

G.I.-30 SEPT. 1976

GEOCRES No. _____

DIST. 31 REGION _____W.P. No. 117-95-00

CONT. No. _____

W. O. No. _____

STR. SITE No. _____

HWY. No. 402LOCATION Hwy 402 - Caradoc Township
Slope InstabilityNo of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____



2180 Meadowvale Boulevard, Mississauga, Ontario L5N 5S3

FACSIMILE: (905) 567-6561 or (905) 567-6566

TELEPHONE: (905) 567-4444

FACSIMILE TRANSMISSION

To: Ministry of Transportation, Ontario
Pavements and Foundations Section
Room #223, Central Building
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

**ATTENTION: MR. DAVE DUNDAS, P.ENG.
SENIOR FOUNDATION ENGINEER**

Facsimile Number: (416) 235-5240

Telephone Number: (416) 235-3482

From: F.J. Heffernan

Date Transmitted: August 14, 1998

RE: SLOPE INSTABILITY AND CULVERT FAILURE

HIGHWAY 402

STATION 24+600

W.P. 117-95-00

COUNTY OF MIDDLESEX, ONTARIO

(Your Reference No. 981-3142)

Number of Pages: 2 (two) including cover page

Original to Follow: No

Following review of the draft report we have the following comments.

- 1) There is an area around and upslope from the sinkhole (approximately 20 metres by 20 metres) which has soft embankment material for a depth of at least 1.5 metres. We recommend sub-excavation of the material in conjunction with proposed drainage works. The sub-excavation should be backfilled with granular earth material. The remainder of the filling for the slope flattening should also consist of non cohesive earth borrow. The construction should take place during a summer construction period. The excavation and filling should be under the supervision of an experienced geotechnical engineer to direct the staging of the excavation to avoid slope instability. The geotechnical engineer would also determine the excavation limits.

Golder Associates

Facsimile
Ministry of Transportation, Ontario
Mr. Dave Dundas

- 2 -

August 14, 1998

- 2) We agree with the flattening of the slope to improve surficial stability. This slope flattening will also improve deep seated stability.
- 3) A drainage blanket alternative to the french drain system could be considered.

Regards.

Geotech

M. Devata
M.S. Devata, P.Eng.

F.J. Heffernan

F.J. Heffernan, P.Eng.

MSD/FJH/clg
WORD & FINAL DATE/FIN/FAK/MTODDHX2

c.c. P.R. Bedell - Golder Associates Ltd.,
London, Ontario

(519) 471-4707

The document(s) with this transmission are only for recipient(s) named above and contain privileged / confidential information. Unauthorized disclosure, dissemination, or copying of this transmission is strictly prohibited. If received in error, please destroy. Questions / problems with transmission: contact the reception at (905) 567-4444.

OFFICES IN AUSTRALIA, CANADA, GERMANY, HUNGARY, ITALY, SWEDEN, UNITED KINGDOM,
UNITED STATES

Golder Associates

AUG 12 1993 08:40 FR DILLON LDN
AUG 11 '98 04:43PM GOLDER ASSOCIATES

519 672 8209 TO 873-5240

P.01/29
P.1/29

FACSIMILE TRANSMISSION

GOLDER ASSOCIATES LTD.

500 Nottinghill Road
London, Ontario N6K 3P1

Tel. No. 519-471-9600
Fax. No. 519-471-4707

Date Sent: August 11, 1998

TO: Dillon Consulting Limited
Mr. B.G. Huston, P. Eng.

Fax. No. SD

FR: Mr. Philip R. Bedell, P. Eng.

RE: DRAFT REPORT
GEOTECHNICAL INVESTIGATION
SLOPE INSTABILITY AND CURRENT FAILURE
HIGHWAY 402
STATION 24+600
WP 117-95-00
COUNTY OF MIDDLESEX, ONTARIO
(Our Reference No. 981-3142)

Post-It [®] Fax Note		7671E	Date	Aug 13	# of pages	29
To	MARK VISAUTHEAN		From	MICHAEL PLANT		
Co./Dept.	FON		Co.	GOLDER ASSOCIATES		
Phone #			Phone #	519-672-4393		
Fax #	416-235-5240		Fax #			

Total number of pages (including this cover page): 29

PRB/cb

Golder Associates

AUG 11 1998 16:44

519 4714707

PAGE.01

AUG 12 1998 08:40 FR DILLON LDN

519 672 8209 TO 873-6300

P.03/29

Golder Associates Ltd.

500 Notingham Road
London, Ontario Canada N6K 3P1
Telephone (519) 471-9600
Fax (519) 471-4707



August 11, 1998

961-3142

Dillon Consulting Limited
P.O. Box 426, Terminal B
495 Richmond Street
London, Ontario
N6A 4W7

Attention: Mr. B.G. Huston, P. Eng.

RE: GEOTECHNICAL INVESTIGATION
SLOPE INSTABILITY AND CURRENT FAILURE
HIGHWAY 402
STATION 24+600
W.P. 117-95-00
COUNTY OF MIDDLESEX, ONTARIO

Dear Sirs:

This report presents the results of the geotechnical investigation carried out on the south side slope of the Highway 402 embankment at Station 24+600, Township of Carleton Place, County of Middlesex, Ontario. The location of the site is shown on the Plan, Figure 1.

1.0 TERMS OF REFERENCE

The purpose of the investigation was to determine, to the extent feasible using manual drilling techniques, the subsurface soil and groundwater condition in the area of the instability in the south slope of the roadway embankment and the sinkhole which has developed over the 900 millimetre diameter ditch culvert and to provide geotechnical engineering recommendations for the stabilization of the embankment slope and the repair and/or replacement of the 900 millimetre culvert.

Authorization to proceed with the investigation in general accordance with our letter dated March 9, 1998 was provided verbally on July 10, 1998. The scope of the geotechnical investigation was subsequently expanded to also include the unstable embankment slope to the

OFFICES IN AUSTRALIA, CANADA, GERMANY, HUNGARY, ITALY, SWEDEN, UNITED KINGDOM, UNITED STATES

AUG 11 1998 16:44

519 4714707

PAGE 03

AUG 12 1998 08:48 FR DILLON LDN
AUG 11 '98 04:44PM GOLDER ASSOCIATES

519 672 8209 TO 8734220

P.04/29

August 1998

-2-

981-3142

east of the 900 millimetre ditch culvert and a preliminary assessment of the present conditions of the 3350 millimetre diameter corrugated steel plate culvert under Highway 402.

