



**TECHNICAL MEMORANDUM FOR CULVERTS IN PHASE 1
ADDENDUM TO FOUNDATION INVESTIGATION
AND DESIGN REPORT
CULVERT C52 - DELAMERE TOWNSHIP
HIGHWAY 69 FOUR-LANING FOR 24.7 KM
FROM 3.8 KM NORTH OF HIGHWAY 522
TO 4.5 KM NORTH OF HIGHWAY 64
SITE NO. 46-545 C1 NBL / 46-545 C2 SBL
W.P. 5463-09-01 NBL / 5565-09-01 SBL
G.W.P. 5206-06-00 (PART OF G.W.P. 5378-02-00)
SUDBURY AREA, ONTARIO**

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Dear Mr. Doyon

Technical Memorandum for Culverts in Phase 1
Addendum to Foundation Investigation and Design Report
Culvert C52 - Delamere Township
Highway 69 Four-Laning for 24.7 km
From 3.8 km North of Highway 522
to 4.5 km North of Highway 64, Site No. 46-545 C1 NBL / 46-545 C2 SBL
W.P. 5463-09-01 NBL / 5565-09-01 SBL, G.W.P. 5206-06-00 (Part of G.W.P. 5378-02-00)
Sudbury Area, Ontario

Planned within the 11.1 km long Phase 1 of the project is the installation of several concrete culverts. Nine of these culverts have been selected for foundation investigation.

This memorandum summarises the results of the field investigation conducted at the location of culverts 33 and 34 at station 11+070, Delamere Township which were assigned a reference number C52. This memorandum also pertains to the design and construction of this proposed culvert and associated bedding/backfill zones.

A timber crib culvert was noted under the existing Highway 69 embankment in the vicinity of the proposed northbound culvert C52.

The field work for culvert C52 was carried out on October 15 and 16, 2008. The subsurface investigation comprised a total of 3 boreholes advanced to depths of 4.3 to 6.2 m below existing grade.

The locations of the boreholes put down along the culvert are shown on Drawing C52-1. The borehole logs, drawing and figures are identified by the prefix codes to reflect the specific culvert number for ease of reference.

1. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, soil boundary elevations, standard penetration resistance values, in-situ vane shear and penetrometer test data and groundwater observations. The results of laboratory Atterberg plasticity limits tests, grain size distribution analyses and moisture content determinations are also shown on the Record of Borehole sheets.

Three boreholes were drilled along the alignment of this culvert. The subsurface stratigraphy revealed in the boreholes generally comprised a surficial peat overlying silty clay/ clayey silt, over



a sand and gravel deposit. Bedrock was contacted at depths of 1.1 to 3.1 m (elevations 201.0 to 203.3). Groundwater was measured at just below existing grade at elevations 203.8 to 204.2 in all of the boreholes.

Reference should be made to the previous boreholes conducted in swamp 104 (boreholes 106-27 to 106-29) that are within proximity to the southbound and northbound culverts. Typically, the boreholes reveal consistent soil conditions with refusal on probable bedrock at elevations 201.3 to 203.4.

1.1 Peat

A deposit of peat was found surficially in all borehole locations. The amorphous peat was 0.1, 0.3 and 0.6 m thick in boreholes C52-1, C52-2 and C52-3, respectively. The peat deposit extended to elevations 204.0, 204.1 and 203.8 in the respective borehole locations.

1.2 Silty Clay

Overlain by peat at 0.3 depth in borehole C52-2 was a cohesive deposit of silty clay. The silty clay deposit was 1.1 m thick and was firm to stiff in consistency. The N values for the silty clay ranged from 2 to 9. The deposit extended to 1.4 m depth (elevation 203.0) in borehole C52-2.

The results of Atterberg plasticity limits testing and grain size distribution analysis conducted on a sample of the silty clay from culvert C52 are presented in respective Figures C52-GS-1 and C52-GS-1.

The liquid limit and plastic limit of the silty clay was 36 and 20, respectively, with a plasticity index value 16. The water content of 32% was recorded on a sample of the silty clay.

1.3 Clayey Silt

Underlying the peat at 0.1 and 0.6 m depth in boreholes C52-1 and C52-3 and underlying the silty clay at 1.4 m depth in borehole C52-2, a cohesive clayey silt deposit was contacted. The clayey silt deposit ranged from 0.5 to 1.5 m in thickness and was stiff in consistency. The N values ranged from 9 to 10. In borehole C52-3 an N value of 15/25 cm was recorded where the sampler was bouncing on the underlying bedrock at 1.1 m depth (elevation 203.3). In boreholes C52-1 and C52-2 the deposit extended to 1.6 and 2.3 m depth (elevations 202.5 and 202.1), respectively.

The results of Atterberg plasticity limits testing and grain size distribution analysis conducted on samples of the clayey silt from culvert C52 are presented in respective Figures C52-GS-2 and C52-GS-2.

The liquid limit of the clayey silt was 25 and 27, with plastic limits of 19, giving plasticity index values of 6 and 8. The water content of representative samples of the clayey silt ranged from 19 to 35%.



1.4 Sand and Gravel

Underlying the clayey silt at 1.6 and 2.3 m depth (elevations 202.5 and 202.1) in boreholes C52-1 and C52-2 a cohesionless sand and gravel deposit was contacted. The deposit was 1.5 m thick in borehole C52-1 and was a 100 mm thick layer in borehole C52-2. The sand and gravel deposit comprised trace silt with cobbles and boulders being contacted in borehole C52-1. The relative density of the sand was compact. The moisture content of the sand at borehole C52-2 was 13%. The sand and gravel deposits extended to the underlying bedrock at 3.1 and 2.4 m depth (elevations 201.0 and 202.0) in boreholes C52-1 and C52-2.

1.5 Bedrock

Bedrock was contacted at depths of 1.1 to 3.1 m (elevations 201.0 to 203.3), with the bedrock surface elevation decreasing from east to west. The bedrock comprises pink, locally to grey Granitic Gneiss and exhibited high strength. A detailed description of the rock cores retrieved from boreholes C52-1, C52-2 and C52-3 is given in Table A, appended.

The measured core recovery was 100%. The RQD determined from the rock cores was in a range of 79 to 100%, thus indicating a good to excellent quality rock.

1.6 Groundwater

Groundwater was observed in all boreholes at depths of 0.2 to 0.3 m (elevations 203.8 to 204.2) upon completion of drilling. The groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

2. ENGINEERING RECOMMENDATIONS

It is understood that precast box culverts are capable of withstanding some 100 mm of differential settlement, provided the settlement is not abrupt. Cast-in-place culverts typically tolerate a maximum of 25 mm of differential settlement, after which, cracking may appear within the culvert. Expansion joints should be provided at the design engineer's discretion to accommodate the differential settlement.

The foundation frost penetration depth at the sites is 2.0 m according to OPSD 3090.101.

It is noted that no responsibility or liability is assumed by MTO or by the consultants for alerting the contractor and to "red-flag" all critical issues. The requirement to deliver acceptable construction quality remains the responsibility of the contractor.

All elevations in the memorandum are expressed in metres. A list of standard specifications referenced in this memorandum is compiled in Table 1. The Granular A and B materials referenced in this memorandum should conform to OPSS 1010.



For culvert C52, separate box culverts are proposed under the northbound and southbound lanes and are designated northbound and southbound culverts, respectively. The northbound culvert will replace an existing timber crib culvert under Highway 69 at approximately the same chainage. The invert levels of the proposed 3.0 m wide concrete box culverts are specified near elevation 203.5 at the west end of the southbound culvert and 203.2 at the east end of the northbound culvert, indicating a west to east flow. The subgrade level of the granular bedding is interpreted to be about 0.5 m below the proposed invert levels at elevations 202.7 to 203.0 allowing for the thickness of the concrete base of the culvert and for the granular bedding and levelling courses.

Culvert C52 is located within swamp 104. At the southbound culvert location, up to 4.3 m of embankment fill will be required above existing grades to construct the proposed road centreline at elevation 208.0.

In view of the proposed road rehabilitation planned for the northbound lanes only minor cuts of up to 0.4 m will be required at the northbound culvert location. A road surface centreline grade elevation 207.4 is proposed at this location.

Bedrock was encountered at elevation 203.3 at the east end of the proposed northbound culvert, 0.6 m above the anticipated subgrade level. The soils revealed in the boreholes below the west end of the southbound culvert and at the centreline median below the subgrade levels comprised cohesive stiff clayey silt and/or silty clay over compact sand and gravel deposits. Bedrock was contacted at 2.0 and 0.8 m depth below the subgrade levels, elevations 201.0 and 202.0 at the west end of the southbound culvert and at the centreline median, respectively.

Groundwater at the time of the field investigation was at 0.3 and 0.2 m depths, elevations 203.8 to 204.2, ranging from the 0.8 to 1.5 m, respectively above the anticipated subgrade levels at the west and east ends of the southbound and northbound culverts.

