Foundation Investigation Report

Highway 24
Alder Creek Culvert
Partial Replacement and Rehabilitation
Station 11+650
Township of North Dumfries
Site No. 33-489/C

G.W.P. 3055-03-00

Geocres No. 40P8-197

Project No. 165000768

May 2011

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FOUNDATION INVESTIGATION REPORT
For
G.W.P 3055-03-00

Highway 24 – Alder Creek Culvert Partial Replacement and Rehabilitation
Station 11+650
Site No. 33-489/C
Township of North Dumfries

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to undertake the detailed design for resurfacing of Highway 24 from 0.3 km north of Glen Morris Road northerly to 0.33 km south of Footbridge Road and from 0.23 km north of Footbridge Road northerly to the south limits of Cambridge. This project also includes the partial replacement and rehabilitation of the existing Alder Creek Culvert (Site No. 33-489-C) at approximate Station 11+650 on Highway 24, south of the Town of Cambridge, in the Township of North Dumfries, Ontario.

This Foundation Investigation Report has been prepared specifically and solely for the partial replacement and rehabilitation of the Alder Creek Culvert.

2.0 Site Description and Geology

Site Location

The site location is shown on the Key Plan inset to Drawing No. 1, provided in Appendix A. The existing Alder Creek Culvert crosses beneath Highway 24 at Station 11+650, approximately 100 m south of Maple Manor Road East.

General Site Description

It is noted that Highway 24 runs approximately north-south at the project location with chainage increasing from south to north. In the vicinity of the culvert, Highway 24 has a two lane rural cross-section with approximately 3 m wide shoulders (see Photo 1 in Appendix A).

Alder Creek flows to the Grand River which is located approximately 80 m west of Highway 24.

A recreational trail (part of the Grand River Trail System) runs along a former railway embankment approximately 25 m west of and parallel to Highway 24. The top of the trail embankment is approximately 4 m wide and has a gravel surface (Photo No. 2 in Appendix A). The trail embankment has side slopes of approximately 2H:1V.

The Alder Creek Culvert extends in an east-west orientation from the east side of Highway 24 to the west side of the recreational trail.

Drainage of the highway is provided via ditches leading to the culvert at the inlet and to an opening in the side of the culvert between Highway 24 and the recreational trail.

At the inlet of the culvert (east end), the Highway 24 paved surface is approximately 3.8 m higher than streambed and the embankment has 2.5H:1V side slopes. At the west side of Highway 24, the embankment is approximately 1.1 m high above the top of the culvert with a side slope of 2H:1V.

The area between Highway 24 and the recreational trail is covered with brush and small trees (see Photos No 1 and 3 in Appendix A).

Existing Culvert

The existing culvert consists of three sections:

1. The original culvert constructed to support the former railway and consisting of a 27.1 m long rigid frame open footing concrete culvert with encased steel beams. This section extends beneath the trail embankment and terminates approximately 1.5 m west of the centerline of Highway 24. This section has an approximate span of 3.1 m and a height of approximately 1.8 m. It is understood that the footings for this culvert are at elevation 252.1 m. This section of the culvert has been identified as requiring replacement.

2. The first extension consisting of an 8.7 m long non-rigid frame open footing concrete culvert which abuts the east (inlet) end of the original culvert.

3. The second extension consisting of a 7 m long concrete rigid frame box culvert constructed in 1990 at the east (inlet) end of the first extension. It is understood that the second extension has a span of 3.05 m and an interior height of 1.85 m.

The approximate alignment of the existing culvert is shown on Drawing No. 1 in Appendix A. Flow in the culvert is from east to west, toward the Grand River.

The outlet of the culvert is visible at the base of the trail embankment on the west side, approximately 2.1 m below the trail surface (see Photo 4 in Appendix A). Signs of erosion and concrete deterioration of the underside of the culvert are visible on the south side of the outlet. A concrete headwall is present at the outlet.

Physiographic Description

The site is located within a physiographic region known as the Waterloo Hills Region (Chapman and Putnam, 1984). In this region, the surface is generally composed of sandy hills, some of them being ridges of sandy till. The extensive area adjoining the hilly regions forms the alluvial terraces of the Grand River spillway. This area is relatively flat and contains similar but more uniform sandy and gravelly materials.

Drainage is generally toward the west toward the Grand River. In the immediate vicinity of the site, drainage is provided via drainage ditches and culverts.

3.0 Method of Investigation

3.1 DRILLING INVESTIGATION

A field investigation consisting of five boreholes was carried out for this assignment. The boreholes were designated BH10-1 through BH10-5 and their locations are shown on the Borehole Location Plan, Drawing No.1 in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of public utilities.

The field drilling program was carried out from November 30 to December 2, 2010. Three boreholes (BH10-1, BH10-2 and BH10-4) were advanced with solid-stem augers using a truck mounted Dietrich D-90 drill rig equipped for soil and bedrock sampling. BH10-3 was advanced with the same drill rig but with a hollow-stem auger. BH10-5 was advanced using portable drilling equipment having drive and flush casing. Both drill rigs were owned and operated by Walker Drilling Ltd. of Utopia, Ontario.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec Field Technologist. Split spoon samples were collected at regularly spaced intervals (typically every 760 mm) during the course of Standard Penetration Testing (ASTM D1586). All samples recovered were returned to Stantec's Ottawa laboratory for detailed classification and testing. Boreholes were backfilled with auger cuttings mixed with bentonite and road holes were topped with cold patch asphalt.

3.2 SURVEY

Borehole locations were established in the field by Stantec personnel relative to the centerline of the existing alignment and the existing culvert. The ground surface elevation at each borehole location was surveyed by Stantec personnel with reference to a Geodetic Benchmark provided by MTO. The benchmark was located at the top of the northwest concrete headwall of the outlet at Station 11+650.4, approximately 28.5 m west of Highway 24 centerline. The Geodetic elevation of this benchmark is reported to be 256.029 m. Table 3-1 summarizes the borehole information.

Table 3.1: Borehole Summary

	Boreholes				
	BH10-1	**BH10-2**	**BH10-3**	**BH10-4**	**BH10-5**
MTM Zone 10 Coordinates					
Northing	4796848.1	4796840.1	4796841.1	4796851.0	4796851.5
Easting	239160.1	239152.9	239134.2	239134.3	239125.7
Station	11+651.4	11+643.3	11+643.9	11+654.5	11+655.0
Offset	2.0 m RT	5.3 m Lt	24.7 m LT	24.4 m LT	33.2 m LT
Ground Surface Elevation, m	257.5	257.1	256.9	256.9	254.6
Total Depth Drilled, m	9.4	9.8	9.1	8.9	2.9
End of Borehole Elevation, m	248.1	247.4	247.7	248.0	251.7
Depth Augered, m	9.4	9.8	9.1	5.2	2.9
Number of Soil Samples	10	11	10	6*	5
Depth Cored, m	0	0	0	3.7*	0

*Three NQ-size cores were retrieved from a boulder(s) in addition to the six soil samples within the overburden.

3.3 LABORATORY TESTING

All samples were taken to our Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Selected soil samples underwent plasticity testing (2 samples), gradation analysis (16 samples) and moisture content testing (21 samples). Two samples were submitted to Parcel Laboratories of Ottawa for analysis of pH, soluble sulphate content, chloride content and resistivity.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

4.0 Subsurface Conditions

4.1 SUBSURFACE PROFILE

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided.

In general, the subsurface stratigraphy consisted of a pavement structure over a silty sand with gravel fill material overlying a silty sand with gravel to silty gravel with sand till deposit.

Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawing No. 1 and 2 in Appendix A.

4.1.1 Pavement Structure

The pavement structure observed in Borehole BH10-1 consisted of the following

HM Asphalt	200 mm
PCC Concrete	150 mm
Base Gravel	none observed

The shoulder granular fill material observed in Borehole BH10-2 was 0.9 m thick. A grain size distribution test was carried out on a sample of the shoulder granular fill, indicating the following composition

- 32% Gravel
- 58% Sand
- 10% Fines (silt and clay size particles)

This material is classified as a well graded sand with silt and gravel (SW-SM); a grain size distribution curve is presented on Figure 1 in Appendix C.

4.1.2 Highway Embankment Fill

The highway embankment fill extends to 4.0 m below the road profile (to elevation 253.1 m to 253.4 m) and generally consists of a silty sand with gravel (SM).

The results of moisture content and grain size distribution tests carried out on the highway embankment fill are summarized below.

- 0 to 34% Gravel
- 42 to 51% Sand
- 24 to 55% Fines (silt and clay size particles)
- Moisture Content 8 to 27%

The higher moisture content and fines content observed are associated with a sandy silt pocket noted in BH10-2. The grain size distribution curves are plotted on Figure 2 in Appendix C.

Standard Penetration Test (STP) N-values observed within the highway embankment fill ranged from 4 to 35 blows per 0.3 m suggesting variable states of compactness ranging from loose to dense.

Atterberg limits tests on one representative sample from the embankment fill indicated that the fill was non-plastic.

Organic Layer

It is noted that an approximately 100 mm thick layer of organic material consisting of dark brown sandy silt with plant remains was encountered beneath the shoulder granular fill in BH10-2 and immediately beneath the embankment fill in BH10-1 and BH10-2. Moisture content testing on one sample of this material yielded a value of 48%. The latter organic material was likely left in place during the placement of the embankment.

4.1.3 Granular Railway Ballast

Approximately 1.0 m of granular fill associated with the former railway was encountered beneath the recreational trail in BH10-3 and BH10-4 (extending to elevation 255.7 m to 256.0 m). One SPT N-value measurement in this layer indicated 39 blows per 0.3 m, suggesting a dense state. One representative sample obtained from this layer revealed the following:

- 59% Gravel
- 33% Sand
- 8% Fines (silt and clay size particles)
- Moisture content 4%

According to USCS, the material can be classified as poorly graded gravel with silt and sand (GP-GM). The grain size distribution test result for this material is provided in Figure 3 in Appendix C.

4.1.4 Recreational Trail Embankment Fill

Embankment fill material was encountered immediately beneath the railway ballast in BH10-3 and BH10-4. The thickness of the embankment fill was 1.4 to 2.2 m (extending to elevation 253.8 m to 254.3 m). The SPT N-values for this layer ranged between 5 and 17 blows per 0.3 m suggesting a loose to compact state. Three representative soil samples retrieved from this layer revealed the following results:

- 0% to 4% Gravel
- 20 to 36% Sand
- 61 to 80% Fines (silt and clay size particles)
- Moisture Content 14 to 18%

The material can be classified as sandy silt with gravel (ML). The grain size distribution test results for this material are provided in Figure 4 in Appendix C.

An Atterberg Limits test conducted on one cohesive sample from this fill layer indicated a plasticity index of 8% suggesting low plasticity (Figure 6 in Appendix C).

4.1.5 Topsoil

Approximately 300 mm of brown sandy silt topsoil was encountered at the ground surface in BH10-5. The bottom elevation of the topsoil was approximately 254.3 m. A 100 mm thick

sandy silt with organic material was noted beneath the fill in BH10-3. Testing on samples from BH10-3 revealed:

- 0% Gravel
- 44% Sand
- 56% Fines (silt and clay size particles)
- Moisture Content 21 to 24%

4.1.6 Silty Gravel with Sand to Silty Sand with Gravel Till

A deposit of silty gravel with sand (GM) to silty sand with gravel (SM) was encountered beneath the fill layers in BH10-4 and beneath the topsoil and organic layers in BH10-1, BH10-2, BH10-3 and BH10-5. The top elevation of this deposit ranged between 253.0 to 254.3 m. The boreholes penetrated into the till to depths ranging from 2.6 m (BH10-5) to 6.3 m (BH10-4). It is noted that drilling was terminated in this layer at all borehole locations at elevation between 251.7 m and 247.4 m and hence the actual thickness for the till deposit was not established. It is further noted that frequent cobbles and boulders were encountered within this deposit.

The SPT N-values for this deposit ranged between 16 blows per 0.3 m to well over 100 (split-spoon refusal) suggesting a compact to very dense state. Testing on seven representative samples obtained from this layer revealed the following:

- 18 to 56% Gravel
- 31 to 63% Sand
- 12 to 51% Fines (silt and clay size particles)
- Moisture Content 8 to 14%

Representative grain size distribution plots for this material are indicated on Figure 5 in Appendix C.

Two soil samples retrieved immediately beneath the existing fill at the site were submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are provided in Table 4.1.

Table 4.1: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
BH10-2	SS6	3.8 to 4.4	7.69	264	9	20.4
BH10-4	SS4	3.1 to 3.7	7.89	30	7	55.6

4.2 BEDROCK

Bedrock was not encountered within the depth of exploration of this investigation.

4.3 GROUNDWATER

Groundwater was encountered in all the boreholes at the time of drilling, between November 30 and December 2, 2010. The observed groundwater levels are summarized in Table 4.2 as "inferred" groundwater level.

Table 4.2: Inferred Groundwater Levels (time of drilling)

Borehole No	Ground Surface Elevation (m)	Groundwater	
		Depth (m)	Elevation (m)
BH10-1	257.5	4.9	252.6
BH10-2	257.1	4.0	253.1
BH10-3	256.9	3.2	253.7
BH10-4	256.9	3.4	253.5
BH10-5	254.6	1.5	253.1

Fluctuations in the groundwater and culvert water level due to seasonal variations or in response to a particular precipitation event should be anticipated.

The water level elevation in the culvert at the inlet (east) and outlet (west) was 254.00 and 253.96 m, respectively, as surveyed on December 3, 2010.

5.0 Closure

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

This report has been prepared by Simon Gudina and Paul Carnaffan and reviewed by Raymond Haché and Fred Griffiths.

Respectfully Submitted;

STANTEC CONSULTING LTD.

Simon Gudina, Ph.D.

