

FINAL REPORT

Foundation Investigation and Design Retaining Wall Rehabilitation and Replacement Highway 417 from Holland Avenue to Kent Street Ottawa, Ontario

G.W.P. 4173-15-00

Submitted to:

WSP Canada Group Limited

300-2611 Queensview Drive
Ottawa, Ontario K2B 8K2

Submitted by:

Golder Associates Ltd.

1931 Robertson Road,
Ottawa, Ontario, K2H 5B7

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PART A

Foundation Investigation
Retaining Wall Rehabilitation and Replacement
Highway 417 from Holland Avenue to Kent Street
Ottawa, Ontario

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP Canada Group Limited (WSP) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the detailed design of numerous bridge replacements, overhead signs, noise barrier walls, retaining walls, temporary roadway protection systems, replacement of storm sewers (including trenchless crossings) and a high fill embankment on Highway 417 between Island Park Drive and Kent Street in Ottawa, Ontario (Assignment number 4016-E-0001).

This report presents the results of the foundation investigation carried out for the rehabilitation/replacement of ten retaining wall structures between Holland Avenue and Kent Street. The rehabilitation/replacement of the structures is to be carried out in accordance with the current version of the Canadian Highway Bridge Design Code, S6-14 (CHBDC).

The work described herein was not included in the original Terms of Reference for this assignment or the scope of work for Foundations Engineering outlined in MTO's Request for Proposal, dated April 2016, subsequent addenda or included as part of Golder's original scope of work for Foundations Engineering services contained in WSP's Technical Proposal.

The scope of work for the foundation engineering services associated with the rehabilitation/replacement of the Highway 417 retaining walls was outlined in Golder's Change Order #2 Technical Memorandum dated July 27, 2018. The investigation program was developed to meet the requirements of Table 17.8a of the RFP Terms of Reference (where applicable) as well as the structural requirements of WSP to complete the designs.

The work has been carried out in accordance with Golder's Quality Control Plan for foundation engineering services for the project dated August 29, 2016.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 Site Description

The retaining wall structures are located along both the north and south sides of Highway 417, between Holland Avenue and Kent Street. The locations of the retaining wall structures are shown on Drawings 1 through 9.

Brief descriptions of the structures, and their location with reference to current Highway 417 stationing and direction, are summarized in Table 1. The description numbering and highway stationing for the retaining walls are based on information provided in the Retaining Wall Summary sheet, dated June 2019, and the revised 60% Contract Drawings provided by WSP on November 8, 2019. Copies of the reference information have been provided after the text of this report.

Table 1: Summary of Retaining Wall Locations and Proposed Rehabilitation/Replacement Works

Retaining Wall	Highway 417 Stationing Direction	Location	Proposed Rehabilitation or Replacement	Maximum Wall Height (m)	Approximate Wall Length (m)
RW2N	225+201 to 225+357 Westbound	Harmer to Holland	Rehabilitation	6.4	156
RW5N	25+960 to 26+077 Westbound	East of Parkdale offramp at Sherbrooke	Rehabilitation	3.3	117
RW10N	27+256 to 27+356 Westbound	South side of Raymond Rochester to Booth	Replacement	5.0	100
RW11N	27+380 to 27+412 Westbound	South side of Raymond Booth to LeBreton	Replacement	5.5	32
RW13N	828+168 to 828+301 Westbound	Lyon onramp to Bronson offramp	Replacement	4.9	133
RW1S	35+440 to 35+490 Eastbound	South of highway at north end of Hinton	Replacement	2.4	50
RW2S	25+983 to 26+103 Eastbound	East of Parkdale onramp Reid towards Fairmont	Rehabilitation	4.0	120
RW4S	27+394 to 27+586 Eastbound	South of Highway 417 along Orangeville from Booth to Bell	Replacement	3.0	192
RW5S	27+617 to 27+689 Eastbound	South of Highway 417 along EB offramp to Bronson	Replacement	1.5	72
RW7S	28+378 to 28+437 Eastbound	South of Highway 417 along Chamberlain from Glendale and Kent	Replacement	2.7	59

2.2 Regional Geology

As delineated in *The Physiography of Southern Ontario*¹, this section of Highway 417 lies within the minor physiographic region known as the Ottawa Valley Clay Plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that were deposited within the former Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock².

This region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain at depth by igneous and metamorphic bedrock of the Precambrian Shield. Regional bedrock mapping indicates that the bedrock west of Parkdale Avenue is dominantly interbedded

¹ Chapman, L. J. and Putnam, D. F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources

² Belanger, J.R. "Urban Geology of Canada's National Capital Area", in *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

limestone and dolomite of the Gull River Formation. East of Parkdale Avenue, the bedrock is indicated to be limestone of the Verulam Formation.³ The limestone is described as interbedded bioclastic, sublithographic to fine crystalline with very thin to medium bedded shale interbeds up to 8 cm thick. Bedrock outcrops are mapped north and south of Highway 417 from about Fairwater Avenue to Bronson Avenue.

Highway 417 crosses two main faults striking southeast to northwest. The more prominent fault, the Gloucester fault, crosses Highway 417 at the approximate location of Preston Street⁴. The second fault crosses Highway 417 at the approximate location of Kent Street. Bedding which is normally sub-horizontal often dips steeply adjacent to and within fault zones.

The sites fall within the Western Québec (WQ) seismic zone according to the Geological Survey of Canada. The WQ zone constitutes a large area which encompasses the urban areas of Montreal, Ottawa-Hull and Cornwall. Within the WQ zone recent seismic activity has been concentrated in two subzones: one along the Ottawa River and another more active subzone along the Montreal-Maniwaki axis. The two major earthquakes that have recently occurred in the WQ zone are the 1935 Témiscaming event, which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2, and the 1944 Cornwall-Massena event, which had a magnitude of 5.6.

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigation

The field work for the current investigation was carried out in two parts, the first in the fall of 2018 and the second in the spring/summer of 2019 and included advancing a total of 20 boreholes, numbered as 18-801, 18-802, 18-901 to 18-904, 18-906 to 18-918, and 18-923.

Tables 2 and 3 further outline the location of the boreholes with respect to the current Highway 417 stationing and related retaining wall structures.

Boreholes 18-901, 18-906, 18-907, and 18-912 to 18-915 were advanced using truck-mounted drilling equipment, while Boreholes 18-902, 18-910, 18-911 and 18-916 to 18-918 were advanced using a combination of hydro-excavation and truck-mounted drilling equipment. The hydro-excavation equipment was supplied and operated by PGC Services (PGC) of Ottawa, Ontario and the drilling equipment was supplied and operated by George Downing Estate Drilling of Hawkesbury, Ontario.

Boreholes 18-908 and 18-909 were advanced using portable rotary drilling equipment using NW and HW sized casing due to the proximity of the borehole locations to the adjacent utilities and embankment slopes. This equipment was supplied and operated by Marathon Underground Constructors Corporation of Greely, Ontario.

³ Urban geology of the National Capital area / Géologie urbaine de la région de la Capitale nationale; Bélanger, R. Geological Survey of Canada, Open File 5311, 2008; 1 DVD, <https://doi.org/10.4095/226165>

⁴ MacDonald, G. and Harrison, J.E. 1976: Generalized Bedrock Geology, Ottawa-Hull, Ontario and Quebec, Geological Survey of Canada, Map 1508A, scale 1:125,000. Geology 1967

Boreholes 18-802 and 18-904 were advanced using portable rotary drilling equipment employing a third weight hammer lifted manually and dropped from the SPT height. Where a third weight hammer was used, the N values presented on the Record of Boreholes are “uncorrected” and should be interpreted in consideration of their reduced penetration energy. This equipment was supplied and operated by Ohlmann Geotechnical Services Inc. of Almonte, Ontario.

Two separate attempts were made to advanced Borehole 18-903, which was located near the middle and in front of retaining wall RW5N, to core the existing footing and determine the underlying founding material. During the first attempt, hydro-excavation activities revealed a fibre optic line that was not previously detected during the utility locate process prior to commencing fieldwork. The location of the borehole was then adjusted such that hydro-excavation and coring activities would not impact the existing utility and a second attempt was carried out. While hydro-excavating the borehole the second time, a large diameter drainage pipe was encountered below the fibre optic line and just above the existing footing. The stacked alignments of the two utilities and the location of the drainage pipe relative to the footing made coring of the footing impossible without damaging the existing utilities.

To resolve the utility conflicts a new Borehole 18-923 was advanced near the western end and behind RW5N.

Boreholes 18-903 and 18-923 were advanced using a combination of hydro-excavation and portable rotary drilling equipment using HW sized casing. The hydro-excavation equipment was supplied and operated by PGC while the drilling equipment was supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario.

Traffic control required to close either the driving lanes of Highway 417 or the various City of Ottawa roadways, while carrying out field operations, was provided by Beacon Lite Ltd. of Ottawa, Ontario.

Grab samples of the overburden were recovered from within the hydro-excavations carried out at Boreholes 18-902, 18-903, 18-910, 18-911, 18-916 to 18-918, 18-923. Soil samples in Boreholes 18-901, 18-906, 18-907, and 18-912 to 18-915 and below the depth of hydro-excavation in Boreholes 18-910, 18-911 and 18-916 to 18-918 were obtained at vertical sampling intervals of about 0.76 m, using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Soil samples from Borehole 18-904 which was advanced with the portable drilling equipment were obtained in continuous vertical increments of about 0.6 m.

Concrete core samples of the existing retaining wall footings were obtained in Boreholes 18-801, 18-802 and 18-904. Concrete and bedrock core samples were obtained in Borehole 18-923. Bedrock core samples were obtained in Boreholes 18-908, 18-909 and 18-912. Both the concrete and bedrock core samples were obtained using a combination of NQ and HQ sized equipment.

Monitoring wells were installed in Boreholes 18-902, 18-911, and 18-913 to 18-917, to observe the stabilised groundwater at the various retaining wall sites. The monitoring wells consisted of 32 mm outside diameter PVC tubing with a 1.5 m long slotted tip. The final groundwater levels were measured in the wells on June 19, 2019. The wells were subsequently decommissioned according to Ontario MOE Regulation 903 (O.Reg 903) by a licenced well technician.

The boreholes were backfilled with bentonite within the bedrock, and bentonite mixed with soil cuttings within the overburden. The boreholes were then capped with either asphaltic concrete cold patch or granular material, depending on the surrounding surface cover. The boreholes were backfilled in general accordance with the intent of O.Reg 903, as amended. The site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of Golder's staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, logged the boreholes and examined and cared for the samples. The soil, concrete and bedrock core samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations, Atterberg Limits Testing and grain size distribution analyses were carried out on selected soil samples at Golder's Ottawa laboratory. Unconfined compressive strength testing was carried out on select core samples of the bedrock and concrete footings at Golder's Mississauga laboratory. The laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

Eight soil samples were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack).

The borehole locations and elevations were surveyed by Golder using a Trimble R8 GPS unit referenced to the NAD83 CSRS CBNv6-2010.0 MTM Zone 9 geodetic datum. The borehole locations, including northing and easting coordinates, ground surface and top of existing retaining wall footing elevations (where encountered), and drilled depths are summarized in Tables 2 and 3.

Table 2: Summary of Borehole Locations North Side for the Highway 417

Retaining Wall	Borehole	Location Approximate Highway 417 (Stationing)	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Footing Thickness (m)	Drilled Length (m)
			Northing (m)	Easting (m)				
RW2N	18-801	Parking lot 250 Holland (25+355)	5028691.4	365104.3	67.4	66.6	1.1	2.4
	18-802	Highway 417 WB Embankment East of Holland (25+405)	5028731.2	365132.6	69.7	66.3	1.0	5.2
RW5N	18-903	Highway 417 WB East of Sherbrooke (26+008)	5029102.8	365614.2	71.6	N/A		1.3 ¹
	18-923	Highway 417 WB West of Sherbrooke (25+955)	5029080.2	365569.0	72.1	69.3	0.6	5.1
RW10N	18-906	Highway 417 WB Embankment toe Raymond	5029624.1	366799.1	65.5	N/A		0.9
	18-907	West of Booth (27+300 / 27+340)	5029631.9	366837.8	66.3			1.3
RW11N	18-908	Highway 417 WB Embankment toe Raymond	5029647.0	366893.3	66.7	N/A		4.0
	18-909	East of Booth (27+400 / 27+455)	5029667.4	366944.3	69.1			4.9
RW13N	18-913	Highway 417 WB Embankment toe Southeast Corner of City Yard at 380 Catherine (28+170)	5029932.5	367605.0	66.9	N/A		5.5
	18-914	Highway 417 WB Embankment toe Southwest Corner of 370 Catherine (28+225)	5029958.8	367649.0	67.5			3.7
RW13N	18-915	Highway 417 WB Embankment toe East of the Southeast Building Corner 340 Catherine (28+305)	5029997.9	367718.4	68.1	N/A		7.0

Note: ¹ Borehole terminated at top of existing buried utility

Table 3: Summary of Borehole Locations South Side for the Highway 417

Retaining Wall	Borehole	Location Approximate Highway 417 Stationing	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Footing Thickness (m)	Drilled Length (m)
			Northing (m)	Easting (m)				
RW1S	18-901	Highway 417 EB Embankment toe West of Hinton (25+450)	5028734.4	365200.6	70.0	N/A		6.3
	18-902	Highway 417 EB Embankment toe East of Hinton (25+460)	5028741.6	365206.9	70.0			6.2
RW2S	18-904	Highway 417 EB East of Reid (26+075)	5029102.8	365691.1	71.0	69.8	0.9	4.0
RW4S	18-910	Highway 417 EB Embankment toe Orangeville West of Bell (27+550)	5029641.4	367056.5	72.1	N/A		3.7
	18-911	Highway 417 EB Embankment toe Bell East of Orangeville (27+585)	5029650.4	367089.2	72.9			3.3
RW5S	18-912	Highway 417 EB Embankment toe North End of Arthur Lane (27+630)	5029660.0	367131.5	72.8	N/A		2.7
RW7S	18-916	Highway 417 EB Embankment toe Chamberlain East of Glendale (28+270)	5029928.2	367723.2	67.1			4.8
	18-917	Highway 417 EB Embankment toe Chamberlain West of Lyon (28+330)	5029956.2	367774.1	66.3	7.5		
RW7S	18-918	Highway 417 EB Embankment toe Chamberlain East of Lyon (28+390)	5029986.3	367825.5	66.6			6.1

3.2 Previous Investigations

As part of the current assignment, previously collected subsurface information pertinent to the retaining wall sites was reviewed and compiled.

The Record of Borehole sheets from the previous investigations pertinent to the current sites are provided for reference in Appendix C. The borehole locations and ground surface elevations for these boreholes are shown on Drawings 7 and 8. The subsurface conditions within the boreholes from the previous investigations are referenced in Section 4.0, only with respect to the bedrock conditions.

3.2.1 Replacement of Sites 3-56/1 & 3-56/2

A foundation investigation was carried out for the rapid bridge replacement of the Highway 417 Overpass Structures at Rochester Street (Sites 3-56/1 and 3-56/2) by Golder in 2018 and 2019. The subsurface information and results of the investigation are contained in the report titled:

- *Foundation Investigation and Design Highway 417 Overpass Structures at Rochester Street Rapid Bridge Replacement Sites: 3-56/1 and 3-56/2, Ottawa, Ontario, dated July 2019, (Report No. 1655214-1110), GEOCREs No. 31G5-295.*

A total of 24 coreholes and four boreholes were advanced along Rochester Street and twelve boreholes within the Highway 417 approach embankments. In particular, Boreholes 17-114, 18-1103 and 18-1107 were advanced along the south side of Highway 417 in the general vicinity of retaining wall RW10N. In general, at the borehole locations the subsurface conditions consist of PCC sidewalk or topsoil at surface, overlying granular sand fill materials, all underlain by limestone bedrock.

3.2.2 Replacement of Sites 3-57/1 and 3-57/2

A foundation investigation was carried out for the rapid bridge replacement of the Highway 417 Overpass Structures at Booth Street (Sites 3-57/1 and 3-57/2) by Golder in 2018 and 2019. The subsurface information and results of the investigation are contained in the report titled:

- *Foundation Investigation and Design Highway 417 Overpass Structures at Booth Street Rapid Bridge Replacement Sites: 3-57/1 and 3-57/2, Ottawa, Ontario, dated July 2019, (Report No. 1655214-1120), GEOCREs No. 31G5-308.*

A total of 24 coreholes and four boreholes were advanced along Booth Street and eight boreholes within the Highway 417 approach embankments. In particular, Boreholes 17-122, 18-1204 and 18-1208 were advanced along the south side of Highway 417 in the general vicinity of retaining wall RW4S. Also, Boreholes 17-123, 17-124, 18-1203 were advanced along the north side of the highway in the general vicinity to retaining walls RW10N and RW11N. In general, at the borehole locations the subsurface conditions consist of PCC sidewalk or asphaltic concrete pavement at surface, overlying granular sand fill materials overlying, glacial till, all underlain by limestone bedrock.

3.2.3 Highway 417 Operational Improvements

A foundation investigation was carried out for the Highway 417 Operational Improvements at the Bronson Avenue Interchange and Off-Ramp Noise Barrier Wall by Thurber Engineering Ltd. in 2014. The subsurface information and results of the investigation are contained in the report titled:

- *Foundation Investigation and Design Report Bronson Avenue W-N/S Ramp Noise Barrier Wall Highway 417 Operational Improvements – Bronson Avenue Interchange Ottawa, Ontario, dated March 2014.* (File No. 19-1351-201D), GEOCREs No. 31G5-254.

A total of seven boreholes were advanced along the south side of the Highway 417. In particular, Boreholes NB-03 to NB-05, 17S-01 and 17S-02 were advanced in the general vicinity of retaining walls RW4S and RW5S. Boreholes NB-03 to NB-05 were terminated upon auger refusal on probable bedrock at depths ranging from 2.9 to 7.8 m. Boreholes 17S-01 and 17S-02 were drilled to depths of 10.4 and 7.3 m, including coring 3.0 and 3.1 m into bedrock respectively. At the borehole locations, the subsurface conditions consist of asphaltic concrete and PCC pavement overlying sandy fill materials underlain by limestone bedrock.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ testing from the current investigation are given on the Record of Borehole and Drillhole sheets presented in Appendix A. The results of the laboratory testing carried out during the current investigation are presented on the Record of Borehole sheets as well as on Figures B1 to B24 in Appendix B. The borehole locations and the interpreted stratigraphic profile projected along each retaining wall location are provided on Drawings 1 to 9.

Photographs of the core recovered from the concrete footings and underlying bedrock are shown on Figures A1 to A14 provided in Appendix A. The results of basic chemical analysis completed on select soil samples are provided in Appendix D.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic sections from Drawings 1 to 9 are inferred from observations of drilling progress and noncontinuous sampling and therefore represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

A detailed description of the overburden soil deposits is provided in Sections 4.2 to 4.11. A detailed description of the concrete footings where encountered is provided in Section 4.12. Auger refusal and bedrock geology where encountered at the borehole locations is discussed in detail in Sections 4.13 and 4.14 and groundwater conditions encountered during the field investigation is provided Section 4.15.

4.2 Retaining Wall 2N

Boreholes 18-801 and 18-802 were advanced at the location of RW2N at the toe of the highway embankment on the north side of Highway 417. The locations of the retaining wall and associated boreholes are shown on Drawing 1.

4.2.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with a thickness of 25 mm was encountered at the surface of Borehole 18-801.

Topsoil with a thickness of 0.2 m was encountered at the surface of Borehole 18-802.

4.2.2 Fill Materials

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete pavement at Borehole 18-801. The top of this layer was encountered at Elevation 67.4 m. The thickness of the fill is about 300 mm.

Fill consisting predominantly of sand with varying amounts of silt was encountered below the pavement structure fill at Borehole 18-801 and below the topsoil in Borehole 18-802. The top of this layer was encountered at elevations 67.1 and 69.4 m and the layer has thicknesses of 0.5 and 2.9 m in Boreholes 18-801 and 18-802, respectively. The measured moisture contents of the two samples tested were 13 and 14 percent. The results of grain size analysis testing carried out on two samples of this material are provided on Figure B1 in Appendix B.

Sand and gravel fill were encountered below the sand fill at Borehole 18-802, at Elevation 66.7 m, and is 0.3 m in thickness. The SPT blow count (i.e., > 50/0.150) noted on the Record of Borehole may have been influenced by the presence of the underlying concrete footing, rather than the state of packing of the soil matrix.

4.2.3 Glacial Till

Glacial till was encountered below the retaining wall footings in both boreholes. The glacial till generally consists of a heterogeneous mixture of sand and gravel within a soil matrix of silt and clay. The top of this layer was encountered at Elevations 65.3 and 65.5 m. The till was not fully penetrated but was proven to the depth of splitspoon refusal of 2.4 and 5.2 m, corresponding to Elevations 65.0 and 64.5 m in Boreholes 18-801 and 18-802 respectively. A SPT N value was 38 blows per 0.3 m of penetration indicating a dense state of packing.

The measured moisture contents of the two samples tested were 7 and 14 percent. The results of grain size analysis testing carried out on two samples of the glacial till are provided on Figure B2 of Appendix B.

4.3 Retaining Wall 5N

Boreholes 18-903 and 18-923 were advanced at the location of RW5N in front of and behind the existing retaining wall, respectively. The locations of the retaining wall and associated boreholes are shown on Drawing 2. Due to conflict with existing buried utilities, Borehole 18-903 was discontinued prior to reaching the required termination depth.

4.3.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with a thickness of 25 mm was encountered at the surface of Borehole 18-903.

Topsoil with a thickness of 0.2 m was encountered at the surface of Borehole 18-923.

4.3.2 Fill Materials

Fill consisting predominantly of sand with varying amounts of gravel and silt was encountered below the asphaltic concrete pavement in Borehole 18-903 and below the topsoil in Borehole 18-923. This layer was encountered at Elevations 71.6 and 71.9 m and is about 2.6 m in thickness in Borehole 18-923.

4.4 Retaining Wall 10N

Boreholes 18-906 and 18-907 were advanced at the location of RW10N, at the toe of the highway embankment on the north side of Highway 417. The locations of the retaining wall and associated boreholes are shown on Drawing 3.

4.4.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with thicknesses of 150 and 100 mm was encountered at the surface of Boreholes 18-906 and 18-907 respectively.

4.4.2 Fill Materials

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete pavement in both boreholes. This layer was encountered at Elevations 65.3 and 66.2 m and is 0.3 and 0.2 m in thickness at Boreholes 18-906 and 18-907, respectively.

Fill consisting predominantly of sand with varying amounts of silt was encountered below the pavement structure fill at Boreholes 18-906 and 18-907 at Elevations 65.1 to 66.0 m respectively. The thickness of the sand fill was 0.5 m in both boreholes. The measured moisture contents of the samples tested ranged from 8 to 10 percent. The results of grain size analysis testing carried out on two samples of the sand fill material are provided on Figure B3 in Appendix B.

A layer of sandy gravel fill was encountered in Borehole 18-907 below the sand fill. This layer was encountered at Elevation 66.5 m and is 0.5 m in thickness.

4.5 Retaining Wall 11N

Boreholes 18-908 and 18-909 were advanced at the location of RW11N at the toe of the highway embankment on the north side of Highway 417. The locations of the retaining wall and associated boreholes are shown on Drawing 3.

4.5.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with a thickness of 100 mm was encountered at the surface of Borehole 18-908.

Topsoil with a thickness of 0.2 m was encountered at the surface of Borehole 18-909.

4.5.2 Fill Materials

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete pavement in Borehole 18-908. This layer was encountered at Elevation 66.6 m and is 1.5 m in thickness. An SPT N value of 21 blows per 0.3 m of penetration was measured in this layer, indicating a compact state of packing. The high SPT blow count (i.e., > 50/0.150) noted on the Record of Borehole may have been influenced by the presence of the underlying bedrock, rather than the state of packing of the soil matrix. The measured moisture content of a single sample of the pavement structure fill was 5 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B4 in Appendix B.

Fill consisting predominantly of sand with varying amounts of silt and gravel was encountered below the topsoil in Borehole 18-909 at Elevation of 68.9 m and is 0.6 m in thickness.

4.5.3 Glacial Till

Glacial till was encountered below the sand fill in Borehole 18-909. The glacial till generally consists of a heterogeneous mixture of sand and gravel within a soil matrix of silt and clay and cobbles. The till was encountered at Elevation 68.3 m and is about 2.3 m in thickness. SPT N values of 13 and 32 blows per 0.3 m of penetration were measured in this layer, indicating a compact to dense state of packing. Cobbles and boulders were encountered in the till and coring techniques were required to advance the borehole through the till layer.

The measured moisture contents of two samples of the glacial till were about 8 percent. The results of grain size analysis testing carried out on two samples of this material are provided on Figure B5 in Appendix B.

4.6 Retaining Wall 13N

Boreholes 18-913 to 18-915 were advanced at the location of RW13N at the toe of the highway embankment on the north side of Highway 417. The locations of the retaining wall and associated boreholes are shown on Drawing 4.

4.6.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with thicknesses ranging from 50 to 100 mm was encountered at the ground surface at Boreholes 18-913, 18-914, and 18-915.

4.6.2 Fill Materials

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete pavement at all three boreholes. The top of this layer was encountered at elevations ranging from 66.8 to 68.1 m. The thickness of the pavement structure fill ranges from about 50 to 400 mm.

Fill consisting predominantly of sand with varying amounts of silt and gravel was encountered below the pavement structure fill in all three boreholes. The top of this layer was encountered at elevations ranging from 66.6 to 68.0 m. The thickness of the sand fill ranges from about 1.0 to 2.6 m. The SPT N values ranged from 4 to 7 blows per 0.3 m of penetration, indicating a loose state of packing. The measured moisture content of one sample of the sand fill layer was about 10 percent. The results of grain size analysis testing carried out on a single sample of this material provided on Figure B6 in Appendix B.

Fill consisting of a mixture of sand and peat, containing metal debris, was encountered beneath the sand fill in Borehole 18-914. The layer was encountered at Elevation 66.0 m and is about 0.5 m in thickness.

Sandy gravel fill was encountered beneath the sand fill in Borehole 18-913, at Elevation 64.5 m. The thickness of the sandy gravel fill is about 1.3 m. An SPT N value of 19 blows per 0.3 m of penetration was measured in this layer, indicating a compact state of packing. Strong hydrocarbon odour was noted in this layer. Further details with regards to the material handling, reuse and/or disposal of environmentally impacted materials are provided in WSP's 2018 Phase II ESA and Earth Management Plan Reports, which are provided under separate cover.

4.6.3 Silty Sand

Silty sand was encountered beneath the sand fill in Borehole 18-915. This layer was encountered at Elevation 64.4 m and is about 1.0 m in thickness. An SPT N value of 7 blows per 0.3 m of penetration was measured in this layer, indicating a loose state of packing.

4.6.4 Peat

Peat was encountered beneath the fill materials in Borehole 18-914. The peat was encountered at Elevation 65.5 m and is about 0.6 m in thickness.

4.6.5 Silty Clay

Silty clay was encountered beneath the peat in Borehole 18-914. This layer was encountered at Elevation 64.9 m and is about 0.5 m in thickness.

4.6.6 Glacial Till

Glacial till was encountered below the fill materials at Borehole 18-913, below the silty clay at Borehole 18-914 and below the silty sand at Borehole 18-915. The glacial till generally consists of a heterogeneous mixture of sand and gravel within a soil matrix of silt. This deposit was encountered at elevations ranging from 63.2 to 64.5 m and is about 0.6 to 3.3 m in thickness. The SPT N values ranged from 6 to 31 blows per 0.3 m of penetration indicating a loose to dense state of packing. The higher blow counts (i.e., > 50/0.150) noted on the Record of Boreholes may have been influenced by the presence of the underlying bedrock, rather than the state of packing of the soil matrix.

The measured moisture contents of three samples of the glacial till ranged from 8 to 11 percent. The results of grain size analysis tests carried out on two samples of the glacial till are provided on Figure B7 in Appendix B. The results of an Atterberg Limits test completed on a single sample of this material indicated a liquid limit value of 19, a plastic limit value of 12 and a plasticity index value of 7. The Atterberg Limits analysis results are provided on Figure B8 in Appendix B and indicate that the fines portion of the till is clayey silt to silt (CL-ML) of low plasticity.

4.7 Retaining Wall 1S

Boreholes 18-901 and 18-902 were advanced at the location of RW1S at the toe of the highway embankment on the south side of Highway 417. The locations of the retaining wall and associated boreholes are shown on Drawing 5.

4.7.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with a thickness of 100 mm was encountered at the ground surface at both boreholes.

4.7.2 Fill Materials

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete pavement at Elevation 69.9 m at both boreholes. The thickness of the pavement structure fill is 500 and 200 mm at Boreholes 18-901 and 18-902 respectively.

Fill consisting predominantly of sand with varying amounts of silt and gravel was encountered below the pavement structure fill in both boreholes. The top of this layer was encountered at elevations ranging from 69.4 to 69.7 m. The thickness of the sand fill is 0.9 and 0.3 m in Boreholes 18-901 and 18-902, respectively. The measured moisture content of a single sample of the sand fill was about 20 percent. The results of a grain size analysis test carried out on a single sample of this material is provided on Figure B9 in Appendix B.

4.7.3 Buried Topsoil

Buried topsoil was encountered beneath the fill materials at Borehole 18-902 at Elevation 69.4 m and is about 0.2 m in thickness.

4.7.4 Silty Sand to Sand

Sand with varying amounts of silt was encountered beneath the fill materials in both boreholes. This deposit was encountered at Elevations 68.5 and 69.2 m and is 3.1 to 3.8 m in thickness at Boreholes 18-901 and 18-902, respectively. The SPT N values ranged from 10 to 37 blows per 0.3 m of penetration, indicating a compact to dense state of packing.

The measured moisture content of a single sample of this material was about 12 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B10 in Appendix B.

4.7.5 Glacial Till

Glacial till was encountered below the silty sand to sand in both boreholes. The glacial till generally consists of a heterogeneous mixture of sand and silt with varying amounts of gravel. This layer was encountered at Elevation 65.4 m in both boreholes and is about 1.6 to 1.7 m in thickness. The SPT N values ranged from 18 to 44 blows per 0.3 m of penetration indicating a compact to dense state of packing.

The measured moisture contents of three samples of the glacial till ranged from 10 to 12 percent. The results of grain size distribution testing carried out on three samples of the glacial till are provided on Figure B11 in Appendix B.

4.8 Retaining Wall 2S

Borehole 18-904 was advanced at the location of RW2S in the eastbound shoulder of Highway 417. The locations of the retaining wall and associated borehole are shown on Drawing 6.

4.8.1 Surface Cover / Surficial Materials

Topsoil with a thickness of 50 mm was encountered at the surface of Borehole 18-904.

4.8.2 Fill Materials

Fill consisting predominantly of sand with varying amounts of gravel was encountered below the topsoil in Borehole 18-904. The top of this layer was encountered at Elevation 70.9 m and the layer is about 1.2 m in thickness. The measured moisture content of one sample of the fill layer was about 12 percent. The results of grain size analysis testing carried out on a single sample of this material provided on Figure B12 in Appendix B.

4.8.3 Glacial Till

Glacial till was encountered below the retaining wall footing at Elevation 68.9 m in Borehole 18-904. The glacial till generally consists of a heterogeneous mixture of sand and gravel within a soil matrix of silt and clay. The till was not fully penetrated but was proven to extend to a depth of 4.0 m below existing grade (i.e., Elevation 67.0 m).

The measured moisture content of one sample of the glacial till was about 12 percent. The results of grain size distribution testing carried out on a single sample of this material provided on Figure B13 of Appendix B.

4.9 Retaining Wall 4S

Boreholes 18-910 and 18-911 were advanced during the current investigation at the location of RW4S, at the toe of the highway embankment on the south side of Highway 417.

A total of six boreholes were advanced along the proposed alignment for RW4S during the previous investigations. Boreholes 18-1204, 18-1208, NB-03, 17S-01, 17S-02 were advanced through the highway embankment to the north of the proposed alignment while Borehole 17-122 was advanced at the toe of the highway embankment on the south side of Highway 417.

The locations of the retaining wall and associated boreholes are shown on Drawing 7.

4.9.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with a thickness of 150 mm was encountered at ground surface at Boreholes 18-910 and 18-911.

4.9.2 Fill Materials

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete pavement at Boreholes 18-910 and 18-911. This layer was encountered at Elevations 72.0 and 72.8 m and is about 1.2 and 0.8 m in thickness at Boreholes 18-910 and 18-911 respectively.

Fill consisting predominantly of sand with varying amounts of gravel and silt was encountered below the pavement structure fill at Boreholes 18-910 and 18-911. This sand fill layer was encountered at Elevations 70.9 and 72.1 m and is 1.8 to 2.4 m in thickness. The measured moisture contents of two samples of this material were about 9 and 15 percent. The results of grain size distribution testing carried out on two samples of the gravel and sand fill are provided on Figure B14 of Appendix B.

4.9.3 Silt and Sand

Silt and sand were encountered beneath the sand fill in Borehole 18-910. This deposit was encountered at Elevation 69.1 m and is about 0.6 m in thickness. A SPT N value of 20 blows per 0.3 m of penetration was recorded in this deposit, indicating a compact state of packing.

The measured moisture content of one sample of this material was about 22 percent. The results of grain size analysis testing carried out on a single sample of the silt and sand are provided on Figure B15 in Appendix B.

4.10 Retaining Wall 5S

Borehole 18-912 was advanced during the current investigation at the location of RW5S at the toe of the highway embankment on the south side of the Highway 417.

A total of two boreholes were advanced along the proposed alignment for RW5S during the previous investigations. Boreholes NB-04 and NB05 were advanced through the highway embankment to the north of the proposed alignment.

The locations of the retaining wall and associated boreholes are shown on Drawing 8.

4.10.1 Surface Cover / Surficial Materials

Asphaltic concrete pavement with a thickness of 100 mm was encountered at the surface at Borehole 18-912.

4.10.2 Fill Materials

Pavement structure fill consisting predominantly of sand and gravel with varying amounts of silt was encountered below the asphaltic concrete pavement in Borehole 18-912. This layer was encountered at Elevation 72.7 m and is about 0.7 m in thickness. Debris, consisting of metal fragments, was noted in the pavement structure fill. The measured moisture content of one sample of this material was about 26 percent. The results of grain size analysis testing carried out on a single sample of the fill provided on Figure B16 in Appendix B.

4.11 Retaining Wall 7S

Boreholes 18-916 to 18-918 were advanced at the location of RW7S at the toe of the highway embankment on the south side of Highway 417. The location of the retaining wall and associated boreholes are shown on Drawing 9.

4.11.1 Surface Cover / Surficial Materials

Topsoil with a thickness of 0.2 m was encountered at the ground surface at Borehole 18-916.

Asphaltic concrete pavement with a thickness of 100 mm was encountered at the ground surface at Boreholes 18-917 and 18-918.

Portland cement concrete (PCC) was encountered beneath the asphaltic concrete pavement with thicknesses of 300 and 400 mm at Boreholes 18-917 and 18-918, respectively.

4.11.2 Fill Materials

Sand fill was encountered below the PCC pavement at Boreholes 18-917 and 18-918 at Elevations 65.9 and 66.1 m respectively. The thickness of the sand fill is 0.8 and 1.5 m. Debris, including brick fragments, was observed at Borehole 18-918. The measured moisture content of a single sample of the sand fill was about 4 percent. The results of grain size analysis testing carried out on single sample of this material is provided on Figure B17 in Appendix B.

Fill consisting predominantly of sand and gravel was encountered below the topsoil at Borehole 18-916 and the sand fill at Boreholes 18-917 and 18-918. The top of this layer was encountered at elevations ranging from 64.6 to 66.9 m. The thickness of this layer ranges from about 0.7 to 1.3 m. This layer was observed to contain debris including brick, concrete, wood, glass, and porcelain fragments, mixed with rock fill. The measured moisture content of a single sample of this material was about 16 percent. The results of grain size analysis testing carried out on a single sample of the sand and gravel fill are provided on Figure B18 in Appendix B.

Sandy clayey silt fill was encountered beneath the sand and gravel fill in Borehole 18-916. This layer was encountered at Elevation 65.6 m and is about 2.0 m in thickness. Debris, including brick, concrete, wood, glass, and metal fragments, was observed throughout the layer.

Gravelly silty sand fill was encountered beneath the clayey silt fill at Borehole 18-916. This layer was encountered at Elevation 63.6 m and is about 0.9 m in thickness. A SPT N value of 20 blows for 0.3 m of penetration was measured in this layer indicating a compact state of packing. The measured moisture content of one sample of the silty sand fill layer was about 7 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B19 in Appendix B.

4.11.3 Clayey Silt

Clayey silt was encountered beneath the fill materials at Borehole 18-918. This layer was encountered at Elevation 64.0 m and is about 0.5 m in thickness.

The measured moisture content of a single sample of this material was about 31 percent. The results of an Atterberg Limits test completed on a single sample of the clayey silt indicated a liquid limit value of 23, a plastic limit value of 14 and a plasticity index value of 9. The Atterberg Limits analysis results are provided on Figure B20 in Appendix B and indicate a clayey silt of low plasticity (CL).

4.11.4 Sand

Sand with varying amounts of silt was encountered beneath the gravelly sand fill at Borehole 18-917. This layer was encountered at Elevation 63.8 m and is about 1.5 m in thickness. A SPT N value of 7 blows for 0.3 m of penetration was measured in this layer, indicating a loose state of packing.

4.11.5 Sandy Silt

Sandy silt was encountered beneath the clayey silt at Borehole 18-918. This layer was encountered at Elevation 63.4 m and is about 2.1 m in thickness. The SPT N values ranged from 15 to 19 blows per 0.3 m of penetration, indicating a compact state of packing.

The measured moisture content of one sample of the sandy silt was about 20 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B21 in Appendix B.

4.11.6 Glacial Till

Glacial till was encountered below the sand and silt deposits at both boreholes. The glacial till generally consists of a heterogeneous mixture of sand and silt within a soil matrix of gravel, clay and cobbles. The glacial till deposit was not fully penetrated but was proven to the depths of auger refusal at 7.5 and 6.1 m below the existing grade at Boreholes 18-917 and 18-918, respectively. The SPT N values ranged from 4 to 21, indicating a loose to compact state of packing.

The measured moisture contents of four samples of the glacial till ranged from about 5 to 14 percent. The results of grain size distribution testing carried out on two samples of this material are provided on Figure B22 in Appendix B. The results of an Atterberg Limits test completed on a single sample of glacial till material encountered at Borehole 18-918 indicate a liquid limit value of 20, a plastic limit value of 13 and a plasticity index value of 7. The Atterberg Limits analysis results are provided on Figure B23 in Appendix B and indicate a clayey silt to silt of low plasticity (CL-ML).

4.12 Concrete Footings

The existing concrete footings for retaining walls RW2N, RW5N and RW2S were cored in order to assess the quality and compressive strength of the concrete and assess the existing founding material. Table 4 summarizes the top of footing elevation, the footing thickness, the anticipated founding material and the results of unconfined compression tests carried out on the concrete cores.

Photographs of the concrete core from the current investigation are provided on Figures A1 to A6, A13 and A14 in Appendix A.

Table 4: Concrete Retaining Wall Footing Summary

Retaining Wall	Borehole	Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Footing Thickness (m)	Concrete Footing UCS Test Results (MPa)	Anticipated Founding Material
RW2N	18-801	67.4	66.6	1.1	26.4	Bedrock
	18-802	69.7	66.3	1.0	N/A	
RW5N	18-923	72.1	69.3	0.6	47	
RW2S	18-904	71.0	69.8	0.9	N/A	Glacial Till

4.13 Auger Refusal

Bedrock was not proven by coring at most retaining wall locations. Auger or sampler refusal was however encountered at several borehole locations.

Based on boreholes from previous investigations along Highway 417, auger/sampler refusal could represent the presence of cobbles and boulders in the fill or glacial till or the bedrock surface.

Table 5 summarizes the auger refusal depths and elevations as encountered at the borehole locations, from both the current and previous investigations, referenced to the particular retaining wall.

Table 5: Summary of Depths to Auger or Sampler (indicated with *) Refusal

Retaining Wall	Borehole	Existing Ground Surface Elevation (m)	Depth to Auger Refusal (m)	Elevation of Auger Refusal (m)
RW2N	18-801	67.4	2.4*	65.0
	18-802	69.7	5.2*	64.5
RW10N	18-906	65.5	0.9	64.6
	18-907	66.3	1.3	65.0
RW13N	18-913	66.9	5.5	61.4
	18-914	67.5	3.7	63.8
	18-915	68.1	7.0	61.1
RW1S	18-901	70.0	6.3	63.7
	18-902	70.0	6.2	63.8
RW4S	18-910	72.1	3.7	68.4
	18-911	72.9	3.3	69.6
	18-1208	72.9	7.6	65.3
	NB-03	73.3	7.8	65.6
RW5S	NB-04	74.7	2.9	71.7
	NB-05	73.5	4.7	68.8
RW7S	18-916	67.1	4.8	62.3
	18-917	66.3	7.5	58.8
	18-918	66.6	6.1	60.5

4.14 Bedrock

Regional bedrock mapping indicates that the retaining wall locations are underlain by limestone bedrock.

Bedrock was proven by coring using a combination of NQ and HQ sized equipment in Boreholes 18-908, 18-909, 18-912 and 18-923. Photographs of the bedrock core from the current investigation are provided in Appendix A.

Weathered bedrock was encountered during SPT testing at Elevations 72.0 and 62.7 m in Boreholes 18-912 and 18-916, respectively.

Bedrock was also proven by coring using NQ sized equipment in Boreholes 17-114, 17-122 to 17-124, 18-1103, 18-1107, 18-1204, 18-1203, 18-1204, 17S-01 and 17S-02 during the previous investigations.

Table 6 summarizes the depths and the elevations of the bedrock surface as encountered at the borehole locations from both the current and previous investigations.

Table 6: Summary of Bedrock Surface Depths and Elevations

Retaining Wall	Borehole	Existing Ground Surface Elevation (m)	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	UCS Test Results (MPa)
RW5N	18-923	72.1	3.4	68.7	29
RW10N	17-114	63.8	1.1	62.7	60
	18-1103	66.3	3.3	63.0	N/A
	18-1107	68.9	5.3	63.6	N/A
	17-123	66.3	1.2	65.2	N/A
RW11N	17-124	66.4	0.9	65.5	N/A
	12-1203	68.7	3.7	65.0	N/A
	18-908	66.7	1.6	65.1	66
	18-909	69.1	3.1	66.0	N/A
RW4S	17-122	66.7	1.0	65.7	N/A
	18-1204	70.5	5.3	65.2	70
	17S-01	73.7	7.4	66.3	N/A
	17S-02	74.1	4.2	69.9	N/A
RW5S	18-912	72.8	1.2	71.6	72

The bedrock encountered during coring operations was slightly weathered to fresh and thinly to medium bedded limestone. Thin shale partings were also present in the bedrock core. Rock Quality Designation (RQD) values measured on recovered bedrock core samples from the current investigation ranged from about 52 to 100 percent, indicating a fair to excellent quality rock

The results of UCS testing carried out on three bedrock core samples from the current investigation are summarized in Table 6; are presented on Figure B24 provided in Appendix B; and, indicate a medium strong to strong bedrock.

4.15 Groundwater Conditions

Monitoring wells were installed in Boreholes 18-902, 18-911, 18-913 to 18-917 to observe the stabilised groundwater level across the various retaining wall sites.

Table 7 summarizes the depths and the elevations of the groundwater levels measured in the monitoring wells installed during the current investigation at the retaining wall sites. All monitoring wells were measured on June 19, 2019 and then decommissioned.

It is expected that the groundwater levels will be subject to fluctuations both seasonally and as a result of precipitation events.

Table 7: Summary of Groundwater Conditions

Retaining Wall	Borehole	Screened Interval	Depth (m)	Elevation (m)
RW13N	18-913	Fill / Glacial Till	3.1	63.9
	18-914	Fill / Peat / Silty Clay / Glacial Till	2.0	65.5
	18-915	Fill / Sand / Glacial Till	2.4	65.7
RW1S	18-902	Sand / Glacial Till	2.9	67.2
RW4S	18-911	Fill	3.1	69.8
RW7S	18-916	Fill	2.3	64.9
	18-917	Glacial Till	1.8	64.5

4.16 Steel Corrosion and Sulphate Attack, Chemical Analysis

A total of eight soil samples were submitted to Eurofins Environmental Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D and are summarized in Table 8.

Table 8: Steel Corrosion and Sulphate Attack, Chemical Analysis

Retaining Wall	Borehole	Sample (Depth)	Sample Type	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
RW2N	18-802	SS3 (1.2 – 1.8)	Fill	0.027	<0.01	0.64	9.7	1,560
RW10N	18-907	SS2 (0.8 – 1.1)	Fill	0.008	<0.01	0.50	9.4	2,000
RW11N	18-909	SS1B (0.5 – 0.8)	Fill	0.006	0.04	0.41	8.1	2,440
RW13N	18-913	SS2 (0.8 – 1.4)	Fill	0.031	<0.01	0.70	8.3	1,430
RW1S	18-901	SS4 (2.1 – 2.7)	Silty Sand	0.007	<0.01	0.29	9.1	3,450
RW4S	18-910	SS1 (1.3 – 1.7)	Fill	0.016	0.02	0.50	8.4	2,000
RW7S	18-917	SS4 (2.5 – 3.1)	Sand	0.051	<0.01	0.73	9.6	1,370
	18-917	SS8 (5.3 – 5.9)	Glacial Till	0.023	0.02	0.38	8.5	2,630

5.0 CLOSURE

This report was prepared by Mr. Kenton Power, P.Eng. It was reviewed by Mr. Bill Cavers, P.Eng., a Senior Geotechnical Engineer and Associate with Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

Golder Associates Ltd.



Kenton C. Power, P.Eng., M.A.Sc.
Geotechnical Engineer



Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

KCP/FJH/hdw

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PART B

Foundation Design
Retaining Wall Rehabilitation and Replacement
Highway 417 from Holland Avenue to Kent Street
Ottawa, Ontario

6.0 FOUNDATION ENGINEERING RECOMMENDATIONS

6.1 General

This report presents the results of the foundation investigation carried out for the rehabilitation/replacement of ten Highway 417 retaining wall structures between Holland Avenue and Kent Street in the City of Ottawa. The input provided herein is based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation, as well as the available GEOCRESS information for the sites, and in accordance with the current Canadian Highway Bridge Design Code CAN/CSA-S6-14 (CHBDC).

The foundation investigation report, discussion, and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

A general description of the analysis methods and general guidelines for design of the retaining walls being replaced are provided in Section 6.2 of this report.

6.2 Proposed Structures

The proposed works related to the rehabilitation or replacement of the existing retaining walls are based on information provided on the Retaining Wall Summary sheet, dated June 2019, and on the revised 60% Contract Drawings provided by WSP on November 8, 2019. Copies of the reference information has been provided after the text of this report.

Table 9 summarizes the proposed rehabilitation or replacement options for the retaining walls under consideration.

It is understood that no further foundation design properties or recommendations are required for the retaining walls that are proposed for rehabilitation, other than those provided in Section 4 of this report, and as such these retaining walls are not discussed further in the following sections.

Table 9: Summary of Rehabilitation/Replacement Options for each Retaining Wall

Retaining Wall	Highway 417 Stationing Direction	Location	Proposed Rehabilitation or Replacement
RW10N	27+256 to 27+356 Westbound	South side of Raymond Rochester to Booth	Replacement RSS wall
RW11N	27+380 to 27+412 Westbound	South side of Raymond Booth to LeBreton	Replacement RSS wall
RW13N	28+168 to 28+301 Westbound	Lyon onramp to Bronson offramp	Replacement RSS wall
RW1S	35+440 to 35+490 Eastbound	South of highway at north end of Hinton	Replacement Post and Panel
RW4S	27+394 to 27+586 Eastbound	South of highway along Orangeville from Booth to Bell	Replacement Post and Panel and Cast-in-place Cantilever RW
RW5S	27+617 to 27+689 Eastbound	South of highway along EB offramp to Bronson	Replacement Cast-in-place Cantilever RW
RW7S	28+378 to 28+437 Eastbound	South of highway along Chamberlain from Glendale and Kent	Replacement Redi-Rock Block Wall
RW2N	25+201 to 25+357 Westbound	Harmer to Holland	Rehabilitation (refacing)
RW5N	25+960 to 26+077 Westbound	East of Parkdale offramp at Sherbrooke	Rehabilitation (refacing/patching)
RW2S	25+983 to 26+103 Eastbound	East of Parkdale onramp Reid towards Fairmont	Rehabilitation (refacing/patching)

6.3 Retaining Wall Options

The following outlines the retaining wall options that have been considered for the proposed replacement locations for this project. The preferred retaining wall option will depend on property constraints, appearance, performance and cost considerations. Section 8 provides the preferred retaining wall option from a geotechnical perspective for each retaining wall. The following is a general summary of the geotechnical considerations for the design and construction of the particular retaining wall types.

1) Reinforced Soil System Walls

The design of proprietary retained soil systems (RSS) is the responsibility of the proprietary supplier/designer. Typically, such systems do not require full frost protection as they are able to tolerate some movement due to frost heave. The RSS system should be designed in accordance with the MTO RSS Design Guidelines. RSS systems are typically built with geogrid reinforcing straps which forms the reinforce soil mass (zone) behind the front face. Checking the wall design for internal stability is the responsibility of the proprietary supplier/designer. As per Sections 5.3 and 5.4.3 of the RSS Guidelines, the base of the reinforced mass of the RSS system will extend back from the wall to at least 80 percent of the height of the wall, although the reinforced mass may extend a greater distance if the wall is founded on low strength soils. Where founded in soil, the concrete leveling pad of an RSS system should be placed on a pad of compacted Granular A pad.

RSS vertical walls are geotechnically feasible and can be considered for the retaining walls required as part of the Highway 417 widening project. Vertical slip joints (typically spaced at 10 to 20 m) can be used to accommodate differential settlement of RSS walls, however the differential settlement along each section between slip joints should not exceed 35 mm. MTO RSS Design Guidelines recommends RSS systems should only be considered where there is sufficient property to construct the reinforced mass behind the wall at a width of approximately 80 percent of the proposed wall height.

2) Concrete Retaining Walls on Shallow Foundations:

This type of wall and foundation can be considered where the total post-construction settlements will be less than approximately 25 mm and should be considered where retaining walls can be typically founded on native glacial till or bedrock or on properly placed and compacted engineered fill overlying native materials or bedrock. This style of retaining wall uses the weight of the concrete wall and retained soil behind to resist overturning and lateral movement of the system. Concrete retaining walls require full depth frost protection and hence require a deeper excavation than would be required for RSS walls and could limit their use in areas where existing buried utilities are present.

3) Interlocking Concrete Block Wall

The design of proprietary concrete block wall components is the responsibility of the supplier. Typically, such systems do not require full frost protection as they are able to tolerate some movement due to frost heave and usually require less excavation depth than a conventional cast-in-place concrete retaining wall. This style of retaining wall typically uses the weight of the concrete blocks to resist overturning and provide support for the retained soils behind the wall. The blocks are founded on/within a compacted granular leveling pad placed along the whole length of the retaining wall. Depending on the height of the wall and proprietary design, reinforcing straps or geogrids can be used which forms the reinforced soil mass (zone) behind the blocks. Wall systems with reinforcing straps or geogrids can only be used where there is sufficient property available behind the wall to construct the reinforced zone. Blocks that make up the front face of the wall vary in size and usually have cast-in shear keys for additional lateral resistance. Typically, the first course of concrete blocks is founded on a compacted Granular A pad.

4) Post and Panel Walls Supported on Deep Foundations

Constructed similarly to noise barrier walls, this style of wall is supported on caissons augured to sufficient depths to provide the required lateral and end bearing resistances. Typically, the maximum wall heights for this type of system is 3.0 m. Where soil depths are insufficient to provide the required lateral resistance caissons can be socketed a nominal depth into bedrock (usually up to 1.0 m), this however does impact cost and installation time. It should be noted that the passive resistance in front of the caissons within frost penetration depth (i.e. 1.8 m for this project) should be neglected to account for frost action.

6.4 Seismic Design

6.4.1 Seismic Hazard and Importance Category

The CHBDC states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC). The current seismic hazard maps (referred to as the 5th generation seismic hazard maps) were developed by the GSC and were made available for public use in December 2015.

In accordance with Section 4.4.2 of the CHBDC, it is understood that Highway 417 at these locations has been given an importance category of “Major Route”.

6.4.2 Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy below the founding elevation. Table 10 summarizes the seismic site classification at each of the replacement retaining wall locations based on the soil conditions encountered below the anticipated founding elevation, in accordance with Table 4.1 of the CHBDC.

Table 10: Summary of Seismic Site Classification for each Replacement Retaining Wall Site

Retaining Wall	Approximate Underside of Foundation Elevation (m)	Seismic Site Class
RW10N	65 to 63	B*
RW11N	66 to 65	B*
RW13N	65 to 63	D
RW1S	65 to 64	C
RW4S	69 to 66	C or B*
RW5S	72 to 69	C or B*
RW7S	64 to 65	D

*Assumed to be founded on bedrock.

The Site Class should be re-evaluated if the founding elevations or conditions assumed in the above table change during design.

6.4.3 Spectral Response Values and Seismic Performance Category

The 2015 National Building Code Seismic Hazard Calculation data sheets for each of the retaining wall sites was obtained from Earthquakes Canada (www.earthquakescanada.nrcan.gc.ca). Due to the close proximity of the retaining wall sites there was negligible difference in the peak seismic hazard values obtained for each, hence the values from the RW10N, generally central to the various locations was used as the baseline value for the following seismic evaluation.

In accordance with Section 4.4.3.1 of the CHBDC and based on the location of the RW10N (latitude 45.40 N longitude 75.70 W), the values provided in Table 11 are the reference Site Class C (reference) peak seismic hazard values based on data obtained from Earthquakes Canada.

Table 11: Site Class C Spectral Values for Subject Site

Parameter	2% Probability of Exceedance in 50 Years (2,475-year) (g)
PGA	0.280
T ≤ 0.2 s	0.438
T = 0.5 s	0.237
T = 1.0 s	0.118
T = 2.0 s	0.056
T = 5.0 s	0.015
T ≥ 10.0 s	0.005

The values given in Table 11 are for the reference ground condition Site Class C and must be modified to the site-specific seismic site classification provided in Table 13 for retaining wall sites with a Site Class B and Site Class D in accordance with Section 4.4.3 of the CHBDC. As indicated in Section 4.4.3.3 of the CHBDC, the value of PGA_{ref} for use with Tables 4.2 to 4.9 shall be taken as 80 percent of the PGA for Site Class C where $S_a(0.2)/PGA$ is less than 2.0. Based on this requirement a PGA_{ref} value of 0.224g was used for the 2,475-year return period. The corresponding site-specific Site Class B and Site Class D seismic hazard values given in Table 12 can be used for design.

Table 12: Site Class B and D Spectral Values for Subject Site

Parameter	2% Probability of Exceedance in 50 Years (2,475-year) (g)	
	Site Class B Sites	Sites Class D Sites
PGA	0.244	0.301
T ≤ 0.2 s	0.337	0.468
T = 0.5 s	0.154	0.302
T = 1.0 s	0.074	0.162
T = 2.0 s	0.035	0.080
T = 5.0 s	0.010	0.022
T ≥ 10.0 s	0.003	0.007

7.0 FOUNDATION DESIGN DISCUSSION

7.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the CHBDC and its Commentary, Highway 417 may be classified as having large traffic volumes and its performance as having potential impacts on other transportation corridors, hence having a “typical” consequence level associated with exceeding limits states design. Given the level of foundation investigation completed to date as presented in Sections 3.0 and 4.0, in comparison to the degree of site understanding in Section 6.5 of the CHBDC, the level of confidence for design is considered to be a “typical degree of site and prediction model understanding” for this site. Accordingly, the appropriate corresponding ULS and SLS consequence factor, ψ of 1.0, and geotechnical resistance factors from Tables 6.1 and 6.2 of the CHBDC have been used for design, as indicated in the following sections.

For seismic design, the consequence factor, Ψ , and resistance factor, ϕ_{gu} , should be taken as unity, as per Section 4.6.3 of the CHBDC.

7.2 General

The design and construction considerations geotechnical recommendations at each retaining wall location are presented in Section 8. A summary comparison of the advantages, disadvantages, relative costs, and risks associated with the retaining wall options at each location is presented in Tables 31 to 36 following the text of this report.

Although various retaining wall options have been considered from a foundation perspective for each location, design and construction recommendations have only been provided for the structurally preferred options as outlined in Table 9 .

7.2.1 Frost Protection

As per Ontario Provincial Standard Drawing (OPSD) 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario*), the frost penetration depth at the site is 1.8 m below the existing ground surface. Footings constructed at these sites (i.e., for concrete retaining walls on shallow foundations not founded on bedrock) should have a minimum embedment depth of 1.8 m for frost protection purposes. Also, the passive resistance within the upper 1.8 m below ground surface should be neglected for any deep foundation type to account for frost action.

7.2.2 Groundwater and Surface Water Control

The Contractor must be prepared to control the groundwater and surface water flow at the various sites to permit the excavation of the existing embankment, the removal of any existing retaining walls and the installation of the proposed retaining walls in dry and stable excavations.

Site specific groundwater control recommendations are provided for each retaining wall site in Section 8; however, the selection and design of temporary unwatering/dewatering system is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the required systems in accordance with MTO SPFOUN0003 (*Dewatering Structure Excavations*) which amends OPSS 902 and OPSS.PROV 517 (*Dewatering*) with amendments as per SP 517F01 (*Dewatering System*).

7.2.3 Erosion Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes behind the retaining walls. The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site as per OPSS.PROV 805 (*Temporary Erosion and Sediment Control Measures*).

To reduce erosion of the embankment side slopes above or below the retaining walls due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection should be in accordance with OPSS.PROV 804 (*Seed and Cover*).

7.2.4 Temporary Protection Systems

Site specific recommendations for temporary protection systems are provided for the various retaining wall sites in Section 8, however it should be noted that the design of the shoring will be entirely the responsibility of the contractor.

Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*), and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities and roadways can tolerate this magnitude of deformation. Traffic

loading should be included as a surcharge load in the design of the protection system. Traffic loading does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm those load requirements.

7.2.5 Geotechnical Bearing Resistances

Site specific bearing resistance values for the various retaining wall sites are provided in Section 8. The factored geotechnical resistances provided in those sections include the following factors:

- Geotechnical resistance factors (CHBDC Table 6.2):
 - Consequence factor (Ψ) of 1.0
 - Bearing (ULS), $\phi_{gu} = 0.5$ (static analysis; typical degree of understanding)
 - Settlement (SLS), $\phi_{gs} = 0.8$ (static analysis; typical degree of understanding)

The factored geotechnical resistance values at SLS provided for the retaining wall foundations corresponds to a stress increase relative to current site conditions that will result in 25 mm of total settlement.

The geotechnical resistances provided in Sections 8 are for vertical concentric loading and will need to be adjusted for the effects of inclined or eccentric loading, if applicable. The geotechnical resistance should be calculated as illustrated in the CHBDC Clause 6.10.3 and Clause 6.10.4.

7.2.6 Corrosion and Cement Type

Eight soil samples from the various retaining walls under consideration for replacement were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The sulphate results in Table 9 of this report, were compared with Table 3 of Canadian Standards Association Standards A23.1-14 (CSA A23.1) and generally indicate a low degree of sulphate attack potential on concrete structures at this site. Accordingly, GU cement could be specified for concrete in below grade applications.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. Generally, the test results provided in Table 9 indicate a moderate to high potential for corrosion of exposed ferrous metal at the site which should be considered in the design.

7.3 Lateral Earth Pressures for Design

The lateral earth pressures acting on the retaining walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of any surcharge loading including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The lateral earth pressure parameters provided in Tables 13 and 14 in the following sections are based on the assumption that the backfill material is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures behind the retaining walls should be considered in the design.

It is considered critical to the design of RSS or block retaining walls that the reinforced mass backfill consist of a free draining material and that proper drainage measures, such as subdrains, be provided behind the walls to prevent any buildup of hydrostatic groundwater pressure acting on the walls.

It is anticipated that the backfill behind all retaining walls will consist of either compacted OPSS.PROV 1010 Granular A or Granular B Type II material placed and compacted in accordance with OPSS.PROV 501. Backfill requirements from any proprietary wall system supplier/designer must also be confirmed.

A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC Section 6.12.3 and Figure 6.6. Care must be taken during the compaction operation not to overstress the walls. Heavy construction equipment should be maintained at a distance of at least 1 m away from the walls while the backfill soils are being placed. Hand operated compaction equipment should be used to compact the backfill soils within a 1 m wide zone adjacent to the walls. Other surcharge loadings should be accounted for in the design, as required.

For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.8 m behind the back of the wall (Case (a) on Figure C6.20 of the Commentary to the CHBDC). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at 1.5H:1V extending up and back from the rear face of the retaining wall footing or base of wall, (Case (b) on Figure C6.20 of the Commentary to the CHBDC).

7.3.1 Static Lateral Earth Pressures for Design

The following guidelines and recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressures assume that the ground above the wall will be flat, not sloping. If the inclination of the slope above the wall changes, then new lateral earth pressures will need to be calculated.

For Case (a), the pressures are based on the proposed embankment fill materials outside backfill zone and for Case (b) the pressures are based on the material within the backfill zone. Table 13 provides the unfactored parameters to be used for both Case (a) for existing embankment fill material or Case (b) for Granular A or Granular B Type II materials.

If lateral movement is not permissible and/or the wall is retained from lateral yielding, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls. For static analysis of permanent structures, passive earth resistance should be ignored, and therefore has not been provided. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the Commentary to the CHBDC.

Table 13: Static Lateral Earth Pressure Coefficients, Granular A, B Type II and Existing Earth Embankment Fill

Soil Type	Internal Angle of Friction (ϕ°)	Unit Weight (γ , kN/m ³)	Coefficients of Earth Pressure	
			Active, K_a	At-Rest, K_o
Granular A	35	22	0.27	0.43
Granular B Type II	35	21	0.27	0.43
Existing Earth Embankment Fill	30	19	0.33	0.50

7.3.2 Seismic Lateral Earth Pressures for Design

Seismic (earthquake) loading must be taken into account in the design in accordance with Section 4.6 of the CHBDC.

Seismic loading will result in increased lateral earth pressures acting on the wall. The wall should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given in Section 7.3.1 above, plus the earthquake-induced dynamic earth pressure.

In accordance with Sections 4.6.5 and C.4.6.5 of the 2014 CHBDC and its Commentary, for structures which do not allow lateral yielding, the horizontal seismic coefficient (k_h) used in the calculation of the seismic active pressure coefficient is taken as equal to the site adjusted PGA estimated at the ground surface is provided in Table 14. Table 10 in Section 6.4.3 summarizes the Seismic Site Class for each retaining wall site. For structures which allow lateral yielding, k_h is taken as 0.5 times the site adjusted PGA estimated at the ground surface.

The seismic active pressure coefficients (K_{AE}) provided in Table 14 for the two backfill cases (Case (a) and Case (b)) may be used in design. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

In accordance with Section C4.6.5 of the Commentary to the CHBDC the K_{AE} value for a yielding wall is applicable provided that the wall can move up to $250k_h$ mm, where k_h is the Site-Specific PGA values as given in Table 14. This corresponds to displacements of about 60, 70 and 75 mm for the 2,475-year design earthquake for Site Class B, C and D retaining wall sites respectively.

Table 14: Seismic Active Pressure Coefficients, K_{AE} for Various Materials

Structure Type	Design Earthquake	Seismic Site Class	Site Specific PGA (g)	Granular A	Granular B Type II
Non-Yielding Wall	2,475-year	B	0.24	0.43	0.43
Yielding Wall				0.34	0.34
Non-Yielding Wall	2,475-year	C	0.28	0.46	0.46
Yielding Wall				0.35	0.35
Non-Yielding Wall	2,475-year	D	0.30	0.48	0.48
Yielding Wall				0.36	0.36

The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:

$$\sigma_h(d) = K_a \gamma d + (K_{AE} - K_a) \gamma (H-d), \text{ yielding walls}$$

$$\sigma_h(d) = K_o \gamma d + (K_{AE} - K_a) \gamma (H-d), \text{ non-yielding walls}$$

- Where:
- $\sigma_h(d)$ is the (static plus seismic) lateral earth pressure at depth, d, (kPa);
 - K_a is the static active earth pressure coefficient;
 - K_o is the static at-rest earth pressure coefficient;
 - K_{AE} is the seismic active earth pressure coefficient;
 - γ is the unit weight of the backfill soil (kN/m³), as given previously;
 - d is the depth below the top of the wall (m); and,
 - H is the total height of the wall (m).

7.4 Augured Caisson Foundations

Site specific geotechnical design parameters for design for lateral resistance of retaining walls with caisson foundations are provided in Section 8. They are based on the subsurface conditions encountered in the boreholes in vicinity of the various retaining wall alignments. The stratigraphy presented has been simplified for the purpose of caisson design and the parameters presented are based on field and laboratory test data as well as accepted correlations (NAVFAC 1986, Bowles, 1984 and Kulhawy and Mayne, 1990) and the analysis was tempered by engineering judgment based on experience in similar soils.

As noted in Section 7.2.1, the frost penetration depth for the City of Ottawa is 1.8 m. The resistance within the upper 1.8 m below ground surface should therefore be neglected to account for frost action. In addition, for foundation design, full resistance will be mobilized only where the ground surface in front of and behind the caissons is level (i.e., the width of soil in front of and behind the caissons is equal to or greater than eight caisson diameters). If the width of soil in front of and/or behind the caissons is insufficient for development of the full resistance, the magnitude of resistance may be determined by interpolating between zero resistance at ground surface and full resistance at the depth where the slope face is at a distance of eight caisson diameters away from the caissons.

The unfactored lateral resistance should be calculated assuming an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to this unfactored lateral resistance to obtain the factored ultimate lateral geotechnical resistance.

The geotechnical design parameters for the sites also includes the factored ultimate geotechnical lateral resistance in bedrock as f_{horiz} . In order to rely on this resistance in design, the caissons must extend a minimum of 1 m into bedrock.

The resistance to lateral loading of caissons may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction (k_h in kPa/m) is determined based on the equations given below:

For cohesionless soils:

$$k_s = n_h \times \frac{z}{d} \quad \text{where} \quad k_s \text{ is in kN/m}^3$$

n_h is the constant of horizontal subgrade reaction, (kPa/m)
 z is the depth (m)
 d is the pile diameter/width (m)

For cohesive soils:

$$k_s = \frac{67 \times S_u}{d} \quad \text{where} \quad S_u \text{ is the undrained shear strength of the soil (kPa); and}$$

d is the pile diameter/width (m)

The coefficient of horizontal subgrade reaction when applied over a specific area provides a spring constant that is commonly used to model load-deformation response of a pile subjected to lateral loading. The spring constant represents the stiffness of the ground and is controlled by the lateral resistance of the ground. The coefficient of horizontal subgrade reaction is not a fundamental soil property and varies with geometry of the foundation (for proper application, refer to NAVFAC DM7.02, pages 234-236, CFEM 1992, 3rd Edition, pages 312-315).

The spring constant, K , for structural analysis may be obtained by the expression:

$$K = k_h \times L \times B \text{ (kN/m),}$$

Where k_h = coefficient of horizontal subgrade reaction (kPa/m);
 B = buried caisson diameter, (m); and
 L = length of the caisson segment used in the analysis (m).

8.0 FOUNDATION DESIGN RECOMMENDATIONS

8.1 Retaining Walls RW10N and RW11N

The existing embankments along the alignment of retaining walls RW10N and RW11N are between 5.5 and 6.5 m in height and sloped at approximately 2H:1V. There is an existing concrete crib wall present along the alignment of RW11N. No wall is present at the proposed location of RW10N.

From a geotechnical perspective, the possible retaining wall alternatives for the proposed widening at this location include:

- Full or partial height reinforced soil system (RSS) wall
- Full or partial height concrete retaining wall, or
- Full or partial height interlocking concrete block wall.

The relatively shallow depth to the bedrock surface at these sites makes the installation of a post and panel wall system uneconomical versus the other more feasible options listed above since the caisson foundations would require relatively deep bedrock sockets to develop the anticipated lateral resistance. As a result, no further discussion of post and panel wall systems is provided in the following sections.

It is understood that an RSS wall system is considered the structurally preferred alternative at these locations to maintain aesthetics between the overpass structures at Booth and Rochester Streets. It should be noted that the design of the RSS system will need to account for the presence of the proposed noise barrier wall caisson foundations within the reinforced mass of the RSS system as shown on General Arrangement Drawings S30 and S32.

8.1.1 RW10N and RW11N Foundations

Drawings S30 and S32 indicate that the base of the RSS walls is to be set at the elevations summarized in Table 15. Based on the results of the boreholes advanced along the wall alignments the bedrock surface is at or just below the proposed bottom of wall elevations.

Table 15: Summary of Bedrock Elevations and Proposed base of Retaining Wall Elevations at RW10 and RW11N

Retaining Wall	Relevant Boreholes (west to east)	Approximate Highway Station	Bedrock Surface Elevation (m)	Proposed Base of Retaining Wall Elevation ¹ (m)	Anticipated Founding Material
RW10N	17-114, 18-1103, 18-1107	27+250 to 27+280	62.7 to 63.6	63.1 to 63.7	Bedrock
	18-1107, 18-906, 18-907	27+280 to 27+340	63.6 to 65.0	63.7 to 65.5	Bedrock
	18-907, 17-123	27+340 to 27+356	65.0 to 65.2	65.5	Bedrock
RW11N	17-124, 18-1203, 18-908,	27+380 to 27+400	65.5 to 65.1	65.8 to 66.1	Bedrock
	18-908, 18-909	27+400 to 27+450	65.1 to 66.0	66.1 to 67.2	Bedrock / glacial till

Notes: ¹ Elevations based on Drawings S30 and S32 from the revised 60% package provided by WSP on November 8, 2019

8.1.1.1 Geotechnical Bearing Resistances

The existing fill materials and topsoil are also not suitable for support of retaining wall footings. The much higher geotechnical resistance available from the underlying bedrock make that strata much preferred for supporting the foundation loads as such, shallow foundations founded on the limestone bedrock is the recommended approach for the support of an RSS, reinforced concrete retaining wall or interlocking concrete block wall for RW10N and RW11N. The maximum underside of footing elevation along RW10N and RW11N are assumed to be the bedrock surface elevations provided in Table 15 above.

Spread footings placed on the surface of limestone bedrock or on mass concrete overlying bedrock may be designed using a factored geotechnical resistance at Ultimate Limit States (ULS) of 2,000 kPa. For footings founded on/in the bedrock, settlement is considered negligible under the anticipated loadings and therefore the Serviceability Limit States (SLS) condition will not govern the design.

Depending on the proposed elevation of the base of the retaining wall for RW11N, shallow foundations for an RSS wall system may be founded within the glacial till east of Station 27+450. The maximum underside of the concrete levelling pad elevation if founded on or within the glacial till should be set at Elevation 67.0 m. The concrete levelling pad should be placed on a 500 mm thick Granular A pad. Further details on the granular pad are provided in Section 8.1.3 below.

An RSS wall founded in the glacial till, after the subgrade preparations outlined in Section 8.1.3 have been carried out, may be designed using a factored geotechnical resistance at ULS of 250 kPa and a geotechnical resistance at SLS of 150 kPa.

8.1.1.2 Sliding Resistance

Resistance to lateral forces through sliding resistance between concrete and underlying materials should be evaluated using the unfactored coefficients of friction provided in Table 16.

Table 16: Unfactored Coefficients of Friction between Concrete and Founding Material

Levelling Pad Material	Founding Material		
	Glacial Till (East of Station 27+450)	Granular A Bedding	Bedrock
Cast-in-place concrete	0.50	0.55	0.70
Precast concrete	0.40	0.45	0.60

Consideration could be given to doweling the concrete retaining wall foundations into the bedrock for additional overturning and sliding resistance, if required. The horizontal resistance of the dowels will be dependent on the strength of the bedrock, grout and steel. For this site, where the rock mass is essentially as strong as or is stronger than concrete, the design of the dowels in the rock may be handled in the same way as the dowel embedment into the concrete. The dowels should have a minimum embedded length within sound bedrock of 1 m, and the structural strength of the dowel and compressive strength of the grout should not be exceeded.

