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HORROCKS & CAROLLO ENGINEERS
A JOINT VENTURE
ONE WEST MAIN
P. O. BOX 377
AMERICAN FORK, UTAH 84003

July 12, 1984

Mr. Wendell Owen
Co-Op Mining Company
P.O. Box 1245
Huntington, Utah 84528

Subject: Bear Creek Canyon Mine Site
Sedimentation Pond "A" - Stability Analysis

Dear Mr. Owen:

Transmitted herewith is a stability analysis report on the embankment of sedimentation pond "A" at the Bear Creek Canyon Mine site. The stability analysis was performed to confirm the stability of the 2H:1V interior slope and to determine the required angle of exterior slopes on the south and east.

If we can answer any questions or be of further help, please contact us.

Very truly yours,

HORROCKS/CAROLLO ENGINEERS

H. Lee Wimmer

H. Lee Wimmer, P.E.
Project Engineer

jlh

Enclosure

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE WIMMER
STATE OF UTAH

SLOPE STABILITY ANALYSIS
ON
EMBANKMENT OF SEDIMENTATION POND "A"
BEAR CREEK CANYON MINE SITE
CO-OP MINING COMPANY

JULY 1984

Prepared by Harold Lee Wimmer
Harold Lee Wimmer, P. E.
Utah P.E. No. 3535

HORROCK & CAROLLO ENGINEERS
One West Main
American Fork, Utah 84003
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SECTION I

In conjunction with the redesign of sedimentation pond "A" of the Bear Creek Canyon Mine site, various in place and laboratory soil tests were performed. Using the parameters obtained from these tests, slope stability analyses were performed to confirm the stability of the 2H:IV interior slope and to determine a stable angle for the exterior slope.

SECTION II

CONSTRUCTION

On September 29, 1983, I visited the site in conjunction with Wendell Owens of the Co-Op Mining Company and reviewed in detail the provisions taken at the site during construction. I also reviewed with Mr. Owen the construction procedures which enabled me to determine how the embankment was constructed to its present slope.

SECTION III

MATERIAL TESTING

While at the site, using a Troxler 3411B nuclear density gauge, I determined the in-place density of the embankment material. I also obtained moisture density samples and samples of the embankment material, which I returned to the lab for additional testing. The results of these in-place determinations indicate that the average in-place density of the material varied from 89% to 94% of the laboratory obtained T-99 standard proctor.

I submitted a sample of the embankment material to Chen and Associates, a consulting soil and foundation engineering firm, to determine the relationship of the loading to the shear stress, and to determine the internal cohesion. These results are included in the Appendix. The material gradation results are also included in the Appendix. The gradation results indicate that the material is free draining confirming the on site tests.

SECTION IV

OCCURRENCE OF GROUND WATER

The results of the gradation analysis indicate that the material is free draining. This was further observed at the site through reviewing the existing material in place and performing percolation tests in the embankment. Because of the geology of the mine plan area the embankment is not effected by ground water, but for purposes of analysis the soil was assumed saturated by the water occasionally held in the pond. This assumed extent of saturation provides for conservative results.

SECTION V

FACTOR OF SAFETY

A computer model was constructed to analyze the stability of the embankment and the following conditions were assumed.

1. The soil below the maximum water elevation on the interior slope to the toe of the exterior slope (soil #2) was assumed saturated.
2. In-place soil density of 118 pounds per cubic foot.
3. 2H:IV angles were used for both interior and exterior slopes.

A computer simulation was then applied to this situation to determine various failure planes. The "Method of Slices" is the basis for the modified Bishop method computer program. Various failure planes were investigated to determine a minimum factor of safety. The results of these computer runs and a copy of the computer listing is attached in the Appendix. The results of these computer simulations indicate that the minimum factor of safety with a .1 g earthquake loading is 3.8 for the interior slope and 2.8 for the exterior slope at the point of maximum length.

SECTION VI

CONCLUSIONS

In conclusion the sedimentation pond "A" embankment as now existing is:

1. Free draining.
2. No water was encountered in test holes dug in embankments.
3. No movement of the embankment has been detected.
4. The computer simulation on failure planes indicates that the factor of safety is at least 2.8 with a .1 g earthquake loading for 2H:IV slopes for both the interior and exterior of the embankment.

ENGINEERS

Project Name: Coop Mine — Date: 10/6/85
Project No. — Station or Pit Location
Sample No: #2 — Requisted by: HLW
Native material, Pond dikes

AS RECEIVED GRADATION

Screen Size	Weight (a)	Percent Retained	Percent Passing	SPECS.
3"				
2"	0	0	100%	
1 1/2"	1132.1	14.0	86.0	
3/4"	875.8	10.9	75.1	
1/2"	466.3	5.8	69.3	
~~3/8"~~				
#4	1112.1	13.8	55.6	
~~Wet Wt. -#4~~				
Dry Wt -#4	4483.1	55.6		
Total Wt Dry	3069.9			

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8	141.7	8.9	91.1	19.7	
#10	31.1	2.0	89.1	17.9	
#16	69.5	4.4	84.7	17.5	
#20	40.7	2.6	82.2	16.7	
#30	31.8	2.0	80.1	16.2	
#40	47.9	3.0	77.1	15.8	
#50	91.4	5.8	71.4	15.2	
#100	350.3	22.1	49.3	14.0	
#200	146.4	9.2	40.1	9.7	
#200	635.7	40.1	0		
Total Wt	15868				

Wt. before washing
Wt. after washing

MOISTURE DETERMINATION	-#4
Container & Wet Soil Weight (gm.)	
Container & Dry Soil Weight (gm.)	
H_2O Loss	
% Moisture	

A.A.S.H.O Classification

COPIES TO:

Tested by: Kirk I. Eschen

ENGINEERS

Project Name Coop Mine Date 10/6/85
Project No. Station or Pit Location
Sample No #1 (Coal Particles) Requested by HLW
~ sediment in Pond

AS RECEIVED GRADATION

Screen Size	Weight (a)	Percent Retained	Percent Passing	SPECS.
3"				
2"				
1"	0	0	100%	
3/4"	63.0	0.8	99.2	
1/2"	94.7	1.2	98.1	
~~3/8"~~				
#4	317.[illegible]	3.9	94.1	
~~Wet Wt. -#4~~				
Dry Wt. -#4	7654.4	94.[illegible]		
Total Wt Dry	8131.9			

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8	126.3	8.5	91.5	18.3	
#10	37.6	2.5	89.0	16.8	
#16	121.7	8.2	80.8	16.3	
#20	79.7	5.4	75.5	14.8	
#30	60.4	4.1	71.4	13.8	
#40	67.1	4.5	66.9	13.1	
#50	95.8	6.4	60.5	12.3	
#100	328.3	22.[illegible]	38.4	11.1	
#200	113.2	7.6	30.8	7.0	
-#200	459.0	30.8	0		
Total Wt	1489.1				

Wt. before washing
Wt. after washing

MOISTURE DETERMINATION	-#4
Container & Wet Soil Weight (gm.)	
Container & Dry Soil Weight (gm.)	
H_2O Loss	
% Moisture	

AASHO Classification		

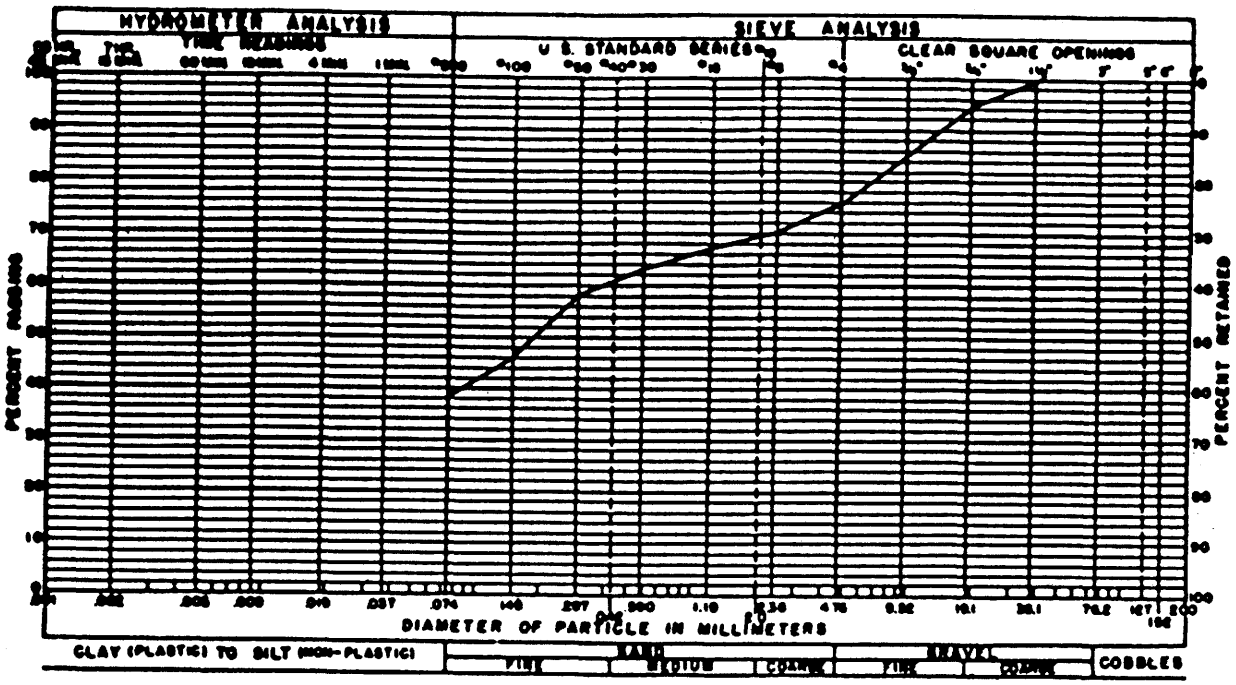
COPIES TO:

Tested by Kirk L. Feeney

CHEN AND ASSOCIATES

Consulting Engineers

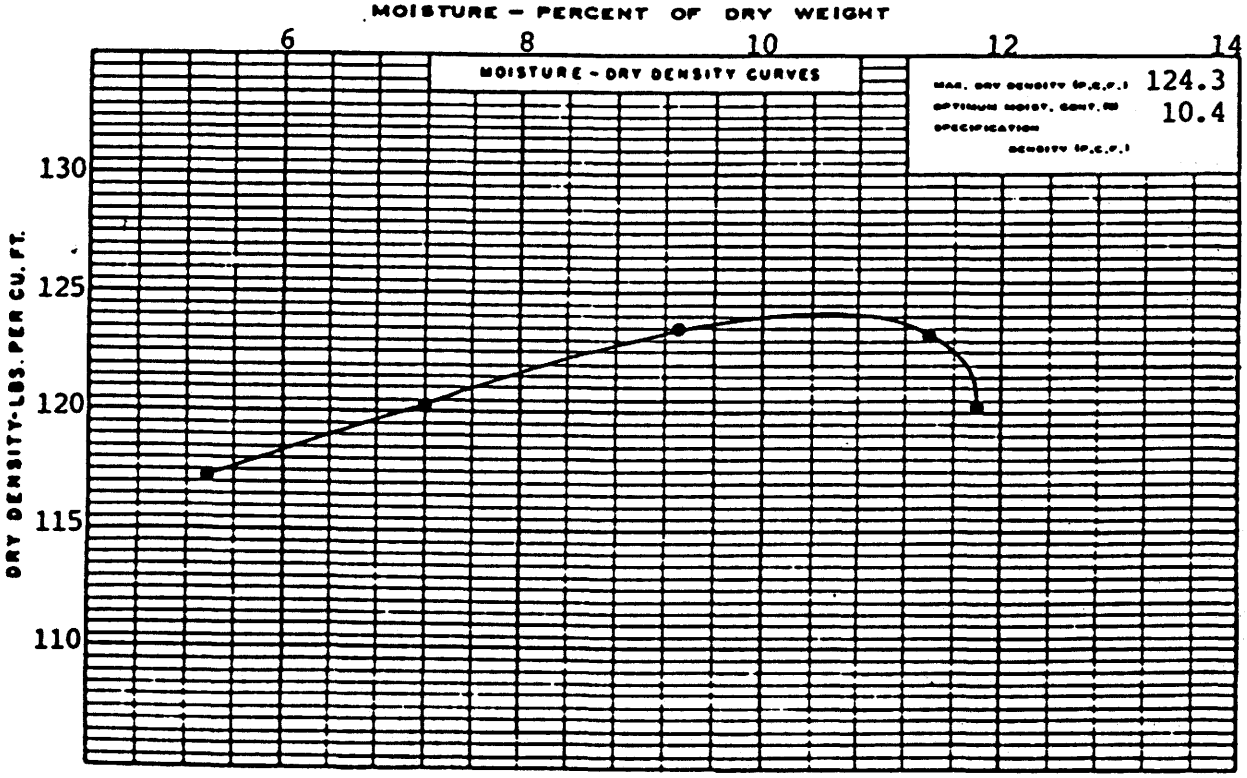
Soil and Foundation Engineering



GRADATION TEST RESULTS

GRAVEL 25 % SAND 37 % SILT AND CLAY 38 %

LIQUID LIMIT % PLASTICITY INDEX %



COMPACTION TEST RESULTS

COMPACTION TEST PROCEDURE ASTM D-698 Method C

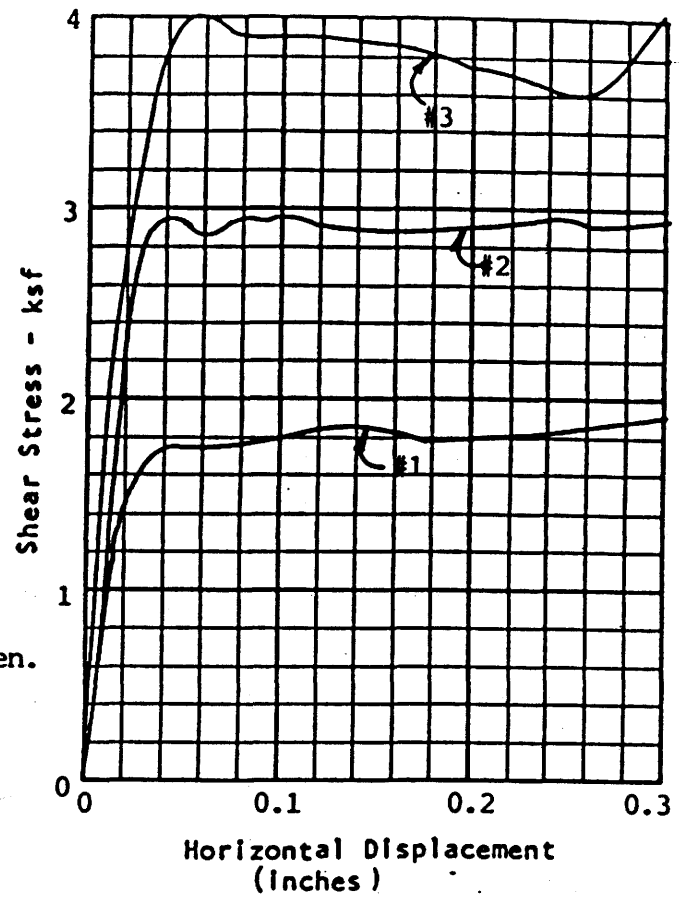
SAMPLE OF Clayey Sand and Gravel

#525284 FROM DEPTH

CA-3

Consulting Soil and Foundation Engineers

TEST NUMBER	1	2	3	4
LOCATION				
HEIGHT-INCH	.75	.75	.75	
DIAMETER-INCH	1.925	1.925	1.925	
WATER CONTENT - %	10.0	10.0	10.0	
DRY DENSITY - pcf	117.8	117.8	117.8	
CONSOL. LOAD - ksf	2.0	4.0	6.0	
NORMAL LOAD - ksf	2.0	4.0	6.0	
SHEAR STRESS - ksf	1.8	3.0	4.0	



TYPE OF SPECIMEN Remolded @ 95% Std.Proctor Den.

SOIL DESCRIPTION Clayey Sand and Gravel

TYPE OF TEST Consolidated-Undrained

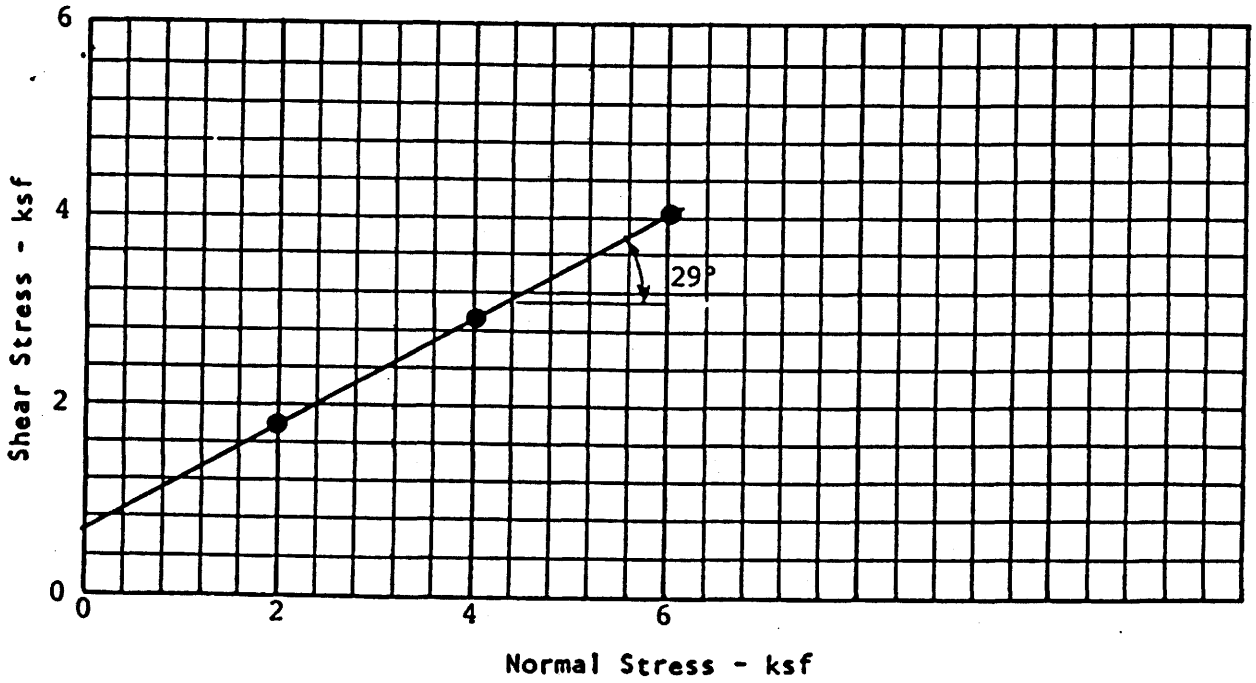
Saturated

Strain Rate 0.02 in/sec

TAN Ø

Ø 29°

COHESION - ksf 0.7



#525284

DIRECT SHEAR TEST RESULTS

HORROCKS ENGINEERS

7/12/83

SLOPE STABILITY ANALYSIS

for

CO-OP MINE - SLOPE STABILITY ** SEDIMENT POND A

DATA FILE: "CPSLOA:T14"

PROJECT NUMBER: 8309-42

by: EGN

WATER UNIT WEIGHT= 62.

Interior Slope

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	108.0	94.0	10.0	4.57

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	255.8	-41.3	700	1.7	120.3	29	101.4
2	670.6	-29.1	700	1.7	315.4	29	103.2
3	994.6	-18.3	700	1.7	467.8	29	104.9
4	1248.6	-8.2	700	1.7	587.2	29	106.6
5	1441.1	1.7	700	1.7	677.7	29	108.3
6	1573.8	11.6	700	1.7	740.1	29	110.0
7	1642.9	21.9	700	1.7	772.6	29	111.7
8	1636.9	33.1	700	1.7	769.8	29	113.4
9	1527.4	46.0	700	1.7	718.3	29	115.1
10	702.7	58.1	700	.9	352.0	29	116.5
11	555.8	71.0	700	.9	326.0	29	117.4
12	69.9	83.6	700	.2	50.6	29	117.9

ITERATION	INITIAL	CALCULATED
1	1.0000	4.3859
2	4.3859	4.5570
3	4.5570	4.5669
4	4.5669	4.5674

FACTOR OF SAFETY= 4.57 AT X= 108 Y= 94 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	110.0	98.0	10.0	5.71

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	119.8	-26.5	700	1.4	56.3	29	105.5
2	327.1	-17.9	700	1.4	153.8	29	106.9
3	497.2	-9.6	700	1.4	233.8	29	108.3
4	633.8	-1.6	700	1.4	298.1	29	109.7
5	738.4	6.5	700	1.4	347.2	29	111.1
6	810.3	14.6	700	1.4	381.1	29	112.5
7	846.8	23.1	700	1.4	398.2	29	113.9
8	842.0	32.1	700	1.4	396.0	29	115.3
9	571.3	40.6	700	1.0	294.8	29	116.5
10	514.1	48.8	700	1.0	320.2	29	117.5
11	423.2	59.6	700	1.1	331.7	29	118.6
12	94.5	72.3	700	.7	94.5	29	119.5

ITERATION	INITIAL	CALCULATED
1	1.0000	4.9462
2	4.9462	5.6651
3	5.6651	5.7085
4	5.7085	5.7108

FACTOR OF SAFETY= 5.71 AT X= 110 Y= 98 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	102.0	96.0	10.0	8.36

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	36.5	-22.2	700	1.2	17.2	29	98.2
2	91.5	-15.0	700	1.2	43.1	29	99.4
3	183.5	-7.9	700	1.3	86.3	29	100.6
4	292.7	-.5	700	1.3	137.7	29	101.9
5	377.6	6.8	700	1.3	177.6	29	103.2
6	437.7	14.2	700	1.3	205.8	29	104.5
7	470.9	21.9	700	1.3	221.5	29	105.7
8	473.6	30.1	700	1.3	222.7	29	107.0
9	438.4	39.0	700	1.3	206.2	29	108.3
10	350.4	49.3	700	1.3	164.8	29	109.5
11	169.8	62.9	700	1.3	79.9	29	110.8

ITERATION	INITIAL	CALCULATED
1	1.0000	7.1635
2	7.1635	8.3138
3	8.3138	8.3580
4	8.3580	8.3595

FACTOR OF SAFETY= 8.36 AT X= 102 Y= 96 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	104.0	98.0	10.0	10.14

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	35.5	-7.0	700	1.0	16.7	29	102.8
2	98.5	-1.5	700	1.0	46.3	29	103.7
3	150.9	4.1	700	1.0	71.0	29	104.7
4	192.6	9.6	700	1.0	90.6	29	105.7
5	223.2	15.3	700	1.0	105.0	29	106.6
6	242.0	21.1	700	1.0	113.8	29	107.6
7	247.7	27.2	700	1.0	116.5	29	108.6
8	238.3	33.6	700	1.0	112.1	29	109.5
9	210.4	40.6	700	1.0	99.0	29	110.5
10	158.0	48.4	700	1.0	74.3	29	111.5
11	68.2	57.8	700	1.0	32.1	29	112.4

ITERATION	INITIAL	CALCULATED
1	1.0000	8.2214
2	8.2214	10.0653
3	10.0653	10.1340
4	10.1340	10.1361

FACTOR OF SAFETY= 10.14 AT X= 104 Y= 98 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	109.0	98.0	15.0	3.94

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	74.3	-39.9	700	1.2	34.9	29	99.4
2	632.5	-31.7	700	2.3	297.4	29	101.1
3	1249.7	-21.9	700	2.3	587.7	29	103.4
4	1748.2	-12.7	700	2.3	822.2	29	105.7
5	2145.1	-3.8	700	2.3	1008.8	29	108.0
6	2446.9	4.9	700	2.3	1150.8	29	110.3
7	2653.4	13.8	700	2.3	1247.8	29	112.6
8	2756.6	23.1	700	2.3	1296.4	29	114.9
9	2400.4	32.3	700	2.0	1233.4	29	117.0
10	2639.8	43.5	700	2.5	1569.2	29	119.3
11	1738.0	59.6	700	2.5	1277.1	29	121.8
12	209.5	75.7	700	.9	209.5	29	123.4

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6937
2	3.6937	3.9291
3	3.9291	3.9432
4	3.9432	3.9440

FACTOR OF SAFETY= 3.94 AT X= 109 Y= 98 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

Interior Slope

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	94.0	15.0	4.09

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	549.4	-54.2	700	2.4	258.4	29	93.9
2	1283.4	-40.2	700	2.4	603.6	29	96.4
3	1755.6	-28.9	700	2.4	825.7	29	98.8
4	2488.6	-18.2	700	2.7	1170.4	29	101.3
5	3099.3	-7.7	700	2.7	1457.5	29	104.0
6	3555.5	2.6	700	2.7	1672.1	29	106.7
7	3861.2	12.9	700	2.7	1815.9	29	109.3
8	4004.5	23.7	700	2.7	1883.3	29	112.0
9	3950.6	35.5	700	2.7	1857.9	29	114.7
10	2756.1	47.5	700	2.0	1400.7	29	117.0
11	1680.6	58.4	700	1.4	961.8	29	118.7
12	1178.1	73.0	700	1.4	768.7	29	120.1
13	48.8	84.9	700	.1	42.6	29	120.9

ITERATION	INITIAL	CALCULATED
1	1.0000	5.0280
2	5.0280	4.1140
3	4.1140	4.0898
4	4.0898	4.0892

FACTOR OF SAFETY= 4.09 AT X= 106 Y= 94 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	105.0	101.0	15.0	4.90

