



**THURBER ENGINEERING LTD.**

**FINAL  
FOUNDATION INVESTIGATION REPORT  
HIGHWAY 11/17 RETAINING WALL FROM STATION 114+375 TO 114+500  
TOWNSHIP OF LYON, ONTARIO  
AGREEMENT NO.: 6022-E-0038  
ASSIGNMENT NO.: 8**

**GEOCRES NO.: 52A16-001**

**Location:** Lat: 48.889105°, Long: -88.422068°

**Client Name:** Ministry of Transportation

**Date:** August 1, 2024

**File:** 53149



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**PART 1. FACTUAL INFORMATION**

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**1. INTRODUCTION**

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This section of the report presents the factual findings obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for a new retaining wall to be constructed along Highway 11/17 from approximate station 114+375 to 114+500 in the Township of Lyon within the District of Thunder Bay, Ontario. Thurber carried out the foundation investigation for the Ontario Ministry of Transportation (MTO) under Retainer Agreement No. 6022-E-0038, Assignment No. 8.

The purpose of the investigation was to explore the subsurface conditions at the site and based on the data obtained, provide a borehole location plan, record of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. The stratigraphic profile of the subsurface conditions was developed during the current investigation.

*It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.*

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**2. SITE DESCRIPTION**

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**2.1 General**

In the area of the proposed retaining wall, Highway 11/17 is currently a two-lane, undivided arterial highway with 3.75 m wide lanes and 2.5 to 3.0 m wide partially paved shoulders. The highway has a posted speed limit of 90 km/h. The 2023 traffic volume for this section of Highway 11/17 is understood to be 4036 with 29% commercial vehicles.

The existing highway through this section is to be shifted to the north while undergoing a grade raise of up to 1.2 m. A retaining wall is to be constructed along the south to facilitate the grade raise while maintaining the existing toe of the embankment slope due to the close proximity of an

environmentally sensitive creek (Valley Creek, Tributary D) that runs adjacent to the embankment.

The proposed retaining wall is understood to consist of a gabion wall with an approximate height of 2.5 m and an approximate length of 125 m from approximate station 114+375 to 114+500.

The existing highway embankment side slopes at the site did not show any visible signs of global instability at the time of the investigation. The embankment near the proposed retaining wall is sloped at approximately 2H:1V.

AutoCAD drawings provided by MTO indicate that the road surface ranges from approximate elevation 211.2 to 212.5 m within the retaining wall limits.

The site is in a rural setting and the area adjacent to the highway is undeveloped and densely vegetated with mixed forests of coniferous and some deciduous trees and shrubs. Overhead utility lines were present along the south side of the highway. A box culvert was present crossing underneath the highway just past the southern limits of the retaining wall.

Photographs of the project area are included in Appendix D. These photographs show the existing condition of the site at the time of the field investigation.

## **2.2 Site Geology**

According to Crins et al. 2009<sup>1</sup> the project area is described as Ecoregion 3W (Lake Nipigon Ecoregion) within the Ontario Shield Ecozone. According to Wester et al. 2018<sup>2</sup> the ecoregion is subdivided into Ecodistrict 3W-3 (Black Sturgeon Ecodistrict). The project area is located in the south part of the ecodistrict, which is characterized by Precambrian bedrock overlain with silts and clays and morainal deposits. Bedrock Geology Map (MRD126)<sup>3</sup> indicates the site is underlain by sandstone and shale of the Sibley Formation.

## **2.3 Existing Subsurface Information**

A historical foundation investigation report was not available for this site within the online Geocres Library.

Base plan mapping was provided by MTO for the preparation of this report.

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<sup>1</sup> <https://files.ontario.ca/mnrf-ecosystemspart1-accessible-july2018-en-2020-01-16.pdf>

<sup>2</sup> <https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf>

<sup>3</sup> <http://www.geologyontario.mndm.gov.on.ca/mines/data/google/mrd126/doc.kml>

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### 3. SITE INVESTIGATION AND FIELD TESTING

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The foundation investigation and field-testing program was carried out between June 3 and June 4, 2024, and consisted of three on-road boreholes identified as 24-01 to 24-03 drilled on the Highway 11/17 eastbound shoulder. The boreholes were advanced using a track-mounted CME 55 drill rig utilizing hollow stem augers. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

A summary of the borehole coordinates, elevations, and termination depths is provided in the table below. The borehole coordinates and elevations were reviewed and referenced to the survey data provided by MTO. The borehole coordinates and elevations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 14.

*Table 3-1 Borehole Summary*

Borehole	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth Below Ground Surface (m)
24-01	5,417,731.4	200,522.2	211.2	8.2
24-02	5,417,774.9	200,565.6	211.5	8.2
24-03	5,417,815.2	200,610.6	212.5	8.2

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's Oakville laboratory for further examination and testing.

Following completion of the field investigation, the boreholes were decommissioned in general in accordance with O. Reg. 903, as amended. All three boreholes were capped with cold patch asphalt to reinstate the pavement surface.

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### 4. LABORATORY TESTING

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Laboratory testing was selected in general accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Selected soil

samples were subjected to grain size distribution and Atterberg limits testing in accordance with MTO and ASTM standards. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B.

Three soil samples (one from each borehole) were selected and submitted for analytical testing of corrosivity parameters and sulphate content.

All laboratory test results from the field investigation are provided in Appendix C.

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## **5. DESCRIPTION OF SUBSURFACE CONDITIONS**

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Details of the encountered subsurface conditions are presented on the Record of Borehole sheets included in Appendix B and on the Borehole Locations and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond the borehole locations.

The subsurface conditions encountered in the boreholes generally consisted of embankment fill overlying sands and silts.

### **5.1 Asphalt**

Asphalt was encountered at the ground surface in all three boreholes. The asphalt was measured to have a thickness of 50 mm.

### **5.2 Fill**

#### **5.2.1 Gravelly Sand Fill**

A fill layer consisting of gravelly sand with occasional cobbles was encountered below the asphalt in Borehole 24-01 and below the sand fill in Borehole 24-02. The fill layer was 0.8 to 2.2 m thick (base elev. 209.0 to 208.5 m). SPT N-values in the gravelly sand fill ranged from 14 to 49 blows, indicating a compact to dense relative density.

Moisture contents ranging from 4 to 8% were recorded in the gravelly sand fill. The results of a gradation analysis completed on a sample of the gravelly sand fill are illustrated on Figure C1 of Appendix C. The results of the test are summarized in the table below and on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	31
Sand	60
Silt	9
Clay	

### 5.2.2 Sand Fill

A layer of sand fill was encountered below the asphalt in Borehole 24-02. The fill layer was 2.2 m thick (base elev. 209.3 m). SPT N-values in the sand fill ranged from 16 to 18 blows, indicating a compact relative density.

Moisture contents ranging from 9 to 15% were recorded in the sand fill. The results of a gradation analysis completed on a sample of the sand fill are illustrated on Figure C2 of Appendix C. The results of the test are summarized in the table below and on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	14
Sand	70
Silt	16
Clay	

### 5.2.3 Silty Sand Fill

A fill layer consisting of silty sand was encountered below the asphalt in Borehole 24-03. The fill layer was 3.0 m thick (base elev. 209.5 m). SPT N-values in the silty sand fill ranged from 12 to 26 blows, indicating a compact relative density.

Moisture contents ranging from 5 to 9% were recorded in the silty sand fill. The results of a gradation analysis completed on a sample of the silty sand fill are illustrated on Figure C3 of Appendix C. The results of the test are summarized in the table below and on the Record of Borehole sheets in Appendix B.



Soil Particle	Percentage (%)
Gravel	17
Sand	52
Silt	31
Clay	

### 5.3 Clayey Silt

A native layer of clayey silt was encountered below the fill in Borehole 24-02. The clayey silt layer had a thickness of 1.5 m and extended to a depth of 4.5 m (base elev. 207.0 m). SPT N-values in the clayey silt ranged from 8 to 22 blows, indicating a stiff to very stiff consistency.