For uplift of the dowels, a factored value of 1 MPa may be assumed for the grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given and it should therefore be verified in the field by pull-out testing. In this case, a Special Provision will have to be included in the Contract Documents to cover this testing.

8.1.1.3 Settlement

Settlements of retaining wall foundations supported on bedrock or native glacial till will be less than 25 mm total and 15 mm differential in magnitude.

Based on the subsurface conditions encountered at the site, only minimal settlement (i.e., less than 25 mm) is anticipated due to the compression of the existing embankment fill, which is expected to take place during the construction of the widening and installation of the retaining walls.

The magnitude of settlement of the new embankment fill will depend on the type of fill placed and, on the method, and sequence of placement and compaction, but is expected to range from about 0.5 to 1.0 percent of the thickness of the embankment fill.

8.1.2 Assessment of Global Stability

The global stability of RSS walls constructed using OPSS.PROV 1010 Granular B Type II, was evaluated using GeoStudio 2018 Slope/W software for limit equilibrium analysis. Input parameters for the analysis provided in Table 17 are based on the in-situ SPT N values and the results of laboratory testing. It has been assumed the site preparation activities as outlined Section 8.1.3 will occur prior to construction of the embankment. However, the internal stability of the wall will be the responsibility of the proprietary supplier/designer.

Table 17: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m ³)	Internal Angle of Friction (ϕ°)
Existing Embankment Fill	20	33
OPSS Granular A	22	35
OPSS Granular B Type II	22	35

The following conditions were also assumed in the analysis:

- The embankment will be constructed with a horizontal backslope
- A traffic surcharge load as per Section 6.12.5 of the CHBDC was used for static analysis
- A seismic horizontal loading of 0.12g, equal to ½ of the site adjusted PGA value (0.244g Site Class B) was used for seismic analysis, (see Section 6.4.3)
- Groundwater level of 64.5 m for RW10N and RW11N founded on bedrock
- Groundwater level of 66.5 m for RW11N founded on till

With appropriate subgrade preparation and proper placement of earth or granular soils, the up to 5 to 6 m high embankment constructed as outlined above, will have a factor of safety greater than 1.54 against deep seated slope instability and a factor of safety greater than 1.1 against seismic instability. The results of the slope stability analysis are illustrated on Figures E1 to E4 provided in Appendix E.

8.1.3 Site Preparation and Construction

Excavation and backfilling for installation of retaining wall backfill should be carried out in accordance with OPSS 902 (*Construction Specification for Excavating and Backfilling – Structures*) and MTO Special Provision (SP) No. 109S12, Amendment to OPSS 902, August 2018.

8.1.3.1 Subgrade Preparation and Backfilling

Subgrade preparation for the retaining walls should include excavation and removal of the existing overburden material, walls and foundations to the bedrock. All loose rock should be removed from the base of the excavations. The bedrock surface should be cleaned and levelled with mass concrete prior to the placement of the foundations. Where the walls are founded on bedrock the placement of a granular pad would not be required.

Depending on the proposed base of wall elevation of RW11N east of Station 27+450, the wall may be founded on or within the glacial till. Subgrade preparation for the RW11N east of Station 27+450 should include excavation and removal of the existing fill, with walls and foundations supported on the compact to dense native glacial till at

a maximum elevation of 66.5 m, to allow for placement of a compacted Granular A leveling pad beneath the foundation elements. A provision should be made in the contract documents for additional excavation and placement of engineered fill, should loose or disturbed materials be encountered at the proposed foundation elevation.

For an RSS wall system, the levelling pad should be at least 500 mm thick and be constructed similarly to that illustrated on Figure 5.2 of the MTO RSS Guidelines with a minimum soil cover to the underside of the concrete levelling pad of 0.8 m.

For an interlocking concrete block wall, the granular pad should be at least 300 mm thick and be constructed with a minimum soil cover to the underside of block/concrete foundation of 300 mm (generally half the height of the first course of blocks). The material for the granular pad should be placed and compacted in accordance with OPSS.PROV 501.

The granular leveling pad requirements must be confirmed with the proprietary wall supplier/designer prior to finalizing the design.

It is considered critical to the design of the retaining walls that the retained soil mass behind the wall system consist of a free draining material and that proper drainage measures, such as subdrains, be provided behind the walls to prevent any buildup of hydrostatic groundwater pressure acting on the walls. It is anticipated that the backfill material will consist of either compacted OPSS.PROV 1010 Granular A or Granular B Type II material placed and compacted in accordance with OPSS.PROV 501. Backfill requirements from the RSS supplier/designer must also be confirmed.

8.1.3.2 Open Cut Excavations

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities.

Excavations to depths of up to about 5.0 and 6.0 m below the existing Highway 417 grade through the existing fill and native materials are anticipated for the removal of existing retaining wall and the construction of RW10N and RW11N. The groundwater level in the area of these walls is expected to at or just above the bedrock surface.

The soils at this site would be generally classified as Type 3 soils (compact to loose fill material above groundwater level) in accordance with the OHSA. Accordingly, excavations should be made with side slopes no steeper than 1H:1V.

8.1.3.3 Temporary Protection Systems

If the required safe side slopes for the open cut excavations cannot be accommodated, then temporary roadway protection (i.e., excavation shoring) will be required to facilitate excavation to the foundation level for the removal of the existing crib wall and construction of the new retaining walls.

The design of the shoring will be entirely the responsibility of the contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*), and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities can tolerate this magnitude of deformation. Traffic loading should be included as a surcharge. Traffic loading does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm those load requirements.

Increased difficulty with the installation of temporary protection systems should be anticipated due to the relatively shallow depth to the bedrock surface. For preliminary assessment purposes, the use of sheet piles is not considered feasible. One option is to use H-piles and timber lagging with the H-piles installed in pre-drilled holes into the bedrock. Recommended wording for an NSSP alerting the Contractor to this condition and the requirement to use appropriate equipment and installation techniques is provided in Appendix F.

8.1.3.4 Groundwater and Surface Water Control

The groundwater level at the site is indicated to be typically near or below the bedrock surface. Excavations to expose the bedrock surface for founding of spread footings will likely involve minimal groundwater and surface water control. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

However, the selection and design of temporary unwatering/dewatering system is the responsibility of the Contractor. In accordance with SP FOUN0003, given the groundwater, soil and bedrock conditions present at these retaining wall sites, it is not a requirement to carry out a preconstruction survey or to require a design Engineer and design-checking Engineer with a minimum of 5 years of experience for the dewatering system as per Table A of SP 517F01.

8.2 Retaining Wall RW13N

The existing embankments along the alignment of RW13N are between 5.0 and 6.1 m in height and sloped at approximately 2H:1V behind an existing concrete crib wall. The proposed retaining wall is similar in height to the existing crib wall and is planned to extend along the same alignment, just behind the existing wall (i.e., slightly nearer to Highway 417).

The subsurface conditions encountered in the boreholes consist of very loose to compact sandy fill materials, overlying peat (at about the centre of the retaining wall), overlying native silty sand and glacial till. The fill materials extend to depths ranging from about 3 to 4 m below the existing ground surface at the base of the existing crib wall.

The new retaining wall at this location extends along, and very near (i.e., within about 3.5 m) of the building at 370 Carling Ave. The edge of the excavation required for construction of the retaining wall will be about 2 m from the building and, assuming the building basement extends to one level, full removal of the existing fill material (which extends to depths of about 3 to 4 m below existing ground surface), has the potential to impact the building. Underpinning or a temporary protection system (depending on the existing foundation depth) may be required alongside the building and this would be in addition to the deep (9 to 10 m) temporary protection system that would be required along Highway 417. Founding retaining walls on the native soils below the existing fill material and peat would therefore be difficult, costly and would potentially require coordination with the building owner.

From a foundation perspective, feasible alternatives for the proposed retaining wall at this location include:

- Full or partial height reinforced soil system (RSS) walls perched within the existing fill
- Full or partial height RSS walls on/in the native sands and/or glacial till
- Full or partial height interlocking concrete block walls on/in the native sands and/or glacial till, or
- Either a RSS or concrete block wall supported on deep foundations, potentially consisting of a grade beam supported on helical piles.

It should be noted that the design of the wall system (either RSS or concrete block walls) will need to account for the presence of the proposed noise barrier wall caisson foundations as shown on Drawing S34.

The existing sandy fill and peat materials extend to depths of about 2.5 to 4.0 m at the borehole locations advanced along the proposed alignment of RW13N. These loose to very loose materials are not suitable for founding a reinforced concrete retaining wall. However, the removal of all the fill materials and founding the retaining wall on the native soils at these depths may not be practical or economical. Hence the use of a concrete gravity wall is not considered feasible at this site. The depth of required excavation also renders a RSS wall founded on native soils impractical. The loose to very loose material would also provide limited lateral resistance for the deep foundations of a post and panel wall system, and the caissons would likely need to be advanced into bedrock, making a post and panel wall system considerably less economical and more time consuming than the more feasible options listed above. As a result, no further discussions on reinforced concrete retaining walls, RSS walls founded on native soils or post and panel walls are provided in the following sections.

A feasible option may be to install a perched RSS wall system, founded on a pad of engineered fill placed on the existing fill and peat. This option would require less excavation (than full removal of the existing fill), however the anticipated settlement would be higher than the conventional SLS criteria of 25 mm and could be up to about 40 mm. Further discussion on the anticipated settlement for a perched RSS wall system is provided in Section 8.2.1.1.

Based on constructability, since excavations to or below the founding level of the building at 370 Carling Avenue would be difficult, and costly, the preferred option for retaining wall 13N is likely a perched RSS wall. However, it should be recognized that the risk of unacceptable settlement that impacts the wall performance and appearance is higher with a perched RSS retaining wall but can be mitigated to some extent by using a thick pad (i.e., 1 m) of engineered fill below the wall (as discussed below) and slip joints to reduce the effects of differential settlement. It should also be noted that the edge of the highway shoulder is more than 3 m from the top of the proposed retaining wall which reduces the impact of higher than typically accepted settlement magnitudes at the wall on the highway surface.

If the risk of intolerable settlement is not considered to be acceptable, then deep foundations would need to be considered. A practical deep foundation option for the proposed retaining wall could be to support the wall on a concrete grade beam supported on helical piles advanced into the native till or to refusal on bedrock. The grade beam would require full frost depth protection (i.e. 1.8 m for this project). The helical piles are considered a proprietary product and further consultation with the supplier would be required to finalize the design.

8.2.1 RW13N Foundations

Drawing S34 indicates that the base of the walls is to be set at the elevations summarized in Table 18.

Table 18: Summary of Proposed Base of Retaining Wall Elevations and Anticipated Founding Material at RW13N

Relevant Boreholes (west to east)	Approximate Highway Station	Proposed Base of Retaining Wall Elevation (m)	Anticipated Founding Material
18-913	28+175 to 28+200	65.6	loose sand fill
18-914	28+200 to 28+275	65.9 to 65.3	sandy peat to peat
18-915	28+275 to 28+300	65.3 to 65.9	very loose sand fill

8.2.1.1 Settlement

Perched RSS Wall Systems

Considering the anticipated founding material and the requirements for RSS walls (i.e., 0.8 m embedment depth), it is recommended that the base of the excavations for a perched RSS wall system be at a depth of 1.8 m below ground surface, which corresponds to about Elevations 65.1 to 66.3 m (from west to east along the wall alignment). The excavation would then be backfilled with a compacted granular pad approximately 1.0 m in thickness in preparation for placement of the concrete leveling pad. Further subgrade preparation recommendations are provided in Section 8.2.3.

Based on the fill and peat encountered, as indicated in the boreholes, the settlement of a perched RSS wall, placed on a 1 m thick pad of engineered fill, due to the increased loading from the wall may be up to 40 mm.

It should also be recognized that the behaviour of random fill (i.e., the composition and placement which are not entirely known) may not be consistent. In addition, peat is also indicated to be present below the existing fill along some of the proposed RSS wall. However, it is likely that the peat has been consolidated under the existing crib wall loading (which is similar to the proposed RSS wall loading and the alignment of the new RSS wall is within the top of wall of the existing crib wall) and the settlement magnitude of 40 mm provided above assumes some contribution from the peat. The RSS wall founded above the peat and on the random fill will have a higher risk of differential settlement however and slip joints will aid in reducing the impact of differential settlements on the wall. Slip joints, spaced at 10 m intervals, should therefore be provided along the length of a perched RSS wall.

Helical Piles

The use of a deep foundation consisting of a helical pile system would reduce the anticipated settlement, in comparison to the other options above, however this system would require deeper excavations and larger material handling requirements than for a perched RSS wall system due to the required frost depth for the grade beam. Further consultation with the supplier / designer would also be required to determine pile spacing / size loading etc.

Embankment Settlement

The magnitude of settlement of the new embankment fill will depend on the type of fill placed and, on the method, and sequence of placement and compaction, but is expected to range from about 0.5 to 1.0 percent of the thickness of the embankment fill.

8.2.1.2 Geotechnical Bearing Resistances

RSS walls founded on engineered fill, at least 1 m in thickness, placed on the existing fill may be designed with a factored geotechnical resistance at ULS of 150 kPa and a geotechnical resistance at SLS of 100 kPa.

8.2.1.3 Sliding Resistance

Resistance to lateral forces through sliding resistance between cast-in-place and pre-cast concrete and the granular pad should be evaluated using an unfactored friction coefficient of 0.55 and 0.45 respectively.

8.2.2 Assessment of Global Stability

The global stability for the proposed backfill behind the RSS walls constructed using Granular A or Granular B Type II material was evaluated using GeoStudio 2018 Slope/W software for limit equilibrium analysis. Input parameters for the analysis provided in Table 19 are based on the in-situ SPT N values and the results of laboratory testing. It has been assumed the site preparation activities outlined in Section 8.2.3 will occur prior to construction of the embankment.

Table 19: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m ³)	Internal Angle of Friction (ϕ°)
Existing Embankment Fill	20	33
Glacial Till	21	34
OPSS Granular A	22	35
Peat	17	28
Silty Sand	20	33

The following conditions were also assumed in the analysis:

- The embankment will be constructed with a 3H:1V backslope above the wall
- A traffic surcharge load as per Section 6.12.5 of the CHBDC was used for static analysis
- A seismic horizontal loading of 0.15g, equal to ½ of the site adjusted PGA value (0.3g Site Class D) was used for seismic analysis, (see Section 6.4.3)
- Groundwater level of 65.5 m

With appropriate subgrade preparation and proper placement of granular soils, the 5 to 6 m high embankment constructed as outlined above, will have a factor of safety greater than 1.54 against deep seated slope instability and a factor of safety greater than 1.1 against seismic instability. The results of the slope stability analysis are provided in Figures E5 and E6 provided in Appendix E.

8.2.3 Site Preparation and Construction

Excavation and backfilling for placement of the retaining wall backfill should be carried out in accordance with OPSS 902 and MTO SP No. 109S12, Amendment to OPSS 902, August 2018.

8.2.3.1 Subgrade Preparation and Backfilling

Subgrade preparation for RW13N should include excavation and removal of the existing overburden materials and foundations to about Elevations 65.1 to 66.2 m for a perched RSS Wall.

For a perched RSS wall system the subgrade preparation recommendations are as follows:

- Excavate to a depth of about 1.8 m below existing ground surface at the base of the wall (i.e., about Elevations 65.5 to 67.0 mm from west to east along the wall)
- If peat is encountered at the subgrade level sub-excavate and replace with compacted Granular B Type II
- Heavily proof roll the exposed subgrade
- Construct a compacted 1.0 m thick Granular B Type II granular pad to the underside of the concrete levelling pad

The basement and/or underside of footing elevations of the building at 370 Carling Avenue will need to be confirmed to ensure that excavations will not undermine the existing foundations.

An NSSP is provided in Appendix F for subgrade preparation for a perched RSS wall to alert the contractor that existing fill material is to be left in place and that the material is not to be disturbed prior to placement of the Granular B Type II pad.

For an RSS wall, the levelling pad should be at least 500 mm thick and be constructed similarly to that illustrated on Figure 5.2 of the MTO RSS Guidelines with a minimum soil cover to the underside of the concrete levelling pad of 0.8 m. The material for the granular pad should be placed and compacted in accordance with OPSS.PROV 501. For a perched RSS wall, the 1 m thick engineered pad described above should meet the requirements for the levelling pad.

The granular leveling pad requirements must be confirmed with the proprietary wall supplier/designer prior to finalizing the design. It is considered critical to the design of the retaining walls that the backfill material consist of a free draining material and that proper drainage measures, such as subdrains, be provided behind the walls to prevent any buildup of hydrostatic groundwater pressure acting on the walls. It is anticipated that the backfill material behind the wall system will consist of either compacted Granular A or Granular B Type II material placed and compacted in accordance with OPSS.PROV 501. Backfill requirements from wall supplier/designer must also be confirmed prior to finalizing the design.

8.2.3.2 Open Cut Excavations

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities.

Excavations to depths of up to about 5.0 and 6.0 m below the existing Highway 417 grade through the existing fill and native materials are anticipated for the construction of RW13N. The groundwater level in the area RW13N alignment is expected to be at Elevation 65.0 m

The soils at this site would be generally classified as Type 3 soils above the groundwater and Type 4 soils below the groundwater level) in accordance with the OHSA. Accordingly, excavations should be made with side slopes no steeper than 1H:1V, provided the groundwater level is lowered in advance of excavation.

8.2.3.3 Temporary Protection Systems

If the required safe side slopes for the open cut excavations cannot be accommodated, then temporary roadway protection (i.e., excavation shoring) will be required to facilitate excavation to the foundation level for the removal of the existing crib wall and the installation of the new RSS retaining wall.

The design of the shoring will be entirely the responsibility of the contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*), and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities can tolerate this magnitude of deformation. Traffic loading should be included as a surcharge. Traffic loading does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm those load requirements.

For preliminary assessment purposes, the use of sheet piles is not considered feasible due to the presence of cobbles and boulders within the till and/or the relatively shallow bedrock. One option is to use H-piles and timber lagging with the H-piles installed in pre-drilled holes into the till and possible bedrock depending on height of the

excavation. A suitable bracing system may also be required. Recommended wording for an NSSP alerting the Contractor to this condition and the requirement to use appropriate equipment and installation techniques is provided in Appendix E.

8.2.3.4 Groundwater and Surface Water Control

The groundwater level at the site is indicated to be at about Elevation 65.0 m. Excavations to the required depths will likely encounter groundwater. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

In accordance with SP FOUN0003, the temporary dewatering system shall be designed and carried out in accordance with OPSS.PROV 517 (Dewatering) with amendments as per SP 517F01 (Dewatering System). Given the groundwater and soil conditions at this site, dewatering is expected to be of low complexity, however as construction of the RW13N will take place adjacent to private property it is therefore a requirement to carry out a preconstruction survey and require a dewatering design Engineer and design check Engineer for the dewatering system to have a minimum of 5 years experience in the design of similar dewatering systems as per Table A of SP 517F01. Wording for an NSSP alerting the Contractor to this requirement has been provided in Appendix F.

8.3 Retaining Wall RW1S

The existing embankment along the alignment of RW1S is approximately 4.0 m in height and sloped at approximately 2H:1V behind an existing concrete crib wall that is approximately 2.5 m in height. Boreholes 18-901 and 18-902 were advanced at the location of RW1S.

From a foundation perspective, a feasible retaining wall alternative at this location would be a post and panel retaining wall, founded on concrete caissons augured into the till or possibly bedrock.

It is understood that a new noise barrier wall will be mounted to the proposed wall at RW1S to replace the existing one currently to the north of the existing crib wall. It is understood that it is not feasible to mount a noise barrier wall to a concrete block wall. Hence a conventional caisson noise barrier foundation would need to be installed for the concrete block wall option to be feasible as a replacement option for RW1S. This would require the full removal of the existing crib wall and noise wall foundations along the alignment of RW1S, which is likely not economical versus the other more feasible option of a post and panel wall system.

The results of the utility locates carried out prior to commencement of the field work indicate that there are existing utility alignments located along and perpendicular the MTO right-of-way in the vicinity of the proposed alignment of RW1S. It is understood that the realignment/moving of the existing utilities is not feasible under the current design or construction plans.

Based on available information, the obverts of the existing utilities would be at or near the required minimum underside of a spread footing elevation required for frost protection of a concrete retaining wall. The use of shallow foundations for this alignment could lead to increased loads on the buried utilities. Also, the increased excavation requirements for the construction of the concrete wall to lower the foundation to at least the obvert of the existing utilities would have a large impact on adjacent private properties. With these considerations, the use of concrete gravity wall is not considered practical at this location.

The current drawings indicate Highway 417 is not being widened at this location, hence there is insufficient space available to install the reinforcing straps required to construct an RSS wall system at this location without encroaching on the travelled highway lanes. Also, the installation of an RSS wall system would require the full removal of the existing crib wall and noise barrier wall foundations.

Based on the above an RSS wall, concrete block wall or gravity wall are not considered feasible replacement options for RW1S and no further discussion on these wall types are provided in the following sections.

A post and panel retaining wall founded on caissons that are properly aligned and spaced to avoid the existing buried utilities is the preferred option from a foundation perspective for the retaining wall at this location. Also, the installation of the caissons within the embankment fill has reduced excavation requirements and could limit the disturbance and repairs required to the private properties along the proposed alignment of RW1S.

8.3.1 RW1S Foundations

Drawing S43 indicates that the top of post and panel wall and the top of caisson elevation is to be set at approximate Elevations 73.1 and 70.0 m respectively. The ground surface elevation of Hinton Avenue South at the foot of the existing retaining wall is approximately 70.0 m.

The results of the investigation indicate that auger refusal was encountered in Boreholes 18-901 and 18-902 at Elevations 63.9 and 63.8 m respectively. The groundwater level is indicated to be at Elevation 67.2 m.

It should be noted that the passive resistance in front of the caissons within frost penetration depth (i.e. 1.8 m for this project) should be neglected to account for frost action. It is anticipated that the approximately 4.0 m of caisson below the frost zone will not provide sufficient lateral support and that the caissons will likely need to be socketed a nominal distance into bedrock to achieve the lateral resistances required to support the proposed noise barrier wall attached to RW1S and the retained soil behind the wall.

8.3.1.1 Axial Bearing Resistance for Caisson Foundations

Caissons socketed nominally (approximately 1.0 m) into the bedrock, should be designed based on end-bearing resistance and a factored geotechnical resistance at ULS of 8,000 kPa. For caissons founded on/in the bedrock, settlement is considered negligible under the anticipated loadings and therefore the SLS condition will not govern the design.

8.3.1.2 Lateral Bearing Resistance for Caisson Foundations

Section 7.4 outlines the procedure for determining the lateral resistance for the proposed caissons. Table 20 below summarizes geotechnical parameters for the soils and bedrock encountered at the borehole locations that can be used in the caisson design for RW1S. The range in values reflects the variability in the subsurface conditions, the soil properties and the approximate nature of the analysis and the non-linear nature of the soil behaviour (such that k_h is a function of deflection).

Table 20: Geotechnical Design Parameters for RW1S Foundations

Borehole	Deposit Description	Approximate Deposit Elevation ^{1,2} (m)	Soil and Bedrock Design Parameters ³					
			ϕ' (°)	n_h (kPa/m)	f_{horz} (kPa)	γ (kN/m ³)	γ_D (kN/m ³)	K_p ⁴
18-901 & 18-902	Sand	68.2 to 67.0	32	6,000 to 8,000	-	19	-	3.3
	Sand	67.0 to 65.4	30	4,000 to 6,000	-	19	9.2	3.0
	TILL – Sand and Silt	65.4 to 63.7	34	6,000 to 8,000	-	21	11.2	3.5
	Bedrock	< 63.7	34	-	2,000	21	11.2	3.5

Notes:

1. Deposit thickness for design to be considered ½ of the fill thickness presented.
2. Approximate deposit elevations are provided starting from the frost depth elevation (1.8 m below the existing ground surface elevations at the proposed caisson location).
3. Design parameters:
 - s_u = undrained shear strength (kPa)
 - ϕ' = effective (drained) friction angle (degrees)
 - K_p = passive earth pressure coefficient
 - n_h = constant of horizontal subgrade reaction (kPa/m)
 - γ = bulk unit weight (kN/m³)
 - γ' = effective unit weight (below the groundwater level) (kN/m³)
4. The passive earth pressure coefficients provided assume a vertical foundation element, zero interface friction between the soil and the foundation element, and a horizontal backslope.

8.3.2 Assessment of Global Stability

The global stability for the proposed grade raise behind the post and panel walls was evaluated using GeoStudio 2018 Slope/W software for limit equilibrium analysis. Input parameters for the analysis provided in Table 21 are based on the in-situ SPT N values and the results of laboratory testing. It has been assumed the site preparation activities as outlined in Section 8.3.3 will occur prior to construction of the embankment.

Table 21: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m ³)	Internal Angle of Friction (ϕ°)
Existing Embankment Fill	20	33
Glacial Till	21	34
OPSS Granular A	22	35
Sand	20	32

The following conditions were also assumed in the analysis:

- The embankment will be constructed with a slightly inclined backslope with a ditchline behind the wall
- A traffic surcharge load as per Section 6.12.5 of the CHBDC was used for static analysis
- A seismic horizontal loading of 0.14g, equal to ½ of the site adjusted PGA value (0.280g Site Class C) was used for seismic analysis, (see Section 6.4.3)
- Groundwater level of 67.2 m

With appropriate subgrade preparation and installation of the caissons, the 4.0 m high embankment constructed as outlined above, will have a factor of safety greater than 1.54 against deep seated slope instability and a factor of safety greater than 1.1 against seismic instability. The results of the slope stability analysis are provided in Figures E7 and E8 provided in Appendix E.

8.3.3 Site Preparation and Construction

Excavation and backfilling for installation of retaining wall backfill should be carried out in accordance with OPSS 902 and MTO SP No. 109S12, Amendment to OPSS 902, August 2018.

8.3.3.1 Groundwater and Surface Water Control

The water-bearing cohesionless soils at this site should be expected to run or flow into the caisson hole during or after drilling of the caisson foundations for retaining wall. Therefore, appropriate equipment and procedures will be required to minimize ground loss during drilling and concrete placement, such as by using temporary or permanent caisson liners, and/or using drilling mud. Suggested wording for a NSSP to alert the Contractor of this condition has been provided in Appendix F.

The selection and design of temporary unwatering/dewatering systems is the responsibility of the Contractor. The contract documents must alert the Contractor to this responsibility and to design the system in accordance with Special Provision (SP) FOUN0003 (Dewatering Structure Excavations) which amends OPSS 902.

In accordance with SP FOUN0003, the temporary dewatering system shall be designed and carried out in accordance with OPSS.PROV 517 (Dewatering) with amendments as per SP 517F01 (Dewatering System). Given the groundwater and soil conditions at this site, dewatering is expected to be of low complexity, however as construction of the RW1S will take place adjacent to private property it is therefore a requirement to carry out a preconstruction survey and require a dewatering design Engineer and design check Engineer for the dewatering system to have a minimum of 5 years experience in the design of similar dewatering systems as per Table A of SP 517F01. Wording for an NSSP alerting the Contractor to this requirement has been provided in Appendix F.

8.4 Retaining Wall RW4S

The existing embankment along the alignment of RW4S ranges in height from 6.2 m at Booth Street (west end of alignment) to 1.6 m at Bell Street (east end of alignment). The existing embankment is sloped at approximately 2H:1V, both behind an existing concrete wall that is approximately 1.0 to 2.0 m in height (at Bell Street) and at the slope down to Orangeville Street (at Booth Street).

Boreholes 18-910 and 18-911 were advanced at the location of RW4S as part of the current investigation and Boreholes 17-122, 18-1204 and 18-1208 as part of the investigation for GEOCRE 31G5-308. Boreholes NB-03, 17S-01 and 17S-02 were advanced along the proposed alignment as part of the investigation for GEOCRE 31G5-254.

From a foundation perspective, feasible retaining wall alternatives for the proposed widening at this location include:

- Post and panel retaining wall, founded on concrete caissons augured into the till or possibly bedrock, or
- Full or partial height concrete retaining wall founded on shallow foundations placed on bedrock.

It is understood that a new noise barrier wall will be mounted on the proposed wall at RW4S to replace the existing one currently to the north of or mounted to the existing wall. It is understood that it is not feasible to mount a noise barrier wall to a concrete block wall. Hence a conventional caisson noise barrier foundation would need to

be installed for the concrete block wall option to be used to replace RW4S. Based on the wall alignment indicated on Drawing 2 there is insufficient property to allow for construction of a separate noise wall and therefore the installation of a concrete block wall is not considered to be a feasible replacement option for RW4S. The limited available property behind the proposed wall alignment would also negate the use of an RSS wall system at this site.

The results of the utility locates carried out prior to commencement of the field work indicate that there are existing utility alignments located along the MTO right-of-way in the vicinity of the proposed alignment of RW4S. It is understood that the realignment/moving of the existing utilities is not feasible under the current construction plan.

Based on available information the obverts of the existing utilities would be at or near the required minimum underside of a spread footing elevation required for frost protection for a concrete retaining wall. In order to ensure that spread footing foundation of a concrete retaining wall does not impact the existing utility the underside of footing elevation would need to be set at or near the invert elevation of the exiting utilities increasing excavation and dewatering time and costs. Excavation activities to prepare the subgrade foundation could also affect the existing utilities. Therefore, the use of a concrete retaining wall west of Station 27+550 is not recommended.

A post and panel retaining wall founded on caissons that are properly aligned and spaced to avoid the existing buried utilities is the preferred option from a foundation perspective for the retaining wall at this location. Also, the installation of the caissons within the embankment fill has reduced excavation requirements over that of a concrete retaining wall and hence will limit interference with existing utilities along the alignment of RW4S.

It is also understood that due to the reduced embankment height along the eastern portion of the RW4S, the use of a post and panel wall system is only proposed between Station 27+393 and 27+550. West of Station 27+550 the soil and bedrock conditions are conducive to the use of concrete gravity walls.

Based on the results of the investigation, the existing ground surface along Orangeville Street is approximately 72.0 m. Concrete gravity walls require full depth frost protection and would therefore need to be founded at with a minimum elevation of 70.2 m. Based on the stratigraphy as indicated in the boreholes the bedrock surface east of Station 27+550 is at elevation 69.9 m. The much higher geotechnical resistance available from the underlying bedrock make that strata much preferred for supporting the foundation loads.

Based on the above, an RSS walls system or concrete block walls are not considered feasible replacement options for RW4S and no further discussion on these wall types are provided in the following sections.

8.4.1 RW4S Foundations

Table 22 summarizes the stationing, top of retaining wall elevation and top of caisson elevation as shown on Drawing 2. The ground surface elevation of Orangeville Street ranges from approximately 66.7 m at Booth Street (west end) to 72.9 m at Bell Street (east end).

Table 22: Proposed Construction Elevations for RW4S

Type	Approximate Highway Station	Top of Retaining Wall Elevation (m)	Top of Caisson Elevation (m)
Post and Panel Wall	27+393 to 27+453	73.3	71.0 to 71.5
	27+453 to 27+550	73.7	72.0 to 73.0
Concrete Wall	27+550 to 27+600	74.4	N/A

Table 23 summarizes the auger refusal and bedrock surface elevations at the borehole locations along the proposed alignment of RW4S.

Table 23: Summary of Auger Refusal and Bedrock Surface Elevations Along the RW4S Alignment

Relevant Boreholes (west to east)	Approximate Highway Station	Elevation of Auger Refusal (m)	Bedrock Surface Elevation (m)
17-122	27+390 (at Booth)	-	65.7
18-1204		-	65.2
18-1208		65.3	-
NB-03	27+455	65.6	-
17S-01	27+510	-	66.3
17S-02	27+550	-	69.9
18-910	27+550	68.4	-
18-911	27+580 (at Bell)	69.6	-

It should be noted that the passive resistance in front of the caissons within frost penetration depth (i.e. 1.8 m for this project) should be neglected to account for frost action. It is anticipated that the approximately 4.0 m of caisson below the frost zone will not provide sufficient lateral support and that the caissons will likely need to be socketed into the bedrock a nominal distance to achieve the lateral resistances required to support the proposed noise barrier wall to be attached to wall RW4S.

8.4.1.1 Axial Bearing Resistance for Caisson Foundations

Caissons founded socketed nominally (approximately 1.0 m) into the bedrock, should be designed based on end-bearing resistance and a factored geotechnical resistance at ULS of 8,000 kPa. For caissons founded on/in the bedrock, settlement is considered negligible under the anticipated loadings and therefore the SLS condition will not govern the design.

8.4.1.2 Lateral Bearing Resistance for Caisson Foundations

Section 7.4 outlines the procedure for determining the lateral resistance for the proposed caissons. Table 25 summarizes the geotechnical parameters for the soils and bedrock encountered at the borehole locations that can be used in the caisson design for RW4S. The ranges in values reflect the variability in the subsurface conditions, the soil properties and the approximate nature of the analysis and the non-linear nature of the soil behaviour (such that k_h is a function of deflection).

8.4.1.3 Bearing Capacity Shallow Foundations

Based on the stratigraphy as indicated in the boreholes the bedrock surface east of Station 27+550 is at Elevation 69.9 m. The much higher geotechnical resistance available from the underlying bedrock make that strata much preferred for supporting the foundation loads. Spread footings for a concrete gravity wall should be placed on the surface of limestone bedrock or on mass concrete overlying bedrock and may be designed using a factored geotechnical resistance at ULS of 2,000 kPa. For footings founded on/in the bedrock, settlement is considered negligible under the anticipated loadings and therefore the SLS condition will not govern the design.

8.4.1.4 Sliding Resistance

Resistance to lateral forces through sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table 24.

Table 24: Unfactored Coefficients of Friction between Concrete and Founding Material

Material	Coefficient of Friction (Bedrock)
Cast-in-place concrete	0.70
Precast concrete	0.60

Consideration could be given to doweling the retaining wall foundations into the bedrock for additional overturning and sliding resistance, if required. The horizontal resistance of the dowels will be dependent on the strength of the bedrock, grout and steel. For this site, where the rock mass is essentially as strong as or is stronger than concrete, the design of the dowels in the rock may be handled in the same way as the dowel embedment into the concrete. The dowels should have a minimum embedded length within sound bedrock of 1 m, and the structural strength of the dowel and compressive strength of the grout should not be exceeded.

For uplift of the dowels, a factored value of 1 MPa may be assumed for the grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given and it should therefore be verified in the field by pull-out testing. In this case, a Special Provision will have to be included in the Contract Documents to cover this testing.

Table 25: Geotechnical Design Parameters for RW4S Foundations

Borehole	Top of Caisson Elevation ²	Approximate Deposit Elevation ³ (m)	Deposit Description	Soil and Bedrock Design Parameters ⁴						
				ϕ' (°)	S_u (kPa)	n_h (kPa/m)	f_{horz} (kPa)	γ (kN/m ³)	γ^{\ominus} (kN/m ³)	K_p ⁵
18-1208	71.0	69.2 to 67.6	Fill – Sand	32	-	4,000 to 6,000	-	19	-	3.3
		67.6 to 67.0	Fill – Clayey Silt	-	50	-	-	18	8.2	-
		67.0 to 65.3	Sand	30	-	2,000 to 4,000	-	19	9.2	3.0
		< 65.3	Bedrock	-	-	-	2,000	-	-	-
NB-03	71.0	70.2 to 68.1	Fill – Sand	32	-	4,000 to 6,000	-	19	-	3.3
		68.1 to 65.6	Sand	30	-	2,000 to 4,000	-	19	9.2	3.0
		< 65.6	Bedrock	-	-	-	2,000	-	-	-
17S-01	72.0	71.2 to 68.5	Fill – Sand	32	-	4,000 to 6,000	-	19	-	3.3
		68.5 to 66.3	Sand	30	-	2,000 to 4,000	-	19	9.2	3.0
		< 66.3	Bedrock	-	-	-	2,000	-	-	-

Notes:

1. Deposit thickness for design to be considered ½ of the fill thickness presented.
2. Top of Caisson Elevation as per Drawing 2 from the revised 60% Contract Package provided by WSP on November 8, 2019
3. Approximate deposit elevations are provided starting from the frost depth elevation (1.8 m below top of proposed to of caisson elevation).
4. Design parameters:
 - s_u = undrained shear strength (kPa)
 - ϕ' = effective (drained) friction angle (degrees)
 - K_p = passive earth pressure coefficient
 - n_h = constant of horizontal subgrade reaction (kPa/m)
 - γ = bulk unit weight (kN/m³)
 - γ' = effective unit weight (below the groundwater level) (kN/m³)
5. The passive earth pressure coefficients provided assume a vertical foundation element, zero interface friction between the soil and the foundation element, and a horizontal backslope.

8.4.2 Assessment of Global Stability

The global stability for the proposed grade raise behind the post and concrete retaining walls was evaluated using GeoStudio 2018 Slope/W software for limit equilibrium analysis. Input parameters for the analysis provided in Table 26 are based on the in-situ SPT N values and the results of laboratory testing. It has been assumed the site preparation activities as outlined in Section 8.4.3 will occur prior to construction of the embankment.

Table 26: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m ³)	Internal Angle of Friction (ϕ°)
Existing Embankment Fill	20	33
Glacial Till	21	34
OPSS Granular A	22	35
Sand	20	32

The following conditions were also assumed in the analysis:

- The embankment constructed with a horizontal backslope
- A traffic surcharge load as per Section 6.12.5 of the CHBDC was used for static analysis
- For the post and panel wall design a seismic horizontal loading of 0.15g, equal to ½ of the site adjusted PGA value (0.3g Site Class D) was used for seismic analysis, (see Section 6.4.3)
- For the concrete retaining wall design a seismic horizontal loading of 0.14g, equal to ½ of the site adjusted PGA value (0.28g Site Class C) was used for seismic analysis, (see Section 6.4.3)
- Groundwater level of 69.0 m

With appropriate subgrade preparation and installation of the caissons and the concrete retaining wall foundation on bedrock, the retaining walls constructed as outlined above will have factors of safety greater than 1.54 against deep seated slope instability and factors of safety greater than 1.1 against seismic instability. The results of the slope stability analysis are illustrated on Figures E9 to E12 provided in Appendix E.

8.4.3 Site Preparation and Construction

Excavation and backfilling for installation of retaining wall backfill should be carried out in accordance with OPSS 902 and MTO SP No. 109S12, Amendment to OPSS 902, August 2018.

8.4.3.1 Subgrade Preparation and Backfilling

For the post and panel wall portion of RW4S the subgrade preparations should include excavation and removal of the existing overburden materials to the top of the caisson elevation to allow for the installation of the caissons.

Subgrade preparation for the concrete retaining wall portion of RW4S should include excavation and removal of the existing overburden material, walls and foundations to the bedrock surface. All loose rock should be removed from the base of the excavations. The bedrock surface should be cleaned and levelled with mass concrete prior to the placement of the foundations. Provision should be made in the contract documents for additional excavation and placement of a mass concrete should the bedrock surface be deeper than anticipated along the retaining wall alignment.

It is considered critical to the design of the retaining walls that the retained soil mass backfill consist of a free draining material and that proper drainage measures, such as subdrains, be provided behind the walls to prevent any buildup of hydrostatic groundwater pressure acting on the walls.

8.4.3.2 Open Cut Excavations

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities.

Excavations to depths of up to about 1.0 and 4.0 m below the existing Highway 417 grade through the existing fill and native materials are anticipated for the construction of components of the RW4S. The groundwater level in the area of the RW4S alignment is indicated to be at about Elevation 69.0 m

The soils at this site would be generally classified as Type 2 soils above the groundwater and excavations should be made with side slopes no steeper than 1H:1V. Excavations into the bedrock to limited depths (if needed) can be made near vertical.

8.4.3.3 Temporary Protection Systems

If the required safe side slopes for the open cut excavations cannot be accommodated, then temporary roadway protection (i.e., excavation shoring) will be required to facilitate excavation to the foundation level for the removal of the existing crib wall and the installation of the new post and panel and concrete retaining walls.

The design of the shoring will be entirely the responsibility of the contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems), and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities can tolerate this magnitude of deformation. Traffic loading should be included as a surcharge. Traffic loading does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm those load requirements.

For preliminary assessment purposes, the use of sheet piles is considered feasible should roadway protection be required for the post and panel portion of RW4S. The sheet piles would be driven to bedrock to provide lateral support. A suitable bracing system may also be required.

However, where roadway protection is required for the concrete retaining wall portion of RW4S the use of sheet piles is not considered feasible due to the relatively shallow depth to bedrock. One option is to use H-piles and timber lagging with the H-piles installed in pre-drilled holes into the bedrock. Recommended wording for an NSSP alerting the Contractor to this condition and the requirement to use appropriate equipment and installation techniques is provided in Appendix F.

8.4.3.4 Groundwater and Surface Water Control

The groundwater level at the RW4S site is anticipated at Elevation 69.0 m.

The water-bearing cohesionless soils at this site should be expected to run or flow into the caisson hole during or after drilling of the caisson foundations for retaining wall. Therefore, appropriate equipment and procedures will be required to minimize ground loss during drilling and concrete placement, such as by using temporary or permanent caisson liners, and/or using drilling mud. Suggested wording for a NSSP to alert the Contractor of this condition has been provided in Appendix F.

For the portion of RW4S to be constructed as a concrete retaining wall, excavations to the required depths will likely encounter groundwater. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

However, the selection and design of temporary unwatering/dewatering system is the responsibility of the Contractor. The contract documents must alert the Contractor to this responsibility and to design the system in accordance with Special Provision (SP) FOUN0003 (Dewatering Structure Excavations) which amends OPSS 902.

In accordance with SP FOUN0003, the temporary dewatering system shall be designed and carried out in accordance with OPSS.PROV 517 (Dewatering) with amendments as per SP 517F01 (Dewatering System). Given the groundwater and soil conditions at this site, dewatering is expected to be of low complexity, and it is therefore not a requirement to carry out a preconstruction survey or to require a dewatering design engineer for the dewatering system as per Table A of SP 517F01.

8.5 Retaining Wall RW5S

The existing embankment along the alignment of RW5S ranges in height from 2.0 m at Arthur Lane South (west end of the wall) to approximately 0.5 m along the Bronson Avenue Offramp at Cambridge Street South (east end of the wall).

Borehole 18-912 was advanced near the location of RW5S as part of the current investigation and NB-04 and NB-05 as part of the investigation for GEOCREC 31G5-254.

From a foundation perspective, the possible retaining wall alternatives for the proposed retaining wall at this location include:

- Full or partial height concrete retaining wall
- Full or partial height reinforced soil system (RSS) walls founded on the native sand

The relatively shallow depth to the bedrock surface at these sites makes the installation of a post and panel wall system likely uneconomical versus the other more feasible options listed above, as the caisson foundations would require bedrock sockets to develop the required lateral resistance.

It is understood that it is not feasible to mount noise barrier walls to a concrete block wall. Hence, a conventional caisson noise barrier foundation would need to be installed for the concrete block wall option to be used to replace wall RW5S. The limited available property behind the proposed wall alignment would not allow the use of a concrete block wall system as there is insufficient property to install the noise barrier wall caisson foundations.

Based on the above, post and panel systems and concrete block walls are not considered feasible replacement options for RW5S and no further discussion on these wall types are provided in the following sections.

8.5.1 RW5S Foundations

Table 27 summarizes the auger refusal and bedrock surface elevations along the alignment of RW5S.

The much higher geotechnical resistance available from the underlying bedrock make that strata much preferred for supporting the foundation loads and the lateral and overturning forces from the noise barrier wall to be attached to the retaining wall. As such, shallow foundations founded on the limestone bedrock is the

recommended approach from a foundation perspective for the support of the reinforced concrete retaining wall option for RW5S. It should be noted that the bedrock surface at the eastern end of the wall may be slightly lower than the required founding elevation and that excavations may be slightly deeper than anticipated.

Table 27: Summary of Auger Refusal and Bedrock Surface Elevations Along the RW5S Alignment

Relevant Boreholes (west to east)	Approximate Highway Station	Ground Surface Elevation (m)	Elevation of Auger Refusal (m)	Bedrock Surface Elevation (m)
18-912	27+625 (at Arthur Lane)	72.8	-	72.0
NB-04	27+650	74.7	71.7	-
NB-05	27+690 (at Cambridge)	73.5	68.8	-

An RSS wall may be founded on either the bedrock, where close to founding level, or on the native sand is considered feasible from foundation perspective.

8.5.1.1 Bearing Capacity Shallow Foundations

Spread footings or RSS walls placed on the surface of limestone bedrock or on mass concrete overlying bedrock may be designed using a factored geotechnical resistance at ULS of 2,000 kPa. For footings founded on the bedrock, settlement is considered negligible under the anticipated loadings and therefore the SLS condition will not govern the design.

RSS walls will need to be founded on a compacted granular leveling pad 500 mm thick. The granular leveling pad requirements must be confirmed with the proprietary supplier/designer prior to finalizing the design. Further details on the granular pad are provided in Section 8.5.3.

RSS walls founded on existing fill or native soils at with a maximum underside of footing elevation of 72.0 m may be designed with a factored geotechnical resistance at ULS of 150 kPa and a geotechnical resistance at SLS of 100 kPa.

8.5.1.2 Sliding Resistance

Resistance to lateral forces through sliding resistance between concrete and underlying materials should be evaluated using the unfactored coefficients of friction provided in Table 28.

Table 28: Unfactored Coefficients of Friction between Concrete and Founding Material

Material	Founding Material	
	Granular A Bedding	Bedrock
Cast-in-place concrete	0.55	0.70
Precast concrete	0.45	0.60

Consideration could be given to doweling the retaining wall foundations into the bedrock for additional overturning and sliding resistance, if required. The horizontal resistance of the dowels will be dependent on the strength of the bedrock, grout and steel. For this site, where the rock mass is essentially as strong as or is stronger than

concrete, the design of the dowels in the rock may be handled in the same way as the dowel embedment into the concrete. The dowels should have a minimum embedded length within sound bedrock of 1 m, and the structural strength of the dowel and compressive strength of the grout should not be exceeded.

For uplift of the dowels, a factored value of 1 MPa may be assumed for the grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given and it should therefore be verified in the field by pull-out testing. In this case, a Special Provision will have to be included in the Contract Documents to cover this testing.

8.5.2 Assessment of Global Stability

The global stability for the proposed grade raise behind the concrete retaining wall was evaluated using GeoStudio 2018 Slope/W software for limit equilibrium analysis. Input parameters for the analysis provided in Table 29 are based on the in-situ SPT N values and the results of laboratory testing. It has been assumed the site preparation activities as outlined in Section 8.5.3 will occur prior to construction of the embankment.

Table 29: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m ³)	Internal Angle of Friction (ϕ °)
Existing Embankment Fill	20	33
OPSS Granular B Type II	22	35

The following conditions were also assumed in the analysis:

- The retaining wall will be constructed with a horizontal backslope
- A traffic surcharge load as per Section 6.12.5 of the CHBDC was used for static analysis
- For an RSS wall system founded on native sands with a seismic horizontal loading of 0.14g, equal to ½ of the site adjusted PGA value (.0.280g Site Class C) was used for seismic analysis, (see Section 6.4.3)
- For the concrete retaining wall founded on bedrock design with a seismic horizontal loading of 0.12g, equal to ½ of the site adjusted PGA value (0.244g Site Class B) was used for seismic analysis, (see Section 6.4.3)
- Groundwater level of 70.0 m

With appropriate subgrade preparation and construction as outlined above, the retaining wall will have a factor of safety greater than 1.54 against deep seated slope instability and a factor of safety greater than 1.1 against seismic instability. The results of the slope stability analysis are provided in Figures E13 to E16 in Appendix E.

8.5.3 Site Preparation and Construction

Excavation and backfilling for installation of retaining wall backfill should be carried out in accordance with OPSS 902 and MTO SP No. 109S12, Amendment to OPSS 902, August 2018.

8.5.3.1 Subgrade Preparation and Backfilling

Subgrade preparation for the retaining walls should include excavation and removal of the existing overburden material, walls and foundations to the bedrock. All loose rock should be removed from the base of the excavations. The bedrock surface should be cleaned of loose rock prior to the placement of the foundations.

Provision should be made in the contract documents for additional excavation and placement of a mass concrete should the bedrock surface extend deeper than anticipated along the alignment of RW5S. Where the walls are founded on bedrock the placement of a granular pad would not be required.

For an RSS wall system, the levelling pad should be at least 500 mm thick and be constructed similarly to that illustrated on Figure 5.2 of the MTO RSS Guidelines with a minimum soil cover to the underside of the concrete levelling pad of 0.8 m.

The granular leveling pad requirements must be confirmed with the proprietary wall supplier/designer prior to finalizing the design.

It is considered critical for the design of the retaining walls that the retained soil mass behind the wall system consist of a free draining material and that proper drainage measures, such as subdrains, be provided behind the walls to prevent any buildup of hydrostatic groundwater pressure acting on the walls. It is anticipated that the backfill material will consist of either compacted OPSS.PROV 1010 Granular A or Granular B Type II material placed and compacted in accordance with OPSS.PROV 501. Backfill requirements from the RSS supplier/designer must also be confirmed.

8.5.3.2 Open Cut Excavations

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities.

The groundwater level in the area RW5S alignment is indicated to be at about Elevation 70.0 m.

Excavations to depths of up to about 1.0 and 4.0 m below the existing Highway 417 grade through the existing fill and native materials to the bedrock surface are anticipated for the construction RW5S.

The soils at this site above the groundwater level would be generally classified as Type 2 soils and excavations should be made with side slopes no steeper than 1H:1V. Excavations within the bedrock may be carried out near vertical.

8.5.4 Temporary Protection Systems

If the required safe side slopes for the open cut excavations cannot be accommodated, then temporary roadway protection (i.e., excavation shoring) will be required to facilitate excavation to the foundation level for the removal of the existing crib wall and the installation of the new concrete retaining wall.

The design of the shoring will be entirely the responsibility of the contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems), and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities can tolerate this magnitude of deformation. Traffic loading should be included as a surcharge. Traffic loading does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm those load requirements.

For preliminary assessment purposes, sheet piles for the construction of RW5S are not considered feasible due to the relatively shallow depth to bedrock. One option is to use H-piles and timber lagging with the H-piles installed in pre-drilled holes into the bedrock. Recommended wording for an Nssp alerting the Contractor to this condition and the requirement to use appropriate equipment and installation techniques is provided in Appendix F.

8.5.4.1 Groundwater and Surface Water Control

The groundwater level at the RW5S site is anticipated to be at Elevation 70.0 m.

Excavations to the required depths will likely encounter groundwater. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

However, the selection and design of temporary unwatering/dewatering system is the responsibility of the Contractor. The contract documents must alert the Contractor to this responsibility and to design the system in accordance with Special Provision (SP) FOUN0003 (Dewatering Structure Excavations) which amends OPSS 902.

In accordance with SP FOUN0003, the temporary dewatering system shall be designed and carried out in accordance with OPSS.PROV 517 (Dewatering) with amendments as per SP 517F01 (Dewatering System). Given the groundwater and soil conditions at this site, dewatering is expected to be of low complexity, and it is therefore not a requirement to carry out a preconstruction survey or to require a dewatering design engineer for the dewatering system as per Table A of SP 517F01.

8.6 Retaining Wall RW7S

The existing embankments along the alignment of retaining walls RW7S are between 5.5 and 6.0 m in height and sloped at approximately 2H:1V behind an existing concrete crib wall that ranges in height from 1.0 to 2.0 m

From a foundation perspective possible retaining wall alternative for the proposed retaining wall at this location include:

- Full or partial height concrete retaining wall founded on shallow foundations
- Full or partial height RSS wall system
- Full or partial height interlocking concrete block wall, or
- Full or partial height post and panel wall system

The results of the utility locates carried out prior to commencement of the field work indicate that there are existing utility alignments located along the MTO right-of-way in the vicinity of the proposed alignment of RW7S. Based on available information the obverts of the existing utilities would be at or near the required minimum underside of a spread footing elevation required for frost protection of a concrete retaining wall. It is understood that the realignment/moving of the existing utilities is not feasible under the current construction plan.

A post and panel retaining wall founded on caissons that are properly aligned and spaced to avoid the existing buried utilities is considered a feasible replacement option for RW7S from a foundation perspective. The installation of the caissons with the embankment fill has reduced excavation requirements over that of a concrete retaining wall and will limit interference with existing utilities and disturbance and repairs required along the alignment of RW7S. However, the relatively shallow depth to the bedrock surface along the current alignment makes the installation of a post and panel wall system likely uneconomical versus the other more feasible options listed above, as the caisson foundations would require bedrock sockets to develop the required lateral resistance.

In order to ensure that spread footing foundation of a concrete gravity retaining wall does not impact the existing utility the underside of footing elevation for a concrete retaining wall should be lowered such that the existing utilities are outside the loading zone of influence of the retaining wall footing. The zone of influence is defined as

an imaginary line drawn out and down from the outside edge of the footing at a slope of 1H:1V. The deeper footing elevation would increase time and costs associated with excavation and dewatering. Therefore, the use of a concrete retaining wall is considered feasible but not necessarily as practical as a concrete block wall or RSS wall system.

A concrete block or RSS wall system wall would be more settlement tolerant and are preferred options over the use of a concrete gravity wall or post and panel wall system for the replacement option at this location. Typically, such systems do not require full frost protection as they are able to tolerate some movement due to frost heave and hence would require less excavation to install and would not interfere with existing buried utilities.

8.6.1 RW7S Foundations

Drawing S51 indicates that the top of the retaining wall elevation is set at Elevation 68.7 m and the base of the retaining walls are to be set at the Elevation 65.9 m. At this elevation the anticipated founding soils would be sand and gravel embankment fill.

8.6.1.1 Geotechnical Bearing Resistances

For preliminary assessment, the following values assume that the base course of the block wall is constructed with blocks between 1.5 and 2.0 m wide or an RSS wall system concrete leveling pad constructed with a compacted Granular A leveling pad founded at a maximum elevation of 65.9 m. Further details on the granular pad are provided in Section 8.6.3 below.

A concrete gravity wall requires the full 1.8 m of frost protection. Based on the existing elevation of Chamberlain Avenue of approximately 66.3 m, the maximum underside footing elevation for a concrete gravity wall would be set at 64.2 m

Spread footings placed founded as described above may be designed with factored geotechnical resistance at ULS of 175 kPa and a geotechnical resistance at SLS of 100 kPa.

8.6.1.2 Sliding Resistance

Resistance to lateral forces through sliding resistance between pre-cast concrete and the granular pad should be evaluated using an unfactored friction coefficient of 0.45.

8.6.1.3 Settlement

Based on the subsurface conditions encountered at the site (and in the absence of any compressible soil layers), only minimal settlement (i.e., less than 25 mm) is anticipated due to the compression of the existing embankment fill, which is expected to take place during the construction of the widening. The magnitude of settlement of the new embankment fill will depend on the type of fill placed and, on the method, and sequence of placement and compaction, but is expected to range from about 0.5 to 1.0 percent of the thickness of the embankment fill.

8.6.2 Assessment of Global Stability

The global stability for the proposed grade raise behind the pre-cast concrete block wall constructed using Granular B Type II was evaluated using GeoStudio 2018 Slope/W software for limit equilibrium analysis. Input parameters for the analysis provided in Table 30 are based on the in-situ SPT N values and the results of laboratory testing. It has been assumed the site preparation activities as outlined in Section 8.6.3 will occur prior to construction retaining wall.

Table 30: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m ³)	Internal Angle of Friction (ϕ°)
Existing Embankment Fill	20	33
Glacial Till	21	34
OPSS Granular B II	22	35
Peat	17	28
Silty Sand	20	33

The following additional parameters were used in the analysis:

- The embankment constructed with a 2H:1V backslope
- A traffic surcharge load as per Section 6.12.5 of the CHBDC was used for static analysis
- A seismic horizontal loading of 0.15g, equal to ½ of the site adjusted PGA value (0.3g Site Class D) was used for seismic analysis, (see Section 6.4.3)
- Groundwater level of 64.5 m

With appropriate subgrade preparation and proper placement of earth or granular soils, the 5 to 6 m high embankment constructed as outlined above, will have a factor of safety greater than 1.54 against deep seated slope instability and a factor of safety greater than 1.1 for seismic. The results of the slope stability analysis are provided in Figures E17 and E18 provided in Appendix E.

8.6.3 Site Preparation and Construction

Excavation and backfilling for installation of retaining wall backfill should be carried out in accordance with OPSS 902 and MTO SP No. 109S12, Amendment to OPSS 902, August 2018.

8.6.3.1 Subgrade Preparation and Backfilling

The underside of the concrete block wall or RSS wall system should set at a maximum elevation of 65.9 m. The underside of a concrete gravity wall should be set a maximum elevation of 64.5 m

Subgrade preparation for concrete block wall or RSS wall system should include excavation and removal of the existing overburden materials, walls and foundations to an elevation of at least 65.6 m to allow for the placement of 300 mm thick Granular A pad placed and compacted in accordance with OPSS.PROV 501. The granular pad requirements from block wall supplier/designer must also be confirmed.

For a concrete gravity wall, the subgrade preparations should include excavation and removal of the existing overburden materials, walls and foundations to an elevation of at least 64.5 m

Provision should be made in the Contract documents for additional excavation and placement of engineered fill should the loose or disturbed materials be encountered at the proposed foundation elevation.

It is considered critical to the design of the retaining walls that the backfill material behind the retaining wall consist of a free draining material and that proper drainage measures, such as subdrains, be provided behind the walls to prevent any buildup of hydrostatic groundwater pressure acting on the walls. It is anticipated that the

backfill will consist of either compacted Granular A or Granular B Type II material placed and compacted in accordance with OPSS.PROV 501. Backfill requirements from block wall supplier/designer must also be confirmed.

8.6.3.2 Open Cut Excavations

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities.

Excavations to depths of up to about 5.0 and 6.0 m below the existing Highway 417 grade through the existing fill and native materials are anticipated for the construction of RW7S.

The soils at this site would be generally classified as Type 2 soils above the groundwater excavations should be made with side slopes no steeper than 1H:1V.

8.6.3.3 Temporary Protection Systems

If the required safe side slopes for the open cut excavations cannot be accommodated, then temporary roadway protection (i.e., excavation shoring) will be required to facilitate excavation to the foundation level for the removal of the existing crib wall and the installation of the new concrete block retaining wall.

The design of the shoring will be entirely the responsibility of the contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems), and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities can tolerate this magnitude of deformation. Traffic loading should be included as a surcharge. Traffic loading does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm those load requirements.

For preliminary assessment purposes, the use of sheet piles is considered feasible. The sheet piles walls would be driven to a suitable depth within the glacial till material to provide lateral support. A suitable bracing system may also be required.

8.6.4 Groundwater and Surface Water Control

The groundwater level at the site is anticipated at Elevation 64.5 m. Excavations to the required depths will likely encounter the groundwater. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

However, the selection and design of temporary unwatering/dewatering system is the responsibility of the Contractor. In accordance with SP FOUN0003, given the groundwater, soil and bedrock conditions present at these retaining wall sites, it is not a requirement to carry out a preconstruction survey or to require a design Engineer and design-checking Engineer with a minimum of 5 years of experience for the dewatering system as per Table A of SP 517F01.


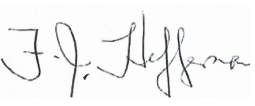
9.0 CLOSURE

This report was prepared by Mr. Kenton Power, P.Eng. and Mr. Bill Cavers, P.Eng., a Senior Geotechnical Engineer and Associate with Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

Golder Associates Ltd.



Kenton C. Power, P.Eng., M.A.Sc.
Geotechnical Engineer



Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

KCP/FJH/hdw

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Table 31: Comparison of Advantages and Disadvantages for the Proposed Retaining Walls RW10N and RW11N

Retaining Wall(s)	Retaining Wall Options	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks
RW10N and RW11N	RSS Wall founded on bedrock or glacial till	<ul style="list-style-type: none"> A preferred option from a foundation perspective 	<ul style="list-style-type: none"> Can be founded above the design frost depth, limiting excavation requirements Can tolerate some movement due to frost heave Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Proprietary product / design Excavation of existing embankment may be required for installation of reinforcing strips Temporary protection system may be required for installation of reinforcing strips Design of reinforcing strips will need to account for the proposed noise wall caisson foundations 	<ul style="list-style-type: none"> Less expensive than a concrete wall 	<ul style="list-style-type: none"> Noise wall caisson foundation interfering with RSS wall reinforcing strips resulting in reduced effectiveness or creating additional loads on wall system.
	Interlocking concrete block retaining wall founded on bedrock or glacial till	<ul style="list-style-type: none"> A preferred option from a foundation perspective 	<ul style="list-style-type: none"> Can be founded above the design frost depth, limiting excavation requirements Can tolerate some movement due to frost heave Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Proprietary product / design Temporary protection system may be required for installation of geo-grid reinforcement. 	<ul style="list-style-type: none"> Less expensive than a concrete wall 	<ul style="list-style-type: none"> Noise wall caisson foundation interfering with geogrid reinforcing resulting in reduced effectiveness or creating additional loads on wall system.
	Concrete Gravity Wall founded on bedrock or glacial till	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Can be designed for both horizontal and sloped backslopes 	<ul style="list-style-type: none"> Cast-in-place units, more involved construction Requires full frost depth protection Temporary protection system may be required during installation Increased dewatering requirements 	<ul style="list-style-type: none"> High 	
	Post and panel wall System – deep foundations	<ul style="list-style-type: none"> Feasible but not realistic 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Shallow depth to bedrock makes installation of caisson uneconomical compared with other options 	<ul style="list-style-type: none"> High 	

Table 32: Comparison of Advantages and Disadvantages for the Proposed Retaining Walls RW13N

Retaining Wall	Retaining Wall Options	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks
RW13N	RSS Wall System founded (perched) on existing fill	<ul style="list-style-type: none"> A preferred option from a foundation perspective 	<ul style="list-style-type: none"> Less potential for impacts to adjacent building (370 Carling Ave.) which is in close proximity to construction excavation. Limits required excavation depths to remove existing fill. Can tolerate some movement due to frost heave Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Greater potential settlement magnitudes Proprietary product / design Excavation of existing embankment may be required for installation of reinforcing strips Temporary protection system may be required for installation of reinforcing strips Design of reinforcing strips will need to account for the proposed noise wall caisson foundations 	<ul style="list-style-type: none"> Least expensive 	<ul style="list-style-type: none"> Higher total or differential settlement magnitudes than can be mitigated by thick engineered fill pad and slip joints due to random nature of fill or thicker peat deposit than indicated. Noise wall caisson foundation interfering with RSS wall reinforcing strips resulting in reduced effectiveness or creating additional loads on wall system.
	Retaining wall founded on a grade beam supported on helical piles	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Minimal settlement if helical piles are drilled into the till or to refusal on bedrock 	<ul style="list-style-type: none"> Proprietary product/design Grade beam requires full frost depth protection Excavation impacts to adjacent private property 	<ul style="list-style-type: none"> High - And dependant on number of piles required 	<ul style="list-style-type: none"> Excavation for grade beam could undermined existing foundation / Confirmation of basement level or foundation elevation is required
	Post and panel wall System – deep foundations	<ul style="list-style-type: none"> Feasible but not realistic 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> The loose to very loose material would provide limited lateral resistance and caissons to or into bedrock would therefore likely be required making a post and panel wall system considerably less economical and more time consuming than the options listed above. 	<ul style="list-style-type: none"> High 	
	RSS Wall System founded on sand or native glacial till	<ul style="list-style-type: none"> Not feasible 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Not practical or economical to excavate and replace existing very loose to loose overburden material to allow for sufficient bearing capacity for a concrete gravity wall 		
	Interlocking concrete block retaining wall founded on bedrock or glacial till	<ul style="list-style-type: none"> Not feasible 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Not practical or economical to excavate and replace existing very loose to loose overburden material to allow for sufficient bearing capacity for a concrete gravity wall 		
	Concrete Gravity Wall	<ul style="list-style-type: none"> Not feasible 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Not practical or economical to excavate and replace existing very loose to loose overburden material to allow for sufficient bearing capacity for a concrete gravity wall 		

Table 33: Comparison of Advantages and Disadvantages for the Proposed Retaining Wall RW1S

Retaining Wall	Retaining Wall Options	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks
RW1S	Post and Panel Retaining wall on caisson foundations	<ul style="list-style-type: none"> The preferred option from a foundation perspective 	<ul style="list-style-type: none"> Caisson foundations can be designed and spaced so not to impact existing utilities Reduced excavation requirements will limit impacts to adjacent private properties Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Lateral loading from noise wall may require caissons to be socketed into bedrock Will require temporary or permanent caisson liners during installation 	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none"> Potential for loss of ground or loss of support during advancement of temporary or permanent liners into and through sandy soils below groundwater table.
	Concrete Gravity Wall founded shallow foundations	<ul style="list-style-type: none"> Feasible, but not practical due to large impacts to adjacent private property due to deeper excavations 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Cast-in-place units, more involved construction Requires full frost depth protection, could impact existing utilities Temporary protection system may be required during installation Increased dewatering requirements versus post and panel Excavation impacts to adjacent private property 	<ul style="list-style-type: none"> High 	
	Interlocking concrete block retaining wall founded on bedrock or glacial till	<ul style="list-style-type: none"> Feasible, but not practical. Would require a separate conventional caisson noise barrier foundation to be install 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Temporary protection system may be required during installation Increased dewatering requirements versus post and panel Excavation impacts to adjacent private property 	<ul style="list-style-type: none"> - 	
	RSS Wall System	<ul style="list-style-type: none"> Not Feasible, insufficient space available to install the reinforcing straps required to construct an RSS wall system 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Insufficient property available for installation of reinforcing straps 	<ul style="list-style-type: none"> - 	-

Table 34: Comparison of Advantages and Disadvantages for the Proposed Retaining Walls RW4S

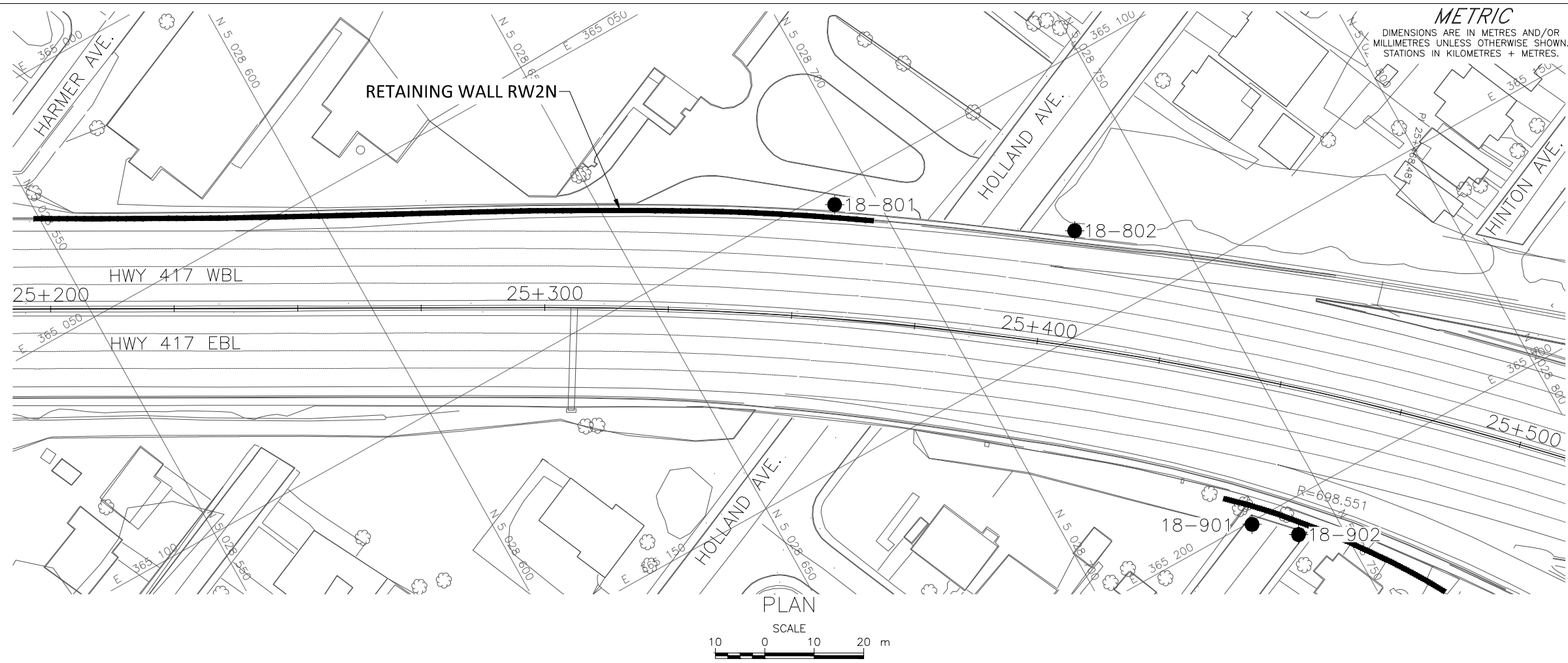
Retaining Wall	Retaining Wall Options	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks	
RW4S	Post and Panel Retaining wall on caisson foundations	<ul style="list-style-type: none"> Feasible - Preferred option from a foundation perspective, west of Station 27+525 	<ul style="list-style-type: none"> Caisson foundations can be designed and spaced so not to impact existing utilities Reduced excavation requirements will limit impacts to adjacent private properties Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Lateral loading from noise wall may require caissons to be socketed into bedrock Will require temporary or permanent caisson liners during installation 	<ul style="list-style-type: none"> High, depending on number and length of caisson foundations 	<ul style="list-style-type: none"> Potential for loss of ground or loss of support during advancement of temporary or permanent liners into and through sandy soils below groundwater table. 	
	Concrete Gravity Wall founded shallow foundations on bedrock	<ul style="list-style-type: none"> Feasible, east of Station 27+550 and a preferred option from a foundation perspective 	<ul style="list-style-type: none"> Can be designed for both horizontal and sloped backslopes Increased bearing and overturning resistance when founded on bedrock 	<ul style="list-style-type: none"> Cast-in-place and therefore more involved construction Requires full frost depth protection, though frost protection may be reduced if founded on bedrock Temporary protection system may be required during installation Increased dewatering requirements 	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none"> 	
	Interlocking concrete block retaining wall founded on bedrock or glacial till	<ul style="list-style-type: none"> Not Feasible. Insufficient space available to install separate conventional caisson noise barrier foundation 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none">
	RSS Wall System	<ul style="list-style-type: none"> Not Feasible, insufficient space available to install the reinforcing straps required to construct an RSS wall system 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none">

Table 35: Comparison of Advantages and Disadvantages for the Proposed Retaining Walls RW5S

Retaining Wall	Retaining Wall Options	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks
RW5S	Concrete Gravity Wall founded on shallow bedrock	<ul style="list-style-type: none"> A preferred option from a foundation perspective 	<ul style="list-style-type: none"> Can be designed for both horizontal and sloped backslopes 	<ul style="list-style-type: none"> Cast-in-place and therefore more involved construction May require bedrock doweling to resist overturning and lateral loading Requires full frost depth protection, could impact existing utilities Temporary protection system may be required during installation Increased dewatering requirements 	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none">
	RSS Wall System	<ul style="list-style-type: none"> A preferred option from a foundation perspective 	<ul style="list-style-type: none"> Can be founded above the design frost depth, limiting excavation requirements Can tolerate some movement due to frost heave Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Proprietary product / design Excavation of existing embankment will be required for installation of reinforcing strips Temporary protection system may be required for installation of reinforcing strips Design of reinforcing strips will need to account for the proposed noise wall caisson foundations (if used) 	<ul style="list-style-type: none"> Less expensive than a concrete wall 	<ul style="list-style-type: none"> Noise wall caisson foundation (if used) interfering with RSS wall reinforcing strips resulting in reduced effectiveness or creating additional loads on wall system.
	Post and panel wall System – deep foundations	<ul style="list-style-type: none"> Feasible but not realistic. Would require constructing bedrock sockets making the installation of this wall system uneconomical compared to a concrete wall 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none">
	Interlocking concrete block retaining wall founded on bedrock or glacial till	<ul style="list-style-type: none"> Not Feasible. Insufficient space available to install separate conventional caisson noise barrier foundation 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none">

Table 36: Comparison of Advantages and Disadvantages for the Proposed Retaining Walls RW7S

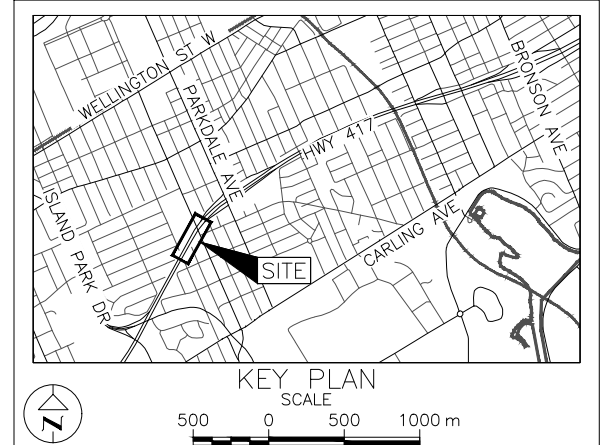
Retaining Wall	Retaining Wall Options	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks
RW7S	Interlocking concrete block retaining wall founded shallow foundations	<ul style="list-style-type: none"> A preferred option from a foundation perspective 	<ul style="list-style-type: none"> Can be founded above the design frost depth, limiting excavation requirements Can tolerate some movement due to frost heave Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Proprietary product / design 	<ul style="list-style-type: none"> Low 	<ul style="list-style-type: none">
	RSS Wall System	<ul style="list-style-type: none"> A preferred option from a foundation perspective 	<ul style="list-style-type: none"> Can be founded above the design frost depth, limiting excavation requirements Can tolerate some movement due to frost heave Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Proprietary product / design Excavation of existing embankment will be required for installation of reinforcing strips Temporary protection system may be required for installation of reinforcing strips Design of reinforcing strips may need to account for the proposed noise wall caisson foundations 	<ul style="list-style-type: none"> More costly than a block wall 	<ul style="list-style-type: none"> Noise wall caisson foundation interfering with RSS wall reinforcing strips resulting in reduced effectiveness or creating additional loads on wall system.
	Concrete Gravity Wall founded shallow foundations	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Can be designed for both horizontal and sloped backslopes Increased bearing and overturning resistance when founded on bedrock 	<ul style="list-style-type: none"> Cast-in-place and therefore more involved construction Requires full frost depth protection therefore deeper excavations would be required than RSS or block wall system Temporary protection system may be required during installation Increased dewatering requirements 	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none">
	Post and Panel Retaining wall on caisson foundations	<ul style="list-style-type: none"> Feasible but not practical – installation of the rock socketed caissons due to the shallow depth to bedrock along the current alignment 	<ul style="list-style-type: none"> Caisson foundations can be designed and spaced so not to impact existing utilities Can be designed for both horizontal and sloped backslopes Appearance may be considered preferable to a concrete wall 	<ul style="list-style-type: none"> Will require temporary or permanent caisson liners during installation 	<ul style="list-style-type: none"> Moderate 	<ul style="list-style-type: none">



CONT No. GWP No. 4173-15-00

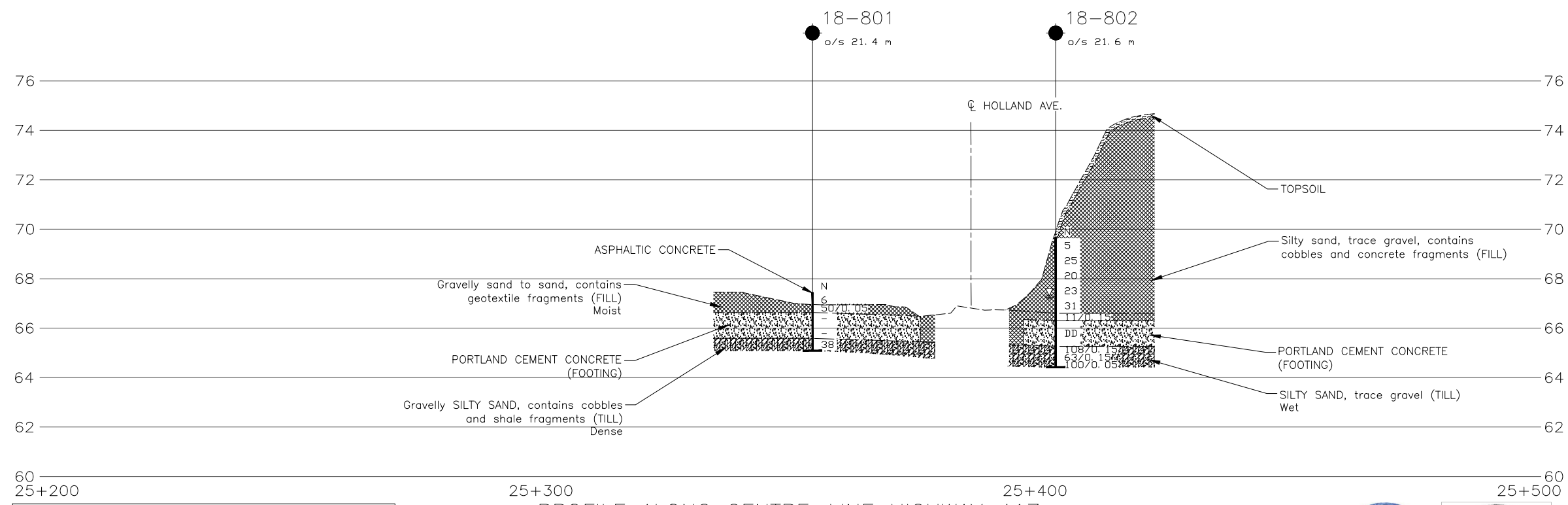
RETAINING WALL REPLACEMENT/REHABILITATION RW2N
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.391846 LONG. -75.732469

SHEET



LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL upon completion of drilling
- ▬ Retaining Wall (RW)



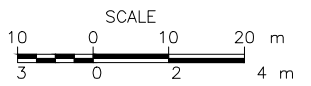
BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
18-801	67.4	5028691.4	365104.3
18-802	69.7	5028731.2	365132.6
18-901	70.0	5028734.4	365200.6
18-902	70.0	5028741.6	365206.9
18-903	71.6	5029102.8	365614.2
18-904	71.0	5029102.8	365691.1
18-906	65.5	5029624.1	366799.1
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
18-913	66.9	5029932.5	367605.0
18-914	67.5	5029958.8	367649.0
18-915	68.1	5029997.9	367718.4
18-916	67.1	5029928.2	367723.2
18-917	66.3	5029956.2	367774.1
18-918	66.6	5029986.3	367825.5
18-923	72.1	5029080.2	365569.0

NOTES

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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.



