ontario hydro

File No. R-NF28-13110--0015

700 University Avenue, Toronto, Ontario M5G 1X6

MEMORANDUM

TO: Jim Schacht
First Line Manager Production
Niagara Plant Group

May 22, 1998

File: R-NF28-13110-0015

Subject: **Assessment of the Glen Access Road**

Please find here attached the final report on the assessment of the Glen Access Road, a draft version of which was circulated to the Plant Group in April of 1997.

The Geotechnical investigation found that in several areas the thickness of road base and sub-base was much less than designed and that ice lenses, wash boarding, and erosion of the side ditch were the main problems affecting the road.

The report recommends that the road is rebuilt in two phases:

In phase one (850k planned for 1999) it is recommended that the road drainage is improved and new culverts added, that the road side ditch is lined with riprap, and that sub-base and base are placed.

In phase two (450k in 2001) it is recommended that the road surface is paved, after two years of observation of the performance of the road.

The above estimates have already been entered in the Work Program.

From a maintenance point of view the report recommends that all obstacles and large fallen rocks are removed from the road side ditch, and that the inlet of all plugged culverts is freed as soon as possible. Until such time that the project is approved and carried out, it is recommended to scarify, re-compact and re-grade the road bed as required when road conditions deteriorate.

If you have any questions about this report, please do not hesitate to contact me at 592-7272 or Alain Diallo at 592-7301.

Yours truly,

Mona Bechai
Manager Civil Field Services

c.c. Dave Heath
Rick Everdell
Matthew Ho
J. Huang

Info-Pro\TSP\4508.doc

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700 University Avenue, Toronto, Ontario M5G 1X6

MEMORANDUM

M. BECHAI
Manager
Civil Field Services
H8 G4

May 25, 1998

File: R-NF28-13110-0015

Re: Glen Access Road: Condition Assessment

As a follow up to the Niagara Plant Group's request please find attached my assessment of the Glen access road condition.

Background History

At the time of construction of the Sir Adam Beck GS #1 and #2 the present Glen access road extended to the north of SAB #1. See Figure 1. The section extending north of SAB #1 was used as an escape route which eventually was destroyed by massive land slides of the river banks as a result of undercutting by tailrace flow downstream from the Power Houses. The section of the road extending to the south and upstream of the Power Houses is the present day Glen access road which is being used both to access and escape from the SAB #1 and SAB #2 Power Houses.

Rock falls have always been a major concern at the Glen access road and the concern is presently being addressed by the placement of catch fences and wire mesh. In 1981 the west side ditch of the road was widened to provide a catchment for rock fall and at the same time the road shoulder was widened, and the access road realigned.

Dumped fill was used to widen the shoulders, and internal records indicate that in 1982 tension cracks parallel to the guardrails developed on the road in the area of the road realignment (between chainages 35+00 and 38+00). The cracking was observed over a distance of 250 feet. Some tension cracks up to 2 inches wide were observed on the road approximately 2-3 feet from the guard rail. A downward displacement of approximately one half inch on the gorge side of the tension crack was observed in one area. The tension cracks were attributed to differential settlement between the old and the new fill.

2.0 ROAD DESCRIPTION

The road is oriented from South to North parallel to the Niagara Parkway Road. (See Figure 1). It is characterized by bends, and steep slopes. Speed is limited to 50 kph and a "steep slope" warning sign is posted.

The road is flanked on the east side by a continued length of guard rails, protecting vehicles from the steep slopes of the Niagara River Gorge.

On the west side, the road is flanked by a steep rock-cliff and is protected against rock falls by the following:

- a drainage/rock catchment ditch extending from Chainage 9+00 to Chainage 65+00;
- a discontinued length of Jersey Barriers extending from chainage 15+00 to chainage 23+50;
- a continuous length of Jersey barriers extending from chainage 23+50 to chainage 43+00, from chainage 51+60 to 54+50, and from chainage 55+60 to 58+00;
- a catch fence extending from 43+00 to 51+ 60 and from 54+50 to 55+60.

3.0 USE AND MAINTENANCE OF THE ROAD

The road is used daily by small trucks and occasionally large floats carrying heavy loads and is maintained annually by the Plant Group Civil crews.

In future years it is anticipated that the access road will experience heavy loads and traffic as a result of the major rehabilitation programs approved for SAB #1 and SAB #2 and also perhaps from a potential development of SAB #3.

4.0 ROAD SURFACE

From chainage 0+00 (which is located 8 feet to the west of the centerline of the Parkway road at it's junction with the Glenn access road) up to chainage 2+00 the entrance to the access road was paved with 2 inches of HL-3 overlaying 2 inches of HL-8. The pavement is characterized by alligator skin development, a typical symptom of a road foundation too soft for the applied loads. See Photos 1 and 2.

From chainage 2+00 to chainage 65+00 (entrance gate to the SAB #2 Power House), the road surface is gravel (type granular A or B) and the foundation is a fill of varied thickness and origin rich in large rocks overlying the different rock formations that the road intersects. From about chainage 28+00 to chainage 65+00 the underlying rock formation is the Queenston shale which is overlain by a fill thickness that varies from 12" to 36".

The surface of the road is characterized, by a large development of 2 feet diameter pot holes about five inches deep as shown in photos (3 and 4). Pot holes occurrences are worse from chainages 2+50 to 5+00, from chainages 36+00 to 38+00 and from chainages 48+00 to 56+00.. At the Glen access road, the pot holes are essentially caused by ice lensing. Ice lensing requires frost susceptible soils (i.e. soil rich in fine sands and silts) and a source of water.

In addition to pot holes, wash-boarding is observed to occur at uphill and down hill sections of the road and also in and out of turns, and are indicative of a shear failure of the road surface under repetitive traffic load..

5.0 ROAD WIDTH

At its narrowest the total width of the road is 22 feet wide at chainage 23+62 and at its widest the total width is 55 feet wide at chainage 61+45.

The road is getting narrower between chainages 20+00 to 30+00 as a result of combined action from erosion of the side ditch and under-mining of the Jersey Barriers, some of which have been toppled in the ditch (see Photo 12).

6.0 ROAD DRAINAGE

Drainage of the road is directed to the west ditch or to the river. The west ditch drains to the river via three cross-road culverts . Two longitudinal culverts allow traffic to cross the ditch and access the west side of the road.

6.1 Road Side Ditch:

The road side ditch is very irregular in size and receives water and debris from the high rock cliffs to the west, particularly in the spring around chainages 22+50 and chainages 26+00. The flow of water and debris block the ditch causing local roadside erosion and washouts

6.2 Cross road Culverts.

Four culverts as described below insure the drainage of the road side ditch towards the river.
At chainage 23+62 the culvert is a 30" diameter wide corrugated pipe, 30 feet long which is totally plugged at the entrance
At chainage 35+80 the culvert is a 30" diameter corrugated pipe, 60 feet long , plugged with debris at the entrance as shown in photo (11) . It is broken at the downstream side an should be repaired.
At chainage 49+19, the culvert is a 30" diameter corrugated pipe, 60 feet long and is in good flowing condition.
at chainage 65+00, the cross road culvert is a concrete culvert about 4 feet wide, 3 feet high and about 60 feet long. Wood logs bridge the sides of the culvert allowing traffic to pass over it. The culvert is in good flowing condition.

6.3 Culvert Longitudinal to the Road

Two 24 inches culverts were installed along the west side road ditch to allow access to the west side of the ditch to equipment and vehicles. These culverts are free flowing and are in good condition.
At chainage 36+00 the longitudinal culvert is 25 feet long it is free flowing and in good condition
At chainage 59+40, the longitudinal culvert is 60 feet long, and it is partly plugged at the entrance with debris.

7.0 Site Investigation:

The original design of the road is 12 inches of granular A overlying 24 inches of granular B
Four test pits were dug on the worst sections of the access road at chainages 3+00, 8+00, 35+00 and 56+00 approximately 10 feet to the east of the centerline of the road. Samples of granular material were taken and sent for lab analysis. The results indicate that the granular material on the road is closer to a granular B type material than to a Granular A material (see appendix 1).

The test pits revealed that the thickness of granular material over the foundation varied widely from the original three feet thick design and ranged from 24 inches thick to six inches thick (at chainage 56+00).
Lab results indicate that in general the granular layer of the road is a sandy gravel with a little silt. Visual examination of the test pits suggested contamination of the sub-base layer by fines from the foundation especially at chainage 56+00 where only six inches of the original 36 inches of granular A and B materials exist on the road and appeared to be colored by red fines from the underlying weathered Queenston Shale as a result of the pounding of heavy loads. However this visual observation is not confirmed by the lab analysis.

8- Conclusions:

8.1 Road Base

Lab tests and test pits confirm that the base layer consisting of 12 inches of granular A material is essentially gone, possibly as a result of grading over many years unless it was never placed to the design thickness.

8.2 Road Sub-base.

In general, the lab analysis indicate that the sub-base granular material is a gravely sand with silt. This material would be susceptible to ice lensing wherever there is a continuous supply of water, and wherever fines from the foundation might have contaminated the sub-base.
At least locally the same observation as for the base layer applies as the granular material above the underlying bedrock is not 24" thick. For example at 56+00, the 24"subbase has either been removed by grading or else never was placed to the design thickness.

8.3 Pumping

Although this observation was not confirmed by the lab analysis (likely as a result of improper sampling), visual inspection at chainage 56+00 indicate that over the years pounding from the heavy loads have pushed the relatively softer reddish weathered Quenston shale foundation of the road into the sub-base by so called pumping action. It is likely that the same phenomenon would take place in those areas where the foundation is softer and the underlying bedrock hard.
In 1993, the road experienced heavy traffic from loaded trucks transporting muck at high speed during the construction of the test tunnel for SAB #3. This intense usage has likely contributed to extend further the damage to the road .

8.4 Foundation

The test pits stopped at the top of the foundation layer and did not extend to it's base. The foundation layer overlies the different rock formations and appears to vary in thickness from zero to four feet at the west side of the road and is much thicker at the east side of the road. The foundation is made of fill of varied origin, generally consisting of silty clay with large boulders. In some areas soft foundation is evidenced by alligator skin development , for example from chainage 0+00 to 2+00.
Without further testing, and for cost estimating purposes, the foundation was assumed to be poor and to require Geogrid reinforcement, wherever it overlies weathered Queenston Shale , i.e from approximately chainage 28+00 to 65+00. Geogrid reinforcement was assumed to be unnecessary uphill from chainage 28+00 where the foundation overlies a bedrock less susceptible to weathering. Requirement for Geogrid reinforcement should be reassessed at the time of design of the new road. In the areas where pot holes are found to develop, the ice lensing problem could originate in the foundation and may require local excavation and trucking away of the frost susceptible materials, especially where proper drainage cannot be provided.

8.5 Roadside Erosion

Erosion of the side of the road is worse from approximately chainage 20+00 to chainage 35+00 and is caused by:

- run off from the above cliff which enters the side ditch around chainage 30+00, (see Photos 14 and 15) with high energy and a load of debris; particularly in the spring.
- water pooling behind the Jersey curbs is causing localized slips to the road shoulder material (see Photo 6);
- rock fall around chainage 21+00 which blocks flow from the ditch enhancing erosion, (see Photo 13);
- Jersey barriers toppled in the ditch(see Photo 12).

9.0 Recommendations

9.1 Ditch Side Erosion

It is recommended that erosion of the side ditch is controlled by:

- adding culverts around Chainages 23+00, 27+00, 30+00 to reduce flow;
- unplugging and repairing existing culverts;
- providing energy dissipation steps in the road-side ditch;
- lining ditch with riprap, or gabion mats
- removing Jersey barriers that are no longer required after the cliff stabilization job .
- placing Jersey barriers that are required on asphalt or gabion mat.
- Ensuring accessibility of the west ditch for removal of rock debris.

9.2 Contamination of Sub-Base and Base.

It is recommended to insure separation of base and sub-base from the foundation by the use of a Geotextile, after drainage of the road has been provided, and pot hole areas treated.
For estimating purposes, use of a geotextile was assumed to be required over the whole length of the road

9.3 Road surface

As indicated above the main problems of the road surface are ice lensing (which results in pot hole in the spring), and wash-boarding.
Three options may be considered in order to reduce ice lensing and potholes formation:
1- Remove the foundation material and replace it with good granular material.
2- Control the drainage of the road by placing longitudinal perforated tile drains,
3- Insulate the road.
Option 2 is the most cost effective. The foundation of the Glen access road must be properly drained before granular sub-base and base are applied. For estimating purposes up to 3 tile drains over the length of the road were assumed to be necessary.
With respect to wash-boarding, although a new granular sub-base and base will greatly enhance the condition of the Glen access road, a gravel surface will not resolve the wash-boarding problem which could be dangerous for flat beds trucks loaded with heavy and costly equipment and rolling down steep and slopes, and turning road. It is therefore recommended to consider the option of paving the Glen access road.

10 Maintenance Work

Until such time that a rehabilitation project of the Glen access road is approved and carried out, the following maintenance items should be carried out immediately or as soon as possible:

1- blast / or break apart with a hoe ram, and remove large rocks debris fallen in the ditch.
2- free the inlet of all plugged culverts.
3- scarify road , re grade and recompact. Although this not will solve the deep rooted problem it should be temporarily good enough in order to maintain the road for 1998-1999 until it is upgraded .

11.0 COST ESTIMATES FOR ROAD REHABILITATION

Two alternatives and preliminary budget estimates are presented for the rehabilitation of the road.

11.1 Alternative One-Rehabilitation and Paving.

In this alternative, three longitudinal drains are installed, base and subbase are stripped and the subgrade is compacted. Filter fabric and Geogrid are placed on the foundation, overlain by 24 inches of granular B material and 12 inches of granular A material.
The side road ditch is riprapped or protected with gabions as per figure (2) in Appendix 3. The pavement of the road consists of 4 inches of HL-3 overlaying 4 inches of HL-8. This alternative would be considered as building a new road and hence would be a capital project. See cost estimate in Appendix 2 .

11.2 Alternative Two- Rehabilitation without Paving

In this alternative, three longitudinal drains are installed, base and subbase are stripped, and the subgrade is compacted. Filter fabric and Geogrid are placed on the foundation, overlain by 24 inches of granular B material and 12 inches of granular A material.
The side road ditch is riprapped or protected gabions per Figure (3) in Appendix 3 and there is no pavement. The cost estimates for this option, as a capital project are also given in appendix 2.
Please note that these estimates are preliminary only and are intended to be used as guide to make a decision. More detailed designs and estimates would require updated longitudinal and cross sections of the road which are not available at the moment.

12 Recommended action plan:

It would not be advisable to pave the Glen access road without insuring that the ice lensing problem has been satisfactorily resolved by the foundation drainage improvement. This could take a few years of observation. In the meantime, when and if wash-boarding develops, it can be resolved temporarily by light grading the road surface. It is therefore recommended that the remedial work proceed in two phases;

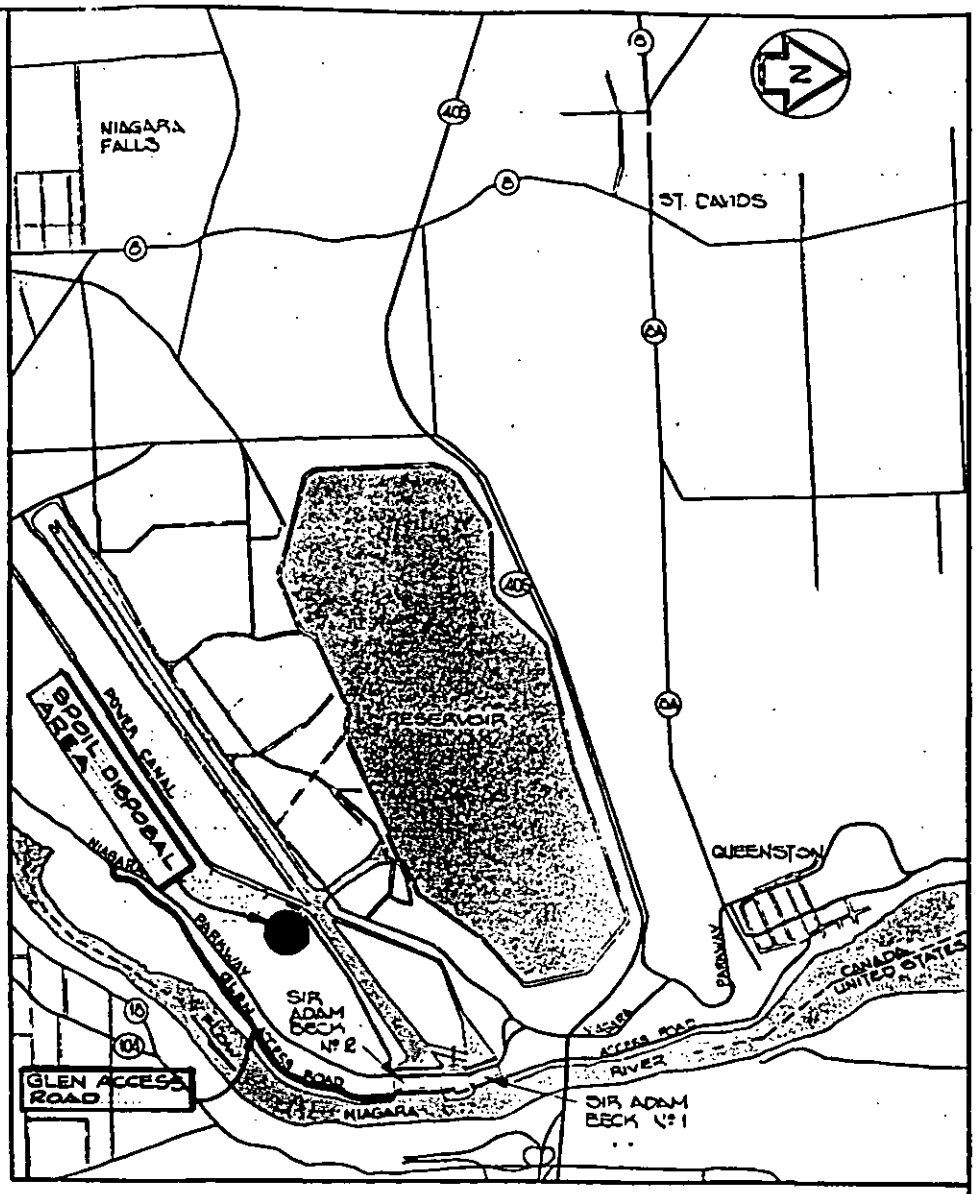
Phase 1:
Place new culverts , excavate /truck away pot hole areas as required, , place road drains, superficially rip and re-compact the road subgrade, place filter fabric and Geogrid reinforcement as required, apply and compact 24"of granular " B and 12" Granular A , place riprap in ditch,.

Phase 2:
Observe road performance over a two years period
Treat poor performance areas.
Pave road when satisfied that foundation, base and sub-base are performing as intended.
Phase 1 should be executed in year 1999 (850k) while phase 2 could be executed after at least two years of observation i.e. in year 2001 for (450 k).

A. Diallo
Geotechnical Engineer Specialist
Civil Field Services

AD:es

Attach



KEY PLAN

SCALE 1:25,000

REFERENCE

SIR ADAM BECK G.S. #2 - LOCATION PLAN
5K-385 G-D-0300 (ACRES DWG.)

NOTE

THIS DRAWING ISSUED FOR CONSTRUCTION PRIORITY 1.

