



THURBER ENGINEERING LTD.

MEMORANDUM

To: Cedar Leung, P.Eng.
LEA Consulting Limited

April 12, 2023

From: Christopher Murray, M.A.Sc., P.Eng.
(Reviewed by Dr. Fred Griffiths, P.Eng.)

Thurber File No.: 35062

**TECHNICAL MEMORANDUM
STEEP COBBLE SLOPE, EROSION MITIGATION
HIGHWAY 129, 37.4 KM NORTH OF HIGHWAY 554
AGREEMENT NO. 5020-E-0012, WORK ITEM #6
GWP 5161-18-00**

GEOCRES NO: 41J-144

1. Introduction

This memorandum presents an assessment of suitable alternatives for erosion mitigation measures for the existing earth cut within the project area and provides foundation recommendations for the tender of the technically preferred alternative. The discussions provided in this memorandum are based on the interpretation of the factual data obtained from a foundation investigation completed by Thurber Engineering Limited (Thurber). A separate Foundation Investigation and Design Report (GEORES: TBD) has been prepared for the design of a retaining wall along the toe of the earth slope. Thurber carried out the assignment as a sub-consultant to a McIntosh Perry | LEA Consulting Joint Venture (MPLJV) under Agreement No. 5020-E-0012, Work Item No. 6.

This interpretation and recommendations contained within this technical memorandum are intended for the use of the Ministry of Transportation, McIntosh Perry Consulting Engineers and LEA Consulting Limited and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data presented in Sections 1 through 4 of this memorandum. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

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



2. Site Description

For project purposes, Highway 129 and the crest of the slope is herein described as oriented north-south. The site is located on the east side of Highway 129 approximately 37.35 km to 37.52 km north of Highway 554 (Station 19+180 to 19+350 RT) in Dagle Township. The Mississagi River runs on the west side of Highway 129, parallel to the highway alignment with flow to the south. The area in the vicinity of the site is generally, undeveloped and densely vegetated with coniferous and deciduous trees. The regional terrain is relatively rugged.

Within the project limits, Highway 129 is a two-lane undivided highway and has a posted speed limit of 80 km/h. The traffic volume is understood to have been 350 AADT (2016). The centerline profile of Highway 129 gradually slopes upwards from Station 19+150 to 19+275 (elev. 303.7 to 307.5 m). North of Station 19+275, the highway surface slopes gradually downward to approximately elevation 305.3 m at Station 19+350 (north project limit). No guiderails are present on either side of the highway at the site. Site photos taken at the time of the field investigation are attached to this memorandum.

It is understood that ongoing erosion with cobbles rolling down the slope and onto the travelled portion of the highway have occurred at this site. In addition, it is noted that the existing ditch at this location is very shallow. A proposed toe wall will widen the east ditch and clear zone adjacent to Highway 129. A drawing showing the existing slope and typical toe wall sections was provided by MPLJV and is attached to this memo. A review of the slope inclination in the project length was completed and the cut slope was found to range from 33 to 39 degrees from horizontal (1.5H:1V to 1.2H:1V) with a median value of 36 degrees. The toe of slope elevation ranges from approximately 307.2 to 303.8 m and crest of cut elevation ranges from approximately 328.1 to 323.4 m within the project area. The length along the slope measured from the existing crest to existing toe ranges from 35 to 40 m. Visible signs of global slope instabilities were not observed, but active surficial erosion with exposed cobbles was noted along the project area, especially near Sta. 19+350. Sand and cobbles, some trees, grass, and shrubs are present on the face of the slope.

No historical information was available within the online GEOCREST library for this site.

3. Methodology

The site investigation and field-testing program was carried out between September 13th and October 11th, 2022. Twelve (12) off-road hand-auger holes were advanced along the existing earth cut slope and are identified as Boreholes 22-06 to 22-17. Hand auger boreholes and sampling were carried out by a member of Thurber's technical staff using an auger with an



external diameter of 51 mm. The target depth for the hand auger holes was set at 3 m below ground surface. At borehole locations which reached refusal at shallower depth, a second hole was augered adjacent to the initial hole. Prior to commencement of the field investigation, utility clearances were obtained in the vicinity of the boreholes.

The as-drilled borehole elevations were surveyed by Thurber with a surveyor's level with a reported vertical accuracy of +/- 1.5 mm. The elevations were reviewed and referenced to the survey provided by LEA. Horizontal locations were measured by Thurber relative to existing site features. The approximate locations of the hand auger boreholes are shown on the Borehole Location Drawing attached to this memorandum. The coordinates and elevation of the hand auger boreholes are provided on this drawing and on the Record of Borehole sheets, also attached to this memorandum.

4. Description of Subsurface Conditions

A general description of the stratigraphy based on the conditions encountered in the hand auger boreholes from the current investigation is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over the general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond borehole locations. Soil classification is in accordance with ASTM D 2487 with cohesive soils described as per current MTO Guidelines for Foundation Engineering Services.

In general terms, the encountered stratigraphy consisted of topsoil (only encountered at the crest of the cut slope) overlying a native sand with silt and gravel to gravel with silt and sand deposit. Frequent cobbles were encountered within the native soil layer. None of the auger holes reached the termination depth of 3 m below ground surface. The borehole logs provided present information from the deepest of multiple hand auger attempts at each location.

4.1 Topsoil

A surficial topsoil layer was encountered at Boreholes 22-07, 22-09, 22-12, and 22-15, which are located at the crest of the earth slope. The topsoil is generally composed of rootmat and has a thickness ranging from 80 to 130 mm.

4.2 Sand with Silt and Gravel to Gravel with Silt and Sand

A native layer of sand with silt and gravel to gravel with silt and sand was encountered below the topsoil in the Boreholes 22-07, 22-09, 22-12, and 22-15 and from ground surface in holes 22-06, 22-08, 22-10, 22-11, 22-13, 22-14, 22-16, and 22-17. Frequent cobbles were encountered within

the layer, and the soil near the crest of the slope was found to contain a greater amount of silt. The layer was not fully penetrated in the hand-auger holes but was proven to extend to approximately 0.5 to 1.5 m below the existing ground surface.

The recorded moisture content ranged from 1 to 19% but was typically less than 8%. The results of gradation analyses completed on five samples of the layer are illustrated on Figure C1. The results of the tests are summarized below and on the Record of Borehole sheets.

Soil Particle	Percentage (%)
Gravel	20 to 64
Sand	30 to 61
Silt & Clay	2 to 26

Although too large for typical gradation testing, the cobbles were observed to range in size from 75 to 200 mm and generally consisted of rounded particles. The heterogeneous mixture of a wide range of particle sizes is indicative of a glacial till deposit. Although not observed in the boreholes or on the slope, it should be anticipated that boulders are also present in this native soil deposit.

