



**TECHNICAL MEMORANDUM FOR CULVERTS IN PHASE 1
ADDENDUM TO FOUNDATION INVESTIGATION
AND DESIGN REPORT
CULVERT C36 - BIGWOOD 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. 46-530 C1 NBL / 46-530 C2 SBL
W.P. 5175-08-01 NBL / 5176-08-01 SBL
G.W.P. 5206-06-00 (PART OF G.W.P. 5378-02-00)
SUDBURY AREA, ONTARIO**

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PML Ref.: 06TF035A
Index No.: 2176LET
GEOCRES No.: 41I-257
June 28, 2010

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Dear Mr. Doyon

**Technical Memorandum for Culverts in Phase 1
Addendum to Foundation Investigation and Design Report
Culvert C36 - Bigwood 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. 46-530 C1 NBL / 46-530 C2 SBL
W.P. 5175-08-01 NBL / 5176-08-01 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 7 and 8 at station 17+710, Bigwood Township which were assigned a reference number C36. 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 about 30 m north of the proposed northbound culvert C36.

The field work for culvert C36 was carried out during the period of September 29 to October 8, 2008. The subsurface investigation comprised a total of 3 boreholes advanced to depths of 8.7 to 14.3 m below existing grade.

The locations of the boreholes put down along the culvert are shown on Drawing C36-1. 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 comprised a surficial topsoil layer or fill, underlain by clayey silt, silty clay/clay and locally sand and silty sand. Bedrock was contacted at depths of 5.6 to 11.2 m (elevations 184.5 to 190.5). Groundwater was measured at elevations 186.9 to 189.6 in boreholes C36-2 and C36-3 during the field investigation at the clay/ sand interface.

Reference should be made to the previous boreholes conducted in swamp 109 (boreholes 109-61 to 109-65) that are within proximity to the southbound and northbound C36 culverts. The boreholes reveal consistent soil conditions with refusal on probable bedrock at elevations 185.6 to 193.2.

1.1 Topsoil/ Fill

Topsoil measuring 200 to 300 mm in thickness was encountered in boreholes C36-1 and C36-2 and penetrated at elevations 195.8 and 195.5, respectively.

In borehole C36-3 surficial fill, comprising sand and gravel over silty clay with organics was encountered to 2.1 m depth (elevation 194.4).

1.2 Clayey Silt

Underlying the topsoil in boreholes C36-1 and C36-2 and fill in borehole C36-3 was a cohesive deposit of clayey silt. This deposit was 1.6 to 2.8 m thick and typically stiff, becoming firm in consistency with increased depth. The N values ranged from 2 to 12. An in-situ vane test conducted at 2.3 m depth in borehole C36-2 indicated a shear strength of 52 kPa. The deposits were penetrated at depths of 2.1 m, 3.0 m and 3.7 m at boreholes C36-1, C36-2 and C36-3, respectively (elevations 192.7 to 194.0).

The results of Atterberg plasticity limits testing and grain size distribution analysis conducted on samples of clayey silt from culvert C36 are presented in respective Figures C36-PC-1 and C36-GS-1. The liquid limit of the clayey silt was 27 to 34, the plastic limits 17 to 18, giving plasticity index values of 9 to 16. The water content of representative samples of the clayey silt ranged from 21 to 45%.

1.3 Silty Clay/ Clay

Overlain by deposits of cohesive clayey silt at 2.1 and 3.0 m depth in boreholes C36-1 and C36-2 was a deposit of silty clay. The silty clay deposit was 3.5 and 5.8 m thick and was firm to soft in consistency. The N values ranged from 0 to 3. Penetrometer testing on samples in the upper silty clay deposit indicated a range of shear strength from 38 to 50 kPa. In-situ vane testing conducted at 3.8 and 5.3 m depth in borehole C36-2 indicated a shear strength from 24 to 26 kPa. Previous boreholes conducted in swamp 109 in proximity to culvert C36 indicated an in-situ field vane shear strength from 25 to 52 kPa. The deposit extended to the underlying bedrock at 5.6 m depth (elevation 190.5), in borehole C36-1 and was penetrated at 8.8 m depth in borehole C36-2 (elevation 186.9).



Underlying the cohesive clayey silt at 3.7 m depth in borehole C36-3 was a clay deposit. The 3.3 m thick deposit comprised clay, with silt, and trace sand. The consistency of the clay was firm becoming soft with depth. N values ranged from 0 to 1. In-situ vane testing conducted at 3.8 and 5.3 m depth in borehole C36-3 indicated a shear strength from 22 to 28 kPa. Previous boreholes conducted in swamp 109 in proximity to culvert C36 indicated an in-situ field vane shear strength from 22 to 25 kPa. The clay deposit was penetrated at 7.0 m depth (elevation 189.5).

The results of Atterberg plasticity limits testing and grain size distribution analysis conducted on samples of the silty clay and clay from culvert C36 are presented in respective Figures C36-PC-2 and C36-GS-2.

The liquid limit and plastic limit of the silty clay was 48 and 25, respectively, with a plasticity index value 23. The water content of representative samples of the silty clay ranged from 37 to 93%.

The liquid limit and plastic limit of the clay was 60 and 25, respectively, with a plasticity index value 35. The water content of representative samples of the clay ranged from 40 to 97%.

1.4 Sand/ Silty Sand

Beneath the silty clay and clay at 8.8 and 7.0 m depths (elevations 186.9 and 189.5) in boreholes C36-2 and C36-3 a cohesionless sand deposit was contacted. The sand deposit was 1.5 and 2.4 m thick, comprising trace to some gravel, trace silt with cobbles and boulders being encountered in borehole C36-2. The relative density of the sand was loose to compact. The N values of the sand were 9 and 15, with moisture contents of 10 and 11%. The deposit extended to the underlying bedrock at 11.2 m depth (elevation 184.5) at borehole C36-2 and was penetrated at 8.5 m depth (elevation 188.0) at borehole C36-3 into the underlying silty sand deposit.

The silty sand deposit contacted in borehole C36-3 at 8.5 m depth (elevation 188.0) was 2.0 m thick. The relative density of the silty sand was compact. The silty sand had an N value of 16 and moisture content of 11%. The silty sand deposit extended to the underlying bedrock at 10.5 m depth (elevation 186.0).

The results of grain size distribution analyses performed on a sample of the sand and silty sand from culvert C36 are presented on Figure C36-GS-3.

1.5 Bedrock

Bedrock was contacted at depths of 5.6 to 11.2 m depth (elevations 184.5 to 190.5), with the bedrock surface elevation increasing from the centerline median to the east and west ends of the northbound and southbound culverts. The bedrock comprises a grey to black Granitic Gneiss (occasionally pink to predominantly pink in the bottom of borehole C36-3) with dark green and black Hornblende and/or Biotite and exhibited high strength. A detailed description of the rock cores retrieved from boreholes C36-1, C36-2 and C36-3 is given in Table A, appended.

The measured core recovery was 98 to 100%. The RQD determined from the rock cores was in a range of 85 to 100%, thus indicating a good to excellent quality rock.