FIGURE #1

GLEN ACCESS ROAD
1997 Geotechnical Assessment, Civil Field Service



PHOTO 1 - "Alligator Skin"



PHOTO 2 - Access road - Alligator Skin from Chainage 0+00 to 2+00

GLEN ACCESS ROAD
1997 Geotechnical Assessment, Civil Field Service



PHOTO 3 - Pot Holes



PHOTO 4 - 2 Feet Wide Pot Holes 6 Inches Deep from Chainage 2 +50 to 5 + 00

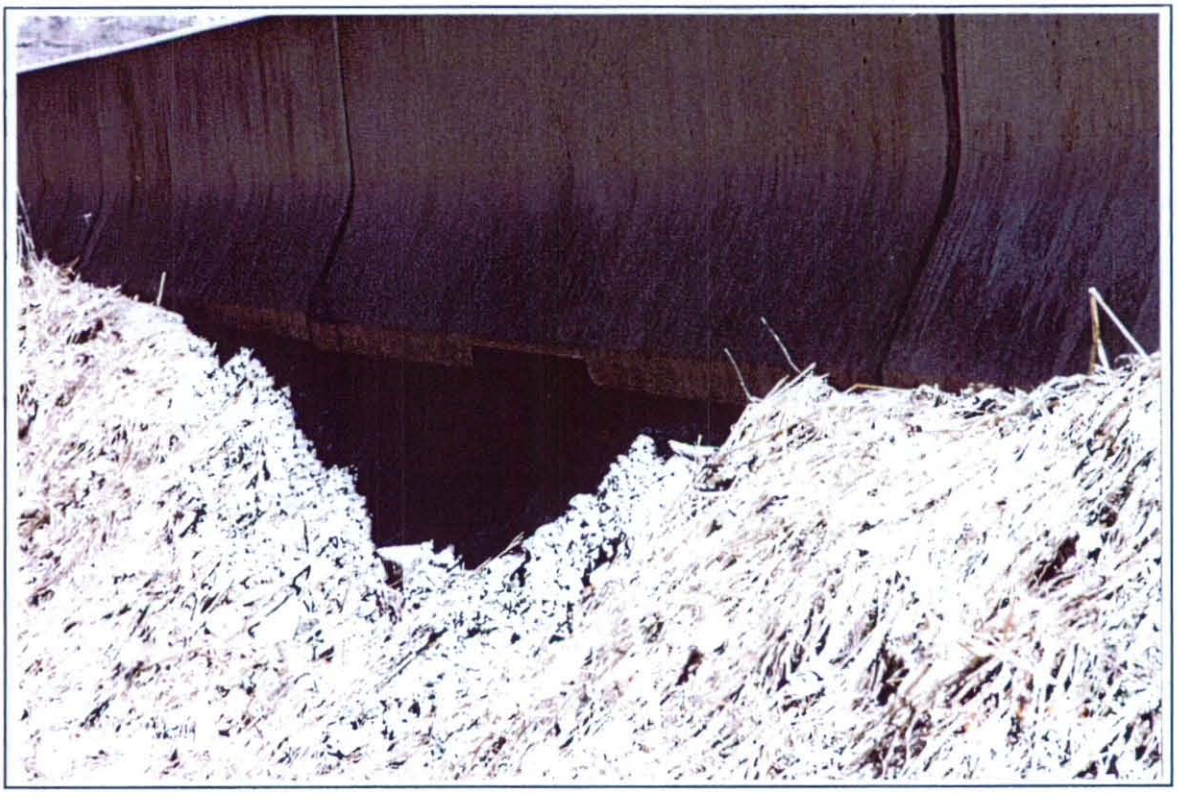


PHOTO 5 - Undercutting of the Jersey Barriers at Drain



PHOTO 6 - Undermining of the Jersey Barriers

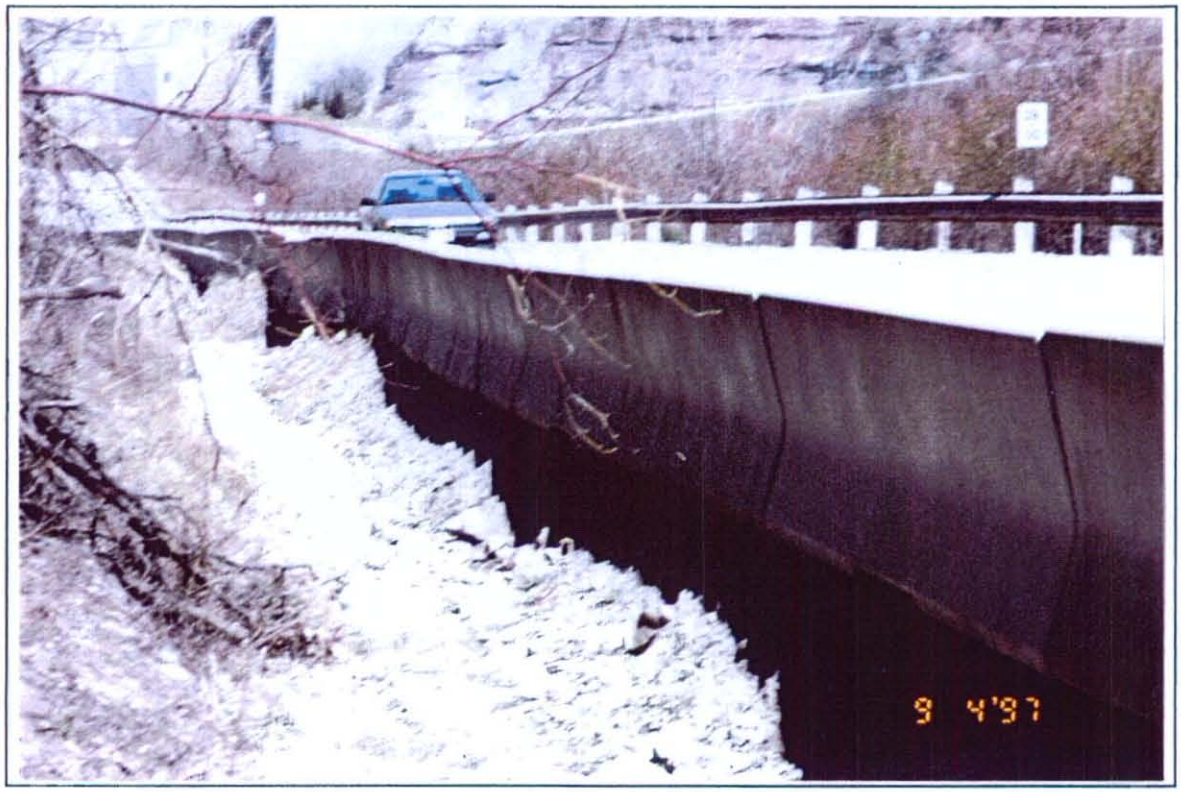


PHOTO 7 - Undermining of Jersey Barriers by Erosion of the Side Ditch



PHOTO 8 - Undercutting of Jersey Barriers by Erosion of the Road Side Ditch



PHOTO 9 - Plugged Culvert at Chainage 23+60



PHOTO 10 - Plugged Culvert at Chainage 23+60



PHOTO 11 - Chainage 35 + 80 Culvert Entrance Plugged with Debris



PHOTO 12 - Toppled Jersey Barriers in Ditch

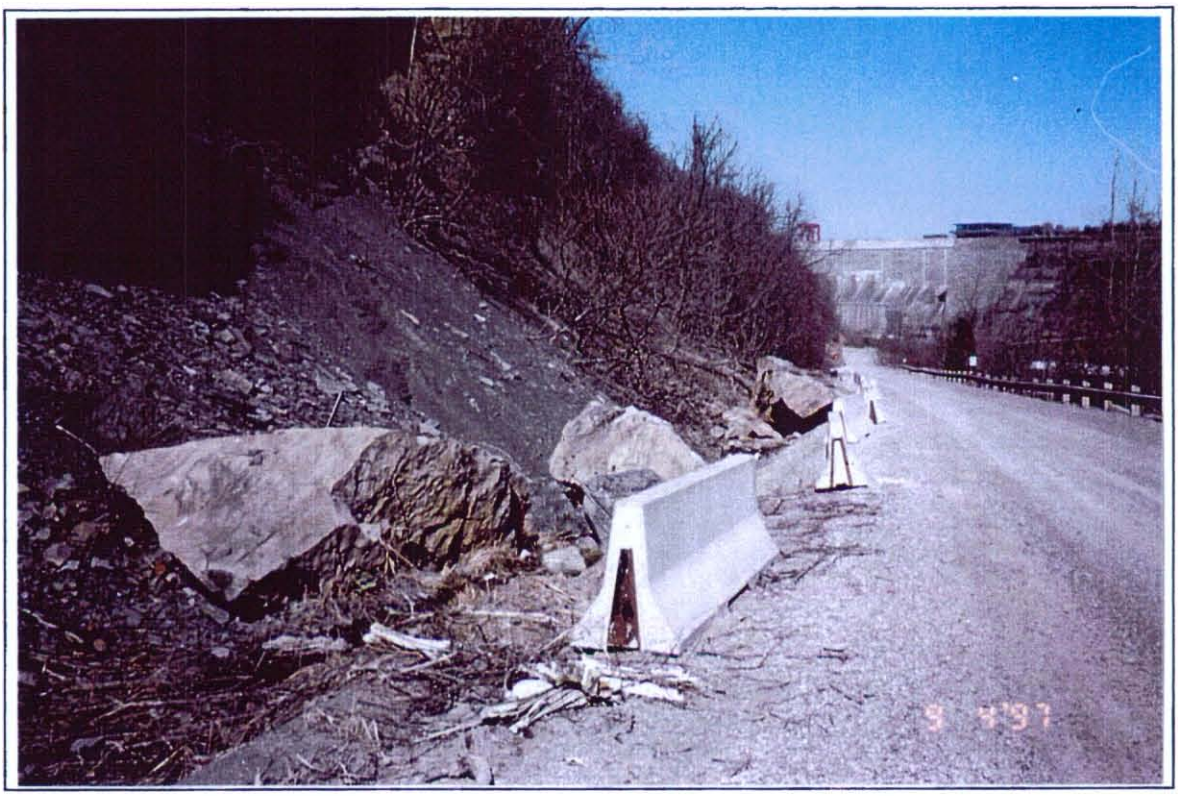


PHOTO 13 - Rockfall Blocking Roadside Ditch at Chainage 21 + 00

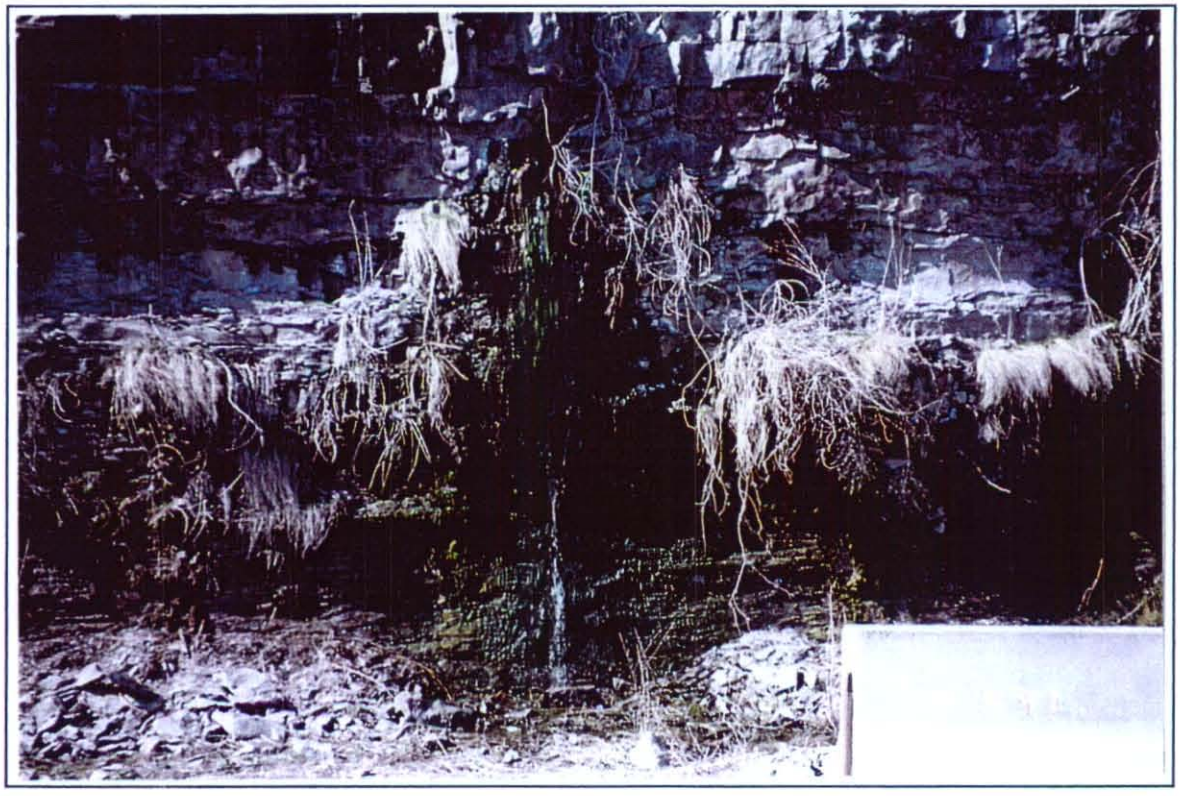


PHOTO 14 - Water from Cliff at Chainage 30 + 00, Causing Erosion of Roadside Ditch

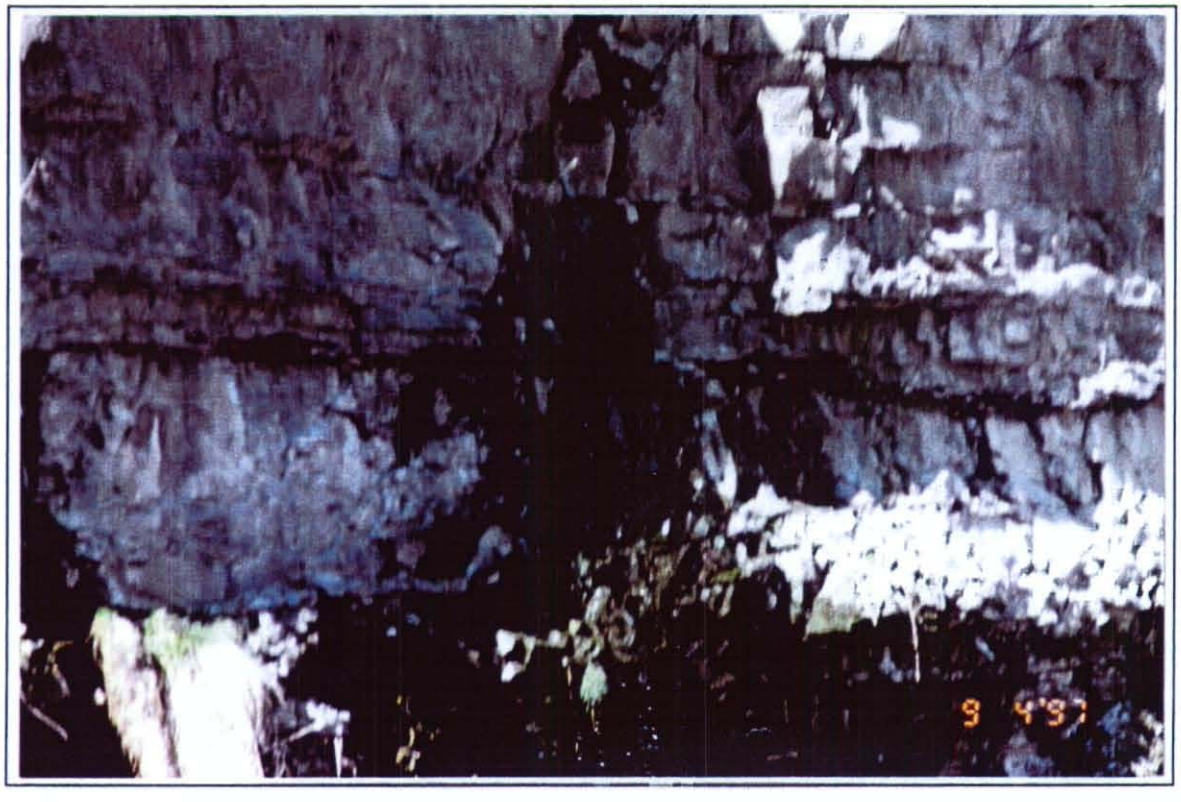


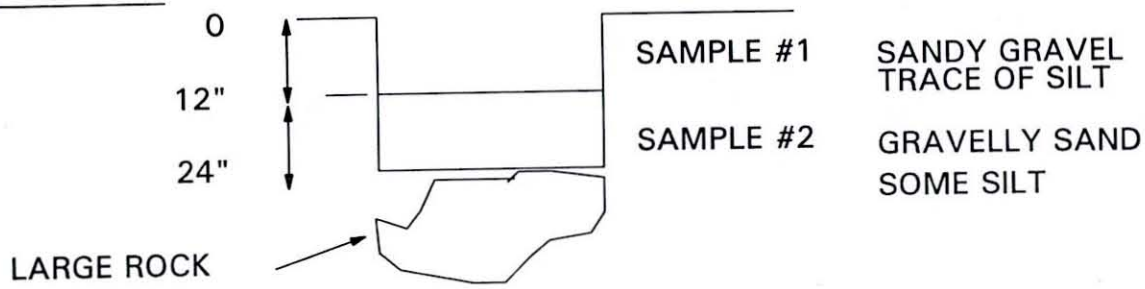
PHOTO 15 - Water from Cliff at Chainage 30 + 00 Causing Erosion of Roadside Ditch