2.0 PROCEDURE

The drilling program for this investigation was carried out between July 21 and 24, 1998 during which time thirteen boreholes and one dynamic penetration test were completed. The locations of the boreholes are shown on the Plan, Figure 1. Since the site was not accessible to conventional drilling equipment, all of the drilling was done manually. The soil stratigraphy encountered in the boreholes is shown on the attached Record of Borehole sheets. An inferred cross-section is shown on Figure 2.

Penetration testing and sampling was carried out at regular intervals of depth in the boreholes using 35 millimetre inside diameter split spoon sampling equipment. It should be noted that a manual penetration test hammer weighing 31.75 kilograms was used rather than the standard 63.5 kilogram hammer and that the penetration resistances shown on the Record of Boreholes have been adjusted to approximate standard penetration test N values. All of the samples were brought to our laboratory for further examination and representative classification testing. In addition, where practical, the undrained shear strength of the cohesive soils was measured by in situ shear vane testing. The results of the field and laboratory testing are shown on the Record of Borehole sheets and on Figures 2 and 3.

Groundwater seepage levels were observed in the open boreholes during drilling and piezometers were installed in selected boreholes as shown on the Record of Borehole sheets.

The borehole locations were designated by members of our engineering staff who also drilled and logged the boreholes, cared for the samples and installed the piezometers.

The final borehole locations and ground surface elevations were determined by Farncomb Kirkpatrick & Stirling Surveying Ltd. in conjunction with their detailed topographical survey of the site. The elevations are understood to be referred to geodetic datum.

Golder Associates

AUG 11 1998 16:44

519 4714787

PAGE.04

August 1998

-3-

981-3142

Representatives of our engineering staff also carried out an inspection of the 3350 millimetre diameter culvert as well as a series of diameter measurements. These measurements are summarized in the attached Table I.

3.0 SITE DESCRIPTION

The embankment slope is located immediately south of the travelled lanes of Highway 402 at about Station 24+600 in the Township of Caradoc, County of Middlesex, Ontario. The embankment slope is about 100 metres long and up to about 17 metres in height.

The existing slope inclinations vary from about 20 to 34 degrees from the horizontal based on measurements with a hand level. The slope shows visual signs of instability in several areas. The slope is generally covered in thick vegetation with the exception of a sinkhole and the unstable area to the east which has little or no vegetal cover. In addition, localized areas of groundwater seepage and bull rushes or cat tails, which indicate wet areas, were noted at various locations on the embankment slope.

A creek is located at the toe of the slope, passing under the highway in a 3350 millimetre diameter corrugated steel plate culvert. A plastic Big 'O' drain was observed to be exposed at ground surface on the slope at several locations.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes drilled at the site are shown in detail on the Record of Borehole sheets. The following discussion has been simplified in terms of major soil strata for the purposes of geotechnical design. The soil boundaries indicated are inferred from non-continuous samples and observations of drilling resistance. They may represent a transition from one soil type to another and should not necessarily be interpreted to represent exact planes of geological change. Furthermore, subsurface conditions may vary significantly between and beyond the borehole locations.

Golder Associates

AUG 11 1998 16:45

519 4714707

PAGE 05

AUG 12 1998 08:41 FR DILLON LDN
AUG 11 '98 04:44PM GOLDER ASSOCIATES

519 672 8209 TO 8734300

P.06/29

August 1998

-4-

981-5142

The professional services retained for this project included only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report and have not been investigated or addressed.

4.2 Soil Conditions

The soil conditions encountered in the boreholes generally consisted of topsoil and the fine grained embankment fill material overlying native clayey silt, sandy silt and silty fine sand.

4.2.1 Topsoil

Topsoil was encountered at ground surface in boreholes 1 through 5, 8, 11, 12 and 14.

The topsoil ranged in thickness from about 0.1 to 0.2 metres. Topsoil was encountered beneath the fill in boreholes 6 and 8. The topsoil layers ranged in thicknesses from about 0.2 to 0.3 metres and had a water content of 24 per cent.

4.2.2 Fill

Beneath the topsoil and/or at ground surface all of the boreholes except borehole 13 encountered the embankment fill materials. The fill materials varied in grain size distribution from clayey silt with a trace of sand to silty sand. The fill had approximate N values ranging from 2 to 20 blows per 0.3 metres.

The fill had in situ water contents ranging from about 7 to 25 per cent with an average water content of about 13. The clayey silt fill had corresponding plastic and liquid limits of 12 and 20 per cent, respectively, based on the results of a single Atterberg limit determination.

Typical grain size distribution curves for the embankment fill materials area shown on Figure 3.

Golder Associates

AUG 11 1998 16:45

519 4714707

PAGE.06

AUG 12 1998 08:41 FR DILLON LDN

519 672 8209 TO 8734620

P.07/29
P.11/29

AUG 11 '98 04:45PM GOLDER ASSOCIATES

August 1998

-5-

981-3142

Undrained shear strengths measured in the clayey silt fill adjacent to borehole 1 ranged from 12 to 23 kilopascals with an average vane sensitivity of 2.3.

It should be noted that the clayey silt fill was found to contain sand layers.

4.2.3 Native Soils

Where the fill was fully penetrated such as in boreholes 4, 5, 6, 8 and 12 layers of native clayey silt, sandy silt and sand were encountered. These materials had natural water contents of from about 10 to 24 per cent and N values of from 4 to 15 blows per 0.3 metres.

Borehole 13 which was drilled adjacent to the creek near the toe of the slope encountered about 2 metres of very loose sand and silt overlying soft silty clay. The sand and silt had an N value of 1 blow per 0.3 metres and water contents of from about 14 to 27 per cent. The silty clay had an N value of 4 blows per 0.3 metres and a water content of about 25 per cent. The silty clay had a corresponding plastic and liquid limit of about 19 and 32 per cent. respectively.

4.3 Groundwater

The groundwater conditions encountered during drilling and subsequently measured in the piezometers are summarized on the Record of Borehole sheets.

close to creek hole
All of the boreholes except boreholes 1 and 13 remained dry during drilling. Groundwater was encountered at a depth of 0.15 metres in borehole 1 during drilling or at elevation 226.51 metres. Borehole 13 encountered groundwater at a depth of about 0.15 metres or at elevation 213.45 metres.

Water levels measured in the piezometers in boreholes 1 and 13 on July 28, 1998 were about 0.50 and 0.30 metres below ground surface respectively or at elevations 226.18 and 213.14 metres.