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	3.3	-20.3	700	.4	1.5	29	99.8
2	182.2	-15.9	700	1.8	85.7	29	100.9
3	450.4	-9.0	700	1.8	211.8	29	102.7
4	672.6	-2.1	700	1.8	316.3	29	104.4
5	850.5	4.7	700	1.8	400.0	29	106.2
6	983.6	11.6	700	1.8	462.6	29	108.0
7	1069.7	18.6	700	1.8	503.0	29	109.8
8	1103.5	26.0	700	1.8	519.0	29	111.6
9	1076.2	33.8	700	1.8	506.1	29	113.3
10	970.8	42.6	700	1.8	456.5	29	115.1
11	457.1	50.1	700	1.0	241.1	29	116.5
12	358.3	56.6	700	1.0	246.9	29	117.5
13	93.8	61.6	700	.4	84.3	29	118.2
14	89.2	66.8	700	.8	89.2	29	118.8

ITERATION	INITIAL	CALCULATED
1	1.0000	4.1830
2	4.1830	4.8519
3	4.8519	4.8964
4	4.8964	4.8990

FACTOR OF SAFETY= 4.90 AT X= 105 Y= 101 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	102.0	15.0	5.22

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	153.5	-14.2	700	1.8	72.2	29	102.3
2	422.0	-7.1	700	1.8	198.5	29	104.2
3	641.7	-.1	700	1.8	301.8	29	106.0
4	813.8	6.9	700	1.8	382.7	29	107.8
5	937.2	14.0	700	1.8	440.8	29	109.6
6	1008.4	21.3	700	1.8	474.2	29	111.4
7	1020.4	29.1	700	1.8	479.9	29	113.3
8	960.7	37.4	700	1.8	451.8	29	115.1
9	466.7	44.5	700	1.0	245.6	29	116.5
10	398.2	50.1	700	1.0	265.7	29	117.5
11	215.7	55.6	700	.7	184.1	29	118.4
12	124.6	62.3	700	1.0	124.6	29	119.2

ITERATION	INITIAL	CALCULATED
1	1.0000	4.4326
2	4.4326	5.1679
3	5.1679	5.2127
4	5.2127	5.2151

FACTOR OF SAFETY= 5.22 AT X= 106 Y= 102 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

Interior Slope

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	109.0	100.0	20.0	3.78

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	591.0	-43.3	700	3.1	277.9	29	95.4
2	1457.2	-32.0	700	3.1	685.3	29	98.5
3	2405.2	-21.8	700	3.2	1131.2	29	101.6
4	3375.3	-12.2	700	3.2	1587.4	29	104.8
5	4137.1	-2.9	700	3.2	1945.6	29	108.0
6	4703.9	6.3	700	3.2	2212.2	29	111.2
7	5072.8	15.7	700	3.2	2385.7	29	114.4
8	3258.4	23.6	700	2.0	1636.9	29	117.0
9	4602.0	31.8	700	3.0	2572.6	29	119.5
10	3801.3	42.7	700	3.0	2385.6	29	122.5
11	2580.8	56.4	700	3.0	2001.1	29	125.5
12	1.2	64.2	700	.0	1.2	29	127.0
13	453.1	70.3	700	1.4	453.1	29	127.7

ITERATION	INITIAL	CALCULATED
1	1.0000	3.7806
2	3.7806	3.7785

FACTOR OF SAFETY= 3.78 AT X= 109 Y= 100 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	106.0	20.0	4.41

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1.1	-17.8	700	.2	.5	29	99.9
2	261.9	-14.1	700	2.3	123.2	29	101.1
3	686.1	-7.4	700	2.3	322.7	29	103.4
4	1038.0	-.8	700	2.3	488.2	29	105.7
5	1319.3	5.7	700	2.3	620.4	29	108.0
6	1528.9	12.4	700	2.3	719.0	29	110.3
7	1662.7	19.2	700	2.3	782.0	29	112.6
8	1712.6	26.3	700	2.3	805.4	29	114.9
9	1461.5	33.4	700	2.0	791.8	29	117.0
10	1055.6	40.0	700	1.7	701.8	29	118.8
11	742.9	46.7	700	1.7	614.1	29	120.5
12	353.9	55.1	700	2.0	353.9	29	122.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8643
2	3.8643	4.3791
3	4.3791	4.4085
4	4.4085	4.4100

FACTOR OF SAFETY= 4.41 AT X= 106 Y= 106 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	102.0	104.0	20.0	4.95

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	269.2	-27.2	700	2.8	126.6	29	92.9
2	667.8	-18.3	700	2.8	314.1	29	95.7
3	906.6	-9.9	700	2.8	426.4	29	98.6
4	1148.3	-1.9	700	2.7	540.0	29	101.3
5	1539.2	5.8	700	2.7	723.9	29	104.0
6	1816.1	13.5	700	2.7	854.1	29	106.7
7	1970.8	21.6	700	2.7	926.8	29	109.3
8	1985.5	30.1	700	2.7	933.7	29	112.0
9	1825.4	39.5	700	2.7	858.5	29	114.7
10	1114.1	48.8	700	2.0	628.5	29	117.0
11	462.2	56.4	700	1.3	366.0	29	118.6
12	141.8	63.0	700	1.1	141.8	29	119.8

ITERATION	INITIAL	CALCULATED
1	1.0000	4.5173
2	4.5173	4.9325
3	4.9325	4.9501
4	4.9501	4.9508

FACTOR OF SAFETY= 4.95 AT X= 102 Y= 104 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	102.0	107.0	20.0	6.40

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	103.9	-2.7	700	1.8	48.8	29	101.0
2	287.4	2.3	700	1.8	135.2	29	102.8
3	438.8	7.4	700	1.8	206.4	29	104.6
4	557.3	12.5	700	1.8	262.1	29	106.3
5	641.2	17.7	700	1.8	301.5	29	108.1
6	687.9	23.1	700	1.8	323.5	29	109.8
7	693.2	28.7	700	1.8	326.0	29	111.6
8	650.7	34.7	700	1.8	306.0	29	113.4
9	550.2	41.1	700	1.8	258.7	29	115.1
10	346.6	47.8	700	1.6	228.6	29	116.8
11	57.2	52.2	700	.4	57.2	29	117.8
12	42.8	54.9	700	.7	42.8	29	118.4

ITERATION	INITIAL	CALCULATED
1	1.0000	5.2973
2	5.2973	6.3473
3	6.3473	6.4019
4	6.4019	6.4043

FACTOR OF SAFETY= 6.40 AT X= 102 Y= 107 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

Exterior Slope

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	53.0	86.0	10.0	4.67

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	.0	-63.4	700	.0	.0	29	44.1
2	403.4	-54.5	700	1.8	207.0	29	45.0
3	984.1	-39.0	700	1.8	512.6	29	46.7
4	1413.9	-26.7	700	1.8	747.1	29	48.5
5	1747.3	-15.6	700	1.8	936.3	29	50.3
6	2004.4	-5.1	700	1.8	1089.7	29	52.1
7	2192.7	5.2	700	1.8	1210.7	29	53.9
8	2312.3	15.6	700	1.8	1299.3	29	55.7
9	2355.5	26.7	700	1.8	1352.1	29	57.5
10	2302.3	39.1	700	1.8	1359.5	29	59.3
11	2097.9	54.6	700	1.8	1295.8	29	61.1
12	846.5	71.4	700	.9	562.6	29	62.4

ITERATION	INITIAL	CALCULATED
1	1.0000	5.9845
2	5.9845	4.6933
3	4.6933	4.6741
4	4.6741	4.6738

FACTOR OF SAFETY= 4.67 AT X= 53 Y= 86 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	92.0	10.0	7.29

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	15.8	-19.6	700	.6	15.8	29	46.6
2	143.2	-14.2	700	1.3	112.5	29	47.5
3	270.5	-6.9	700	1.3	188.3	29	48.8
4	373.8	.3	700	1.3	252.9	29	50.1
5	453.8	7.6	700	1.3	306.5	29	51.3
6	509.8	14.9	700	1.3	348.8	29	52.6
7	539.8	22.5	700	1.3	378.9	29	53.8
8	540.1	30.6	700	1.3	395.0	29	55.1
9	503.4	39.4	700	1.3	393.7	29	56.3
10	415.0	49.7	700	1.3	368.1	29	57.6
11	162.0	59.2	700	.7	162.0	29	58.6
12	72.6	68.8	700	.7	72.6	29	59.3

ITERATION	INITIAL	CALCULATED
1	1.0000	6.0224
2	6.0224	7.2216
3	7.2216	7.2876
4	7.2876	7.2907

FACTOR OF SAFETY= 7.29 AT X= 50 Y= 92 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	94.0	10.0	9.24

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	36.9	-11.2	700	.9	36.9	29	50.1
2	103.3	-5.8	700	.9	103.3	29	51.0
3	174.9	-.3	700	1.0	163.3	29	52.0
4	228.9	5.5	700	1.0	198.9	29	53.0
5	270.8	11.3	700	1.0	228.9	29	54.0
6	299.9	17.3	700	1.0	252.8	29	55.0
7	315.3	23.5	700	1.0	270.3	29	56.0
8	315.1	29.9	700	1.0	280.5	29	57.0
9	296.4	36.8	700	1.0	281.9	29	58.0
10	232.0	44.1	700	.9	232.0	29	58.9
11	173.4	51.9	700	.9	173.4	29	59.8
12	75.7	61.6	700	.9	75.7	29	60.8

ITERATION	INITIAL	CALCULATED
1	1.0000	7.5257
2	7.5257	9.1670
3	9.1670	9.2357
4	9.2357	9.2381

FACTOR OF SAFETY= 9.24 AT X= 52 Y= 94 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	46.0	92.0	10.0	13.12

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	6.4	-4.0	700	.4	6.4	29	45.3
2	48.3	-.3	700	.9	39.8	29	45.9
3	89.1	4.7	700	.9	66.6	29	46.8
4	122.1	9.7	700	.9	89.7	29	47.7
5	147.1	14.8	700	.9	109.0	29	48.5
6	163.6	20.0	700	.9	124.4	29	49.4
7	171.0	25.3	700	.9	135.5	29	50.3
8	168.0	31.0	700	.9	141.6	29	51.1
9	152.7	37.0	700	.9	142.1	29	52.0
10	101.1	42.8	700	.7	101.1	29	52.8
11	71.7	48.5	700	.7	71.7	29	53.5
12	28.7	54.9	700	.7	28.7	29	54.2

ITERATION	INITIAL	CALCULATED
1	1.0000	10.5338
2	10.5338	13.0454
3	13.0454	13.1176
4	13.1176	13.1192

FACTOR OF SAFETY= 13.12 AT X= 46 Y= 92 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

Exterior Slope

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	57.0	90.0	15.0	3.50

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	.2	-56.4	700	.0	.2	29	44.5
2	771.2	-48.6	700	2.7	412.6	29	45.9
3	1918.5	-34.7	700	2.7	1023.9	29	48.5
4	2790.9	-23.0	700	2.7	1505.9	29	51.2
5	3470.9	-12.2	700	2.7	1897.5	29	53.8
6	3991.0	-2.0	700	2.7	2213.8	29	56.5
7	4361.8	8.3	700	2.7	2460.0	29	59.2
8	4578.8	18.8	700	2.7	2633.8	29	61.8
9	4619.4	30.0	700	2.7	2724.6	29	64.5
10	4426.6	42.9	700	2.7	2705.7	29	67.1
11	3832.4	60.1	700	2.7	2498.0	29	69.8
12	894.7	78.3	700	.8	658.1	29	71.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6880
2	3.6880	3.5051
3	3.5051	3.4972
4	3.4972	3.4969

FACTOR OF SAFETY= 3.50 AT X= 57 Y= 90 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	98.0	15.0	4.45

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	105.4	-26.1	700	1.3	105.4	29	51.4
2	558.7	-19.0	700	2.1	458.1	29	53.1
3	959.9	-10.7	700	2.1	691.9	29	55.2
4	1282.8	-2.5	700	2.1	889.0	29	57.3
5	1531.3	5.6	700	2.1	1051.0	29	59.5
6	1704.3	13.8	700	2.1	1177.6	29	61.6
7	1796.2	22.3	700	2.1	1266.0	29	63.7
8	1793.9	31.4	700	2.1	1310.1	29	65.8
9	1670.8	41.5	700	2.1	1297.4	29	67.9
10	1365.3	53.8	700	2.1	1198.9	29	70.0
11	624.6	71.3	700	1.8	624.6	29	72.0

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8124
2	3.8124	4.4023
3	4.4023	4.4514
4	4.4514	4.4550

FACTOR OF SAFETY= 4.45 AT X= 58 Y= 98 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	96.0	15.0	4.70