APPENDIX 1

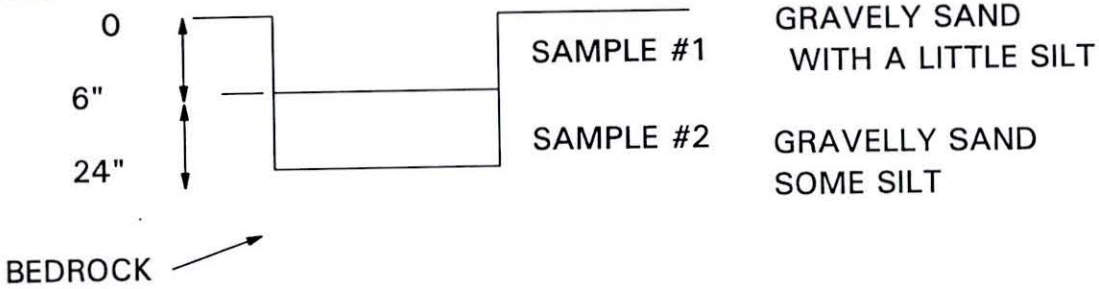
GLEN ACCESS ROAD

TEST PITS

CHAINAGE 3+00



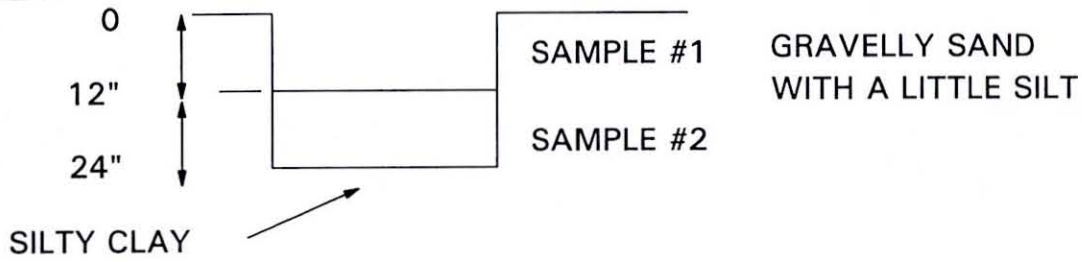
CHAINAGE 8+00



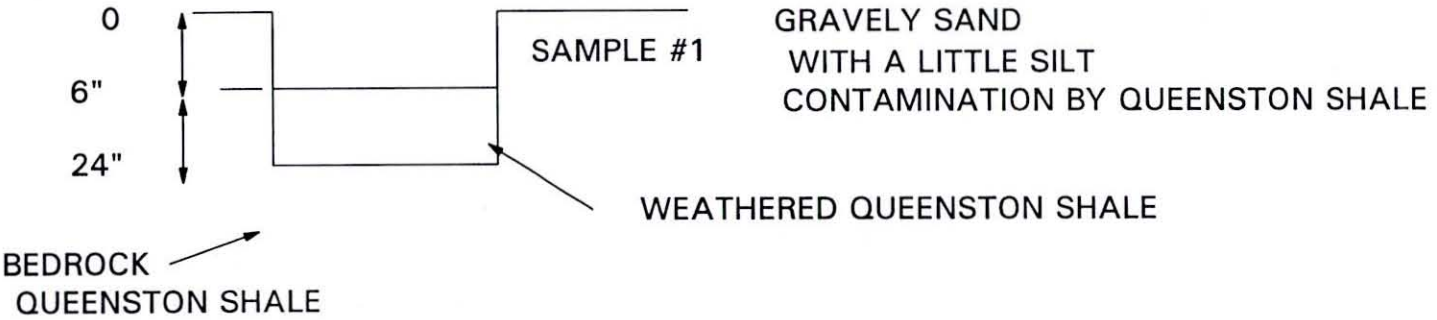
GLEN ACCESS ROAD

TEST PITS

CHAINAGE 35+00

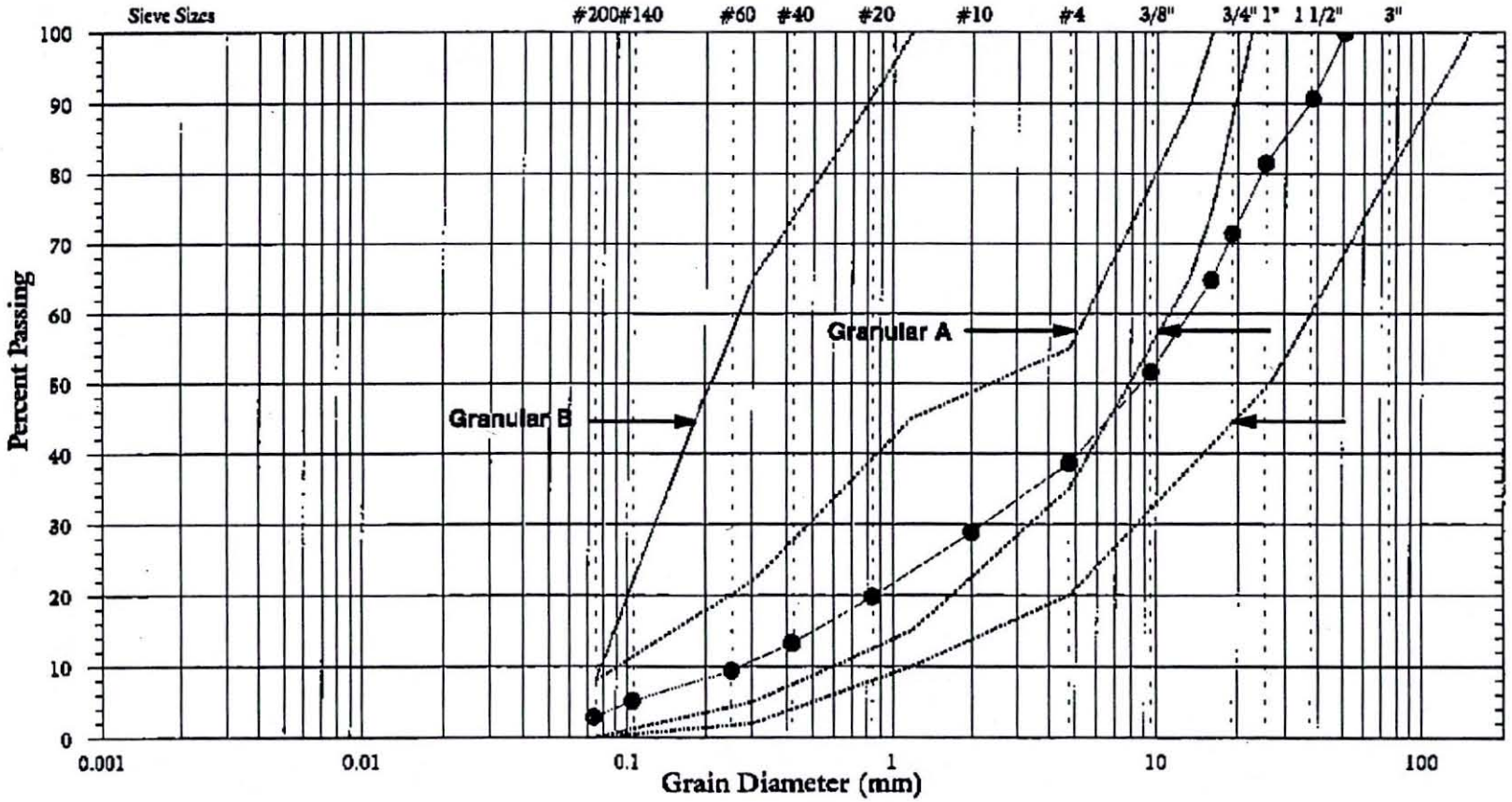


CHAINAGE 56+00



GRAIN SIZE ANALYSIS

Project : *Niagara Road Work - April 97 - BH-1, S-1 (3+00)*





Clay	Silt	Sand			Gravel		Cobbles
		Fine	Medium	Coarse	Fine	Coarse	

UNIFIED SOIL CLASSIFICATION

Gravel
Sand
Silt
Clay

BOREHOLE : BH-1

SAMPLE : S-1

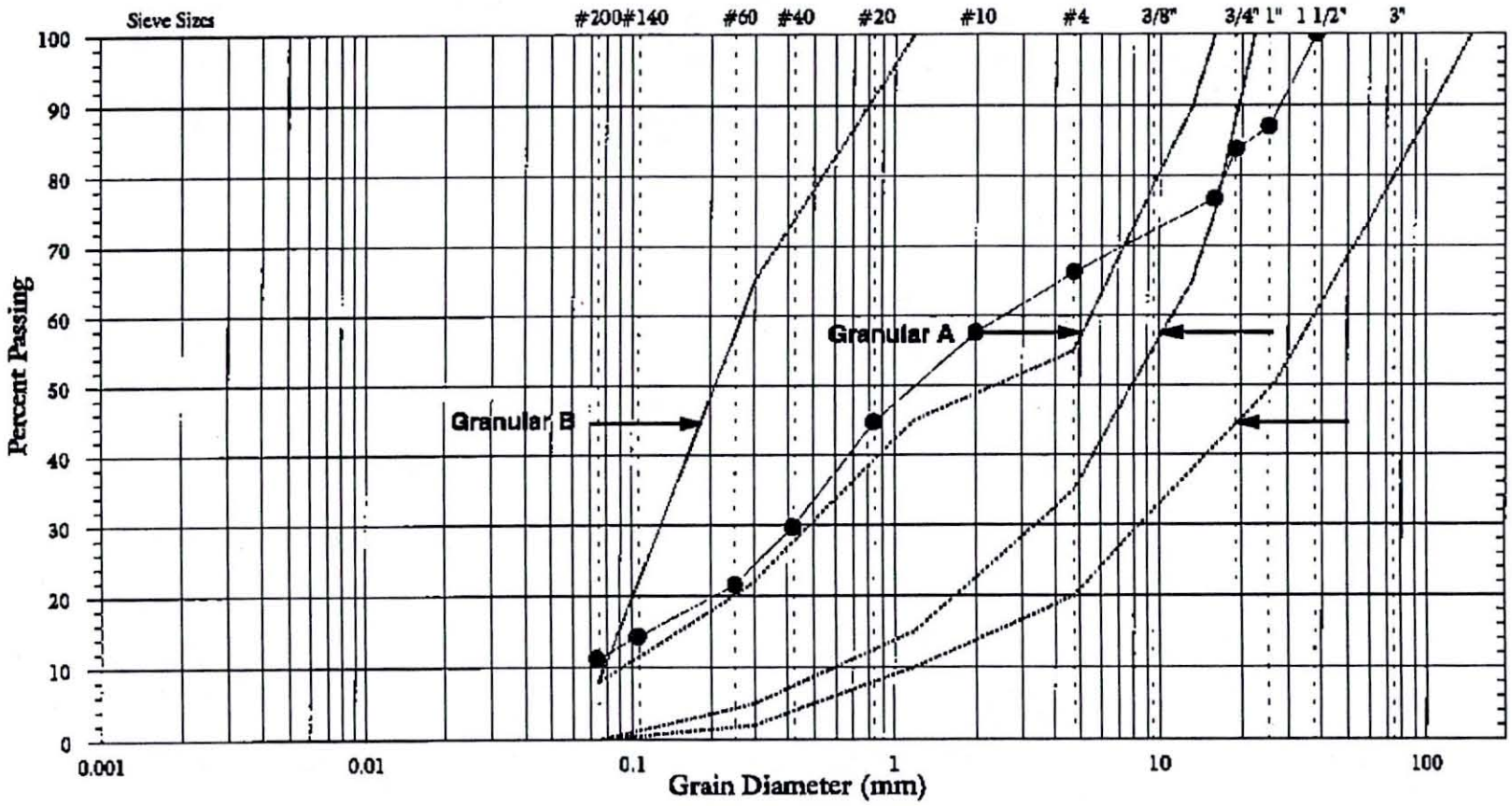
DEPTH : 0-12 in

DESCRIPTION : Sandy GRAVEL with a trace of Silt

Ontario Hydro *TECHNOLOGIES*

GRAIN SIZE ANALYSIS

Project : *Niagara Road Work - April 97 - BH-1, S-2 (3+00)*



Clay	Silt	Sand			Gravel		Cobbles
		Fine	Medium	Coarse	Fine	Coarse	

UNIFIED SOIL CLASSIFICATION

Gravel
Sand
Silt
Clay

BOREHOLE : BH-1

SAMPLE : S-2

DEPTH : 12-24 in

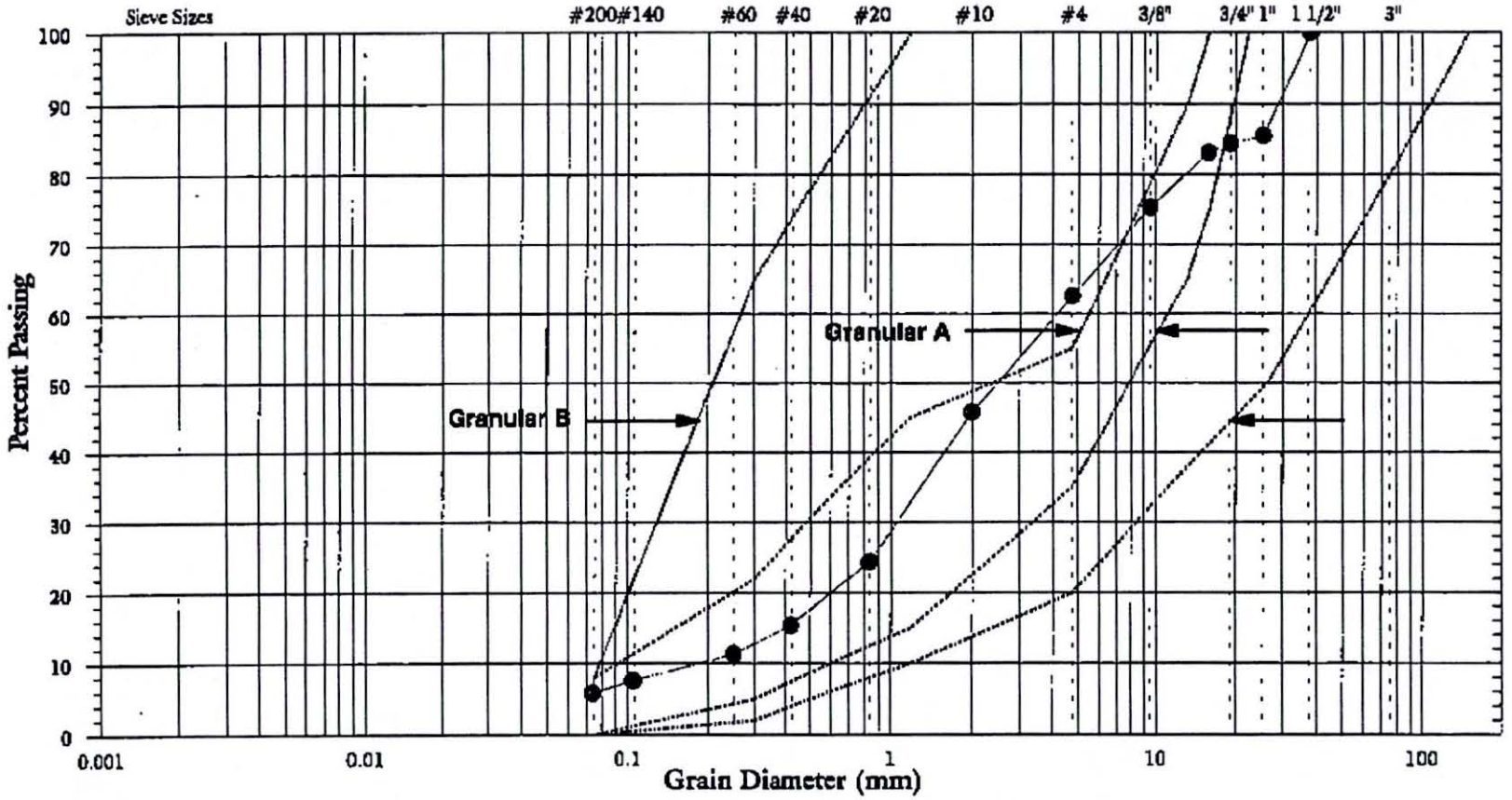
DESCRIPTION : Gravelly SAND with some silt.

Ontario Hydro
TECHNOLOGIES

04/29/97 10:17 FAX 4162341511 003

GRAIN SIZE ANALYSIS

Project : *Niagara Road Work - April 97 - BH-2, S-1 (8+00)*





Gravel
Sand
Silt
Clay

Clay	Silt	Sand			Gravel		Cobbles
		Fine	Medium	Coarse	Fine	Coarse	

UNIFIED SOIL CLASSIFICATION

BOREHOLE : BH-2

SAMPLE : S-1

DEPTH : 0-6 in

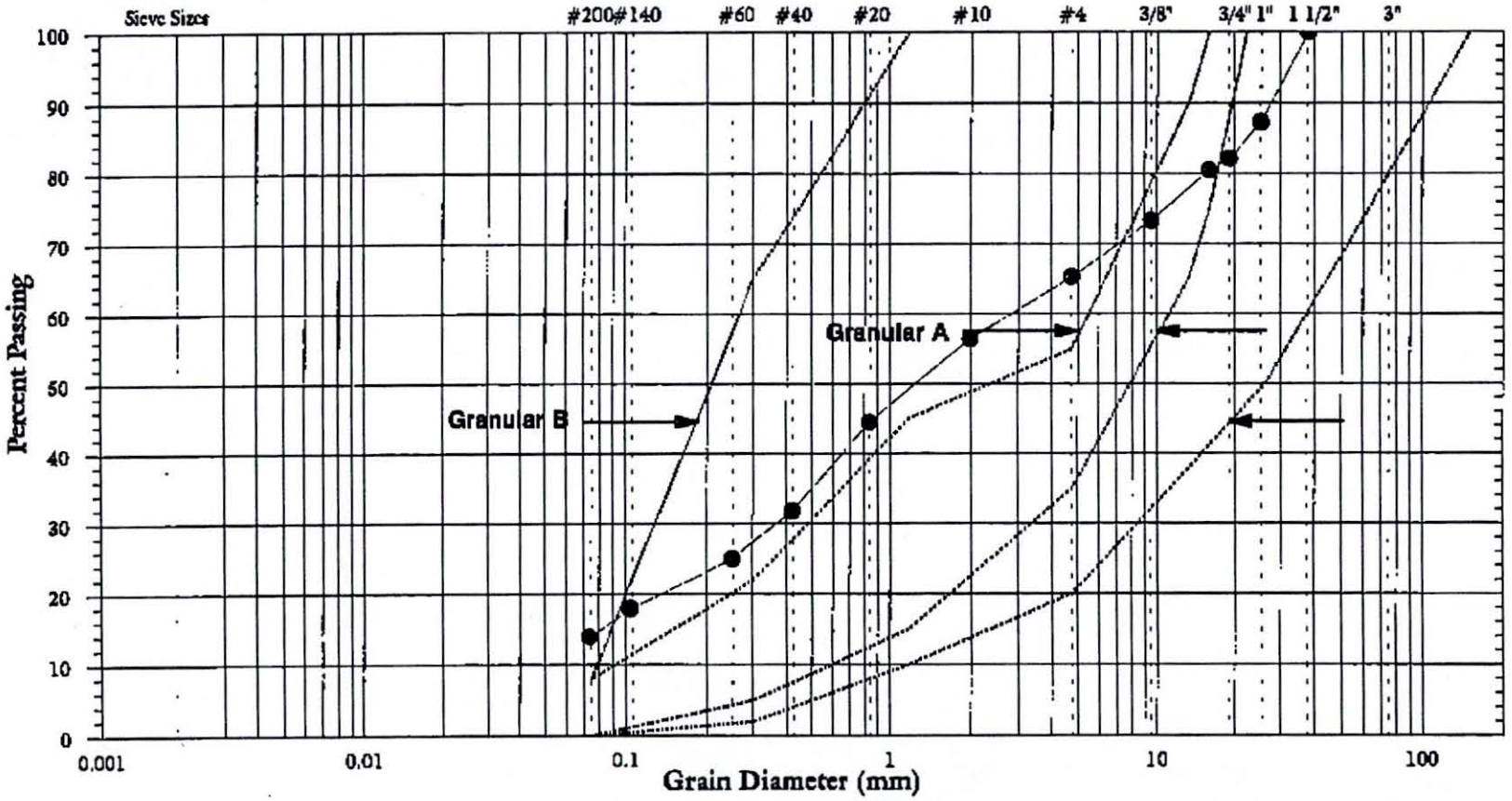
DESCRIPTION : Gravelly SAND with a little silt.

Ontario Hydro TECHNOLOGIES

04/29/97 10:17 FAX 4162341511 004

GRAIN SIZE ANALYSIS

Project : *Niagara Road Work - April 97 - BH-2, S-2 (8+00)*



Clay	Silt	Sand			Gravel		Cobbles
		Fine	Medium	Coarse	Fine	Coarse	

UNIFIED SOIL CLASSIFICATION



BOREHOLE : BH-2

SAMPLE : S-2

DEPTH : 6-18 in

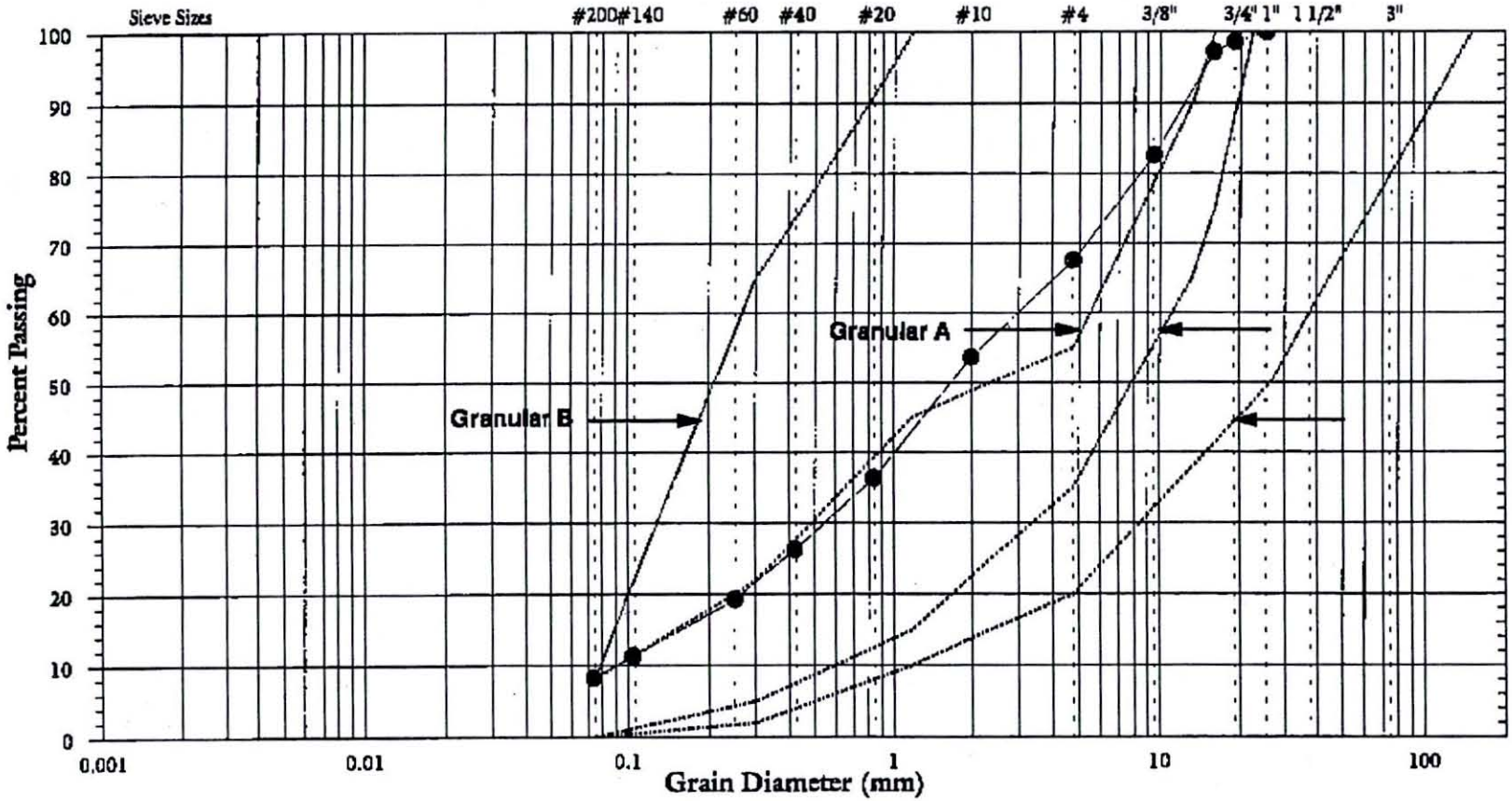
DESCRIPTION : Gravelly SAND with some silt.

Ontario Hydro *TECHNOLOGIES*

04/29/97 10:17 FAX 4162341511 005

GRAIN SIZE ANALYSIS

Project : *Niagara Road Work - April 97 - BH-3, S-1 (35+00)*





Clay	Silt	Sand			Gravel		Cobbles
		Fine	Medium	Coarse	Fine	Coarse	

Gravel
Sand
Silt
Clay

UNIFIED SOIL CLASSIFICATION

BOREHOLE : BH-3

SAMPLE : S-1

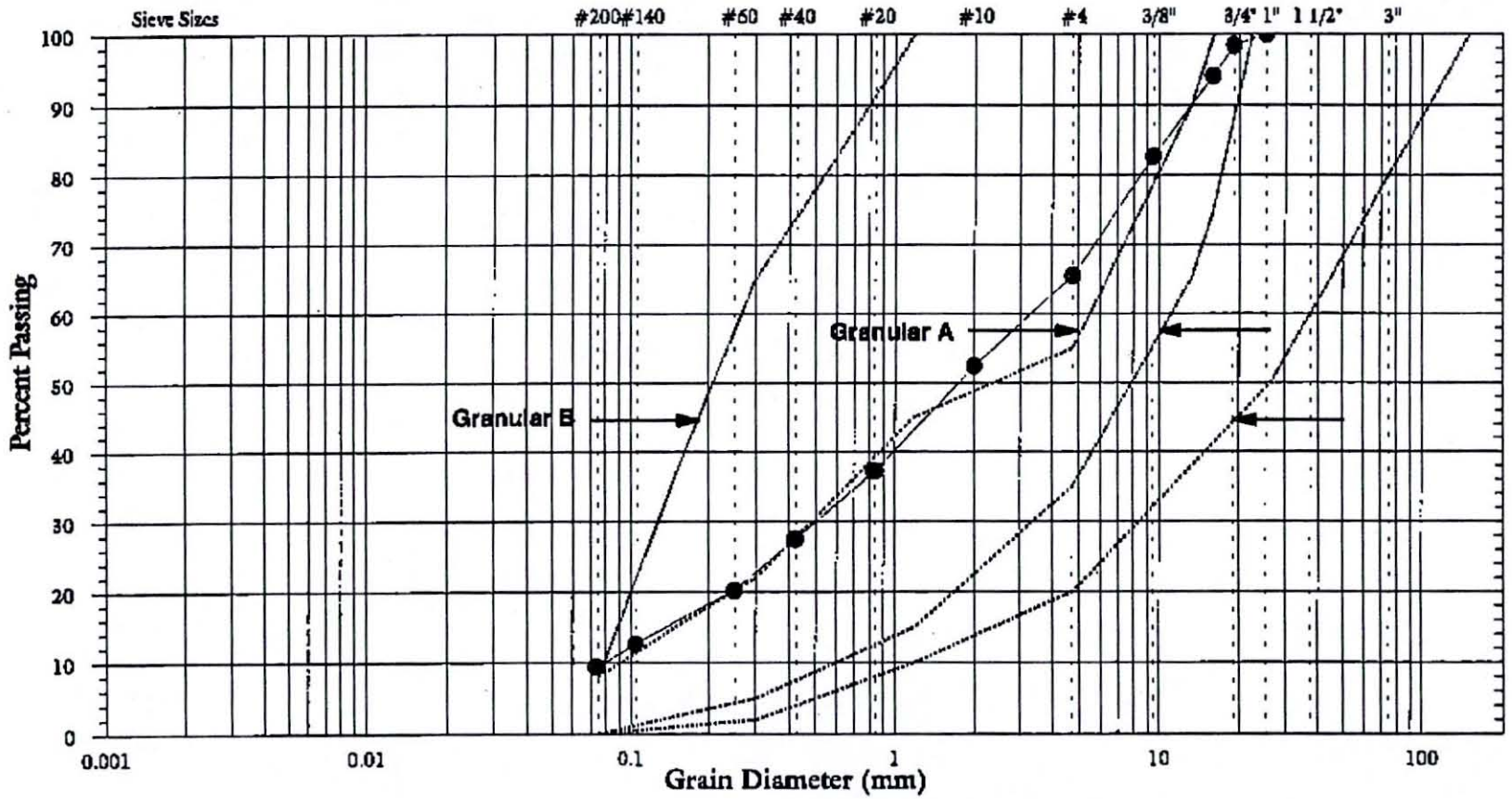
DEPTH : 0-12 in

DESCRIPTION : Gravelly SAND with a little silt.