The water level in the creek was at about elevation 213.25 metres at the time of this investigation.

Golder Associates

August 1998

-6-

981-3142

5.0 DISCUSSION

5.1 General

It is understood that the side slope of the Highway 402 embankment in the area of Station 24+600, Township of Caradoc is to be stabilized and the 900 millimetre culvert is to be replaced or repaired.

Based on the results of this investigation, both visual observations and engineering analyses confirm that the embankment slope is presently unstable with visual signs of on-going surficial movement at several locations. It is therefore considered essential that the overall embankment slope be stabilized prior to any work to address the 900 millimetre diameter culvert.

5.2 Embankment Slope Stabilization

Based on the soil and groundwater conditions encountered in the boreholes, it is recommended that the slope be regraded to achieve as flat a slope as possible with the present property constraints. Extending the 3350 millimetres diameter culvert by 11 metres and filling to the property line would achieve an overall slope inclination in the order of 2.5 horizontal to 1 vertical as shown on Figure 2. This inclination is slightly steeper than the visually stable slope immediately to the east. As an alternative to constructing a uniform slope, at approximately 2.4 horizontal to 1 vertical, it is recommended that consideration be given to utilize incremental slopes not exceeding 2 horizontal to 1 vertical with a 4 metre wide horizontal bench at mid height of the slope, as shown on Figure 2.

Following the extension of the 3350 millimetres diameter culvert and the removal of any sloughed materials and vegetation from the face of the slope, the placement of fill may commence. The fill may consist of suitable excavated materials from the adjacent highway works. The material should be placed in maximum 300 millimetre thick lifts and uniformly compacted to at least 95 per cent of standard Proctor maximum dry density. Each lift of fill should be properly benched into the existing slope. Following completion of the fill placement the slope should be covered with 150 millimetres of topsoil and seeded and mulched or provided with a vegetative mat system.

Golder Associates

AUG 12 1998 08:42 FR DILLON LDN
AUG 11 '98 04:40 PM GOLDER ASSOCIATES

519 672 8209 TO 8734620

P.09/29

August 1998

-7-

981-3142

It should be noted that site constraints do not permit removal of all of the existing poor quality fill materials and some relatively minor post construction movements should therefore be anticipated.

5.3 Drainage

Based on the results of this investigation and an examination of the vegetation on the slope, it is anticipated that localized portions of the slope face will be wet and groundwater flows may be encountered such as in the area of borehole 1. It is therefore considered essential that an adequate drainage system be installed in conjunction with the slope regrading to provide long-term groundwater control. This drainage system may consist of properly constructed french drains with finger drains installed to address wet areas as they are exposed during construction. In addition, free draining granular blanket may be required in some areas.

What's this mean?

5.4 900 Millimetre Culvert Replacement/Repair

Based on the condition of the existing slope, it is not considered geotechnically feasible to repair the existing 900 millimetre culvert nor to reinstall it and its current location.

It is recommended that once the slope stabilization work has been completed that the remaining portion of 900 millimetre culvert be bulkheaded and filled with a material such as low strength cement grout. The storm drainage from the southwest ditch could be directed down the slope in a properly lined ditch or in a newly constructed shallow bury culvert. The open ditch would provide an outlet for the slope drainage system. The ditch lining should consist of cabled precast concrete blocks placed on a suitable geotextile.

5.5 3350 Millimetre Culvert Inspection

Following a review of the Ministry of Transportation (MTO) inspection report of the culvert dated April 23, 1997 an inspection was carried out on July 27, 1998. The visual inspection revealed numerous areas of groundwater seepage into the culvert and severe deformation at longitudinal construction joints. However no evidence of plate tearing at/or between bolts was observed.

Golder Associates

AUG 12 1998 08:42 FR DILLON LDN
AUG 11 '98 08:42 FR DILLON LDN

519 672 8209 TO 8734600

P.10/29

August 1998

-8-

981-3142

Subsequent culvert diameter measurements indicated deformation of up to 7.5 per cent from the theoretical diameter of 3350 millimetres. Deformations in excess of 5 per cent are considered to be significant and of concern. Based on our inspection, the deformations appear to have occurred during construction rather than as a result of long-term movement. However, it should be noted that the area of the culvert where deformations typically exceed 5 per cent at sections 9, 10 and 11 are located beneath the unstable south embankment side slope.

5.6 Summary

The south side slope of the Highway 402 embankment in the study area is unstable and requires remedial work prior to addressing the 900 millimetre culvert and sinkhole.

The embankment instability is considered to be the result of the poor quality fill material, localized high groundwater levels and slope inclinations as steep as 1:5 horizontal to 1 vertical. The placement of fill to flatten the slope will be complicated by the existing culverts and creek as well as the lack of working area. Care will be required to ensure that the fill materials are suitable and that the specified degree of compaction is achieved. The location and extent of the french drain system can only be determined as the project proceeds and the wet areas are exposed. The proper installation of the drainage system will have a significant impact on the performance of the remediated slope and culvert(s).

Replacement of the 900 millimetre culvert should only be undertaken following stabilization of the embankment slope and should not adversely impact the stabilized slope.

AUG 12 1998 08:42 FR DILLON LDN
AUG 11 '98 04:48PM GOLDER ASSOCIATES LTD

519 672 8209 TO 8734625

P.11/29

August 1998

-9-

981-3142

We trust that this report provides sufficient geotechnical information for your present requirements. Should any point require further clarification, please contact this office.

Yours truly,

GOLDER ASSOCIATES LTD.

David J. Mitchell

Philip R. Bedell, P. Eng.