4.3 Refusal

All the boreholes advanced during the current investigation were terminated upon encountering practical refusal to hand auger advancement. The hand-auger refusals encountered during the current investigation may represent the presence of cobbles or a boulder within the layer.

4.4 Groundwater Level

Groundwater was not encountered within the depth of the boreholes.

5. Geotechnical Considerations

Based on the results of the field and laboratory investigation and the information provided by the MPLJV with regards to the proposed project requirements, the geotechnical design considerations include:

- The existing cut slope is steep (1.5H:1V to 1.2H:1V).
- The existing cut slope is high (~20 m in elevation).
- The existing cut slope geometry including height, inclination and the length allows for a long, unimpeded run for surface water resulting from snowmelt and/or precipitation causing erosion.



- The presence of cobbles within the cut slope soils is an inherent hazard with cobbles rolling down the slope and into the near driving lane. The cobbles are released from the slope as the surrounding soil matrix is eroded away by flowing water.
- The vegetation cover on the existing slope is minimal.
- Property constraints will limit the available property to allow for slope flattening above the existing cut slope crest as well as access to the crest of slope.

6. Evaluation of Design Options

Given the geometry of the existing cut slope, the proposed construction of a toe wall to increase the ditch and clear zone at the toe and the requirement to mitigate against erosion of the existing cut slope, the following options were considered for control of erosion of the existing slope behind the toe wall:

- Maintain Existing Slope and Enhance Catchment
- Slope Flattening
- Turf Reinforcement Mat
- Turf Reinforcement Mat with Anchored Wire Mesh

These alternatives are discussed in the following paragraphs and evaluated from a geotechnical perspective in terms of their respective advantages, disadvantages, risks and consequences. The evaluation is summarized in a table attached to this memo. A preferred erosion mitigation alternative from a geotechnical engineering perspective is identified.

- Maintain Existing Slope and Enhance Catchment
Consideration could be given to maintaining the existing slope and reducing the risk of cobbles reaching the driving lanes by providing a catchment barrier. This could consist of constructing a wire mesh fence on top of the proposed toe wall to catch cobbles as they roll down the slope. The wire mesh fence and the toe wall would need to be designed to withstand the impact energy of free rolling cobbles. Alternatively, a guiderail could be installed along the eastern shoulder of Highway 129 within the project area. The guiderail would need to be equipped with additional, lower, channels. This option would involve continued maintenance costs to clear the cobbles from behind the catchment barrier as needed as well as periodic barrier repairs.
- Slope Flattening
Flattening and vegetating the existing slope with benches incorporated could be considered as an erosion mitigation measure. Slope flattening would involve substantial

earth works and significant property acquisition above the existing crest of the cut. This option would reduce the unimpeded flow of water over the slope and thus the erosion of the existing soil. The benches would provide intermediate catchment zones if cobbles do come free along the slope due to erosion. In addition, an interceptor ditch such as that indicated on OPSD 200.010 should be constructed at the top of the slope to direct overland flow to erosion protected channels.

- **Turf Reinforcement Mat**

Turf Reinforcement Mats are proprietary systems that can either be vegetated or unvegetated and provide immediate erosion protection and long-term site armoring. If vegetated, they can assist in the establishment and permanent reinforcement of vegetation in applications where the force exerted by water exceed the shear limits of unreinforced vegetation such as unimpeded water flow over a long slope. Given the existing slope inclination and anticipated length of unimpeded water flow, a high-performance turf reinforcement mat consisting of a three-dimensional woven polypropylene geotextile and ground anchors would likely be required for this site. If vegetation above the turf reinforcement mat is desired, coir logs should be considered to reduce the unimpeded water flow down the slope to reduce erosion of topsoil during the establishment of vegetation.

- **Turf Reinforcement Mat with Anchored Wire Mesh**

Turf reinforcement mats discussed above can be reinforced with proprietary steel woven wire mesh installed and anchored above the turf reinforcement mat to provide increased slope friction between low friction angle surfaces, permanent erosion control and reinforcement of steep slopes. Anchored wire mesh systems are suitable for rock control and the system can be vegetated or unvegetated. Coir logs should still be considered in conjunction with this system to aid in the establishment of vegetation.

7. Recommended Erosion Mitigation Alternative

Based on an evaluation of the erosion mitigation design alternatives and the geometry of the existing slope, the proposed toe wall and the MTO right of way property available, the recommended erosion mitigation option is a turf reinforcement mat with anchored wire mesh.

Foundation considerations are presented for the recommended alternative in the following sections.



8. Construction Considerations

8.1 Turf Reinforcement Mat with Anchored Wire Mesh Design

The design of the turf reinforcement mat with anchored wire mesh must be completed by the selected specialty supplier since these are proprietary systems. The system should be designed to meet the following requirements:

- Provide erosion protection over the complete slope.
- Provide rock control to prevent the cobbles from rolling down the slope.
- Allow for the establishment of vegetation over the entire protected face of the slope.
- A minimum design life of 75 years with respect to polypropylene turf reinforcement mat and corrosion resistance of the wire mesh and anchors.

It is our understanding that the Ministry specified a Maccaferri MACMAT R8P in Contract 2021-5095. That product combines a three-dimensional polypropylene turf reinforcement mat with a layer of anchored Galfan and PVC coated double twisted hexagonal steel wire mesh. Example project specifications based on Contract 2021-5095 are attached to this memo. The determination of whether this system will work for the Highway 129 steep cobble slope would need to be confirmed by Maccaferri prior to finalizing the turf reinforcement mat specifications for this assignment.

8.2 Interceptor Ditch

An interceptor ditch such as that indicated on OPSD 200.010 should be considered behind the crest of the existing slope to direct overland flow away from the cut slope. A reduction in surface water flow will aid in the establishment of vegetation on the turf reinforcement mat with anchored wire mesh system.

8.3 Corrosion Resistance

The turf reinforcement mat should consist of UV stabilized polypropylene and the anchored wire mesh should be both galvanized (or equivalent) and PVC coated to prevent corrosion to ensure that the lifespan of the turf reinforcement mat with anchored wire mesh meets the 75 year design life requirement. The polypropylene turf reinforcement mat, although UV stabilized, should be provided with vegetation cover as soon as practical following placement since prolonged UV exposure will still cause degradation of the polypropylene reduce the service life. If the wire mesh corrosion protection becomes damaged during installation it should be repaired in a manner approved by the manufacturer.



8.4 Construction Staging

Construction should be staged in such a way that the turf reinforcement mat with anchored wire mesh is installed following the installation of the toe wall. This will allow the turf reinforcement mat with anchored wire mesh system to be secured to the toe wall at the toe of the slope and prevent damage to the system that could result from the installation of the toe wall.

