



THURBER ENGINEERING LTD.

**FOUNDATION DESKTOP STUDY REPORT
PRELIMINARY DESIGN AND ENVIRONMENTAL ASSESSMENT
GRINDSTONE CREEK CULVERT REHABILITATION
HIGHWAY 403 AND HIGHWAY 6 INTERCHANGE
HAMILTON, ONTARIO
SITE 10-193/C
WO#16-20004**

GEOCRES NO. 30M5-345

**Latitude: 43.306917°
Longitude: -79.866695°**

Report

to

AECOM

Date: November 9, 2022
File: 25963



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PART 1: FACTUAL INFORMATION

1.0 INTRODUCTION

This report presents the results of a foundation desktop study carried out by Thurber Engineering Ltd. (Thurber) for the preliminary design and environmental assessment of the culvert rehabilitation at the crossing of Grindstone Creek under Highway 403 located in Hamilton, Ontario.

This Phase 1 study is carried out for planning, structure evaluation and preliminary design purposes only. As part of the Phase 1 scope, a desktop study is to be carried out based on currently available subsurface and foundation information. Where this study determines that the existing foundation information is insufficient to complete the preliminary design, additional foundation investigation and assessment will be recommended for completing Phase 1. It is understood that the budget for this additional investigation is to be drawn from the Phase 2 contingency upon approval by MTO.

Thurber was retained by AECOM to carry out this Phase 1 study under the Ministry of Transportation Ontario (MTO) Assignment Number 2016-E-0027.

This site is a part of the overall Highway 403 and Highway 6 Interchange project where up to 14 bridges, 3 structural culverts and 15 retaining walls are planned to be replaced, reconstructed or rehabilitated.

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

Client: AECOM

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The following references and drawings are available for the general vicinity of this site.

- Foundation Investigation Report, Highway Bridge West of Aldershot crossing at Hidden Valley, Report No. S-500-505/55/T-93-1, Geocres No. 30M05-064 prepared by Racey, MacCallum and Associates Limited, dated July 19, 1955. (Reference 1).
- Fill Failure Memorandum, Highway 403 and Hidden Valley Road, Station 231+50 to Station 232+00, District No. 4 (Hamilton), W.J. 68-F-51, W.P. 16-56-1, Geocres No. 30M05-067, dated July 8, 1968. (Reference 2).
- Archive drawings (Hidden Valley Road Bridge FW-14, Roadway Arch - Foundation Plan, Roadway Arch - Cross Section, and Grindstone Creek Bridge FW-13 – Site Plan, Department of Highways Ontario, Bridge Office, Toronto – East of Flamborough Township at Aldershot, TWP# 1337-192-1-A, 2-A & 3-A, dated April and June 1956 (Reference 3).

2.0 SITE AND PROJECT DESCRIPTION

The existing culvert is located at the crossing of Grindstone Creek and Highway 403, approximately 2.5 km east of the Highway 6 and Highway 403 interchange, in the City of Hamilton, Ontario. The existing arch culvert carries Grindstone Creek under Highway 403.

Highway 403 in the vicinity of the site generally runs in an east to west orientation along relatively flat terrain. CN rail tracks run parallel to Highway 403 at approximately 75 m to the south. Hidden Valley Road is located approximately 50 m west of Grindstone Creek. The lands surrounding the site are generally residential and commercial. Grindstone Creek flows in a southerly direction. The width of the creek varies from approximately 8 m on the north side of the culvert (inlet) to about 5 m at the south end (outlet) of the culvert.

According to the archive drawings, the existing structure is a concrete arch culvert of approximately 112.2 m in length and 12.5 m in width. The culvert is oriented at an approximate 18° skew to the centreline of Highway 403. The maximum height of the opening inside the arch is approximately 6 m. Based on a preliminary general arrangement (GA) drawing dated May 2021, the Highway 403 platform grade at the culvert decreases north to south from approximate Elevations 108.0 to 106.8. The highway embankment is up to the order of 14 m to 15 m in height and has no mid-height bench at this location.

No record is available on the year of construction of the arch structure, or if there was any previous rehabilitation completed at this site.



Select photographs of the site are included in Appendix C.

Preliminary General Arrangement (GA) drawings provided by AECOM indicate that two culvert configuration alternatives are currently being considered as part of the preliminary design for the culvert rehabilitation. One additional travel lane is proposed for each of the Highway 403 EBL and WBL directions. The two rehabilitation alternatives are as follows:

- Alternative 1 – The proposed rehabilitation program shown in GA drawing dated May 2021, provided by AECOM to Thurber in October 2021, involves the following:
 - Construction of four new retaining walls, one at each corner of the existing arch culvert (at the inlet and outlet). Each wall will be approximately 3.5 m long. The new retaining walls will be perpendicular to the culvert centreline/alignment.
- Alternative 2 – This proposed rehabilitation program indicated in GA drawing dated December 2021, provided by AECOM to Thurber in March 2022 indicates the following:
 - Combine the rehabilitation programs for both existing adjacent culverts (Hidden Valley Culvert and Grindstone Creek Culvert) at this location, by installing Retained Soil Systems (RSS) above both culverts. The retaining walls will be installed at the crest of the Highway 403 embankment, one near each end (north and south) of the culverts. Both RSS walls will be up to about 2.5 m in height. The RSS walls will eliminate the need for retaining walls proposed at the corners of the culvert considered in Alternative 1.

Alternative 2 has been proposed to reduce environmental impacts and eliminate in-water operation at the Grindstone Creek Culvert. Instead of adding retaining walls at the four corners of the culvert, the RSS walls will be required to accommodate the proposed highway widening.

The project area is situated within the physiographic region known as the Niagara Escarpment, which forms a north-south trending strip, and is a major topographic break in the bedrock between the carbonate Amabel Formation to the west and the soft sediments of the Queenston Formation to the northeast. At many locations, the Queenston Formation consists of up to 1.2 m of very weathered bedrock (red clay) which grades downward into typical brick-red shale and often with green mottling. Thin to medium hard/strong beds of grey-green, and reddish argillaceous limestone are present at most sections. The Queenston shale is overlain by Halton Till in the area of the site. The Halton Till is a red clay to clayey silt till and is exposed in the form of a till plain extending from Lake Ontario southward to the Niagara escarpment.



3.0 SITE OBSERVATIONS

A site reconnaissance visit was conducted by a Thurber Senior Geotechnical Engineer in July 2021 to observe conditions related to the foundation performance of the existing arch structure and approaches. The following observations for the Grindstone Creek culvert have been noted during our site visit.

- There was no visible sign of settlement or distress at the culvert inlet and outlet.
- The existing approach embankments are covered with heavy vegetation, bushes and trees and appeared to be in stable condition. The embankment slopes adjacent to the culvert did not exhibit obvious signs of instability or bulging.
- Multiple spots of minor water seepage were noted on the interior face of the arch.
- Creek water was flowing relatively fast during the site visit.
- Debris and gravel built-up were noted inside the culvert, generally on the west side.
- Rip-rap was observed at the northeast corner of the culvert.
- Highly weathered red shale bedrock with green beddings was exposed on the east face of the north embankment, approximately 10 m from the culvert inlet.
- Erosion was observed on the nearly vertical face on the east side of the north approach. Several roots from the trees located at the top of the embankment are completely exposed.

Selected photographs of the site taken during the site visits are presented in Appendix C.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

A foundation investigation was conducted at the site in 1955 (Reference 1) for Hidden Valley Road Culvert and Grindstone Creek Culvert. These sites are located approximately 45 m to 50 m apart. Six boreholes (numbered 1 to 6) were drilled in proximity to the original culvert alignments. The actual locations of these boreholes in relation to the existing culvert cannot be confirmed since a co-ordinate system was not used at the time, and there was no available record of the as-drilled locations of the boreholes and as-built location of the culvert. It is noted that the proposed works for the Hidden Valley Road Culvert are addressed under separate cover.

In general, Boreholes 1 to 6 of the 1955 investigation (Reference 1) were advanced through soils using a 75 mm (3 in.) diameter “extra-heavy duty” pipe driven by a 300 lb. drop hammer to



refusal on shale bedrock, and further advanced by rock coring using an AXT diamond bit. Record of Borehole Sheets from the previous investigation are presented in Appendix A.

In general, the subsurface stratigraphy encountered in the boreholes, prior to culvert and Highway 403 embankment construction, consists of typically stiff to very stiff, red to occasionally grey-green silty clay. The thickness of the silty clay varied from 0.76 m to 1.3 m. An N-value of 75 blows was recorded in Borehole 1 using a “standard” 50 mm (2 in.) split spoon sampler. The silty clay is underlain by shale bedrock of the Queenston Formation.

Results of the 1968 investigation (Reference 2), after construction of the nearby Hidden Valley culvert, indicated that the embankment material consisted of compact to very dense silty sand to sandy silt overlying weathered to sound red shale. Occasional seams of shale or silty clay, up to 300 mm in thickness were encountered within the fill material.

The bedrock encountered below the native silty clay and/or embankment fill, was described as red, slightly calcareous clay shale with green interbeds and horizontal beddings. The rock was also described as soft with fissility along the bedding planes. Typically, the upper 1 m to 2 m of the Queenston shale is completely to highly weathered. Below that depth, the degree of weathering of the shale varies from moderate to fresh. For the purpose of reporting herein, this upper zone will be referred to as weathered shale and the underlying sound portion will be considered as shale bedrock.

The depths and elevations where shale bedrock was proven are presented in Table 4.1.

Table 4.1 – Depth and Elevation of Top of Bedrock

Approximate location relative to existing culvert ⁽¹⁾	Borehole	Bedrock Depth ⁽²⁾ (m)	Bedrock Elevation ⁽³⁾ (m)	Comments
North side	2 ⁽⁴⁾	0.8	94.7	Shale bedrock proven by coring
	6 ⁽⁵⁾	0.8	93.6	Shale bedrock proven by coring
Middle	1 ⁽⁴⁾	1.3	93.8	Shale bedrock proven by coring
	5 ⁽⁵⁾	0.8	93.4	Shale bedrock proven by coring
South side	3 ⁽⁴⁾	0.8	93.4	Shale bedrock proven by coring
	4 ⁽⁵⁾	0.8	92.9	Shale bedrock proven by coring

⁽¹⁾ The actual locations of these boreholes cannot be confirmed due to incomplete information.

⁽²⁾ All depths were converted from Imperial Units and relative to the ground surface prior to construction of the existing culvert.

⁽³⁾ It is unknown how the elevations are related to the Canadian Geodetic Datum currently in use.

⁽⁴⁾ Boreholes 1, 2 and 3 were drilled along Hidden Valley Road culvert alignment

⁽⁵⁾ Boreholes 4, 5 and 6 were drilled along Grindstone Creek culvert alignment

Rock core recovery values ranged from 42 percent to 100 percent, except for Run 2 in Borehole 1 where the recovery was considered poor at 20 percent.

Groundwater levels measured in the boreholes in Reference 1 are presented in Table 4.2.

Table 4.2 – Groundwater Level Measurements

Approximate location relative to existing culvert ⁽¹⁾	Borehole	Water Level Depth ⁽²⁾ (m)	Water Level Elevation ⁽³⁾ (m)
North side	2 ⁽⁴⁾	1.3	94.2
Middle section	1 ⁽⁴⁾	1.1	94.0
South side	3 ⁽⁴⁾	0.9	93.3
	4 ⁽⁵⁾	1.0	92.7

Note: Refer to the notes under Table 4.1 above.

The preliminary GA drawing dated May 2021 indicated that the high water level (HWL 50 years) at Grindstone Creek is at Elevation 94.5.



5.0 EXISTING FOUNDATION

Based on archive design drawings (Reference 3) and foundation recommendations (Reference 1), the existing Grindstone Creek structure consists of a concrete arch culvert supported on spread footings founded on shale bedrock. Based on previous boreholes (Boreholes 4 to 6) drilled in proximity to the Grindstone Creek culvert alignment, the bedrock was present at 0.8 m depth below original ground surface.