A moisture content of 42% was recorded in the clayey silt.

### 5.4 Silt and Sand to Sand and Silt

A layer of silt and sand to sand and silt was encountered below the fill in Borehole 24-01 and below the clayey silt in Borehole 24-02. The thickness of the layer ranged from 1.9 to 3.4 m and extended to depths ranging from 5.6 to 6.4 m (base elev. 205.6 to 205.1 m). SPT N-values in the layer ranged from 5 to 16 blows, indicating a loose to compact relative density.

The recorded moisture contents ranged from 15 to 40%. The results of gradation analyses completed on two samples of the silt and sand to sand and silt are illustrated on Figure C4 of Appendix C. The results of the test are summarized in the table below and on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	47 to 54
Silt	43 to 48
Clay	3 to 4

### 5.5 Silt

A deposit of silt was encountered below the silt and sand in Borehole 24-01, below the sand and silt in Borehole 24-02 and below the fill in Borehole 24-03. The layer was noted to contain organics and wood chips in Borehole 24-03 at a depth of 4.9 m. The silt layer extended to the borehole

termination depth of 8.2 m in all three boreholes (base elev. 204.3 to 203.0 m). SPT N-values in the silt ranged from 4 to 22 blows, indicating a loose to compact relative density.

The recorded moisture contents in the silt typically ranged from 13 to 34%. A moisture content of 146% was recorded in Borehole 24-03 at a depth of 4.9 m where organics and wood chips were noted. The results of gradation analyses completed on four samples of the silt are illustrated on Figure C5 of Appendix C. The results of the tests are summarized in the table below and on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	3 to 14
Silt	79 to 96
Clay	1 to 8

Atterberg limits testing was completed on a sample of the silt. The results are illustrated on Figure C6 of Appendix C and summarized below and on the Record of Borehole sheets in Appendix B. The laboratory results indicate that the clayey silt exhibits low plastic behaviour (ML).

Parameter	Value (%)
Liquid Limit	19
Plastic Limit	18
Plasticity Index	1

## 5.6 Groundwater Level

The groundwater levels from the open boreholes were recorded upon completion of drilling and are summarized in the table below.

**Table 5-1 Groundwater Level Measurements**

Borehole	Groundwater Level		Date of Reading	Note
	Depth (m)	Elevation (m)		
24-01	4.0	207.2	June 3, 2024	Open Borehole
24-02	6.0	205.5	June 3, 2024	Open Borehole
24-03	3.8	208.7	June 4, 2024	Open Borehole

It should be noted that the above values are considered short-term readings and may not reflect the groundwater level at the time of construction. Seasonal fluctuations of the groundwater level

are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

## 5.7 Analytical Testing

Three soil samples were submitted for analytical testing of corrosivity parameters and sulphate content. The analytical results are included in Appendix C and are summarized in the table below.

**Table 5-2 Analytical Test Results**

Borehole	Sample	Sample Depth (m)	Conductivity (µS/cm)	pH	Resistivity (ohm-cm)	Chloride (mg/kg)	Sulphate (mg/kg)	Sulphide (mg/kg)
24-01	SS2	0.76 – 1.37	2570	7.87	390	1550	65	<0.21
24-02	SS3	1.52 – 2.13	3050	7.76	330	1920	68	<0.22
24-03	SS4	2.29 – 2.90	1520	7.89	660	789	50	<0.21

## 6. MISCELLANEOUS

The as-drilled borehole locations and ground surface elevations were estimated by Thurber following completion of the field program based on physical landmarks and site features. RPM Drilling of Thunder Bay, Ontario, supplied and operated the drill rig used to drill, test, sample, and decommission the boreholes. Traffic control was performed in accordance with Ontario Book 7 and was provided by Taranis Contracting Group Ltd. of Thunder Bay, Ontario. The field investigation was supervised on a full-time basis by Mr. Y. Kim, P.Eng. Overall supervision of the field investigation program was provided by Mr. M. Eastman, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Oakville, Ontario. Analytical testing was carried out by ALS Canada Ltd. in Waterloo, Ontario.



**THURBER** ENGINEERING LTD.

Interpretation of the factual data and preparation of this report was completed by Mr. M. Eastman, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.

Report Prepared By:



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Senior Geotechnical Engineer

## STATEMENT OF LIMITATIONS AND CONDITIONS

### 1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

### 2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

### 3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

### 4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

### 5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

### 6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

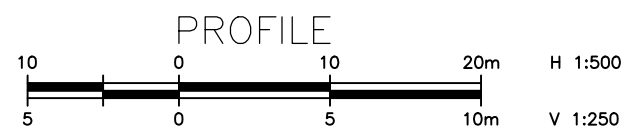
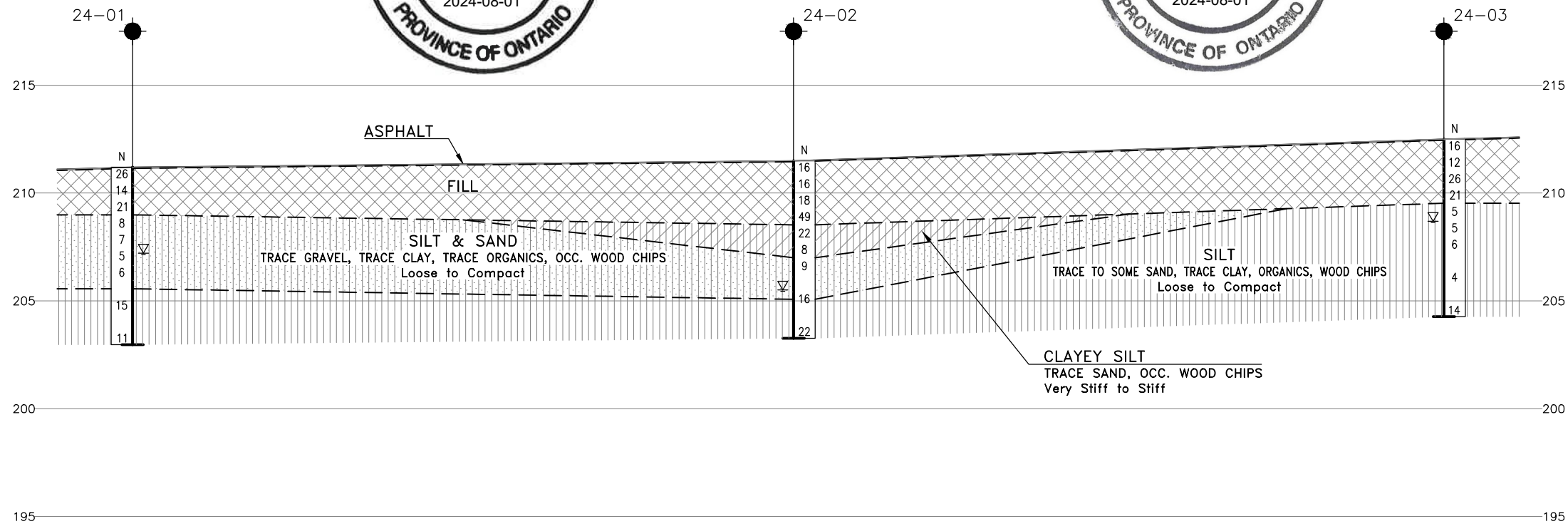
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

### 7. INDEPENDENT JUDGEMENTS OF CLIENT

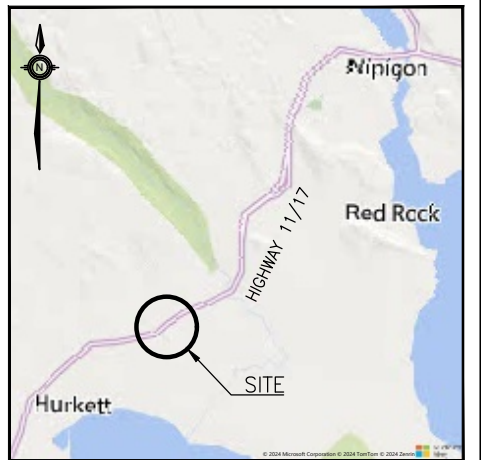
The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

## **APPENDIX A**






### Borehole Locations and Soil Strata Drawing



SHEET

[illegible]

### LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
24-01	211.2	5 417 731.4	200 522.2
24-02	211.5	5 417 774.9	200 565.6
24-03	212.5	5 417 815.2	200 610.6

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 14.