8.5 Removal of Existing Trees/Shrubs

The existing small trees and shrubs should be removed from the slope with close cut tree clearing prior to the installation of the turf reinforcement mat with anchored wire mesh to allow for the installation of the system. Allowing trees to remain on the slope would require additional turf reinforcement mat splices and could lead to localized zones of reduced vegetation on the turf reinforcement mat.

8.6 Establishing Vegetation

It is anticipated that it will be difficult to establish vegetation on the slope due to its steepness and the existing soil type. Selection of the seed mix and type of topsoil for the site environment should be completed by qualified persons. Coir logs could be considered to reduce the flow velocity of water draining down the slope and assist in establishing vegetation by reducing erosion prior to the formation of a solid rootmat.

9. Closure

Engineering analysis and preparation of this technical memorandum were carried out by Mr. Anderson de Oliveira and Mr. Christopher Murray, P.Eng. The report was reviewed Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:



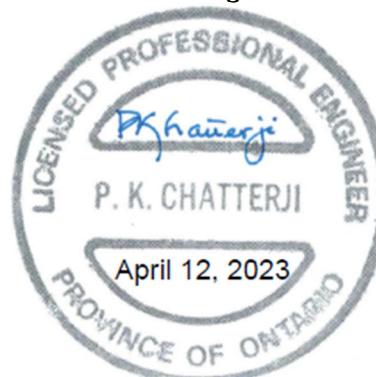
Anderson de Oliveira, M.A.Sc., E.I.T.
Geotechnical Engineering Intern



Dr. Fred Griffiths, P.Eng.
Senior Associate
Senior Geotechnical Engineer



Christopher Murray, M.A.Sc., P.Eng.
Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.
Designated Principal Contact
Senior Geotechnical Engineer

Attachments:

- Statement of Limitations and Conditions
- Site Photographs
- Borehole Location Drawing
- Symbols and Terms
- Record of Boreholes
- Laboratory Test Results
- Typical Slope Cross-Section
- Comparison Table of Erosion Mitigation Measures
- Example Turf Reinforcement Mat with Anchored Wire Mesh Specification

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

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

2. COMPLETE REPORT

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

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

3. BASIS OF REPORT

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

4. USE OF THE REPORT

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

5. INTERPRETATION OF THE REPORT

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

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

7. INDEPENDENT JUDGEMENTS OF CLIENT

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



Photo 1. Toe of earth slope (looking north) *[taken Sept. 2022]*



Photo 2. Active erosion near Sta. 19+350 (looking east) *[taken Sept. 2022]*



Photo 3. Mississagi River running parallel to Hwy 129 (looking south) *[taken Sept. 2022]*

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No

HIGHWAY 129
COBBLE HILL



SHEET

BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

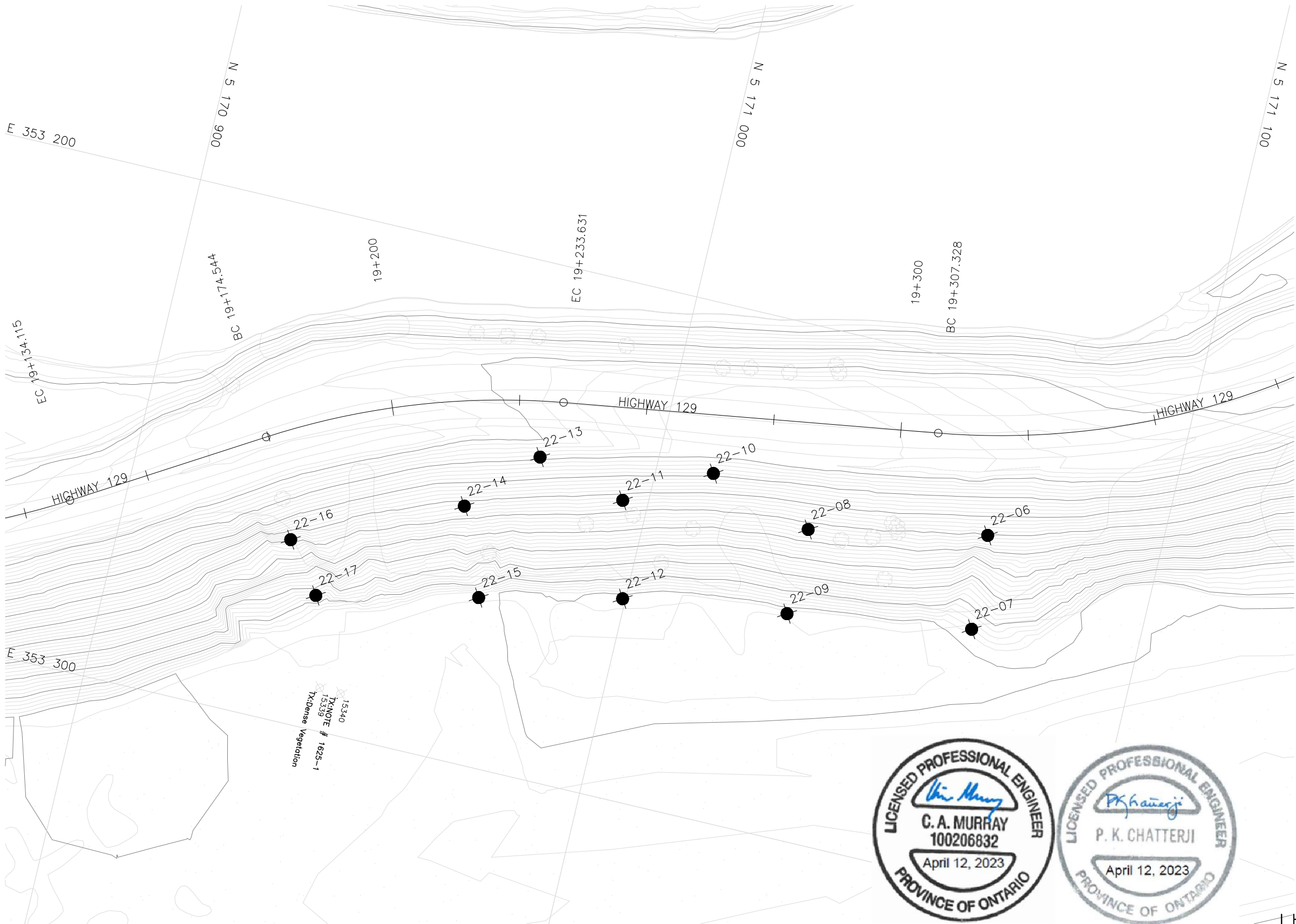
NO	ELEVATION	NORTHING	EASTING
22-06	314.8	5 171 066.2	353 232.4
22-07	327.8	5 171 067.4	353 251.0
22-08	315.6	5 171 031.7	353 239.4
22-09	328.1	5 171 031.5	353 256.4
22-10	309.3	5 171 011.1	353 233.0
22-11	313.1	5 170 995.0	353 242.2
22-12	327.4	5 170 999.4	353 260.9
22-13	306.6	5 170 977.3	353 237.6
22-14	312.8	5 170 965.1	353 250.4
22-15	327.0	5 170 971.9	353 267.2
22-16	313.7	5 170 933.4	353 264.6
22-17	323.4	5 170 940.8	353 274.1

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 13.