1.6 Groundwater

Groundwater was observed in two of the boreholes during the course of the field work. Water was contacted at depths of 8.8 and 6.9 m (elevations 186.9 and 189.6) in boreholes C36-2 and C36-3. During the investigation for the swamp 109 crossings in October 2006 the ground water level was about 4.3 to 8.0 m higher at levels ranging from elevations 193.9 to 194.9. No water was observed in borehole C36-1. 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 C36, separate box culverts are proposed under the northbound and southbound lanes of the new Highway 69 (designated northbound and southbound culverts). The invert levels of the proposed 3.5 m wide concrete box culverts are specified near elevation 193.4 at the west end of the southbound culvert and 193.5 at the east end of the northbound culvert, indicating an east to west flow. The subgrade level of the granular bedding is interpreted to be about 0.5 m below the proposed invert levels at elevations 192.9 to 193.0 allowing for the thickness of the concrete base of the culvert and for the granular bedding and levelling courses.

Culvert C36 is located within swamp 109. At the culvert location, the southbound lanes will require up to 1.0 m of embankment fill from existing grades to achieve the proposed road centreline grade elevation 197.3. In the northbound lanes, only minor cut or fill will be required for the proposed road rehabilitation and a centreline grade elevation 197.1 is proposed.

In summary, the subgrade soils revealed in the boreholes below the culvert invert levels typically comprise cohesive firm clayey silt, overlying firm to soft silty clay or clay. These cohesive soils mantle bedrock at elevation 190.5 at the west end of the southbound culvert and overlay cohesionless loose to compact sand at 8.8 and 7.0 m depths, elevations 186.9 and 189.5 at the centreline median and the east end of the northbound culvert, respectively.



Groundwater at the time of the field investigation for the culvert was at 8.8 and 6.9 m depths, elevations 186.9 and 189.6. These levels are 6.1 and 3.4 m, respectively below the anticipated subgrade level at the median and east end of the northbound culvert alignment. However, during the investigation for the swamp 109 crossing in October 2006, the groundwater level was about 4.3 to 8.0 m higher at levels ranging from elevations 193.9 to 194.9.

Culvert C36 is within a previously identified area of Swamp 109 that will require special treatment to construct the southbound lanes to maintain the stability of the existing NBL road embankment. The treatment includes a partial excavation to a maximum depth of 5.0 m at the centreline median and extending for a 5.0 m wide strip from the centreline median to the west after which the excavation can be deepened at a backslope of 1H:1V to bedrock or competent soil.

2.1 Foundations for Culvert C36 Under Southbound Lanes

The clayey silt and silty clay subgrade soils underlying the proposed southbound culvert will be excavated and the platform subgrade will be made of rockfill following completion of the recommended treatment for construction of the embankment of the southbound lanes. The rockfill is envisioned to extend below the subgrade level of the culvert to approximate depths of 2.4 m about elevation 190.5 at the west end to 6.1 m about elevation 186.9 at the east end of the culvert. Accordingly, the rockfill under the culvert will be placed on bedrock at the west end and on compact sand at the east end of the culvert.

From approximately 3 m east of the east end of this culvert, the level of the excavation of the subgrade soil will be sloped up from about 6.1 m to about 5.0 m, as these soils will be only partially excavated to 5.0 m depth, elevation 190.7, to a distance of about 5 m from the centreline median to maintain the stability of the existing Highway 69 embankment. Consequently, approximately 3.8 m of firm to soft silty clay will remain below the eastern toe of the new embankment.

The future rockfill and existing firm to soft silty clay is within the zone of influence below the design subgrade level is considered capable of adequately supporting the stress imposed by the embankment and concrete box culvert foundations.

The magnitude of settlement under the culvert will depend on the fill placement method and timing of construction of the embankment and the culvert. If the culvert is constructed concurrently with the embankment, the west end of the culvert would undergo estimated total settlements of about 50 mm due to the proposed 2.4 m thick rockfill under the subgrade level. At the eastern section of the culvert the settlements would be about 120 mm due to the proposed 6.1 m thick rockfill and / or combination of 2.3 m thick rockfill over 3.8 m of silty clay under the subgrade level. These total settlements include some 50% occurring after construction, assuming rockfill is end dumped and placed below the water table.

In view of the 70 mm of differential settlement a precast box culvert could be employed and the culvert could be constructed concurrently with the embankment.

Alternatively, if a cast-in-place culvert is selected for this location, the anticipated 70 mm of differential settlement would exceed the allowable criteria. To mitigate the magnitude of differential settlement, it is recommended that the culvert be constructed after the embankment fill



has been placed and a surcharge of 2.0 m of material (about 40 kPa of pressure) is maintained above the proposed culvert subgrade level for a 12-month period. The surcharging will result in settlements of about 30 mm under the west end of the culvert and about 70 mm under the east end of the culvert. A surcharge stage will reduce the estimated post-construction settlements to about 20 mm at the west end of the culvert and to about 50 mm at the east end of the culvert for differential settlement of about 30 mm. If surcharging is not carried out, the structural design should accommodate the movement/rotation which would result from the differential settlements by adding joints to 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.

2.2 Foundations for Culvert C36 Under Northbound Lanes

The recommended treatment for the new northbound lanes of the new Highway 69 at the proposed culvert C36 location will comprise pavement rehabilitation of the existing Highway 69. The existing clayey silt and silty clay/ clay subgrade will therefore remain intact along the northbound alignment of the highway.

Fill soils were contacted to 2.1 m depth, elevation 194.4 in borehole C36-3 under the existing northbound road platform. Reference is also made to borehole 109-62 which contacted similar fill soils to 3.0 m depth, elevation 194.0.

The subgrade level of the northbound culvert is anticipated to be approximately at elevation 193.0. Accordingly, fill ranging from 3.5 to 4.0 m in thickness is currently placed above the subgrade level. Cohesive firm clayey silt, overlying firm to soft silty clay or clay is within the zone of influence below the anticipated culvert design subgrade level. Because only minor cut or fill will be required for the pavement rehabilitation and the underlying cohesive soils have been loaded with some 3.5 to 4.0 m of fill for a substantial period of time (estimated over 20 years), only negligible settlement is anticipated from the underlying soils after the culvert is installed.

2.3 Geotechnical Bearing Resistance For Culvert C36

The recommended geotechnical bearing resistances at ultimate and serviceability limit states (ULS and SLS) for the proposed 3.5 m wide culvert constructed on rockfill or clayey silt is as follows:

CULVERT SECTION	SOIL TYPE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL RESISTANCE AT SLS (kPa)
Southbound	Rockfill	900	250
Northbound	Firm Clayey Silt	150	100



The geotechnical resistance at SLS normally allows for 25 mm compression of the founding medium. In addition, the rockfill settlement at the east and west ends of the southbound culvert 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 resistances.

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.

For the northbound culvert where firm to soft clayey silt and silty clay / clay soils are anticipated at subgrade level, the subgrade should be immediately covered with a layer of biaxial geogrid (25 by 35 mm max. aperture, 1.2 to 2.0 KN/m min. peak tensile strength) and backfilled with the select bedding material. It is recommended to provide 300 mm of granular bedding above the geogrid. The bedding material should comprise 300 mm of Granular A, compacted as detailed above.



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 C36 constructed on clayey silt or on rockfill are as follows:

SOIL TYPE	MODULUS OF SUBGRADE REACTION MN/m ³
Firm Clayey Silt	5
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
FIRM CLAYEY SILT	0	50	21.0
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 ϕ = 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. The groundwater level measured during the field investigation was 6.1 and 3.4 m, respectively below the anticipated subgrade level at the median and east end of the northbound culvert alignment. 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 μm 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 soft, locally stiff clayey silt/ silty clay or clay) 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 C36 will comprise pavement rehabilitation of the existing Highway 69. The existing firm to soft, locally stiff clayey silt and silty clay subgrade will therefore remain intact along the northbound alignment of the highway.