Ontario Hydro *TECHNOLOGIES*

GRAIN SIZE ANALYSIS

Project : *Niagara Road Work - April 97 - BH-3, S-2 (35+00)*



Clay	Silt	Sand			Gravel		Cobbles
		Fine	Medium	Coarse	Fine	Coarse	

UNIFIED SOIL CLASSIFICATION



BOREHOLE : BH-3

SAMPLE : S-2

DEPTH : 12-24 in

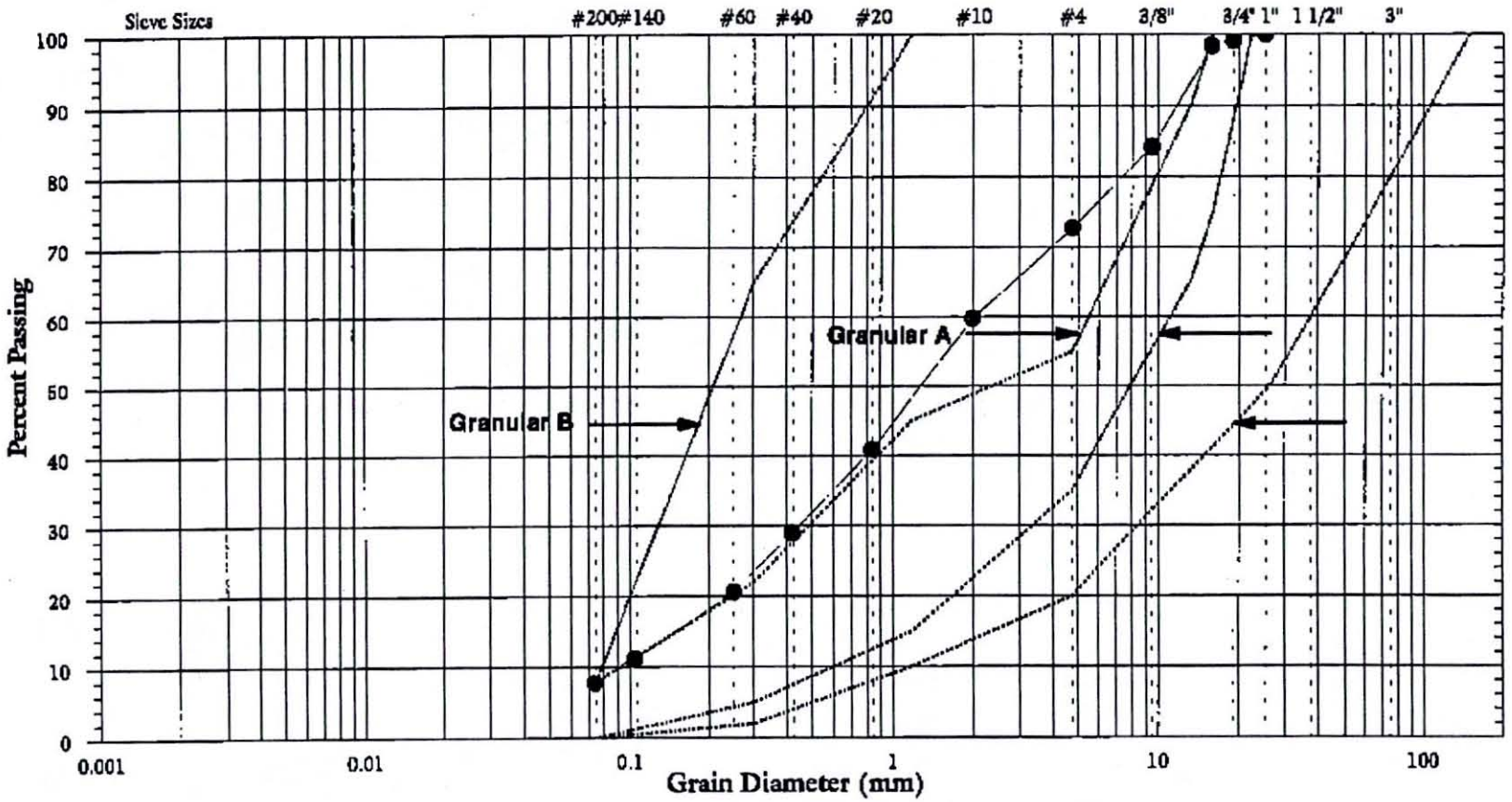
DESCRIPTION : Gravelly SAND with a little silt.

Ontario Hydro TECHNOLOGIES

04/29/97 10:17 FAX 4162341511 007

GRAIN SIZE ANALYSIS

Project : *Niagara Road Work - April 97 - BH-4, S-1 (56+00)*



Clay	Silt	Sand			Gravel		Cobbles
		Fine	Medium	Coarse	Fine	Coarse	

UNIFIED SOIL CLASSIFICATION



BOREHOLE : BH-4

SAMPLE : S-1

DEPTH : 0-6 in

DESCRIPTION : Gravelly SAND with a little silt.

Ontario Hydro TECHNOLOGIES

04/29/97 10:17 FAX 4162341511 008

APPENDIX 2

Preliminary Estimate
Glen Access Road
Alternative #1: Rehabilitation and Paving.as a Capital Project

HBU LABOUR		
Quality Control	- 280 hrs @ $39 (PWU)	10900
Drafting	- 280 hrs @ $39	10900
Project Management	(14hrs/week x 16 weeks) @ $56/hr	12544
Subtotal HBU Labour		**34344**
CONTRACT LABOUR & MATERIALS		
Direct Materials		
- Granular A (12") + Granular B (24") - 27600 tons @ $10/t		276000
- Filter Fabric ≈ 260.000 ft -sq @ $.10/ft sq		26000
- Geo Grid ≈ 163.000 ft-sq^2@ $.20/t		32600
- Three 24" ⌀ culvert, 60 feet long @ $60/ft		10800
- Three 12 " ⌀ perforated tile drains. 6500 feet long @ $1/ft		19500
Contract Labour & Materials		
- Rip-rap 11000 tons @ $12/ton		120000
- Paving : 4" HL3 over 4" HL8, 7500t @ $50/t		375000
- Paving - stop/roadmesh ($5/m^2) x 8.000 m^2 (Maccaferri)		40000
- Replace 6500 feet of guardrail at $20/ft		130000
Subtotal Labour & Materials		**1029900**
OVERHEAD/INTEREST/CONTINGENCIES		
HBU Overhead	= 1.25 (34344)	42930
Corporate Overhead	= .02 (1029900+42930+34344)	22144
Interest	= 0.05 (22144 + 42930 + 1029900 + 34344)	56466
Contingency	= 0.1 (56466+42930+34344+22144+1029900)	118578
Subtotal Overhead/Interest/Contingencies		**240118**
TOTAL		**1,304,362**

Preliminary Estimate
Glen Access Road
Alternative #2: No Paving - Capital Project

HBU LABOUR		
Quality Control	- 280 hrs @ $39 (PWU)	10900
Drafting	- 280 hrs @ $39	10900
Project Management	(14hrs/week x 16 weeks) @ $56/hr	12544
Subtotal HBU Labour		**34344**
CONTRACT LABOUR & MATERIALS		
Direct Materials		
-	Granular A (12") + Granular B (24") - 27600 tons @ $10/t	276000
-	Filter Fabric ≈ 260.000 ft -sq @ $.10/ft sq	26000
-	Geo Grid ≈ 163.000 ft-sq^2@ $.20/t	32600
-	Three 24" ⌀ culvert, 60 feet long @ $60/ft	10800
-	Three 12 " ⌀ perforated tile drains. 6500 feet long @ $1/ft	19500
Contract Labour & Materials		
-	Rip-rap 11000 tons @ $12/ton	120000
-	Replace 6500 feet of guardrail at $20/ft	130000
Subtotal Labour & Materials		**614900**
OVERHEAD/INTEREST/CONTINGENCIES		
HBU Overhead	= 1.25 (34344)	42930
Corporate Overhead	= .02 (614900+42930+34344)	13845
Interest	= 0.05 (13845 + 42930 + 614900 + 34344)	35300
Contingency	= 0.1 (35300+13845+42930+34344+614900)	74102
Subtotal Overhead/Interest/Contingencies		**166177.00**
TOTAL		**815,421**

HBU LABOUR

APPENDIX 3

GLEN ACCESS ROAD

TYPICAL DESIGN

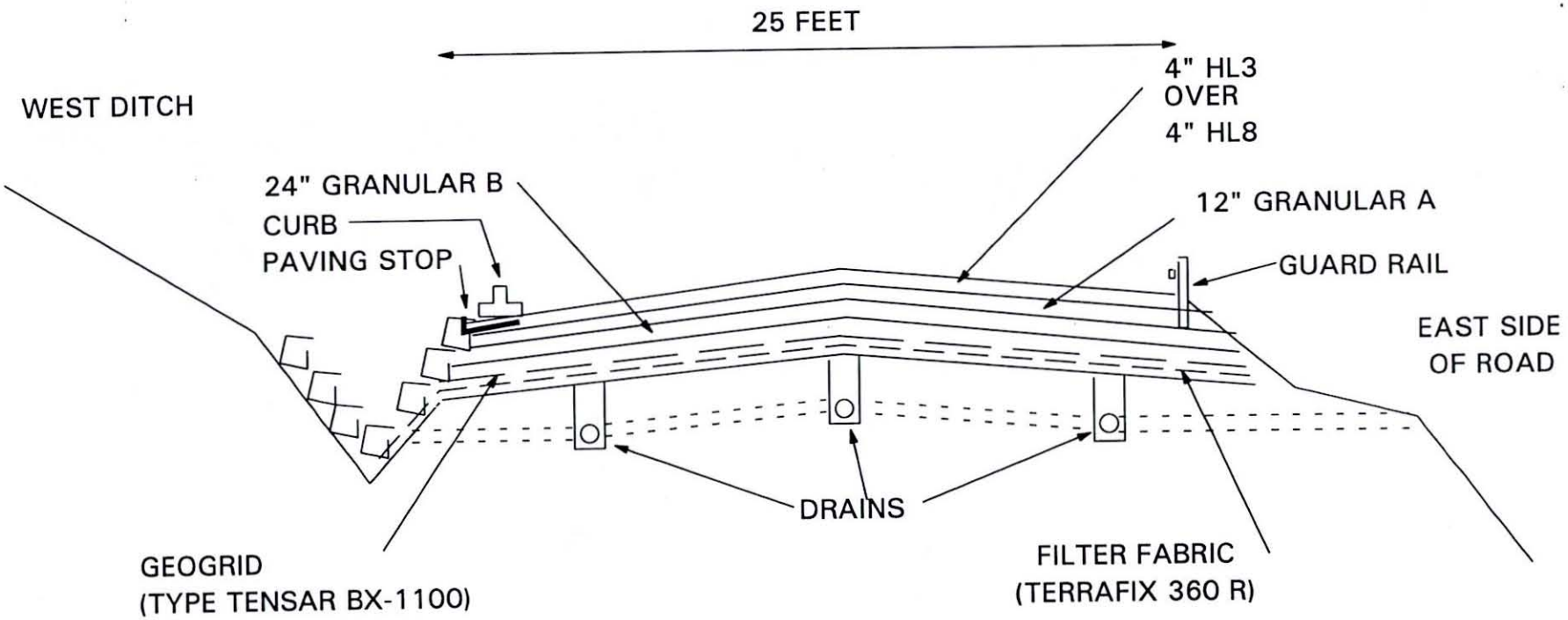


FIGURE 2

GLEN ACCESS ROAD
TYPICAL DESIGN

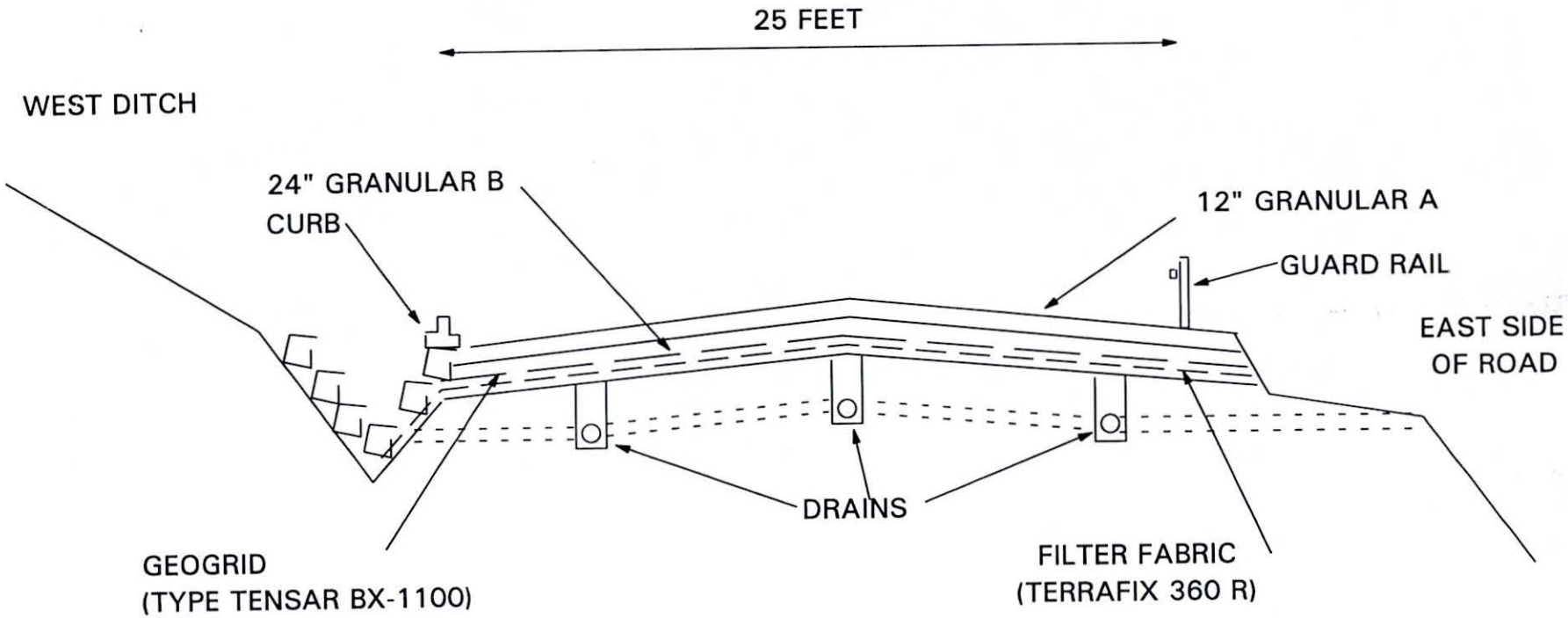


FIGURE 3

SECTION @ 56+00
SCALE 1"=5'

335.00 340.00 345.00

TOP SLOPE 335.69
SHOULDER 337.69
B/L 338.29
EDGE OF ROAD 338.59
℄ ROAD 338.99
EDGE OF ROAD 338.89
TOE OF BARRIER 338.69
TOP OF BARRIER 341.19
TOE OF BARRIER 338.49
TOP SLOPE 338.19
℄ DITCH 335.89

SECTION @ 64+00
SCALE 1"=5'

295.00 300.00 305.00

TOP SLOPE 296.7
GROUND 297.8
TOE SHOULDER 298.4
B/L 299.1
EDGE OF ROAD 299.1
℄ Rd 299.3
EDGE OF ROAD 299.0
SHOULDER 298.6
DITCH 297.8
TOE BLOCKS 298.3
TOP BLOCKS 300.8

PROFILE ALONG ℄ Rd
SCALE 1"=50'

250.00 300.00 350.00 400.00 450.00 500.00 550.00 600.00

65+50
65+00
64+50
64+00
63+50
63+00
62+50
62+00
61+50
61+00
60+50
60+00
59+50
59+00
58+50
58+00
57+50
57+00
56+50
56+00
55+50
55+00
54+50
54+00
53+50
53+00
52+50
52+00
51+50
51+00

℄ Rd @ GATE 294
℄ Rd 294.85
LOCATION OF 3'x4' CONCRETE CULVERT 60' LONG (ACROSS ROAD)
℄ Rd 296.95
℄ Rd 299.30
℄ Rd 300.80
℄ Rd 303.10
℄ Rd 305.65
℄ Rd 307.75
℄ Rd 310.25
℄ Rd 312.85
℄ Rd 315.78
℄ Rd 318.88
℄ Rd 321.88
LOCATION OF 24" CULVERT 60' LONG (LONGITUDINAL)
℄ Rd 324.80
℄ Rd 328.30
℄ Rd 331.60
℄ Rd 334.20
℄ Rd 336.10
℄ Rd 337.72
← TEST PIT #4
℄ Rd 338.99
℄ Rd 340.02
℄ Rd 340.59
℄ Rd 340.79
℄ Rd 340.89
℄ Rd 340.89
℄ Rd 340.89
℄ Rd 340.86
℄ Rd 340.36
℄ Rd 340.76
℄ Rd 340.56
℄ Rd 340.34
℄ Rd 340.44
LOCATION OF 24" CULVERT 60' LONG (ACROSS ROAD)
℄ Rd 340.64
℄ Rd 340.94

SECTION @ 52+00
SCALE 1"=5'

335.00 340.00 345.00

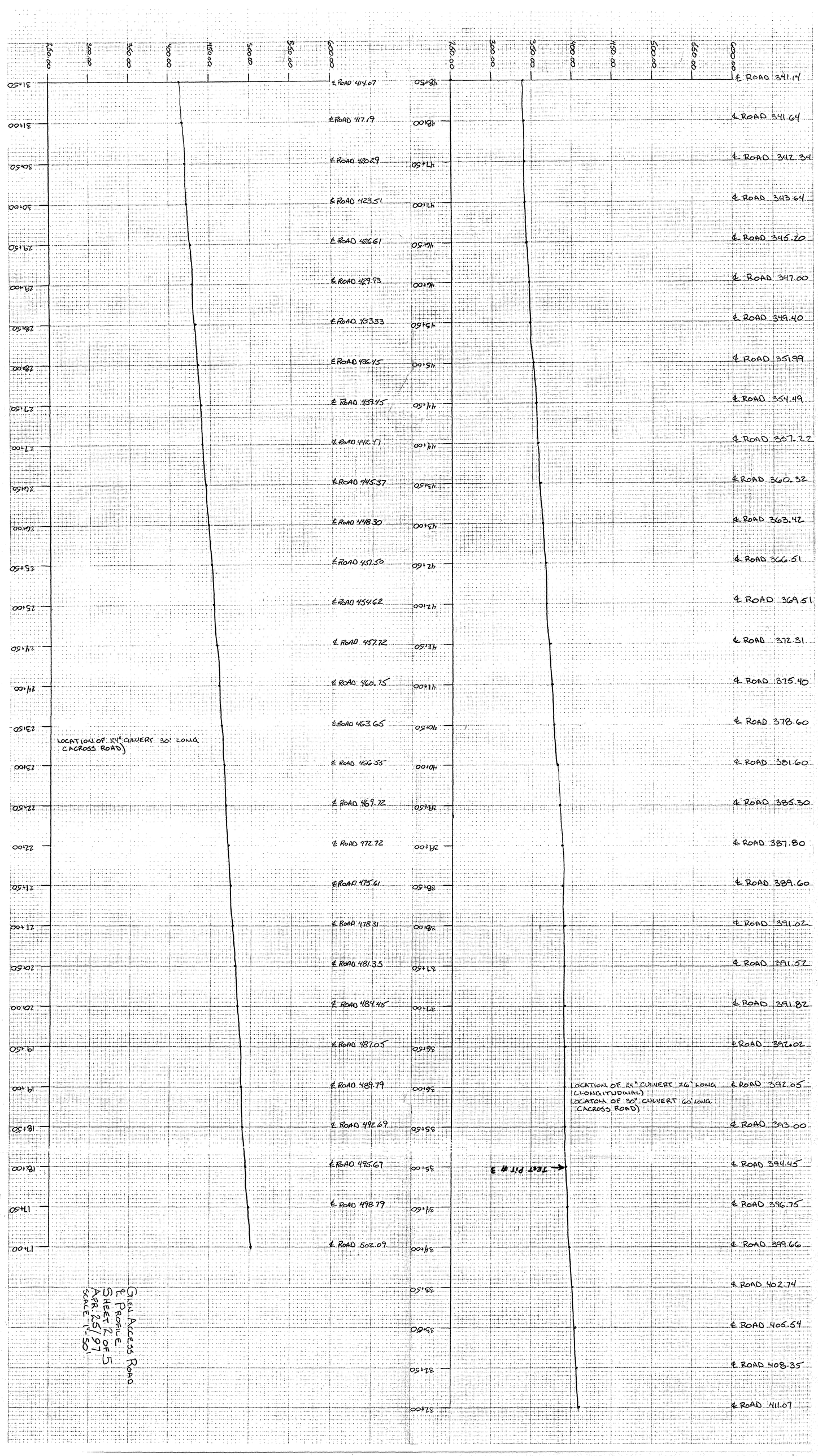
TOP SLOPE 337.86
TOE SHOULDER 339.96
B/L 340.46
EDGE ROAD 340.66
℄ ROAD 340.76
EDGE ROAD 340.36
TOE BARRIER 340.36
TOP BARRIER 342.86
TOE BARRIER 339.96
TOP DITCH SLOPE 339.76
TOE DITCH SLOPE - 336.66
TOE CLIFF SLOPE 336.56

SECTION @ 60+00
SCALE 1"=5'