Paul Carnaffan, M.Eng., P.Eng.
Associate

Fred J. Griffiths, Ph.D., P.Eng.
Principal and Project QC Auditor

Raymond Haché, M.Sc., P.Eng.
Central Canada Practice Lead and
Designated Principal MTO Foundation Contact

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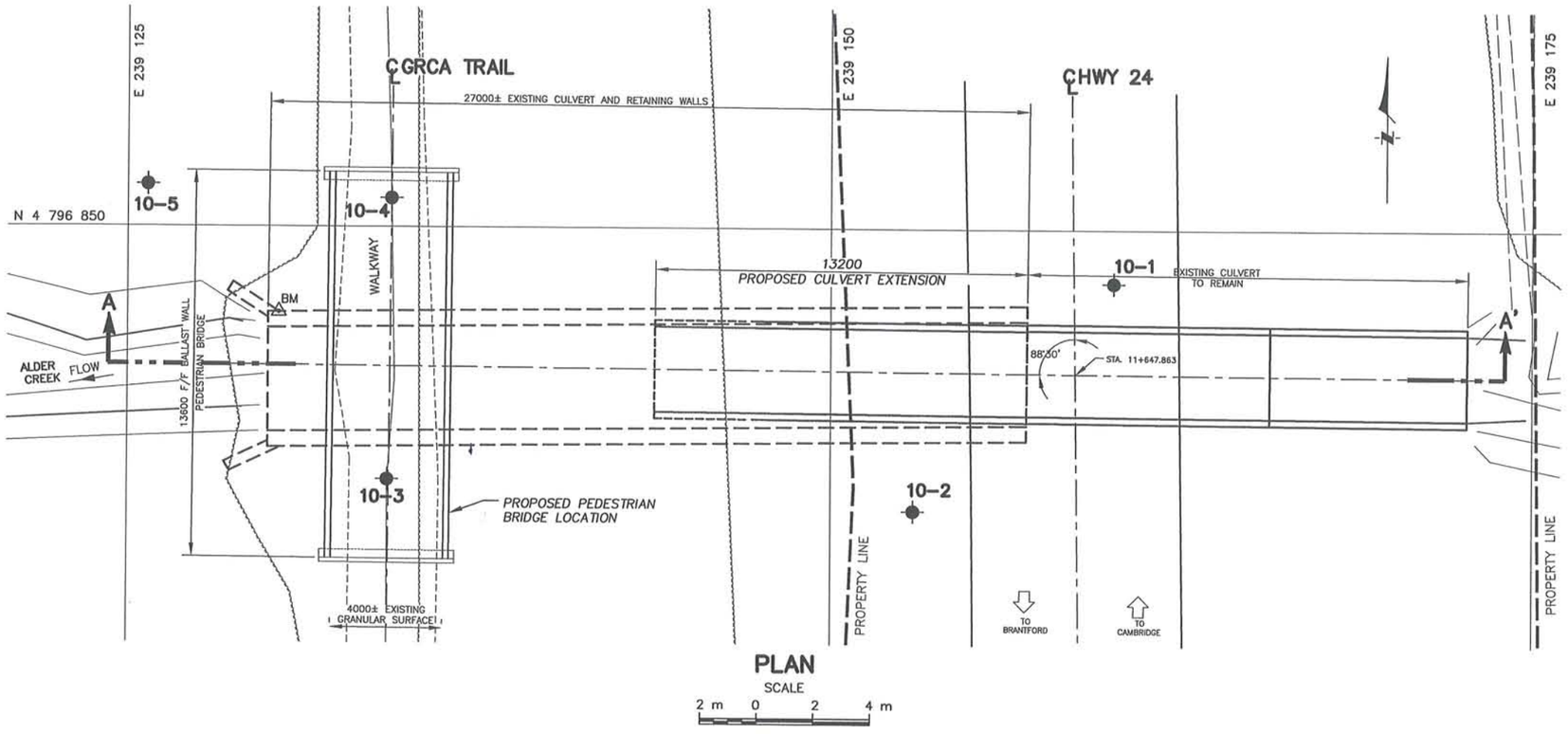
APPENDIX A

Drawing No. 1 and 2 – Borehole Location Plan and Soil Strata Plot

Site Photos



PLAN

SCALE

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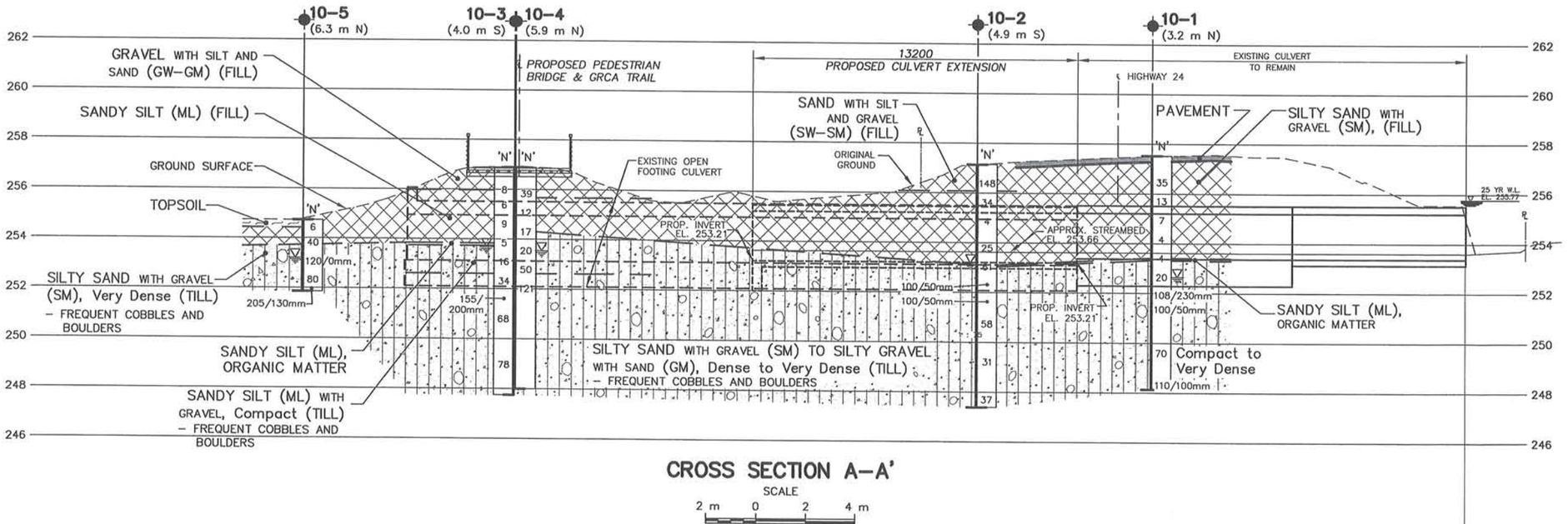

CROSS SECTION A–A'

SCALE

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METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

PLATE No
CONT
WP 3055–03–00

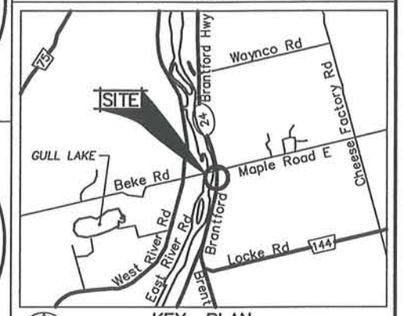
HWY 24, CAMBRIDGE, ON
STA TO STA
BOREHOLE LOCATIONS & SOIL STRATA

SHEET

LICENSED PROFESSIONAL ENGINEER
F.J. GRIFFITHS
May 27 '11
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
J.G.A.R. HACHÉ
11/05/27
PROVINCE OF ONTARIO

Stantec



LEGEND

- Bore Hole
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- WL at Time of Investigation Dec 2010
- BM — Benchmark (Top NW Corner of Concrete HD Wall, 28.5 LT, STA 11+650.4) Elev. = 256.029 m Geodetic
- (3.2 m N) Offset from Cross Section Line

No	ELEVATION	MTM ZONE 10 COORDINATES NORTH	EAST
10–1	257.5	4 796 848.1	239 160.1
10–2	257.1	4 796 840.1	239 152.9
10–3	256.9	4 796 841.1	239 134.2
10–4	256.9	4 796 851.0	239 134.3
10–5	254.6	4 796 851.5	239 125.7

NOTES

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102–2 of Form 100.