GEOCREST information (Reference 1) indicates that the design of the spread footings was carried out in accordance with the 1953 Edition of the National Building Code of Canada, which at the time, showed an allowable bearing value of 950 kPa (10 tsf) for hard shale and a bearing value of 480 KPa (5 tsf) for soft shale or hard glacial till. The rock properties were considered to lie between hard and soft shale. A maximum allowable “soil” pressure of 715 kPa (7.5 tsf) was recommended for the spread footings at this site. This value is also presented on archive drawings dated 1956 (Reference 3).

A soil profile from Reference 3 shows that the founding base of the footings was at approximate Elevation 91.4 within the shale bedrock. However, there is no available construction records or archive drawings to indicate information of the footings such as length, width and height.

The borehole location plan in Appendix A shows that the embankment slopes were designed for an inclination of 2H : 1V. The inlet and outlet zones were to be protected by a layer of rip-rap. The rip-rap was observed at the culvert inlet (north side) during our site reconnaissance visit. However, the presence of rip-rap was not visually confirmed at the culvert outlet (south side) due to heavy vegetation.

6.0 ASSESSMENT OF EXISTING FOUNDATIONS

The archive boreholes from Reference 1 were advanced at locations and elevations that cannot be confirmed. Given the uncertainties regarding the archive boreholes and lack of information on the shale, it is recommended that new boreholes be advanced for each alternative at selected locations presented in Section 13, in order to obtain adequate information for preliminary design of the proposed retaining walls and confirmation of the existing culvert foundation to accommodate the structural rehabilitation.

A foundation assessment of the existing culvert, based on current information, has been carried out to provide preliminary information to the designers regarding the feasibility of the foundation aspects of the proposed works.



For both rehabilitation alternatives, the designer should establish the additional loading, if any, on the culvert footings. Should the additional foundation loading be less than 10 percent of the existing loading and in accordance with current MTO practice, it is not anticipated that the proposed rehabilitation works for the culvert would have an impact on the existing culvert foundations, provided that the footings are structurally sound.

6.1 Alternative 1 - Retaining Walls at Corners of the Existing Culvert

There is insufficient subsurface information for assessing the strength and deformation characteristics of the shale bedrock. There is very limited to no data on unconfined compressive strength, rock quality and fracture index on which the geotechnical resistance may be based. For the purpose of this assessment, the Hoek and Brown rock characterization criteria and typical range of unconfined compressive strengths for Queenston shale have been used. Reference has also been made to geotechnical resistances found in published information and past projects in the general area of the site.

For spread footings founded on undisturbed, weathered, fair quality Queenston shale bedrock, it is assessed that the factored geotechnical resistance would be in the order of 1,000 kPa at Ultimate Limit States (ULS). For sound, slightly weathered to fresh intact shale, it is assessed that the factored geotechnical resistance at ULS could be up to the order of 1,500 kPa or higher depending on fracture patterns and rock strength etc. These values apply to vertical and concentric loads. The SLS condition does not apply to footings founded on unyielding bedrock.

According to the archive drawing, the existing culvert footings were founded on undisturbed solid Queenston shale (below the weathered zone) and designed as per the recommendations in Reference 1 outlined above. The recommended design bearing capacity of 715 kPa from Reference 1 is lower than the assessed values above.

At the time of preparation of this desktop study, the type of retaining walls proposed at each corner is unknown. However, it is anticipated that for any selected option (concrete cantilever, etc.), the new walls will be founded on shale bedrock.

Given that there is no borehole information close to the new wingwall alignments, new boreholes are proposed in Section 13 for preliminary foundation design. It is anticipated that the factored geotechnical resistance at Ultimate Limit States (ULS) available for design would not be less than the 715 kPa reported to have been used in the design of the existing culvert.



6.2 Alternative 2 - Retained Soil Systems (RSS) Walls

RSS walls are proposed above the culvert and to be founded on the existing embankment fill, at approximate Elevations 104.5 and 104.0 at the north and south sides of the embankment, respectively. Reference 2 (1968) indicates that the embankment fill on the north embankment consists of compact to very dense silty sand to sandy silt overlying weathered to sound shale. There is no available information on the south embankment.

There is insufficient information on the existing embankment fill and the underlying soil/shale to provide foundation recommendations and geotechnical resistances for RSS walls founded on the existing fill. A borehole program is presented in Section 13 to obtain information for preliminary design of the proposed RSS walls.

RSS walls will require excavations upslope for reinforcing strip installation (up to the order of 0.7 to 1.0 times the wall height) and backfill placement. Temporary protection (shoring) will be required to facilitate construction of this type of wall.

During Phase 2, global stability of the overall embankment slope with an RSS wall and settlement analysis due to additional fill loading should be carried out. The designers should assess the implication and effect of additional loading on the existing culvert.

7.0 EMBANKMENT DESIGN AND CONSTRUCTION

Reference 1 recommended that the design of the approach and side slopes be at inclination of 2H : 1V. The existing Highway 403 embankments are up to the order of 15 m in height in the vicinities of the culvert inlet and outlet. According to the available preliminary GA drawings, these embankment slopes are at an inclination of 2H : 1V. Our site observations indicate that the existing approach fills are in stable condition.

Preliminary GA drawings for both alternatives indicate the proposed addition of one travel lane on each of the EBL and WBL. The preliminary GA drawing for Alternative 1 does not appear to illustrate any change to the embankment configuration. It is anticipated that some regrading within the lower portion of the highway embankment slopes will be required to accommodate the new wingwalls and probable decommissioning of the existing walls. Alternative 2 will require embankment widening and grade raise in the order of 0.5 m at the EBL.

The new slopes should be designed to match the existing slope configuration with an inclination of 2H : 1V or flatter. Where applicable, benching of the existing earth slope surface should be carried out as per OPSD 208.010 in order to enhance the keying in of the new fill.



Based on typical MTO practice, earth fill embankments higher than 8 m should be incorporated with mid-height berms at each 8 m vertical interval. The berms should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2 percent positive grade to shed run-off water.

It is noted that the existing highway embankments in the vicinity of Grindstone Creek do not have mid-height benches, despite their heights. The designers should confirm with MTO that this can remain to be the case.

The subgrade for new fill (where required) is expected to be existing fill, native silty clay or weathered shale. No global stability issues are anticipated for the slopes at this site provided the approved new fill is placed and compacted in accordance with OPSS.PROV 206 and OPSS.PROV 501, and provided that all surficial vegetation, organics and topsoil, soft/loosened or wet soils and debris are removed from the proposed embankment areas prior to fill placement.

It is recommended that all exposed slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. Erosion protection measures must be provided for lower portions of the slopes with which potential creek water can be in contact.

Drainage measures at the top of the embankment should be designed to minimize surface runoff and precipitation from flowing perpendicularly down the slope. This occurrence could increase surficial erosion on the embankment face.

For Alternative 1, foundation settlement of the soil subgrade due to the new fill (where required), is expected to take place as the fill is placed and be completed by the end of construction. The magnitude of post construction settlement due to compression of the embankment fill itself depends on the type of materials to be used, but is not anticipated to exceed 10 mm if the new fill is placed and compacted as outlined above.

For Alternative 2, foundation settlement of the soil subgrade due to the new fill and construction of RSS wall will be analyzed and preliminary estimates provided in Phase 2.

8.0 LATERAL EARTH PRESSURES

Earth pressures acting on the culvert walls may be assumed to impose a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2019 but are generally given by the expression:



$$p_h = K (\gamma h + q)$$

where

p_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see table below)

γ = bulk unit weight of retained soil (see table below)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill are dependent on the material used as backfill. Recommended unfactored values are shown in the following Table 8.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for unrestrained walls.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is generally preferred as it results in lower earth pressures acting on the wall.

Table 8.1 - Earth Pressure Coefficients (K)

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		Embankment Fill $\phi = 30^\circ, \gamma = 20.0 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H : 1V)	Horizontal Backfill	Sloping Backfill (2H : 1V)
Active (Unrestrained Wall)	0.27	0.40	0.33	0.48
At-rest (Restrained Wall)	0.43	0.62	0.50	0.72
Passive	3.7	-	3.0	-

9.0 EXCAVATION AND GROUNDWATER CONTROL

All excavations must be carried out in accordance with OPSS.PROV 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope and temporary support requirements in compliance with the OHSA, the embankment fill, native silty clay and weathered shale are classified as Type 3 soils. Sound shale may be considered as Type 1 material.



For Alternative 1, shale excavation will likely be required at the foundation locations to prepare the founding surface of the retaining walls. Shale excavation should be carried out using methods that will avoid disturbing the bedrock below the founding elevation. It is possible that excavation of the bedrock will become more arduous should the stronger limestone and siltstone layers be encountered. The contractor may have to employ specialized methods such as ripping, and pneumatic breaking to dislodge the stronger layers.

For Alternative 2, the anticipated excavations for construction of the new RSS walls will be carried out within the existing embankment fill and will not extend below the groundwater level.

Groundwater levels were measured at 0.9 m and 1.3 m depths (Elevations 92.7 to 94.2) during the investigation conducted prior to the culvert construction. The preliminary GA drawing dated December 2021 indicates that the high water level in Grindstone Creek was at Elevation 94.5 in June 1956. Based on this data, temporary excavation for wall footing construction of Alternative 1 would extend below the water level. Once new borehole information is available in Phase 2, further recommendations and comments on the potential need for dewatering and unwatering will be provided. Wall footing construction should be scheduled during the dryer months to minimize dewatering and unwatering requirements.

For both rehabilitation alternatives, the Contractor should be prepared to pump from properly filtered sumps to remove any seepage water or surface water collecting in an excavation. Unwatering must remain operational and effective until the excavation is backfilled.

The design of any dewatering system that may be required is the responsibility of the Contractor.

Where required, construction will need to be carried out in conjunction with temporary protection.

Dewatering of all excavations should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017).

10.0 EROSION CONTROL

Erosion control should be reinstated after construction at the culvert inlet and outlet areas where applicable, should Alternative 1 be selected. Design of erosion and scour protection measures must consider hydrologic and hydraulic issues and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A



vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

11.0 TEMPORARY PROTECTION SYSTEMS

Temporary protection (shoring) systems will likely be required for construction of the new retaining walls in general accordance with OPSS.PROV 539. It is recommended that Performance Level 2 be specified. The use of temporary protection to retain the embankment slope will be required where any excavation cut into the existing embankment fill.

The selection and design of suitable temporary protection systems are the responsibilities of the Contractor. All shoring systems must be designed by a Professional Engineer experienced in such designs.

12.0 ADJACENT STRUCTURES AND BURIED UTILITIES

It is recommended that the exact locations of any existing utilities and drainage pipes that are present in the vicinity of the work areas be established by the designer and compared with the extent of the potential work zones related to the proposed construction.

The utilities and drainage pipes should not be undermined or damaged during construction of the new retaining walls, and probable demolition of the existing walls. Relocation of, and/or special protective measures for, some or all of these affected utilities may be required.

13.0 INVESTIGATION FOR PRELIMINARY DESIGN

References 1 to 3 are available from the GEOCREST library for this site. As discussed previously, the foundation investigation and reporting were carried out in the late 1950's prior to construction of the existing culvert. The locations and elevations of the boreholes cannot be confirmed. It is also known that the site topography had been altered as part of the original construction. Moreover, the archive boreholes do not provide much information on the shale including unconfined compressive strength, rock quality and fracture pattern to facilitate a more detailed assessment of rock geotechnical resistance that is critical for the retaining wall foundation design for Alternative 1. There is also no information on the embankment fill for Alternative 2. Accordingly, it will be necessary to carry out additional site investigation and field testing to support the preparation of foundation design recommendations for preliminary design of the new retaining walls.



In consideration of the currently available design information, a preliminary investigation for preliminary design is proposed as follows:

- One (1) borehole near the proposed north RSS wall.

The borehole will be drilled from Highway 403 WBL grade and will be advanced to practical refusal on shale bedrock.

Based on archive information, the embankment heights are in the order of 15 m and the bedrock is approximately 2 m to 3 m below floodplain grade. Therefore, it is anticipated that the borehole drilled from Highway 403 will be in the order of 18 m deep.

- A similar borehole will be advanced for the Hidden Valley Culvert. The results of that borehole will also be used for preliminary design assessment.

The locations of the proposed boreholes are schematically shown on plan in Appendix D for illustrative purposes.

14.0 CLOSURE

Engineering analysis and preparation of the preliminary foundation design report were carried out by Ms. R. Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.