315.00 320.00

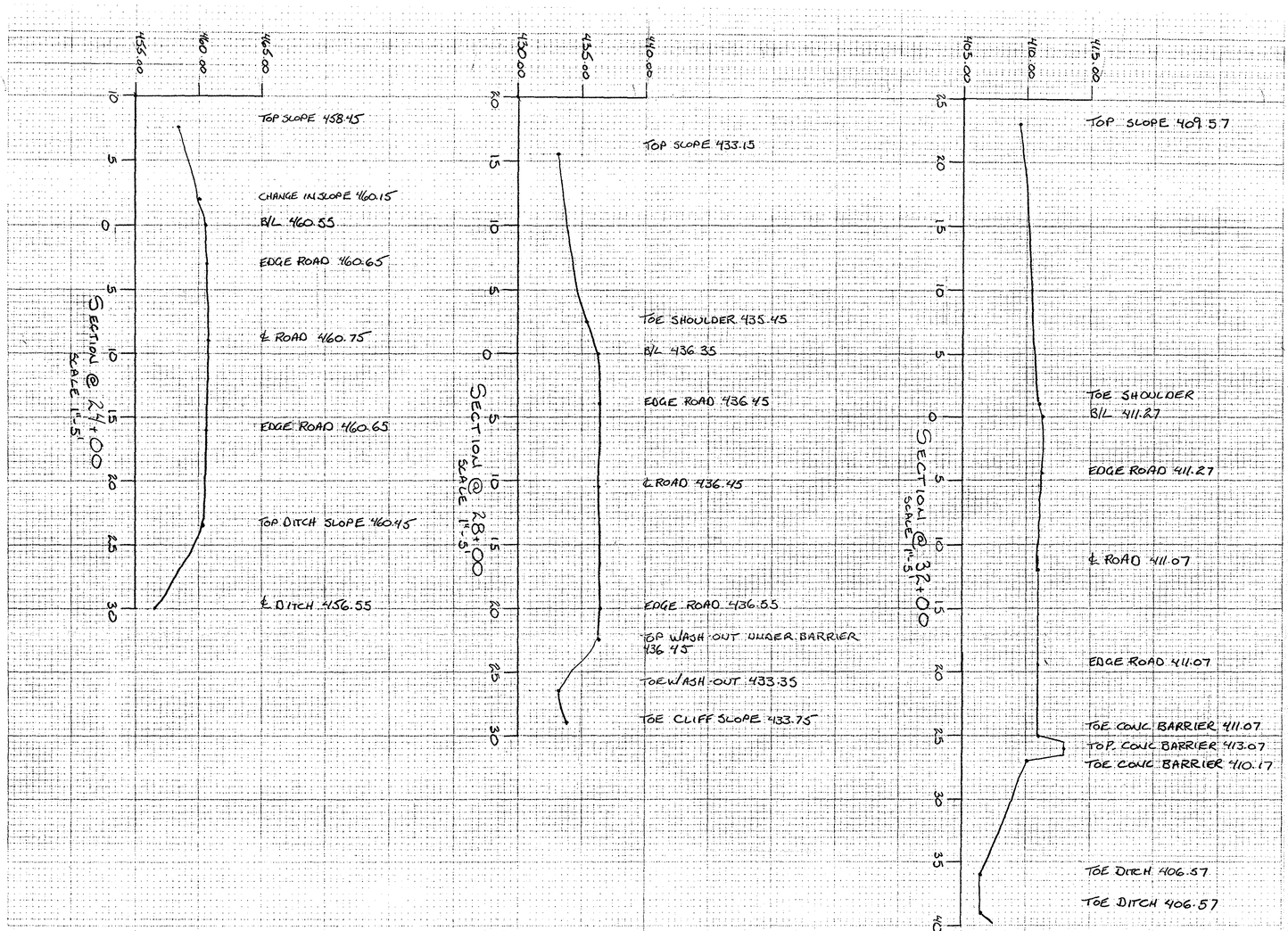
TOP SLOPE 317.38
GROUND 318.48
B/L 318.58
EDGE ROAD 318.68
℄ ROAD 318.88
EDGE ROAD 318.78
TOP DITCH SLOPE 318.18
TOE SLOPE 316.58
TOE SLOPE 316.68

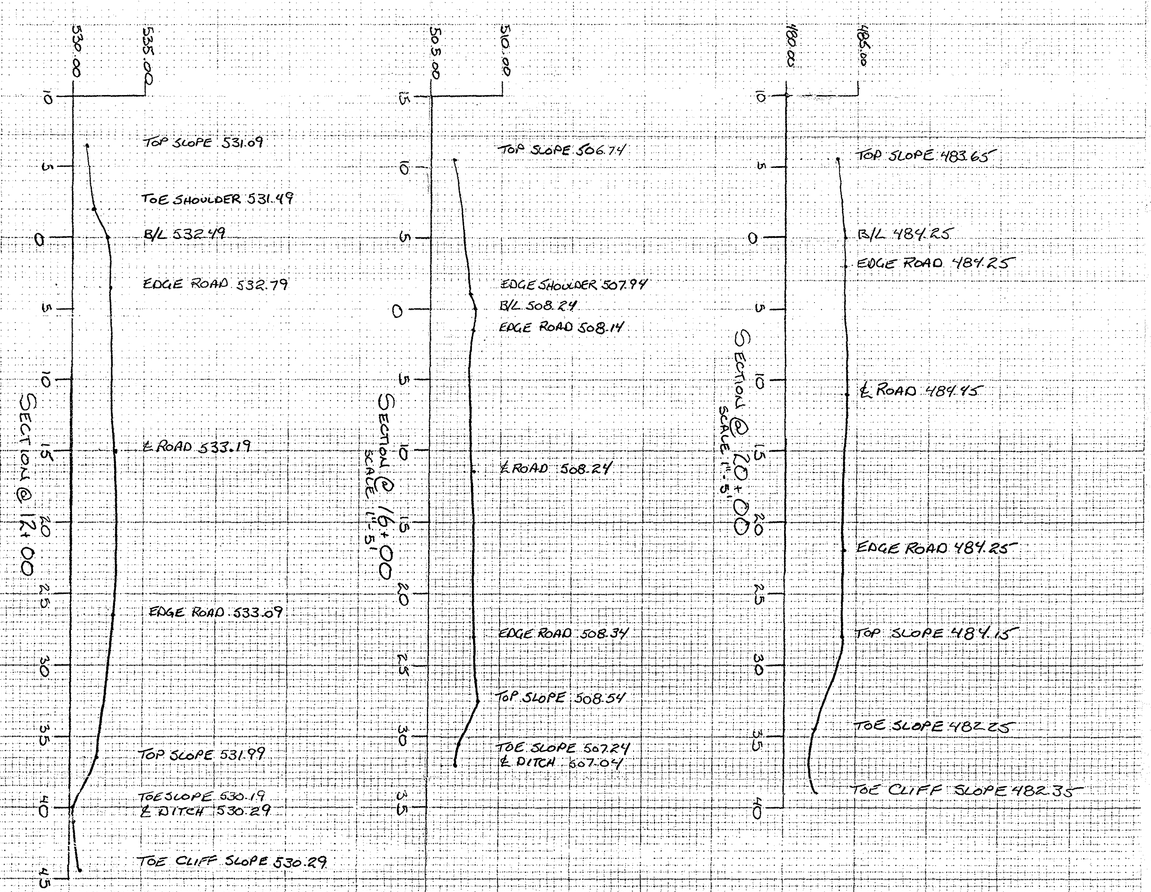
GLEN ACCESS ROAD
PROFILE + SECTIONS
SHEET 1 OF 5
APR 25/97
SCALE: AS NOTED


Glen Access Road
E Profile
Sheet 2 of 5
Apr. 25/97
Scale 1" = 50'
LOCATION OF 24" CULVERT 30' LONG (ACROSS ROAD)
LOCATION OF 24" CULVERT 26' LONG (LONGITUDINAL)
LOCATON OF 30" CULVERT 60' LONG (ACROSS ROAD)
Test Pit # 3
℄ Road 414.07
℄ Road 417.19
℄ Road 420.29
℄ Road 423.51
℄ Road 426.61
℄ Road 429.93
℄ Road 433.33
℄ Road 436.45
℄ Road 439.45
℄ Road 442.47
℄ Road 445.37
℄ Road 448.30
℄ Road 451.50
℄ Road 454.62
℄ Road 457.72
℄ Road 460.75
℄ Road 463.65
℄ Road 466.55
℄ Road 469.72
℄ Road 472.72
℄ Road 475.61
℄ Road 478.31
℄ Road 481.35
℄ Road 484.45
℄ Road 487.05
℄ Road 489.79
℄ Road 492.69
℄ Road 495.67
℄ Road 498.79
℄ Road 502.09
℄ Road 341.14
℄ Road 341.64
℄ Road 342.34
℄ Road 343.64
℄ Road 345.20
℄ Road 347.00
℄ Road 349.40
℄ Road 351.99
℄ Road 354.49
℄ Road 357.22
℄ Road 360.32
℄ Road 363.42
℄ Road 366.51
℄ Road 369.51
℄ Road 372.31
℄ Road 375.40
℄ Road 378.60
℄ Road 381.60
℄ Road 385.30
℄ Road 387.80
℄ Road 389.60
℄ Road 391.02
℄ Road 391.57
℄ Road 391.82
℄ Road 392.02
℄ Road 392.05
℄ Road 393.00
℄ Road 394.45
℄ Road 396.75
℄ Road 399.66
℄ Road 402.74
℄ Road 405.54
℄ Road 408.35
℄ Road 411.07

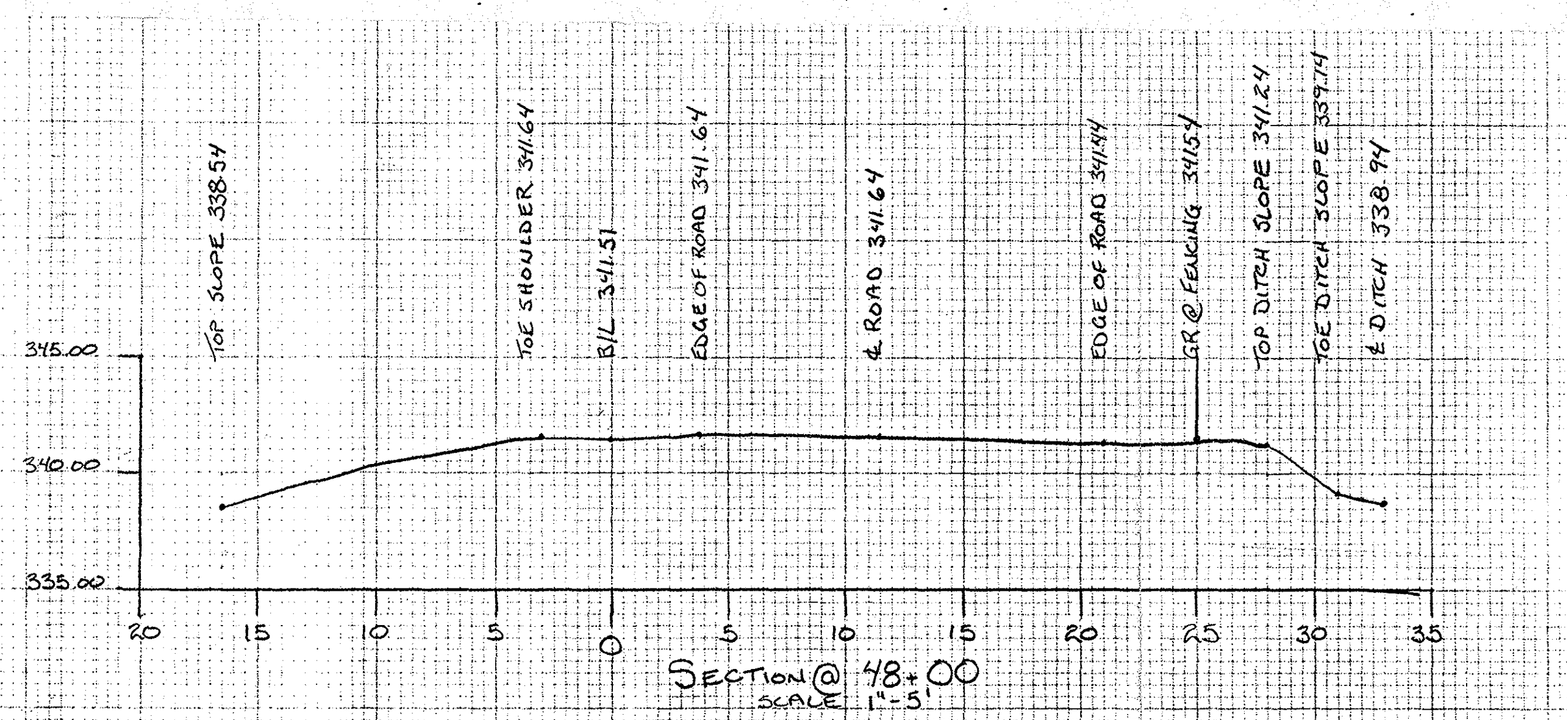
NO. 1354—CROSS SECTION 10 x 10

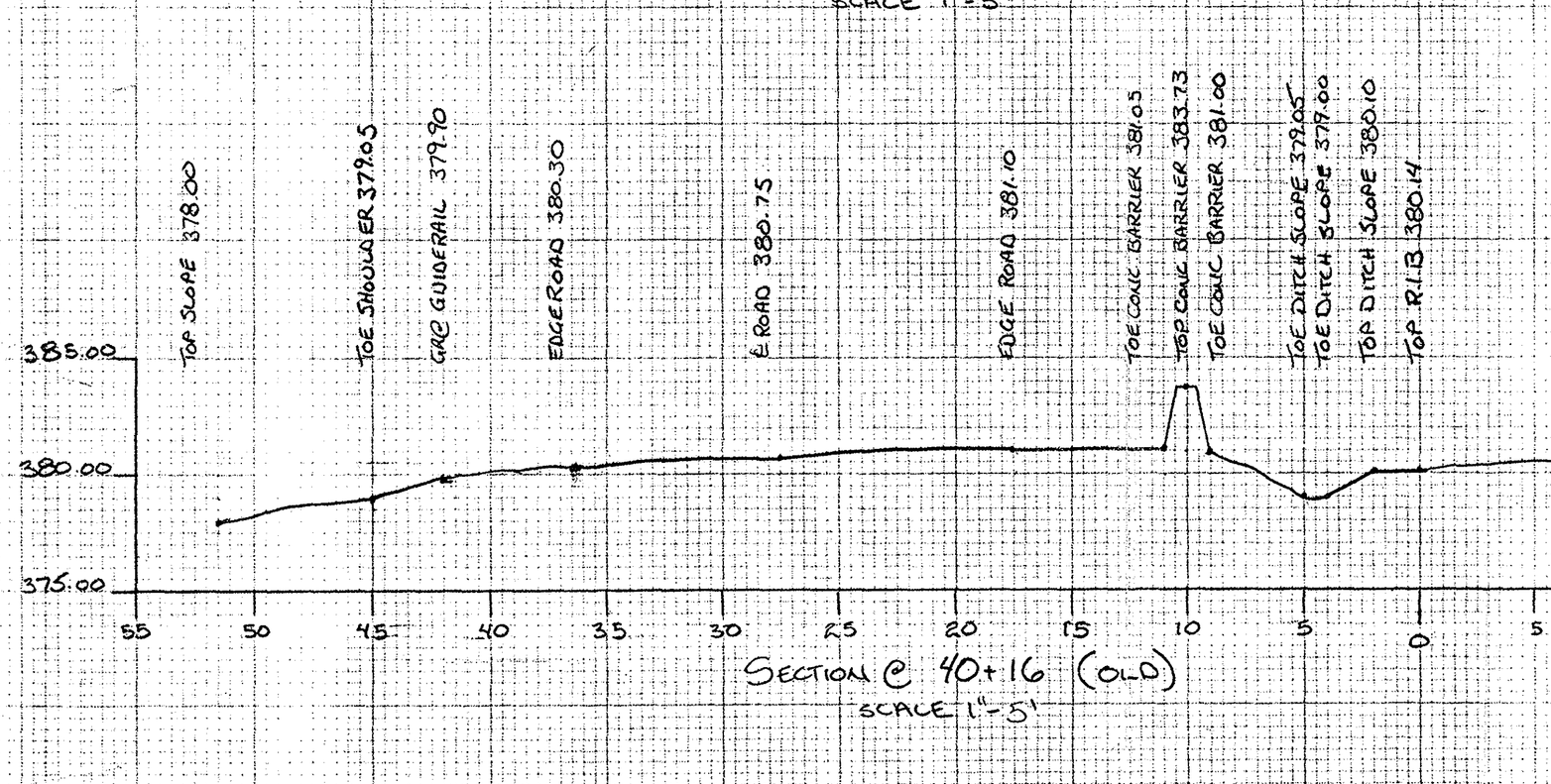


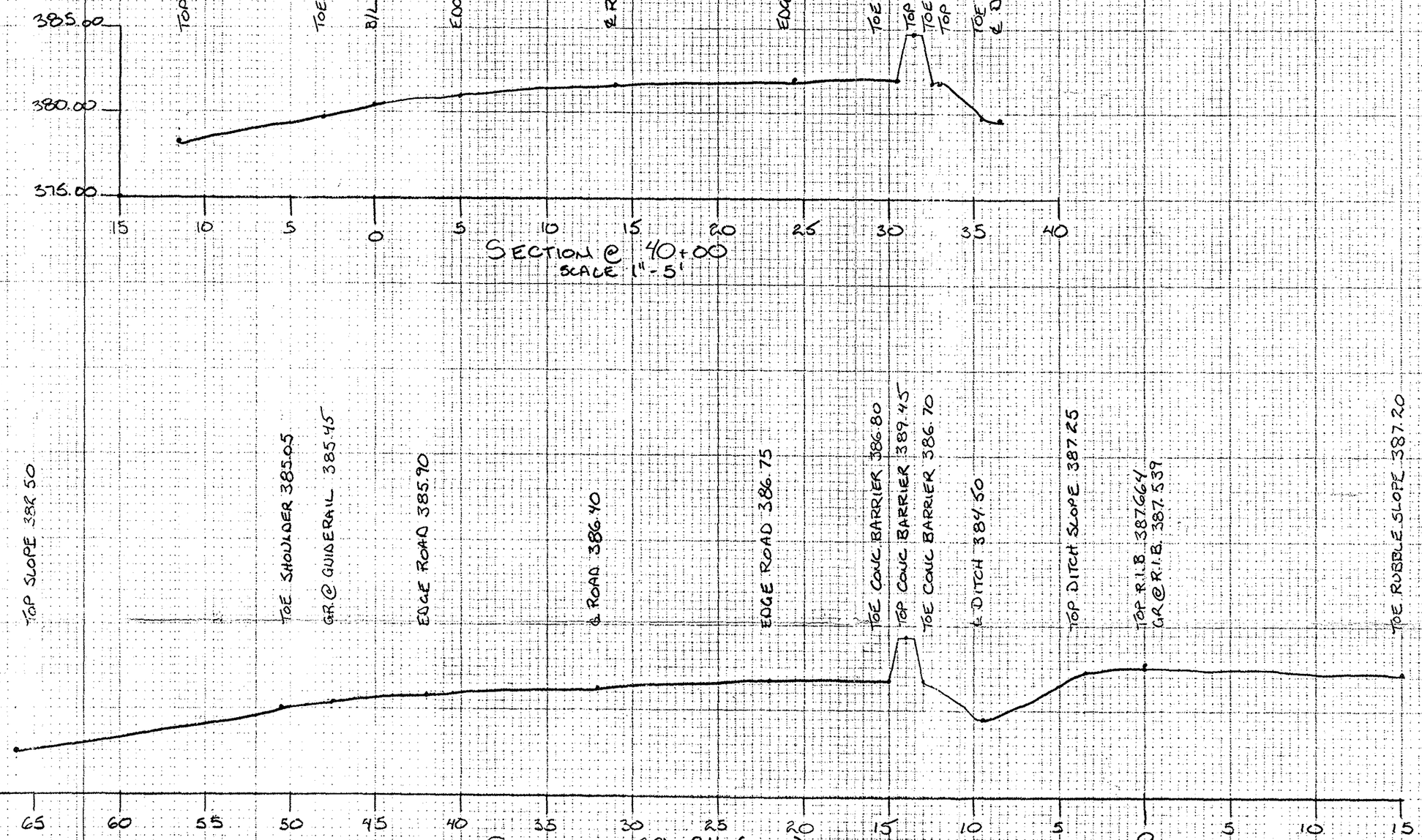


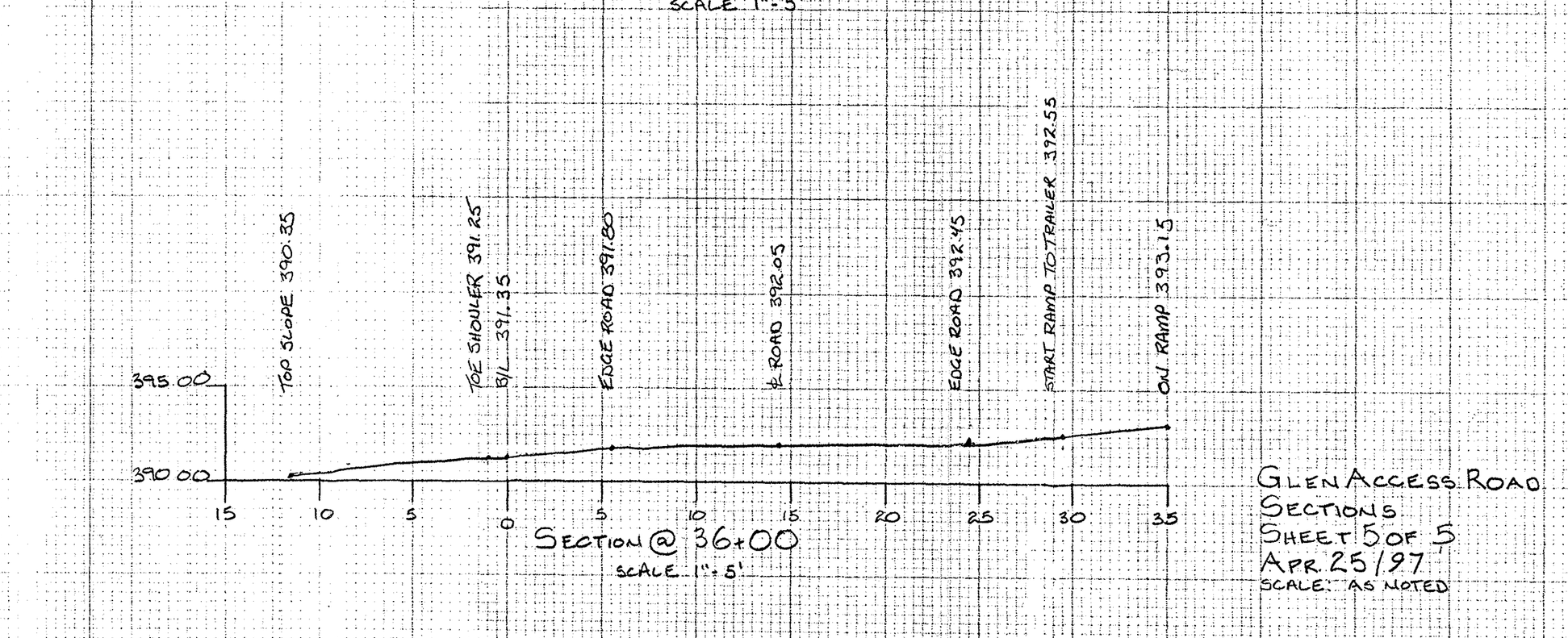


GLEN ACCESS ROAD
SECTIONS
SHEET 4 OF 5
APR. 25/97
SCALE: AS NOTED.

