GEOCRES No:
31E-234

FOUNDATION INVESTIGATION REPORT
EMBANKMENTS ALONG HIGHWAY 11 - STA.13+260 TO STA.14+600
ROBINS ROAD/BLACK CREEK ROAD I/C UNDERPASS STRUCTURE
APPROACH EMBANKMENTS AND ACCESS RAMPS
HIGHWAY 11, BURK'S FALLS TO SOUTH RIVER
ONTARIO
G.W.P. 742-93-00, WP 757-93-01, SITE 44-421
Geocres Number: 31E-234

Report to

Marshall Macklin Monaghan

Volume 1/3

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THURBER

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1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation for the proposed Robins Road/Black Creek Road Interchange Underpass (Site 44-421), associated approach embankments and ramps, and embankments along Highway 11, between Stations 13+260 and 14+600. The project area is approximately 10km north of Burk's Falls, in the Township of Strong, Ontario. A plan view of the project area is shown on Figure 1.1.

Included in the project area described above are two bridges over the Bernard Creek at Highway 11. The results of a foundation investigation carried out for the Bernard Creek bridges have been presented in separate reports[1].

Golder Associates Ltd. (Golder) carried out a preliminary investigation in the spring of 2000 at the site and the factual data from that investigation was available for the current assignment.

The purpose of the present investigation was to explore the subsurface conditions at the proposed bridge site along Robins Road and Black Creek Road and embankments referred to above and, based on the data obtained, to provide a borehole location plan, borehole logs, stratigraphic profile and cross-sections and a written description of the subsurface conditions. A model of the subsurface conditions was developed through considering a combination of the data from the previous Golder report and the data obtained in the course of the present investigation.

Thurber Engineering Ltd. (Thurber) carried out the investigation as a sub-consultant to Marshall Macklin Monaghan (MMM), under the Ministry of Transportation Ontario (MTO) Agreement Number 6005-A-000188.

2 SITE DESCRIPTION

The site is approximately 10 km north of Burk's Falls and it covers the following road alignments:

1 Foundation Investigation Report – Bernard Creek Bridge SBL – Hwy11, Burk's Falls to South River – GWP 742-93-00, WP 756-93-01, Site 44-99 (Draft) – April 7, 2004
and
Foundation Investigation Report – Bernard Creek Bridge NBL – Hwy11, Burk's Falls to South River – GWP 742-93-00, WP 756-93-01, Site 44-99 (Draft) – April 15, 2004

- Along Hwy11, in the south-north direction: from approximately 350m south of Bernard Creek to 450m north of the intersection of existing Highway 11 and Black Creek Road/Robins Road
- Along Black Creek Road and Robins Road alignment, in the west-east direction: from 440m west to 280m east of the intersection of existing Highway 11 and Black Creek Road/Robins Road

The general site area is located within the physiographic region known as the Canadian Shield, characterized by Pre-Cambrian bedrock typically occurring as rounded knobs and ridges where exposed. Locally, however, the site lies in a comparatively flat area with soils characterized by glacio-lacutrine deposits. The ground rises slightly to the east and within 1 km Robins Road crosses Bernard Creek in an area of shallow and exposed bedrock.

The site environs are drained by Bernard Creek to the south and Stirling Creek to the west. However, local drainage is poor and the groundwater table is near the ground surface.

The area to the east of Highway 11 is farmland, mostly pasture, and there is one farmhouse and barns close to the present intersection with Robins Road. There is a seasonal trailer park and associated buildings approximately 50m south of Bernard Creek and east of the existing Hwy11.

South and west of the Highway 11 and Black Creek Road/Robins Road intersection, the land is described as rough pasture to scrub land and near Bernard Creek the land is covered by alder brush. This area is typically wet in the spring and early summer, with shallow standing water extending well beyond the creek banks.

North and west of the Highway 11 and Black Creek Road/Robins Road intersection, the land is wooded with typically second growth softwoods, mostly spruce and cedar.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out in three stages as follows:

- First Stage: carried out between March 20 and March 27, 2003;
- Second Stage: carried out between July 23 and 27, 2003
- Third Stage: carried out between September 21 and October 3, 2004

The boreholes drilled as part of the foundation investigation program for the Bernard Creek SBL and NBL Bridges[1], between January 8 and March 10, 2004, have also been considered for the preparation of this report.

The site investigation can be separated in the following groups according to their location and purpose:

- Highway 11 Mainline
  - Drilling and sampling boreholes BH24-1, BH24-5 and BH24-7 along the Hwy11 mainline to depths ranging from 3.1 to 23.9m. These boreholes are in addition to the boreholes

drilled along Hwy11 for the Bernard Creek SBL and NBL bridges (BH99S-1 through BH99S-5 and BH99N-1 through BH99N-5) and the boreholes listed below, drilled for the Black Creek Road/Robins Road Bridge.

- Advancing four piezocone tests (CPTU9, CPTU10, CPTU11 and CPTU16) to depths ranging from 5.5m to 30.5m to provide more detailed information on stratigraphy and consolidation characteristics of the compressible foundation soils for the design of the embankments along Hwy 11.

- Black Creek Road/Robins Road Bridge
  - Drilling and sampling Boreholes 421-2, 421-3 and 421-4 located at the proposed bridge foundation elements. These boreholes were drilled to depths of 27.6m, 29.0m and 23.1m at the west abutment, central pier and east abutment locations, respectively. These boreholes were advanced to obtain information relating to the subsurface conditions for the design of the underpass structure foundation elements.
- Black Creek Road/Robins Road Approach Embankments
  - Drilling and sampling Boreholes 24-3, 421-1, 421-5, 421-9+925-R1.5 and 421-10+225-R2.5. These boreholes were drilled along the existing Black Creek Road and Robins Road in order to provide information for the design of the approach embankments to the bridge. Boreholes 24-3, 421-1 and 421-5 were drilled to 46.3m, 7.1m and 6.7m depth, respectively. Boreholes 421-9+925-R1.5 and 421-10+225-R2.5 were drilled to auger refusal to 24.4m and 5.4m depth, respectively.
  - Advancing four dynamic cone tests (421-9+795-L21.4, 421-9+900-R29.2, 421-10+50-L26.9, 421-10+150-R23) along the toes of the proposed approach embankments along Black Creek Road and Robins Road to depths ranging from 3.4m to 10.7m.
  - Advancing eight piezocone tests (CPTU1 through CPTU8) to depths ranging from 4.2m to 36.6m to provide more detailed information on stratigraphy and consolidation characteristics of the compressible foundation soils for the design of the approach embankments to the Black Creek Road/Robins Road Bridge.
- Embankments along the ramps west of Hwy 11: N-EW, W-S, E-S and EW-S
  - Drilling and sampling eight boreholes (421-N-EW-14+075-R18, 421-N-EW-14+100-CL, 421-W-S-14+512.5-CL, 421-W-S-14+537.5-R19, 421-E-S-14+525-CL, 421-E-S-14+550-R23.2, 421-E-S-14+575-CL, 421-E-S-14+612.5-CL). The boreholes were drilled to depths up to 11.6m. None of the boreholes were drilled to auger refusal.
  - Advancing four dynamic cone tests (421-N-EW-14+075-L17.8, 421-W-S-14+537.5-L22.9, 421-E-S-14+550-L18.4, 421-E-S-14+612.5-CL) along the proposed approach embankments, to 7.6m depth. None of the dynamic cone tests encountered refusal.
  - Advancing four piezocone tests (CPTU12 through CPTU15) to depths ranging from 2.4m to 23.9m to provide more detailed information on stratigraphy and consolidation

characteristics of the compressible foundation soils for the design of the embankments along the Ramps West of Hwy 11.

- Embankments along the ramps east of Hwy 11: S-EW, EW-N, W-N, E-N, Valley View Road
  - Drilling and sampling eleven boreholes (421-S-EW-14+187.5-CL, 421-S-EW-14+212.5-L20.5, 421-S-EW-14+239.5-CL, 421-E-N-13+754-CL, 421-W-N-13+700-R1.5, 421-W-N-13+725-R21.8, 421-W-N-13+750-CL, 421-W-N-13+800-CL, 421-VV-10+050-CL, 421-VV-10+075-L20, 421-VV-10+100-CL). The boreholes were drilled to depths up to 8.5m. Auger refusal was encountered in boreholes 421-S-EW-14+187.5-CL at 5.3m depth and all boreholes advanced along Valley View Road, at depths ranging from 0.6m to 5.6m.
  - Advancing four dynamic cone tests (421-S-EW-14+212.5-R16.1, 421-E-N-13+754-R16.9, 421-W-N-13+725-L21.7, 421-VV-10+075-R20) to depths ranging from 3.4m to 4.0m. Only the dynamic cone test advanced at Valley View Road, 421-VV-10+075-R20, was advanced to refusal, at 3.4m. The remaining dynamic cone tests were advanced to depths selected as a function of the embankment height.

The approximate locations of the boreholes, dynamic cone tests and piezocone tests are shown on Figure 3.1.

Surveyors from Marshall Macklin Monaghan Ltd. marked the borehole locations in the field and utility clearances were obtained by Thurber prior to any drilling being carried out.

George Downing of Port Hawkesbury, Ontario and All-Terrain of Waterloo, Ontario, supplied and operated the drilling and sampling equipment. A combination of hollow stem auger and rotary drilling techniques were used to advance the boreholes and samples were obtained using a split spoon sampler in conjunction with Standard Penetration Testing (SPT), thin wall Shelby tubes and diamond core barrels.

ConeTec Inc. supplied and operated the piezocone testing. The piezocone testing included standard static penetration with pore pressure measurement and pore pressure dissipation tests at selected depths in order to obtain horizontal coefficient of consolidation values for the design of wick drains. In addition pore pressure dissipation tests were carried out in the sand layer underlying the silty clay deposit to obtain the piezometric head and the possible presence of artesian pressure at that elevation. The piezocone locations and results of the pore pressure dissipation tests are provided in ConeTec's reported included in Appendix D, for the investigations carried out in 2003 (Appendix D1) and 2004 (Appendix D2) and summarized in Table 3.1.

A member of Thurber's engineering staff supervised the piezocone testing, drilling and sampling operations on a full time basis. The inspector logged the boreholes and the recovered samples and processed them for transport to Thurber's Oakville office.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A.

Selected soil samples were subjected to gradation analysis (sieve and hydrometer), Atterberg Limit and Oedometer testing. Point Load Tests were carried out on rock cores for correlation with unconfined compressive strength. The test results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A, to the Record of Borehole sheets prepared by Golder included in Appendix C and to ConeTec's reports included in Appendix D. Details of the encountered soil and rock stratigraphy are also presented on the attached drawings entitled Borehole Locations and Soil Strata. A description of the stratigraphy is given in the following paragraphs.

In general terms, the site was found to be underlain by metamorphic bedrock of the Canadian Shield. The bedrock is overlain by broadly graded generally very dense granular soils including cobbles and boulders, which are overlain by compressible glacio-lacutrine or fluvial soils deposited in the recent geological past. Topsoil, peat and roadbed fills were present at or near the ground surface, as described in the following paragraphs.

5.2 Roadbed Fill, Topsoil and Peat

Roadbed fill consisting of sand and gravel was encountered in the boreholes drilled at the existing roadways to depths ranging from 0.2 to 1.5m. In Golder's Borehole 5-2 a thin layer of topsoil overlay the fill.

A layer of topsoil, with thicknesses in the order of 0.1m to 0.3m, was encountered in several of the boreholes. Peat was encountered in most boreholes drilled west of the existing Hwy11. The peak thickness was in the order of 2.4m to 2.7m at the boreholes along the E-S and N-EW Ramps. Topsoil or peat was also encountered underlying the Black Creek Road roadbed fill west of Hwy11.

The water content of the peat samples ranged from 98% to 670%, with most values ranging from 150% to 400%.

The SPT blow count in the peat was typically zero, with the split spoon sampler sinking more than 300mm under the weight of the rods and hammer.

5.3 Silt and Sand

A geologically recent deposit of silt and sand lies immediately below the topsoil layer along the Hwy11 alignment, south of the Robins Road/Black Creek Intersection. This soil was probably deposited in a glacial lake environment and is characterized by the interbedding of sand and silt layers with intermittent clay seams. The variability of the sequence is consistent with the changing depositional environments understood to occur in glacial and post-glacial lakes. The clay size content, and plasticity, is generally greater toward the base of the layer and the sand content and occurrences of sand seams increases towards the top. The base of the silt and sand layer extended to depths of 8.8m (El.303.4m) at the north abutment of the SBL of the Bernard Creek Bridge and it is typically shallow (EL.310 and higher) elsewhere along the Hwy11 aligment.

The silt and sand deposit is classified as very loose to compact, based on SPT "N" values ranging from 2 to 17. Where cohesive seams were observed within the silt during visual identification, they were described as soft.

The deposit is brown at the top, changing to grey with increasing depth. The measured natural water content ranged from 15% to 30%.

Typical grain size distributions for this soil are shown in Figures B33 and B34 in Appendix B. The results of Atterberg Limit tests on the more cohesive seams identified during visual identification are shown in Figure B40 in Appendix B.

5.4 Silty Clay

A thick silty clay deposit was encountered in most boreholes and piezocones. The thickness of this deposit increased from the northeast to the southwest. The deposit was absent at the proposed Valley View Road, where bedrock is present at or close to the surface. At Black Creek Road, in BH24-3, the base of the deposit was the deepest in the project area, at 36.6m depth (El. 275.6m).

East of the existing Hwy11 and north of approximate Station 14+400 along Hwy11, variable amounts of firm to very stiff clay, silt and sand mixtures in the upper 3m to 8m of the silty clay deposit were detected. This layer, referred herein as "crust", was generally brown in the upper part and grading to grey at depth. The SPT blow count ranged from 6 to 44 and the water content varied typically from 25% to 35%, with the higher values closer to the bottom of the crust.

Below the crust and where no crust was noted, the silty clay was grey in colour and locally varved.