DJM/PRB/cb

Attachments:

Table I
List of Abbreviations
List of Symbols
Record of Boreholes
Figures 1, 2 and 3

Golder Associates

AUG 12 1998 08:42 FR DILLON LDN
AUG 11 '98 04:46PM GOLDER ASSOCIATES

519 672 8209 TO 8734600

P.12/29

August 1998

TABLE I

981-3142

SUMMARY OF CULVERT MEASUREMENTS

3350 Millimetre Diameter Culvert
Station 24+650, Highway 402
Township of Caradoc, County of Middlesex, Ontario

SECTION	LOCATION (m)	DIAMETERS (mm) DEFORMATION (%)		45° RIGHT	45° LEFT
		Horizontal	Vertical		
1	3.4	3410 1.8	3270 2.4	3390 1.2	3350 0
2	14.6	3430 2.4	3290 1.8	3330 0.6	3420 2.1
3	31.5	3390 1.2	3290 1.8	3320 0.9	3380 0.9
4	45.0	3420 2.1	3190 4.8	3330 0.6	3320 0.9
5	58.8	3500 4.5	3160 5.7	3290 1.8	3240 3.3
6	72.2	3430 2.4	3180 5.1	3370 0.6	3320 0.9
7	86.5	3320 0.9	3200 4.5	3270 2.4	3360 0.3
8	100.3	3460 3.3	3230 3.6	3290 1.8	3280 2.1
9	114.0	3550 6.0	3100 7.5	3270 2.4	3280 2.1
10	128.5	3570 6.6	3100 7.5	3180 5.1	3310 1.2
11	142.7	3510 4.8	3150 6.0	3200 4.5	3430 2.4
12	152.1	3280 2.1	3330 0.6	3310 1.2	3400 1.5

- NOTES: 1. Locations measured from the downstream end of the culvert.
2. Deformation is based on theoretical diameter of 3350 millimetres.
3. Right and left are looking upstream.

Golder Associates

AUG 12 1998 08:42 FR DILLON LDN

519 672 8209 TO 8734600

P.13/29

AUG 11 '98 04:46PM GOLDER ASSOC. LTD. HOLE OF BOREHOLE 1

SHEET 1 OF 1

LOCATION: - REFER TO LOCATION PLAN

BORING DATE: JULY 21, 1998

DATUM: GEODETIC

SAMPLER HAMMER, 31.75kg; DROP, 750mm

PENETRATION TEST HAMMER, 31.75kg; DROP, 750mm

((NOTE: Blows/0.3m Are Approximate Standard Penetration N Value Only.))

SHEET 1 OF 1

NUMBER SELF DATA SHEET 0001

DEPTH FROM METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWN/0.3m				HYDRAULIC CONDUCTIVITY, K cm/s		ADDITIONAL LAB. TESTING	MEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA ELEV. DEPTH m	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH CU kPa	UNLV - + UNLV - - U.O	Q - + Q - - U.O	WATER CONTENT, PERCENT Wp	Wc		
0		GROUND SURFACE	228.85										
0.08		Black silty TOPSOIL	0.08										
1	MANUAL (UNCLASS)	Very soft to soft grey clayey silt, trace sand trace sand layer (FILL)		1	SD	PM							
2				2	SD	SD							
2.24		END OF BOREHOLE	2.24										
1.60			1.60										

DRAFT COPY

Clay Seal
07/28/98
Backfill
Pne. Tip

WATER LEVEL
ENCOUNTERED AT
ELEV. 228.81
DURING DRILLING

WATER LEVEL
IN STANDPIPE
AT ELEV. 228.18
JULY 20, 1998

15 - 20 PERCENT AVERAGE STRAIN AT FAILURE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DJM
CHECKED:

AUG 12 1998 08:43 FR DILLON LDN

519 672 8209 TO 8734600

P.14/29

AUG 11 '98 04:46PM GOLDER ASSOCIATES
PROJECT: 891-0142

RECORD OF BOREHOLE 2

SHEET 4 OF 4

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 21, 1998

DATUM: GEODETIC

SAMPLER HAMMER, 81.75kg; DROP, 750mm

PENETRATION TEST HAMMER, 81.75kg; DROP, 750mm

((NOTE: Blows/30cm Are Approximate Standard Penetration N-Value Only.))

DEPTH SCALE METRES	SOIL PROFILE	STRATA PLOT	SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOW/30cm	HYDRAULIC CONDUCTIVITY Kc CM/S		PIEZOMETER OR STANDPIPE INSTALLATION
			NUMBER	TYPE		WATER CONTENT, PERCENT		
DESCRIPTION	ELEV. DEPTH (m)				CLAY, %	Wp		
GROUND SURFACE	225.88							
Black silty TOPSOIL	225.88							
Silt to very stiff gray clayey silt with sand layers (ALL)	225.88	1	SS	21				
	225.88	2	SS	24				
	225.88	3	SS	11				
	225.88	4	SS	12				
END OF BOREHOLE	222.33							

DRAFT COPY

BOREHOLE DRY
DURING DRILLING
JULY 21, 1998

15-5 PERCENT AXIAL STRAIN AT FAILURE

Golder Associates

LOGGED: DJM
CHECKED:

AUG 12 1998 08:43 FR DILLON LDN

519 672 8209 TO 8734620

P.15/29

AUG 11 '98 04:47PM GOLDER ASSOCIATES BUILD OF BOREHOLE 3

SHEET 1 OF 1

LOCATION: - REFER TO LOCATION PLAN

BORING DATE: JULY 21, 1998

DATUM: GEODETIQ

SAMPLER HAMMER, 31.75kg, DROP, 760mm

PENETRATION TEST HAMMER, 31.75kg, DROP, 760mm

((NOTE: Blows/0.3m Are Approximate Standard Penetration N-Value Only.))

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, K, cm/s				PIEZOMETER OR STANDARD INSTALLATION	
		DESCRIPTION	STRATA DEPTH (m)	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH				WATER CONTENT, PERCENT				
							CU, kPa	CU, kPa	CU, kPa	CU, kPa	Wp	Wp	Wp		Wp
0		GROUND SURFACE	220.14												
0		Black silty TOP SOIL	220.14												
1	MANUAL (DEKAS20)	Soft gray clayey silt trace to some sand, with sand layers (FILL)	218.77	1	SS										
2				SS											
3				SS											
4				SS											
5				SS											
5		END OF BOREHOLE	218.77												

DRAFT COPY

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DJM
CHECKED:

AUG 12 1998 08:43 FR DILLON LDN

519 672 8209 TO 8734600

P. 16/29

AUG 11 '98 04:47PM GOLDER ASSOCIATES

SHEET 1 OF 1 P. 16/29

RECORD OF BOREHOLE 4

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 23, 1998

DATUM: GEODETIC

SAMPLER-HAMMER: 31.75kg DROP, 750mm

PENETRATION TEST: HAMMER, 31.75kg DROP, 750mm

((NOTE: Blows/30cm Are Approximate Standard Penetration N Value Only.))