REFERENCE

Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.

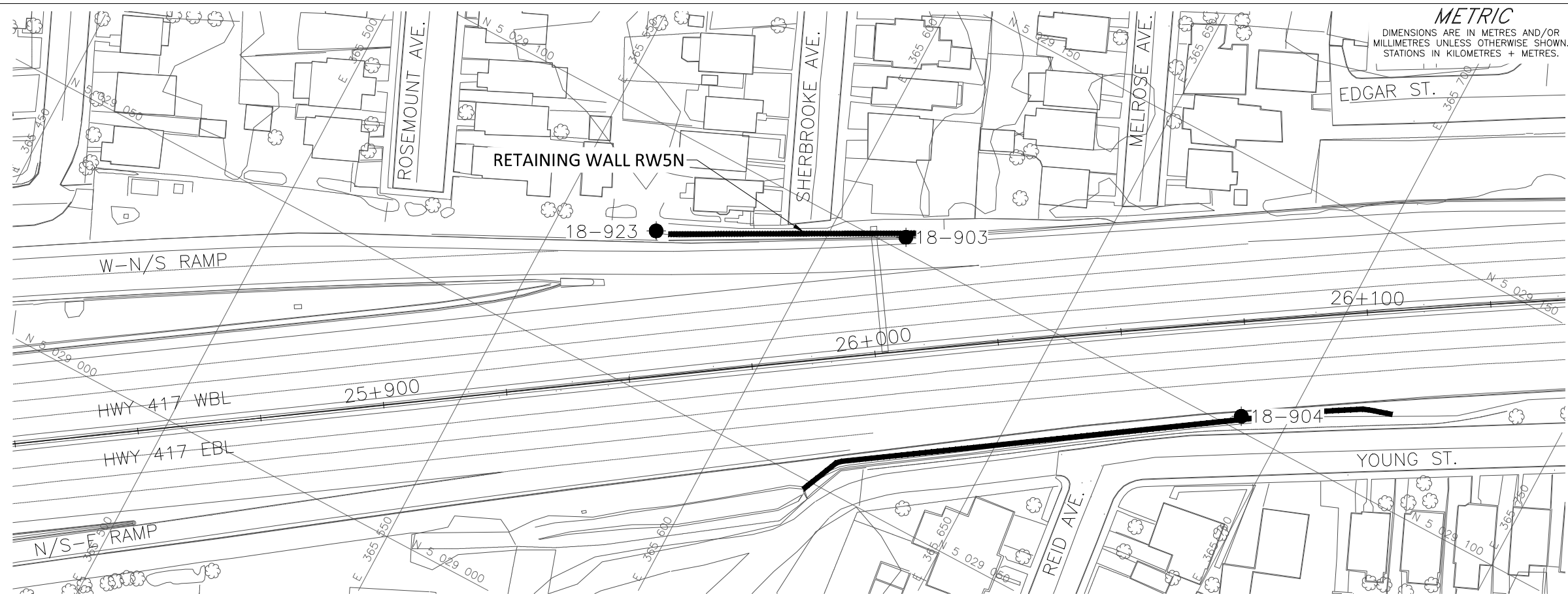


NO.	DATE	BY	REVISION

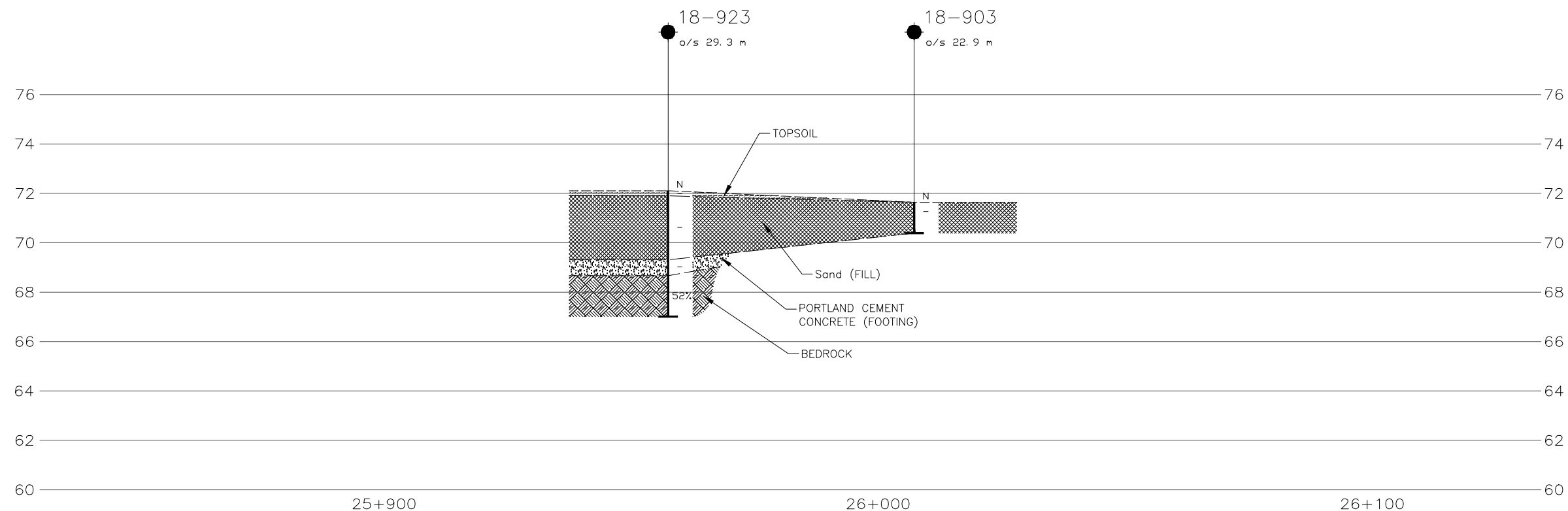
Geocres No. 31G5-315

HWY. 417	PROJECT NO. 1655214-1900	DIST. EASTERN
SUBM'D. RK	CHKD. RK	DATE: 3/6/2020
SITE: -		
DRAWN: JM	CHKD. KP	APPD. FJH
DWG. 1		

PLOT DATE: March 6, 2020
 FILE NAME: K:\Users\jheffernan\My Documents\Projects\1655214-1900-1600-0001.dwg



PLAN
SCALE
10 0 10 20 m



PROFILE ALONG CENTRE-LINE HIGHWAY 417

SCALE
10 0 10 20 m
3 0 3 6 m

NOTES
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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE
Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.



CONT No. GWP No. 4173-15-00
RETAINING WALL REPLACEMENT/REHABILITATION RW5N
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.399231 LONG. -75.723216



SHEET



KEY PLAN
SCALE
500 0 500 1000 m

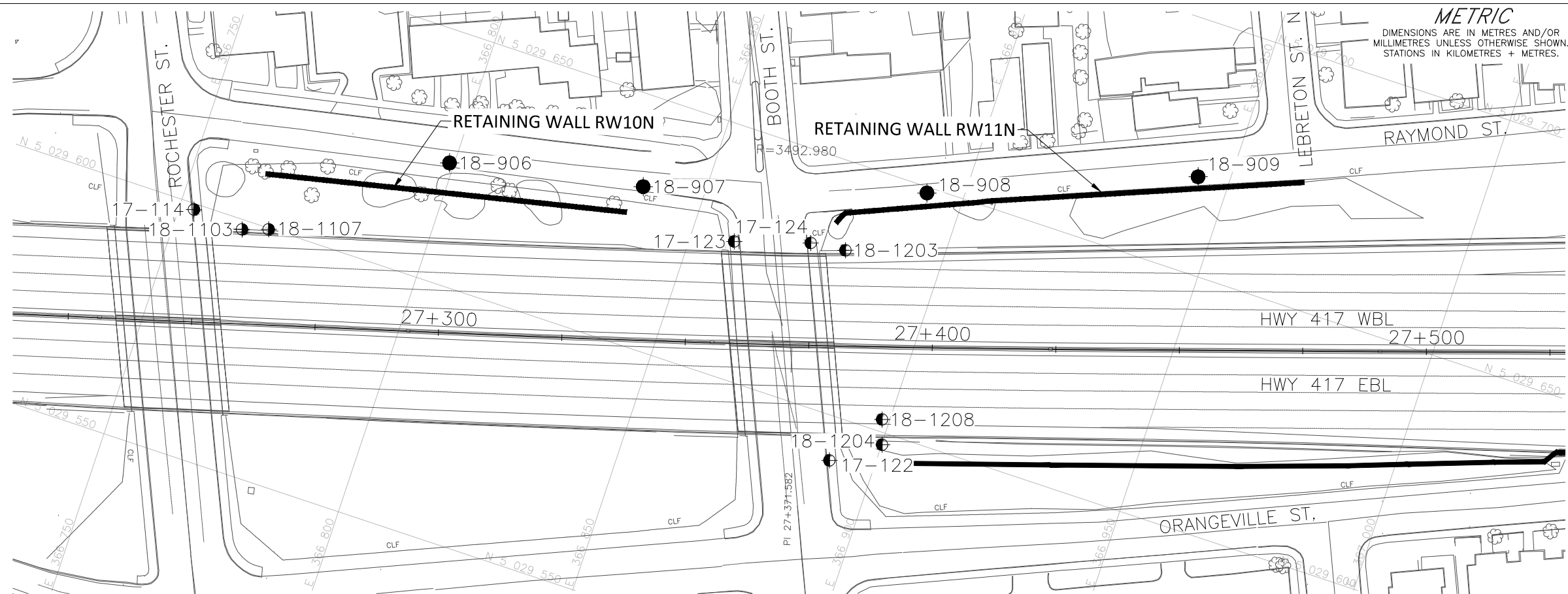
- LEGEND**
- Borehole - Current Investigation
 - ⊥ Seal
 - ⊥ Piezometer
 - N Standard Penetration Test Value
 - 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
 - 100% Rock Quality Designation (RQD)
 - ▬ Retaining Wall (RW)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
18-801	67.4	5028691.4	365104.3
18-802	69.7	5028731.2	365132.6
18-901	70.0	5028734.4	365200.6
18-902	70.0	5028741.6	365206.9
18-903	71.6	5029102.8	365614.2
18-904	71.0	5029102.8	365691.1
18-906	65.5	5029624.1	366799.1
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
18-913	66.9	5029932.5	367605.0
18-914	67.5	5029958.8	367649.0
18-915	68.1	5029997.9	367718.4
18-916	67.1	5029928.2	367723.2
18-917	66.3	5029956.2	367774.1
18-918	66.6	5029986.3	367825.5
18-923	72.1	5029080.2	365569.0

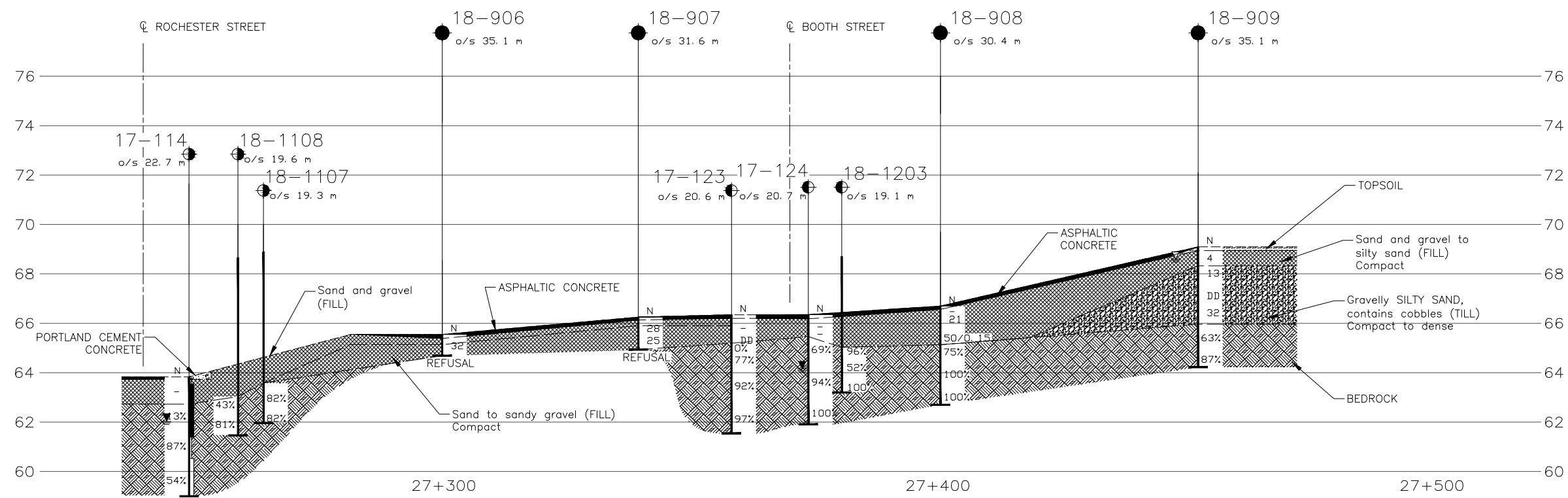
NO.	DATE	BY	REVISION

Geocres No. 31G5-315

HWY. 417	PROJECT NO. 1655214-1900	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 3/5/2020
DRAWN: ZS	CHKD. FJH	APPD. FJH



PLAN
SCALE
10 0 10 20 m



PROFILE ALONG CENTRE-LINE HIGHWAY 417

SCALE
10 0 10 20 m
3 0 3 6 m

NOTES
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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE
Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.



CONT No. GWP No. 4173-15-00
RETAINING WALL REPLACEMENT/REHABILITATION RW10N & RW11N
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.391846 LONG. -75.732469



SHEET



KEY PLAN
SCALE
500 0 500 1000 m

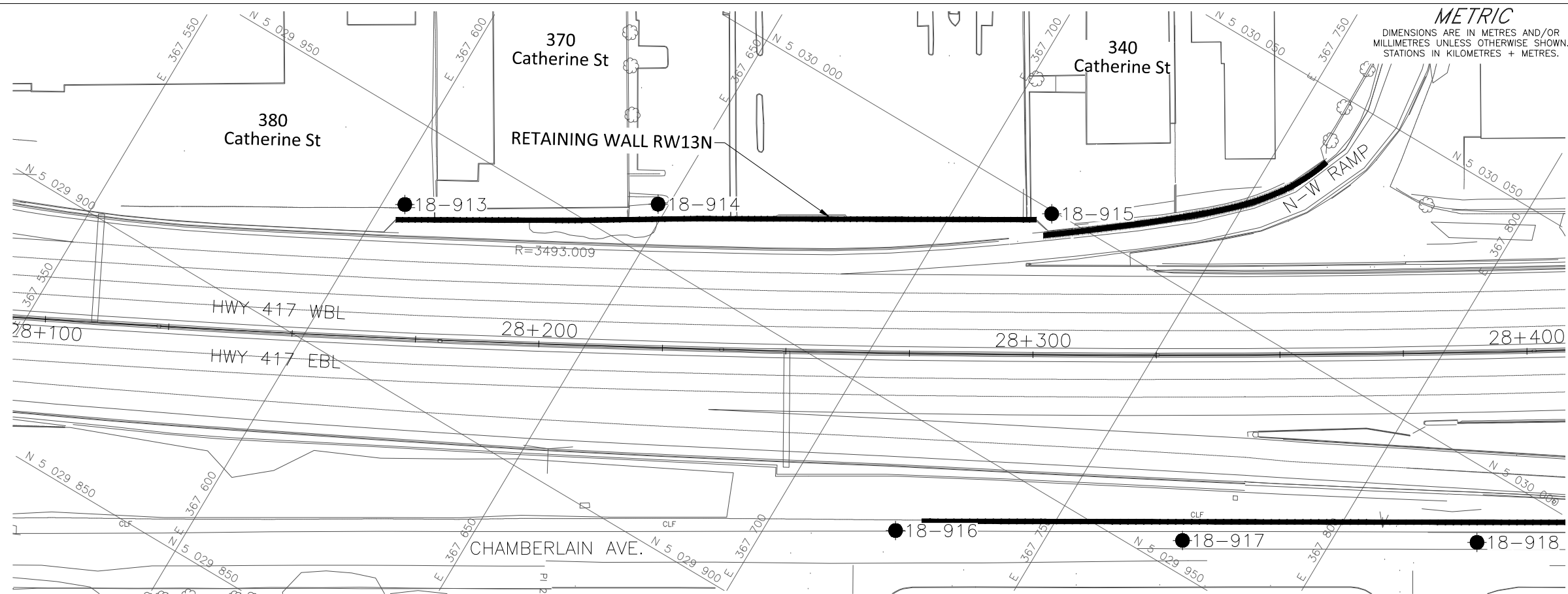
- LEGEND**
- Borehole - Current Investigation
 - ⊕ Borehole - From Geocres 31G5-295
 - ⊕ Borehole - From Geocres 31G5-308
 - Seal
 - Piezometer
 - N Standard Penetration Test Value
 - 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
 - 100% Rock Quality Designation (RQD)
 - ∇ WL upon completion of drilling
 - ∇ WL in piezometer, measured on April 26, 2017 and October 27, 2017
 - Retaining Wall (RW)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
18-906	65.5	5029624.1	366799.1
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
17-114	63.8	5029598.8	366753.0
18-1103	66.3	5029598.0	366763.5
18-1107	68.9	5029599.8	366768.6
17-123	66.3	5029627.2	366858.8
17-124	66.4	5029631.8	366873.5
18-1203	68.7	5029632.6	366880.7
17-122	66.7	5029591.2	366891.0
18-1204	70.5	5029597.6	366900.1
18-1208	72.9	5029602.4	366898.5

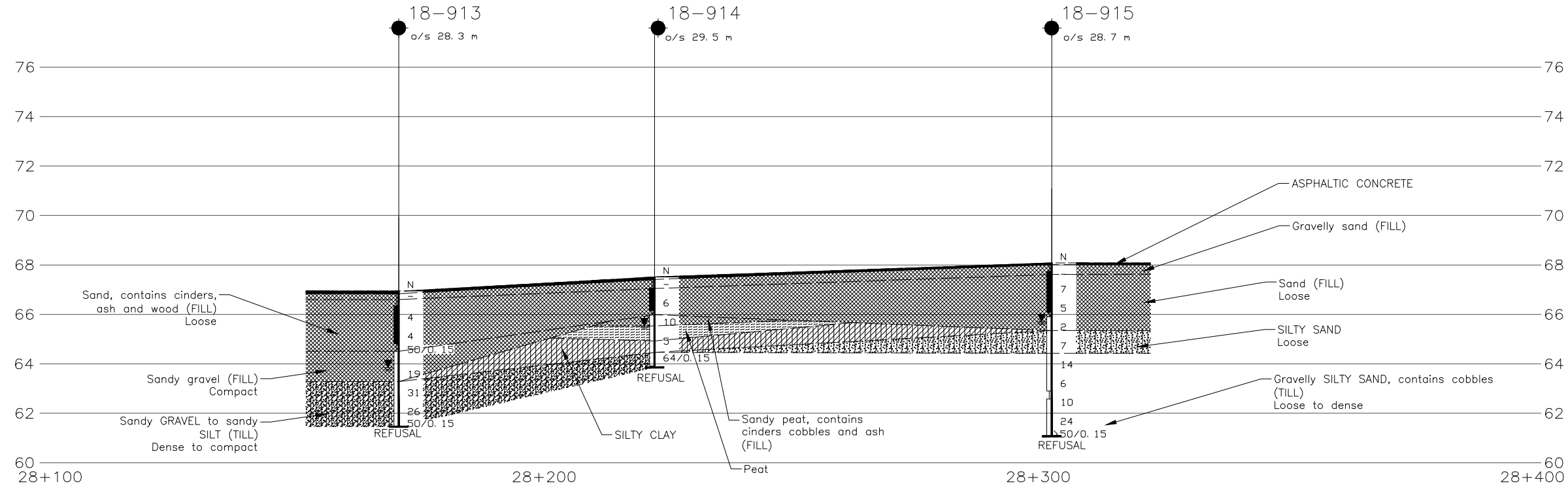
NO.	DATE	BY	REVISION

Geocres No. 31G5-315
 HWY. 417 PROJECT NO. 1655214-1900 DIST. EASTERN
 SUBM'D. KCP CHKD. KCP DATE: 3/5/2020 SITE: -
 DRAWN: ZS CHKD. FJH APPD. FJH DWG. 3

PLOT DATE: March 6, 2020
 FILENAME: K:\Users\zsc200\My Documents\Projects\1655214-1900-BC-0003.dwg



PLAN
SCALE
10 0 10 20 m



NOTES

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SCALE
10 0 10 20 m
3 0 3 6 m

REFERENCE

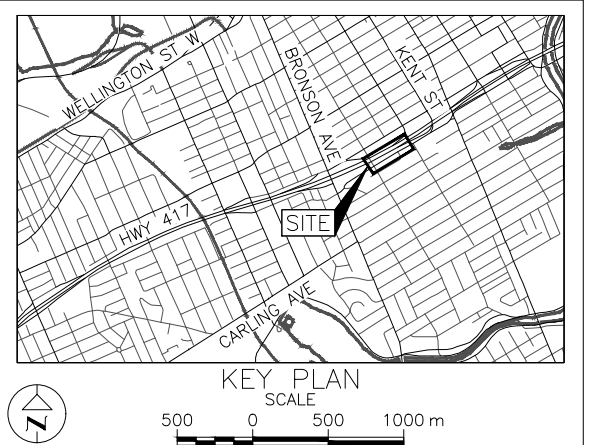
Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.



CONT No. GWP No. 4173-15-00

RETAINING WALL REPLACEMENT/REHABILITATION RW13N
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.391846 LONG. -75.732469

SHEET



LEGEND

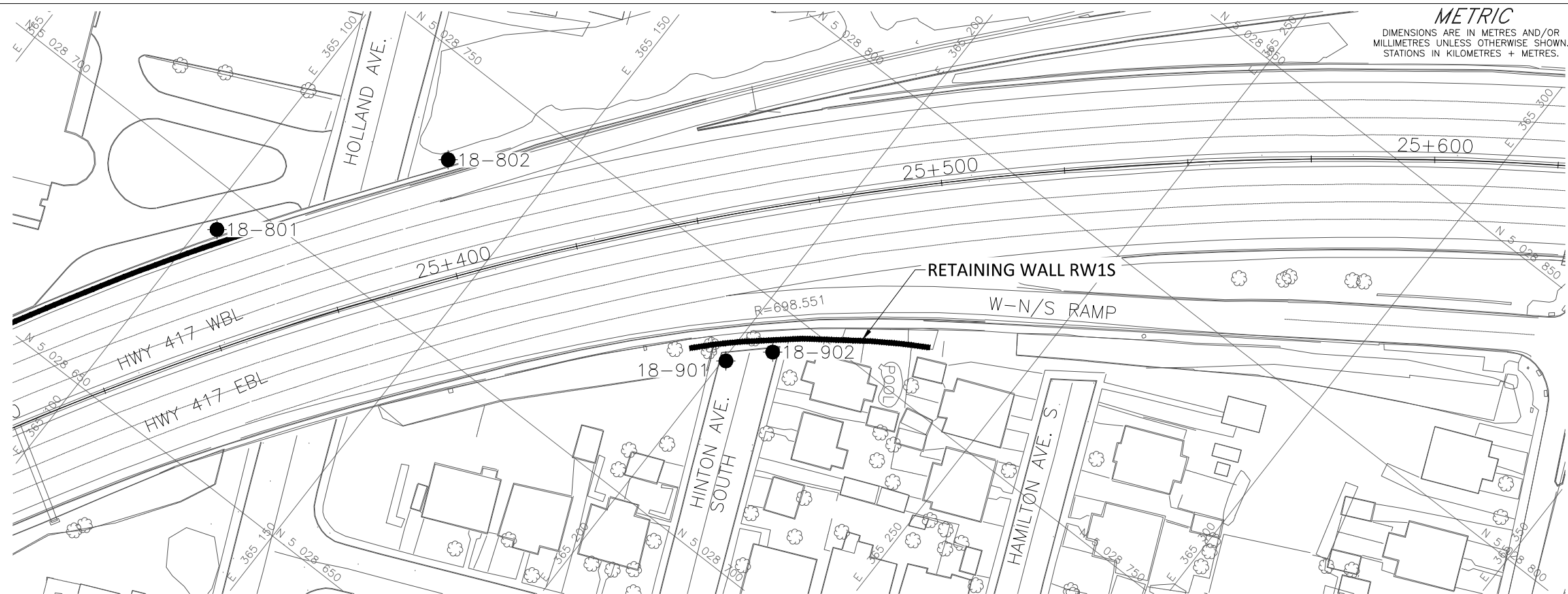
- Borehole - Current Investigation
- ⊥ Seal
- ⊏ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL in piezometer, measured on June 19, 2019
- ▬ Retaining Wall (RW)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
18-801	67.4	5028691.4	365104.3
18-802	69.7	5028731.2	365132.6
18-901	70.0	5028734.4	365200.6
18-902	70.0	5028741.6	365206.9
18-903	71.6	5029102.8	365614.2
18-904	71.0	5029102.8	365691.1
18-906	65.5	5029624.1	366799.1
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
18-913	66.9	5029932.5	367605.0
18-914	67.5	5029958.8	367649.0
18-915	68.1	5029997.9	367718.4
18-916	67.1	5029928.2	367723.2
18-917	66.3	5029956.2	367774.1
18-918	66.6	5029986.3	367825.5
18-923	72.1	5029080.2	365569.0

NO.	DATE	BY	REVISION

Geocres No. 31G5-315

HWY. 417	PROJECT NO. 1655214-1900	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 3/5/2020
SITE: -		
DRAWN: ZS	CHKD. FJH	APPD. FJH
DWG. 4		

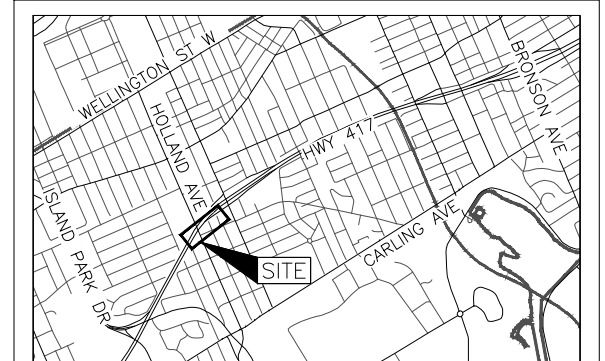


METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. GWP No. 4173-15-00

RETAINING WALL REPLACEMENT/REHABILITATION RW1S
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.399231 LONG. -75.723216

SHEET

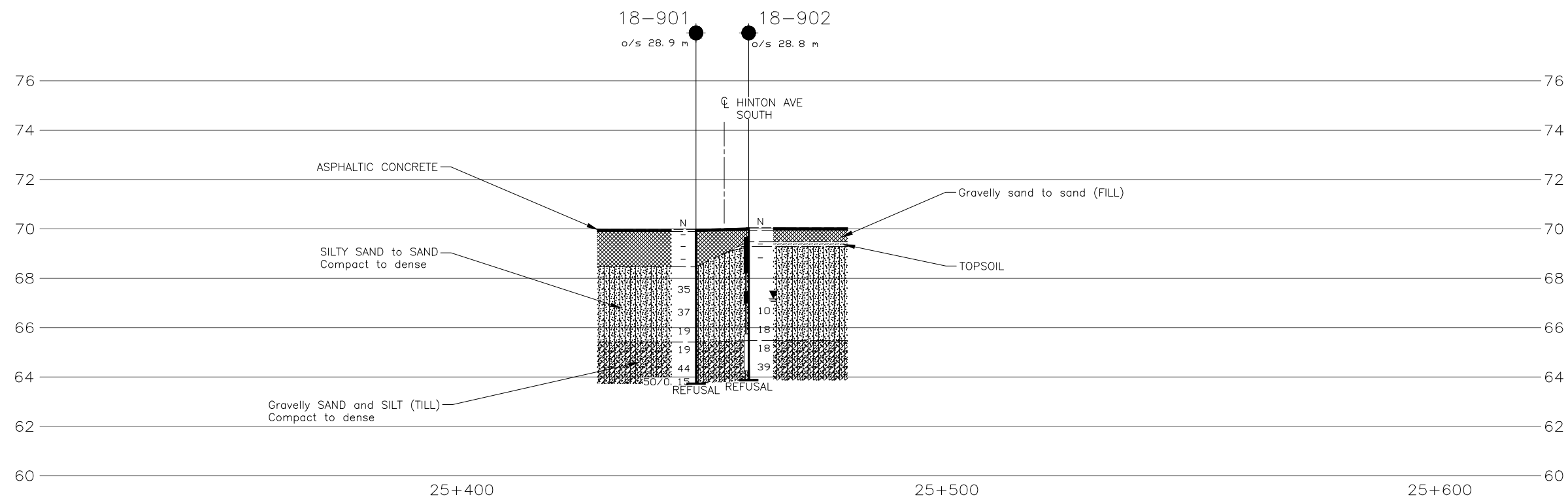


KEY PLAN
SCALE
500 0 500 1000 m

PLAN
SCALE
10 0 10 20 m

LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL in piezometer, measured on June 19, 2019
- ▬ Retaining Wall (RW)



PROFILE ALONG CENTRE-LINE HIGHWAY 417
SCALE
10 0 10 20 m
3 0 3 6 m

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
18-801	67.4	5028691.4	365104.3
18-802	69.7	5028731.2	365132.6
18-901	70.0	5028734.4	365200.6
18-902	70.0	5028741.6	365206.9
18-903	71.6	5029102.8	365614.2
18-904	71.0	5029102.8	365691.1
18-906	65.5	5029624.1	366799.1
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
18-913	66.9	5029932.5	367605.0
18-914	67.5	5029958.8	367649.0
18-915	68.1	5029997.9	367718.4
18-916	67.1	5029928.2	367723.2
18-917	66.3	5029956.2	367774.1
18-918	66.6	5029986.3	367825.5
18-923	72.1	5029080.2	365569.0

NOTES

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REFERENCE

Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.

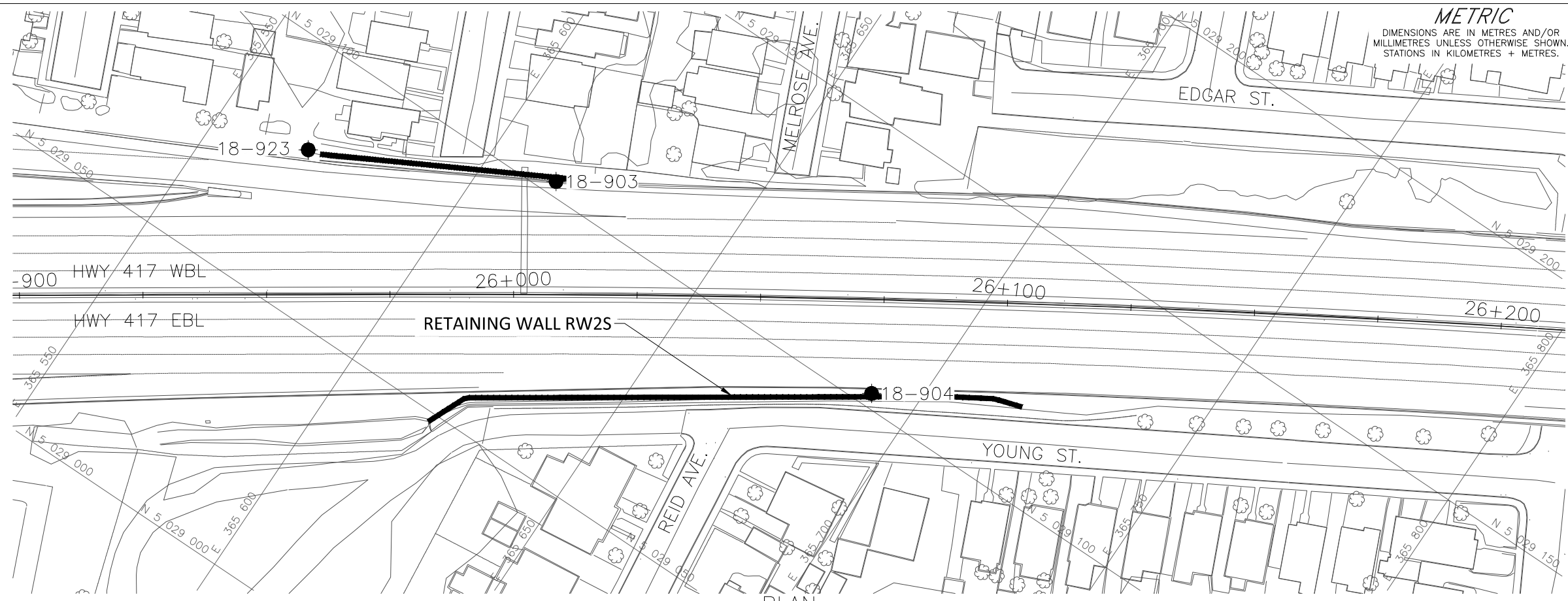


NO.	DATE	BY	REVISION

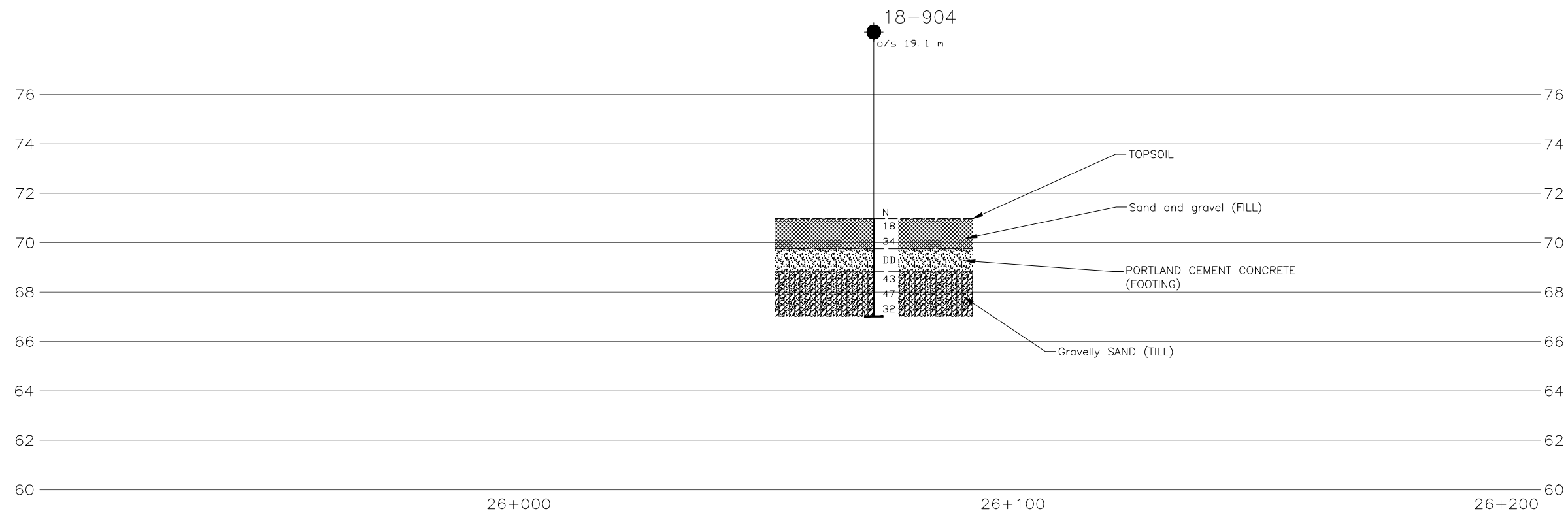
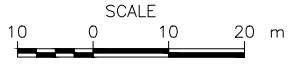
Geocres No. 31G5-315

HWY. 417	PROJECT NO. 1655214-1900	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 3/5/2020
SITE: -		
DRAWN: ZS	CHKD. FJH	APPD. FJH
		DWG. 5

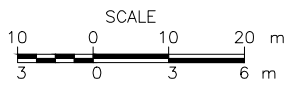
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PLAN



PROFILE ALONG CENTRE-LINE HIGHWAY 417



CONT No. GWP No. 4173-15-00

RETAINING WALL REPLACEMENT/REHABILITATION RW2S
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.399224 LONG. -75.722234

SHEET



KEY PLAN SCALE 500 0 500 1000 m

LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ▬ Retaining Wall (RW)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
18-801	67.4	5028691.4	365104.3
18-802	69.7	5028731.2	365132.6
18-901	70.0	5028734.4	365200.6
18-902	70.0	5028741.6	365206.9
18-903	71.6	5029102.8	365614.2
18-904	71.0	5029102.8	365691.1
18-906	65.5	5029624.1	366799.1
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
18-913	66.9	5029932.5	367605.0
18-914	67.5	5029958.8	367649.0
18-915	68.1	5029997.9	367718.4
18-916	67.1	5029928.2	367723.2
18-917	66.3	5029956.2	367774.1
18-918	66.6	5029986.3	367825.5
18-923	72.1	5029080.2	365569.0

NOTES

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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

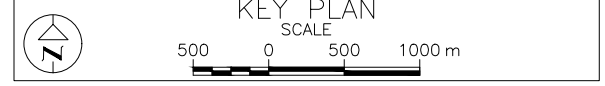
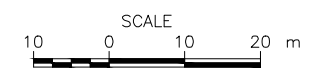
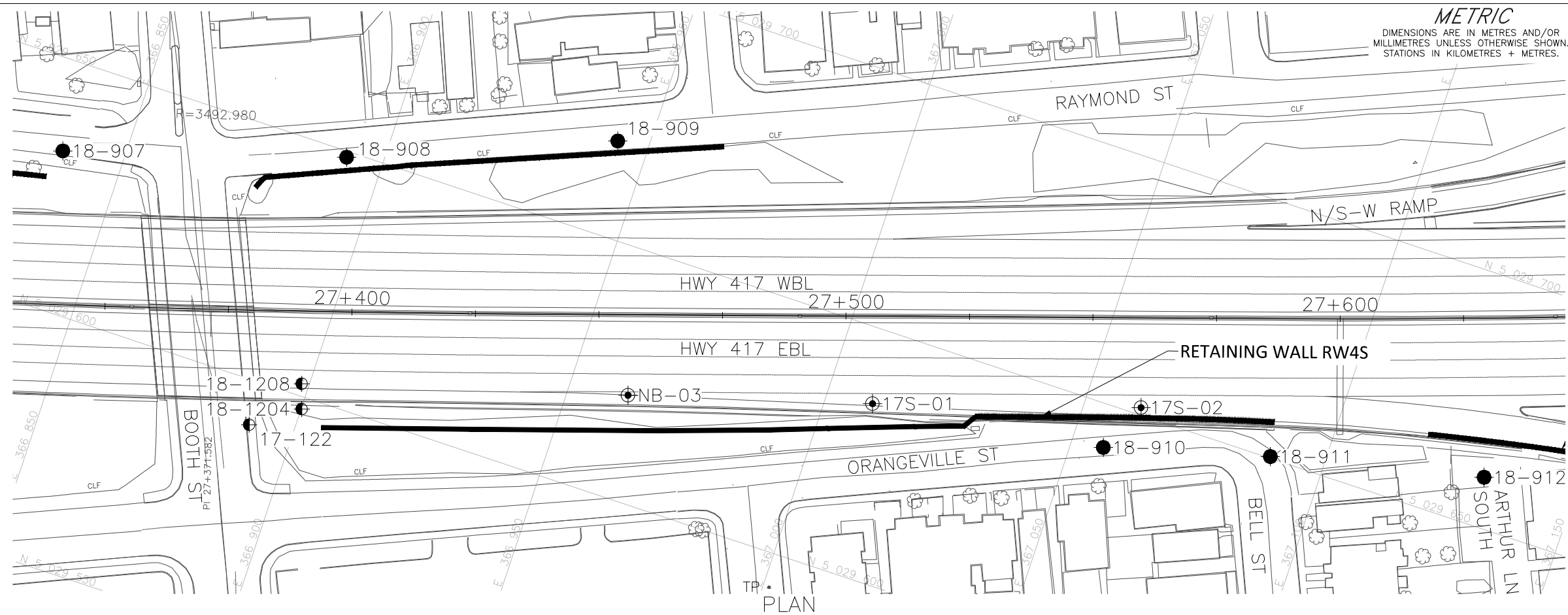
Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.



NO.	DATE	BY	REVISION

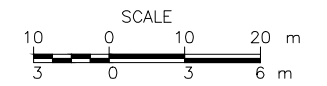
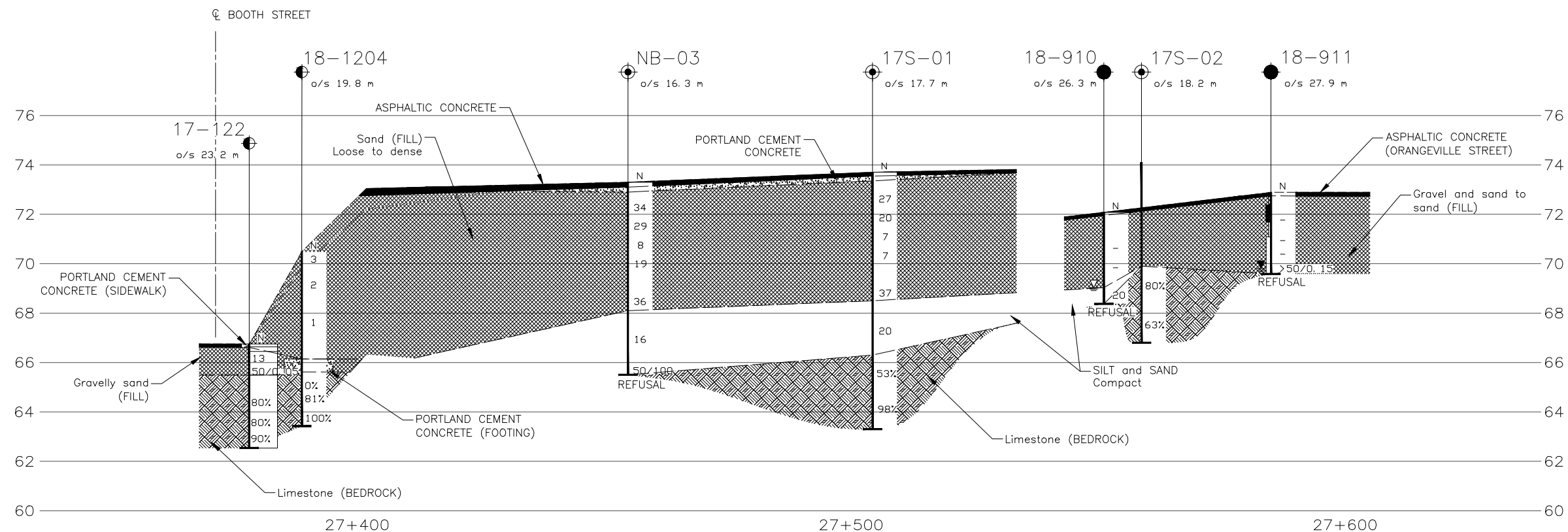
Geocres No. 31G5-315

HWY. 417	PROJECT NO. 1655214-1900	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 3/5/2020
SITE: -		
DRAWN: ZS	CHKD. FJH	APPD. FJH
DWG. 6		



LEGEND

- Borehole - Current Investigation
- ⊕ Borehole - From Geocres 31G5-308
- ⊕ Borehole - From Geocres 31G5-254
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL in piezometer, measured on June 19, 2019
- ≡ WL upon completion of drilling
- Retaining Wall (RW)



BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
18-1204	70.5	5029597.6	366900.1
18-1208	72.9	5029602.4	366898.5
17-122	66.7	5029591.2	366891.0
NB-03	73.3	5029621.1	366961.9
17S-01	73.7	5029635.1	367009.4
17S-02	74.1	5029651.5	367061.2

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

PROFILE ALONG CENTRE-LINE HIGHWAY 417

REFERENCE
Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.

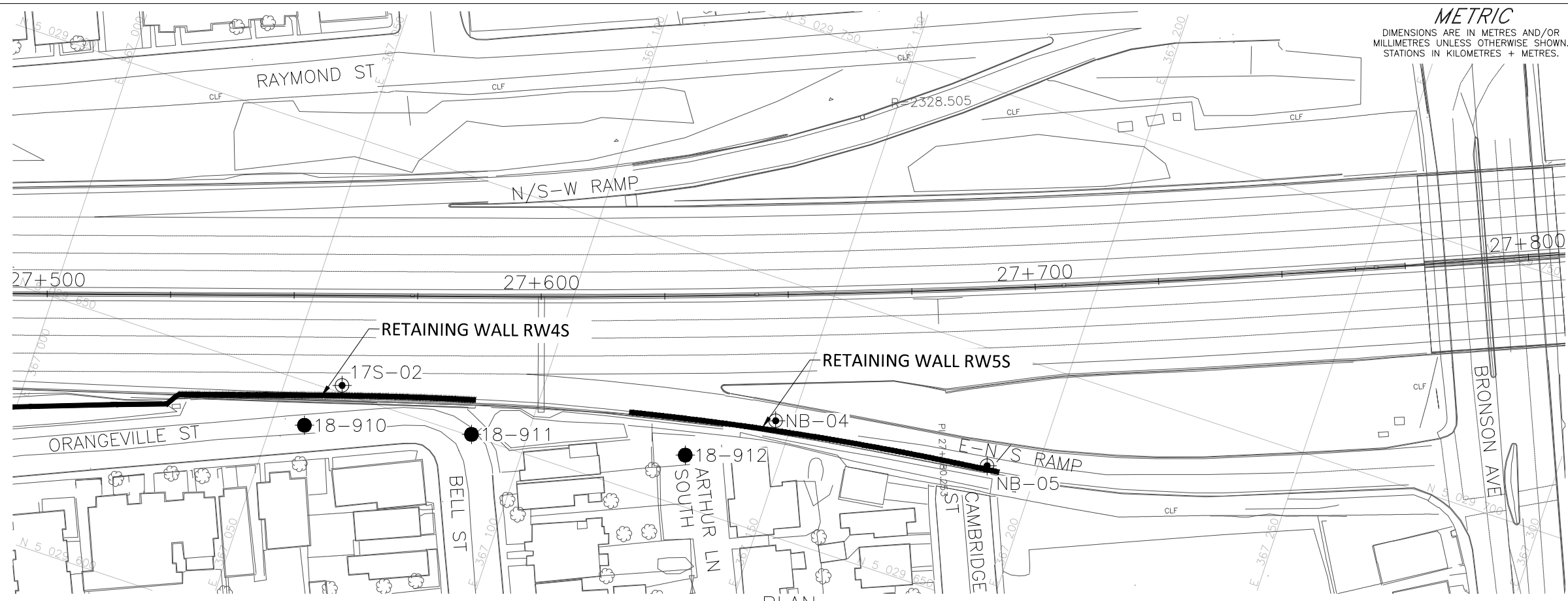


NO.	DATE	BY	REVISION

Geocres No. 31G5-315

HWY. 417	PROJECT NO. 1655214-1900	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 3/5/2020
DRAWN: ZS	CHKD. FJH	APPD. FJH
		SITE: -
		DWG. 7

PLOT DATE: March 6, 2020
 FILENAME: K:\Users\scottb\My Documents\Projects\1655214-1900-18-0007.dwg

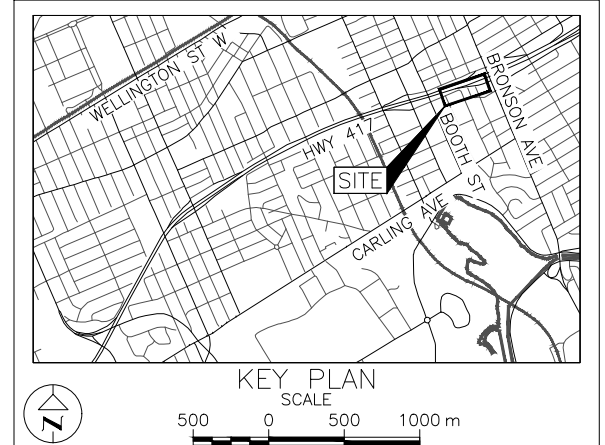


METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. GWP No. 4173-15-00

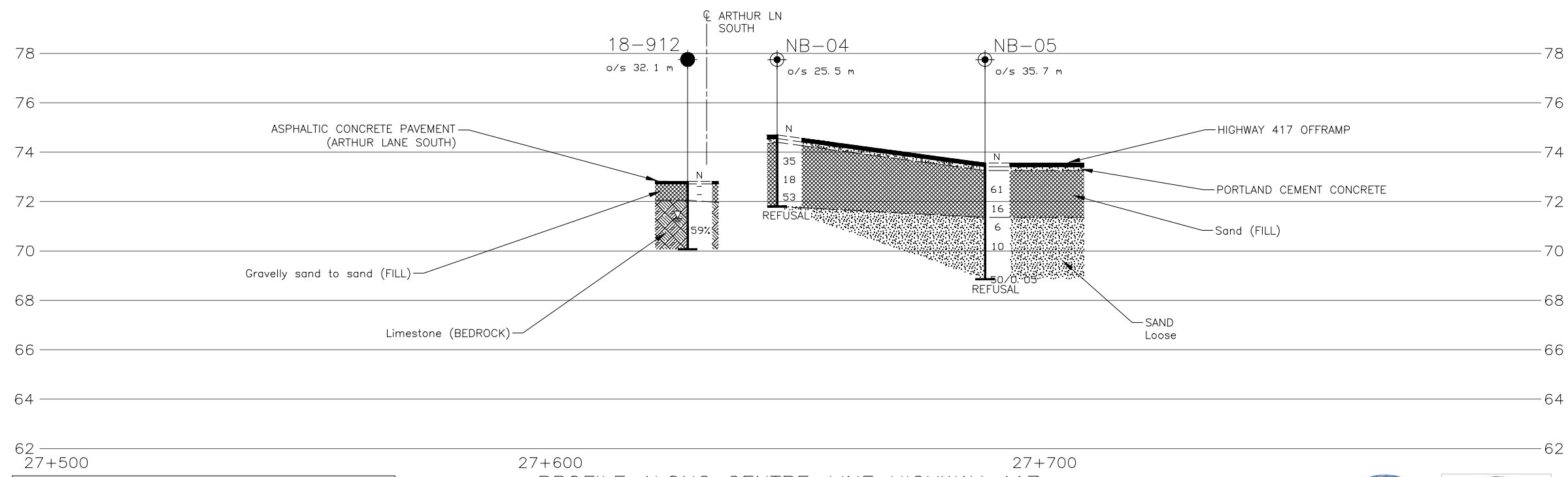
RETAINING WALL REPLACEMENT/REHABILITATION RW5S
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.404112 LONG. -75.703767

SHEET



LEGEND

- Borehole - Current Investigation
- ⊕ Borehole - From Geocres 31G5-254
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL upon completion of drilling
- ▬ Retaining Wall (RW)



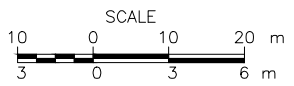
BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
NB-04	74.7	5029672.4	367146.7
NB-05	73.5	5029677.3	367190.2

NOTES

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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.



REFERENCE

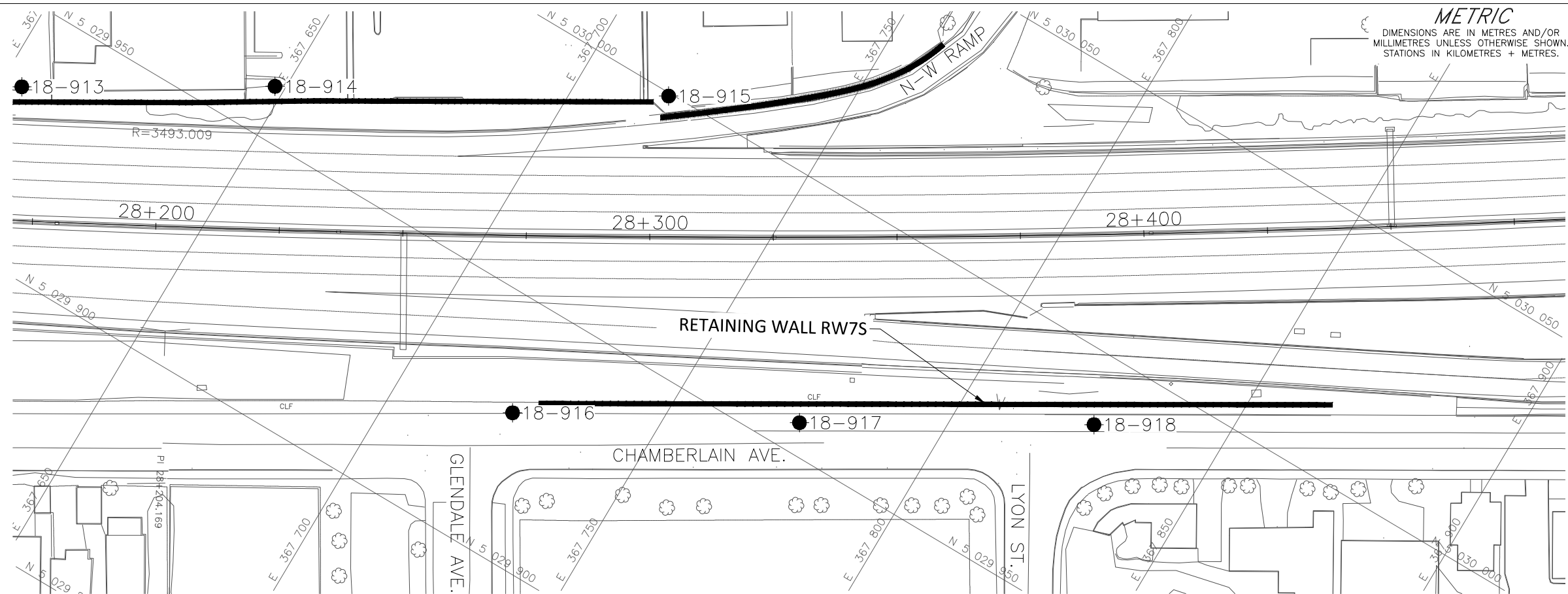
Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.



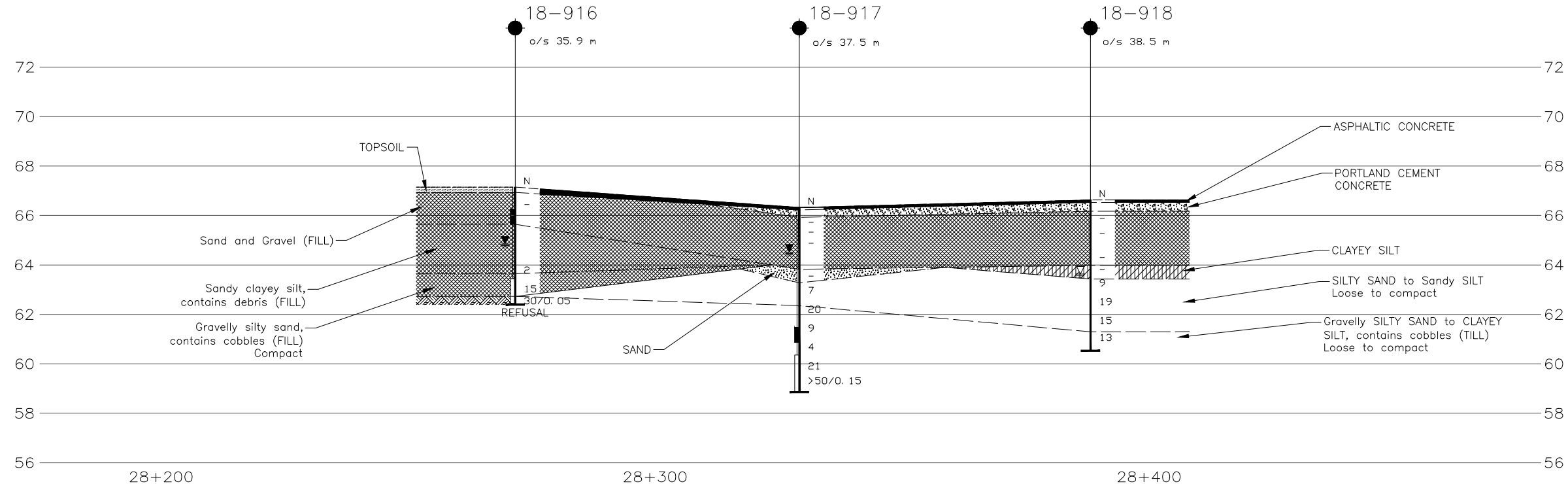
NO.	DATE	BY	REVISION
A			

Geocres No. 31G5-315

HWY. 417	PROJECT NO. 1655214-1900	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 3/5/2020
SITE: -	APPD. FJH	DWG. 8



PLAN
SCALE
10 0 10 20 m



PROFILE ALONG CENTRE-LINE HIGHWAY 417

SCALE
10 0 10 20 m
3 0 3 6 m

NOTES
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE
Base plans provided in digital format by WSP, drawing file no. 3416024-Noise and Retaining wall overview.dwg, received MAR. 18, 2019.



CONT No. GWP No. 4173-15-00
RETAINING WALL REPLACEMENT/REHABILITATION RW7S
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.406719 LONG. -75.695522



KEY PLAN
SCALE
500 0 500 1000 m

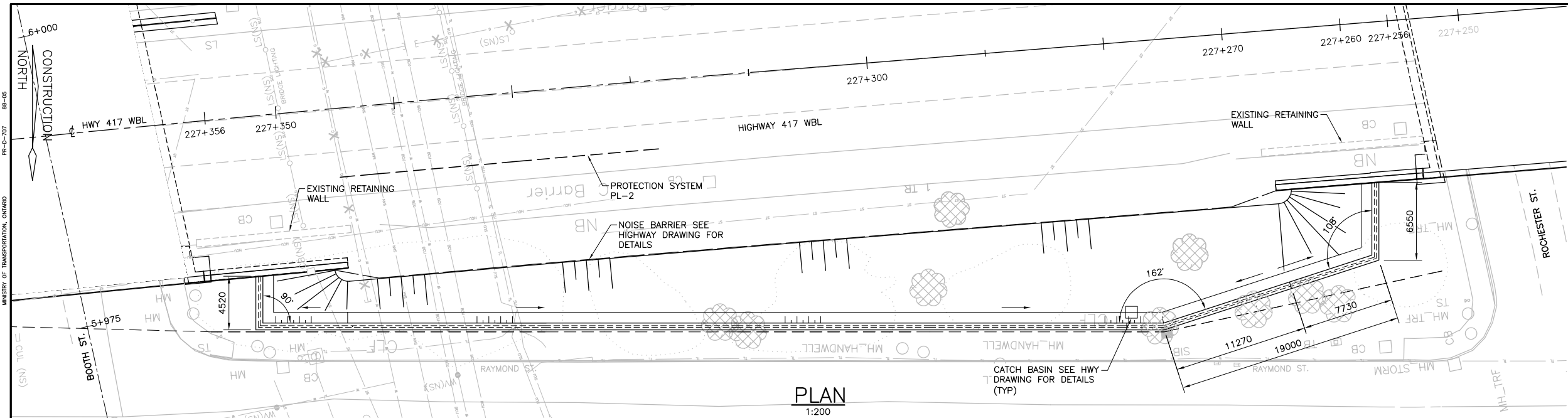
- LEGEND**
- Borehole - Current Investigation
 - ⊥ Seal
 - ⊥ Piezometer
 - N Standard Penetration Test Value
 - 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
 - 100% Rock Quality Designation (RQD)
 - ▽ WL in piezometer, measured on June 19, 2019
 - ▽ WL upon completion of drilling
 - ▬ Retaining Wall (RW)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
18-801	67.4	5028691.4	365104.3
18-802	69.7	5028731.2	365132.6
18-901	70.0	5028734.4	365200.6
18-902	70.0	5028741.6	365206.9
18-903	71.6	5029102.8	365614.2
18-904	71.0	5029102.8	365691.1
18-906	65.5	5029624.1	366799.1
18-907	66.3	5029631.9	366837.8
18-908	66.7	5029647.0	366893.3
18-909	69.1	5029667.4	366944.3
18-910	72.1	5029641.4	367056.5
18-911	72.9	5029650.4	367089.2
18-912	72.8	5029660.0	367131.5
18-913	66.9	5029932.5	367605.0
18-914	67.5	5029958.8	367649.0
18-915	68.1	5029997.9	367718.4
18-916	67.1	5029928.2	367723.2
18-917	66.3	5029956.2	367774.1
18-918	66.6	5029986.3	367825.5
18-923	72.1	5029080.2	365569.0

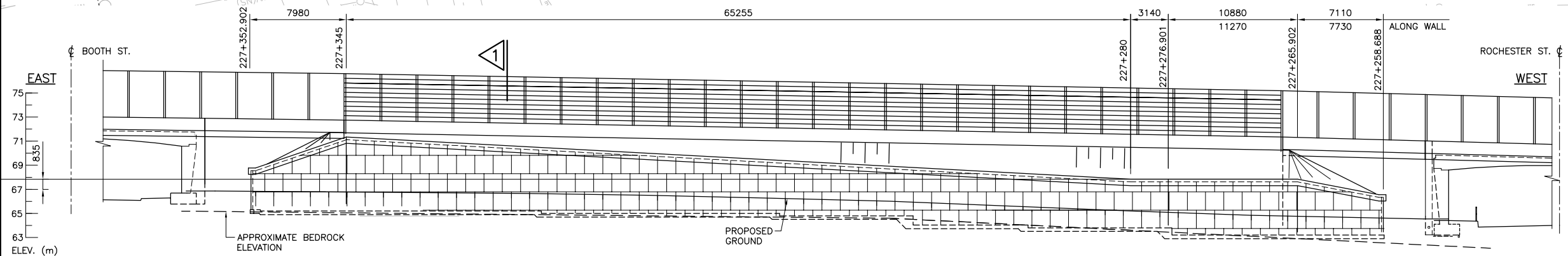
NO.	DATE	BY	REVISION

Geocres No. 31G5-315
HWY. 417 PROJECT NO. 1655214-1900 DIST. EASTERN
SUBM'D. KCP CHKD. KCP DATE: 3/5/2020 SITE: -
DRAWN: ZS CHKD. FJH APPD. FJH DWG. 9

PLOT DATE: March 6, 2020
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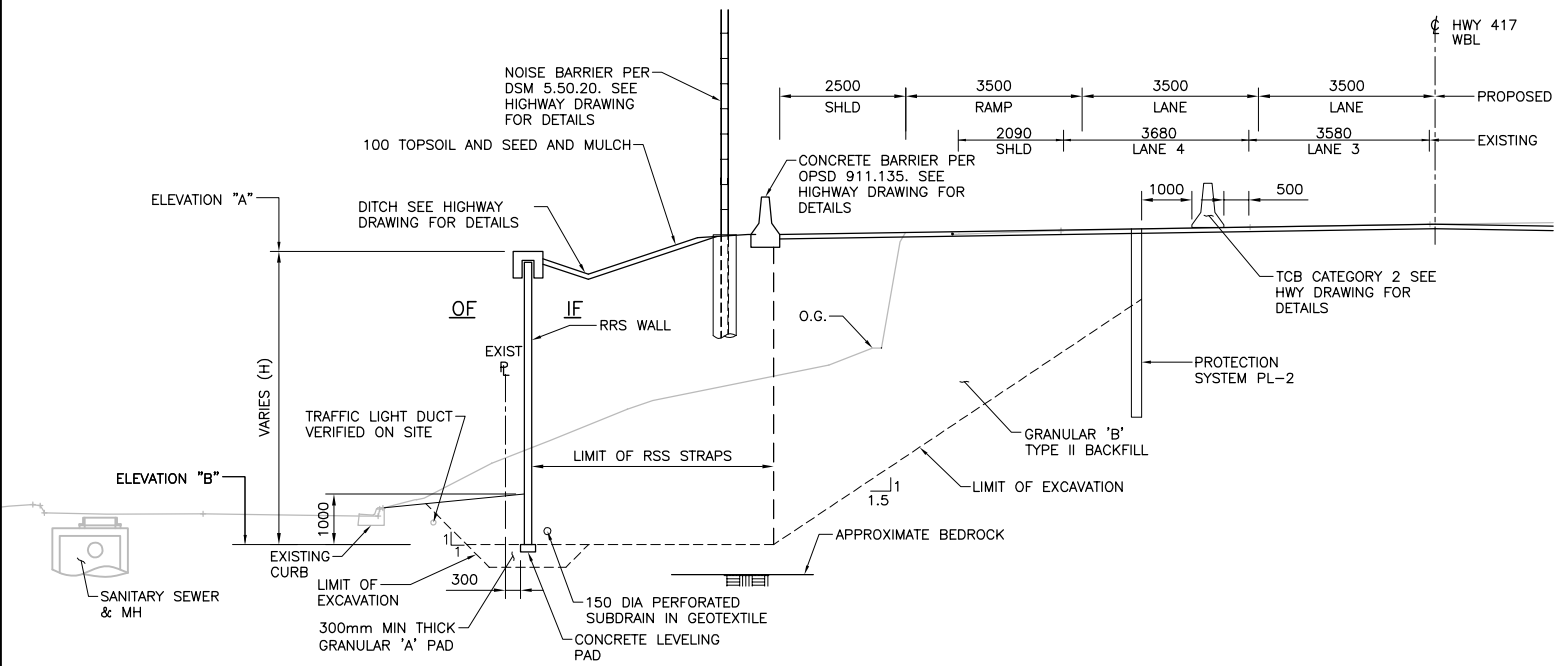


PLAN
1:200



STATION	227+352.902	227+345	227+340	227+330	227+320	227+310	227+300	227+290	227+280	227+276.901	227+265.902	227+258.688
OFFSET FROM CL HWY 417 EBL (m) (TO OUTSIDE FACE OF RRS WALL)	17.775	18.508	18.964	18.852	20.720	21.552	22.355	23.163	23.971	24.222	21.622	19.905
ELEVATION "A"	67.030	71.344	71.028	70.555	69.975	69.406	68.833	68.233	67.835	67.835	67.835	66.559
ELEVATION "B"	65.300	65.200	65.200	65.200	65.000	65.000	64.800	64.030	63.800	63.200	63.200	63.200

ELEVATION - PROPOSED
1:200



1 PROPOSED
1:75

CONT. No. WP No.	HIGHWAY 417 RETAINING WALL 10-N (RW26) STA 227+256 TO STA 227+356	SHEET S30
GENERAL ARRANGEMENT		METRIC

- GENERAL NOTES:**
- ALL REINFORCING STEEL IN RSS WALL PANELS, COPING, AND SLIP JOINTS SHALL BE STAINLESS STEEL TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPA. UNLESS OTHERWISE SPECIFIED.
- RETAINED SOIL SYSTEM:**
- WALL SHALL BE AS LISTED IN THE MTO DESIGNATED SOURCE OF MATERIALS MANUAL WITH THE FOLLOWING
 - RETAINED SOIL SYSTEM WALLS SHALL HAVE THE FOLLOWING ATTRIBUTES:
PERFORMANCE - HIGH
APPEARANCE - HIGH
MAX. ANGLE - 90°
 - LENGTH OF RETAINED SOIL SYSTEM MAY BE INCREASED TO SUIT NEAREST NUMBER OF WHOLE PANELS FOR RETAINED SOIL SYSTEM, INCLUDING GRANULAR FILL, EXCAVATION, CONCRETE CAP AND THE LIKE, WITH NO ADDITIONAL COST TO THE OWNER. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE CONTRACT ADMINISTRATOR.
 - TOP SOIL, SOFT/LOOSE SOIL, AND ANY SOFT/WET NATIVE MATERIAL SHOULD BE STRIPPED FROM THE FOOTING OF THE RSS. THE NATIVE SUBGRADE UNDER THE RSS FOUNDATION SHOULD BE PROOF ROLLED TO DETECT AND REPLACE ANY SOFT AREAS.
 - PRIOR TO PLACING THE GRANULAR PAD FOR THE RSS, THE SUBEXCAVATED GRADE SHALL BE PROOF-ROLLED AND THE CONTRACTOR AND RSS SUPPLIER SHALL INSPECT THE SUBEXCAVATED GRADE AND CONFIRM ITS CAPACITY TO SUPPORT THE RSS SYSTEM BEFORE PROCEEDING WITH THE WORK.
 - THE GRANULAR 'A' PADS SHALL BE COMPACTED TO 100% STANDARD PROCTOR MAXIMUM DRY DENSITY (SPMDD) AT A MOISTURE CONTENT WITHIN 2% OF OPTIMUM.
 - PROTECTION SYSTEMS SHALL BE DESIGNED BY CONTRACTOR IN ACCORDANCE WITH OPSS 539 PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATIC ONLY, EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.
 - RSS REINFORCING STRIP LOCATIONS SHALL NOT INTERFERE AND WITH NOISE BARRIER FOUNDATION AND CATCH BASIN LOCATIONS.