Gradation test showed that the silty clay has variable amounts of silt and clay, and typically less than 5% of sand. Most samples tested for gradation consisted of 40% to 70% silt and 30% to 65% clay. Locally, in particular in the "crust" along Valley View Road and it's junction with Robins Road, the clay content is as low as 15%.

The Atterberg Limit test results included in Appendix B indicate that the silty clay deposit is generally low to intermediate plastic and is classified as CL, CL-ML and CI according to the Modified Unified Soil Classification System. Only two of the samples, collected from BH24-1 and BH24-3 at approximate El.299m and EL.281m, respectively, are high plastic and are classified as CH.

An analysis of the borehole logs shows that the Liquidity Index in the crust is about 50% whereas below the crust, the water content in the silty clay deposit was higher than the Liquid Limit (Liquidity Index greater than one).

Attached Figures 5.1 through 5.19 present a summary of the SPT and undrained shear strength values obtained in the silty clay encountered in the boreholes and piezocones. Undrained shear strength values in the crust were high near the surface (typically more than 100kPa), reflecting very stiff conditions, and decreased with depth to values in the order of 40kPa at 4m to 12m depth, depending on the thickness of the crust. Below the crust the undrained shear strength typically increased with a ratio of the undrained shear strength over the vertical effective stress (S_u/σ'_v) of 0.2 to 0.3 reflecting normal to slightly over-consolidated conditions. Zones of firm to very stiff silty clay were encountered in some of the piezocones and boreholes between El.305 and El.290. These zones are highlighted in the longitudinal profiles along and west of Highway 11, attached at the end of this text. The over-consolidation ratios inferred from piezocone tests show that the silty clay is over-consolidated to depths ranging from 6m to 12m. The oedometer tests, summarized in Table 5.1, show that the soils samples were normally to over-consolidated at 6.4m depth. The p'_c-p_o (pre-consolidation pressure minus the insitu vertical effective strees) for the over-consolidated samples ranged from 15kPa to 64kPa. Below 6.4m depth the samples were normally consolidated.

Vane tests indicated that the sensitivity ratio of the clay (S_u/S_r: peak undrained strength over remoulded strength) measured using in situ vane tests ranged from 2 to 12.5 indicating sensitivity range of Moderate to Very Sensitive. The great majority of the tests, however, reflected Moderate Sensitivity for the clay with Su/Sr values typically less than 4. The presence of sensitive silty clay was detected in many of the piezocone tests, as shown in the piezocone logs presented in Appendix D.

The results of eleven oedometer tests carried out on silty clay samples, collected from depths ranging from 6.3m to 30.8m, are summarized on the borehole logs and in Table 5.1. The compression index ratio ($C_{c\varepsilon} = C_c/(1+e_o)$) ranged from 0.07 to 0.36, with an average value of 0.17. The recompression index ratio ($C_{s\varepsilon} = C_s/(1+e_o)$) ranged from 0.01 to 0.03 with an average of 0.02. The vertical coefficient of consolidation (C_v) obtained from the oedometer tests at the anticipated working vertical effective stresses after the embankment construction ranged from 25 to 100m^2/y with most values between 25 and 50m^2/y. The horizontal coefficient of consolidation (Ch) obtained from piezocones ranged from 30 to 500m^2/y. The higher values of Ch (more than 200m^2/y) were measured in silt of sand lenses in the silty clay.

Time dependent tests were carried out in some of the oedometer tests for approximately 48 hours at constant stress values for measurement of coefficient of secondary consolidation (C_α). The constant stress values for these tests were selected based on the anticipated vertical effective stress at the sample elevation after the end of construction of the embankment. C_α values interpreted from these tests are summarized in Table 5.1. Table 5.1 shows that the coefficient of secondary consolidation ratio ($C_\alpha/(1+e_o)$) ranged from 0.001 to 0.015 with an average value of 0.003.

5.5 Clayey Silt and Silt

At the bottom 1m to 4m of several of the piezocones and boreholes an increase of the silt and fine sand content was noted. This material underlies the silty clay deposit and it is referred to as clayey silt or silt. The silt content in this stratum is typically more than 80% and the clay content is less than 20%. The water content ranged from 22% to 41% with the lower values representing the samples with higher silt content. The SPT values ranged from 2 to 15. The low SPT values probably do not reflect the in situ conditions of this deposit which are expected to be stiff to very stiff or compact. One set of Atterberg Limit tests carried out in a sample collected from BH24-6 at EL.300, along the N-EW Ramp, had Liquid Limit of 23% and Plasticity Index of 6%. This soil sample is classified as CL-ML according to the Modified Unified Soil Classification System.

5.6 Sand Till

A layer of glacial till described in the borehole logs as silty sand or gravely sand, with variable amounts of silt, gravel, cobbles and boulders, underlies the silty clay and clayey silt deposits.

Boulders were encountered in the sand till layer, at elevations ranging from 292m to 274m, at the boreholes drilled at the Bernard Creek Bridge site. The thicknesses of these boulders, measured along the axis of the borehole core, were 0.3 to 0.8m. Additional cobbles and boulders were inferred in this deposit from the response of the drill string as it advanced. This layer should be assumed to contain many more cobbles and boulders than what was positively identified in the course of drilling. Augering in this stratum was only possible in the top 1m to 2m due to the presence of boulders. Where required, the boreholes were advanced using tri-cone and diamond coring techniques in order to penetrate the boulders.

The maximum thickness of this deposit was 10.1m, observed in BH99-S5 at the Bernard Creek Bridge, although this borehole was terminated before reaching bedrock. The SPT "N" values in the sand till were typically high, indicating dense to very dense conditions. The water content generally ranged from 10% to 15% with values up to 25% where the silt content is higher.

5.7 Bedrock

The bedrock at the site consists of Precambrian rock of Mezoproterozoic age, consisting of granitic gneiss of the Central Gneiss Belt. Bedrock was encountered underlying the sand

till in two of the boreholes drilled at the Robins Road/Black Creek I/C Underpass, BH421-2 and 421-3, at EL.287.5m and EL.287.1m , respectively, and in two of the boreholes drilled at the Bernard Creek NBL Bridge, 99N-2 and 99N-5, at EL.276.1m and EL.289.0m, respectively.

The bedrock is described as slightly weathered, granitic gneiss, laminated to thinly banded, pale pink with sub-vertical dark banding. Rough, sub-planar joints were noted, generally with a sub-horizontal orientation. Clayey infilling was noted in some joints. Both total core recovery (TCR) and solid core recovery (SCR) were 97% to 100% and the rock quality designation (RQD) ranged from 74% to 100%.

The compressive strength of the bedrock, assessed by means of point load testing, ranged from 87 to 188 MPa. Based on this range of strengths, the rock is classified as strong to very strong.

The available information indicates that along the Robins Road/Black Creek Road I/C Underpass alignment the bedrock surface is relatively flat between the West Abutment and the Centre Pier. The bedrock elevation has not been established at the east abutment.

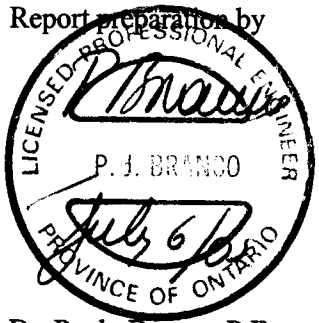
5.8 Water Levels

The groundwater levels at this site were encountered within 2m of the ground surface, as shown in Table 5.2. Relatively small artesian pressures (less than 1.5m above ground surface) were encountered in some of the boreholes and were inferred from CPTU pore pressure dissipation tests in the sand till deposit.

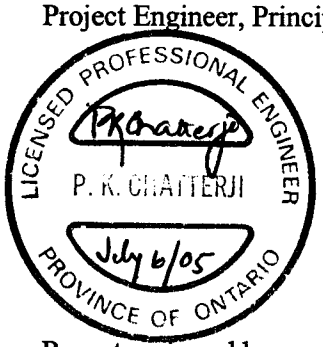
The deep piezometers sealed in the sand till layer indicate the presence of artesian piezometric head up to 1.5m above ground surface. This measurement confirmed the observations of artesian conditions encountered during drilling, when the boreholes were advanced into the sand till. The water level in the shallower piezometers installed in the silty sand and in the silty clay were 0.1m and 0.3m below ground surface, respectively. This information indicates that there is potential for an upward groundwater flow in the silty clay layer. However, the hydraulic gradient in the silty clay is expected to be small and it is not anticipated to affect the performance of piles or wick drains.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall. The level of Bernard Creek will also vary seasonally and after severe weather events, leading to flooding of the area around the proposed structure.

Direction of field work and
Report preparation by



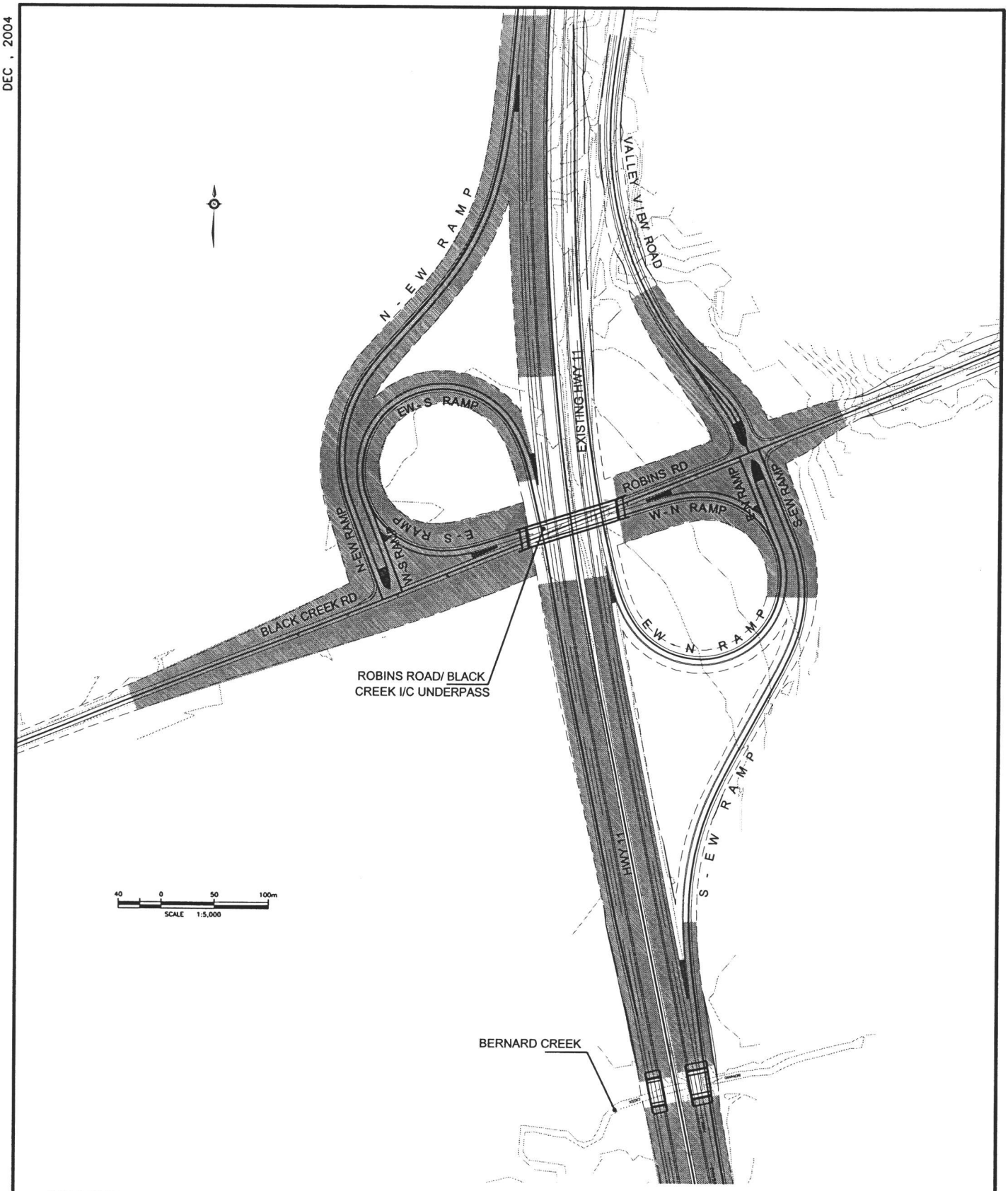
Dr. Paulo Branco, P.Eng.
Project Engineer, Principal



Report reviewed by:
Dr. P.K. Chatterji, P.Eng.
Review Principal

FIGURES

DEC , 2004



LEGEND

EMBANKMENT HEIGHT MORE THAN 2m

Hwy 11, Burk's Fall to South River, Ontario
Robins Rd./ Black Creek Rd. I/C
And Bernard Creek Area

FIGURE 1.1

TED42312 .DWG

LEGEND

- ■ CPTU - 2004 INVESTIGATION
- ⟐ DCPT - 2003 INVESTIGATION
- ◈ CPTU - 2003 INVESTIGATION
- • BH (BY THURBER)
- ◆ BH (BY GOLDER)
- EMBANKMENT HEIGHT MORE THAN 2m
- H : EMBANKMENT HEIGHT