Rocío Palomeque Reyna, P.Eng.
Senior Geotechnical Engineer



Sydney Pang, P.Eng.
Senior Associate, Senior Foundation Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

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

2. COMPLETE REPORT

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

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

3. BASIS OF REPORT

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

4. USE OF THE REPORT

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

5. INTERPRETATION OF THE REPORT

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

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

7. INDEPENDENT JUDGEMENTS OF CLIENT

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



Appendix A

Record of Borehole Sheets and Borehole Plan (GEOCRES Previous investigation)

Order No.: 5-500-505/55/T-93 RACEY, MACCALLUM AND ASSOCIATES

LIMITED

M. CHEVRIER
Driller

Hole Begun 10/6/55

Foundation Engineering Division

Hole Ended 10/6/55

Engineering Data Sheet for Borehole: N^o 1

Helper

Job Name: HIDDEN VALLEY BRIDGE

P.E.M.M.

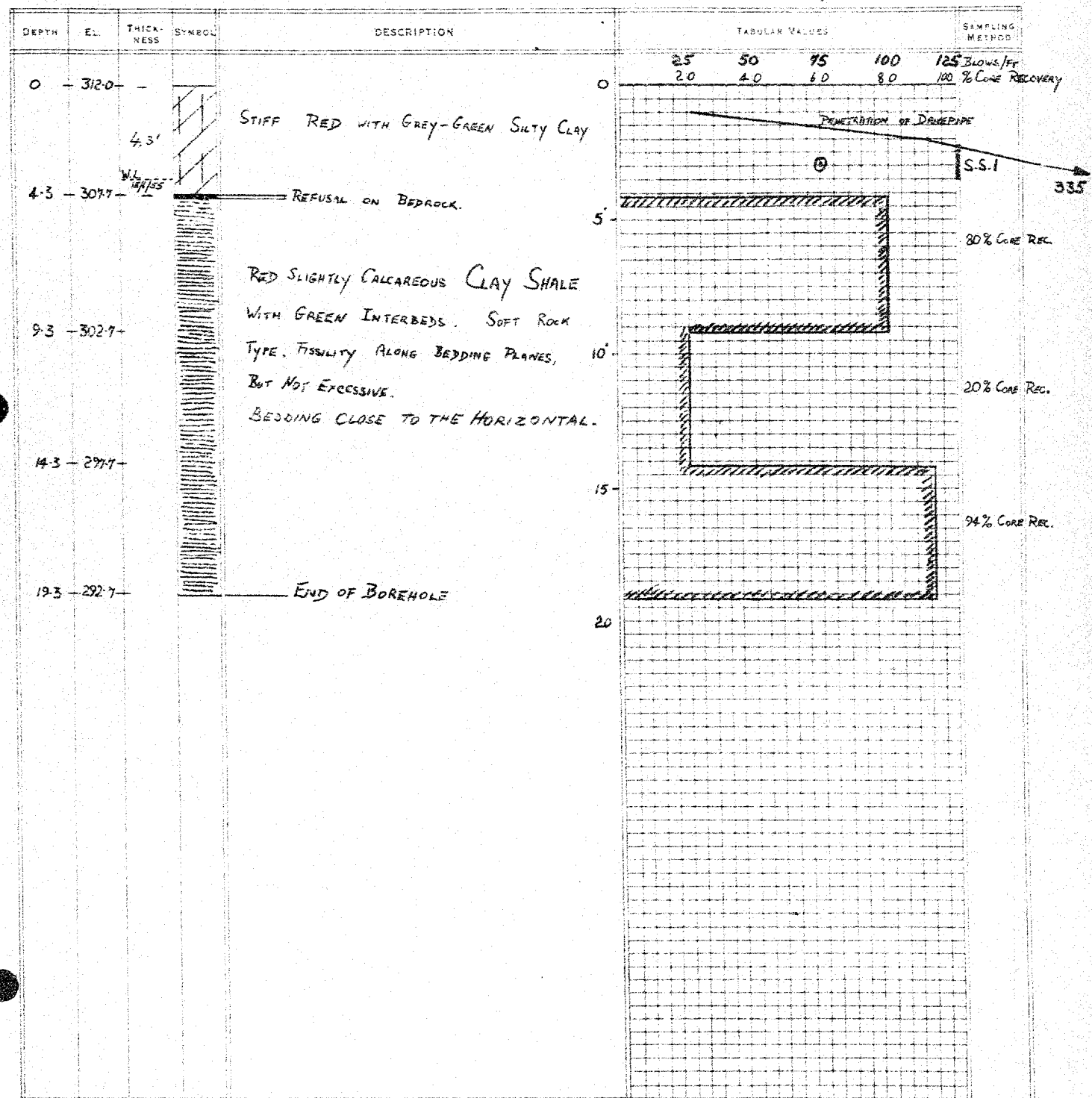
Job Located:

Checked by

Hole Located: AS SHOWN ON ATTACHED SKETCH PLAN.

Hole Elevation: 312.0 Datum:

11 Day 7 Month 55 Year



Order No.: 5502-505/55/T-93 RACEY, MacCALLUM AND ASSOCIATES
LIMITEDM. CHEVRIER
DrillerHole Begun 11/6/55

Foundation Engineering Division

Hole Ended 11/6/55Engineering Data Sheet for Borehole: N^o 2

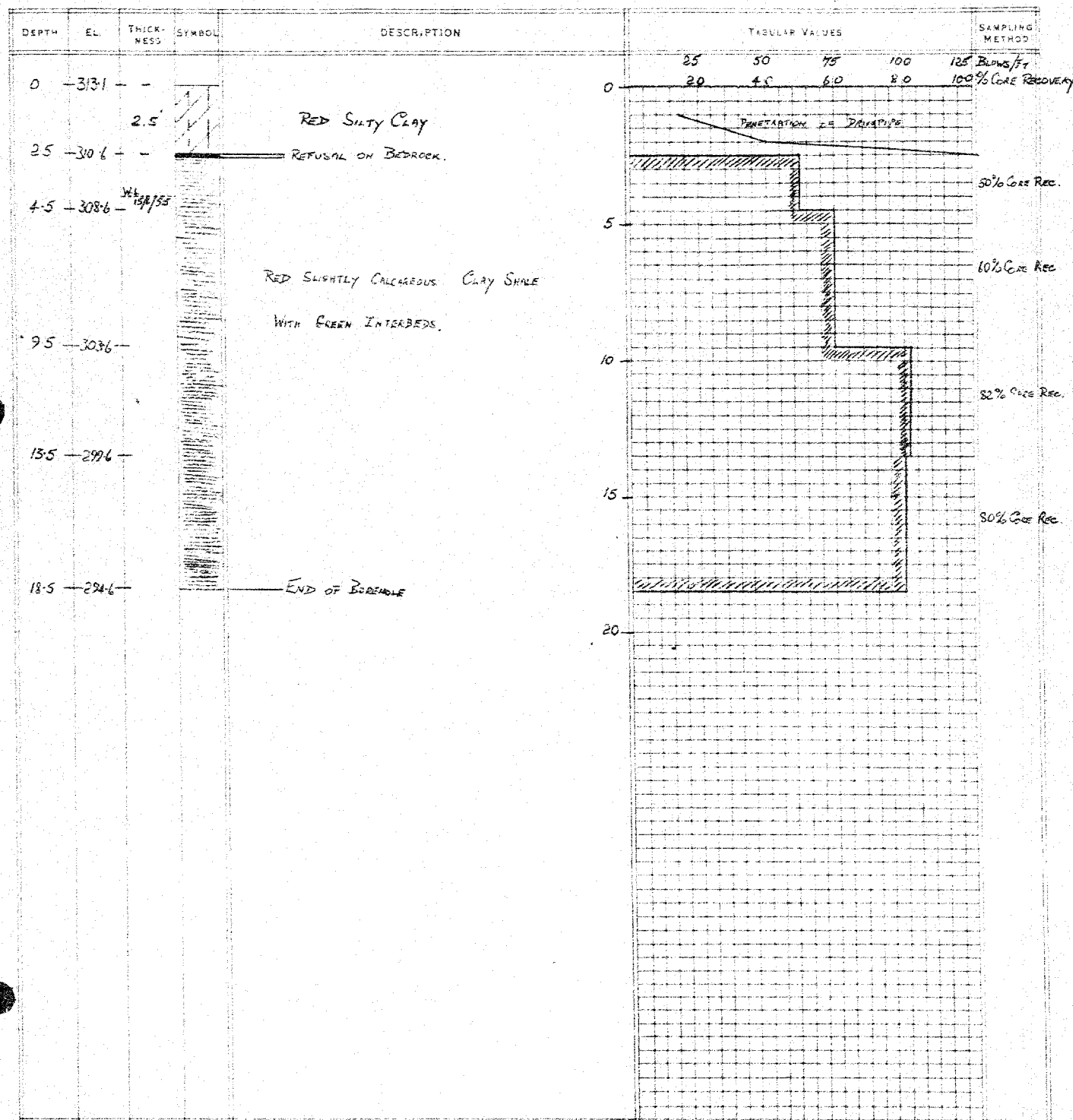
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: AS SHOWN ON ATTACHED SKETCH PLANHole Elevation: 313.1 Datum:11 7 55
Day Month Year

Order No. 5-500-503/55/T-93 RACEY, MACCALLUM AND ASSOCIATES
LIMITEDM. CHEVRIER
DrillerHole Begun 13/6/55

Foundation Engineering Division

Hole Ended 13/6/55Engineering Data Sheet for Borehole: 1123

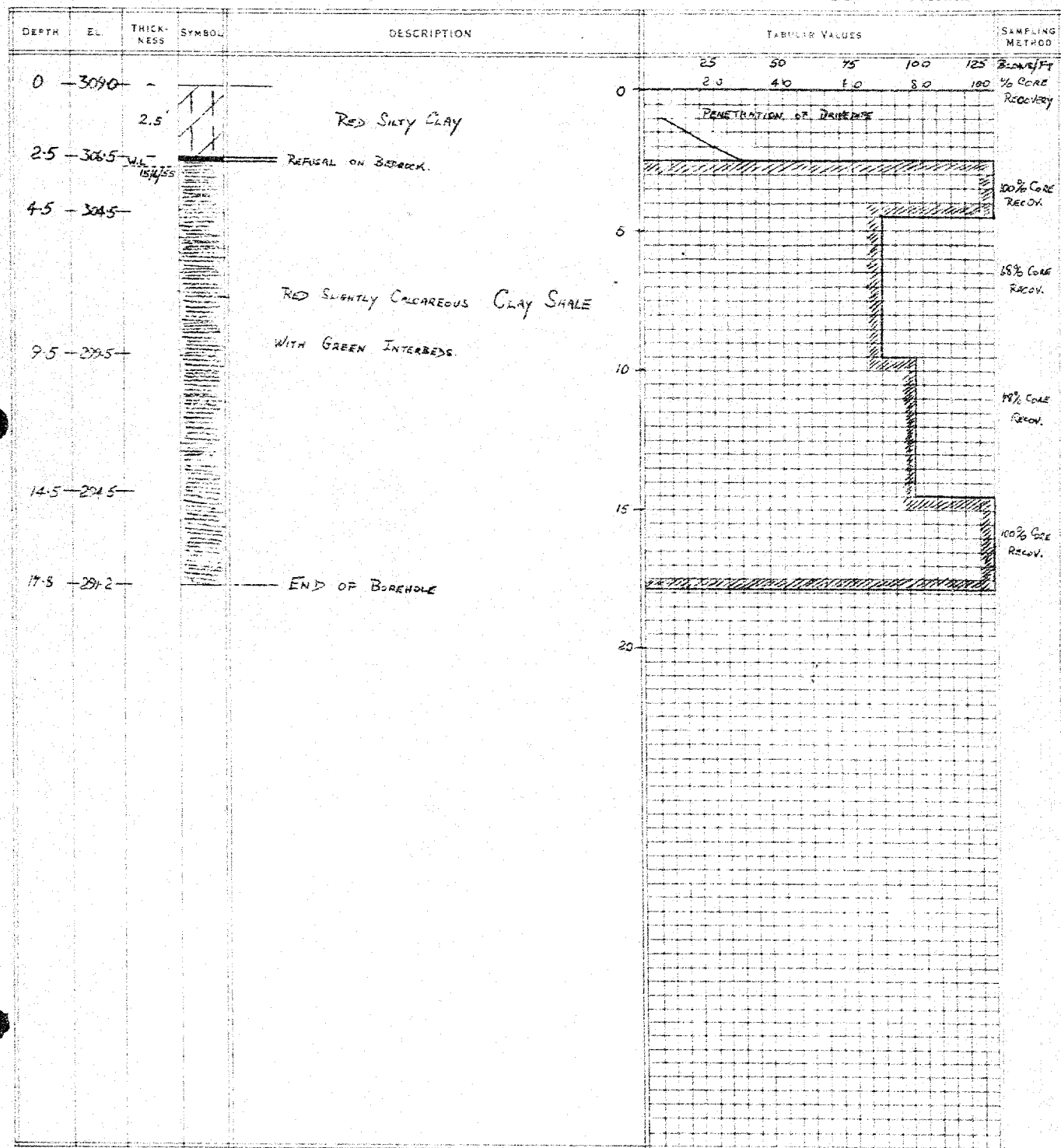
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: As shown on attached sketch plan.Hole Elevation: 302.0 Datum:11 7 55
Day Month Year