REVISIONS								
	DATE	BY	DESCRIPTION					
DESIGN	MKE	CHK	PKC	CODE	LOAD	DATE	JUN 2024	
DRAWN	MFA	CHK	MKE	SITE	STRUCT	DWG	1	

## **APPENDIX B**

### Record of Borehole Sheets



## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

### 2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

### 5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

RECORD OF BOREHOLE No 24-01

1 OF 1

METRIC

WP# 6022-E-0038 LOCATION ORIGINATED BY YK  
DIST Thunder Bay HWY 11/17 BOREHOLE TYPE CME 55 Track-Mount, HSA (203mm O.D.) COMPILED BY AN  
DATUM Geodetic DATE 2024.06.03 - 2024.06.03 LATITUDE 48.889131 LONGITUDE -88.422117 CHECKED BY MKE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						w <sub>p</sub> w      w <sub>L</sub>						
211.2	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (50mm)																			
	Gravelly SAND, trace silt		1	SS	26								○					31	60	
	Compact																	9	(SI+CL)	
	Brown																			
	Moist		2	SS	14								○							
	(FILL)																			
			3	SS	21								○							
209.0																				
2.2	SILT and SAND, trace gravel, trace clay																			
	Loose		4	SS	8								○							
	Brown to Grey																			
	Moist																			
			5	SS	7									○						
	Becoming wet		6	SS	5										○			1	47	
																	48	4		
			7	SS	6									○						
205.6																				
5.6	SILT, some sand, trace clay																			
	Compact																			
	Grey		8	SS	15								○							
	Wet													○						
			9	SS	11									○				0	14	
203.0																		79	7	
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN TO 7.3m AND WATER LEVEL AT 4.0m UPON COMPLETION OF DRILLING.																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 24-02

1 OF 1

METRIC

WP# 6022-E-0038 LOCATION ORIGINATED BY YK  
DIST Thunder Bay HWY 11/17 BOREHOLE TYPE CME 55 Track-Mount, HSA (203mm O.D.) COMPILED BY AN  
DATUM Geodetic DATE 2024.06.03 - 2024.06.03 LATITUDE 48.889529 LONGITUDE -88.421537 CHECKED BY MKE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE				WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>				
211.5	GROUND SURFACE							20	40	60	80	100				
0.0	ASPHALT: (50mm)															
	SAND, some gravel, some silt Compact Brown Moist (FILL)		1	SS	16		211						○			
			2	SS	16		210						○			14 70 16 (SI+CL)
			3	SS	18								○			
209.3																
2.2	Gravelly SAND, occasional cobbles Dense Brown Moist (FILL)		4	SS	49		209						○			
208.5																
3.0	Clayey SILT, trace sand, occasional wood chips Very Stiff to Stiff Grey Moist		5	SS	22		208							○		
			6	SS	8											
207.0							207									
4.5	SAND and SILT, trace clay, trace organics, occasional wood chips Loose to Compact Brownish Grey Moist		7	SS	9		206							○		0 54 43 3
205.1																
6.4	SILT, trace sand, trace clay Compact Grey Wet		8	SS	16		205						○			
							204									
			9	SS	22									●		0 7 88 5
203.3																
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN TO 7.0m AND WATER LEVEL AT 6.0m UPON COMPLETION OF DRILLING.															

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 24-03

1 OF 1

METRIC

WP# 6022-E-0038 LOCATION ORIGINATED BY YK  
DIST Thunder Bay HWY 11/17 BOREHOLE TYPE CME 55 Track-Mount, HSA (203mm O.D.) COMPILED BY AN  
DATUM Geodetic DATE 2024.06.04 - 2024.06.04 LATITUDE 48.889899 LONGITUDE -88.420934 CHECKED BY MKE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE							PLASTIC LIMIT w <sub>p</sub> NATURAL MOISTURE CONTENT w LIQUID LIMIT w <sub>L</sub> WATER CONTENT (%)			
212.5	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT: (50mm)																	
	Silty SAND, some gravel Compact Brown Moist (FILL)		1	SS	16		212							○				
			2	SS	12		211							○				17 52 31 (SI+CL)
			3	SS	26									○				
			4	SS	21		210							○				
209.5																		
3.0	SILT, trace to some sand, trace clay Loose to Compact Grey Moist to Wet		5	SS	5		209							○				
			6	SS	5		208							○				
	Organics, frequent wood chips		7	SS	6									○			148	0 3 96 1
			8	SS	4		206							○				
			9	SS	14		205							○				0 11 81 8
204.3																		
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN TO 4.6m AND WATER LEVEL AT 3.8m UPON COMPLETION OF DRILLING.																	

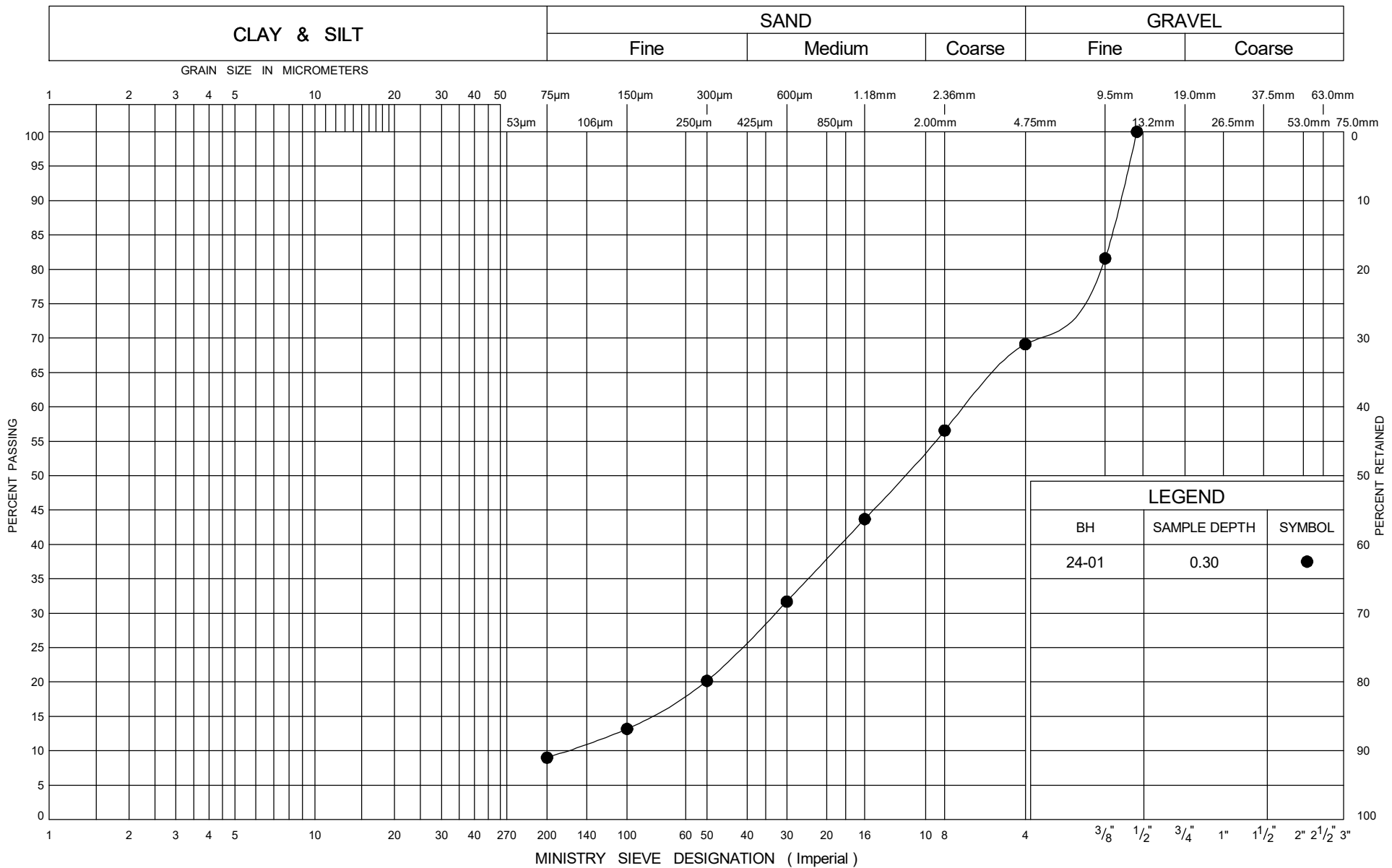
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## **APPENDIX C**