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	7.3	-23.9	700	.4	7.3	29	45.9
2	264.1	-19.3	700	1.9	182.7	29	47.0
3	593.0	-11.8	700	1.9	373.9	29	48.9
4	864.7	-4.5	700	1.9	538.1	29	50.8
5	1082.3	2.8	700	1.9	676.8	29	52.7
6	1246.0	10.1	700	1.9	790.2	29	54.6
7	1353.5	17.6	700	1.9	877.2	29	56.5
8	1398.9	25.4	700	1.9	934.9	29	58.4
9	1371.1	33.8	700	1.9	958.3	29	60.3
10	1248.9	43.1	700	1.9	937.2	29	62.2
11	985.1	54.3	700	1.9	849.5	29	64.1
12	412.6	69.1	700	1.6	412.6	29	65.9

ITERATION	INITIAL	CALCULATED
1	1.0000	3.9771
2	3.9771	4.6404
3	4.6404	4.6925
4	4.6925	4.6961

FACTOR OF SAFETY= 4.70 AT X= 52 Y= 96 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	220.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	47.0	97.0	15.0	8.30

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	7.2	-6.0	700	.4	7.2	29	45.4
2	113.9	-2.4	700	1.4	88.1	29	46.4
3	233.3	3.1	700	1.4	165.0	29	47.8
4	329.4	8.6	700	1.4	231.0	29	49.2
5	401.6	14.2	700	1.4	285.8	29	50.7
6	448.4	19.9	700	1.4	328.6	29	52.1
7	467.3	25.9	700	1.4	358.3	29	53.5
8	454.3	32.2	700	1.4	373.0	29	55.0
9	403.0	38.9	700	1.4	369.7	29	56.4
10	302.2	46.4	700	1.4	302.2	29	57.8
11	128.9	55.2	700	1.4	128.9	29	59.3

ITERATION	INITIAL	CALCULATED
1	1.0000	6.7507
2	6.7507	8.2322
3	8.2322	8.2974
4	8.2974	8.2998

FACTOR OF SAFETY= 8.30 AT X= 47 Y= 97 R= 15
EARTHQUAKE= .10

Exterior Slope

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	95.0	20.0	3.00

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	35.8	-46.0	700	.8	16.8	29	43.6
2	1141.1	-38.5	700	3.2	589.3	29	45.6
3	2540.2	-27.4	700	3.2	1352.6	29	48.8
4	3653.0	-17.4	700	3.2	1981.2	29	52.1
5	4537.0	-7.8	700	3.2	2502.2	29	55.3
6	5216.8	1.4	700	3.2	2927.2	29	58.5
7	5698.1	10.8	700	3.2	3258.8	29	61.7
8	5970.0	20.4	700	3.2	3491.9	29	64.9
9	5999.8	30.7	700	3.2	3611.2	29	68.2
10	5713.3	42.3	700	3.2	3581.8	29	71.4
11	3659.4	54.7	700	2.4	2377.4	29	74.2
12	2355.2	72.4	700	2.4	1638.0	29	76.7
13	25.1	85.6	700	.1	25.1	29	77.9

ITERATION	INITIAL	CALCULATED
1	1.0000	2.8932
2	2.8932	2.9918
3	2.9918	2.9982
4	2.9982	2.9986

FACTOR OF SAFETY= 3.00 AT X= 58 Y= 95 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	20.0	4.21

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	58.1	-19.9	700	1.6	27.3	29	43.2
2	468.3	-13.7	700	2.5	252.9	29	45.3
3	981.2	-6.3	700	2.5	559.4	29	47.8
4	1395.7	1.0	700	2.5	819.6	29	50.3
5	1713.5	8.3	700	2.5	1034.4	29	52.9
6	1931.5	15.8	700	2.5	1202.2	29	55.4
7	2040.9	23.5	700	2.5	1319.0	29	58.0
8	2024.6	31.7	700	2.5	1376.5	29	60.5
9	1849.6	40.8	700	2.5	1359.5	29	63.0
10	1446.3	51.5	700	2.5	1235.2	29	65.6
11	603.2	65.0	700	2.3	603.2	29	68.0

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6025
2	3.6025	4.1625
3	4.1625	4.2063
4	4.2063	4.2093

FACTOR OF SAFETY= 4.21 AT X= 50 Y= 100 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	102.0	20.0	4.61

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	21.2	-14.9	700	.7	21.2	29	46.9
2	355.1	-10.6	700	2.3	266.6	29	48.3
3	733.9	-4.0	700	2.3	496.7	29	50.6
4	1043.7	2.5	700	2.3	694.3	29	52.9
5	1284.8	9.0	700	2.3	859.6	29	55.1
6	1454.7	15.7	700	2.3	991.5	29	57.4
7	1547.7	22.6	700	2.3	1087.2	29	59.7
8	1553.5	29.8	700	2.3	1141.9	29	61.9
9	1453.8	37.6	700	2.3	1146.9	29	64.2
10	1214.3	46.5	700	2.3	1086.2	29	66.4
11	581.7	55.0	700	1.5	581.7	29	68.4
12	250.1	64.0	700	1.5	250.1	29	69.9

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8773
2	3.8773	4.5600
3	4.5600	4.6115
4	4.6115	4.6148

FACTOR OF SAFETY= 4.61 AT X= 52 Y= 102 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	46.0	102.0	20.0	7.88

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	6.6	-2.1	700	.5	6.6	29	45.3
2	125.4	.9	700	1.6	97.1	29	46.3
3	263.6	5.6	700	1.6	189.0	29	47.9
4	376.1	10.3	700	1.6	268.7	29	49.6
5	461.9	15.1	700	1.6	335.9	29	51.2
6	519.5	20.0	700	1.6	389.8	29	52.8
7	546.5	25.0	700	1.6	429.3	29	54.4
8	539.3	30.3	700	1.6	452.8	29	56.1
9	492.6	35.9	700	1.6	457.6	29	57.7
10	338.0	41.3	700	1.3	338.0	29	59.2
11	239.0	46.7	700	1.3	239.0	29	60.5
12	94.8	52.7	700	1.3	94.8	29	61.9

ITERATION	INITIAL	CALCULATED
1	1.0000	6.4094
2	6.4094	7.8126
3	7.8126	7.8758
4	7.8758	7.8782

FACTOR OF SAFETY= 7.88 AT X= 46 Y= 102 R= 20
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	57.0	99.0	25.0	2.82

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	330.9	-41.8	700	2.4	155.6	29	40.4
2	876.6	-34.7	700	2.4	412.3	29	42.8
3	2938.2	-26.0	700	4.1	1468.8	29	46.1
4	4718.6	-15.8	700	4.1	2480.1	29	50.2
5	6119.1	-6.1	700	4.1	3312.9	29	54.4
6	7176.4	3.5	700	4.1	3984.1	29	58.5
7	7894.5	13.1	700	4.1	4495.8	29	62.6
8	8246.7	23.1	700	4.1	4835.5	29	66.8
9	8162.1	34.1	700	4.1	4969.8	29	70.9
10	7138.5	47.0	700	4.3	4419.6	29	75.1
11	4073.3	66.5	700	4.3	2595.1	29	79.4
12	35.2	81.0	700	.3	35.2	29	81.7

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7148
2	2.7148	2.8136
3	2.8136	2.8196
4	2.8196	2.8200

FACTOR OF SAFETY= 2.82 AT X= 57 Y= 99 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	25.0	3.27

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	633.0	-37.1	700	3.6	297.7	29	35.0
2	1590.7	-27.2	700	3.6	748.1	29	38.6
3	2230.1	-18.2	700	3.6	1048.8	29	42.2
4	3526.1	-9.1	700	4.1	1745.3	29	46.1
5	4688.1	.5	700	4.1	2465.8	29	50.2
6	5512.7	10.1	700	4.1	3027.7	29	54.4
7	5983.5	20.0	700	4.1	3423.1	29	58.5
8	6046.2	30.5	700	4.1	3626.6	29	62.6
9	5573.1	42.5	700	4.1	3578.2	29	66.8
10	4216.0	57.9	700	4.1	3114.0	29	70.9
11	302.4	68.5	700	.5	284.9	29	73.2
12	376.3	75.4	700	1.2	376.3	29	74.1

ITERATION	INITIAL	CALCULATED
1	1.0000	3.0608
2	3.0608	3.2527
3	3.2527	3.2655
4	3.2655	3.2663

FACTOR OF SAFETY= 3.27 AT X= 50 Y= 100 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	48.0	106.0	25.0	4.72

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	10.8	-10.3	700	1.0	5.1	29	43.5
2	283.9	-6.3	700	2.5	164.9	29	45.2
3	692.3	-.6	700	2.5	419.6	29	47.7
4	1028.1	5.1	700	2.5	640.2	29	50.2
5	1290.4	10.9	700	2.5	826.3	29	52.7
6	1475.9	16.7	700	2.5	976.3	29	55.2
7	1578.7	22.8	700	2.5	1087.3	29	57.7
8	1588.6	29.2	700	2.5	1154.6	29	60.2
9	1488.9	36.0	700	2.5	1170.4	29	62.6
10	1251.1	43.4	700	2.5	1121.3	29	65.1
11	687.7	50.9	700	1.9	687.7	29	67.4
12	284.9	58.7	700	1.9	284.9	29	69.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.9636
2	3.9636	4.6680
3	4.6680	4.7174
4	4.7174	4.7203

FACTOR OF SAFETY= 4.72 AT X= 48 Y= 106 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	42.0	106.0	25.0	11.03

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	56.9	-8.8	700	2.3	26.7	29	38.2
2	124.8	-3.4	700	2.3	58.7	29	40.5
3	133.1	1.9	700	2.3	62.6	29	42.8
4	210.3	7.0	700	2.1	121.7	29	45.1
5	386.5	12.0	700	2.1	250.1	29	47.2
6	514.6	17.0	700	2.1	355.9	29	49.3
7	591.2	22.2	700	2.1	437.5	29	51.4
8	611.2	27.5	700	2.1	492.5	29	53.5
9	566.4	33.2	700	2.1	517.0	29	55.7
10	477.6	39.5	700	2.3	477.6	29	57.9
11	202.3	46.9	700	2.3	202.3	29	60.2

ITERATION	INITIAL	CALCULATED
1	1.0000	9.4221
2	9.4221	10.9930
3	10.9930	11.0292
4	11.0292	11.0299

FACTOR OF SAFETY= 11.03 AT X= 42 Y= 106 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

Exterior Slope

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	55.0	102.0	30.0	2.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	763.6	-42.2	700	3.6	359.1	29	34.9
2	1963.7	-33.4	700	3.6	923.5	29	38.5
3	2836.0	-25.4	700	3.6	1333.7	29	42.2
4	5382.9	-16.7	700	4.8	2650.0	29	46.4
5	7339.0	-7.2	700	4.8	3806.8	29	51.3
6	8837.8	2.1	700	4.8	4748.5	29	56.1
7	9889.4	11.4	700	4.8	5480.0	29	60.9
8	10466.6	21.1	700	4.8	5988.3	29	65.8
9	10491.6	31.5	700	4.8	6236.9	29	70.6
10	8552.9	42.7	700	4.5	5132.4	29	75.3
11	5806.7	56.4	700	4.5	3414.4	29	79.8
12	1006.1	69.7	700	2.0	577.7	29	83.0
13	6.3	75.8	700	.2	3.0	29	84.1

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7349
2	2.7349	2.7707
3	2.7707	2.7723

FACTOR OF SAFETY= 2.77 AT X= 55 Y= 102 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	30.0	3.00

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1302.1	-45.9	700	4.4	612.4	29	28.6
2	3222.5	-34.7	700	4.4	1515.5	29	33.0
3	4525.5	-24.9	700	4.4	2128.3	29	37.4
4	5373.3	-15.9	700	4.4	2527.0	29	41.8
5	7113.4	-6.9	700	4.8	3463.8	29	46.4
6	8596.8	2.4	700	4.8	4398.3	29	51.3
7	9632.8	11.7	700	4.8	5122.4	29	56.1
8	10192.6	21.4	700	4.8	5622.5	29	60.9
9	10196.3	31.8	700	4.8	5861.2	29	65.8
10	9460.9	43.7	700	4.8	5752.2	29	70.6
11	4878.3	55.3	700	3.1	3112.1	29	74.6
12	2775.9	68.9	700	3.1	1916.7	29	77.7
13	80.3	79.8	700	.5	80.3	29	79.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.0347
2	3.0347	2.9976
3	2.9976	2.9960

FACTOR OF SAFETY= 3.00 AT X= 50 Y= 100 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.[illegible]

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	45.0	105.0	30.0	3.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	827.9	-33.4	700	4.4	389.4	29	28.6
2	2069.8	-23.7	700	4.4	973.4	29	33.0
3	2867.2	-14.8	700	4.4	1348.4	29	37.4
4	3289.0	-6.2	700	4.4	1546.8	29	41.8
5	4095.7	2.5	700	4.6	2031.9	29	46.3
6	5028.9	11.3	700	4.6	2682.2	29	50.8
7	5562.9	20.4	700	4.6	3144.8	29	55.4
8	5638.5	30.1	700	4.6	3391.7	29	60.0
9	5126.7	40.9	700	4.6	3362.5	29	64.5
10	3713.4	54.2	700	4.6	2909.2	29	69.1
11	614.8	65.3	700	1.6	614.8	29	72.2
12	67.7	70.8	700	.6	67.7	29	73.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.5111
2	3.5111	3.7524
3	3.7524	3.7651
4	3.7651	3.7657