2.1 Foundations for Culvert C52 Under Northbound Lanes

The new northbound lanes will be constructed by carrying out pavement rehabilitation of the existing Highway 69. The clayey silt and/ or silty clay subgrade will therefore remain intact along the northbound alignment. Subgrade preparation should be carried out following careful removal of the existing culvert.

An invert elevation 203.2 is proposed at the east end of the northbound culvert and bedrock was encountered 0.6 m above the anticipated subgrade level of the culvert at elevation 203.3. At the west end of the northbound culvert the excavation will extend 0.2 m into the stiff clayey silt encountered at the centreline median of the culvert. Any bedrock encountered above the subgrade level should be excavated down to at least 300 mm below the underside of the culvert to avoid point loads. The excavated rock and cohesive deposits should be replaced with compacted Granular A or Granular B Type II bedding material to raise the subgrade to the design level of the underside of the culvert. Granular B Type II should be preferred for construction under wet conditions.

Since the existing embankment and culvert have effectively pre-loaded the existing subsoil the magnitude of the resulting settlements is considered to be not significant to the performance of the culvert, consequently, cambering of this culvert is not considered necessary.



2.2 Foundations for Culvert C52 Under Southbound Lanes

The recommended treatment of swamp 104 at the location of southbound culvert C52 is for full excavation of the compressible soils and backfilling the excavation with rockfill for construction of the southbound lane embankment. Consequently, the peat and the firm to stiff silty clay and/ or clayey silt subgrade soils underlying the proposed southbound culvert will be excavated and the platform subgrade will comprise rockfill. The rockfill is envisioned to extend to approximate depths of 0.7 to 1.2 m, elevation of about 201.8 to 202.1 below the subgrade levels. Accordingly, the rockfill placed for the embankment will be placed on the underlying compact sand and gravel deposit.

The proposed rockfill within the zone of influence below the design subgrade level is considered capable of adequately supporting the stress imposed by the concrete box culvert foundations. The proposed 0.7 to 1.2 m thick rockfill under the west and east ends of the culvert will undergo estimated total settlements of about 15 to 25 mm with some 50% occurring after construction. The estimated settlements assume that the groundwater level will be either just above or below the anticipated subgrade level, accordingly the rockfill will most likely be end dumped and placed with minimal or no compaction effort.

The estimated magnitude of settlement under the culvert is relatively small and the differential settlements tolerable. Therefore, either a cast-in-place or precast culvert could be constructed concurrently with the embankment. However, since the new southbound embankment will be surcharged for a period of 9 months, it is recommended that the culvert be constructed after the embankment fill has been placed and the surcharge period has been carried out to optimize the culvert performance and facilitate construction of the highway. The surcharging will result in settlements of about 10 mm under the west end of the culvert and about 15 mm under the east end of the culvert. A surcharge stage will reduce the estimated post-construction settlements to 5 mm at the west end of the culvert and to 10 mm at the east end of the culvert.

Various materials could be employed for surcharging the proposed culvert location. For ease of handling and the constant and uniform unit weight, granular materials are recommended for surcharging. If granular materials are not selected, the proposed subgrade level of the culvert should be covered with a geosynthetic filter fabric to prevent loss of materials into the voids of the rockfill. When selecting a surcharge material the unit weight and stability of the material should not be susceptible to changing weather conditions over the course of the surcharge period.



2.3 Geotechnical Bearing Resistance For Culvert C52

The recommended geotechnical bearing resistances at ultimate and serviceability limit states (ULS and SLS) for the proposed 3.0 m wide box culverts constructed on structural fill (Granular A or Granular B Type II) or on rockfill is as follows:

CULVERT SECTION	SOIL TYPE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL RESISTANCE AT SLS (kPa)
Northbound	Structural Fill (Granular A or Granular B Type II)	900	350
Southbound	Rockfill	900	250

The geotechnical resistance at SLS normally allows for 25 mm compression of the founding medium. In addition, the rockfill settlement at the west and east ends of the southbound and northbound culverts as discussed previously in this section should be considered.

A foundation embedment depth of 2.0 m and groundwater at about the level of the culvert invert were assumed for computation of the geotechnical resistance.

2.4 Subgrade Preparation

Preparation of the subgrade for construction of the culverts should be performed and monitored in accordance with OPSS 902 and SP 902S01. This should include site review by qualified geotechnical personnel during preparation of the subgrade as well as during placement and compaction of the granular fill and during the removal of existing culverts where applicable.

Where the Ministry has approved the substitution of precast box culverts for cast-in-place box culverts, it is recommended to provide 300 mm of granular bedding below the culvert. The bedding material should comprise Granular A compacted to 100% of the ASTM D-698 (standard Proctor) maximum dry density in conformance to OPSS 501 (Method A).

The topsoil and any other deleterious soils revealed at and below the subgrade level should be excavated prior to placement of the granular base below the box culvert and replaced with compacted Granular A or Granular B Type II.

Subgrade preparation, cover, backfill and frost treatment for the proposed culverts should be carried out in accordance with OPSD 803.010, OPSS 422 and SP 422S01. A foundation frost penetration depth in the area is at least 2.0 m according to OPSD 3090.101. Rockfill does not require frost tapers.

Rockfill should be placed in accordance with SP 206S03. This is particularly important above the water level within the zone of influence of the culvert, defined by an imaginary line inclined downwards at 2H:1V from a point located at the invert level 1 m beyond the edge of the culvert.



For the southbound culvert, the granular bedding material and rockfill material should be separated by a geosynthetic filter fabric to prevent loss of the granular materials into the voids of the rockfill. The rockfill surface should be chinked in accordance with the requirements of SP 206S03, prior to placing the geotextile. The filter fabric should conform to OPSS 1860 and comprise a Class II non-woven geotextile with a filtration opening size (FOS) of 105 to 210 μm . The filter fabric should be placed horizontally beneath the bedding and extend up on each side and to the top of the bedding and/or granular cover material.

In view of the anticipated presence of rockfill below the southbound culvert, settlements of the culverts may exceed the 25 mm compression of the founding medium normally allowed for by SLS resistance values in particular where a surcharge stage cannot be completed. The capability of the culvert to sustain such settlements, the need to shape the invert of the culvert to conform to the predicted settlements and reduce the structural distress that may result from the differential settlement as well as minimise 'low areas' in the culvert when settlement is complete should be reviewed by the structural designer.

2.5 Modulus of Subgrade Reaction

The estimated values of the modulus of subgrade reaction for culvert C52 constructed on structural fill (Granular A or B Type II) or on rockfill are as follows:

SOIL TYPE	MODULUS OF SUBGRADE REACTION MN/m^3
Granular A or B Type II	45
Rockfill	50

2.6 Sliding Resistance

The following parameters should be used for sliding resistance of cast-in-place culvert foundations. The friction angle in case of precast concrete should be reduced by a factor of 0.67.

SOIL TYPE	Friction Angle, degrees	Cohesion, kPa	Unit Weight, kN/m^3
GRANULAR A OR GRANULAR B TYPE II	35	0	22.8
ROCKFILL	42	0	18.0

The structural designer should use a factor of 0.8 for the above values of friction angle and cohesion when checking the sliding resistance.

2.7 Seismic Site Coefficient

The seismic site coefficient for the conditions at the culvert sites is 1.0 – Type I soil profile as per clause 4.4.6 of the CHBDC.



3. CULVERT BACKFILL

Backfill adjacent to the culverts should be placed in accordance with OPSD 803.010, OPSS 422 and SP 422S01.

Backfill should be brought up simultaneously on each side of the culvert and operation of heavy equipment within 0.5 times the height of the culvert (each side) restricted to minimise the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction. Refer to SP 105S10 for additional comments.

The culverts and headwalls must be designed to support the stress imposed by the overlying fill as well as to resist the unbalanced lateral earth pressure and compaction pressure exerted by the backfill adjacent to the culvert walls. Recommendations for headwalls and wingwalls are also provided in Section 4 of this memorandum.

The lateral earth and water pressure, p (kPa), should be computed using the equivalent fluid pressures presented in Section 6.9 of the CHBDC or employing the following equation assuming a triangular pressure distribution:

$$P = K (\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p + C_s$$

where K = lateral earth pressure coefficient

γ = unit weight of free draining granular material above the design water level (kN/m^3)

γ' = unit weight of backfill submerged below the design water level (kN/m^3)

h_1 = depth below final grade (m), above the design water level

h_2 = depth below the design water level (m)

q = any surcharge load (kN/m^2)

γ_w = unit weight of water equal to 9.8 kN/m^3

C_p = compaction pressure (refer to clause 6.9.3 of CHBDC)

C_s = earth pressure induced by seismic events, kPa (refer to clause 4.6.4 of CHBDC)

where \emptyset = angle of internal friction of retained soil (35° for Granular A)

δ = angle of friction between soil and wall (23.5° for Granular A)

The following parameters are recommended for design:

PARAMETER	GRANULAR A, GRANULAR B TYPE II	ROCKFILL
Angle of Internal Friction, degrees	35	42
Unit Weight, kN/m^3	22.8	18.0
Active Earth Pressure Coefficient (K_a)	0.27	0.20
At-Rest Earth Pressure Coefficient (K_o)	0.43	0.33
Passive Earth Pressure Coefficient (K_p)	3.69	5.04



The design should consider both the maximum water level in the stream and the stabilised groundwater level condition. Groundwater at the time of the field investigation was at 0.3 and 0.2 m depths, elevations 203.8 to 204.2, ranging from the 0.8 to 1.5 m, respectively above the anticipated subgrade levels at the west and east ends of the southbound and northbound culverts. The maximum stream water level will be dictated by flood flow conditions and should be defined by the project hydraulic engineer.

