500 µg/g are considered corrosive. As noted in the table, chloride concentrations are less than 500 µg/g in the tested samples. Corrosion protection measures shouldn’t be utilized in this area of the site to protect subsurface infrastructure.

The concentration of sulphate indicates the degree of sulphate attack for concrete buried at the site. As shown in the table, the sulphate concentrations are less than 1000 µg/g indicating a low degree of sulphate attack. Type GU Portland Cement should be suitable for use at this site.

7. CLOSURE

This geotechnical report has been prepared by TULLOCH for The Town of Blind River and their authorized agents for the New Water Intake and Huron Street Reconstruction project. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering, for the above-noted location. Classification and identification of soils, and geologic units have been based upon commonly accepted methods employed in professional geotechnical practice. No warranty or other conditions, expressed or implied, should be understood. Please refer to Appendix F, Notice to Reader, which pertains to this report.

We trust that the information in this report will be sufficient for the project. Should further elaboration be required for any portion of this project, we would be pleased to assist.

Laura M

Laura Meneghetti
Engineering Technologist

Reviewed By:
George Liang, P.Eng.
Senior Geotechnical Engineer/Project Manager

Jackson Mercer, P. Eng
Project Engineer

REFERENCES

TULLOCH Geotechnical Report for Project 1038712 - 1038713 Pedestrian Paving and Roadway Renewal for the Ontario Government Building, 5520 Highway 101 East, South Porcupine, Ontario, September 2017.

VanDine, D.F. 1979. Northern Ontario Engineering Geology Terrain Study. Data Base Map, Blind River. Ontario Geological Survey, Map 5008. Scale 1:100 000.

Ministry of Transportation, Pavement Design and Rehabilitation Manual. Queen's Printer, 2013

Ontario Geological Survey 1991. Bedrock Geology of Ontario, scale 1:1000 000.

Quaternary Geology of Ontario, East-Central Sheet Map, scale 1:1000 000.

Ministry of Northern Development and Mines, Surficial Geology of Northern Ontario.

Ontario Geological Survey 1991, Quaternary Geology of Ontario, southern sheet. scale 1:1 000 000.

Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160.

Occupational Health and Safety Act (OHSA), Ontario Regulation 213/9, Construction Projects, January 1, 2010, Part III - Excavations, Section 226.

Canadian Geotechnical Foundation Engineering Design Manual 4th Edition, 2006.

APPENDIX A

SITE LOCATION PLAN

BOREHOLE LOCATION PLAN

PROJECT LOCATION

COORDINATES					
NAME	EASTING	NORTHING	NAME	EASTING	NORTHING
BH-23-01	349 247	5 116 261	BH-23-07	349 498	5 116 513
BH-23-02	349 299	5 116 307	BH-23-08	349 511	5 116 551
BH-23-03	349 344	5 116 361	BH-23-09	349 557	5 116 629
BH-23-04	349 409	5 116 373	BH-23-10	349 578	5 116 660
BH-23-05	349 454	5 116 455	BH-23-11	349 592	5 116 674
BH-23-06	349 475	5 116 484	BH-23-12	349 607	5 116 699

NOTES:

1. CO−ORDINATES ARE IN UTM ZONE 17T (NAD83 CSRS).

LEGEND:

BH−23−01 ● BOREHOLE LOCATION

No.	DATE	BY	ISSUES / REVISIONS
0	2024-01-10	LM	ISSUED FOR USE

TULLOCH

DRAWING:
BOREHOLE
LOCATION PLAN

PROJECT:
BLIND RIVER WATER INTAKE
GEOTECHNICAL INVESTIGATION

DRAWN BY: L. MENEGHETTI
CHECKED BY: E. GILES
DESIGNED BY: L. MENEGHETTI
APPROVED BY: E. GILES
SCALE: AS NOTED
DATE: 2024-01-10
PROJECT No. : 23-0821
DRAWING No. 23-0821-001
REVISION No. 0

P:\2023\230821 Blind River Water Intake\Geotechnical\03 Drawings\03.02 Current\Siteplan\230821_Siteplan.dwg

APPENDIX B

TERMINOLOGY

ABBREVIATIONS, TERMINOLOGY AND PRINCIPAL SYMBOLS USED IN REPORT AND BOREHOLE LOGS

BOREHOLES AND TEST PIT LOGS

Soils

AS	Auger/Grab Sample	w	Water Content
SS	Split Spoon	wP	Plastic Limit
SH	Shelby Tube	wL	Liquid Limit
PISTON	Thin-walled Piston	VANE	Field Vane
WS	Washed Sample	OR	Organic Content
SC	Soil Core	GR	Gravel
BS	Block Sample	SA	Sand
WH	Weight of Rods & Hammer	SI	Silt
WR	Weight of Rods	CL	Clay

Bedrock

TCR	Total Core Recover	VN	Vein
SCR	Solid Core Recovery	CO	Contact
FI	Fracture Frequency Index	KV	Karstic Void
HQ	Rock Core (63.5 mm dia.)	MB	Mechanical Break
NQ	Rock Core (47.6 mm dia.)	PL	Planar
BQ	Rock Core (36.5 mm dia.)	CU	Curved
JN	Joint	UN	Undulating
FLT	Fault	IR	Irregular
SH	Shear	SM	Smooth
SK	Slickensided	SR	Slightly Rough
BD	Bedding	R	Rough
FO	Foliation	VR	Very rough

IN SITU SOIL TESTING

Standard Penetration Test (SPT) "N" value is the number of blows required to drive a 51 mm OD split barrel sampler into the soil a distance of 300 mm with a 63.5kg weight free falling a distance of 760 mm after an initial penetration of 150 mm has been achieved.

Dynamic Cone Penetration Test (DCPT) is the number of blows required to drive a cone with a 60-degree apex attached to "A" size drill rods continuously into the soil for each 300 mm penetration with a 63.5 kg weight free falling a distance of 760 mm.

Cone Penetration Test (CPT) is an electronic cone point with a 10 cm base area with a 60-degree apex pushed through the soil at a penetration rate of 2cm/s.

Field Vane Test (FVT) consists of a vane blade, a set of rods and torque measuring apparatus used to determine the undrained shear strength of cohesive soils.

SOIL DESCRIPTIONS

The soil descriptions and classifications are based on an expanded Unified Soil Classification System (USCS). The USCS classifies soils on the basis of engineering properties. The system divides soils into three major categories: coarse grained, fine grained and highly organic soils. The soil is then subdivided based on either gradation or plasticity characteristics. The classification excludes particles larger than 75 mm. To aid in quantifying material amounts by weight within the respective grain size fractions, the following terms have been included to expand the USCS:

Soil Classification	
Clay	<0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.075 to 4.75 mm
Gravel	4.751 to 75 mm
Cobbles	75 to 300 mm
Boulders	>300 mm

Terminology	Proportion
"trace", sand, etc.	1% to 10%
"some"	10% to 20%
Sandy, Gravelly, etc.	20% to 35%
"and" SAND, SILT, (non-cohesive)	>35%
"with" SAND, SILT, (cohesive)	>35%

Notes:

1. Soil properties, such as strength, gradation, plasticity, structure, etc., dictate the soils engineering behaviour over the grain size fractions;
2. With the exception of soil samples tested for grain size distribution or plasticity, all soil sample classifications are based on visual and tactile observations and, therefore, constitute an approximate description.

The following table outlines the qualitative terms used to describe the relative density condition of cohesionless soils related to the SPT "N" value:

Cohesionless Soils

Compactness	SPT "N" Value (blows/30cm)
Very Loose	0 to 4
Loose	5 to 10
Compact	11 to 30
Dense	31 to 50
Very Dense	>50

The following table outlines the qualitative terms used to describe the consistency of cohesive soils related to undrained shear strength and SPT "N" value:

Cohesive Soils

Consistency	Undrained Shear Strength (kPa)	SPT "N" Value (blows/30 cm)
Very Soft	<12.5	< 2
Soft	12.5 to 25	2 to 4
Firm	25 to 50	5 to 8
Stiff	50 to 100	9 to 15
Very Stiff	100 to 200	16 to 30
Hard	> 200	>30

Note: Utilizing the SPT "N" value to correlate the consistency and undrained shear strength of cohesive soils is very approximate and needs to be used with caution.

Particle Sizes

Constituent	Description	Size (mm)	Size (in)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by Plasticity	< 0.075	< (200)

Note: Brackets () indicate US Standard Sieve Size Number

ROCK CORING

Rock Quality Designation (RQD) is an indirect measure of the number of fractures within a rock mass, Deere et al. (1967). It is the sum of sound pieces of rock core equal to or greater than 100 mm recovered from the core run, divided by the total length of the core run, expressed as a percentage. If the core section is broken during coring or handling, the pieces are fitted together and, if 100 mm or greater included in the total sum.

Intact Rock Strength

Intact Strength (MPa)	Description
< 1	Extremely low strength
1 to 5	Very low strength
5 to 25	Low strength
25 to 50	Medium strength
50 to 100	High strength
100 to 250	Very high strength
>250	Extremely high strength

Rock Mass Quality

RQD Classification	RQD Value (%)
Very Poor Quality	<25
Poor Quality	25 to 50
Fair Quality	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100

Rock Mass Weathering

Term	Description
Unweathered (Fresh)	No visible sign of material weathering and slight discoloration on major discontinuity surfaces.
Slightly Weathered	Discoloration indicates the weathering of rock material and discontinuity of surfaces. All of the rock material may be discoloured by weathering and may be somewhat weaker than its fresh condition.
Moderately Weathered	Less than half the rock material is decomposed and/or disintegrates to soil. Fresh or discoloured rock is present either as a continuous framework of as core stones.
Highly Weathered	More than half the rock material is decomposed and/or disintegrated to soil. Fresh or discoloured rock is present either as a discontinuous framework or as core stones.
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is largely intact.
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

Joint and Foliation Spacing

Description	Spacing
Very Wide	Greater than 3 m
Wide	1 m to 3 m
Moderately Close	0.3 m to 1 m
Close	50 mm to 300 mm
Very Close	Less than 50 mm

Bedding Thickness

Description	Spacing
Very thick	Greater than 2 m
Thick	0.6 m to 2 m
Medium	0.2 m to 0.6 m
Thin	60 mm to 0.2 m
Very thin	20 mm to 60 mm
Laminated	6 to 20 mm
Thinly Laminated	Less than 6 mm

SYMBOLS

General

w_N	Natural water content within the soil sample
γ	Unit weight
γ'	Effective unit weight
γ_D	Dry unit weight
γ_{SAT}	Saturated unit weight
ρ	Density
ρ_s	Density of solid particles
ρ_w	Density of water
ρ_D	Dry density
ρ_{SAT}	Saturated density
e	Void ratio
n	Porosity
S	Degree of saturation
E_{50}	Fifty percent secant modulus

Consistency

w_L	Liquid Limit
w_P	Plrastic Limit
I_P	Plasticity Index
w_S	Shrinkage Limit
I_L	Liquidity Index
I_C	Consistency Index
e_{max}	Void ratio in loosest state
e_{min}	Void ratio in densest state
I_D	Density Index (formerly relative density)

Shear Strength

S_u	Undrained shear strength parameter (total stress)
c'	Effective cohesion intercept
ϕ'	Effective friction angle
τ_P	Peak shear strength
τ_R	Residual shear strength
δ	Angle of interface friction
μ	Coefficient of friction = tan ϕ'

Consolidation

C_c	Compression index (normally consolidated range)
C_r	Recompression index (over consolidated range)
m_v	Coefficient of volume change
c_v	Coefficient of consolidation
T_v	Time factor (vertical direction)
U	Degree of consolidation
σ_v'	Effictive overburden pressure
OCR	Overconsolidation ratio

APPENDIX C

SITE PHOTOGRAPH LOG

Photo 1: BH-23-01 during advancement. Photo taken facing west.

Photo 2: BH-23-01 following completion of backfill. Photo taken facing southwest.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-01 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			1

Photo 3: BH-23-02 during advancement. Photo taken facing northwest.

Photo 4: BH-23-02 following completion of backfill. Photo taken facing north.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-02 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			2

Photo 5: BH-23-03 during advancement. Photo taken facing southwest.

Photo 6: BH-23-03 following completion of backfill. Photo taken facing southwest.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD 2024-01-29
PREPARED LM
DESIGNED
REVIEWED JM
APPROVED EG

TITLE
BH-23-03 Site Photographs

PROJECT NO. 23-0821
Phase/Task
Rev.
FIGURE 3

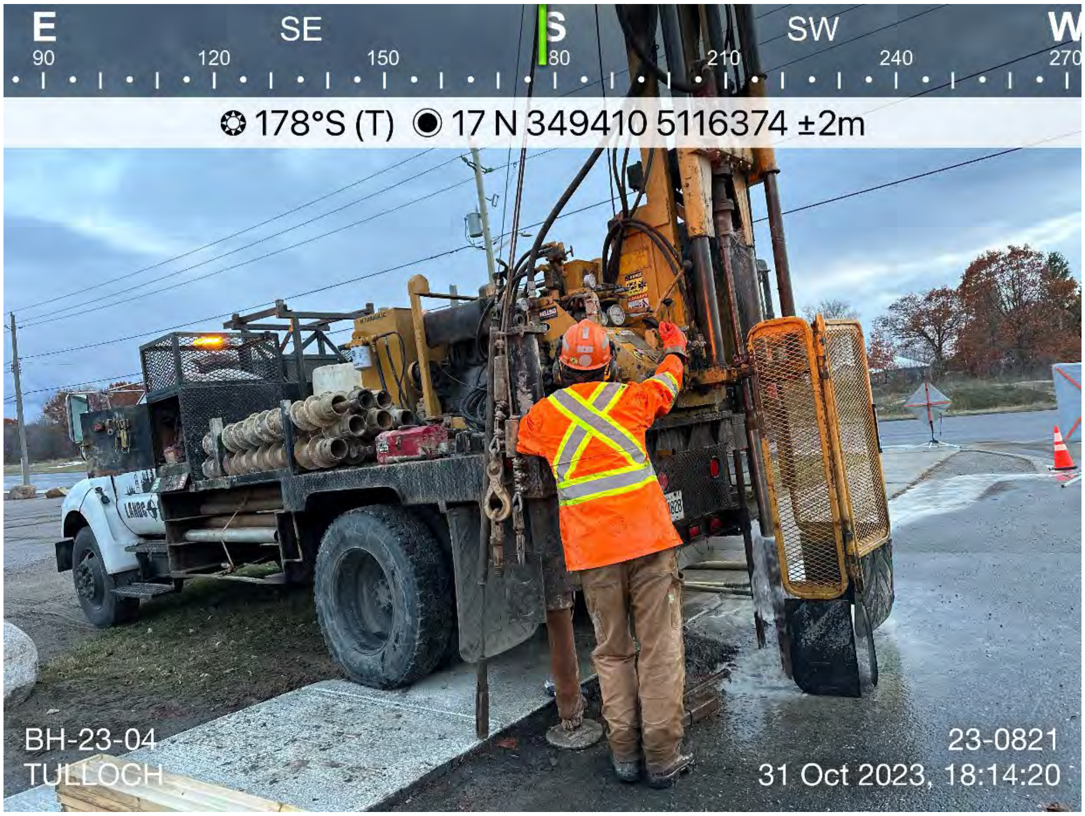


Photo 7: BH-23-04 during advancement. Photo taken facing south.

Photo 8: BH-23-04 following completion of backfill. Photo taken facing north.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-04 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			4

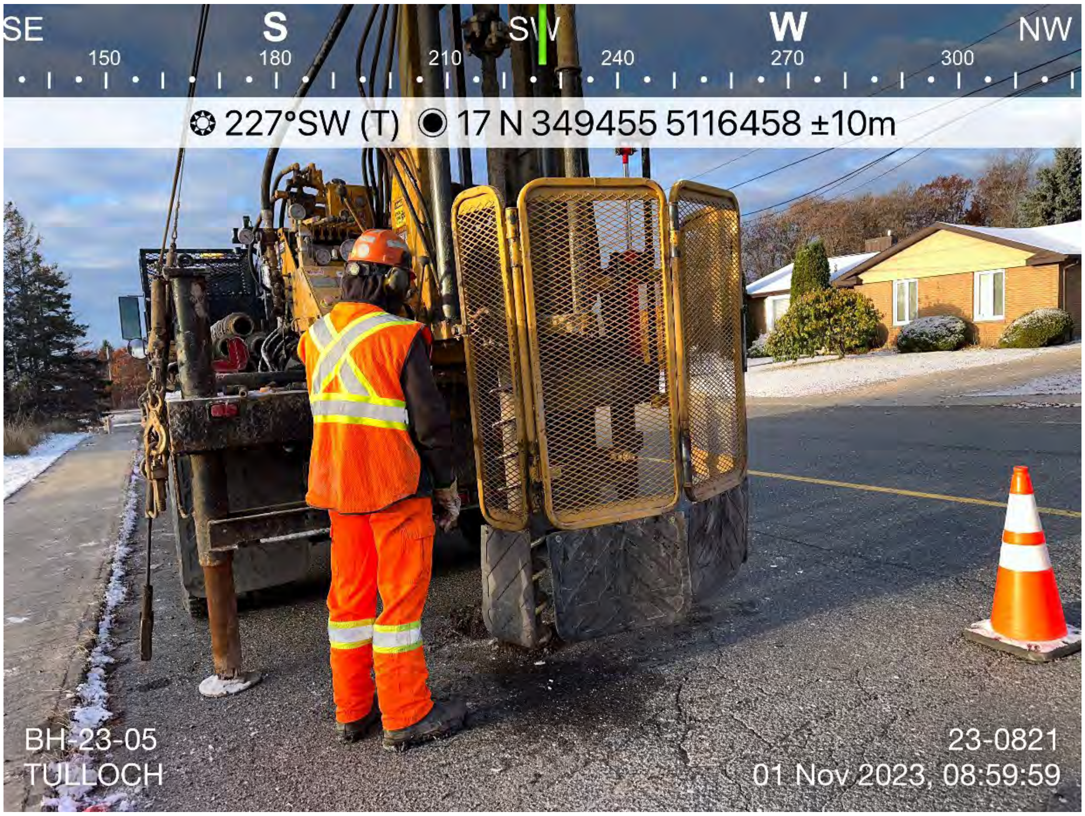


Photo 9: BH-23-05 during advancement. Photo taken facing south.