Order No. S-500-505/5/T-93 RACEY, MacCALLUM AND ASSOCIATES
LIMITEDM. CHEVRIER
DrillerHole Begun 13/4/55

Foundation Engineering Division

Hole Ended 14/4/55Engineering Data Sheet for Borehole: N^o 4

Helper

Job Name:

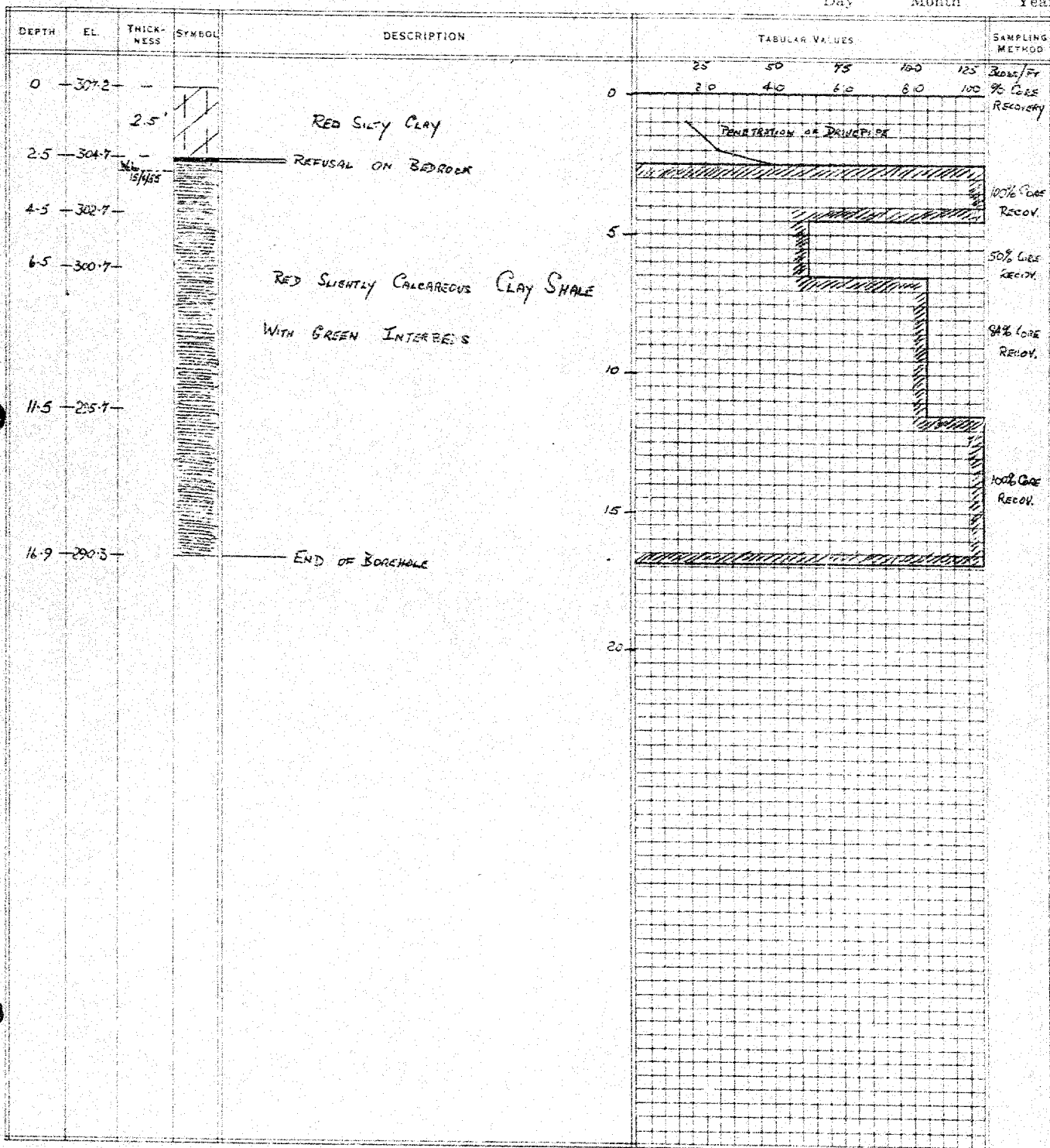
P.E.M.M.

Job Located:

Checked by

Hole Located: As show on ATTACHED SKETCH PLANHole Elevation: 307.2 Datum:

11 Day 7 Month 55 Year



Order No. 5-506-SU/55/T-93 RACEY, MACCALLUM AND ASSOCIATES

LIMITED

M. CHEVRIER
DrillerHole Begun 14/6/55

Foundation Engineering Division

Hole Ended 14/6/55Engineering Data Sheet for Borehole: N° 5

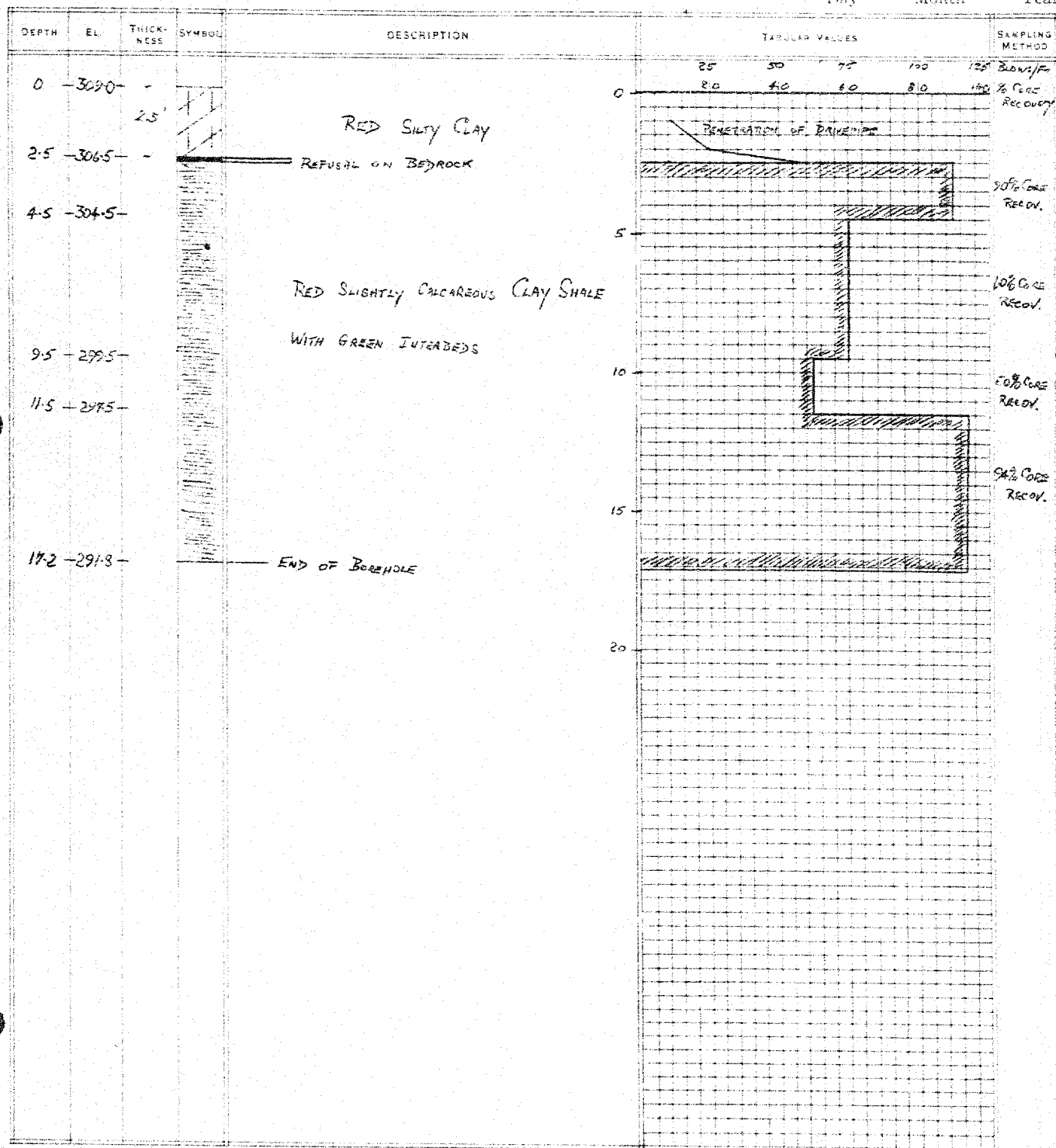
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: As shown on attached sketch planHole Elevation: 302.0 Datum:12
Day7
Month55
Year

Order No.: S-500-S05/55/T-93 RACEY, MACCALLUM AND ASSOCIATES
LIMITEDM. C. NEYRER
DrillerHole Begun 15/6/55

Foundation Engineering Division

Hole Ended 15/6/55Engineering Data Sheet for Borehole: NB 6

Helper

Job Name:

Job Located:

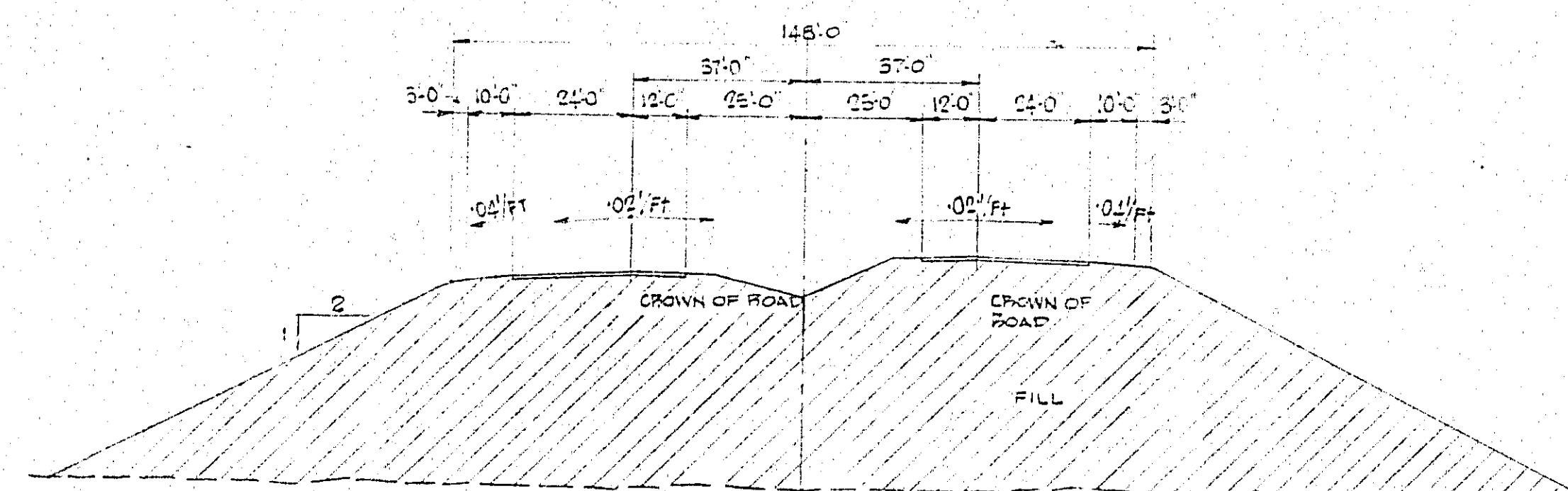
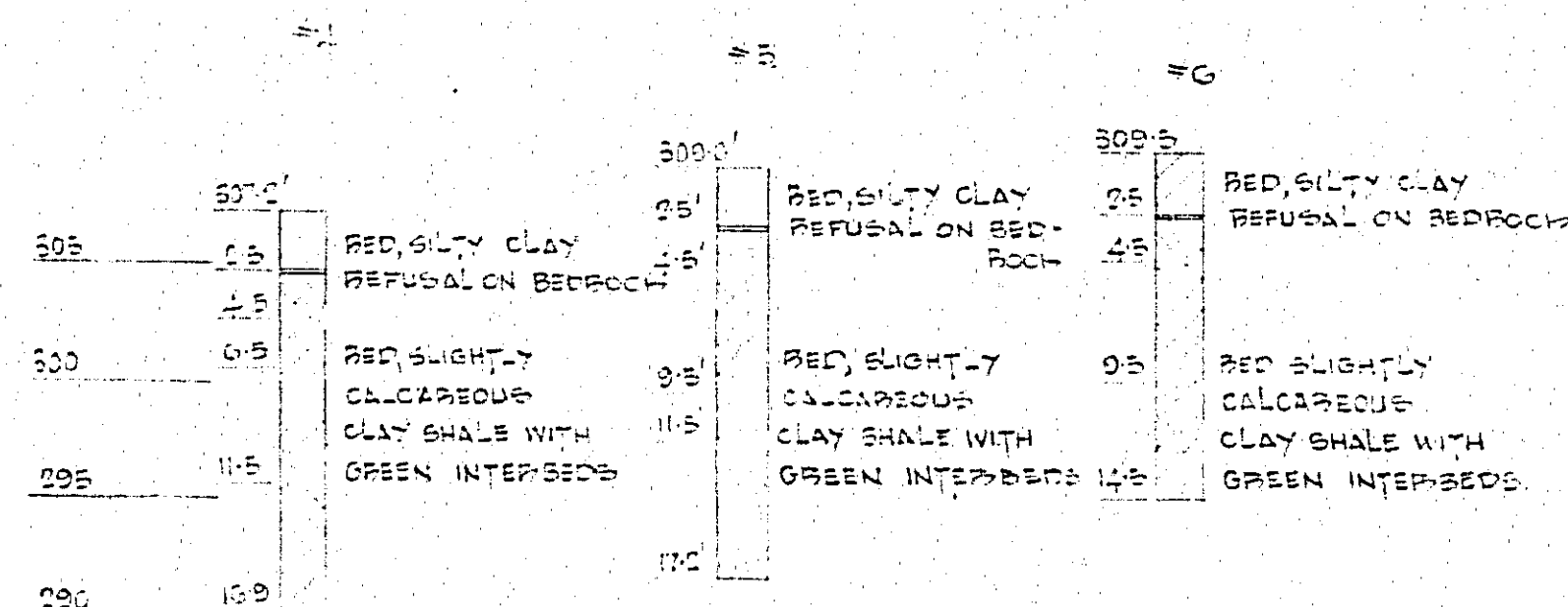
Hole Located: As shown on attached sketch planHole Elevation: 309.5 Datum:P.E.M.M.
Checked by

12 Day 7 Month 55 Year

DEPTH	EL.	THICK- NESS	SYMBOL	DESCRIPTION	TABULAR VALUES	SAMPLING METHOD
0	309.5	-			25 50 75 100 125 150 175 200	17.5' BRAND/FI 100% CORE RECOVERED
2.5	307.0	2.5		RED Silty Clay		
4.5	305.0	-		REFUSAL OF BED ROCK		42% CORE RECOVERED
9.5	300.0	-		RED SLIGHTLY CALCAREOUS CLAY SHALE WITH GREEN INTERBEDS		16.5% CORE RECOVERED
14.5	295.0	-		END OF BOREHOLE		40.5% CORE RECOVERED

ENGINEERS ARE: RAGEY, MACGILLIVRAY & ASSOCIATES LTD - JUNE 1988
ENGINEERS ARE FOR GENERAL INFORMATION ONLY, AND ARE NOT
GUARANTEED BY THE DEPARTMENT. THE COMPLETE SOIL INVESTIGATION
REPORT NR BA-42 MAY BE SEEN AT THE BRIDGE OFFICE DOWNSVIEW.
THE DEPARTMENT DOES NOT GUARANTEE THE ACCURACY OF THIS
REPORT NOR THE ABRIDGED VERSION SHOWN HERE.
LEVEL OF EXISTING GROUND & PROFILE OF CONTROLLED ACCESS.
HIGHWAY TAKEN FROM D.H.O. PLAN E-2395-1, DATED AUGUST 5, 1980.
MAXIMUM ALLOWABLE SOIL PRESSURE FOR FOOTINGS = 7 1/2 TONS/50 sq.ft.

#1	#2	#3
310	315	3000
305	310	2950
300	305	2900
295	300	2850
290	295	2800
285	290	2750
280	285	2700
275	280	2650
270	275	2600
265	270	2550
260	265	2500
255	260	2450
250	255	2400
245	250	2350
240	245	2300
235	240	2250
230	235	2200
225	230	2150
220	225	2100
215	220	2050
210	215	2000
205	210	1950
200	205	1900
195	200	1850
190	195	1800
185	190	1750
180	185	1700
175	180	1650
170	175	1600
165	170	1550
160	165	1500
155	160	1450
150	155	1400
145	150	1350
140	145	1300
135	140	1250
130	135	1200
125	130	1150
120	125	1100
115	120	1050
110	115	1000
105	110	950
100	105	900
95	100	850
90	95	800
85	90	750
80	85	700
75	80	650
70	75	600
65	70	550
60	65	500
55	60	450
50	55	400
45	50	350
40	45	300
35	40	250
30	35	200
25	30	150
20	25	100
15	20	50
10	15	0



TYPICAL CROSS-SECTION
THROUGH FILL NEAR STRUCTURE
SCALE 30' TO 1"

REINFORCING

D-3636-1 SITE PLAN

D-3636-2 PLAN, SECTION & MISC. DETAIL

D-3636-3 FTS. PLAN, REINFR. & MISC. DETAILS

D-3636-4 PANEL 'A' ENTRADOS REINF.

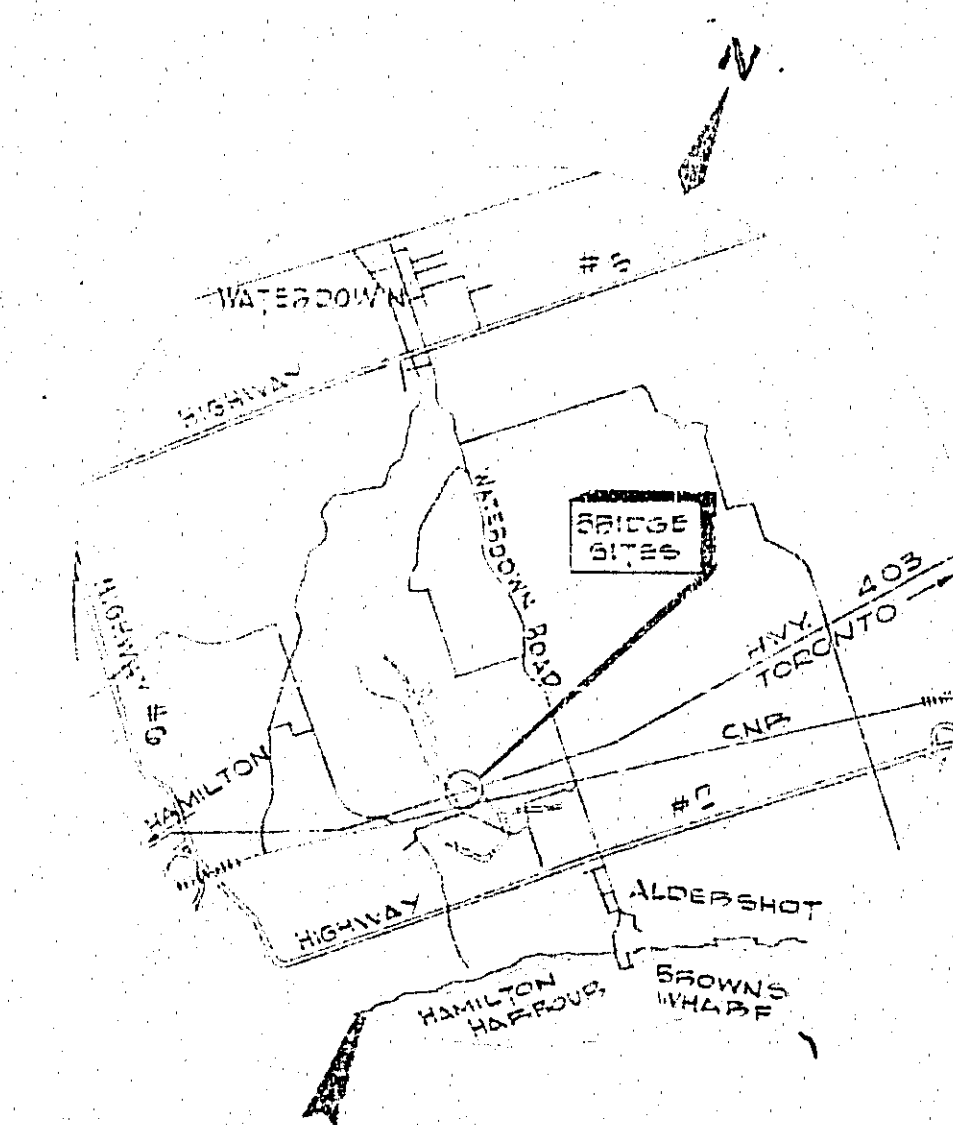
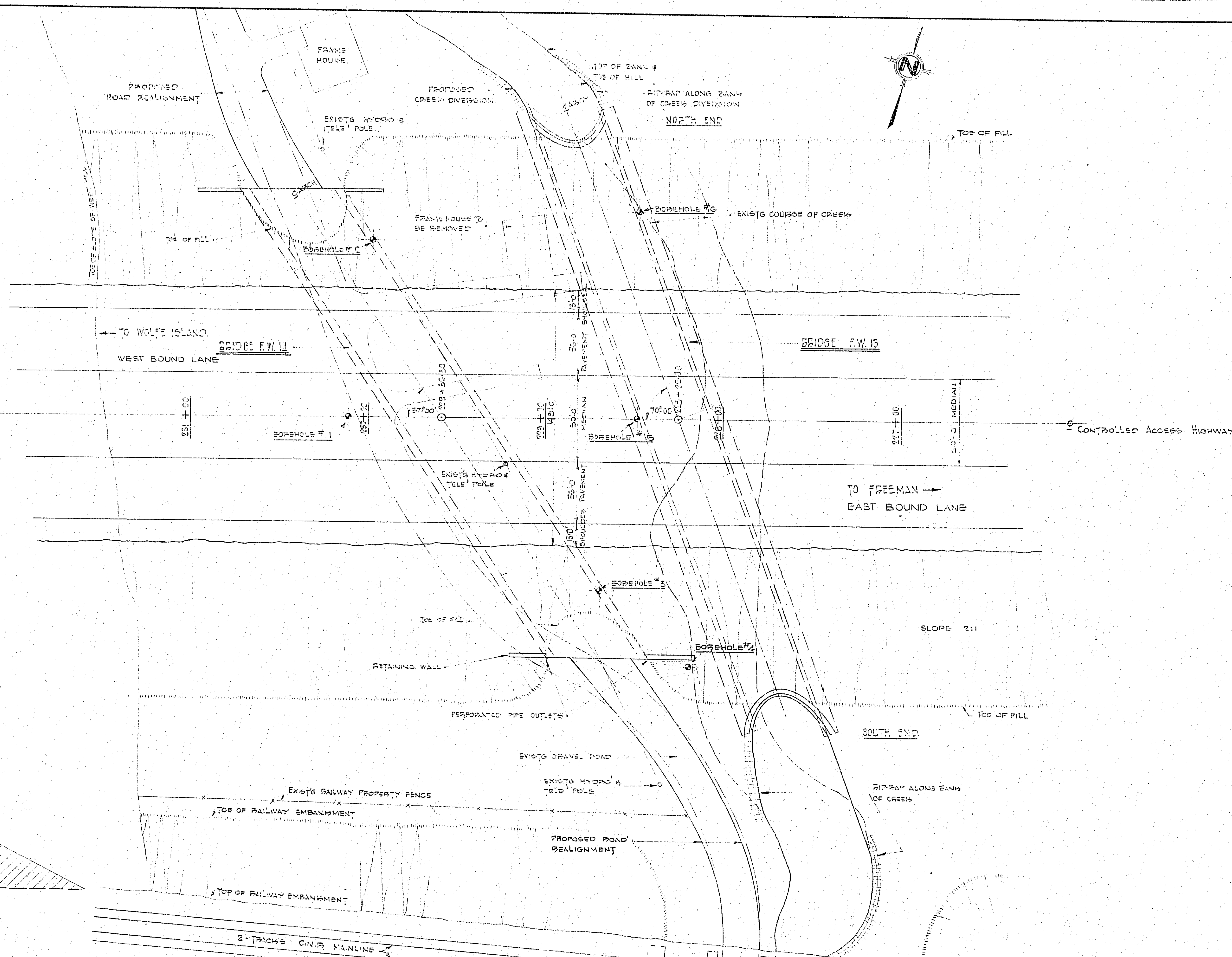
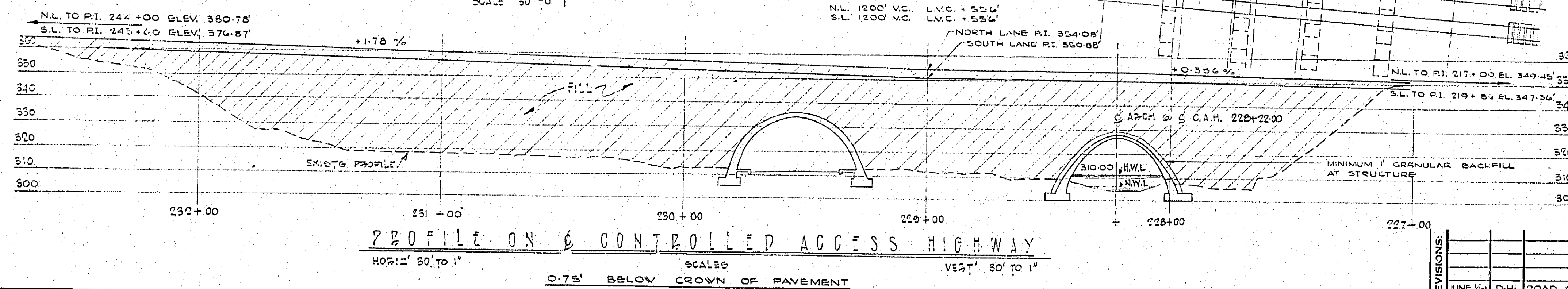
D-3636-5 PANEL 'A' ENTRADOS REINF.-PANEL 'C' EXTRADOS & ENTRADOS, REINF.