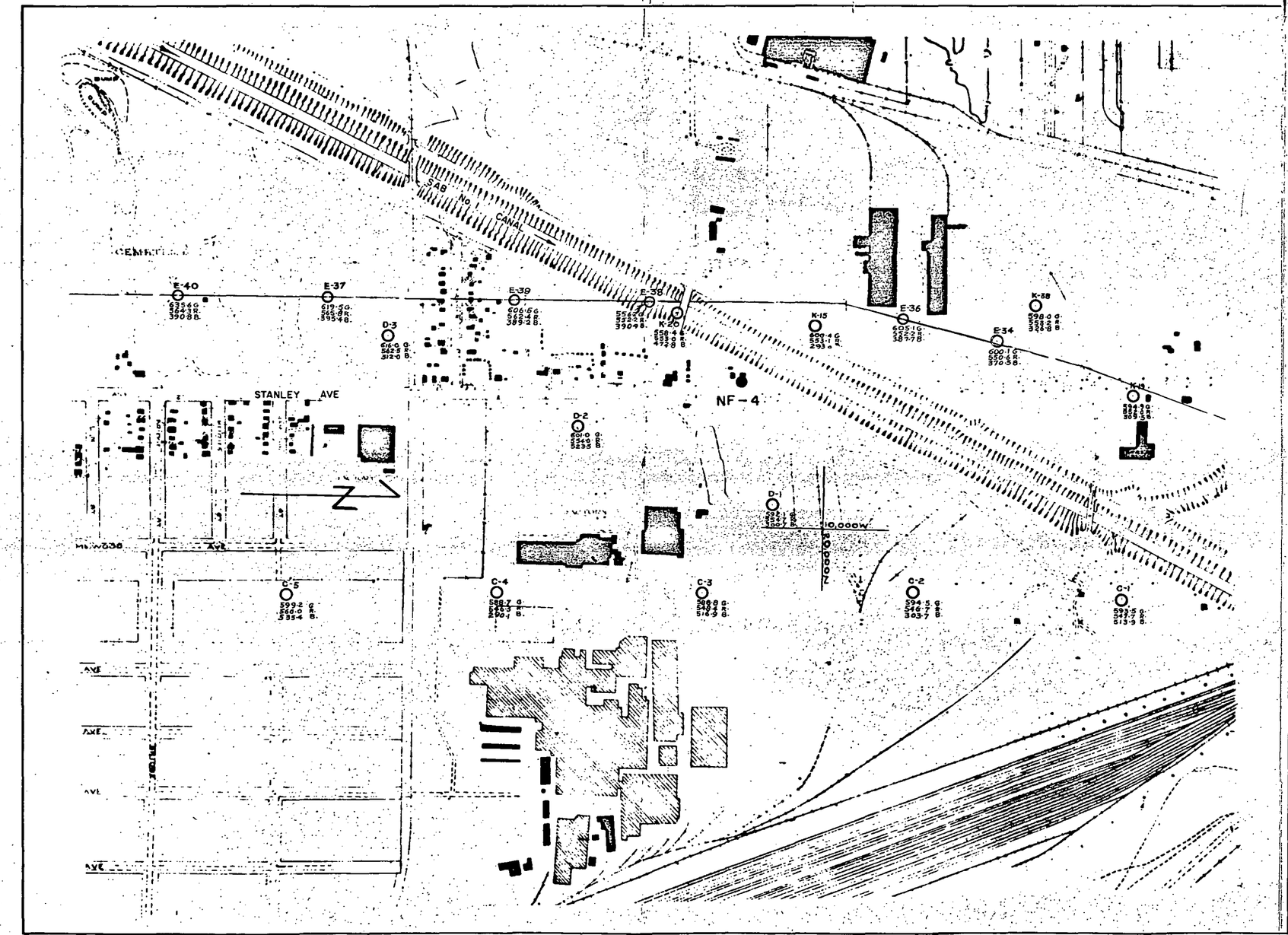








GLEN ACCESS ROAD
SECTIONS
SHEET 5 OF 5
APR 25/97
SCALE: AS NOTED



LEGEND

- ○ Borehole (SAB-N GS No. 2 Investigation)
- ● Borehole (SAB-N GS No. 3 Investigation)

REFERENCES

1. SAB-N GS No.2
   General Plan
   Location of Borings NF28-e-2085

NOTES

1. For Details of Geological Information in Boreholes see Geotechnical Data Sheets
2. This Drawing is in Imperial Units

FIG. 3

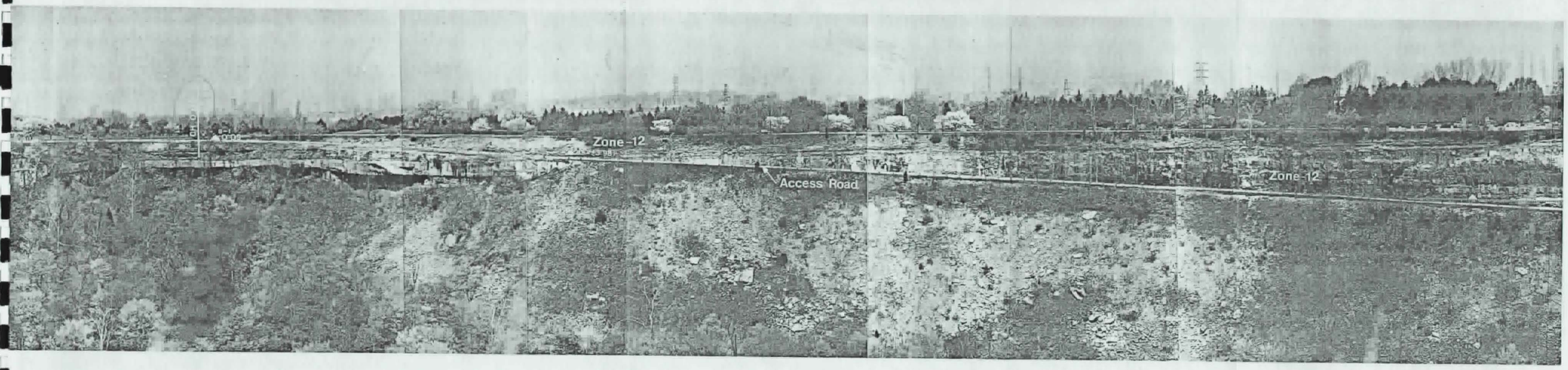
mf roll number	rev no	date	particulars	dwn / chkd	appd

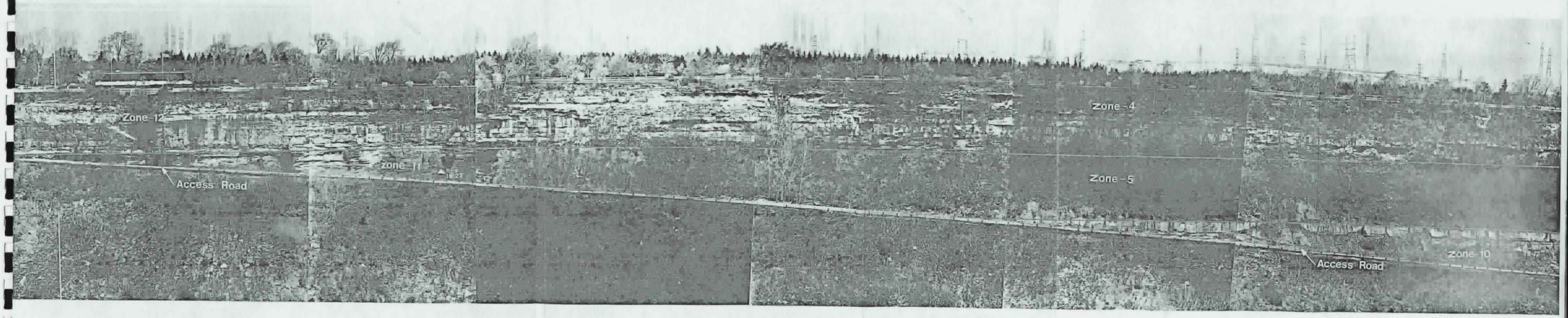
SAB-NIAGARA GS No. 3

LOCATION OF BOREHOLE NF-4
1984 GEOTECHNICAL INVESTIGATION

Ontario Hydro
design & construction branch
geotechnical engineering

work order	dwn AS / chkd	chief draftsman	sr geotech design eng
525-03369			
date: 22 NOV 84	designed by: BRSamec		sr geotech development eng: C.F.C
scale: 1" = 400'	supervising eng		manager - geotechnical engrg
dwg no: 992 DXH 10120 0202			rev

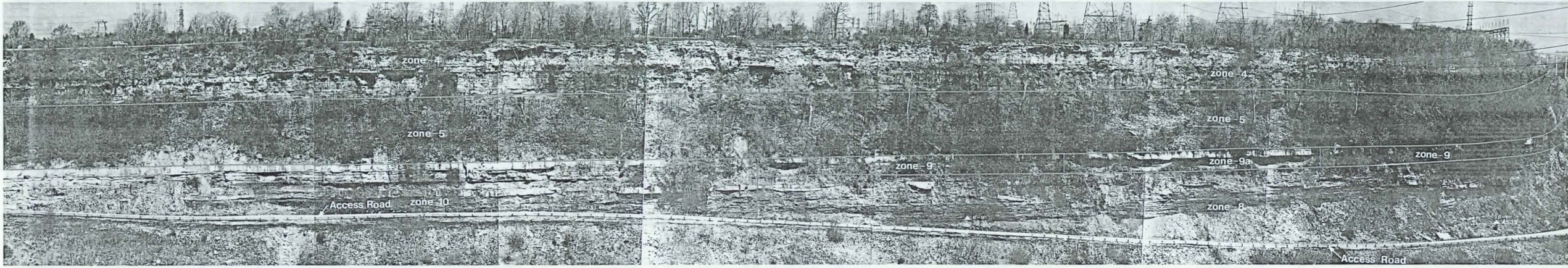


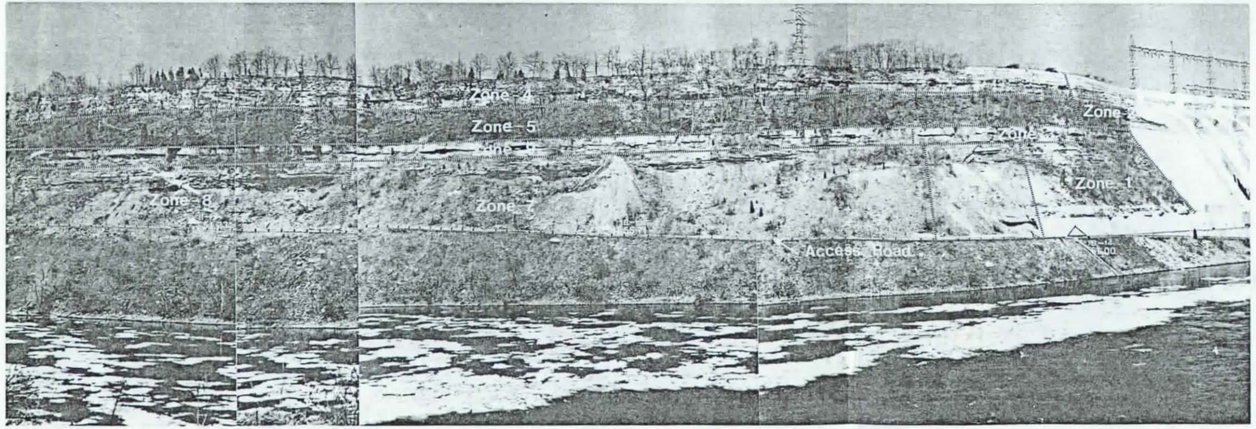


GLEN ACCESS ROAD

CLIFF ELEVATION VIEW

PHOTO - 1 (SHEET 1 of 2)





GLEN ACCESS ROAD

CLIFF ELEVATION VIEW

PHOTO - 1 (SHEET 2 of 2)

AS FROM CHAINAGE 56+00 TO 60+00

CLIFF FACE OF LOCKPORT FRESHENED WITH DOLLING. PRESENT CONDITION GOOD

ZONE 4

3-FT OVERHANG

STRESS RELIEF JOINTS

DECEW DOLOMITE EXHIBITS STRESS RELIEF JOINTING AND CONCHOIDAL FRACTURING

LOCKPORT FACE VERTICAL, LOCAL STRESS RELIEF SLABBING. CONDITION GENERALLY GOOD

ZONE 2

ZONE 5

SOIL TALUS

60+50

SLOUGHING SLAB

ROCHESTER SHALE COVERED WITH WEATHERED MATERIAL AND TALUS

SLOPE COVERED WITH ROCK TALUS, 3 C.Y. IN SIZE

EXISTING CONCRETE CAPTIVENT WALL

UNDER 5 FT OVERHANG

LOOSE BLOCK

HIGHLY IRREGULAR, VERTICAL FACE. NUMEROUS UNDERCUT STRESS RELIEF SLABS & BLOCKS

ZONE 3

4 FT OVERHANG

EXPOSED ROCK FACE - SOUND

5FT OVERHANG

LOOSE FACE CONTROLLED BY STRESS RELIEF JOINTS APPROX. 500 C

1 C.Y.

3 C.Y.

2 C.Y.

4 C.Y.

ZONE 1

45° SLOPE, SIGN OF SLOUGHING

EXISTING CONCRETE FACE

ZONE 6

AREA OF SLOUGHING

5 C.Y.

SOIL SLIDE

SIR ADAM BECK #2 POWERHOUSE

7 FT OVERHANG

ROCK FACE MASSIVE AND IRREGULAR LOCAL OVERHANG UP TO 5 FT

GATE

EXISTING CONCRETE FACE

DETACHED ROCK BY 1 FT OPEN JOINT

END OF GUARDRAIL

3 2 1

ELEVATION IN FEET

600 550 500 450 400 350 300 250

CAT ISLAND DOLOMITE

GASPORT LIMESTONE

ROCHESTER SHALE

IRONDEQUOIT LIMESTONE

REYNALES DOLOMITE

ALEDA SHALE

THOROLD SANDSTONE

GRIMSBY UNIT

LOWER GLEN SHALE

WHIRLPOOL SANDSTONE

QUEENSTON SHALE

PLATE-2

SIR ADAM BECK GS No2 0

GLEN ACCESS ROAD
CLIFF FACE ELEVATION

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generation engineering

1" = 5000			
OCT. 70	K R Lee		
			0

1700 E 54+00

1600 E 55+00

1500 E 56+00

1400 E 57+00

1300 E 58+00

1200 E 59+00

1100 E 60+00

GOAT ISLAND CLOSELY BEDDED WITH NUMEROUS OVERHANGS AND STRESS RELIEF JOINTS. EVIDENCE OF RECENT ROCK FALL

DRUM FM

GASPORT DISPLAYS MINOR SLOUGHING

MASSIVE, STABLE, OCCASIONAL FRACTURING IN GOAT ISLAND

ZONE 4

GASPORT OVERHANG UP TO 8 FT.

SOIL AND ROCK TALUS SLOPE 40°

ZONE 5

SOIL AND ROCK TALUS SLOPE 45°

15 C.Y. UNSTABLE OVERHANG STRESS RELIEF JOINTS

3 FT OVERHANG

5 FT OVERHANG

ZONE 9

MICCOD RELIEF JOINT

JOINT

3 FT OVERHANG

30 C.Y. UNSTABLE

UNSTABLE OVERHANG 6 FT. DEEP

ZONE 3

1 FT OVERHANG

UNSTABLE ROCK

ZONE 6

SOIL AND ROCK TALUS SLOPE AT 45°. SOME ROCK BLOCKS ARE 1-2 C.Y.

ZONE 7

FOOT PATH

SOIL AND ROCK TALUS SLOPE 55°

AREA OF SLOUGHING

SOIL AND ROCK TALUS SLOPE 55°

B-13

5 C.Y.

GOAT ISLAND DOLOMITE

GASPORT LIMESTONE

ROCHESTER SHALE

IRONDEQUOIT LIMESTONE

DOLOMITE

SHALE

THOROLD SANDSTONE

GRIMSBY UNIT

POWER GLEN SHALE

QUEENSTON SHALE

ELEVATION IN FEET

600 550 500 450 400 350 300

4

PLATE-3

SIR ADAM BECK GS No2 O

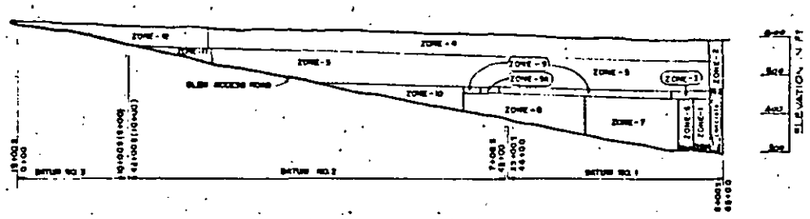
GLEN ACCESS ROAD
CLIFF FACE ELEVATION

Ontario Hydro
design & construction branch
geotechnical engineering

556-5000

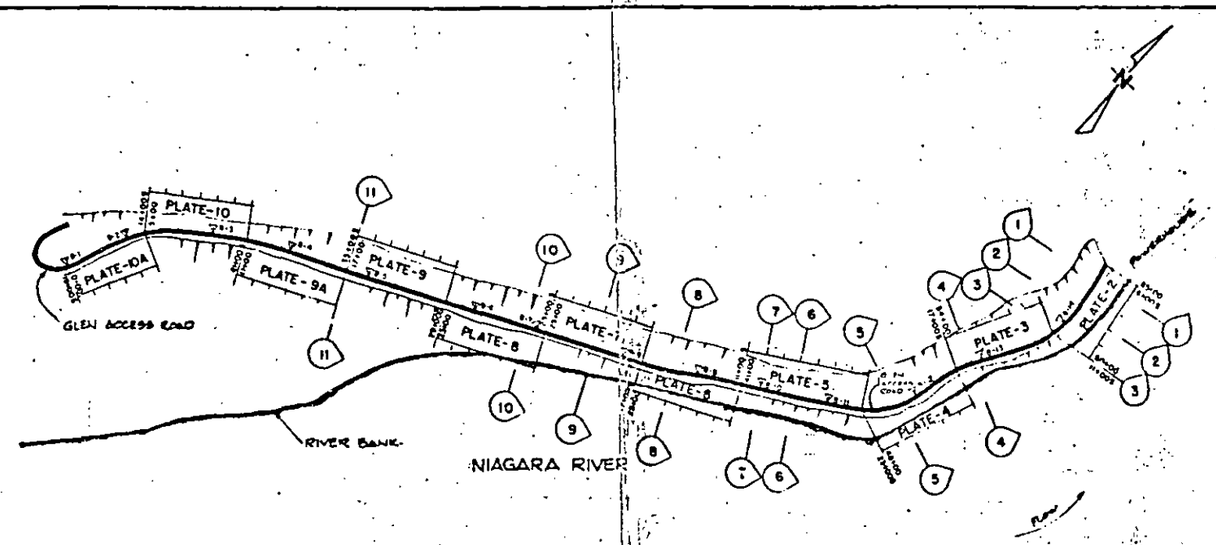
OCT 78

0



SCHEMATIC LAYOUT OF ZONES OF CLIFF FACE

NOT DRAWN TO SCALE



KEY PLAN

SCALE : 1 inch = 450 ft. (APPROX.)

SIR ADAM BECK G.S. NO. 2

GLEN ACCESS ROAD

CLIFF ENGINEERING STABILITY EVALUATION

LEGEND

- GOAT ISLAND DOLOMITE
- GASPORT LIMESTONE
- DECEW DOLOMITE
- ROCHESTER SHALE
- IRONDEQUOIT LIMESTONE
- REYNALES DOLOMITE
- NEAGHA SHALE
- THOROLD SANDSTONE
- GRIMSBY UNIT
- POWER GLEN SHALE
- WHIRLPOOL SANDSTONE
- QUEENSTON SHALE
- CONCRETE FACE
- ROCK OUTCROP
- 1100 S / 60+00 — TYPICAL CHAINAGE USED IN PREVIOUS CLIFF FACE STUDY; CHAINAGE ESTABLISHED PRIMARILY FOR THIS REPORT
- ZONE BOUNDARY
- B-5 — TYPICAL BENCH MARK
- 2 GPM — SEEPAGE LOCATION WITH ESTIMATED QUANTITY
- GEOLOGICAL CONTACT - ASSUMED

LIST OF DRAWINGS

PLATE NO. 1 REFERENCE PLATE
PLATE NO. 2 GLEN ACCESS ROAD — CLIFF FACE ELEVATION
" NO. 3 " " " " " " "
" NO. 4 " " " " " " "
" NO. 5 " " " " " " "
" NO. 6 " " " " " " "
" NO. 7 " " " " " " "
" NO. 8 " " " " " " "
" NO. 9 & 9A " " " " " " "
" NO. 10, 10A " " " " " " "
PLATE NO. 11 GLEN ACCESS ROAD — CROSS SECTION 1 AND SECTION 2
" NO. 12 " " " " SECTION 3, AND 4
" NO. 13 " " " " SECTION 5, 6, AND 7
" NO. 14 " " " " SECTION 8, 9, 10 AND 11
" NO. 15 GLEN ACCESS ROAD - PROPOSED ROAD REALIGNMENT - PLAN AND SECTION
" NO. 16 CLIFF FACE ABOVE PENSTOCK - ELEVATION AND SECTION
" NO 17 ENGINEERING AND CONSTRUCTION SCHEDULE

REFERENCES

NF28-4-2522 ..... SIR ADAM BECK GS NO. 2 CLIFF FACE PROFILE ACCESS ROAD AREA.