Photo 10: BH-23-05 following completion of backfill. Photo taken facing north.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-05 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			5

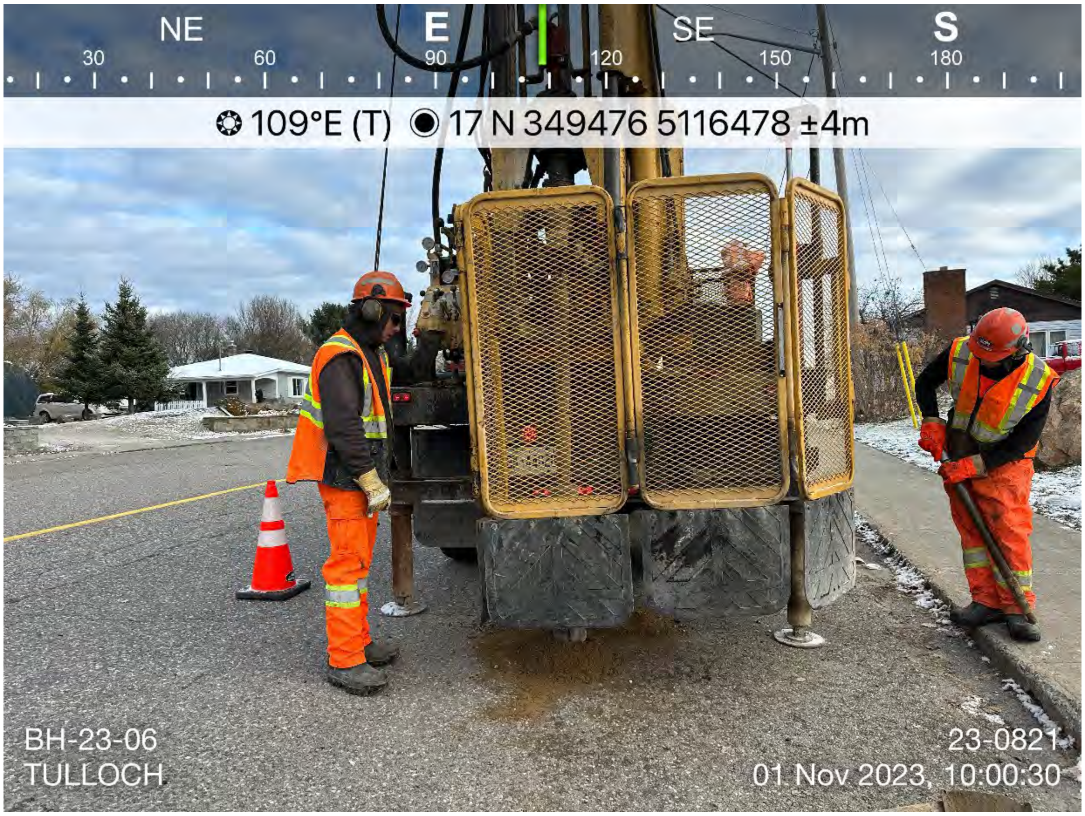


Photo 11: BH-23-06 during advancement. Photo taken facing southeast.

Photo 12: BH-23-06 following completion of backfill. Photo taken facing southwest.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-06 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			6

Photo 13: BH-23-07 following completion of backfill. Photo taken facing northeast.

CLIENT Town of Blind River		PROJECT Blind River Water Intake Geotechnical Investigation	
CONSULTANT TULLOCH ENGINEERING	YYYY-MM-DD	2024-01-29	TITLE BH-23-07 Site Photographs
	PREPARED	LM	
	DESIGNED		
	REVIEWED	JM	PROJECT NO. 23-0821 · Phase/Task · Rev. · FIGURE 7
	APPROVED	EG	

Photo 14: BH-23-08 during advancement. Photo taken facing northeast.

Photo 15: BH-23-08 following completion of backfill. Photo taken facing northeast.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-08 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
25 mm
0

Photo 16: BH-23-09 during advancement. Photo taken facing northeast.

Photo 17: BH-23-09 following completion of backfill. Photo taken facing southeast.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-09 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
25 mm
0

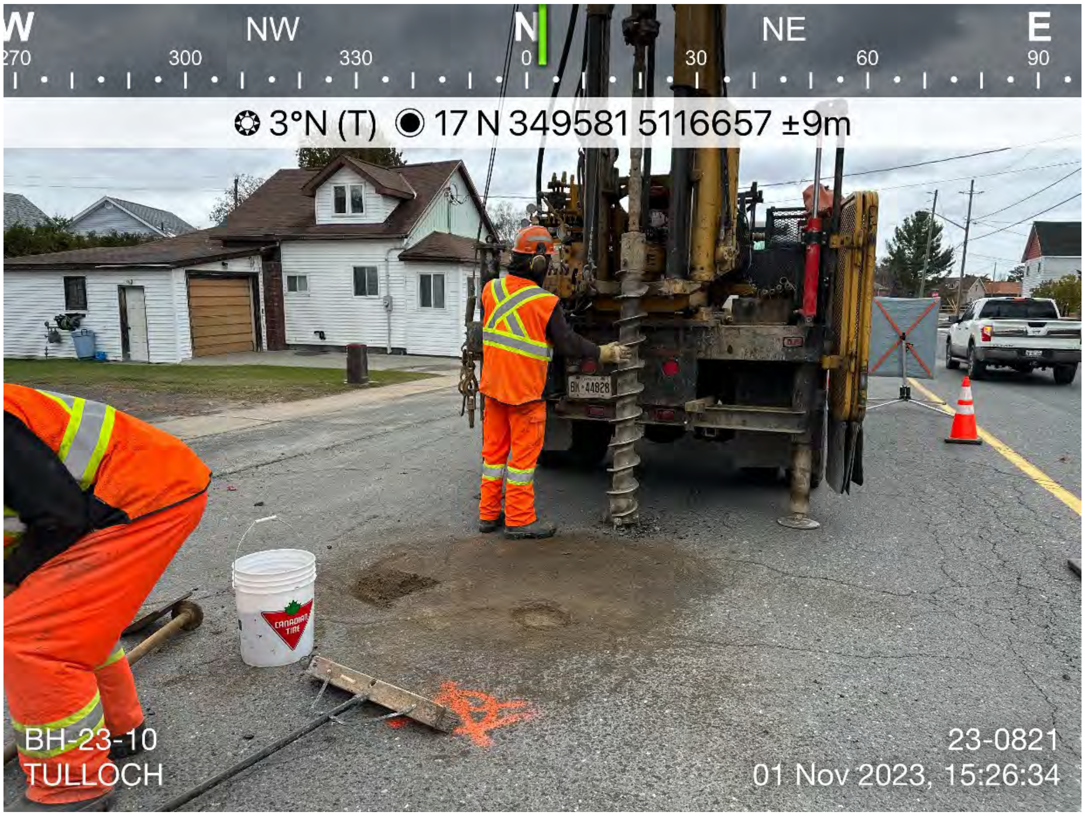


Photo 18: BH-23-10 during advancement. Photo taken facing north.

Photo 19: BH-23-10 following completion of backfill. Photo taken facing northeast.

CLIENT

Town of Blind River

PROJECT

Blind River Water Intake Geotechnical Investigation

CONSULTANT

TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE

BH-23-10 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			10

Photo 20: BH-23-11 during advancement. Photo taken facing south.

Photo 21: BH-23-11 following completion of backfill. Photo taken facing south.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-11 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			11

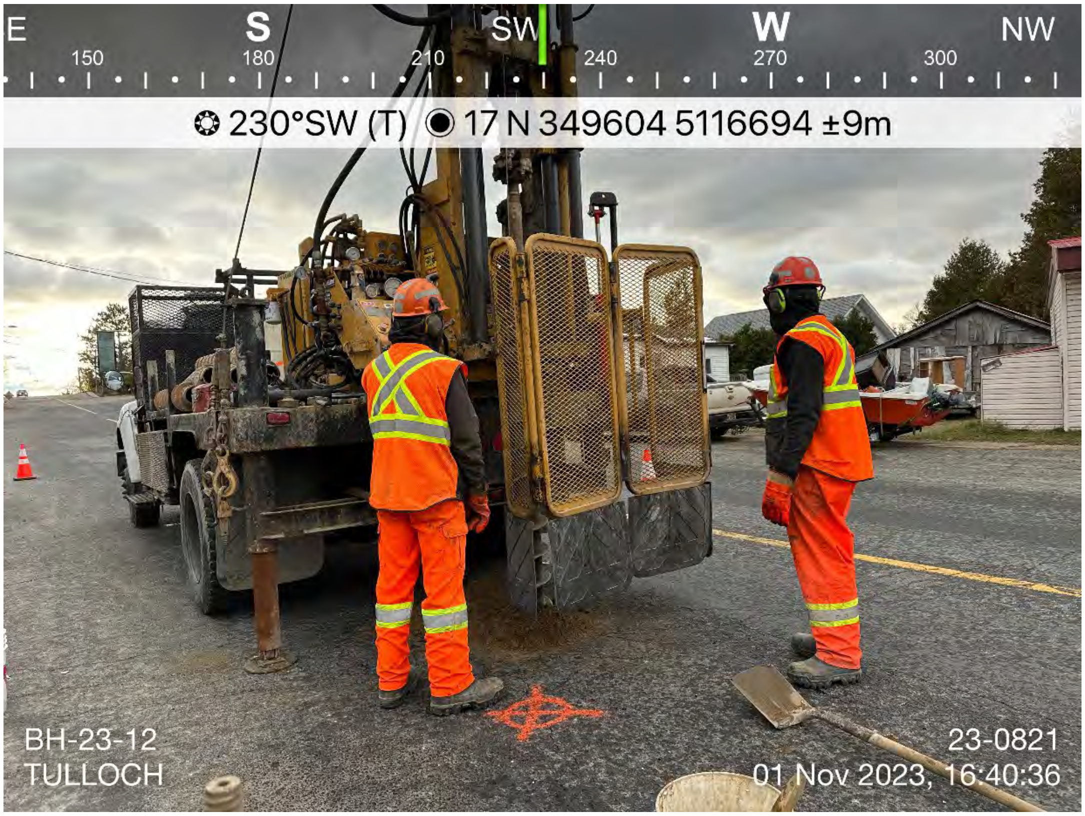


Photo 22: BH-23-12 during advancement. Photo taken facing southwest.

Photo 23: BH-23-12 following completion of backfill. Photo taken facing west.

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-01-29
PREPARED	LM
DESIGNED	
REVIEWED	JM
APPROVED	EG

TITLE
BH-23-12 Site Photographs

PROJECT NO.	Phase/Task	Rev.	FIGURE
23-0821			12

APPENDIX D

BOREHOLE LOGS

TULLOCH ENGINEERING

RECORD OF ROCKCORE No BH-23-01

1 OF 1

METRIC

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM
CLIENT Town of Blind River DATUM 17T BOREHOLE TYPE NW/NQ COMPILED BY LM
DRILLER Landcore Drilling DATE 2023.10.30 NORTHING 5116261 EASTING 349247 CHECKED BY JM

Elev. Depth	Description	Sample No.	Recovery Parameters	RQD %	Fracture index / ft	Compressive Strength (MPa)	Remarks
178.6 0.00	TOPSOIL - with organics and rootlets, fine to coarse grained sand, some fine to coarse grained gravel, non-plastic, dark brown, non-cohesive, moist						
178.2 0.43	- Switched from hollow stem augers to NW casing and NQ core barrel at 0.43 mbgs COBBLES and BOULDERS encountered from 0.39 mbgs to 3.05 mbgs	RUN 1 RUN 2 RUN 3					
175.5 3.11	GREYWACKE, dark grey, fine to medium grained, fresh to faintly weathered rock, poor rock quality based on RQD	RUN 4	TCR= 61% SCR= 45% RQD= 36%		1		
	- Good rock quality based on RQD below 3.55 mbgs	RUN 5	TCR= 98% SCR= 78% RQD= 76%		2 2 1 1		
		RUN 6	TCR= 100% SCR= 72% RQD= 52%		2 3 2		
	- Excellent rock quality based on RQD below 6.14 mbgs	RUN 7	TCR= 97% SCR= 92% RQD= 95%		1 1	45.8	
171.5 7.12	END OF BOREHOLE Note(s): 1. Groundwater level was unable to be accurately measured following drilling due to injection of water during coring. 2. It should be noted that groundwater may not have stabilized upon completion of the borehole.						

Discontinuity Data: Dip Angles W.R.T Core Axis; Type and Description (see core log photos)

TULLOCH ENGINEERING

Filling		Surface		Type		Aperture	Weathering	
Clean - CL	Clay - Cy	PL	Planar	BD	Bedding	Tight: 0.1 - 0.5mm (T)	FR	Fresh
Iron Stained - Fe	Calcite - Cal	CU	Curved	JN	Joint	Moderately Open: 0.5-2.5mm (MO)	SW	Slighty
Manganese Stained - Mn	Hematite - Hem	UN	Undulating	FLT	Fault	Open: 2.5-10mm (O)	MW	Moderately
Carbonate - C	Pyrite - Py	IR	Irregular	SH	Shear	Very Open: > 10mm (VO)	HW	Highly
Gypsum - G	Serpentine - St			KV	Karstic Void		EW	Extremely
Silty/Clay - SC	Chlorite - Ch							

TULLOCH
ENGINEERING

RECORD OF BOREHOLE No BH-23-02

1 OF 2

METRIC

JOB NUMBER 23-0821
LOCATION Blind River, Ontario
ORIGINATED BY LM
CLIENT Town of Blind River
Geodetic
DATUM Geodetic
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY LM
DRILLER Landcore Drilling
DATE 2023.10.30
NORTHING 5116307
EASTING 349299
CHECKED BY JM

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ POCKET PEN + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	GROUND WATER CONDITIONS	ELEVATION (M)			
180.90											
0.00 180.75 0.15	TOPSOIL - with organics and rootlets, some medium grained sand, non-plastic, dark brown, non-cohesive, moist, very dense		SS01A	SS	60	54				○	7 77 (16)
	(SP) SAND, fine to medium grained, some fine grained gravel, some non-plastic fines, brown, non-cohesive, moist, very dense		SS01B	SS	60	54					SS01A: HEX = 60 ppm, IBL = 0 ppm SS01B: HEX = 60 ppm, IBL = 0 ppm
180.09 0.81	- Switched from hollow stem augers to NW casing and NQ core barrel at 0.81 mbgs										
	END OF SOIL BOREHOLE LOG; see attached RECORD OF ROCKCORE No. BH-23-02										

200 + : Numbers refer to Field Vane Over Limit
+3, ×3 : Numbers refer to Sensitivity
○ 3% STRAIN AT FAILURE

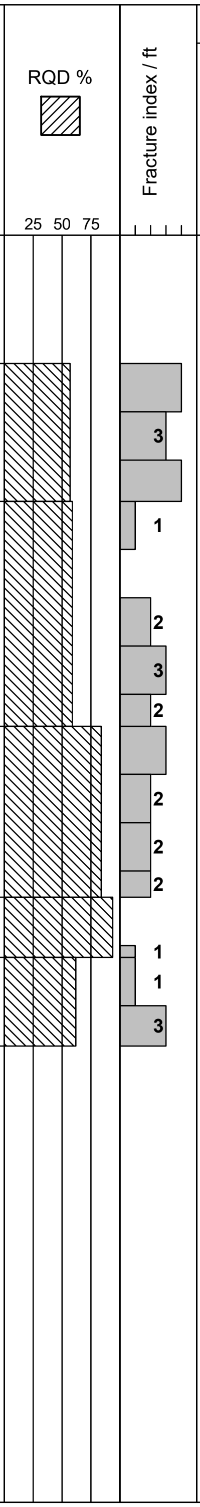
TULLOCH ENGINEERING

RECORD OF ROCKCORE No BH-23-02

2 OF 2 **METRIC**

JOB NUMBER 23-0821
LOCATION Blind River, Ontario
ORIGINATED BY LM
CLIENT Town of Blind River
DATUM 17T
BOREHOLE TYPE NW/NQ
COMPILED BY LM
DRILLER Landcore Drilling
DATE 2023.10.30
NORTHING 5116307
EASTING 349299
CHECKED BY JM

Elev. Depth	Description	Sample No.	Recovery Parameters	Compressive Strength (MPa)	Remarks
180.9 0.00	Soil Overburden; Please refer to RECORD OF BOREHOLE No. BH-23-02				
180.1 0.81	GREYWACKE, dark grey, fine to medium grained, fresh to faintly weathered rock, fair rock quality based on RQD	RUN 1	TCR= 91% SCR= 53% RQD= 57%		
		RUN 2	TCR= 100% SCR= 52% RQD= 59%		
	- Good rock quality based on RQD below 3.0 mbgs	RUN 3	TCR= 88% SCR= 84% RQD= 84%		
	- Excellent rock quality based on RQD below 4.19 mbgs	RUN 4	TCR= 78% SCR= 78% RQD= 94%		
		RUN 5	TCR= 100% SCR= 54% RQD= 62%	73	
175.8 5.12	END OF BOREHOLE Note(s): 1. Groundwater level was unable to be accurately measured following drilling due to injection of water during coring. 2. It should be noted that groundwater may not have stabilized upon completion of the borehole.				



Discontinuity Data: Dip Angles W.R.T Core Axis (30 60); Type and Description (see core log photos)

TULLOCH ENGINEERING

Filling		Surface		Type		Aperture	Weathering	
Clean - CL	Clay - Cy	PL	Planar	BD	Bedding	Tight: 0.1 - 0.5mm (T)	FR	Fresh
Iron Stained - Fe	Calcite - Cal	CU	Curved	JN	Joint	Moderately Open:	SW	Slighty
Manganese Stained - Mn	Hematite - Hem	UN	Undulating	FLT	Fault	0.5-2.5mm (MO)	MW	Moderately
Carbonate - C	Pyrite - Py	IR	Irregular	SH	Shear	Open: 2.5-10mm (O)	HW	Highly
Gypsum - G	Serpentine - St			KV	Karstic Void	Very Open: > 10mm (VO)	EW	Extremely
Silty/Clay - SC	Chlorite - Ch							

TULLOCH ENGINEERING

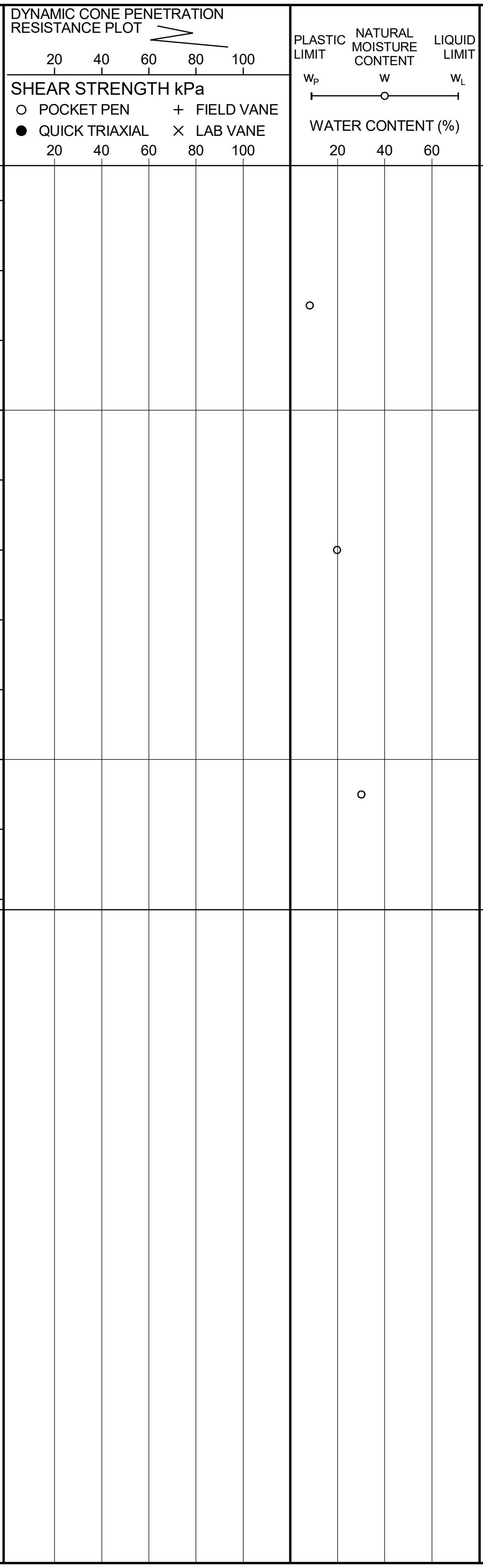
RECORD OF BOREHOLE No BH-23-03

1 OF 2

METRIC

JOB NUMBER 23-0821
LOCATION Blind River, Ontario
ORIGINATED BY LM
CLIENT Town of Blind River Geodetic
DATUM Geodetic
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY LM
DRILLER Landcore Drilling
DATE 2023.10.31
NORTHING 5116361
EASTING 349344
CHECKED BY JM

SOIL PROFILE			SAMPLES						REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	GROUND WATER CONDITIONS	ELEVATION (M)	GR SA SI CL
182.70									
0.00	TOPSOIL - trace organics and rootlets, some fine to coarse grained sand and gravel, non-plastic, dark brown, non-cohesive, moist, compact		SS01A	SS	23	58			SS01A: HEX = 5 ppm, IBL = 3 ppm
182.55 0.15	FILL - (SW) Gravelly SAND, fine to coarse grained, trace to some non-plastic fines, dark brown to black, with asphalt debris, non-cohesive, moist to wet, compact to very loose		SS01B	SS	23	58			SS01B: HEX = 15 ppm, IBL = 20 ppm
								182	
			SS02	SS	3	8			SS02: HEX = 0 ppm, IBL = 0 ppm
								181	SS03: HEX = 0 ppm, IBL = 1 ppm
			SS03 AS01	SS AS	5	13			26 60 (14) AS01: HEX = 15 ppm, IBL = 20 ppm
180.57 2.13	- Switched from hollow stem augers to NW casing and NQ core barrel at 2.13 mbgs								
	END OF SOIL BOREHOLE LOG; see attached RECORD OF ROCKCORE No. BH-23-03								



200 + : Numbers refer to Field Vane Over Limit
$+^3, \times^3$: Numbers refer to Sensitivity
$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF ROCKCORE No BH-23-03

METRIC

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM
CLIENT Town of Blind River DATUM 17T BOREHOLE TYPE NW/NQ COMPILED BY LM
DRILLER Landcore Drilling DATE 2023.10.31 NORTHING 5116361 EASTING 349344 CHECKED BY JM

Elev. Depth	Description	Sample No.	Recovery Parameters	Fracture index / ft	Compressive Strength (MPa)
182.7 0.00	Soil Overburden; Please refer to RECORD OF BOREHOLE No. BH-23-03				
180.6 2.13	GREYWACKE, dark grey, fine to medium grained, faintly to slightly weathered rock, poor rock quality based on RQD	RUN 1	TCR= 93% SCR= 48% RQD= 15%	2 1	
		RUN 2	TCR= 92% SCR= 42% RQD= 36%	2 4	
		RUN 3	TCR= 94% SCR= 29% RQD= 15%	3 1	
		RUN 4	TCR= 92% SCR= 40% RQD= 29%	2 2 4 5	
		RUN 5	TCR= 100% SCR= 33% RQD= 12%	3 2	
		RUN 6	TCR= 100% SCR= 50% RQD= 42%	1 2	
	- Good rock quality based on RQD below 7.47 mbgs	RUN 7	TCR= 100% SCR= 72% RQD= 77%	1	48.3
173.7 8.99	END OF BOREHOLE Note(s): 1. Groundwater level was unable to be accurately measured following drilling due to injection of water during coring. 2. It should be noted that groundwater may not have stabilized upon completion of the borehole.				

