



**FOUNDATION INVESTIGATION REPORT,
PROPOSED WIDENING OF SOUTHBOUND
HIGHWAY 400 BRIDGE OVER THE
SEVERN RIVER BOAT CHANNEL,
TOWNSHIP OF BAXTER, MTO CENTRAL
REGION, W.P. 2376-09-00, SITE 42-87/1&2,
GEOCRES 31D-566**

McCormick Rankin

Project: TRANETOB20462AA
January 07, 2014

REPORT

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**FOUNDATION INVESTIGATION REPORT
PROPOSED WIDENING OF SOUTHBOUND HIGHWAY 400 BRIDGE OVER THE SEVERN
RIVER BOAT CHANNEL, TOWNSHIP OF BAXTER, MTO CENTRAL REGION,
W.P. 2376-09-00, SITE 42-87/1&2**

1 INTRODUCTION

Coffey was retained by McCormick Rankin (MRC) to carry out a foundation investigation for the proposed Highway 400 Southbound Bridge widening for realigned northbound lanes over the Severn River Boat Channel in the Township of Baxter, Ontario.

The existing northbound Severn River Boat Channel Bridge is an approximately 93.7 m long, 11.3 m wide, open spandrel deck arch bridge. This structure, which was built in 1957, will be demolished. The existing southbound bridge, built in 1992, will be widened to accommodate the proposed realigned northbound lanes. The widening will take place towards the median of the existing highway.

The proposed bridge widening is planned to be identical (width in GA is different) to the existing southbound bridge, which is a three span slab on steel I-girder structure. The existing bridge has a length of 118 m and a width of 12 m. It was built in 1992 and is supported on integral abutments with piers supported on bedrock.

The purpose of this investigation was to obtain information about the subsurface conditions at the proposed bridge widening site by means of boreholes, and to determine the engineering characteristics of the overburden soils and of the underlying bedrock, by means of field and laboratory tests.

The findings of the investigation are presented in this report.

2 SITE DESCRIPTION AND GEOLOGY

The site is located on Highway 400 at the mouth of Severn River Boat Channel at Little Lake joining Georgian Bay, as shown on Drawing 1. The surrounding area is generally gently rolling and rock outcrops are visible in the vicinity.

According to the Physiography of Southern Ontario by L.J. Chapman and D.F. Putnam, 1984, the project site is located at the interface of Physiographic Regions 'Algonquin Highland' and 'Carden Plain'.

The geology at the site is dominated by felsic igneous bedrock with shallow overburden. Bedrock at the site is known as granite and biotite gneiss of the Grenville Province.

According to Map 2418 of Ontario Geologic Survey, the site is located immediately north of the confluence of Precambrian rocks with more recent Ordovician formations. The main body of geologic formations consists of late to middle Cambrian clastic metasediments which are comprised of conglomerate, greywacke, arkose, calcareous sandstone and siltstone, shale and derived metamorphic rocks, while in the vicinity of the site late Precambrian granitic to syenitic rocks are also found.

Previous site specific investigations show the presence of granite gneiss rocks.

Overburden, where present, consists of silty sands, either surficial loose deposits or as dense glacial till above the bedrock. Silty clay is also present in areas where bedrock is relatively deeper in occurrence. Organic mucks are also common in marshy areas.

3 METHOD OF INVESTIGATION

The field work for this investigation was performed between the period of May 15 and June 12, 2013, and consisted of drilling and sampling of twelve boreholes. The boreholes were numbered from 9 to 20 to continue the numbering sequence of the boreholes drilled (i.e. Boreholes 1 to 8) at the nearby Severn River bridge site (report prepared under separate cover).

Boreholes 9, 10, 19 and 20, which were put down from the top of the existing road embankment by hollow-stem augering, were terminated upon encountering refusal on the augers, probably on the surface of the bedrock. The depths of these boreholes ranged from 9.2 to 11.0 m below the existing grades.

Boreholes 11, 12, 17 and 18 were also advanced from the top of the existing road embankment by hollow-stem augering; however, in these boreholes, upon encountering refusal on the augers at depths of 8.0 to 11.1 m below the ground surface, the boreholes were further advanced by diamond drilling methods and rock cores were obtained. The length of rock coring ranged from 2.3 to 4.1 m and the depths of the boreholes ranged from 10.5 to 14.3 m below the ground surface (i.e. top of embankment).

Boreholes 13 and 14 were drilled using a drill rig mounted on a barge, from the surface of water in the Channel. At the time of our investigation, the depth of the water in the Channel was 0.8 to 1.0 m at the borehole locations, and no overburden was found (i.e. rock was exposed at the Channel bottom). Consequently, these two boreholes were advanced 3.4 to 4.0 m by NQ and BQ size rock coring, below the bottom of the Channel.

Boreholes 15 and 16 were advanced using a portable drill rig by manual wash boring methods in the overburden. Upon encountering refusal to further advancing the boreholes by wash boring methods, the bedrock was cored by 3.7 – 4.1 m and BQ size rock cores were obtained. The depth of the boreholes were 6.5 and 6.3 m, respectively.

The drilling of Boreholes 9 through 12 and 17 through 20 was carried out using a track-mounted CME 55 drill rig owned and operated by Davis Drilling of Milton, Ontario. Boreholes 13 and 14, which were advanced from a barge, were drilled using a D25 Diedrich type drill rig, owned and operated by Walker Drilling of Utopia, Ontario. Boreholes 15 and 16 were put down using a portable Pionjar 120 drilling system (due to limited access), owned and operated by Sonic Soil Sampling of Concord, Ontario.

Samples in the overburden were taken at frequent intervals of depth by the Standard Penetration Test method (SPT), in general accordance with ASTM D1586. This test consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm O.D. split barrel (SS-split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.3 m is recorded as the Standard Penetration Resistance or the N-value of the soil which is indicative of the compactness condition of cohesionless granular soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils).

In Boreholes 15 and 16, where manual drilling was effected in the overburden, a 31.8 kg hammer was used, instead of the standard 63.5 kg hammer. The recorded resistance values in these two boreholes were divided by two, to obtain approximate equivalent N-values in the overburden.

Groundwater conditions were observed during drilling and upon completion free-standing water levels were measured. In addition, a piezometer was installed in each of Boreholes 12 and 18 to enable us to monitor the groundwater table over a prolonged period of time, without interference from surface water. The remaining boreholes were grouted upon their completion using a cement/bentonite mixture as per MTO

procedures. Boreholes 12 and 18 were not grouted, as measuring the groundwater levels at the time of construction may be useful. We recommend, however, a clause be included in the contract to decommission these piezometers at the time of construction.

The field work was carried out under the supervision and direction of technical personnel from our office. The borehole locations were established in the field by Coffey engineering staff, in relation to the existing site features. The borehole locations and the geodetic ground surface elevations at the borehole locations were subsequently determined by MRC's surveyors, who provided this information to us.

The soil and rock samples obtained from the boreholes were transported to our geotechnical laboratory in Toronto for further examination and classification. A laboratory programme, consisting of natural moisture content and grain size analyses was performed on selected representative soil samples and point load tests on selected rock cores. Subsequently, some selected rock cores were shipped to Golder Associates' Laboratory, in Mississauga, Ontario, for unconfined compressive strength testing.

4 SUBSURFACE CONDITIONS

The subsurface conditions were explored at twelve borehole locations. The locations of the boreholes are shown on Drawing No. 1. Stratigraphic sections and profiles are presented in Drawing Nos. 2 to 5.

Boreholes 9, 11, 17 and 19 were advanced from the paved road surface and contacted a 160 to 230 mm thick asphalt layer underlain by pavement and embankment fill to depths ranging between 8.2 and 11.1 m. In Boreholes 9 and 19, a veneer of overburden was contacted underlain by bedrock, while in Boreholes 11 and 17 the embankment fill is underlain directly by bedrock.

Boreholes 10, 12, 18 and 20 were also put down from the top of the highway embankment, but from an unpaved portion. Below some topsoil, these boreholes encountered embankment fill to 7.6 to 9.4 m below the ground surface. In BH 10, the embankment fill was found to extend to the surface of the bedrock, while in the remaining three boreholes the bedrock is overlain by a 0.4 to 0.7 m thick native overburden.

In summary, the embankment fill was found to extend to depths of 7.6 to 11.1 m below the ground surface or to El. 179.6 to 176.0 m. In Boreholes 10, 11 and 17, it extends to the surface of the bedrock while in the remaining seven boreholes which were drilled from land, it is underlain by 0.1 to 0.7 m thick native overburden (i.e. excluding Boreholes 13 and 14 which were advanced from water's surface).

Boreholes 15 and 16 were put down from a lower elevation and these boreholes contacted below a veneer of topsoil an approximately 2 m thick fill layer (to elevations 177.6 m and 177.3 m, respectively), underlain by a 0.1 m to 0.8 m thick native sand deposit, overlaying the bedrock.

No fill or overburden was contacted in Boreholes 13 and 14, put down from the Channel, from a barge. Here, the bedrock was exposed at the Channel base.

Bedrock was contacted or inferred in all the boreholes. Bedrock was contacted in Boreholes 10, 11 and 17 directly below the embankment fill. In Boreholes 9, 12, 15, 16, 18, 19 and 20, it was encountered below a relatively thin layer of basal overburden, while in Boreholes 13 and 14 it was contacted immediately below the Channel bottom. The surface of the bedrock at the borehole locations was encountered between El. 179.6 m (BH 17) to 174.9 m (BH 13).

The bedrock was found to consist of greyish/pinkish granite gneiss of generally sound quality.

Details of the subsurface conditions encountered in the boreholes are given on the individual Record of Borehole Sheets in Appendix A. Detailed laboratory test results (soil and rock) are enclosed in Appendices B and D.

The following description of the individual soil strata is to assist the designers of the project with an understanding of the anticipated subsurface conditions underlying the site. It should be noted that the soil and groundwater conditions may vary in between and beyond borehole locations.

4.1 Asphalt

Boreholes 9, 11, 17 and 19 were put down from the surface of the paved highway and consequently contacted asphaltic concrete, ranging in thickness from 160 mm (BH 9) to 230 mm (BH 11). In Boreholes 17 and 19, the thickness of the asphalt was found to be 180 and 190 mm, respectively.

4.2 Topsoil

Boreholes 10, 12, 15, 16, 18 and 20, which were drilled from the existing highway embankment, off the roadway, contacted a 0.05 to 0.15 m thick veneer of topsoil at the ground surface. In addition, in BH 19 an approximately 0.1 m thick topsoil layer was contacted immediately below the embankment fill at a depth of 9.1 m immediately overlying the bedrock.

4.3 Pavement and Embankment Fill

4.3.1 Pavement Fill

As mentioned before, Boreholes 9, 11, 17 and 19 were advanced from the top of the paved road surface and these boreholes contacted, below the asphaltic concrete, granular pavement fill which extended to 0.9 m (Boreholes 9 and 19) and 1.3 m (BH 11).

The grain size distribution of three samples from the granular pavement fill is given in Figure B-1 (Appendix B). The following grain size distribution is indicated:

| | |
|---------|--------|
| Gravel: | 24-40% |
| Sand: | 46-62% |
| Silt: | 14-17% |

N-values recorded in the pavement fill range from 25 to 48 blows/0.3m, which indicate a compact to dense relative density of the compacted granular pavement fill.

4.3.2 Embankment Fill

Underlying the pavement fill in Boreholes 9, 11, 17 and 19 and the topsoil in Boreholes 10, 12, 18 and 20, embankment fill was found to extend to depths ranging from 8.2 to 11.1 m below the ground surface.

In Boreholes 10, 11 and 17, the embankment fill was found to extend to the surface of bedrock/inferred bedrock at depths of 8.2 to 11.1 m below the ground surface or at El. 179.6 to 176.0 m, while in the remaining boreholes the embankment fill was found to extend to the surface of the overburden at depths of 7.6 to 10.6 m (El. 178.9 – 176.2 m).

Boreholes 15 and 16 were put down near the toe of the embankment, using portable equipment. These boreholes encountered fill extending to 2.0 m (El. 177.6 m) and 2.1 m (El. 177.3 m), respectively.

The embankment fill generally consists of a heterogeneous mixture of silty sand to sandy silt with trace to some clay and gravel size particles. From a visual examination of the split-spoon samples obtained from the material and the results of the grain-size analyses on the samples, it can be surmised that the source of the embankment fill is the local glacial till soils. In general, the fill appeared to be relatively clean (i.e. devoid of organic and other deleterious material); the presence of some clay in the fill was noted.

The grain-size distribution of fourteen samples from the embankment fill is given in an envelope form in Figure. B-2 in Appendix B, showing the following grain-size distribution:

| | |
|---------|--------|
| Gravel: | 2-8% |
| Sand: | 45-58% |
| Silt: | 21-36% |
| Clay: | 15-18% |

There are in the embankment fill somewhat sandier zones. Figure B-3 in Appendix B presents the grain size distribution of two such samples from Boreholes 9 and 11. The following is the grain-size distribution indicated:

| | |
|---------|--------|
| Gravel: | 2-4% |
| Sand: | 61-66% |
| Silt: | 16-24% |
| Clay: | 11-16% |

In BH 10, the lower portion of the fill below 6.0 m (El. 179.7 m) was found to be even more sandy. The grain-size distribution of a sample from between 6 and 7 m depth from this borehole is presented in Figure B-4 (Appendix B), which indicates 4% gravel, 83% sand, 9% silt and 4% clay size particles. As well in BH 20, the lower portion of the fill below about 7.6 m (El. 178.9 m) was found to be a basically gravelly fine sand with some silt lenses.

As was also mentioned before, the presence of occasional siltier and more clayey zones was also noted. Figure B-5 in Appendix B presents the grain-size distribution of a sample from BH 20 from such a zone, which shows 3% gravel, 36% sand, 41% silt and 20% clay size particles.

The fill can be classified as a basically granular (i.e. non-cohesive) soil type, with occasional cohesive zones.

Standard Penetration Tests performed in the embankment fill yielded N-values which range from 3 to in excess of 60 blows/0.3 m, but typically between 12 and 24 blows/0.3 m, indicating a very loose to very dense relative density but generally compact. There are occasional weak (i.e. loose to very loose) zones as evidenced by N-values of between 3 and 8 blows/0.3 m in Boreholes 10, 17, 18, 19 and 20 and particularly in Boreholes 11 and 12 as rather thick zones.

From these results, it can be concluded that the embankment fill generally received adequate compaction when it was first constructed in the early 1990's but there are sporadic zones which did not receive compaction, especially in BH 11 in the upper 4 m and in BH 12 below the top 2 m.

Boreholes 15 and 16 were put down from a lower level near the toe of the highway embankment. In these boreholes the adjusted and approximately equivalent resistance values in the fill were between 2 and 9 blows/0.3 m, indicating a very loose to loose relative density. The grain-size distribution of two samples encountered in these two boreholes is given in Figure B-6 (Appendix B). The results are as follows:

| | |
|---------|--------|
| Gravel: | 2-4% |
| Sand: | 49% |
| Silt: | 29-32% |
| Clay: | 17-18% |

These are considered similar to the embankment fill material grain-size distributions encountered in the other boreholes.

4.4 Native Overburden

Thin basal native overburden deposits were encountered in Boreholes 9, 12, 15, 16, 18, 19 and 20, underlying the embankment fill.

The thickness of the native overburden at the borehole locations was found to range from 0.1 m (Boreholes 16 and 19) to 0.8 m (Borehole 15).

In BH 19, a 0.1 m thick veneer of topsoil was contacted, underlying the embankment fill. In the remaining boreholes, the natural overburden was found to consist of granular (non-cohesive) soils, ranging from silty sand to sand.

A modified Standard Penetration Test in BH 15, using portable equipment, yielded an equivalent N-value of 19 blows/0.3 m, which indicates a compact condition.

In Boreholes 9 and 18, N-values in excess of 100 blows/0.3 m were recorded and based on this, the relative density of the soil is described as very dense. In the remaining boreholes, the recorded values may not be reliable (i.e. presence of rock pieces immediately above the bedrock surface). But there is some evidence that the overburden soils are generally dense to very dense. A word of caution is however in order in this respect. These resistances reflect the values beneath considerable embankment fill. As such, the soil is likely to have densified under the weight of the fill and may not reflect the denseness condition of the overburden soils beyond the embankment fill influence zone.

4.5 Bedrock

Bedrock was encountered/inferred at all borehole locations.

In Boreholes 9, 10, 19 and 20, the presence of bedrock was inferred from refusal to augering, while in the remaining eight boreholes upon encountering refusal, the presence of bedrock was proven by diamond drilling and obtaining rock cores to depths ranging from 2.3 and 3.2 m in Boreholes 17 and 11, respectively, to between 3.4 and 4.1 m in Boreholes 12, 13, 14, 15, 16 and 18.

Generally, NQ size cores were obtained. However, Boreholes 13 and 14 were advanced from a barge using smaller equipment and thus both NQ and BQ size coring was effected. Similarly, Boreholes 15 and 16 were advanced using portable equipment and as a result, in these boreholes BQ size cores were retrieved.