REVISIONS

DATE	BY	DESCRIPTION

GEOCRES No 40P8–197

HWY No			DIST
SUBM'D SG	CHECKED	DATE 2011/03/07	SITE
DRAWN GBB	CHECKED	APPROVED	DWG 1

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MODIFIED: 11/05/20
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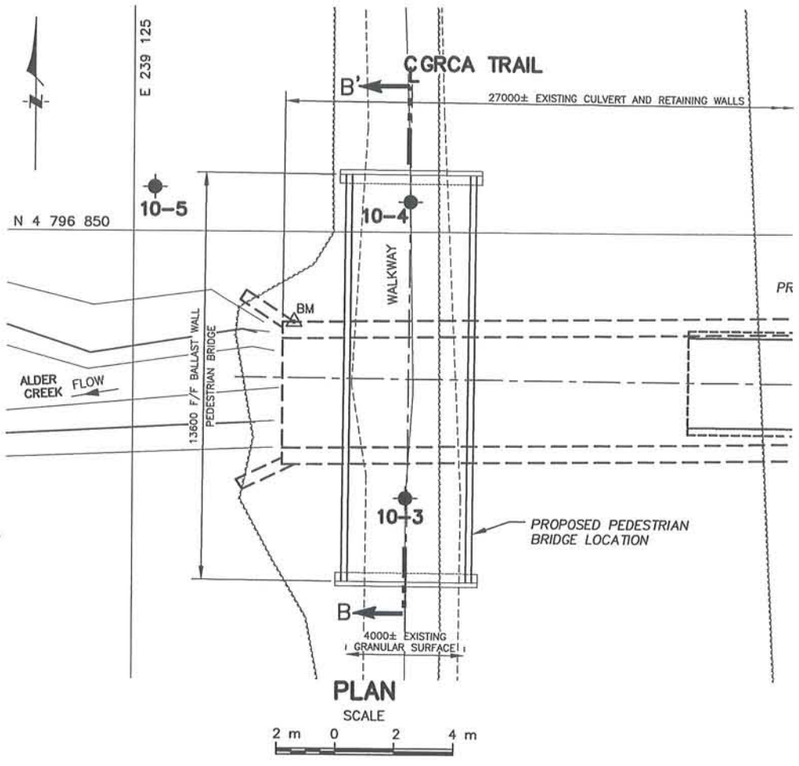
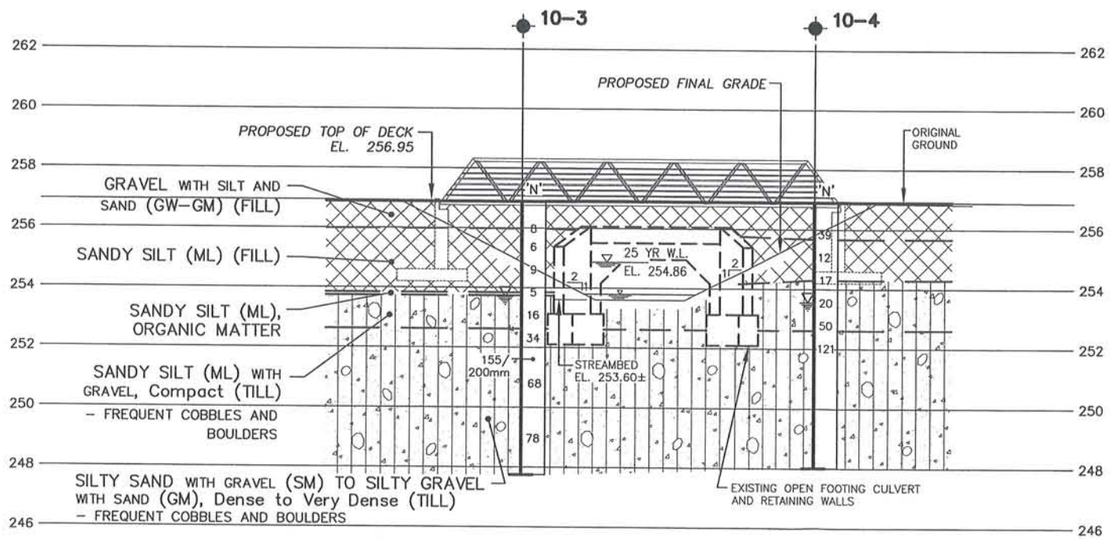
MINISTRY OF TRANSPORTATION, ONTARIO PR–D–707 88–05





CROSS SECTION B–B'

SCALE

2 m 0 2 4 m

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

PLATE No

CONT WP 3055–03–00

HWY 24, CAMBRIDGE, ON

STA TO STA

BOREHOLE LOCATIONS & SOIL STRATA

SHEET

Stantec

LICENSED PROFESSIONAL ENGINEER
F.J. GRIFFITHS
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PROVINCE OF ONTARIO

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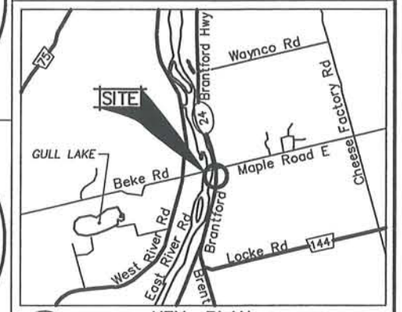

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REVISIONS			
	DATE	BY	DESCRIPTION

GEOCRES No 40P8–197

HWY No			DIST
SUBM'D SG	CHECKED	DATE 2011/03/07	SITE
DRAWN GBB	CHECKED	APPROVED	DWG 2

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

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CREATED: GBB MODIFIED: 11/05/20
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Photo No. 1: Hwy 24 looking south at culvert site.

Photo No. 2: Recreational trail looking north at culvert site.

Photo No. 3: View from recreational trail toward Hwy 24 with exposed culvert section in between.

Photo No. 4: Culvert outlet with signs of erosion and deterioration at the south side.

APPENDIX B

Symbols and Terms Used on Borehole Records

Borehole Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index). A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
Very Soft	<0.25	<12.5
Soft	0.25 - 0.5	12.5 - 25
Firm	0.5 - 1.0	25 - 50
Stiff	1.0 - 2.0	50 – 100
Very Stiff	2.0 - 4.0	100 - 200
Hard	>4.0	>200

ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor*
25-50	*Poor*
50-75	*Fair*
75-90	*Good*
90-100	*Excellent*

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

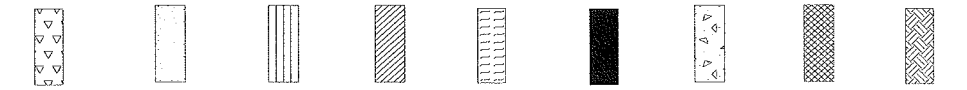
Strength Classification	Unconfined Compressive Strength (MPa)
Extremely Weak	< 1
Very Weak	1 – 5
Weak	5 – 25
Medium Strong	25 – 50
Strong	50 – 100
Very Strong	100 – 250
Extremely Strong	> 250

Terminology describing rock weathering:

Term	Description
Fresh	No visible signs of rock weathering. Slight discolouration along major discontinuities
Slightly Weathered	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
Moderately Weathered	Less than half the rock is decomposed and/or disintegrated into soil.
Highly Weathered	More than half the rock is decomposed and/or disintegrated into soil.
Completely Weathered	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

measured in standpipe, piezometer, or well

inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

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RECORD OF BOREHOLE No BH 10-1 1 OF 1 METRIC

W.P. 3055-03-00 LOCATION Alder Creek Culvert N: 4 796 848 E: 239 160 ORIGINATED BY JF