The coefficient of earth pressure at rest should be employed to design rigid and unyielding walls and the active earth pressure coefficient for unrestrained structures.

4. HEADWALLS AND WINGWALLS

For headwalls and wingwalls, the previous recommendations and geotechnical parameters for culvert foundations and backfill should be used for the design of their foundations, and in accordance with OPSD 3121.150. The wall founding levels should match those of the respective culverts where the walls are designed integral with the culvert structure. For walls designed separately from the culvert structure, the founding levels should be established minimum 2.0 m below the culvert invert level for adequate frost protection.

The design of the walls should be checked for sliding resistance using the geotechnical parameters provided in Section 2.6 for cast-in-place concrete foundations.

For headwalls and wingwalls, a weeping tile system should be installed to minimise the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or non-woven Class II geotextile (with an FOS of 75-150 μ m according to OPSS 1860) placed to prevent migration of fines into the system. The wall drainage pipe should outlet onto a positive slope away from the wall and where possible lead to a frost free outlet.

5. EXCAVATION

Excavation to the anticipated founding level of the culverts is expected to extend through the rockfill and/ or existing fill, native clayey silt and silty clay deposits. Provision for excavation of cobbles and boulders should be made. Subject to adequate groundwater control, excavation of the soils should be feasible using conventional equipment. All excavations should be conducted in accordance with OPSS 902 and SP 902S01.

According to the Occupational Health and Safety Act (Ontario Regulation 213/91) criteria, typically the in situ soils (cohesive firm to stiff clayey silt/ silty clay over compact sand and gravel) are classified as Type 3 soils necessitating temporary cut slopes to be inclined at 1H:1V.

The recommended treatment for the new northbound lanes of the new Highway 69 at the proposed culvert C52 will comprise pavement rehabilitation of the existing Highway 69. The existing firm to stiff clayey silt and silty clay subgrade will therefore remain intact along the northbound alignment of the highway.



Excavation of bedrock will likely be required at the northbound culvert C52. Conventional rock excavation techniques such as blasting as per OPSS 120 and jack-hammering should be suitable. It is important that blasting/excavation of the rock is controlled to prevent fracturing and/or disturbance of the bedrock surface directly beneath the culverts. The equipment required and method of excavation within the bedrock will be dependent upon the actual geometry of cut and relative depth of excavation into the bedrock.

Mechanical means such as a large excavator equipped with a tiger-toothed bucket in conjunction with a jack-hammer or hoe ram is the preferred method of excavation to shallow depths in rock at foundation locations. Mass concrete could be employed to level minor variations in the bedrock surface.

If blasting is required, a NSSP should be prepared to provide specific direction to the contractor to control the blasting/excavation of the rock to prevent fracturing and/or disturbance of the bedrock surface, require that a blasting specialist be retained to establish the charge to minimise overbreak, advise that any overblasting/overexcavation will be the sole responsibility of the contractor and require that loosened rock resulting from blasting operations be removed by mechanical means.

The excavation at the culvert sites should allow for the backfill and cover requirements in accordance with OPSD 803.010. Near vertical sidewalls may be utilised for excavations in bedrock. Examination of the sidewalls and removal of any loosened rock fragments should be carried out continually for the safety of workmen.

6. GROUNDWATER CONTROL

Groundwater at the time of the field investigation was at 0.3 and 0.2 m depths, elevations 203.8 to 204.2, ranging from the 0.8 to 1.5 m, respectively above the anticipated subgrade levels at the west and east ends of the southbound and northbound culverts.

It is considered that dewatering with conventional sump pumping techniques will generally be sufficient to handle groundwater seepage or surface water inadvertently entering the excavations at the northbound culvert C52, provided surface water flow is controlled. However, it is considered that dewatering with conventional sump pumping techniques will generally not be sufficient to handle groundwater seepage or surface water entering the excavations at the southbound culvert C52. The contract documents should have a specific item to clearly state that groundwater control of excavations is the contractor's responsibility.

It will be necessary to implement measures to control groundwater flow at the southbound culvert C52 and surface water flow at both of the culvert sites. Conventional procedures such as dam and pump and/or diversion of the stream should be sufficient to control surface water flow. We note that, in view of the relatively pervious nature of the subsoil at the southbound culvert C52, dewatering may be required from within a cofferdam to control groundwater flow.



In case the cast-in-place headwalls and wingwalls are designed separately from the culverts and to allow for dry conditions for the construction of cut-off walls, the groundwater levels would range from 2.3 to 3.0 m above the founding levels.

Sand and gravel are anticipated as the subgrade material below founding levels for the headwalls or wingwalls at the southbound culvert C52. Dewatering will likely be required to temporarily lower the groundwater table and permit construction, pending the actual hydraulic conditions after the recommended swamp treatment is implemented. The dewatering system must be designed and installed by specialists in the field. The groundwater level should be lowered to a minimum 0.5 m below the proposed founding levels.

In accordance with the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment is required if the dewatering discharge is greater than 50,000 L/day. It is anticipated that a PTTW will be necessary for temporary dewatering operations considering the relatively pervious soils at some of the culvert sites (rockfill, sand and gravel).

It must be noted that the assessment of the need for an application for a PTTW will be undertaken by others. This will include the expected daily flows at each culvert location which should be assessed by the hydraulic engineer.

It is recommended that the work be carried out during the dry months of June to September to minimize the amount of groundwater inflow to be handled and the volume of surface water, if any, to be diverted from the construction area.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

All construction work should be carried out in accordance with the Occupational Health and Safety Act and with local/MTO regulations.

7. EMBANKMENT FILL

The anticipated subgrade for the embankments will comprise bedrock or compact sand and gravel soils. The construction specifications for grading in SP 206S03 should be followed. In particular, the topsoil and other excessively loose, soft, organic or otherwise deleterious materials within the limits of the embankment fill should be subexcavated prior to fill placement. The new embankment fill should be placed and compacted in accordance with OPSS 501 and SP 105S10.

The rockfill embankment side slopes should be inclined no steeper than 1.25H:1V. A vegetation cover over slope flattening material or other measures should be established to control surface runoff and minimise erosion of the embankment slopes.



8. EROSION CONTROL

The protective measures noted in the OPSD 800 series to deal with erosion (inlet/outlet treatment, headwalls, cut-off walls, etc.) are considered to be appropriate. The backfill should comprise OPSS Granular A or Granular B Type II. The cut-off walls should extend laterally to protect the granular backfill material and to a depth at least equal to the fluctuation of the water level at each culvert location to prevent flow below the culvert that could erode the granular base/bedding material. The requirements of CHBDC clauses 1.9.5.6 and 1.9.11.6.5 should be applied.

Inlet and outlet protection in accordance with OPSS 511 and 1004 and OPSD 810.010 is recommended to prevent erosion adjacent to the culvert as well as scour that could undermine the culvert and/or embankment foundation. The actual design requirements concerning the length and width of aprons at the inlet/outlet of the culvert as well as the rock size, apron thickness, height of erosion protection on the embankment slope and type of material (clay seals at the inlet, drainage and/or filter blankets at the outlet) will be dictated by stream hydraulics, stream configuration, the water level in the stream and should be established by a hydraulic engineer. A non-woven Class II geotextile with an FOS of 75-150 µm according to OPSS 1860 should be placed below the rip-rap to minimise the potential for erosion of fine particles from below the treatment.

All newly constructed embankment slopes and retained soils behind the headwalls and wingwalls (if provided) should be covered with topsoil or suitable excess earth material from swamps or muskeg areas and seeded in accordance with OPSS 570 and 572, as soon after grading as possible to prevent erosion. Where slopes are inclined at 2.5H:1V or steeper, the permanent slopes should be protected with erosion control blankets. Also, sod (as per OPSS 571) shall be placed where it currently exists with a view to aesthetics. Additional appropriate erosion control measures for the project should be assessed using the following erodibility K factor:

<u>SOIL TYPE</u>	<u>K FACTOR</u>
Clayey Silt	0.45
Clay / Silty Clay	0.2 to 0.3
Gravelly Sand	0.1



This technical memorandum was prepared by Mr. C.M.P. Nascimento, P.Eng. with the assistance of Mr. M.J. Narduzzi, BEng., and was independently reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact.

Yours very truly

Peto MacCallum Ltd.