D-3636-6 REINFORCING STEEL SCHEDULE

D-3636-7 REINFORCING STEEL SCHEDULE.

D-3636-8 REINFORCING STEEL SCHEDULE.

D-3636-9 REINFORCING STEEL SCHEDULE.



KEY PLAN
SCALE : 1 IN. = 1 MI

NOTE TO DISTRICT ENGINEER - CONCRETE WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED & CHECKED BY THE DISTRICT ENGINEER.

NOTE TO CONTRACTOR - STRUCTURE TO BE BUILT IN ACCORDANCE WITH SPECIFICATIONS FOR STRUCTURES, D.M.O. FORM NO 9, AND THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE DISTRICT ENGINEER.

CONCRETE MIX - ALL CONCRETE IN STRUCTURE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 3000 PSI AT 28 DAYS. APPROVED ADMIXTURE SUPPLIED BY CONTRACTOR AND ADDED TO CONCRETE AS DIRECTED BY ENGINEER.

REINFORCING STEEL - CLEAR COVER IN FOOTINGS - 3". CLEAR COVER IN ALL CONCRETE IN CONTACT WITH EARTH OR ROCK - 3". CLEAR COVER IN ALL REMAINING CONC' IN STRUCTURE - 2" EXCEPT WHERE OTHERWISE NOTED. ALL BAR SPICES TO BE LAPPED 35 DIAMETERS EXCEPT WHERE OTHERWISE NOTED.

CONSTRUCTION NOTES:

1. FOUNDATIONS: FOOTINGS DESIGNED FOR A MAXIMUM ALLOWABLE SOIL PRESSURE OF 7.5 TONS PER SQ. FT. EXCAVATIONS FOR FOOTINGS TO BE CUT AS NEATLY AS POSSIBLE AND COMPLETELY FILLED WITH CONCRETE.

2. CONSTRUCTION JOINTS SHALL BE MADE ONLY WHERE LOCATED ON THE DRAWINGS UNLESS OTHERWISE APPROVED BY THE ENGINEER. EACH

3. ARCH SHORING MUST NOT BE STRUCK UNTIL CONCRETE HAS REACHED DESIGN STRENGTH, AND IN ANY CASE NOT LESS THAN 14 DAYS AFTER

CONCRETE HAS BEEN PLACED. THE ENGINEER MUST GIVE WRITTEN PERMISSION BEFORE REMOVAL IS BEGUN.

4. FILL OVER ARCH TO BE PLACED EVENLY & SIMULTANEOUSLY ON BOTH SIDES

5. FILL AGAINST ARCH SHALL BE COMPACTED IN 6" LAYERS:

6.FALSEWORK AT CENTRE OF ARCH TO BE REMOVED FIRST THEN WORKING EACH WAY FROM THE CENTRE, THE REMAINING FALSEWORK SHALL BE REMOVED SO THAT THE ARCH SUPPORT IS EQUALLY BALANCED AT ALL TIMES.

7. PROVISION FOR THE DEFLECTION OF FALSEWORK WILL BE MADE BY THE CONTRACTOR IN ADDITION TO THE D.L. DEFLECTION.

DEFLECTION.

PROVINCE OF

W.F. 16

SIN	0.939693
COS	0.342020
TAN	2.747477

SIN 0.838071
COS 0.544639
TAN 1.539805

C. C. PARKER AND ASSOCIATES LIMITED
HAMILTON CONSULTING ENGINEERS. ONTARIO

DEPARTMENT OF HIGHWAYS: ONTARIO-
BRIDGE OFFICE: TORONTO

GRINDSTONE CREEK
EAST FLAMBOROUGH TOWNSHIP

AT ALDERSHOT
BRIDGE FW-13

THE KING'S HIGHWAY No. 403 DIST. No. 4
CO. HALTON

TWP. EAST FLAMBOROUGH LOT 8 CON. I

APPROVED

BRIDGE ENGINEER

DESIGN ENGINEER

DESIGN	V. B. A	CHECK	J. A. B	CONTRACT NUMBERS			GENERAL
DRAWING	G. S. N	CHECK	J. A. B				60-227

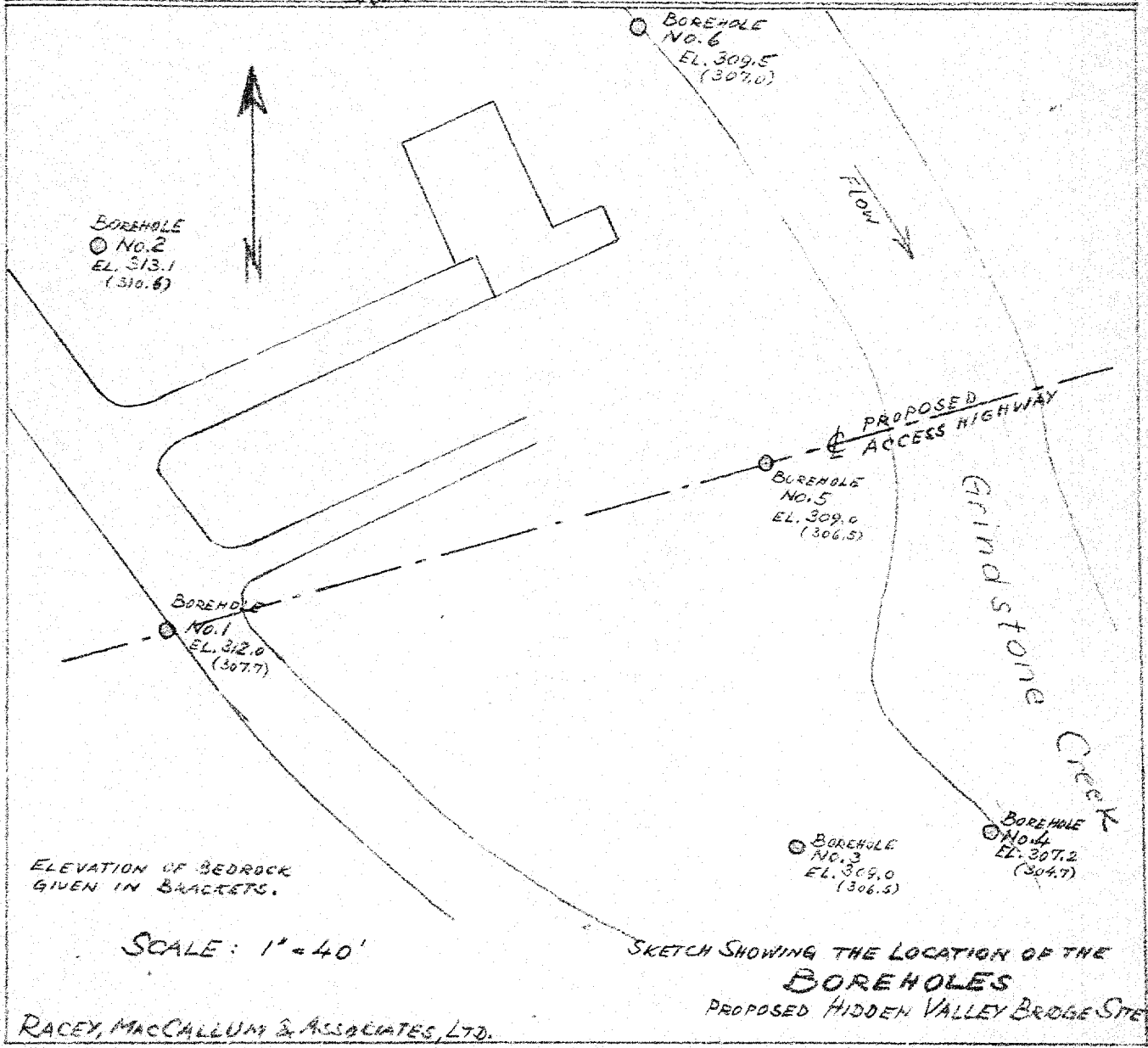
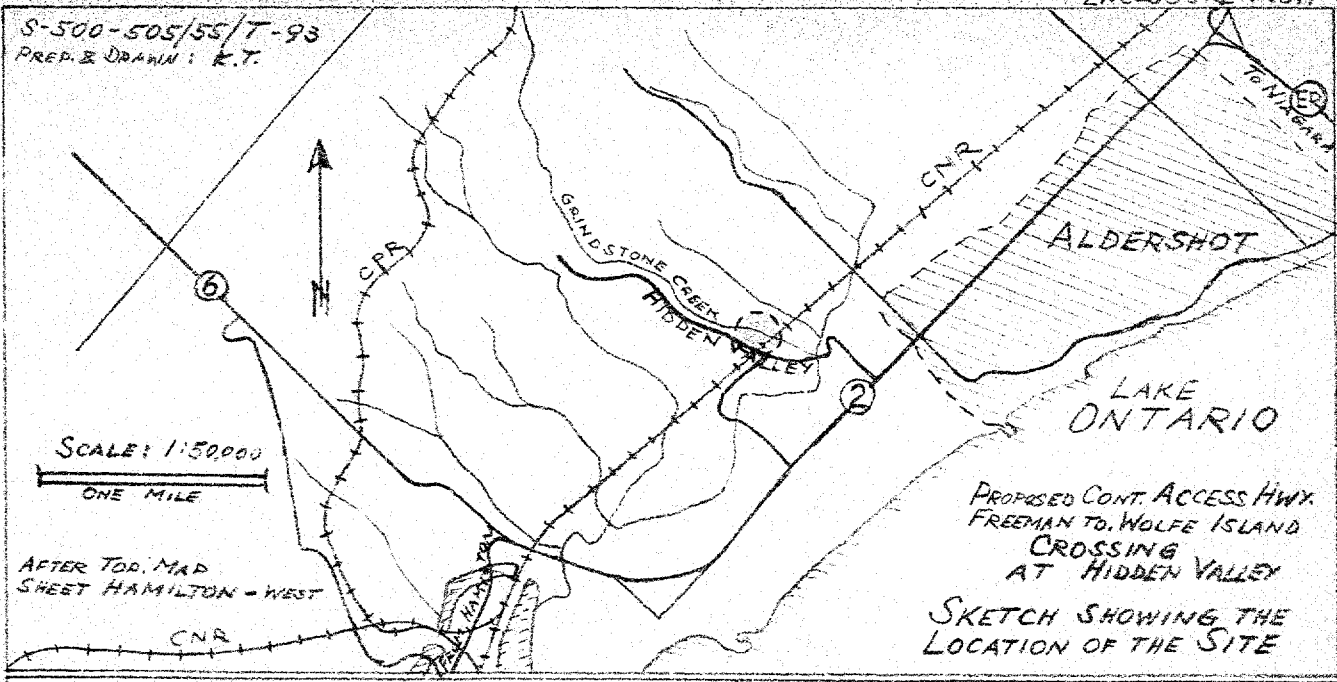
TRACING	B. H. Y	CHECK	D. C. C	LOADING					
DATE JUNE 29, 1956				H20-516	DRAWING NUMBER	D-9553 +			