GEOCRES No. 41J-144

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CM	CHK PKC	CODE
DRAWN	MC	CHK CM	SITE
LOAD	DATE	NOV 2022	
STRUCT	DWG	1	



BOREHOLE PLAN



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

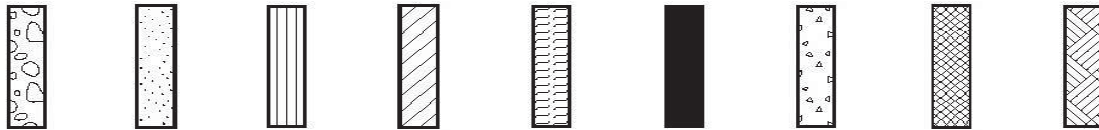
DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



STRATA PLOT:

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



Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Bedrock
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TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No 22-06

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.677441°, Long: -83.366936°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 171 066.2 E 353 232.4 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.10.10 - 2022.10.10 CHECKED BY CM


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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
314.8	Ground Surface																
0.0	SAND with Silt and Gravel to GRAVEL with Silt and Sand Frequent Cobbles Loose Greyish brown		1	GS	-											39 55 6 (SI+CL)	
314.1																	
0.7	End of Borehole																

RECORD OF BOREHOLE No 22-07

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.677449°, Long: -83.366692°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 171 067.4 E 353 251.0 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM

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									
327.8	Ground Surface																
0.0	TOPSOIL (130 mm)																
0.1	SAND with Silt and Gravel to GRAVEL with Silt and Sand Trace Rootlets Frequent Cobbles Very loose Brown		1	GS	-												
327.1	End of Borehole																
0.7																	

DOUBLE LINE 35062 COBBLE HILL - HAND AUGER HOLES.GPJ 2012TEMPLATE(MTO).GDT 4-13-23

RECORD OF BOREHOLE No 22-08

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.677129°, Long: -83.366849°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 171 031.7 E 353 239.4 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
315.6	Ground Surface																
0.0	SAND with Silt and Gravel to GRAVEL with Silt and Sand Trace Rootlets Frequent Cobbles Loose		1	GS	-												
314.9	Greyish brown																
0.7	End of Borehole																

RECORD OF BOREHOLE No 22-09

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.677125°, Long: -83.366626°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 171 031.5 E 353 256.4 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM


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	100					
328.1	Ground Surface																
0.0	TOPSOIL (120 mm)					328											
0.1	SAND with Silt and Gravel to GRAVEL with Silt and Sand Trace Rootlets Frequent Cobbles Very loose Light brown		1	GS	-											64 30 6 (SI+CL)	
327.1	End of Borehole																
1.0																	

RECORD OF BOREHOLE No 22-10

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676944°, Long: -83.366935°
 HWY 129 BOREHOLE TYPE Hand Auger ORIGINATED BY AH
 DATUM Geodetic DATE 2022.09.19 - 2022.09.19 COMPILED BY AO
 CHECKED BY CM

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										WATER CONTENT (%)				
309.3	Ground Surface		1	GS	-		309	20	40	60	80	100										
0.0	SAND with Silt and Gravel to GRAVEL with Silt and Sand																					
308.8	Trace Rootlets																					
0.5	Frequent Cobbles Loose Brown End of Borehole																					


DOUBLE LINE 35062 COBBLE HILL - HAND AUGER HOLES.GPJ 2012TEMPLATE(MTO).GDT 4-13-23

RECORD OF BOREHOLE No 22-11

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676798°, Long: -83.366816°
 Hwy 129 Steep Cobble Slope, MTM z13: N 5 170 995.0 E 353 242.2 ORIGINATED BY BC
 HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
 DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM

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														
313.1	Ground Surface		1	GS	-		313	20	40	60	80	100										
0.0	SAND with Silt and Gravel to GRAVEL with Silt and Sand Trace Rootlets Frequent Cobbles Loose Greyish brown																					
312.2																						
0.9	End of Borehole																					

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22-12

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676837°, Long: -83.366571°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 170 999.4 E 353 260.9 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM


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	100					
327.4	Ground Surface																
0.0	TOPSOIL (100 mm)																
0.1	SILTY SAND with Gravel Trace Rootlets Frequent Cobbles Very loose Brown		1	GS	-												
326.4																	
1.0	End of Borehole																

RECORD OF BOREHOLE No 22-13

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676639°, Long: -83.366877°
 Hwy 129 Steep Cobble Slope, MTM z13: N 5 170 977.3 E 353 237.6 ORIGINATED BY AH
 HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
 DATUM Geodetic DATE 2022.09.19 - 2022.09.09 CHECKED BY CM

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									
306.6	Ground Surface							20	40	60	80	100					GR SA SI CL
0.0	SAND with Silt and Gravel to GRAVEL with Silt and Sand Trace Rootlets Frequent Cobbles Loose Brown		1	GS	-		306										34 61 5 (SI+CL)
305.1																	
1.5	End of Borehole																

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 22-14

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676528°, Long: -83.366712°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 170 965.1 E 353 250.4 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM

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						
312.8	Ground Surface																
0.0	SAND with Silt and Gravel to GRAVEL with Silt and Sand Trace Rootlets Frequent Cobbles		1	GS	-												
312.2	Loose Greyish brown																
0.6	End of Borehole																

RECORD OF BOREHOLE No 22-15

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676589°, Long: -83.366491°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 170 971.9 E 353 267.2 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM

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									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
327.0	Ground Surface																
0.0	TOPSOIL (80 mm)																
0.1	SILTY SAND with Gravel Trace Rootlets Frequent Cobbles Very loose Light yellowish brown		1	GS	-											20 54 26 (SI+CL)	
326.0																	
1.0	End of Borehole																

RECORD OF BOREHOLE No 22-16

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676243°, Long: -83.366529°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 170 933.4 E 353 264.6 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
313.7	Ground Surface																
0.0	SAND with Silt and Gravel to GRAVEL with Sand Trace Rootlets Frequent Cobbles Loose Greyish brown		1	GS	-											62 36 2 (SI+CL)	
313.1																	
0.6	End of Borehole																