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MN/CN/BRG:mn-mi

Enclosure(s):

Table A – Rock Core Descriptions
Table 1 – List of Standard Specifications Referenced in Memorandum
Figures C52-PC-1 and C52-PC-2 – Results of Atterberg Limits Testing
Figures C52-GS-1 and C52-GS-2 – Results of Grain Size Distribution Analyses
Explanation of Terms Used in Report
Record of Borehole Sheets
Drawing C52-1 – Borehole Locations and Soil Strata
Appendix A – Rock Core Photographs



TABLE A
ROCK CORE DESCRIPTION

LOCATION (BH)	CORE RECOVERY				CORE DESCRIPTION	
	RC	DEPTH (m)	REC (%)	RQD (%)	DEPTH (m)	DESCRIPTION
C52-1	6	3.1 – 3.7	100	100	3.1 – 6.2	GRANITIC GNEISS: Pink, fine to medium grained, high strength, unweathered, moderate to wide (locally close) spaced flat cross joints, rough planar, tight, excellent quality.
	7	3.7 – 4.3	100	100		
	8	4.3 – 5.5	100	100		
	9	5.5 – 6.2	100	100		
C52-2	5	2.4 – 4.0	100	100	2.4 – 5.5	GRANITIC GNEISS: Pink to grey, fine to medium grained, high strength, unweathered, moderate to wide spaced flat cross joints, rough planar, tight (separating on schistosity), excellent quality.
	6	4.0 – 5.5	100	100		
C52-3	3	1.1 – 2.7	100	79	1.1 – 4.3	GRANITIC GNEISS: Pink, fine to medium grained, occasionally with sugary texture, high strength, unweathered, close to wide spaced flat cross joints, rough planar, tight, occasional vertical parting, good to excellent quality.
	4	2.7 – 2.9	100	100		
	5	2.9 – 4.3	100	100		

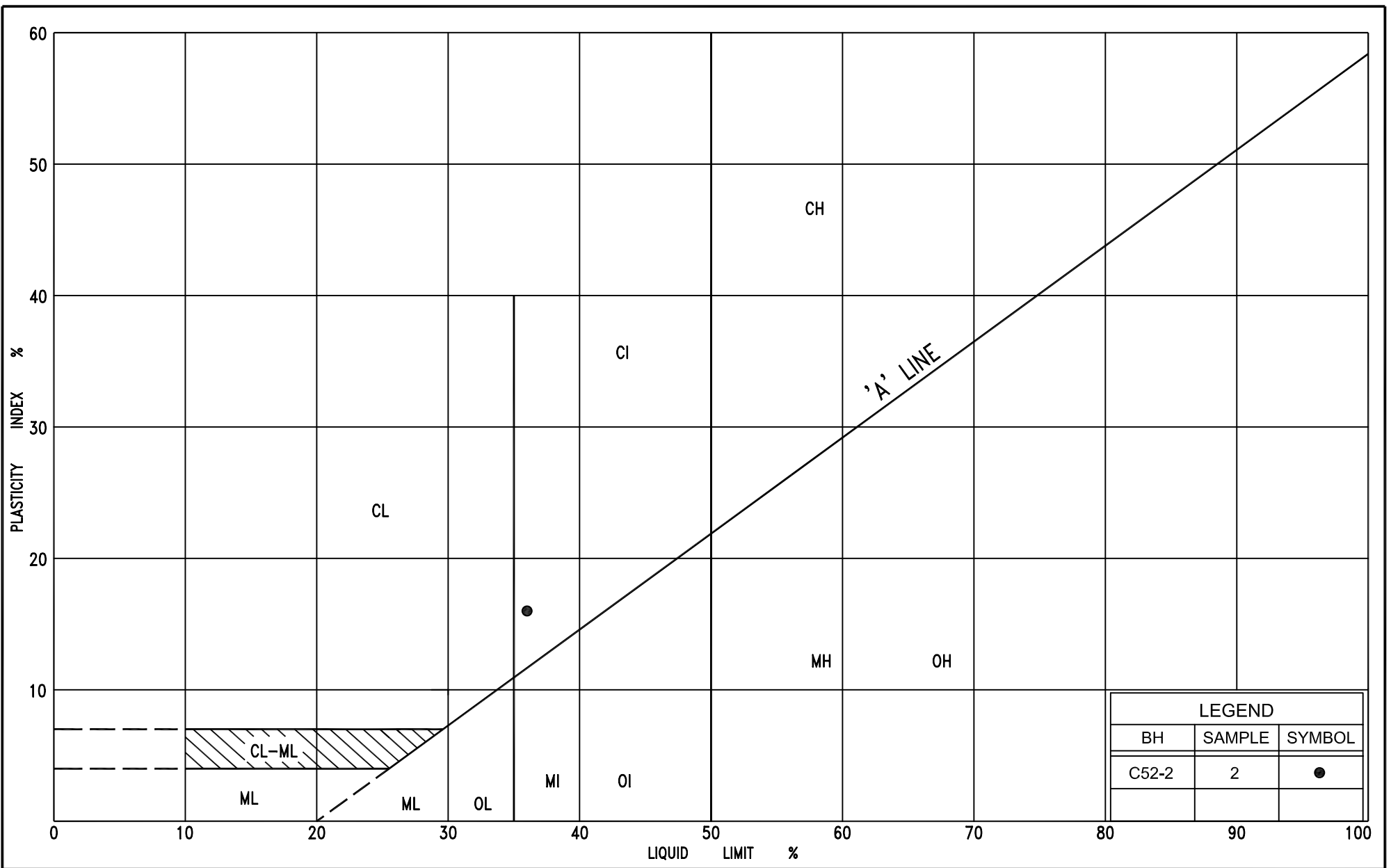
RQD = Rock Quality Designation

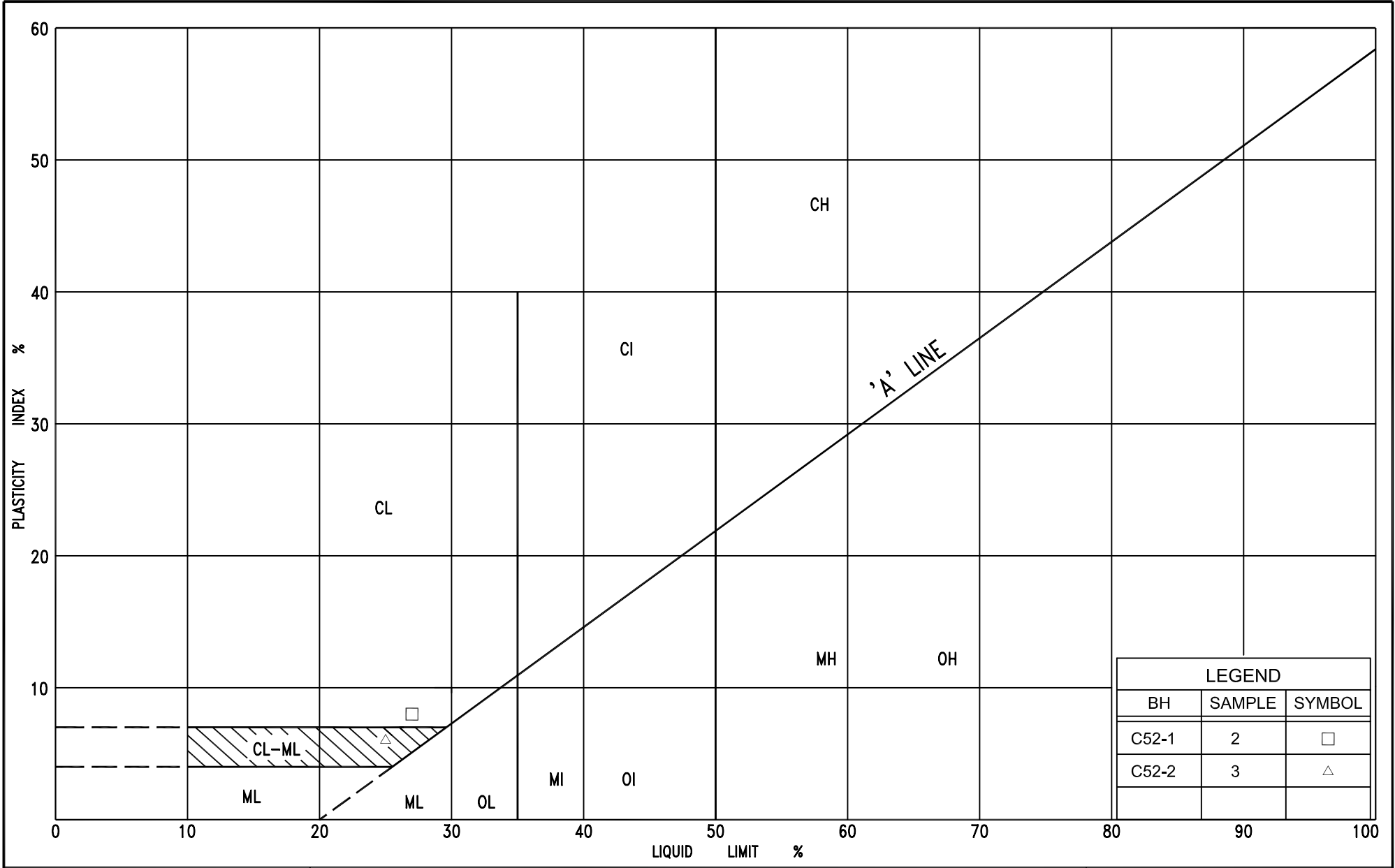
Originated: FP
Compiled: JFW
Checked: MN / CN