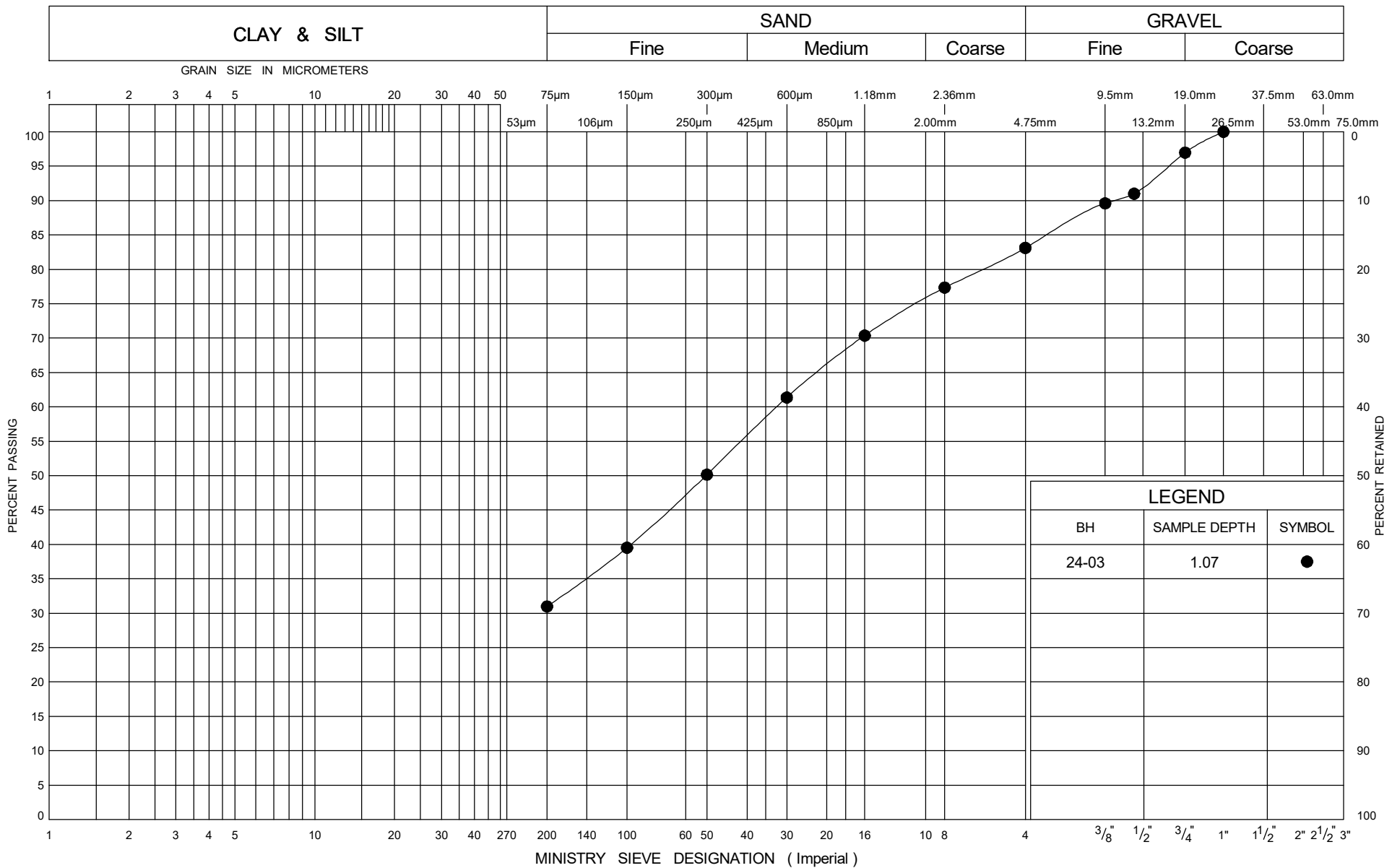
### Laboratory Test Results



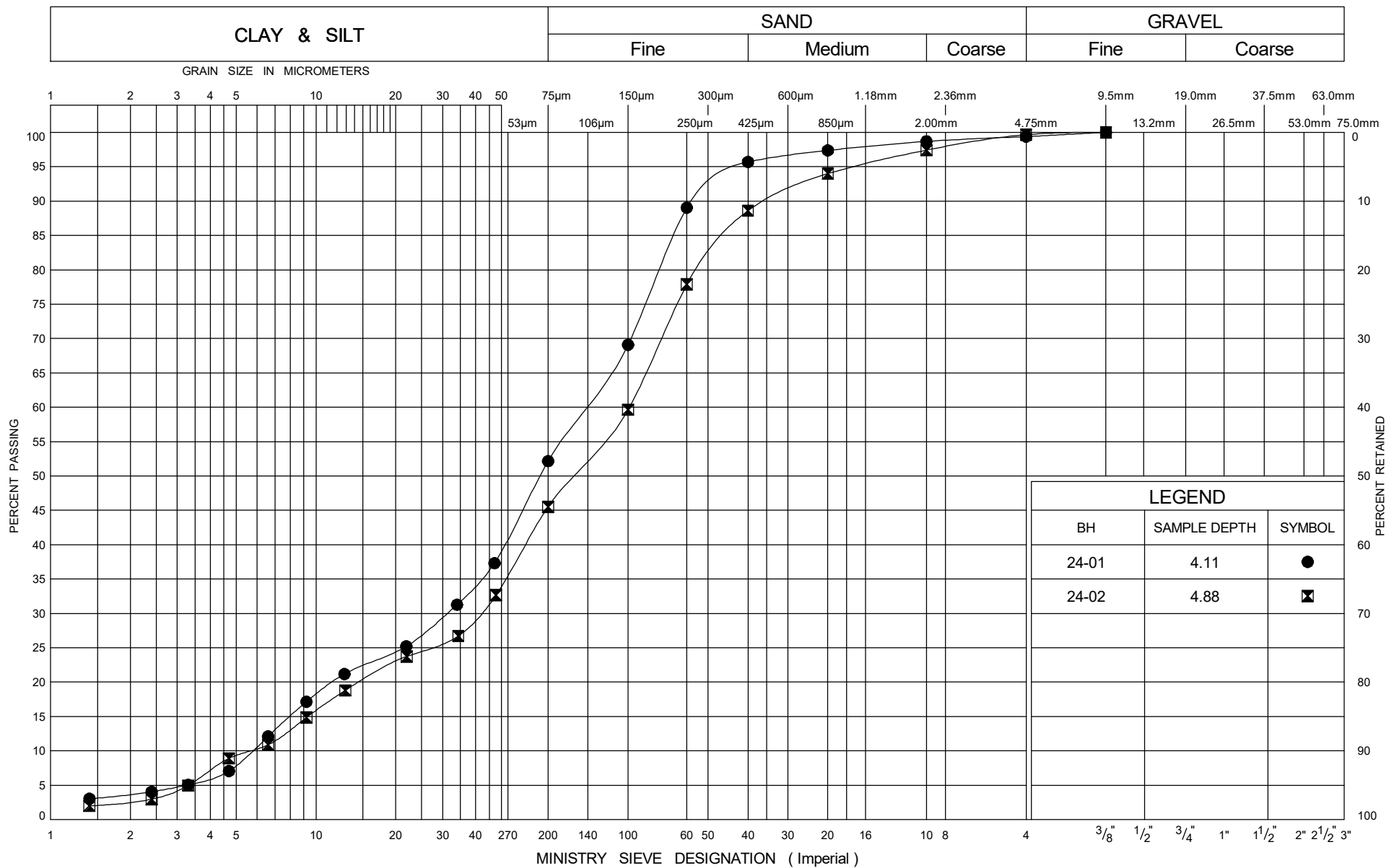


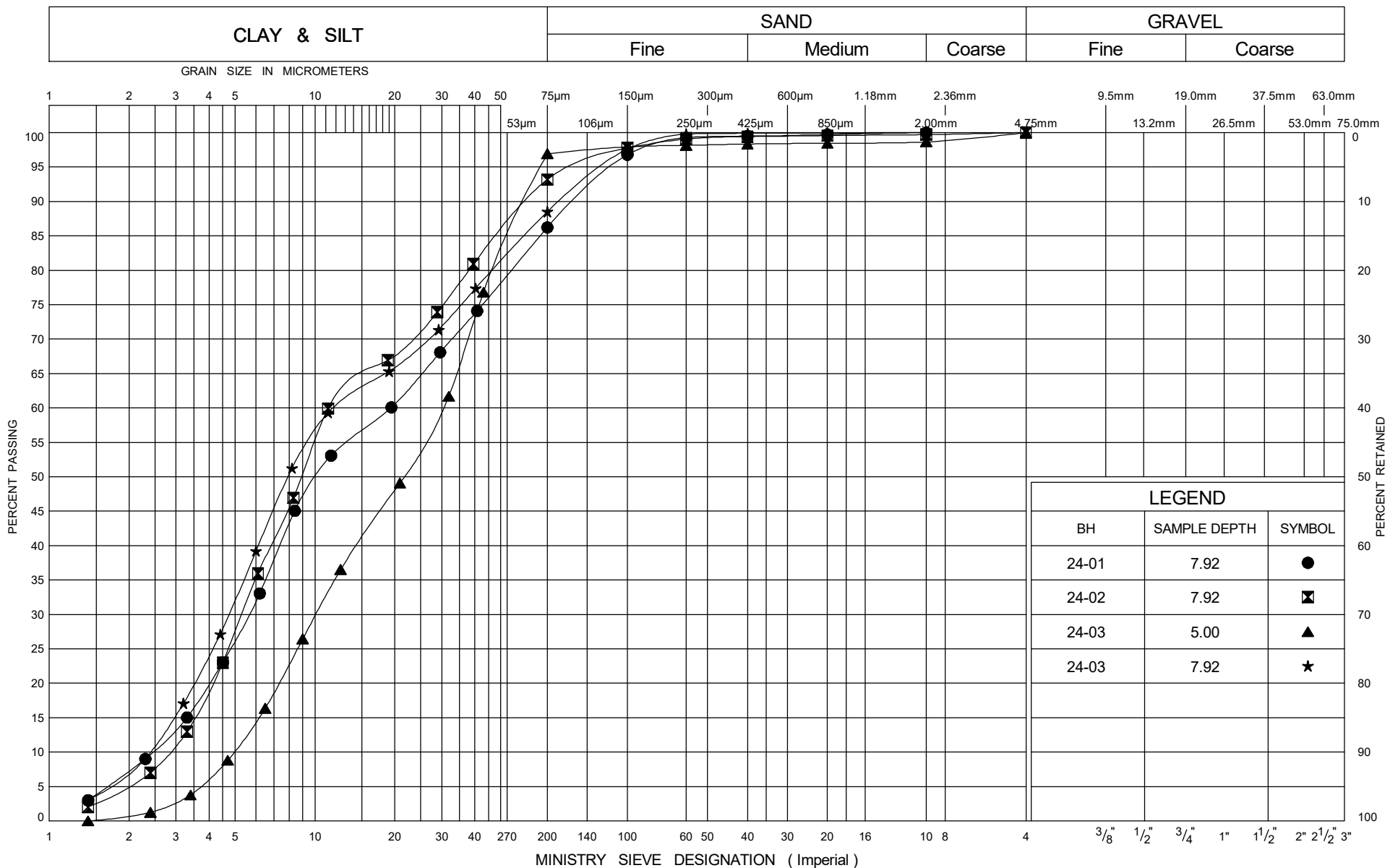
## FIG No C2

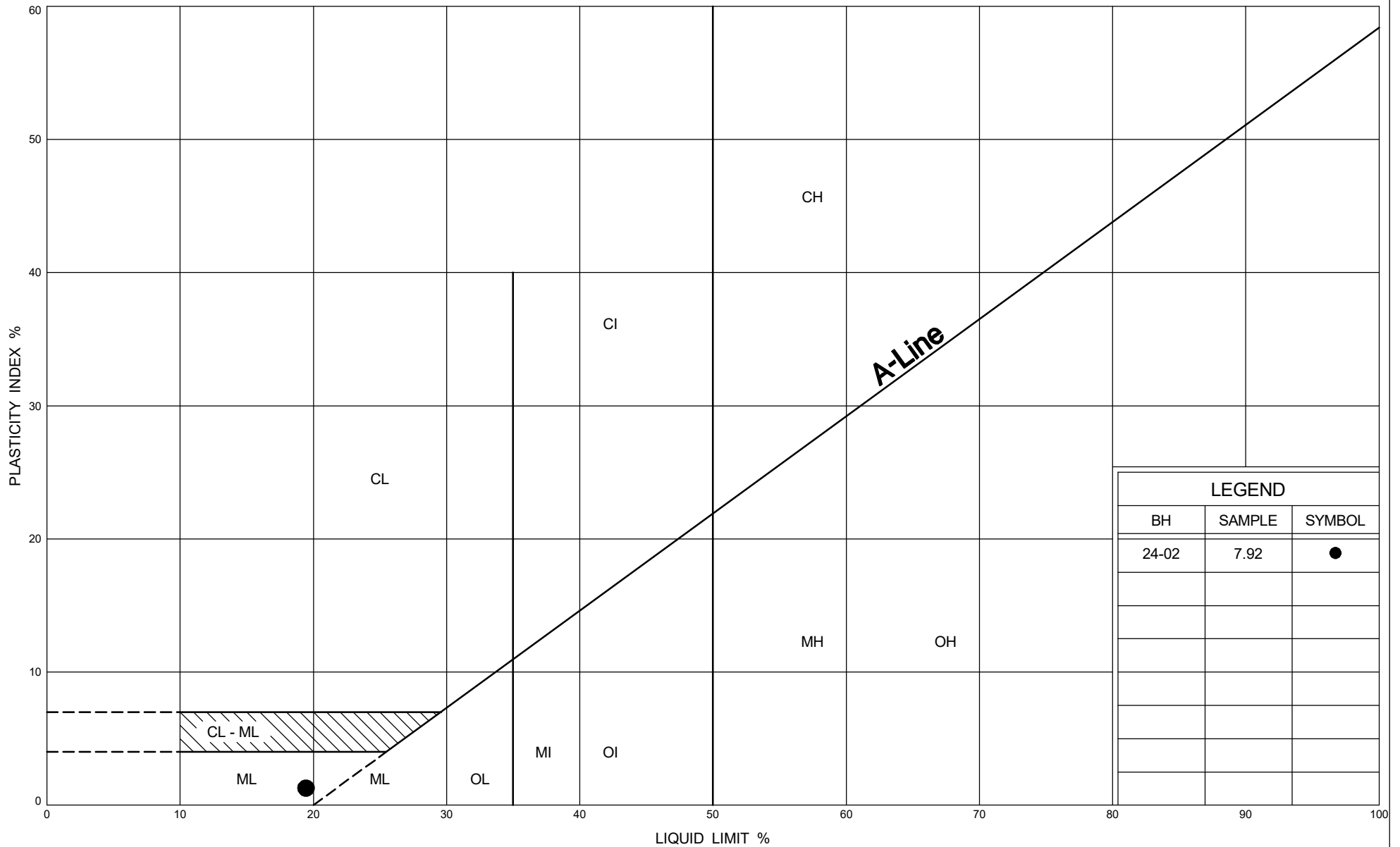
WP# 6022-E-0038











LEGEND		
BH	SAMPLE	SYMBOL
24-02	7.92	●

CERTIFICATE OF ANALYSIS

Work Order	: WT2415338	Page	: 1 of 3
Client	: Thurber Engineering Ltd.	Laboratory	: ALS Environmental - Waterloo
Contact	: Michael Eastman	Account Manager	: Amanda Overholster
Address	: 1908 Ironoak Way Suite 202 Oakville ON Canada L6H 0N1	Address	: 60 Northland Road, Unit 1 Waterloo ON Canada N2V 2B8
Telephone	: ----	Telephone	: 1 416 817 2944
Project	: HWY11/17 RSS WALL/53149	Date Samples Received	: 11-Jun-2024 08:45
PO	: ----	Date Analysis Commenced	: 11-Jun-2024
C-O-C number	: ----	Issue Date	: 18-Jun-2024 17:34
Sampler	: CLIENT		
Site	: ----		
Quote number	: 2024 SOA		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	Position	Laboratory Department
Greg Pokocky	Manager - Inorganics	Inorganics, Waterloo, Ontario
Jon Fisher	Production Manager, Environmental	Inorganics, Waterloo, Ontario
Josphin Masihi	Analyst	Centralized Prep, Waterloo, Ontario



## General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances  
LOR: Limit of Reporting (detection limit).

Unit	Description
%	percent
µS/cm	microsiemens per centimetre
mg/kg	milligrams per kilogram
mV	millivolts
ohm cm	ohm centimetres (resistivity)
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.



Analytical Results

Sub-Matrix: Soil/Solid (Matrix: Soil/Solid)					Client sample ID	Assignment#8/ Job#53149/BH 24-01/SS-2 (2'6"-4'6")	Assignment#8/ Job#53149/BH 24-02/SS-3 (5'-7')	Assignment#8/ Job#53149/BH 24-03/SS-4 (7'6"-9'6")	----	----
					Client sampling date / time	03-Jun-2024 11:50	03-Jun-2024 15:00	04-Jun-2024 10:20	----	----
Analyte	CAS Number	Method/Lab	LOR	Unit	WT2415338-001	WT2415338-002	WT2415338-003	-----	-----	
					Result	Result	Result	----	----	