Twp #1337-193-1-A 337-50

~~10-193~~

~~D36,6~~
~~1 to 9~~

S-500-505/55/T-93
PREP. & DRAWN: R.T.



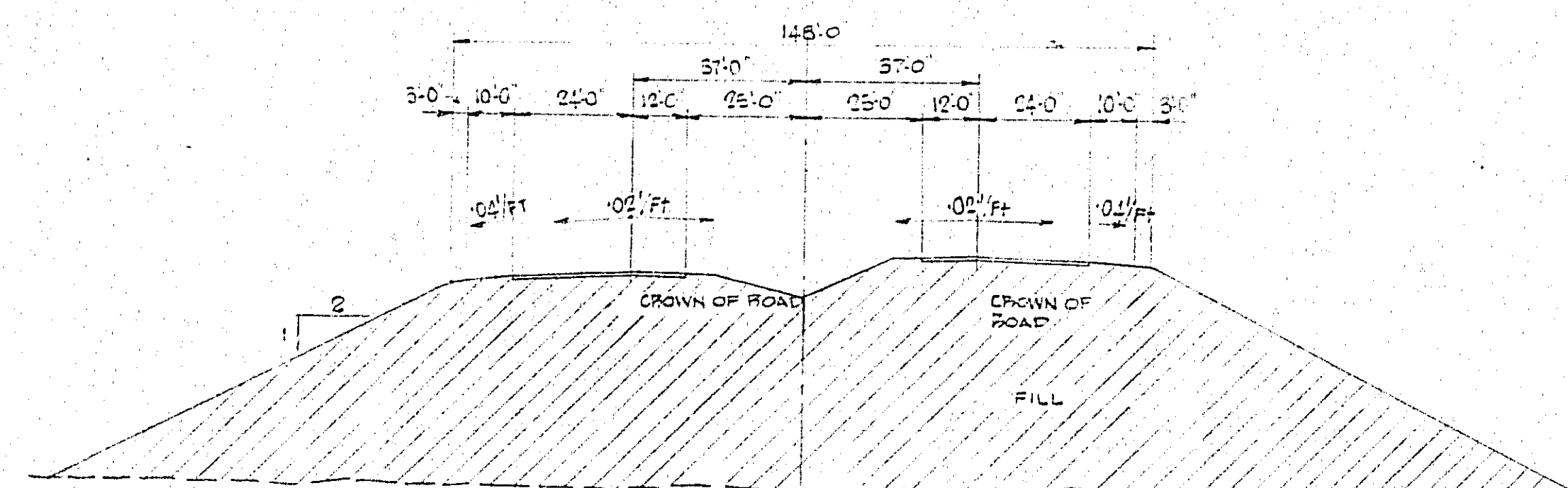
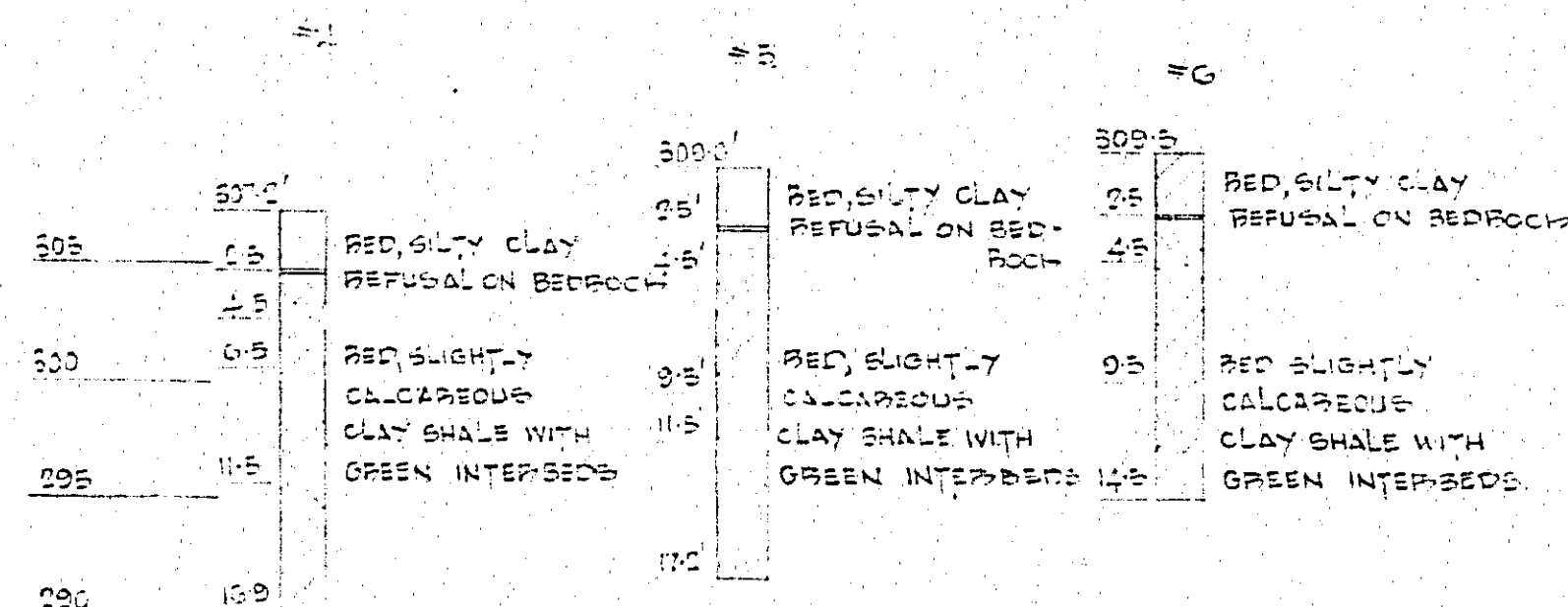


Appendix B

Archive Drawings of Existing Culvert

ENGINEERS ARE: RAGEY, MACGILLIVRAY & ASSOCIATES LTD - JUNE 1986
ENGINEERS ARE FOR GENERAL INFORMATION ONLY, AND ARE NOT
GUARANTEED BY THE DEPARTMENT. THE COMPLETE SOIL INVESTIGATION
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LEVEL OF EXISTING GROUND & PROFILE OF CONTROLLED ACCESS.
HIGHWAY TAKEN FROM D.H.O. PLAN E-2395-1, DATED AUGUST 5, 1980.
MAXIMUM ALLOWABLE SOIL PRESSURE FOR FOOTINGS = 7 1/2 TONS/50 sq. ft.

#1	#2	#3
310	305	3000
305	300	2950
300	295	2900
295	290	2850
290	285	2800
285	280	2750
280	275	2700
275	270	2650
270	265	2600
265	260	2550
260	255	2500
255	250	2450
250	245	2400
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240	235	2300
235	230	2250
230	225	2200
225	220	2150
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160	155	1500
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150	145	1400
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140	135	1300
135	130	1250
130	125	1200
125	120	1150
120	115	1100
115	110	1050
110	105	1000
105	100	950
100	95	900
95	90	850
90	85	800
85	80	750
80	75	700
75	70	650
70	65	600
65	60	550
60	55	500
55	50	450
50	45	400
45	40	350
40	35	300
35	30	250
30	25	200
25	20	150
20	15	100
15	10	50
10	5	0



TYPICAL CROSS-SECTION
THROUGH FILL NEAR STRUCTURE
SCALE 30' TO 1"

REINFORCING

D-3636-1 SITE PLAN

D-3636-2 PLAN, SECTION & MISC. DETAIL

D-3636-3 FTS. PLAN, REINFR. & MISC. DETAILS

D-3636-4 PANEL 'A' ENTRADOS REINF.

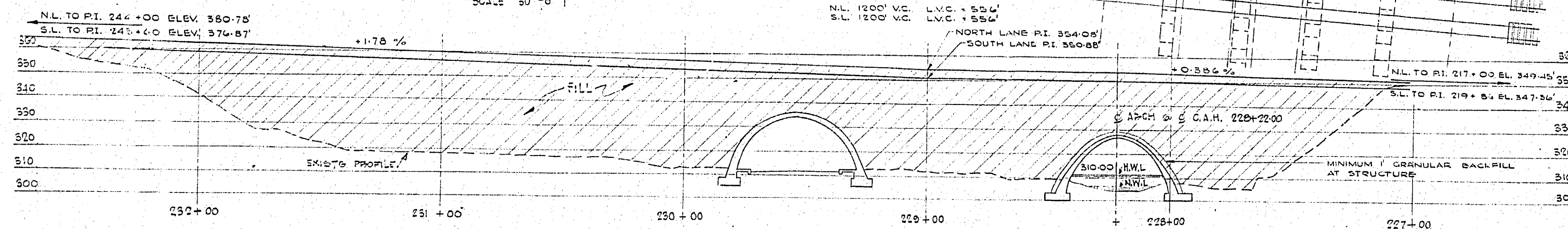
D-3636-5 PANEL 'A' ENTRADOS REINF.-PANEL 'C' EXTRADOS & ENTRADOS, REINF.