- APPLICABLE STANDARD DRAWINGS:**
- OPSD 3121.150 WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
 - OPSD 600.040 CONCRETE BARRIER CURB WITH STANDARD GUTTER
 - CITY STANDARD SC1.1

- LIST OF DRAWINGS:**
- GENERAL ARRANGEMENT
 - RETAINING WALL DETAILS

- LEGEND:**
- REMOVALS
- LIST OF ABBREVIATIONS**
- IF DENOTES INSIDE FACE
 - OF DENOTES OUTSIDE FACE
 - RSS DENOTES RETAINED SOIL SYSTEM
 - PL DENOTES PROPERTY LINE



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

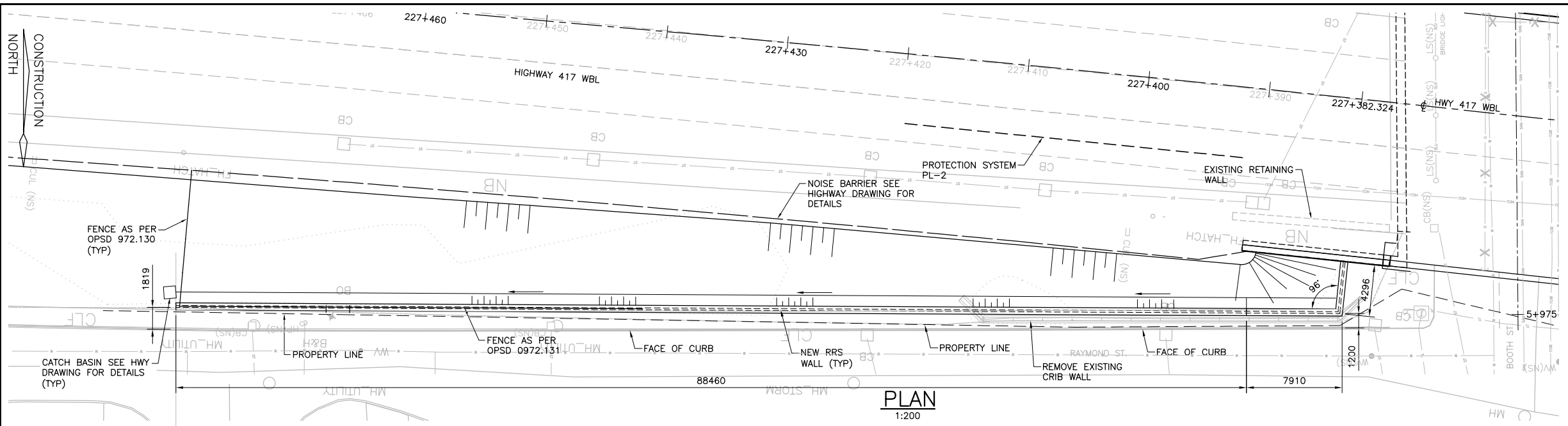
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DESIGN	WW	CHK	YY	CODE CHBDC 2014 LOAD CL-625-ONT	DATE	JAN/20
DRAWN	ZP	CHK	WW	SITE 03X-0938/W0	DWG	1

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 DATE PLOTTED: 1/23/2020 9:21:08 AM BY: PAN, WILSON

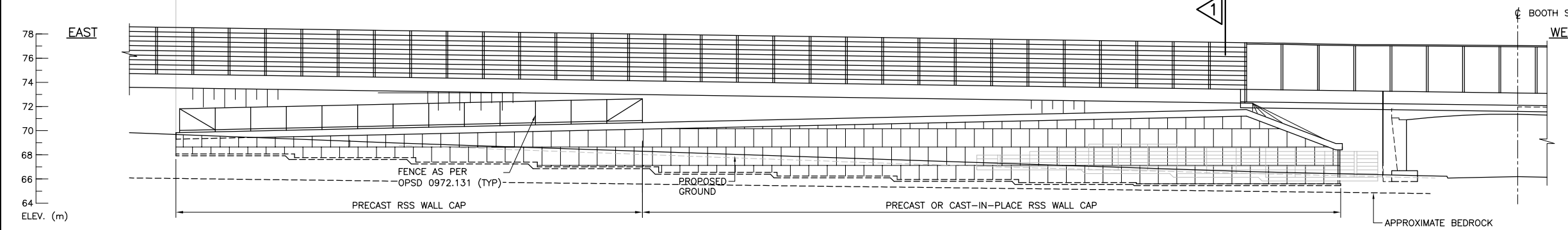
PR-D-707 88-05

MINISTRY OF TRANSPORTATION, ONTARIO

CAD FILE LOCATION AND NAME: s:\2016\34\3416024\326 RW10 - Booth to Lebraton\16M-01636-326-001GA.dwg
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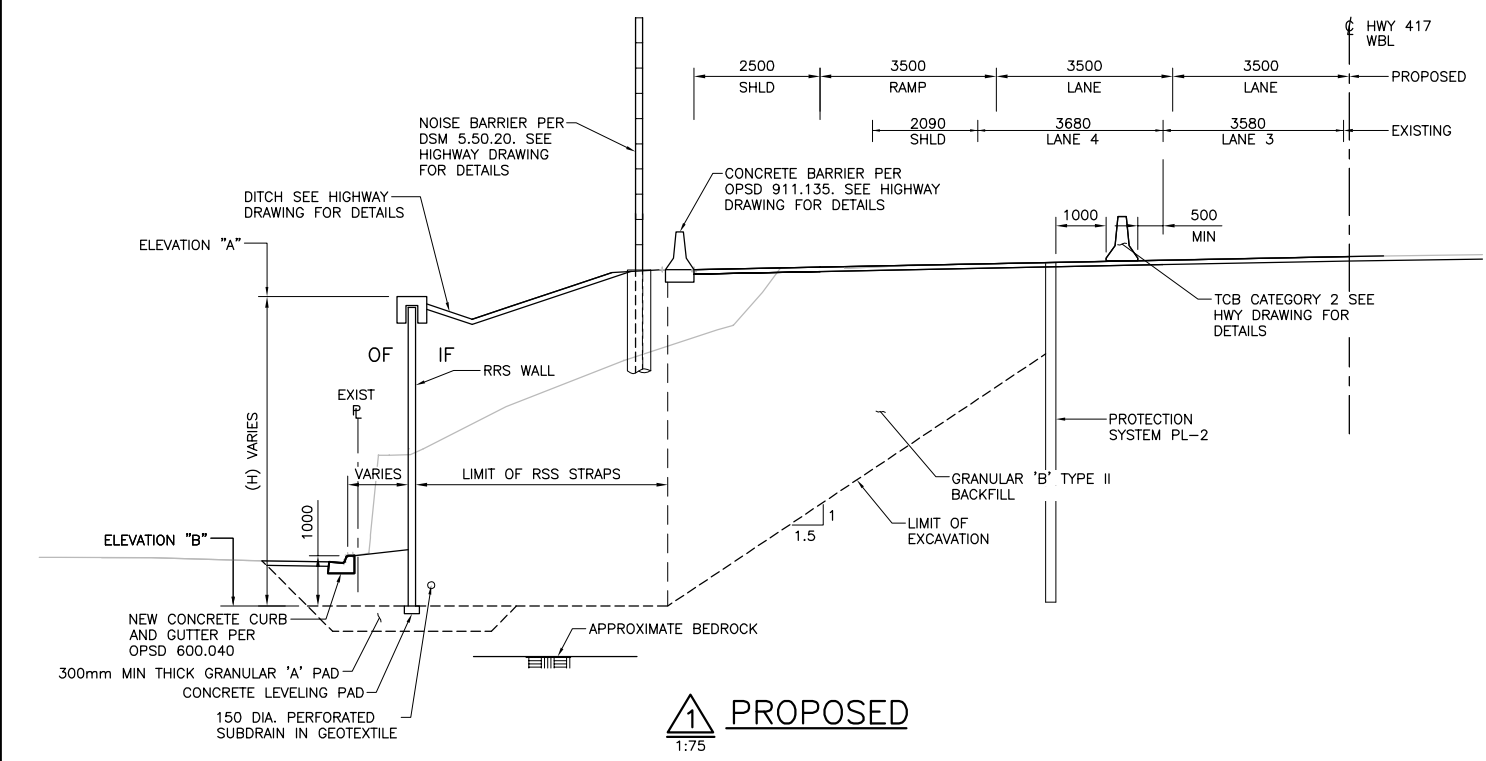


PLAN
1:200



ELEVATION — PROPOSED
1:200

STATION	227+478.416	227+470	227+460	227+450	227+440	227+430	227+420	227+410	227+400	227+390	227+382.324
OFFSET FROM CL HWY 417 EBL (m) (TO OUTSIDE FACE OF RRS WALL)	26.309	25.603	24.764	24.045	23.201	22.326	21.442	21.518	19.570	18.580	17.820
ELEVATION "A"	69.827	70.009	70.311	70.443	70.672	70.747	70.982	71.247	71.576	71.738	68.939
ELEVATION "B"	67.070	68.070	67.770	67.400	67.000	66.550	66.250	65.950	65.700	65.500	65.500



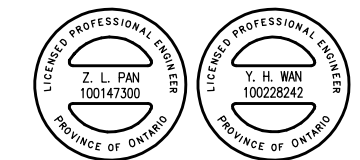
PROPOSED
1:75

CONT. No. WP No. 4173-15-00	 SHEET S32
HIGHWAY 417 RETAINING WALL RETAINING WALL 11-N (RW10) STA 227+478 TO STA 227+382	
GENERAL ARRANGEMENT	METRIC

- GENERAL NOTES:**
- ALL REINFORCING STEEL IN RSS WALL PANELS, COPING, AND SLIP JOINTS SHALL BE STAINLESS STEEL TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPA. UNLESS OTHERWISE SPECIFIED.
- RETAINED SOIL SYSTEM:**
- WALL SHALL BE AS LISTED IN THE MTO DESIGNATED SOURCE OF MATERIALS MANUAL WITH THE FOLLOWING ATTRIBUTES:
 PERFORMANCE — HIGH
 APPEARANCE — HIGH
 MAX. ANGLE — 90°
 - LENGTH OF RETAINED SOIL SYSTEM MAY BE INCREASED TO SUIT NEAREST NUMBER OF WHOLE PANELS FOR RETAINED SOIL SYSTEM, INCLUDING GRANULAR FILL, EXCAVATION, CONCRETE CAP AND THE LIKE, WITH NO ADDITIONAL COST TO THE OWNER. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE CONTRACT ADMINISTRATOR.
 - TOP SOIL, SOFT/LOOSE SOIL, AND ANY SOFT/WET NATIVE MATERIAL SHOULD BE STRIPPED FROM THE FOOTING OF THE RSS. THE NATIVE SUBGRADE UNDER THE RSS FOUNDATION SHOULD BE PROOF ROLLED TO DETECT AND REPLACE ANY SOFT AREAS.
 - PRIOR TO PLACING THE GRANULAR PAD FOR THE RSS, THE SUBEXCAVATED GRADE SHALL BE PROOF-ROLLED AND THE CONTRACTOR AND RSS SUPPLIER SHALL INSPECT THE SUBEXCAVATED GRADE AND CONFIRM ITS CAPACITY TO SUPPORT THE RSS SYSTEM BEFORE PROCEEDING WITH THE WORK.
 - THE GRANULAR 'A' PADS SHALL BE COMPACTED TO 100% STANDARD PROCTOR MAXIMUM DRY DENSITY (SPMDD) AT A MOISTURE CONTENT WITHIN 2% OF OPTIMUM.
 - PROTECTION SYSTEMS SHALL BE DESIGNED BY CONTRACTOR IN ACCORDANCE WITH OPSS 539 PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATIC ONLY, EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.
 - RSS REINFORCING STRIP LOCATIONS SHALL NOT INTERFERE AND WITH NOISE BARRIER FOUNDATION AND CATCH BASIN LOCATIONS.

- APPLICABLE STANDARD DRAWINGS:**
- OPSD 3121.150 WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
 - OPSD 972.130 FENCE, CHAIN-LINK INSTALLATION — ROADWAY
 - OPSD 972.131 FENCE, CHAIN-LINK INSTALLATION — CONCRETE BARRIER
 - CITY STANDARD SC1.1

- LIST OF DRAWINGS:**
- GENERAL ARRANGEMENT
 - RETAINING WALL DETAILS
- LIST OF ABBREVIATIONS**
- IF DENOTES INSIDE FACE
 - OF DENOTES OUTSIDE FACE
 - RSS DENOTES RETAINED SOIL SYSTEM
 - PL DENOTES PROPERTY LINE



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	ZP	CHK	WW	CODE	CHBDC 2014	LOAD	CL-625-ONT	DATE	JAN/20
DRAWN	ZP	CHK	WW	SITE	03X-0749/WO			DWG	1

DISTRICT
CONT. No.
WP No. 4173-15-00



RETAINING WALL 13-N (RW11)
STA 282+167.676 TO STA 828+300.850

SHEET
S34

GENERAL ARRANGEMENT



METRIC

GENERAL NOTES:

ALL REINFORCING STEEL IN RSS WALL PANELS, COPING, AND SLIP JOINTS SHALL BE STAINLESS STEEL TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPA. UNLESS OTHERWISE SPECIFIED.

CLASS OF CONCRETE:

30 MPa

CLEAR COVER TO REINFORCING STEEL:

70 ± 20 mm UNLESS OTHERWISE NOTED

REINFORCING STEEL:

1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
2. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
3. STAINLESS REINFORCING STEEL SHALL BE TYPE 316 LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500MPa, UNLESS OTHERWISE SPECIFIED.
4. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
5. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.

RETAINED SOIL SYSTEM (RSS):

1. WALL SHALL BE AS LISTED IN THE MTO DESIGNATED SOURCE OF MATERIALS MANUAL WITH THE FOLLOWING
2. RSS WALL SHALL HAVE THE FOLLOWING ATTRIBUTES:

APPLICATION	WALL/SLOPE
GEOMETRY	VERTICAL
PERFORMANCE	MEDIUM
APPEARANCE	HIGH
3. LENGTH OF RETAINED SOIL SYSTEM MAY BE INCREASED TO SUIT NEAREST NUMBER OF WHOLE PANELS FOR RETAINED SOIL SYSTEM, INCLUDING GRANULAR FILL, EXCAVATION, CONCRETE CAP AND THE LIKE, WITH NO ADDITIONAL COST TO THE OWNER. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE CONTRACT ADMINISTRATOR.
4. TOP SOIL, SOFT/LOOSE SOIL, AND ANY SOFT/WET NATIVE MATERIAL SHOULD BE STRIPPED FROM THE FOOTING OF THE RSS. THE NATIVE SUBGRADE UNDER THE RSS FOUNDATION SHOULD BE PROOF ROLLED TO DETECT AND REPLACE ANY SOFT AREAS.
5. PRIOR TO PLACING THE GRANULAR PAD FOR THE RSS, THE SUBEXCAVATED GRADE SHALL BE PROOF-ROLLED AND THE CONTRACTOR AND RSS SUPPLIER SHALL INSPECT THE SUBEXCAVATED GRADE AND CONFIRM ITS CAPACITY TO SUPPORT THE RSS SYSTEM BEFORE PROCEEDING WITH THE WORK.
6. THE GRANULAR 'A' PADS SHALL BE COMPACTED TO 100% STANDARD PROCTOR MAXIMUM DRY DENSITY (SPMDD) AT A MOISTURE CONTENT WITHIN 2% OF OPTIMUM.
7. PROTECTION SYSTEMS SHALL BE DESIGNED BY CONTRACTOR IN ACCORDANCE WITH OPSS 539 PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATIC ONLY, EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.
8. RSS REINFORCING STRIP LOCATIONS SHALL NOT INTERFERE AND WITH NOISE BARRIER FOUNDATION AND CATCH BASIN LOCATIONS.

1. GENERAL ARRANGEMENT
2. STANDARD DETAILS

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. STANDARD DETAILS

LEGEND:



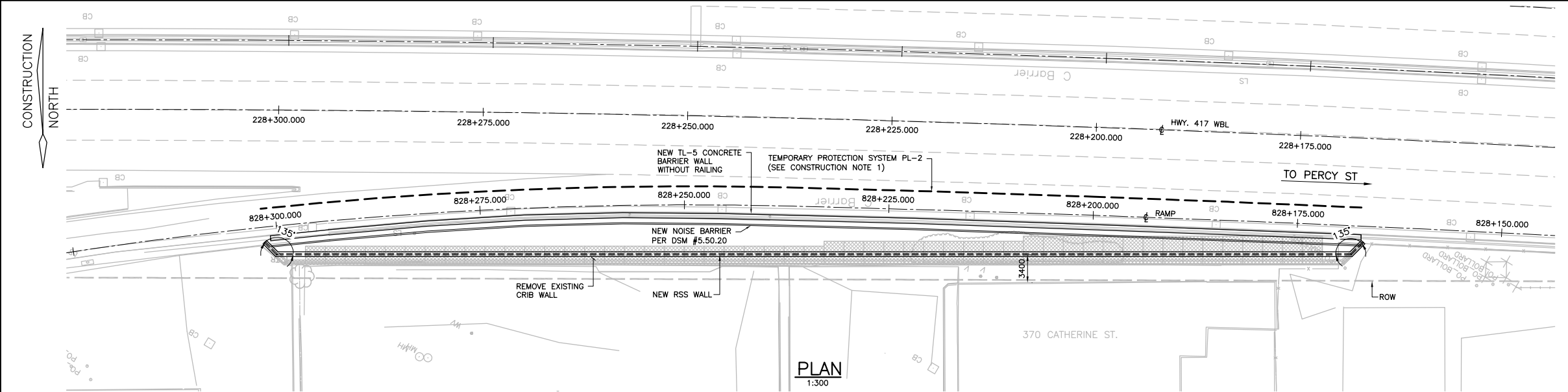
REMOVAL

LIST OF ABBREVIATIONS:

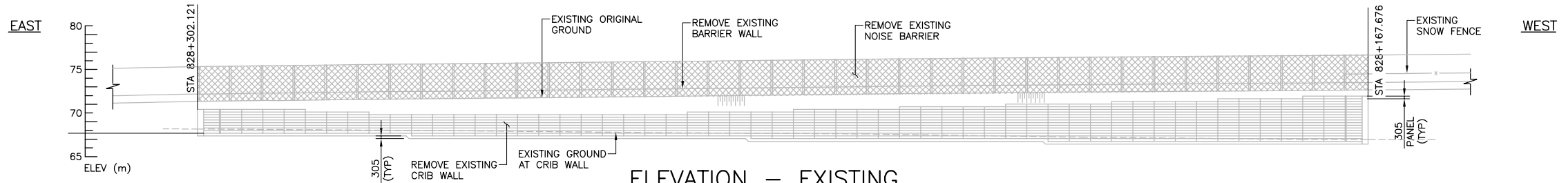
- F.O.S. - DENOTES FILTRATION OPENING SIZE
IF - DENOTES INSIDE FACE
OF - DENOTES OUTSIDE FACE
RSS - DENOTES RETAINED SOIL SYSTEM

CONSTRUCTION NOTE:

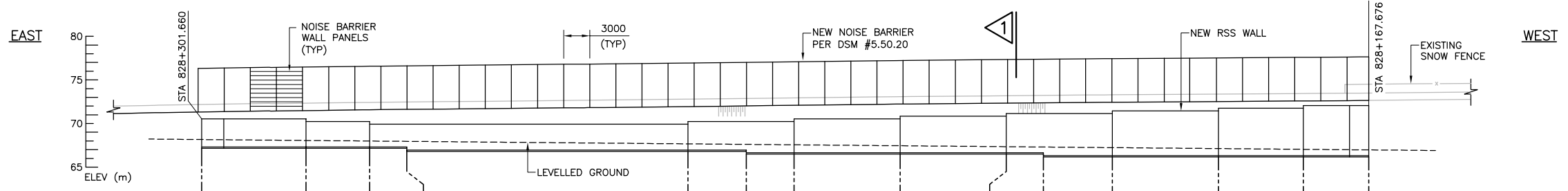
1. TEMPORARY PROTECTION SYSTEM SHALL BE REMOVED TO 1.8m BELOW GRADE WHEN NO LONGER REQUIRED.



PLAN
1:300

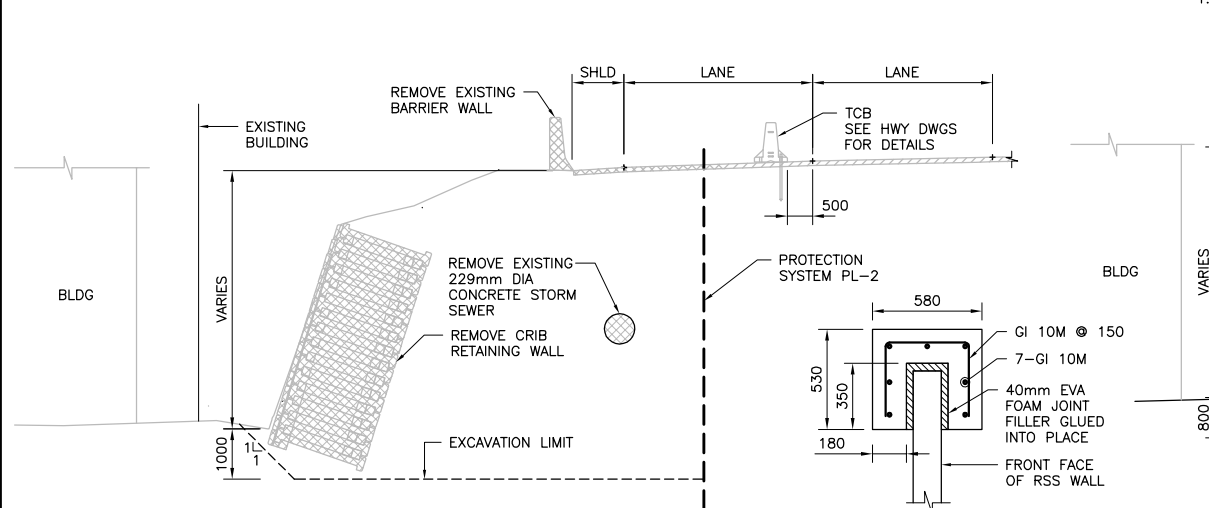


ELEVATION - EXISTING
1:300

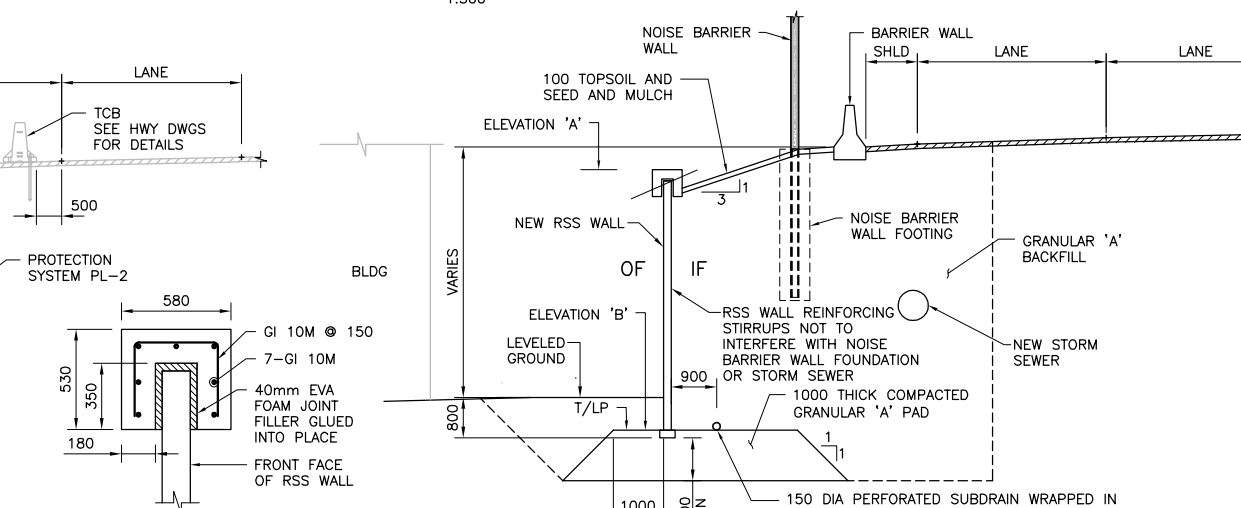


ELEVATION - REHABILITATED
1:300

STATION (828+)	301.660	289.793	282.429	278.140	245.455	238.665	233.157	220.951	208.749	204.479	196.545	184.352	174.597	166.833
OFFSET FROM RAMP TO OUTSIDE FACE OF RSS WALL	1.885	4.481	5.019	5.503	6.091	6.214	5.858	5.518	5.135	4.991	4.709	4.240	3.834	1.999
ELEVATION POINT 'A'	70.531	70.226	69.921	69.921	70.226	70.226	70.531	70.836	71.141	71.141	71.446	71.751	72.056	72.055
ELEVATION POINT 'B'	67	67	67	67	67	67	67	67	67	67	67	67	67	67



TYPICAL EXISTING SECTION
1:75



CONCRETE FINISHING CAP
TYPICAL RSS WALL SECTION
1:20



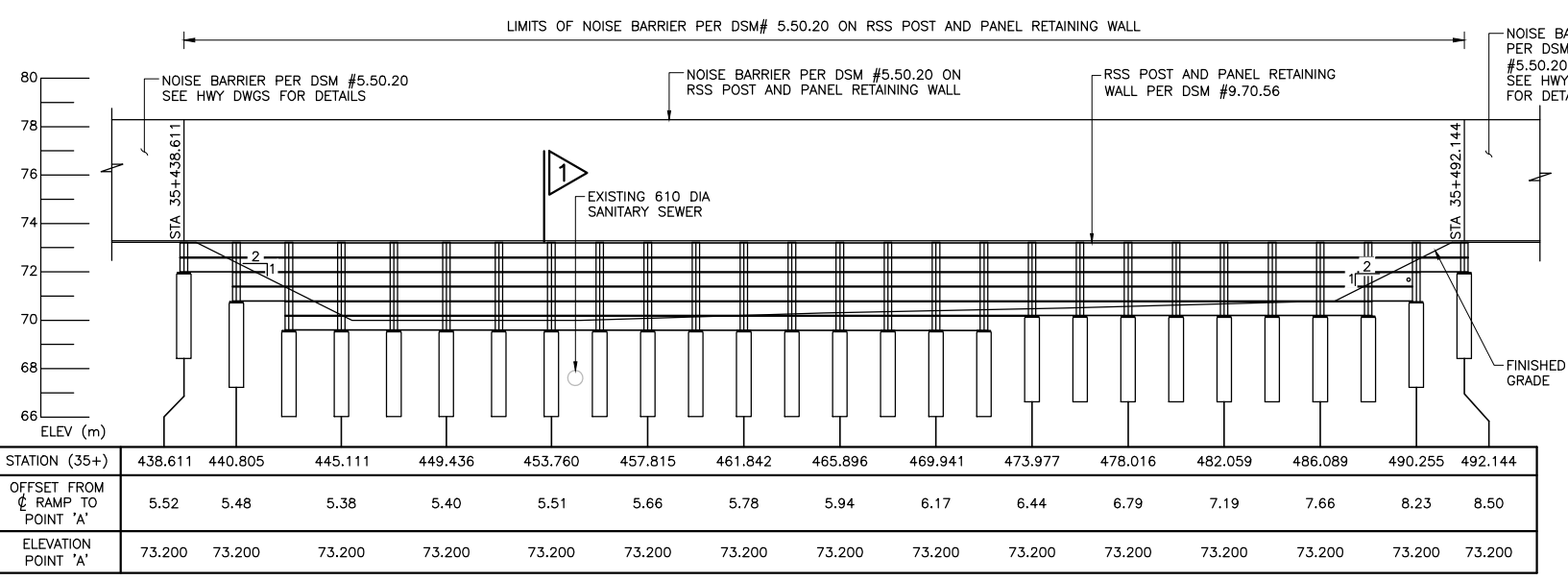
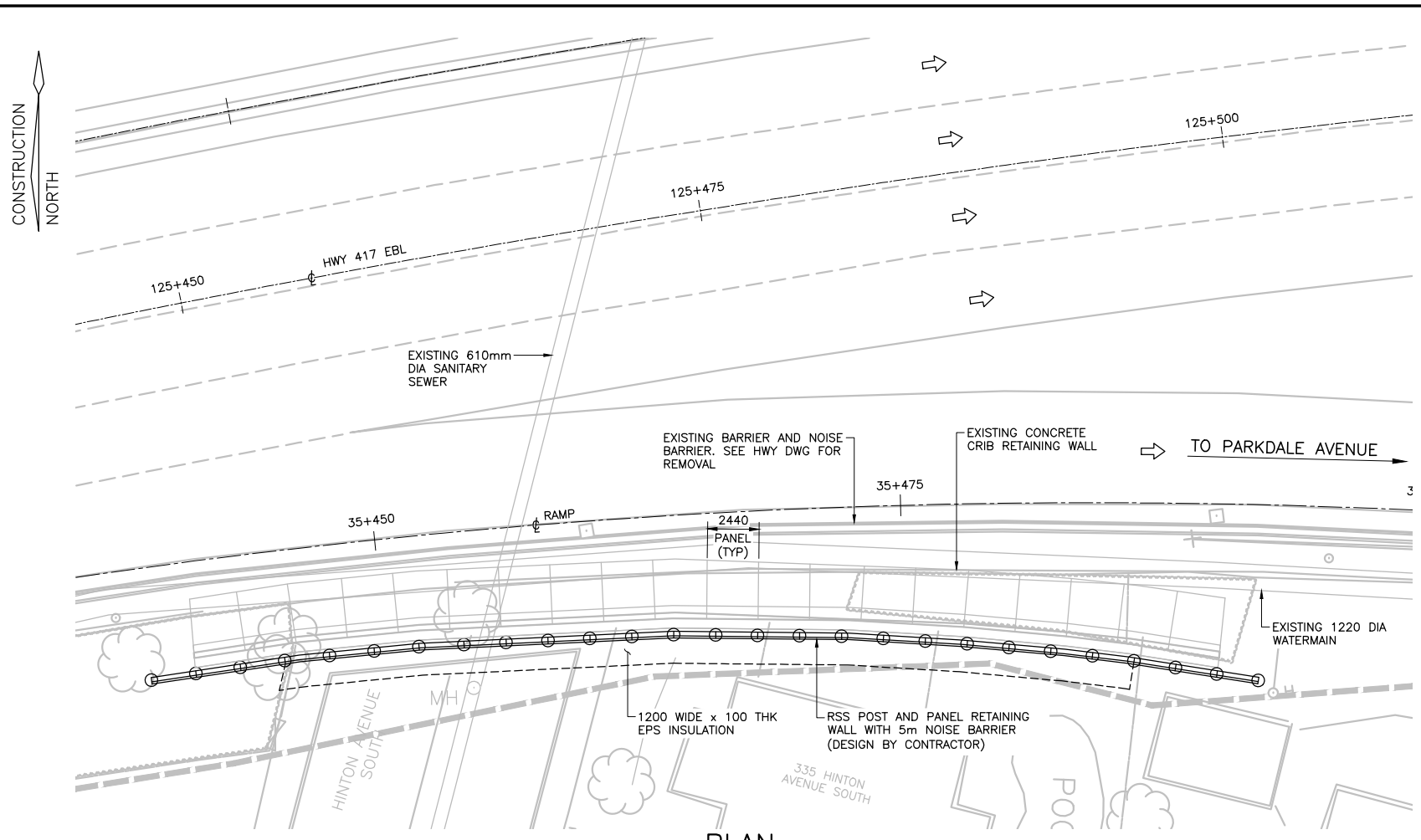
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DATE	BY	DESCRIPTION
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DRAWN RYR	CHK JY	SITE 03X-0745/WO/STRUCT
		SCHEME DWG 1

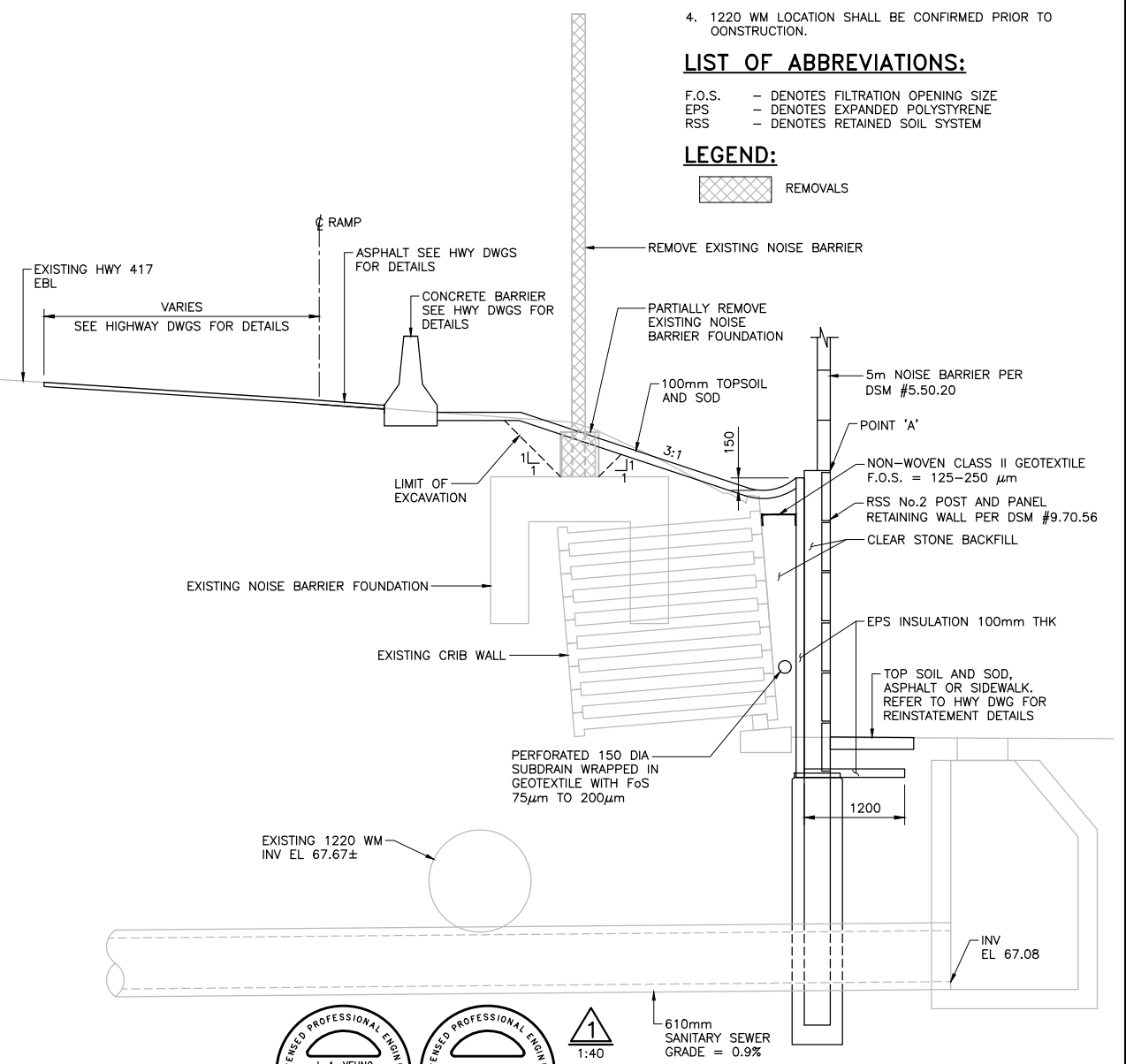
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 DATE PLOTTED: 1/21/2020 4:08:11 PM BY: HILL, CORY

PR-3-207 88-05
 MINISTRY OF TRANSPORTATION, ONTARIO



* ACTUAL CAISSON SPACING FOR RSS POST AND PANEL RETAINING WALL SHALL BE IN ACCORDANCE WITH DSM #9.70.56



LICENSED PROFESSIONAL ENGINEER
 J. A. YEUNG
 100179431
 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
 T. P. A. SMALL
 100179431
 PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DISTRICT CONT. No. WP No. 4173-15-00	 SHEET S44
HIGHWAY 417 RETAINING WALL 1-S (RW14) STA 35+438 TO STA 35+492	
GENERAL ARRANGMENT	METRIC

GENERAL NOTES:
CONSTRUCTION NOTES:

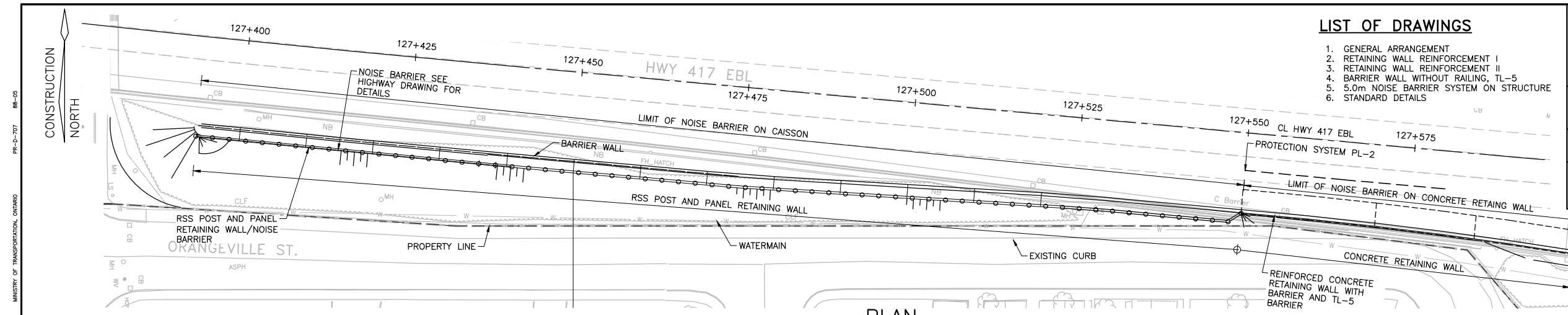
- THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO THE COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
- THE CONTRACTOR SHALL COORDINATE WITH UTILITY OWNERS TO VERIFY LOCATION AND TO AVOID CONFLICT OR DAMAGE TO THE UTILITIES DURING CONSTRUCTION.
- CAISSONS SHALL NOT BE LOCATED WITHIN 800mm CLEAR OF EXISTING 610 DIA SANITARY SEWER.
- 1220 WM LOCATION SHALL BE CONFIRMED PRIOR TO CONSTRUCTION.

LIST OF ABBREVIATIONS:
 F.O.S. - DENOTES FILTRATION OPENING SIZE
 EPS - DENOTES EXPANDED POLYSTYRENE
 RSS - DENOTES RETAINED SOIL SYSTEM

LEGEND:
 REMOVALS

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JY	CHK TS	CODE CHBDC 2014 LOAD CL-625-ONT
DRAWN	RJR	CHK JY	SITE 03X-0939/W0
			DATE NOV/19
			DWG 1

CAO FILE LOCATION AND NAME: F:\Transportation\Oakville\2019\RW 4-S\16M-01636-327-0010A_TBAV_200124.dwg
 MODIFIED: 1/28/2020 10:16:05 AM BY: CORY HILL
 DATE PLOTTED: 1/28/2020 10:17:17 AM BY: HILL, CORY



PLAN
1:250

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. RETAINING WALL REINFORCEMENT I
3. RETAINING WALL REINFORCEMENT II
4. BARRIER WALL WITHOUT RAILING, TL-5
5. 5.0m NOISE BARRIER SYSTEM ON STRUCTURE
6. STANDARD DETAILS

CONT. No. WP No. 4173-15-00	
HIGHWAY 417 RETAINING WALL RETAINING WALL 4-S (RW17) STA 127+393 TO STA 127+600 GENERAL ARRANGEMENT	
SHEET METRIC	

GENERAL NOTES:

CLASS OF CONCRETE:

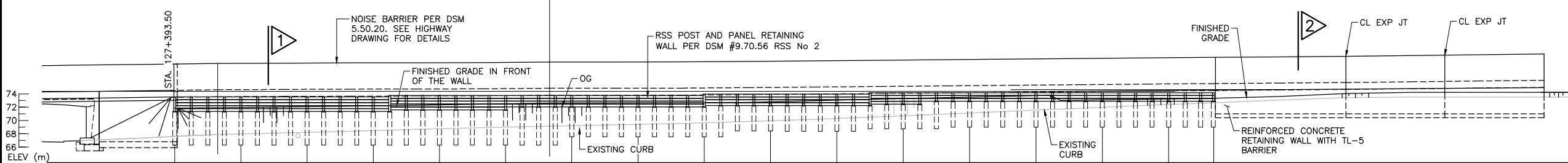
30MPa

CLEAR COVER TO REINFORCING:

FOOTING BOTTOM 100 ± 25mm
 UNLESS OTHERWISE NOTED 70 ± 20mm

CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO THE COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
2. THE CONTRACTOR SHALL COORDINATE WITH UTILITY OWNERS TO VERIFY THE LOCATION AND TO AVOID CONFLICT OR DAMAGE TO THE UTILITIES DURING CONSTRUCTION.



ELEVATION
1:250

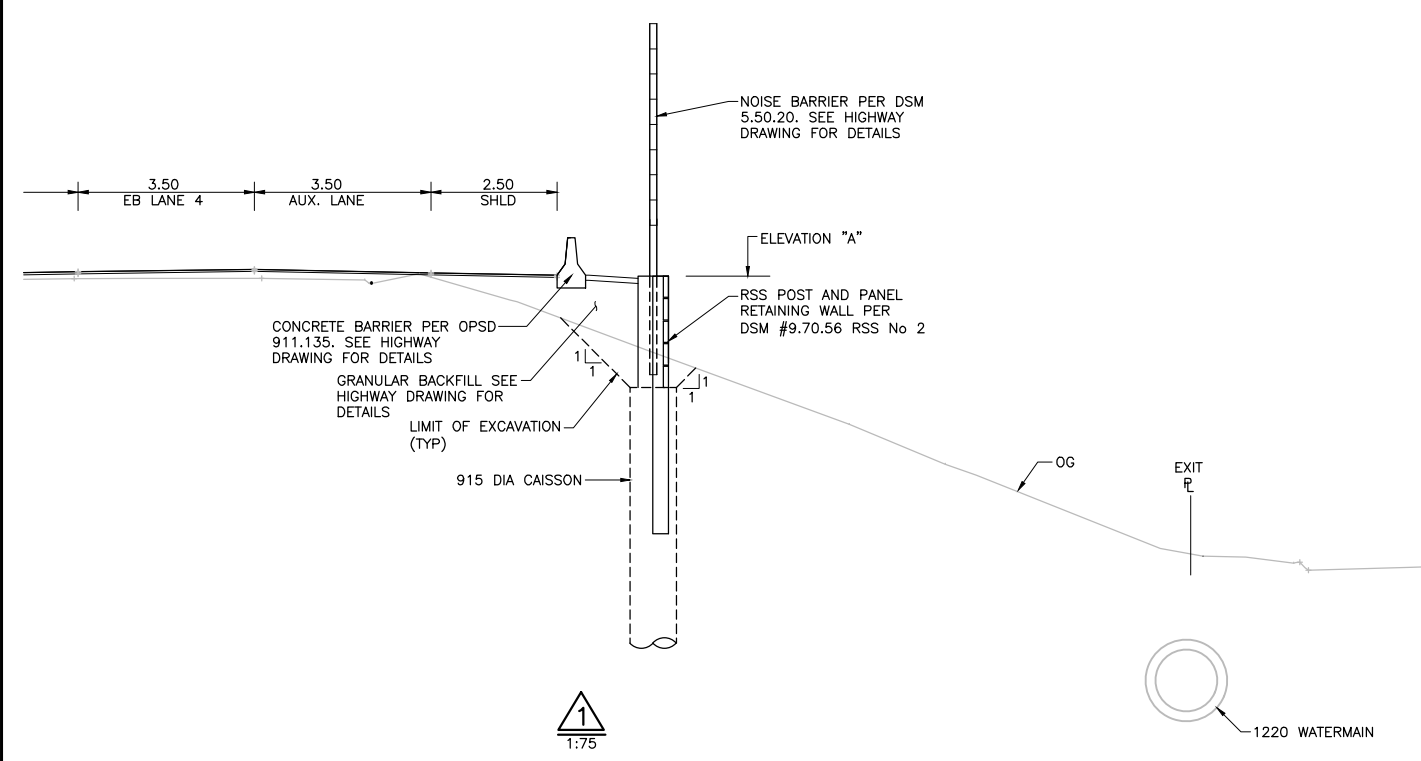
* ACTUAL CAISSONS SPACING FOR POST AND PANEL RETAINING WALL SHALL BE IN ACCORDANCE WITH DSM #9.70.56 RSS No 2 AND SHALL AVOID CONFLICT WITH REINFORCED CONCRETE RETAINING WALL

REINFORCING:

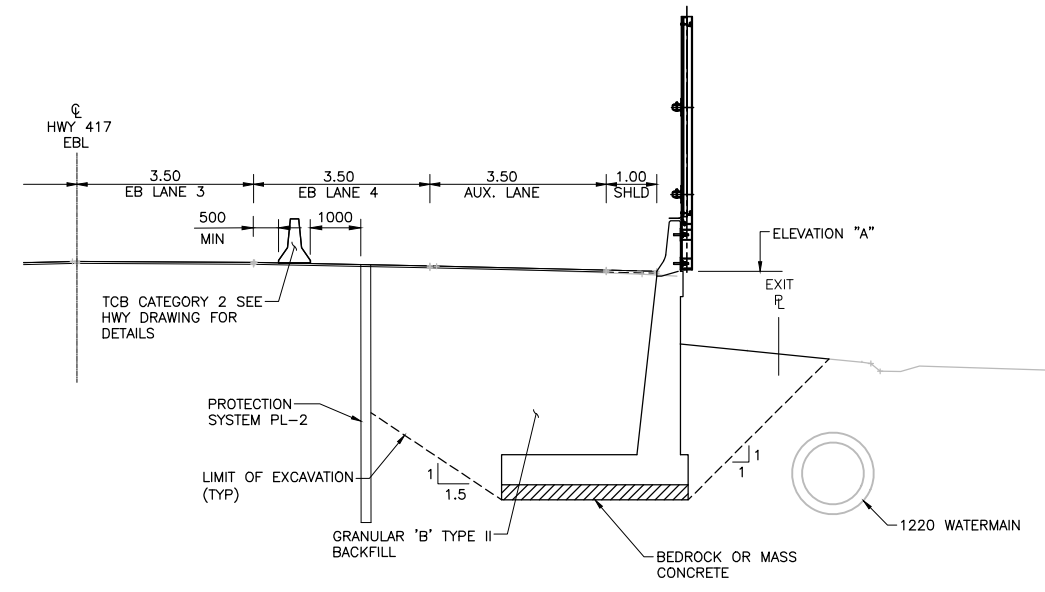
1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.
4. HORIZONTAL LAP SPLICES MUST NOT LAP THROUGH CONTROL JOINTS.
5. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
6. STAINLESS REINFORCING STEEL SHALL BE TYPE 316 LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.

APPLICABLE STANDARD DRAWINGS:

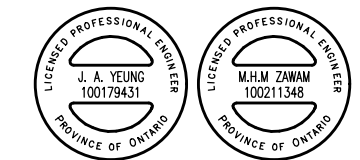
- | | |
|---------------|---|
| OPSD 911.381 | GUIDE RAIL SYSTEM, CONCRETE BARRIER PERMANENT TRANSITION INSTALLATION |
| OPSD 911.382 | GUIDE RAIL SYSTEM, CONCRETE BARRIER DOWEL CONNECTION DETAIL |
| OPSD 3121.150 | WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT |
| OPSD 3190.100 | WALLS, RETAINING AND ABUTMENT WALL DRAIN |
| OPSD 3950.100 | JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE |



1
1:75



2
1:75



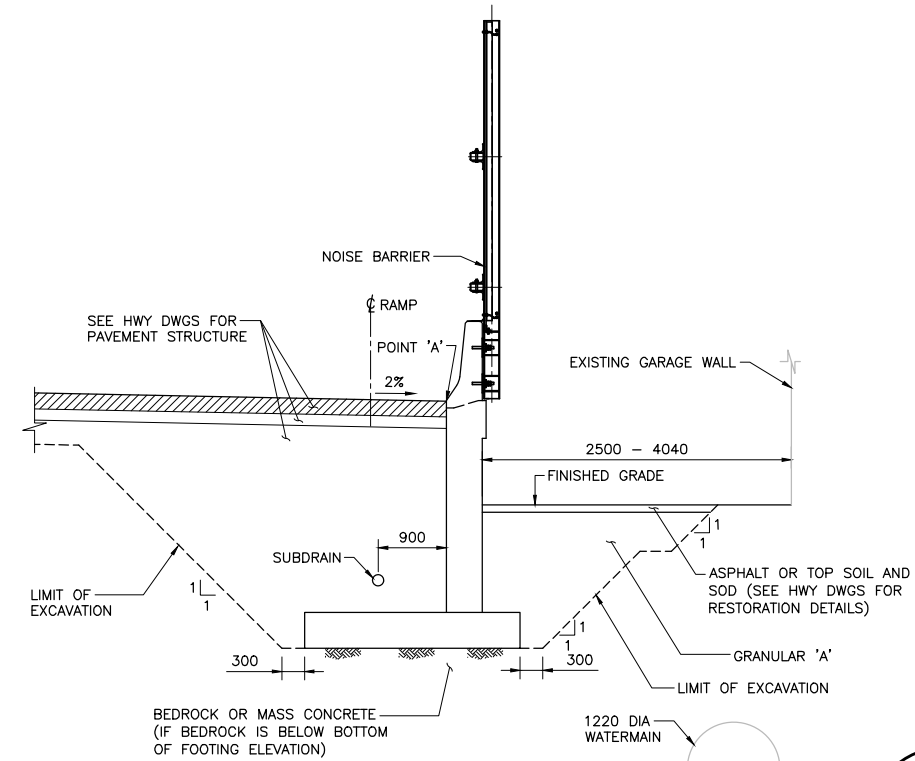
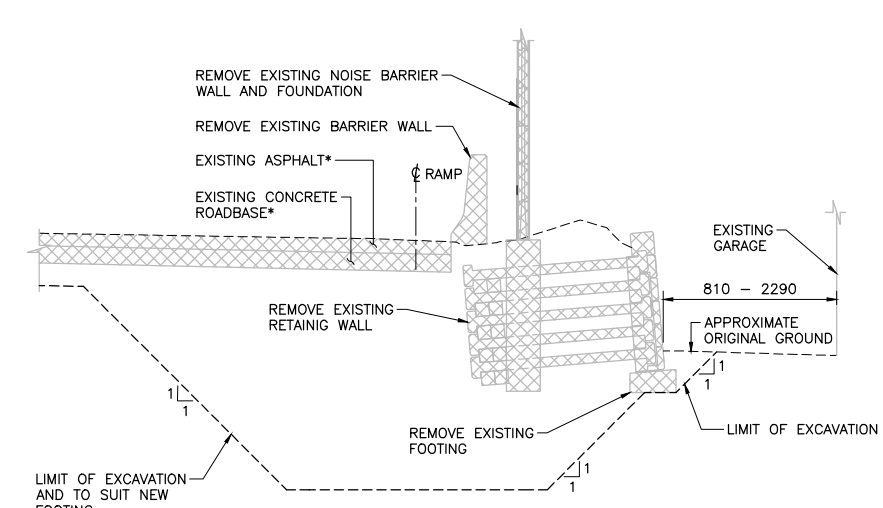
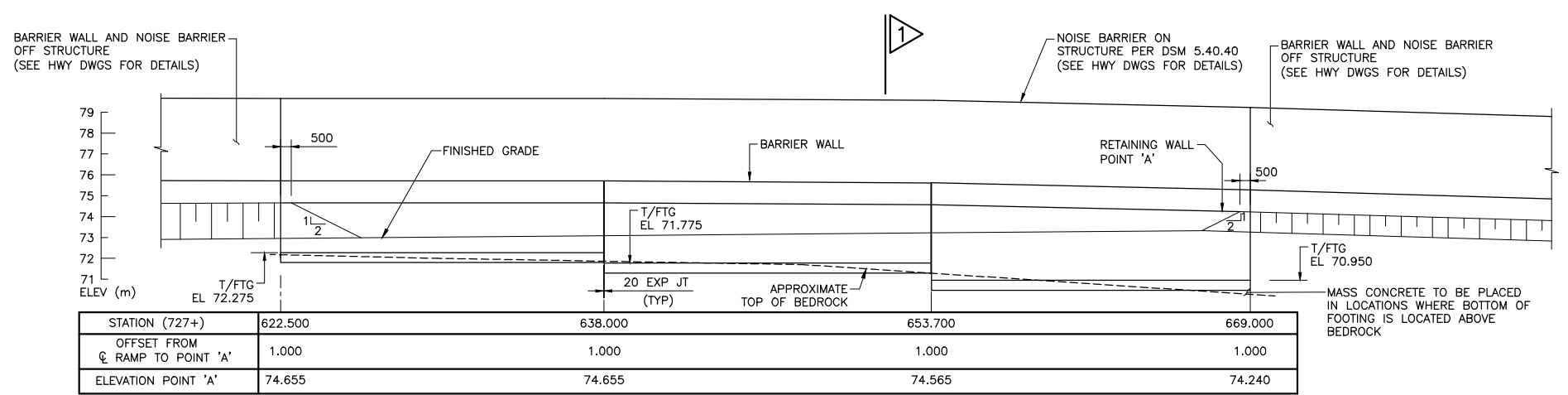
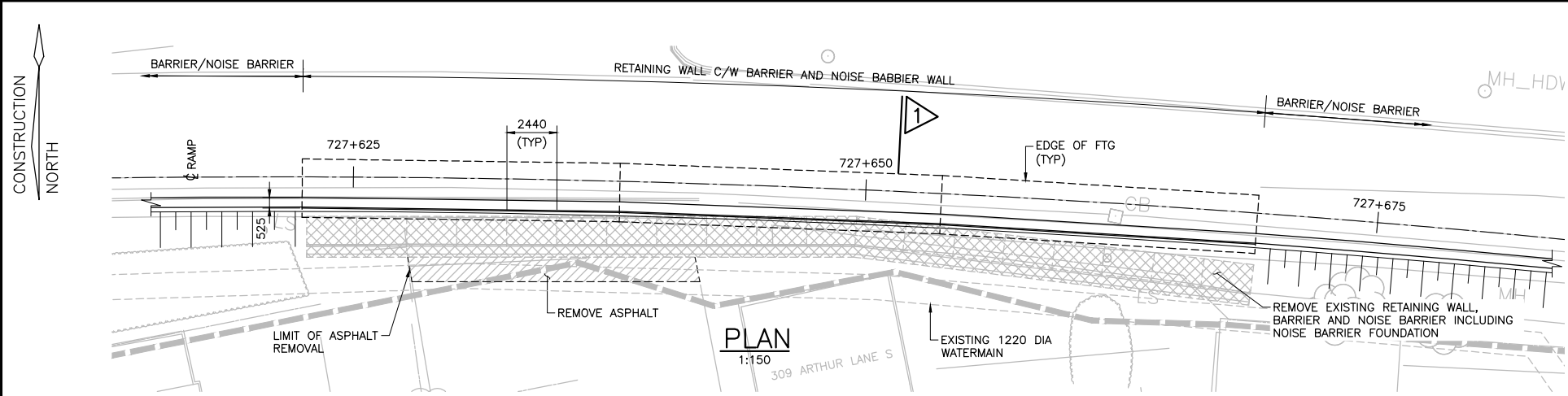
DRAWING NOT TO BE SCALED
 100mm ON ORIGINAL DRAWING

REVISIONS		DATE	BY	DESCRIPTION
DESIGN	JY	CHK	MZ	CODE CHBDC 2014 LOAD CL-625-ONT
DRAWN	CH	CHK	JY	SITE 03X-0926/W0
				DATE JAN/20
				DWG 1

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 MODIFIED: 1/28/2020 10:05:00 AM BY: CORY.HILL
 DATE PLOTTED: 1/28/2020 10:05:55 AM BY: HILL, CORY

MINISTRY OF TRANSPORTATION, ONTARIO

PR-D-707 88-05



SECTION AT 309 ARTHUR LANE S SHOWN, SEE HIGHWAY DRAWINGS FOR ASPHALT REMOVAL AT ARTHUR LANE AND HWY 417 RAMP
 * SEE HIGHWAY DRAWINGS FOR DETAILS

- LIST OF DRAWINGS**
1. GENERAL ARRANGEMENT
 2. RETAINING WALL REINFORCEMENT I
 3. RETAINING WALL REINFORCEMENT II
 4. RETAINING WALL REINFORCEMENT III
 5. BARRIER WALL WITHOUT RAILING TL-5
 6. STANDARD DETAILS

CONT. No. WP No.	HIGHWAY 417 RETAINING WALL 5-S (RW 18) STA 727+622 TO STA 727+669	SHEET
GENERAL ARRANGEMENT		
		METRIC

- GENERAL NOTES:**
- CLASS OF CONCRETE:**
30MPa
- CLEAR COVER TO REINFORCING:**
FOOTING BOTTOM 100 ± 25mm
UNLESS OTHERWISE NOTED 70 ± 20mm
- CONSTRUCTION NOTES:**
1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO THE COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
 2. THE CONTRACTOR SHALL COORDINATE WITH UTILITY OWNERS TO VERIFY THE LOCATION AND TO AVOID CONFLICT OR DAMAGE TO THE UTILITIES DURING CONSTRUCTION.

- REINFORCING:**
1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
 2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
 3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.
 4. HORIZONTAL LAP SPLICES MUST NOT LAP THROUGH CONTROL JOINTS.
 5. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
 6. STAINLESS REINFORCING STEEL SHALL BE TYPE 316 LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.

- LEGEND:**
- REMOVALS
 - ASPHALT REMOVALS

- APPLICABLE STANDARD DRAWINGS:**
- OPSD 911.381 GUIDE RAIL SYSTEM, CONCRETE BARRIER PERMANENT TRANSITION INSTALLATION ROADSIDE CONCRETE BARRIER TO STRUCTURE
 - OPSD 911.382 GUIDE RAIL SYSTEM, CONCRETE BARRIER DOWEL CONNECTION DETAIL
 - OPSD 3121.150 WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
 - OPSD 3190.100 WALLS, RETAINING AND ABUTMENT WALL DRAIN
 - OPSD 3950.100 JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE

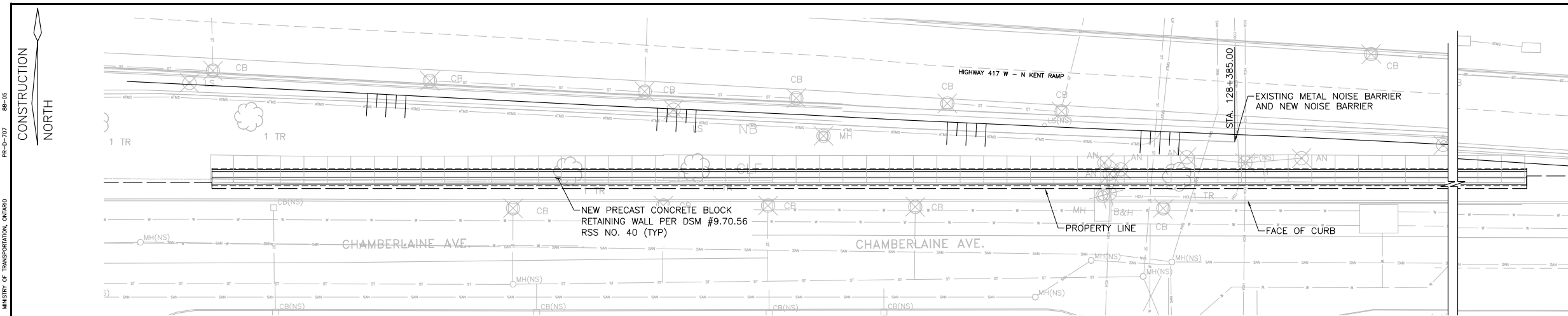


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100mm ON ORIGINAL DRAWING

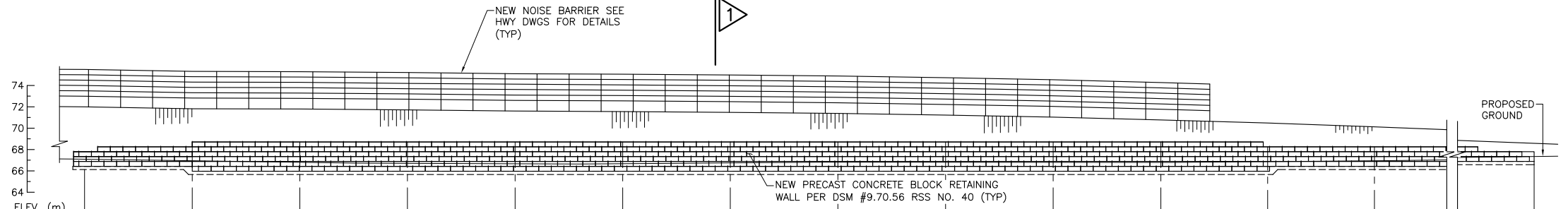
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DESIGN	JY	CHK	MZ	CODE	CHBDC 2014	LOAD	CL-625-ONT	DATE	JAN 2020
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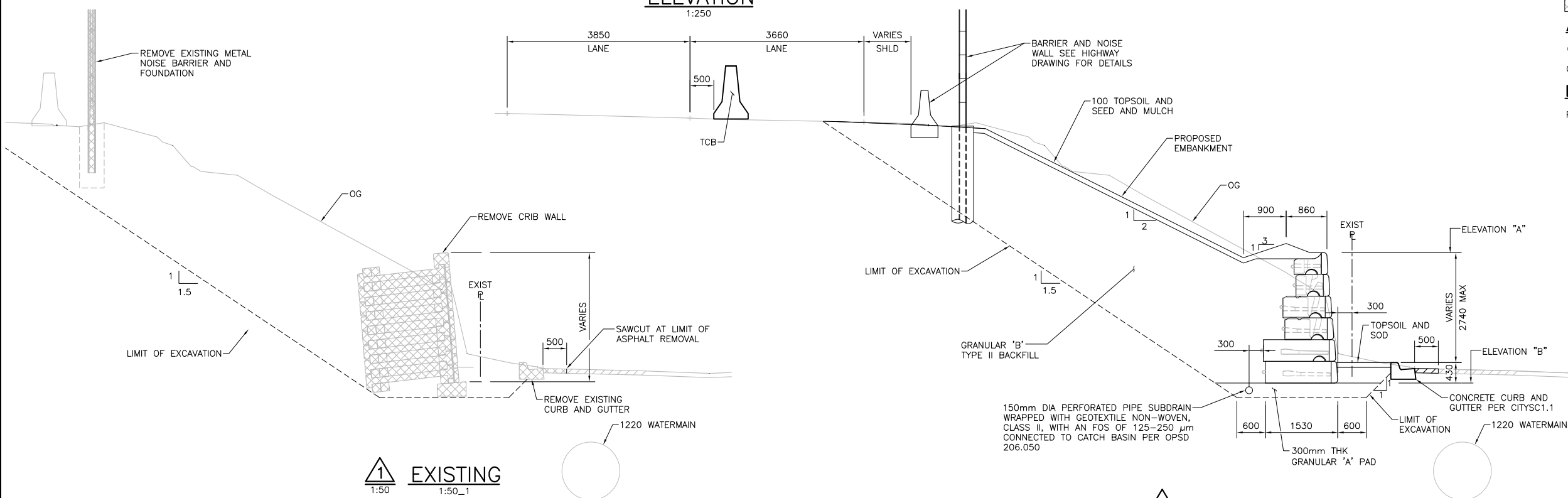


PLAN
1:250



ELEVATION
1:250

STATION	128+278.61	128+290	128+300	128+310	128+320	128+330	128+340	128+350	128+360	128+370	128+380	128+390	128+400	128+349.144
OFFSET FROM CL HWY 417 EBL (m) (TO BOTTOM OF BLOCK WALL)	25.689	25.571	25.482	25.421	25.389	25.386	25.411	25.465	25.549	25.661	25.802	26.970	26.167	27.212
ELEVATION "A" (m)	67.798	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.255	68.255	67.798
ELEVATION "B" (m)	66.427	66.427	65.970	65.970	65.970	65.970	65.970	65.970	65.970	65.970	65.970	65.970	66.427	66.884



EXISTING
1:50

PROPOSED
1:50

DISTRICT CONT. No. WP No. 4173-15-00	 SHEET S51
HIGHWAY 417 RETAINING WALL 7-S (RW19) STA. 128+280 TO STA. 128+440	
GENERAL ARRANGEMENT	METRIC

GENERAL NOTES:

CONSTRUCTION NOTES:

- THIS DESIGN IS BASED ON THE FOLLOWING PROPERTIES:
PROPERTY: RETAINING FILL
FRICTION ANGLE: ϕ 30°
UNIT WEIGHT: γ 22kN/m³
SOIL TYPE: TYPE II OPSS GRANULAR B
- WALL GEOMETRY AND GRADE ELEVATIONS ABOVE AND BELOW THE WALL SHOULD CONFORM WITH GRADING. IF ACTUAL SITE GRADES VARY SIGNIFICANTLY FROM THOSE SHOWN OR IF THE BACK SLOPE DOES NOT CONFORM, INSTALLATION SHALL NOT PROCEED UNTIL THE CALL DESIGN IS VERIFIED OR MODIFIED IN THE APPLICABLE AREA.
- THE GRANULAR B TYPE II SHOULD BE COMPACTED TO MIN. 98% OF THE MATERIALS SPMD AND TESTED BY THE GEOTECHNICAL CONSULTANT AT THE TIME OF CONSTRUCTION.
- INSTALL 150mm DIAMETER PERFORATED PIPE DRAIN BEHIND HEEL OF WALL. PROVIDE CLEAR STONE SURROUND TO PROTECT PIPE FROM CLOGGING AND DAMAGE. PROVIDE OUTLETS THROUGH WALL.
- THE CONDITIONS WILL BE EVALUATED BY THE GEOTECHNICAL ENGINEER DURING PREPARATION FOR WALL CONSTRUCTION IN EACH AREA. WHERE GRANULAR BEDDING WILL NOT BE SUFFICIENT THE USE OF CONCRETE BEDDING MAY BE REQUIRED.
- BACK FILL MATERIAL SHALL BE APPROVED BY THE SITE GEOTECHNICAL ENGINEER PRIOR TO USE AND SHOULD CONSIST OF OPSS GRANULAR B TYPE II BUFFER OF MINIMUM 1.0M WIDTH, FOLLOWED BY SUITABLE GRANULAR FILL. ALL FILL ZONE UP AND BACK FROM THE HEEL SHOULD ALSO BE COMPACTED BACKFILL SHALL BE PLACED IN MAXIMUM 300mm LOOSE LIFTS AND COMPACTED TO A MINIMUM 98% OF SPMD.
- MAINTAIN TEMPORARY GRADES TO DIVERT SURFACE WATER AWAY FROM THE RETAINING WALL EXCAVATION. SLOPE FINAL BACKFILL TO PROVIDE POSITIVE DRAINAGE AND TO ELIMINATE PONDING.