NF28-4-2523 ..... SIR ADAM BECK GS NO. 2 CLIFF FACE TERRESTRIAL PHOTOGRAMMETRIC CONTOUR PLAN, (6035 UPSTREAM TO 2500 S ON NO. 1 DATUM LINE)

NF28-4-2524 ..... SIR ADAM BECK GS NO. 2 CLIFF FACE TERRESTRIAL PHOTOGRAMMETRIC CONTOUR PLAN, (700 S UPSTREAM TO 4200 S ON NO. 2 DATUM LINE AND 1000 S UPSTREAM TO 1900 S ON NO. 3 DATUM LINE)

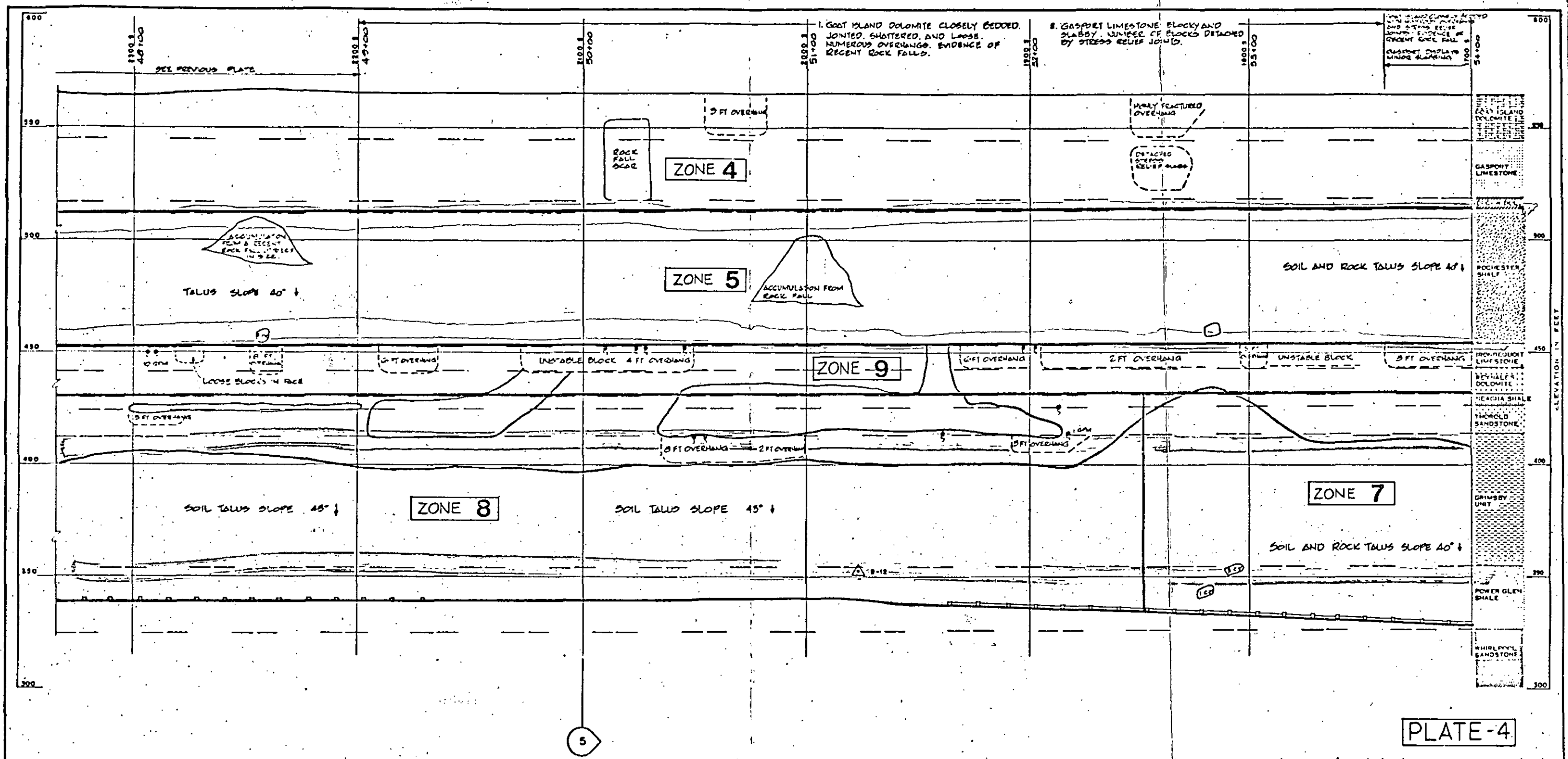
PLATE-1

SIR ADAM BECK GS No2 0

REFERENCE PLATE

Ontario Hydro
design & construction branch
geotechnical engineering

556-5000	
OCT 1978	W. B. Lee
AS SHOWN	



5

PLATE-4

SIR ADAM BECK GS No2

GLEN ACCESS ROAD
CLIFF FACE ELEVATION

Ontario Hydro
design & construction branch
geotechnical engineering

550 - 8000	AWL	
OCT. 1978		
F = 20FT (VERT.) F = 20FT (HORIZ.)		

0

1100 E 41+00 | 1000 E 42+00 | 900 E 43+00 | 800 E 44+00 | 700 E 45+00 | 2500S 46+00 | 2400 E 47+00 | 2300 E 48+00

1. GOAT ISLAND CLOSELY BEDDED, WITH FREQUENT STRESS RELIEF JOINTS. FACE GENERALLY VERTICAL.
2. GASPORT FACE MASSIVE: STRESS RELIEF JOINTS FREQUENT

1. GOAT ISLAND DOLOMITE CLOSELY BEDDED AND BLOCKY. NUMEROUS DETACHED BLOCKS AND OVERHANGS OBSERVED.
2. GASPORT LIMESTONE MASSIVE, STRESS RELIEF JOINTS AND SLABS LOCAL.

ZONE 4

ZONE 5

ZONE 9A

ZONE 9

ZONE 8

DETACHED ROCK SLAB

ACCUMULATION OF ROCK FALL.

ACCUMULATION OF ROCK TALUS FROM ROCK FALL

ROCK TALUS SLOPE 40° ↓

ROCK TALUS SLOPE 40° ↓

5m CONTINUOUS OVERHANGS AS NOTED IN ZONE OF DISTRESS

3 FT OVERHANG

5 FT OVERHANG

3 FT OVERHANG

10 FT OVERHANG

24" OPEN STRESS RELIEF JOINT

4 FT OVERHANG

LOOSE BLOCKS 1-2 cy

8 FT OVERHANG

4 FT UNSTABLE OVERHANG

OFF UNSTABLE OVERHANG CONTROLLED BY STRESS RELIEF JOINT.

0.5 cy

ROCK TALUS SCATTERED OVER SLOPE

SOIL TALUS SLOPE 45° ↓

SOIL TALUS SLOPE 45° ↓

B-10

B-11

7

6

ELEVATION IN FEET

GOAT ISLAND DOLOMITE

GASPORT LIMESTONE

ROCHESTER SHALE

IRONDEQUOIT/LIMESTONE

REYNALES/DOLOMITE

NEAGHA SHALE

THOROLD/SANDSTONE

GRIMSBY UNIT

POWER GLEN SHALE

WHIRLPOOL SANDSTONE

PLATE-5

SIR ADAM BECK GS No.2 | 0

GLEN ACCESS ROAD
CLIFF FACE ELEVATION

Ontario Hydro
design & construction branch
geotechnical engineering

556-5000

OCT 1978

V > 20 FT (VERT)
H > 20 FT (HORIZ)

0

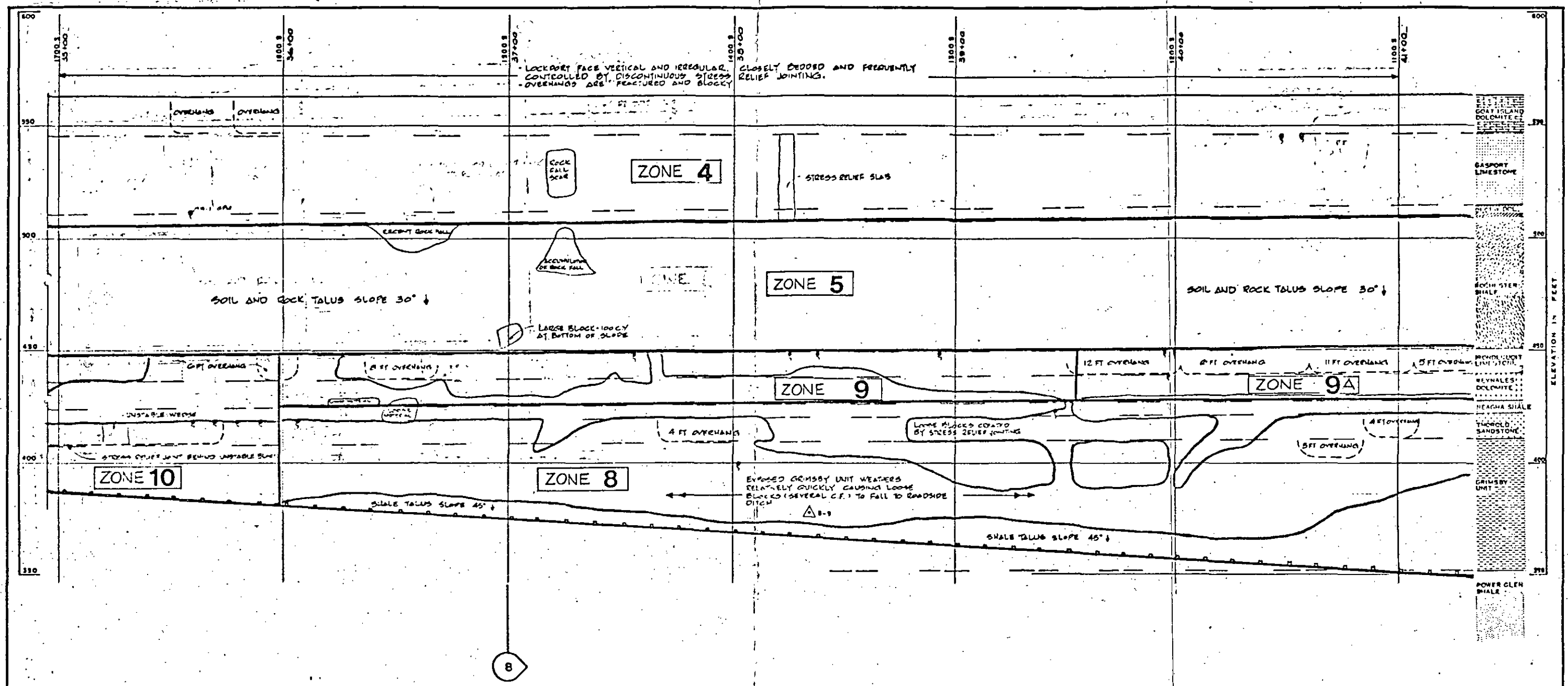


PLATE - 6

SIR ADAM BECK GS No2: O

GLEN ACCESS ROAD
CLIFF FACE ELEVATION

Ontario Hydro
design & construction branch
geotechnical engineering

556 - 5000			
OCT 1978			
1" = 20ft (VERT) 1" = 20ft (HORIZ)			7 sheets
			O

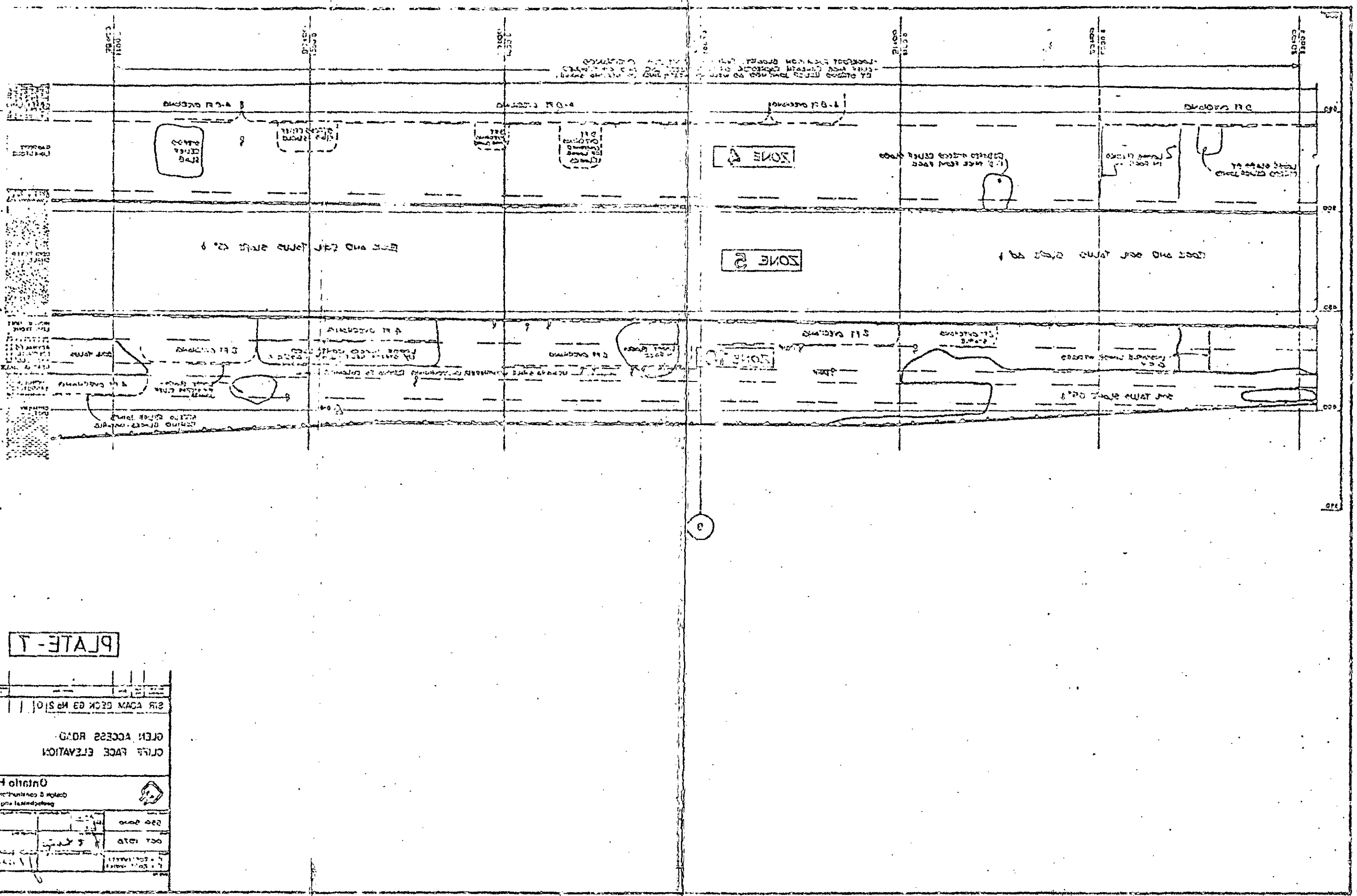
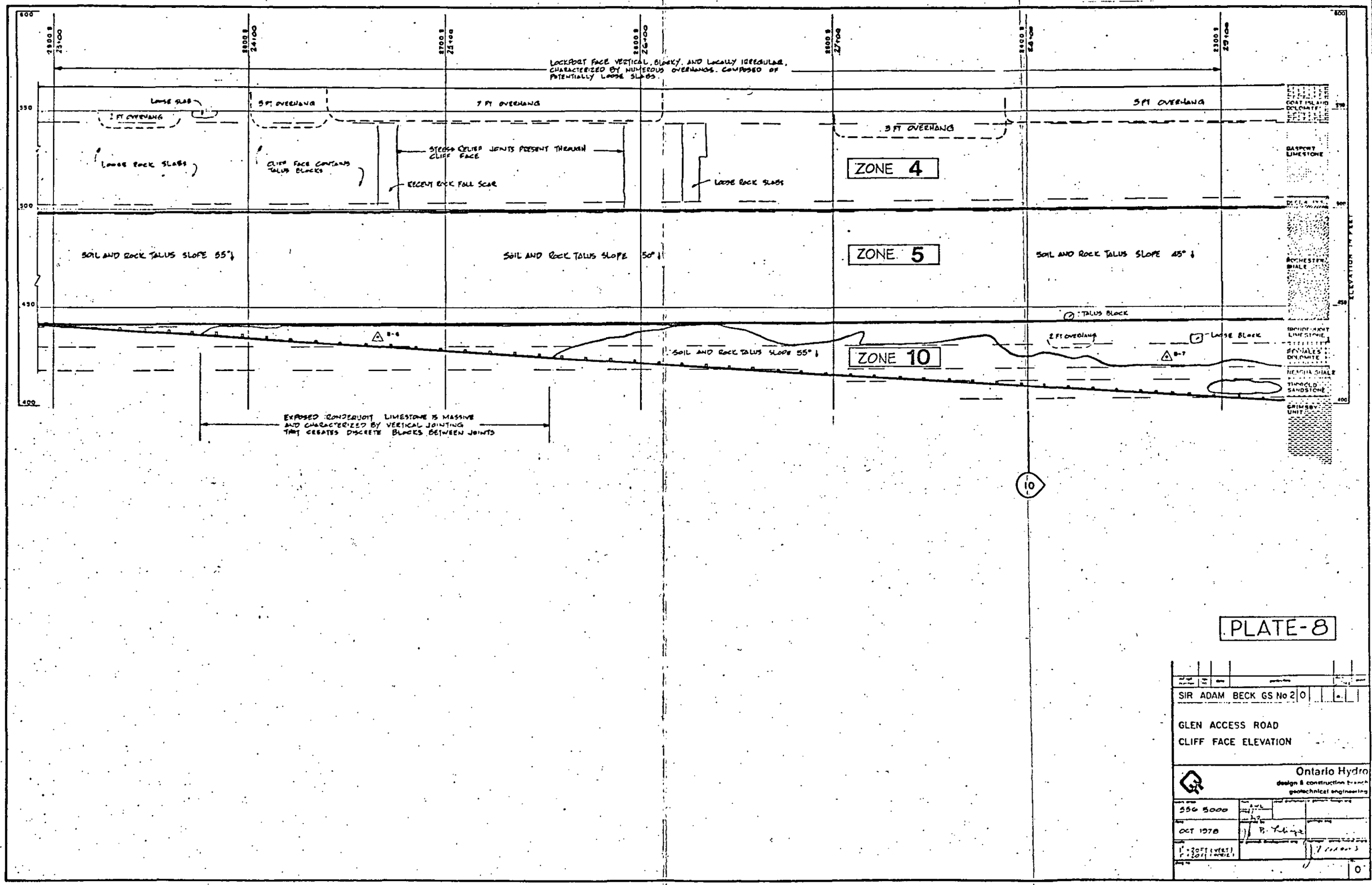


PLATE - 7



10

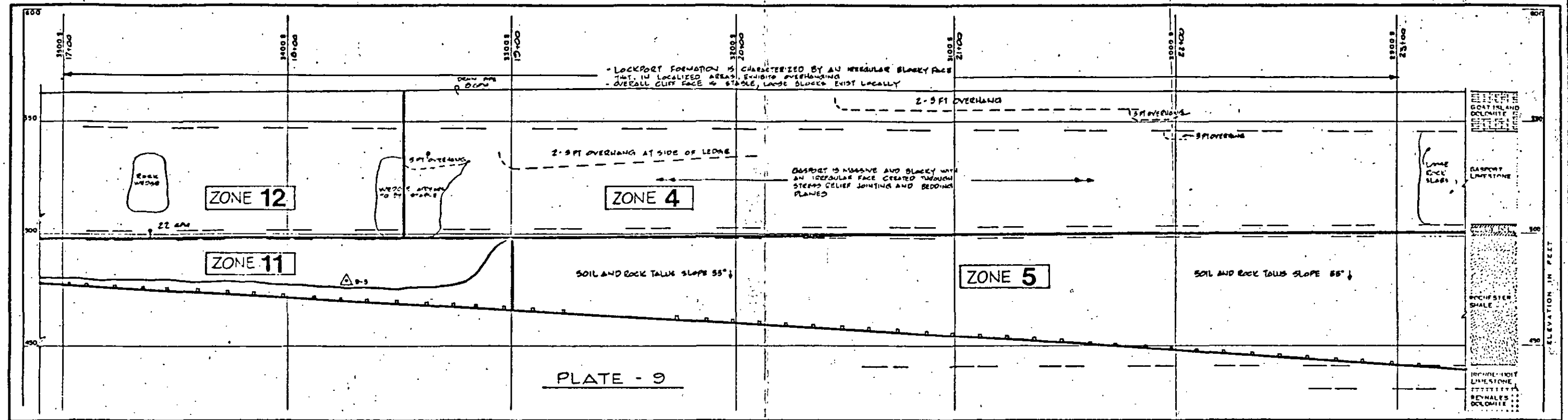
PLATE-8

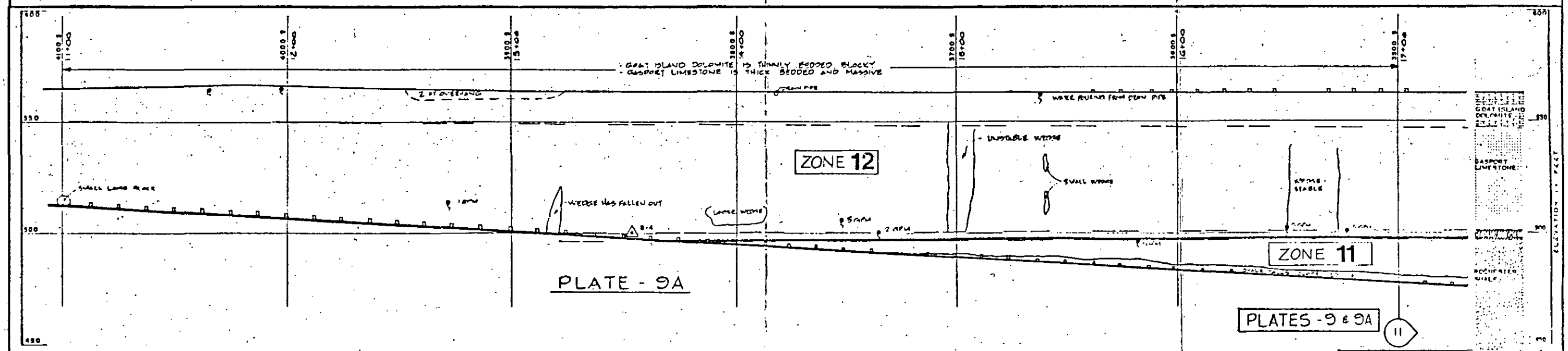
SIR ADAM BECK GS No 2 | 0

GLEN ACCESS ROAD
CLIFF FACE ELEVATION

Ontario Hydro
design & construction branch
geotechnical engineering

556 5000
OCT 1978
B. Telfer
1" = 20 FT (VERT.)
1" = 20 FT (HORIZ.)
0





PLATES - 9 & 9A

11

SIR ADAM BECK GS No 2 | 0

GLEN ACCESS ROAD
CLIFF FACE ELEVATION

Ontario Hydro
design & construction branch
geotechnical engineering

SCALE - 1:200	
OCT 1978	
1" = 20 FT (VERT) 1" = 20 FT (HORIZ)	