DIST London HWY 24 BOREHOLE TYPE Split-spoons, Solid-stem Augers COMPILED BY JF

DATUM Geodetic DATE 2010 12 02 - 2010 12 02 CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.5	Asphalt										
0.0	200 mm ASPHALT										
257.3											
257.2	150 mm CONCRETE										
0.4	Silty sand with gravel (SM), brown to reddish brown, FILL		1	SS	35		257		o		34 42 (24)
			2	SS	13		256				
			3	SS	7		255				
			4	SS	4		254				
253.4			5	SS	4				48		
253.3	Sandy silt (ML), dark brown, wet, ORGANIC matter										
4.2	Silty sand with gravel (SM) to silty Gravel with sand (GM), compact to very dense, brown, TILL		6	SS	20	▽	253				
	- frequent cobbles and boulders		7	SS	108/ 230mm		252				
			8	SS	100/ 50mm						
							251				
			9	SS	70		250				
							249				
248.1			10	SS	110/ 100mm						
9.4	End of Borehole										

✖ 3, × 3. Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH 10-2 1 OF 1 METRIC

W.P. 3055-03-00 LOCATION Alder Creek Culvert N: 4 796 840 E: 239 153 ORIGINATED BY JF

DIST London HWY 24 BOREHOLE TYPE Split-spoons, Solid-stem Augers COMPILED BY JF

DATUM Geodetic DATE 2010 12 01 - 2010 12 01 CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.1	Gravel Shoulder										
0.0	Well graded sand with silt and gravel (SW-SM), brown to dark grey, FILL		1	BS			257				32 58 (10)
			2	SS	148						
256.2											
256.0 1.1	Sandy silt (ML), dark brown, wet, ORGANIC matter	(OL)									
	Silty sand with gravel (SM), grey to reddish brown, FILL		3	SS	34		256				25 51 (24)
			4	SS	4		255				0 45 (55)
	- Sandy silt pocket at 2.4 m - Very little gravel below 2.4 m										
			5	SS	25		254				
253.1						▽					
253.0 4.1	Sandy silt (ML), dark brown, wet, ORGANIC matter	(OL)	6	SS	61		253				
	Silty sand with gravel (SM) to silty gravel with sand (GM), dense to very dense, brown to grey, TILL		7	SS	100/ 50mm						38 33 (29)
	- frequent cobbles and boulders						252				
			8	SS	100/ 50mm						
			9	SS	58		251				56 32 (12)
							250				
			10	SS	31						23 63 (14)
							249				
							248				
247.4			11	SS	37						
9.8	End of Borehole										

✖³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH 10-3

1 OF 1 **METRIC**

W.P. 3055-03-00 LOCATION Alder Creek Culvert N: 4 796 841 E: 239 134 ORIGINATED BY JF

DIST London HWY 24 BOREHOLE TYPE Split-spoons, Hollow-stem Augers COMPILED BY JF

DATUM Geodetic DATE 2010 11 30 - 2010 12 01 CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.9	Gravel Trail										
0.0	Poorly graded gravel with silt and sand (GW-GM), brown, FILL		1	BS							59 33 (8)
256.0			2	SS	8		256				0 20 (80)
0.9	Sandy silt (ML), reddish brown, FILL - Clayey pocket at 1.0 m		3	SS	6						
			4	SS	9		255				
253.8			5	SS	5	▽	254				3 36 (61)
253.7	Sandy silt (ML), dark brown, wet,										0 44 (56)
3.2	ORGANIC matter										
	Sandy silt (ML), compact, brown to greyish brown, TILL - With gravel below 3.5 m		6	SS	16		253				
252.6											
4.3	Silty sand with gravel (SM) to silty gravel with sand (GM), dense to very dense, grey, TILL - frequent cobbles and boulders		7	SS	34		252				
			8	SS	155/200mm						
			9	SS	68		251				45 39 (16)
							250				
			10	SS	78		249				
247.7							248				
9.1	End of Borehole										

$\times^{3}$, $\times^{3}$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH 10-4 1 OF 1 METRIC

W.P. 3055-03-00 LOCATION Alder Creek Culvert N: 4 796 851 E: 239 134 ORIGINATED BY JF

DIST London HWY 24 BOREHOLE TYPE Split-spoons, Solid-stem Augers COMPILED BY JF

DATUM Geodetic DATE 2010 12 02 - 2010 12 02 CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE, 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.9	Gravel Trail										
0.0	Poorly graded gravel with silt and sand (GP-GM), brown, FILL										
			1	SS	39		256				
255.7											
1.2	Sandy silt (ML), reddish brown, FILL		2	SS	12		255		o		4 35 (61)
254.3											
2.6	Sandy silt with gravel (ML), compact to dense, greyish brown to brown, TILL		3	SS	17		254				
			4	SS	20	▽					
			5	SS	50		253		o		18 31 (51)
252.6											
4.3	Silty sand with gravel (SM), dense to very dense, brown, TILL - frequent cobbles and boulders - coring carried out to advance through boulder		6	SS	121		252				
			7	NQ			251				
			8	NQ			250				
			9	NQ			249				
248.0											
8.9	End of Borehole										

✖ 3, × 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH 10-5 1 OF 1 METRIC

W.P. 3055-03-00 LOCATION Alder Creek Culvert N: 4 796 852 E: 239 126 ORIGINATED BY JF

DIST London HWY 24 BOREHOLE TYPE Portable Equipment, Split-spoons COMPILED BY JF

DATUM Geodetic DATE 2010 12 02 - 2010 12 03 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
254.6	Low grass										
0.0 / 254.3	TOPSOIL		1	SS	6		254				
0.3	Silty sand with gravel (SM), very dense, brown, TILL - frequent cobbles and boulders		2	SS	40	▽			o		30 36 (34)
			3	SS	120/ ,0mm		253				
			4	SS	80		252		o		32 40 (28)
251.7			5	SS	205/ 130mm						
2.9	End of Borehole										