Depth (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

RQD %: 25 50 75

Dip Angles W.R.T Core Axis: 30 60

Type and Description (see core log photos)

Compressive Strength (MPa): 50 100 150

Remarks

TULLOCH ENGINEERING

Filling		Surface		Type		Aperture	Weathering	
Clean - CL	Clay - Cy	PL	Planar	BD	Bedding	Tight: 0.1 - 0.5mm (T)	FR	Fresh
Iron Stained - Fe	Calcite - Cal	CU	Curved	JN	Joint	Moderately Open:	SW	Slighty
Manganese Stained - Mn	Hematite - Hem	UN	Undulating	FLT	Fault	0.5-2.5mm (MO)	MW	Moderately
Carbonate - C	Pyrite - Py	IR	Irregular	SH	Shear	Open: 2.5-10mm (O)	HW	Highly
Gypsum - G	Serpentine - St			KV	Karstic Void	Very Open: > 10mm (VO)	EW	Extremely
Silty/Clay - SC	Chlorite - Ch							

TULLOCH ENGINEERING

RECORD OF BOREHOLE No BH-23-04

1 OF 1

METRIC

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM

CLIENT Town of Blind River DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger COMPILED BY LM

DRILLER Landcore Drilling DATE 2023.10.31 NORTHING 5116373 EASTING 349409 CHECKED BY JM

SOIL PROFILE			SAMPLES								REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	GROUND WATER CONDITIONS	DEPTH (M)	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ POCKET PEN + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60		GR	SA	SI	CL
182.30															
0.00	ASPHALT - 75 mm	■													
182.23 0.08	FILL - (SW) Gravelly SAND, fine to coarse grained, trace non-plastic fines, brown, non-cohesive, moist, dense to very dense	▨	SS01 AS01	SS AS	35	25				○	SS01: HEX = 0 ppm, IBL = 4 ppm AS01: HEX = 0 ppm, IBL = 0 ppm	28	62	(10)	
181.39 0.91	- Switched from hollow stem augers to NW casing and NQ core barrel at 0.91 mbgs	▨	SS02	SS	55	25				○		23	71	(6)	
	END OF SOIL BOREHOLE LOG; see attached RECORD OF ROCKCORE No. BH-23-04										SS02: HEX = 0 ppm, IBL = 0 ppm				

200 + : Numbers refer to Field Vane Over Limit

+ 3, × 3: Numbers refer to Sensitivity

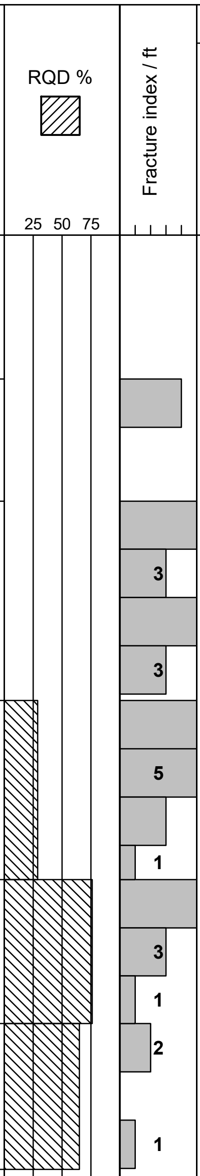
○ 3% STRAIN AT FAILURE

RECORD OF ROCKCORE No BH-23-04

2 OF 2

METRIC

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM
CLIENT Town of Blind River DATUM 17T BOREHOLE TYPE NW/NQ COMPILED BY LM
DRILLER Landcore Drilling DATE 2023.10.31 NORTHING 5116373 EASTING 349409 CHECKED BY JM



Elev. Depth	Strat Plot	Description	Depth (m)	Sample No.	Recovery Parameters	RQD %	Fracture index / ft	Dip Angles W.R.T Core Axis	Type and Description (see core log photos)	Compressive Strength (MPa)	Remarks
182.3 0.00		Soil Overburden; Please refer to RECORD OF BOREHOLE No. BH-23-04									
181.4 0.91		GREYWACKE, dark grey, fine to medium grained, faintly to slightly weathered rock, very poor to poor rock quality based on RQD	1	RUN 1	TCR= 47% SCR= 14% RQD= 0%						
			2	RUN 2	TCR= 72% SCR= 8% RQD= 0%		3 3				
			3	RUN 3	TCR= 88% SCR= 47% RQD= 29%		5 1				
		- Good rock quality based on RQD below 4.07 mbgs	4	RUN 4	TCR= 92% SCR= 58% RQD= 76%		3 1				
			5	RUN 5	TCR= 94% SCR= 53% RQD= 65%		2 1			135.2	
176.4 5.90		END OF BOREHOLE Note(s): 1. Groundwater level was unable to be accurately measured following drilling due to injection of water during coring. 2. It should be noted that groundwater may not have stabilized upon completion of the borehole.	6 7 8								

Dip Angles scale: 30 60
Compressive Strength scale: 50 100 150

TULLOCH ENGINEERING

Filling

Clean - CL
Iron Stained - Fe
Manganese Stained - Mn
Carbonate - C
Gypsum - G
Silty/Clay - SC
Clay - Cy
Calcite - Cal
Hematite - Hem
Pyrite - Py
Serpentine - St
Chlorite - Ch

Surface

PL	Planar
CU	Curved
UN	Undulating
IR	Irregular

Type

BD	Bedding
JN	Joint
FLT	Fault
SH	Shear
KV	Karstic Void

Aperture

Tight: 0.1 - 0.5mm (T)
Moderately Open: 0.5-2.5mm (MO)
Open: 2.5-10mm (O)
Very Open: > 10mm (VO)

Weathering

FR	Fresh
SW	Slighty
MW	Moderately
HW	Highly
EW	Extremely

TULLOCH ENGINEERING

RECORD OF BOREHOLE No BH-23-05

1 OF 1

METRIC

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM

CLIENT Town of Blind River Geodetic DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger COMPILED BY LM

DRILLER Landcore Drilling DATE 2023.11.01 NORTHING 5116455 EASTING 349454 CHECKED BY JM

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ POCKET PEN + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	GROUND WATER CONDITIONS	ELEVATION (M)			
189.20											
0.00 189.15 0.05	ASPHALT - 50mm	■									
	FILL - (SW) Gravelly SAND, fine to coarse grained, trace non-plastic fines, brown, non-cohesive, moist, very dense	▨	1 1	SS AS	83	83		189		○	25 67 (8)
188.74 0.46	Auger and spoon refusal - END OF BOREHOLE Note(s): - Groundwater was not encountered upon completion of drilling. - It should be noted that groundwater may not have stabilized upon completion of the borehole. - Borehole did not cave in upon removal of augers.										SS01: HEX = 0 ppm, IBL = 4 ppm - Auger and spoon refusal at 0.46 mbgs - Borehole moved 1m southwest

$200+$: Numbers refer to Field Vane Over Limit $+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

TULLOCH ENGINEERING

RECORD OF BOREHOLE No BH-23-06

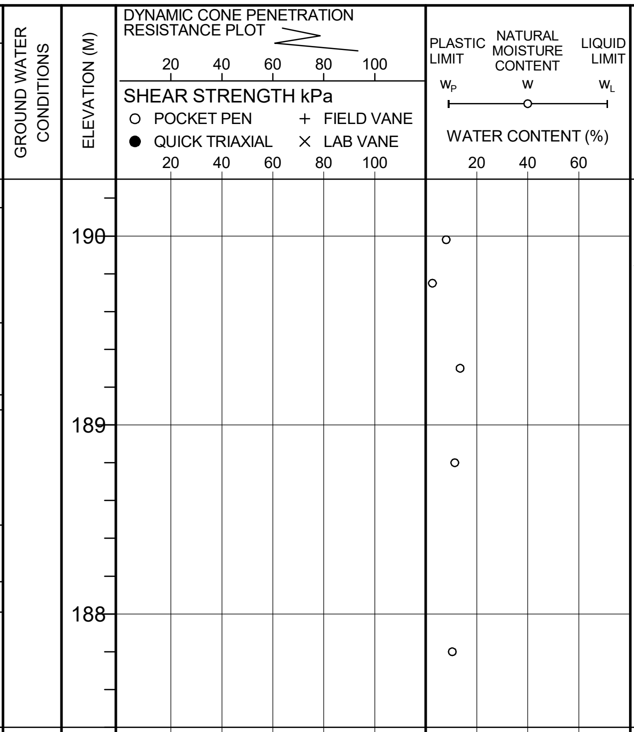
1 OF 1 **METRIC**

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM

CLIENT Town of Blind River Geodetic DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger COMPILED BY LM

DRILLER Landcore Drilling DATE 2023.11.01 NORTHING 5116484 EASTING 349475 CHECKED BY JM

SOIL PROFILE		SAMPLES				REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	
190.30 0.00	ASPHALT - 50mm					SS01: HEX = 0 ppm, IBL = 0 ppm
190.25 0.05	FILL - (SW) SAND , fine to coarse grained, some fine grained gravel, trace non-plastic fines, brown, non-cohesive, moist, dense to compact	1 1	SS AS	39	75	17 75 (8) AS01: HEX = 0 ppm, IBL = 0 ppm SS02: HEX = 5 ppm, IBL = 0 ppm
		2	SS	27	53	19 74 (7)
	- Loose below 1.22 mbgs	3	SS	6	29	SS03: Spoon refusal encountered at 1.14 mbgs, augered to 1.22 mbgs SS03: HEX = 5 ppm, IBL = 0 ppm
		4	SS	5	58	SS04: HEX = 0 ppm, IBL = 0 ppm
188.01 2.29	FILL - (SW/GW) SAND and GRAVEL, fine to coarse grained, trace non-plastic fines, brown, wet, very loose	5	SS	2	13	44 51 (5) SS05: HEX = 5 ppm, IBL = 0 ppm
187.40 2.90	END OF BOREHOLE					



Note(s):
- Borehole terminated when crew could not retrieve the spoon following SS05. Crew required to pull augers to retrieve sample and elected to terminate the borehole due to caving and heaving sands.
- Heaving sands encountered between 2.74 and 2.90 mbgs
- Borehole cave-in at 2.19 mbgs upon removal of augers.
- Groundwater was not encountered upon completion of drilling.
- It should be noted that groundwater may not have stabilized upon completion of the borehole.

$200+$: Numbers refer to Field Vane Over Limit $+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

TULLOCH
ENGINEERING

RECORD OF BOREHOLE No BH-23-07

1 OF 1

METRIC

JOB NUMBER 23-0821
LOCATION Blind River, Ontario
ORIGINATED BY LM
CLIENT Town of Blind River
Geodetic DATUM Geodetic
BOREHOLE TYPE Solid Stem Auger
COMPILED BY LM
DRILLER Landcore Drilling
DATE 2023.11.01
NORTHING 5116513
EASTING 349498
CHECKED BY JM

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ POCKET PEN + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	GROUND WATER CONDITIONS	ELEVATION (M)			
190.40											
0.00 190.35 0.05	ASPHALT - 50mm	▬									
189.64	FILL - (SP) SAND, fine to medium grained, trace fine gravel, brown, non-cohesive, moist	⊠	1	AS				190			SS01: HEX = 0 ppm, IBL = 0 ppm
0.76	END OF BOREHOLE Note(s): - Groundwater was not encountered upon completion of drilling. - It should be noted that groundwater may not have stabilized upon completion of the borehole. - Borehole did not cave in upon removal of augers.										

$200+$: Numbers refer to Field Vane Over Limit

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

TULLOCH ENGINEERING

RECORD OF BOREHOLE No BH-23-08

1 OF 1 **METRIC**

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM
CLIENT Town of Blind River Geodetic DATUM Geodetic BOREHOLE TYPE Solid Stem Auger COMPILED BY LM
DRILLER Landcore Drilling DATE 2023.11.01 NORTHING 5116551 EASTING 349511 CHECKED BY JM

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ POCKET PEN + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	GROUND WATER CONDITIONS	ELEVATION (M)			
188.50											
0.00 188.45 0.05	ASPHALT - 50mm	■									
	FILL - (SP) SAND, fine to medium grained, trace fine gravel, dark brown, non-cohesive, moist	▨	1	AS				188			SS01: HEX = 10 ppm, IBL = 0 ppm
187.74 0.76	END OF BOREHOLE Note(s): - Groundwater was not encountered upon completion of drilling. - It should be noted that groundwater may not have stabilized upon completion of the borehole. - Borehole did not cave in upon removal of augers.										

$200 +$: Numbers refer to Field Vane Over Limit

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

TULLOCH ENGINEERING

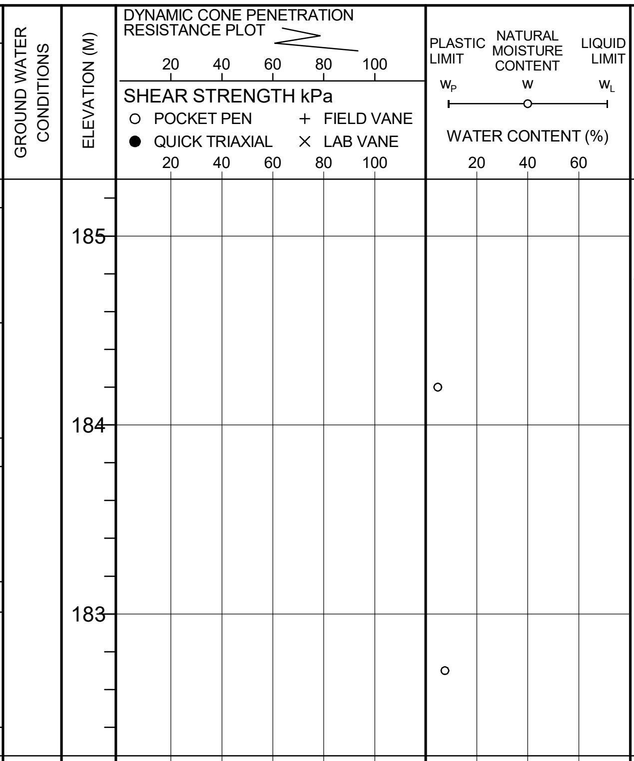
RECORD OF BOREHOLE No BH-23-09

1 OF 1

METRIC

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM
CLIENT Town of Blind River Geodetic DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger COMPILED BY LM
DRILLER Landcore Drilling DATE 2023.11.01 NORTHING 5116629 EASTING 349557 CHECKED BY JM

SOIL PROFILE			SAMPLES				REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)	GR SA SI CL
185.30							
0.00 185.25 0.05	ASPHALT - 50mm						
	FILL - (SP) Gravelly SAND, fine to medium grained, some non-plastic fines, brown, non-cohesive, moist, dense	⊠	1 1	SS AS	39	54	SS01: HEX = 15 ppm, IBL = 0 ppm AS01: HEX = 15 ppm, IBL = 0 ppm
			2	SS	25	29	SS02: HEX = 0 ppm, IBL = 0 ppm 38 50 (12)
183.85 1.45	(SM) SILTY SAND, fine to medium grained, some to trace fine gravel, non-plastic, brownish grey, non-cohesive, moist, very dense		3	SS	72	67	SS03: HEX = 0 ppm, IBL = 0 ppm - Auger and spoon refusal at 2.29 mbgs - Borehole moved 1m northeast
			4	SS	121	79	7 61 (32) SS04: HEX = 0 ppm, IBL = 0 ppm
182.25 3.05	END OF BOREHOLE Note(s): - Groundwater was not encountered upon completion of drilling. - It should be noted that groundwater may not have stabilized upon completion of the borehole. - Borehole did not cave in upon removal of augers.						



200 + : Numbers refer to Field Vane Over Limit

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

TULLOCH ENGINEERING

RECORD OF BOREHOLE No BH-23-10

1 OF 1 **METRIC**

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM

CLIENT Town of Blind River Geodetic DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger COMPILED BY LM

DRILLER Landcore Drilling DATE 2023.11.01 NORTHING 5116660 EASTING 349578 CHECKED BY JM

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION (M)	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ POCKET PEN + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)					
183.70 0.00	ASPHALT - 50mm										
183.65 0.05	FILL - (SP) SAND, fine to medium grained, some to trace fine gravel, greyish brown, with asphalt debris, non-cohesive, moist, very dense - Approximately 50 mm of ashaplt pavement encoutnered at approximately 0.40 mbgs.		1 1	SS AS	22	92				○	SS01: HEX = 0 ppm, IBL = 0 ppm 5 70 22 3 AS01: HEX = 0 ppm, IBL = 0 ppm
183.25 0.45	(SM) SILTY SAND, fine to medium grained, trace fine gravel, non-plastic, greyish brown, non-cohesive, moist, very dense		2	SS	12	79		183			SS02: HEX = 0 ppm, IBL = 0 ppm
182.18 1.52	END OF BOREHOLE Note(s): - Groundwater was not encountered upon completion of drilling. - It should be noted that groundwater may not have stabilized upon completion of the borehole. - Borehole did not cave in upon removal of augers.										