RECORD OF BOREHOLE No 22-17

1 OF 1

METRIC

GWP# 5020-E-0012 LOCATION Lat: 46.676308°, Long: -83.366404°
Hwy 129 Steep Cobble Slope, MTM z13: N 5 170 940.8 E 353 274.1 ORIGINATED BY BC
HWY 129 BOREHOLE TYPE Hand Auger COMPILED BY AO
DATUM Geodetic DATE 2022.11.10 - 2022.11.10 CHECKED BY CM

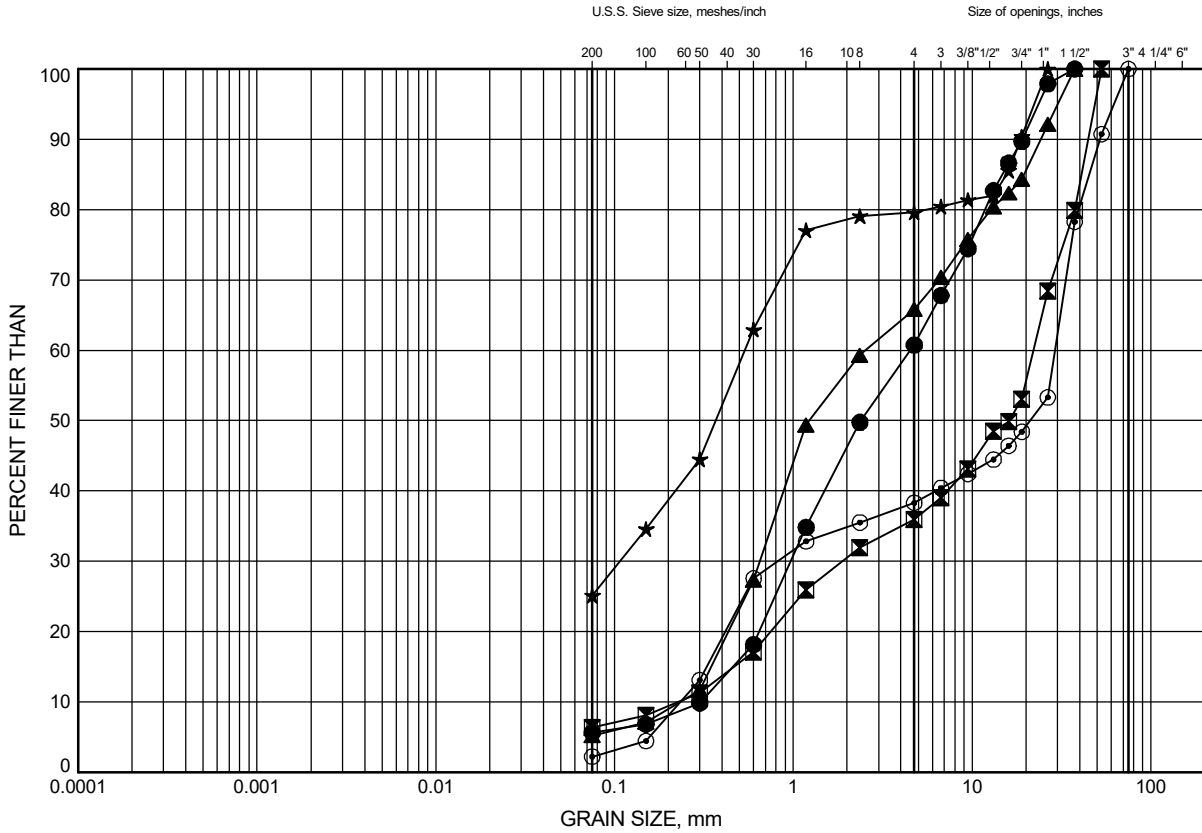
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
323.4	Ground Surface																
0.0	SAND with Silt and Gravel to GRAVEL with Silt and Sand Trace Rootlets Frequent Cobbles Loose Brown		1	GS	-												
322.7																	
0.7	End of Borehole																

Highway 129 - Cobble Hill

GRAIN SIZE DISTRIBUTION

FIGURE C1

Sand with Silt and Gravel to Gravel with Silt and Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	22-06	0.3	314.5
⊠	22-09	0.6	327.5
▲	22-13	0.7	305.9
★	22-15	0.5	326.5
⊙	22-16	0.3	313.4