From the cores, the bedrock was identified as granite gneiss. Its colour was found to range from light to medium and occasionally dark grey with a pinkish tone and/or pink insets.

The following table summarizes the bedrock surface elevations and the condition of the bedrock, as revealed by the rock cores obtained from the boreholes.

Photographs of the rock cores are included in Appendix D.

Table 4.5.1: Bedrock Surface Elevations and Rock Details

| Borehole Number | Top of Bedrock Elevation (m) | Coring Size | Total Core Length (m) | T.C.R. (%)** | R.Q.D. (%)*** |
|-----------------|------------------------------|-------------|-----------------------|--------------|---------------|
| 9 | 175.8* | N/A | N/A | N/A | N/A |
| 10 | 176.2* | N/A | N/A | N/A | N/A |
| 11 | 176.0 | NQ | 3.2 | 97-100 | 90-100 |
| 12 | 176.3 | NQ | 4.1 | 95-100 | 90-98 |
| 13 | 174.9 | BQ & NQ | 4.0 | 100 | 35-100 |
| 14 | 175.1 | BQ | 3.4 | 100 | 82-100 |
| 15 | 176.8 | BQ | 3.7 | 96-100 | 23-100 |
| 16 | 177.2 | BQ | 4.1 | 91-100 | 91-100 |
| 17 | 179.6 | NQ | 2.3 | 83-100 | 83-100 |
| 18 | 178.5 | NQ | 4.1 | 98-100 | 75-100 |
| 19 | 178.6* | N/A | N/A | N/A | N/A |
| 20 | 177.2* | N/A | N/A | N/A | N/A |

* inferred

** T.C.R. = Total Core Recovery

*** R.Q.D. = Rock Quality Designation

From the table presented, it can be seen that the surface of the bedrock was contacted or inferred between elevations 179.6 m (at BH 17) and 174.9 m (at BH 13). This represents an elevation difference of 4.7 m over a horizontal distance of about 100 m. It is possible that the surface of the rock underlying the Channel may have been lowered by blasting when the Channel itself was first built. If this hypothesis is true, this operation would likely to have modified the rock surface elevation at Boreholes 13 and 14 and indeed here the recorded surface of the bedrock is the lower (i.e. 174.9 m and 175.1 m, respectively). It may also possibly have affect the rock surface elevation at Boreholes 15 and 16 and again the rock surface elevation at these locations is somewhat lower than the elevations at Boreholes 17 and 18 which are on the same side of the Channel (i.e. El. 177.2 – 176.8 m vs 179.6 – 178.5 m).

On the south side of the Channel (i.e. towards Barrie) in Boreholes 9 through 12, the surface of the rock appears to be relatively level ranging from El. 176.3 m to 175.8 m, while to the north (i.e. towards Parry Sound) it appears to be more undulating at Boreholes 17 through 20, ranging from El. 179.6 m to 177.3 m; in particular BH 17 seems to represent a peak at El. 179.6 m.

In general, the top 0.1 to 0.4 m of the bedrock, as determined by core results, was found to be highly fractured. The depth of fracturing in BH 13 was found to be 0.6 m but this is likely to be the result of blasting operations when the Channel was built.

The percentage of core recovery in the boreholes ranged from 83 – 100%, but generally ranged from 93 to 100%. The RQD values (i.e. Rock Quality Designation) were recorded between 23 and 100% but generally were between 75 and 100%. The lowest RQD values of 23 and 35% were obtained within the upper zones of the core samples immediately below or near the Channel bottom at Boreholes 15 and 13, respectively, probably reflecting the effects of previous blasting operations. If these latter two values are discarded, the recorded RQD values are indicative of a good to excellent rock quality (see Appendix A), at the cored locations.

To determine the compressive strength and hardness of the rock, a total of five samples were subjected to unconfined compressive testing. The unconfined compressive strength (UCS) of the tested samples ranged from 49.7 to 109.3 MPa with an average of 77.9 MPa. The results of these unconfined compressive tests are given in Appendix D.

Point Load Index tests were performed in our laboratory on 20 rock core samples. The test results are presented in Appendix D. Is(50) values ranging from 2.4 to 8.6 MPa and UCS values (using typical K=24) of 57.7 to 206.3 MPa were recorded.

Based on these results, the rock encountered at the site is classified as typically strong to very strong.

4.6 Groundwater Conditions

Groundwater conditions in the open boreholes were observed while drilling and upon completion of each borehole. In addition, piezometers were installed in Boreholes 12 and 18 to enable us to monitor groundwater levels over a prolonged period of time, without interference from surface water. As Boreholes 13 and 14 were advanced from a barge in the Channel, no groundwater observations could be made in these two boreholes. At these borehole locations at the time of our investigation the depth of water in the Channel was 1.0 m and 0.8 m, respectively and the water surface elevation in Channel was at 175.9 m.

On the south side of the Channel (i.e. towards Barrie) in Boreholes 9, 10 and 11, the groundwater was measured, upon completion of each borehole (i.e. not necessarily stabilized) and from soil moisture and the wetness condition of the sampler, to be at between El. 178 and 176 m. In the piezometer installed in BH 12, the groundwater level was measured twenty days after the installation at El. 178.8 m. From these it is concluded that at the time of our investigation the groundwater table at the south side of the site was between El. 179 – 176 m.

On the north side of the Channel, in Boreholes 15, 16, 17, 18, 19 and 20, the water level during and upon completion (i.e. not necessarily stabilized) was at El. 179 – 178 m. In BH 18, the sampler was found to be wet at El. 179 m but subsequently in the piezometer installed, it was recorded eighteen days after drilling at El. 181.7 m. All these observations indicate that at the time of our investigation the groundwater level on the north side was between El. 182 – 178 m.

It should be pointed out that the groundwater table at the site can be expected to fluctuate seasonally and in response to major weather events.

It should also be pointed out that the groundwater level at the site would also be influenced by the water level in the Channel, which is regulated. We took elevations of the water in the Channel once a day during the period of June 12 – 13 and 14, 2013, during which time it was measured to be between 176.0 and 175.9 m. However, the water level in the Channel would fluctuate as it is controlled (regulated) by the Trent Severn waterway system authority.

For and on behalf of Coffey Geotechnics Inc.



Gwangha Roh, P.Eng., Ph. D.
Senior Geotechnical Engineer



Zuhtu Ozden, P.Eng.
Senior Principal

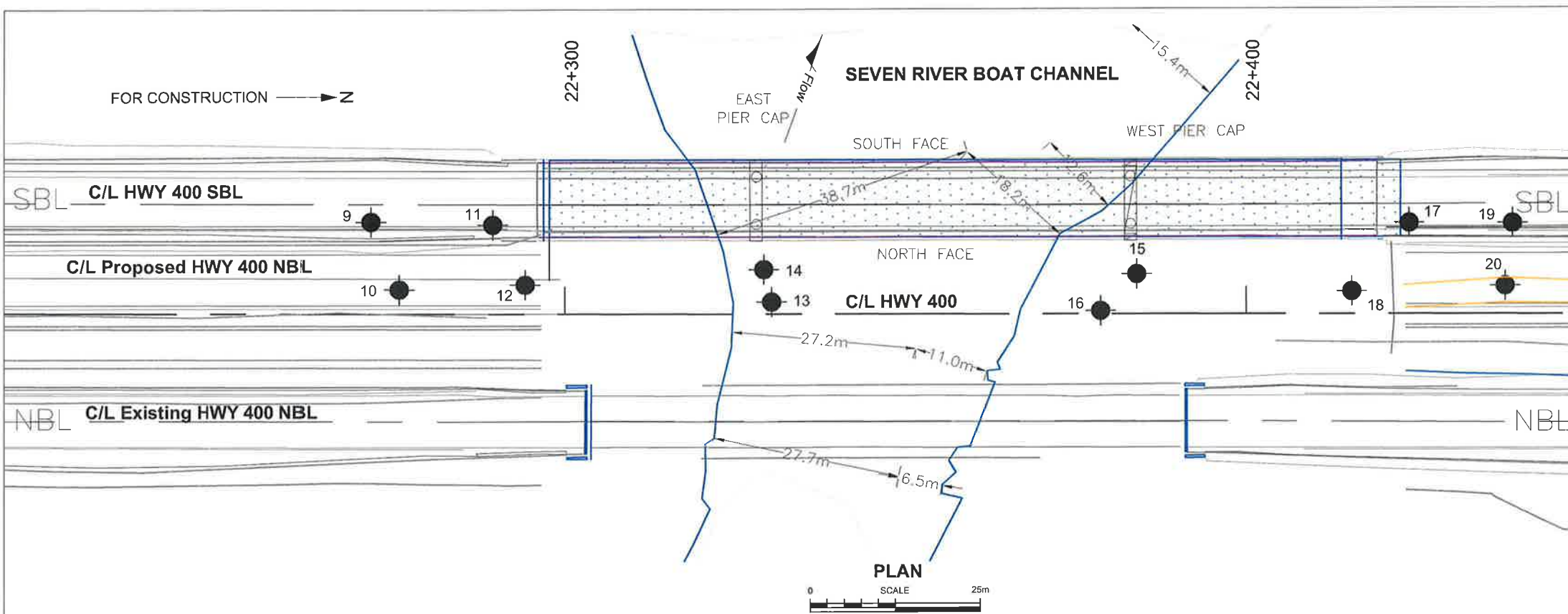


Drawings



KEY MAP

Severn River Boat Channel Bridges on Highway 400



METRIC

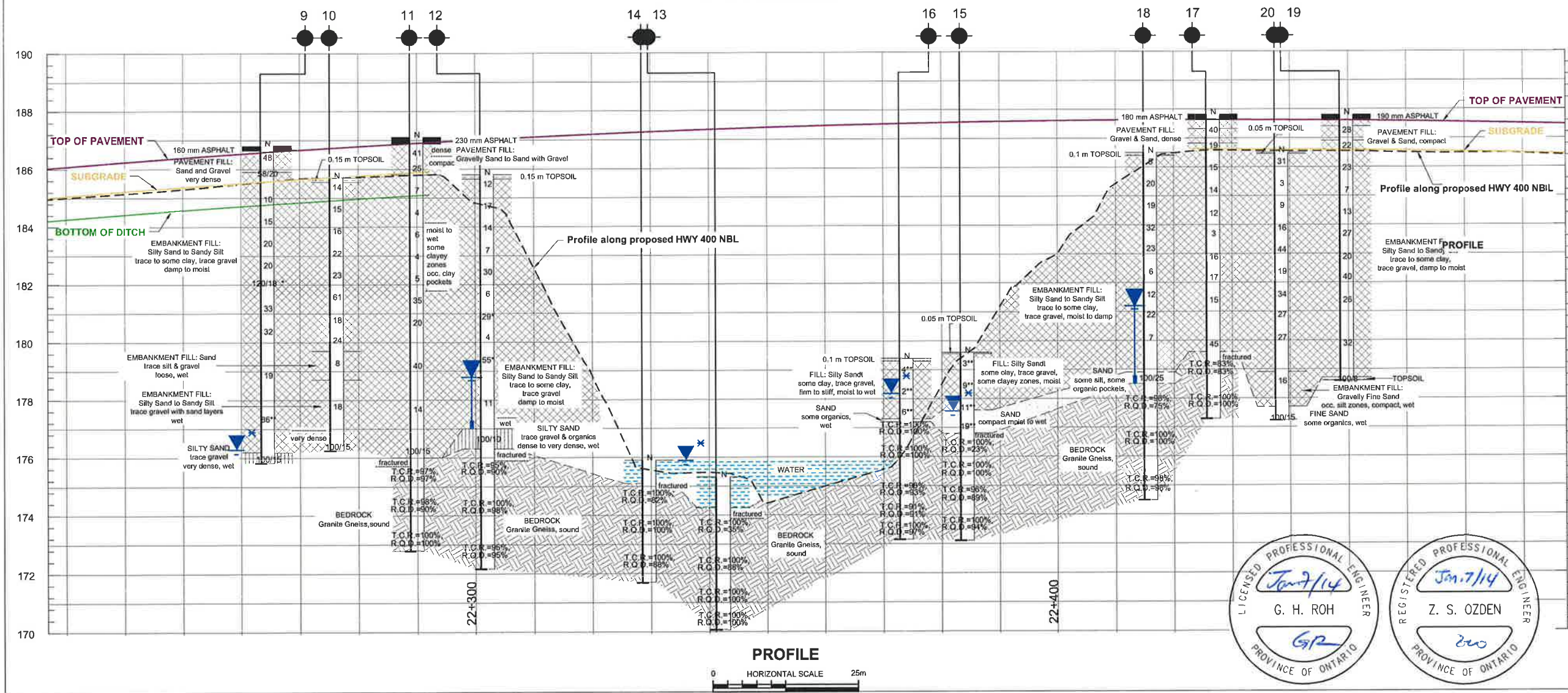
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
ARE IN KILOMETRES + METRES.

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No. -
W.P.: 2376-09-00

CONTRACT A, HIGHWAY 400, PORT SEVERN
RIVER BOAT CHANNEL BRIDGE
BOREHOLE LOCATION PLAN
AND SOIL STRATA



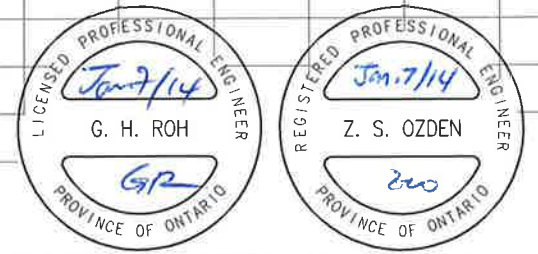
LEGEND

- Borehole
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

| No. | ELEVATION | STATION | OFFSET |
|------|-----------|---------|--------------|
| BH9 | 186.8 | 22+272 | 13.8m LI C/L |
| BH10 | 185.7 | 22+276 | 3.6m LI C/L |
| BH11 | 187.1 | 22+289 | 13.2m LI C/L |
| BH12 | 185.8 | 22+294 | 4.3m LI C/L |
| BH13 | 175.9 | 22+330 | 1.8m LI C/L |
| BH14 | 175.9 | 22+329 | 6.6m LI C/L |
| BH15 | 179.6 | 22+384 | 5.9m LI C/L |
| BH16 | 179.4 | 22+379 | 0.5m LI C/L |
| BH17 | 187.8 | 22+424 | 13.4m LI C/L |
| BH18 | 186.5 | 22+415 | 3.3m LI C/L |
| BH19 | 187.8 | 22+439 | 13.4m LI C/L |
| BH20 | 186.5 | 22+438 | 4.2 m LI C/L |

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

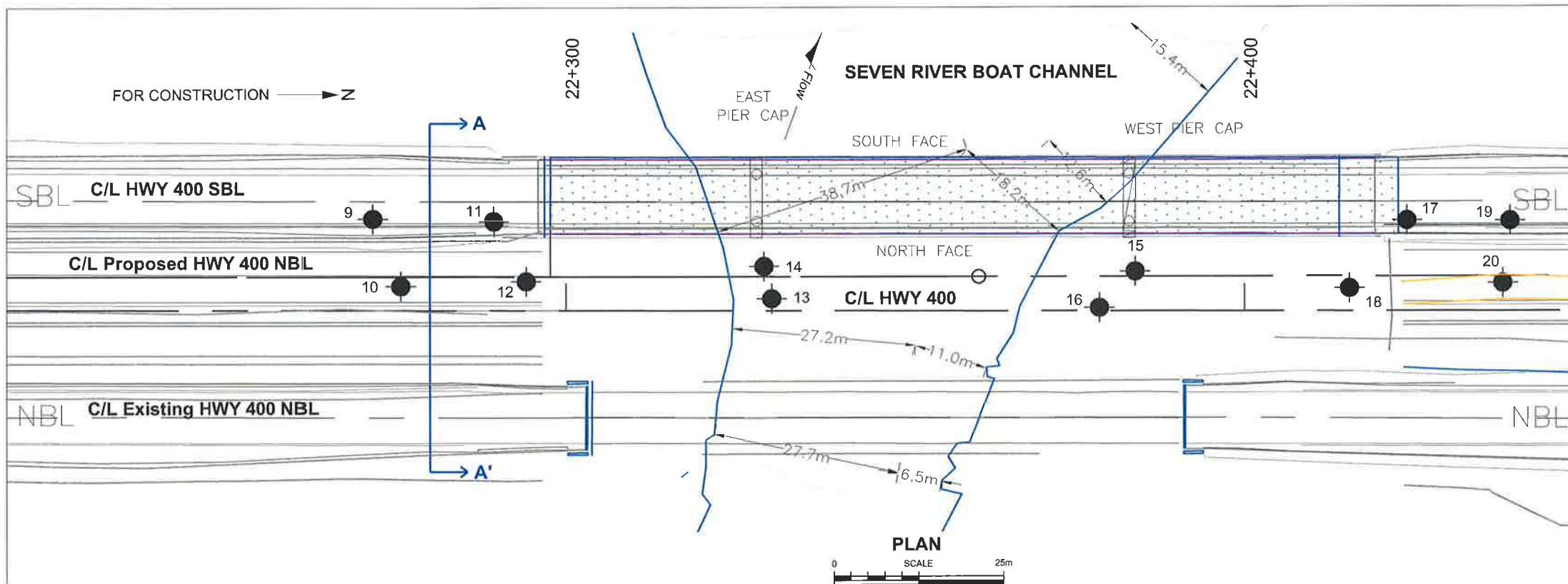


REVISIONS

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Geocres No -31D-566

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| TRANETOB20462AA | | DIST |
| SUB/M/D | CHECKED | DATE January , 2014 |
| DRAWN | SSH | CHECKED GR |
| APPROVED | ZO | DWG |
| SITE | | 42-87/1&2 |
| DWG | | 1 |



METRIC

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

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS;
REFER TO RECORD OF BOREHOLE SHEETS.