200 + : Numbers refer to Field Vane Over Limit

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

TULLOCH ENGINEERING

RECORD OF BOREHOLE No BH-23-11

1 OF 1

METRIC

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM
CLIENT Town of Blind River Geodetic DATUM Geodetic BOREHOLE TYPE Solid Stem Auger COMPILED BY LM
DRILLER Landcore Drilling DATE 2023.11.01 NORTHING 5116674 EASTING 349592 CHECKED BY JM

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION (M)	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ POCKET PEN + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)					
183.20											
183.15 0.00 0.05	ASPHALT - 50mm	■									
182.44	FILL - (SP) SAND, fine grained, trace fine gravel, brown, non-cohesive, moist	▨	1	AS				183			SS01: HEX = 0 ppm, IBL = 0 ppm
0.76	END OF BOREHOLE Note(s): - Groundwater was not encountered upon completion of drilling. - It should be noted that groundwater may not have stabilized upon completion of the borehole. - Borehole did not cave in upon removal of augers.										

3. SOIL REPORT+REC. (ELEVATION) 230821 SOIL LOGS W ELEVATIONS.GPJ ONTARIO MTO.GDT 24-2-13

200 + : Numbers refer to Field Vane Over Limit +3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TULLOCH
ENGINEERING

RECORD OF BOREHOLE No BH-23-12

1 OF 1 **METRIC**

JOB NUMBER 23-0821 LOCATION Blind River, Ontario ORIGINATED BY LM

CLIENT Town of Blind River Geodetic DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger COMPILED BY LM

DRILLER Landcore Drilling DATE 2023.11.01 NORTHING 5116699 EASTING 349607 CHECKED BY JM

SOIL PROFILE		SAMPLES				REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	RECOVERY RATIO (%)		GR	SA	SI	CL
182.90 0.00	ASPHALT - 50mm									
182.85 0.05	FILL - (SP) SAND, fine grained, trace coarse gravel, light brown, non-cohesive, moist, compact	1	SS	16	83	SS01: HEX = 0 ppm, IBL = 0 ppm				
182.14 0.76	(SM) SILTY SAND, fine grained, non-plastic, greyish brown, non-cohesive, moist, loose	2	SS	5	63	SS02: HEX = 0 ppm, IBL = 0 ppm	0	65	27	8
		3	SS	8	83	SS03: HEX = 0 ppm, IBL = 0 ppm				
180.69 2.21	(ML) SILT and SAND, non-plastic, fine grained sand, trace clay, greyish brown, non-cohesive, moist to wet, loose to very loose	4	SS	9	71	SS04: HEX = 0 ppm, IBL = 0 ppm	0	44	54	2
		5	SS	4	71	SS05: HEX = 0 ppm, IBL = 0 ppm				
		6	SS	3	58	SS06: HEX = 0 ppm, IBL = 0 ppm				
177.72 5.18	END OF BOREHOLE Note(s): - Groundwater was not encountered upon completion of drilling. - It should be noted that groundwater may not have stabilized upon completion of the borehole. - Borehole cave-in at 3.81 mbgs upon removal of augers.									

GROUND WATER CONDITIONS

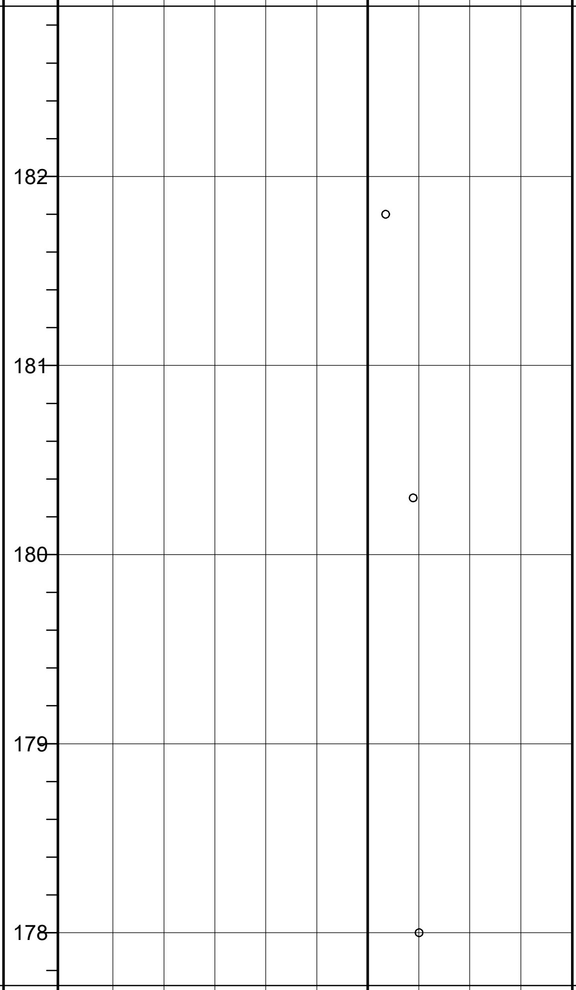
ELEVATION (M)

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ POCKET PEN + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%) 20 40 60



200 + : Numbers refer to Field Vane Over Limit

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

APPENDIX E

ROCK CORE PHOTOGRAPH LOG

Retrieved Rock Core at Borehole Location

BH-23-01

Run 1 to 6

Top of Bedrock Elevation: 178.6 m

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-01

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**1**

Photos of Bedrock Core – Discontinuity Logging

BH-23-01

Run 1 to 6

1

2

3

4

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-01

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**2**

Retrieved Rock Core at Borehole Location

BH-23-01

Run 7

Bottom of Core Elevation: 171.5 m

CLIENT	Town of Blind River
PROJECT	Blind River Water Intake Geotechnical Investigation
CONSULTANT	TULLOCH ENGINEERING
YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL
TITLE	Rock Core Photos – BH-23-01

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**3**

Photos of Bedrock Core – Discontinuity Logging

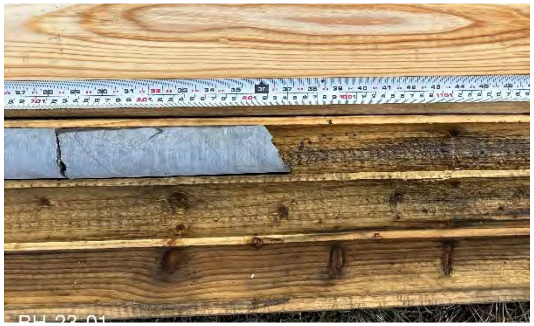
BH-23-01

Run 7

1

2

3



CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-01

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	4

Retrieved Rock Core at Borehole Location

BH-23-02

Run 1 to 3

Top of Bedrock Elevation: 180.90 m

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-02

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**5**

Photos of Bedrock Core – Discontinuity Logging

BH-23-02

Run 1 to 3

1

2

3

4

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-02

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**6**

Retrieved Rock Core at Borehole Location

BH-23-02

Run 4 to 5

CLIENT	
Town of Blind River	

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE

Rock Core Photos – BH-23-02

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	7

Photos of Bedrock Core – Discontinuity Logging

BH-23-02

Run 4 to 5

1

2

3

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-02

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	8

Retrieved Rock Core at Borehole Location

BH-23-03

Run 1 to 4

Top of Bedrock Elevation: 182.70 m

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-03

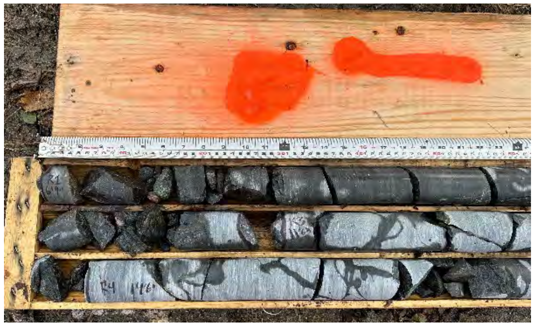
PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	9

Photos of Bedrock Core – Discontinuity Logging

BH-23-03

Run 1 to 4

1



2

3

4

CLIENT Town of Blind River		PROJECT Blind River Water Intake Geotechnical Investigation	
CONSULTANT	YYYY-MM-DD	2024-02-13	TITLE Rock Core Photos – BH-23-03
TULLOCH ENGINEERING	PREPARED	AU	
	DESIGN	AU	
	REVIEW	JM	
	APPROVED	GL	

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**10**

Retrieved Rock Core at Borehole Location

BH-23-03

Run 4 to 6

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-03

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	11

Photos of Bedrock Core – Discontinuity Logging

BH-23-03

Run 4 to 6

1

2

3

4

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-03

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	12

Retrieved Rock Core at Borehole Location

BH-23-03

Run 7

Bottom of Core Elevation: 175.8 m

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-03

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**13**

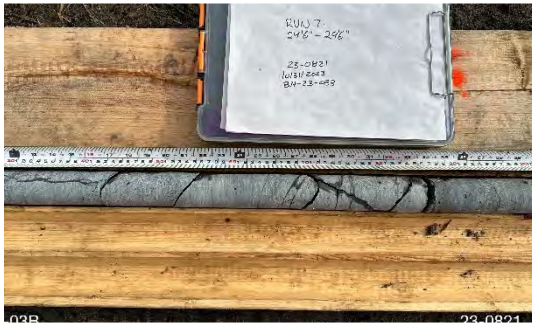
Photos of Bedrock Core – Discontinuity Logging

BH-23-03

Run 7

1

2



3

4

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-03

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	**103**	**0**	**14**

Retrieved Rock Core at Borehole Location

BH-23-04

Run 1 to 5

Top of Bedrock Elevation: 182.30 m

Bottom of Core Elevation: 176.4 m

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH
ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-04

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	15

Photos of Bedrock Core – Discontinuity Logging

BH-23-04

Run 1 to 5

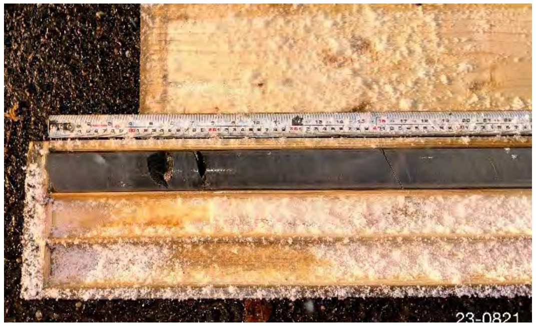
1

2

3

4

5



6

CLIENT
Town of Blind River

PROJECT
Blind River Water Intake Geotechnical Investigation

CONSULTANT
TULLOCH ENGINEERING

YYYY-MM-DD	2024-02-13
PREPARED	AU
DESIGN	AU
REVIEW	JM
APPROVED	GL

TITLE
Rock Core Photos – BH-23-04

PROJECT No.	Phase / Task	Rev.	Figure
23-0821	103	0	16

APPENDIX F

LABORATORY RESULTS

TULLOCH
ENGINEERING

CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821
DATE SAMPLED: 2023-10-31
PROJECT: Blind River Water Intake
SOURCE: Boreholes
DATE TESTED: 2023-11-20
TESTED BY: J.Draper

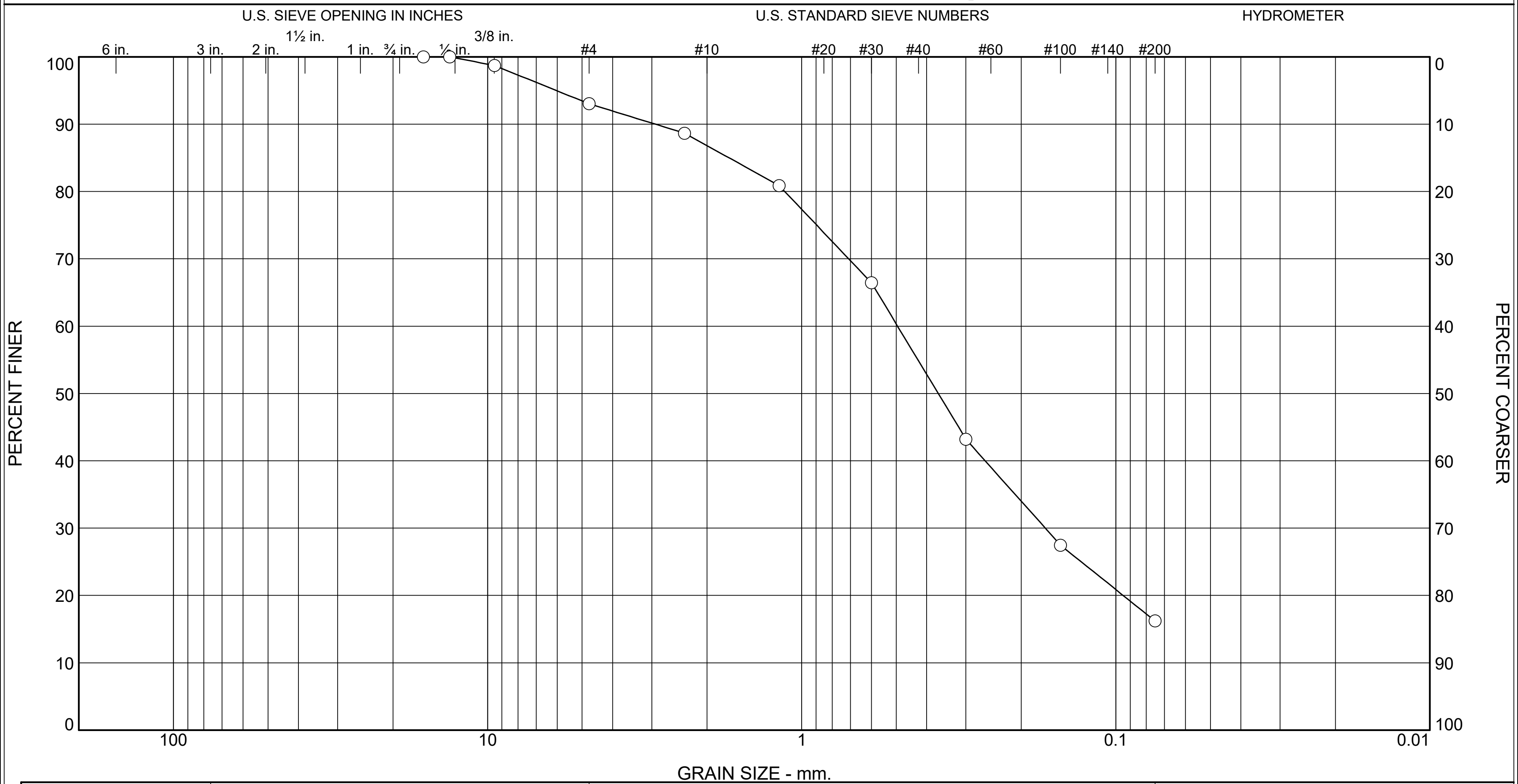
			Gross (inc. Tare) (g)				
Tare ID	**Sample ID**	**Depth (m)**	**Wet Weight**	**Dry Weight**	**TARE**	**Mass Lost**	**Water %**
	BH23-02 SS01A	0.0 to 0.2	357.62	335.96	212.55	21.66	17.6%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	0.0	7.0	6.2	31.9	38.7	16.2

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-02 Sample Number: SS1A	Oct 31, 2023		Nov 24, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821

Figure

TULLOCH
ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-02
Sample Number: SS1A
Date Sampled: Oct 31, 2023 **Date Tested:** Nov 24, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
336.00	212.60	16mm	0.00	0.00	100.0	0.0
		13.2mm	0.00	0.00	100.0	0.0
		9.5mm	1.60	0.00	98.7	1.3
		#4	7.00	0.00	93.0	7.0
		#8	5.40	0.00	88.7	11.3
		#16	9.60	0.00	80.9	19.1
		#30	17.80	0.00	66.5	33.5
		#50	28.70	0.00	43.2	56.8
		#100	19.40	0.00	27.5	72.5
		#200	13.90	0.00	16.2	83.8

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	7.0	7.0	6.2	31.9	38.7	76.8			16.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
			0.0947	0.1677	0.2606	0.3675	0.4951	1.1326	1.7041	2.9262	6.0422

Fineness Modulus
2.02

TULLOCH
ENGINEERING

CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821
DATE SAMPLED: 2023-10-31
PROJECT: Blind River Water Intake
SOURCE: Boreholes
DATE TESTED: 2023-11-20
TESTED BY: J.Draper

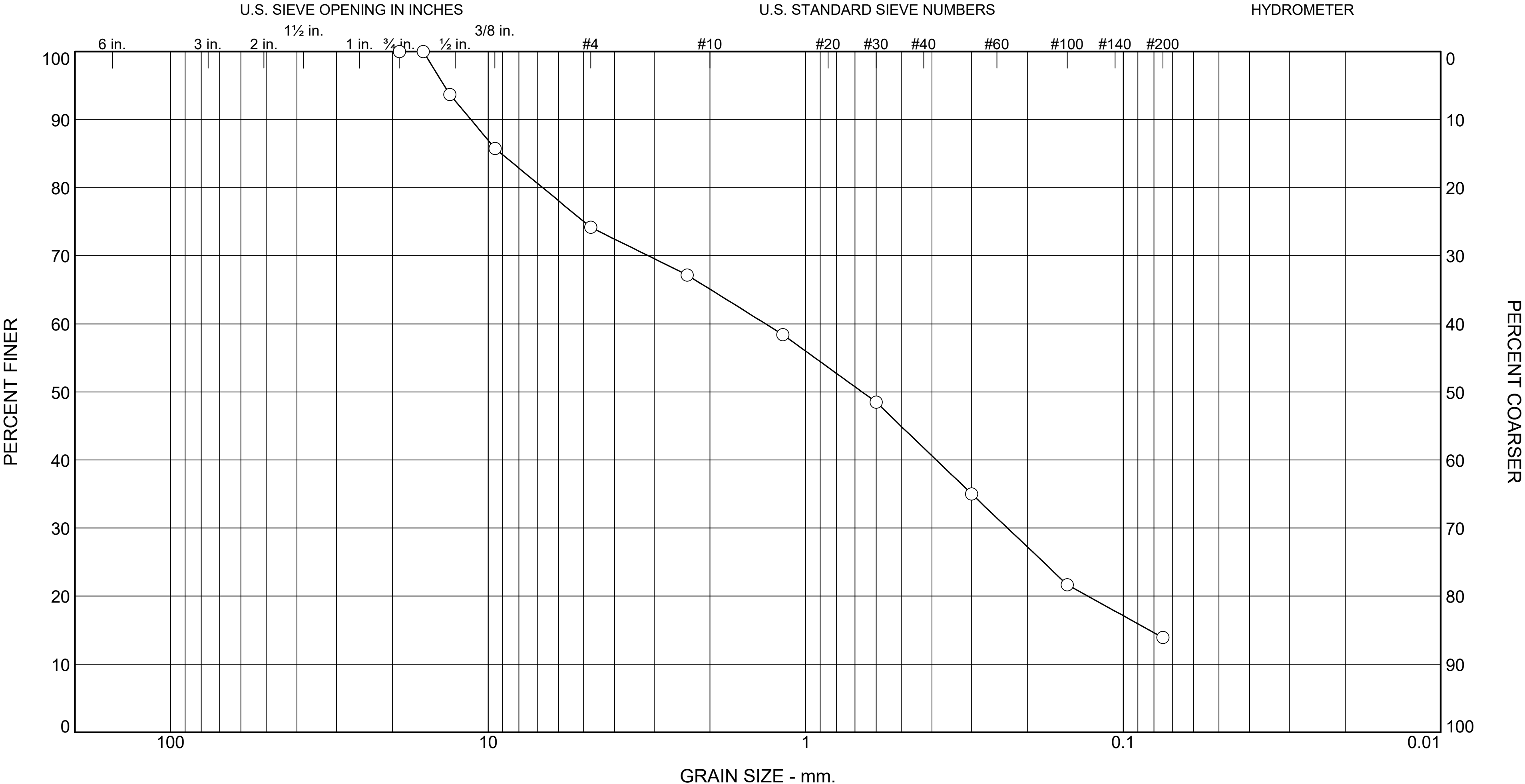
			Gross (inc. Tare) (g)				
Tare ID	**Sample ID**	**Depth (m)**	**Wet Weight**	**Dry Weight**	**TARE**	**Mass Lost**	**Water %**
	BH23-03 SS01A	0.2 to 0.6	689.53	658.03	271.80	31.5	8.2%
	BH23-03 SS02	0.8 to 1.4	101.57	87.06	13.78	14.51	19.8%
	BH23-03 SS03	1.5 to 2.1	398.06	361.89	241.85	36.17	30.1%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	0.0	25.8	9.1	23.3	27.9	13.9