To maintain basal stability at the subgrade level in the existing firm to soft soils, special treatment for the temporary cut slopes of the excavation should be applied during the construction of the proposed culverts C36 under the northbound lanes.

The temporary cut slopes should be excavated at 1H:1V and partially excavated (benched) to ensure a maximum height of 1.5 m is maintained for the excavation cut slopes above the subgrade level adjacent to the culvert. The width of each bench should be equal to the total depth of the excavation including if applicable, the surcharge fill height. Heavy construction equipment should not be permitted on the benches adjacent to the culvert excavation.

The excavation at the culvert sites should allow for the backfill and cover requirements in accordance with OPSD 803.010.



6. GROUNDWATER CONTROL

Groundwater at the time of the field investigation for the culvert was at 8.8 and 6.9 m depths, elevations 186.9 and 189.6. These levels are 6.1 and 3.4 m, respectively below the anticipated subgrade level at the median and east end of the northbound culvert alignment. However, during the investigation for the swamp 109 crossing in October 2006, the groundwater level was about 4.3 to 8.0 m higher at levels ranging from elevations 193.9 to 194.9.

The anticipated groundwater level is lower than the inferred subgrade level at southbound and northbound culverts. It is considered that dewatering with conventional sump pumping techniques will generally be sufficient to handle any groundwater seepage or surface water inadvertently entering the excavations at the culverts, provided surface water flow is controlled. The contract documents should have a specific item to clearly state that groundwater control of excavations is the contractor's responsibility.

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 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 rockfill and the existing embankment fill soils, including the remaining wedges of cohesive soils near the centreline median at 5.0 m depth. 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.



Carlos M. P. Nascimento, P.Eng.
Senior Project Engineer



Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

MN/CN/BRG:mn-mi

Enclosure(s):

Table A – Rock Core Descriptions
Table 1 – List of Standard Specifications Referenced in Memorandum
Figures C36-PC-1 and C36-PC-2 – Results of Atterberg Limits Testing
Figures C36-GS-1 to C36-GS-3 – Results of Grain Size Distribution Analyses
Explanation of Terms Used in Report
Record of Borehole Sheets
Drawing C36-1 – 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
C36-1	9	5.6 – 7.2	98	85	5.6 – 8.7	GRANITIC GNEISS: Grey, fine to medium grained, with occasional concentrations of dark green to black Hornblende and/or Biotite, garnetiferous, high strength, unweathered, close to moderate spaced flat to dipping cross joints, rough planar, tight to slightly altered (sugary texture) with dark green to black oxidation and/or brown scale on parting surface, good to excellent quality.
	10	7.2 – 8.7	100	96		
C36-2	12	11.2 – 12.8	100	96	11.2 – 14.3	GRANITIC GNEISS: Grey, with occasional pink tinge, fine to medium grained, with occasional concentrations of dark green to black Hornblende and/or Biotite, high strength, unweathered, close to moderate (locally very close) spaced flat to dipping cross joints, rough planar, tight to slightly altered with white scale and/or silt on parting surface, excellent quality.
	13	12.8 – 14.3	98	94		
C36-3	12	10.5 – 12.0	100	100	10.5 – 13.4	GRANITIC GNEISS: Black and pink with vertical banding, becoming predominantly pink at depth, fine to medium grained, high strength, unweathered, wide becoming moderate to close spaced flat to dipping cross joints, rough planar, tight to slightly altered with red or black oxidation on parting surface, excellent quality.
	13	12.0 – 13.4	100	100		