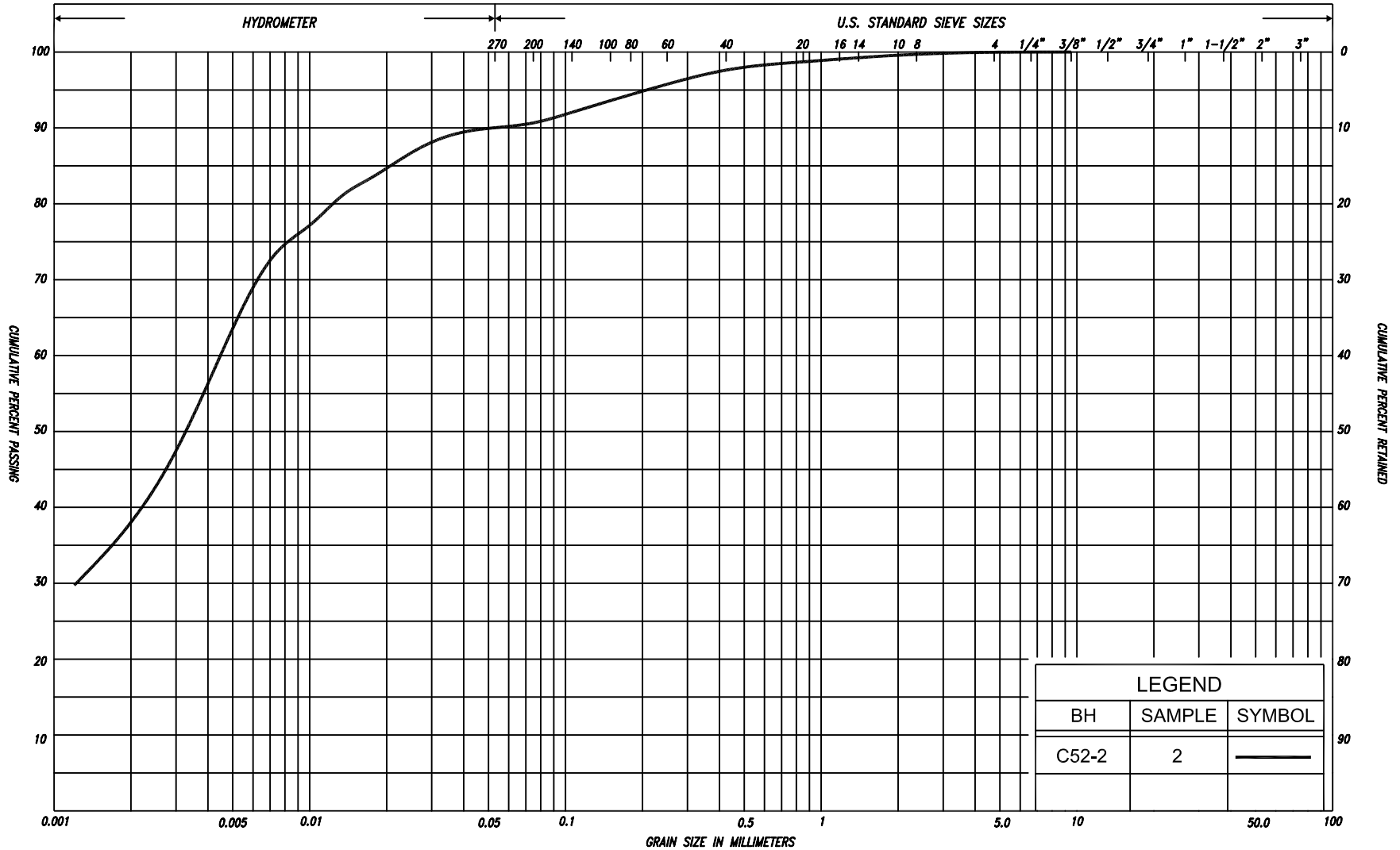


TABLE 1
LIST OF STANDARD SPECIFICATIONS REFERENCED IN MEMORANDUM

DOCUMENT	TITLE
OPSS 120	General Specification for the Use of Explosives
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 570	Construction Specification for Topsoil
OPSS 571	Construction Specification for Sodding
OPSS 572	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS 1004	Material Specification for Aggregates – Miscellaneous
OPSS 1010	Material Specification for Aggregates, Base, Subbase, Select Subgrade and Backfill Material
OPSS 1860	Material Specification for Geotextiles
SP 105S10	Construction Specification for Compaction
SP 206S03	Construction Specification for Grading
SP 422S01	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers
SP 902S01	Excavation and Backfilling of Structures
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Depth for Southern Ontario
OPSD 3121.150	Minimum Granular Backfill Requirements – Retaining Walls







SILT & CLAY					FINE		MEDIUM		COARSE	GRAVEL				COB BLES	UNIFIED
CLAY	FINE		MEDIUM		COARSE	SAND								COBBLES	M.I.T.
	SILT					FINE		MEDIUM		COARSE		GRAVEL			
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL						U.S. BUREAU

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

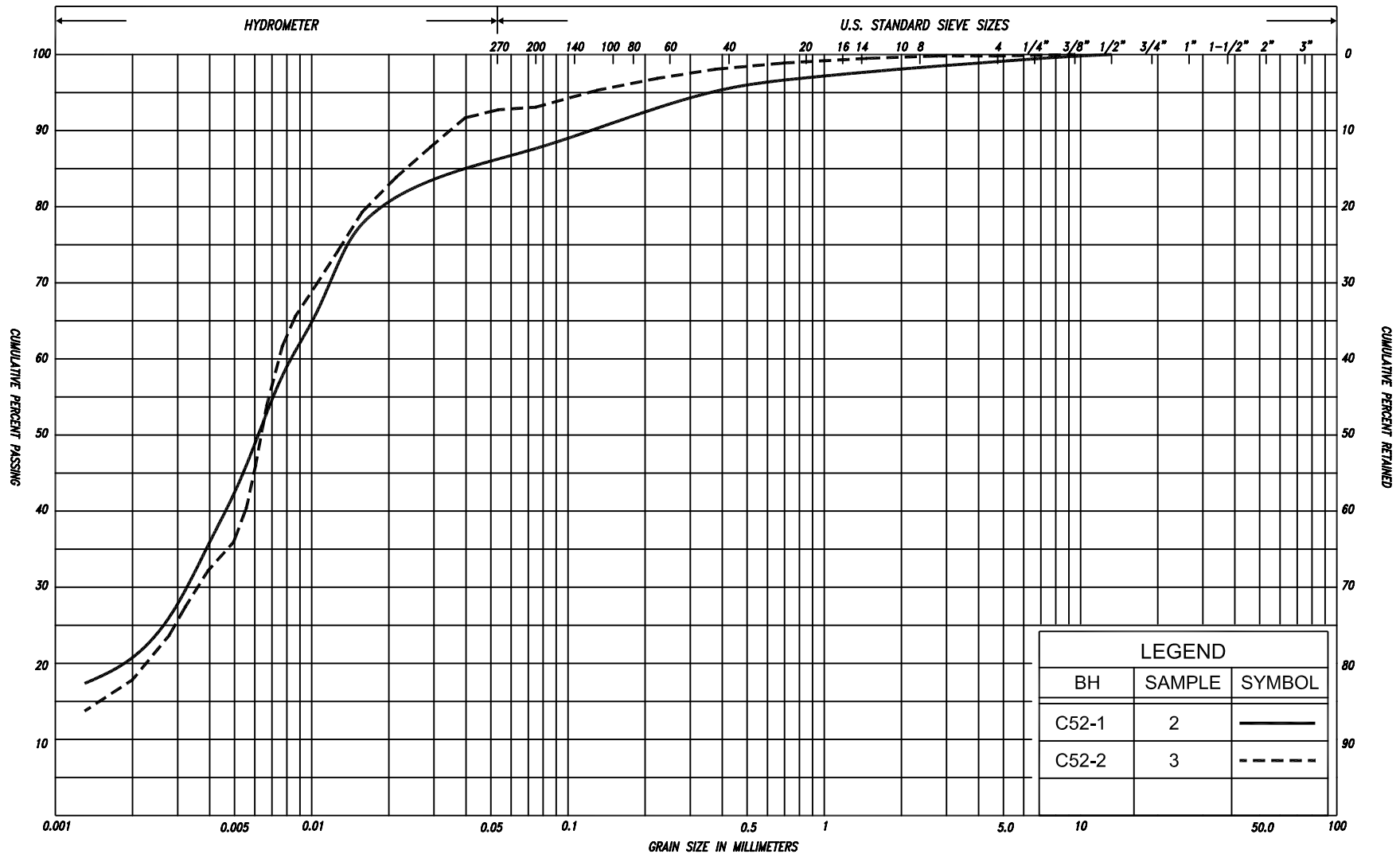
FIG No. C52-GS-1

HWY: 69

G.W.P. No. 5206-06-00



Ministry of
Transportation
Ontario



SILT & CLAY					FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED		
					SAND											
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL		COBBLES	M.I.T.
	SILT							SAND								
CLAY		SILT				V. FINE	FINE	MED.	COARSE	GRAVEL						U.S. BUREAU
						SAND										