ROBINS RD./ BERNARD CREEK RD.
I/C UNDERPASS

BERNARD CREEK

BLACK CREEK RD

HWY 11

EXISTING HWY 11

VALLEY VIEW ROAD

ROBINS RD

W-S RAMP

E-W S RAMP

S-E W RAMP

N-EW RAMP

EW-N RAMP

N-S RAMP

S-N RAMP

BH24-1 BH24-2 BH24-3 BH24-4 BH24-5 BH24-6 BH24-7

CPTU1 CPTU2 CPTU3 CPTU4 CPTU5 CPTU6 CPTU7 CPTU8 CPTU9 CPTU10 CPTU11 CPTU12 CPTU13 CPTU14 CPTU15 CPTU16

99S-1 99S-2 99S-5 99S-6 99N-1 99N-5 99N-6

H>2m H>6m

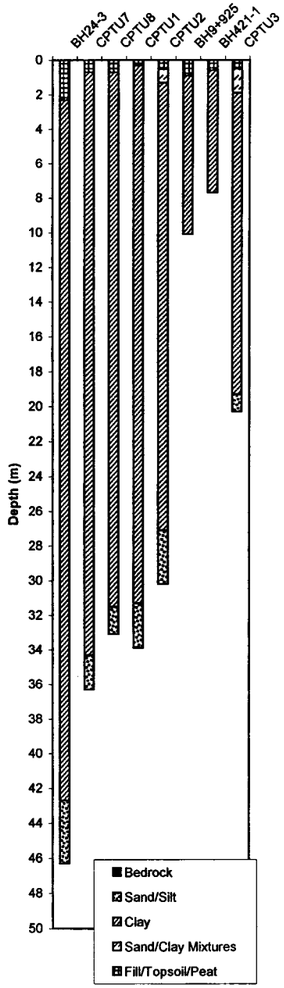
40 0 50 100m
SCALE 1:3,000

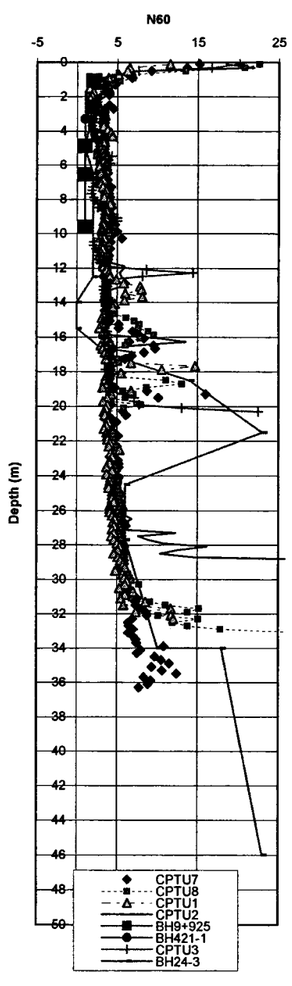
Hwy 11, Burk's Fall to South River, Ontario
Robins Rd./ Black Creek Rd. I/C
And Bernard Creek Area
TEST HOLE LOCATIONS

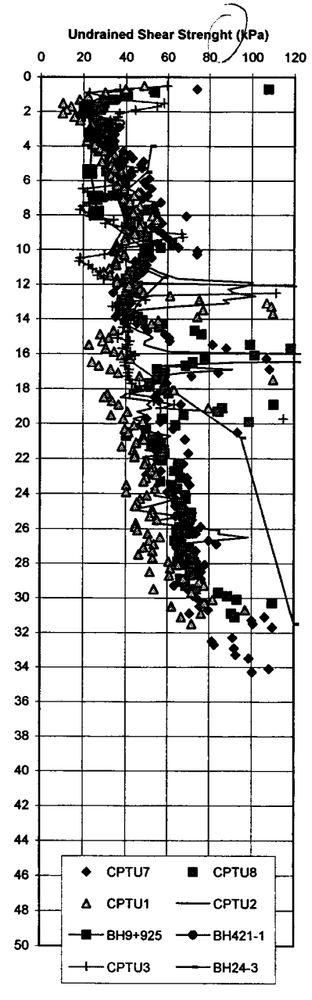
THURBER | 19-1423-24 | FIGURE 3.1

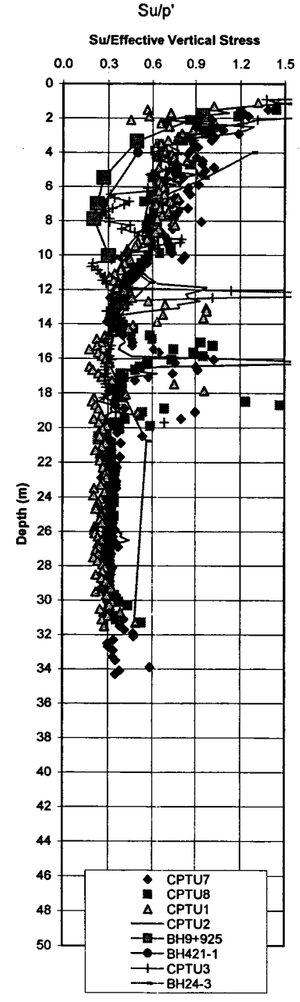
HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
BLACK CREEK - WEST APPROACH

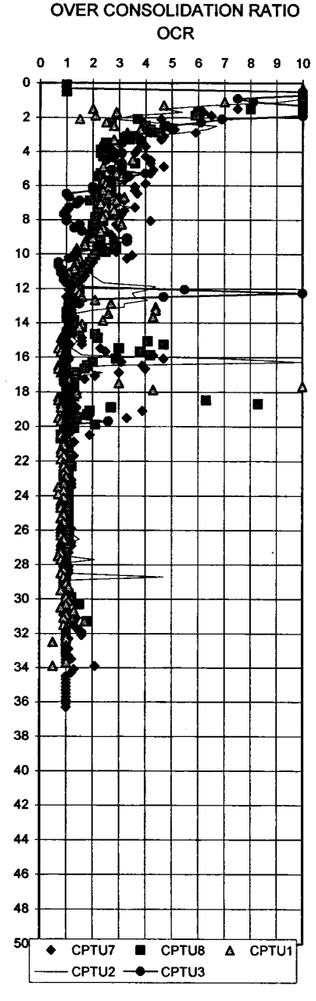
STRATIGRAPHY
(TEST HOLE)

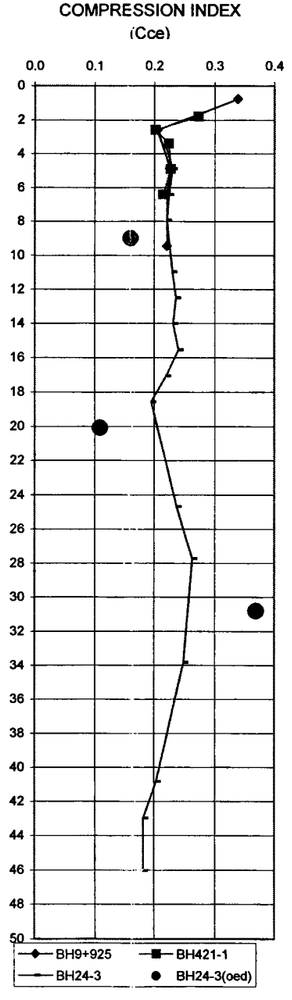


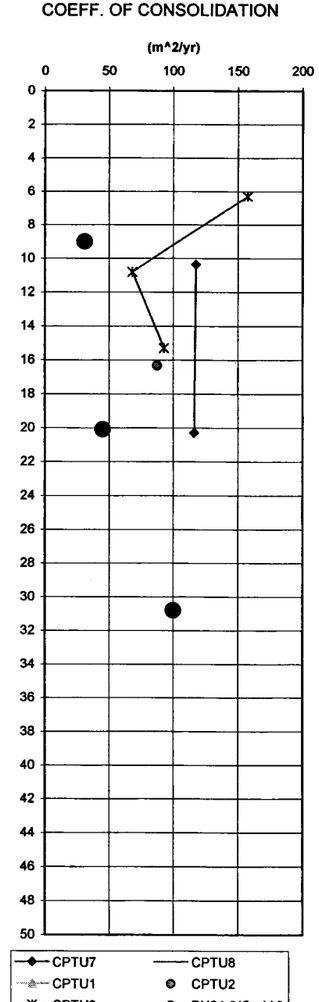








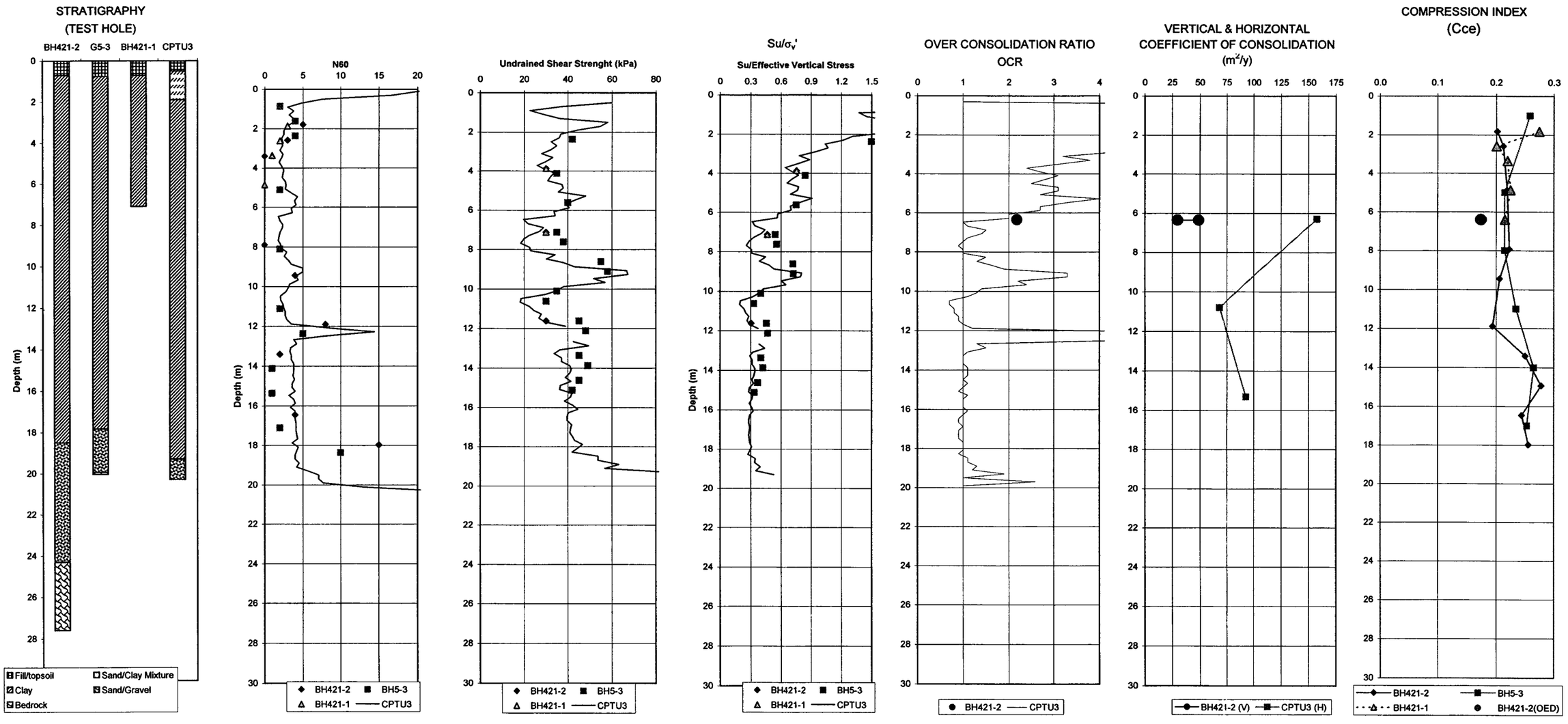




MASTER PLOT

FIGURE 5.1

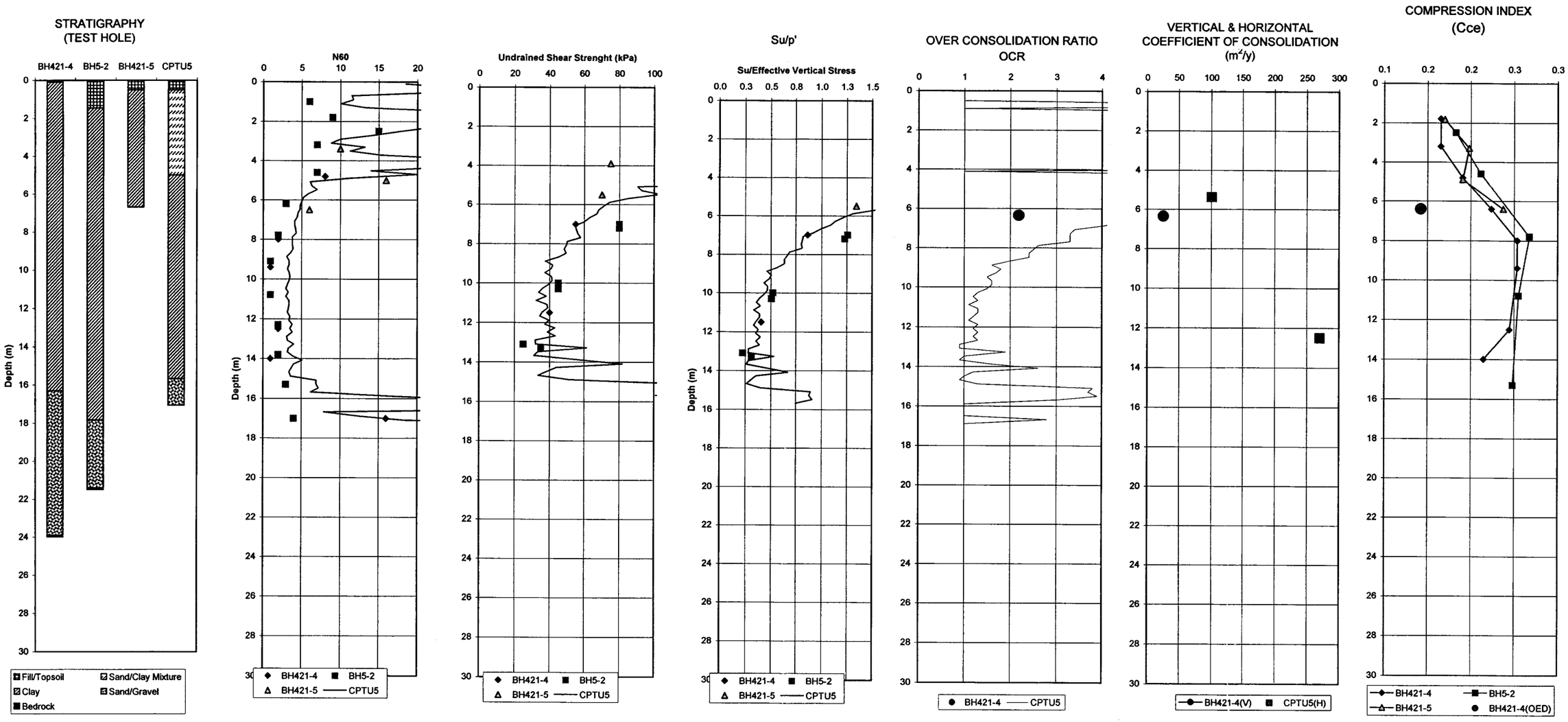
HIGHWAY 11 - ROBINS ROAD BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
BLACK CREEK - WEST ABUTMENT