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-03 Depth: 1.5m - 2.1m Sample Number: SS03	Oct 31, 2023		Nov 21, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 **Figure**

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-03
Depth: 1.5m - 2.1m **Sample Number:** SS03
Date Sampled: Oct 31, 2023 **Date Tested:** Nov 21, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
361.90	241.90	19mm	0.00	0.00	100.0	0.0
		16mm	0.00	0.00	100.0	0.0
		13.2mm	7.60	0.00	93.7	6.3
		9.5mm	9.50	0.00	85.8	14.2
		#4	13.90	0.00	74.2	25.8
		#8	8.40	0.00	67.2	32.8
		#16	10.50	0.00	58.4	41.6
		#30	11.90	0.00	48.5	51.5
		#50	16.20	0.00	35.0	65.0
		#100	16.00	0.00	21.7	78.3
		#200	9.30	0.00	13.9	86.1

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	25.8	25.8	9.1	23.3	27.9	60.3			13.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
		0.0826	0.1292	0.2313	0.3878	0.6646	1.3377	6.7343	9.0831	11.3347	13.7456

Fineness Modulus
3.09

TULLOCH
ENGINEERING

CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821
DATE SAMPLED: 2023-10-31

PROJECT: Blind River Water Intake
SOURCE: Boreholes

DATE TESTED: 2023-11-20
TESTED BY: J.Draper

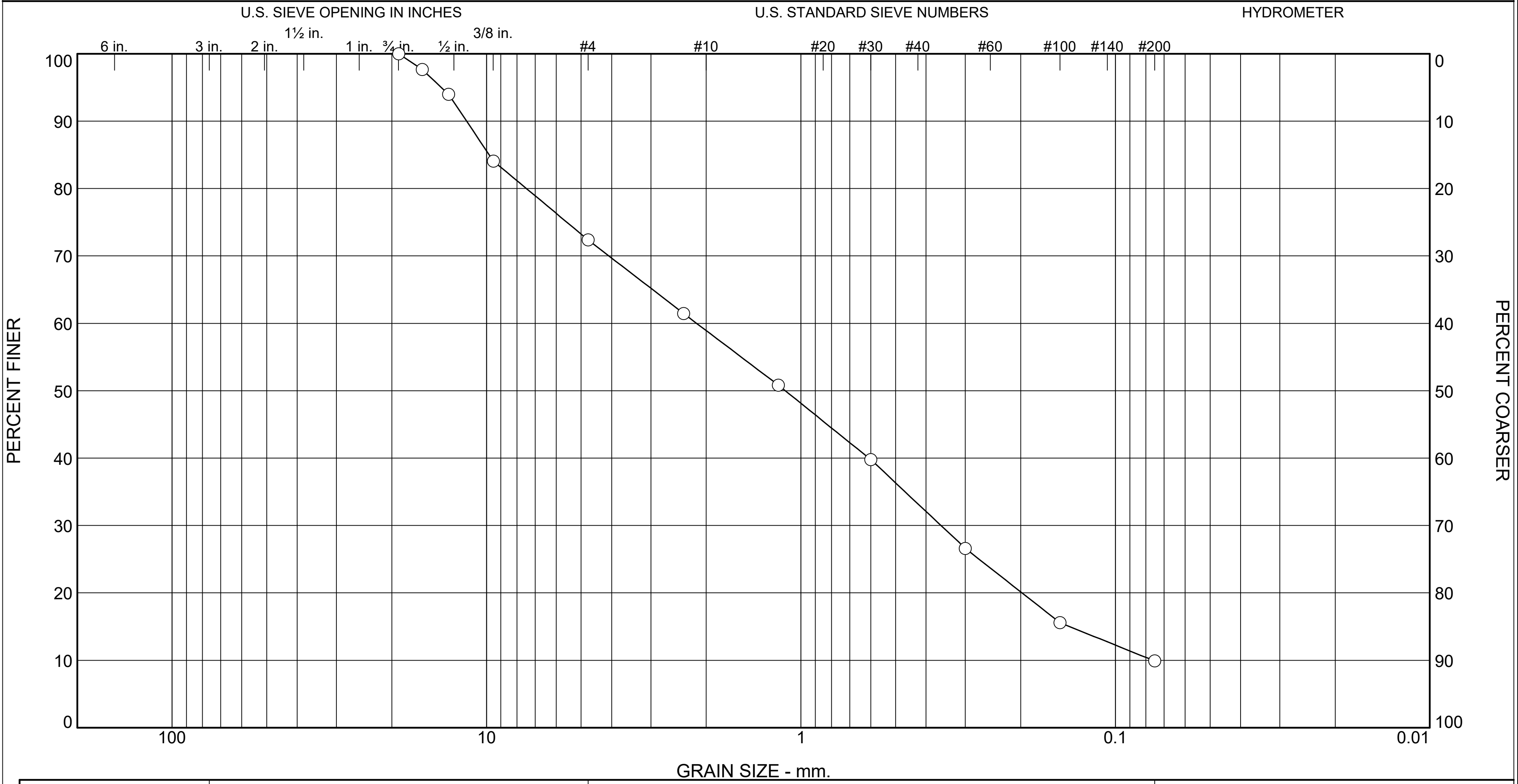
			Gross (inc. Tare) (g)				
Tare ID	**Sample ID**	**Depth (m)**	**Wet Weight**	**Dry Weight**	**TARE**	**Mass Lost**	**Water %**
	BH23-04-SS01	0.2 to 0.8	658.70	634.46	217.58	24.24	5.8%
	BH23-04-SS02	0.8 to 1.4	510.36	486.26	219.53	24.1	9.0%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	0.0	27.6	13.5	25.7	23.3	9.9

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-04 Depth: 0.2m - 0.8m Sample Number: SS1	Oct 31, 2023		Nov 22, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821

Figure

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-04
Depth: 0.2m - 0.8m **Sample Number:** SS1
Date Sampled: Oct 31, 2023 **Date Tested:** Nov 22, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
634.50	217.60	19mm	0.00	0.00	100.0	0.0
		16mm	9.80	0.00	97.6	2.4
		13.2mm	15.30	0.00	94.0	6.0
		9.5mm	41.30	0.00	84.1	15.9
		#4	48.80	0.00	72.4	27.6
		#8	45.50	0.00	61.5	38.5
		#16	44.30	0.00	50.8	49.2
		#30	46.00	0.00	39.8	60.2
		#50	55.00	0.00	26.6	73.4
		#100	46.00	0.00	15.6	84.4
		#200	23.60	0.00	9.9	90.1

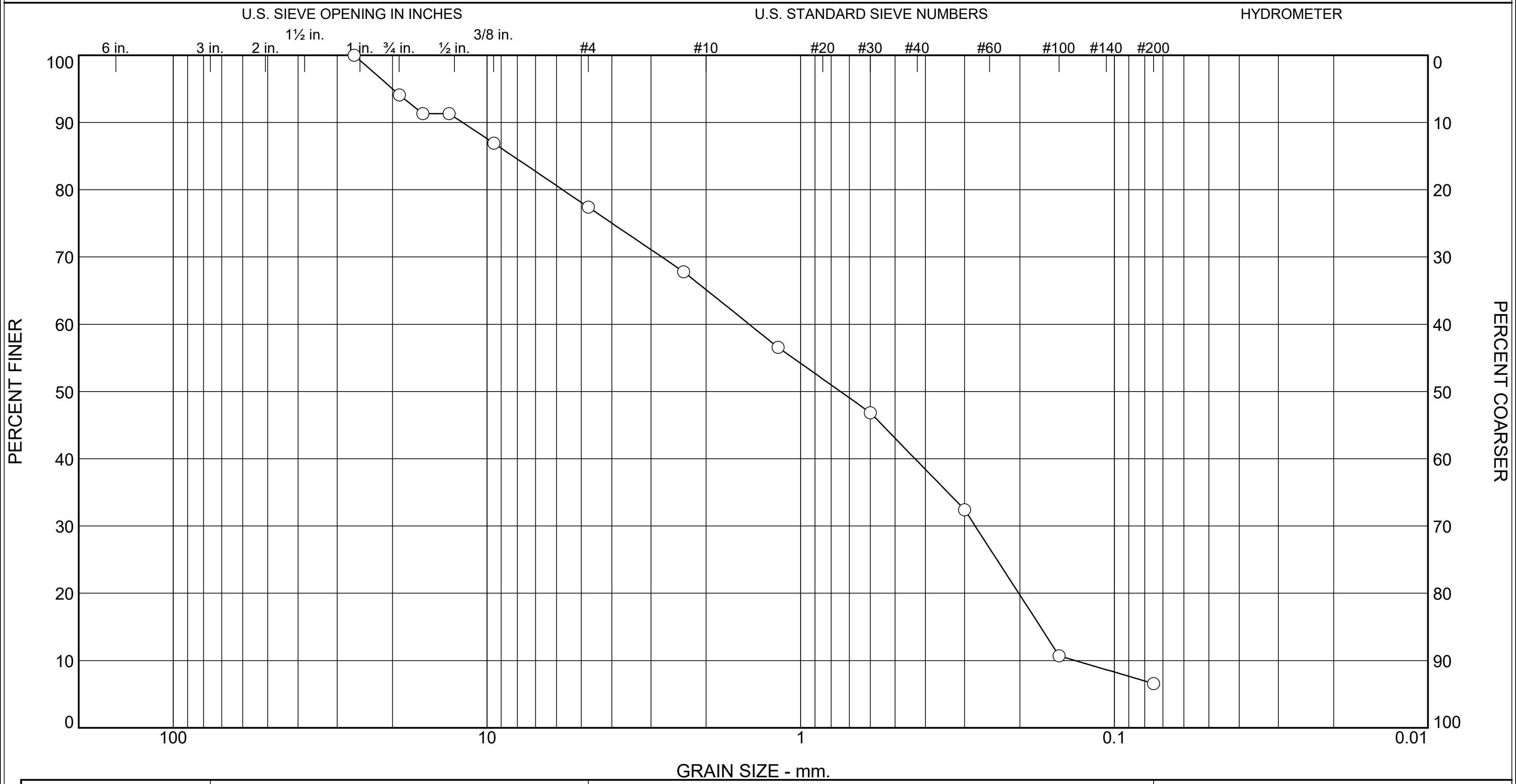
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	27.6	27.6	13.5	25.7	23.3	62.5			9.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0759	0.1399	0.1982	0.3587	0.6076	1.1216	2.1465	7.4641	9.7970	11.5662	13.9254

Fineness Modulus	C_u	C_c
3.49	28.29	0.79

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	5.9	16.7	12.3	25.4	33.1	6.6

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-04 Depth: 0.8m - 1.4m Sample Number: SS2	Oct 31, 2023		Nov 23, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821

Figure

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-04
Depth: 0.8m - 1.4m **Sample Number:** SS2
Date Sampled: Oct 31, 2023 **Date Tested:** Nov 23, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
486.30	219.50	26.5mm	0.00	0.00	100.0	0.0
		19mm	15.80	0.00	94.1	5.9
		16mm	7.40	0.00	91.3	8.7
		13.2mm	0.00	0.00	91.3	8.7
		9.5mm	11.70	0.00	86.9	13.1
		#4	25.40	0.00	77.4	22.6
		#8	25.60	0.00	67.8	32.2
		#16	30.00	0.00	56.6	43.4
		#30	25.90	0.00	46.9	53.1
		#50	38.50	0.00	32.4	67.6
		#100	57.90	0.00	10.7	89.3
		#200	11.10	0.00	6.6	93.4

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	5.9	16.7	22.6	12.3	25.4	33.1	70.8			6.6

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.1331	0.1720	0.2018	0.2777	0.4317	0.7472	1.4588	5.7404	8.2612	11.9698	20.0102

Fineness Modulus	C_u	C_c
3.27	10.96	0.40

TULLOCH
ENGINEERING

CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821

DATE SAMPLED: 2023-11-01

PROJECT: Blind River Water Intake

SOURCE: Boreholes

DATE TESTED: 2023-11-20

TESTED BY: J.Draper

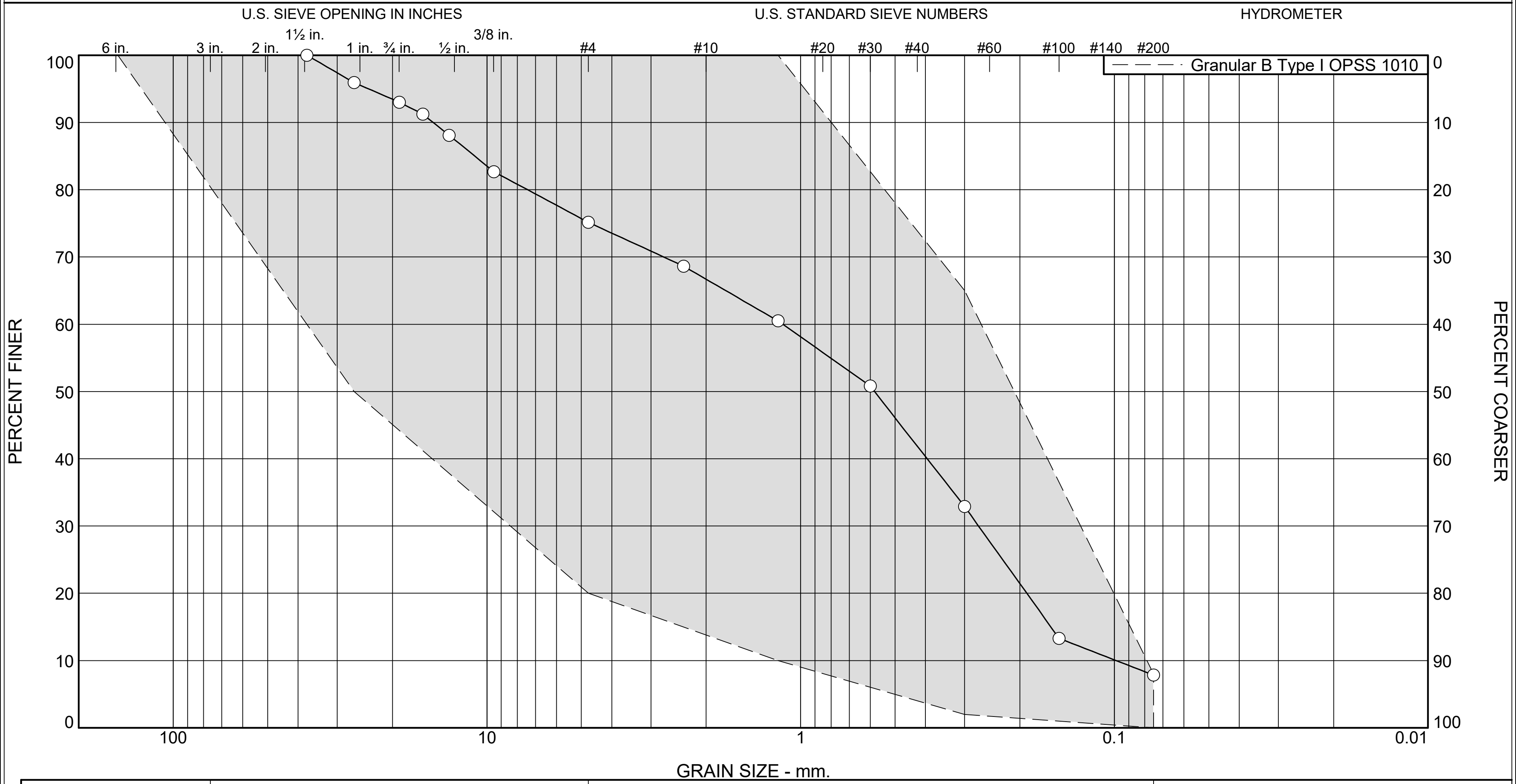
			Gross (inc. Tare) (g)				
Tare ID	**Sample ID**	**Depth (m)**	**Wet Weight**	**Dry Weight**	**TARE**	**Mass Lost**	**Water %**
	BH23-05-SS01	0.2 to 0.5	869.91	820.24	214.53	49.67	8.2%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	7.0	17.8	8.5	24.8	34.1	7.8

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-05 Depth: 0.2m - 0.5m Sample Number: SS1	Nov 1, 2023		Nov 21, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 **Figure**

TULLOCH ENGINEERING
71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-05
Depth: 0.2m - 0.5m **Sample Number:** SS1
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 21, 2023
Tested by: S. Campbell **Checked by:** T. Linley
Material specification: Granular B Type I OPSS 1010

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained	Lower Spec. Limit, %	Upper Spec. Limit, %	Deviation From Spec., %
820.20	214.50	37.5mm	0.00	0.00	100.0	0.0			
		26.5mm	24.70	0.00	95.9	4.1	50.0	100.0	
		19mm	17.70	0.00	93.0	7.0			
		16mm	10.70	0.00	91.2	8.8			
		13.2mm	19.00	0.00	88.1	11.9			
		9.5mm	32.80	0.00	82.7	17.3			
		#4	45.60	0.00	75.2	24.8	20.0	100.0	
		#8	39.50	0.00	68.6	31.4			
		#16	49.30	0.00	60.5	39.5	10.0	100.0	
		#30	58.70	0.00	50.8	49.2			
		#50	108.50	0.00	32.9	67.1	2.0	65.0	
		#100	118.70	0.00	13.3	86.7			
		#200	33.00	0.00	7.8	92.2	0.0	8.0	

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	7.0	17.8	24.8	8.5	24.8	34.1	67.4			7.8

D_{5}	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0987	0.1594	0.1902	0.2709	0.3950	0.5817	1.1402	7.4219	10.9369	14.8345	23.8591

Fineness Modulus	C_{u}	C_{c}
3.23	11.55	0.65

TULLOCH ENGINEERING

CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821
DATE SAMPLED: 2023-11-01
PROJECT: Blind River Water Intake
SOURCE: Boreholes
DATE TESTED: 2023-11-20
TESTED BY: J.Draper