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace to some sand

FIG No. C52-GS-2

HWY: 69

G.W.P. No. 5206-06-00

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

STRESS AND STRAIN


u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	e_{max}	1, %	VOID RATIO IN LOOSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	e_{min}	1, %	VOID RATIO IN DENSEST STATE
ρ_w	kg/m^3	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m^3	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m^3	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m^3/s	RATE OF DISCHARGE
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL	WTPL		WETTER THAN PLASTIC LIMIT	j	kN/m^3	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No C52-1 1 of 1 METRIC																	
G.W.P. 5206-06-00		LOCATION		Coords: 5 108 267 N; 330 155 E Hwy 69 (New), Sta. 11+070, o/s 31.7m Lt. CL				ORIGINATED BY F.P.									
DIST 54 HWY 69		BOREHOLE TYPE		C.F.H.S.A. AND NQ DIAMOND CORING				COMPILED BY M.N.									
DATUM Geodetic		DATE		October 16, 2008				CHECKED BY C.N.									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION kPa 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										
204.1 0.0	Ground Surface						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
204.0 0.1	Peat, amorphous Dark brown/black Wet		1	SS	2	↓*	204										
	Clayey silt, some sand organics		2	SS	10	▽*	203										1 12 66 21
202.5 1.6	Stiff Grey/brown Moist to wet		3	SS	15/5cm		202										
201.8 2.3	Boulder		4	RC NQ	RC NQ		201										
201.0 3.1	Sand and gravel, trace silt Compact Brown Wet		5	SS	35/3cm		200										
	Bedrock Granitic Gneiss Bedrock Unweathered High strength Excellent quality		6	RC NQ	REC 100%		199										RQD 100%
			7	RC NQ	REC 100%		198										RQD 100%
			8	RC NQ	REC 100%												RQD 100%
			9	RC NQ	REC 100%												RQD 100%
197.9 6.2	End of borehole																
<p>Samples 3 and 5: Sampler bouncing</p> <p>* 2008 10 16</p> <p>▽ Water level observed during drilling</p> <p>▼ Water level measured after drilling</p> <p>C.F.H.S.A: Denotes Continuous Flight Hollow Stem Augers</p>																	

RECORD OF BOREHOLE No C52-2

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Coords: 5 108 282 N; 330 186 E
Hwy 69 (New), Sta. 11+070, o/s 2.3m Rt. CL ORIGINATED BY F.P.
DIST 54 HWY 69 BOREHOLE TYPE C.F.H.S.A. AND NQ DIAMOND CORING COMPILED BY M.N.
DATUM Geodetic DATE October 16, 2008 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION kPa RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								○		
204.4	Ground Surface																			
0.0	Peat, amorphous		1	SS	2		204							○						
0.1	Dark brown																			
0.3	Wet																			
	Silty clay, trace sand		2	SS	9															
203.0	Firm to Dark brown						203									0 9 53 38				
1.4	Stiff																			
	Clayey silt, trace sand																			
202.1	Stiff Grey/ brown		3	SS	9											0 7 75 18				
2.3	Wet																			
			4	SS	20/10cm		202							○						
202.0	Sand and gravel, trace silt																			
2.4	Compact Brown Wet																			
	Bedrock		5	RC NQ	REC 100%		201									RQD 100%				
	Granitic Gneiss Bedrock																			
	Unweathered																			
	High strength																			
	Excellent quality		6	RC NQ	REC 100%		200									RQD 100%				
198.9							199													
5.5	End of borehole																			

RECORD OF BOREHOLE No C52-3

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Coords: 5 108 293 N; 330 218 E
Hwy 69 (New), Sta. 11+070, o/s 32.0m Rt. CL ORIGINATED BY F.P.
DIST 54 HWY 69 BOREHOLE TYPE C.F.H.S.A. AND NQ DIAMOND CORING COMPILED BY M.N.
DATUM Geodetic DATE October 15 & 16, 2008 CHECKED BY C.N.



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION kPa RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
204.4	Ground Surface																
0.0	Peat, amorphous		1	SS	2	▼*	204										
203.8	Dark/ Wet																
0.6	Clayey silt, trace sand		2	SS	15/25cm												
203.3	Stiff Grey/ Wet																
1.1	Bedrock						203										
	Granitic Gneiss Bedrock		3	RC NQ	REC 100%												RQD 79%
	Unweathered						202										
	High strength		4	RC NQ	REC 100%												RQD 100%
	Good to excellent quality						201										RQD 100%
200.1			5	RC NQ	REC 100%												
4.3	End of borehole																
	Sample 2: Sampler bouncing																
	* 2008 10 16																
	▼ Water level measured after drilling																
	C.F.H.S.A: Denotes Continuous Flight Hollow Stem Augers																

RECORD OF BOREHOLE No 104-25

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 11+050 o/s 18.8m Lt. CL median ORIGINATED BY F.P.
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE January 31, 2007 CHECKED BY G.D.

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													
204.7	Ground surface		1	SS	4		204	20	40	60	80	100	20	40	60						
0.0	Peat, fine fibrous Dark brown																				
0.3	Clayey silt trace sand, organics layers of sandy silt																				
203.8	Firm Brown Moist																				
0.9	End of borehole Refusal on probable bedrock																				
										</											

RECORD OF BOREHOLE No 104-26

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 11+050 o/s 14.0m Rt. CL median ORIGINATED BY F.P.
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
 DATUM Geodetic DATE October 27, 2006 CHECKED BY G.D.

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										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
207.7	Ground Surface							20	40	60	80	100								
0.0	Gravelly sand, trace silt		1	SS	13		207										5 87 (8)			
0.2	Compact Brown Moist (PAVEMENT FILL)																			
	Sand trace silt, trace gravel		2	SS	7		206						o							
	Compact Brown Moist to loose to wet																			
205.9	Clayey silt organic inclusions		3	SS	4															
1.8	Firm Brown Moist (FILL)																			
205.1	Clayey silt, trace sand sand seams		4	SS	5/15cm															
2.6	Firm Brown Moist to stiff																			
	End of borehole																			
	Refusal on probable bedrock																			
	Sample 4: Sampler bouncing																			
	* Borehole dry																			

RECORD OF PENETRATION TEST No 104-27

1 of 1 METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 11+075 o/s 38.5m Lt. CL median ORIGINATED BY F.P.
 DIST 54 HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY G.D.
 DATUM Geodetic DATE October 27, 2006 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
204.2 0.0	Ground Surface						204										
203.4 0.8	Probable clayey soils Firm																
	End of dynamic cone penetration test																
	Refusal on probable bedrock																

RECORD OF BOREHOLE No 104-28

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 11+075 o/s 3.0m Rt. CL median ORIGINATED BY F.P.
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 27, 2006 CHECKED BY G.D.


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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								—		
							20	40	60	80	100									
204.7	Ground Surface																			
0.0	Sand some gravel, some silt organic inclusions		1	SS	3								○			14 65 (21)				
204.1	Very loose Brown Wet (FILL)																			
0.6	Peat, fine fibrous		2	SS	3								○							
203.8	Clayey silt, trace sand organic inclusions																			
0.9																				
203.3	Firm Brown Wet Clay, trace sand		3	SS	6								—○—			0 2 51 47				
1.4	Firm Brown Moist to wet sand seams																			
201.3			4	SS	1/15cm															
3.4	End of borehole Refusal on probable bedrock																			
	Sample 4: Sampler bouncing																			
	* 2006 10 27																			
	▽ Water level observed during drilling																			
	▼ Water level measured after drilling																			

RECORD OF BOREHOLE No 104-29

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 11+075 o/s 38.5m Rt. CL median ORIGINATED BY F.P.
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
 DATUM Geodetic DATE October 28, 2006 CHECKED BY G.D.