Physical Tests										
Conductivity (1:2 leachate)	----	E100-L/WT	5.00	µS/cm	2570	3050	1520	----	----	
Moisture	----	E144/WT	0.25	%	6.04	11.4	7.36	----	----	
Oxidation-reduction potential [ORP]	----	E125/WT	0.10	mV	293	290	278	----	----	
pH (1:2 soil:CaCl2-aq)	----	E108A/WT	0.10	pH units	7.87	7.76	7.89	----	----	
Resistivity	----	EC100R/WT	100	ohm cm	390	330	660	----	----	
Inorganics										
Sulfides, acid volatile	----	E396-L/WT	0.20	mg/kg	<0.21	<0.22	<0.21	----	----	
Leachable Anions & Nutrients										
Chloride, soluble ion content	16887-00-6	E236.Cl/WT	5.0	mg/kg	1550	1920	789	----	----	
Sulfate, soluble ion content	14808-79-8	E236.SO4/WT	20	mg/kg	65	68	50	----	----	

Please refer to the General Comments section for an explanation of any result qualifiers detected.

Please refer to the Accreditation section for an explanation of analyte accreditations.

## QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: WT2415338	Page	: 1 of 8
Client	: Thurber Engineering Ltd.	Laboratory	: ALS Environmental - Waterloo
Contact	: Michael Eastman	Account Manager	: Amanda Overholster
Address	: 1908 Ironoak Way Suite 202 Oakville ON Canada L6H 0N1	Address	: 60 Northland Road, Unit 1 Waterloo, Ontario Canada N2V 2B8
Telephone	: ----	Telephone	: 1 416 817 2944
Project	: HWY11/17 RSS WALL/53149	Date Samples Received	: 11-Jun-2024 08:45
PO	: ----	Issue Date	: 18-Jun-2024 17:34
C-O-C number	: ----		
Sampler	: CLIENT		
Site	: ----		
Quote number	: 2024 SOA		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

### Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.

CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.

DQO: Data Quality Objective.

LOR: Limit of Reporting (detection limit).

RPD: Relative Percent Difference.

### Workorder Comments

Holding times are displayed as "----" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

### Summary of Outliers

#### Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Test sample Surrogate recovery outliers exist.

#### Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

#### Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

### ***Outliers : Frequency of Quality Control Samples***

- No Quality Control Sample Frequency Outliers occur.





## Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Soil/Solid**

Evaluation: ✖ = Holding time exceedance ; ✔ = Within Holding Time

Analyte Group : Analytical Method Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times		Eval	Analysis Date	Holding Times		Eval
				Rec	Actual			Rec	Actual	
Inorganics : Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-01/SS-2 (2'6"-4'6")	E396-L	03-Jun-2024	13-Jun-2024	14 days	10 days	✓	13-Jun-2024	7 days	0 days	✓
Inorganics : Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-02/SS-3 (5'-7')	E396-L	03-Jun-2024	13-Jun-2024	14 days	10 days	✓	13-Jun-2024	7 days	0 days	✓
Inorganics : Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-03/SS-4 (7'6"-9'6")	E396-L	04-Jun-2024	17-Jun-2024	14 days	13 days	✓	17-Jun-2024	7 days	0 days	✓
Leachable Anions & Nutrients : Water Extractable Chloride by IC										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-01/SS-2 (2'6"-4'6")	E236.Cl	03-Jun-2024	13-Jun-2024	30 days	10 days	✓	14-Jun-2024	28 days	1 days	✓
Leachable Anions & Nutrients : Water Extractable Chloride by IC										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-02/SS-3 (5'-7')	E236.Cl	03-Jun-2024	13-Jun-2024	30 days	10 days	✓	14-Jun-2024	28 days	1 days	✓
Leachable Anions & Nutrients : Water Extractable Chloride by IC										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-03/SS-4 (7'6"-9'6")	E236.Cl	04-Jun-2024	13-Jun-2024	30 days	9 days	✓	14-Jun-2024	28 days	1 days	✓
Leachable Anions & Nutrients : Water Extractable Sulfate by IC										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-01/SS-2 (2'6"-4'6")	E236.SO4	03-Jun-2024	13-Jun-2024	30 days	10 days	✓	14-Jun-2024	28 days	1 days	✓