11 | 0

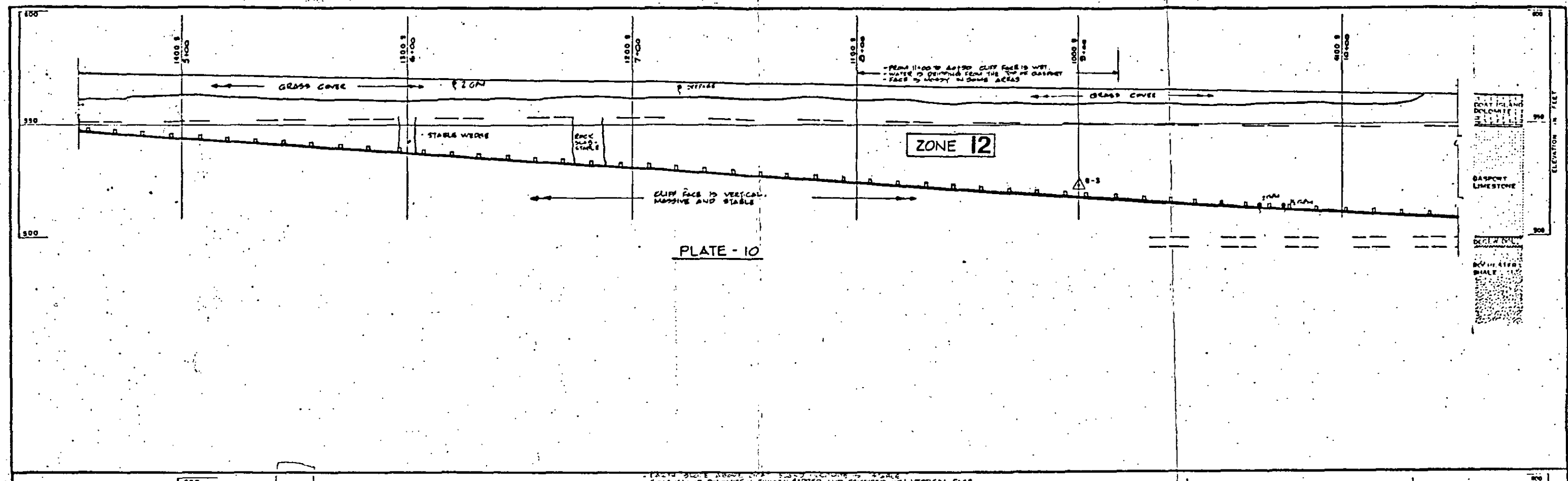


PLATE - 10

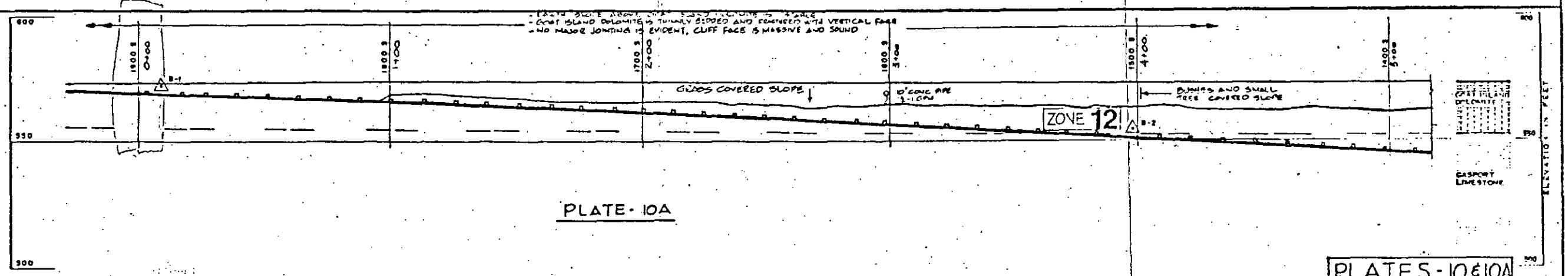


PLATE - 10A

PLATES - 10 & 10A

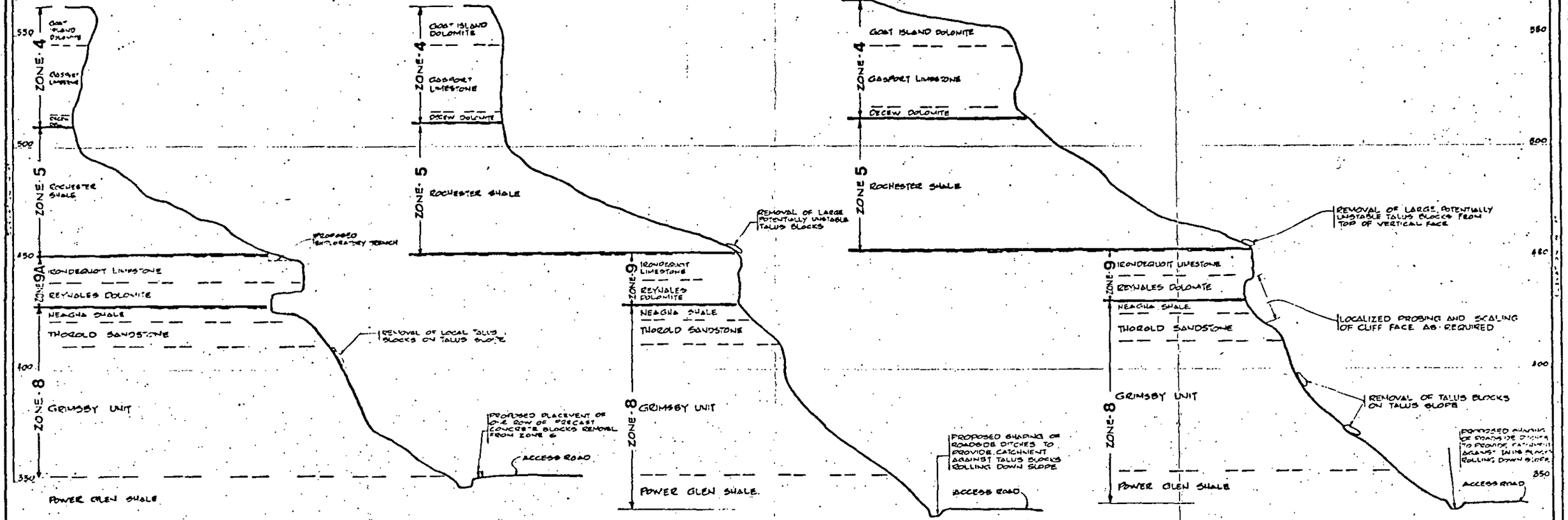
SIR ADAM BECK GS No 2

GLEN ACCESS ROAD

CLIFF FACE ELEVATION

Ontario Hydro
design & construction branch
geotechnical engineering

1:50 - 5000	
OCT 1978	
	0



SECTION - 7

CHAINAGE: 10+006 / 42·00

SECTION - 6

CHAINAGE: 8+006 / 44·00

SECTION - 5

CHAINAGE: 21+005 / 50·00

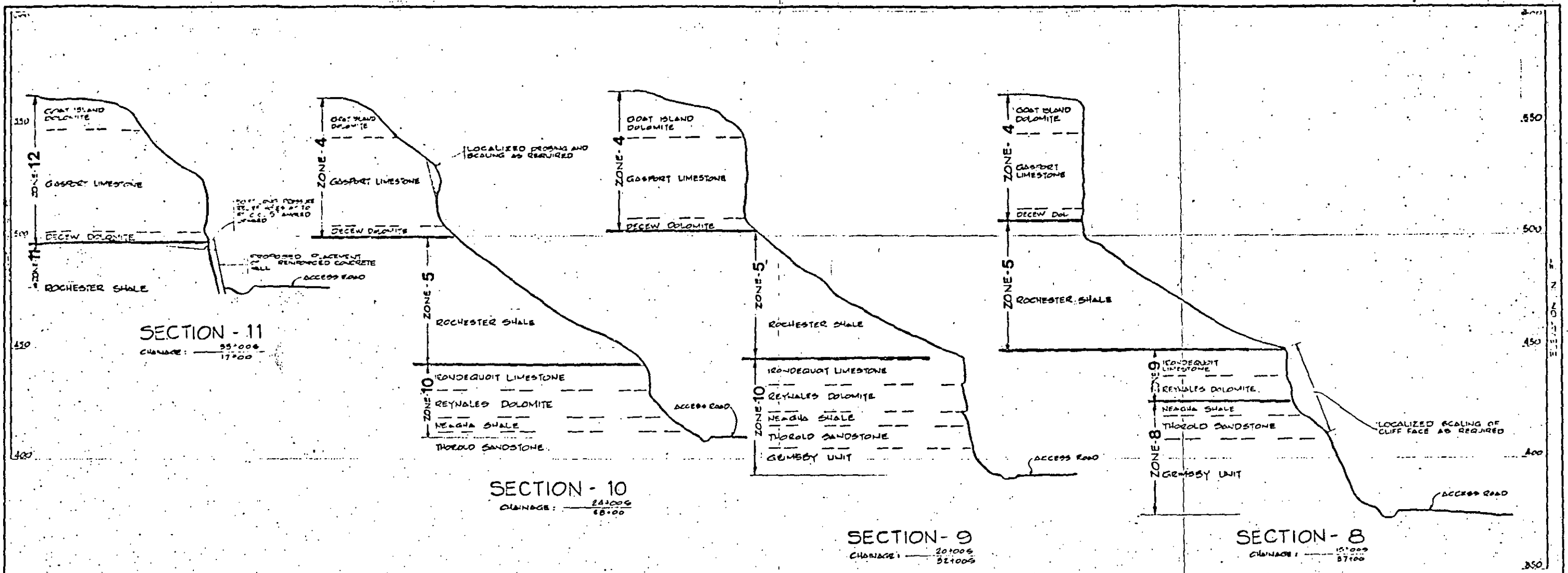
PLATE-13

SIR ADAM BECK G.S. No 2

GLEN ACCESS ROAD
CROSS SECTION-5, 6 & 7

Ontario Hydro
design & construction branch
geotechnical engineering

556-8000
OCT 1978



SECTION - 11
CHAINAGE: 55+00S / 17+00

SECTION - 10
CHAINAGE: 24+00S / 68+00

SECTION - 9
CHAINAGE: 20+00S / 32+00S

SECTION - 8
CHAINAGE: 15+00S / 37+00

PLATE - 14

SIR ADAM BECK G.S No 2

GLEN ACCESS ROAD
CROSS SECTIONS - 8, 9, 10 & 11

Ontario Hydro
design & construction branch
geotechnical engineering

ADM - BECK
OCT 1978

0

1979

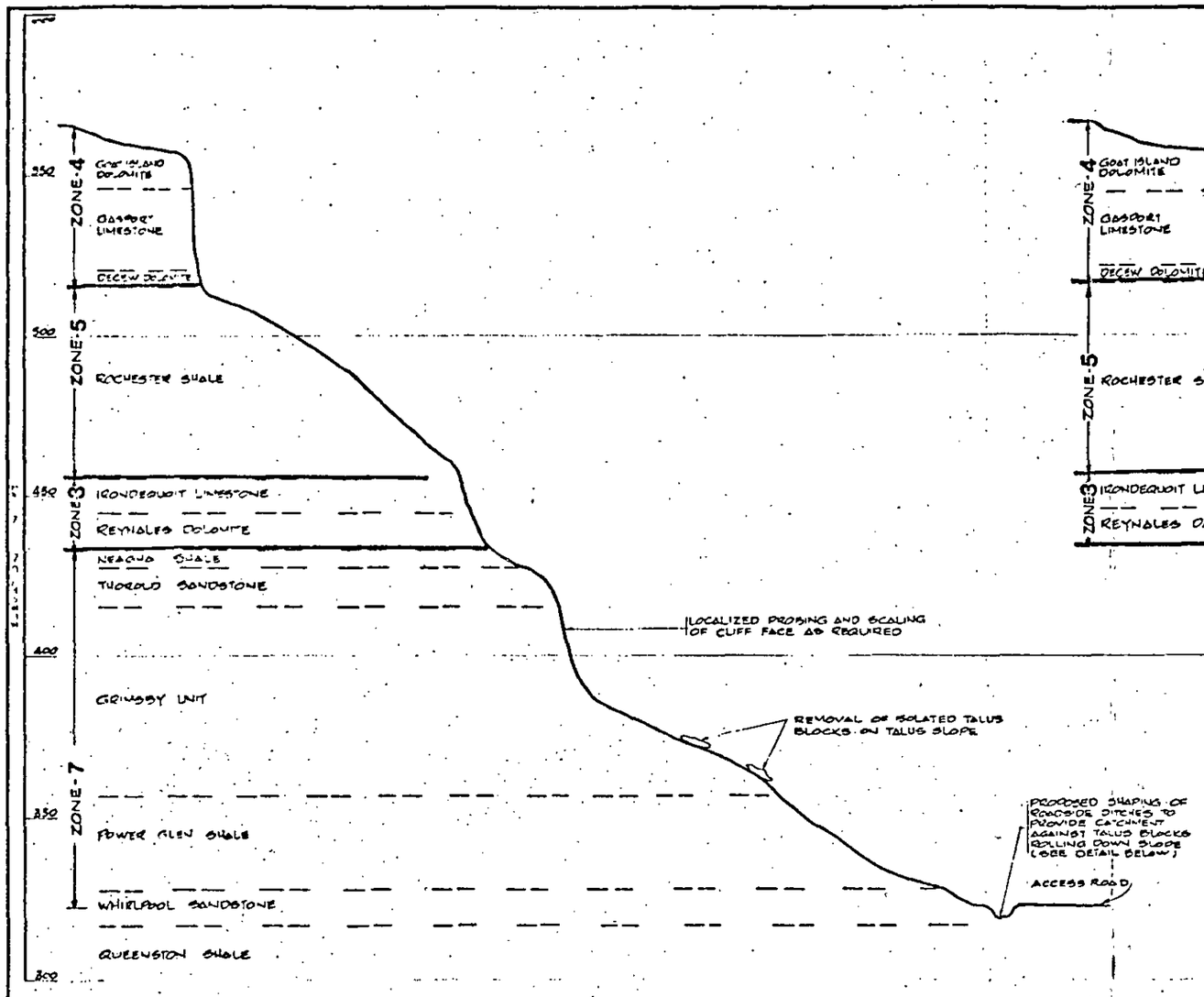
ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PHASE III												
REVIEW OF REPORT BY CIVIL WORKS DEPT		D										
PHASE IV												
(a) DESIGN AND PREPARATION OF T. S.				IT								
(b) EVALUATION AND AWARD OF CONTRACT					RT	AC						
PHASE V												
(a) MOBILIZATION AND DEMOBILIZATION												
(b) CONSTRUCTION												
(c) CLEAN UP												
PRIORITY 1 - (b)												
Zone 1 - Scaling												
Concreting												
Pressure relief drilling												
Zone 2 - Debris clean up												
Scaling												
Zone 3 - Scaling												
Zone 6 - Debris clean up												
Concreting												
Penstocks - Scaling												
Dowels and rock bolts												
Wire - mesh												
Pressure relief drilling												
PRIORITY 2 - (b)												
Zone 7 - Scaling												
Debris removal												
Zone 8 - Scaling												
Debris removal												
Zone 9 - Scaling												
Rock bolts												
Zone 9A - Exploratory trench												
Concrete wall if required												
Zone 10 - Scaling												
Rock bolts												
Road realignment												
Exploratory trench												
PRIORITY 3 - (b)												
Zone 4 - Scaling												

LEGEND D - Decision on remedial works by Civil Works Dept.
I T - Issue of tenders
R T - Receipt of tenders
A C - Award of contract

ENGINEERING AND CONSTRUCTION SCHEDULE

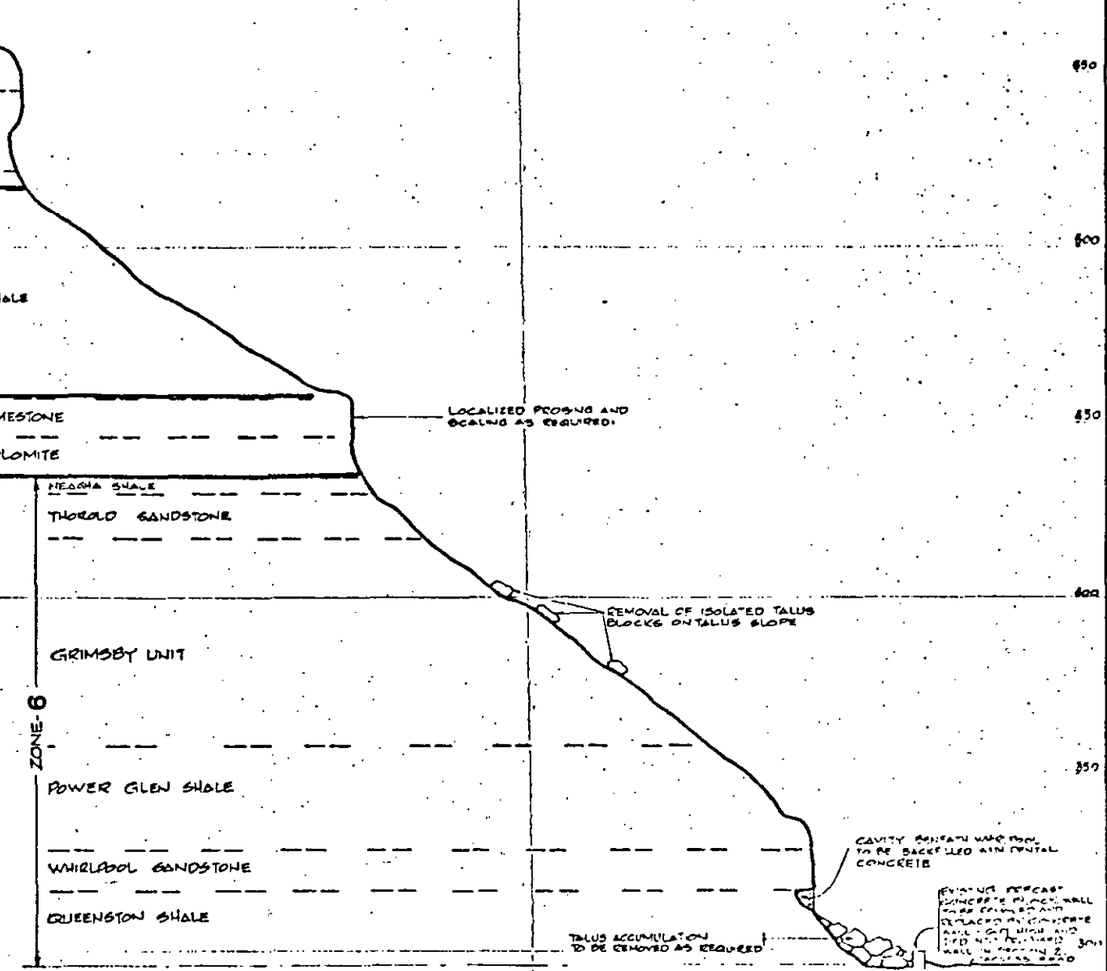
SAB GS No 2
GLEN ACCESS RD

PLATE 17



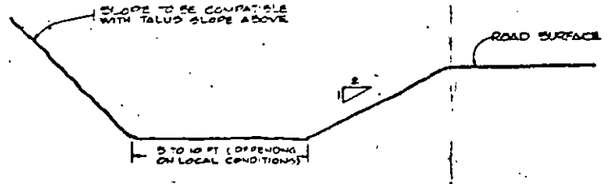
SECTION - 4

CHAINAGE: 16+000 S 55+00



SECTION - 3

CHAINAGE: 11+000 S 60+00



SHAPING OF DITCH
(ZONES 7 AND 8)
SCALE: 1/8" = 1'-0"

PLATE - 12

SIR ADAM BECK G.S No 2

GLEN ACCESS ROAD
CROSS SECTION - 3 & 4

Ontario Hydro
design & construction branch
geotechnical engineering

556-5000		
OCT 1978	B.H.	
1" = 20FT HOR. 1" = 10FT VERT.		

0

1979

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PHASE III												
REVIEW OF REPORT BY CIVIL WORKS DEPT		D										
PHASE IV												
(a) DESIGN AND PREPARATION OF T. S.				IT								
(b) EVALUATION AND AWARD OF CONTRACT					RT	AC						
PHASE V												
(a) MOBILIZATION AND DEMOBILIZATION												
(b) CONSTRUCTION												
(c) CLEAN UP												
PRIORITY 1 - (b)												
Zone 1 - Scaling												
Concreting												
Pressure relief drilling												
Zone 2 - Debris clean up												
Scaling												
Zone 3 - Scaling												
Zone 6 - Debris clean up												
Concreting												
Penstocks - Scaling												
Dowels and rock bolts												
Wire - mesh												
Pressure relief drilling												
PRIORITY 2 - (b)												
Zone 7 - Scaling												
Debris removal												
Zone 8 - Scaling												
Debris removal												
Zone 9 - Scaling												
Rock bolts												
Zone 9A - Exploratory trench												
Concrete wall if required												
Zone 10 - Scaling												
Rock bolts												
Road realignment												
Exploratory trench												
PRIORITY 3 - (b)												
Zone 4 - Scaling												

LEGEND D – Decision on remedial works by Civil Works Dept.
I T – Issue of tenders
R T – Receipt of tenders
A C – Award of contract

ENGINEERING AND CONSTRUCTION SCHEDULE

SAB GS No 2
GLEN ACCESS RD

PLATE 17