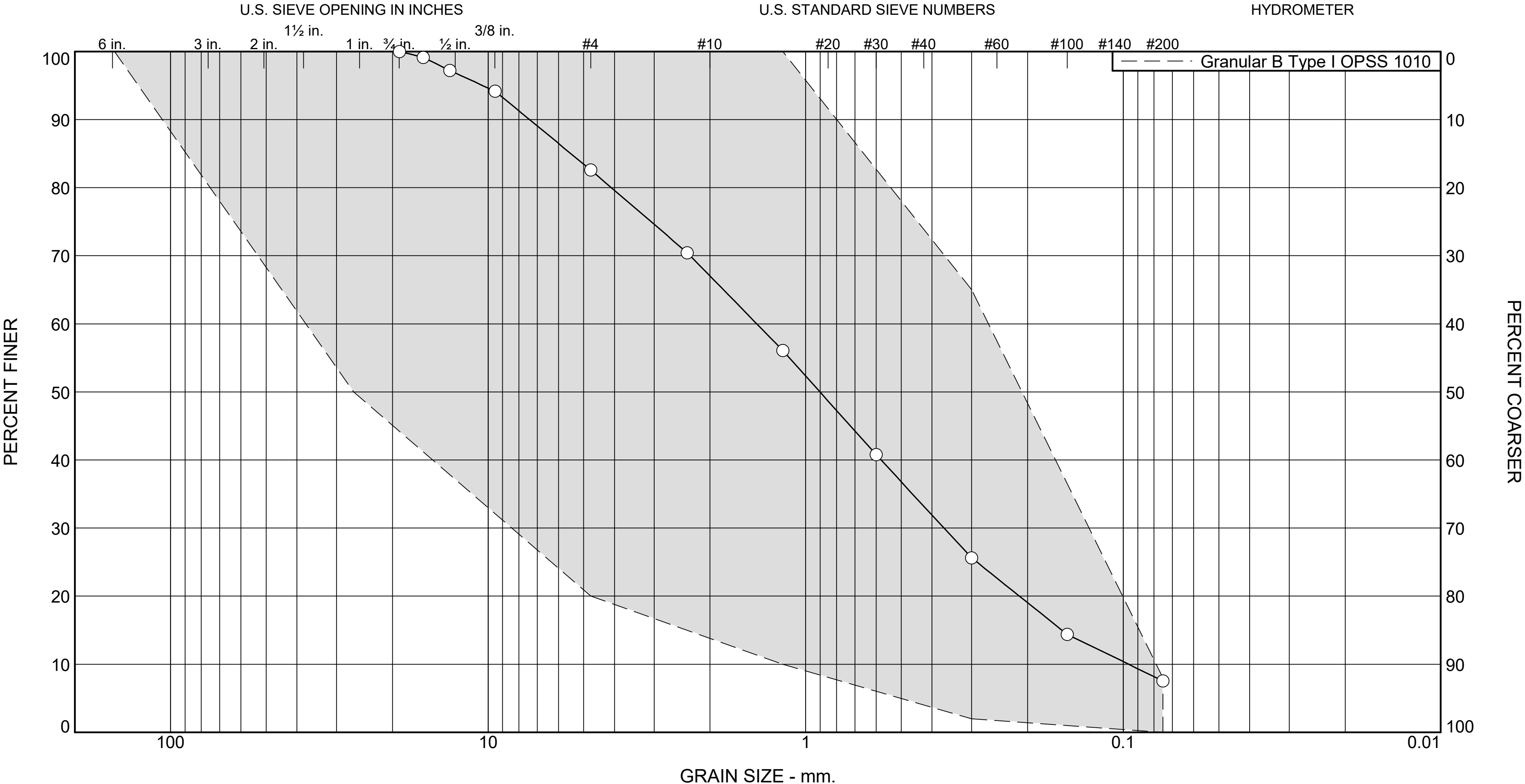
			Gross (inc. Tare) (g)				
Tare ID	Sample ID	Depth (m)	Wet Weight	Dry Weight	TARE	Mass Lost	Water %
	BH23-06-SS01	0.2 to 0.8	1350.76	1265.53	204.26	85.23	8.0%
	BH23-06-AS01	0.2 to 0.8	93.89	91.84	13.78	2.05	2.6%
	BH23-06-SS02	0.8 to 1.2	500.91	487.46	171.33	13.45	4.3%
	BH23-06-SS03	1.2 to 1.8	135.62	124.26	15.24	11.36	10.4%
	BH23-06-SS05	2.3 to 2.9	413.49	390.51	169.39	22.98	10.4%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	0.0	17.4	15.6	33.8	25.6	7.6

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-06 Depth: 0.2m - 0.8m Sample Number: SS1	Nov 1, 2023		Nov 23, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821

Figure

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-06
Depth: 0.2m - 0.8m **Sample Number:** SS1
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 23, 2023
Tested by: S. Campbell **Checked by:** T. Linley
Material specification: Granular B Type I OPSS 1010

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained	Lower Spec. Limit, %	Upper Spec. Limit, %	Deviation From Spec., %
1265.50	204.30	19mm	0.00	0.00	100.0	0.0			
		16mm	9.30	0.00	99.1	0.9			
		13.2mm	20.30	0.00	97.2	2.8			
		9.5mm	32.40	0.00	94.2	5.8			
		#4	122.80	0.00	82.6	17.4	20.0	100.0	
		#8	128.90	0.00	70.4	29.6			
		#16	152.30	0.00	56.1	43.9	10.0	100.0	
		#30	162.40	0.00	40.8	59.2			
		#50	161.00	0.00	25.6	74.4	2.0	65.0	
		#100	119.30	0.00	14.4	85.6			
		#200	72.30	0.00	7.6	92.4	0.0	8.0	

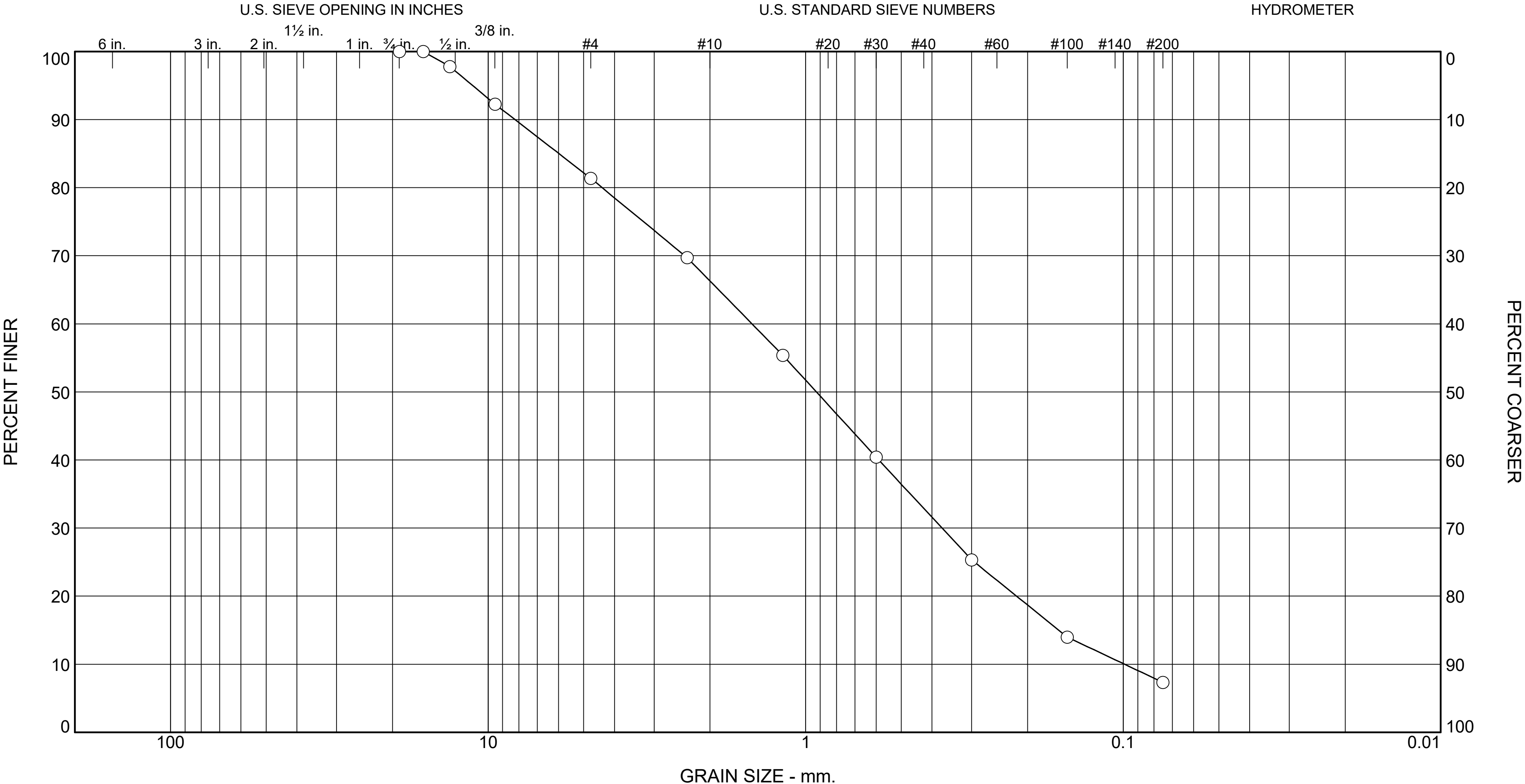
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	17.4	17.4	15.6	33.8	25.6	75.0			7.6

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0962	0.1559	0.2122	0.3666	0.5789	0.9017	1.4254	4.0928	5.4891	7.4057	10.4025

Fineness Modulus	C_u	C_c
3.16	14.82	0.98

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	0.0	18.6	15.1	33.4	25.6	7.3

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-06 Depth: 0.8m - 1.2m Sample Number: SS2	Nov 1, 2023		Nov 24, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 **Figure**

TULLOCH
ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-06
Depth: 0.8m - 1.2m **Sample Number:** SS2
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 24, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
487.50	171.30	19mm	0.00	0.00	100.0	0.0
		16mm	0.00	0.00	100.0	0.0
		13.2mm	7.00	0.00	97.8	2.2
		9.5mm	17.50	0.00	92.3	7.7
		#4	34.40	0.00	81.4	18.6
		#8	36.90	0.00	69.7	30.3
		#16	45.30	0.00	55.4	44.6
		#30	47.30	0.00	40.4	59.6
		#50	47.70	0.00	25.3	74.7
		#100	35.90	0.00	14.0	86.0
		#200	21.00	0.00	7.3	92.7

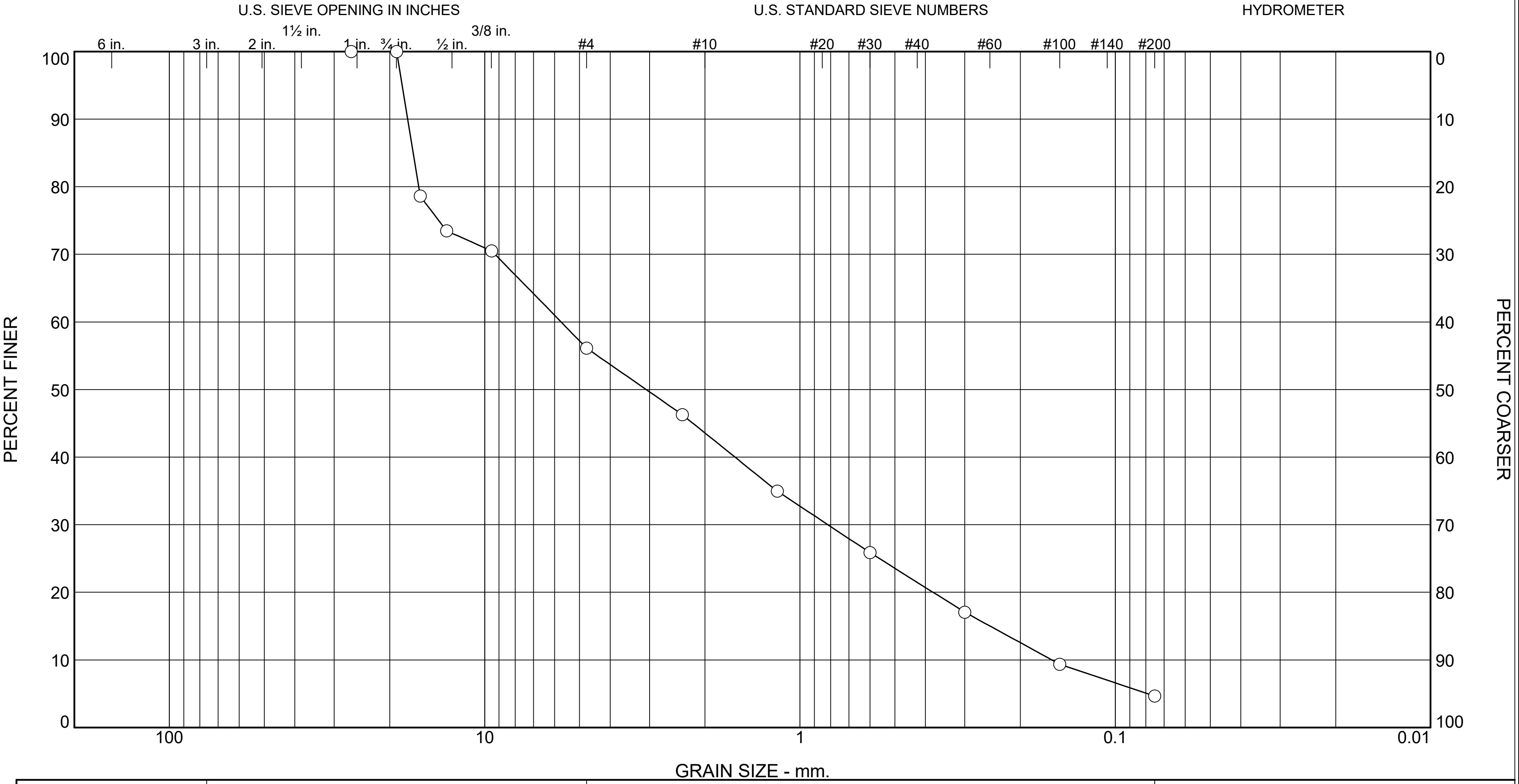
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	18.6	18.6	15.1	33.4	25.6	74.1			7.3

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0990	0.1597	0.2166	0.3718	0.5886	0.9254	1.4758	4.3749	5.9850	8.2303	11.1856

Fineness Modulus	C_u	C_c
3.22	14.90	0.95

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	0.0	43.9	12.5	22.1	16.8	4.7

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-06 Depth: 2.3m - 2.9m Sample Number: SS5	Nov 1, 2023		Nov 23, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821

Figure

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-06
Depth: 2.3m - 2.9m **Sample Number:** SS5
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 23, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
390.50	169.40	26.5mm	0.00	0.00	100.0	0.0
		19mm	0.00	0.00	100.0	0.0
		16mm	47.30	0.00	78.6	21.4
		13.2mm	11.40	0.00	73.5	26.5
		9.5mm	6.50	0.00	70.5	29.5
		#4	31.80	0.00	56.1	43.9
		#8	21.80	0.00	46.3	53.7
		#16	25.00	0.00	35.0	65.0
		#30	20.10	0.00	25.9	74.1
		#50	19.50	0.00	17.1	82.9
		#100	17.00	0.00	9.4	90.6
		#200	10.40	0.00	4.7	95.3

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	43.9	43.9	12.5	22.1	16.8	51.4			4.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0789	0.1589	0.2494	0.3782	0.8158	1.6070	3.0752	5.7243	16.1800	16.8431	17.5334	18.2520

Fineness Modulus	C_u	C_c
4.40	36.03	0.73

TULLOCH
ENGINEERING

CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821

DATE SAMPLED: 2023-11-01

PROJECT: Blind River Water Intake

SOURCE: Boreholes

DATE TESTED: 2023-11-20

TESTED BY: J.Draper

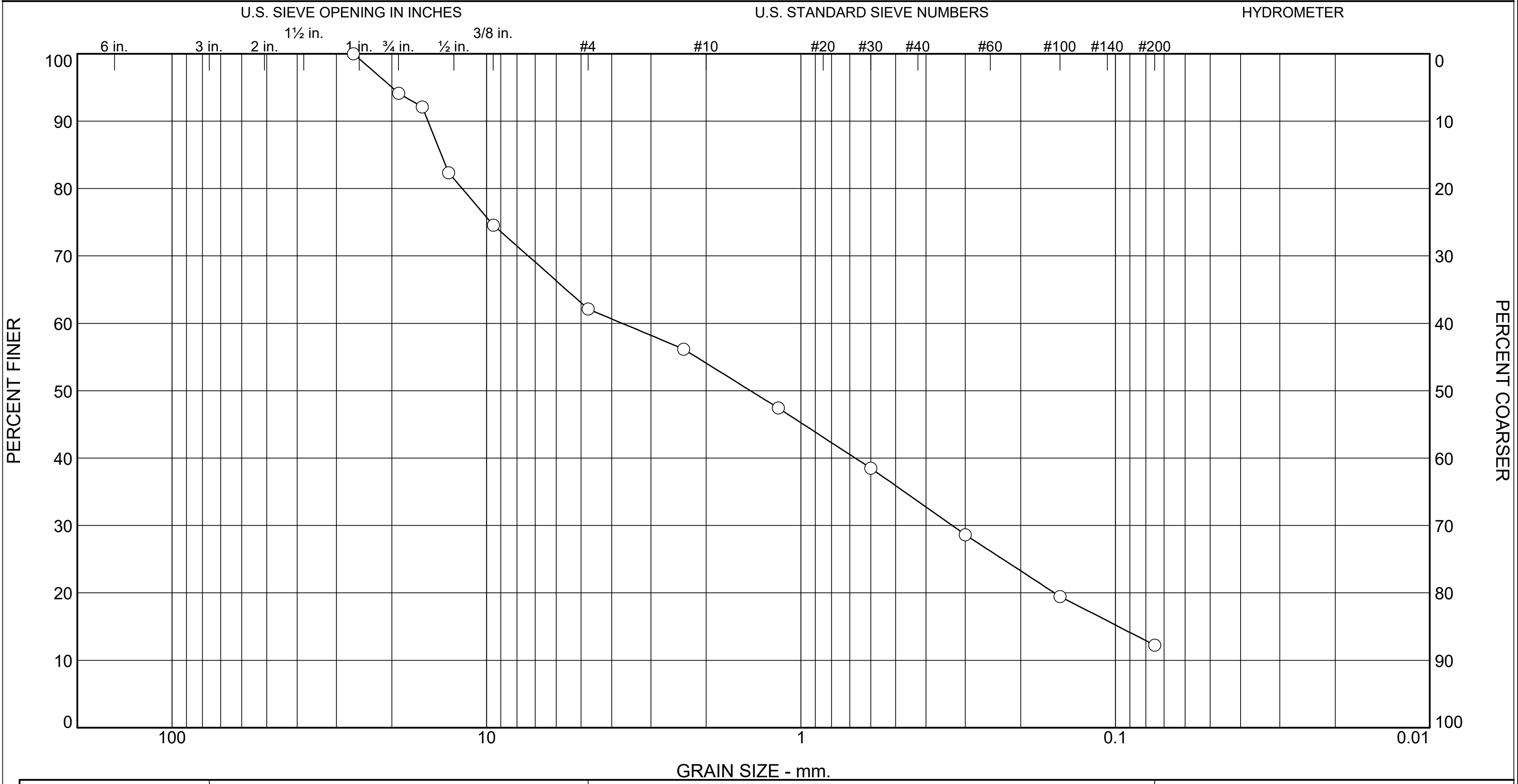
			Gross (inc. Tare) (g)				
Tare ID	**Sample ID**	**Depth (m)**	**Wet Weight**	**Dry Weight**	**TARE**	**Mass Lost**	**Water %**
	BH23-09-SS02	0.8 to 1.4	649.27	630.25	221.93	19.02	4.7%
	BH23-09-SS04	2.3 to 2.9	1595.47	1508.82	349.56	86.65	7.5%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	5.8	32.1	8.0	20.5	21.4	12.2

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-09 Depth: 0.8m - 1.4m Sample Number: SS2	Nov 1, 2023		Nov 24, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 Figure

TULLOCH
ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-09
Depth: 0.8m - 1.4m **Sample Number:** SS2
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 24, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
630.30	221.90	26.5mm	0.00	0.00	100.0	0.0
		19mm	24.00	0.00	94.1	5.9
		16mm	8.20	0.00	92.1	7.9
		13.2mm	39.90	0.00	82.3	17.7
		9.5mm	31.80	0.00	74.6	25.4
		#4	50.80	0.00	62.1	37.9
		#8	24.30	0.00	56.2	43.8
		#16	35.70	0.00	47.4	52.6
		#30	36.40	0.00	38.5	61.5
		#50	40.40	0.00	28.6	71.4
		#100	37.40	0.00	19.5	80.5
		#200	29.50	0.00	12.2	87.8