MASTER PLOT

FIGURE 5.2

HIGHWAY 11 - ROBINS ROAD BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
ROBINS ROAD - EAST ABUTMENT

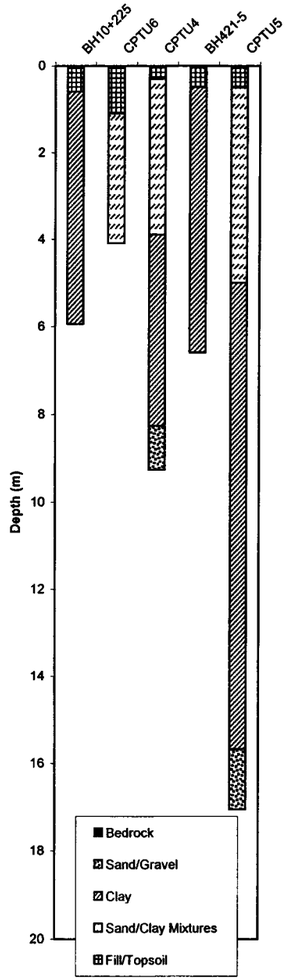


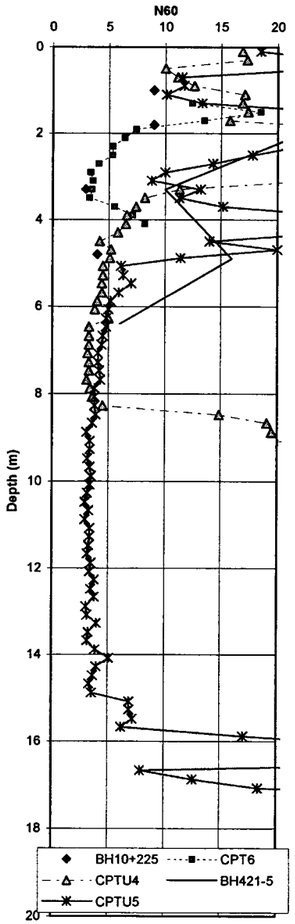
MASTER PLOT

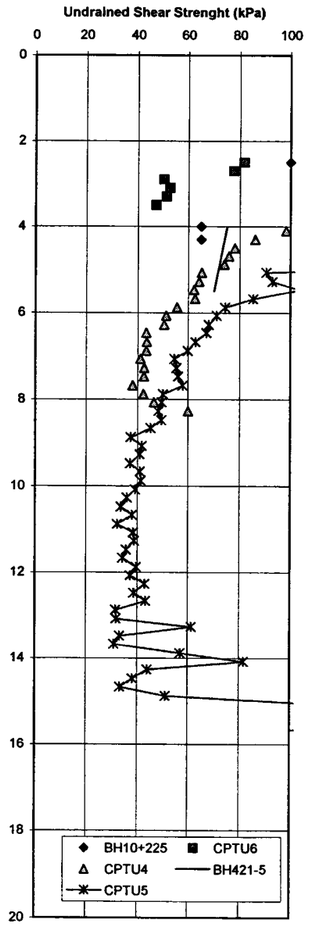
FIGURE 5.3

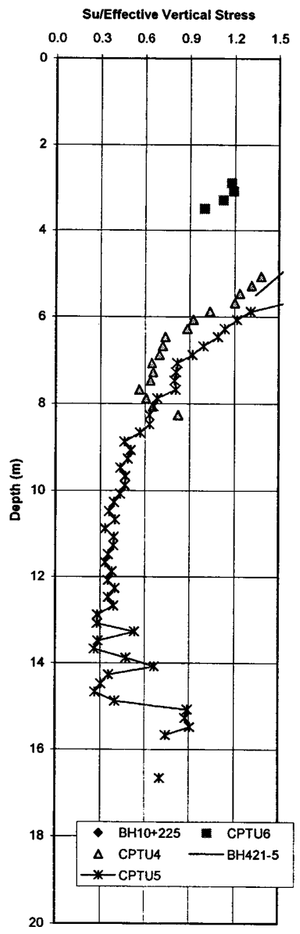
HIGHWAY 11 - ROBINS ROAD BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
ROBINS ROAD - EAST APPROACH

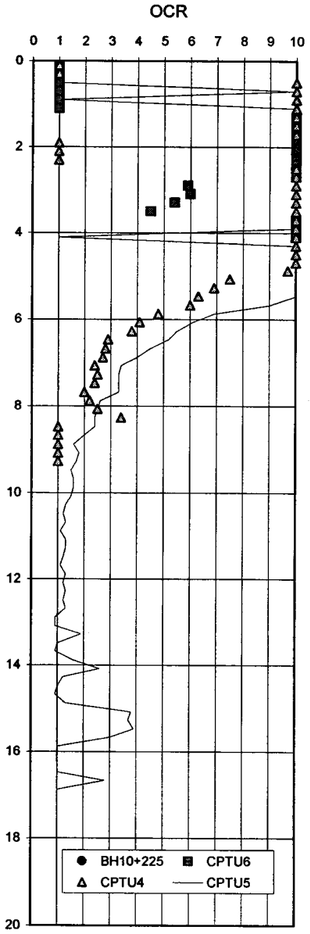
STRATIGRAPHY
(TEST HOLE)

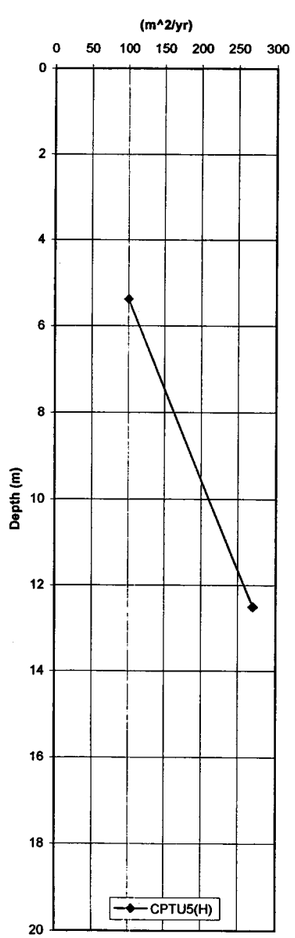


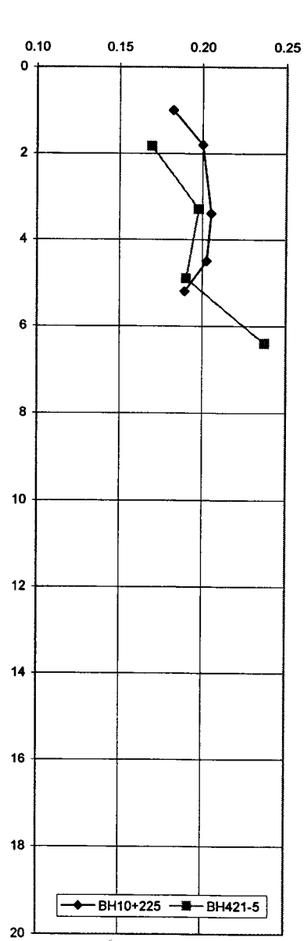








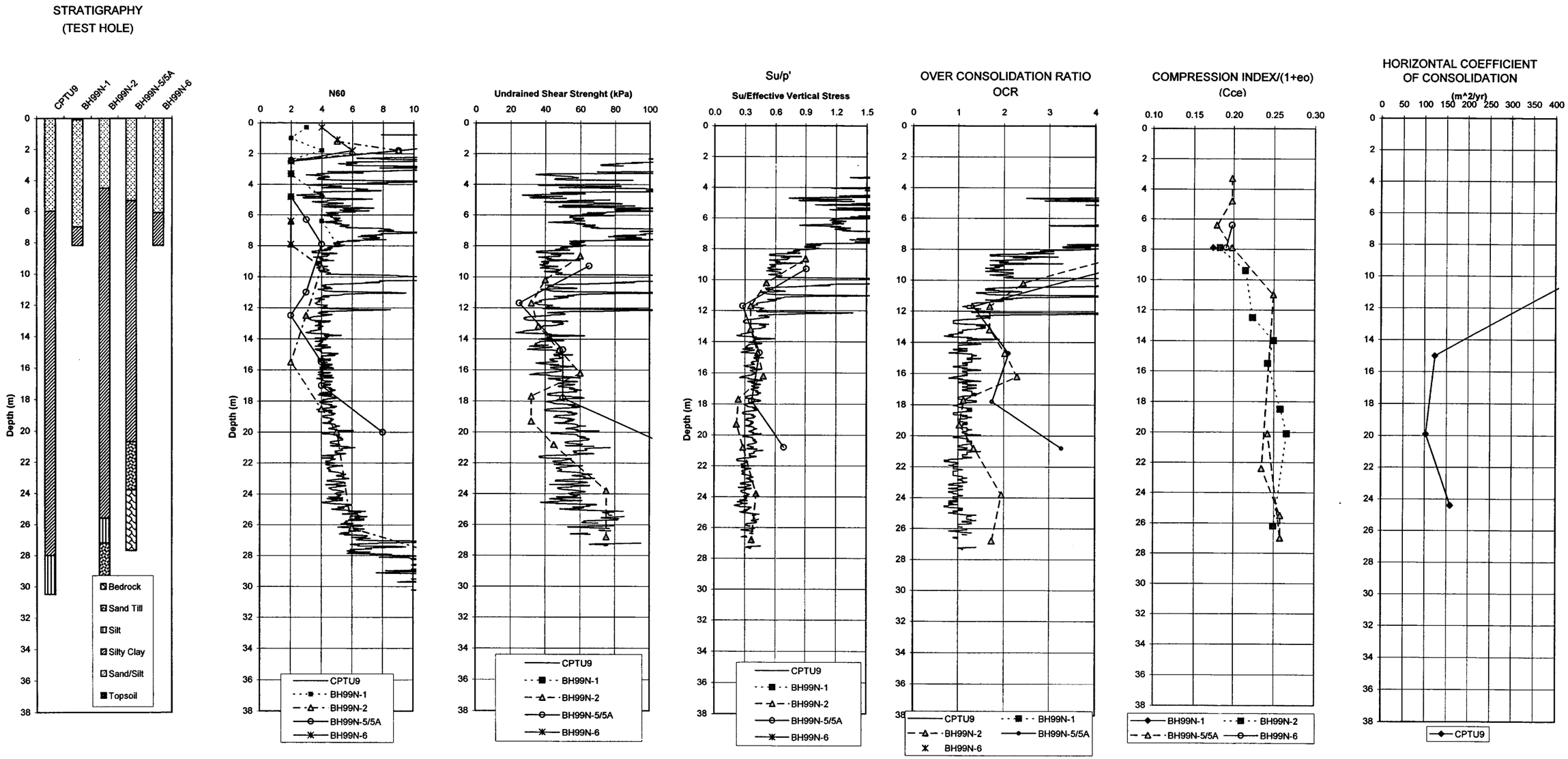




MASTER PLOT

FIGURE 5.4

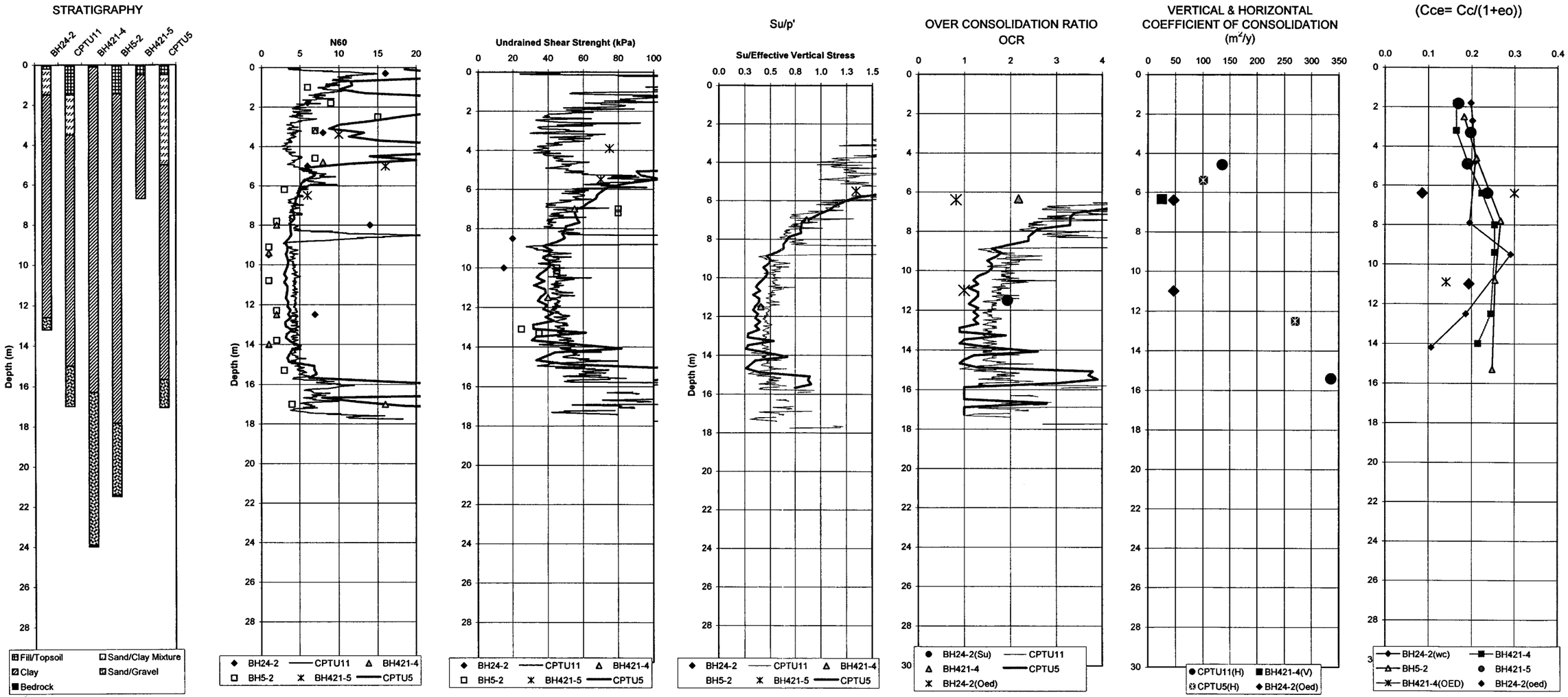
HIGHWAY 11 - NBL - Sta. 13+260 to 13+700
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.5