FACTOR OF SAFETY= 3.77 AT X= 45 Y= 105 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	112.0	30.0	3.84

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	18.1	-10.6	700	.7	18.1	29	46.5
2	481.0	-7.1	700	2.9	352.3	29	48.3
3	1055.4	-1.6	700	2.9	708.2	29	51.2
4	1532.7	4.0	700	2.9	1018.5	29	54.1
5	1912.4	9.6	700	2.9	1282.8	29	57.0
6	2190.9	15.3	700	2.9	1499.7	29	59.9
7	2361.4	21.2	700	2.9	1665.6	29	62.8
8	2412.2	27.3	700	2.9	1775.3	29	65.7
9	2324.4	33.7	700	2.9	1819.9	29	68.6
10	2067.1	40.8	700	2.9	1784.7	29	71.5
11	594.6	45.8	700	1.0	570.9	29	73.5
12	674.7	49.7	700	1.7	674.7	29	74.9
13	247.9	55.0	700	1.7	247.9	29	76.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.3179
2	3.3179	3.8044
3	3.8044	3.8394
4	3.8394	3.8416

FACTOR OF SAFETY= 3.84 AT X= 52 Y= 112 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

Exterior Slope

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	55.0	105.0	35.0	2.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1457.3	-42.3	700	5.0	685.4	29	31.6
2	3654.5	-32.0	700	5.0	1718.7	29	36.5
3	5159.2	-22.7	700	5.0	2426.3	29	41.5
4	8198.8	-13.4	700	5.8	4026.3	29	46.9
5	10777.7	-3.8	700	5.8	5580.3	29	52.7
6	12690.9	5.8	700	5.8	6821.2	29	58.5
7	13932.5	15.5	700	5.8	7746.2	29	64.3
8	14433.5	25.7	700	5.8	8322.9	29	70.1
9	10361.9	35.5	700	4.5	5983.1	29	75.3
10	8347.7	45.2	700	4.5	4609.4	29	79.8
11	2709.4	53.2	700	2.0	1378.7	29	83.0
12	2466.0	63.0	700	3.9	1159.7	29	85.9

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7941
2	2.7941	2.7726
3	2.7726	2.7720

FACTOR OF SAFETY= 2.77 AT X= 55 Y= 105 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	108.0	35.0	2.79

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	919.2	-36.3	700	4.4	432.3	29	37.4
2	2358.1	-27.7	700	4.4	1109.0	29	41.8
3	4404.6	-19.4	700	4.8	2189.9	29	46.4
4	6529.5	-11.1	700	4.8	3426.1	29	51.3
5	8249.6	-3.1	700	4.8	4471.9	29	56.1
6	9586.2	4.8	700	4.8	5337.4	29	60.9
7	10536.8	12.8	700	4.8	6021.3	29	65.8
8	11075.0	21.1	700	4.8	6511.3	29	70.6
9	9782.4	29.6	700	4.5	5710.6	29	75.3
10	8174.9	38.6	700	4.5	4528.1	29	79.8
11	2826.0	45.6	700	2.0	1433.6	29	83.0
12	3608.6	55.7	700	5.3	1697.1	29	86.7

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7363
2	2.7363	2.7910
3	2.7910	2.7928

FACTOR OF SAFETY= 2.79 AT X= 58 Y= 108 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.4

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	35.0	2.93

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	2844.9	-50.4	700	5.9	1337.9	29	23.3
2	6727.7	-36.7	700	5.9	3164.0	29	29.2
3	9199.3	-25.3	700	5.9	4326.3	29	35.1
4	10706.7	-14.9	700	5.9	5035.2	29	41.0
5	12170.2	-5.1	700	5.8	5894.0	29	46.9
6	14174.3	4.4	700	5.8	7177.7	29	52.7
7	15511.0	14.1	700	5.8	8147.4	29	58.5
8	16121.3	24.2	700	5.8	8775.6	29	64.3
9	15853.2	35.3	700	5.8	8990.6	29	70.1
10	10727.7	46.4	700	4.5	6155.1	29	75.3
11	7653.3	58.9	700	4.5	4282.8	29	79.8
12	1687.3	71.2	700	2.0	898.1	29	83.0
13	128.2	78.8	700	.6	60.3	29	84.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.2239
2	3.2239	2.9346
3	2.9346	2.9289
4	2.9289	2.9287

FACTOR OF SAFETY= 2.93 AT X= 50 Y= 100 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	45.0	105.0	35.0	3.20

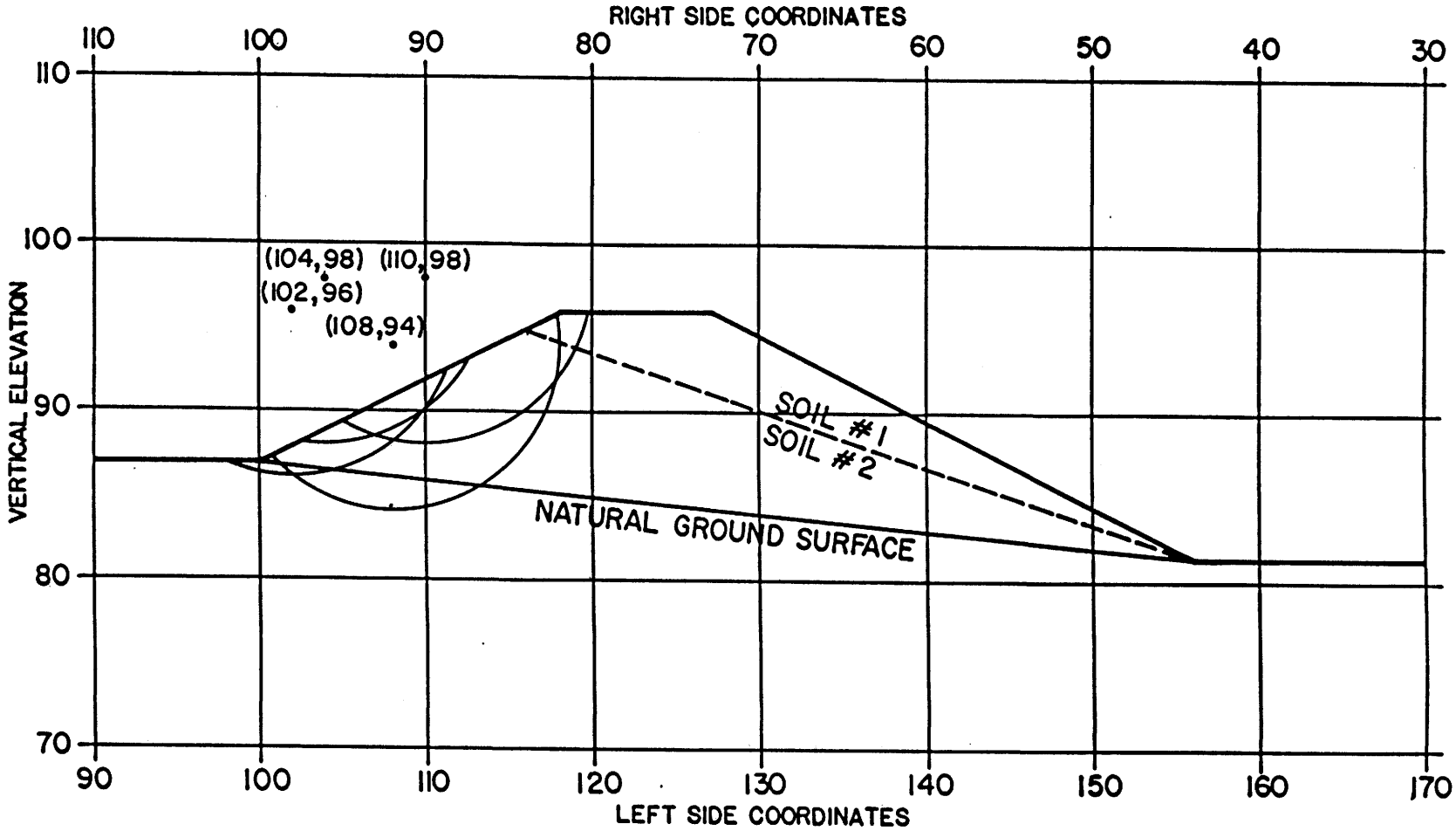
SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1462.0	-42.3	700	5.0	687.5	29	21.6
2	3665.2	-32.0	700	5.0	1723.7	29	26.5
3	5173.0	-22.7	700	5.0	2432.8	29	31.5
4	6143.7	-14.1	700	5.0	2889.3	29	36.5
5	6653.8	-5.7	700	5.0	3129.2	29	41.5
6	8812.7	3.1	700	5.8	4315.1	29	46.9
7	10243.5	12.8	700	5.8	5329.1	29	52.7
8	10960.3	22.8	700	5.8	6007.3	29	58.5
9	10827.8	33.7	700	5.8	6286.1	29	64.3
10	9526.0	46.2	700	5.8	6015.0	29	70.1
11	4743.0	61.5	700	4.9	3409.3	29	75.4
12	190.1	72.5	700	1.0	190.1	29	78.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.1718
2	3.1718	3.1953
3	3.1953	3.1962

FACTOR OF SAFETY= 3.20 AT X= 45 Y= 105 R= 35
EARTHQUAKE= .10

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 10'

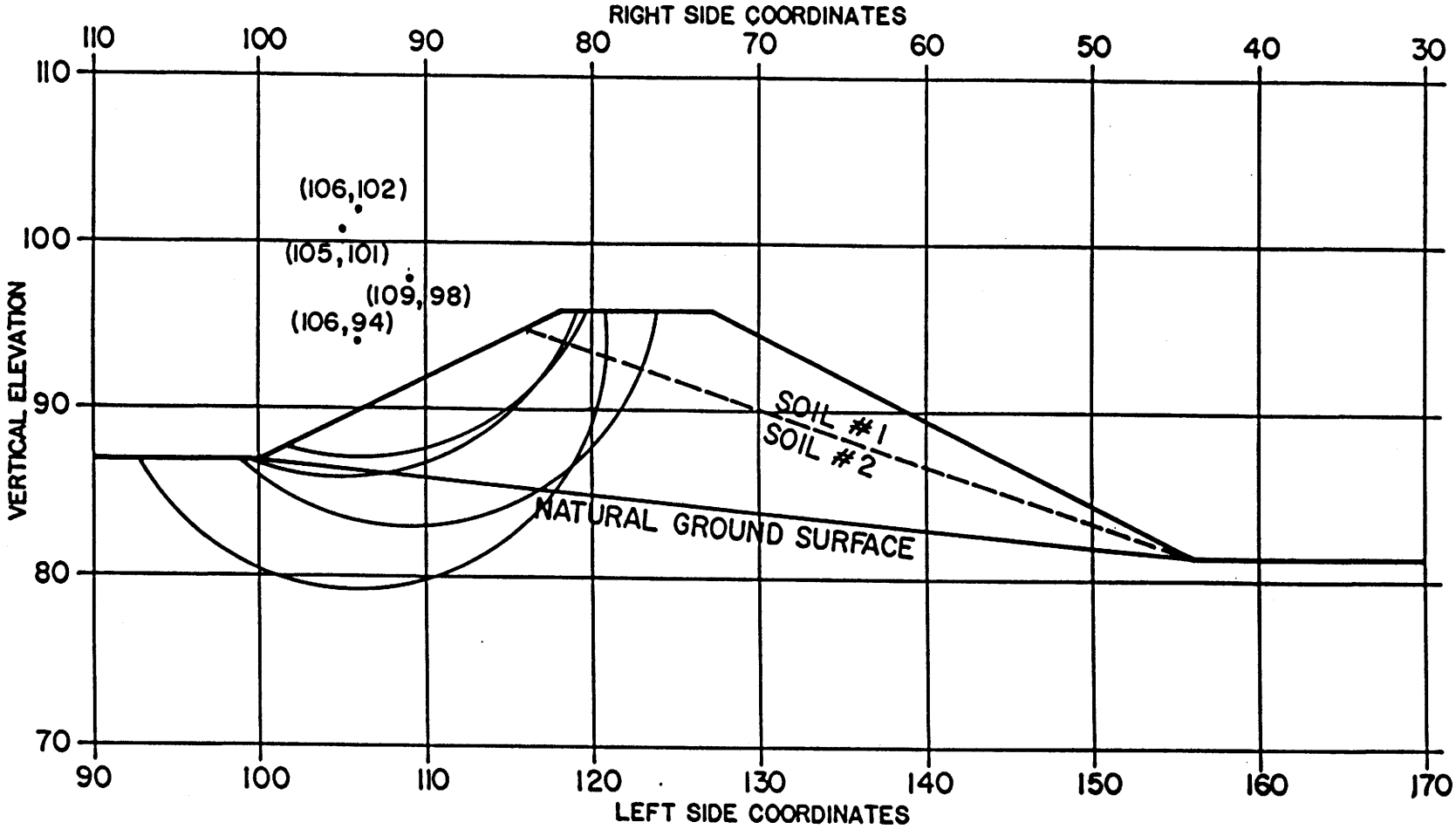
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 15'