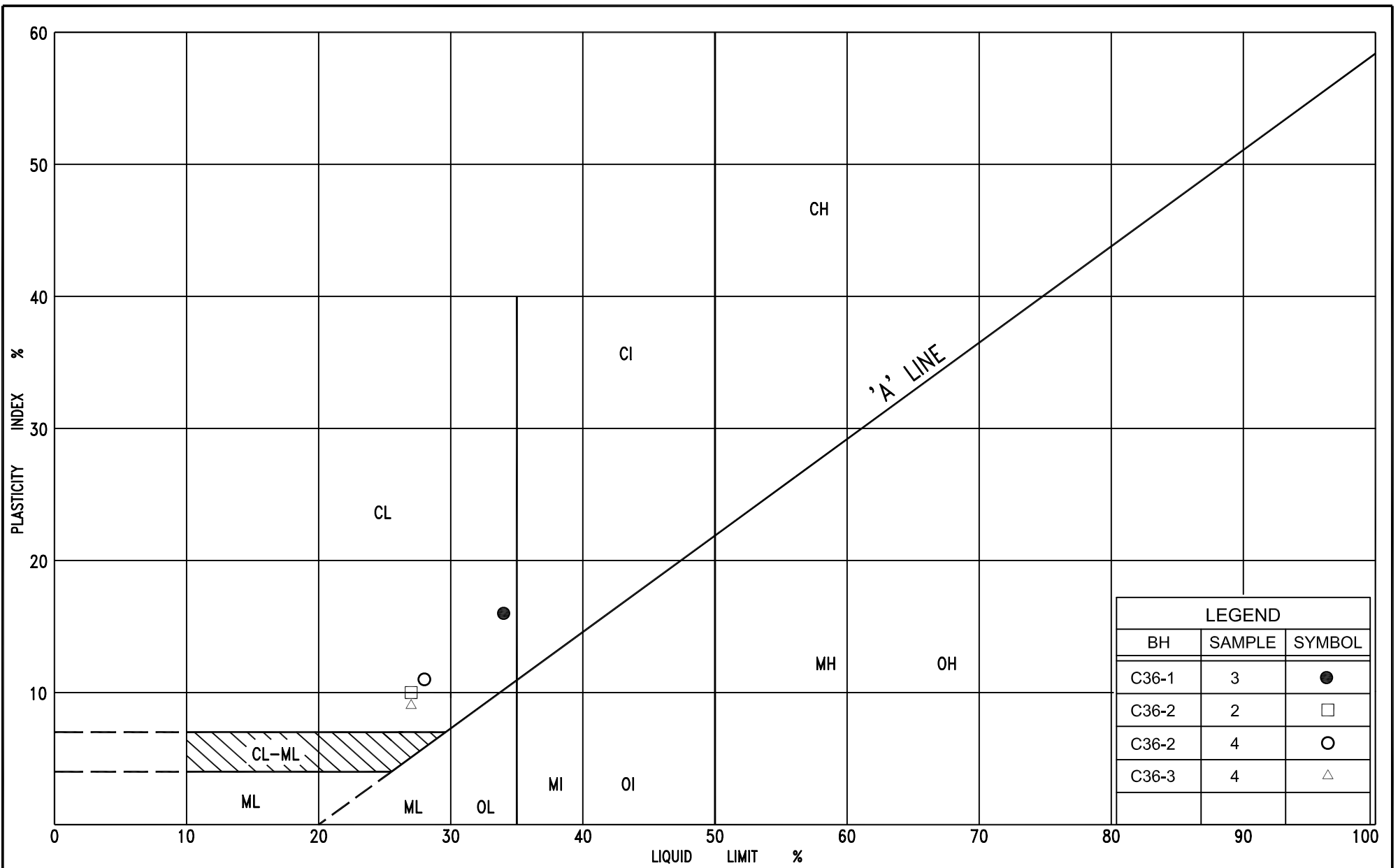
RQD = Rock Quality Designation

Originated: FP
Compiled: JFW
Checked: MN / CN

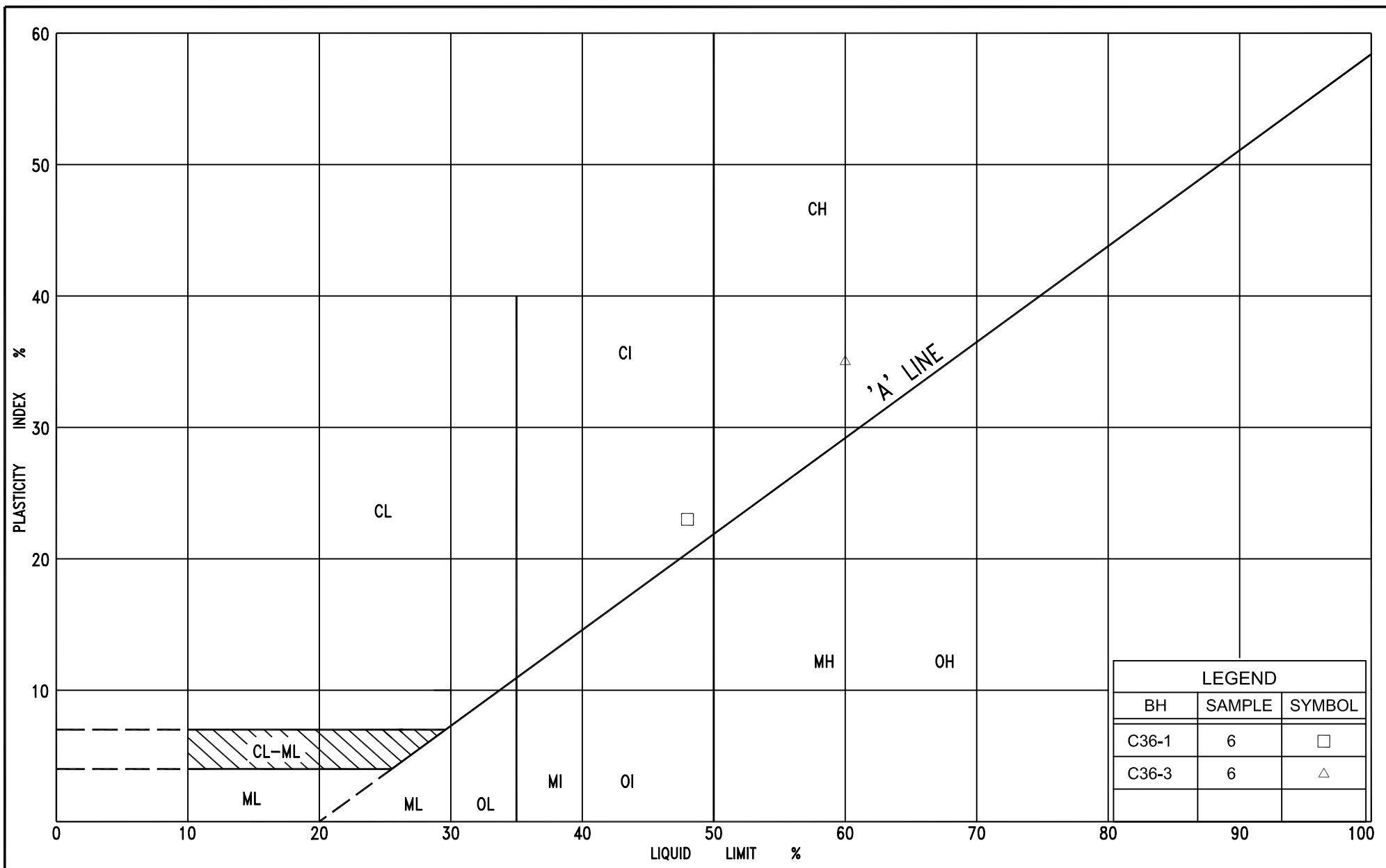


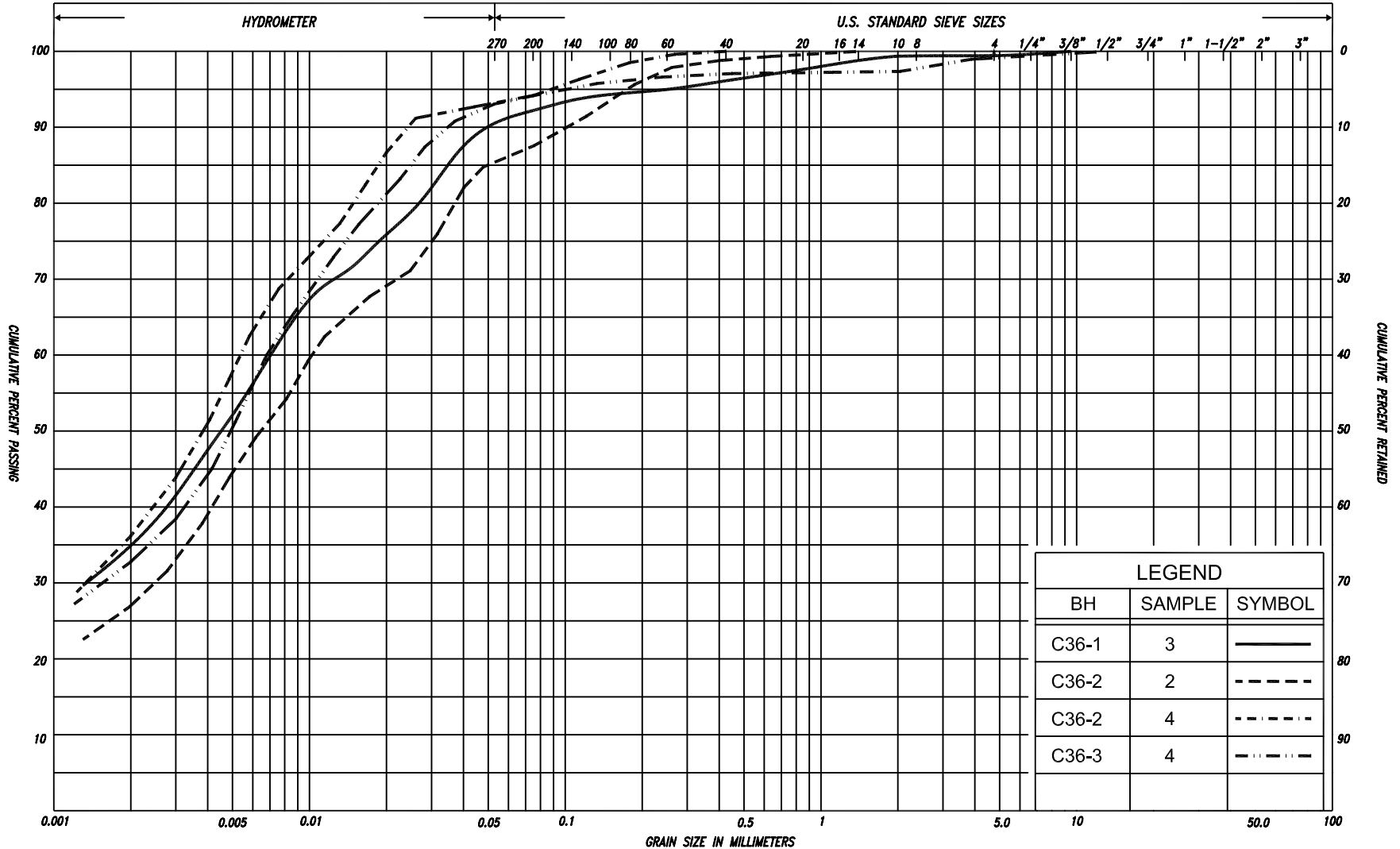
TABLE 1
LIST OF STANDARD SPECIFICATIONS REFERENCED IN MEMORANDUM

DOCUMENT	TITLE
OPSS 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



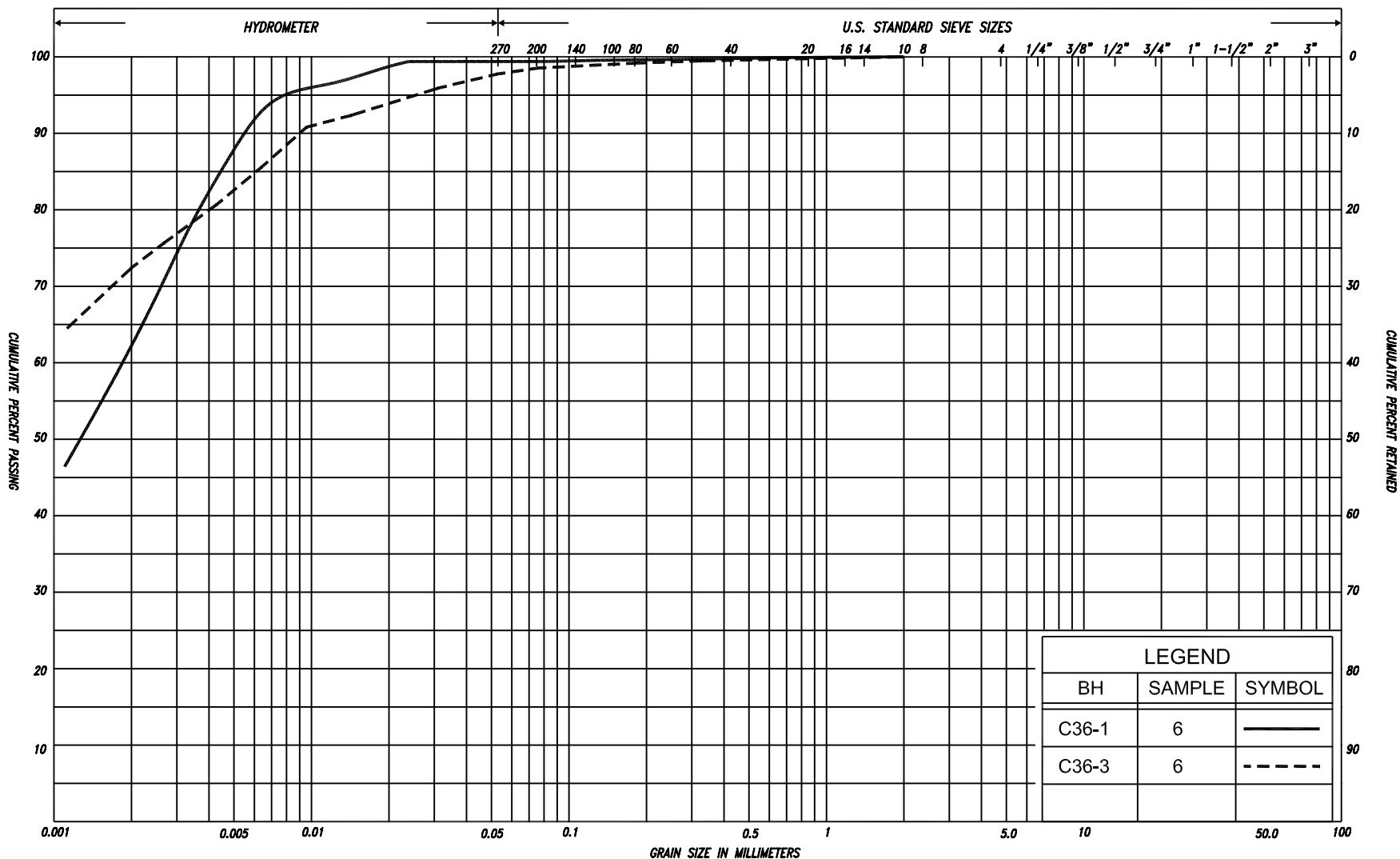
LEGEND		
BH	SAMPLE	SYMBOL