LEGEND:

REMOVALS

APPLICATION STANDARD DRAWING

OPSD 206.050 SUBDRAIN PIPE CONNECTION AND OUTLET
RURAL
CITY STANDARD SC1.1

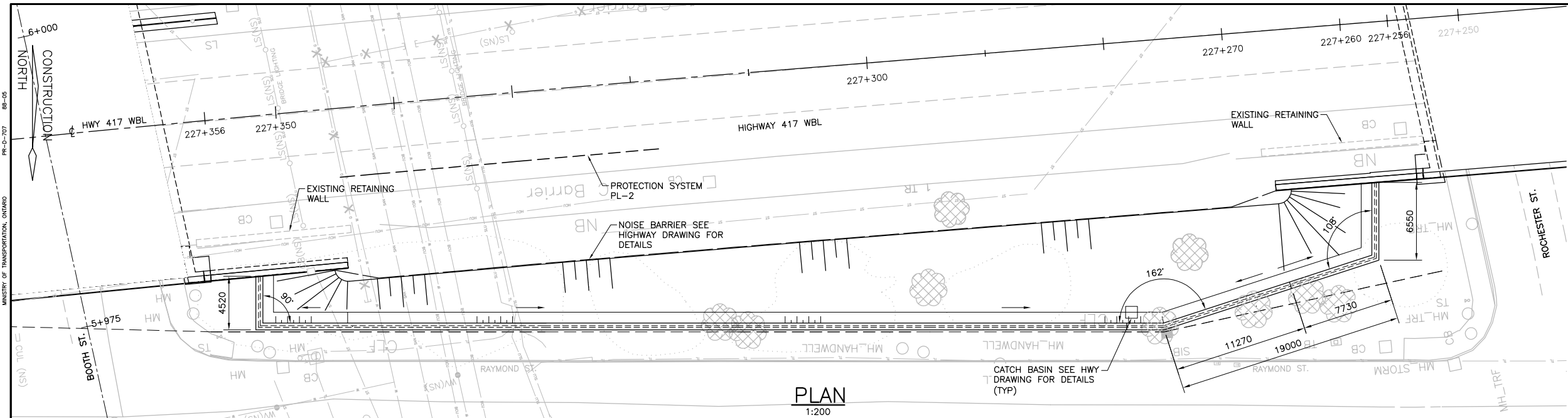
LIST OF ABBREVIATIONS

DENOTES PROPERTY LINE

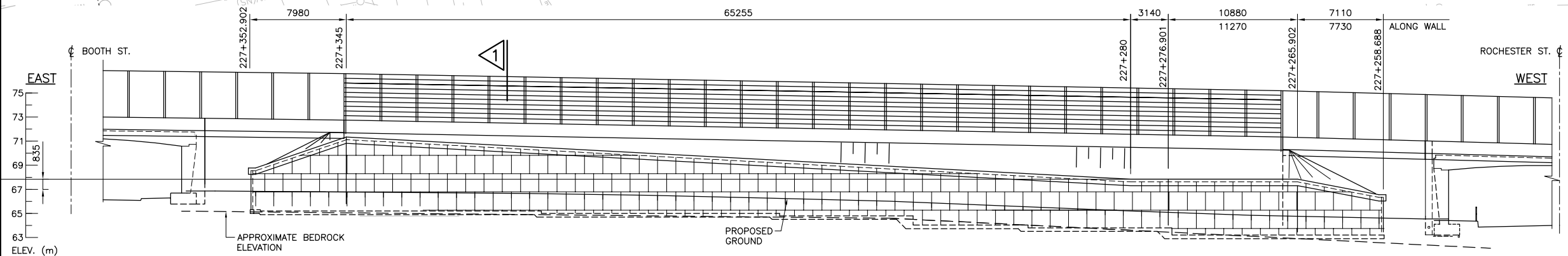


REVISIONS	DATE	BY	DESCRIPTION

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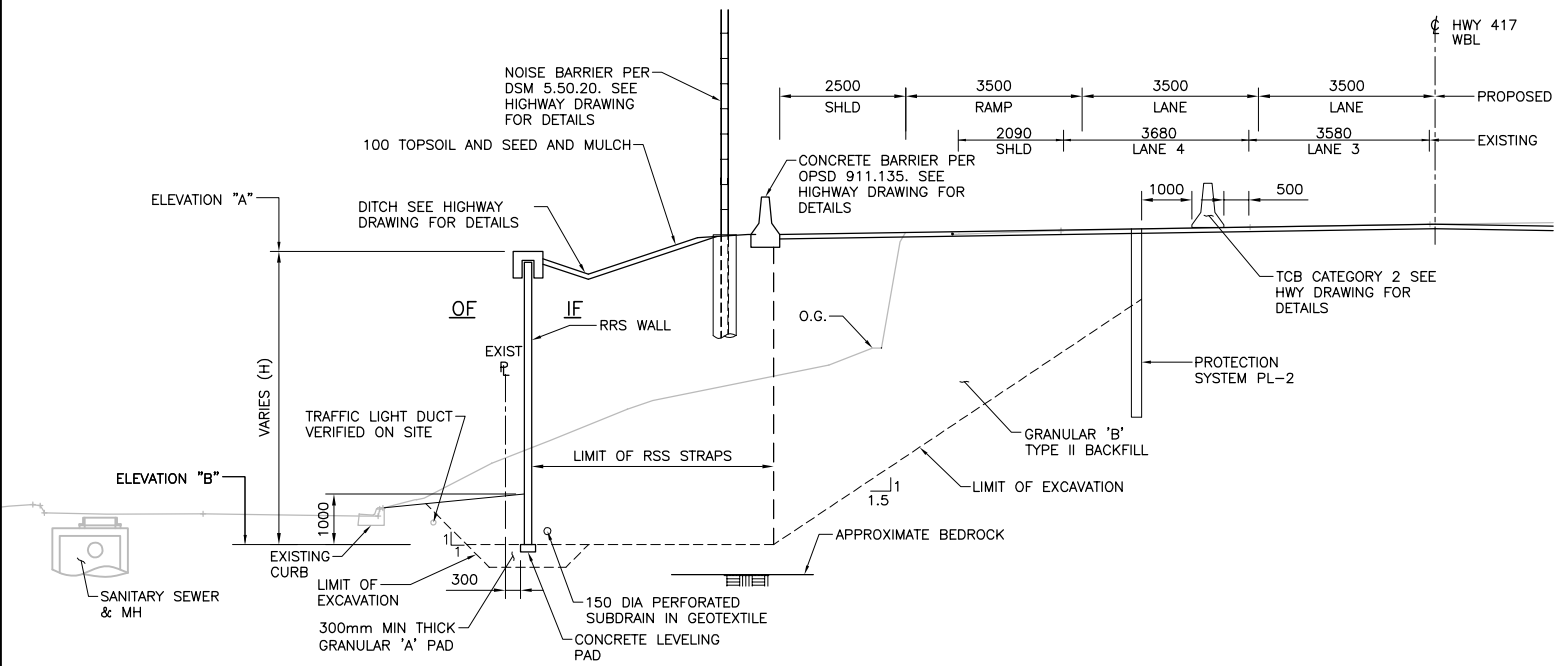


PLAN
1:200



STATION	227+352.902	227+345	227+340	227+330	227+320	227+310	227+300	227+290	227+280	227+276.901	227+265.902	227+258.688
OFFSET FROM CL HWY 417 EBL (m) (TO OUTSIDE FACE OF RRS WALL)	17.775	18.508	18.964	18.852	20.720	21.552	22.355	23.163	23.971	24.222	21.622	19.905
ELEVATION "A"	67.030	71.344	71.028	70.555	69.975	69.406	68.833	68.233	67.835	67.835	67.835	66.559
ELEVATION "B"	65.300	65.200	65.200	65.200	65.000	65.000	64.800	64.030	63.800	63.200	63.200	63.200

ELEVATION - PROPOSED
1:200



1 PROPOSED
1:75

CONT. No.	HIGHWAY 417 RETAINING WALL 10-N (RW26) STA 227+256 TO STA 227+356	SHEET S30
WP No.		
GENERAL ARRANGEMENT		METRIC

- GENERAL NOTES:**
- ALL REINFORCING STEEL IN RSS WALL PANELS, COPING, AND SLIP JOINTS SHALL BE STAINLESS STEEL TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPA. UNLESS OTHERWISE SPECIFIED.
- RETAINED SOIL SYSTEM:**
- WALL SHALL BE AS LISTED IN THE MTO DESIGNATED SOURCE OF MATERIALS MANUAL WITH THE FOLLOWING
 - RETAINED SOIL SYSTEM WALLS SHALL HAVE THE FOLLOWING ATTRIBUTES:
PERFORMANCE - HIGH
APPEARANCE - HIGH
MAX. ANGLE - 90°
 - LENGTH OF RETAINED SOIL SYSTEM MAY BE INCREASED TO SUIT NEAREST NUMBER OF WHOLE PANELS FOR RETAINED SOIL SYSTEM, INCLUDING GRANULAR FILL, EXCAVATION, CONCRETE CAP AND THE LIKE, WITH NO ADDITIONAL COST TO THE OWNER. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE CONTRACT ADMINISTRATOR.
 - TOP SOIL, SOFT/LOOSE SOIL, AND ANY SOFT/WET NATIVE MATERIAL SHOULD BE STRIPPED FROM THE FOOTING OF THE RSS. THE NATIVE SUBGRADE UNDER THE RSS FOUNDATION SHOULD BE PROOF ROLLED TO DETECT AND REPLACE ANY SOFT AREAS.
 - PRIOR TO PLACING THE GRANULAR PAD FOR THE RSS, THE SUBEXCAVATED GRADE SHALL BE PROOF-ROLLED AND THE CONTRACTOR AND RSS SUPPLIER SHALL INSPECT THE SUBEXCAVATED GRADE AND CONFIRM ITS CAPACITY TO SUPPORT THE RSS SYSTEM BEFORE PROCEEDING WITH THE WORK.
 - THE GRANULAR 'A' PADS SHALL BE COMPACTED TO 100% STANDARD PROCTOR MAXIMUM DRY DENSITY (SPMDD) AT A MOISTURE CONTENT WITHIN 2% OF OPTIMUM.
 - PROTECTION SYSTEMS SHALL BE DESIGNED BY CONTRACTOR IN ACCORDANCE WITH OPSS 539 PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATIC ONLY, EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.
 - RSS REINFORCING STRIP LOCATIONS SHALL NOT INTERFERE AND WITH NOISE BARRIER FOUNDATION AND CATCH BASIN LOCATIONS.

- APPLICABLE STANDARD DRAWINGS:**
- OPSD 3121.150 WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
 - OPSD 600.040 CONCRETE BARRIER CURB WITH STANDARD GUTTER
 - CITY STANDARD SC1.1

- LIST OF DRAWINGS:**
- GENERAL ARRANGEMENT
 - RETAINING WALL DETAILS

- LEGEND:**
- REMOVALS
- LIST OF ABBREVIATIONS**
- IF DENOTES INSIDE FACE
 - OF DENOTES OUTSIDE FACE
 - RSS DENOTES RETAINED SOIL SYSTEM
 - PL DENOTES PROPERTY LINE



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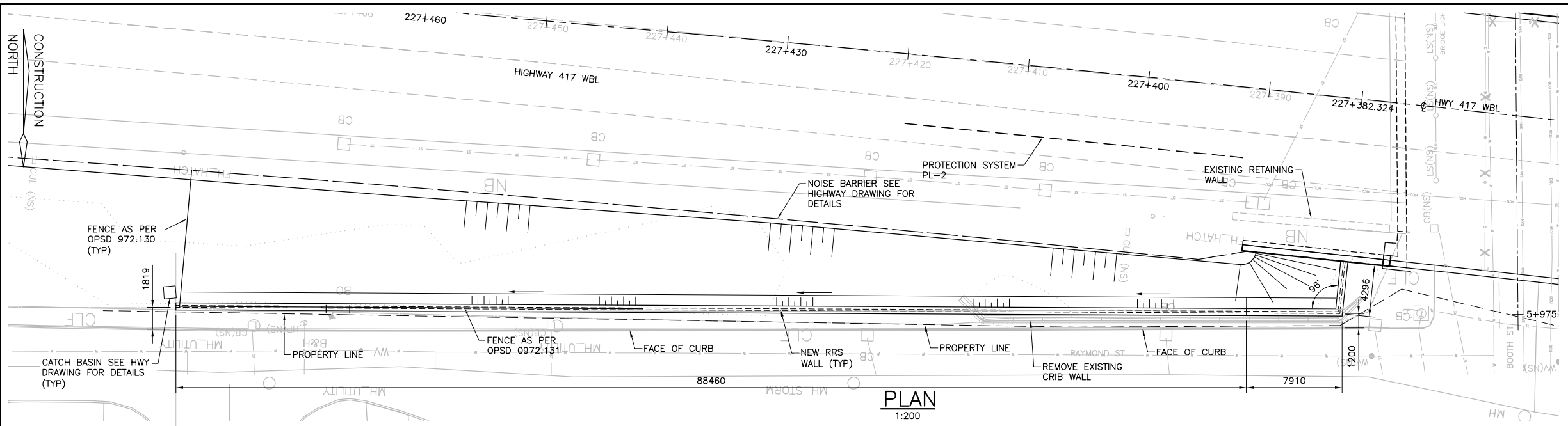
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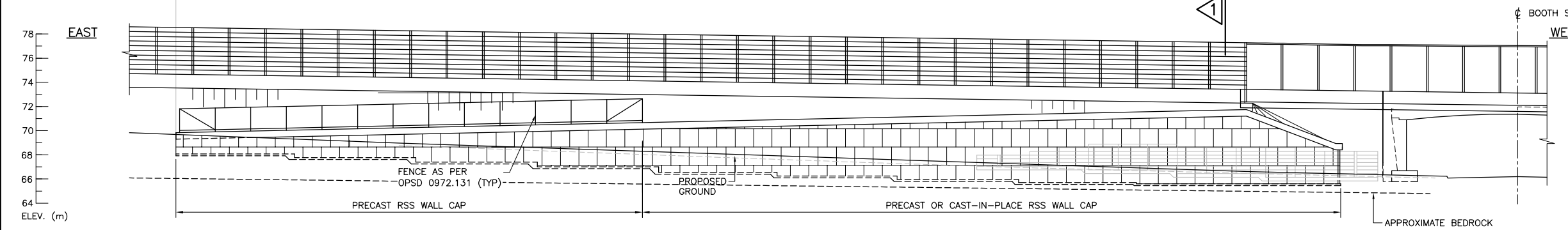
PR-D-707 88-05

MINISTRY OF TRANSPORTATION, ONTARIO

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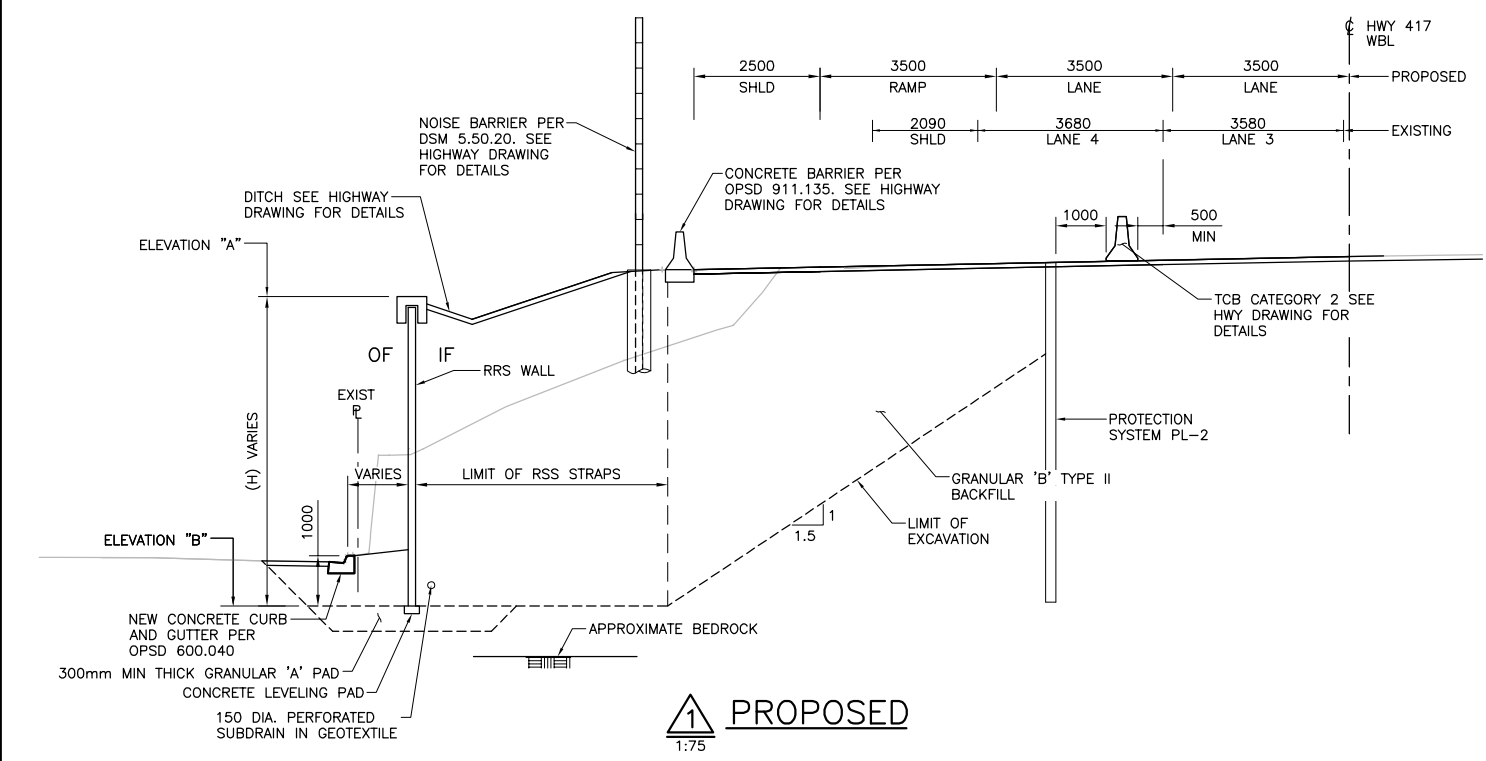


PLAN
1:200



ELEVATION — PROPOSED
1:200

STATION	227+478.416	227+470	227+460	227+450	227+440	227+430	227+420	227+410	227+400	227+390	227+382.324
OFFSET FROM CL HWY 417 EBL (m) (TO OUTSIDE FACE OF RRS WALL)	26.309	25.603	24.764	24.045	23.201	22.326	21.442	21.518	19.570	18.580	17.820
ELEVATION "A"	69.827	70.009	70.311	70.443	70.672	70.747	70.982	71.247	71.576	71.738	68.939
ELEVATION "B"	67.070	68.070	67.770	67.400	67.000	66.550	66.250	65.950	65.700	65.500	65.500



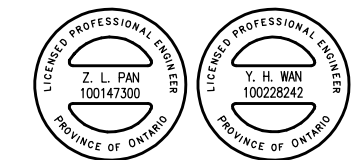
PROPOSED
1:75

CONT. No. WP No. 4173-15-00	 SHEET S32
HIGHWAY 417 RETAINING WALL RETAINING WALL 11-N (RW10) STA 227+478 TO STA 227+382	
GENERAL ARRANGEMENT	S32
	METRIC

- GENERAL NOTES:**
- ALL REINFORCING STEEL IN RSS WALL PANELS, COPING, AND SLIP JOINTS SHALL BE STAINLESS STEEL TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPA. UNLESS OTHERWISE SPECIFIED.
- RETAINED SOIL SYSTEM:**
- WALL SHALL BE AS LISTED IN THE MTO DESIGNATED SOURCE OF MATERIALS MANUAL WITH THE FOLLOWING ATTRIBUTES:
 PERFORMANCE — HIGH
 APPEARANCE — HIGH
 MAX. ANGLE — 90°
 - LENGTH OF RETAINED SOIL SYSTEM MAY BE INCREASED TO SUIT NEAREST NUMBER OF WHOLE PANELS FOR RETAINED SOIL SYSTEM, INCLUDING GRANULAR FILL, EXCAVATION, CONCRETE CAP AND THE LIKE, WITH NO ADDITIONAL COST TO THE OWNER. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE CONTRACT ADMINISTRATOR.
 - TOP SOIL, SOFT/LOOSE SOIL, AND ANY SOFT/WET NATIVE MATERIAL SHOULD BE STRIPPED FROM THE FOOTING OF THE RSS. THE NATIVE SUBGRADE UNDER THE RSS FOUNDATION SHOULD BE PROOF ROLLED TO DETECT AND REPLACE ANY SOFT AREAS.
 - PRIOR TO PLACING THE GRANULAR PAD FOR THE RSS, THE SUBEXCAVATED GRADE SHALL BE PROOF-ROLLED AND THE CONTRACTOR AND RSS SUPPLIER SHALL INSPECT THE SUBEXCAVATED GRADE AND CONFIRM ITS CAPACITY TO SUPPORT THE RSS SYSTEM BEFORE PROCEEDING WITH THE WORK.
 - THE GRANULAR 'A' PADS SHALL BE COMPACTED TO 100% STANDARD PROCTOR MAXIMUM DRY DENSITY (SPMDD) AT A MOISTURE CONTENT WITHIN 2% OF OPTIMUM.
 - PROTECTION SYSTEMS SHALL BE DESIGNED BY CONTRACTOR IN ACCORDANCE WITH OPS 539 PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATIC ONLY, EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.
 - RRS REINFORCING STRIP LOCATIONS SHALL NOT INTERFERE AND WITH NOISE BARRIER FOUNDATION AND CATCH BASIN LOCATIONS.

- APPLICABLE STANDARD DRAWINGS:**
- OPSD 3121.150 WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
 - OPSD 972.130 FENCE, CHAIN-LINK INSTALLATION — ROADWAY
 - OPSD 972.131 FENCE, CHAIN-LINK INSTALLATION — CONCRETE BARRIER
 - CITY STANDARD SC1.1

- LIST OF DRAWINGS:**
- GENERAL ARRANGEMENT
 - RETAINING WALL DETAILS
- LIST OF ABBREVIATIONS**
- IF DENOTES INSIDE FACE
 - OF DENOTES OUTSIDE FACE
 - RRS DENOTES RETAINED SOIL SYSTEM
 - PL DENOTES PROPERTY LINE



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	ZP	CHK	WW	CODE	CHBDC 2014	LOAD	CL-625-ONT	DATE	JAN/20
DRAWN	ZP	CHK	WW	SITE	03X-0749/WO			DWG	1

DISTRICT
CONT. No.
WP No. 4173-15-00



RETAINING WALL 13-N (RW11)
STA 282+167.676 TO STA 828+300.850

SHEET
S34

GENERAL ARRANGEMENT



METRIC

GENERAL NOTES:

ALL REINFORCING STEEL IN RSS WALL PANELS, COPING, AND SLIP JOINTS SHALL BE STAINLESS STEEL TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPA. UNLESS OTHERWISE SPECIFIED.

CLASS OF CONCRETE:

30 MPa

CLEAR COVER TO REINFORCING STEEL:

70 ± 20 mm UNLESS OTHERWISE NOTED

REINFORCING STEEL:

1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
2. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
3. STAINLESS REINFORCING STEEL SHALL BE TYPE 316 LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500MPa, UNLESS OTHERWISE SPECIFIED.
4. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
5. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.

RETAINED SOIL SYSTEM (RSS):

1. WALL SHALL BE AS LISTED IN THE MTO DESIGNATED SOURCE OF MATERIALS MANUAL WITH THE FOLLOWING
2. RSS WALL SHALL HAVE THE FOLLOWING ATTRIBUTES:

APPLICATION	WALL/SLOPE
GEOMETRY	VERTICAL
PERFORMANCE	MEDIUM
APPEARANCE	HIGH
3. LENGTH OF RETAINED SOIL SYSTEM MAY BE INCREASED TO SUIT NEAREST NUMBER OF WHOLE PANELS FOR RETAINED SOIL SYSTEM, INCLUDING GRANULAR FILL, EXCAVATION, CONCRETE CAP AND THE LIKE, WITH NO ADDITIONAL COST TO THE OWNER. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE CONTRACT ADMINISTRATOR.
4. TOP SOIL, SOFT/LOOSE SOIL, AND ANY SOFT/WET NATIVE MATERIAL SHOULD BE STRIPPED FROM THE FOOTING OF THE RSS. THE NATIVE SUBGRADE UNDER THE RSS FOUNDATION SHOULD BE PROOF ROLLED TO DETECT AND REPLACE ANY SOFT AREAS.
5. PRIOR TO PLACING THE GRANULAR PAD FOR THE RSS, THE SUBEXCAVATED GRADE SHALL BE PROOF-ROLLED AND THE CONTRACTOR AND RSS SUPPLIER SHALL INSPECT THE SUBEXCAVATED GRADE AND CONFIRM ITS CAPACITY TO SUPPORT THE RSS SYSTEM BEFORE PROCEEDING WITH THE WORK.
6. THE GRANULAR 'A' PADS SHALL BE COMPACTED TO 100% STANDARD PROCTOR MAXIMUM DRY DENSITY (SPMDD) AT A MOISTURE CONTENT WITHIN 2% OF OPTIMUM.
7. PROTECTION SYSTEMS SHALL BE DESIGNED BY CONTRACTOR IN ACCORDANCE WITH OPSS 539 PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATIC ONLY, EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.
8. RSS REINFORCING STRIP LOCATIONS SHALL NOT INTERFERE AND WITH NOISE BARRIER FOUNDATION AND CATCH BASIN LOCATIONS.

1. GENERAL ARRANGEMENT
2. STANDARD DETAILS

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. STANDARD DETAILS

LEGEND:



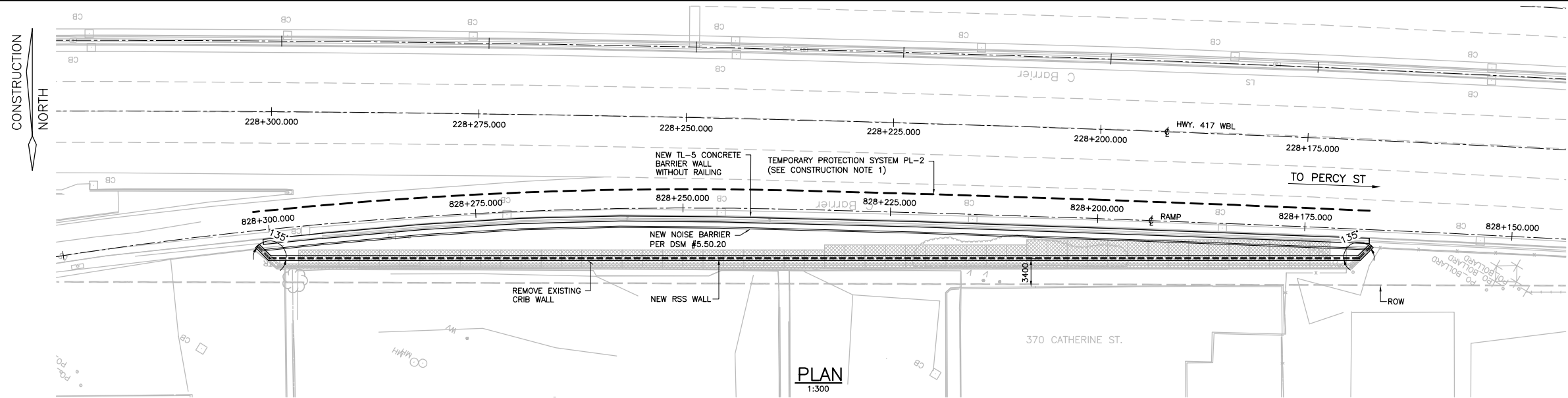
REMOVAL

LIST OF ABBREVIATIONS:

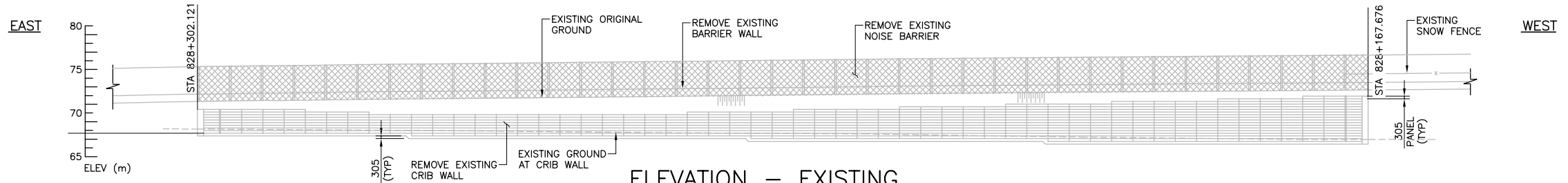
- F.O.S. - DENOTES FILTRATION OPENING SIZE
IF - DENOTES INSIDE FACE
OF - DENOTES OUTSIDE FACE
RSS - DENOTES RETAINED SOIL SYSTEM

CONSTRUCTION NOTE:

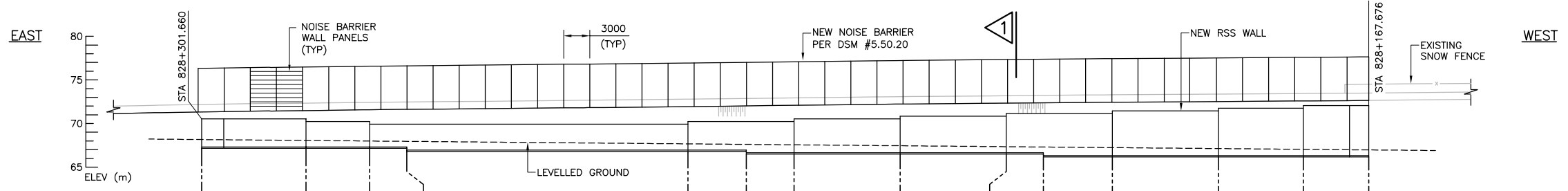
1. TEMPORARY PROTECTION SYSTEM SHALL BE REMOVED TO 1.8m BELOW GRADE WHEN NO LONGER REQUIRED.



PLAN
1:300

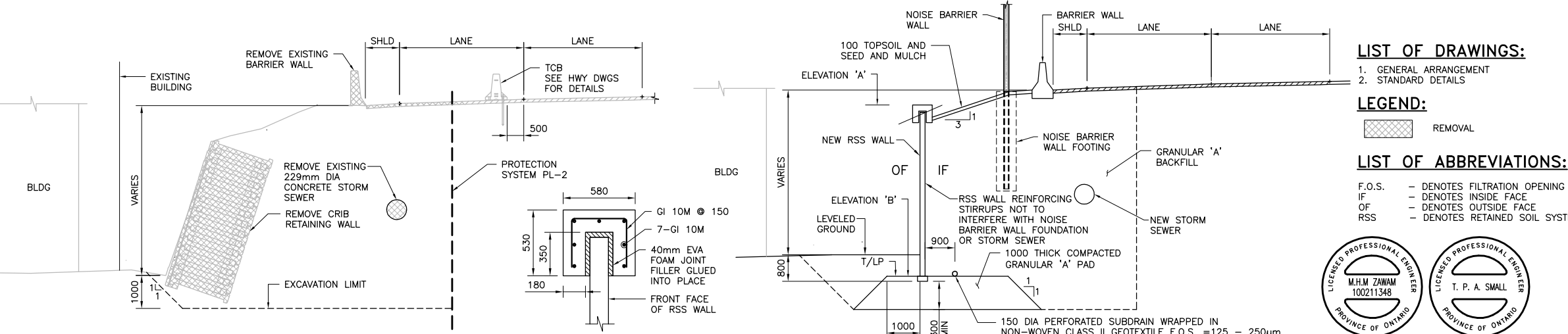


ELEVATION - EXISTING
1:300



ELEVATION - REHABILITATED
1:300

STATION (828+)	301.660	289.793	282.429	278.140	245.455	238.665	233.157	220.951	208.749	204.479	196.545	184.352	174.597	166.833
OFFSET FROM RAMP TO OUTSIDE FACE OF RSS WALL	1.885	4.481	5.019	5.503	6.091	6.214	5.858	5.518	5.135	4.991	4.709	4.240	3.834	1.999
ELEVATION POINT 'A'	70.531	70.226	69.921	69.921	70.226	70.226	70.531	70.836	71.141	71.141	71.446	71.751	72.056	72.055
ELEVATION POINT 'B'	67	67	67	67	67	67	67	67	67	67	67	67	67	67



TYPICAL EXISTING SECTION
1:75

CONCRETE FINISHING CAP
1:20

TYPICAL RSS WALL SECTION
1:75



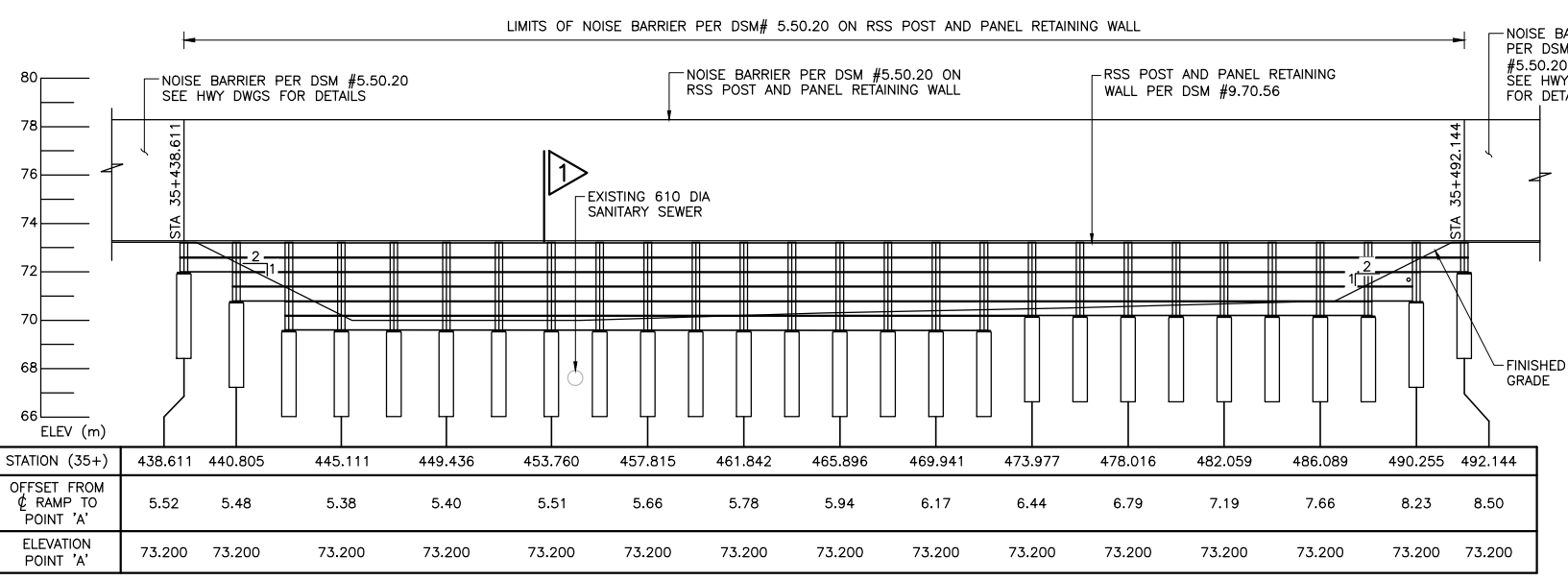
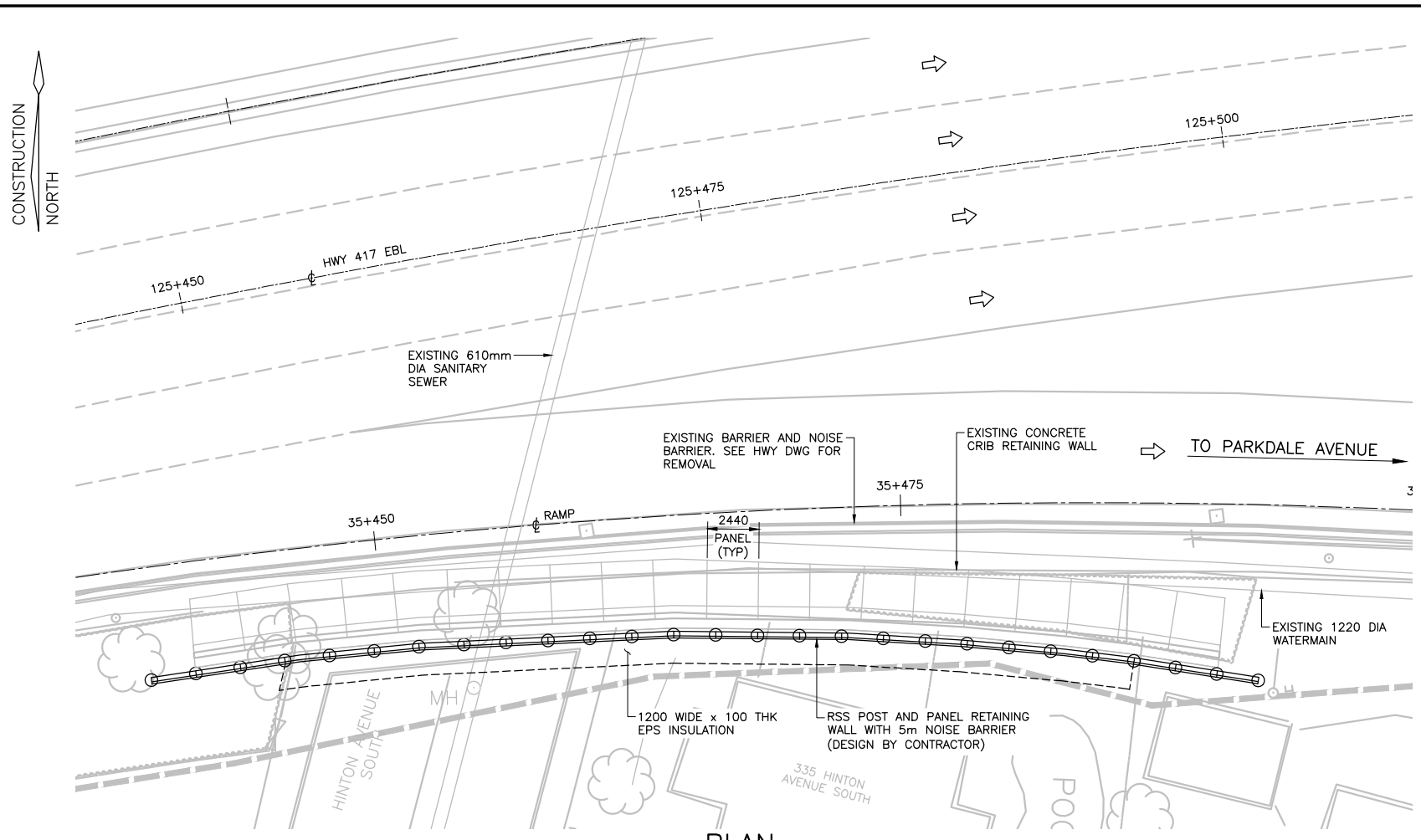
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

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DRAWN	RJR	CHK	JY	SITE	03X-0745/WO	STRUCT	SCHEME	DWG	1	

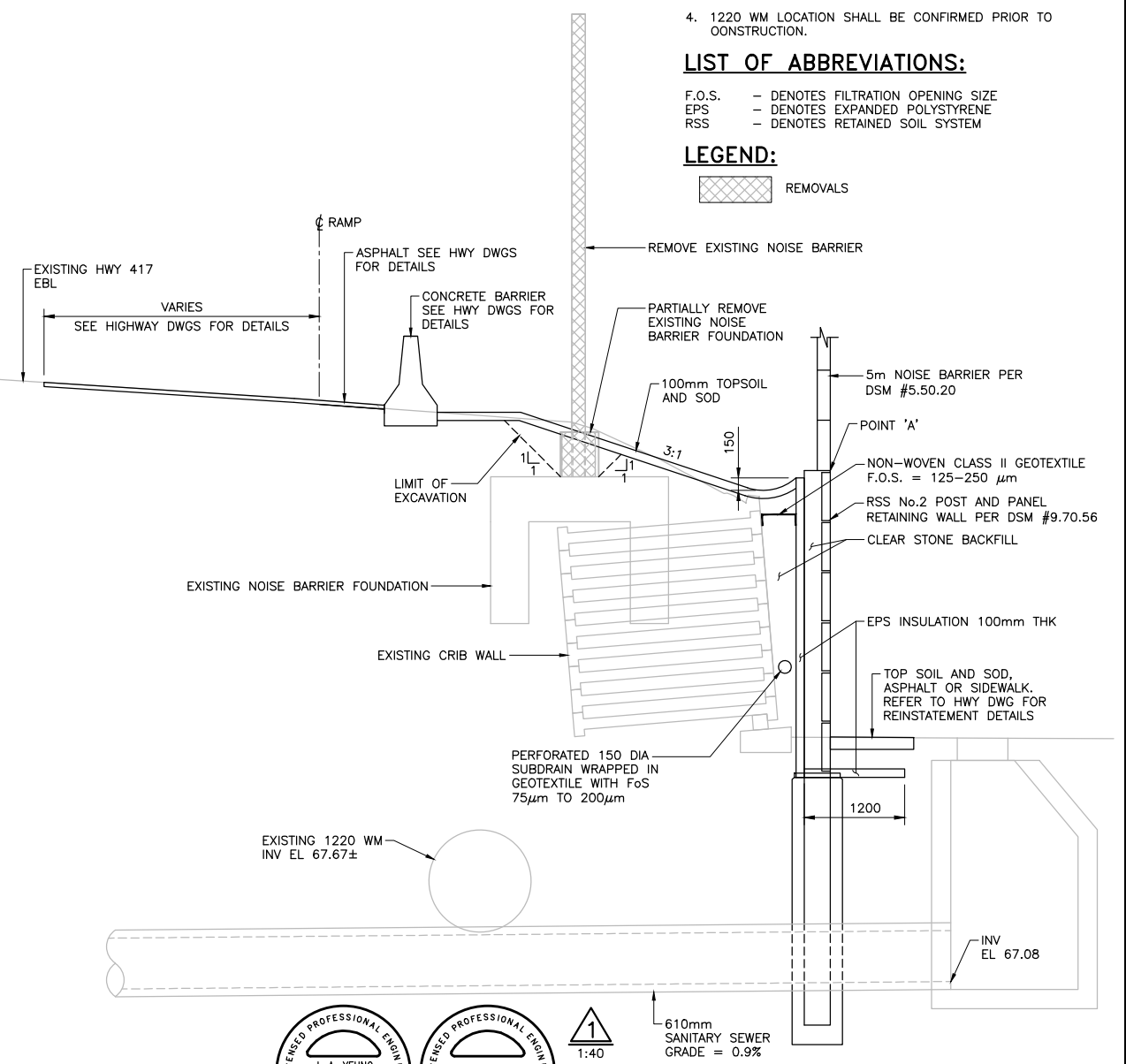
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 DATE PLOTTED: 1/21/2020 4:08:11 PM BY: HILL, CORY

PR-0-207 88-05
 MINISTRY OF TRANSPORTATION, ONTARIO



* ACTUAL CAISSON SPACING FOR RSS POST AND PANEL RETAINING WALL SHALL BE IN ACCORDANCE WITH DSM #9.70.56



LICENSED PROFESSIONAL ENGINEER
 J. A. YEUNG
 100179431
 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
 T. P. A. SMALL
 100179431
 PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DISTRICT CONT. No. WP No. 4173-15-00	 SHEET S44
HIGHWAY 417 RETAINING WALL 1-S (RW14) STA 35+438 TO STA 35+492	
GENERAL ARRANGMENT	METRIC

GENERAL NOTES:
CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO THE COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
2. THE CONTRACTOR SHALL COORDINATE WITH UTILITY OWNERS TO VERIFY LOCATION AND TO AVOID CONFLICT OR DAMAGE TO THE UTILITIES DURING CONSTRUCTION.
3. CAISSONS SHALL NOT BE LOCATED WITHIN 800mm CLEAR OF EXISTING 610 DIA SANITARY SEWER.
4. 1220 WM LOCATION SHALL BE CONFIRMED PRIOR TO CONSTRUCTION.

LIST OF ABBREVIATIONS:
 F.O.S. - DENOTES FILTRATION OPENING SIZE
 EPS - DENOTES EXPANDED POLYSTYRENE
 RSS - DENOTES RETAINED SOIL SYSTEM

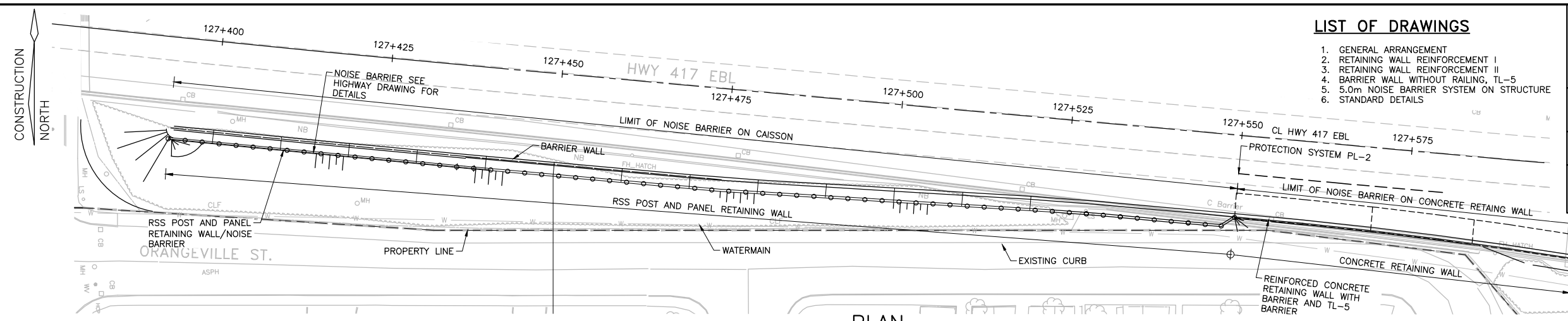
LEGEND:
 REMOVALS

REVISIONS	DATE	BY	DESCRIPTION
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DRAWN	RJR	CHK JY	SITE 03X-0939/W0

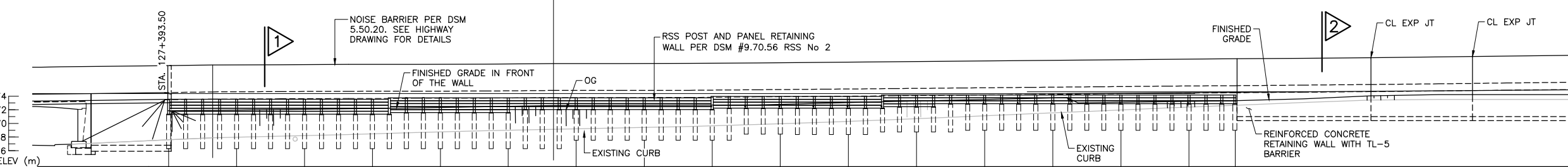
DATE NOV/19
DWG 1

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PR-0-207 88-05
 MINISTRY OF TRANSPORTATION, ONTARIO



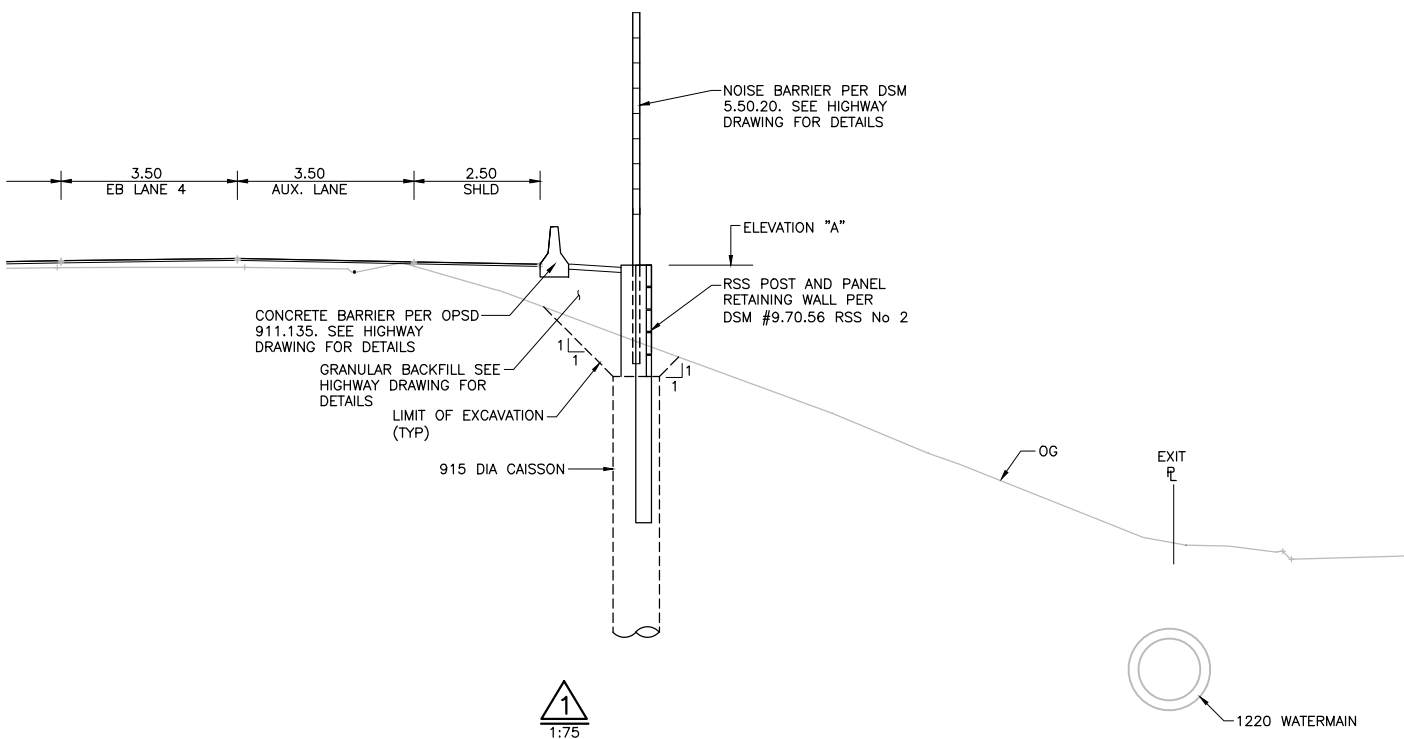
PLAN
1:250



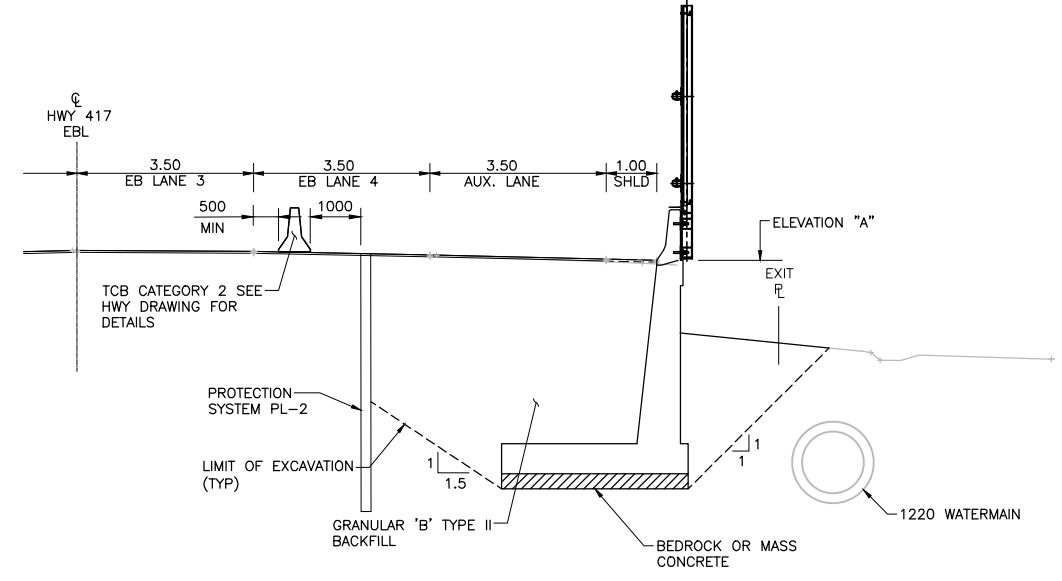
ELEVATION
1:250

* ACTUAL CAISSONS SPACING FOR POST AND PANEL RETAINING WALL SHALL BE IN ACCORDANCE WITH DSM #9.70.56 RSS No 2 AND SHALL AVOID CONFLICT WITH REINFORCED CONCRETE RETAINING WALL

STATION (127+)	393.50	403.50	413.50	423.50	433.50	443.335	453.335	463.335	473.335	483.335	493.329	503.325	513.321	523.317	533.330	543.317	550.00	560.00	570.00	585.00	600.00
OFFSET FROM CL HWY 417 EBL (m) (TO CENTER OF CAISSON)	14.939	14.917	14.917	14.917	14.917	14.945	14.945	14.945	14.945	14.698	14.416	14.134	13.852	13.570	13.485	13.470	12.043				
OFFSET FROM CL HWY 417 EBL (m) (TO FRONT FACE OF RETAINING WALL)																		11.977	12.137	12.682	14.74
ELEVATION POINT 'A' TOP OF FOOTING ELEVATION	73.044	73.044	73.044	73.044	73.255	73.255	73.255	73.255	73.466	73.466	73.466	73.677	73.677	73.759	73.849	73.932	74.052	74.126	74.199	74.310	74.420
																		70.50	70.50	70.50	70.50



1
1:75



2
1:75



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. RETAINING WALL REINFORCEMENT I
3. RETAINING WALL REINFORCEMENT II
4. BARRIER WALL WITHOUT RAILING, TL-5
5. 5.0m NOISE BARRIER SYSTEM ON STRUCTURE
6. STANDARD DETAILS

CONT. No.
WP No. 4173-15-00
HIGHWAY 417 RETAINING WALL
RETAINING WALL 4-S (RW17)
STA 127+393 TO STA 127+600
GENERAL ARRANGEMENT



SHEET



METRIC

GENERAL NOTES:

CLASS OF CONCRETE:

30MPa

CLEAR COVER TO REINFORCING:

FOOTING BOTTOM 100 ± 25mm
UNLESS OTHERWISE NOTED 70 ± 20mm

CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO THE COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
2. THE CONTRACTOR SHALL COORDINATE WITH UTILITY OWNERS TO VERIFY THE LOCATION AND TO AVOID CONFLICT OR DAMAGE TO THE UTILITIES DURING CONSTRUCTION.

REINFORCING:

1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.
4. HORIZONTAL LAP SPLICES MUST NOT LAP THROUGH CONTROL JOINTS.
5. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
6. STAINLESS REINFORCING STEEL SHALL BE TYPE 316 LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.

APPLICABLE STANDARD DRAWINGS:

- OPSD 911.381 GUIDE RAIL SYSTEM, CONCRETE BARRIER PERMANENT TRANSITION INSTALLATION
- OPSD 911.382 GUIDE RAIL SYSTEM, CONCRETE BARRIER DOWEL CONNECTION DETAIL
- OPSD 3121.150 WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
- OPSD 3190.100 WALLS, RETAINING AND ABUTMENT WALL DRAIN
- OPSD 3950.100 JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE

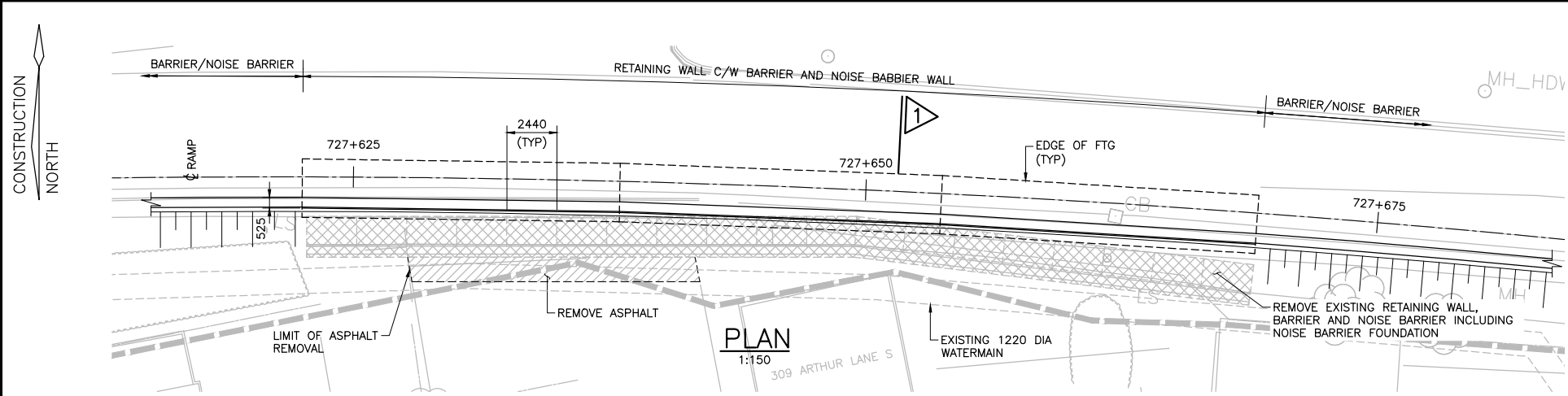
REVISIONS	DATE	BY	DESCRIPTION

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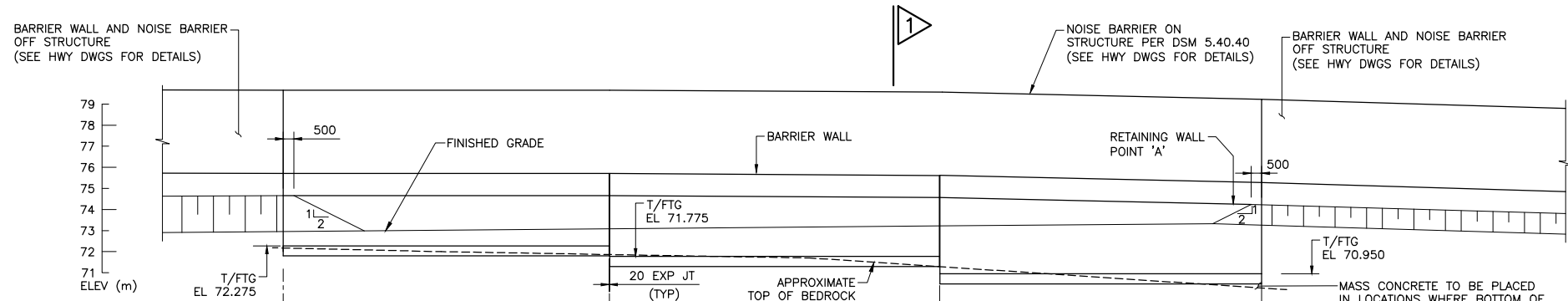
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MINISTRY OF TRANSPORTATION, ONTARIO

PR-D-707 88-05

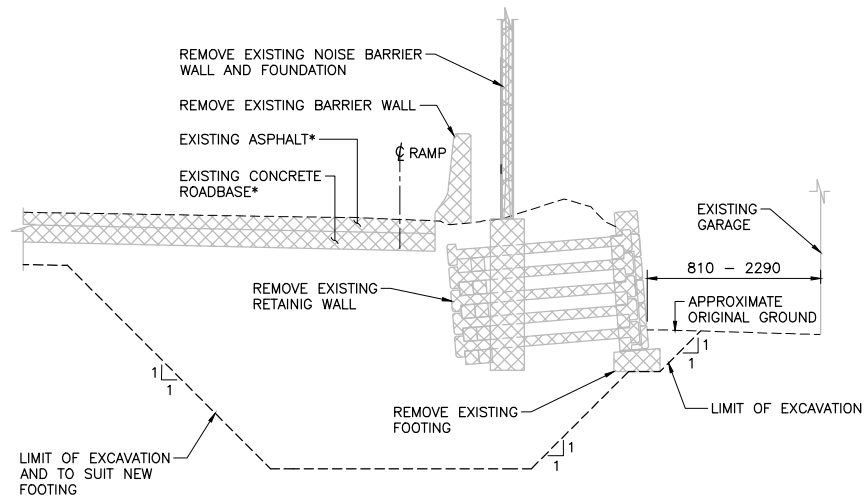


PLAN
1:150



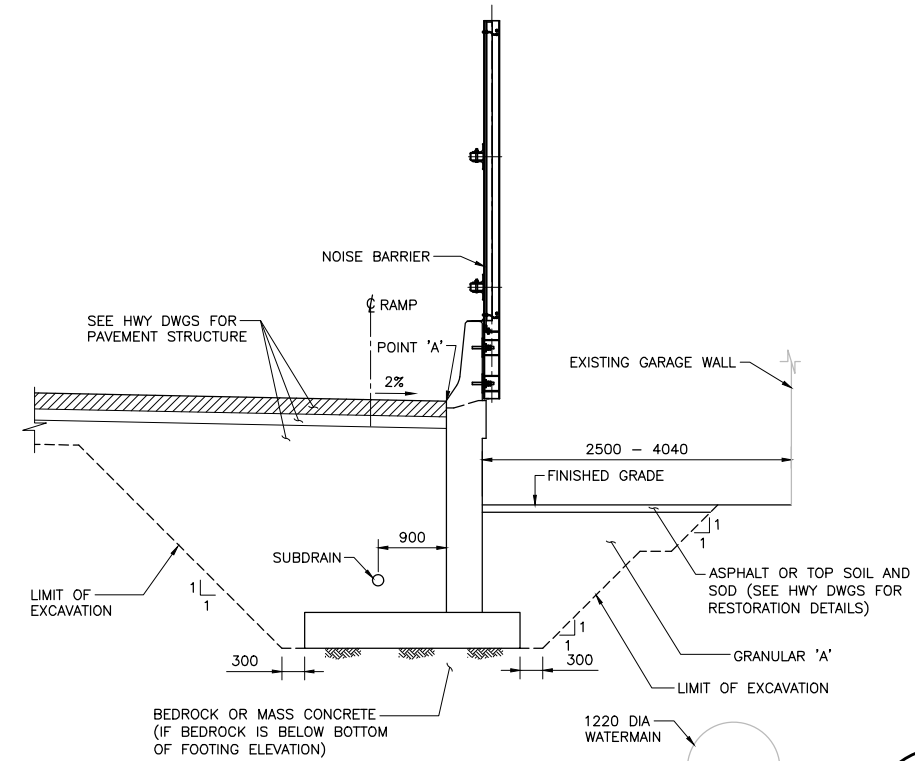
ELEVATION
1:150

STATION (727+)	622.500	638.000	653.700	669.000
OFFSET FROM C RAMP TO POINT 'A'	1.000	1.000	1.000	1.000
ELEVATION POINT 'A'	74.655	74.655	74.565	74.240



REMOVALS
1:50

SECTION AT 309 ARTHUR LANE S SHOWN,
 SEE HIGHWAY DRAWINGS FOR ASPHALT REMOVAL
 AT ARTHUR LANE AND HWY 417 RAMP
 * SEE HIGHWAY DRAWINGS FOR DETAILS



REMOVALS
1:50

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. RETAINING WALL REINFORCEMENT I
3. RETAINING WALL REINFORCEMENT II
4. RETAINING WALL REINFORCEMENT III
5. BARRIER WALL WITHOUT RAILING TL-5
6. STANDARD DETAILS

CONT. No. WP No.	HIGHWAY 417 RETAINING WALL 5-S (RW 18) STA 727+622 TO STA 727+669	SHEET
GENERAL ARRANGEMENT		
wsp		METRIC

GENERAL NOTES:

CLASS OF CONCRETE:

30MPa

CLEAR COVER TO REINFORCING:

FOOTING BOTTOM 100 ± 25mm
 UNLESS OTHERWISE NOTED 70 ± 20mm

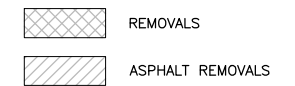
CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO THE COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
2. THE CONTRACTOR SHALL COORDINATE WITH UTILITY OWNERS TO VERIFY THE LOCATION AND TO AVOID CONFLICT OR DAMAGE TO THE UTILITIES DURING CONSTRUCTION.

REINFORCING:

1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1, UNLESS INDICATED OTHERWISE.
4. HORIZONTAL LAP SPLICES MUST NOT LAP THROUGH CONTROL JOINTS.
5. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
6. STAINLESS REINFORCING STEEL SHALL BE TYPE 316 LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.

LEGEND:



APPLICABLE STANDARD DRAWINGS:

- OPSD 911.381 GUIDE RAIL SYSTEM, CONCRETE BARRIER PERMANENT TRANSITION INSTALLATION ROADSIDE CONCRETE BARRIER TO STRUCTURE
- OPSD 911.382 GUIDE RAIL SYSTEM, CONCRETE BARRIER DOWEL CONNECTION DETAIL
- OPSD 3121.150 WALLS RETAINING, BACKFILL MINIMUM GRANULAR REQUIREMENT
- OPSD 3190.100 WALLS, RETAINING AND ABUTMENT WALL DRAIN
- OPSD 3950.100 JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE

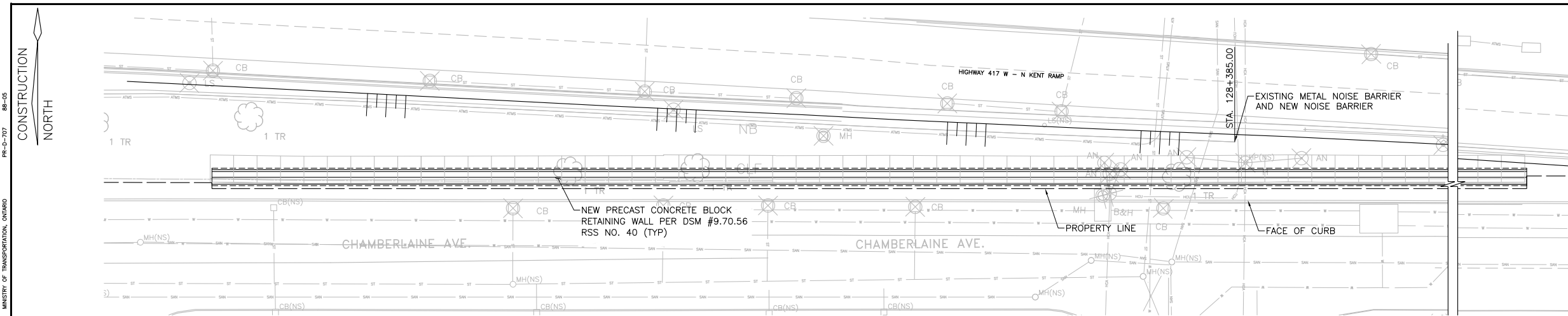


DRAWING NOT TO BE SCALED
 100mm ON ORIGINAL DRAWING

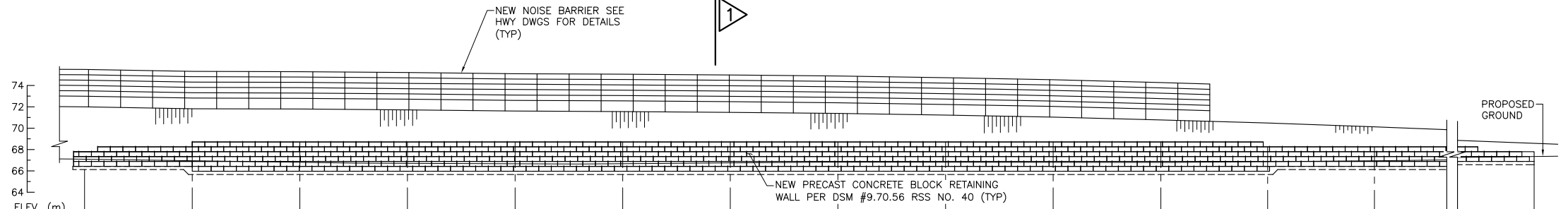
REVISIONS	DATE	BY	DESCRIPTION

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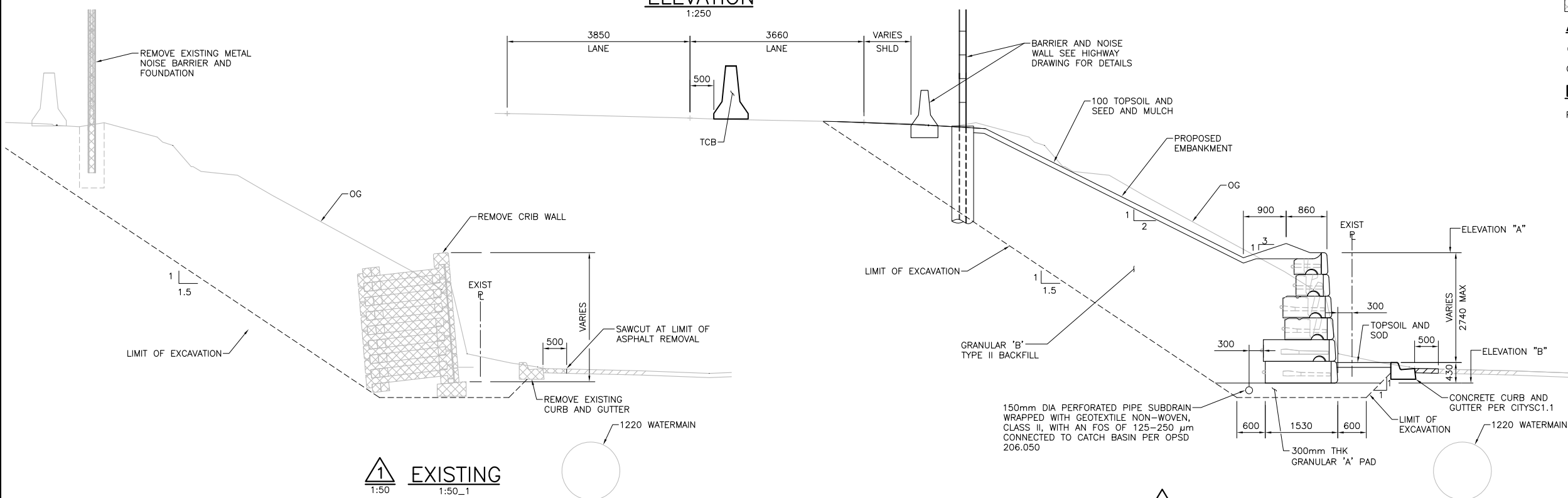


PLAN
1:250



ELEVATION
1:250

STATION	128+278.61	128+290	128+300	128+310	128+320	128+330	128+340	128+350	128+360	128+370	128+380	128+390	128+400	128+349.144
OFFSET FROM CL HWY 417 EBL (m) (TO BOTTOM OF BLOCK WALL)	25.689	25.571	25.482	25.421	25.389	25.386	25.411	25.465	25.549	25.661	25.802	26.970	26.167	27.212
ELEVATION "A" (m)	67.798	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.712	68.255	68.255	67.798
ELEVATION "B" (m)	66.427	66.427	65.970	65.970	65.970	65.970	65.970	65.970	65.970	65.970	65.970	65.970	66.427	66.884



EXISTING
1:50

PROPOSED
1:50

DISTRICT CONT. No. WP No. 4173-15-00	
HIGHWAY 417 RETAINING WALL 7-S (RW19) STA. 128+280 TO STA. 128+440	
GENERAL ARRANGEMENT	SHEET S51
	METRIC

GENERAL NOTES:
CONSTRUCTION NOTES:

- THIS DESIGN IS BASED ON THE FOLLOWING PROPERTIES:
PROPERTY: RETAINING FILL
FRICTION ANGLE: ϕ 30°
UNIT WEIGHT: γ 22kN/m³
SOIL TYPE: TYPE II OPSS GRANULAR B
- WALL GEOMETRY AND GRADE ELEVATIONS ABOVE AND BELOW THE WALL SHOULD CONFORM WITH GRADING. IF ACTUAL SITE GRADES VARY SIGNIFICANTLY FROM THOSE SHOWN OR IF THE BACK SLOPE DOES NOT CONFORM, INSTALLATION SHALL NOT PROCEED UNTIL THE CALL DESIGN IS VERIFIED OR MODIFIED IN THE APPLICABLE AREA.
- THE GRANULAR B TYPE II SHOULD BE COMPACTED TO MIN. 98% OF THE MATERIALS SPMD AND TESTED BY THE GEOTECHNICAL CONSULTANT AT THE TIME OF CONSTRUCTION.
- INSTALL 150mm DIAMETER PERFORATED PIPE DRAIN BEHIND HEEL OF WALL. PROVIDE CLEAR STONE SURROUND TO PROTECT PIPE FROM CLOGGING AND DAMAGE. PROVIDE OUTLETS THROUGH WALL.
- THE CONDITIONS WILL BE EVALUATED BY THE GEOTECHNICAL ENGINEER DURING PREPARATION FOR WALL CONSTRUCTION IN EACH AREA. WHERE GRANULAR BEDDING WILL NOT BE SUFFICIENT THE USE OF CONCRETE BEDDING MAY BE REQUIRED.
- BACK FILL MATERIAL SHALL BE APPROVED BY THE SITE GEOTECHNICAL ENGINEER PRIOR TO USE AND SHOULD CONSIST OF OPSS GRANULAR B TYPE II BUFFER OF MINIMUM 1.0M WIDTH, FOLLOWED BY SUITABLE GRANULAR FILL. ALL FILL ZONE UP AND BACK FROM THE HEEL SHOULD ALSO BE COMPACTED BACKFILL SHALL BE PLACED IN MAXIMUM 300mm LOOSE LIFTS AND COMPACTED TO A MINIMUM 98% OF SPMD.
- MAINTAIN TEMPORARY GRADES TO DIVERT SURFACE WATER AWAY FROM THE RETAINING WALL EXCAVATION. SLOPE FINAL BACKFILL TO PROVIDE POSITIVE DRAINAGE AND TO ELIMINATE PONDING.