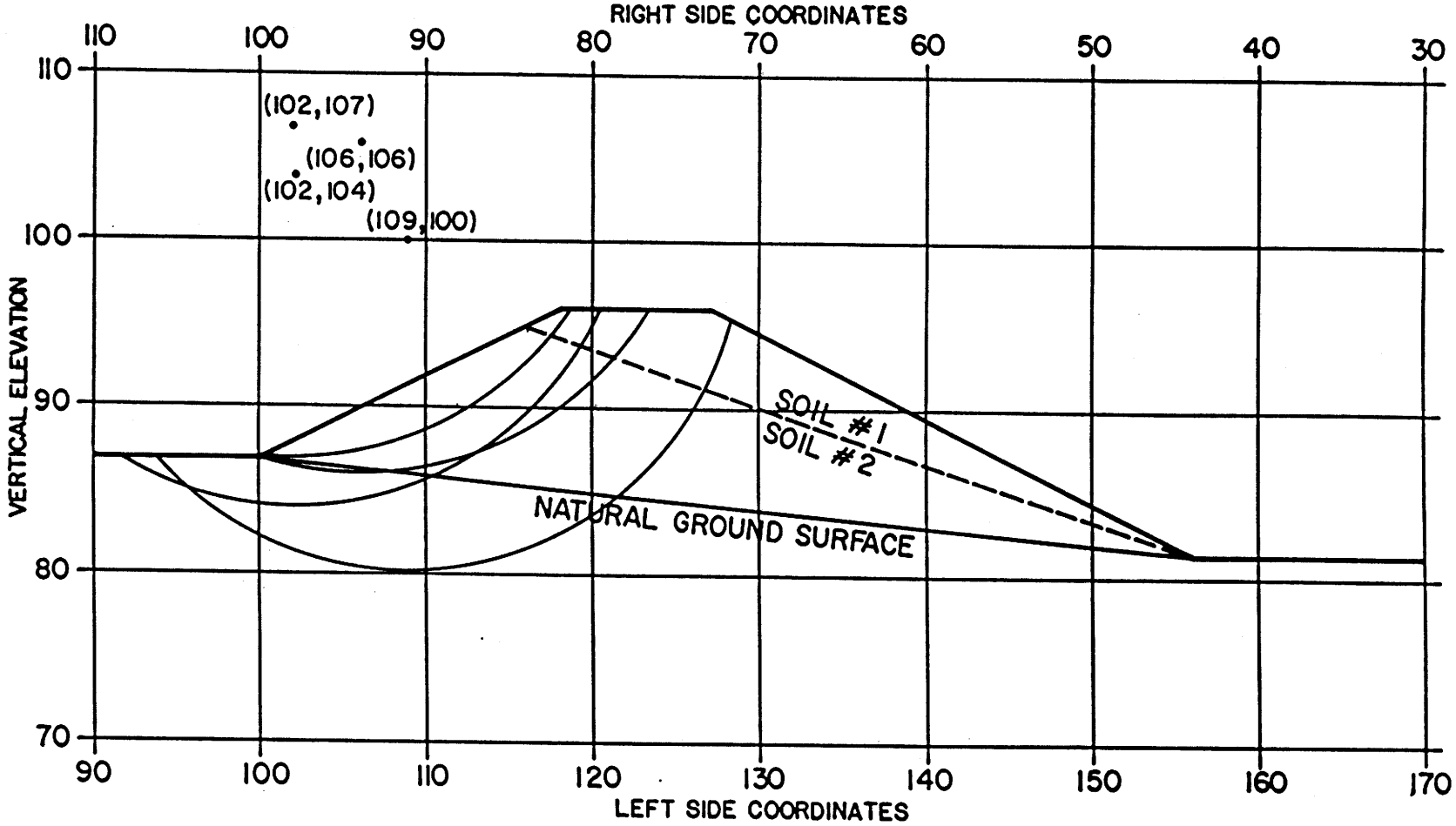
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 20'

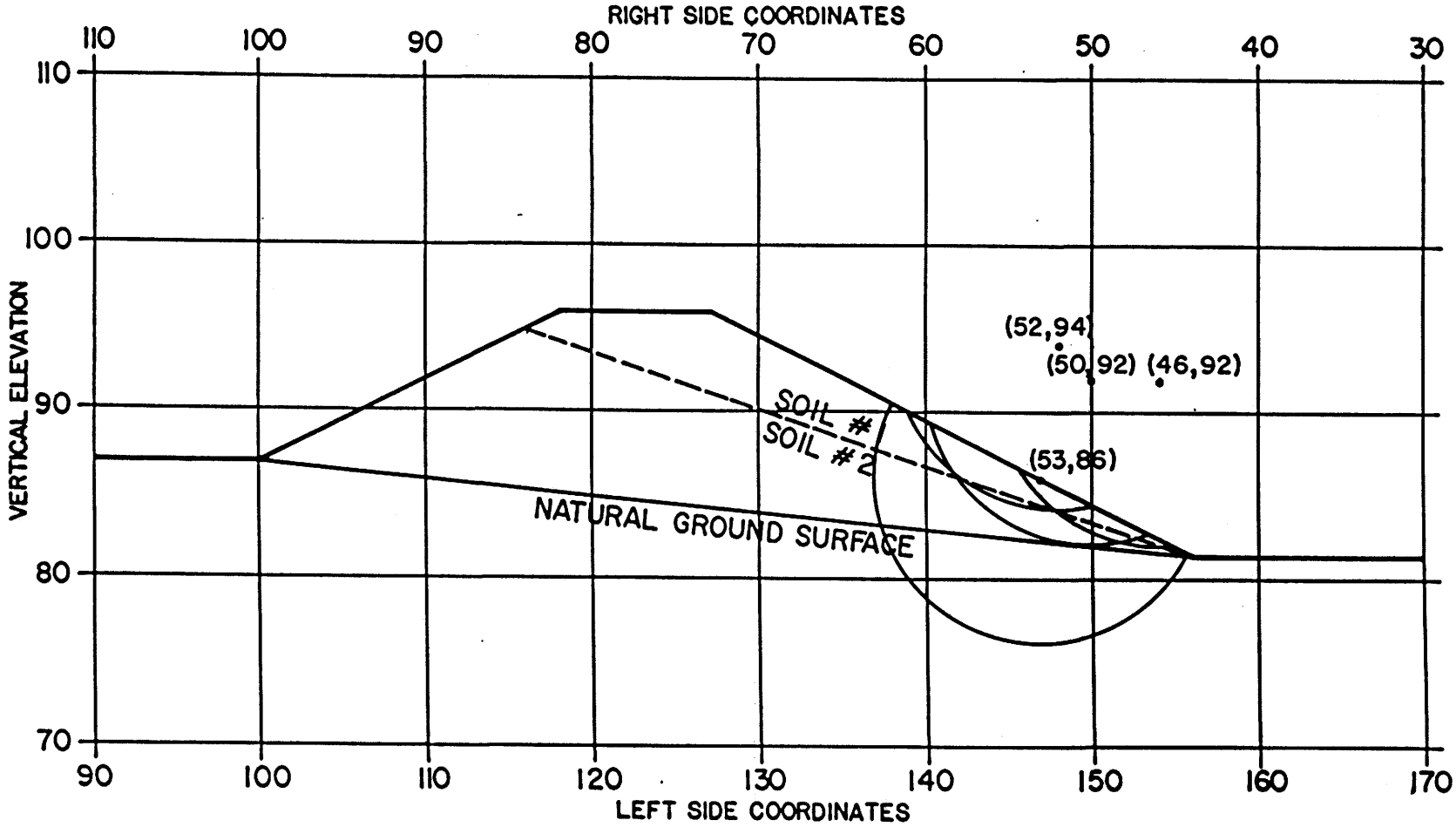
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 10'

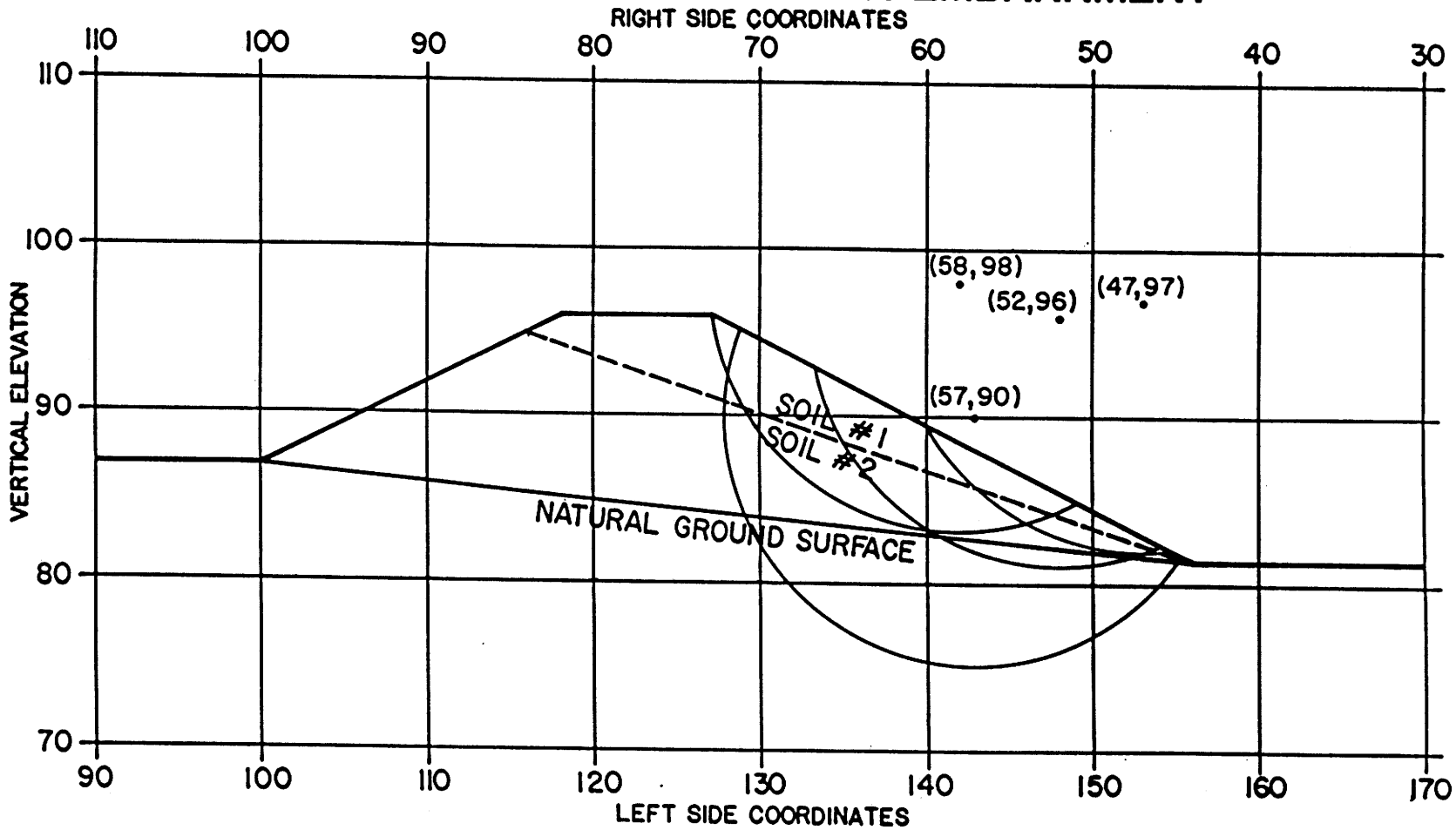
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 15'