DEPTH-SCENE METERS	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWN/30cm		HYDRAULIC CONDUCTIVITY, cm/sec		ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/30cm	SHEAR STRENGTH C _u 10% mm V. + mm V. -	WATER CONTENT, PERCENT W _s			
0		GROUND SURFACE	326.85								
0.15		Black silty TOPSOIL	0.60								
0.15			0.15								
1.0		Firm gray clayey silt trace to some sand with sand layers (FILL)		1	SS	6					
2.0				2	SS	4					
3.0				3	SS	0					
4.0				4	SS	6					
5.0		Firm gray CLAYEY SILT some sand	323.25								
5.1			3.24								
5.1			3.24								
5.1		Loose gray SANDY SILT trace clay	320.62								
5.1			3.24								
5.1			3.24								
5.1		END OF BOREHOLE	321.75								
5.1			3.24								

DRAFT COPY

15-25 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE
1 : 80

Golder Associates

LOGGED: DJM
CHECKED:

BOREHOLE DRY
CURING DURING
JULY 28, 1998

R-96%

519 672 8209

08-12-98 08:33AM P016 #06

AUG 12 1998 08:43 FR DILLON LDN

519 672 8209 TO 8734600

P.17/29

AUG 11 '98 04:47PM GOLDER ASSOCIATES

SHEET 1 OF 1

LOCATION: - REFER TO LOCATION PLAN

BORING DATE: JULY 23, 1998

DATUM: GEODETIC

SAMPLER HAMMER, 61.75kg; DROP, 760mm

PENETRATION TEST HAMMER, 31.75kg; DROP, 760mm

((NOTE: Shows 0.2m Air Approximate Standard Penetration N Value Only.))

DEPTH SCALE METERS

BORING DATE: JULY 23, 1998

DEPTH SCALE METERS	BORING METHOD	SOIL PROFILE		ELEV. (m)	SAMPLE NUMBER	TYPE	DYNAMIC PENETRATION RESISTANCE, SLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K (m/s)		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STARTED				STOPPED	CL. kPa	CL. MPa	WATER CONTENT, PERCENT		
0		GROUND SURFACE		222.52								
0.5		Black silty TOPSOIL		0.66								
1.0				0.13								
1.5		Loose gray sandy silt trace clay occasional sand layers (FILL)			1	SS						
2.0					2	SS						
2.5		Loose dark brown SANDY SILT trace organic material		2.45	2	SS						
3.0				2.74								
3.5		Brown SILTY FINE SAND			4	SS						
4.0				2.91								
4.5		Compact brown SILT trace sand with clayey silt layers		3.51	5	SS						
5.0				2.85								
5.5		END OF BOREHOLE		2.27								

10-15 PERCENT AXIAL STRAIN AT FAILURE

LOGGED: DJM
CHECKED:

Borehole

Piez. Tip

BOREHOLE DRY
DURING DRILLING
JULY 23, 1998

STANDPIPE
DRY TO
ELEV. 219.27
JULY 23, 1998

DEPTH SCALE

1: 50

Golder Associates

R-96%

519 672 8209

08-12-98 08:33AM P017 #06

AUG 12 1998 08:44 FR DILLON LDN

519 672 8209 TO 8734600

P.18/29

AUG 11 '98 04:48PM GOLDER ASSOCIATES OF BOREHOLE 6.

SHEET 1 OF 1 P.18/29

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 23, 1998

DATUM: GEODETIC

SAMPLER HAMMER, 31.75kg; DROP, 750mm

PENETRATION TEST HAMMER, 31.75kg; DROP, 750mm

((NOTE: Elevations Are Approximate Standard Penetration N Values Only.))

04975306 8100004

DEPTH SCALE METERS	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMO PENETRATION RESISTANCE, BLOWED 2m				HYDRAULIC CONDUCTIVITY, k, cm/s				MEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	SWATHA PLOT	ELEV. DEPTH m	NUMBER	TYPE	SHEAR STRENGTH Cv, kPa	UNV. + C.C.		UNV. - S U.C.		WATER CONTENT, PERCENT Wt %		
								25	50	75	100		15	
0		GROUND SURFACE		217.91 0.00										
0.5	MANUAL (UNCASED)	Silt gray clayey silt trace sand (FILL)			1	SS								BOREHOLE DRY DURING DRILLING JULY 23, 1998
1		Very loose black silty TOP SOIL		215.54 1.37	2	SS								
1.5		Very loose brown fine SAND some silt		215.27 1.62	3	SS								
2		END OF BOREHOLE		215.47 2.44										
3														
4														
5														
6														
7														
8														
9														
10														

COPY

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DJM
CHECKED:

AUG 12 1998 08:44 FR DILLON LDN

519 672 8209 TO 8734600

P.19/29

AUG 11 '98 04:48PM GOLDER ASSOCIATES END OF BOREHOLE

SHEET 1 OF 1 P.19/29

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 22, 1998

DATUM: GEODETIC

SAMPLER HAMMER, 31.76kg DROP, 760mm

PENETRATION TEST HAMMER, 31.75kg DROP, 760mm

(* NOTE: Blows/0.3m Are Approximate Standard Penetration N-Value Only. *)

DEPTH (m)	SOIL PROFILE	SAMPLER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, cm/s		PIEZOMETER OR STANDPIPE INSTALLATION
					20	40	20	40	
0.00	GROUND SURFACE								
0.50	PROBABLY Very soft clayey silt (PILL)								
1.00									
1.50									
2.00									
2.50	END OF PENETRATION TEST								
3.00									
3.50									
4.00									
4.50									
5.00									
5.50									
6.00									
6.50									
7.00									
7.50									
8.00									
8.50									
9.00									
9.50									
10.00									

DEPT COPY

15-25 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DJM
CHECKED:

AUG 12 1998 08:44 FR DILLON LDN

519 672 8209 TO 8734600

P.20/29

AUG 11 '98 04:48PM GOLDER ASSOCIATES OF BUREAU OF

DATUM: GEODETIC

LOCATION: - REFER TO LOCATION PLAN

BORING DATE: JULY 23, 1998

PENETRATION TEST HAMMER, 31.75kg; DROP: 760mm

SAMPLER HAMMER, 31.75kg; DROP: 760mm

((NOTE: Blows/0.3m Are Approximate Standard Penetration N-Value Only.))