- LEGEND:**
- REMOVALS
- APPLICATION STANDARD DRAWING**
- OPSD 206.050 SUBDRAIN PIPE CONNECTION AND OUTLET
RURAL
CITY STANDARD SC1.1
- LIST OF ABBREVIATIONS**
- DENOTES PROPERTY LINE



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN ZP CHK TS | CODE CHBDC 2014 | LOAD CL-625-ONT | DATE NOV/19
 DRAWN ZP CHK WW | SITE 03X-0744/W0 | STRUCT | SCHEME | DWG 1

APPENDIX A

Lists of Abbreviations and Symbols
Lithological and Geotechnical Rock
Description Terminology
Record of Boreholes 18-801, 18-802, 18-901
to 18-904, 18-906 to 18-918 and 18-923
Bedrock Core Photographs, Figures A1 to A14

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I.	GENERAL	(a)	Index Properties (continued)
π	3.1416	w	water content
$\ln x$,	natural logarithm of x	w_l or LL	liquid limit
\log_{10}	x or log x, logarithm of x to base 10	w_p or PL	plastic limit
g	acceleration due to gravity	I_p or PI	plasticity index = $(w_l - w_p)$
t	time	w_s	shrinkage limit
FoS	factor of safety	I_L	liquidity index = $(w - w_p) / I_p$
		I_C	consistency index = $(w_l - w) / I_p$
		e_{max}	void ratio in loosest state
		e_{min}	void ratio in densest state
		I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)
II.	STRESS AND STRAIN	(b)	Hydraulic Properties
γ	shear strain	h	hydraulic head or potential
Δ	change in, e.g. in stress: $\Delta \sigma$	q	rate of flow
ϵ	linear strain	v	velocity of flow
ϵ_v	volumetric strain	i	hydraulic gradient
η	coefficient of viscosity	k	hydraulic conductivity (coefficient of permeability)
ν	Poisson's ratio	j	seepage force per unit volume
σ	total stress	(c)	Consolidation (one-dimensional)
σ'	effective stress ($\sigma' = \sigma - u$)	C	compression index (normally consolidated range)
σ'_{vo}	initial effective overburden stress	C_r	recompression index (over-consolidated range)
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, minor)	C_s	swelling index
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3) / 3$	C_α	secondary compression index
τ	shear stress	m_v	coefficient of volume change
u	porewater pressure	C_v	coefficient of consolidation (vertical direction)
E	modulus of deformation	C_h	coefficient of consolidation (horizontal direction)
G	shear modulus of deformation	T_v	time factor (vertical direction)
K	bulk modulus of compressibility	U	degree of consolidation
III.	SOIL PROPERTIES	σ'_p	pre-consolidation stress
(a)	Index Properties	OCR	over-consolidation ratio = σ'_p / σ'_{vo}
$\rho(\gamma)$	bulk density (bulk unit weight)*	(d)	Shear Strength
$\rho_d(\gamma_d)$	dry density (dry unit weight)	τ_p, τ_r	peak and residual shear strength
$\rho_w(\gamma_w)$	density (unit weight) of water	ϕ'	effective angle of internal friction
$\rho_s(\gamma_s)$	density (unit weight) of solid particles	δ	angle of interface friction
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)	μ	coefficient of friction = $\tan \delta$
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)	c'	effective cohesion
e	void ratio	c_u, s_u	undrained shear strength ($\phi=0$ analysis)
n	porosity	p	mean total stress $(\sigma_1 + \sigma_3) / 2$
S	degree of saturation	p'	mean effective stress $(\sigma'_1 + \sigma'_3) / 2$
		q	$(\sigma_1 - \sigma_3) / 2$ or $(\sigma'_1 - \sigma'_3) / 2$
		q_u	compressive strength $(\sigma_1 - \sigma_3)$
		S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 10	Trace	Trace sand
10 to 20	Some	Some sand
20 to 35	(ey) or (y)	Sandy
over 35	And	Sand and Gravel

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT <u>1655214-1800</u>	RECORD OF BOREHOLE No 18-801	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5028691.4; E 365104.3 NAD 83 MTM ZONE 9 (LAT. 45.395573; LONG. -75.729778)</u>	ORIGINATED BY <u>CRG</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Track Mount Portable/Power Rotary Drill, HW Casing, HQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>July 25, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
67.4	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
67.1	(SW) Gravelly sand (FILL)																
0.3	Moist		1	SS	6												
66.6	(SP) Sand, trace silt, contains geotextile fragments (FILL)		2	SS	50/0.05												
0.8	Moist																
66.6	- Cobbles from 0.7 to 0.8 m depth		R1	RC	-												UCS = 26 MPa
	PORTLAND CEMENT CONCRETE (FOOTING)		R2	RC	-												
65.5	(SM/ML) Gravelly SILTY SAND, contains cobbles and bedrock fragments (TILL)		3	SS	38												25 47 (28)
1.9	Dense																
65.0	Grey																
2.4	Moist																
	END OF BOREHOLE SPLITSPOON REFUSAL																

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1800</u>	RECORD OF BOREHOLE No 18-802	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5028731.2; E 365132.6 NAD 83 MTM ZONE 9 (LAT. 45.395929; LONG. -75.729413)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Portable Rotary Drill, NW Casing, NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 23-24, 2019</u>	CHECKED BY _____	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20	40	60	80	100		
69.7	GROUND SURFACE													
0.0	(SM) Silty sand, contains organic matter (TOPSOIL)													
0.2	Brown (SM/ML) Silty sand, trace gravel, trace concrete fragments, contains cobbles (FILL) Grey brown Moist to wet		1	SS	5									
			2	SS	25									10 52 28 10
			3	SS	20									
			4	SS	23									5 58 28 9
			5	SS	31									
66.7	(SW/GW) Sand and gravel (FILL) Brown Wet		6	SS	50/0.15									
66.3	PORTLAND CEMENT CONCRETE (FOOTING)		7	RC	-									
65.3	(SM) SILTY SAND, trace gravel (TILL) Grey Wet		8	SS	146									6 61 (33)
64.5	Limestone fragments		9	SS	173									
5.2	END OF BOREHOLE SPLITSPOON REFUSAL		10	SS	00/0.05									

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NOTES:

- Manual third weight hammer used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of their reduced energy.
- Water level in open borehole at a depth of 2.4 m (Elev. 67.3 m) on may 24, 2019

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-901	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5028734.4; E 365200.6 NAD 83 MTM ZONE 9 (LAT. 45.395952; LONG. -75.728544)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 16, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)					
							20	40	60	80	100	25	50	75			
70.0	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.1	(SW) Gravelly sand (FILL) Grey		1	GS	-												
69.4																	
0.6	(SM) Sand, some silt and gravel (FILL) Grey brown Moist		2	GS	-							○					13 69 (18)
69.4																	
0.6			3	GS	-												
68.5																	
1.5	(SM) SILTY SAND, contains cobbles Dense to compact Grey Moist to wet																
68.5																	
1.5			4	SS	35												
68.5																	
1.5			5	SS	37							○					3 68 (29)
68.5																	
1.5			6	SS	19												
68.5																	
65.4																	
4.6	(SM/ML) Gravelly SAND and SILT (TILL) Compact to dense Grey Wet		7	SS	19												
65.4																	
4.6			8	SS	44							○					23 41 (36)
65.4																	
63.7																	
6.3	END OF BOREHOLE AUGER REFUSAL		9	SS	50/0.15												

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-902	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5028741.6; E 365206.9 NAD 83 MTM ZONE 9 (LAT. 45.396016; LONG. -75.728462)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro Excavation/Power Auger, 200 mm Diam. (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 16, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							20 40 60 80 100	PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED WATER CONTENT (%) 25 50 75						
70.0	GROUND SURFACE													
0.0	ASPHALTIC CONCRETE													
69.7	(SW) Gravelly sand (FILL) Grey													
69.4	(SP) Sand (FILL) Brown													
69.2	Moist		1	GS	-									
0.8	(SM) Silty sand, contains rootlets (TOPSOIL) Dark brown Moist		2	GS	-									
68.5	(SM) SILTY SAND, some gravel Grey brown Moist													
1.5	(SP-SM) SAND, some silt Compact Grey brown Moist to wet													
			3	SS	10									
			4	SS	18									
65.4														
4.6	(SM/ML) SAND and SILT, trace gravel (TILL) Compact to dense Wet		5	SS	18								1	43 (56)
			6	SS	39								7	53 (40)
63.8														
6.2	END OF BOREHOLE AUGER REFUSAL													
	NOTE: 1. Water level in well screen at a depth of 2.9 m below ground surface (Elev. 67.2 m), measured on June 19, 2019													

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-903	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029102.8; E 365614.2 NAD 83 MTM ZONE 9 (LAT. 45.399231; LONG. -75.723216)</u>	ORIGINATED BY <u>RI</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro-excavation</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>July 14-15, 2019</u>	CHECKED BY <u>KCP</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20 40 60 80 100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED						
71.6	GROUND SURFACE															
8.8	ASPHALTIC CONCRETE (SW/GW) Gravelly sand, contains wood and concret Grey Moist		1	GS	-											
70.4						71										
1.3	END OF BOREHOLE															

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-904	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029102.8; E 365691.1 NAD 83 MTM ZONE 9 (LAT. 45.399224; LONG. -75.722234)</u>	ORIGINATED BY <u>DJG</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Portable Drill, NW Casing/NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>October 15, 2018</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
71.0	GROUND SURFACE																
8.0	(SM) Silty sand (TOPSOIL) Dark Brown Moist		1	SS	18												
70.4	(SP/GP) Sand and gravel, contains wood pieces (FILL) Dark brown Moist		2	SS	34												17 76 (7)
69.9	(SP-SM) Sand, some gravel, trace silt (FILL) Brown Wet						70										
1.2	(GP) Gravel (FILL) Grey PORTLAND CEMENT CONCRETE (FOOTING)		3	RC	-												
68.9	(SM/ML) Gravelly SAND, some silt, contains clayey silt seams (TILL) Grey Wet		4	SS	43		69										
			5	SS	47		68										28 51 14 7
			6	SS	32												
67.0	END OF BOREHOLE																
4.0	NOTES: 1. Manual third weight hammer used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of their reduced energy.																

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PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-906	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029624.1; E 366799.1 NAD 83 MTM ZONE 9 (LAT. 45.403818; LONG. -75.708018)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 8, 2019</u>	CHECKED BY <u>KCP</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80					
65.5	GROUND SURFACE															
0.0	ASPHALTIC CONCRETE															
65.1	(SW/GW) Sand and gravel (FILL) Brown															
0.4	(SM) Sand, some silt and gravel (FILL) Brown		1	SS	32											
64.6	Moist															
0.9	END OF BOREHOLE AUGER REFUSAL															19 66 (15)

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-907	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029631.9; E 366837.8 NAD 83 MTM ZONE 9 (LAT. 45.403884; LONG. -75.707522)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 8, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
66.3	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
66.0	(SW/GW) Sand and gravel (FILL) Brown						66										
0.3	(SM) Sand, some silt, trace gravel (FILL) Brown		1	SS	28												9 72 (19)
65.5	Brown Moist																
0.8	(GW-SW) Sandy gravel, some silt (FILL) Compact Brown Moist		2	SS	25												
65.0	END OF BOREHOLE AUGER REFUSAL						65										
1.3																	

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-908	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029647.0; E 366893.3 NAD 83 MTM ZONE 9 (LAT. 45.404016; LONG. -75.706812)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Rotary Drill, HW Casing/NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 22, 2019</u>	CHECKED BY <u>KCP</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	25 50 75	25 50 75	25 50 75			
66.7	GROUND SURFACE															
0.0	ASPHALTIC CONCRETE															
0.1	(GW/SW) SAND and GRAVEL (FILL) Compact Grey		1	GS	-											
			2	SS	21										45 45 (10)	
			3	SS	50/0.15											
65.1	Limestone (BEDROCK), with thin black shale partings															
1.6	Bedrock cored from depths 1.6 m to 4.0 m For bedrock coring details refer to Record of Drillhole 18-908		1	RC	REC 98%										RQD = 75%	
			2	RC	REC 100%										RQD = 100%	
			3	RC	REC 100%										RQD = 100%	
62.7	END OF BOREHOLE															
4.0																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 20-3-5 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-909	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029667.4; E 366944.3 NAD 83 MTM ZONE 9 (LAT. 45.404195; LONG. -75.706157)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Rotary Drill, HW Casing/HQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 21, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
								20	40	60	80	100	25	50	75		
69.1	GROUND SURFACE																
0.0	(SM) Silty sand, contains organic matter (roots) (TOPSOIL) Brown						69										
0.2																	
68.6	(SM) Silty sand, trace organic matter (FILL) Brown			4													
0.5																	
68.3	(SW) Gravelly sand (FILL) Grey																
0.8																	
	(SM/GM) Gravelly SILTY SAND, contains cobbles (TILL) Compact to dense Grey brown Moist - Cobbles and boulders from 1.5 m to 2.3 m depth		2	SS	13		68										16 56 (28)
			3	RC	-		67										
			4	SS	32		66										26 48 (26)
66.0																	
3.1	Limestone (BEDROCK), with thin black shale partings Bedrock cored from depths 3.1 m to 4.9 m For bedrock coring details refer to Record of Drillhole 18-909		1	RC	REC 95%		65										RQD = 63%
			2	RC	REC 98%												RQD = 87%
64.2																	
4.9	END OF BOREHOLE																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 20-3-5 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-910	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029641.4; E 367056.5 NAD 83 MTM ZONE 9 (LAT. 45.403951; LONG. -75.704727)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro Excavation/Power Auger, 200 mm Diam, (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 3, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
								20	40	60	80	100	25	50	75		
72.1	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE						72										
0.1	(SW) Gravelly sand (FILL) Grey																
70.9							71										
1.3	(SP/SM) Sand, fine, trace silt (FILL) Brown Moist		1	GS	-												
70.4																	
1.7	(SM/GM) Gravelly sand, some silt, contains cobbles (FILL) Brown Moist		2	GS	-		70						○				34 49 (17)
69.1																	
3.1	(ML/SM) SILT and SAND Compact Brown Wet		3	SS	20		69						○				0 42 54 4
68.4																	
3.7	END OF BOREHOLE AUGER REFUSAL																
	NOTE: 1. Water level in open borehole at a depth of 3.1 m below ground surface (Elev. 69.0 m), upon completion of drilling.																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ_GAL-GTA.GDT 20-3-5 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-911	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029650.4; E 367089.2 NAD 83 MTM ZONE 9 (LAT. 45.404028; LONG. -75.704309)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro Excavation/Power Auger, 200 mm Diam, (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 3, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
72.9	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.1	(SW) Gravelly sand (FILL) Grey																
72.1	(SP-SM) Sand, some silt (FILL) Brown to red brown Moist		1	GS	-		72										
71.6	(SP-SM) Sand, some silt (FILL) Grey Moist		2	GS	-		71										
70.6	(GW/SW) Gravel and sand, trace silt, contains cobbles (FILL) Brown Moist		3	GS	-		70										50 44 (6)
69.6	END OF BOREHOLE AUGER REFUSAL		4	SS	50/0.1												
3.3	NOTE: 1. Water level in well screen at a depth of 3.1 m below ground surface (Elev. 69.8 m), on June 19, 2019																

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PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-912	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029660.0; E 367131.5 NAD 83 MTM ZONE 9 (LAT. 45.404112; LONG. -75.703767)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/NW Casing/NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 10, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
72.8	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.1	(SM) Gravelly silty sand, contains metal fragments (FILL) Grey Moist		1	AS	-												29 49 (22)
72.0			2	AS	-												
0.8	Weathered Limestone (BEDROCK)		3	SS	95		72										
71.6	Limestone (BEDROCK), with thin black shale partings																
1.2	Bedrock cored from depths 1.2 m to 2.7 m For bedrock coring details refer to Record of Drillhole 18-912		1	RC	REC 100%	∇	71										RQD = 59%
70.1	END OF BOREHOLE																
2.7	NOTE: 1. Water level in open borehole at a depth of 1.5 m below ground surface (Elev. 71.3 m), upon completion of drilling																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 20-3-5 JM

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-913	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029932.5; E 367605.0 NAD 83 MTM ZONE 9 (LAT. 45.406521; LONG. -75.697685)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 13, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
							20	40	60	80	100	PLASTIC LIMIT W_p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W_L				
							○ UNCONFINED + FIELD VANE					WATER CONTENT (%)						
							● QUICK TRIAXIAL × REMOULDED					25	50	75				
							20	40	60	80	100							
66.9	GROUND SURFACE																	
0.0	ASPHALTIC CONCRETE																	
66.6	(SW) Gravelly sand (FILL)		1	AS	-													
66.6	(SP) Sand, some gravel, contains cinders, ash and wood (FILL)		2	SS	4		66											
66.6	Loose Brown Moist		3	SS	4		65											
64.5	(GW) Sandy gravel, with strong hydrocarbon odour (FILL)		4	SS	50/0.15		64											
64.5	Compact Grey Wet		5	SS	19		64											
63.2	(GM/SM) Sandy GRAVEL, some silt (TILL)		6	SS	31		63											
63.2	Dense to compact Grey Wet		7	SS	26		62											
61.7	(ML) Sandy SILT, some gravel (TILL)		8	SS	50/0.15		62											
61.7	Grey Wet																	
61.4	END OF BOREHOLE AUGER REFUSAL																	
5.5	NOTES:																	
	1. Water level in well screen at a depth of 3.1 m below ground surface (Elev. 63.9 m), measured on June 19, 2019																	

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ_GAL-GTA.GDT 20-3-5 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-914	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029958.8; E 367649.0 NAD 83 MTM ZONE 9 (LAT. 45.406754; LONG. -75.697119)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 14, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
67.5	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.1	(SW) Gravelly sand (FILL) Grey		1	AS	-												
67.0																	
0.5	(SM) Silty sand, some gravel, trace organic matter, contains metal fragments (FILL) Loose Dark brown Moist		2	SS	6												
66.0																	
1.5	(PT) Organics, sandy peat, trace gravel, contains cinders and ash (FILL)		3	SS	10												
65.5																	
2.0	(PT) Fibrous PEAT Black																
64.9																	
2.6	(CI) Silty clay, contains organic matter (rootlets) Grey		4	SS	5												
64.5																	
3.1	(SM) SILTY SAND, some gravel (TILL) Dark grey Wet		5	SS	64/0.15												
63.8																	
3.7	END OF BOREHOLE AUGER REFUSAL NOTE: 1. Water level in well screen at a depth of 2.0 m below ground surface (Elev. 65.5 m), measured on June 19, 2019																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTOHWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 20-3-5 JM

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-916	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029928.2; E 367723.2 NAD 83 MTM ZONE 9 (LAT. 45.406471; LONG. -75.696176)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro Excavation/Power Auger, 200 mm Diam, (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 2 and 9, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)				
								20	40	60	80	100	25	50	75		
67.1	GROUND SURFACE																
0.0	(SM) Silty sand, fine, contains organic matter (TOPSOIL)																
66.9	Dark brown																
0.2	(SW/GW) Sand and gravel, contains rock fill, concrete and brick fragments (FILL)																
	Brown		1	GS	-												
65.6	(ML-CL) Sandy clayey silt, contains organic matter, wood fibers, brick, wood, glass and metal wire (FILL)																
	Grey and black																
	Moist																
63.6	(MM/SM) Gravelly silty sand, contains cobbles (FILL)																
	Compact		2	SS	2												
	Grey brown																
	Wet		3	SS	15												
62.7	Weathered BEDROCK																
62.3			4	SS	50/0.1												
4.8	END OF BOREHOLE AUGER REFUSAL																
	NOTE:																
	1. Water level in well screen at a depth of 2.3 m below ground surface (Elev. 64.9 m), measured on June 19, 2019																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 20-3-5 JM

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-917	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029956.2; E 367774.1 NAD 83 MTM ZONE 9 (LAT. 45.406719; LONG. -75.695522)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro Excavation/Power Auger, 200 mm Diam, (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 2 and 9, 2019</u>	CHECKED BY <u>KCP</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20	40	60	80	100	25	50	75
66.3	GROUND SURFACE																								
0.0	ASPHALTIC CONCRETE																								
0.1	PORTLAND CEMENT CONCRETE																								
65.9																									
0.4	(SP) Sand (FILL) Brown Moist		1	GS	-																				
65.1			2	GS	-																				0 99 (1)
1.2	(SW) Gravelly sand, contains brick, wood, glass and porcelain (FILL) Grey Moist		3	GS	-																				
63.8																									
2.5	(SP) SAND Grey Wet		4	GS	-																				
63.3																									
3.1	(SM) SILTY SAND Loose Grey Wet		5	SS	7																				
62.3																									
4.0	(SM) Gravelly SILTY SAND, contains cobbles and shale fragments (TILL) Loose to compact Grey Wet		6	SS	20																				
62.3																									
7			7	SS	9																				24 36 27 13
61			8	SS	4																				
60			9	SS	21																				
59			10	SS	50/0.1																				22 49 (29)
58.8																									
7.5	END OF BOREHOLE AUGER REFUSAL																								
	NOTES: 1. Water level in well screen at a depth of 1.8 m below ground surface (Elev. 64.5 m), measured on June 19, 2019																								

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ_GAL-GTA.GDT 20-3-5 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-918	SHEET 1 OF 1	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029986.3; E 367825.5 NAD 83 MTM ZONE 9 (LAT. 45.406985; LONG. -75.694861)</u>	ORIGINATED BY <u>PAH</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro Excavation/Power Auger, 200 mm Diam, (Hollow Stem)</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>May 2 and 9, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20 40 60 80 100	20 40 60 80 100	25 50 75								
66.6	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.1	PORTLAND CEMENT CONCRETE																
66.1																	
0.5	(SP) Sand, contains brick fragments (FILL) Brown Moist		1	GS	-		66										
			2	GS	-												
64.6							65										
2.0	(SW/GW) Sand and gravel, trace silt (FILL) Brown Wet		3	GS	-							o				37 54 (9)	
64.0							64										
2.7	(CL) CLAYEY SILT, some gravel, contains silty sand seams Grey brown to grey		4	GS	-												
63.4																	
3.2	(ML) Sandy SILT, trace gravel and clay Compact Grey Wet		5	SS	9		63										
			6	SS	19							o				5 25 65 5	
			7	SS	15		62										
61.3																	
5.3	(CL-ML) CLAYEY SILT to SILT, some gravel (TILL) Compact Grey Wet		8	SS	13		61										
60.5																	
6.1	END OF BOREHOLE AUGER REFUSAL																
	NOTE: 1. Water level measured in open borehole at a depth of 3.0 m below ground surface (Elev. 63.6 m), upon completion of drilling																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ_GAL-GTA.GDT 20-3-5 JM

PROJECT <u>1655214-1900</u>	RECORD OF BOREHOLE No 18-923	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029080.2; E 365569.0 NAD 83 MTM ZONE 9 (LAT. 45.399032; LONG. -75.723797)</u>	ORIGINATED BY <u>DJG/SB</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro-excavation/Portable Rotary Drill, HW Casing, HQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>August 20, 2019</u>	CHECKED BY <u>KCP</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)						
						20	40	60	80	100	20	40	60	80	100	25	50	75	GR	SA	SI	CL	
72.1	GROUND SURFACE																						
0.0 71.9 0.2	(SM) Silty sand, contains organic matter (rootlets) (TOPSOIL) Brown moist (SP) Sand, trace silt (FILL) Brown		1	GS	-																		
69.3																							
2.8	PORTLAND CEMENT CONCRETE (FOOTING)		3	RC	-																		UCS = 47 MPa
68.7																							
3.4	Limestone (BEDROCK), with thin black shale partings Bedrock cored from depths 3.4 m to 5.1 m For bedrock coring details refer to Record of Drillhole 18-923		4	RC	REC 100%																		RQD = 52%
67.0																							
5.1	END OF BOREHOLE																						

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 20-3-5 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

BH 18-801 (Dry)
Core Box 1 of 1

Cobbles

Top of Footing Elevation 66.6 m



Bottom of Footing Elevation 65.6 m

Elevation 65.0 m EOH

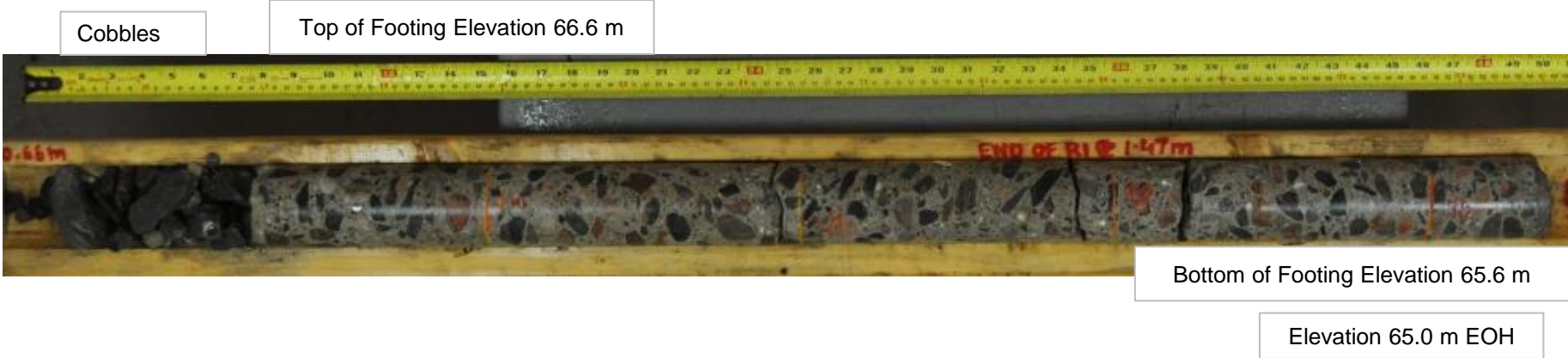


Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario

Project No.	1655214 / 1900
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Figure A1

BH 18-801 (Wet)
Core Box 1 of 1



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Figure A2

**BH 18-802 (Dry)
Core Box 1 of 1**



Top of Footing Elevation 66.4 m

Bottom of Footing Elevation 65.3 m

Elevation 64.5 m EOH



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Figure A3

**BH 18-802 (Dry)
Core Box 1 of 1**



Bottom of Footing Elevation 65.3 m

Elevation 64.5 m EOH



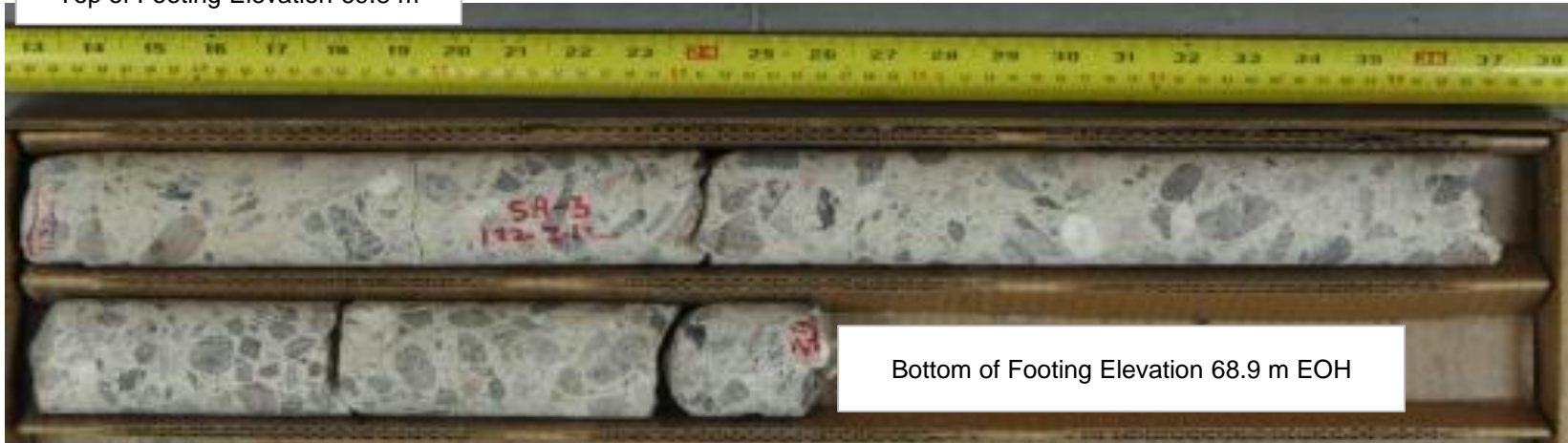
**Foundation Investigation
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Figure A4

**BH 18-904 (Dry)
Core Box 1 of 1**

Top of Footing Elevation 69.8 m



Bottom of Footing Elevation 68.9 m EOH

Elevation 67.0 m EOH



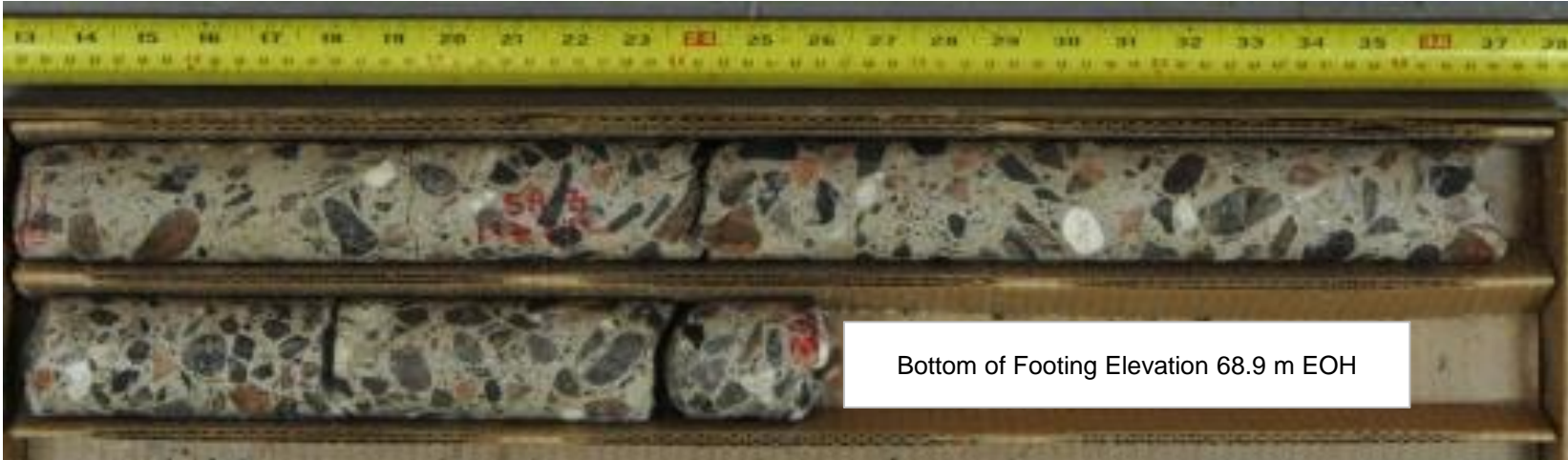
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Drawn:	RA
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Review:	FJH

Figure A5

**BH 18-904 (wet)
Core Box 1 of 1**

Top of Footing Elevation 69.8 m



Bottom of Footing Elevation 68.9 m EOH

Elevation 67.0 m EOH



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Figure A6

**BH 18-908 (Dry)
Core Box 1 of 1**

Top of Bedrock elevation 65.1 m



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Highway 417 Retaining Wall Structures
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Figure A7

**BH 18-908 (wet)
Core Box 1 of 1**

Top of Bedrock Elevation 65.1 m



Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario

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Figure A8

**BH 18-909 (Dry)
Core Box 1 of 1**



**Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario**

Project No.	1655214 / 1900
Drawn:	RA
Date:	2019-10-18
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Figure A9

**BH 18-909 (wet)
Core Box 1 of 1**

Cobbles

Top of Bedrock Elevation 66.0 m



Elevation 64.2 m EOH

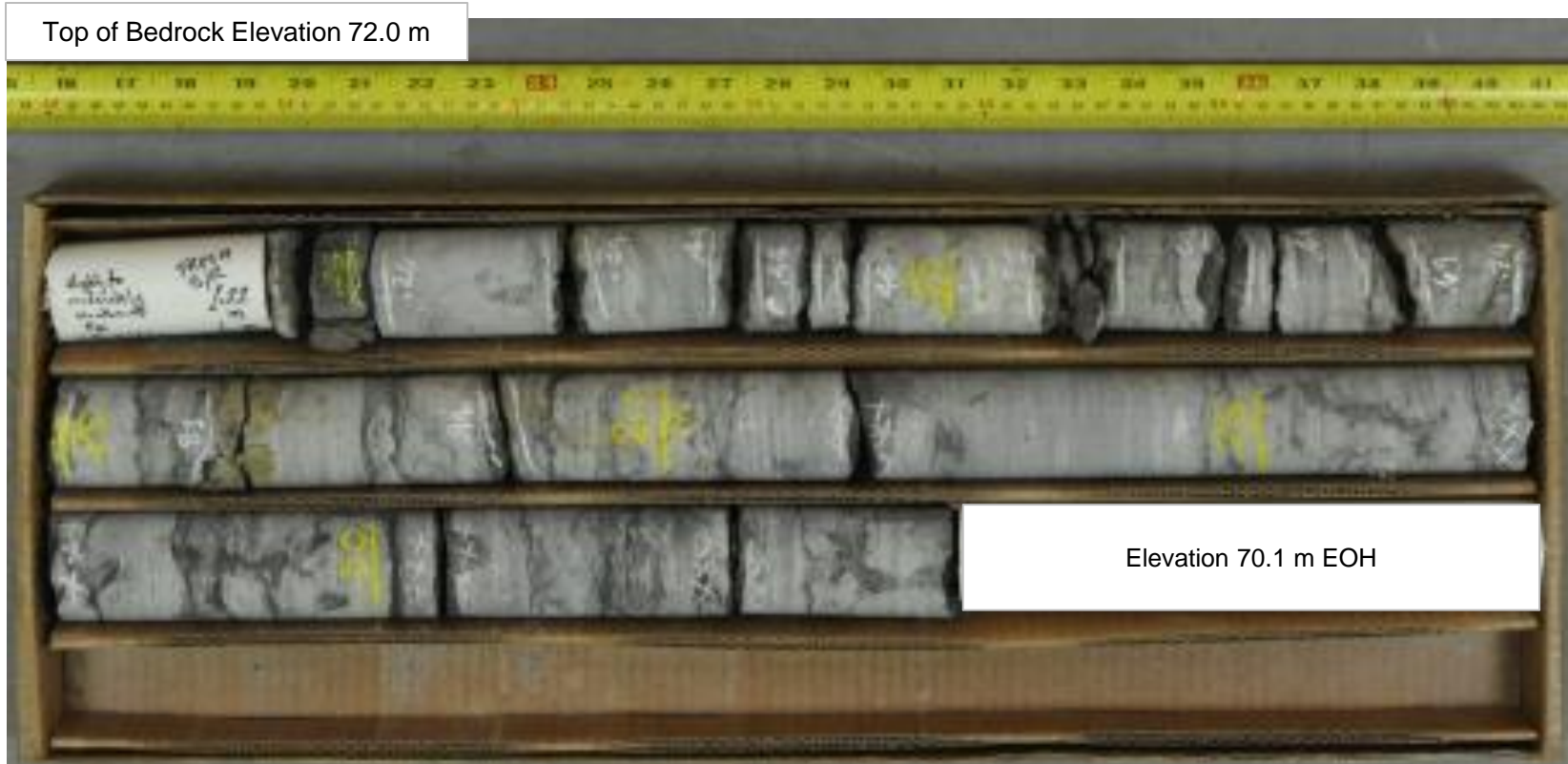


**Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario**

Project No.	1655214 / 1900
Drawn:	RA
Date:	2019-10-18
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Review:	FJH

Figure A10

BH 18-912 (Dry)
Core Box 1 of 1



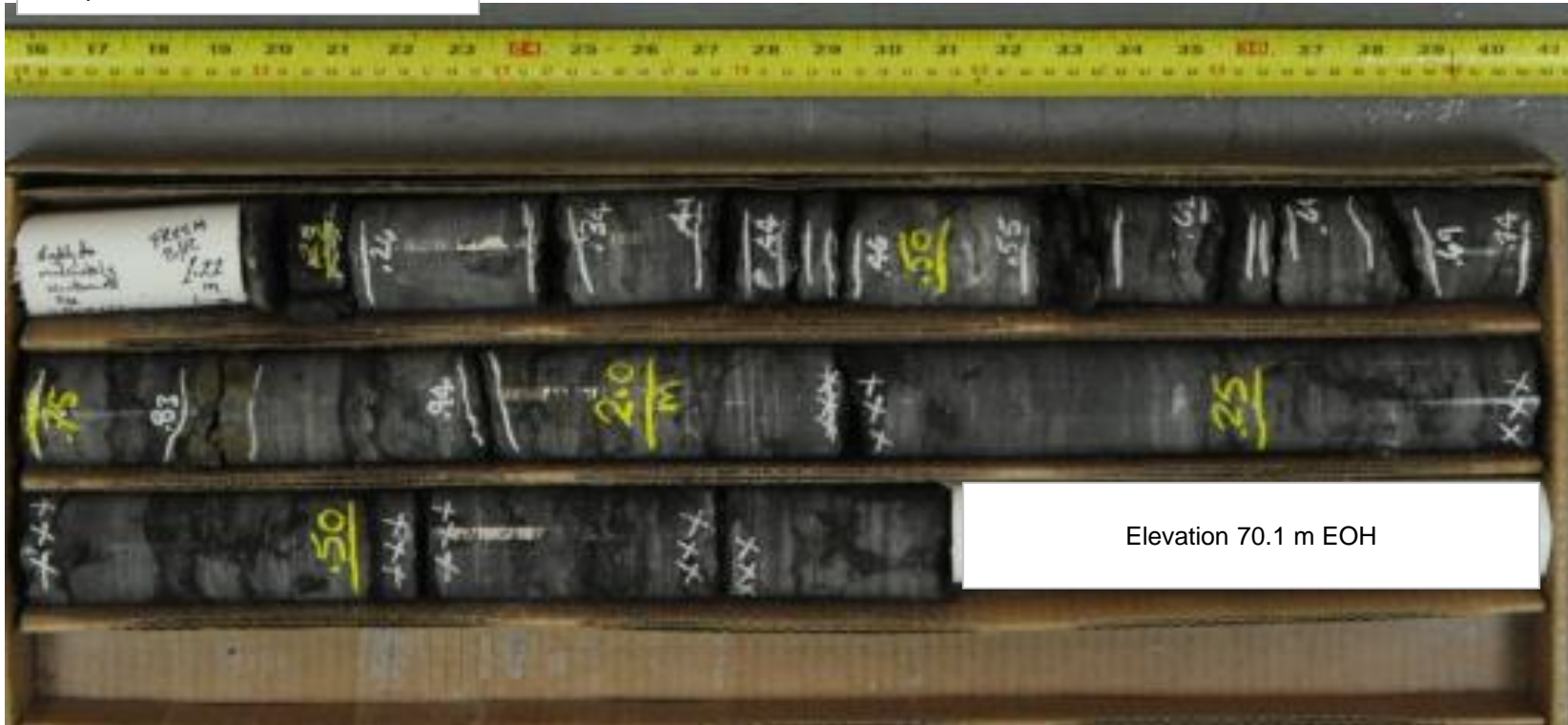
Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario

Project No.	1655214 / 1900
Drawn:	RA
Date:	2019-10-18
Checked:	KCP
Review:	FJH

Figure A11

BH 18-912 (wet)
Core Box 1 of 1

Top of Bedrock Elevation 72.0 m



Elevation 70.1 m EOH



Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario

Project No.	1655214 / 1900
Drawn:	RA
Date:	2019-10-18
Checked:	KCP
Review:	FJH

Figure A12

**BH 18-923 (Dry)
Core Box 1 and 2 of 2**

Top of Footing Elevation 69.3 m



Top of Bedrock elevation 68.7 m

Elevation 67.0 m EOH



**Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario**

Project No.	1655214 / 1900
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Date:	2019-10-18
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Figure A13

**BH 18-923 (wet)
Core Box 1 and 2 of 2**

Top of Footing Elevation 69.3 m



Top of Bedrock elevation 68.7 m

Elevation 67.0 m EOH



**Foundation Investigation
Highway 417 Retaining Wall Structures
Ottawa, Ontario**

Project No.	1655214 / 1900
Drawn:	RA
Date:	2019-10-18
Checked:	KCP
Review:	FJH

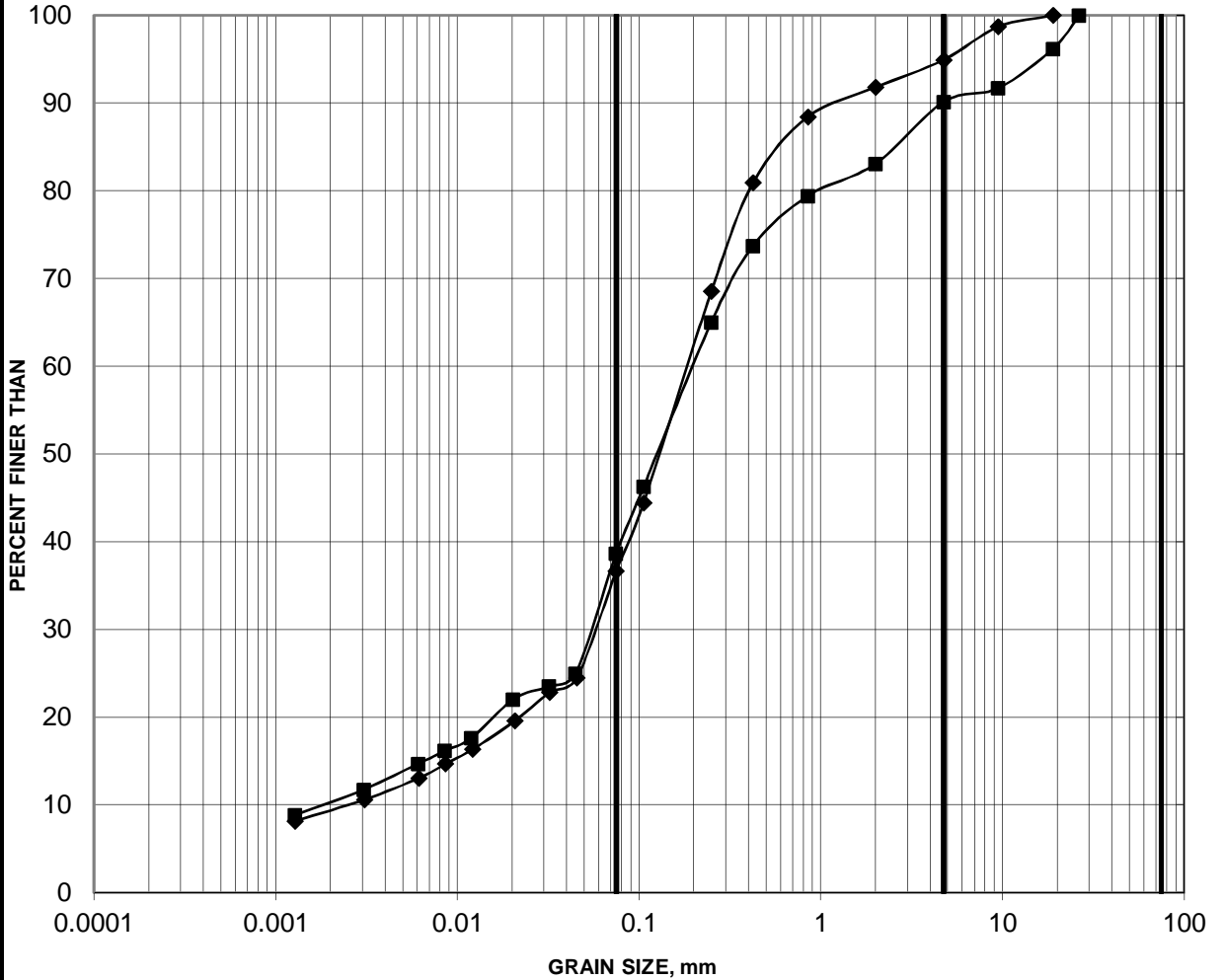
Figure A14

APPENDIX B

Laboratory Test Results, Current Investigation

Figures B1 to B24

RETAINING WALL 2N: SILTY SAND (FILL)



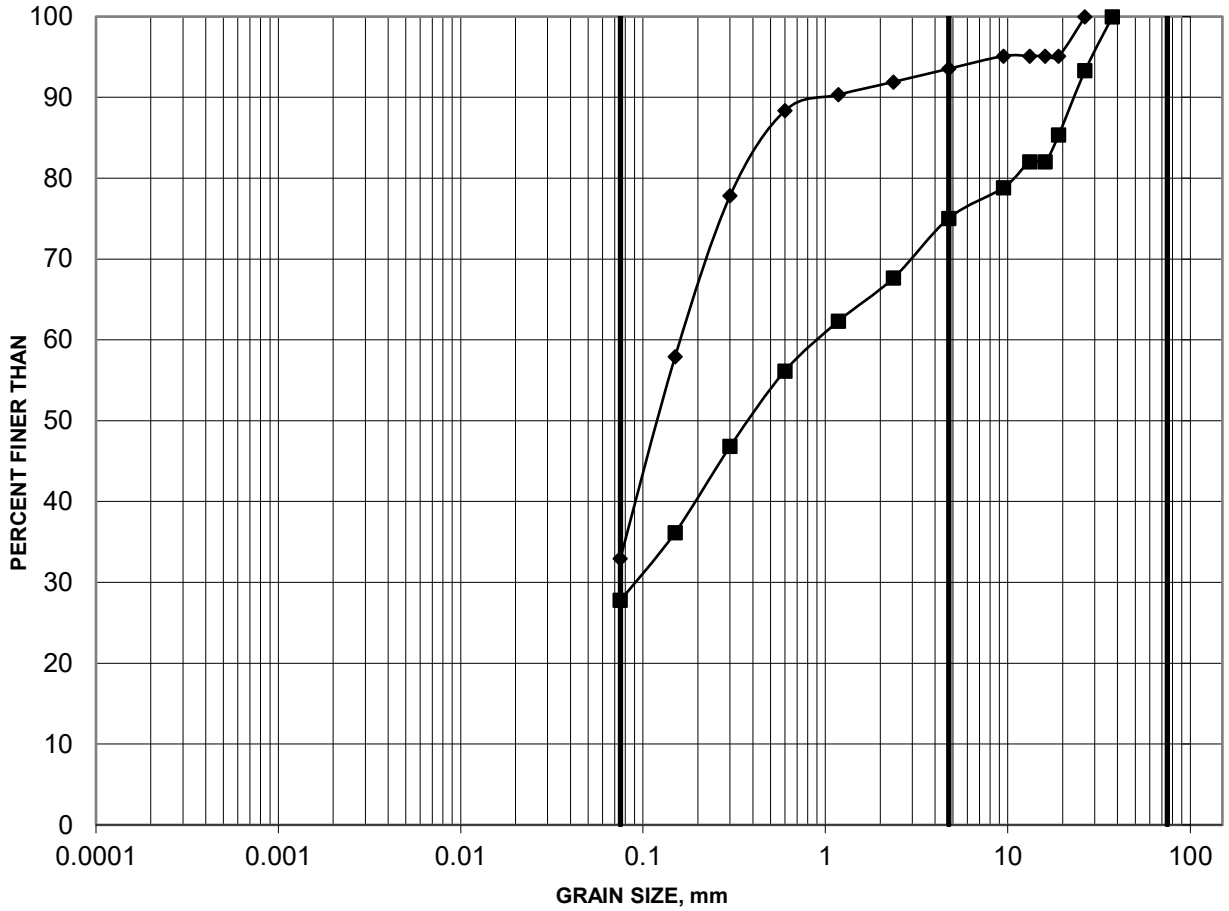
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-802	2	0.61-1.22
18-802	4	1.83-2.44

GRAIN SIZE DISTRIBUTION

FIGURE B2

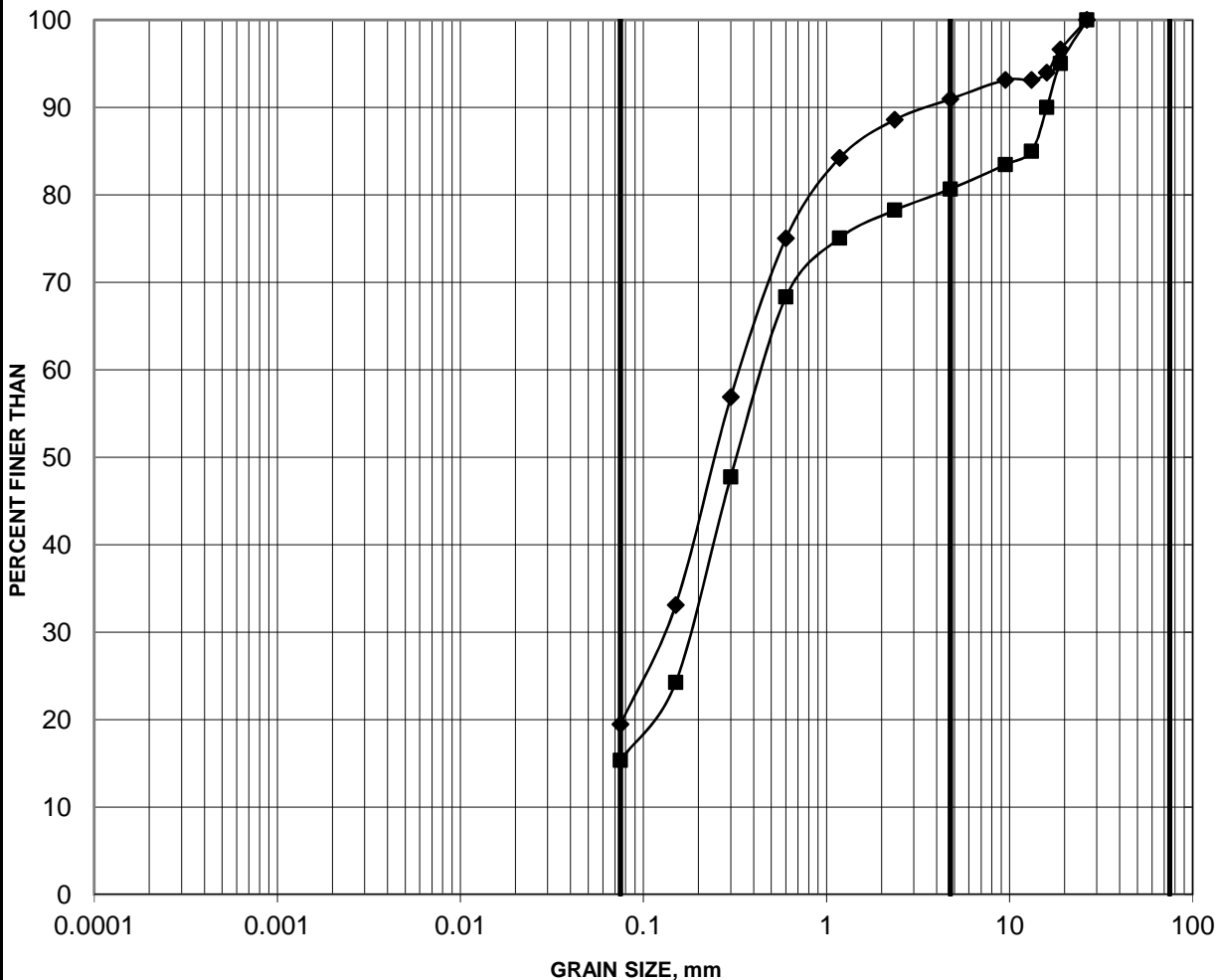
RETAINING WALL 2N: GLACIAL TILL



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-801	3	1.85-2.36
18-802	8	4.42-4.88

RETAINING WALL 10N: SAND (FILL)



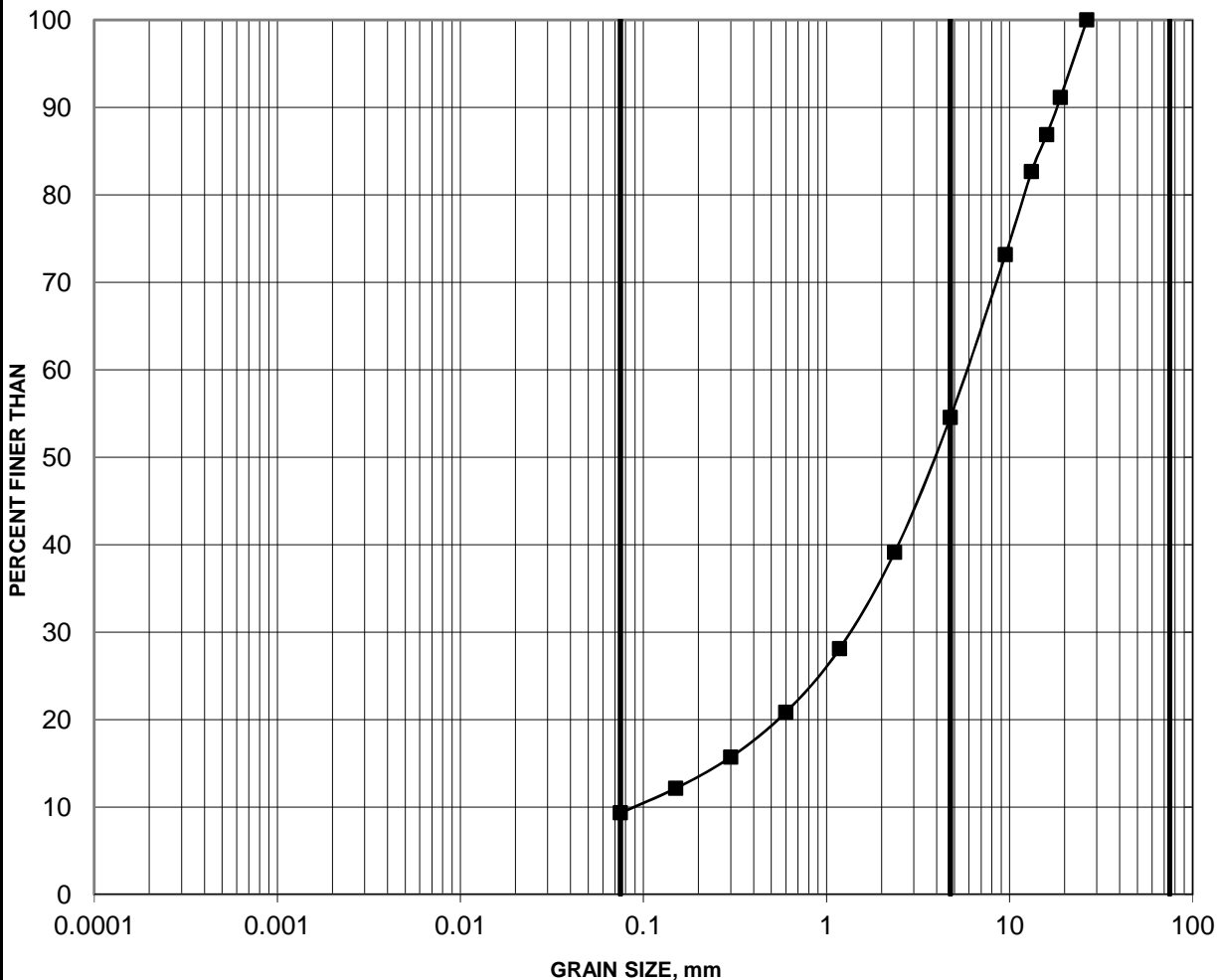
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
—■— 18-906	1B	0.41-0.76
—◆— 18-907	1B	0.34-0.76

GRAIN SIZE DISTRIBUTION

FIGURE B4

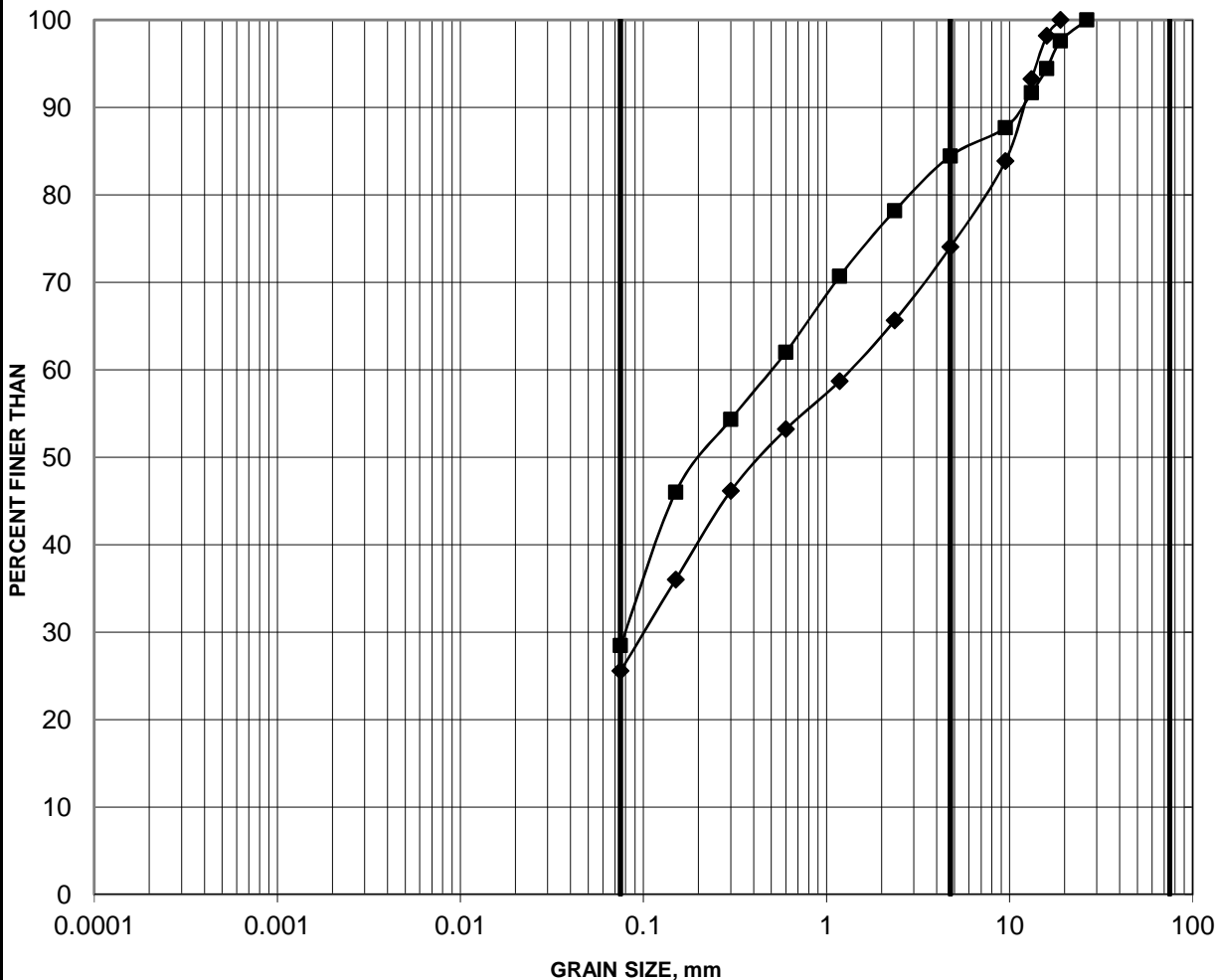
RETAINING WALL 11N: SAND AND GRAVEL (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
■ 18-908	2	0.30-1.52

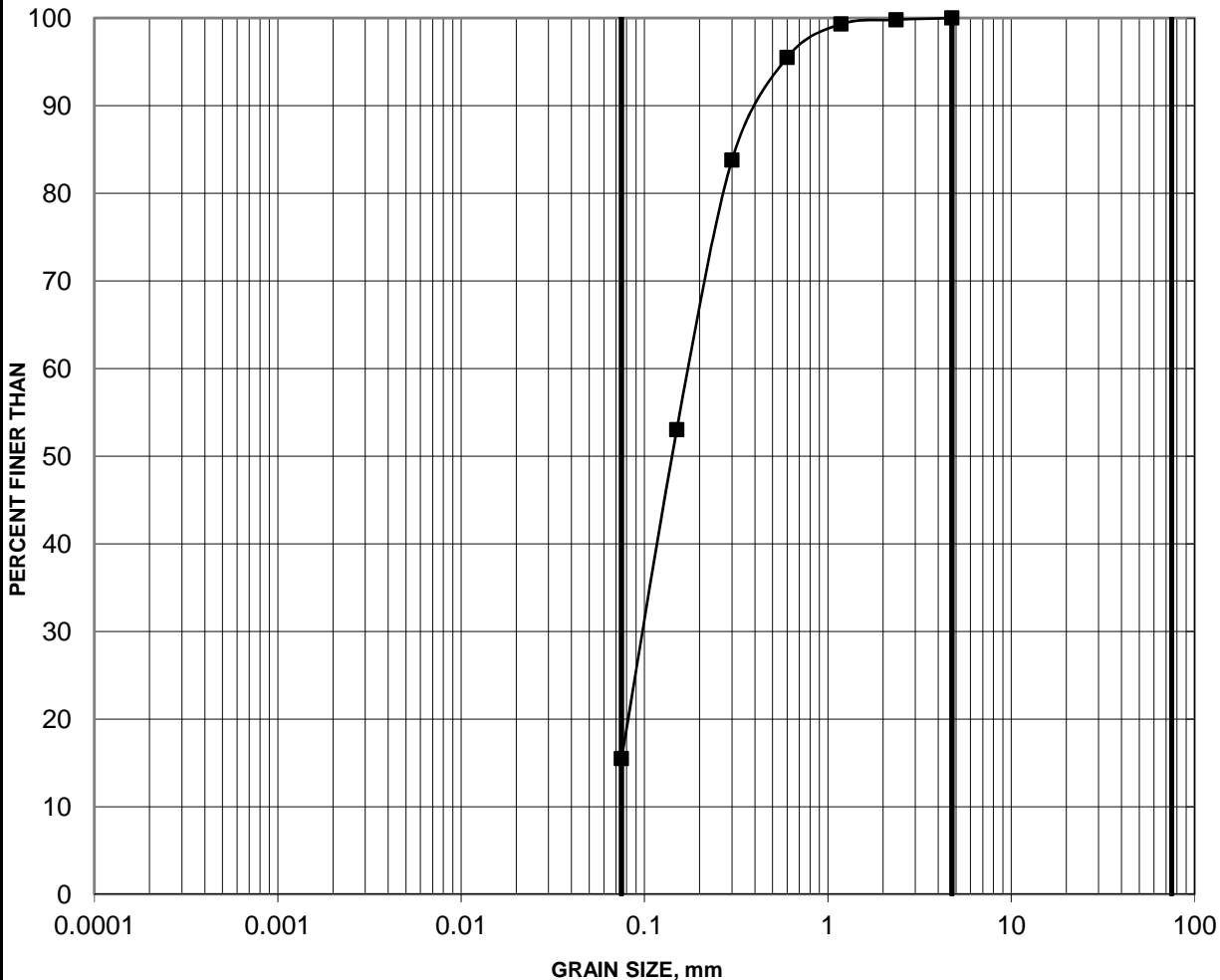
RETAINING WALL 11N: GLACIAL TILL



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-909	2	0.76-1.37
18-909	4	2.44-2.90

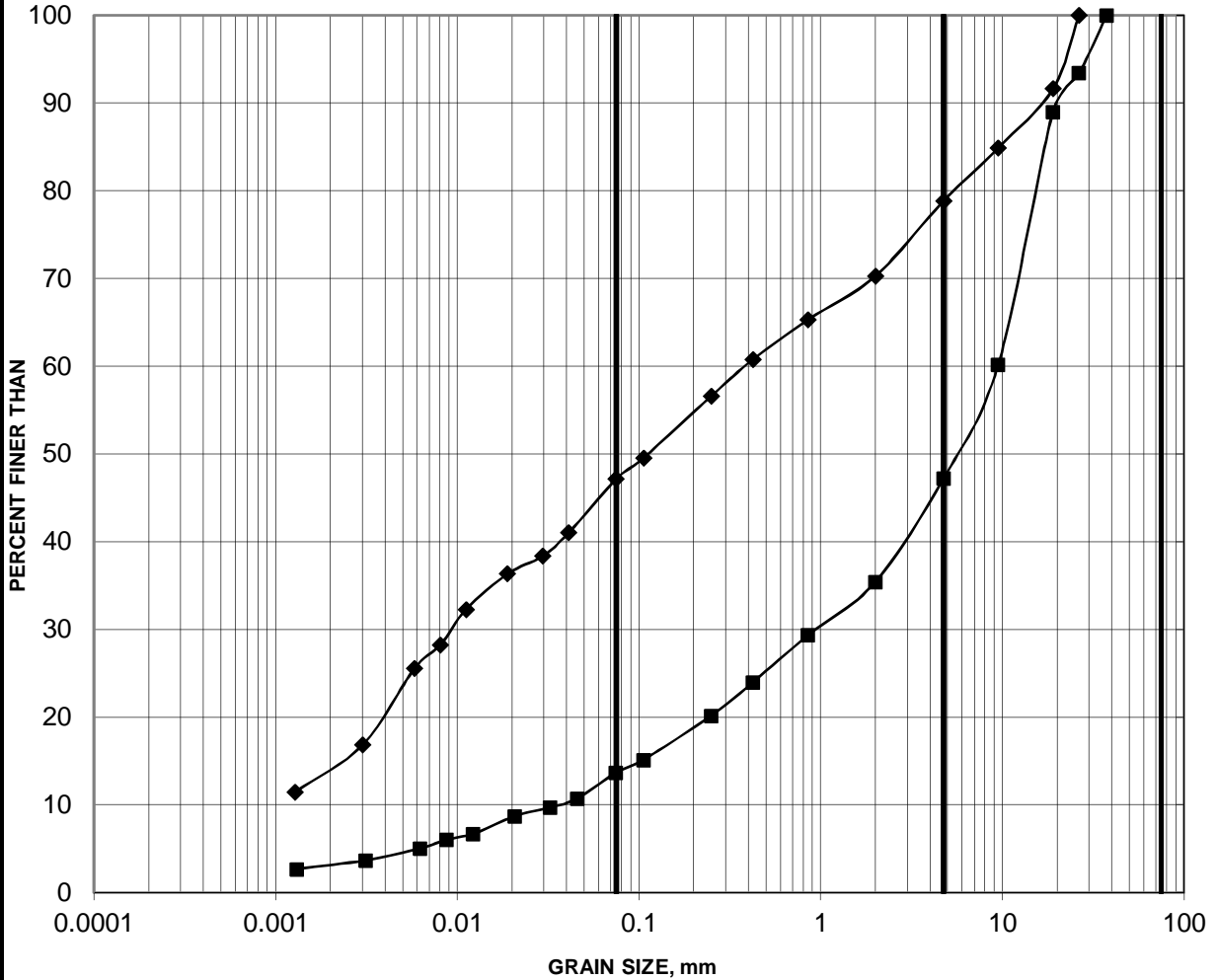
RETAINING WALL 13N: SAND (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

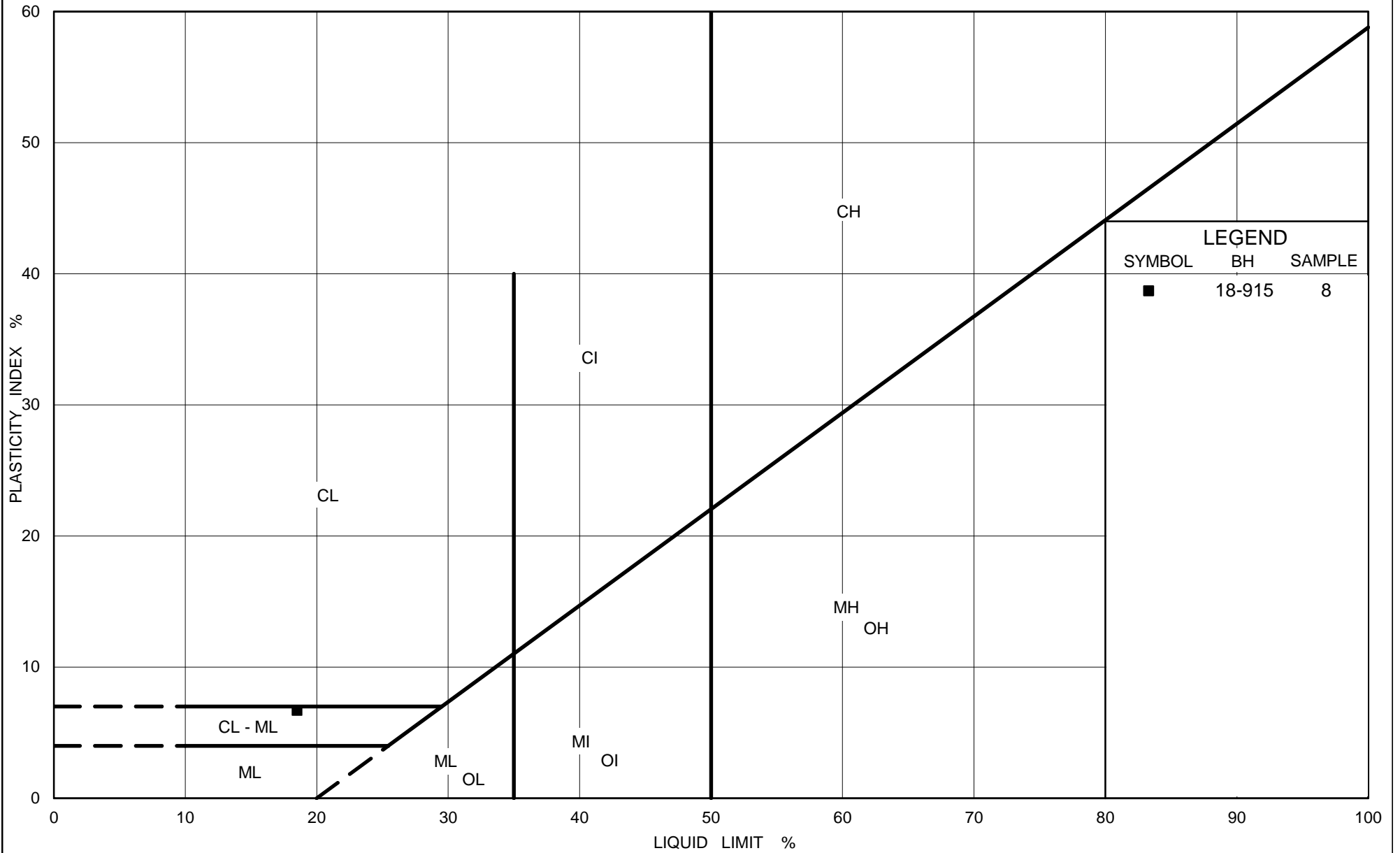
Borehole	Sample	Depth (m)
■ 18-915	2	0.76-1.37

RETAINING WALL 13N: GLACIAL TILL



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

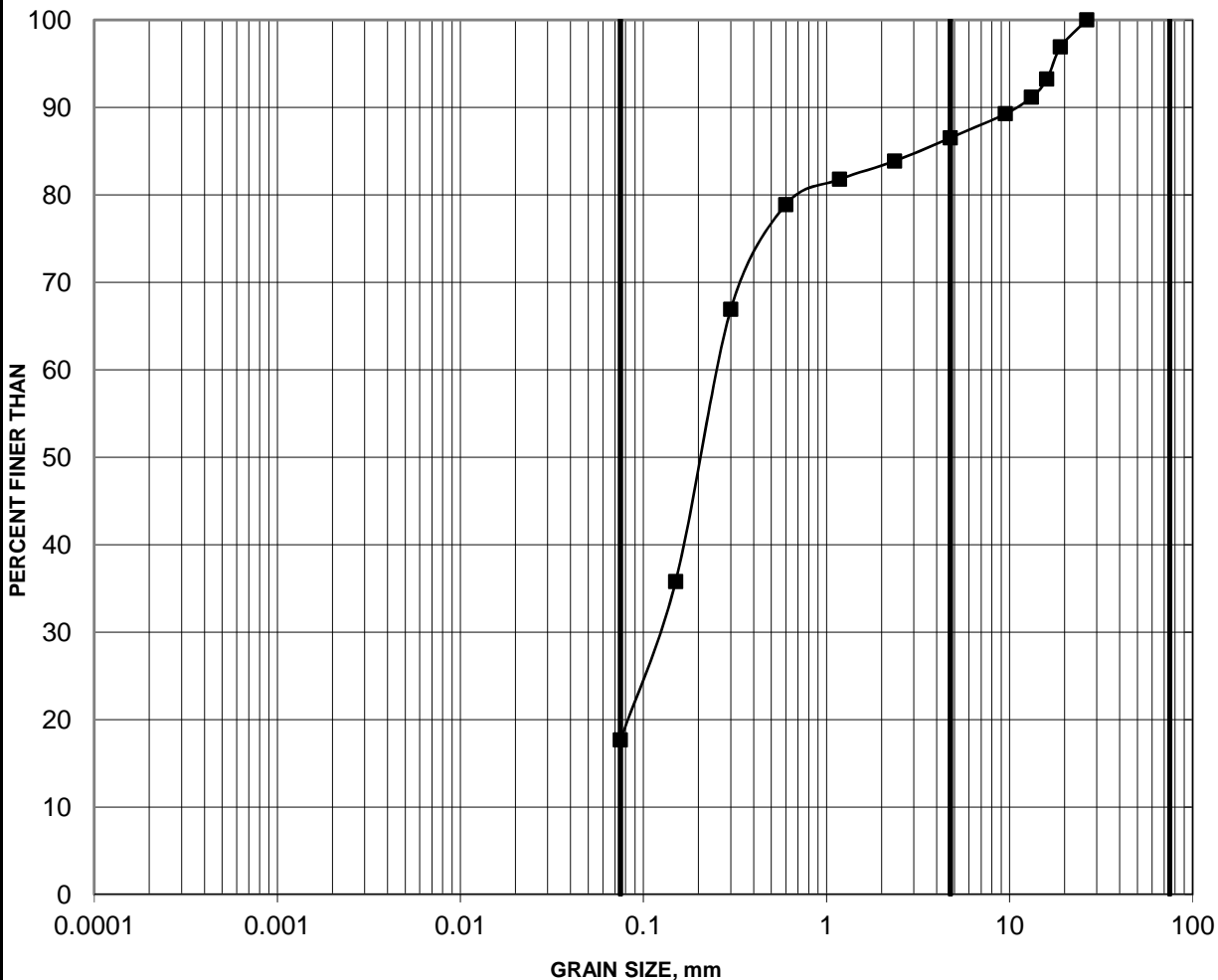
Borehole	Sample	Depth (m)
—■—	18-913	7
—◆—	18-915	6
		4.57-5.18
		3.81-4.42