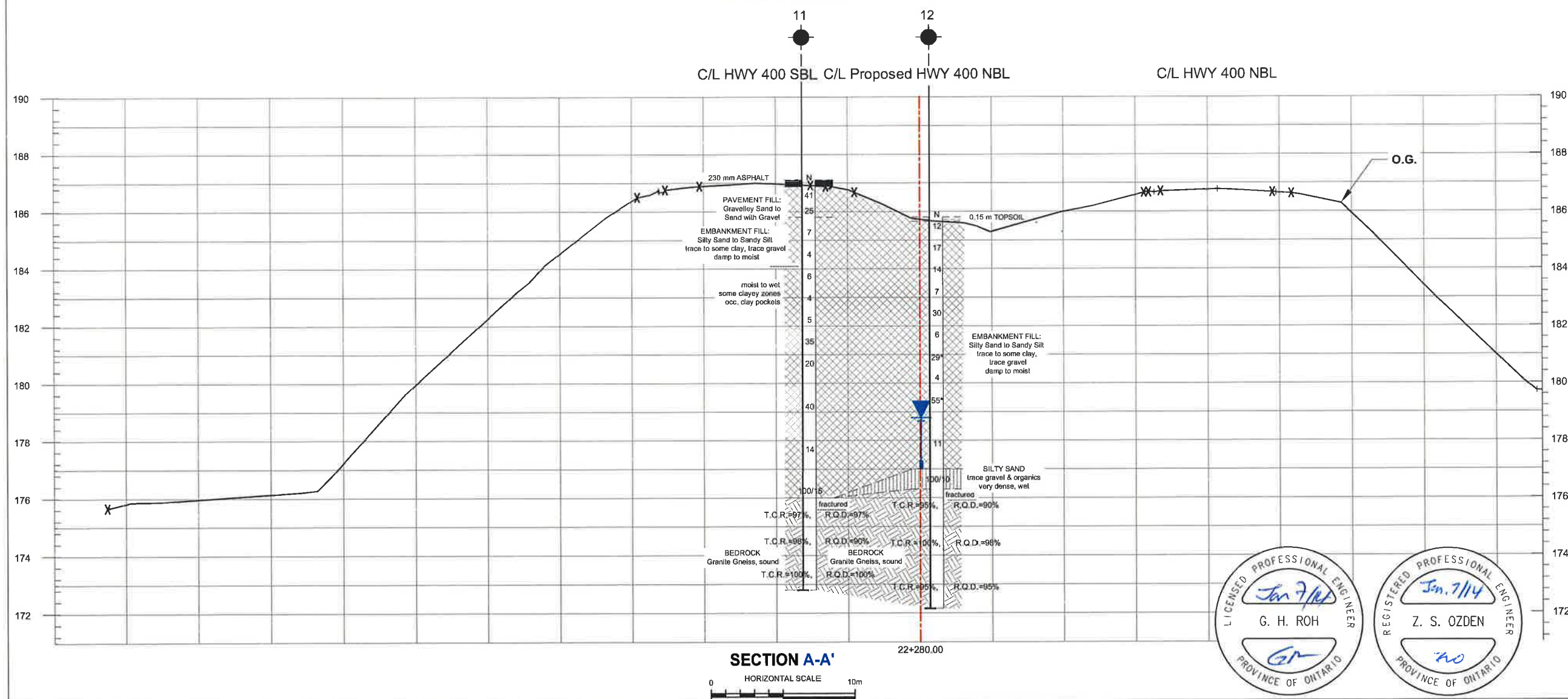
CONT No. -

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CONTRACT A, HIGHWAY 400, PORT SEVERN
RIVER BOAT CHANNEL BRIDGE
BOREHOLE LOCATION PLAN
AND SOIL STRATA



SHEET



| LEGEND | | | |
|--------|---|--|--|
| | Borehole | | |
| | Blows/0.3m (Std. Pen. Test, 475 J/blow) | | |
| | Water Level at Time of Investigation (W. L. NOT STABILIZED) | | |
| | Water Level in Piezometer | | |
| | Piezometer | | |
| | Section | | |

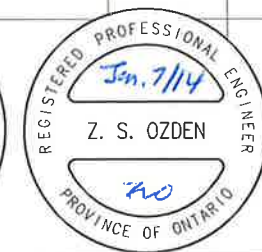
| No. | ELEVATION | STATION | OFFSET |
|------|-----------|---------|--------------|
| BH11 | 187.1 | 22+289 | 13.2m LI C/L |
| BH12 | 185.8 | 22+294 | 4.3m LI C/L |

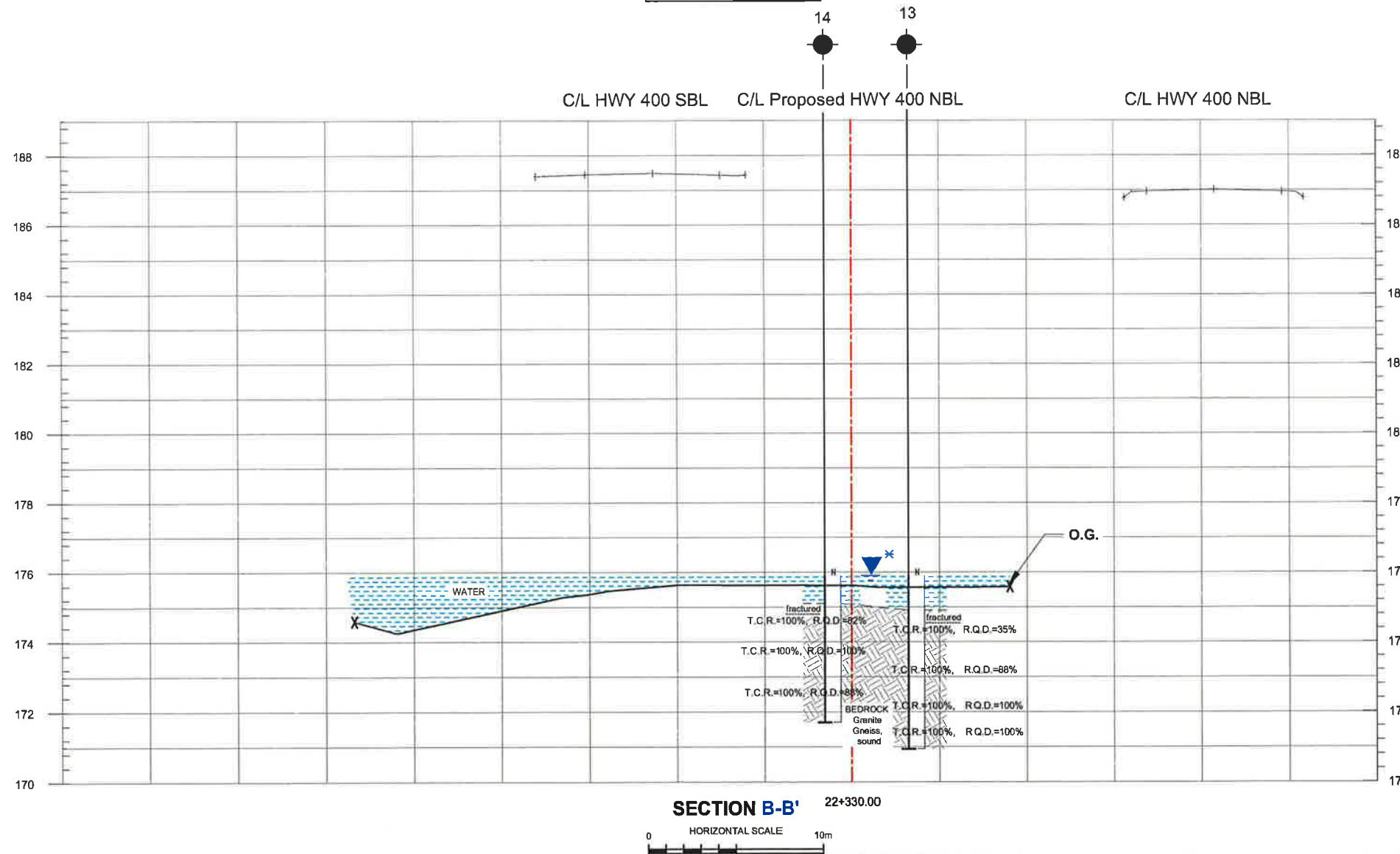
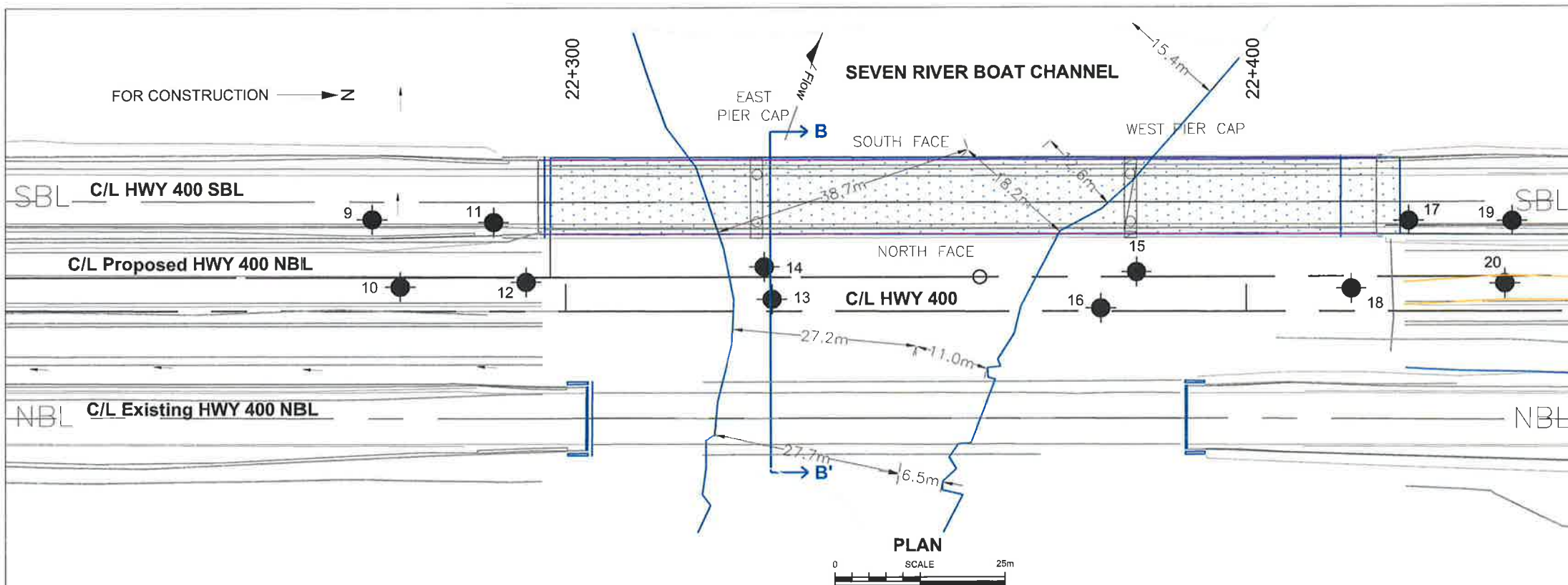
-NOTE-
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
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| | | | |
|---------------------|---------|---------|---------------|
| Geocres No -31D-566 | | | |
| TRANETOB20462AA | | | |
| SUBMD | CHECKED | DATE | JANUARY, 2014 |
| DRAWN | SSH | CHECKED | GR |
| APPROVED | | ZO | DWG |
| DIST | | SITE | 42-87/1&2 |
| | | | 2 |





METRIC

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

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS;
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No. -
W.P.: 2376-09-00

CONTRACT A, HIGHWAY 400, PORT SEVERN
RIVER BOAT CHANNEL BRIDGE
BOREHOLE LOCATION PLAN
AND SOIL STRATA



SHEET



| LEGEND | | | |
|--------|---|--|--|
| | Borehole | | |
| | Blows/0.3m (Std. Pen. Test, 475 J/blow) | | |
| | Water Level at Time of Investigation (W. L. NOT STABILIZED) | | |
| | Water Level in Piezometer | | |
| | Piezometer | | |
| | Section | | |

| No. | ELEVATION | STATION | OFFSET |
|------|-----------|---------|-------------|
| BH13 | 175.9 | 22+330 | 1.8m LI C/L |
| BH14 | 175.9 | 22+329 | 6.6m LI C/L |

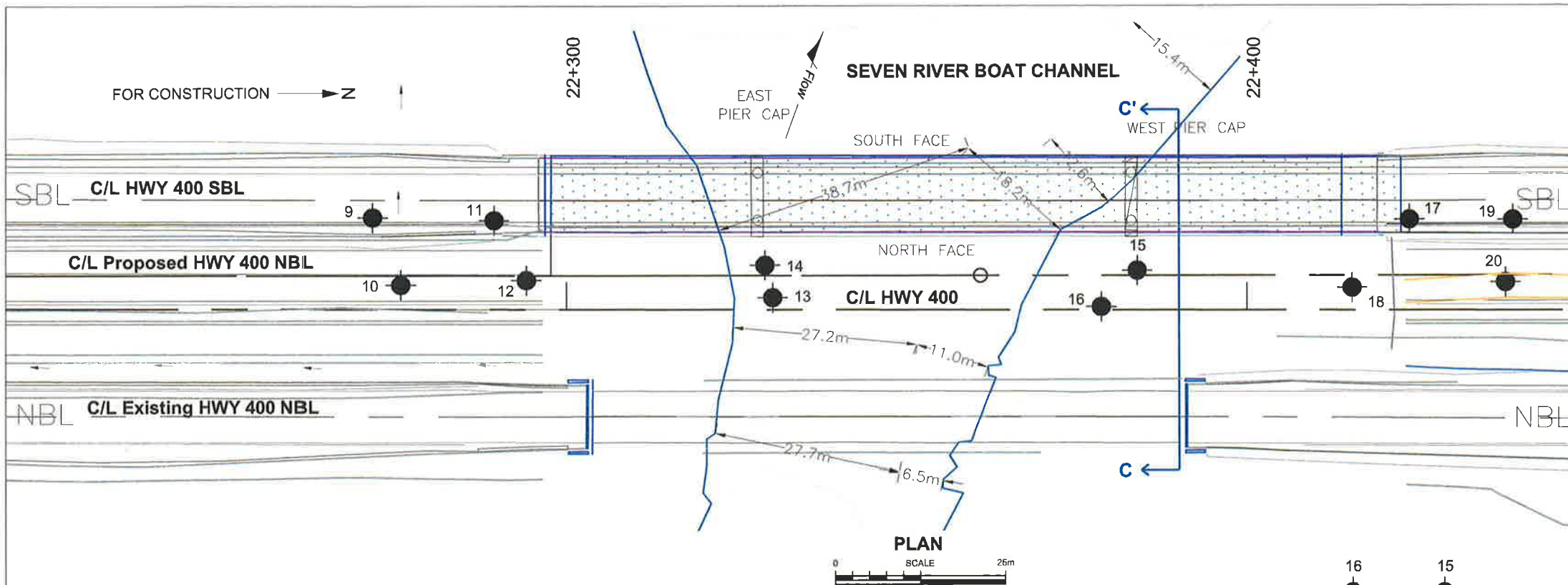
-NOTE-
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
| | | | |
| | | | |
| | | | |

| | | | |
|---------------------|---------|----------|------|
| Geocres No -31D-586 | | | |
| TRANETOB20462AA | | | |
| SUBM/D | CHECKED | DATE | SITE |
| DRAWN | SSH | APPROVED | DWG |





METRIC

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

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS:
REFER TO RECORD OF BOREHOLE SHEETS.