D-3636-6 REINFORCING STEEL SCHEDULE

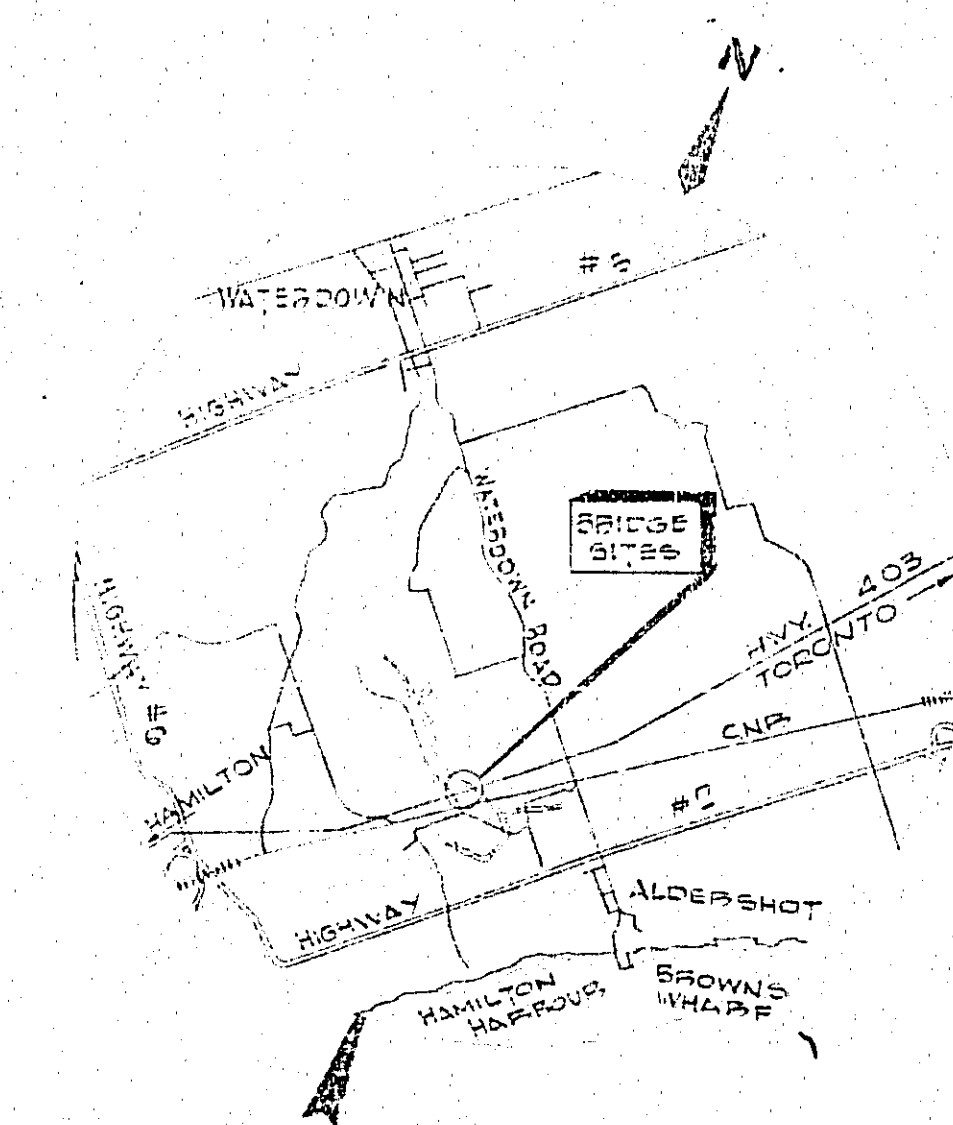
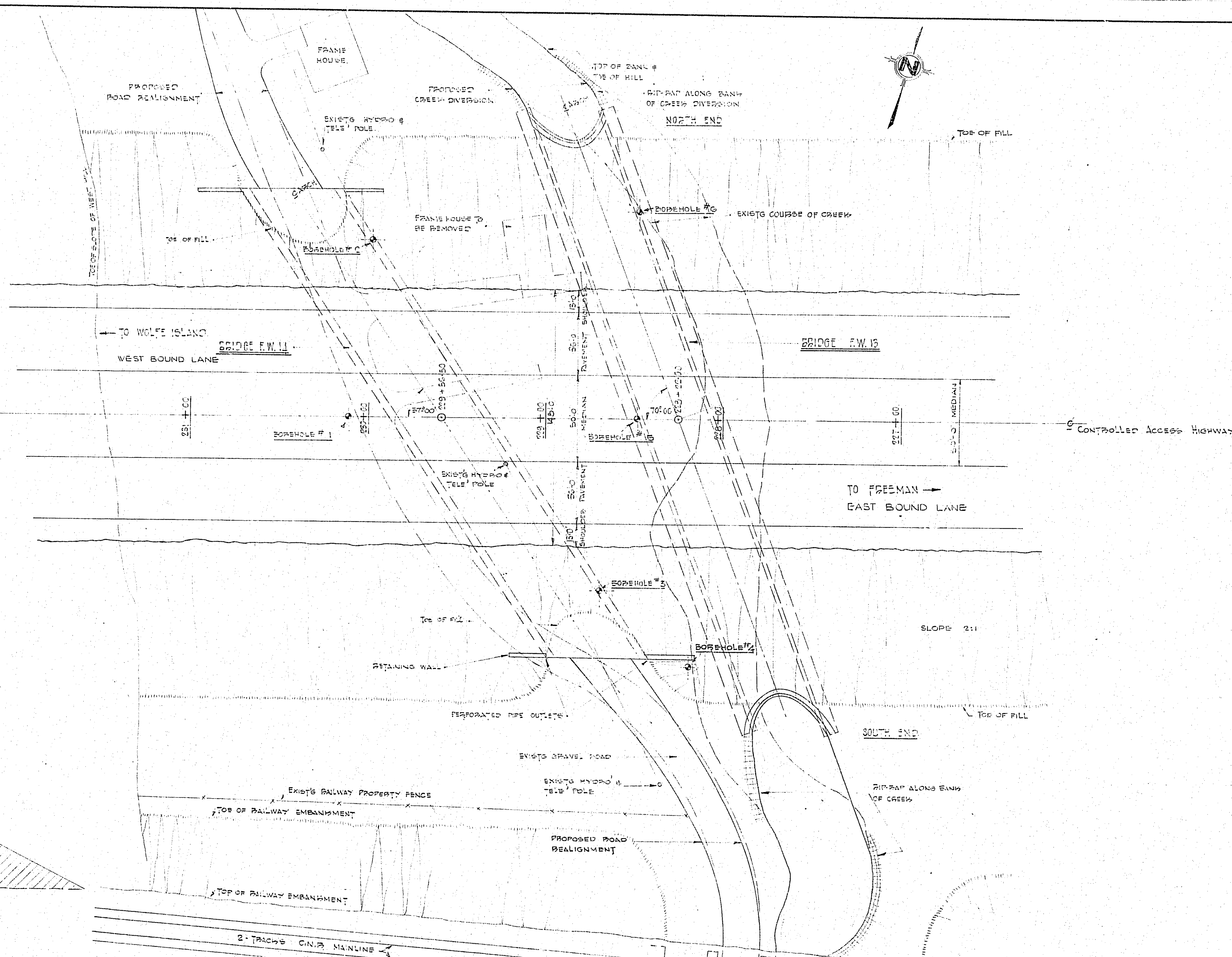
D-3636-7 REINFORCING STEEL SCHEDULE.

D-3636-8 REINFORCING STEEL SCHEDULE.

D-3636-9 REINFORCING STEEL SCHEDULE.



PROFILE ON C CONTROLLED ACCESS HIGHWAY
HORIZ: 80' TO 1" SCALE: 1" = 40' VERT: 30' TO 1"
0.75' BELOW CROWN OF PAVEMENT



KEY PLAN
SCALE : 1 IN. = 1 MI

NOTE TO DISTRICT ENGINEER - CONCRETE WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED & CHECKED BY THE DISTRICT ENGINEER.

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DEFLECTION.

PROVINCE OF

W.F. 16

SIN	0.939693
COS	0.342020
TAN	2.747477

SIN	0.838071
COS	0.544639
TAN	1.539805

REVISIONS:					REFERENCE PLANS	BRIDGE ENGINEER				DESIGN ENGINEER			
					B = 2890 - 1	DESIGN	V. P. A.	CHECK	J. A. B.	CONTRACT NUMBER			G.N.C.B.A.
					F = 2407-26	DRAWING	G. S. N.	CHECK	J. A. B.				64-227
					F = 2407-27	TRACING	P. H. V.	CHECK	D. C. C.	LOADING			
						DATE	JUNE	29, 1956		H20-S16	DRAWING NUMBER	D-5555	
DATE	D.H.	ROAD CROSS-SECTION, PROFILE, GENERAL NOTES											
	BY	DESCRIPTION											

Twp #1337-193-1-A 337-50



Appendix C

Selected Site Photographs

Hidden Valley
Road Culvert

Grindstone
Creek Culvert

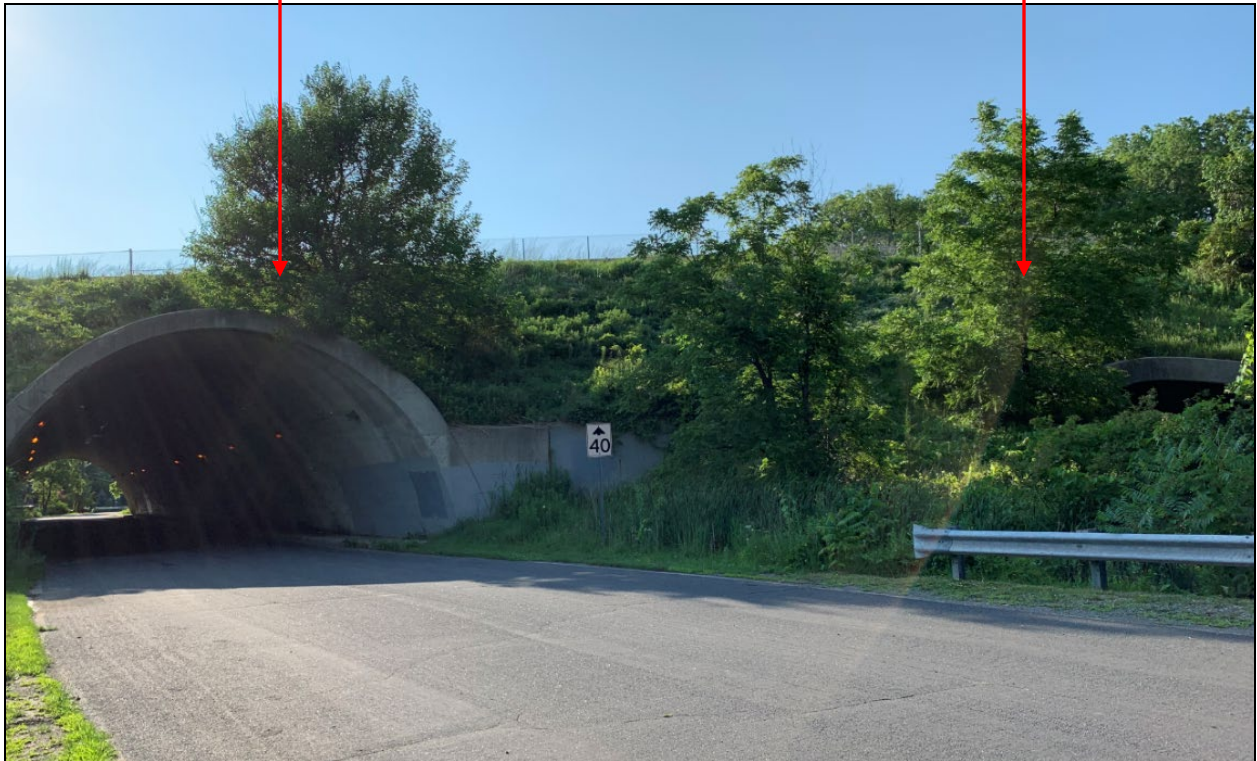


Photo 1- Hidden Valley Road culvert and Grindstone Creek culvert, south side
Photo taken on July 14, 2021



Photo 2- Grindstone Creek culvert , south side
Photo taken on July 14, 2021



Photo 3- Grindstone Creek culvert , north side, culvert inlet
Photo taken on July 14, 2021



Photo 4- Grindstone Creek culvert , northeast side
Photo taken on July 14, 2021



Photo 5- Grindstone Creek culvert , northwest side
Photo taken on July 14, 2021



Photo 6- Grindstone Creek culvert , north side
Photo taken on July 14, 2021



Photo 7- Grindstone Creek culvert , northwest side, before the culvert inlet
Photo taken on July 14, 2021



Appendix D

Plan of Proposed Borehole



PLAN

- PROPOSED BOREHOLES
- PREVIOUS BOREHOLES (PREVIOUS INVESTIGATION 1960)

HIGHWAY 403 & HIGHWAY 6 INTERCHANGE GRINDSTONE CREEK CULVERT / HIDDEN VALLEY ROAD CULVERT REHABILITATION ALTERNATIVE 2 PRELIMINARY DESIGN & ENVIRONMENTAL ASSESSMENT PROPOSED BOREHOLE LOCATIONS

(N.T.S. SCHEMATIC ONLY)