GRAIN SIZE DISTRIBUTION

FIGURE B9

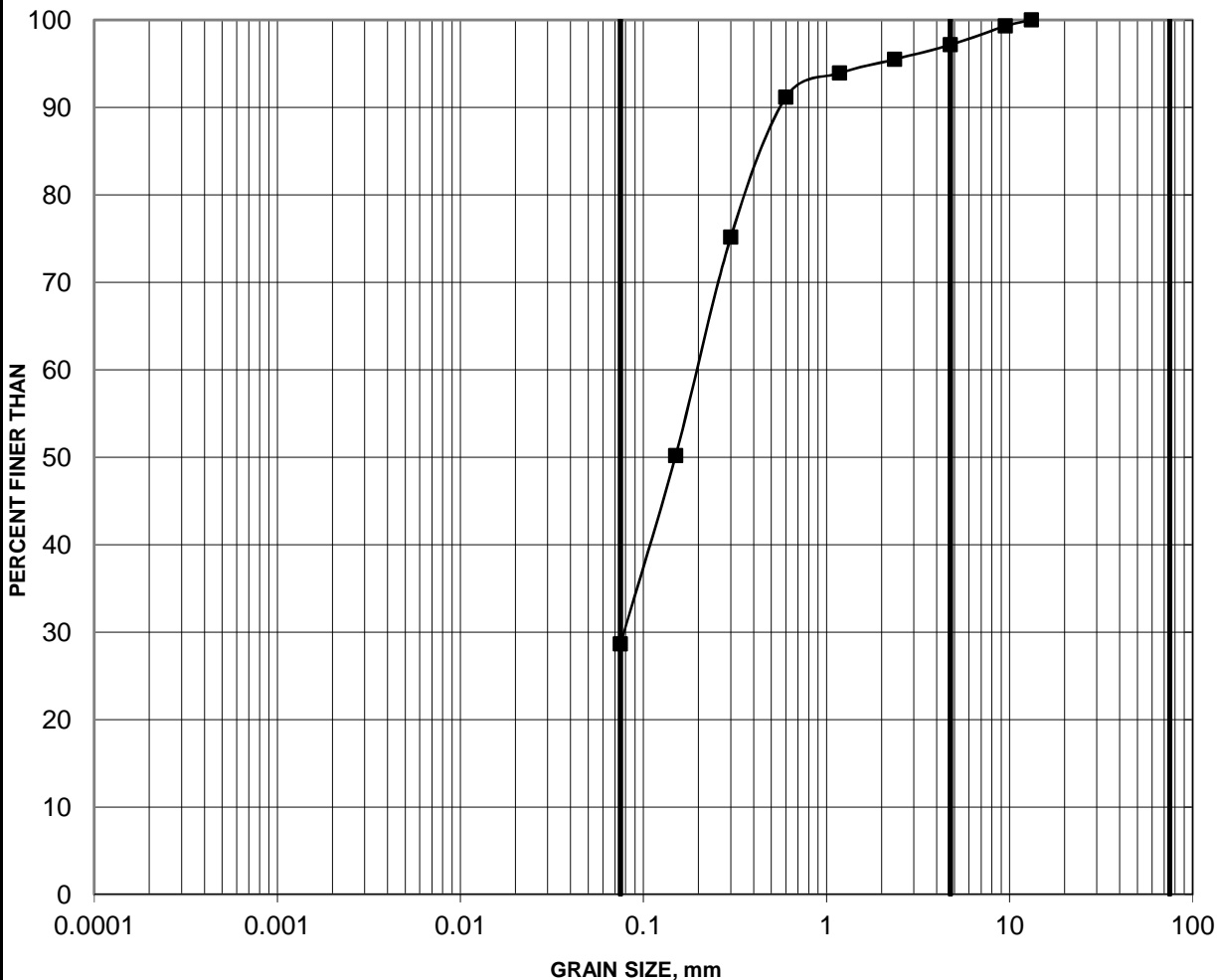
RETAINING WALL 1S: SAND (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
■ 19-901	2	0.56-0.84

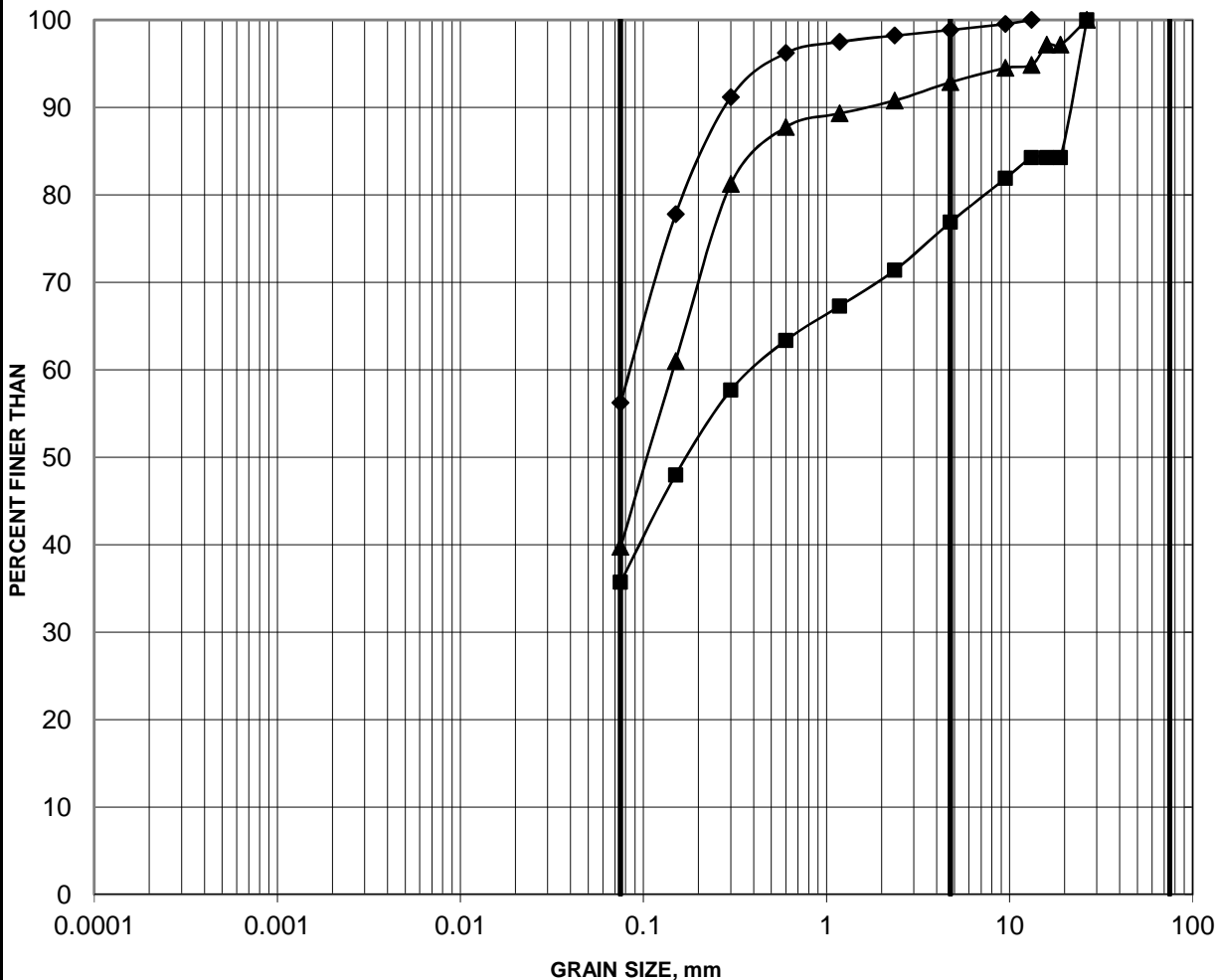
RETAINING WALL 1S: SILTY SAND



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
■ 18-901	5	3.05-3.66

RETAINING WALL 1S: GLACIAL TILL



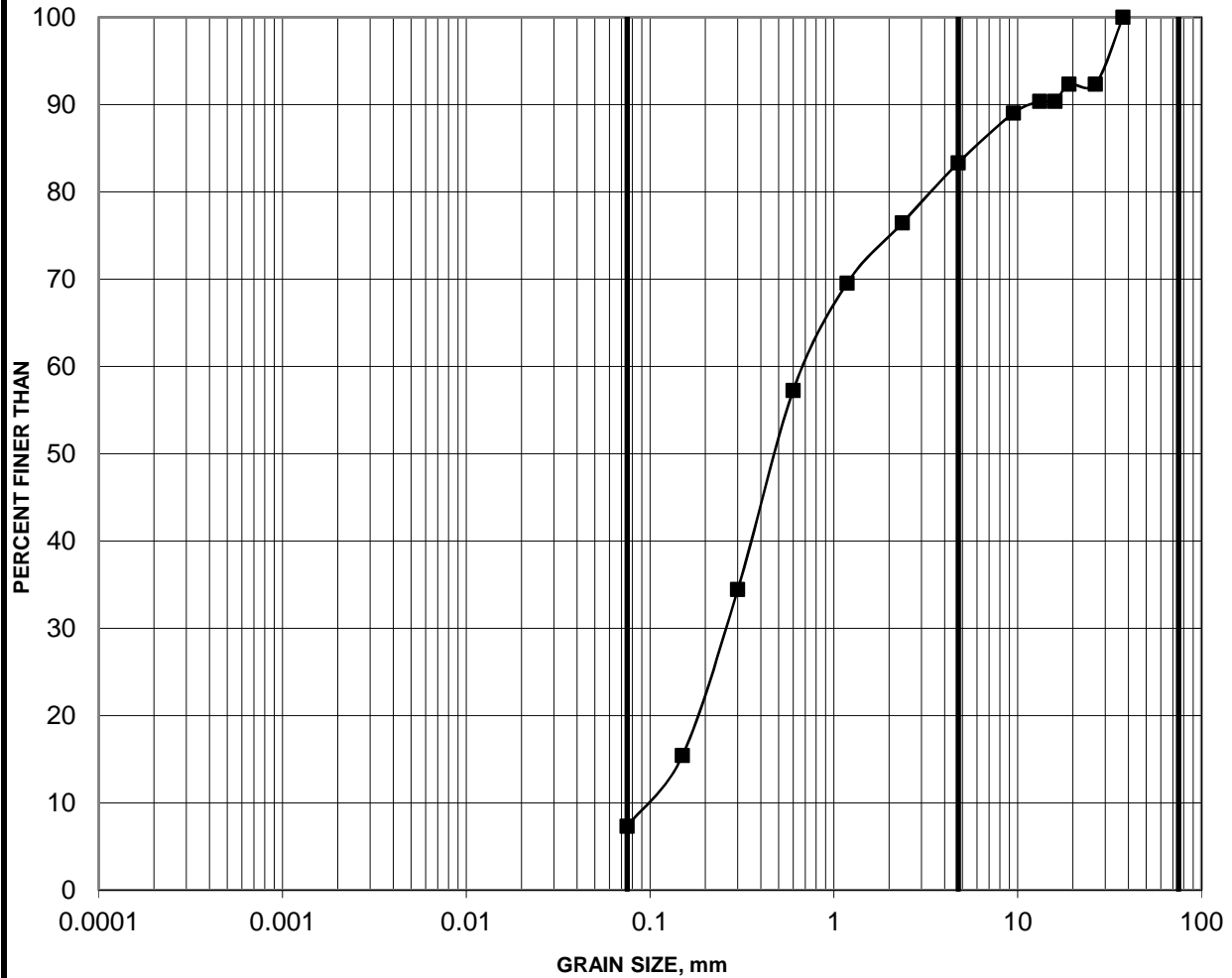
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-901	8	5.49-5.94
18-902	5	4.57-5.18
18-902	6	5.33-5.94

GRAIN SIZE DISTRIBUTION

FIGURE B12

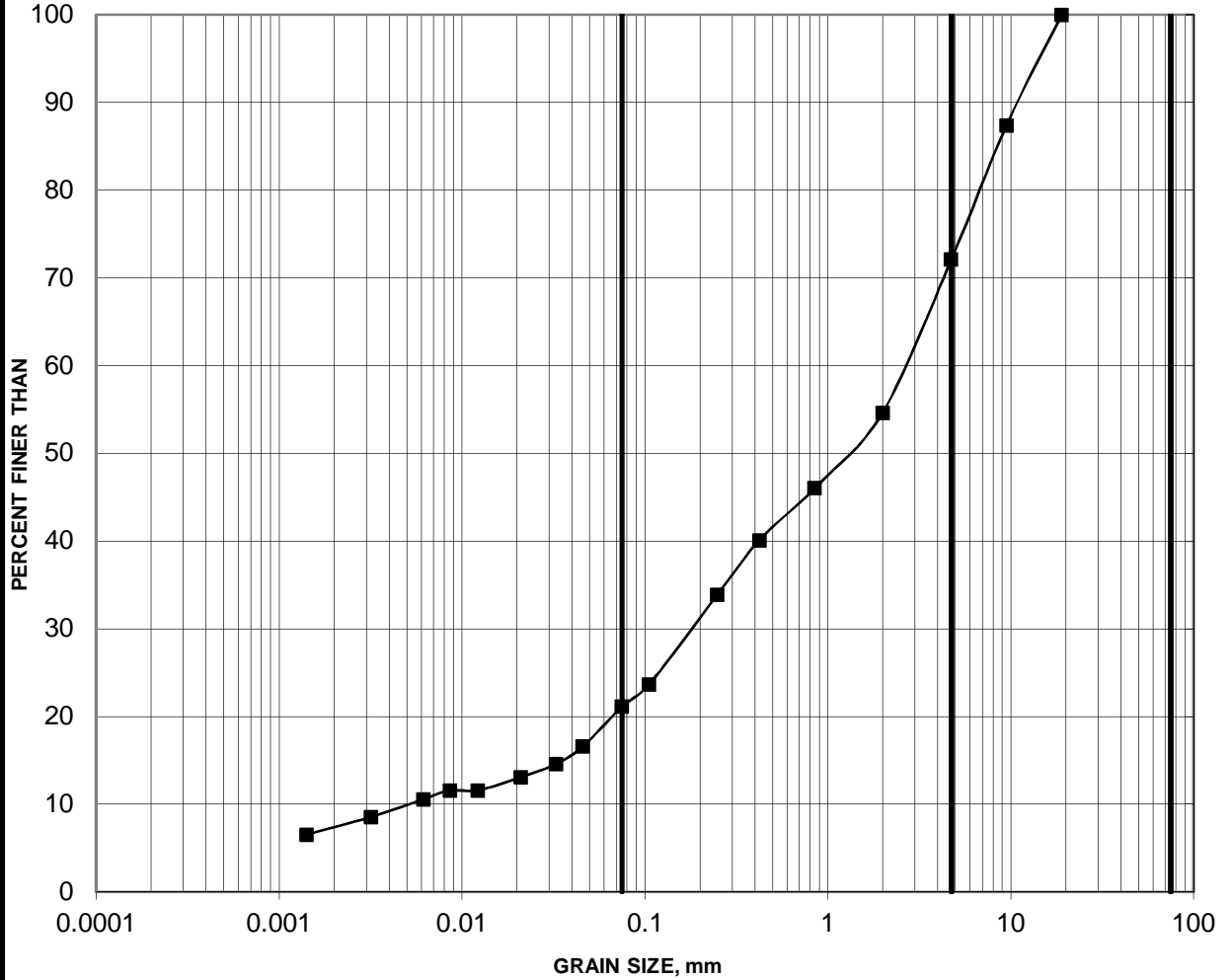
RETAINING WALL 2S: SAND (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-904	2A	0.61-1.13

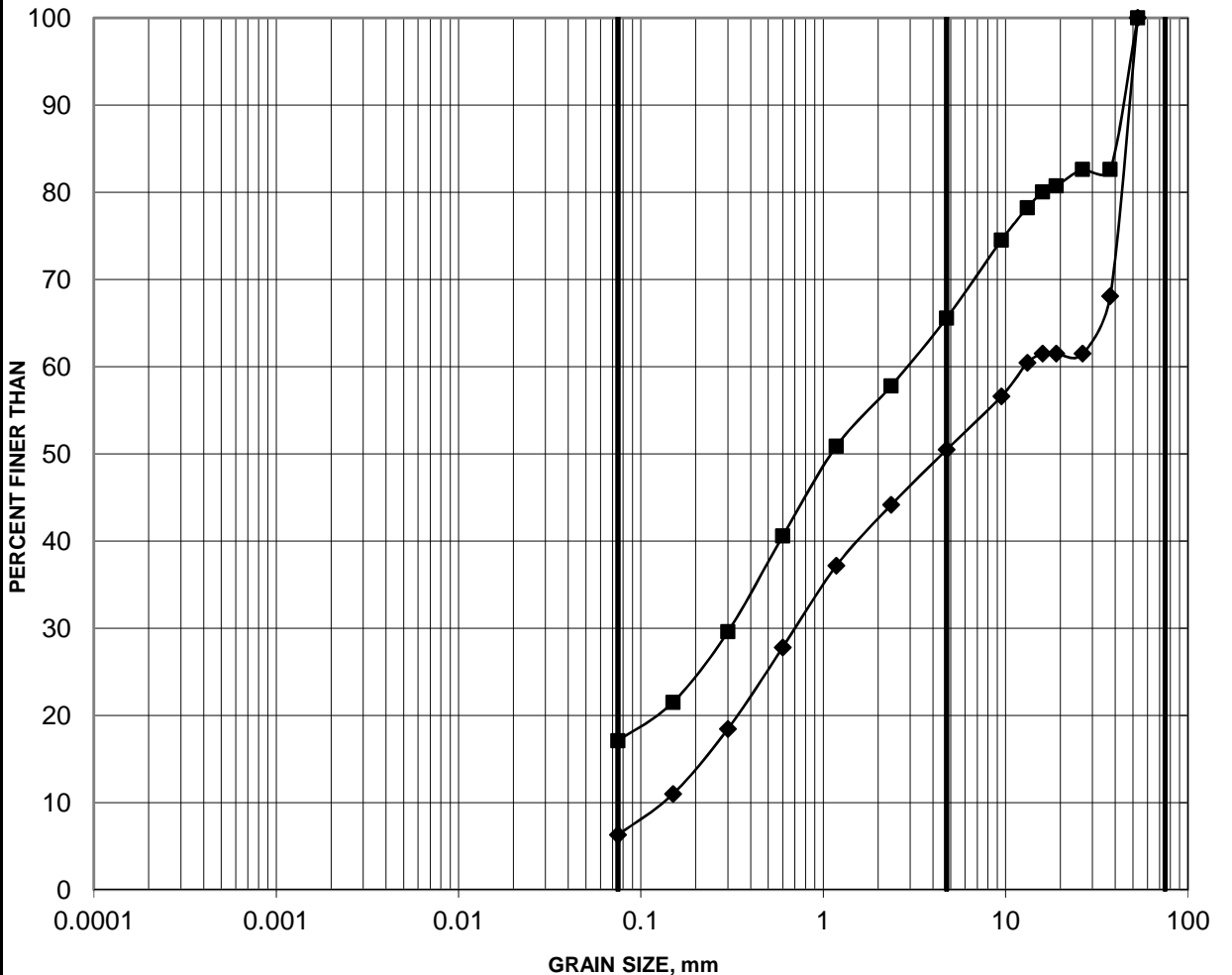
RETAINING WALL 2S: GLACIAL TILL



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-904	5	2.7-3.35

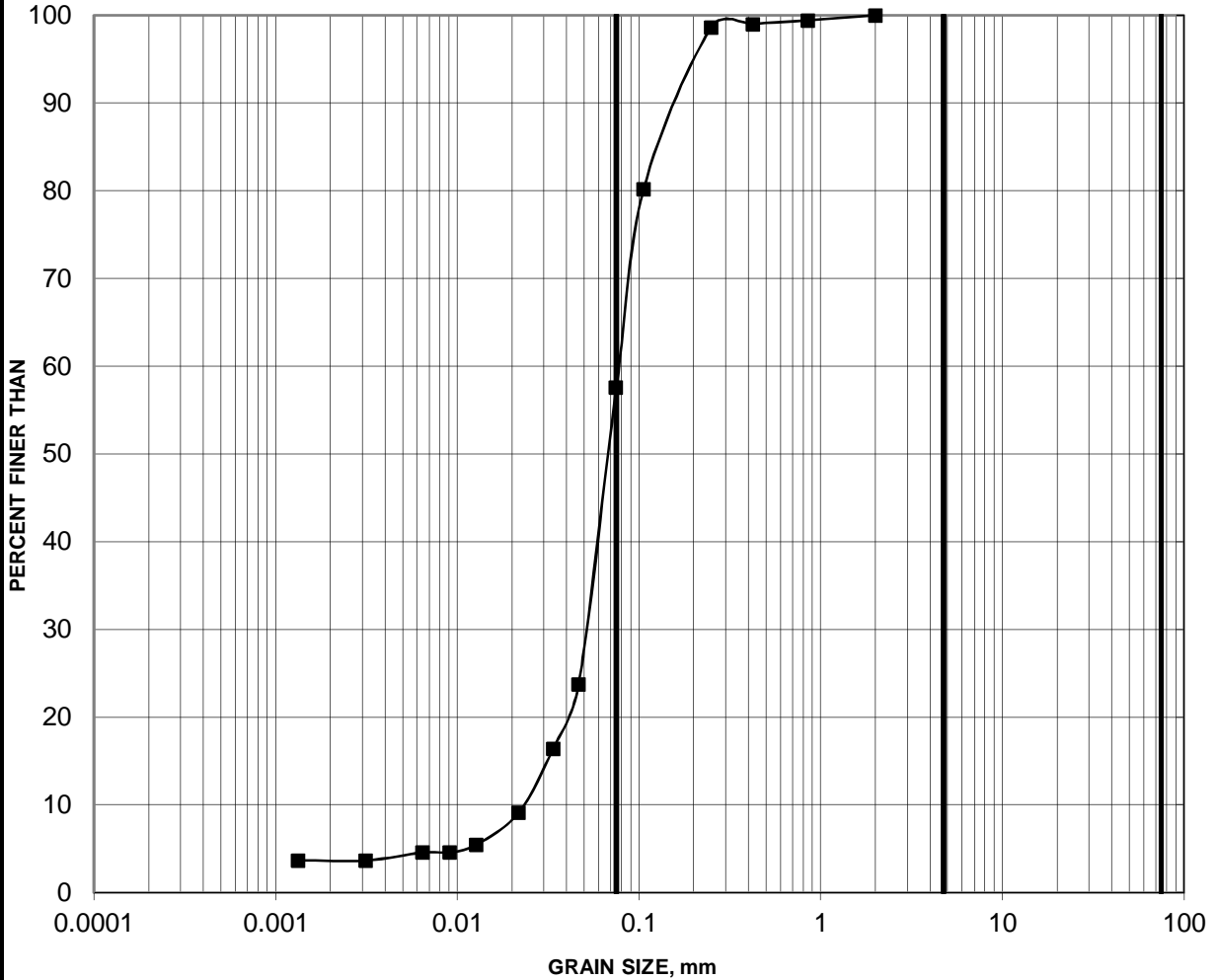
RETAINING WALL 4S: GRAVEL AND SAND (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
■ 18-910	2	2.00-2.50
◆ 18-911	3	2.40-2.60

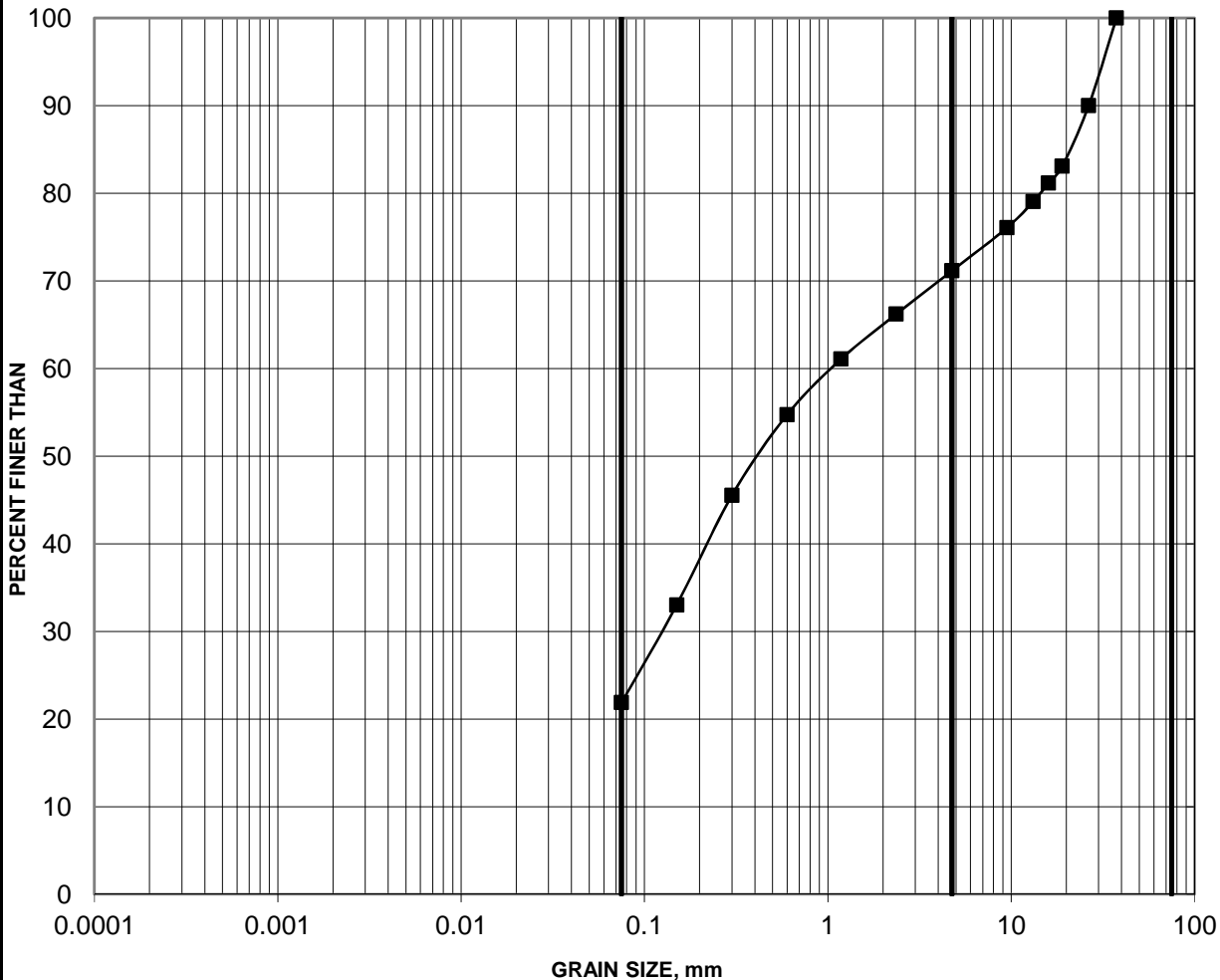
RETAINING WALL 4S: SILT AND SAND



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-910	3	3.05-3.66

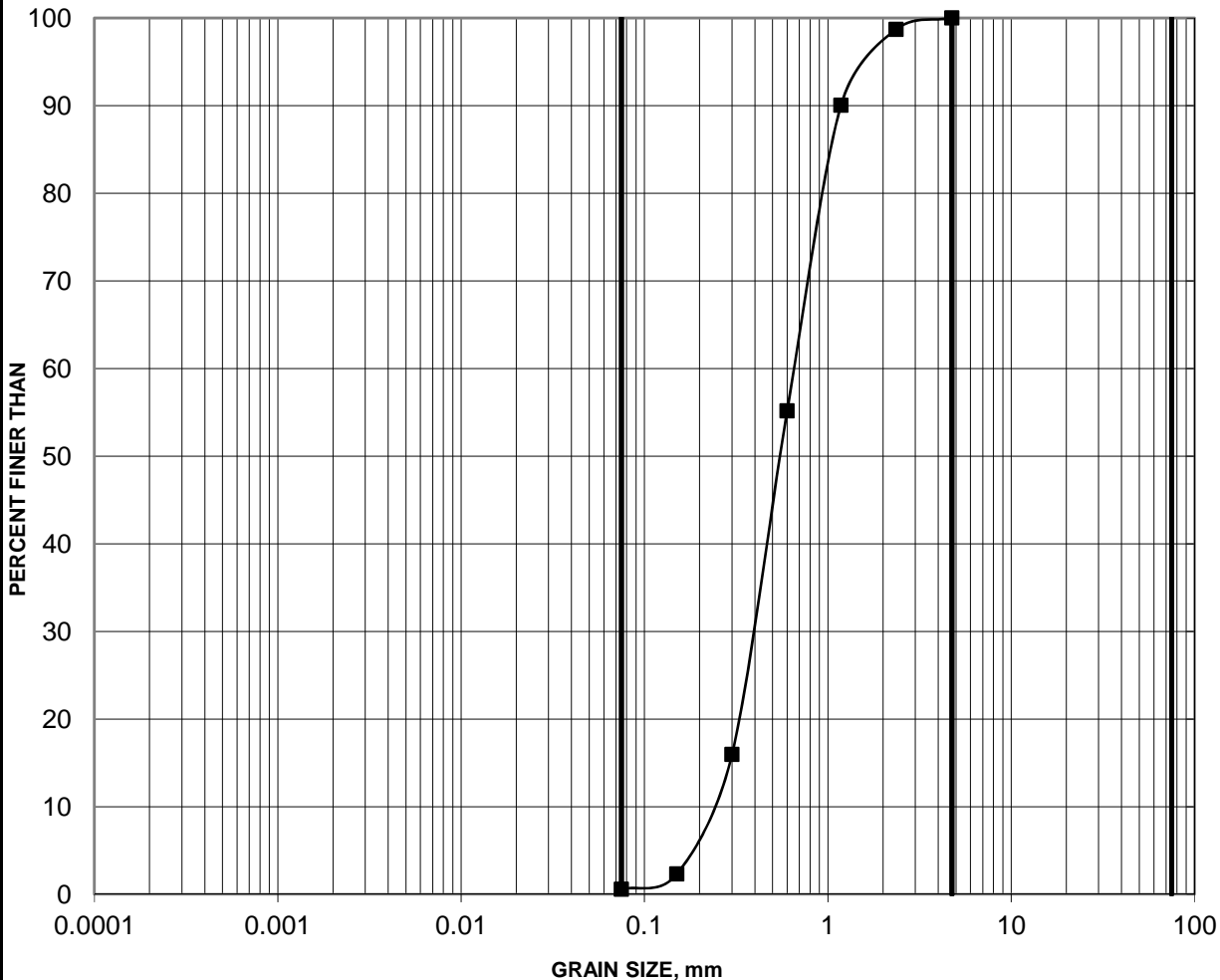
RETAINING WALL 5S: SILTY SAND (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
■ 18-912	2	0.30-0.76

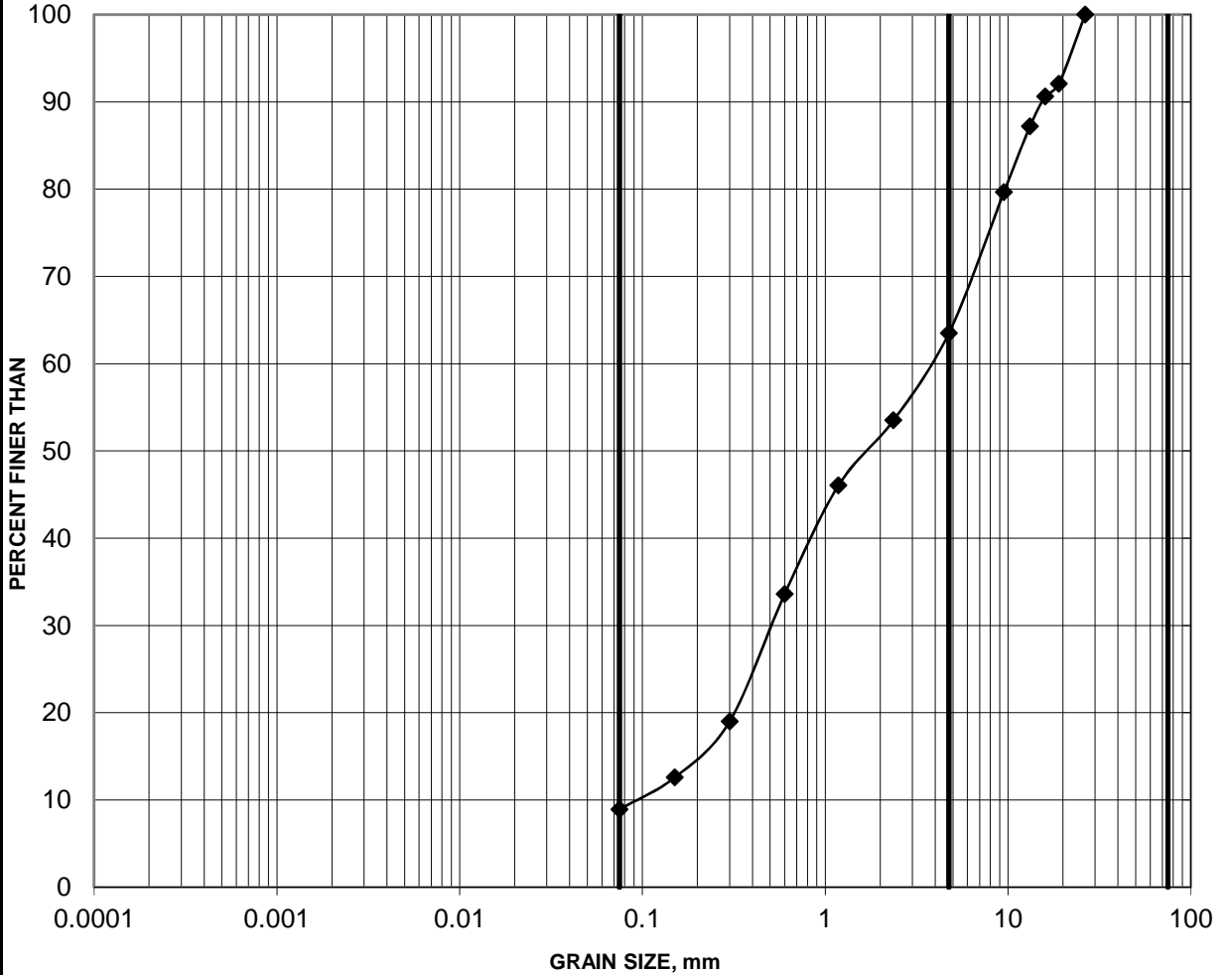
RETAINING WALL 7S: SAND (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
■ 18-917	2	0.80-0.12

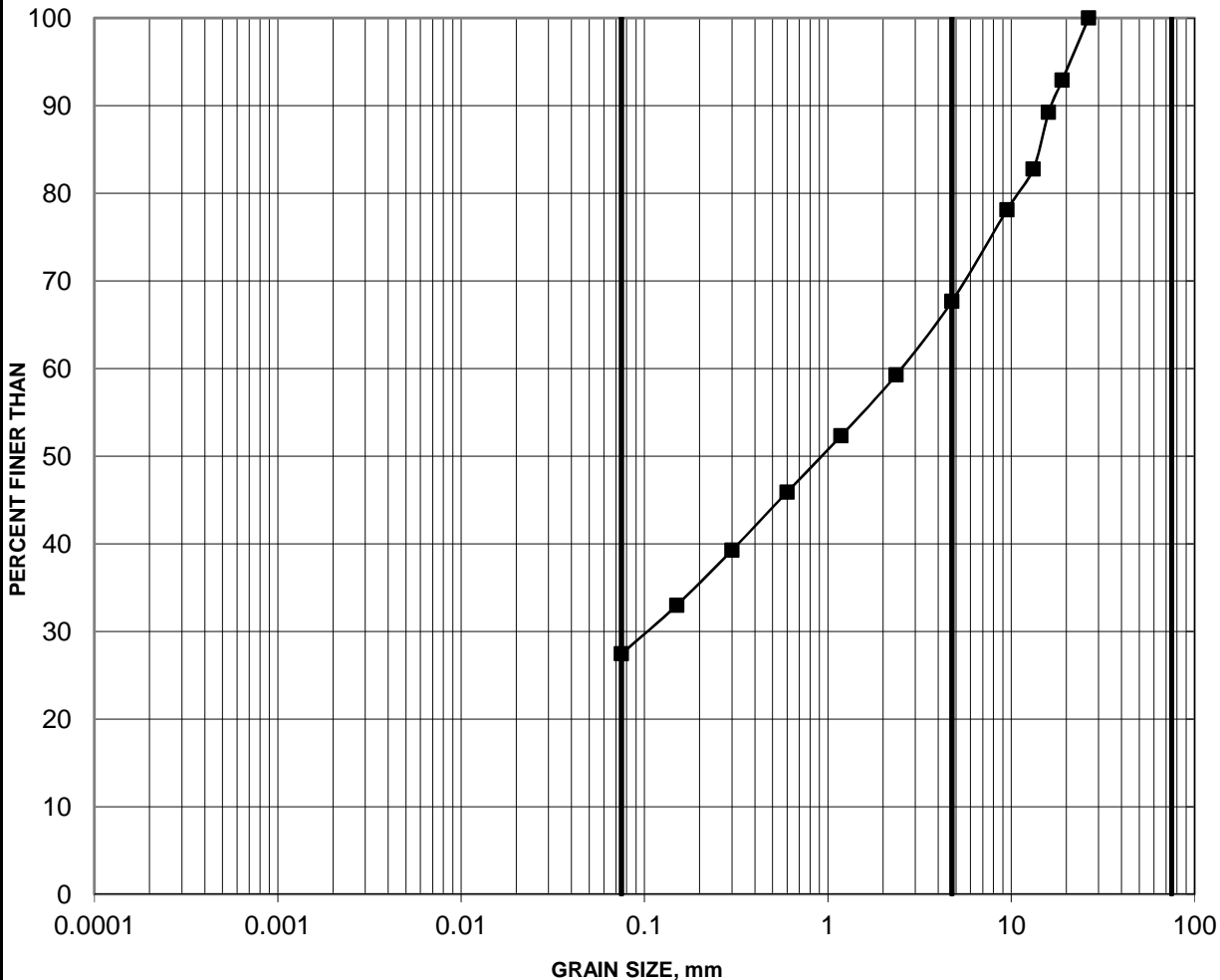
RETAINING WALL 7S: SAND AND GRAVEL (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

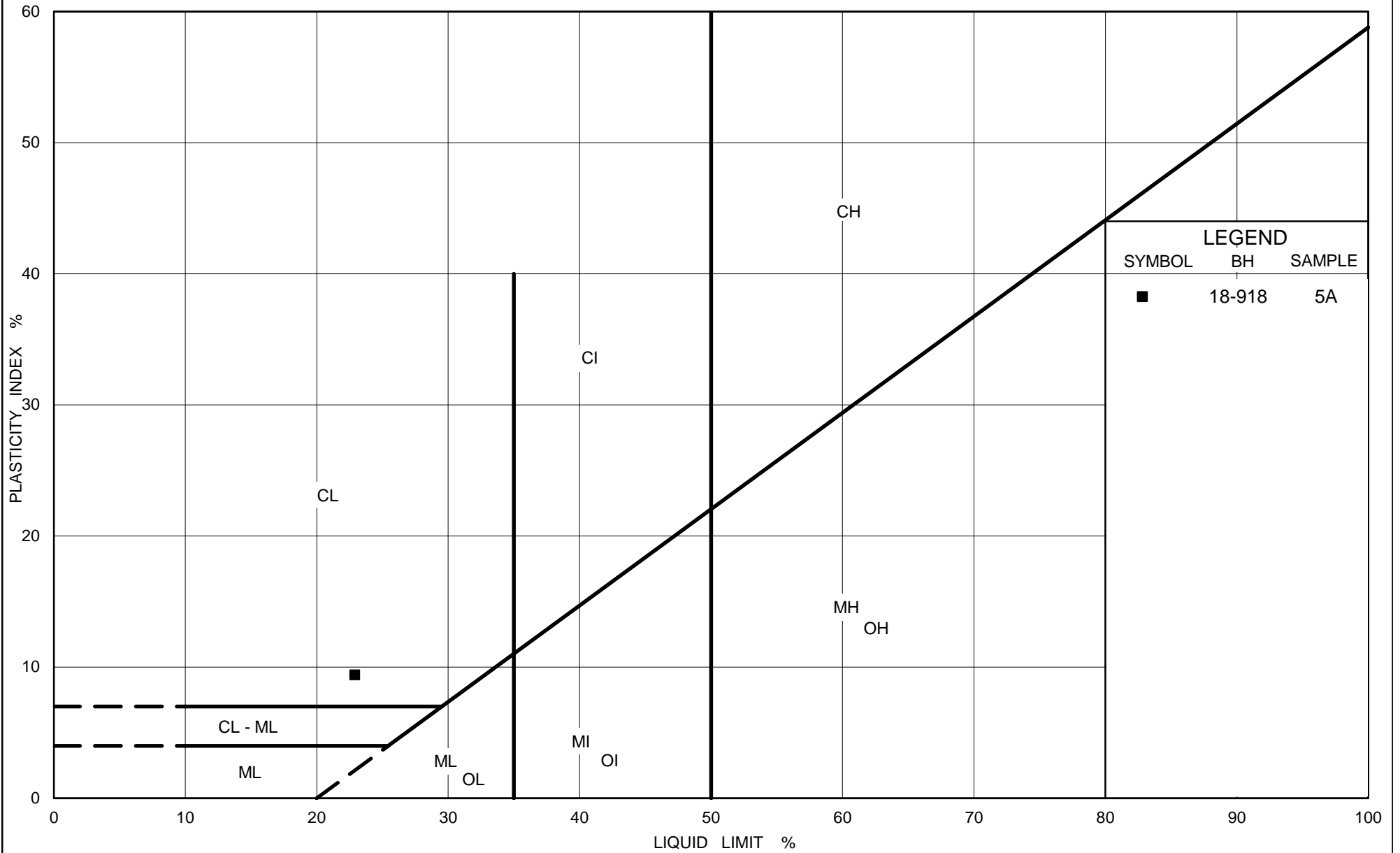
Borehole	Sample	Depth (m)
◆ 18-918	3	2.00-2.65

RETAINING WALL 7S: GRAVELLY SILTY SAND (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

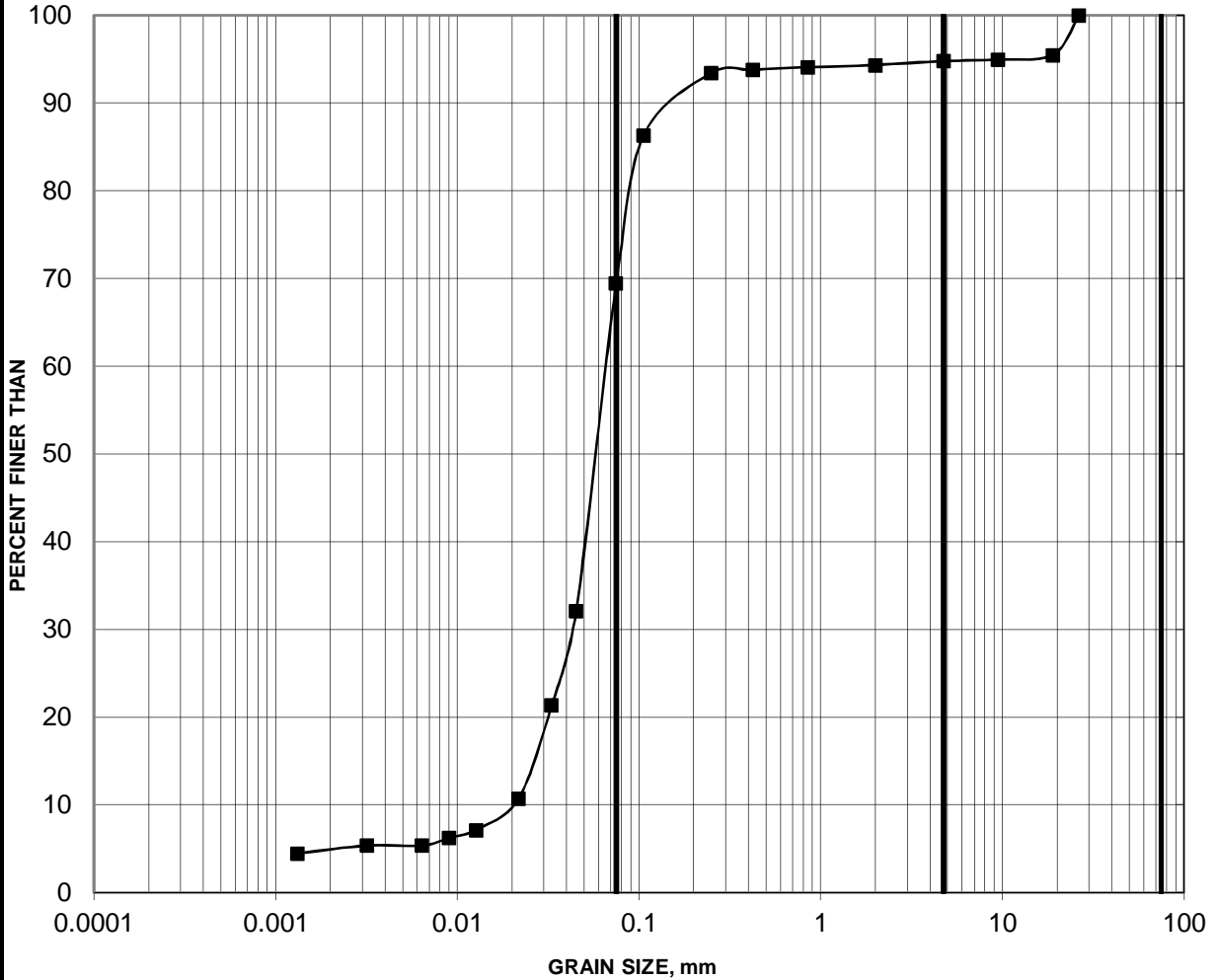
Borehole	Sample	Depth (m)
18-916	3	3.81-4.42



GRAIN SIZE DISTRIBUTION

FIGURE B21

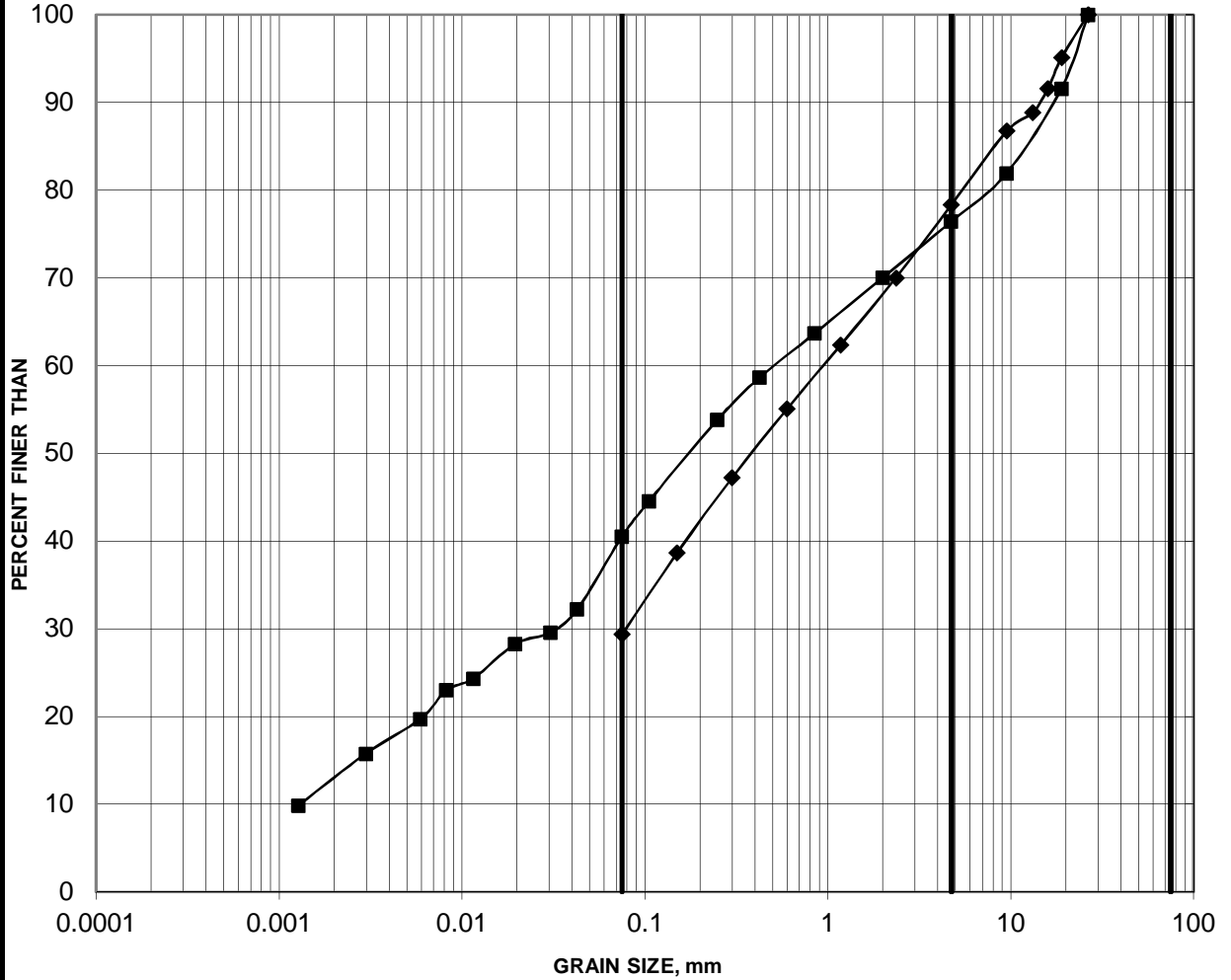
RETAINING WALL 7S: SANDY SILT



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

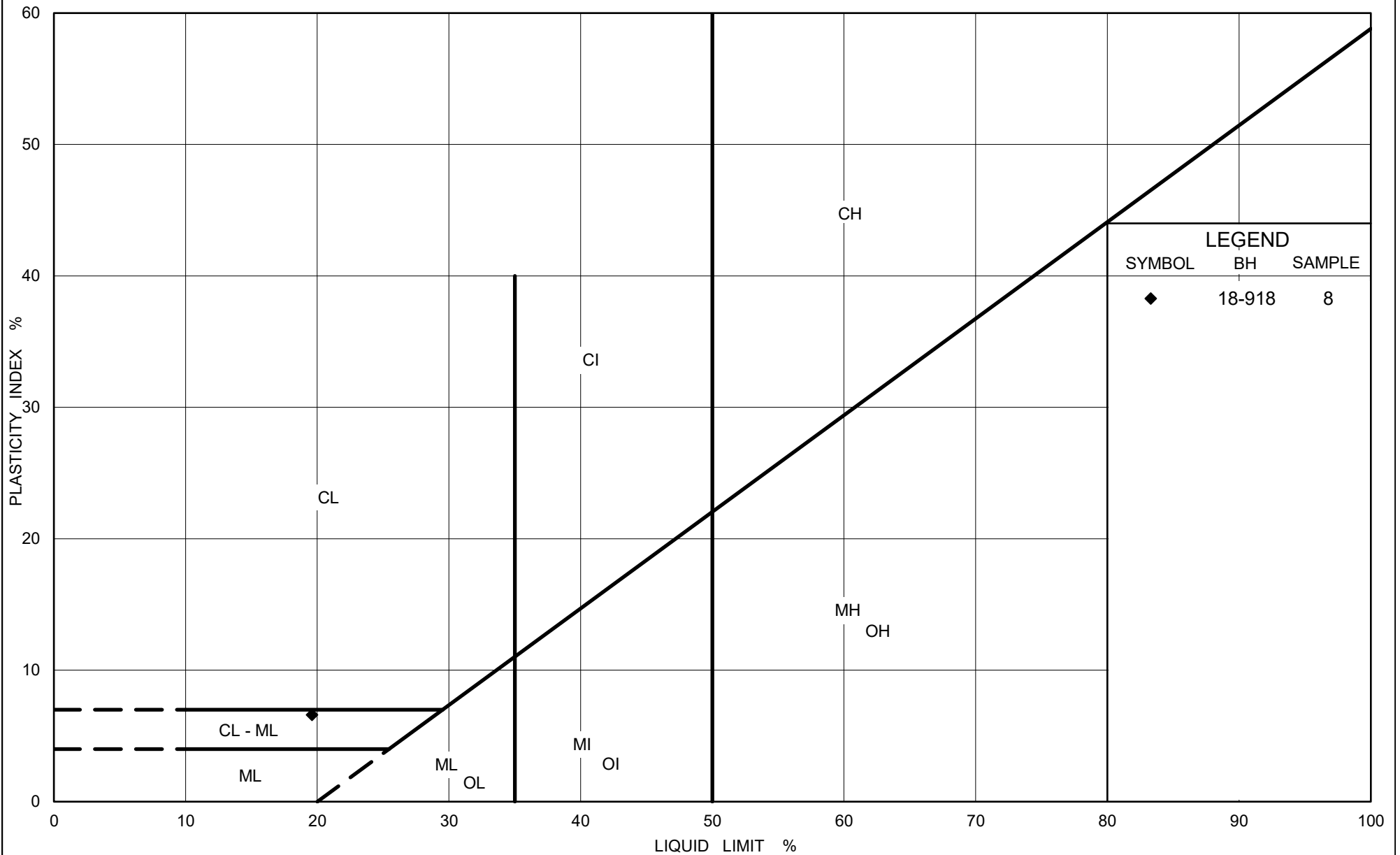
Borehole	Sample	Depth (m)
18-918	6	3.81-4.42

RETAINING WALL 7S: GLACIAL TILL



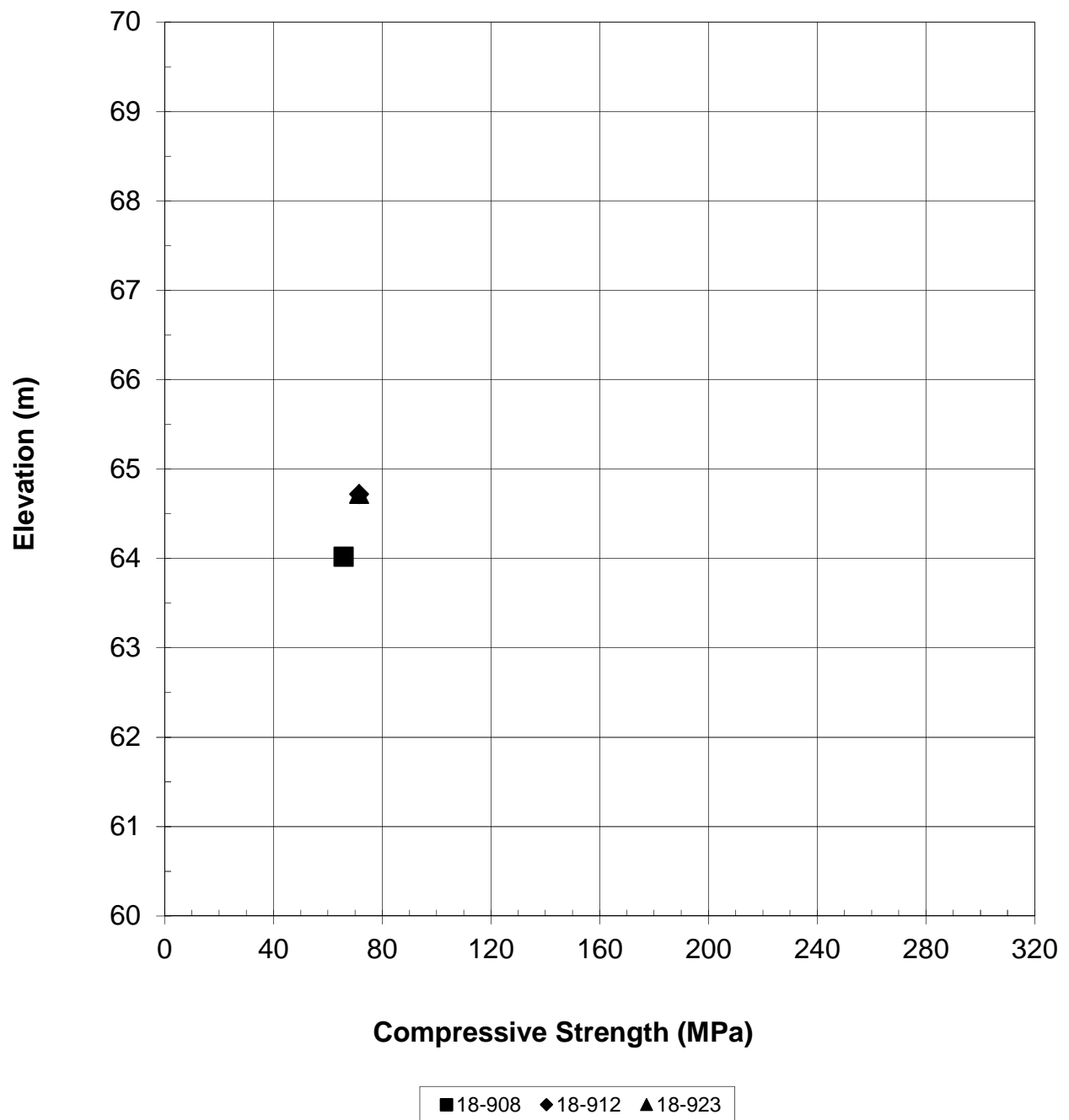
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
18-917	7	4.57-5.18
18-917	10	6.86-7.16



**SUMMARY OF LABORATORY COMPRESSIVE STRENGTH
UNCONFINED COMPRESSION TESTS**

FIGURE B24



APPENDIX C

Previous Investigations

GEOCRES No. 31G5-308: Record of Boreholes 17-122 to 17-124, 18-1203, 18-1204
and 18-1208

GEOCRES No. 31G5-295: Record of Boreholes 17-114, 18-1103 and 18-1107

GEOCRES No. 31G5-254: Record of Boreholes NB-03 to NB-05, 17S-01 and 17S-02

PROJECT 1655214-1120	RECORD OF BOREHOLE No 17-122	SHEET 1 OF 2	METRIC
G.W.P. 4173-15-00	LOCATION N 5029591.2; E 366891.0 NAD 83 MTM ZONE 9 (LAT. 45.403514; LONG. -75.706847)	ORIGINATED BY DWM	
DIST Eastern HWY 417	BOREHOLE TYPE Continuous 50 mm Diam. Split Spoon/NQ Core	COMPILED BY ZS	
DATUM Geodetic	DATE April 3, 2017	CHECKED BY KCP	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
						20 40 60 80 100	20 40 60 80 100									GR SA SI CL	
66.7	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
66.6	(SP) Gravelly sand (FILL) Grey																
0.1																	
66.4	(SP) Sand, some gravel, trace silt (FILL) Compact Grey brown Dry																
0.3			1	SS	13												
65.7			2	SS	50/0.05												
1.0	Limestone (BEDROCK) Bedrock cored from depths of 1.0 m to 4.2 m For bedrock coring details refer to Record of Drillhole 17-122		C1	RC	REC 96%											RQD = 80%	
			C2	RC	REC 99%												RQD = 80%
			C3	RC	REC 100%												RQD = 90%
62.5																	
4.2	END OF BOREHOLE																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/12/19 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1120</u>	RECORD OF BOREHOLE No 17-123	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029627.2; E 366858.8 NAD 83 MTM ZONE 9 (LAT. 45.403840; LONG. -75.707255)</u>	ORIGINATED BY <u>KM</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro-excavation/NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>April 6/10, 2017</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20	40	60	80	100						GR SA SI CL
66.3	GROUND SURFACE																	
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																	
66.2	(SP) Gravelly sand (FILL) Grey																	
0.1																		
66.0																		
0.3	(SP) Sand, trace gravel and silt, contains organic matter (FILL) Brown Moist		1	GRAB	-		66											
65.5																		
0.8	(GP) Gravel and cobbles (FILL)		2	RC	DD													
65.2																		
1.2	Limestone (BEDROCK) Bedrock cored from depths of 1.2 m to 4.8 m For bedrock coring details refer to Record of Drillhole 17-123		C1	RC	REC 65%		65											RQD = 0%
			C2	RC	REC 95%													RQD = 77%
			C3	RC	REC 99%		64											RQD = 92%
			C4	RC	REC 97%		63											RQD = 97%
							62											
61.5																		
4.8	END OF BOREHOLE																	

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/12/19 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1120</u>	RECORD OF BOREHOLE No 18-1204	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029597.6; E 366900.1 NAD 83 MTM ZONE 9 (LAT. 45.403560; LONG. -75.706730)</u>	ORIGINATED BY <u>RI/RK</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Rotary Drill/Wash Boring, NW Casing/NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>April 10, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
70.5	GROUND SURFACE																
0.0	(SM) Silty sand, contains organic matter (FILL) Brown to dark brown Moist		1	SS	3		70										
69.9	(SW) Sand (FILL) Brown Moist to wet		2	SS	2		69										
0.6							68										
67.3			3	SS	1		67										3 94 (3)
3.2	BOULDER						66										
66.7							65										
3.8	(SW) Sand, contains cobbles (FILL) Brown Moist to wet		1	RC	-		64										
66.2							63										
4.3	PORTLAND CEMENT CONCRETE (FOOTING)		2A	RC	-		62										
65.2							61										
5.3	Limestone (BEDROCK)		2B	RC	REC 100%		60										RQD = 0%
	Bedrock cored from depths 5.3 m to 7.1 m						59										
	For bedrock coring details refer to Record of Drillhole 18-1204		3	RC	REC 93%		58										RQD = 81%
63.4							57										
7.1	END OF BOREHOLE		4	RC	REC 100%		56										
	NOTE: 1. A reduced SPT hammer drop of 0.61 m was used for all split spoon samples "N" values are not representative of ASTM D1586 SPTN and should be interpreted in consideration of this reduced energy.						55										

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/12/19 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 1655214-1120 **RECORD OF BOREHOLE No 18-1208** SHEET 1 OF 1 **METRIC**
G.W.P. 4173-15-00 **LOCATION** N 5029602.4; E 366898.5 NAD 83 MTM ZONE 9 (LAT. 45.403610; LONG. -75.706750) **ORIGINATED BY** DJG
DIST Eastern **HWY** 417 **BOREHOLE TYPE** Power Auger, 200 mm Diam. (Hollow Stem) **COMPILED BY** ZS
DATUM Geodetic **DATE** October 9, 2018 **CHECKED BY** KCP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)							
						20	40	60	80	100	20	40	60	80	100	25	50	75		GR	SA	SI	CL	
72.9	GROUND SURFACE																							
0.0	ASPHALTIC CONCRETE																							
72.5	PORTLAND CEMENT CONCRETE, with rebar																							
0.4	(SP/GP) Sand and gravel (FILL) Grey Moist		1	GS	-																			
72.1	(SP) Sand, trace silt and gravel (FILL) Very dense to compact Brown Dry		2	SS	55																			
0.8			3	SS	51																			
			4	SS	52																			
			5	SS	35																			
			6	SS	39																			
			7	SS	12																			2 96 (2)
67.6	(CL) Sandy clayey silt (FILL) Firm Brown Moist		8	SS	2																			2 45 32 21
5.3			9	SS	2																			
67.0	(SP) Sand, trace silt (FILL) Very loose to compact Brown Moist		10	SS	24																			
5.9																								
65.3	END OF BOREHOLE AUGER REFUSAL																							
7.6																								

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/12/19 JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1110</u>	RECORD OF BOREHOLE No 17-114	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029598.8; E 366753.0 NAD 83 MTM ZONE 9 (LAT. 45.403594; LONG. -75.708610)</u>	ORIGINATED BY <u>DWM</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro-excavation/NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>April 6/7, 2017</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
63.8	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
63.7																	
0.1	(GP/SP) Gravel and sand, trace silt (FILL) Grey Moist																
			1	GRAB	-												53 42 4 1
62.7																	
1.1	Limestone (BEDROCK) Bedrock cored from depths 1.1 m to 4.8 m For bedrock coring details refer to Record of Drillhole 17-114		C1	RC	REC 56%												RQD = 13%
			C2	RC	REC 100%												RQD = 87%
			C3	RC	REC 91%												RQD = 54%
59.0																	
4.8																	

GTA-MTO 001 \GOLDER.GDS\GALOTTAWACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 19-8-1 JM

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1110</u>	RECORD OF BOREHOLE No 17-114	SHEET 2 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029598.8; E 366753.0 NAD 83 MTM ZONE 9 (LAT. 45.403594; LONG. -75.708610)</u>	ORIGINATED BY <u>DWM</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Hydro-excavation/NQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>April 6/7, 2017</u>	CHECKED BY <u>KCP</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L			25
	END OF BOREHOLE																
	NOTES: 1. Water level in well screen at a depth of 1.8 m below ground surface (Elev. 62.0 m), measured on April 26, 2017.																

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+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1110</u>	RECORD OF BOREHOLE No 18-1103	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029598.0; E 366763.5 NAD 83 MTM ZONE 9 (LAT. 45.403580; LONG. -75.708470)</u>	ORIGINATED BY <u>RI</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Rotary Drill, HW Casing/HQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>April 16, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								20	40	60	80	100					
66.3 0.0	GROUND SURFACE (SW) Sand (FILL) Brown Moist		1	SS	4		66										
65.1 1.2	(SM) Gravelly silty sand, contains brick (FILL) Brown Moist to wet		2	SS	13		65										
64.5 1.8	PORTLAND CEMENT CONCRETE (FOOTING)		1	RC	-		64										
			2	RC	-												
			3A	RC	-												
63.0 3.3	Limestone (BEDROCK) Bedrock cored from depths 3.3 m to 4.9 m For bedrock coring details refer to Record of Drillhole 18-1102		3B	RC	REC 96%		63									RQD = 0%	
			4	RC	REC 96%		62									RQD = 59%	
			5	RC	REC 98%												RQD = 73%
61.4 4.9	END OF BOREHOLE NOTES: 1. A reduced hammer drop of 0.61 m was used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of this reduced energy.																

GTA-MTO 001 \GOLDER.GDS\GALOTTAWACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ_GAL-GTA.GDT_19-8-1_JM

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1655214-1110</u>	RECORD OF BOREHOLE No 18-1107	SHEET 1 OF 2	METRIC
G.W.P. <u>4173-15-00</u>	LOCATION <u>N 5029599.8; E 366768.6 NAD 83 MTM ZONE 9 (LAT. 45.403590; LONG. -75.708410)</u>	ORIGINATED BY <u>RI</u>	
DIST <u>Eastern</u> HWY <u>417</u>	BOREHOLE TYPE <u>Rotary Drill, HW Casing/HQ Core</u>	COMPILED BY <u>ZS</u>	
DATUM <u>Geodetic</u>	DATE <u>April 17, 2019</u>	CHECKED BY <u>KCP</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20	40	60	80	100						GR SA SI CL
68.9	GROUND SURFACE																	
0.0	(SW) Sand, some silt, trace gravel (FILL) Dark brown to brown moist to wet		1	SS	7													
							68											
			2	SS	2													4 84 (12)
							67											
			3	SS	2													
							66											
64.9			4	SS	50/0.08													
64.6	(SW) Sand, some gravel, contains cobbles and wood (FILL) Brown Moist to wet																	
4.3	PORTLAND CEMENT CONCRETE (FOOTING)		1	RC	-													
							64											
63.6			2A	RC	-													
5.3	Limestone (BEDROCK) Bedrock cored from depths 5.3 m to 6.9 m For bedrock coring details refer to Record of Drillhole 18-1107																	RQD = 82%
			2B	RC	REC 100%													
							63											
			3	RC	REC 97%													RQD = 82%
							62											
62.0	END OF BOREHOLE																	
6.9	NOTES: 1. A reduced hammer drop of 0.61 m was used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of this reduced energy.																	

GTA-MTO 001 \GOLDER.GDS\GALOTTAWACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING02_DATA\GINT1655214.GPJ_GAL-GTA.GDT_19-8-1_JM

RECORD OF BOREHOLE No 17S-01 1 OF 2 METRIC

W.P. 4089-07-01 LOCATION N 5 029 635.1 E 367 009.4 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2012.07.31 - 2012.07.31 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE WATER CONTENT (%) 20 40 60								
73.7														
0.0	ASPHALT:(150mm)													
0.2	CONCRETE:(200mm)													
73.3														
0.4	SAND, trace gravel, trace silt, occasional cobbles Compact to Loose Brown Damp (FILL)		1	SS	27									
			2	SS	20									
			3	SS	7									
			4	SS	7									
			5	SS	37									
68.5														
5.2	Silty SAND Compact Brown Moist		6	SS	20									
	Auger refusal at 7.4m													
66.3														
7.4	BEDROCK limestone with shale interbeds, thinly laminated, dark grey Broken cores at 7.4 to 7.5, and 7.7 to 7.9m. Horizontal fractures at 7.5, 7.6, 7.7, 8.0, 8.1, 8.2, 8.4, 8.5, and 8.7m. Subvertical fractures at 7.9, and 8.4m. Horizontal fractures at 8.9, 9.0, 9.2, 9.6, 9.7, 10.0, 10.1, and 10.2m. Subhorizontal fractures at 9.4, 9.5, and 10.2m. Broken core at 9.7 to 9.8m.		1	RUN										
			2	RUN										

ONTMT4S_1201D.GPJ 2012TEMPLATE(MTO).GDT 10/25/13

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20
15
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17S-01

2 OF 2

METRIC

W.P. 4089-07-01 LOCATION N 5 029 635.1 E 367 009.4 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2012.07.31 - 2012.07.31 CHECKED BY LRB

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)	
	Continued From Previous Page							20	40	60	80	100	W _p	W	W _L				
63.2																			
10.4	END OF BOREHOLE AT 10.4m. BOREHOLE BACKFILLED WITH CUTTINGS AND BENTONITE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.																		