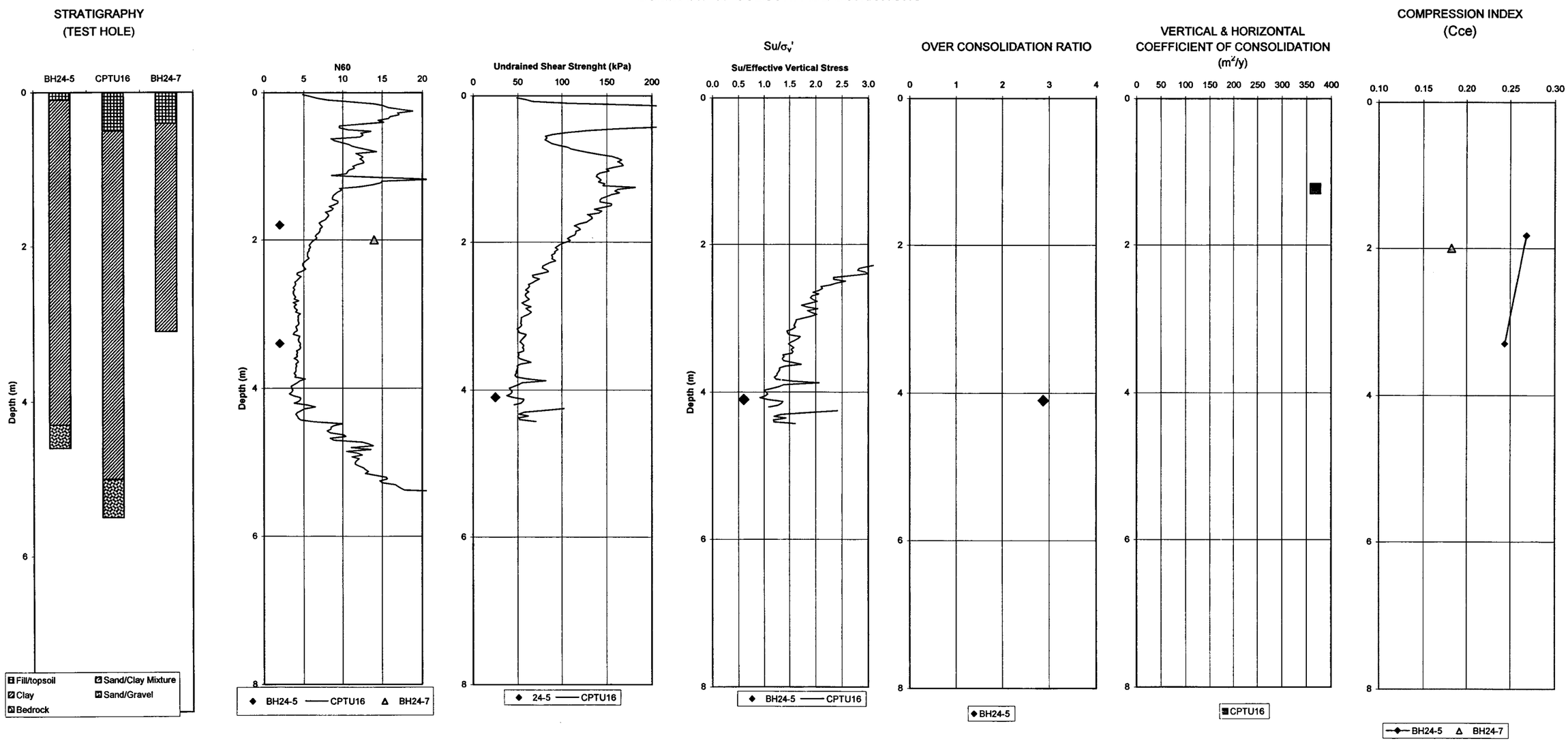
HIGHWAY 11 - NBL - 13+700 to 14+250
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.6

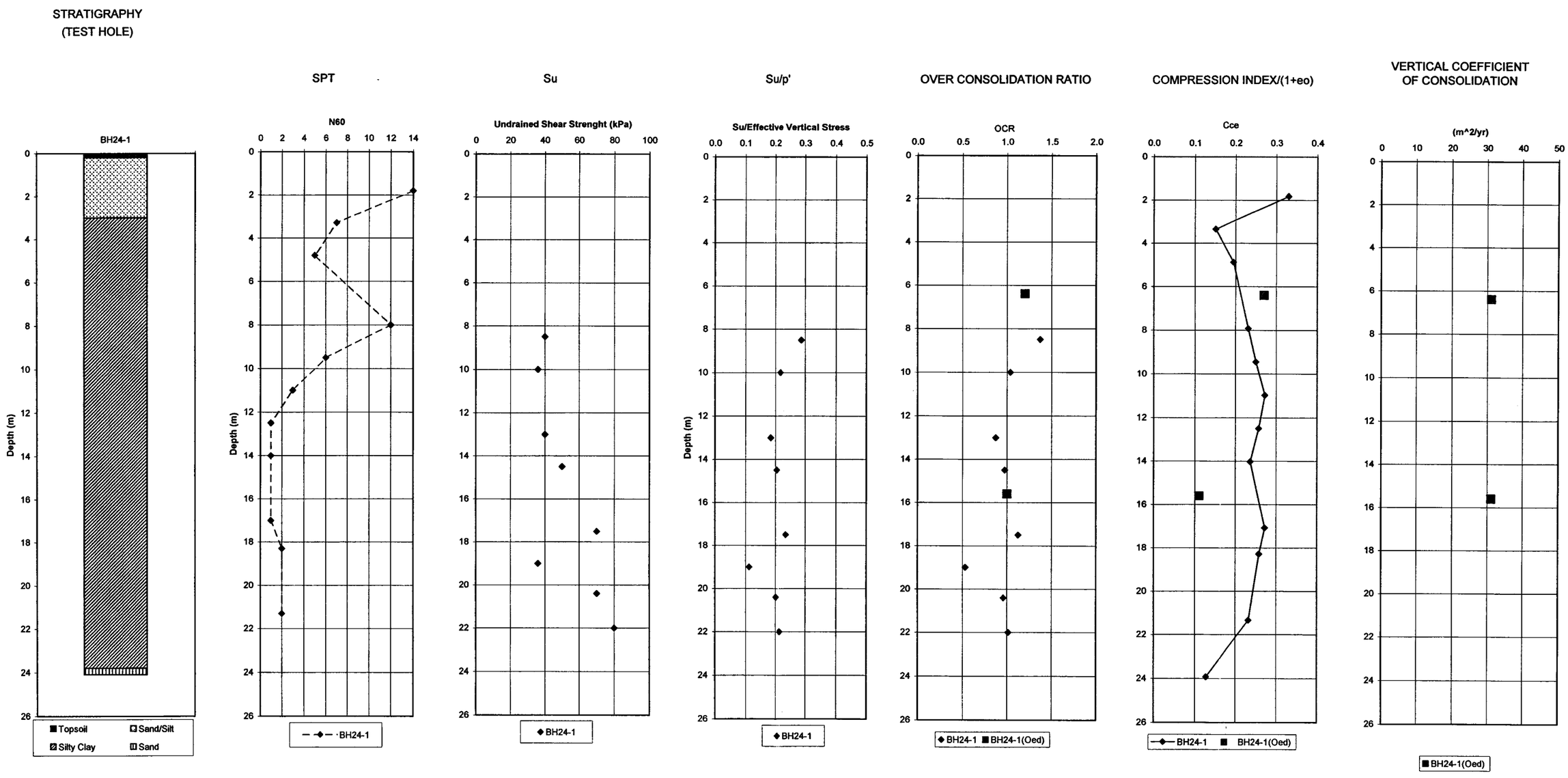
HIGHWAY 11 - NBL - Sta. 14+250 to 14+600
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.7

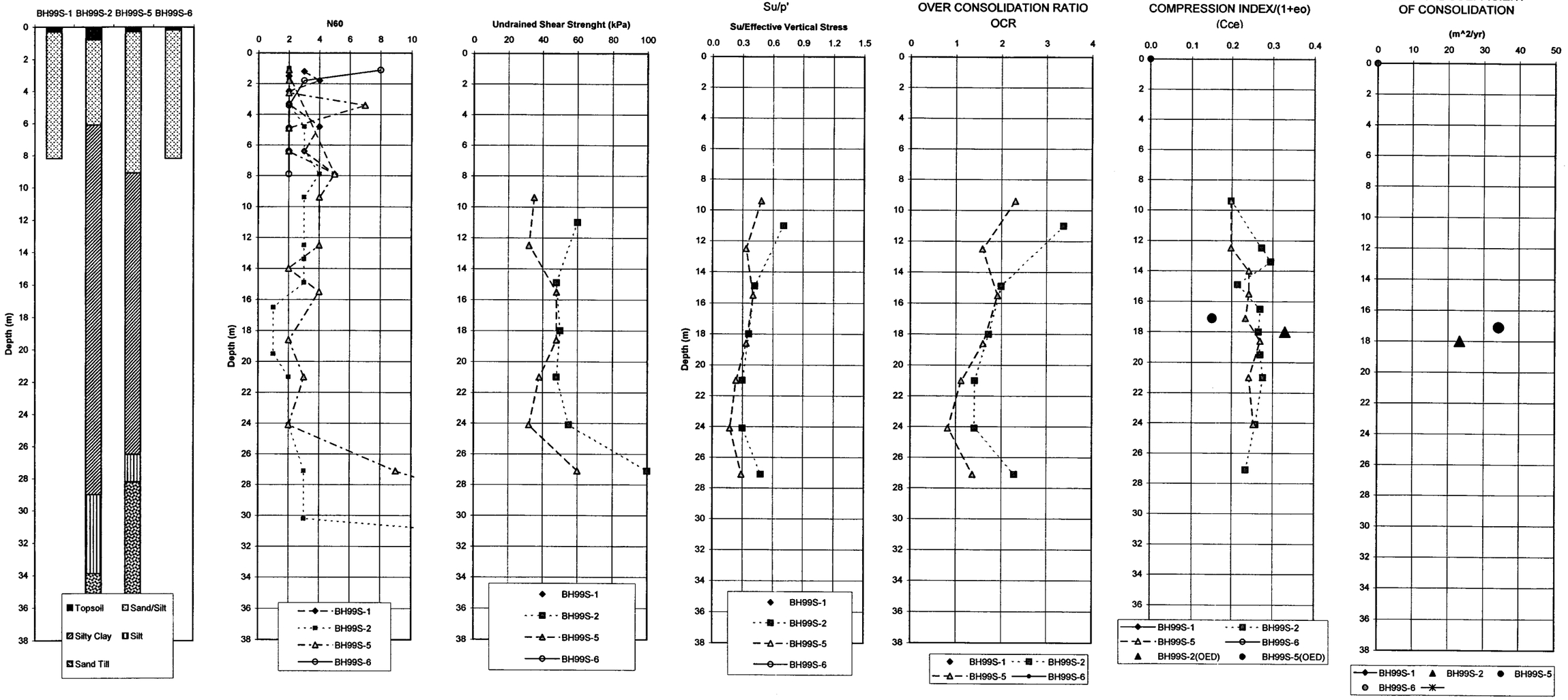
HIGHWAY 11 - SBL - Sta.13+260 to 13+570
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.8