DEPTH SCALE METERS	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOW/0.3m		HYDRAULIC CONDUCTIVITY, m/dm/s		ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	DEPTH (m)	ELEV. (m)	TYPE	BLOWS/0.3m	SHEAR STRENGTH CU, kPa	REL. V. - REL. V. +	WATER CONTENT, PERCENT		
1	SAMPLER (METERS)	GROUND SURFACE	218.88	0.00							
2		Black silty TOPSOIL	0.15								
3		Soft grey clayey silt trace sand (FILL)	218.92	1.23	1	20	50				
4		Very loose grey silty fine sand (FILL)	218.10	1.92	2	50	50				
5		Loose brown and grey sandy silt with clayey silt layers (FILL)	215.10	2.90	3	50	50				
6		Very loose black silty TOPSOIL	214.65	3.25	4	50	50				
7		Compact brown fine-med. SAND	214.65	3.25							
8		END OF BOREHOLE	214.65	3.25							

DRAFT COPY

100% POSITIVE STRAIN AT FAILURE

BOREHOLE DRY
DURING DRILLING
JULY 23, 1998

DEPTH SCALE

1: 50

Golder Associates

LOGGED: DJM

CHECKED:

AUG 12 1998 08:45 FR DILLON LDN

519 672 8209 TO 8734600

P.21/29

AUG 11 '98 04:48PM GOLDER ASSOCIATES OF BOHEMIA

DATUM: GEODETIC

LOCATION: - REFER TO LOCATION PLAN

BORING DATE: JULY 23, 1998

PENETRATION TEST HAMMER, 31.75kg; DROP, 750mm

SAMPLER HAMMER, 31.75kg; DROP, 750mm

((NOTE: Blows/0.3m Are Approximate Standard Penetration N-Value Only))

Data File No. 138903

DEPTH SCALE METRES	RETURNED SAMPLES	SOIL PROFILE		SAMPLER		DYNAMIC PENETRATION RESISTANCE, BLOWN/0.3m		HYDRAULIC CONDUCTIVITY, K, CM/S		ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cv, kPa	ANV - + S - E (kN - 0 U - C)	WATER CONTENT, PERCENT w _p — w _L — w _U			
0		GROUND SURFACE	221.45 0.00								
1		Firm to soft grey clayey silt with cone layers (FILL)		1	SD	5					
2			218.47 1.88	2	SD	3					
3		Loose grey silty sand trace clay (FILL)	218.71 2.74	3	SD	5					
4		Compacted brown fine to medium sand trace brick (FILL)	218.10 3.26	4	SD	10					
5		END OF BOREHOLE									

DRAFT COPY

GOLDER ASSOCIATES

LOGGED: DJM
CHECKED:

BOREHOLE DRY
DURING DRILLING
JULY 23, 1998

DEPTH SCALE

1: 30

Golder Associates

LOGGED: DJM

CHECKED:

AUG 12 1998 08:45 FR DILLON LDN

519 672 8209 TO 8734600

P.22/29

AUG 11 '98 04:49PM GOLDER ASSOCIATES OF BOREHOLE 10

SHEET 1 OF 1 P. 22/29

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 24, 1998

DATUM: GEODETIC

SAMPLER HAMMER, 31.75kg; DROP, 760mm

PENETRATION TEST HAMMER, 31.75kg; DROP, 760mm

((NOTE: Blows/0.3m Are Approximate Standard Penetration N Values Only.))

DEPTH SCALE METERS	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, K _{AVG}				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	SEPTA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOW/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
							Ca, kPa	tan δ, %	φ, °	c, kPa	U-C	Wp	W			Li
0		GROUND SURFACE	222.56 0.00													
1	MANUAL (UNCLASS.)	Very soft to firm gray clayey siltstone to sand and gravel, with sand layers (FILL.)		1	25	10										
2				25	0											
3				25	12											
4				25	4/100mm											
5		END OF BOREHOLE	218.05 5.20													

ORIGINAL COPY

Borehole Dry
During Drilling
July 24, 1998
Standpipe
Dry To
Elev. 218.05
July 28, 1998

GOLDER ASSOCIATES

DEPTH SCALE
1: 20

LOGGED: D.J.M.
CHECKED:

AUG 12 1998 08:45 FR DILLON LDN

519 672 8209 TO 8734500

P.23/29

AUG 11 '98 04:49PM GOLDER ASSOCIATES OF BOHEMIA

SHEET 1 OF 1

LOCATION: - REFER TO LOCATION PLAN

BORING DATE: JULY 24, 1998

DATUM: GEODETIC

SAMPLER-HAMMER, 31.75kg; DROP, 760mm

PENETRATION TEST HAMMER, 31.75kg; DROP, 760mm

(NOTE: Blows/0.3m Are Approximate Standard Penetration N-Value; Only.)

DEPTH SCALE METERS	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOW/0.3m		HYDRAULIC CONDUCTIVITY, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANOMETER INSTALLATION
		DESCRIPTION	SUBSTRATE ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH C _v , kPa	S _v , kPa	WATER CONTENT, PERCENT w _p	HYDRAULIC CONDUCTIVITY, cm/s		
0		GROUND SURFACE	225.55								
		Black silty TOPSOIL	0.00								
			0.15								
1	MANUAL (WICKED)	65% gray clayey silty sand with sand layers (FILL)		1	DS	10					
2	2			DS	13						
3	3			DS	11						
		END OF BOREHOLE	222.51								
			2.74								

DRAFT COPY

11-6 PERCENT AXIAL STRAIN AT FAILURE

BOREHOLE DRY
DURING DRILLING
JULY 24, 1998

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DJM

CHECKED:

08-13-98 09:02AM

TO 8/14162355240

P023

AUG 13 '98 08:12AM

AUG 12 1998 08:45 FR DILLON LDN

519 672 8209 TO 8734600

P.24/29

AUG 11 '98 04:49PM GOLDER ASSOCIATES LTD OF BURNETTVILLE

DATUM: GEODETIC

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 24, 1998

PENETRATION TEST HAMMER, 31.75kg; DROP, 760mm

SAMPLER HAMMER, 31.75kg; DROP, 760mm

((+ NOTE: Blows/0.3m Are Approximate Standard Penetration N Value Only.))

DEPTH SCALE METERS	BORING METHOD	SOIL PROFILE		SAMPLER		DYNAMIC PENETRATION RESISTANCE, BLOW/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH		WATER CONTENT, PERCENT			
						CU, KPa	CU, %	Wp	Wl		
1		GROUND SURFACE	120.75								
2		Black silty TOPSOIL	0.00								
3			0.31								
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											
31											
32											
33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											
61											
62											
63											
64											
65											
66											
67											
68											
69											
70											
71											
72											
73											
74											
75											
76											
77											
78											
79											
80											
81											
82											
83											
84											
85											
86											
87											
88											
89											
90											
91											
92											
93											
94											
95											
96											
97											
98											
99											
100											

BOREHOLE DRY
DURING DRILLING
JULY 24, 1998

COPY

3-5 PERCENT AXIAL STRAIN AT FAILURE

LOGGED: DJM

CHECKED:

DEPTH SCALE

1 : 50

Golder Associates

AUG 12 1998 08:46 FR DILLON LDN

519 672 8209 TO 8734600

P.25/29

DILLON, IL, 75 64-50FT GOLDEN GULLER OF DILLON

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 24, 1998

DATUM: GEODETIC

SAMPLER/HAMMER: 31.75kg; DROP: 750mm

PENETRATION TEST HAMMER: 31.75kg; DROP: 750mm

((NOTE: Blows 0-3m Are Approximate Standard Penetration N Value Only.))