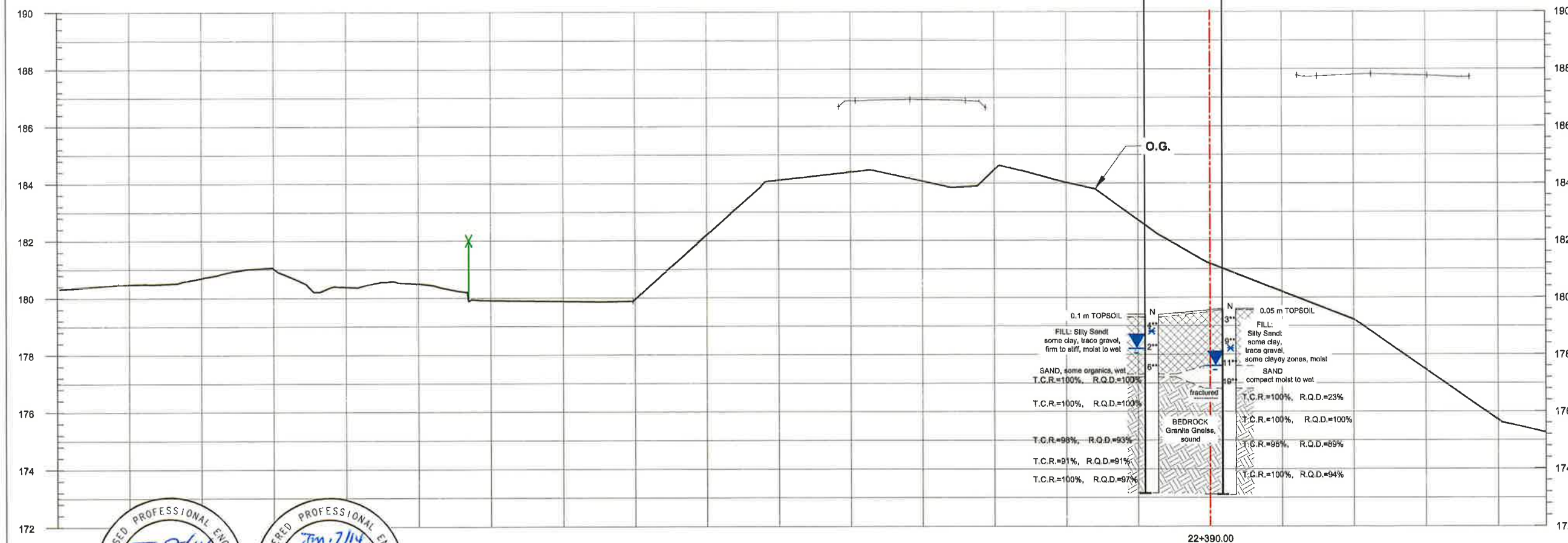
CONT No. -

W.P.: 2376-09-00

CONTRACT A, HIGHWAY 400, PORT SEVERN
RIVER BOAT CHANNEL BRIDGE
BOREHOLE LOCATION PLAN
AND SOIL STRATA



SHEET



LEGEND

- Borehole
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer
- Section

| No. | ELEVATION | STATION | OFFSET |
|------|-----------|---------|-------------|
| BH15 | 178.6 | 22+384 | 5.9m LI C/L |
| BH16 | 178.4 | 22+379 | 0.5m LI C/L |

-NOTE-

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
| | | | |
| | | | |
| | | | |

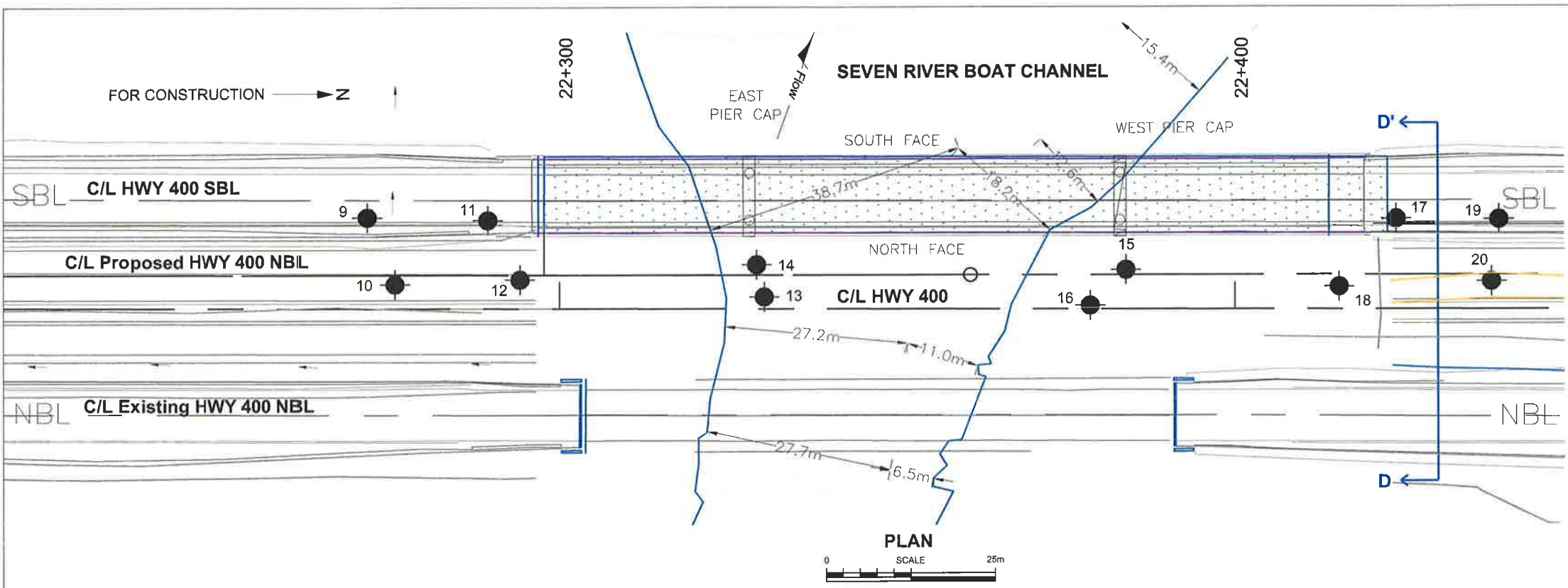
Geoties No -31D-566

| SUBMD | CHECKED | DATE | JANUARY, 2014 | SITE | 42-87/1&2 |
|-------|---------|---------|---------------|----------|-----------|
| DRAWN | SSH | CHECKED | GR | APPROVED | ZO |
| | | | | | |



SECTION C-C'





METRIC

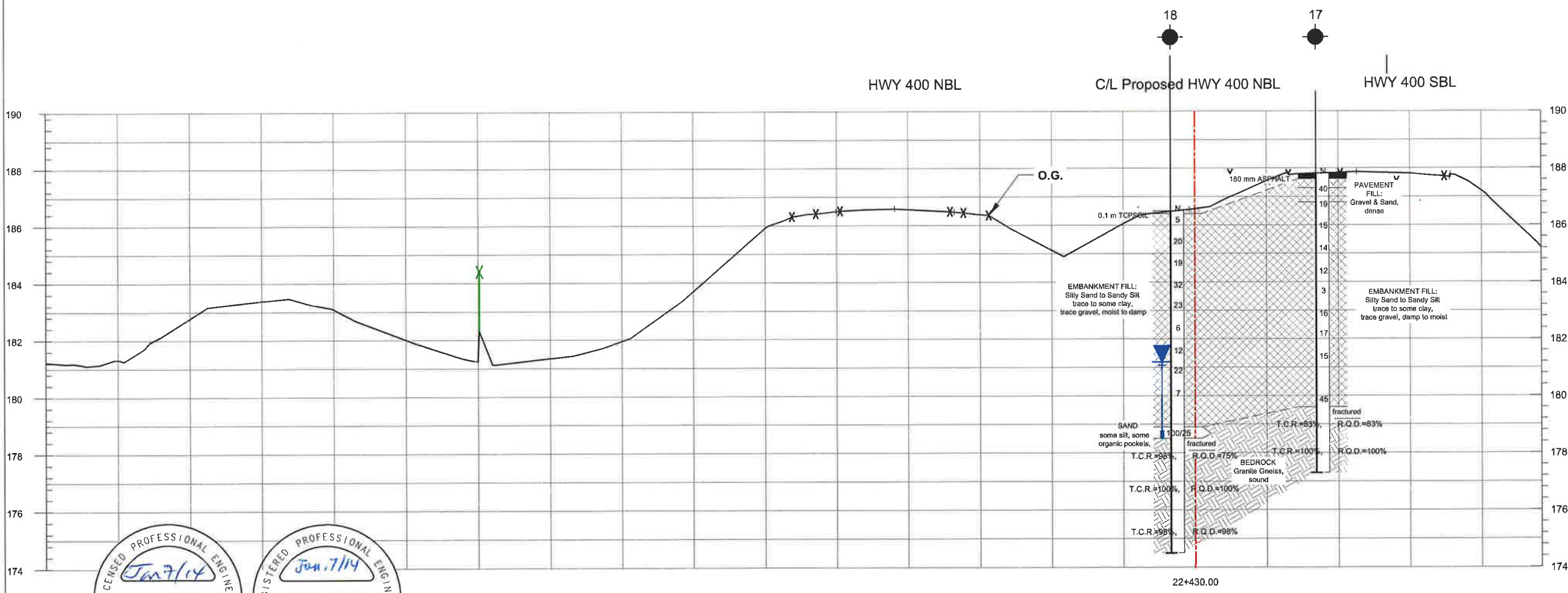
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
ARE IN KILOMETRES + METRES.

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS;
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No. -
W.P.: 2376-09-00

CONTRACT A, HIGHWAY 400, PORT SEVERN
RIVER BOAT CHANNEL BRIDGE
BOREHOLE LOCATION PLAN
AND SOIL STRATA

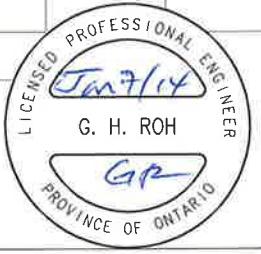


| LEGEND | | | | |
|--------|---|---------|--------------|--|
| ● | Borehole | | | |
| N | Blows/0.3m (Std. Pen. Test, 475 J/blow) | | | |
| ▼ | Water Level at Time of Investigation (W. L. NOT STABILIZED) | | | |
| ▼ | Water Level in Piezometer | | | |
| — | Piezometer | | | |
| D-D' | Section | | | |
| No. | ELEVATION | STATION | OFFSET | |
| BH17 | 187.8 | 22+424 | 13.4m LI C/L | |
| BH18 | 186.5 | 22+415 | 3.3m LI C/L | |

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

NOTE: This drawing is for subsurface information only.. Surface details and features are for conceptual illustration.

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
| | | | |
| | | | |
| | | | |



| | | | | |
|---------------------|---------|---------|---------------|-------------------|
| Geocres No -31D-566 | | | | |
| TRANETO20462AA | | | DIST | |
| SUBMD | CHECKED | DATE | January, 2014 | SITE 42-87/162 |
| DRAWN | SSH | CHECKED | GR | APPROVED ZO DWG 5 |

Appendix A

Record of Borehole Sheets

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+272, 13.6 m Lt C/L (N 4962191.991, E 287256.512) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
DATUM Geodetic DATE 22/05/2013 22/05/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | | |
| 186.8 | GROUND SURFACE | | | | | | | | | | | | | |
| 185.8 | 160 mm ASPHALT | | | | | | | | | | | | | |
| 0.2 | PAVEMENT FILL: Sand & Gravel brown, very dense | | 1 | SS | 48 | | | | | | | | | 40 46 (14) |
| 185.9 | | | 2 | SS | 58/20 | | 186 | | | | | | | |
| 0.9 | | | 3 | SS | 10 | | 185 | | | | | | | 4 57 21 18 |
| | EMBANKMENT FILL: Silty Sand to Sandy Silt trace to some clay, trace gravel greyish brown, compact, damp to moist | | 4 | SS | 15 | | 184 | | | | | | | |
| | | | 5 | SS | 20 | | 183 | | | | | | | 7 58 29 16 |
| | | | 6 | SS | 20 | | 182 | | | | | | | |
| | | dense | 7 | SS | 120/18 * | | 181 | | | | | | | *spon bouncing probable boulder N-value not reliable |
| | | | 8 | SS | 33 | | 180 | | | | | | | |
| | | compact | 9 | SS | 32 | | 179 | | | | | | | 4 61 24 11 |
| | | | 10 | SS | 19 | | 178 | | | | | | | |
| | | | 11 | SS | 86** | | 177 | | | | | | | **oversized gravel N-value not reliable |
| 176.2 | | | | | | | 176 | | | | | | | wet spoon |
| 10.6 | SILTY SAND trace gravel grey, very dense, wet | | 12 | SS | 100/15 | | | | | | | | | |
| 175.8 | | | | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | | | | |
| <p>End of Borehole Auger refusal @ 11.0 m Probable Bedrock ***Water level @ 10.5 m (El. 176.3 m) upon completion (not stabilized)</p> | | | | | | | | | | | | | | |

METRIC

CHECKED BY ZO

+ 3, x 3: Numbers refer to Sensitivity

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+289, 13.2 m Lt C/L (N 4962197.730, E 287239.700) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE Hollow Stem Auger & NQ Coring COMPILED BY SSH
DATUM Geodetic DATE 16/05/2013 16/05/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|---|------------|---------|------|----------------------------|-------------------------|-----------------|--|----|----|----|-----|--|---------------------------------------|
| ELEV. DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | | |
| 187.1 | GROUND SURFACE | | | | | | | | | | | | | |
| 186.9 | 230 mm ASPHALT | | | | | | | | | | | | | |
| 0.2 | | | | | | | | | | | | | | |
| 185.8 | PAVEMENT FILL: Gravelly Sand to Sand with Gravel brown | | 1 | SS | 41 | | | | | | | | | 32 51 (17) |
| 1.3 | | | 2 | SS | 25 | | | | | | | | | |
| | | | 3 | SS | 7 | | | | | | | | | |
| | | | 4 | SS | 4 | | | | | | | | | |
| | | | 5 | SS | 6 | | | | | | | | | |
| | | | 6 | SS | 4 | | | | | | | | | |
| | | | 7 | SS | 5 | | | | | | | | | |
| | | | 8 | SS | 35 | | | | | | | | | |
| | | | 9 | SS | 20 | | | | | | | | | |
| | | | 10 | SS | 40 | | | | | | | | | |
| | | | 11 | SS | 14 | | | | | | | | | |
| | | | 12 | SS | 100/15 | | | | | | | | | |
| 176.0 | | | 13 | RC | T.C.R.=97% R.Q.D.=97% | | | | | | | | | |
| 11.1 | | | 14 | RC | T.C.R.=98% R.Q.D.=90% | | | | | | | | | |
| | | | 15 | RC | T.C.R.=100% R.Q.D.=100% | | | | | | | | | |
| 172.8 | | | | | | | | | | | | | | |
| 14.3 | | | | | | | | | | | | | | |
| | End of Borehole Borehole open and dry upon completion of overburden drilling (not stabilized) | | | | | | | | | | | | | |

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

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 12

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+294, 4.4 m LI C/L (N 4962207.608, E 287237.829) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE Hollow Stem Auger & NQ Coring COMPILED BY SSH
DATUM Geodetic DATE 27/05/2013 27/05/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
|--|--|--------------------------|---------|------|---------------------------|----------------------------|-----------------|---|--------------|-----------------|---|---|-------------------|--|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH (kPa) | | | | | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED | + FIELD VANE | ● POCKET PENETR | | | × LAB VANE | W _P | W |
| 185.8 | GROUND SURFACE | | | | | | 20 | 40 | 60 | 80 | 100 | 10 | 20 | 30 | GR SA SI CL |
| 185.7 | 0.15 m TOPSOIL | | | | | | 20 | 40 | 60 | 80 | 100 | | | | |
| 0.2 | EMBANKMENT FILL: Silty Sand to Sandy Silt trace to some clay, trace gravel greyish brown, damp to moist | | 1 | SS | 12 | | | | | | | | | | 5 51 27 17 |
| | | | 2 | SS | 17 | | | | | | | | | | |
| | | | 3 | SS | 14 | | | | | | | | | | |
| | | compact | | | | | | | | | | | | | |
| | | loose | | 4 | SS | 7 | | | | | | | | | |
| | | compact | | | | | | | | | | | | | |
| | | | 5 | SS | 30 | | | | | | | | | | |
| | | loose | | 6 | SS | 6 | | | | | | | | | |
| | | compact | | 7 | SS | 29* | | | | | | | | | |
| | | very loose to compact | | 8 | SS | 4 | | | | | | | | | |
| | | | 9 | SS | 55* | | | | | | | | | * oversize gravel in sampler, N-value may not be reliable | |
| | | | 10 | SS | 11 | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 177.0 | 8.8 | wet | 11 | SS | 100/10 | | | | | | | | | | Auger refusal and start of NQ coring at 9.5 m |
| 176.3 | 9.5 | fractured | 12 | RC | T.C.R.=95% R.Q.D.=90% | | | | | | | | | | |
| | BEDROCK Granite Gneiss greyish / pink, sound | | 13 | RC | T.C.R.=100% R.Q.D.=98% | | | | | | | | | | |
| | | | 14 | RC | T.C.R.=95% R.Q.D.=95% | | | | | | | | | | |
| 172.2 | 13.6 | | | | | | | | | | | | | | |
| End of Borehole Piezometer installed to 8.6 m. Water level in piezometer @ 2.5 m upon installation (not reliable due to water used for coring). Water level in piezometer @ 7.0 m (El. 178.6 m) on June 17, 2013 | | | | | | | | | | | | | | | |