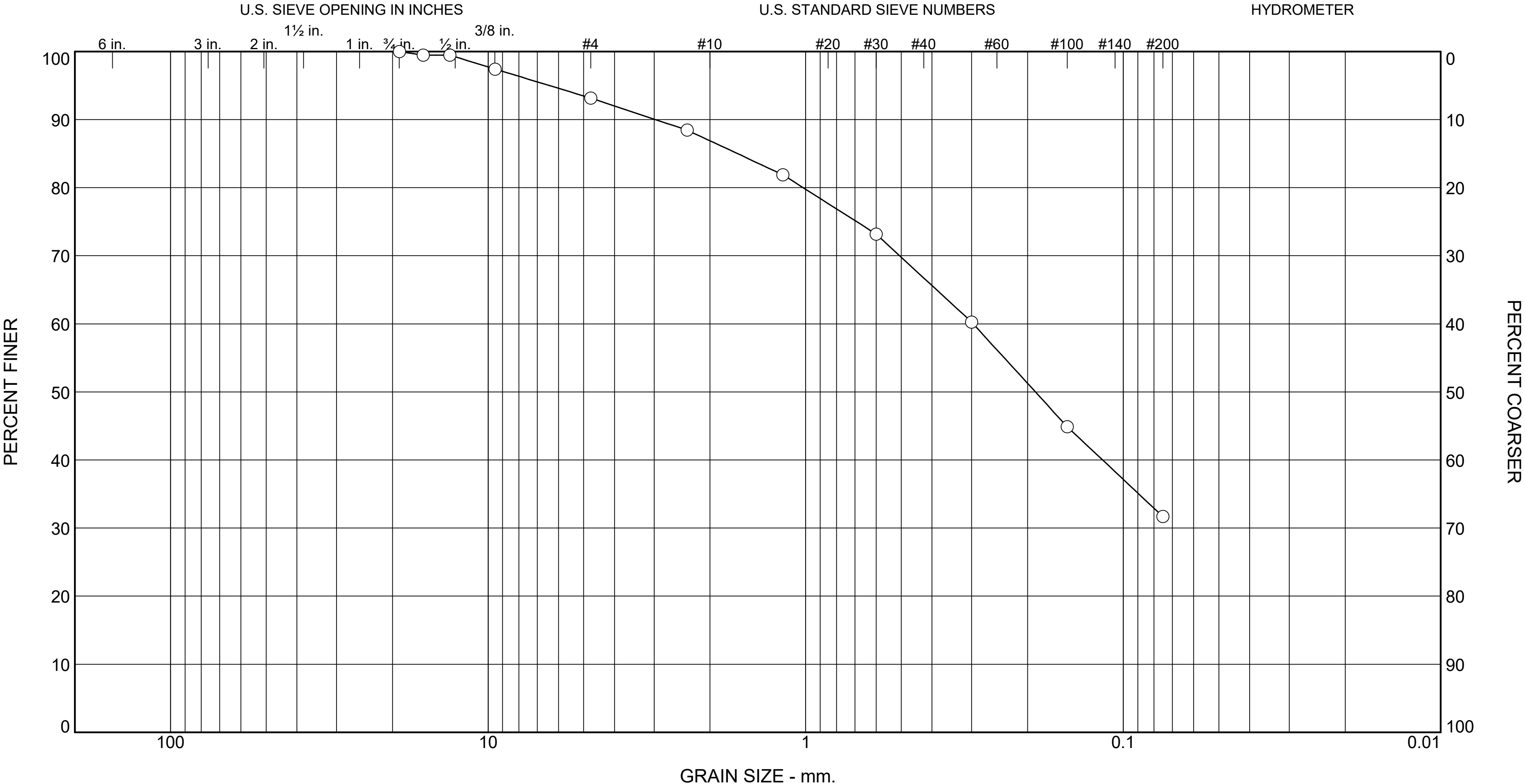
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	5.8	32.1	37.9	8.0	20.5	21.4	49.9			12.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
		0.0977	0.1562	0.3304	0.6715	1.4468	3.7020	11.9547	13.9082	15.3472	19.9667

Fineness Modulus
3.79

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt
○	0.0	0.0	6.8	6.3	20.2	35.0	31.7

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-09 Depth: 2.3m - 2.9m Sample Number: SS4	Nov 1, 2023		Nov 24, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 Figure

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: S. Campbell **Checked By:** T. Linley

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-28

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-09
Depth: 2.3m - 2.9m **Sample Number:** SS4
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 24, 2023
Tested by: S. Campbell **Checked by:** T. Linley

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
1508.80	349.60	19mm	0.00	0.00	100.0	0.0
		16mm	6.30	0.00	99.5	0.5
		13.2mm	0.00	0.00	99.5	0.5
		9.5mm	23.80	0.00	97.4	2.6
		#4	49.20	0.00	93.2	6.8
		#8	54.70	0.00	88.4	11.6
		#16	75.90	0.00	81.9	18.1
		#30	101.00	0.00	73.2	26.8
		#50	150.00	0.00	60.2	39.8
		#100	178.20	0.00	44.9	55.1
		#200	152.80	0.00	31.7	68.3

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	6.8	6.8	6.3	20.2	35.0	61.5			31.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
					0.1161	0.1891	0.2968	1.0188	1.6396	2.9739	6.4160

Fineness Modulus
1.61

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821

DATE SAMPLED: 2023-11-01

PROJECT: Blind River Water Intake

SOURCE: Boreholes

DATE TESTED: 2023-11-20

TESTED BY: J.Draper

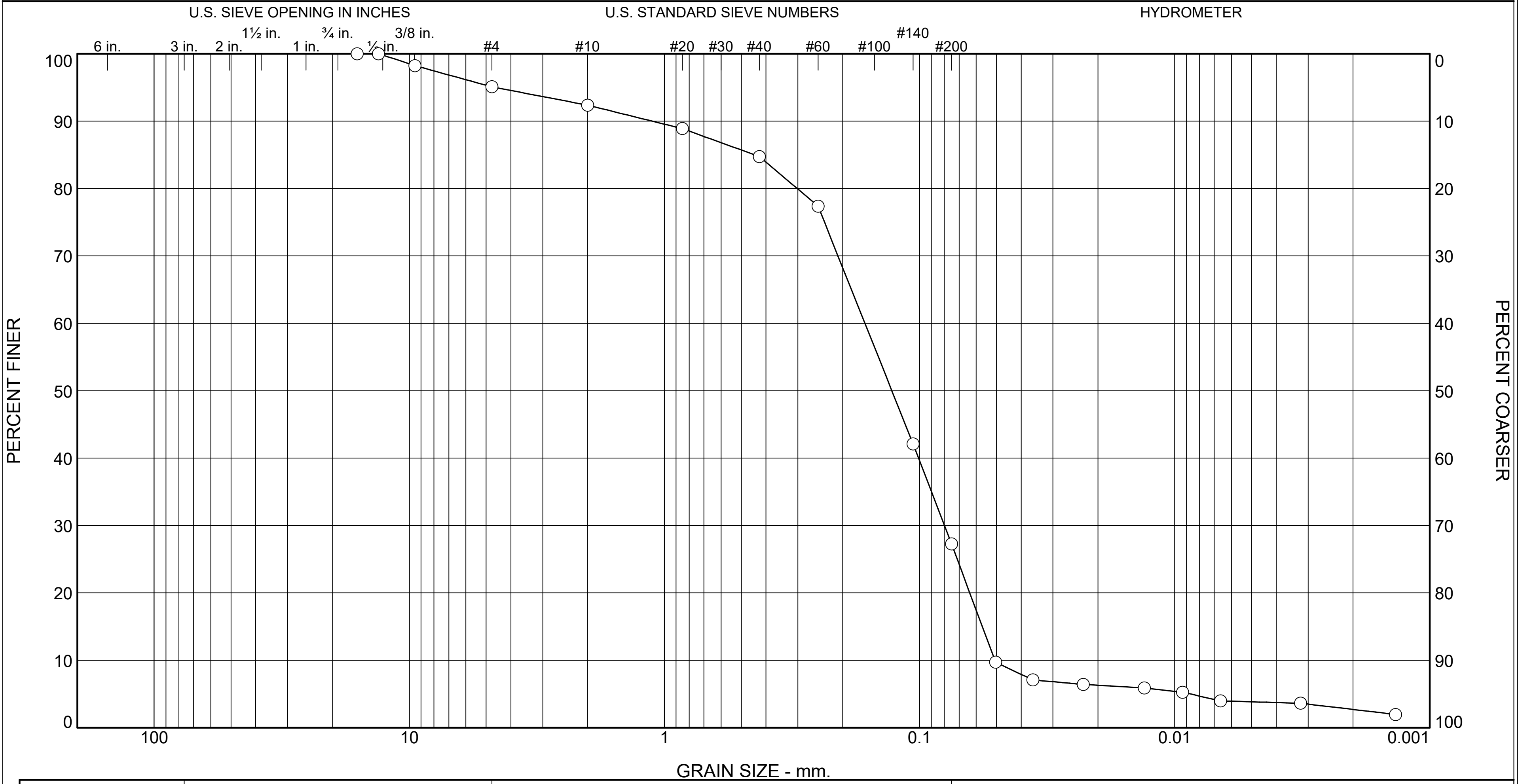
Tare ID	Sample ID	Depth (m)	Gross (inc. Tare) (g) Wet Weight	Dry Weight	TARE	Mass Lost	Water %
	BH23-10-SS01	0.2 to 0.8	1337.19	1259.02	375.09	78.17	8.8%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	4.9	2.7	7.7	57.4	24.6	2.7

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-10 Depth: 0.2m - 0.8m Sample Number: SS1	Nov 1, 2023		Nov 28, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 **Figure**

TULLOCH
ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: T. Linley **Checked By:** D. Stadnisky

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-29

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-10
Depth: 0.2m - 0.8m **Sample Number:** SS1
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 28, 2023
Tested by: T. Linley **Checked by:** D. Stadnisky

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
1259.00	375.10	16mm	0.00	0.00	100.0	0.0
		13.2mm	0.00	0.00	100.0	0.0
		9.5mm.	15.70	0.00	98.2	1.8
		#4	27.70	0.00	95.1	4.9
		#10	24.10	0.00	92.4	7.6
69.10	0.00	#20	2.60	0.00	88.9	11.1
		#40	3.10	0.00	84.7	15.3
		#60	5.50	0.00	77.4	22.6
		#140	26.40	0.00	42.1	57.9
		#200	11.10	0.00	27.3	72.7

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 92.4
Weight of hydrometer sample =69.1
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -4
Meniscus correction only = -1.0
Specific gravity of solids = 2.70
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - .164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.8	11.0	7.4	0.0131	10.0	14.7	0.0503	9.7	90.3
2.00	21.8	9.0	5.4	0.0131	8.0	15.0	0.0360	7.1	92.9
5.00	21.8	8.5	4.9	0.0131	7.5	15.1	0.0228	6.4	93.6
15.00	22.2	8.0	4.5	0.0131	7.0	15.1	0.0131	5.9	94.1
30.00	22.3	7.5	4.0	0.0131	6.5	15.2	0.0093	5.3	94.7
60.00	22.4	6.5	3.0	0.0131	5.5	15.4	0.0066	4.0	96.0
250.00	23.3	6.0	2.7	0.0129	5.0	15.5	0.0032	3.6	96.4
1440.00	22.3	5.0	1.5	0.0131	4.0	15.6	0.0014	2.0	98.0

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	4.9	4.9	2.7	7.7	57.4	67.8	24.6	2.7	27.3

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0087	0.0506	0.0567	0.0636	0.0799	0.1009	0.1284	0.1638	0.3018	0.4436	1.1177	4.6164

Fineness Modulus	C_u	C_c
1.00	3.23	0.77

TULLOCH ENGINEERING

CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

WATER CONTENT TEST

TEST METHOD: LS 701 / ASTM C 566 / D 2216

CONTRACT NO: 23-0821
DATE SAMPLED: 2023-11-01

PROJECT: Blind River Water Intake
SOURCE: Boreholes

DATE TESTED: 2023-11-20
TESTED BY: J.Draper

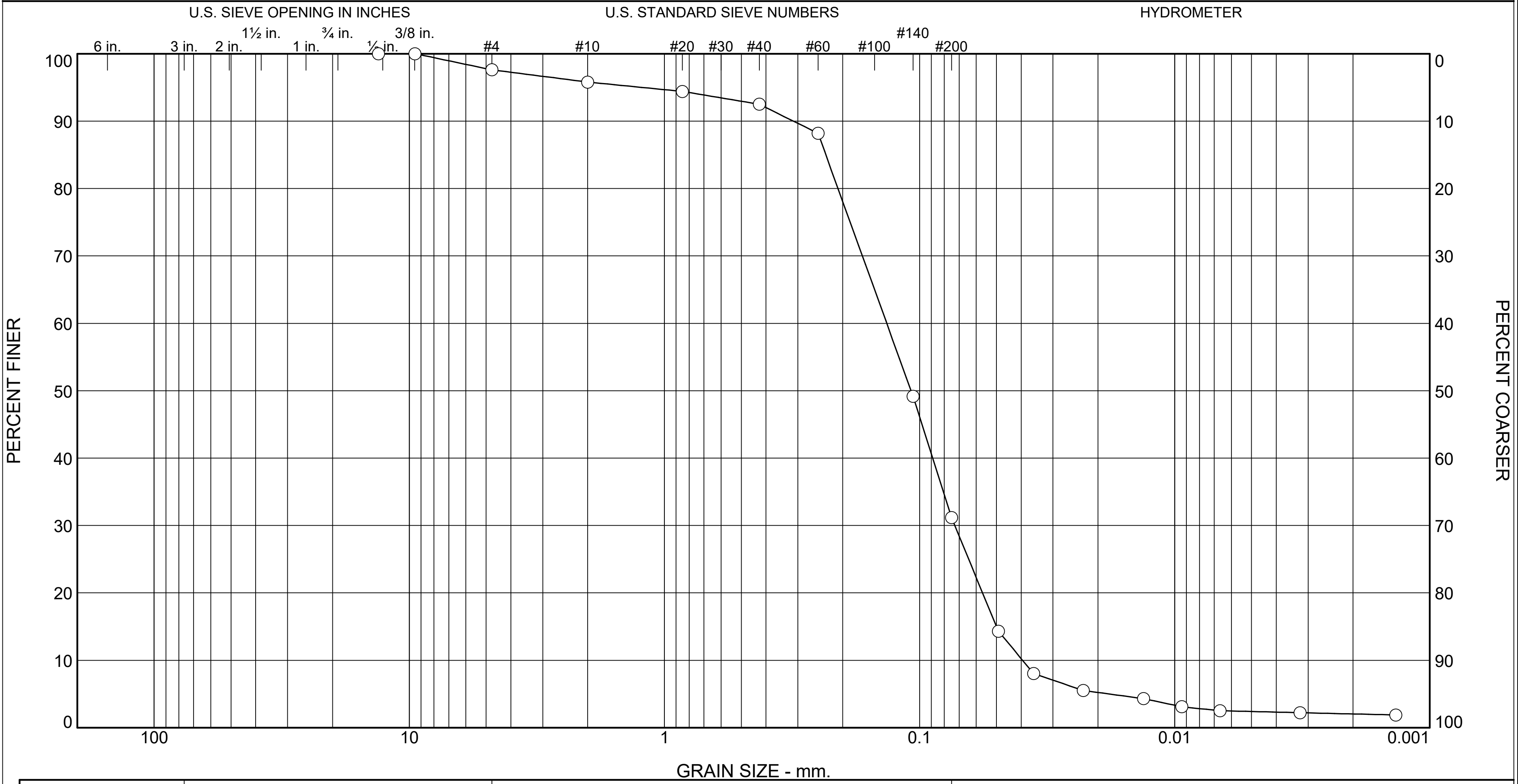
			Gross (inc. Tare) (g)				
Tare ID	Sample ID	Depth (m)	Wet Weight	Dry Weight	TARE	Mass Lost	Water %
	BH23-12-SS02	0.8 to 1.4	844.34	804.13	230.85	40.21	7.0%
	BH23-12-SS04	2.3 to 2.9	1138.69	1005.07	255.92	133.62	17.8%
	BH23-12-SS06	4.6 to 5.2	97.48	83.44	13.67	14.04	20.1%

REMARKS:

CLIENT: Town of Blind River

COPIES TO:

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.4	1.8	3.3	61.3	29.2	2.0

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-12 Depth: 0.8m - 1.4m Sample Number: SS2	Nov 1, 2023		Nov 28, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 **Figure**

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: T. Linley **Checked By:** D. Stadnisky

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-29

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-12
Depth: 0.8m - 1.4m **Sample Number:** SS2
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 28, 2023
Tested by: T. Linley **Checked by:** D. Stadnisky

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
804.10	230.90	13.2mm	0.00	0.00	100.0	0.0
		9.5mm.	0.00	0.00	100.0	0.0
		#4	13.70	0.00	97.6	2.4
		#10	10.40	0.00	95.8	4.2
75.60	0.00	#20	1.10	0.00	94.4	5.6
		#40	1.50	0.00	92.5	7.5
		#60	3.40	0.00	88.2	11.8
		#140	30.80	0.00	49.2	50.8
		#200	14.20	0.00	31.2	68.8

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 95.8
Weight of hydrometer sample =75.6
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -4
Meniscus correction only = -1.0
Specific gravity of solids = 2.70
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - .164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	22.0	15.0	11.4	0.0131	14.0	14.0	0.0491	14.3	85.7
2.00	22.0	10.0	6.4	0.0131	9.0	14.8	0.0357	8.0	92.0
5.00	22.0	8.0	4.4	0.0131	7.0	15.1	0.0228	5.5	94.5
15.00	22.1	7.0	3.4	0.0131	6.0	15.3	0.0132	4.3	95.7
30.00	22.3	6.0	2.5	0.0131	5.0	15.5	0.0094	3.1	96.9
60.00	22.4	5.5	2.0	0.0131	4.5	15.6	0.0066	2.5	97.5
250.00	23.4	5.0	1.8	0.0129	4.0	15.6	0.0032	2.2	97.8
1440.00	22.4	5.0	1.5	0.0131	4.0	15.6	0.0014	1.9	98.1