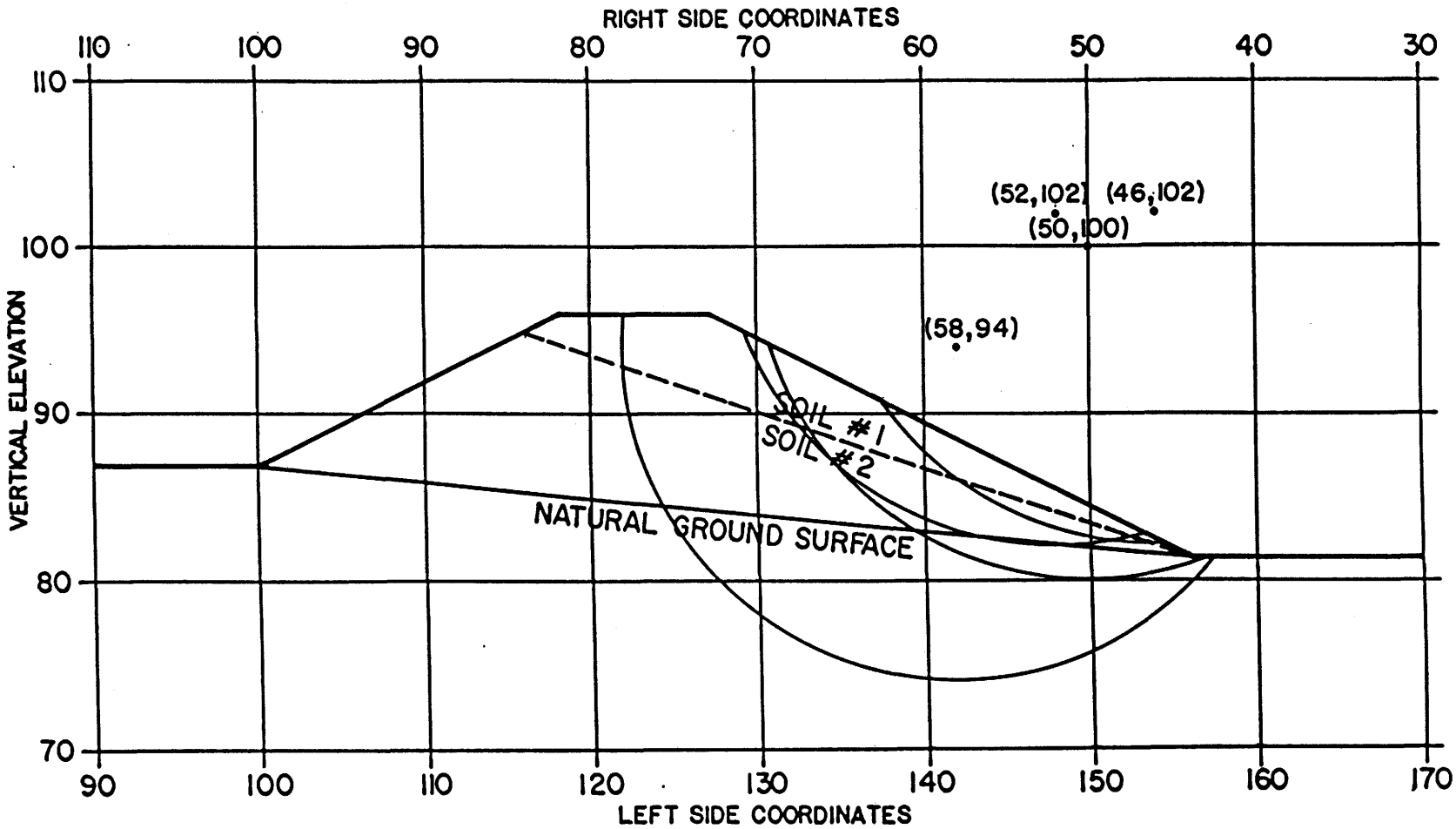
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

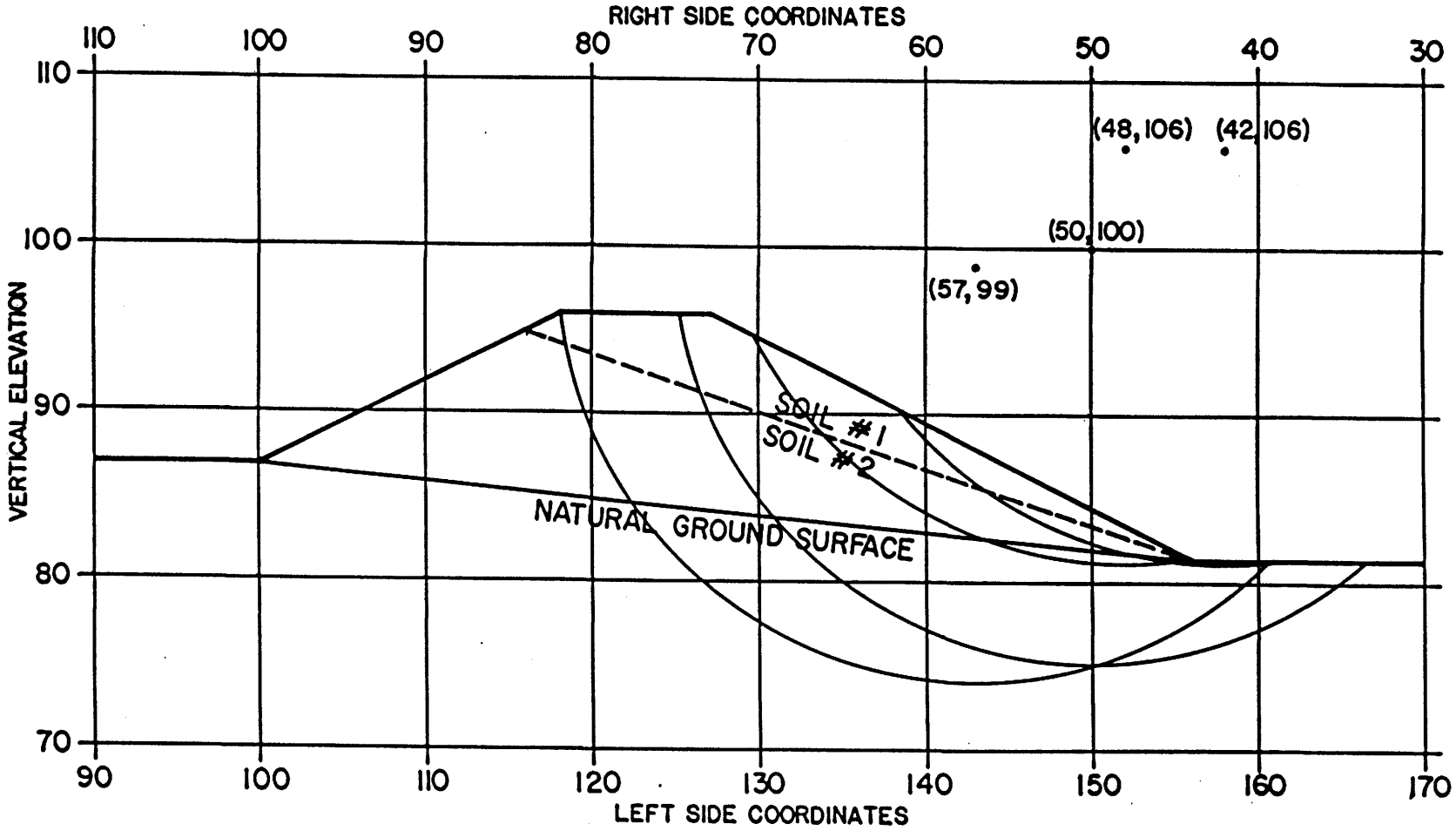
RADIUS=20'

SCALE 1"=10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 25'

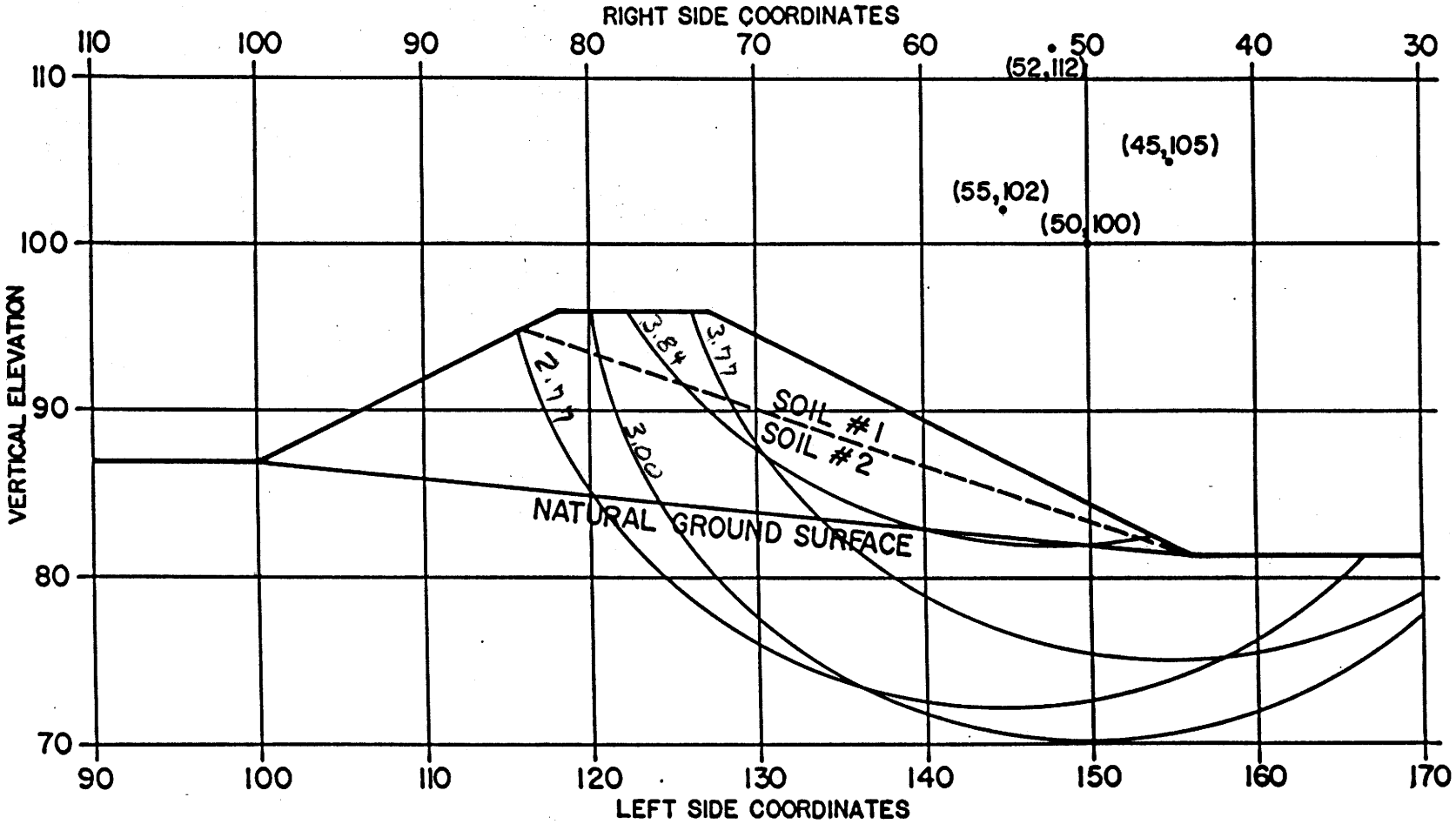
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 30'

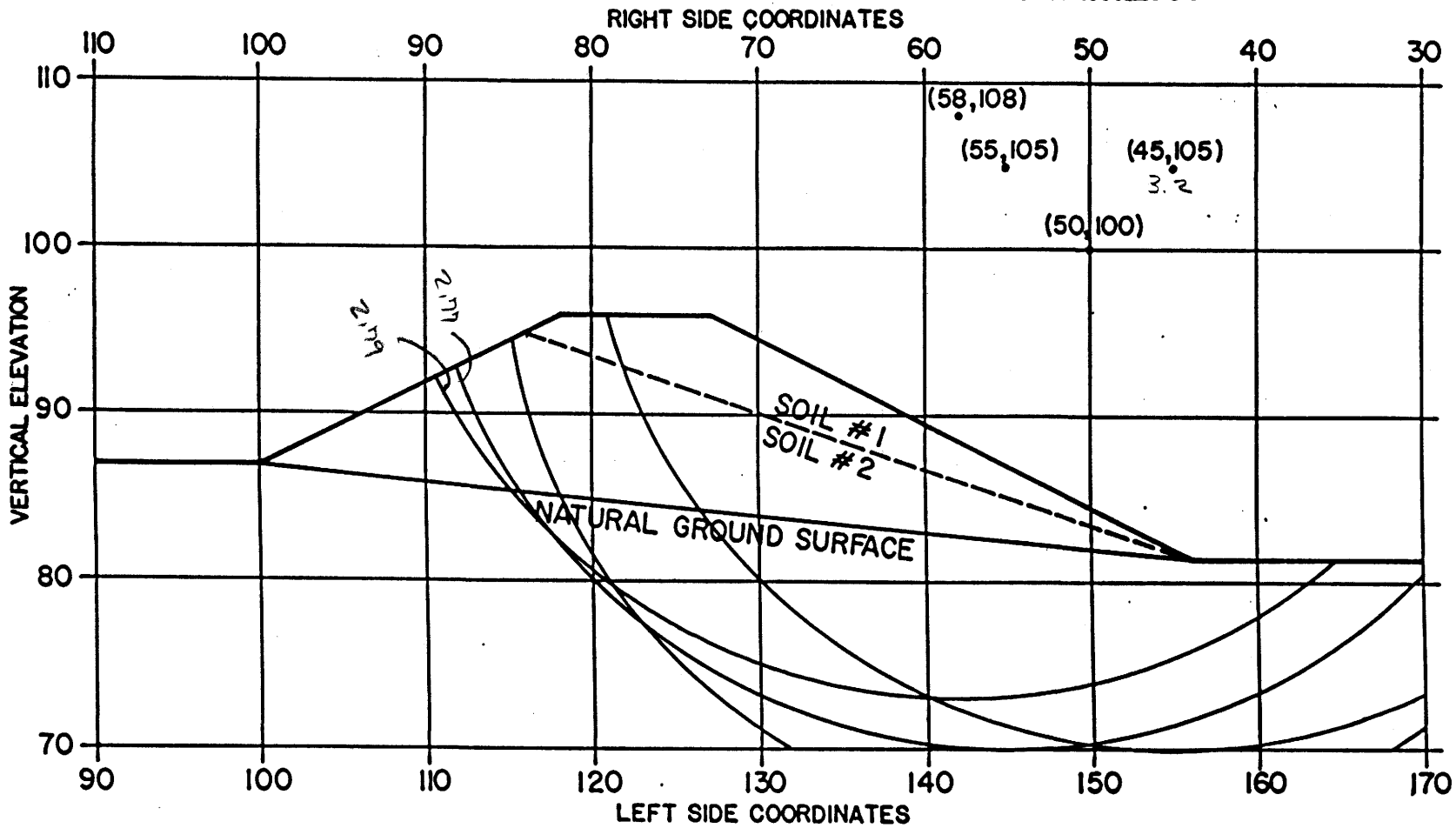
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 35'

CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

"SLOPE"

A slope stability program utilizing the simplified or "modified Bishop" method.