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 (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								20	40	60	80	100											
204.4	Ground Surface		1	SS	2		204																
0.0	Peat, fine fibrous																						
0.3	Clayey silt trace sand, organics																						
203.2	Firm Brown Moist to stiff		2	SS	10/15cm																		
1.2	End of borehole																						
	Refusal on probable bedrock																						
	Sample 2: Sampler bouncing																						
	* Borehole dry																						

RECORD OF BOREHOLE No 104-30

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 11+100 o/s 18.8m Lt. CL median ORIGINATED BY F.P.
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 27, 2006 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							W _p W W _L		
															○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		
204.2	Ground Surface							20	40	60	80	100					
0.0	Peat, fine fibrous		1	SS	2		204										
0.3	Clayey silt, trace sand organics																
	Firm Mottled Moist to stiff grey/brown		2	SS	9								138				
202.8							203										
1.4	Clay, trace sand layers of clayey silt																
	Stiff Brown Moist to firm to wet		3	SS	4								125				0 1 42 57
201.1							202										
3.1	Clayey silt trace sand, trace gravel						201										
	Soft Brown Wet		4	SS	1												1 12 73 14
200.1	sand seams																
4.1	Grey																
	End of borehole																
	Refusal on probable bedrock																
	<div>* 2006 10 27</div> <div> Water level observed during drilling</div> <div> Water level measured after drilling</div> <div> Penetrometer test</div>																

* 2006 10 27

▽ Water level observed
during drilling

▽ Water level measured
after drilling

■ Penetrometer test

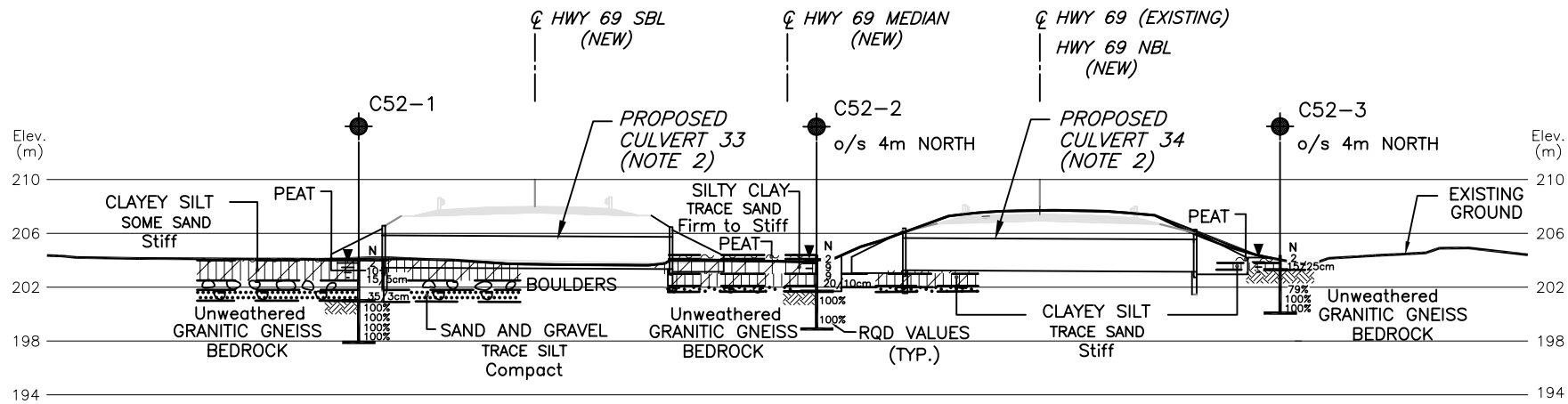
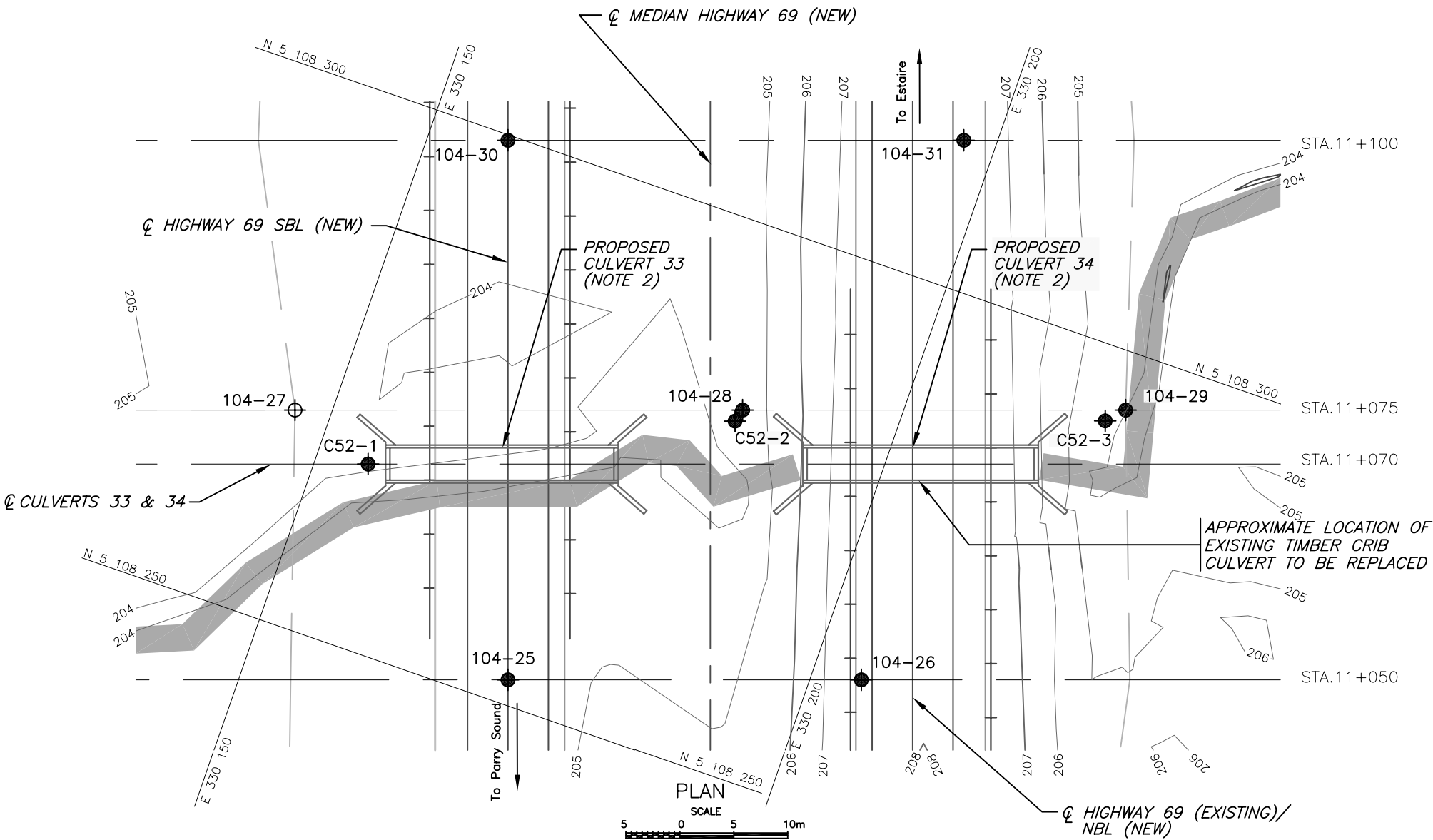
RECORD OF BOREHOLE No 104-31

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 11+100 o/s 23.5m Rt. CL median ORIGINATED BY F.P.
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
 DATUM Geodetic DATE November 07, 2006 CHECKED BY G.D.

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					w _p	w	w _L		GR	SA	SI	CL
					○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)										
207.2	Ground Surface							20	40	60	80	100								
0.0	Gravelly sand, trace silt		1	SS	22		207							○						
	Compact Brown Moist																			
	(PAVEMENT FILL)																			
206.3	Silty clay		2	SS	6		206							○						
0.9	pockets of organics and peat																			
	Firm to Brown Moist		3	SS	11										○					
	stiff																			
	Clayey silt						205													
204.6	Very Grey Moist		4	SS	12/15cm									○						
2.6	stiff																			
	(FILL)																			
	End of borehole																			
	Refusal on probable bedrock																			
	Sample 4: Sampler bouncing																			
	* Borehole dry																			

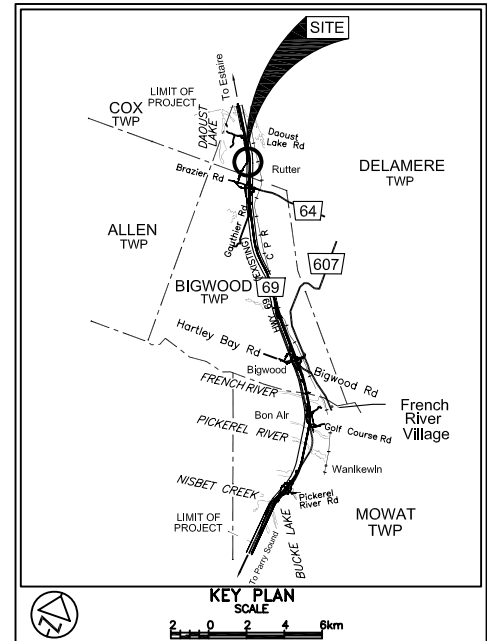


PROFILE \varnothing CULVERT 33/34 (C52)

NOTES:

- DRAWING C52-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
- CULVERT 33/34 WAS DESIGNATED AS C52 FOR THE INVESTIGATION.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

CONT No	WP No 5463-09-01
WP No 5565-09-01	
CULVERT 33/34 (C52)	
HIGHWAY 69 FOUR-LANING	
STA. 11+070 DELAMERE TWP	
BOREHOLE LOCATIONS AND SOIL STRATA	



LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation Sept. 2008
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

(Legend Continued)

BH No	ELEVATION	STA DELAMERE TWP	o/s CL MED
104-25	204.7	11+050	18.8m Lt.
104-26	207.7	11+050	14.0m Rt.
104-27	204.2	11+075	38.5m Lt.
104-28	204.7	11+075	3.0m Rt.
104-29	204.4	11+075	38.5m Lt.
104-30	204.2	11+100	18.8m Lt.
104-31	207.2	11+100	23.5m Rt.