ONTMT4S_1201D.GPJ 2012TEMPLATE(MTO).GDT 10/25/13

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17S-02

1 OF 1

METRIC

W.P. 4089-07-01 LOCATION N 5 029 651.5 E 367 061.2 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2012.08.01 - 2012.08.01 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
					20	40	60	80	100	20	40	60	γ	GR SA SI CL		
74.1																
0.0	ASPHALT: (225mm)															
0.2	CONCRETE: (200mm)															
0.4	SAND , trace gravel, trace silt, occasional cobbles Dense to Very Dense Brown Damp (FILL)	1	SS	34												
		2	SS	51											4 85 11 (SI+CL)	
		3	SS	32												
	Loose Wet	4	SS	8												
	Auger refusal at 4.2m															
69.9																
4.2	BEDROCK limestone, thinly laminated, dark grey Subvertical fracture at 4.2m. Horizontal fractures at 4.3, 4.4, 4.5, 5.0, 5.2, and 5.4m. Broken core at 4.5, and 4.7m. Subhorizontal joint at 4.8m.	1	RUN												RUN #1 TCR=90% SCR=82% RQD=80% UCS=83MPa (Average)	
	Horizontal fractures at 5.8, 5.9, 6.0, 6.1, 6.3, 6.4, 6.6, 6.7, 7.0, 7.1, and 7.2m. Vertical fracture at 5.9m. Broken core at 6.6m.	2	RUN												RUN #2 TCR=98% SCR=93% RQD=63% UCS=79MPa (Average)	
66.8																
7.3	END OF BOREHOLE AT 7.3m. WATER LEVEL AT 4.4m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2012.08.21 5.1 69.0 2012.11.21 5.2 68.9															

ONTMT4S_1201D.GPJ_2012TEMPLATE(MTO).GDT_10/25/13

+ 3, x 3. Numbers refer to 20
Sensitivity 15 (5) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No NB-03

1 OF 1

METRIC

W.P. 4089-07-01 LOCATION N 5 029 621.1 E 366 961.9 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2012.08.01 - 2012.08.01 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20
73.3	ASPHALT:(225mm)																
72.9	CONCRETE:(200mm)																
0.4	SAND, trace gravel, trace silt, occasional cobbles and metal fragments Dense to Loose Brown Damp (FILL) Asphalt (50mm) at 2.0m	1	SS	34													
		2	SS	29													
		3	SS	8													7 88 5 (SI+CL)
		4	SS	19													
		5	SS	36													1 94 5 (SI+CL)
68.1	Silty SAND, trace gravel, occasional cobbles Compact Brown/Grey Moist	6	SS	16													
5.2																	
65.6		7	SS	50/													
7.8	END OF BOREHOLE AT 7.8m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 5.8m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2012.08.21 6.5 66.8 2012.11.21 4.4 68.9			.100													

ONTMT4S_1201D.GPJ_2012TEMPLATE(MTO).GDT_10/25/13

+ 3, x 3. Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NB-04

1 OF 1

METRIC

W.P. 4089-07-01 LOCATION N 5 029 672.4 E 367 146.7 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2012.07.24 - 2012.07.24 CHECKED BY LRB

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
							20	40	60	80	100	W _p	W	W _L		
74.7																
0.0	ASPHALT:(150mm)															
70.2	CONCRETE:(150mm)															
0.3	SAND, trace gravel, some silt, occasional cobbles Dense to Compact Brown Damp (FILL)		1	SS	35											5 82 13 (SI+CL)
			2	SS	18											
			3	SS	53											
71.7																
2.9	END OF BOREHOLE AT 2.9m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE OPEN TO 2.9m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS AND BENTONITE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.															

ONTMT4S_1201D.GPJ 2012TEMPLATE(MTO).GDT 10/25/13

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NB-05

1 OF 1

METRIC

W.P. 4089-07-01 LOCATION N 5 029 677.3 E 367 190.2 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2012.07.31 - 2012.07.31 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
							20	40	60	80	100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
							20	40	60	80	100	20	40	60	GR SA SI CL	
73.5																
0.0	ASPHALT:(150mm)															
70.2	CONCRETE:(150mm)															
0.3	Gravelly SAND, trace silt, occasional cobbles Very Dense to Compact Brown Damp (FILL) Hydrocarbon odour		1	SS	61							○			24 66 10 (SI+CL)	
			2	SS	16							○				
71.3																
2.2	SAND, some gravel, trace silt, occasional bedrock fragments Loose Brown Moist		3	SS	6							○				
			4	SS	10							○				
68.8			5	SS	50							○				
4.7	END OF BOREHOLE AT 4.7m UPON REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 4.7m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2012.08.21 2.8 70.7 2012.11.21 3.6 69.9				.050											

ONTMT4S_1201D.GPJ 2012TEMPLATE(MTO).GDT 10/25/13

APPENDIX D

Results of Chemical Analysis

Results of Chemical Analysis Eurofins Environment Testing Report No. 1911490

Results of Chemical Analysis Eurofins Environment Testing Report No. 1908451

Results of Chemical Analysis Eurofins Environment Testing Report No. 1911489

Results of Chemical Analysis Eurofins Environment Testing Report No. 1908709

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario

Attention: Kenton Power

PO#:

Invoice to: Golder Associates Ltd

Report Number: 1911490
Date Submitted: 2019-07-04
Date Reported: 2019-07-11
Project: 1655214/1805
COC #: 845746

Lab I.D.
Sample Matrix
Sample Type
Sampling Date
Sample I.D.

1437984
Soil

2019-05-23
18-802sa3/4-6'

Group	Analyte	MRL	Units	Guideline	
Anions	Cl	0.002	%		0.027
	SO4	0.01	%		<0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.64
	pH	2.00			9.69
	Resistivity		mS/cm		1560

Guideline =

*** = Guideline Exceedence**

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

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

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario

Attention: Kenton Power

PO#:

Invoice to: Golder Associates Ltd

Report Number: 1911489
Date Submitted: 2019-07-04
Date Reported: 2019-07-11
Project: 165521411900
COC #: 845745

Lab I.D. 1437983
Sample Matrix Soil
Sample Type
Sampling Date 2019-05-21
Sample I.D. 18-909sa1B/1.5-2.5'

Group	Analyte	MRL	Units	Guideline	
Anions	Cl	0.002	%		0.006
	SO4	0.01	%		0.04
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.41
	pH	2.00			8.07
	Resistivity		mS/cm		2440

Guideline = * = **Guideline Exceedence**

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

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

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario

Attention: Kenton Power
PO#:

Invoice to: Golder Associates Ltd

Report Number: 1908451
Date Submitted: 2019-05-29
Date Reported: 2019-06-05
Project: 1655214/1900
COC #: 843944

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1429395 Soil 2019-05-16 18-901 sa4 7-9	1429396 Soil 2019-05-08 18-907 sa2 2.5-3.75	1429397 Soil 2019-05-03 18-910 sa1 1250-1660mm	1429398 Soil 2019-05-13 18-913 sa2 2.5-4.5
Anions	SO4	0.01	%			<0.01	<0.01	0.02	<0.01
Cl in Concrete	Cl	0.002	%			0.007	0.008	0.016	0.031
General Chemistry	Electrical Conductivity	0.05	mS/cm			0.29	0.50	0.50	0.70
	pH	2.00				9.08	9.40	8.41	8.34
	Resistivity	1	ohm-cm			3450	2000	2000	1430

Guideline = * = **Guideline Exceedence**

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

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

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
 1931 Robertson Road,
 Ottawa, Ontario
 K2E 7Y1
 Attention: Kenton Power
 PO#:
 Invoice to: Golder Associates Ltd

Report Number: 1908709
 Date Submitted: 2019-06-03
 Date Reported: 2019-06-13
 Project: 1655214/1900
 COC #: 844282

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1430165 Soil 2019-05-02 18-917 SA 4/2.5-2.8	1430166 Soil 2019-05-02 18-917 SA 8/17.5
Anions	Cl	0.002	%			0.051	0.023
	SO4	0.01	%			<0.01	0.02
General Chemistry	Electrical Conductivity	0.05	mS/cm			0.73	0.38
	pH	2.00				9.61	8.48
	Resistivity	1	ohm-cm			1370	2630

Guideline = * = **Guideline Exceedence**

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






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

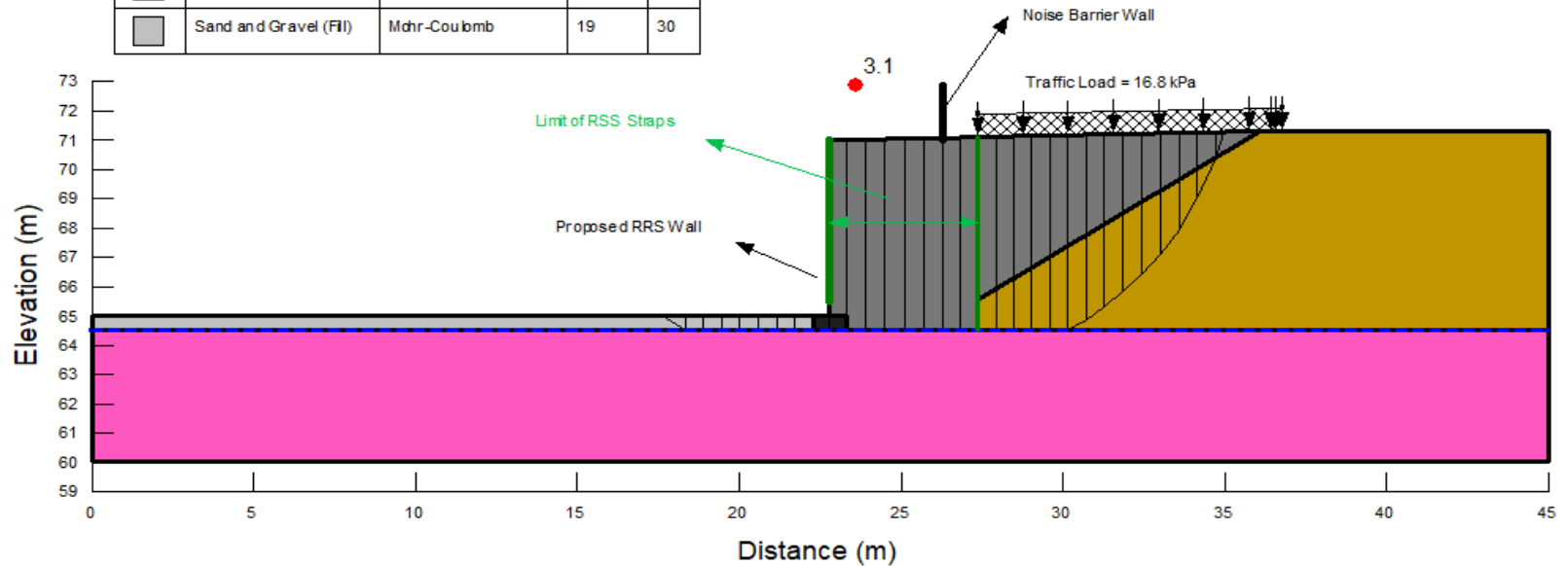
APPENDIX E

Slope Stability Analysis Results

Figures E1 to E18

Title: RW10N Rochester
 File Name: 1655214-1900 RW 10N Rochester.gsz
 Name: 1.1 Static Drained
 Method: Morgenstern-Price
 Direction of movement: Right to Left
 Horz Seismic Coef.:
 Groundwater Elevation of 64.5 m

Color	Name	Model	Unit Weight (kNm ³)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)		
	Existing Embankment Fill	Mohr-Coulomb	20	33
	Granular B Type II	Mohr-Coulomb	22	35
	Retaining Wall Base	Mohr-Coulomb	24	55
	Sand and Gravel (Fill)	Mohr-Coulomb	19	30








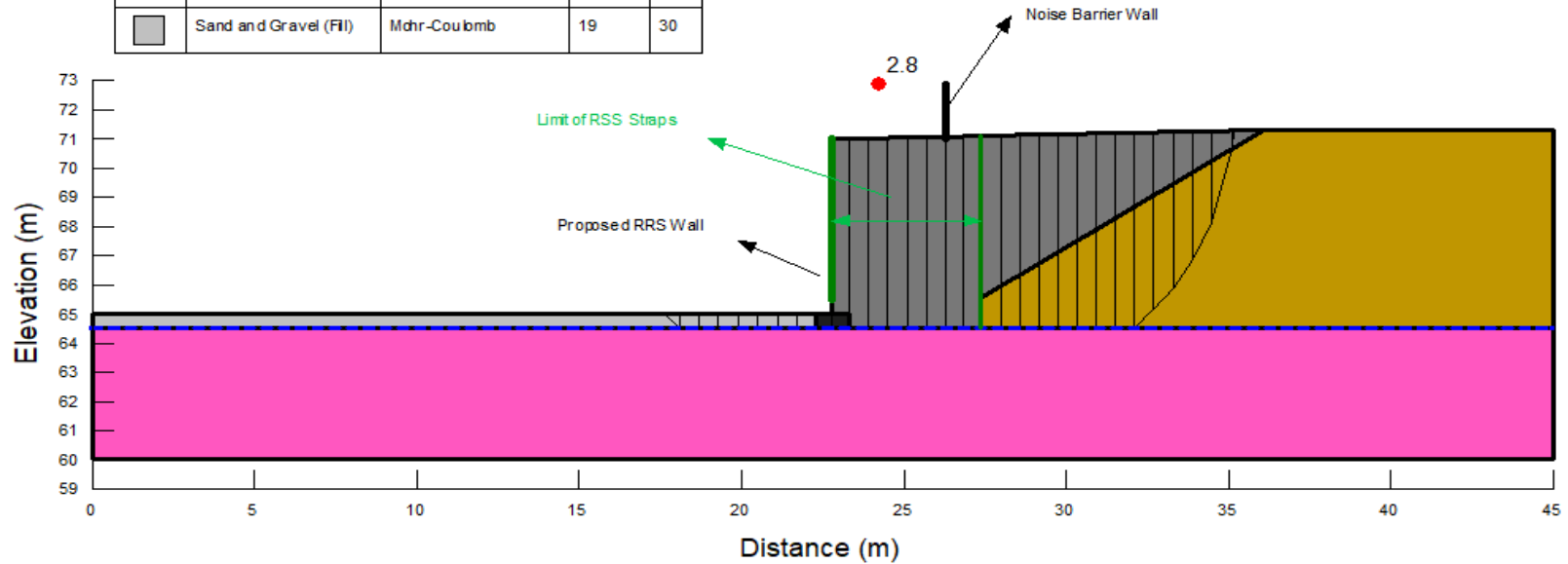
Foundation Investigation
Highway 417 Retaining Wall Replacement
and Rehabilitation
Retaining Wall RW 10N
Slope Stability - Static Analysis
Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
Checked:	KCP
Review:	FJH

Figure E1

Title: RW10N Rochester
 File Name: 1655214-1900 RW 10N Rochester.gsz
 Name: 12 Seismic Drained
 Method: Morgenstern-Price
 Direction of movement: Right to Left
 Horz Seismic Coef.: 0.12
 Groundwater Elevation of 64.5 m

Color	Name	Model	Unit Weight (kN/m ³)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)		
	Existing Embankment Fill	Mohr-Coulomb	20	33
	Granular B Type II	Mohr-Coulomb	22	35
	Retaining Wall Base	Mohr-Coulomb	24	55
	Sand and Gravel (Fill)	Mohr-Coulomb	19	30









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Retaining Wall RW 10N
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Ottawa, Ontario

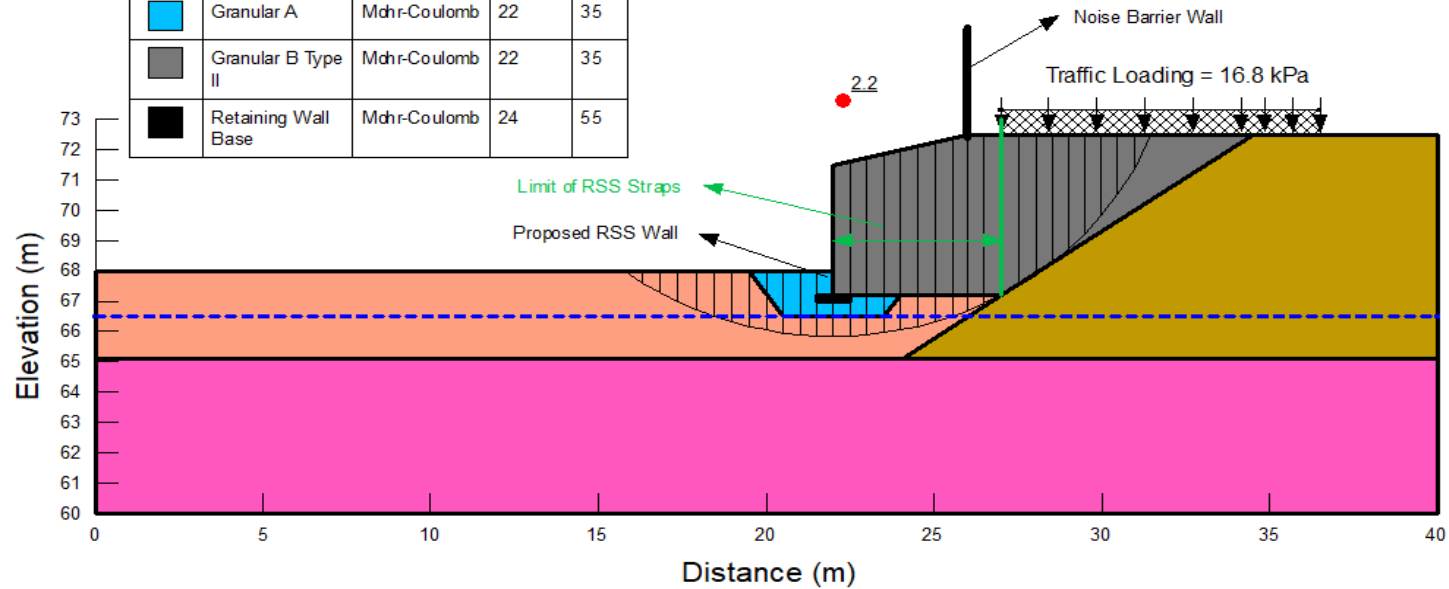
Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
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Review:	FJH

Figure E2

Title: RW 11N Booth to LeBreton
 File Name: 1655214-1900 RW 11N Booth to LeBreton.gsz
 Name: 1.1 Static Drained
 Method: Morgenstern-Price
 Direction of movement: Right to Left
 Horz Seismic Coef:

Groundwater Elevation of 66.5 m

Color	Name	Model	Unit Weight (kN/m ³)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)		
	Existing Embankment Fill	Mohr-Coulomb	20	33
	Glacial Till	Mohr-Coulomb	21	34
	Granular A	Mohr-Coulomb	22	35
	Granular B Type II	Mohr-Coulomb	22	35
	Retaining Wall Base	Mohr-Coulomb	24	55









Foundation Investigation
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Retaining Wall RW 11N
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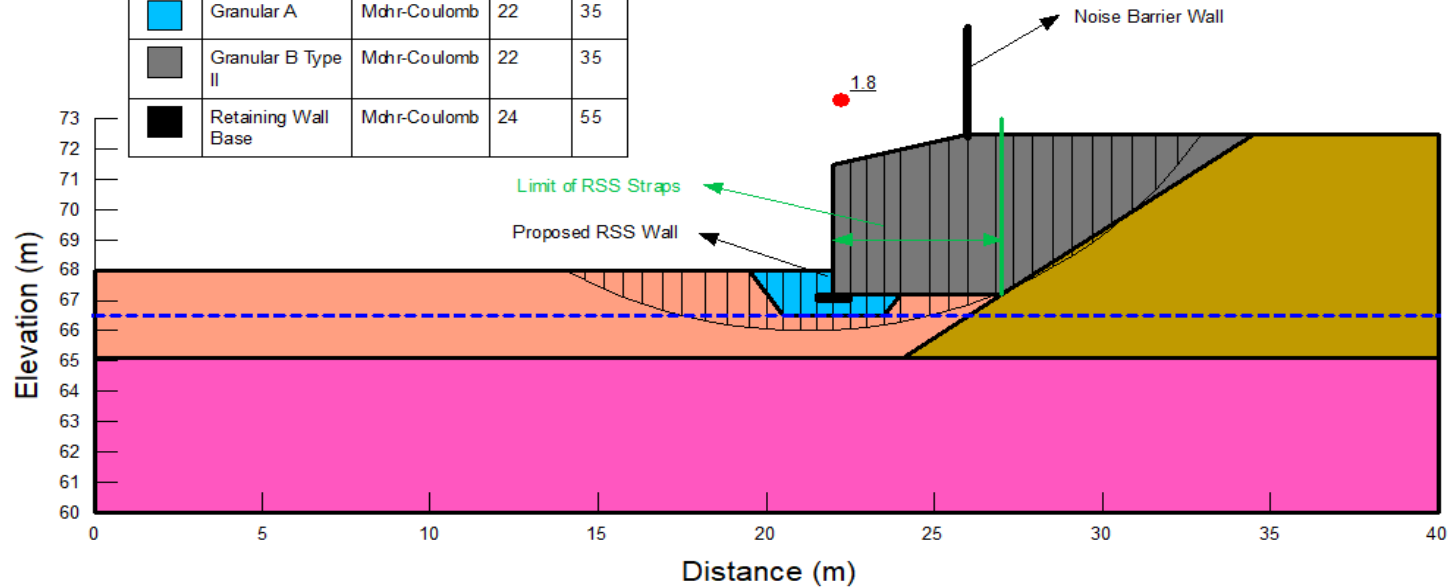
Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
Checked:	KCP
Review:	FJH

Figure E3

Title: RW 11N Booth to LeBreton
 File Name: 1655214-1900 RW 11N Booth to LeBreton.gsz
 Name: 12 Seismic Drained
 Method: Morgenstern-Price
 Direction of movement: Right to Left
 Horz Seismic Coef: 0.12

Groundwater Elevation of 66.5 m







Color	Name	Model	Unit Weight (kN/m ³)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)		
	Existing Embankment Fill	Mohr-Coulomb	20	33
	Glacial Till	Mohr-Coulomb	21	34
	Granular A	Mohr-Coulomb	22	35
	Granular B Type II	Mohr-Coulomb	22	35
	Retaining Wall Base	Mohr-Coulomb	24	55



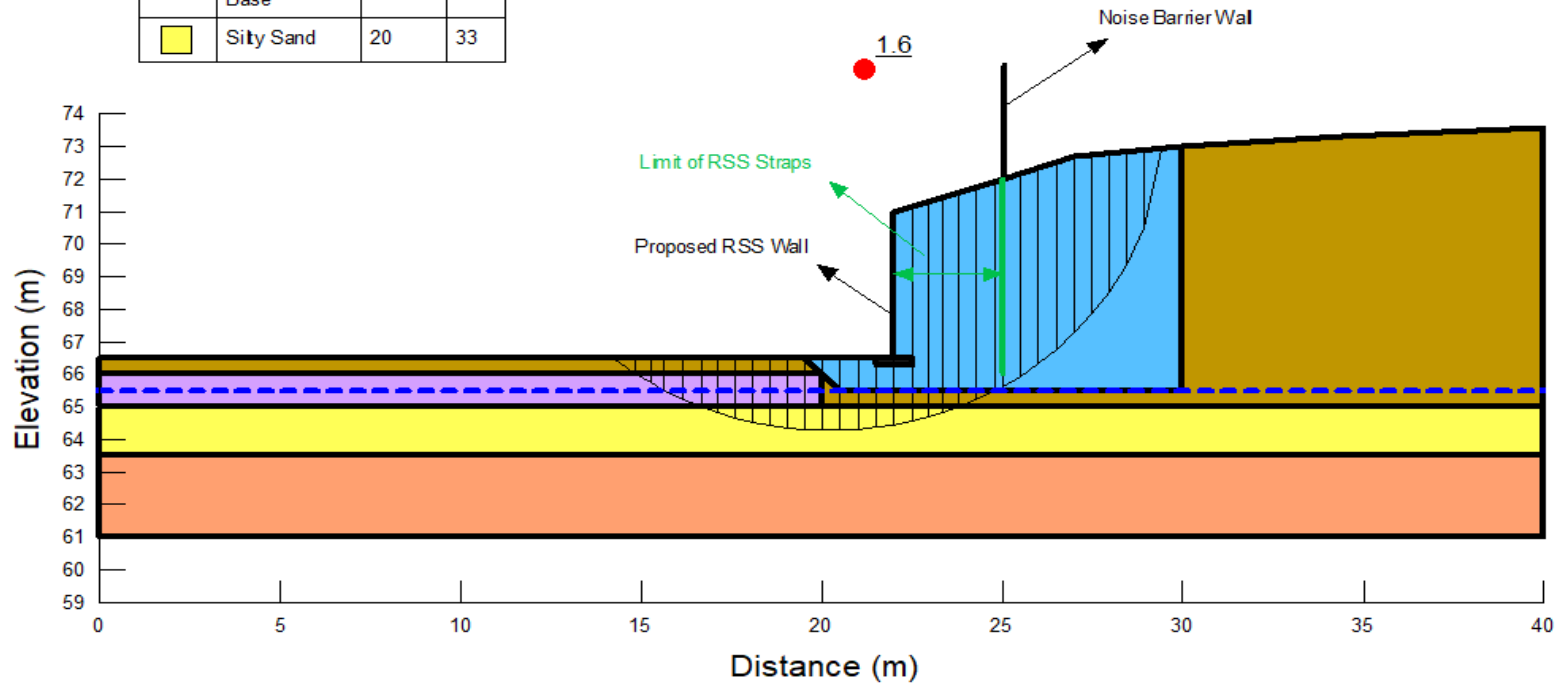
**Foundation Investigation
 Highway 417 Retaining Wall Replacement
 and Rehabilitation
 Retaining Wall RW 11N
 Slope Stability - Seismic Analysis
 Ottawa, Ontario**

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
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Figure E4

Color	Name	Unit Weight (kN/m ³)	Phi ^o
	Existing Embankment Fill	20	33
	Glacial Till	21	34
	Granular A	22	35
	Peat	17	28
	Retaining Wall Base	24	55
	Silty Sand	20	33







Title: RW 13N Percy NE
 File Name: 1655214-1900 RW 13N Percy NE.gsz
 Name: 1.1 Static Drained
 Method: Morgenstem-Price
 Direction of movement: Right to Left
 Horz Seismic Coef.: 0
 Groundwater Elevation of 65.5 m



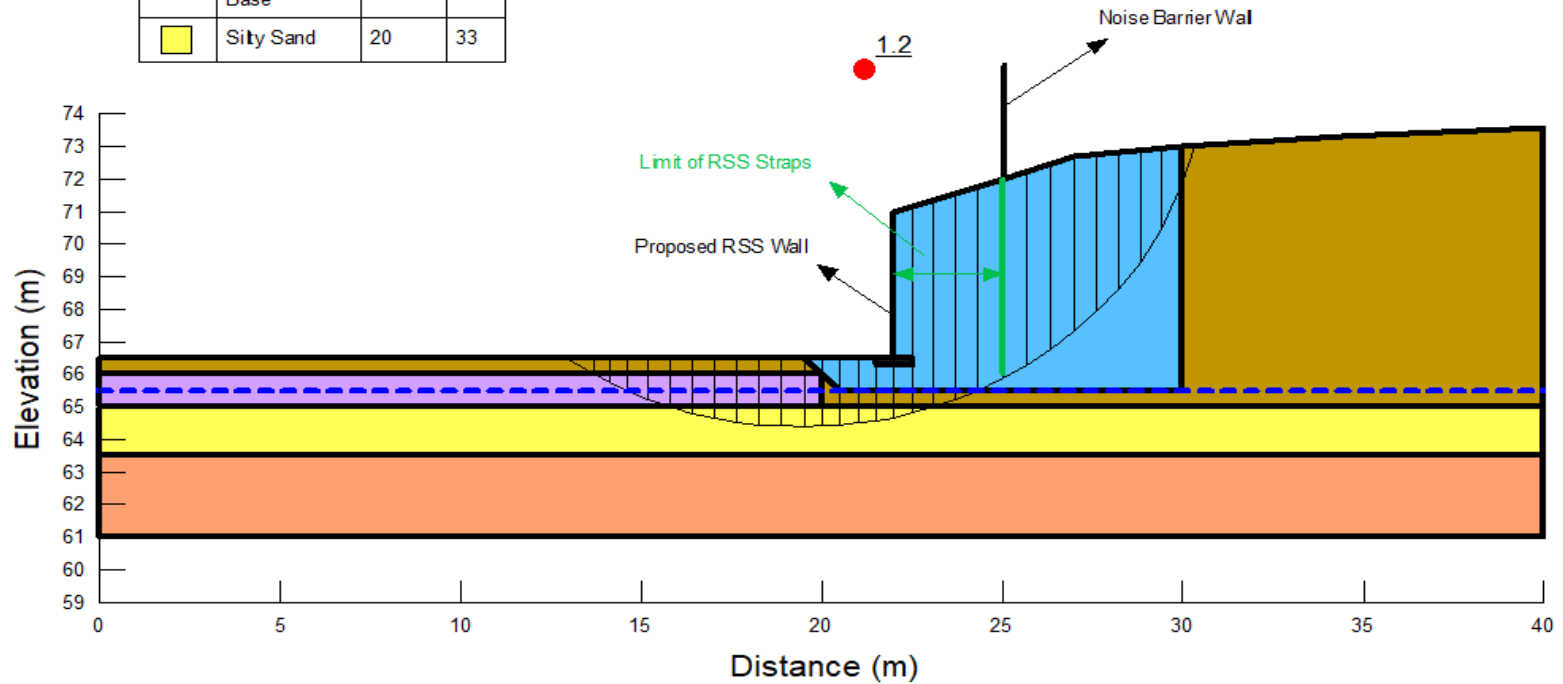
Foundation Investigation
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Retaining Wall RW 13N
Slope Stability - Static Analysis
Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
Checked:	KCP
Review:	FJH

Figure E5

Color	Name	Unit Weight (kN/m ³)	Phi ^o (°)
	Existing Embankment Fill	20	33
	Glacial Till	21	34
	Granular A	22	35
	Peat	17	28
	Retaining Wall Base	24	55
	Silty Sand	20	33

Title: RW 13N Percy NE
 File Name: 1655214-1900 RW 13N Percy NE.gsz
 Name: 1.2 Seismic Drained
 Method: Morgenstem-Price
 Direction of movement: Right to Left
 Horz Seismic Coef.: 0.15
 Groundwater Elevation of 65.5 m



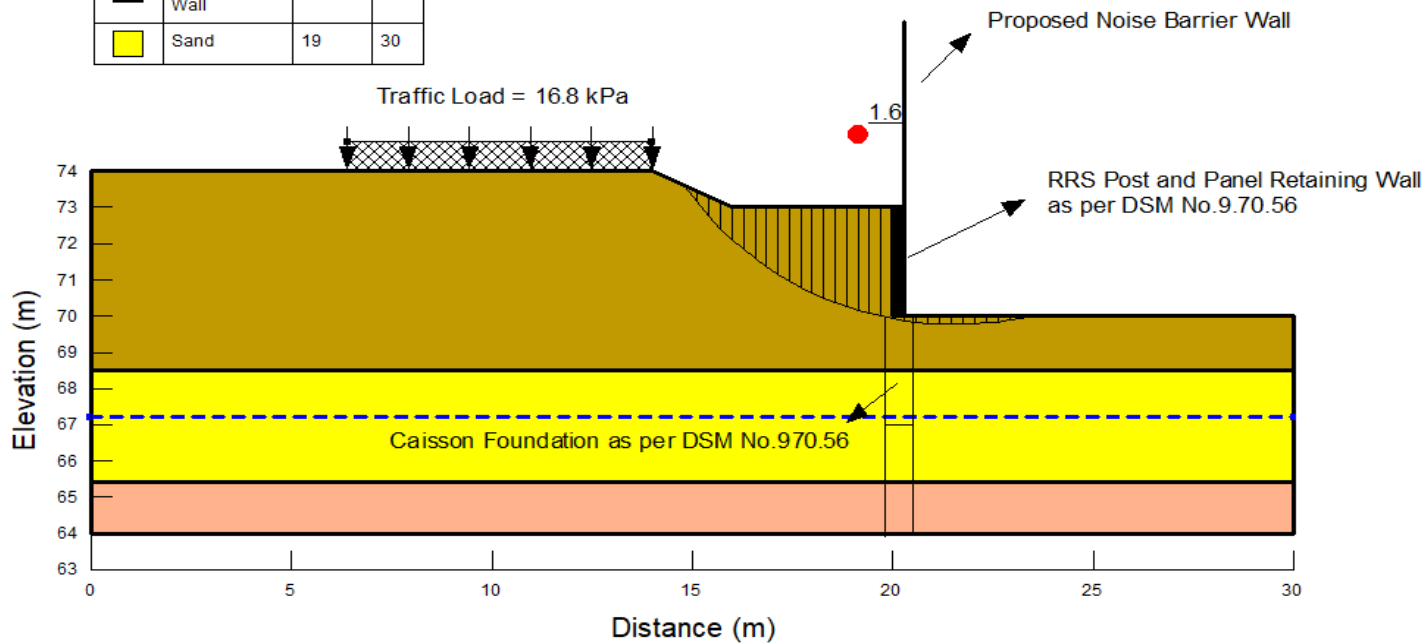
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Retaining Wall RW 13N
Slope Stability - Seismic Analysis
 Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
Checked:	KCP
Review:	FJH

Figure E6

Title: RW 1-S Hinton Ave South
 File Name: 1655214-1900 RW 1S Hinton South.gsz
 Name: 1.1 Static Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horiz Seismic Coef:
 Groundwater Elevation of 67.2 m

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
■	Existing Embankment Fill	20	33
■	Glacial Till	21	34
■	Retaining Wall	24	55
■	Sand	19	30







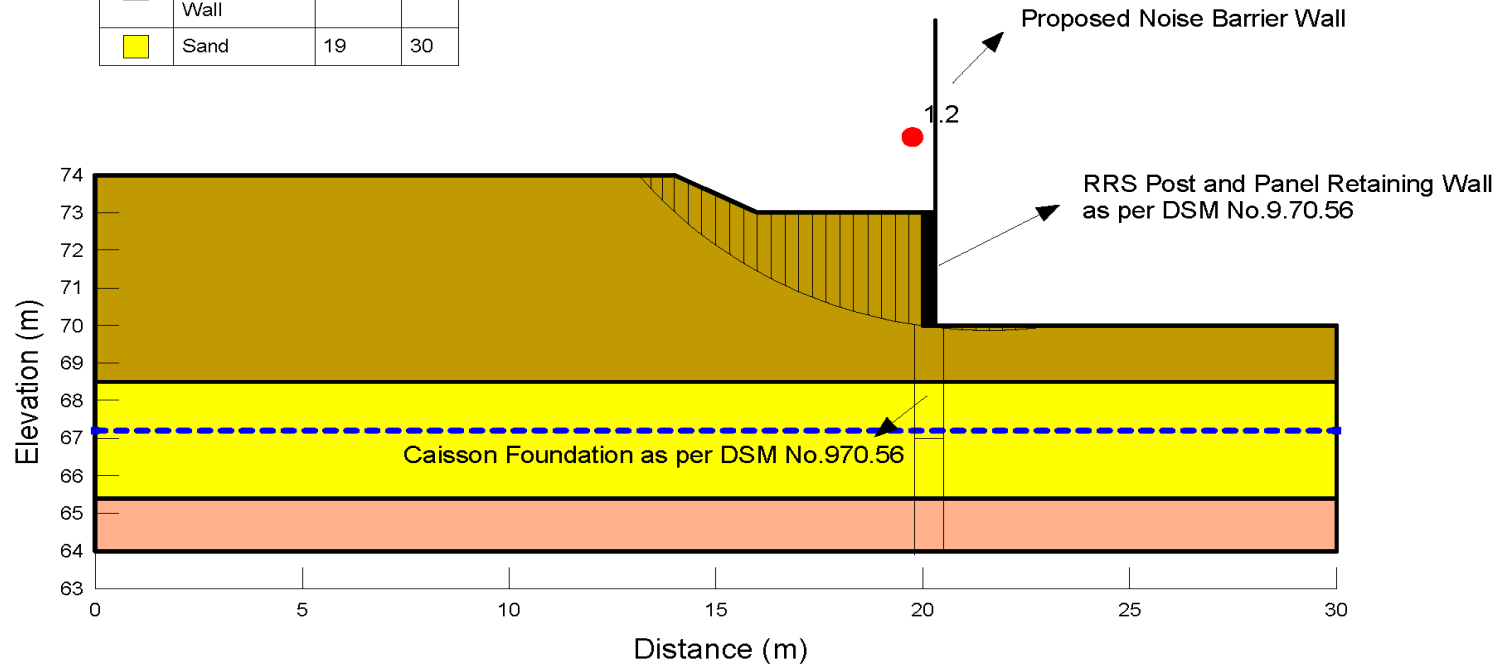
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Retaining Wall RW 1S
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Ottawa, Ontario

Project No.	1655214-1900
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Date:	2019-11-26
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Figure E7

Title: RW 1-S Hinton Ave South
 File Name: 1655214-1900 RW 1S Hinton South.gsz
 Name: 1.2 Seismic Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horz Seismic Coef.: 0.14
 Groundwater Elevation of 67.2 m

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
	Existing Embankment Fill	20	33
	Glacial Till	21	34
	Retaining Wall	24	55
	Sand	19	30








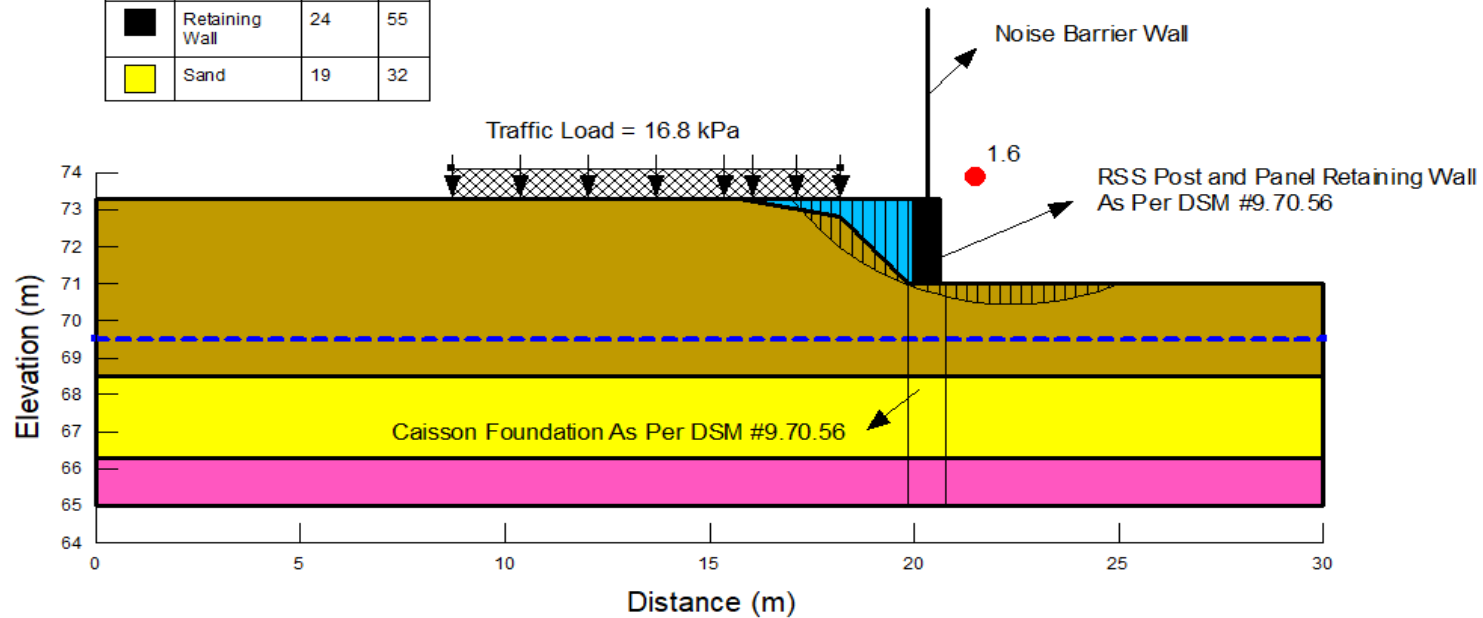
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 1S
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Ottawa, Ontario

Project No.	1655214-1900
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Figure E8

Title: RW4-S Orangeville Street
 File Name: 1655214-1900 RW 4S - Section 1.gsz
 Name: 1.1Static Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horiz. Seismic Coef.:
 Groundwater Elevation of 69.5 m

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
	Bedrock		
	Existing Embankment Fill	20	33
	Granular A	22	35
	Retaining Wall	24	55
	Sand	19	32








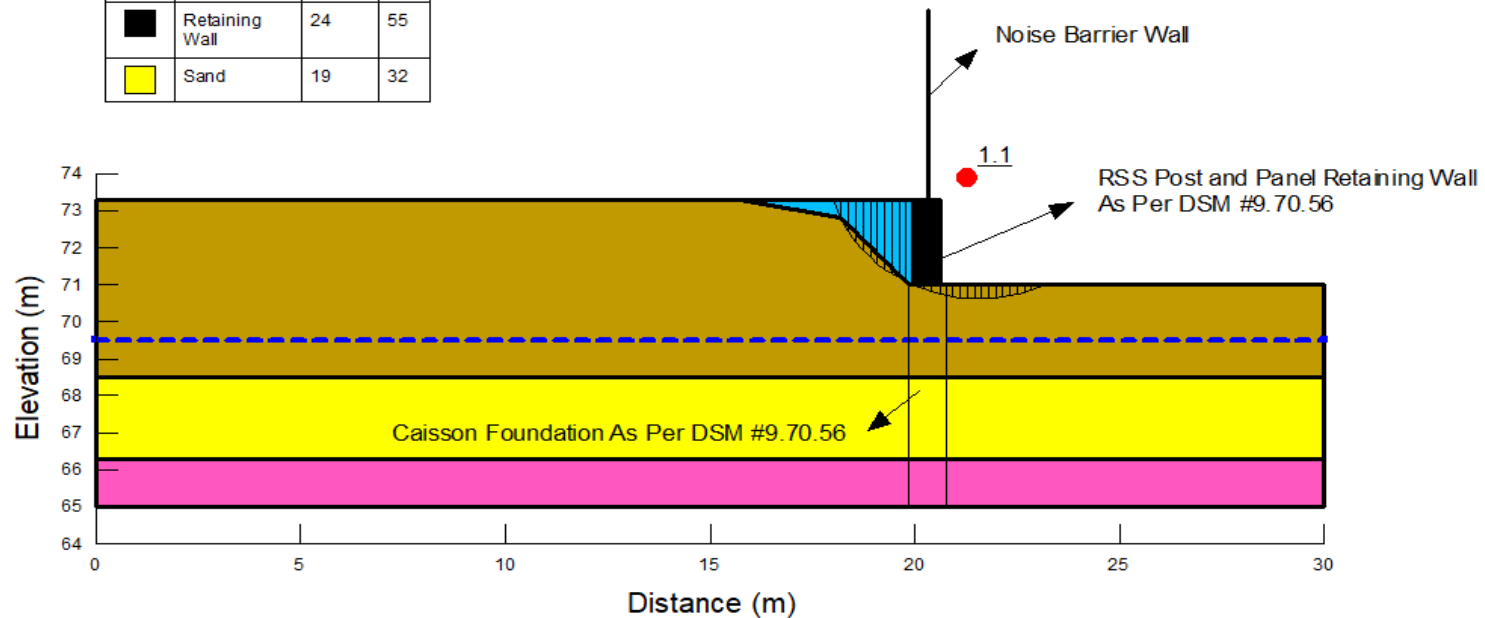
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 4S - Section 1 Post and Panel
Slope Stability - Static Analysis
 Ottawa, Ontario

Project No.	1655214-1900
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Date:	2019-11-26
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Figure E9

Title: RW4-S Orangeville Street
 File Name: 1655214-1900 RW 4S - Section 1.gsz
 Name: 1.2 Seismic Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horiz Seismic Coef: 0.14
 Groundwater Elevation of 69.5 m

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
	Bedrock		
	Existing Embankment Fill	20	33
	Granular A	22	35
	Retaining Wall	24	55
	Sand	19	32



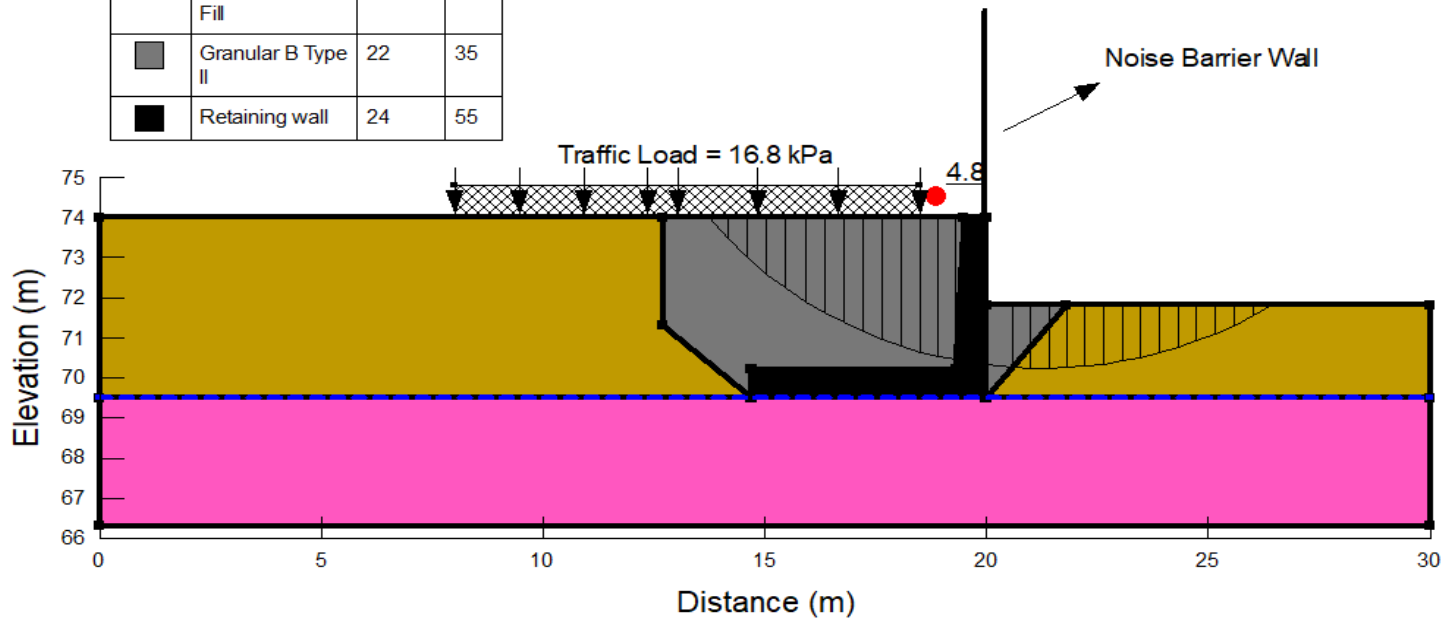
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 4S - Section 1 Post and Panel
Slope Stability - Seismic Analysis
Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
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Figure E10

Title: RW 4-S Orangeville Street
 File Name: 1655214-1900 RW 4S - Section 2.gsz
 Name: 1.1 Static Drained
 Method: Morgenstem-Price
 Direction of movement: Left to Right
 Horz Seismic Coef.:
 Groundwater Elevation of 69.5 m

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
█	Bedrock		
█	Existing Embankment Fill	20	33
█	Granular B Type II	22	35
█	Retaining wall	24	55







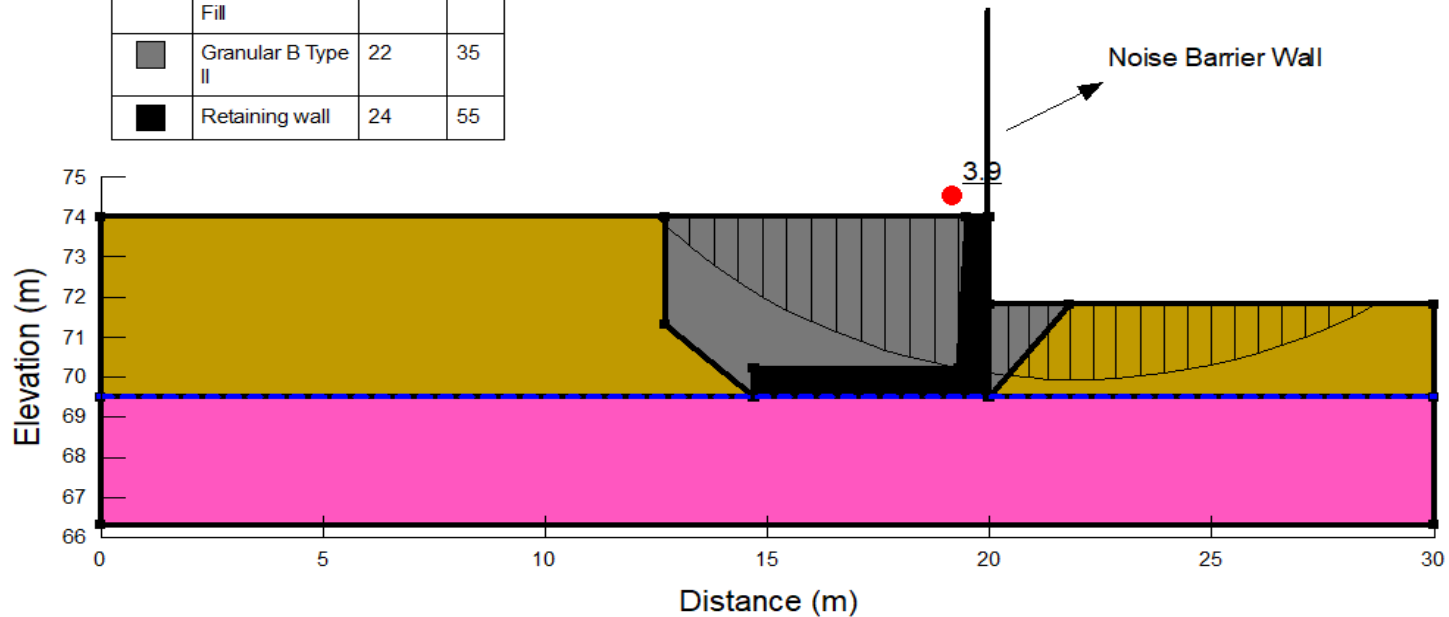
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 4S - Section 2 Concrete Retaining Wall
Slope Stability - Static Analysis
 Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
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Figure E11

Title: RW 4-S Orangeville Street
 File Name: 1655214-1900 RW 4S - Section 2.gsz
 Name: 1.2 Seismic Drained
 Method: Morgenstem-Price
 Direction of movement: Left to Right
 Horz Seismic Coef.: 0.14
 Groundwater Elevation of 69.5 m

Color	Name	Unit Weight (kN/m ³)	Phi ^r (°)
	Bedrock		
	Existing Embankment Fill	20	33
	Granular B Type II	22	35
	Retaining wall	24	55









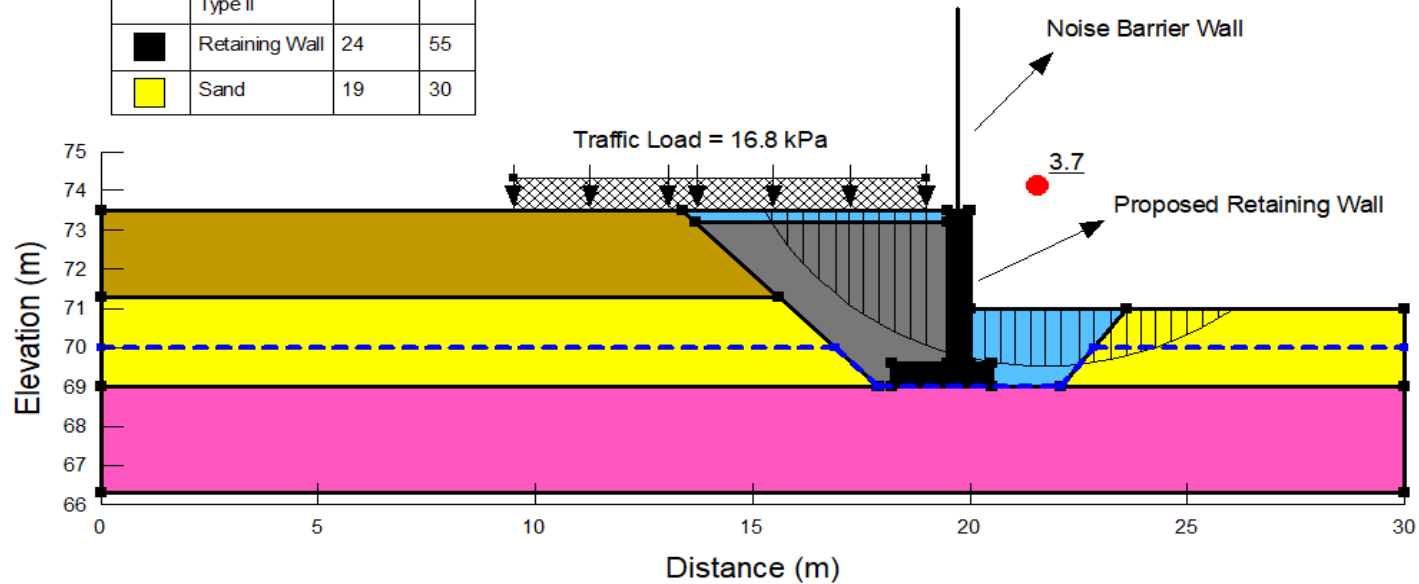
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 4S - Section 2 Concrete Retaining Wall
Slope Stability - Seismic Analysis
Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
Checked:	KCP
Review:	FJH

Figure E12

Title: RW 5-S Orangeville Street
 File Name: 1655214-1900 RW 5S on BR.gsz
 Name: 1.1 Static Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horz Seismic Coef.:
 Groundwater Elevation: 70 m

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
	Bedrock		
	Existing Embankment Fill	20	33
	Granular A	22	35
	Granular B Type II	22	35
	Retaining Wall	24	55
	Sand	19	30









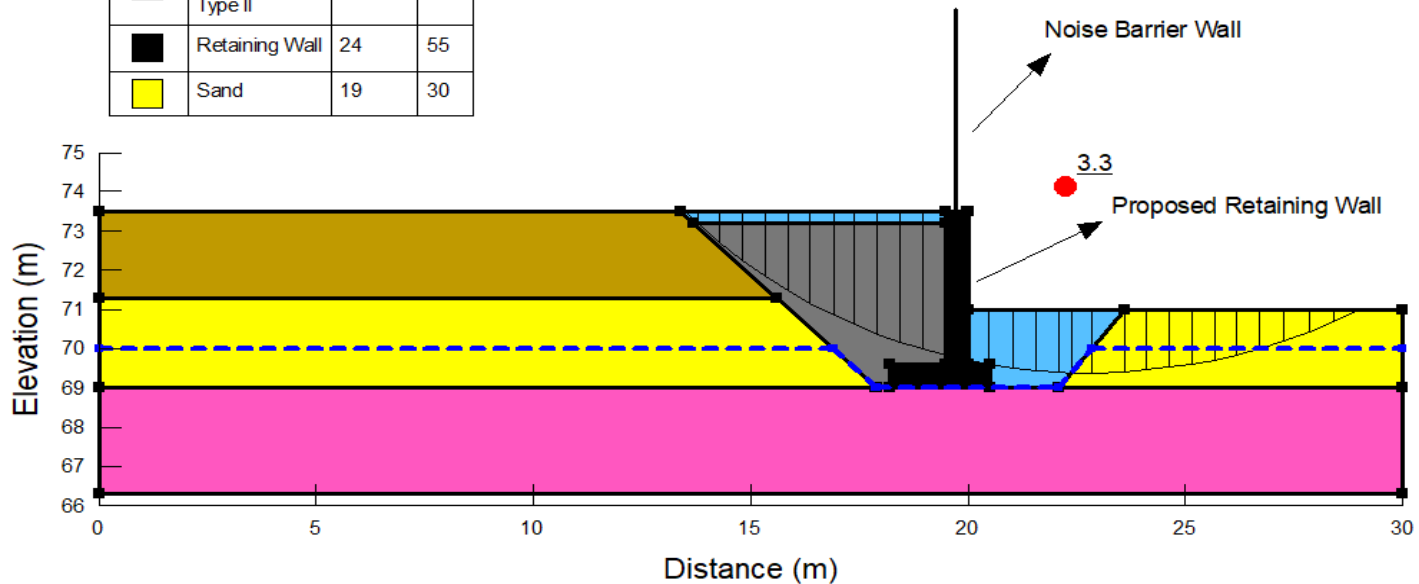
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 5S - Section 1 Concrete Retaining Wall
Slope Stability - Static Analysis
 Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
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Figure E13

Title: RW 5-S Orangeville Street
 File Name: 1655214-1900 RW 5S on BR.gsz
 Name: 1.2 Seismic Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horz Seismic Coef.: 0.12
 Groundwater Elevation: 70 m

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
	Bedrock		
	Existing Embankment Fill	20	33
	Granular A	22	35
	Granular B Type II	22	35
	Retaining Wall	24	55
	Sand	19	30



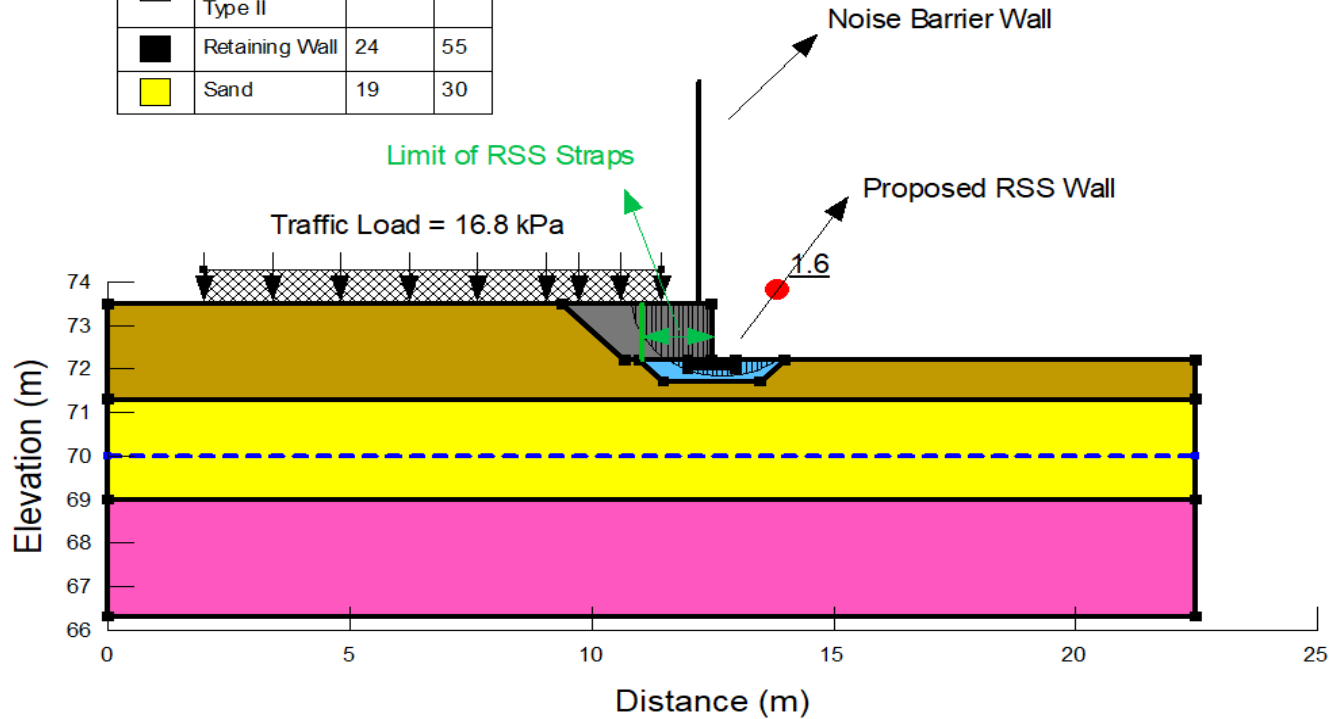
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 5S - Section 1 Concrete Retaining Wall
Slope Stability - Seismic Analysis
 Ottawa, Ontario

Project No.	1655214-1900
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Figure E14

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
■	Bedrock		
■	Existing Embankment Fill	20	33
■	Granular A	22	35
■	Granular B Type II	22	35
■	Retaining Wall	24	55
■	Sand	19	30

Title: RW 5-S Orangeville Street
 File Name: 1655214-1900 RW 5S.gsz
 Name: 1.1 Static Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horz Seismic Coef.:
 Groundwater Elevation: 70 m



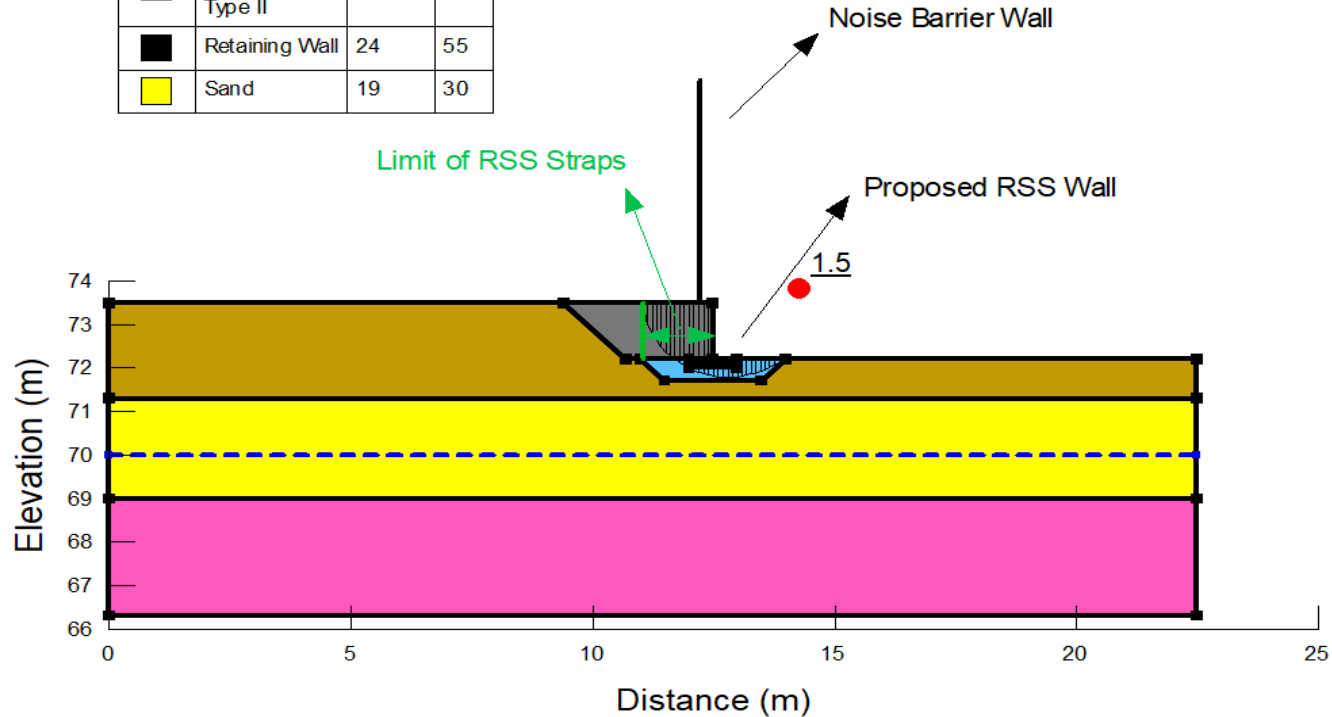
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 5S - Section 2 RSS Wall System
Slope Stability - Static Analysis
Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
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Figure E15

Color	Name	Unit Weight (kN/m ³)	Phi' (°)
■	Bedrock		
■	Existing Embankment Fill	20	33
■	Granular A	22	35
■	Granular B Type II	22	35
■	Retaining Wall	24	55
■	Sand	19	30

Title: RW 5-S Orangeville Street
 File Name: 1655214-1900 RW 5S.gsz
 Name: 1.2 Seismic Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horz Seismic Coef.: 0.15
 Groundwater Elevation: 70 m









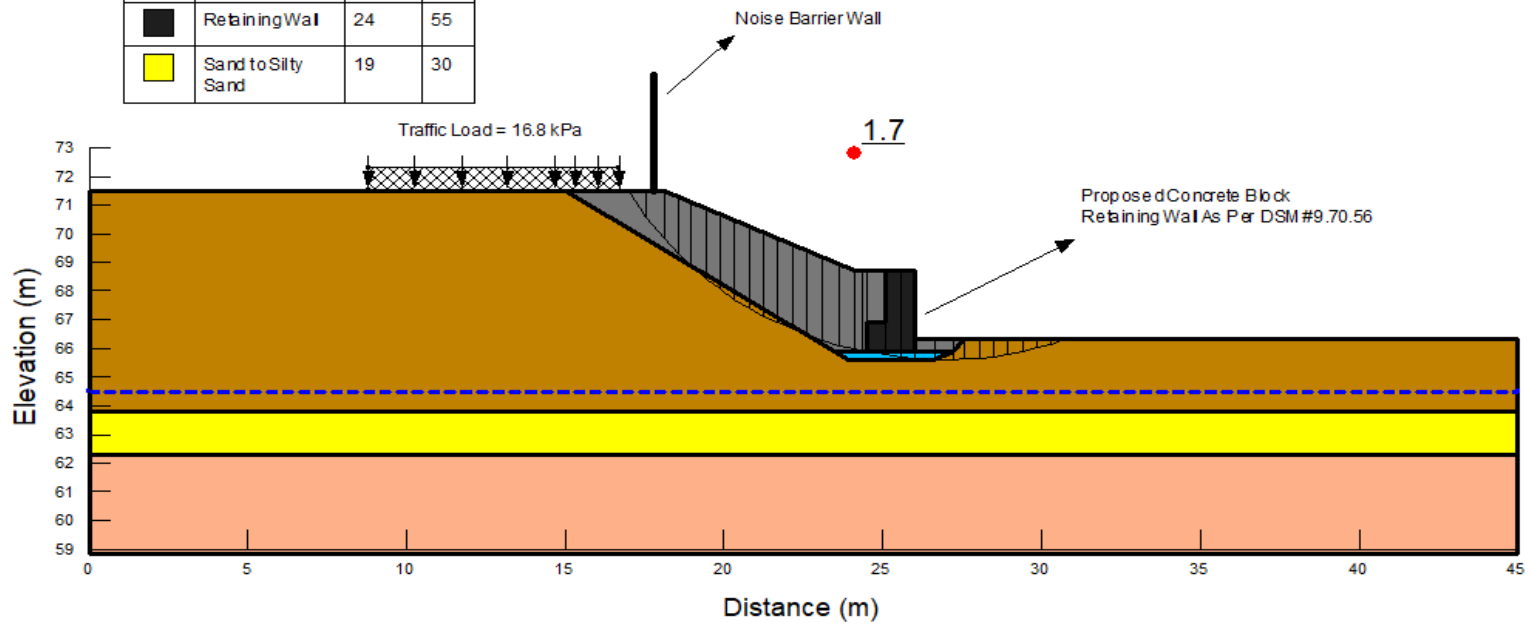
Foundation Investigation
Highway 417 Retaining Wall Replacement
and Rehabilitation
Retaining Wall RW 5S - Section 2 RSS Wall System
Slope Stability - Seismic Analysis
 Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
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Figure E16

File Name: 1655214 RW 7S Chamberlain Ave..gsz
 Name: 1.1 Static Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horiz Seismic Coef:
 Groundwater Level: 64.5 m

Color	Name	Unit Weight (kN/m ³)	Phi (°)
	Existing Embankment Fill	20	33
	Glacial Till	19	35
	Granular A	22	35
	Granular B Type II	22	35
	Retaining Wall	24	55
	Sand to Silty Sand	19	30









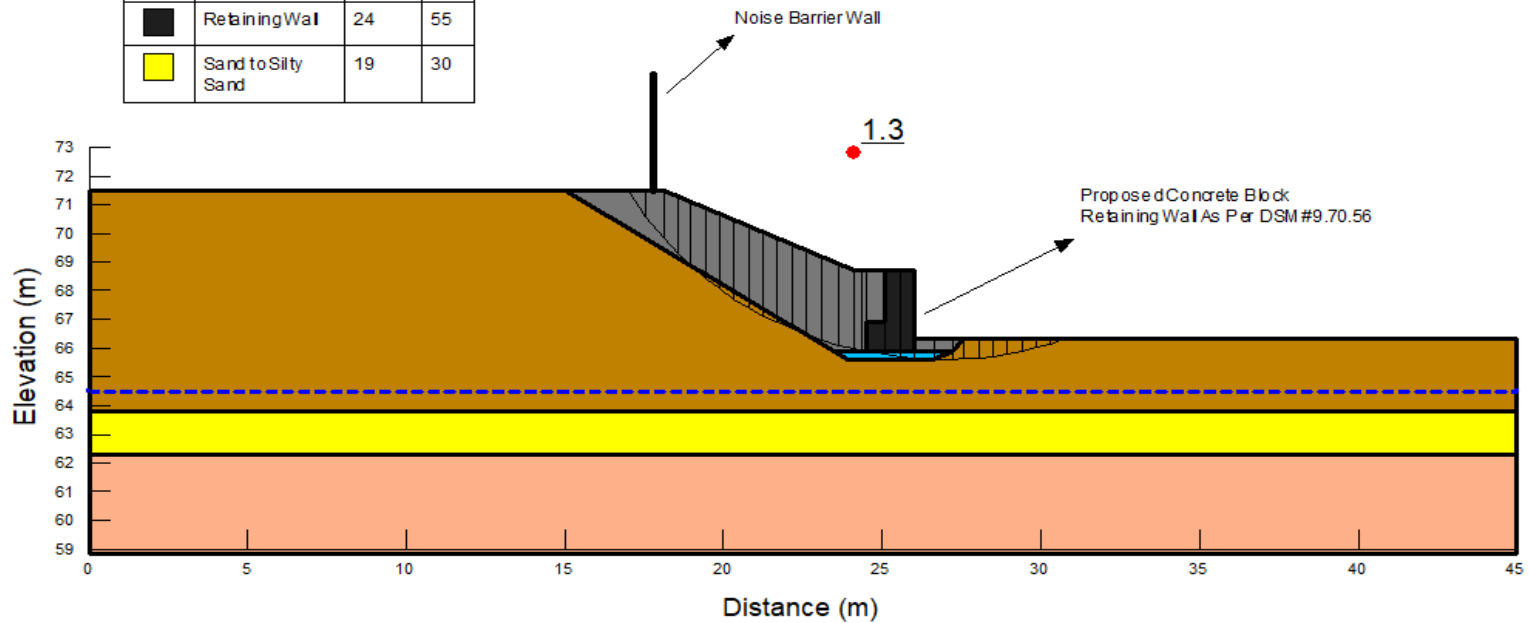
Foundation Investigation
Highway 417 Retaining Wall Replacement and Rehabilitation
Retaining Wall RW 7S
Slope Stability - Static Analysis
Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
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Figure E17

File Name: 1655214 RW 7S ChamberlainAve..gsz
 Name: 1.2 Seismic Drained
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horiz Seismic Coef: 0.15
 Groundwater Level: 64.5 m

Color	Name	Unit Weight (kN/m ³)	Phi (°)
	Existing Embankment Fill	20	33
	Glacial Till	19	35
	Granular A	22	35
	Granular B Type II	22	35
	Retaining Wall	24	55
	Sand to Silty Sand	19	30



Foundation Investigation
Highway 417 Retaining Wall Replacement
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Retaining Wall RW 7S
Slope Stability - Seismic Analysis
Ottawa, Ontario

Project No.	1655214-1900
Drawn:	RK
Date:	2019-11-26
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Figure E18

APPENDIX F

NON-STANDARD SPECIAL PROVISION

NON-STANDARD SPECIAL PROVISIONS

RECOMMENDED WORDING FOR “NSSP – TEMPORARY PROTECTION SYSTEM”

Temporary protection system will be installed in ground conditions that include cobbles, boulders and relatively shallow depth to bedrock. The Contractor’s installation method and temporary protection system must penetrate obstructions such as cobbles, boulders or other obstructions within the fill and glacial till and bedrock.

RECOMMENDED WORDING FOR “NSSP CONTROL OF OVERBURDEN SOILS”

Excavations for the caisson installation will be advanced through granular fill materials, various interlayers of granular native material through/into glacial till and into the limestone bedrock at some locations. The granular soils could slough (if dry) or flow (if water-bearing) into unsupported auger holes during caissons installation. Appropriate construction procedures and equipment will be required to minimize ground loss during drilling, caisson installation and concrete placement.

RECOMMENDED WORDING FOR “NSSP – SPECIAL PROVISION 517F01 – DEWATERING SYSTEM RW13N and RW1S”

Table A of SP517F01 is amended by the addition of the following: The design Engineer and design-checking Engineer of the dewatering system shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work.

RECOMMENDED WORDING FOR “NSSP – PERCHED RETAINED SOIL SYSTEM RW13N”

The Contractor is advised that the proposed retaining wall structure for RW13N is designed as a perched RSS wall system that is to be founded on existing fill. As such should fill materials be encountered at the founding elevation during subgrade preparations the fill is not to be disturbed prior to placement of the Granular B Type II pad. Excavations to the required depths will likely encounter groundwater hence control of the groundwater and surface water flow will be required at the site to permit the removal of the existing wall, construction of the granular pad and installation of the proposed wall system in a dry and stable excavation.

The Contractor is also advised that the soil that will be exposed at the subgrade during the construction of the foundation for RW13N is moisture sensitive and may become disturbed or otherwise negatively impacted when subjected to construction or personal traffic, freeze thaw actions, ingress or ponding water. The Contractor shall be responsible for implementing adequate groundwater control measures and to minimize construction and personnel traffic on the founding subgrade.



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