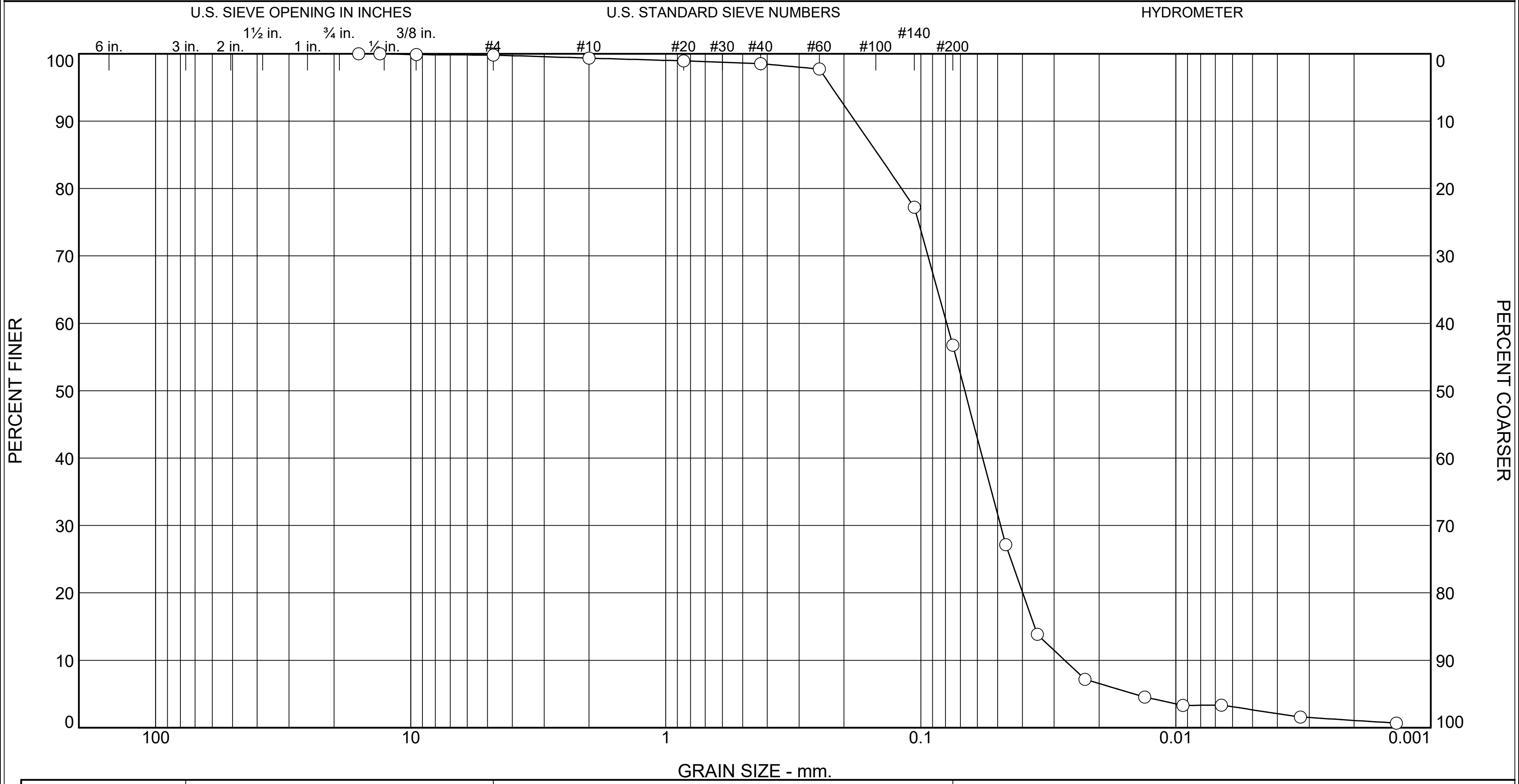
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	2.4	2.4	1.8	3.3	61.3	66.4	29.2	2.0	31.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0181	0.0395	0.0500	0.0566	0.0728	0.0889	0.1080	0.1345	0.2088	0.2331	0.3123	1.2273

Fineness Modulus	C_u	C_c
0.63	3.41	1.00

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.2	0.5	0.8	41.8	55.6	1.1

Identification	Date Sampled	Date Received	Date Tested
Source of Sample: BH-23-12 Depth: 2.3m - 2.9m Sample Number: SS4	Nov 1, 2023		Nov 28, 2023

Client Town of Blind River

Project Blind River Water Intake

Project No. 23-0821 **Figure**

TULLOCH ENGINEERING

71 Black Road
Unit 8
Sault Ste. Marie, ON
P6B 0A3

T. 705 949.1457
F. 705 949.9606
TF. 866 806.6602
Daren.Stadnisky@TULLOCH.ca

Tested By: T. Linley **Checked By:** D. Stadnisky

GRAIN SIZE DISTRIBUTION TEST DATA

2023-11-29

Client: Town of Blind River
Project: Blind River Water Intake
Project Number: 23-0821
Location: BH-23-12
Depth: 2.3m - 2.9m **Sample Number:** SS4
Date Sampled: Nov 1, 2023 **Date Tested:** Nov 28, 2023
Tested by: T. Linley **Checked by:** D. Stadnisky

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Percent Retained
1005.10	255.90	16mm	0.00	0.00	100.0	0.0
		13.2mm	0.00	0.00	100.0	0.0
		9.5mm.	1.00	0.00	99.9	0.1
		#4	0.50	0.00	99.8	0.2
		#10	3.40	0.00	99.3	0.7
73.70	0.00	#20	0.30	0.00	98.9	1.1
		#40	0.30	0.00	98.5	1.5
		#60	0.60	0.00	97.7	2.3
		#140	15.20	0.00	77.2	22.8
		#200	15.20	0.00	56.7	43.3

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 99.3
Weight of hydrometer sample =73.7
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -4
Meniscus correction only = -1.0
Specific gravity of solids = 2.70
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 **-** .164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.9	24.0	20.4	0.0131	23.0	12.5	0.0465	27.2	72.8
2.00	21.9	14.0	10.4	0.0131	13.0	14.2	0.0349	13.8	86.2
5.00	21.9	9.0	5.4	0.0131	8.0	15.0	0.0227	7.2	92.8
15.00	22.0	7.0	3.4	0.0131	6.0	15.3	0.0133	4.5	95.5
30.00	22.3	6.0	2.5	0.0131	5.0	15.5	0.0094	3.3	96.7
60.00	22.4	6.0	2.5	0.0131	5.0	15.5	0.0066	3.3	96.7
250.00	23.1	4.5	1.2	0.0129	3.5	15.7	0.0032	1.6	98.4
1440.00	22.4	4.0	0.5	0.0131	3.0	15.8	0.0014	0.7	99.3

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.2	0.2	0.5	0.8	41.8	43.1	55.6	1.1	56.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0146	0.0273	0.0358	0.0399	0.0486	0.0572	0.0672	0.0792	0.1190	0.1467	0.1809	0.2230

Fineness Modulus	C_u	C_c
0.20	2.91	1.10

TULLOCH ENGINEERING

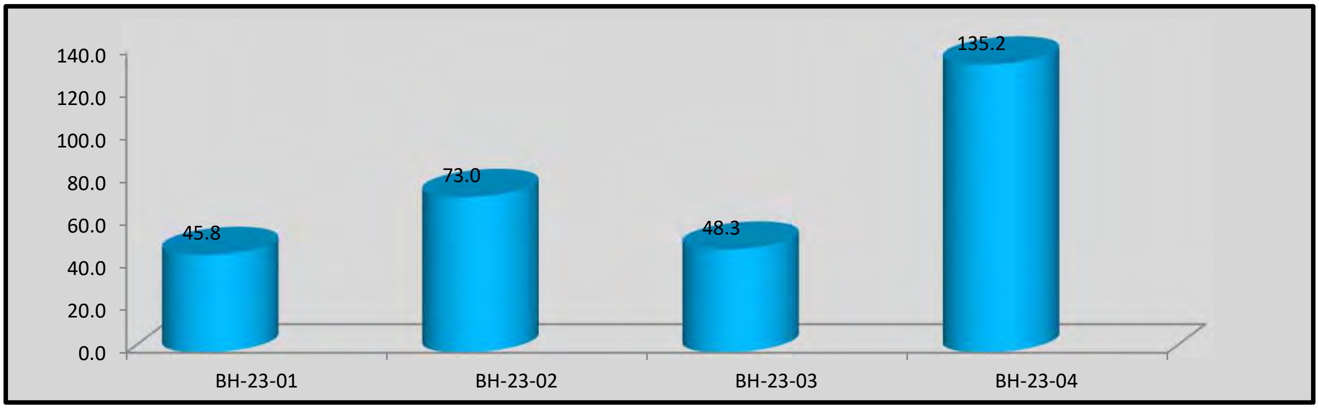
CSA A283 Certified Laboratory for Concrete Testing
CCIL Certified Laboratory for Aggregates and Asphalt Testing
CSA/CCIL Certified Technicians

Canadian Council of Independent Laboratories
Conseil canadien des laboratoires indépendants

Rock Core Compressive Strength Report

PROJECT: Blind River Water Intake
CONTRACT: 23-0821
DATE SAMPLED: Oct 30-31/23
RUN BY: J.Draper
DATE TESTED: Nov 22/23
SOURCE: Boreholes

Sample Location	Run #	Distance from top of run (cm)	Height (mm)	Diameter (mm)	L/D Ratio	Correction Factor	Peak Load (lbs)	Compressive Stength (Mpa)
BH-23-01	7	40	94.76	47.38	2	1.000	18140	45.8
BH-23-02	5	24	94.66	47.33	2	1.000	28860	73.0
BH-23-03	7	94	94.70	47.35	2	1.000	19110	48.3
BH-23-04	5	53	94.72	47.36	2	1.000	53530	135.2



TESTMARK Laboratories Ltd.
Committed to Quality and Service

CERTIFICATE OF ANALYSIS

Client:	Laura Meneghetti	Work Order Number:	520089
Company:	Tulloch Engineering - Sault Ste. Marie	PO #:	
Address:	71 Black Road Unit 8 Sault Ste. Marie, ON, P6B 0A3	Regulation:	Information not provided
		Project #:	23-0821
Phone/Fax:	(705) 949-1457 / (705) 949-9606	DWS #:	
Email:	Laura.Meneghetti@tulloch.ca	Sampled By:	Laura Meneghetti
Date Order Received:	11/24/2023	Analysis Started:	11/25/2023
Arrival Temperature:	8 C	Analysis Completed:	12/1/2023

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
BH-23-06 SS04	1955638	Soil	None		11/1/2023	
BH-23-12 SS03	1955639	Soil	None		11/1/2023	

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Anions Soil (A5)	Garson	Determination of Anions in Soil	Modified from SW846-9056A
Cond Soil (R12)	Garson	Determination of conductivity in soil (1:2)	Modified from EPA SW846-9050A
Moisture (A99)	Garson	Determination of Percent Moisture	In-House
pH Soil (A2.0)	Garson	Determination of soil pH by Ion Selective Electrode	Modified from EPA SW-846 9045D
RedOx - Soil (T06)	Mississauga	Determination of RedOx Potential of Soil	Modified from APHA-2580B
Resistivity Soil (R12)	Garson	Determination of Resistivity in Soil (1:2)	Modified from Carter 18.3
Sulphide/S (R98)	Garson	Determination of Sulphide in Soil	In-House

REPORT COMMENTS

RedOx - Soil (A6): Hold time exceeded for methods BEFORE receipt date/time.

CERTIFICATE OF ANALYSIS

Tulloch Engineering - Sault Ste. Marie

Work Order Number: 520089

This report has been approved by:

Brad Halvorson, B.Sc.
Laboratory Director

CERTIFICATE OF ANALYSIS

Tulloch Engineering - Sault Ste. Marie

Work Order Number: 520089

WORK ORDER RESULTS

Sample Description	BH - 23 - 06 SS04		BH - 23 - 12 SS03		
Sample Date	11/1/2023 12:00 AM		11/1/2023 12:00 AM		
Lab ID	1955638		1955639		
Anions (Soil)	**Result**	**MDL**	**Result**	**MDL**	**Units**
Bromide	<0.2	0.2	<0.2	0.2	µg/g
Chloride	4.3	0.4	89.8	0.4	µg/g
Fluoride	0.38	0.02	0.09	0.02	µg/g
Nitrate (as N)	0.17	0.06	0.70	0.06	µg/g
Nitrite (as N)	<0.04	0.04	<0.04	0.04	µg/g
Sulphate	11.2	0.4	15.7	0.4	µg/g

Sample Description	BH - 23 - 06 SS04		BH - 23 - 12 SS03		
Sample Date	11/1/2023 12:00 AM		11/1/2023 12:00 AM		
Lab ID	1955638		1955639		
General Chemistry	**Result**	**MDL**	**Result**	**MDL**	**Units**
% Moisture	0.3	0.1	13.5	0.1	%
Conductivity	47	1	215	1	µS/cm
pH	6.48	N/A	6.26	N/A	pH
RedOx (vs. S.H.E.)	350 [350]	N/A	383	N/A	mV
Resistivity	21300	N/A	4650	N/A	ohm-cm
Sulphide	<0.2	0.2	<0.3	0.3	µg/g

CERTIFICATE OF ANALYSIS

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Organic Soil Analysis: Data reported for organic analysis in soils samples are corrected for moisture content.

Quality Control: All associated Quality Control data is available on request.

LCL: Lower Control Limit.

UCL: Upper Control Limit.

QAQCID: This is a unique reference to the quality control data set used to generate the reported value. Contact our lab for this information, as it is traceable through our LIMS.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

Reproduction of Report: Report shall not be reproduced, except in full, without the approval of Testmark Laboratories Ltd.

ICPMS Dustfall Insoluble: The ICPMS Dustfall Insoluble Portion method analyzes only the particulate matter from the Dustfall Sampler which is retained on the analysis filter during the Dustfall method.

Regulation Comparisons: Disclaimer: Please note that regulation criteria are provided for comparative purposes, however the onus on ensuring the validity of this comparison rests with the client.

CERTIFICATE OF ANALYSIS

QUALITY CONTROL DATA

THIS SECTION REPORTS QC RESULTS ASSOCIATED WITH THE TEST BATCH; THESE ARE NOT YOUR SAMPLE RESULTS.
QAQC details include only values where sufficient sample data allowed measurement.

Anions (Soil)

Blank: LRB-6 (Blank) (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Bromide	0.2	µg/g	0	<0.2	0.6	20231128.A5C
Chloride	0.4	µg/g	0	<0.4	1.2	20231128.A5C
Fluoride	0.02	µg/g	0	<0.02	0.6	20231128.A5C
Nitrate (as N)	0.2	µg/g	0	<0.2	0.6	20231128.A5C
Nitrite (as N)	0.1	µg/g	0	<0.1	0.18	20231128.A5C
Sulphate	0.4	µg/g	0	<0.4	6	20231128.A5C

Positive Control: LFB-5 (0.1/0.02/0.002 mg/g equiv) (5)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Bromide	N/A	%	80	115	120	20231128.A5C
Chloride	N/A	%	80	107	120	20231128.A5C
Fluoride	N/A	%	80	111	120	20231128.A5C
Nitrate (as N)	N/A	%	80	111	120	20231128.A5C
Nitrite (as N)	N/A	%	80	118	120	20231128.A5C
Sulphate	N/A	%	80	102	120	20231128.A5C

Positive Control: LFB-7 (0.2/0.1/0.02 mg/g equiv) (7)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Bromide	N/A	%	80	91.1	120	20231128.A5C
Chloride	N/A	%	80	102	120	20231128.A5C
Fluoride	N/A	%	80	99.9	120	20231128.A5C
Nitrate (as N)	N/A	%	80	101	120	20231128.A5C
Nitrite (as N)	N/A	%	80	86.6	120	20231128.A5C
Sulphate	N/A	%	80	98.1	120	20231128.A5C

CERTIFICATE OF ANALYSIS

Sample Replicate: % RPD (8)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Fluoride	N/A	%	0	14.3	35	20231128.A5C
Sulphate	N/A	%	0	4.5	35	20231128.A5C

General Chemistry

Calibration Check: Lab Control Sample (2)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Conductivity	N/A	%	475	519	525	20231127.TM-G.R12B

Method Blank: Method Blank (1)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Conductivity	1	µS/cm	0	<1	5	20231127.TM-G.R12B

Positive Control: LCS (pH 8) (2)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
pH	N/A	pH	7.8	7.93	8.2	20231127.TM-G.R2B

Positive Control: LFB-7 (7)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Sulphide	0.05	µg/g	0.24	0.288	0.36	20231201.R98B

Positive Control: LRB-6 (Blank) (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Sulphide	0.02	µg/g	0	<0.02	0.06	20231201.R98B

Positive Control: ORP Control 240 (7)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
RedOx (vs. S.H.E.)	N/A	mV	220	243	260	20231130.TM-M.A6B

Sample Replicate: % RPD (3)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
pH	N/A	pH	0	0.05	0.3	20231127.TM-G.R2B

CERTIFICATE OF ANALYSIS

Sample Replicate: % RPD (8)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Conductivity	N/A	%	0	12.3	10	20231127.TM-G.R12B

Sample Replicate: % RPD (9)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
RedOx (vs. S.H.E.)	N/A	%	0	0	10	20231130.TM-M.A6B

THIS INDEX SHOWS HOW YOUR SAMPLES ARE ASSOCIATED TO THE CONTROLS INCLUDED IN THE IDENTIFIED BATCHES.

Sample Description	Lab ID	Method	QAQCID	Prep QAQCID
BH - 23 - 06 SS04	1955638	Anions Soil (A5)	20231128.A5C	
BH - 23 - 06 SS04	1955638	Cond Soil (R12)	20231127.TM-G.R12B	
BH - 23 - 06 SS04	1955638	Moisture (A99)	20231125.TM-G.A99B	
BH - 23 - 06 SS04	1955638	pH Soil (A2.0)	20231127.TM-G.R2B	
BH - 23 - 06 SS04	1955638	RedOx - Soil (T06)	20231130.TM-M.A6B	
BH - 23 - 06 SS04	1955638	Resistivity Soil (R12)	20231129.TM-G.R12B	
BH - 23 - 06 SS04	1955638	Sulphide/S (R98)	20231201.R98B	
BH - 23 - 06 SS04	1955638r	RedOx - Soil (T06)	20231130.TM-M.A6B	
BH - 23 - 12 SS03	1955639	Anions Soil (A5)	20231128.A5C	
BH - 23 - 12 SS03	1955639	Cond Soil (R12)	20231127.TM-G.R12B	
BH - 23 - 12 SS03	1955639	Moisture (A99)	20231125.TM-G.A99B	
BH - 23 - 12 SS03	1955639	pH Soil (A2.0)	20231127.TM-G.R2B	
BH - 23 - 12 SS03	1955639	RedOx - Soil (T06)	20231130.TM-M.A6B	
BH - 23 - 12 SS03	1955639	Resistivity Soil (R12)	20231129.TM-G.R12B	
BH - 23 - 12 SS03	1955639	Sulphide/S (R98)	20231201.R98B	

APPENDIX G

NOTICE TO READER

NOTICE TO READER

This Report has been prepared by TULLOCH Engineering Inc. (‘TULLOCH’) for the sole and exclusive use of the Town of Blind River (the ‘Client’) to support the New Water Intake and Huron Street Reconstruction (the ‘Development’) in Blind River, Ontario (the ‘Site’). The Report shall not be used for any other purpose, or provided to, relied upon or used by any third party without the express written consent of TULLOCH.

A limited number of boreholes were advanced at the Site; and as such, the information collected and presented herein applies to the borehole locations only. The subsurface conditions between boreholes can change and accordingly any use of the data contained in this Report should take into consideration the nature of the materials and potential variation between test pit locations.

This Report contains opinions, conclusions and recommendations made by TULLOCH using professional judgment and reasonable care for the purpose of pavement design for the Development. Use of or reliance on this report by the Client is subject to the following conditions:

a) the report being read in the context of and subject to the terms of the Engineering Services Agreement for the Work, including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions specified or agreed therein;
b) the report being read in its entirety. TULLOCH is not responsible for the use of portions of the report without reference to the entire report;
c) the conditions of the site may change over time or may have already changed due to natural forces or human intervention, and TULLOCH takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report;
d) the classification of soils and rocks in this report is based on commonly accepted methods. However, the classification of geologic materials and the boundaries between subsurface layers involves judgement. Boundaries between different soils layers may also be transitional rather than abrupt. TULLOCH does not warrant or guarantee the exactness of these descriptions and boundaries.
e) the subsurface conditions must be verified by a qualified geotechnical engineer during construction to ensure that the borehole data presented herein is representative of the actual site conditions so that the design recommendations contained herein remain valid; and
f) the report is based on information made available to TULLOCH by the Client or by certain third parties; and unless stated otherwise in the Agreement, TULLOCH has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.

This report has been prepared with the degree of care, skill and diligence normally provided by engineers in the performance of comparable services for projects of similar nature. The scope of this report includes foundation engineering design only and it specifically excludes investigation, detection, prevention and assessment of the presence of subsurface contaminants. No conclusions or inferences should be drawn regarding contamination at the site including but not limited to molds, fungi, spores, bacteria, viruses, soil gases such as Radon, PCBs, petroleum hydrocarbons, inorganic and volatile organic compounds, polycyclic aromatic hydrocarbons and or any by products thereof.