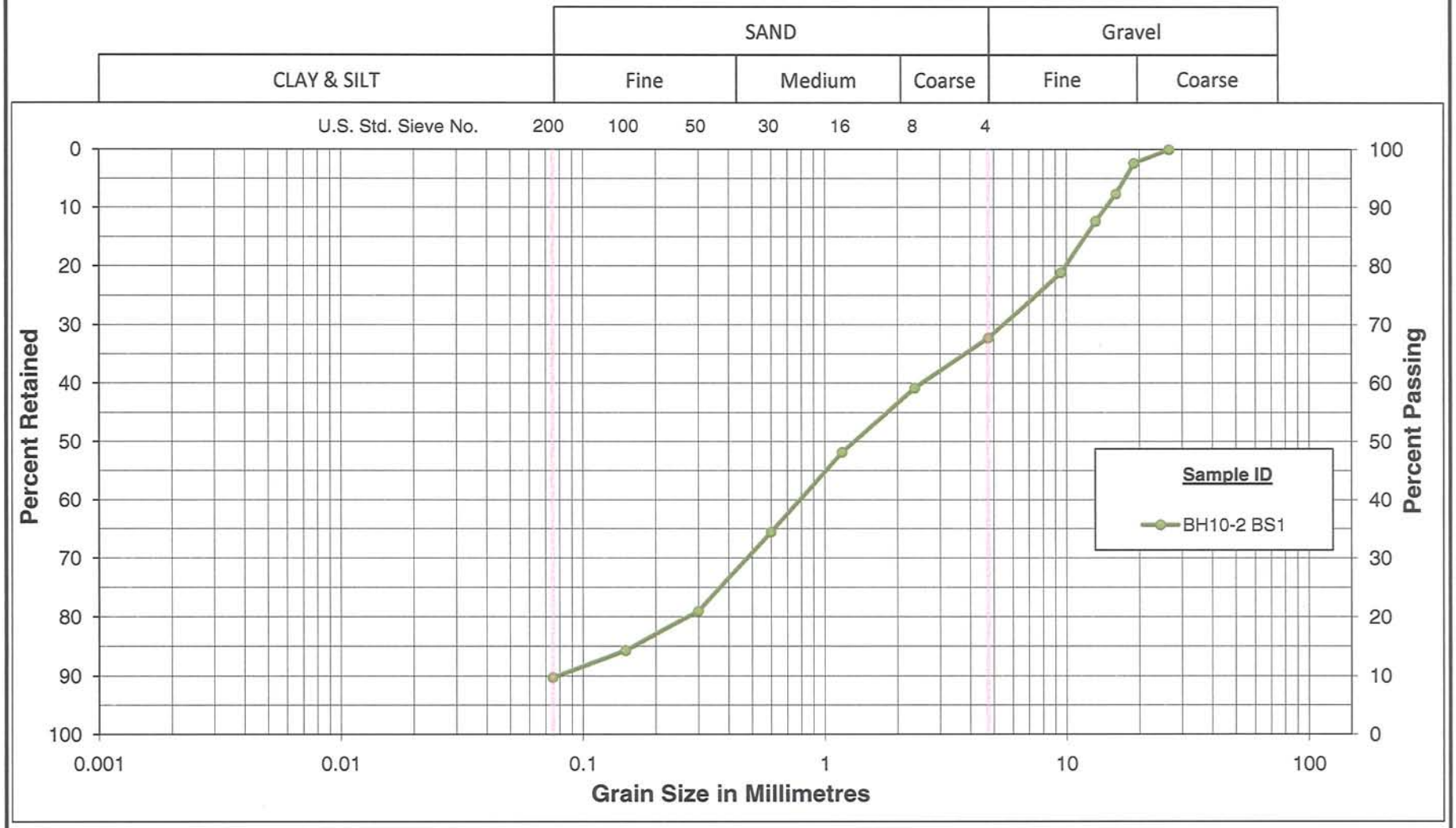
✖³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

ONTARIO MTO STANTEC 165000768 - HIGHWAY 24 CULVERT.GPJ ONTARIO MOT.GDT 11/5/18

APPENDIX C

Laboratory Test Results

Unified Soil Classification System



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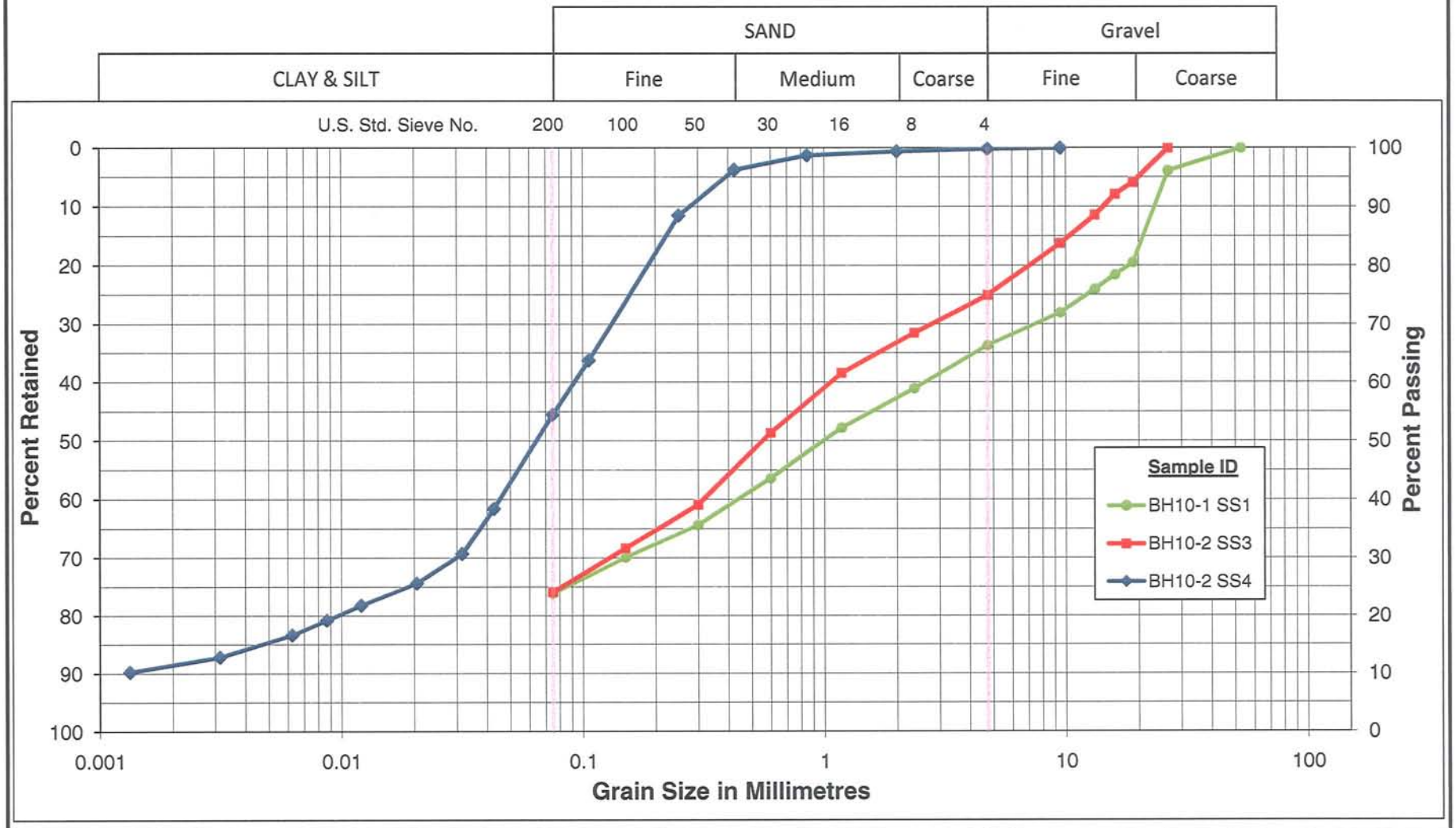
GRAIN SIZE DISTRIBUTION