+ 3 x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE


TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 13

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+330, 1.8 m Lt C/L (N 4962220.901, E 287204.168) ORIGINATED BY LG
 DIST 5 HWY 400 BOREHOLE TYPE NQ and BQ Coring from barge COMPILED BY SSH
 DATUM Geodetic DATE 11/06/2013 11/06/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|----------------|---|---|---------|----------------------------|----------------------------|----------------------------|-----------------|--|--|--|---|---|--|
| ELEV. DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE | | | | | |
| 175.9 0.0 | WATER SURFACE WATER |  | | | | | | | | | | | |
| 174.9 1.0 | Channel Bottom | | | | | | | | | | | | |
| | BEDROCK Granite Gneiss greyish / pink sound below 0.6 m | | 1 | RC | T.C.R.=100% R.Q.D.=35% | | | | | | | | |
| | | | 2 | RC | T.C.R.=100% R.Q.D.=88% | | | | | | | | |
| | | | 3 | RC | T.C.R.=100% R.Q.D.=100% | | | | | | | | |
| | | 4 | RC | T.C.R.=100% R.Q.D.=100% | | | | | | | | | |
| 170.9 5.0 | End of Borehole NQ coring to 3.0 m below channel bottom then BQ coring to the end of the borehole | | | | | | | | | | | | change to BQ coring @ 3.0 m below channel bottom |

+ 3 x 3 : Numbers refer to
Sensitivity

20
15
10
5
0
(%) STRAIN AT FAILURE

TRANETO820462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 14

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+329, 6.6 m Lt C/L (N 4962215.984, E 287203.809) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE BQ Coring from barge COMPILED BY SSH
DATUM Geodetic DATE 12/06/2013 12/06/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|----------------|---|-------------|---------|------|------------|----------------------------|-----------------|---|----|----|---|----|----|--|--|
| ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR × LAB VANE | | | WATER CONTENT (%) w _P w w _L | | | | |
| 175.9 0.0 | WATER SURFACE | | | | | | 20 | 40 | 60 | 80 | 100 | 10 | 20 | 30 | |
| 175.1 0.8 | WATER Channel Bottom | | | | | | | | | | | | | | |
| 171.7 4.2 | fractured | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to
Sensitivity

20
15
10
5
(%) STRAIN AT FAILURE

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 15

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+384, 5.9 m Lt C/L (N 4962233.161, E 287151.839) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE Manual Drilling by Washboring & BQ Coring COMPILED BY SSH
DATUM Geodetic DATE 03/06/2013 04/06/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC LIMIT W _P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|--|------------|---------|------|----------------------------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| FLV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 179.6 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 179.6 0.1 | 0.05 m TOPSOIL | | | | | | | | | | | | | | | | |
| | FILL: Silty Sand some clay, trace gravel, some clayey zones brown, very loose to loose, moist | | 1 | SS | 3** | | 179 | | | | | | | | | | |
| | | | 2 | SS | 9** | | 178 | | | | | | | | | | 4 49 29 18 |
| 177.6 2.0 | SAND with silty zones, trace gravel brown to 2.4 m, grey below, compact, moist to wet | | 3 | SS | 11** | | 177 | | | | | | | | | | |
| 176.8 2.8 | | | 4 | SS | 19** | | 176 | | | | | | | | | | |
| | fractured | | 5 | RC | T.C.R.=100% R.Q.D.=23% | | 175 | | | | | | | | | | Auger refusal and start of BQ coring at 2.8 m |
| | | | 6 | RC | T.C.R.=100% R.Q.D.=100% | | 174 | | | | | | | | | | |
| | BEDROCK Granite Gneiss greyish / pink sound | | 7 | RC | T.C.R.=96% R.Q.D.=89% | | | | | | | | | | | | |
| | | | 8 | RC | T.C.R.=100% R.Q.D.=94% | | | | | | | | | | | | |
| 173.1 6.5 | End of Borehole *water level @ 2.0 m (El. 177.6 m) upon completion (not stabilized) **31.8 kg hammer used instead of standard 63.6 kg hammer, due to manual drilling; recorded resistance values were divided by 2 to obtain approximate equivalent N-values | | | | | | | | | | | | | | | | |

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 16

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+379, 0.5 m Lt C/L (N 4962236.712, E 287158.483) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE Manual Drilling by Washboring & BQ Coring COMPILED BY SSH
DATUM Geodetic DATE 03/06/2013 05/06/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|----------------|--|------------|---------|------|----------------------------|----------------------------|-----------------|---|--------------|------------------|---|----------------|----|--|--|
| ELEV. DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH (kPa) | | | WATER CONTENT (%) | | | | |
| | | | | | | | | ○ UNCONFINED | + FIELD VANE | ● POCKET PENETR. | × LAB VANE | W _P | W | | |
| | | | | | | | 20 | 40 | 60 | 80 | 100 | 10 | 20 | 30 | |
| 179.4 | GROUND SURFACE | | | | | | | | | | | | | | |
| 179.3 | 0.1 m TOPSOIL | | 1 | SS | 4** | | | | | | | | | | |
| 0.1 | FILL: Silly Sand some clay, trace gravel brown, very loose to compact firm to stiff, moist to wet | | 2 | SS | 2** | | | | | | | | | | 2 49 32 17 |
| | | | 3 | SS | 6** | | | | | | | | | | |
| 177.3 | | | 4 | RC | T.C.R.=100% R.Q.D.=100% | | | | | | | | | | Auger refusal and start of BQ coring at 2.2 m |
| 2.1 | SAND some organics, brown, wet | | 5 | RC | T.C.R.=100% R.Q.D.=100% | | | | | | | | | | |
| 177.2 | | | 6 | RC | T.C.R.=98% R.Q.D.=93% | | | | | | | | | | |
| 2.2 | | | 7 | RC | T.C.R.=91% R.Q.D.=91% | | | | | | | | | | |
| | BEDROCK Granite Gneiss greyish / pink sound | | 8 | RC | T.C.R.=100% R.Q.D.=97% | | | | | | | | | | |
| 173.2 | End of Borehole * Water level before coring @ 1.2 m (El. 178.2 m) (not stabilized) **31.8 kg hammer used instead of standard 63.6 kg hammer, due to manual drilling recorded resistance values were divided by 2 to obtain approximate equivalent N-values | | | | | | | | | | | | | | |
| 6.3 | | | | | | | | | | | | | | | |

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 17

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+424, 13.4 m Lt C/L (N 4962237 999, E 287111.392) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE Hollow Stem Auger & NQ Coring COMPILED BY SSH
DATUM Geodetic DATE 15/05/2013 15/05/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|----------------------------|----------------------------|-----------------|---|----|----|----|-----|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | | |
| 187.8 | GROUND SURFACE | | | | | | | | | | | | | |
| 187.6 | 180 mm ASPHALT | | | | | | | | | | | | | |
| 0.2 | | | | | | | | | | | | | | |
| 187.3 | PAVEMENT FILL: | | | | | | | | | | | | | |
| 0.5 | Gravel & Sand, brown, dense | | 1 | SS | 40 | | 187 | | | | | | | |
| 186.8 | PAVEMENT FILL: | | | | | | | | | | | | | |
| 1.0 | Gravelly Sand, brown, dense | | 2 | SS | 19 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 3 | SS | 15 | | 186 | | | | | | | |
| | EMBANKMENT FILL: | | | | | | | | | | | | | |
| | Silty Sand to Sandy Silt | | | | | | | | | | | | | |
| | trace to some clay, trace gravel | | 4 | SS | 14 | | 185 | | | | | | | 8 54 23 15 |
| | greyish brown, compact, damp to moist | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 5 | SS | 12 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 6 | SS | 3 | | 184 | | | | | | | 4 52 36 18 |
| | very loose, wet | | | | | | | | | | | | | |
| | brown from 4.5 to 7.5 m | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 7 | SS | 16 | | 183 | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 8 | SS | 17 | | 182 | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 9 | SS | 15 | | 181 | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | 180 | | | | | | | |
| | | | 10 | SS | 45 | | | | | | | | | |
| 179.6 | | | | | | | | | | | | | | |
| 8.2 | fractured | | 11 | RC | T.C.R.=83% R.Q.D.=83% | | 179 | | | | | | | Auger refusal and start of NQ coring at 8.2 m |
| | | | | | | | | | | | | | | |
| | BEDROCK | | | | | | | | | | | | | |
| | Granite Gneiss | | 12 | RC | T.C.R.=100% R.Q.D.=100% | | 178 | | | | | | | |
| | greyish / pink | | | | | | | | | | | | | |
| | sound | | | | | | | | | | | | | |
| 177.3 | | | | | | | | | | | | | | |
| 10.5 | End of Borehole | | | | | | | | | | | | | |
| | Borehole open and dry upon completion of overburden drilling (not stabilized) | | | | | | | | | | | | | |

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 18

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+416, 3.3 m Lt C/L (N 4962245.103, E 287122.481) ORIGINATED BY LG
 DIST 5 HWY 400 BOREHOLE TYPE Hollow Stem Auger & NQ Coring COMPILED BY SSH
 DATUM Geodetic DATE 29/05/2013 29/05/2013 CHECKED BY ZO

| 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) | | | | | | |
| 186.5 | GROUND SURFACE | | | | | | | | | | | | | |
| 185.4 | 0.1 m TOPSOIL | | 1 | SS | 5 | | | | | | | | | |
| 0.1 | very loose | | | | | | | | | | | | | |
| | compact to dense | | 2 | SS | 20 | | | | | | | | | |
| | | | 3 | SS | 19 | | | | | | | | | |
| | EMBANKMENT FILL: Silty Sand to Sandy Silt trace to some clay, trace gravel greyish brown, moist to damp | | 4 | SS | 32 | | | | | | | | | |
| | | | 5 | SS | 23 | | | | | | | | | |
| | loose to compact | | 6 | SS | 6 | | | | | | | | | |
| | | | 7 | SS | 12 | | | | | | | | | |
| | | | 8 | SS | 22 | | | | | | | | | |
| | | | 9 | SS | 7 | | | | | | | | | |
| 178.9 | | | | | | | | | | | | | | |
| 7.6 | SAND | | 10 | SS | 100/25 | | | | | | | | | |
| 178.5 | some silt, some organic pockets, greyish brown, wet | | | | | | | | | | | | | |
| 8.0 | fractured | | 11 | RC | T.C.R.=98% R.Q.D.=75% | | | | | | | | | |
| | BEDROCK Granite Gneiss greyish / pink sound | | 12 | RC | T.C.R.=100% R.Q.D.=100% | | | | | | | | | |
| | black, dark grey | | | | | | | | | | | | | |
| | | | 13 | RC | T.C.R.=98% R.Q.D.=98% | | | | | | | | | |
| 174.5 | | | | | | | | | | | | | | |
| 12.0 | End of Borehole Piezometer installed to 8.0 m. Water level in piezometer @ 0.9 m upon installation. (not reliable due to water used for coring). Water level in piezometer @5.3 m (El. 181.7 m) on June 17, 2013 | | | | | | | | | | | | | |

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

TRANETOB20462AA: Severn River Boat Channel Bridge

RECORD OF BOREHOLE No 19

1 OF 1

METRIC

GWP W.P. 2376-09-00 LOCATION 22+439, 13.4 m Lt C/L (N 4962242.619, E 287096.899) ORIGINATED BY LG
DIST 5 HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
DATUM Geodetic DATE 15/05/2013 15/05/2013 CHECKED BY ZO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|-----------------|------------------------------------|-------------------------------------|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 40 60 80 100 | 20 40 60 80 100 | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | |
| 187.8 | GROUND SURFACE | | | | | | | | | | | | |
| 187.6 | 190 mm ASPHALT | | | | | | | | | | | | |
| 0.2 | PAVEMENT FILL: | | | | | | | | | | | | |
| 187.4 | Gravel & Sand, brown, compact | | 1 | SS | 28 | | 187 | | | | | | 24 62 (14) |
| 0.4 | PAVEMENT FILL: | | | | | | | | | | | | |
| 186.9 | Gravelly Sand, brown, compact | | 2 | SS | 22 | | | | | | | | 2 58 22 18 |
| 0.9 | | | | | | | | | | | | | |
| | | | 3 | SS | 23 | | 186 | | | | | | |
| | | | | | | | | | | | | | |
| | | | 4 | SS | 7 | | 185 | | | | | | |
| | | | | | | | | | | | | | |
| | | | 5 | SS | 13 | | 184 | | | | | | |
| | | | | | | | | | | | | | |
| | | | 6 | SS | 27 | | 183 | | | | | | |
| | | | | | | | | | | | | | |
| | | | 7 | SS | 20 | | 182 | | | | | | |
| | | | | | | | | | | | | | |
| | | | 8 | SS | 40 | | 181 | | | | | | |
| | | | | | | | | | | | | | |
| | | | 9 | SS | 26 | | 180 | | | | | | |
| | | | | | | | | | | | | | |
| | | | 10 | SS | 32 | | 179 | | | | | | |
| | | | | | | | | | | | | | |
| 178.7 | | | | | | | | | | | | | |
| 9.1 | | | 11 | SS | 100/8 | | | | | | | | spoon bouncing |
| 178.6 | TOPSOIL | | | | | | | | | | | | |
| 9.2 | black, wet | | | | | | | | | | | | |
| | End of Borehole Auger refusal @ 9.2 m Probable Bedrock Borehole dry and open upon completion | | | | | | | | | | | | |

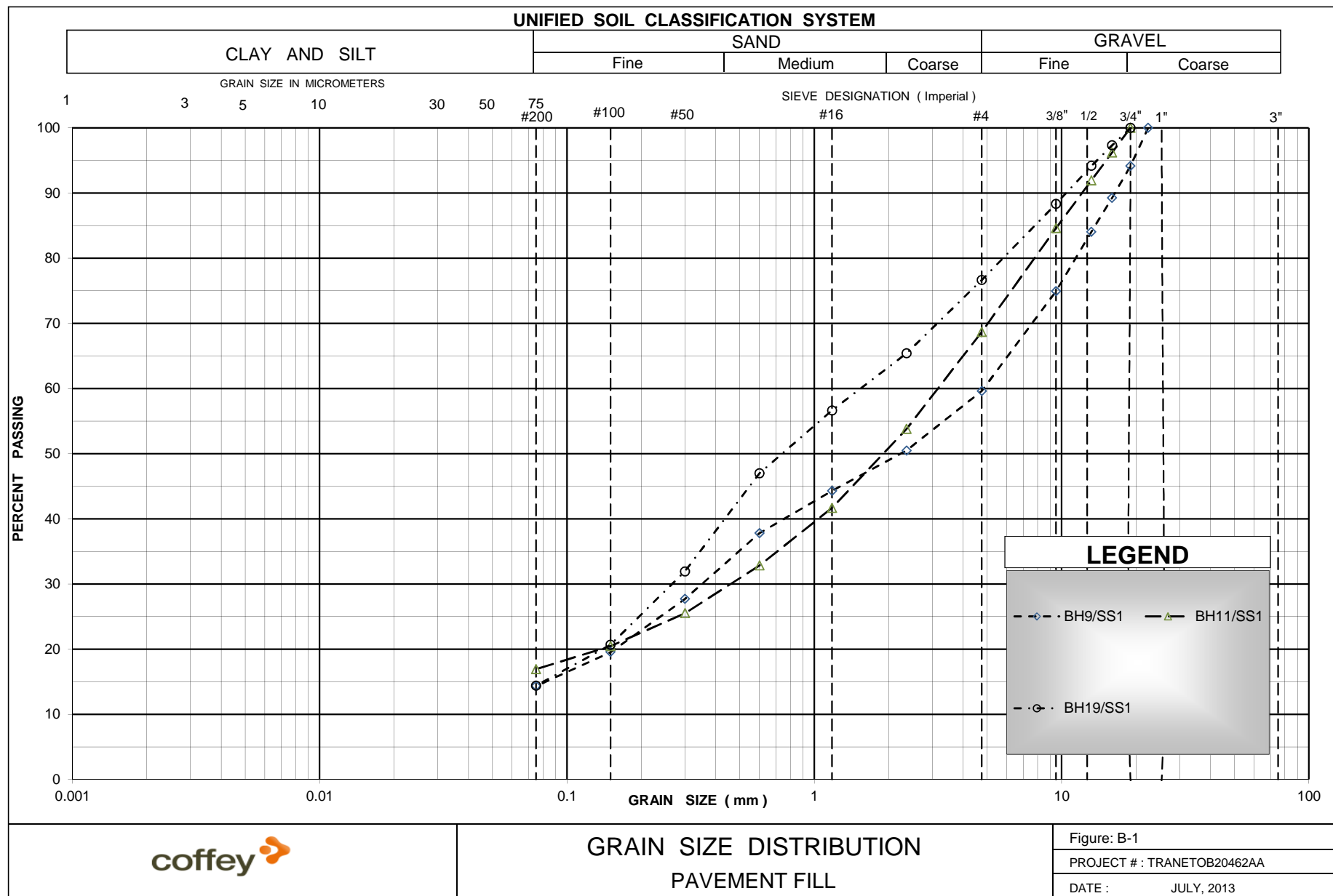
+ 3 x 3 Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