C36-1	3	●
C36-2	2	□
C36-2	4	○
C36-3	4	△



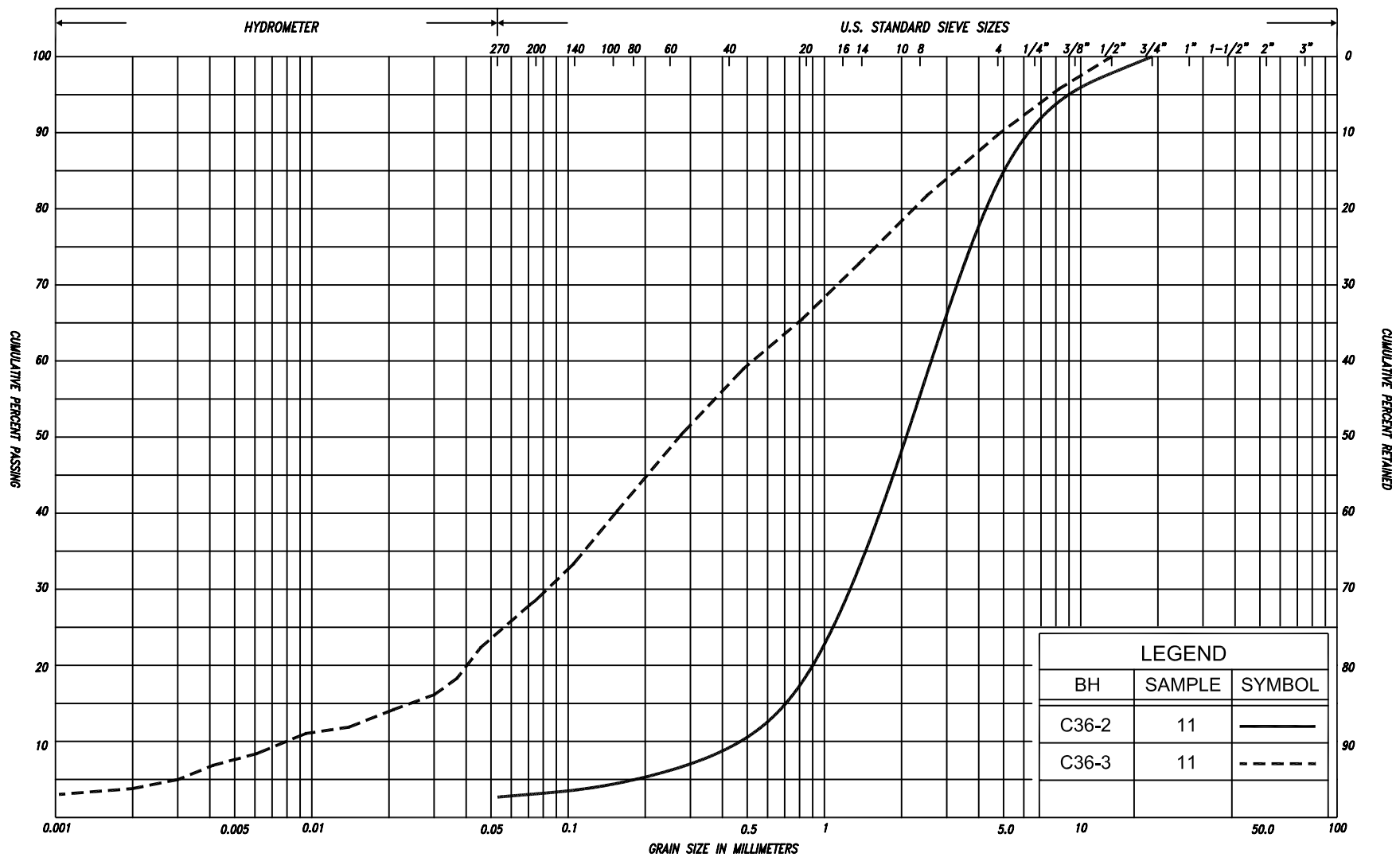


LEGEND		
BH	SAMPLE	SYMBOL
C36-1	3	————
C36-2	2	-----
C36-2	4	- . - . - .
C36-3	4	- · - · - ·

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



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



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

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:

RQD (%)	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^2	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No C36-1

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Coords: 5 103 801 N; 332 308 E
Hwy 69 (New), Sta. 17+711, o/s 32.5m 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 08, 2008 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION kPa 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													
						WATER CONTENT (%)															
						20 40 60 80 100						20 40 60									
196.1	Ground Surface																				
0.0	Topsoil		1	SS	7		196														
195.8	Clayey silt trace sand, trace gravel thin layers of sand																				
0.3			2	SS	12		195														
			3	SS	4		194														
194.0	Silty clay, trace sand																				
2.1			4	SS	2																
			5	SS	3		193														
			6	SS	1		192														
		7	SS	1		191															
190.5			8	SS	10/15cm																
5.6	Granitic Gneiss Bedrock Unweathered High strength Good to excellent quality		9	RC NQ	REC 98%		190														
							189														
			10	RC NQ	REC 100%		188														
187.4	End of borehole																				
8.7	Sample 8: sampler bouncing * Borehole charged with drilling water ■ Penetrometer test C.F.H.S.A. Denotes Continuous Flight Hollow Stem Augers																				

RECORD OF BOREHOLE No C36-2

1 of 2

METRIC

G.W.P. 5206-06-00 LOCATION Coords: 5 103 823 N; 332 329 E
DIST 54 HWY 69 BOREHOLE TYPE C.F.H.S.A. AND NQ DIAMOND CORING ORIGINATED BY F.P.
DATUM Geodetic DATE October 07, 2008 COMPILED BY M.N.
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					
195.7	Ground Surface																
0.0	Topsoil																
195.5	Clayey silt		1	SS	7		195							o			
0.2	some sand, trace gravel organics																
	Stiff Mottled Moist grey/ brown		2	SS	9									o			0 13 60 27
	layers of silty sand																
	Firm Grey Wet		3	SS	5		194							o			
			4	SS	2		193							o			0 6 57 37
192.7	Silty clay, trace sand																
3.0	Firm to Grey Wet soft		5	SS	1											93	
							192									o	
			6	SS	1												
							191									o	
			7	SS	1												
							190									82	
			8	SS	1												
							189									o	
			9	SS	WH**												
							188										
			10	SS	WH												
186.9	Sand						187										
8.8	some gravel, trace silt cobble and boulders																
	Compact Grey Wet		11	SS	15		186							o			17 80 3 0
							185										
184.5	Granitic Gneiss Bedrock						184										
11.2	Unweathered High strength Excellent quality		12	RC NQ	REC 100%												RQD 96%
							183										
			13	RC NQ	REC 98%		182										RQD 94%
181.4	End of borehole																
14.3																	

Cont'd

RECORD OF BOREHOLE No C36-2

2 of 2

METRIC

G.W.P. 5206-06-00 LOCATION Coords: 5 103 823 N; 332 329 E
Hwy 69 (New), Sta. 17+710, 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 07, 2008 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION kPa 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		GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						WATER CONTENT (%)							
180.7								20	40	60	80	100		20	40	60					
	<div><div>*</div><div>2008 10 07</div></div> <div><div>▽</div><div>Water level observed during drilling</div></div> <div><div>WH**</div><div>Denotes penetration due to weight of rods and hammer</div></div> <div><div>■</div><div>Penetrometer test</div></div> <div><div></div><div>C.F.H.S.A. Denotes Continuous Flight Hollow Stem Augers</div></div>																				

RECORD OF BOREHOLE No C36-3

1 of 2

METRIC

G.W.P. 5206-06-00 LOCATION Coords: 5 103 845 N; 332 352 E
Hwy 69 (New), Sta. 17+709, o/s 29.3m 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 September 29, 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					
196.5	Ground Surface																
0.0	Sand and gravel		1	SS	13		196										
	Compact Brown																
	(PAVEMENT FILL)																
	Silty clay		2	SS	3												
	organics																
	Firm Grey Moist						195										
	(FILL)		3	SS	5												
194.4																	
2.1	Clayey silt		4	SS	3		194										
	trace sand, trace gravel																
	organics to 3.5m																
	Firm Grey Wet																
	thin silty sand seams		5	SS	2		193										
192.8																	
3.7	Clay		6	SS	1		192										
	with silt, trace sand																
	Firm to Reddish Wet																
	soft brown		7	SS	1		191										
	Grey		8	SS	1		190										
			9	SS	WR**		189										
189.5																	
7.0	Sand																
	trace gravel, trace silt																
	Loose Grey Wet		10	SS	9		188										
188.0																	
8.5	Silty sand																
	trace clay, trace gravel																
	Compact Grey Moist		11	SS	16		187										
186.0																	
10.5	Granitic Gneiss Bedrock						186										
	Unweathered																
	High strength		12	RC	REC		185										
	Excellent quality		NQ		100%												
			13	RC	REC		184										
			NQ		100%												
183.1																	
13.4	End of borehole																

Cont'd

METRIC

Hwy 69 (New), Sta. 17+709, o/s 29.3m Rt. CL

ORIGINATED BY F.P.

COMPILED BY M.N.

— CHECKED BY C.N.

20
15 — 5 (%) STRAIN AT FAILURE
10

1 of 1

METRIC

Foundation Design

ON MOT VER3 SWAMP 109 FINAL.GPJ ON MOT.GDT 8/19/2008 4:50:10 PM

$+^7, \times^5$: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 109-62

1 of 1

METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 17+700 o/s 14.0m Rt. of CL Med ORIGINATED BY F.P.
DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 03, 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									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
197.0	Ground surface						20	40	60	80	100						
0.0	Gravelly sand, trace silt Compact Brown Moist		1	SS	23											35 57 (8)	
196.2	(PAVEMENT FILL)																
0.8	num. cobbles and boulders		2	SS	31												
	Sand some silt, trace gravel		3	SS	7											8 81 (11)	
	Loose Brown Moist Silty clay trace sand, organics		4	SS	12												
194.0	Stiff Brown Moist (FILL)																
3.0	Silty clay trace sand, trace gravel Stiff Brown Moist		5	SS	3											1 7 56 36	
				FV													
	Firm																