Hwy 24 Shoulder Granular Fill

Figure No. 1

Project No. 165000768

Unified Soil Classification System



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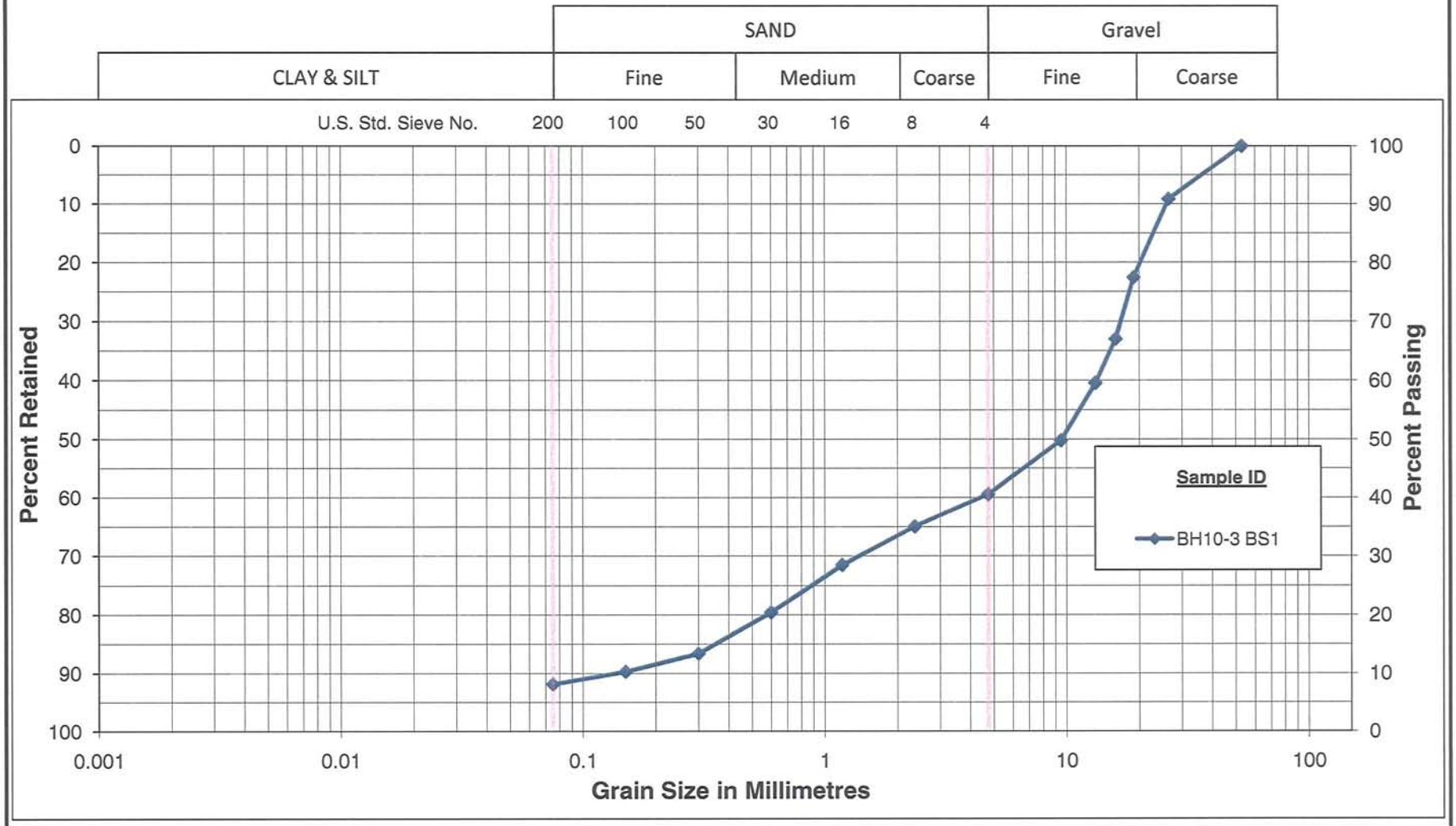
GRAIN SIZE DISTRIBUTION

Hwy 24 Embankment Fill

Figure No. 2

Project No. 165000768

Unified Soil Classification System



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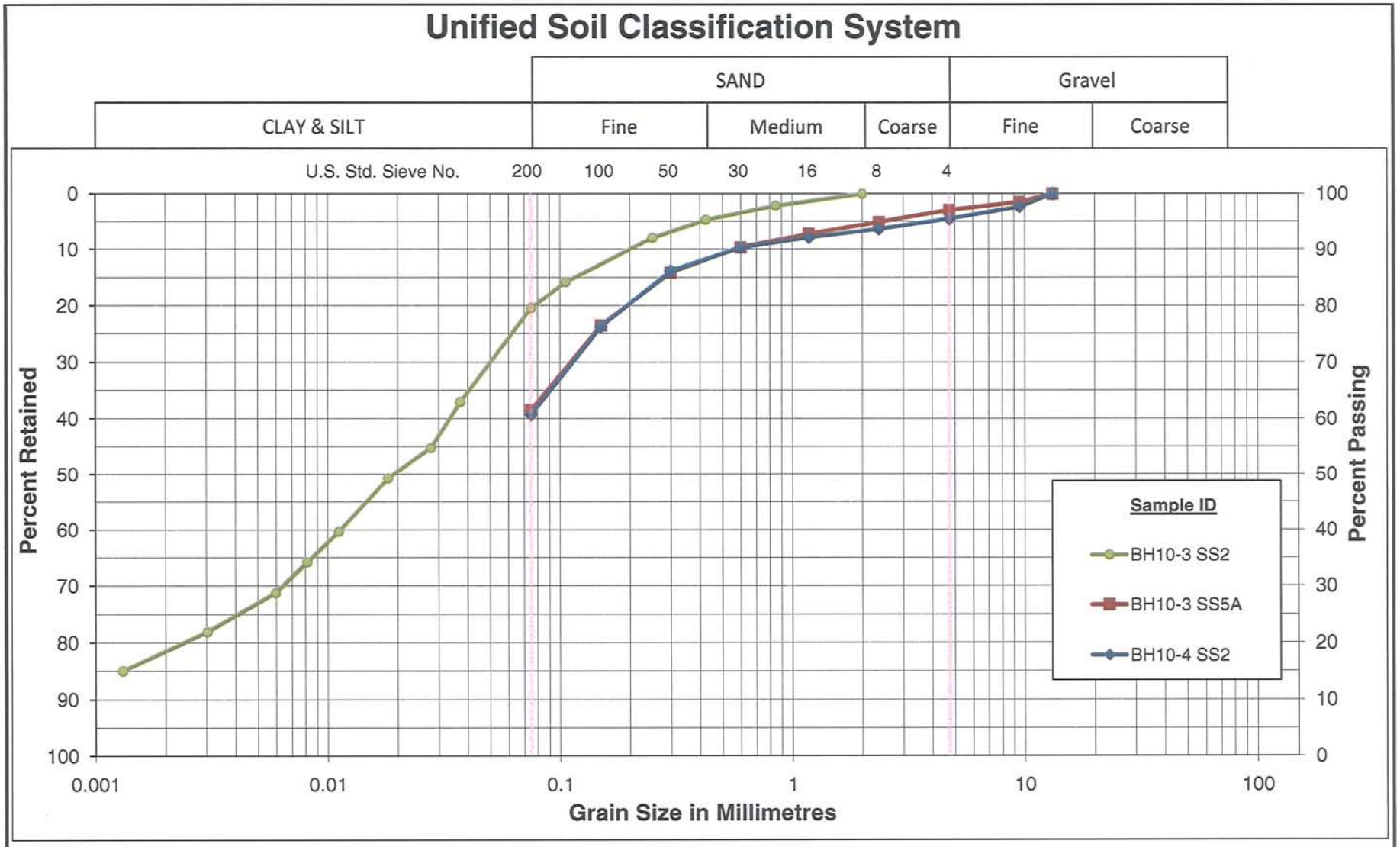
GRAIN SIZE DISTRIBUTION