BH No	ELEVATION	CO-ORDS	
		NORTHING	EASTING
C52-1	204.1	N 5 108 267	E 330 155
C52-2	204.4	N 5 108 282	E 330 186
C52-3	204.4	N 5 108 293	E 330 218

(Legend Continues)

NOTE

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



REF.: MRC DRAWINGS : 6454 ds Plan View of Phase 1 Culverts 090821.dwg; 6454 ds Culvert Xsect Phase 1 Zone 12 Mainline Culverts 090821.dwg; H6454_PHASE1_XA01.dwg; H6454_PHASE1_XN01.dwg and X6454xb02 contours zone 12.dwg.

REVISIONS	DATE	BY	DESCRIPTION
06/18/10	CN	WP NO. AND SITE NO. ADDED, AS PER MRC EMAIL DATED JUNE 17, 2010	

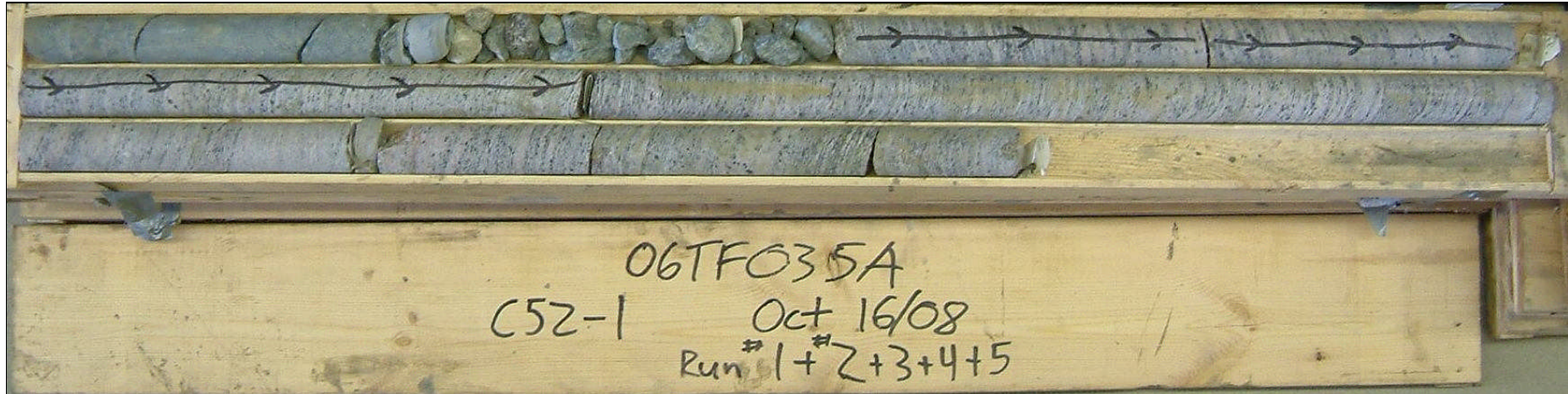
Geocres No.	411-257
HWY No	69
SUBM'D	MN
CHECKED	MN
DATE	MAY 03, 2010
DRAWN	NA
CHECKED	CN
APPROVED	BRG
DIST	54
SITE	46-545/C1&C2
DWG	C52-1

Technical Memorandum – Culvert C52, Highway 69 Four-Laning
Phase 1, Site No. 46-545 C1 NBL/46-545 C2 SBL
W.P. 5463-09-01 NBL/ 5565-09-01 SBL, G.W.P. 5206-06-00 (Part of G.W.P. 5378-02-00)
Index No.: 2177LET, PML Ref.: 06TF035A, June 28, 2010

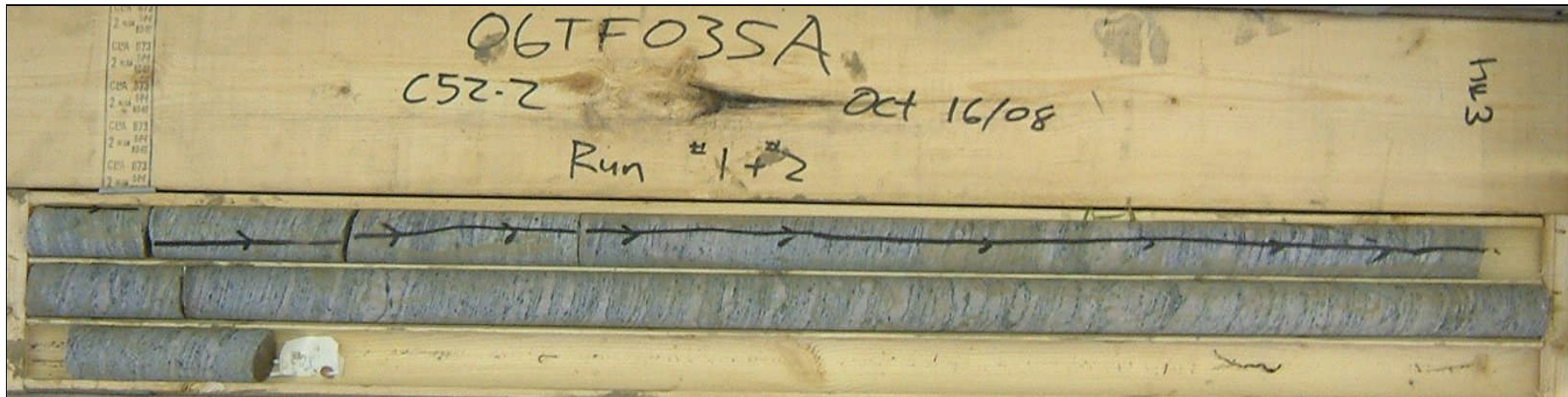


APPENDIX A

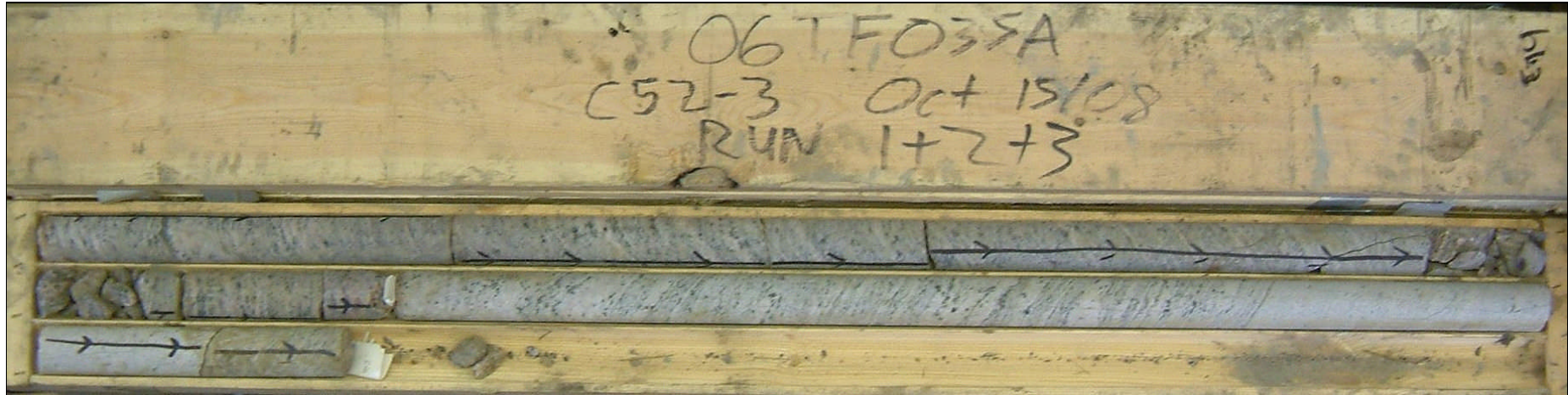
ROCK CORE PHOTOGRAPHS



Photograph 1: Culvert C52, borehole C52-1, samples RC-6, RC-7, RC-8 and RC-9



Photograph 2: Culvert C52, borehole C52-2, samples RC-5 and RC-6



Photograph 3: Culvert C52, borehole C52-3, samples RC-3, RC-4 and RC-5