RECORD OF BOREHOLE No 109-63

1 of 1

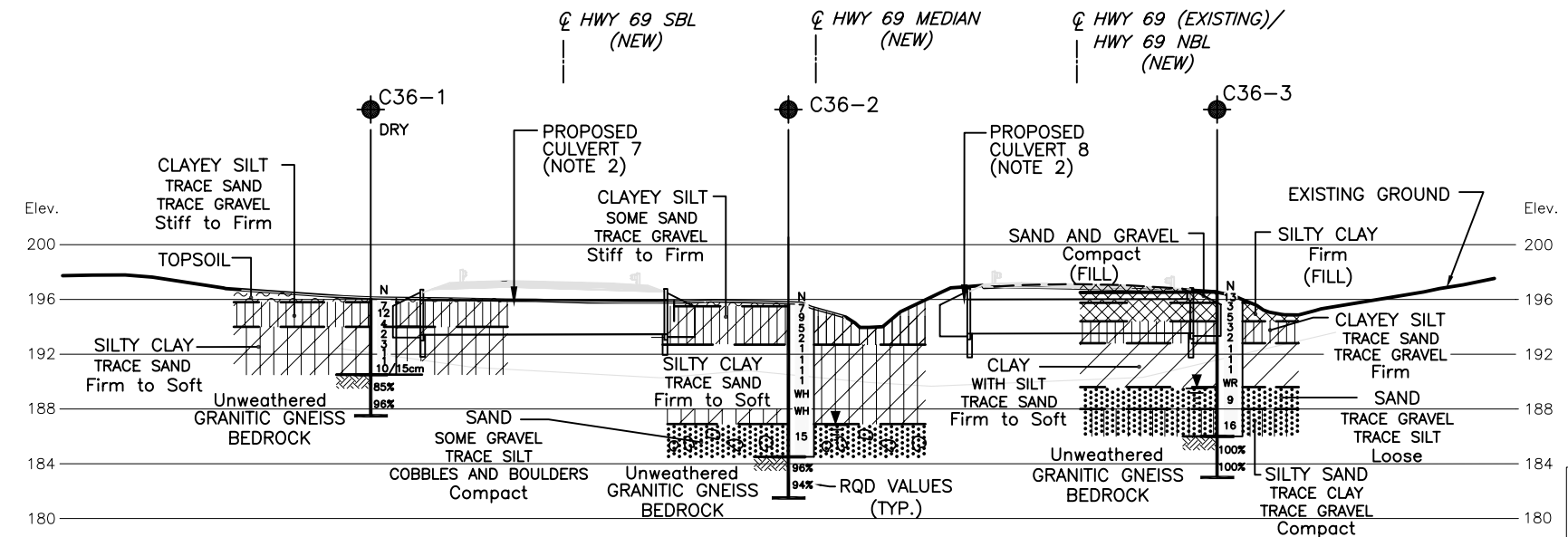
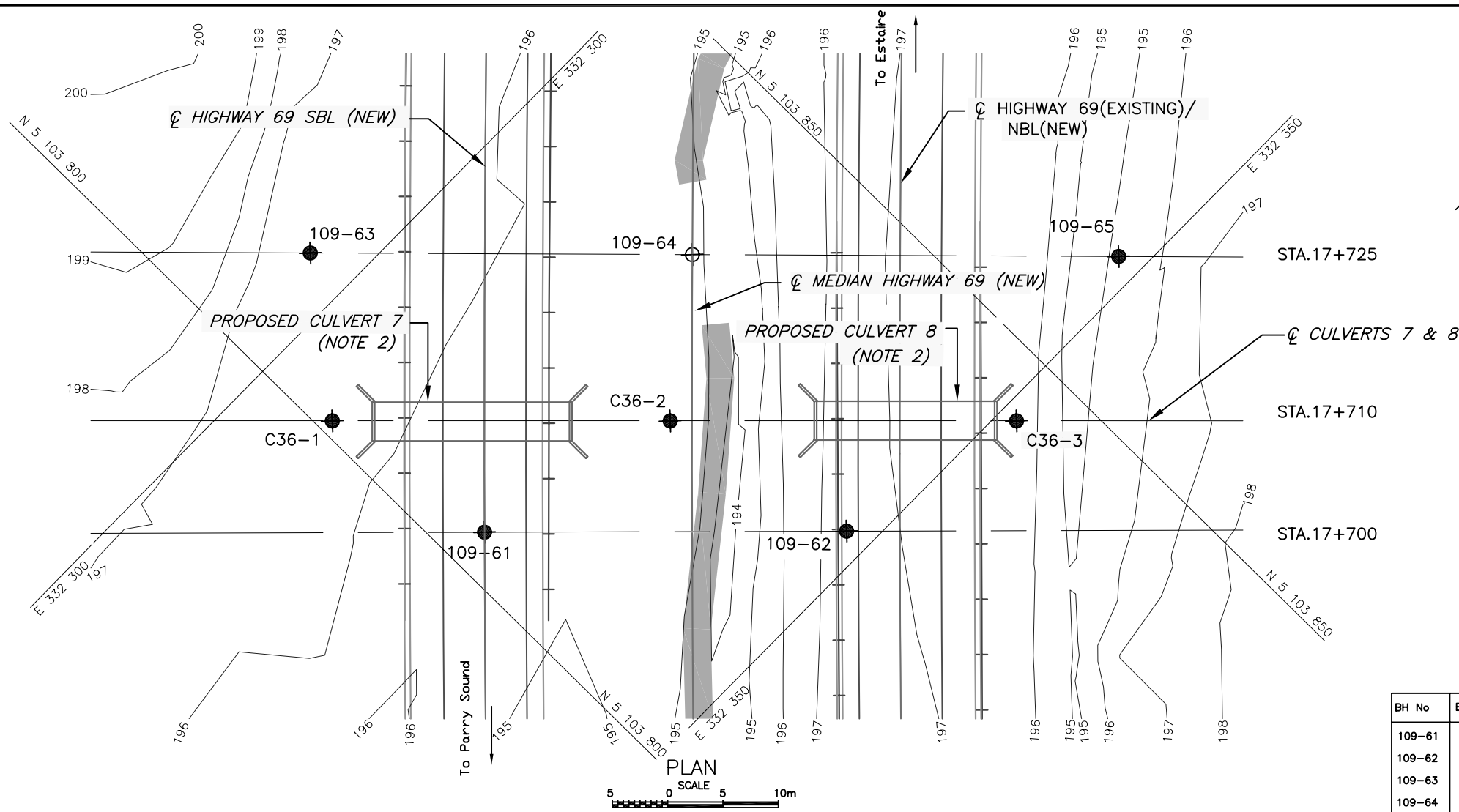
METRIC

G.W.P. 5206-06-00 LOCATION Hwy 69(New), Sta. 17+725 o/s 34.5m Lt. of CL Med ORIGINATED BY F.P.
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
 DATUM Geodetic DATE October 14, 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			SHEAR STRENGTH kPa										w _p	w	w _L
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
196.4	Ground surface							20	40	60	80	100								
0.0	Topsoil																			
0.2	Clayey silt, trace sand		1	SS	9	▽* ▼*	196													
195.7	Stiff Brown Dry to moist																			
0.7	Silty clay, trace sand		2	SS	8															
	Stiff Brown Moist to firm						195													
			3	SS	3															
							194													
193.2			4	SS	10/5cm															
3.2	End of borehole																			
	Refusal on probable bedrock																			
	Sample 4: Sampler bouncing																			

1 of 1 **METRIC**

(%) STRAIN AT FAILURE



PROFILE \varnothing CULVERT 7/8 (C36)

NOTES:

- DRAWING C36-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
- CULVERT 7/8 WAS DESIGNATED AS C36 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.