Date December 2022

GWP# 5020-E-0012

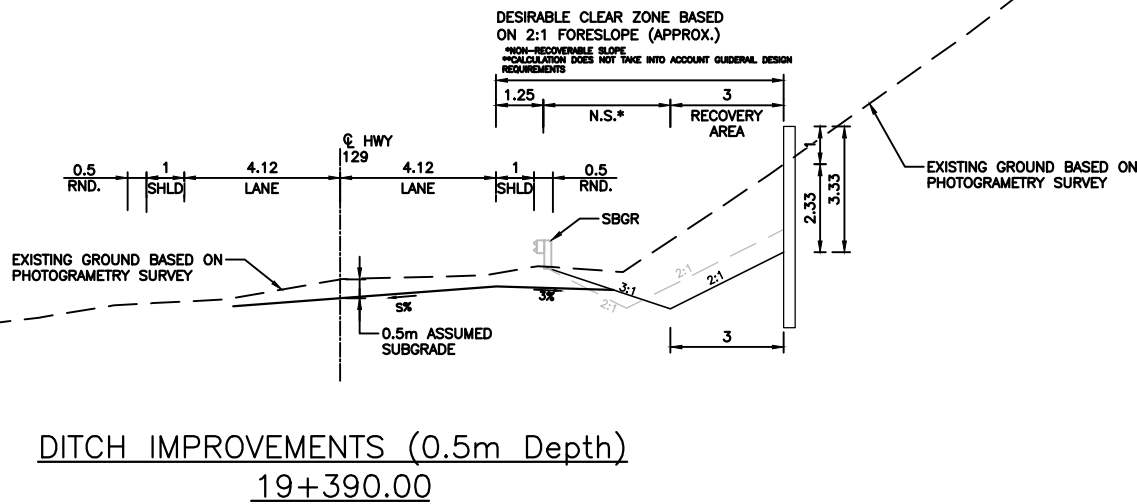
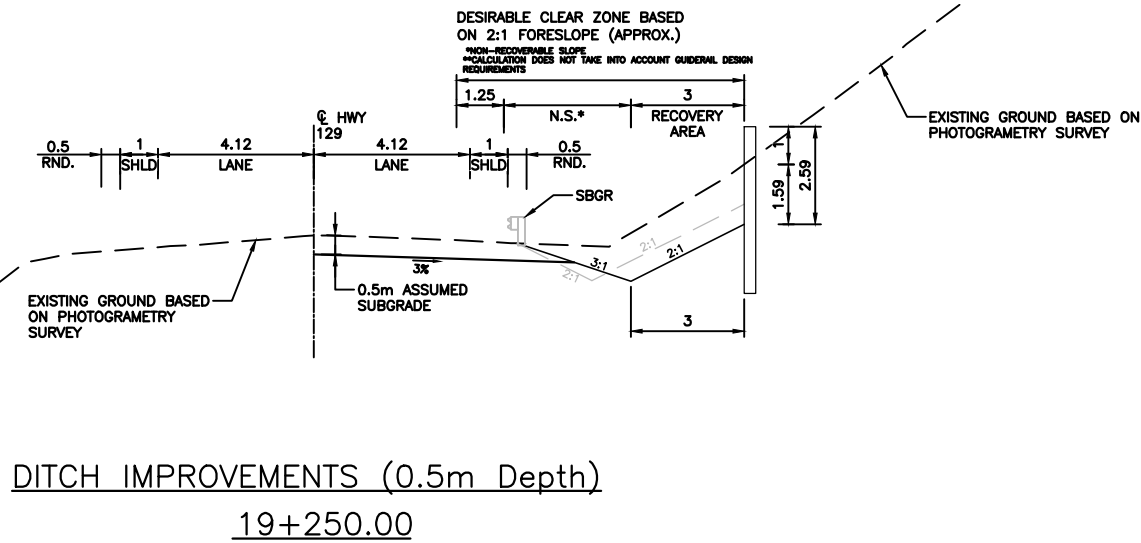
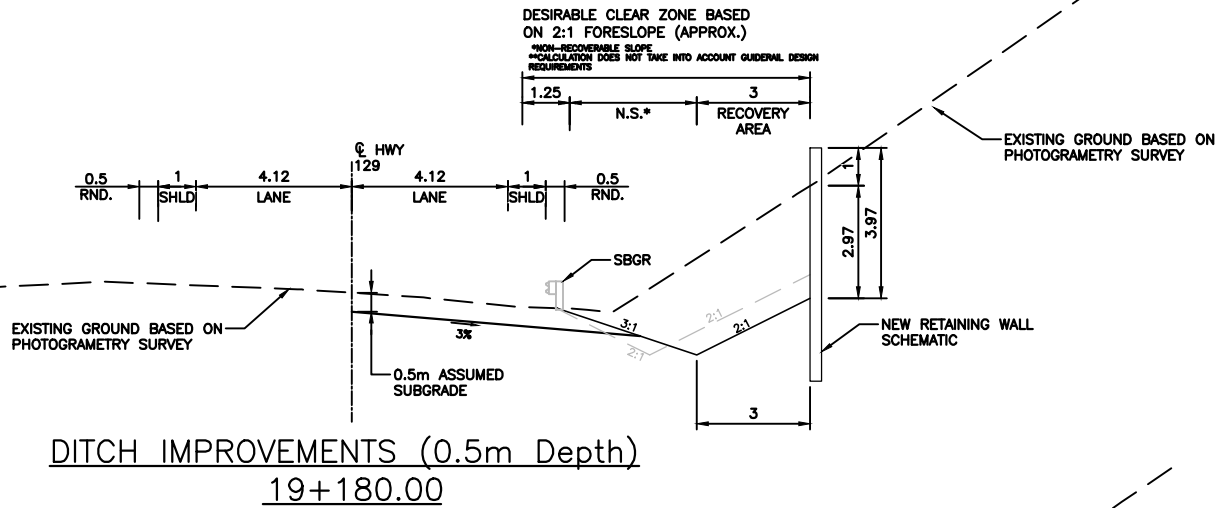


Prep'd RH

Chkd. CM

FILE NAME: F:\22139\Work Order #6 - Hwy 129 Cobble Hill\Structural\DWGs\22139 Ditch Profile & Section Rev.2.dwg
MODIFIED: 2022-10-21 12:12

2017-08
ANSI-D
MINISTRY OF TRANSPORTATION, ONTARIO



METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DIST.	HWY	
CONT	—	
GWP	5161-18-00	
CCOBLE HILL RETAINING WALL TYPICAL RETAINING WALL HEIGHTS WITH DITCH IMPROVEMENTS (0.5m DEPTH)		SHEET 02
LEA		

3:1 FORESLOPE

REVISIONS						
	DATE	BY	DESCRIPTION	DATE	DATE	DATE
DESIGN	—	CHK	—	CODE	—	LOAD
DRAWN	—	CHK	—	SITE	—	DWG

COMPARISON OF ERROSION MITIGATION ALTERNATIVES

	<i>Maintain Existing Slope and Enhance Catchment</i>	<i>Slope Flattening</i>	<i>Turf Reinforcement Mat</i>	<i>Turf Reinforcement Mat with Anchored Wire Mesh</i>
Description	<ul style="list-style-type: none">• Maintain the existing slope above the toe wall and provide a barrier to prevent cobbles from reaching the roadway with either a wire mesh fence on top of the proposed toe wall or a guide rail along the side of Highway 129 with additional channels.	<ul style="list-style-type: none">• Flattening of the existing slope above the proposed toe wall with benches incorporated to reduce unimpeded flow of water down the slope. Vegetate slope. Installation of an interceptor ditch at the crest of the cut to direct overland flow into protected channels.	<ul style="list-style-type: none">• Proprietary system placed on the existing slope that can either be vegetated or unvegetated and provides immediate erosion protection. Given the existing slope inclination and slope length a high-performance turf reinforcement mat consisting of a three-dimensional woven polypropylene geotextile and ground anchors would likely be required.	<ul style="list-style-type: none">• Turf reinforcement mat reinforced with proprietary steel woven wire mesh installed and anchored above the turf reinforcement mat.
Advantages	<ul style="list-style-type: none">• No construction on the steep slope required.• Mitigates concern of cobbles reaching Highway 129 driving lanes.	<ul style="list-style-type: none">• Improves global and surficial slope stability.• Reduces erosion potential of slope.• Benches provide attenuation zones for cobbles.	<ul style="list-style-type: none">• Cost effective for erosion protection of existing slopes.• Can accommodate some surficial movement below the turf reinforcement mat and remain functional.• Readily repaired if damaged.	<ul style="list-style-type: none">• Suitable for both cobble control and erosion protection.• Can accommodate some surficial movement below the turf reinforcement mat and remain functional.• Reinforces the surface of the existing slope more than just a turf reinforcement mat.• Readily repaired if damaged.
Disadvantages	<ul style="list-style-type: none">• Slope erosion is not mitigated.• Does not improve surficial stability of existing slope.	<ul style="list-style-type: none">• Substantial earth work required to construct the flattened slope.• Slope erosion is not fully mitigated.• The limit of the slope flattening would require property acquisition.	<ul style="list-style-type: none">• Less suitable for cobble control than turf reinforcement mat with anchored wire mesh.• Does not reinforce the surface of the slope as much as turf reinforcement mat with anchored wire mesh.• Due to the steepness and location of the slope, vegetation could be difficult to establish. Coir logs may be required.• Durability of the polypropylene is dependant on UV exposure and must be fully vegetated to meet the required service life	<ul style="list-style-type: none">• Less cost effective than just a turf reinforcement mat.• Due to the steepness and location of the slope, vegetation could be difficult to establish. Coir logs may be required.• Durability of the polypropylene is dependant on UV exposure and must be fully vegetated to meet the required service life
Constructability	<ul style="list-style-type: none">• No concerns	<ul style="list-style-type: none">• Limits of flattened slope would far exceed the MTO right of way.	<ul style="list-style-type: none">• Working on the existing steep slope required. Much of the installation would be done by hand.• Anchor installation through cobbles could be challenging	<ul style="list-style-type: none">• Working on the existing steep slope required. Much of the installation would be done by hand.• Anchor installation through cobbles could be challenging.• More labour-intensive installation than just a turf reinforcement mat.
Maintenance	<ul style="list-style-type: none">• Regular clearing of eroded material and cobble debris from barrier system and clear zone required.• Periodic repairs to barriers required.	<ul style="list-style-type: none">• Regular clearing of eroded material and rock debris from clear zone required.	<ul style="list-style-type: none">• Occasional inspections of TRM and repair if necessary.	<ul style="list-style-type: none">• Occasional inspections of TRM and repair if necessary.
Relative Cost	<ul style="list-style-type: none">• Low	<ul style="list-style-type: none">• High	<ul style="list-style-type: none">• Low to Moderate	<ul style="list-style-type: none">• Moderate
Recommendations	<ul style="list-style-type: none">• Feasible, Not Recommended	<ul style="list-style-type: none">• Not Feasible	<ul style="list-style-type: none">• Feasible, Not Recommended	<ul style="list-style-type: none">• Recommended