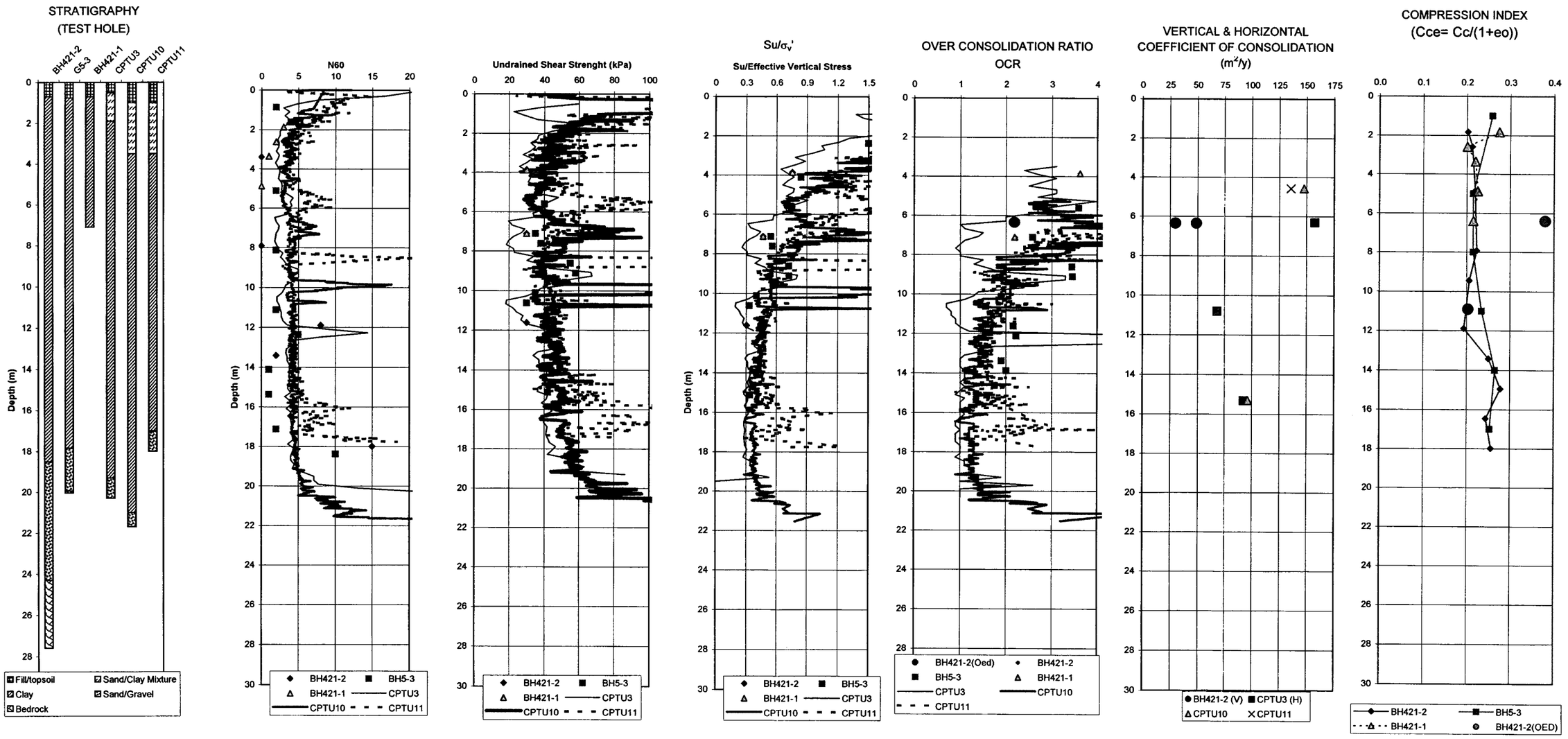
HIGHWAY 11 - SBL - Sta.13+570 to 13+700
SUMMARY OF SUBSURFACE CONDITIONS



MASTER PLOT

FIGURE 5.9

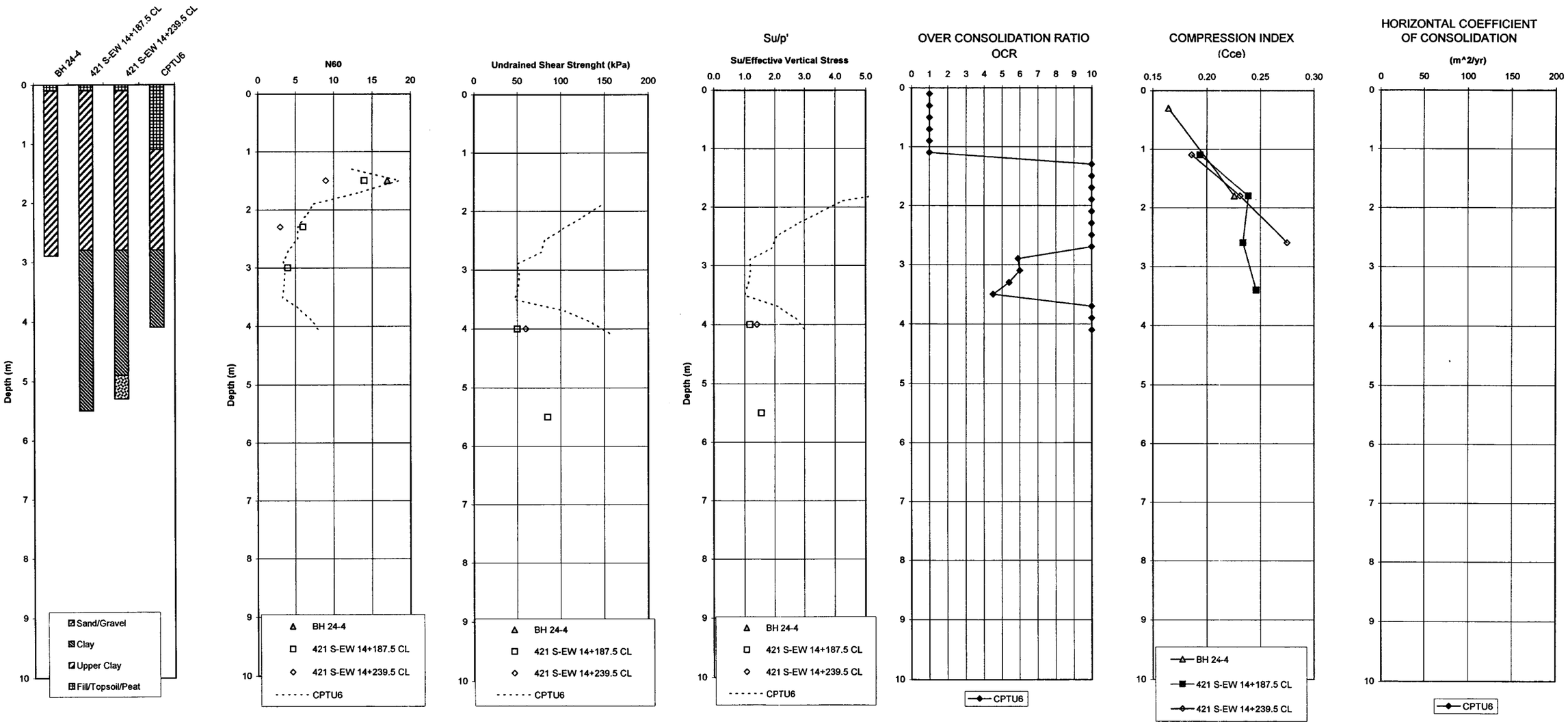
HIGHWAY 11 - SBL - Sta. 13+700 to 14+250
SUMMARY OF SUBSURFACE CONDITIONS
WEST ABUTMENT



MASTER PLOT

FIGURE 5.10

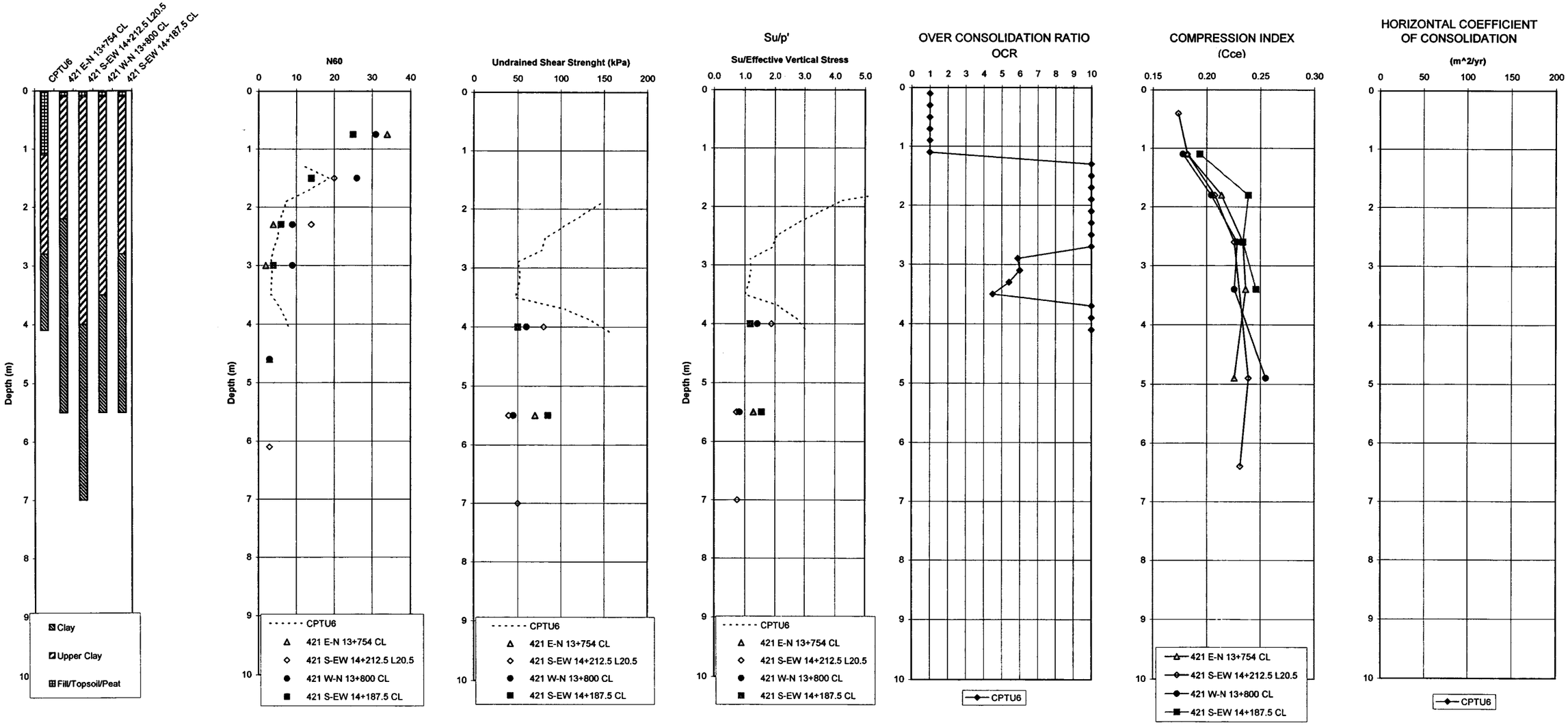
HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
S-E/W Ramp - STATIONS 14+100 TO 14+245



MASTER PLOT

FIGURE 5.12

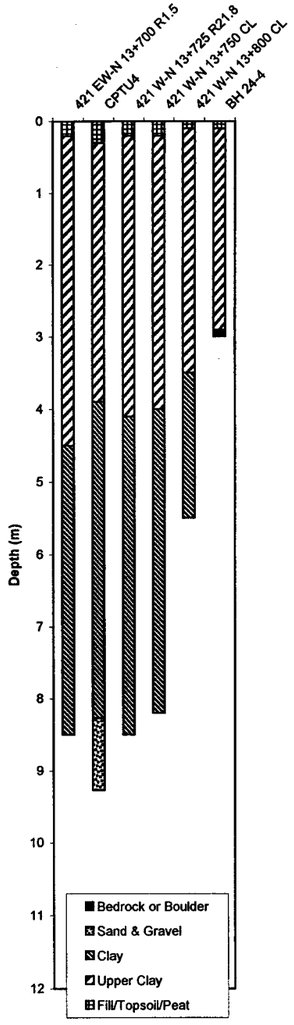
HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
E-N Ramp - STATIONS 13+740 TO 13+800

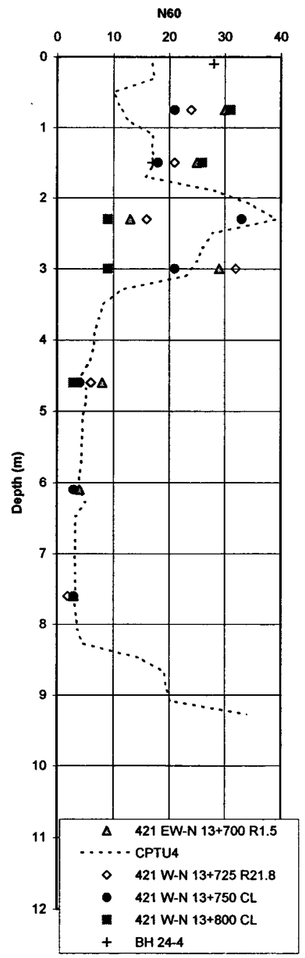


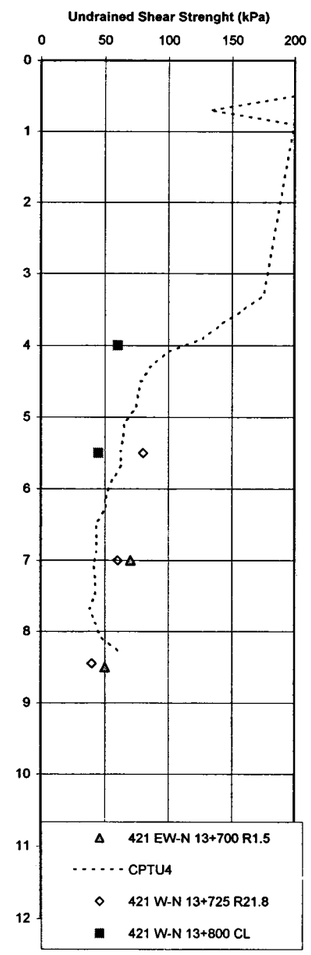
MASTER PLOT

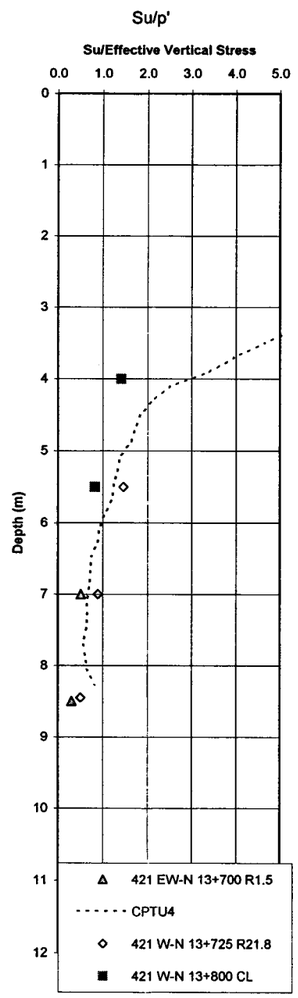
FIGURE 5.13

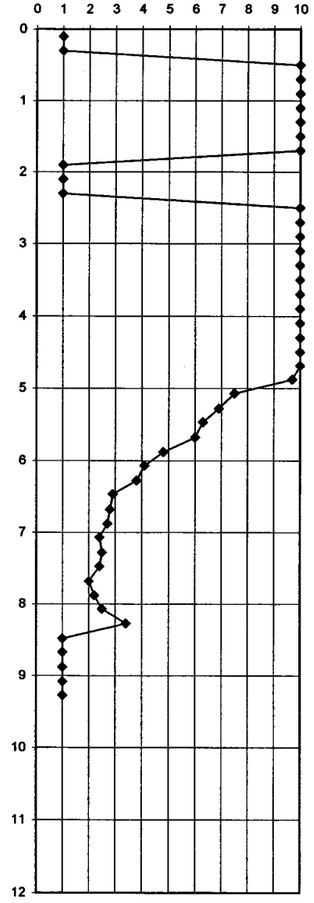
HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
W-N & E/W-N Ramp - STATIONS 13+700 TO 13+880