Matrix: Soil/Solid

Evaluation: ✖ = Holding time exceedance ; ✔ = Within Holding Time

Analyte Group : Analytical Method Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times		Eval	Analysis Date	Holding Times		Eval
				Rec	Actual			Rec	Actual	
Leachable Anions & Nutrients : Water Extractable Sulfate by IC										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-02/SS-3 (5'-7')	E236.SO4	03-Jun-2024	13-Jun-2024	30 days	10 days	✓	14-Jun-2024	28 days	1 days	✓
Leachable Anions & Nutrients : Water Extractable Sulfate by IC										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-03/SS-4 (7'6"-9'6")	E236.SO4	04-Jun-2024	13-Jun-2024	30 days	9 days	✓	14-Jun-2024	28 days	1 days	✓
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-01/SS-2 (2'6"-4'6")	E100-L	03-Jun-2024	13-Jun-2024	30 days	10 days	✓	14-Jun-2024	30 days	11 days	✓
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-03/SS-4 (7'6"-9'6")	E100-L	04-Jun-2024	13-Jun-2024	30 days	9 days	✓	14-Jun-2024	30 days	10 days	✓
Physical Tests : Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-02/SS-3 (5'-7')	E100-L	03-Jun-2024	13-Jun-2024	30 days	9 days	✓	14-Jun-2024	30 days	11 days	✓
Physical Tests : Moisture Content by Gravimetry										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-01/SS-2 (2'6"-4'6")	E144	03-Jun-2024	----	----	----		13-Jun-2024	----	10 days	
Physical Tests : Moisture Content by Gravimetry										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-02/SS-3 (5'-7')	E144	03-Jun-2024	----	----	----		13-Jun-2024	----	9 days	
Physical Tests : Moisture Content by Gravimetry										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-03/SS-4 (7'6"-9'6")	E144	04-Jun-2024	----	----	----		13-Jun-2024	----	9 days	
Physical Tests : ORP by Electrode										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-03/SS-4 (7'6"-9'6")	E125	04-Jun-2024	11-Jun-2024	180 days	7 days	✓	18-Jun-2024	180 days	14 days	✓



Matrix: Soil/Solid

Evaluation: ✖ = Holding time exceedance ; ✔ = Within Holding Time

Analyte Group : Analytical Method Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times		Eval	Analysis Date	Holding Times		Eval
				Rec	Actual			Rec	Actual	
Physical Tests : ORP by Electrode										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-01/SS-2 (2'6"-4'6")	E125	03-Jun-2024	11-Jun-2024	180 days	8 days	✓	18-Jun-2024	180 days	15 days	✓
Physical Tests : ORP by Electrode										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-02/SS-3 (5'-7")	E125	03-Jun-2024	11-Jun-2024	180 days	8 days	✓	18-Jun-2024	180 days	15 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-01/SS-2 (2'6"-4'6")	E108A	03-Jun-2024	13-Jun-2024	30 days	10 days	✓	17-Jun-2024	30 days	14 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-02/SS-3 (5'-7")	E108A	03-Jun-2024	13-Jun-2024	30 days	10 days	✓	17-Jun-2024	30 days	14 days	✓
Physical Tests : pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received										
Glass soil jar/Teflon lined cap [ON MECP] Assignment#8/Job#53149/BH 24-03/SS-4 (7'6"-9'6")	E108A	04-Jun-2024	13-Jun-2024	30 days	9 days	✓	17-Jun-2024	30 days	13 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).



## Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Soil/Solid**

Evaluation: ✖ = QC frequency outside specification; ✔ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	Method	QC Lot #	QC	Regular	Actual	Expected	Evaluation
Laboratory Duplicates (DUP)							
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L	1498133	2	24	8.3	4.7	✓
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1487458	1	14	7.1	5.0	✓
Moisture Content by Gravimetry	E144	1490896	1	20	5.0	5.0	✓
ORP by Electrode	E125	1487387	1	8	12.5	5.0	✓
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A	1491105	1	20	5.0	5.0	✓
Water Extractable Chloride by IC	E236.Cl	1491995	1	13	7.6	5.0	✓
Water Extractable Sulfate by IC	E236.SO4	1491996	1	13	7.6	5.0	✓
Laboratory Control Samples (LCS)							
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L	1498133	2	24	8.3	4.7	✓
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1487458	2	14	14.2	10.0	✓
Moisture Content by Gravimetry	E144	1490896	1	20	5.0	5.0	✓
ORP by Electrode	E125	1487387	1	8	12.5	5.0	✓
pH by Meter (1:2 Soil:0.01M CaCl2 Extraction) - As Received	E108A	1491105	1	20	5.0	5.0	✓
Water Extractable Chloride by IC	E236.Cl	1491995	2	13	15.3	10.0	✓
Water Extractable Sulfate by IC	E236.SO4	1491996	2	13	15.3	10.0	✓
Method Blanks (MB)							
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L	1498133	2	24	8.3	4.7	✓
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L	1487458	1	14	7.1	5.0	✓
Moisture Content by Gravimetry	E144	1490896	1	20	5.0	5.0	✓
Water Extractable Chloride by IC	E236.Cl	1491995	1	13	7.6	5.0	✓
Water Extractable Sulfate by IC	E236.SO4	1491996	1	13	7.6	5.0	✓



## Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Soil (1:2 Soil:Water Extraction) (Low Level)	E100-L  ALS Environmental - Waterloo	Soil/Solid	CSSS Ch. 15 (mod)/APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a soil sample that has been added in a defined ratio of soil to deionized water, then shaken well and allowed to settle. Conductance is measured in the fluid that is observed in the upper layer.
pH by Meter (1:2 Soil:0.01M CaCl <sub>2</sub> Extraction) - As Received	E108A  ALS Environmental - Waterloo	Soil/Solid	MECP E3530	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C) and is carried out in accordance with procedures described in the Analytical Protocol (prescriptive method). A minimum 10g portion of the sample, as received, is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil by centrifuging, settling, or decanting and then analyzed using a pH meter and electrode.  This method is equivalent to ASTM D4972 and is acceptable for topsoil analysis.
ORP by Electrode	E125  ALS Environmental - Waterloo	Soil/Solid	APHA 2580 (mod)	Oxidation Reduction Potential (ORP) is reported as the oxidation-reduction potential of the platinum metal-reference electrode employed in the analysis, measured in mV.
Moisture Content by Gravimetry	E144  ALS Environmental - Waterloo	Soil/Solid	CCME PHC in Soil - Tier 1	Moisture is measured gravimetrically by drying the sample at 105°C. Moisture content is calculated as the weight loss (due to water) divided by the wet weight of the sample, expressed as a percentage.
Water Extractable Chloride by IC	E236.Cl  ALS Environmental - Waterloo	Soil/Solid	EPA 300.1	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection using a soil sample that has been added in a defined ratio of soil to deionized water, then shaken well and allowed to settle. Anions are measured in the fluid that is observed in the upper layer.
Water Extractable Sulfate by IC	E236.SO <sub>4</sub>  ALS Environmental - Waterloo	Soil/Solid	EPA 300.1	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection using a soil sample that has been added in a defined ratio of soil to deionized water, then shaken well and allowed to settle. Anions are measured in the fluid that is observed in the upper layer.
Acid Volatile Sulfide in Soil by Colourimetry (0.2 mg/kg)	E396-L  ALS Environmental - Waterloo	Soil/Solid	APHA 4500S2J	This analysis is carried out in accordance with the method described in APHA 4500 S2-J. After extraction the Acid Volatile Sulphide is determined colourimetrically.
Resistivity Calculation for Soil Using E100-L	EC100R  ALS Environmental - Waterloo	Soil/Solid	APHA 2510 B	Soil Resistivity (calculated) is determined as the inverse of the conductivity of a 2:1 water:soil leachate (dry weight). This method is intended as a rapid approximation for Soil Resistivity. Where high accuracy results are required, direct measurement of Soil Resistivity by the Wenner Four-Electrode Method (ASTM G57) is recommended.
Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions



Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Leach 1:2 Soil:Water for pH/EC	EP108  ALS Environmental - Waterloo	Soil/Solid	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL	The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water.
Leach 1:2 Soil : 0.01CaCl <sub>2</sub> - As Received for pH	EP108A  ALS Environmental - Waterloo	Soil/Solid	MOEE E3137A	A minimum 10g portion of the sample, as received, is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil by centrifuging, settling or decanting and then analyzed using a pH meter and electrode.
Preparation of ORP by Electrode	EP125  ALS Environmental - Waterloo	Soil/Solid	APHA 2580 (mod)	Field-moist sample is extracted in a 1:2 ratio with DI water and then analyzed by ORP meter.
Anions Leach 1:10 Soil:Water (Dry)	EP236  ALS Environmental - Waterloo	Soil/Solid	EPA 300.1	5 grams of dried soil is mixed with 50 grams of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.
Distillation for Acid Volatile Sulfide in Soil	EP396-L  ALS Environmental - Waterloo	Soil/Solid	APHA 4500S <sub>2</sub> J	Acid Volatile Sulfide is determined by colourimetric measurement on a sediment sample that has been treated with hydrochloric acid within a purge and trap system, where the evolved hydrogen sulfide gas is carried into a basic solution by argon gas for analysis.