TURF REINFORCEMENT MAT WITH VEGETATION - Item No. XX

Special Provision

SCOPE

This special provision covers the requirements for the supply, delivery, storage, handling and installation of the reinforcement mat with vegetation for the slope rehabilitation on Highway 129.

REFERENCES

This special provision refers to the following standards, specifications or publications:

Canadian Standards Association

A23.1-14/A23.2-14 - Concrete Materials and Methods of Concrete Construction / Test Methods and Standard Practices for Concrete
G30.18-09 (R2014) - Carbon Steel Bars for Concrete Reinforcement

Ontario Provincial Standard Specifications, Construction

OPSS.PROV 202 Construction Specification for Rock Removal by Manual Scaling, Machine Scaling, Trim Blasting, or Controlled Blasting
OPSS 206 Construction Specification for Grading
OPSS 804 Construction Specification for Seed and Cover
OPSS 805 Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS 942 Construction Specification for Prestressed Soil and Rock Anchors

Ontario Provincial Standard Specifications, Material

OPSS 905 Construction Specification for Steel Reinforcement for Concrete
OPSS 1002 Aggregates – Concrete
OPSS 1301 Hydraulic Cementing Materials
OPSS 1302 Water
OPSS 1303 Admixtures for Concrete
OPSS 1350 Concrete - Materials and Production
OPSS 1440 Steel Reinforcement for Concrete

American Society for Testing and Materials (ASTM)

A615/A615M-16 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
A 856/A856M-03 (2014) Standard Specification for Zinc-5% Aluminium-Mischmetal Alloy-Coated Carbon Steel Wire
A 975 Standard Specification for Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire with Poly Vinyl Chloride (PVC))

Coating)

- D 4595-11 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- D 6525/D6525M-16 Standard Test Method for Measuring Nominal Thickness of Rolled Erosion Control Products
- D 6566-17 Standard Test Method for Measuring Mass per Unit Area of Turf Reinforcement Mats
- D G154-16 Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Non-metallic Materials
- D 6625-13 Standard Practice for Conducting a Test of Protective Properties of Polish Applied to a Painted Panel Using Fluorescent UV-Condensation Light- and Water-Exposure Apparatus
- G154-16 Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

DEFINITIONS – Not Used

DESIGN AND SUBMISSION REQUIREMENTS

4.1 Submission Requirements

At least 20 days prior to the commencement of construction, the Contractor shall provide the Contract Administrator a method statement including the data sheet for material, installation procedures, calculation sheets, and detailed drawings, etc., for installation of the proposed erosion control measures with the following:

A reinforcement mat product sample measuring 10 x 20 cm or larger;

A mill certificate from the manufacturer stating the name of the manufacturer, product name, style number, chemical composition, and other pertinent information to fully describe the reinforcement mat as evaluated under the manufacturer's Quality Control (QC) program;

A copy of the manufacturer's storage, handling and installation instructions and general recommendations;

Separate documentation certifying that the reinforcement mat meets the requirements of Table 1 of this special provision;

Calculation sheets, installation procedures and detailed drawings; and,

Herbaceous seed mix per requirements of OPSS 804

The Contract Administrator shall review the Contractor's submission. The reinforcement mat shall not be placed until the Contract Administrator has provided written confirmation to the Contractor of the conformance to the Contract requirements for the reinforcement mat. The Owner shall bear no responsibility for the rejection of any materials which do not conform to the Contract requirements.

Confirmation of conformance to the Contract requirements for the reinforcement mat does not relieve the Contractor of the responsibility for ensuring the specified quality of Materials and workmanship.

5.0 MATERIALS

The reinforcement mat will be the following product or equivalent:

Maccaferri Canada Ltd.
 MACMAT R8P turf reinforcement mat
 www.maccaferri.ca

The reinforcement mat supplied shall have the characteristics specified in Table 1.

TABLE 1: MACMAT R8P PROPERTY REQUIREMENTS

Property	Test Method	Units	Requirements ¹
Tensile Strength	ASTM D4595-11	kN/m	41.7
Thickness	ASTM D6525-16	mm	25
Mass/Unit Area	ASTM D6566-17	g/m ²	2120
UV Stability	ASTM G154-16	% strength retained	Stabilized
Minimum Weight of Coating (Galfan [®])	ASTM A865/ A865M-03	g/m ²	244
Minimum Weight of Coating (PVC)	ASTM A975	mm	0.38
Diameter of Wire Mesh	ASTM A975	mm	2.7
Diameter of Selvedge Mesh	ASTM A975	mm	3.4
Diameter of Wire Mesh (Galfan [®] & PVC)	ASTM A975	mm	3.7
Diameter of Selvedge Mesh (Galfan [®] & PVC)	ASTM A975	mm	4.4

Notes:

1. All values are Minimum Average Roll Values (MD), unless a range or characteristic is indicated.

The grout shall be colloiddally mixed to the supplier's specification; however the Water/Cement Ratio by weight shall not exceed 0.45. A minimum 28-day compressive strength equal to 35 MPa shall be used. Minimum grout strength shall be 25 MPa at seven (7) days when tested in accordance with CSA A23.2-1B Test Methods. The grout shall bleed less than 2 percent when allowed to stand for 1 hour.