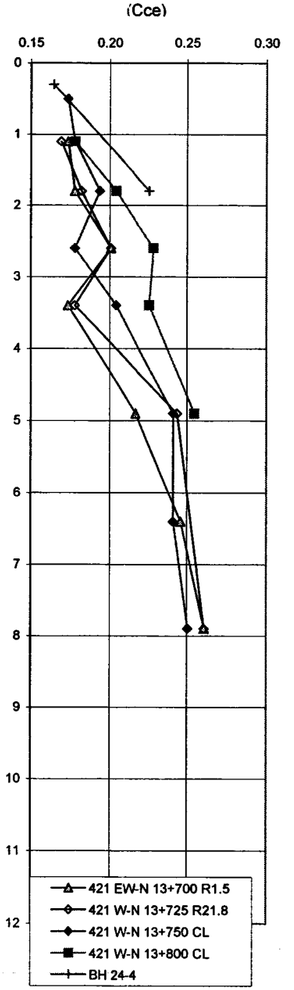


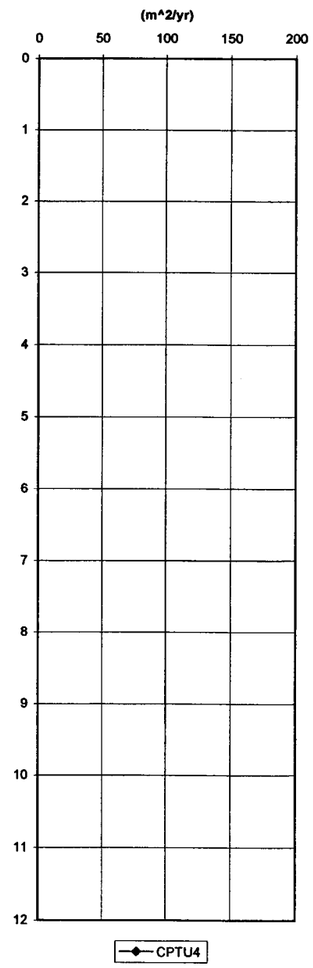








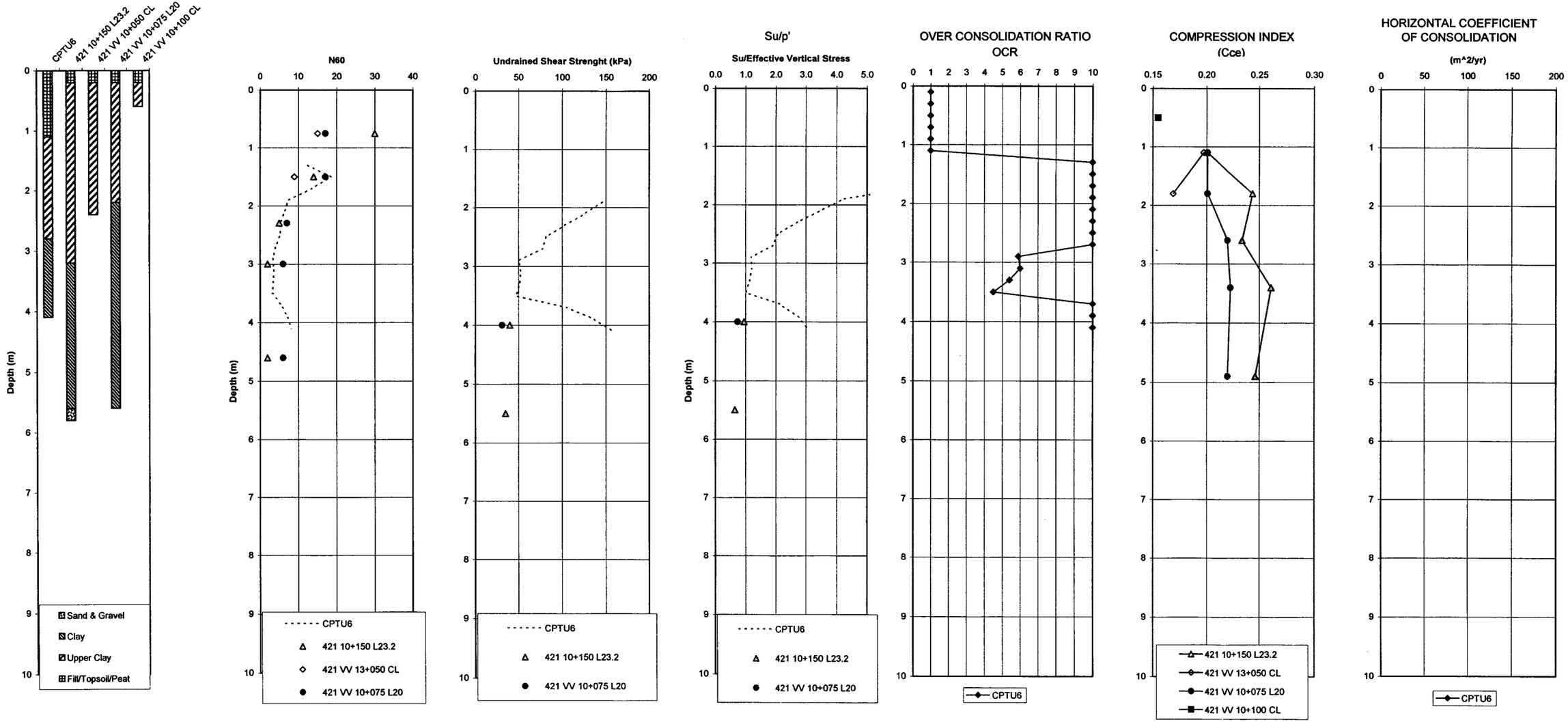




MASTER PLOT

FIGURE 5.14

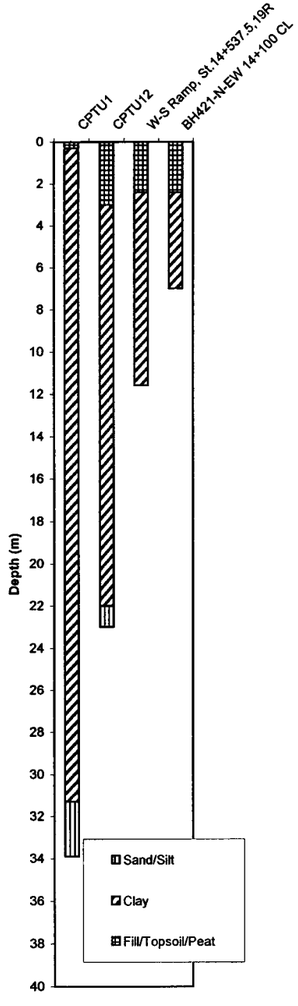
HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
Valley View Road - STATIONS 10+000 TO 10+310

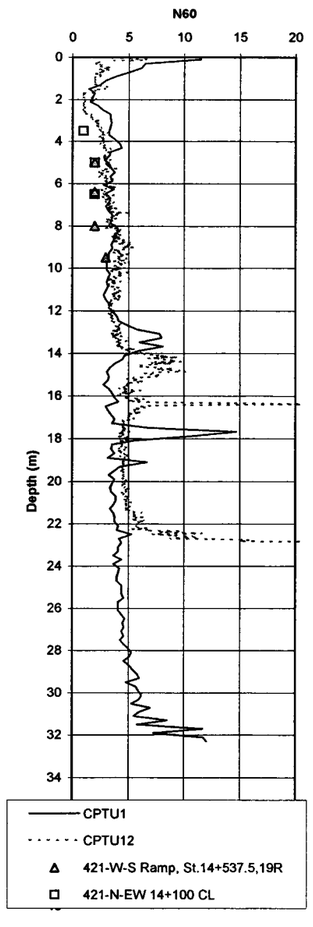


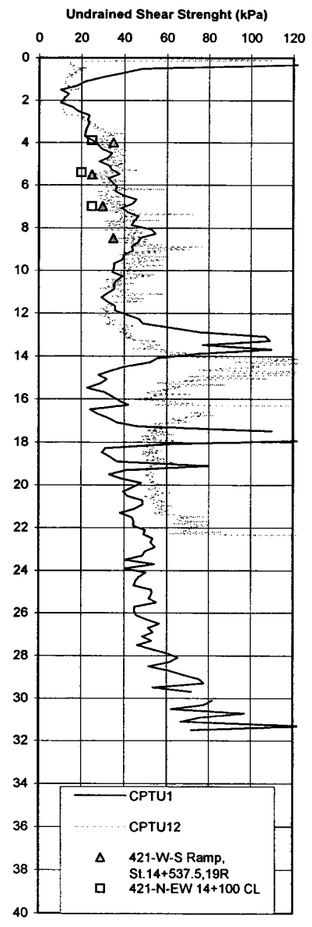
MASTER PLOT

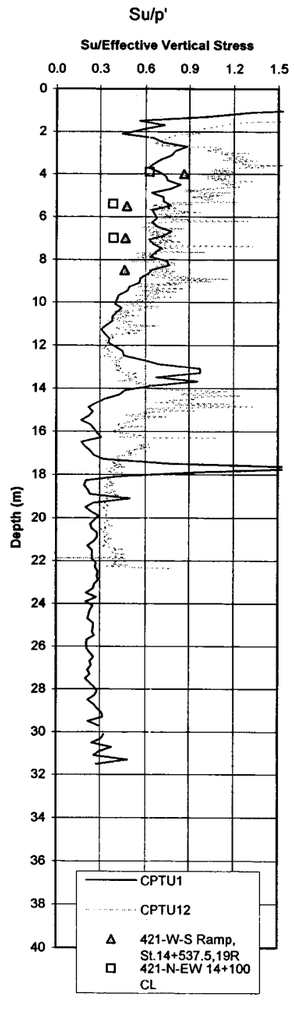
FIGURE 5.15

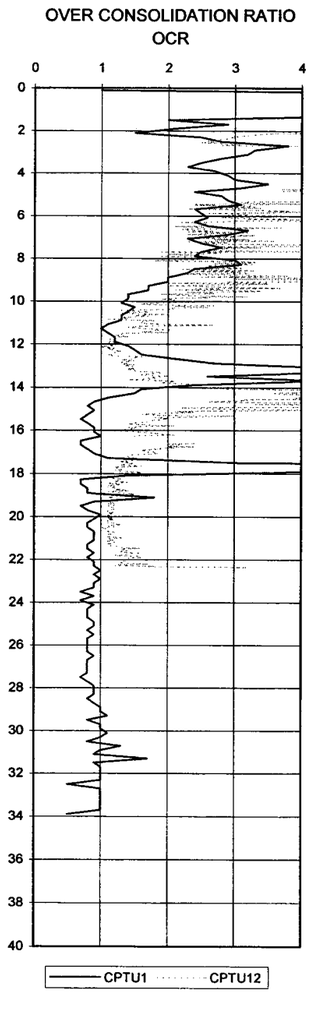
HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
N-E/W Ramp - STATIONS 14+030 TO 14+230 & W-S Ramp - STATIONS 14+510 to 14+570