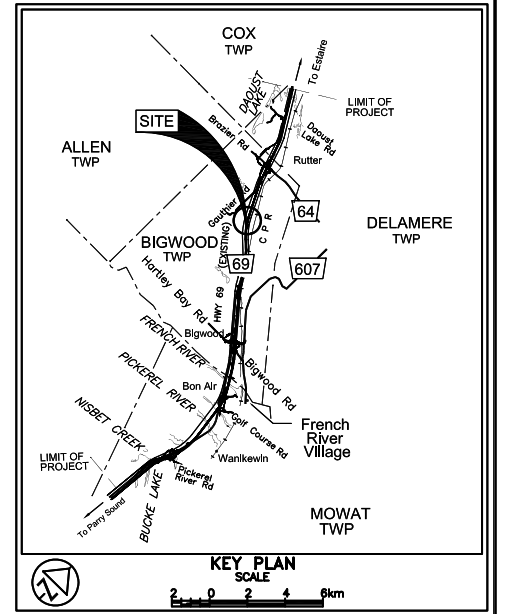
(Legend Continued)

BH No	ELEVATION	STA	o/s CL MED
109-61	195.9	17+700	18.8m Lt.
109-62	197.0	17+700	14.0m Rt.
109-63	196.4	17+725	34.5m Lt.
109-64	195.8	17+725	CL
109-65	196.7	17+725	38.5m Rt.

CONT No
WP No 5175-08-01
WP No 5176-08-01

CULVERT 7/8 (C36)
HIGHWAY 69 FOUR-LANING
STA. 17+710 BIGWOOD TWP
BOREHOLE LOCATIONS AND SOIL STRATA

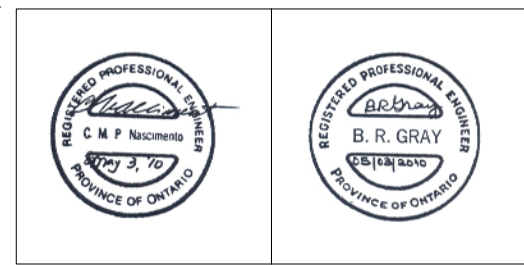
SHEET



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)		
WH	Penetration due to weight of hammer and rods		
WR	Penetration due to weight of rods only		
WL	W L at time of investigation Sept & Oct 2008		
Head	ARTESIAN WATER Encountered		
	PIEZOMETER		
BH No	ELEVATION	CO-ORDS	
		NORTHING	EASTING
C36-1	196.1	N 5 103 801	E 332 308
C36-2	195.7	N 5 103 823	E 332 329
C36-3	196.5	N 5 103 845	E 332 352

(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			DIST 54
SUBM'D	MN	CHECKED	MN	DATE MAY 03, 2010
DRAWN	NA	CHECKED	CN	APPROVED BRG
				SITE 46-530/C1&C2
				DWG C36-1

Technical Memorandum – Culvert C36, Highway 69 Four-Laning
Phase 1, Site No. 46-530 C1 NBL/ 46-530 C2 SBL
W.P. 5175-08-01 NBL/ 5176-08-01 SBL, G.W.P. 5206-06-00 (Part of G.W.P. 5378-02-00)
Index No.: 2176LET, PML Ref.: 06TF035A, June 28, 2010

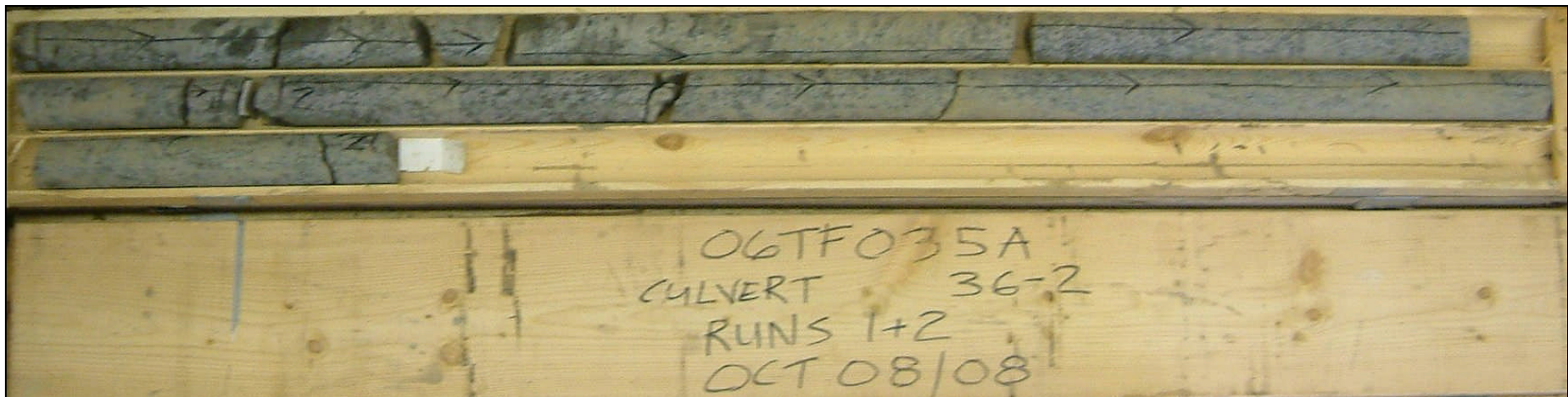


APPENDIX A

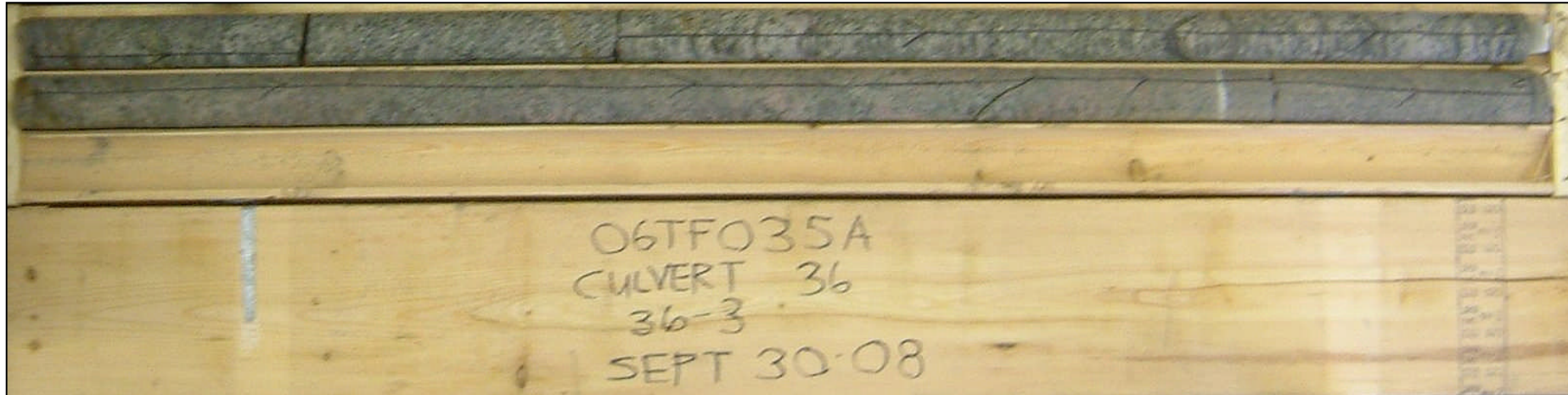
ROCK CORE PHOTOGRAPHS



Photograph 1: Culvert C36, borehole C36-1, samples RC-9 and RC-10



Photograph 2: Culvert C36, borehole C36-2, samples RC-12 and RC-13



Photograph 3: Culvert C36, borehole C36-3, samples RC-12 and RC-13