Dillon, IL, 75

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/30cm	HYDRAULIC CONDUCTIVITY, cm/sec	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA DEPTH (m)	NUMBER	TYPE				
0	MARKER (UNCHISEL)	GROUND SURFACE	212.50	0.00					
0.5		Brown SAND trace gravel	213.00	0.50					
1.0		Very loose gray SILTY FINE SAND trace organic material	213.50	1.00	1	SS			
1.5		Very loose gray SANDY SILT trace organic material	214.00	1.50	2	SS			
2.0		Soft gray SILTY CLAY	214.57	2.00	3	SS			
2.5		END OF BOREHOLE	215.20	2.50					

WATER LEVEL
ENCOUNTERED
AT ELEV. 213.45
DURING DRILLING
JULY 24, 1998

WATER LEVEL
IN STANDPIPE
AT ELEV. 213.10
JULY 26, 1998

LOGGED: DJM
CHECKED:

DEPTH SCALE
11.50

Golder Associates

DRAFT COPY

AUG 12 1998 08:46 FR DILLON LDN
 PREPARED BY: 11/98 04:50PM GOLDER ASSOCIATES OF BOREHOLE 14

P.26/29

SHEET 1 OF 1 P.26/29

LOCATION: REFER TO LOCATION PLAN

BORING DATE: JULY 24, 1998

DATUM: GEODETIC

SAMPLES: HAMMER, 0.75kg; DROP, 750mm

PENETRATION TEST HAMMER, 0.170kg; DROP, 750mm

(* NOTE: Blows/0.3m Are Approximate Standard Penetration N-Value Only. *)

DEPTH SCALE METERS	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, m DPM				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	HAMMER TYPE	TYPE	SHEAR STRENGTH CU, kPa	REL. + REL. - U.C.	REL. + REL. - U.C.	REL. + REL. - U.C.	WATER CONTENT, PERCENT	W	W	W		
0	MANUAL (PNEUMATIC)	GROUND SURFACE	224.00												
0		Black silty TOPSOIL	0.00												
0.5			0.18												
1		Loose grey sandy silt trace clay (FILL)													
1.5			0.22												
2		Loose grey silt trace clay some sand (FILL)													
2.5			0.22												
3		Stiff grey clayey silt trace sand (FILL)													
3.5			0.21												
4		END OF BOREHOLE	2.00												

DRAFT COPY

BOREHOLE DRY
DURING DRILLING
JULY 24, 1998

5-5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE
1 : 30

Golder Associates

LOGGED: DJM
CHECKED:

AUG 13 '98 08:12AM

62/22.1

2025 RELEASE UNDER E.O. 14176



REFERENCE

TOPOGRAPHICAL PLAN OF SURVEY
OF
17122, RANGE 1, NORTH OF THE LONGWOOD ROAD
IN THE
TOWNSHIP OF CRAWFORD
COUNTY OF WINNEBEGON
STATE OF IOWA
FRANKLIN, JOSEPH & SONS SURVEYORS, LTD.
JAN 20/11. 117 222, 100