QUALITY CONTROL REPORT

Work Order	: WT2415338	Page	: 1 of 6
Client	: Thurber Engineering Ltd.	Laboratory	: ALS Environmental - Waterloo
Contact	: Michael Eastman	Account Manager	: Amanda Overholster
Address	: 1908 Ironoak Way Suite 202 Oakville ON Canada L6H 0N1	Address	: 60 Northland Road, Unit 1 Waterloo, Ontario Canada N2V 2B8
Telephone	: ----	Telephone	: 1 416 817 2944
Project	: HWY11/17 RSS WALL/53149	Date Samples Received	: 11-Jun-2024 08:45
PO	: ----	Date Analysis Commenced	: 11-Jun-2024
C-O-C number	: ----	Issue Date	: 18-Jun-2024 17:34
Sampler	: CLIENT		
Site	: ----		
Quote number	: 2024 SOA		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percent Difference (RPD) and Data Quality Objectives
- Reference Material (RM) Report; Recovery and Data Quality Objectives
- Method Blank (MB) Report; Recovery and Data Quality Objectives
- Laboratory Control Sample (LCS) Report; Recovery and Data Quality Objectives

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	Position	Laboratory Department
Greg Pokocky	Manager - Inorganics	Waterloo Inorganics, Waterloo, Ontario
Jon Fisher	Production Manager, Environmental	Waterloo Inorganics, Waterloo, Ontario
Josphin Masihi	Analyst	Waterloo Centralized Prep, Waterloo, Ontario



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## General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

### Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.

CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.

DQO = Data Quality Objective.

LOR = Limit of Reporting (detection limit).

RPD = Relative Percent Difference

# = Indicates a QC result that did not meet the ALS DQO.

## Workorder Comments

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Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

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Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test-specific).

Sub-Matrix: Soil/Solid					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 1487387)											
WT2415338-001	Assignment#8/Job#53149/ BH 24-01/SS-2 (2'6"-4'6")	Oxidation-reduction potential [ORP]	----	E125	0.10	mV	293	292	0.342%	25%	----
Physical Tests (QC Lot: 1487458)											
WT2415183-002	Anonymous	Conductivity (1:2 leachate)	----	E100-L	5.00	µS/cm	0.158 mS/cm	157	0.697%	20%	----
Physical Tests (QC Lot: 1490896)											
EO2404553-001	Anonymous	Moisture	----	E144	0.25	%	15.8	15.5	2.02%	20%	----
Physical Tests (QC Lot: 1491105)											
WT2415338-001	Assignment#8/Job#53149/ BH 24-01/SS-2 (2'6"-4'6")	pH (1:2 soil:CaCl2-aq)	----	E108A	0.10	pH units	7.87	7.88	0.127%	5%	----
Inorganics (QC Lot: 1492609)											
WT2415338-001	Assignment#8/Job#53149/ BH 24-01/SS-2 (2'6"-4'6")	Sulfides, acid volatile	----	E396-L	0.21	mg/kg	<0.21	<0.21	0.001	Diff <2x LOR	----
Inorganics (QC Lot: 1498133)											
CG2407987-001	Anonymous	Sulfides, acid volatile	----	E396-L	0.25	mg/kg	<0.24	<0.25	0.24	Diff <2x LOR	----
Leachable Anions & Nutrients (QC Lot: 1491995)											
EO2404493-001	Anonymous	Chloride, soluble ion content	16887-00-6	E236.Cl	5.0	mg/kg	16.8	15.8	1.0	Diff <2x LOR	----
Leachable Anions & Nutrients (QC Lot: 1491996)											
EO2404493-001	Anonymous	Sulfate, soluble ion content	14808-79-8	E236.SO4	20	mg/kg	31	32	0.5	Diff <2x LOR	----



Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: Soil/Solid

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 1487458)						
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	<5.00	----
Physical Tests (QCLot: 1490896)						
Moisture	----	E144	0.25	%	<0.25	----
Inorganics (QCLot: 1492609)						
Sulfides, acid volatile	----	E396-L	0.2	mg/kg	<0.20	----
Inorganics (QCLot: 1498133)						
Sulfides, acid volatile	----	E396-L	0.2	mg/kg	<0.20	----
Leachable Anions & Nutrients (QCLot: 1491995)						
Chloride, soluble ion content	16887-00-6	E236.Cl	5	mg/kg	<5.0	----
Leachable Anions & Nutrients (QCLot: 1491996)						
Sulfate, soluble ion content	14808-79-8	E236.SO4	20	mg/kg	<20	----



Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: Soil/Solid

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Target Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 1487458)									
Conductivity (1:2 leachate)	----	E100-L	5	µS/cm	1410 µS/cm	95.4	90.0	110	----
Physical Tests (QCLot: 1490896)									
Moisture	----	E144	0.25	%	50 %	99.6	90.0	110	----
Physical Tests (QCLot: 1491105)									
pH (1:2 soil:CaCl2-aq)	----	E108A	----	pH units	7 pH units	101	98.0	102	----
Inorganics (QCLot: 1492609)									
Sulfides, acid volatile	----	E396-L	0.2	mg/kg	100 mg/kg	79.0	70.0	130	----
Inorganics (QCLot: 1498133)									
Sulfides, acid volatile	----	E396-L	0.2	mg/kg	100 mg/kg	76.0	70.0	130	----
Leachable Anions & Nutrients (QCLot: 1491995)									
Chloride, soluble ion content	16887-00-6	E236.Cl	5	mg/kg	1000 mg/kg	99.4	80.0	120	----
Leachable Anions & Nutrients (QCLot: 1491996)									
Sulfate, soluble ion content	14808-79-8	E236.SO4	20	mg/kg	1000 mg/kg	99.5	80.0	120	----

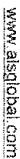
Reference Material (RM) Report

A Reference Material (RM) is a homogenous material with known and well-established analyte concentrations. RMs are processed in an identical manner to test samples, and are used to monitor and control the accuracy and precision of a test method for a typical sample matrix. RM results are expressed as percent recovery of the target analyte concentration. RM targets may be certified target concentrations provided by the RM supplier, or may be ALS long-term mean values (for empirical test methods).

Sub-Matrix:

					Reference Material (RM) Report				
					RM Target Concentration	Recovery (%) RM	Recovery Limits (%)		
Laboratory sample ID	Reference Material ID	Analyte	CAS Number	Method			Low	High	Qualifier
Physical Tests (QCLot: 1487387)									
QC-1487387-001	RM	Oxidation-reduction potential [ORP]	----	E125	475 mV	98.9	90.0	110	----
Physical Tests (QCLot: 1487458)									
QC-1487458-003	RM	Conductivity (1:2 leachate)	----	E100-L	3460 µS/cm	104	70.0	130	----
Leachable Anions & Nutrients (QCLot: 1491995)									
QC-1491995-003	RM	Chloride, soluble ion content	16887-00-6	E236.Cl	601 mg/kg	90.3	70.0	130	----
Leachable Anions & Nutrients (QCLot: 1491996)									
QC-1491996-003	RM	Sulfate, soluble ion content	14808-79-8	E236.SO4	172 mg/kg	117	70.0	130	----





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Telephone : +1 519 886 6910

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**

WHITE - LABORATORY COPY      YELLOW - CLIENT COPY

of the white - report copy

862-243

MAY 2023 EDITION

## **APPENDIX D**

### Site Photographs





THURBER ENGINEERING LTD.



Photo 1: Looking north along Highway 11/17 at location of Borehole 24-01 (taken on June 3, 2024).



Photo 2: Looking north along Highway 11/17 at location of Borehole 24-02 (taken on June 4, 2024).





Photo 3: Looking south along Highway 11/17 at location of Borehole 24-03 (*taken on June 4, 2024*).