Granular Railway Ballast

Figure No. 3

Project No. 165000768



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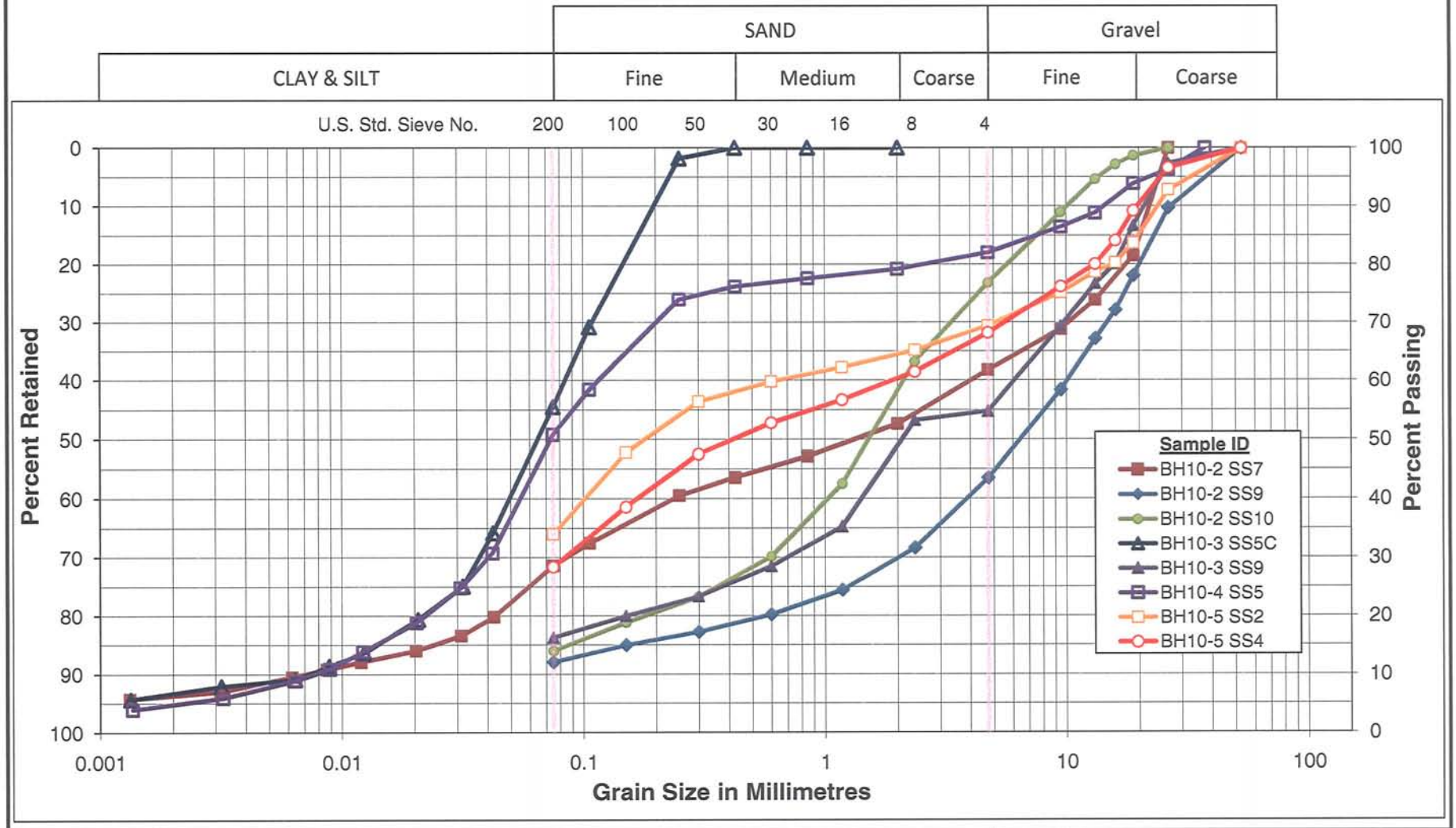
GRAIN SIZE DISTRIBUTION

Recreational Trail Embankment Fill

Figure No. 4

Project No. 165000768

Unified Soil Classification System



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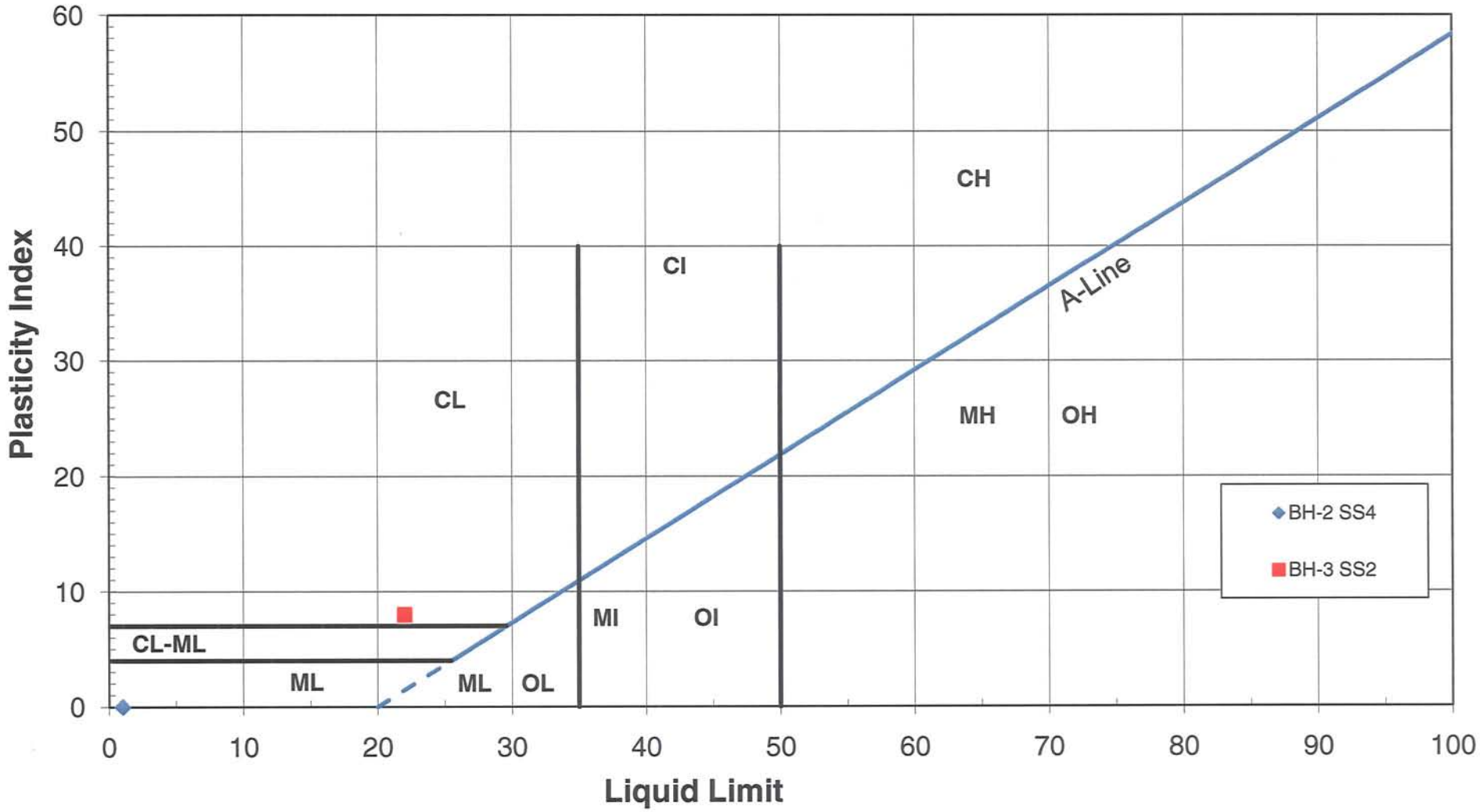
GRAIN SIZE DISTRIBUTION

Native TILL (ML, SM and GM)

Figure No. 5

Project No. 165000768



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PLASTICITY CHART

Figure No. 6

Project No. 165000768