METRIC

+ 3, × 3, Numbers refer to Sensitivity

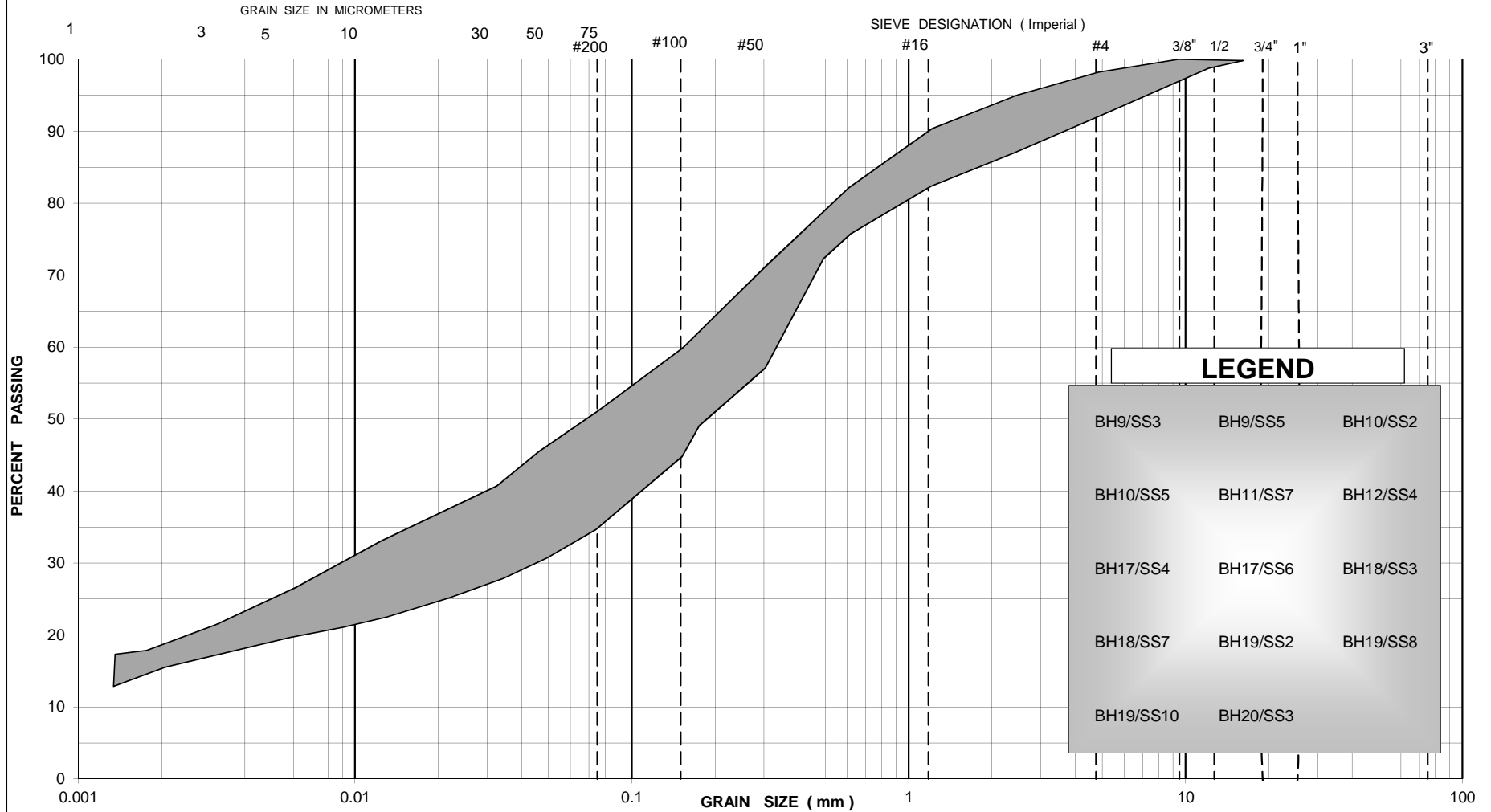
Appendix B

Test Results



UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |



GRAIN SIZE DISTRIBUTION
 EMBANKMENT FILL
 Silty Sand, trace to some clay, trace gravel

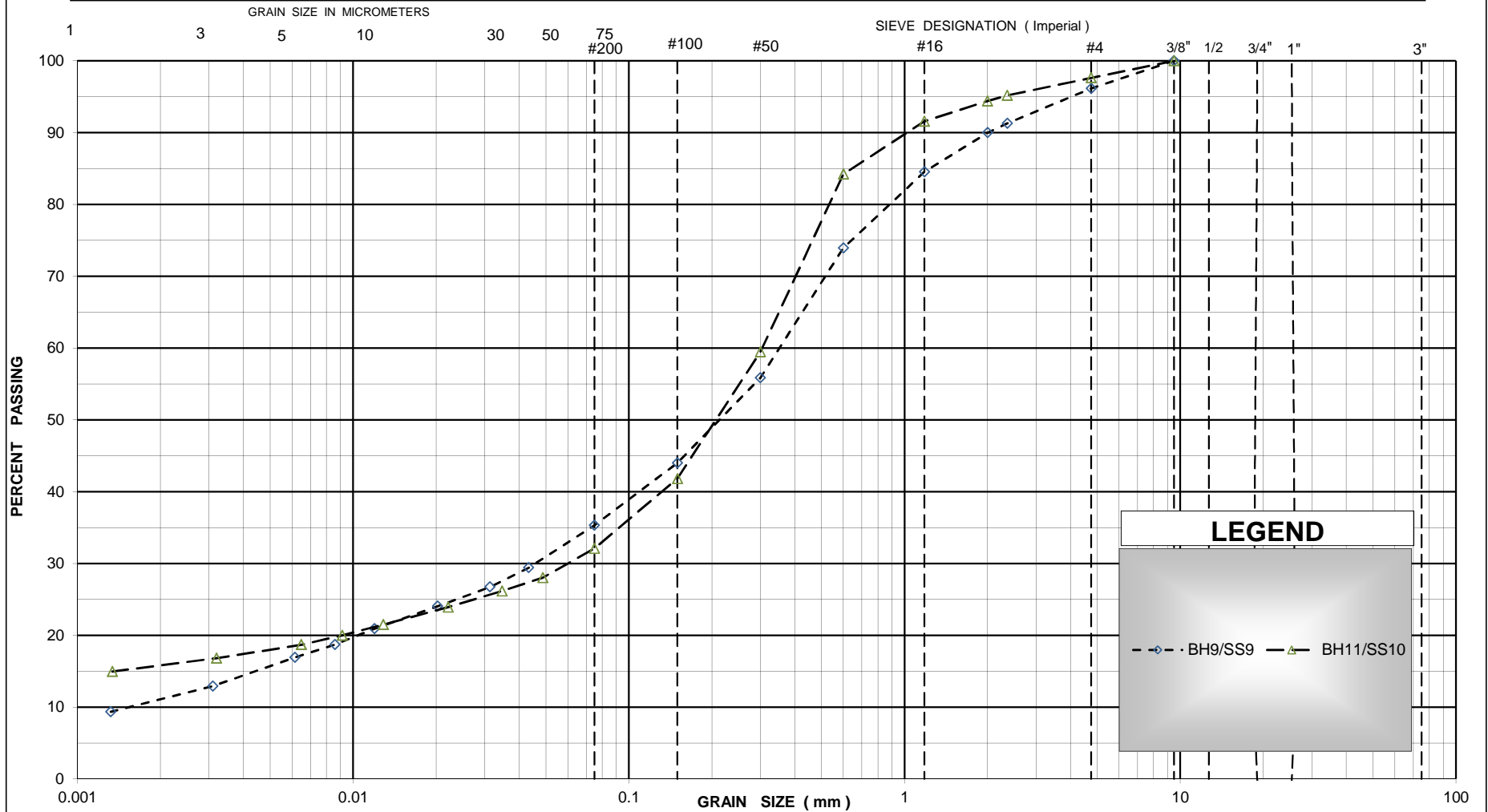
Figure: B-2

PROJECT # : TRANETO20462AA

DATE SEPTEMBER, 2013

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | | | | SAND | | | GRAVEL | |
|---------------|--|--|--|------|--------|--------|--------|--------|
| | | | | Fine | Medium | Coarse | Fine | Coarse |



GRAIN SIZE DISTRIBUTION
 EMBANKMENT FILL
 Sand, some silt and clay, trace gravel

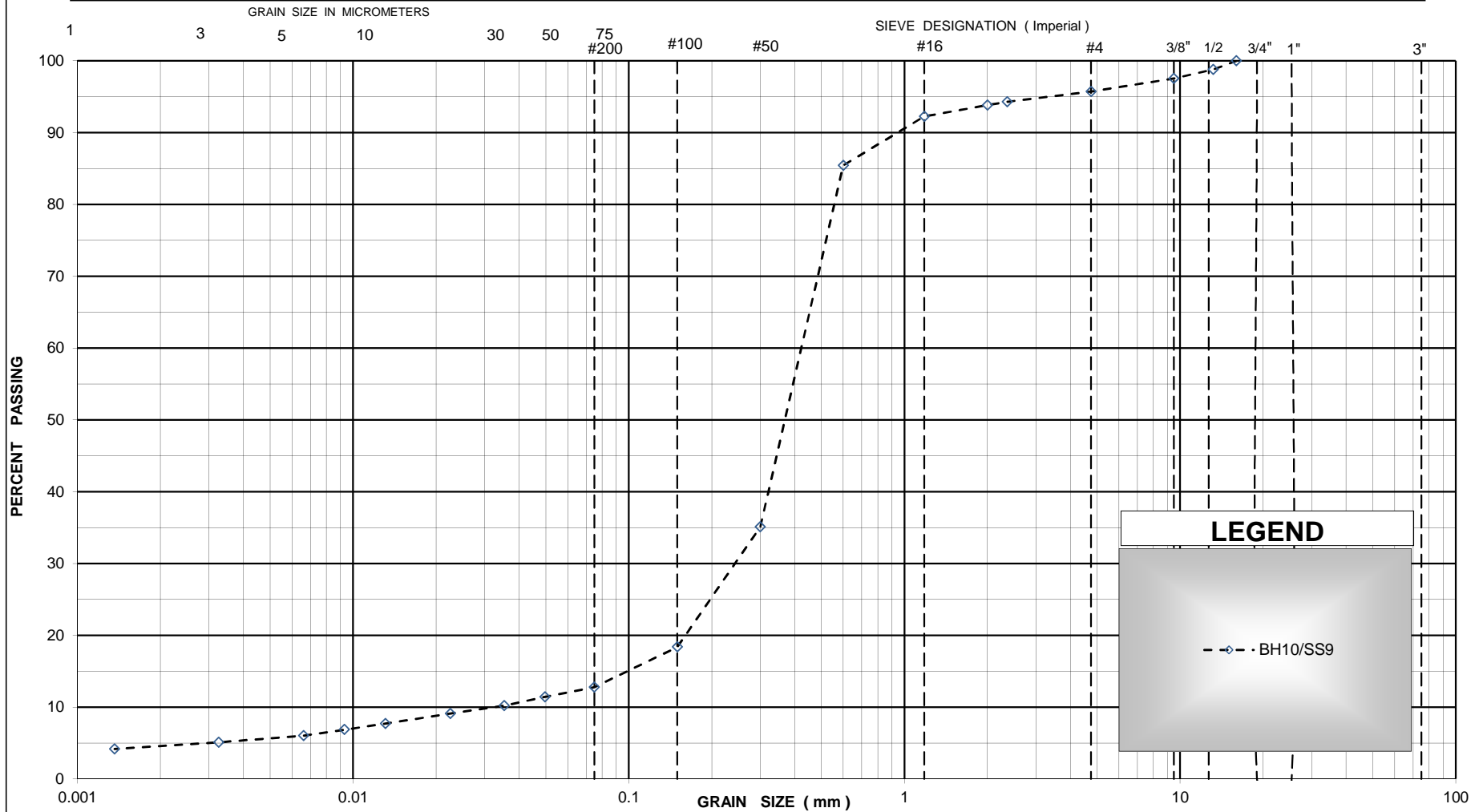
Figure: B-3

PROJECT # : TRANETO20462AA

DATE : SEPTEMBER, 2013

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |



GRAIN SIZE DISTRIBUTION
 EMBANKMENT FILL
 Sand, trace silt, clay and gravel

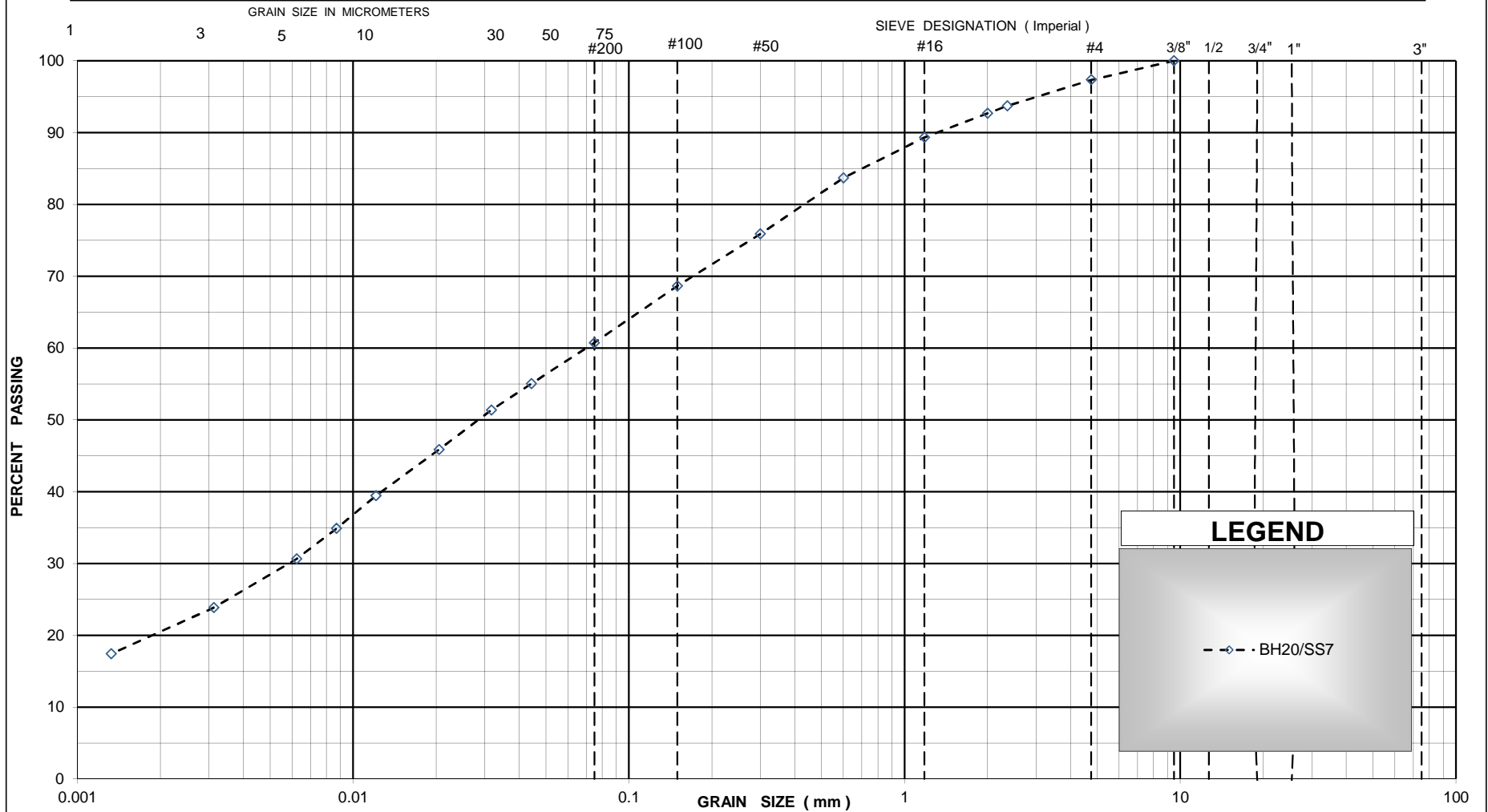
Figure: B-4

PROJECT # : TRANETO20462AA

DATE : SEPTEMBER, 2013

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |



GRAIN SIZE DISTRIBUTION
 EMBANKMENT FILL
 Sandy Silt, some clay, trace gravel

Figure: B-5

PROJECT # : TRANETO20462AA

DATE : SEPTEMBER, 2013

Appendix C

Site Photographs



Photograph 1. Boreholes 10 and 12, looking west (construction north)