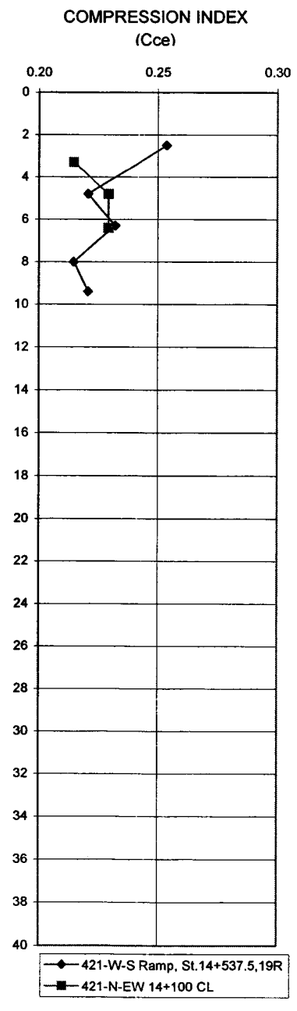


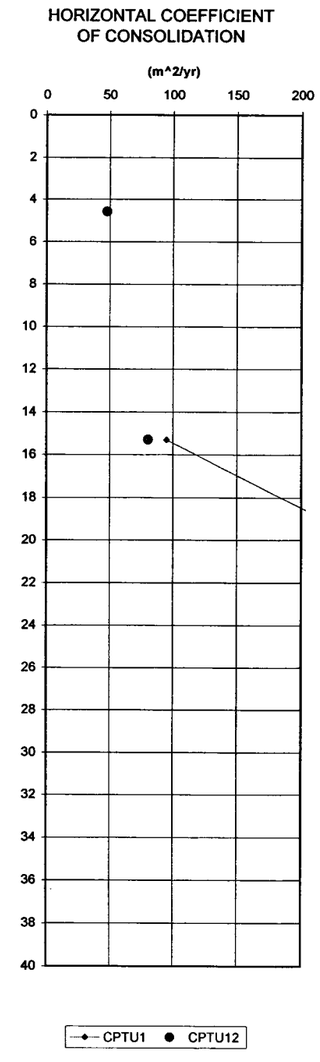








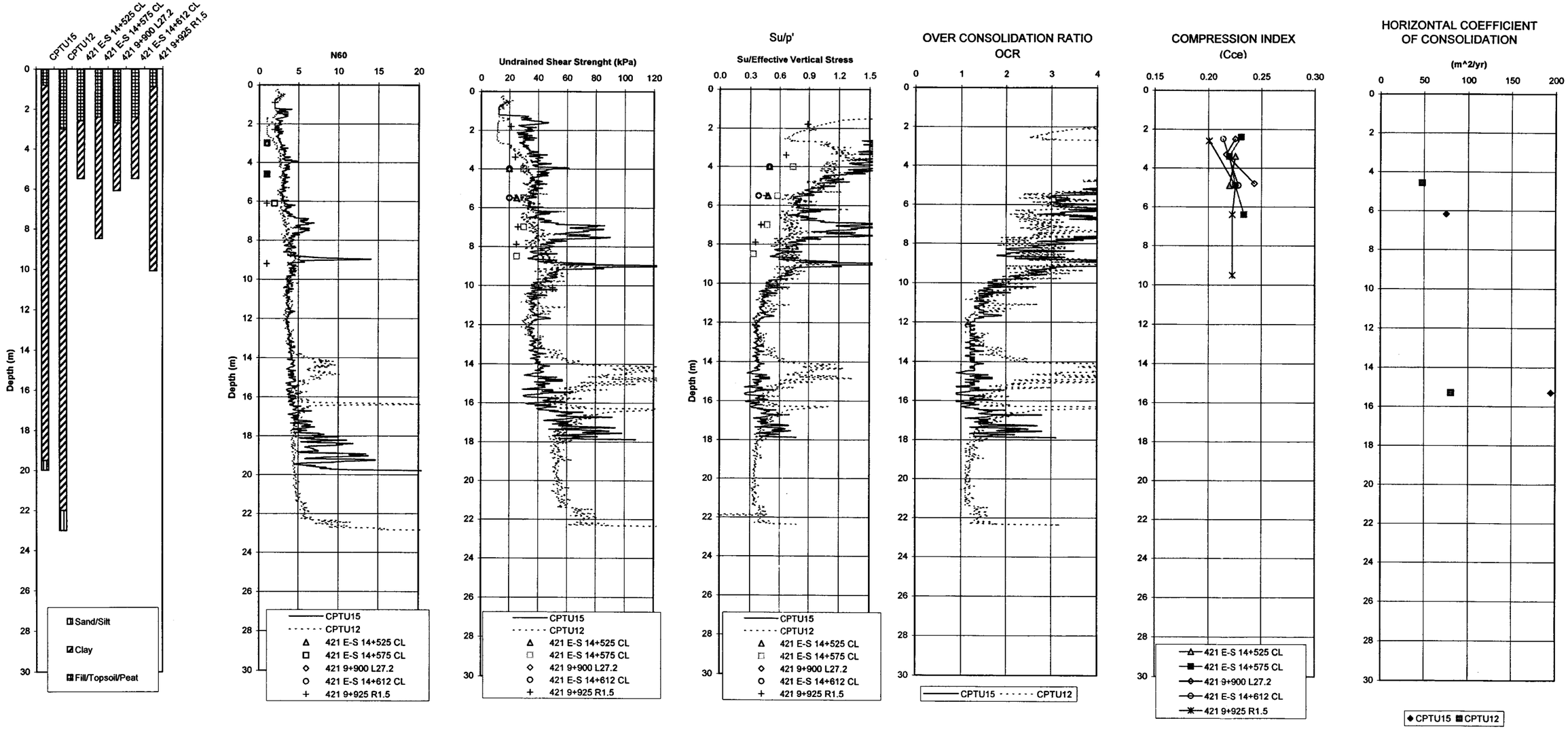




MASTER PLOT

FIGURE 5.16

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SUMMARY OF SUBSURFACE CONDITIONS
E-S & E/W-S Ramp - STATIONS 14+200 TO 14+620



MASTER PLOT

FIGURE 5.19

TABLES

GENERAL

19-1423-24 - Highway 11 - Robins Road/Black Creek Road and Bernard Creek Area
Piezocone Testing

						Groundwater Table		Pore Pressure Dissipation Tests												
Piezocone	Location	Station	G.S. Elevation	Northing	Easting	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Ch (cm^2/min)	Elevation (m)	Depth (m)	Ch (cm^2/min)	Elevation (m)	Depth (m)	Ch (cm^2/min)	Elevation (m)	Depth (m)	Ch (cm^2/min)	Elevation (m)	Depth (m)	Ch (cm^2/min)
CPTU1	Black Creek Rd.	9+825	312.3	5063007.12	309179.50	311.5	0.8	296.98	15.32	1.81	281.03	31.27	11.89	279.85	32.45	>> -0.5m	278.12	34.18	>> 0.1m	-	-	-
CPTU2	Black Creek Rd.	9+875	312.5	5063025.32	309226.07	311.5	1.0	296.15	16.35	1.69	283.38	29.12	>> 0.0m	-	-	-	-	-	-	-	-	-
CPTU3	Black Creek Rd.	9+950	312.6	5063054.21	309295.28	311.5	1.1	306.3	6.30	3.04	301.8	10.8	1.31	297.28	15.32	1.79	292.15	20.45	>> -0.1m	-	-	-
CPTU4	Robins Rd.	10+125	314.8	5063120.16	309457.37	314.3	0.5	312.47	2.33	3.27	308.45	6.35	2.75	305.5	9.3	>> 0.5m	-	-	-	-	-	-
CPTU5	Robins Rd.	10+055	314.0	5063093.78	309392.53	313.2	0.8	308.62	5.38	1.94	301.5	12.5	5.21	296.48	17.52	>> 0.8m	-	-	-	-	-	-
CPTU6	Black Creek Rd.	10+180	315.6	5063144.08	309516.15	313.8	1.8	311.27	4.33	>> 1.8m	-	-	-	-	-	-	-	-	-	-	-	-
CPTU7	Black Creek Rd.	9+725	312.5	5062970.72	309086.35	311.7	0.8	302.15	10.35	2.27	292.2	20.3	2.24	275.9	36.6	>> -0.4m	-	-	-	-	-	-
CPTU8	Black Creek Rd.	9+775	312.3	5062988.92	309132.92	311.5	0.8	279.1	33.20	>> -0.1m	-	-	-	-	-	-	-	-	-	-	-	-
CPTU 9	Hwy11 - NBL	13+520	314.4	5062436.00	309493.81	314.5 (*)	-0.1	308.4	6.00	13.77	299.4	15	2.35	294.5	19.9	1.95	290.0	24.4	3.02	284.1	30.35	>>-0.1m
CPTU 10	Hwy11 - SBL	13+900	311.7	5062818.98	309362.31	312.6 (*)	-0.9	307.1	4.58	2.81	296.4	15.3	1.83	290.0	21.7	>>-0.9m	-	-	-	-	-	-
CPTU 11	Hwy11 - NBL	14+000	312.6	5062919.03	309400.39	313.2 (*)	-0.6	308.0	4.58	2.58	297.2	15.4	6.39	294.6	17.95	>>-0.6m	-	-	-	-	-	-
CPTU 12	N-EW Ramp	14+200	313.1	5063166.07	309141.28	313.2 (*)	-0.1	308.5	4.58	0.91	297.8	15.3	1.53	290.2	22.88	>>-0.1m	-	-	-	-	-	-
CPTU 13	N-EW Ramp	14+300	313.2	5063247.03	309177.36	312 (*)	0	308.6	4.58	0.56	297.9	15.3	5.91	296.7	16.55	>>0.0m	-	-	-	-	-	-
CPTU 14	N-EW Ramp	14+500	313.2	5063418.96	309273.24	N/A	N/A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CPTU 15	EW-S Ramp	14+300	313.1	5063192.96	309249.38	313 (*)	0.1	306.9	6.18	1.43	297.8	15.3	3.71	293.2	19.92	>>0.1m	-	-	-	-	-	-
CPTU 16	Hwy11 - SBL	14+400	313.2	5063317.97	309303.59	313.4 (*)	-0.2	311.9	1.23	7	308.6	4.58	>>-0.6m	307.7	5.5	>>-0.2m	-	-	-	-	-	-

Notes: ">>1.8m" indicates fast dissipation with depth of piezometric head 1.8m below GS. Negative depth means piezometric head above ground surface.
(*) Short Term Piezometric Heat at Base of Compressible Deposit

TABLE 3.1

OEDOMETER TEST RESULTS

Location	Black Creed Road				Robins Rd.	Highway 11					
Borehole	BH 24-3	BH 24-3	BH-24-3	BH 421-2	BH 421-4	BH 24-1	BH 24-1	BH 24-2	BH 24-2	BH 99-S2	BH 99-S5
Sample	ST#1	ST#2	ST#3	ST#2	ST#1	ST#1	ST#2	ST#1	ST#2	ST#2	ST#2
Depth (m)	9.4	20.1	30.8	6.3	6.3	6.4	15.5	6.4	11.0	18.2	17.1
Elevation (m)	302.8	292.1	281.4	305.7	306.9	308.4	299.3	305.9	301.3	294	295.1
Soil Type	CL	CL	CH	CI	CI	CL	CH	CL	CL	CI	CL
% Clay	30%	26%	56%	32%	46%	30%	52%	29%	32%	45%	50%
W.C. (%)	46.6%	38.2%	57.2%	43.3%	37.6%	55.4%	36.7%	35.3%	47.8%	55.9%	41.6%
Unit Weight (γ) (kN/m3)	17.3	18.3	16.4	17.7	17.7	18.7	16.6	18.7	17.2	16.7	17.8
Specific Gravity (G)	2.78	2.75	2.78	2.78	2.76	2.76	2.74	2.74	2.76	2.81	2.77
Initial Void Ratio	1.28	1.063	1.62	1.179	1.107	0.916	1.54	0.972	1.324	1.573	1.165
In situ effective vertical stress (po')(kPa)	86	171	256	55	55	61	135	61	98	117	118
Preconsolidation Pressure (p') (kPa)	80	82	256	120	120	75	140	50	100	117	103
p'-po	-	-	0	65	65	14	5	-	2	0	-
Over Consolidation Ratio (OCR)	0.9	0.5	1.0	2.2	2.2	1.2	1.0	0.8	1.0	1.0	0.9
Compression Index (Cc)	0.16	0.225	0.94	0.38	0.30	0.11	0.68	0.17	0.45	0.74	0.33
Compression Ratio (Cc_ε=Cc/(1+eo))	0.07	0.11	0.36	0.17	0.14	0.06	0.27	0.09	0.19	0.29	0.15
Recompression Index (Cr)	0.04	0.05	0.09	0.06	0.06	0.015	0.05	0.04	0.06	0.15	0.05
Recompression Ratio (Cr_ε=Cr/(1+eo))	0.02	0.02	0.03	0.03	0.03	0.01	0.02	0.02	0.03	0.06	0.02
Coefficient of Seconday Consolidation (C_α)	0.005	0.002	-	0.032	0.002	0.001	0.003	0.003	-	-	-
Coeff.of Secondary Cons. Ratio (C_α/(1+eo))	0.002	0.001	-	0.015	0.001	0.001	0.001	0.002	-	-	-

PIEZOMETRIC HEAD OBSERVATIONS

Location	Test Hole	Date	Tip Elevation (m)	Soil at the Tip	Ground Surface Elevation (m)	Piezometric Head (**) Elevation (m)	Depth (*) Below G.Surface (m)
Black Creek Rd.	CPTU7	23/7/2003	275.9	Sand Till	312.5	312.9	-0.4
	CPTU8	23/7/2003	279.1	Sand Till	312.3	312.4	-0.1
	BH421 9+800 R24.2	15/8/2003	305.0	Silty Clay	312.0	311.9	0.1
	CPTU1	23/7/2003	278.1	Sand Till	312.3	312.2	0.1
	CPTU2	23/7/2003	283.4	Sand Till	312.5	312.5	0.0
	BH421 9+925 R1.5	31/7/2003	288.2	Sand Till	312.6	312.4	0.2
	CPTU3	23/7/2003	292.2	Sand Till	312.6	312.7	-0.1
Robins Road	BH5-2	26/3/2000	293.0	Sand Till	314.1	313.4	0.7
	CPTU5	23/720/03	296.5	Sand Till	314.0	313.2	0.8
	BH421 10+075 L7	20/6/2003	305.4	Silty Clay	318.8	318.5	0.3
	CPTU4	23/7/2003	305.5	Sand Till	314.8	314.3	0.5
	CPTU6	23/7/2003	311.3	Sand Till	315.6	313.8	1.8
Hwy 11 - Mainline	CPTU 9	21/9/2004	284.05	Sand Till	314.4	314.5	-0.1
	BH99S-2	11/3/2004	274.0	Sand Till	312.2	313.7	-1.5
	BH99N-2	11/3/2004	280.0	Sand Till	311.7	312.9	-1.2
	BH99S-5	11/3/2004	307.9	Silt and Sand	312.2	312.1	0.1
	CPTU10	21/9/2004	290.0	Sand Till	311.7	312.6	-0.9
	CPTU11	21/9/2004	294.7	Sand Till	312.6	313.2	-0.6
	CPTU16	22/9/2004	307.7	Sand Till	313.2	313.4	-0.2
N-EW Ramp	CPTU12	23/9/2004	290.22	Sand Till	313.1	313.2	-0.1
	CPTU13	23/9/2004	296.55	Sand Till	313.2	313.2	0
EW-S Ramp	CPTU15	23/9/2004	293.18	Sand Till	313.1	313	0.1

(*) - Negative depth indicates piezometric head above ground surface
(**) - Elevations shown are the highest pizometric reads measured

TABLE 5.2