~~SECRET~~

PLAN
SCALE 1:300

Date AUG. 21, 1958
Project 581-3142



Drawn **WCS**
2 200 100 0000

Child **1**
2 200 100 0000

R-97% AIR 11 1988 16:54

519 672 8209

4014222 08-12-98 08:53AM P027 #06

08-13-98 09:02AM

TO 8/14/98 08:52AM

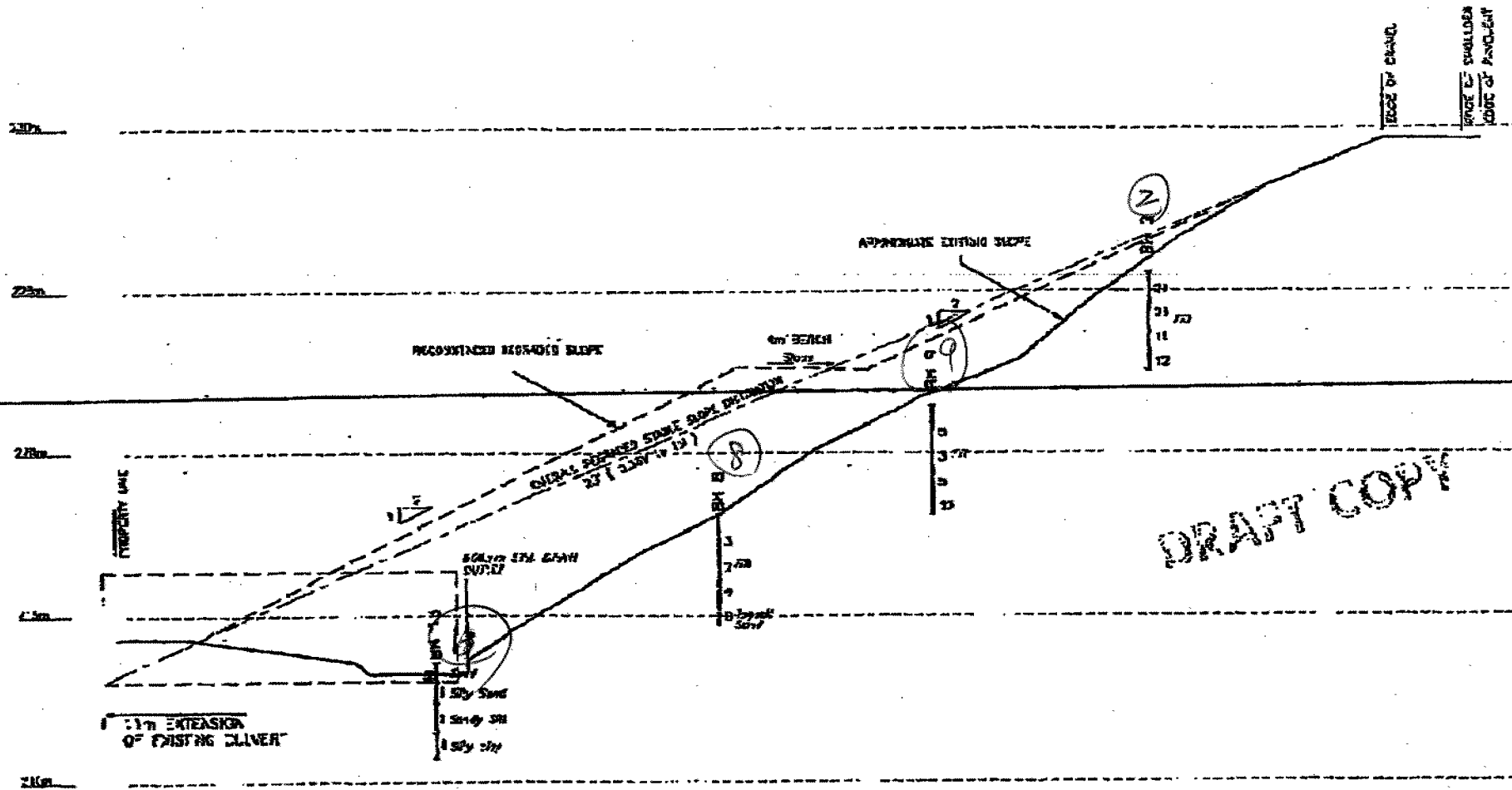
P027 AUG 13 '98 08:12AM

AUG 12 1998 08:46 FR DILLON LON
AUG 11 '98 04:51PM GULFER RESOLUTIONS

519 672 8209 TO 8734600

P.28/29

ATCWA:SECIN MW 08/14/98 10:15



DATE AUG. 11, 1998
PROJECT 881-3142



Drawn by
Checked by

R-97%

519 672 8209

08-12-98 08:33AM P028 #06

SCHEMATIC SECTION

FIGURE 2

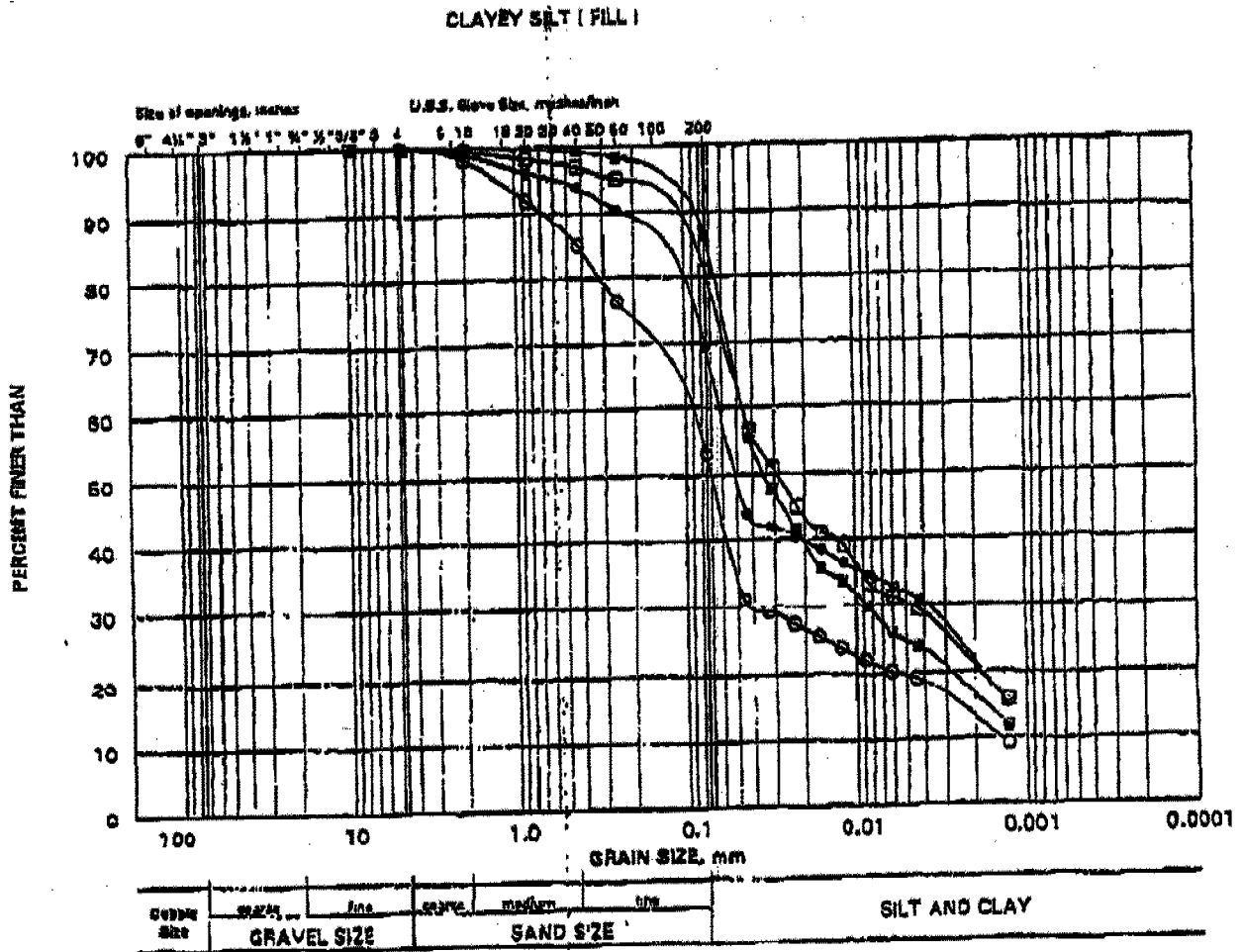
AUG 12 1998 08:47 FR DILLON LDN
AUG 11 '98 04:51PM GOLDER

519 672 8209 TO 8734600

P.29/29

GRAIN SIZE DISTRIBUTION

FIGURE 3



LEGEND			
SYMBOL	BORHOLE	SAMPLE	ELEV. (m)
•	3	4	220.0
■	4	2	224.4
○	9	2	219.8
□	11	1	224.7

DRAFT COPY

Project 881-3142

Golder Associates

519.4714707

PAGE 29

AUG 11 1998 16:51

R-95%

519 672 8209

08-12-98 08:33AM P029 #06