The alternative of grout can be reviewed/approved by the Contract Administrator after the Contractor submit the specification of material, equipment, installation procedures to meet the requirement of produce a minimum average ultimate grout-to-ground bond strength of 300 kPa to be verified by the pre-production tests and proof tests of anchor stated in Section 7.02.

Reinforcing steel bar shall be deformed bars in accordance with OPSS 905 (CSA G.30.18 or ASTM A615) Grade 520 as supplied by Dywidag (DSI) or approved equivalent.

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION

7.01 Storage and Handling

The Contractor shall store and handle the reinforcement mat in a manner to prevent excessive mud, wet concrete, epoxy or other deleterious materials from coming into contact with and affixing to the mat materials as recommended by the manufacturer.

Rolls shall not be left exposed to direct sunlight for periods longer than recommended by the manufacturer.

7.02 Examination

The Contractor shall check the reinforcement mat upon delivery to verify that the proper material has been received. The reinforcement mat shall be inspected by the Contractor to be free of flaws or damage occurring during manufacturing, shipping or handling.

At least two (2) pre-production tests of anchor and five (5) proof tests on the installed anchors shall be carried out per requirement of OPSS 942. The test reports should be submitted to the Contract Administrator for reviewing no later than 7 days after completion of the tests in the field.

7.03 Preparation

The subgrade on the slope shall be shaped to provide positive drainage as indicated in the Contract Drawings, and shall be cleared of any sharp objects that might damage the reinforcement mat. At no time shall any machine rig/vehicle be allowed directly on any portion of the prepared subgrade. Grooves, such as those that may result from the use of toothed excavator buckets, shall not be left in the subgrade surface.

7.04 Installation

The reinforcement mat shall be placed longitudinally along the crest and slope shown in the Contract Drawings. The material shall be free of tears and folds. The temporary erosion and sedimentary control measures should be provided per OPSS 805 to meet the requirements of the Ministry of Environment and Climate Change (MOECC).

1. Before cutting the slope:

The reinforcement mat has to be fixed at the crest before the rolls of mat can be rolled down and placed on the cut slope. An anchorage line (or the other accepted alternative) consisting of 25 mm diameter threaded anchor bar installed vertically on the crest at 4 m spacing and connected by 16 mm steel cable is to be installed along the existing crest utilizing the available access prior to commencement of excavation of the cut slope in accordance with the following procedures:

Drill 100 mm diameter (minimum) boreholes and install the anchor bars with adequate centralizers at 1 m intervals to a minimum depth of 3 m below grade using the appropriate cement grouting method or approved alternative method to produce a minimum average ultimate grout-to-ground bond strength of 300 kPa;

Install a 100 mm x100 mm steel plate with nut at each head of the installed anchorage location on the crest; and

Stretch the 16 mm diameter steel cable through the wrapped rolls of reinforcement mat to each of the anchor bolts installed on the crest.

2. Undertake slope cutting and shaping, area by area.

3. After completion of the slope cut, area by area:

Unwrap the rolls of reinforcement mat and connect wire meshes using the Spenax rings around the steel ropes after the cut slope area is graded and cleared of any loose soils and/or small rock pieces;

Unroll the rolls of reinforcement mat from the fixed anchorage at steel cable on the crest down the face of

the slope;

Install the fixing 8 mm diameter J-shaped steel pins with asymmetric 500 mm/200 mm long legs at 1 m grid spacing on the isometric triangle arrays to ensure intimate contact between the placed reinforcement mat and the subgrade. If boulder-sized rock fragments and/or bedrock outcrops are encountered on the slope, the placed mat may be either adjusted around the obstruction and/or an additional anchor bolt with plate/nut installed to secure the reinforcement mat in position, depending on dimension and location of the obstruction;

Fasten the rolled out reinforcement mats side by side using the pneumatic Spenax tool with clips between the twisted wire meshes; and;

Install the fixing 8 mm diameter J-shaped steel pins described above at 1 m spacing at the bottom of earth slope as required.

7.05 Topsoil Placement over Reinforcement Mat

Once installation of the reinforcement mat is completed, place a minimum 100 mm thick layer of topsoil over the mat with the hydroseed or terraseed seed mix. Temporary Bonded Fibre Matrix (BFM) per OPSS 804 shall be installed as soon as practical and no later than 48 hours after placement of topsoil and seed mix until successful vegetation is established.

The selection of the herbaceous seed mix should meet requirements of OPSS 804 and be reviewed/approved by the authorities as required. The performance and evaluation for the installed erosion control measures should meet requirements per OPSS 804.

7.06 Inspection

The Contract Administrator shall randomly inspect the reinforcement mat before and during construction operations and may randomly inspect after installation using test pits.

Any damaged or defective reinforcement mat (i.e. frayed coating, separated junctions, separated layers, tears, etc.) shall be repaired/replaced in accordance with Clause 7.07.

7.07 Repair

Reinforcement mat damaged before, during or after installation shall be replaced with new materials. Proper replacement shall consist of replacing the damaged materials, within the affected area, as recommended by the manufacturer.

7.08 Temporary Erosion Control

Temporary erosion control measures (rolled erosion control products and/or plastic sheeting) shall be applied as soon as practical and no later than 48 hours or prior to any forecasted precipitation after the removal of any portion of the existing vegetative or other earth cover.

8.0 QUALITY ASSURANCE

The Contract Administrator shall be provided with supplier documents and shipping receipts that verifies the reinforcement mat product. In addition, three 1 m sample lengths of the reinforcement mat shall be provided to the Contract Administrator.

9.0 MEASUREMENT FOR PAYMENT

9.01 Actual Measurement

Measurement for payment shall be in square metres of the installed reinforcement mat product, with no allowance for overlap.

10.0 BASIS FOR PAYMENT

10.01 Turf Reinforcement Mat with Vegetation

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment, materials and tests necessary to do the work.

Replacement of erosion control materials used for repairs shall be at no additional cost to the Owner.

10.02 Topsoil, Imported

Topsoil shall be paid for under the appropriate item specified in the Contract Documents.

10.03 Seed and Matrix

Seed and Matrix shall be paid for under the appropriate item specified in the Contract Documents.