Photograph 2. Boreholes 13 and 14, looking east (construction south)



Photograph 3. Boreholes 15 and 16, looking west (construction north)



Photograph 4. Borehole 18, looking east (construction south)



Photograph 5. Borehole 18, looking east (construction south)

Appendix D

Rock Core Photographs and Test Results



BH 12 (wooden box is 5 feet long)



BH 13 (wooden box is 5 feet long)



BH 14 (wooden box is 5 feet long)



BH 15 (wooden box is 5 feet long)



BH 16 (wooden box is 5 feet long)



BH 18 (wooden box is 5 feet long)



BH 11 (wooden box is 26 inches long)



BH 17 (wooden box is 26 inches long)

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

| | | | |
|-----------------|--------------|-----------------|-----------|
| PROJECT NUMBER | 13-1183-0082 | SAMPLE NUMBER | - |
| BOREHOLE NUMBER | 11 | SAMPLE DEPTH, m | 11.1-11.4 |

TEST CONDITIONS

| | | | |
|-----------------------|--------|------------------|-----------|
| MACHINE SPEED, mm/min | - | TYPE OF SPECIMEN | Rock Core |
| DURATION OF TEST, min | >2 <15 | L/D | 2.25 |

SPECIMEN INFORMATION

| | | | |
|--------------------------------|--------|---------------------------------|-------|
| SAMPLE HEIGHT, cm | 10.65 | WATER CONTENT, (specimen) % | 0.08 |
| SAMPLE DIAMETER, cm | 4.73 | UNIT WEIGHT, kN/m ³ | 26.08 |
| SAMPLE AREA, cm ² | 17.60 | DRY UNIT WT., kN/m ³ | 26.06 |
| SAMPLE VOLUME, cm ³ | 187.40 | SPECIFIC GRAVITY | - |
| WET WEIGHT, g | 498.52 | VOID RATIO | - |
| DRY WEIGHT, g | 498.12 | | |

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

| | | | |
|----------------------|---|-------------------------|-------|
| STRAIN AT FAILURE, % | - | COMPRESSIVE STRESS, MPa | 101.1 |
|----------------------|---|-------------------------|-------|

REMARKS:

DATE:

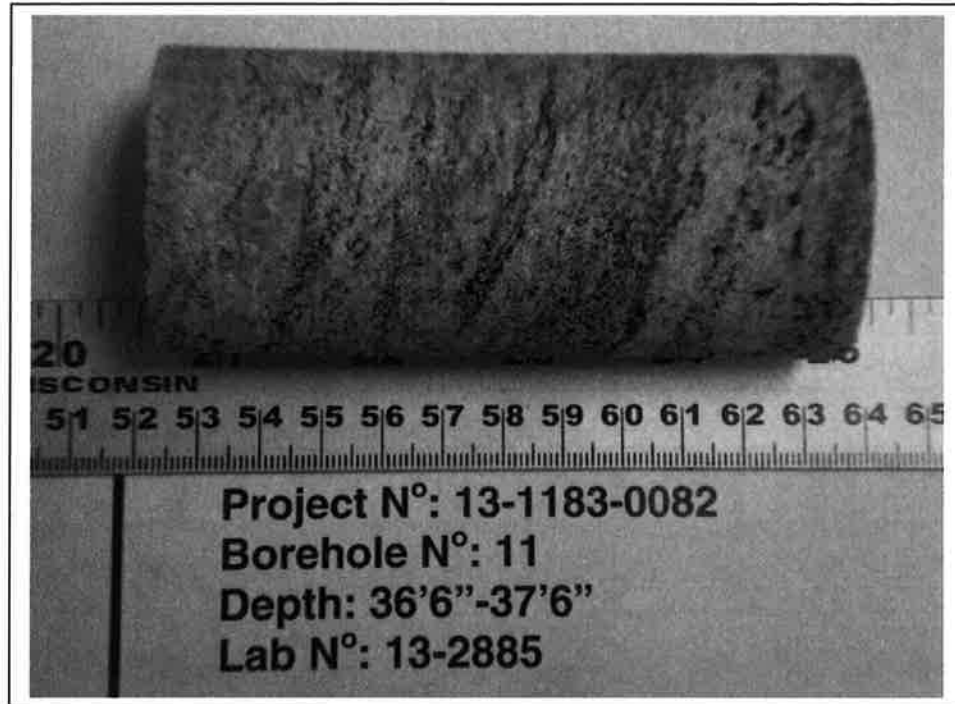
7/24/2013

Checked By: *RO*

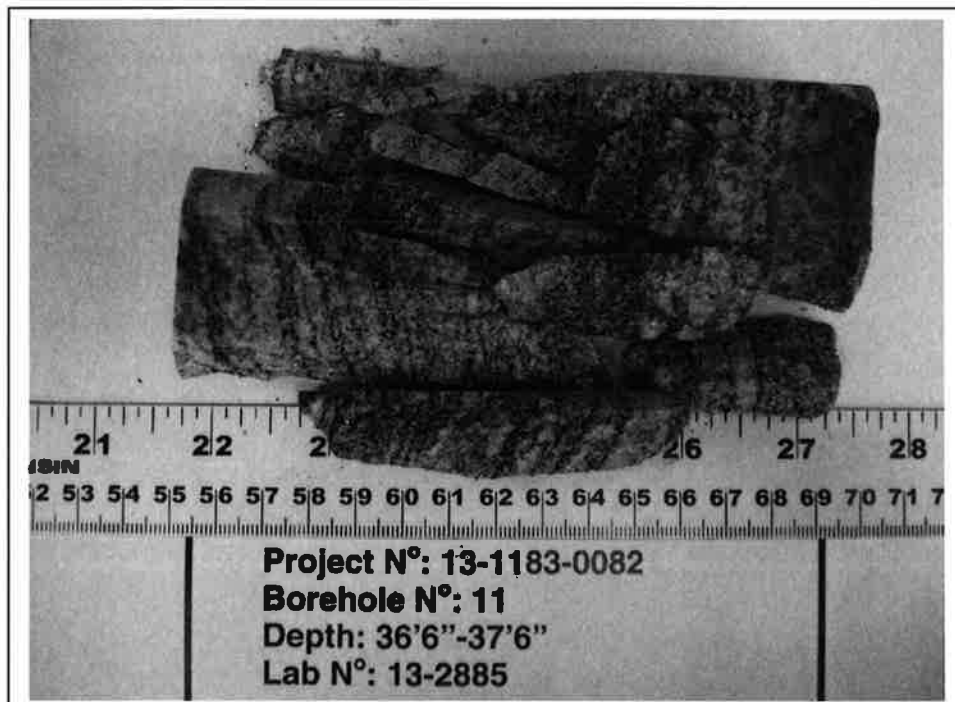
Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. *fo*

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

| | | | |
|-----------------|--------------|-----------------|---------|
| PROJECT NUMBER | 13-1183-0082 | SAMPLE NUMBER | - |
| BOREHOLE NUMBER | 13 | SAMPLE DEPTH, m | 0.9-1.2 |

TEST CONDITIONS

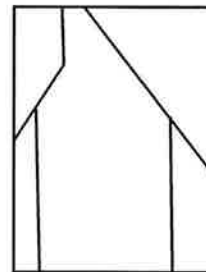
| | | | |
|-----------------------|--------|------------------|-----------|
| MACHINE SPEED, mm/min | - | TYPE OF SPECIMEN | Rock Core |
| DURATION OF TEST,min | >2 <15 | L/D | 2.23 |

SPECIMEN INFORMATION

| | | | |
|--------------------------------|--------|---------------------------------|-------|
| SAMPLE HEIGHT, cm | 10.67 | WATER CONTENT, (specimen) % | 0.08 |
| SAMPLE DIAMETER, cm | 4.78 | UNIT WEIGHT, kN/m ³ | 26.88 |
| SAMPLE AREA, cm ² | 17.92 | DRY UNIT WT., kN/m ³ | 26.86 |
| SAMPLE VOLUME, cm ³ | 191.12 | SPECIFIC GRAVITY | - |
| WET WEIGHT, g | 524.11 | VOID RATIO | - |
| DRY WEIGHT, g | 523.69 | | |

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

| | | | |
|----------------------|---|-------------------------|------|
| STRAIN AT FAILURE, % | - | COMPRESSIVE STRESS, MPa | 49.7 |
|----------------------|---|-------------------------|------|

REMARKS:

DATE:

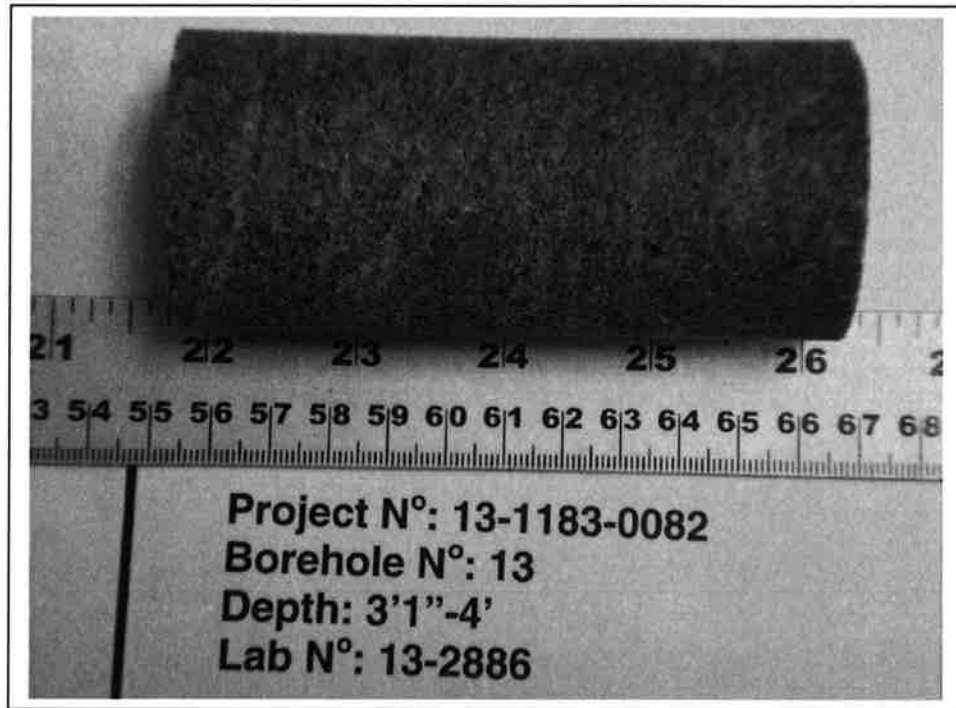
7/24/2013

Checked By: *PO*

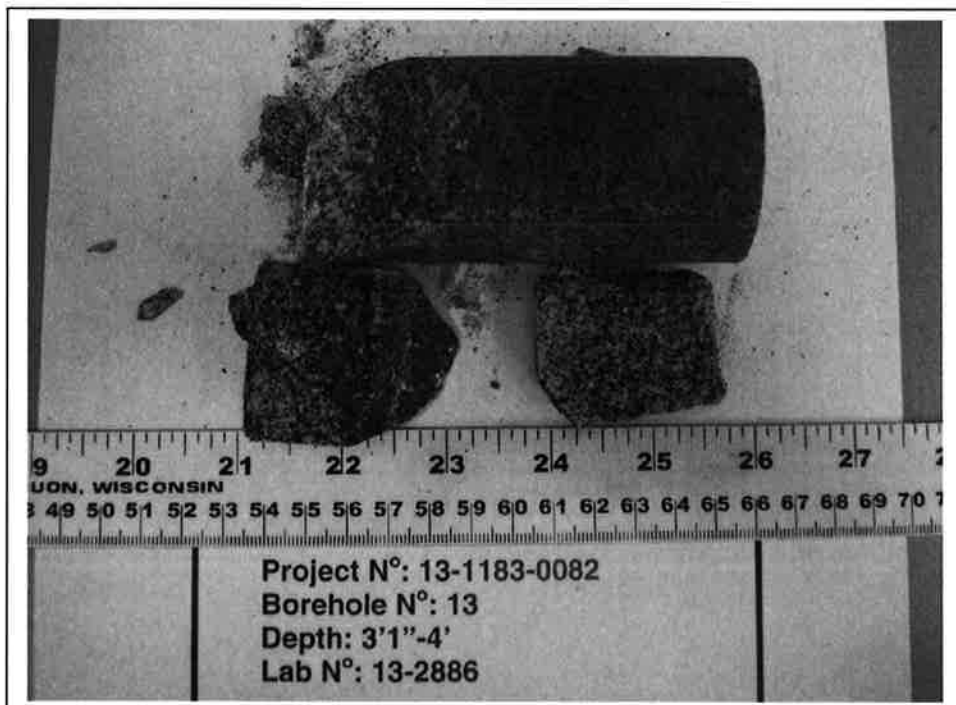
Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. Ro

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

| | | | |
|-----------------|--------------|-----------------|---------|
| PROJECT NUMBER | 13-1183-0082 | SAMPLE NUMBER | - |
| BOREHOLE NUMBER | 15 | SAMPLE DEPTH, m | 2.8-3.4 |

TEST CONDITIONS

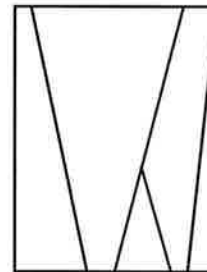
| | | | |
|-----------------------|--------|------------------|-----------|
| MACHINE SPEED, mm/min | - | TYPE OF SPECIMEN | Rock Core |
| DURATION OF TEST,min | >2 <15 | L/D | 2.24 |

SPECIMEN INFORMATION

| | | | |
|--------------------------------|--------|---------------------------------|-------|
| SAMPLE HEIGHT, cm | 7.89 | WATER CONTENT, (specimen) % | 4.36 |
| SAMPLE DIAMETER, cm | 3.52 | UNIT WEIGHT, kN/m ³ | 26.40 |
| SAMPLE AREA, cm ² | 9.70 | DRY UNIT WT., kN/m ³ | 25.30 |
| SAMPLE VOLUME, cm ³ | 76.51 | SPECIFIC GRAVITY | - |
| WET WEIGHT, g | 206.06 | VOID RATIO | - |
| DRY WEIGHT, g | 197.45 | | |

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

| | | | |
|----------------------|---|-------------------------|------|
| STRAIN AT FAILURE, % | - | COMPRESSIVE STRESS, MPa | 64.2 |
|----------------------|---|-------------------------|------|

REMARKS:

DATE:

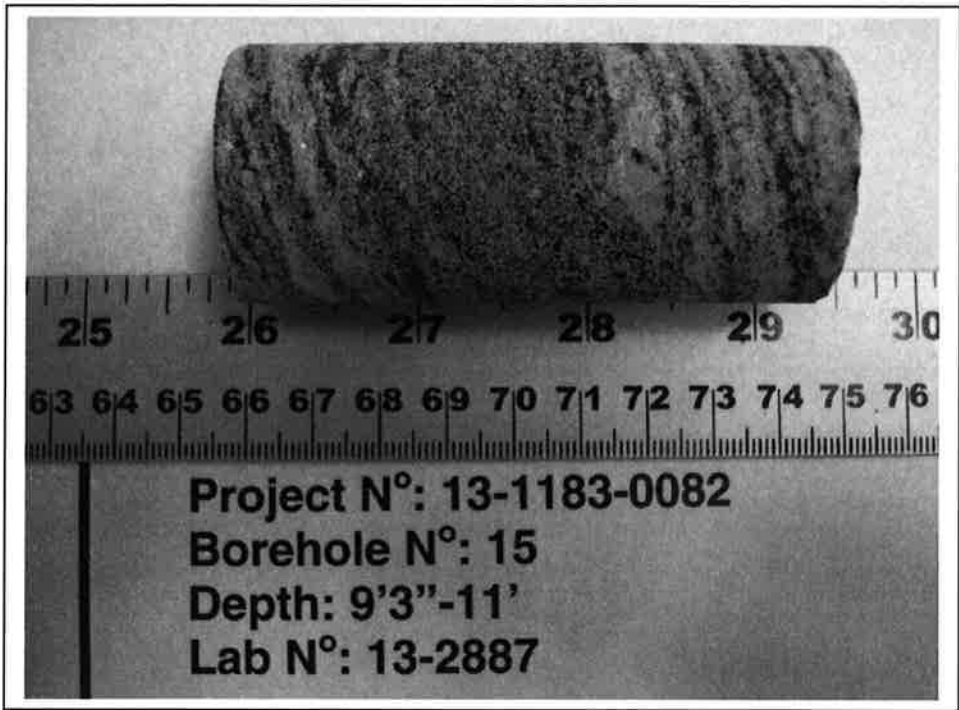
7/24/2013

Checked By: *Ro*

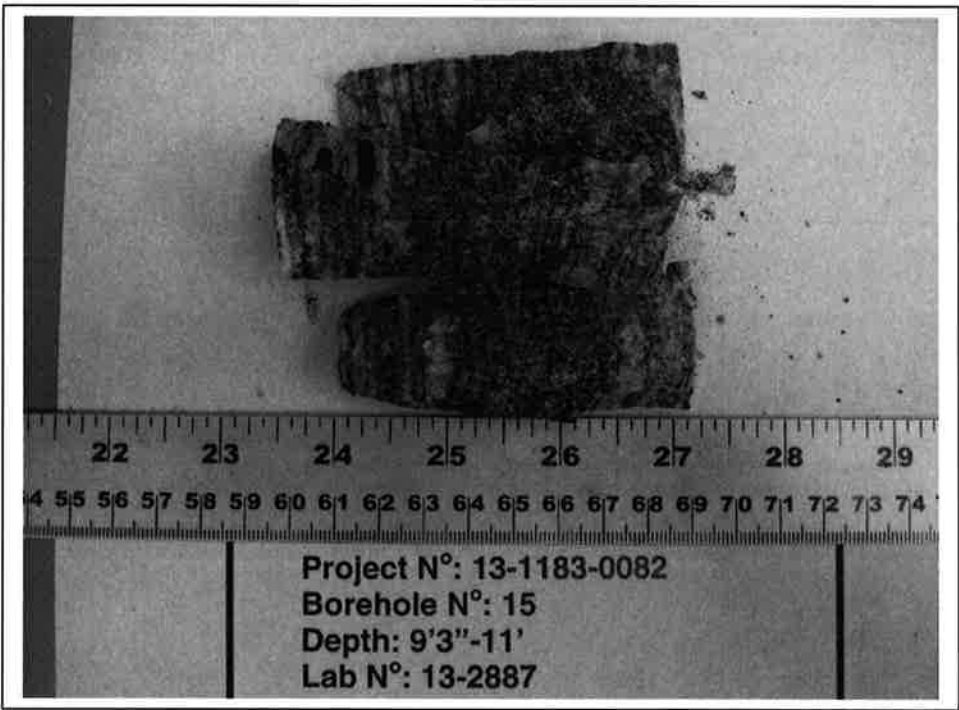
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UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. po

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

| | | | |
|-----------------|--------------|-----------------|---------|
| PROJECT NUMBER | 13-1183-0082 | SAMPLE NUMBER | - |
| BOREHOLE NUMBER | 18 | SAMPLE DEPTH, m | 8.1-8.4 |

TEST CONDITIONS

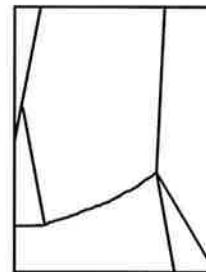
| | | | |
|-----------------------|--------|------------------|-----------|
| MACHINE SPEED, mm/min | - | TYPE OF SPECIMEN | Rock Core |
| DURATION OF TEST,min | >2 <15 | L/D | 2.21 |

SPECIMEN INFORMATION

| | | | |
|--------------------------------|--------|---------------------------------|-------|
| SAMPLE HEIGHT, cm | 10.49 | WATER CONTENT, (specimen) % | 0.05 |
| SAMPLE DIAMETER, cm | 4.75 | UNIT WEIGHT, kN/m ³ | 25.70 |
| SAMPLE AREA, cm ² | 17.71 | DRY UNIT WT., kN/m ³ | 25.69 |
| SAMPLE VOLUME, cm ³ | 185.80 | SPECIFIC GRAVITY | - |
| WET WEIGHT, g | 487.14 | VOID RATIO | - |
| DRY WEIGHT, g | 486.90 | | |

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

| | | | |
|----------------------|---|-------------------------|-------|
| STRAIN AT FAILURE, % | - | COMPRESSIVE STRESS, MPa | 109.3 |
|----------------------|---|-------------------------|-------|

REMARKS:

DATE:

7/24/2013

Checked By: *Jo*

Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. Ro

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

| | | | |
|-----------------|--------------|-----------------|---------|
| PROJECT NUMBER | 13-1183-0082 | SAMPLE NUMBER | - |
| BOREHOLE NUMBER | 18 | SAMPLE DEPTH, m | 9.4-9.8 |

TEST CONDITIONS

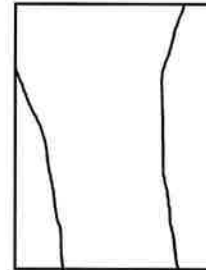
| | | | |
|-----------------------|--------|------------------|-----------|
| MACHINE SPEED, mm/min | - | TYPE OF SPECIMEN | Rock Core |
| DURATION OF TEST, min | >2 <15 | L/D | 2.12 |

SPECIMEN INFORMATION

| | | | |
|--------------------------------|--------|---------------------------------|-------|
| SAMPLE HEIGHT, cm | 10.06 | WATER CONTENT, (specimen) % | 0.07 |
| SAMPLE DIAMETER, cm | 4.75 | UNIT WEIGHT, kN/m ³ | 26.99 |
| SAMPLE AREA, cm ² | 17.71 | DRY UNIT WT., kN/m ³ | 26.97 |
| SAMPLE VOLUME, cm ³ | 178.21 | SPECIFIC GRAVITY | - |
| WET WEIGHT, g | 490.66 | VOID RATIO | - |
| DRY WEIGHT, g | 490.32 | | |

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

| | | | |
|----------------------|---|-------------------------|------|
| STRAIN AT FAILURE, % | - | COMPRESSIVE STRESS, MPa | 65.3 |
|----------------------|---|-------------------------|------|

REMARKS:

DATE:

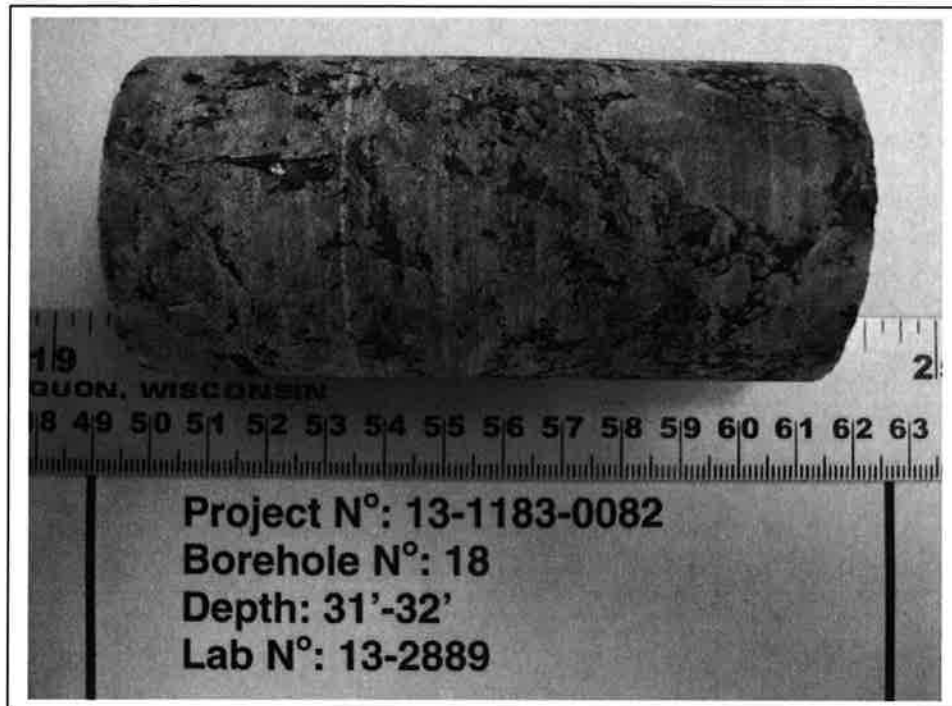
7/24/2013

Checked By: *lo*

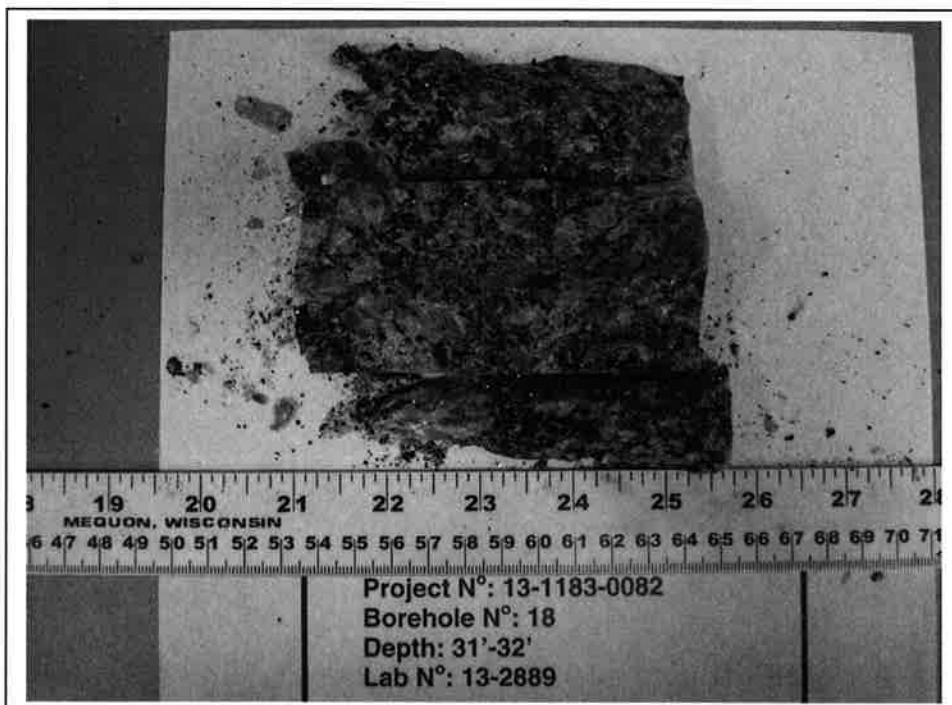
Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd Ro

| Borehole No. | Run No. | Depth (ft) | Depth (m) | Test Type | Length (mm) | Core Diameter (mm) | Force (kN) | Rock Type | Is (MPa) | Is(50) (MPa) | Equivalent UCS (MPa) |
|--------------|---------|------------|-----------|-----------|-------------|--------------------|------------|-----------|----------|--------------|----------------------|
| BH11 | 1 | 37.8 | 11.5 A | | 41.0 | 48.0 | 20.8 | GNEISS | 8.3 | 8.3 | 199.0 |
| | 1 | 38.3 | 11.7 D | | | 48.0 | 18.2 | GNEISS | 7.8 | 7.8 | 186.4 |
| | 2 | 42.5 | 13.0 A | | 41.0 | 48.0 | 21.5 | GNEISS | 8.6 | 8.6 | 206.3 |
| | 2 | 42.7 | 13.0 D | | | 48.0 | 14.9 | GNEISS | 6.3 | 6.3 | 152.2 |
| BH13 | 2 | 3.5 | 1.1 A | | 44.0 | 48.0 | 19.2 | GNEISS | 7.1 | 7.2 | 173.8 |
| | 2 | 4.0 | 1.2 D | | | 48.0 | 10.8 | GNEISS | 4.6 | 4.6 | 110.8 |
| | 3 | 8.5 | 2.6 A | | 50.0 | 48.0 | 22.9 | GNEISS | 7.5 | 7.8 | 188.3 |
| | 3 | 8.7 | 2.6 D | | | 48.0 | 17.6 | GNEISS | 7.5 | 7.5 | 179.8 |
| BH15 | 2 | 9.3 | 2.8 A | | 33.0 | 37.0 | 13.8 | GNEISS | 8.9 | 8.0 | 191.2 |
| | 2 | 9.5 | 2.9 D | | | 37.0 | 6.5 | GNEISS | 4.2 | 4.2 | 99.9 |
| | 3 | 14.7 | 4.5 A | | 26.0 | 37.0 | 10.7 | GNEISS | 8.7 | 7.4 | 178.5 |
| | 3 | 10.8 | 3.3 D | | | 37.0 | 4.9 | GNEISS | 3.1 | 3.1 | 75.4 |
| | 4 | 19.8 | 6.0 A | | 26.0 | 37.0 | 7.7 | GNEISS | 6.3 | 5.4 | 129.0 |
| | 4 | 20.0 | 6.1 D | | 26.0 | 37.0 | 11.3 | GNEISS | 7.2 | 7.2 | 173.1 |
| BH18 | 1 | 27.8 | 8.5 A | | 40.0 | 48.0 | 16.4 | GNEISS | 6.7 | 6.7 | 160.0 |
| | 1 | 27.9 | 8.5 D | | | 48.0 | 17.8 | GNEISS | 7.6 | 7.6 | 181.6 |
| | 2 | 34.0 | 10.4 D | | | 48.0 | 18.6 | GNEISS | 7.9 | 7.9 | 190.2 |
| | 2 | 34.5 | 10.5 A | | 48.0 | 48.0 | 22.9 | GNEISS | 7.8 | 8.1 | 194.1 |
| | 3 | 38.9 | 11.9 A | | 31.0 | 48.0 | 12.3 | GNEISS | 6.5 | 6.1 | 146.5 |
| | 3 | 39.2 | 11.9 D | | | 48.0 | 5.6 | GNEISS | 2.4 | 2.4 | 57.7 |

Appendix E

Explanation of Terms Used in the Report

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 63.5 kg, 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 N.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J 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 (RQD), FOR MODIFIED RECOVERY IS:

| RQD (%) | 0 – 25 | 25 – 50 | 50 – 75 | 75 – 90 | 90 – 100 |
|---------|-----------|---------|---------|---------|-----------|
| | VERY POOR | POOR | FAIR | GOOD | EXCELLENT |

JOINT 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

| | | | |
|----|---------------------|----|---------------------------|
| SS | SPLIT SPOON | TP | THINWALL PISTON |
| WS | WASH SAMPLE | OS | OSTERBERG SAMPLE |
| ST | SLOTTED TUBE SAMPLE | RC | ROCK CORE |
| BS | BLOCK SAMPLE | PH | TW ADVANCED HYDRAULICALLY |
| CS | CHUNK SAMPLE | PM | TW ADVANCED MANUALLY |
| TW | THINWALL OPEN | FS | FOIL SAMPLE |

STRESS AND STRAIN

| | | |
|--------------------------------------|-----|-------------------------------|
| u_w | kPa | PORE WATER PRESSURE |
| r_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 = c_u / τ_r |

PHYSICAL PROPERTIES OF SOIL

| | | | | | | | | |
|----------------|------------------------|--------------------------------|-----------|------|--|-----------|------------------------|---|
| ρ_s | kg/m^3 | DENSITY OF SOLID PARTICLES | e | 1, % | VOID RATIO | e_{min} | 1, % | VOID RATIO IN DENSEST STATE |
| γ_s | kN/m^3 | UNIT WEIGHT OF SOLID PARTICLES | n | 1, % | POROSITY | I_D | 1 | DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$ |
| ρ_w | kg/m^3 | DENSITY OF WATER | w | 1, % | WATER CONTENT | D | mm | GRAIN DIAMETER |
| γ_w | kN/m^3 | UNIT WEIGHT OF WATER | S_r | % | DEGREE OF SATURATION | D_n | mm | N PERCENT – DIAMETER |
| ρ | kg/m^3 | DENSITY OF SOIL | W_L | % | LIQUID LIMIT | C_u | 1 | UNIFORMITY COEFFICIENT |
| γ | kN/m^3 | UNIT WEIGHT OF SOIL | W_p | % | PLASTIC LIMIT | h | m | HYDRAULIC HEAD OR POTENTIAL |
| ρ_d | kg/m^3 | DENSITY OF DRY SOIL | W_s | % | SHRINKAGE LIMIT | q | m^3/s | RATE OF DISCHARGE |
| γ_d | kN/m^3 | UNIT WEIGHT OF DRY SOIL | I_p | % | PLASTICITY INDEX = $(W_L - W_p) / I_p$ | v | m/s | DISCHARGE VELOCITY |
| ρ_{sat} | kg/m^3 | DENSITY OF SATURATED SOIL | I_L | 1 | LIQUIDITY INDEX = $(W - W_p) / I_p$ | i | 1 | HYDAULIC GRADIENT |
| γ_{sat} | kN/m^3 | UNIT WEIGHT OF SATURATED SOIL | I_C | 1 | CONSISTENCY INDEX = $(W_L - W) / I_p$ | k | m/s | HYDRAULIC CONDUCTIVITY |
| ρ' | kg/m^3 | DENSITY OF SUBMERGED SOIL | e_{max} | 1, % | VOID RATIO IN LOOSEST STATE | j | kN/m^2 | SEEPAGE FORCE |
| γ' | kN/m^3 | UNIT WEIGHT OF SUBMERGED SOIL | | | | | | |