The program was written by John P. Cross, P.E., Processing Manager of STS Consultants, Northbrook, Illinois. This program was printed in the October 1982 issue of "CIVIL ENGINEERING."

This version was copied from "CIVIL ENGINEERING" and edited for the Hewlett-Packard 9845 desk-top computer by Horrocks Engineers in March 1983. The format for the input and the output was changed from the original version, however, the program itself was not changed.

HORROCKS ENGINEERS
ONE WEST MAIN STREET
AMERICAN FORK, UTAH 83003
TELEPHONE (801)756-7628

```
42    OPTION BASE 1
44    OVERLAP
46    PRINTER IS 16
48    PRINT "SLOPE STABILITY ANALYSIS"
50    DIM P(50,2),L(50,3),S2(5,4),A(50),F(50,7),Z(50,4),H$[80],Sbit$(0:1)[3]
52    INTEGER Logo(2)
54    Sbit$(1)=" NO"
56    Sbit$(0)="YES"
58    S9=10
60    J6=0
62    OUTPUT 5;"R"
64    ENTER 5;M,D,Time$
66    Date$=VAL$(M)&"/"&VAL$(D)&"/83"
68    PRINTER IS 0
70    PRINT "",LIN(4),TAB(80-LEN(Date$));Date$,LIN(0);
72    GOSUB Logo   ! PRINT HORROCKS ENGINEERS' LOGO
74    PRINT LIN(5),TAB(28),"SLOPE STABILITY ANALYSIS",LIN(2),TAB(38),"for",LIN(2
);
```

*** INPUT OF PROGRAM VARIABLES ***

```
78    INPUT "ENTER THE DATA FILE NAME",File$
79    INPUT "ENTER THE PROJECT NUMBER",Pn$
82    INPUT "ENTER THE USER'S INITIALS",User$
186   LINK File$,5000
190   READ H$
191   PRINT TAB(40-LEN(H$)/2);H$
195   PRINT LIN(30),TAB(30),"DATA FILE: "&CHR$(34)&File$&CHR$(34),LIN(1)
200   PRINT TAB(25),"PROJECT NUMBER: "&Pn$,LIN(1)
201   PRINT TAB(37),"by: "&User$
203   PRINTER IS 16
210   READ S0
211   IF S0=0 THEN 270
230   READ S6
250   READ S7
270   READ W0
290   READ E1
310   READ P1
311   PRINTER IS 16
315   PRINT "POINT      X-ORD       Y-ORD"
320   FOR I=1 TO P1
331     PRINT SPA(2),I;
```

```
332     IMAGE 3X,2(7D.3D,2X)
350     READ P(I,1),P(I,2)
371     PRINT USING 332;P(I,1),P(I,2)
380   NEXT I
400   READ L1
401   PRINT LIN(1),"LINE    FROM       TO     SOIL BENEATH"
402   IMAGE 3X,2(4D,3X),2X,2D
410   FOR I=1 TO L1
421     PRINT I;
440     READ L(I,1),L(I,2),L(I,3)
480     PRINT USING 402;L(I,1),L(I,2),L(I,3)
490   NEXT I
510   READ S1
511   PRINT LIN(1),"SOIL   UNIT WEIGHT  COHESION    "&CHR$(210)&"   SATURATION"
512   IMAGE 3X,4D.DD,2X,9D,3X,3D,3X,3A
520   FOR I=1 TO S1
531     PRINT I;
550     READ S2(I,1),S2(I,2),S2(I,3),S2(I,4)
610     PRINT USING 512;S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
620   NEXT I


*** CIRCLE DEFINITION  ***

640   F9=0
641   PRINTER IS 16
650   PRINT "CIRCLE DEFINITION"
660   INPUT "ENTER THE X-ORD, Y-ORD, AND RADIUS OF THE FAIL SURFACE  FORMAT X,Y,
R ",X,Y,R


*** CHECK TO SEE IF CIRCLE EXCEEDS TOP LINE END POINTS ***

730   U1=P1
740   FOR I=2 TO P1
750     IF (P(I,1)<P(I-1,1)) AND (U1=P1) THEN 770
760     GOTO 780
770     U1=I-1
780   NEXT I
790   J1=R*R-(P(1,2)-Y)^2
800   J2=R*R-(P(U1,2)-Y)^2
810   IF J1<=0 THEN 830
820   IF (J1>0) AND (P(1,1)>X-SQR(J1)) THEN 860
830   IF J2<=0 THEN 850
840   IF (J2>0) AND (P(U1,1)<X+SQR(J2)) THEN 860
850   GOTO 880
860   DISP "CIRCLE EXCEEDS TOP LINE END POINTS";
870   GOTO 4380


*** DEFINE INTERSECTION OF CIRCLE WITH LINES ***

890   FOR I=1 TO L1
900     X1=P(L(I,1),1)
910     Y1=P(L(I,1),2)
920     X2=P(L(I,2),1)
930     Y2=P(L(I,2),2)
940     IF X2=X1 THEN 960
950     GOTO 970
960     S=9.99E10
970     IF X2<>X1 THEN 990
980     GOTO 1000
990     S=(Y2-Y1)/(X2-X1)
1000    IF ABS(S)<1.0E-5 THEN 1150
```

```
1010    C1=X1-Y1/S
1020    C2=1/S^2+1
1030    C3=2*C1/S-2*X/S-2*Y
1040    C4=C1^2-2*X*C1+X^2+Y^2-R^2
1050    C5=C3^2-4*C2*C4
1060    IF C5<0 THEN 1080
1070    GOTO 1090
1080    Z(I,1)=0
1090    IF C5<0 THEN 1630
1100    Q1=(-C3+SQR(C5))/(2*C2)
1110    Q2=(-C3-SQR(C5))/(2*C2)
1120    Q3=Q1/S+C1
1130    Q4=Q2/S+C1
1140    GOTO 1240
1150    C5=R^2-(Y-Y1)^2
1160    IF C5<0 THEN 1180
1170    GOTO 1190
1180    Z(I,1)=0
1190    IF C5<0 THEN 1630
1200    Q3=X+SQR(C5)
1210    Q4=X-SQR(C5)
1220    Q1=Y1
1230    Q2=Y1
1240    J1=0
1250    J2=0
1260    IF (ABS(S)<=9.99E9) AND (Q3>=X1) AND (Q3<=X2) THEN 1280
1270    GOTO 1290
1280    J1=1
1290    IF (ABS(S)<=9.99E9) AND (Q4>=X1) AND (Q4<=X2) THEN 1310
1300    GOTO 1320
1310    J2=1
1320    IF (S<-9.99E9) AND (Q1>=Y2) AND (Q1<=Y1) THEN 1340
1330    GOTO 1350
1340    J1=1
1350    IF (S<-9.99E9) AND (Q2>=Y2) AND (Q2<=Y1) THEN 1370
1360    GOTO 1380
1370    J2=1
1380    IF (S>9.99E9) AND (Q1>=Y1) AND (Q1<=Y2) THEN 1400
1390    GOTO 1410
1400    J1=1
1410    IF (S>9.99E9) AND (Q2>=Y1) AND (Q2<=Y2) THEN 1430
1420    GOTO 1440
1430    J2=1
1440    Z(I,1)=J1+J2
1450    IF J1=1 THEN 1470
1460    GOTO 1480
1470    Z(I,2)=Q3
1480    IF J1=1 THEN 1500
1490    GOTO 1510
1500    Z(I,3)=Q1
1510    IF (J1=0) AND (J2=1) THEN 1530
1520    GOTO 1540
1530    Z(I,2)=Q4
1540    IF (J1=0) AND (J2=1) THEN 1560
1550    GOTO 1570
1560    Z(I,3)=Q2
1570    IF (J1=1) AND (J2=1) THEN 1590
1580    GOTO 1600
1590    Z(I,4)=Q4
1600    IF (J1=1) AND (J2=1) THEN 1620
1610    GOTO 1630
1620    Z(I,3)=Q2
1630  NEXT I
1640  X4=0
1650  X5=9.99E20
1660  I1=1
1670  FOR I=1 TO L1
```

```
1680    IF Z(I,1)>=1 THEN 1700
1690    GOTO 1710
1700    A(I1)=Z(I,2)
1710    IF Z(I,1)>=1 THEN 1730
1720    GOTO 1740
1730    I1=I1+1
1740    IF Z(I,1)=2 THEN 1760
1750    GOTO 1770
1760    A(I1)=Z(I,4)
1770    IF Z(I,1)=2 THEN 1790
1780    GOTO 1800
1790    I1=I1+1
1800  NEXT I
1810  IF I1=1 THEN 1830
1820  GOTO 1840
1830  PRINT "CIRCLE DOES NOT INTERSECT SLOPE"
1840  IF I1=1 THEN 4380
```

*** SET UP SLICE ARRAY ***

```
1860  FOR I=1 TO I1-1
1870    IF A(I)>X4 THEN 1890
1880    GOTO 1900
1890    X4=A(I)
1900    IF A(I)<X5 THEN 1920
1910    GOTO 1930
1920    X5=A(I)
1930  NEXT I
1940  FOR I=1 TO P1
1950    IF (P(I,1)<X4) AND (P(I,1)>X5) THEN 1970
1960    GOTO 1980
1970    A(I1)=P(I,1)
1980    IF (P(I,1)<X4) AND (P(I,1)>X5) THEN 2000
1990    GOTO 2010
2000    I1=I1+1
2010  NEXT I
2020  I1=I1-1
2030  FOR I=1 TO I1
2040    FOR J=1 TO I1-1
2050      IF A(J+1)>A(J) THEN 2090
2060      J1=A(J+1)
2070      A(J+1)=A(J)
2080      A(J)=J1
2090    NEXT J
2100  NEXT I
2110  U1=0
2120  FOR I=1 TO I1-1
2130    IF A(I)<A(I+1) THEN 2150
2140    GOTO 2160
2150    U1=U1+1
2160    IF A(I)<A(I+1) THEN 2180
2170    GOTO 2190
2180    A(U1)=A(I)
2190  NEXT I
2200  U1=U1+1
2210  A(U1)=A(I1)
2220  I1=U1
```

*** DEFINE SLICE BOUNDARIES ***

```
2240  Q1=A(I1)-A(1)
2250  Q2=Q1/S9
2260  U1=I1
```

```
2270  FOR I=1 TO U1-1
2280    Q3=A(I+1)-A(I)
2290    Q4=INT(Q3/Q2)+1
2300    C1=Q3/Q4
2310    C2=A(I)
2320    FOR J=1 TO Q4
2330      IF J<Q4 THEN 2350
2340      GOTO 2360
2350      I1=I1+1
2360      IF J<Q4 THEN 2380
2370      GOTO 2390
2380      A(I1)=C2+C1
2390      IF J<Q4 THEN 2410
2400      GOTO 2420
2410      C2=C2+C1
2420    NEXT J
2430  NEXT I
2440  FOR I=1 TO I1
2450    FOR J=1 TO I1-1
2460      IF A(J+1)>A(J) THEN 2500
2470      J1=A(J+1)
2480      A(J+1)=A(J)
2490      A(J)=J1
2500    NEXT J
2510  NEXT I
```

*** DEFINE SOIL PARAMETERS FOR EACH SLICE ***

```
2530  F1=I1-1
2540  FOR I=1 TO F1
2550    F(I,4)=A(I+1)-A(I)
2560    X6=F(I,4)
2570    F(I,7)=(A(I+1)+A(I))/2
2580    X3=F(I,7)
2590    Y1=Y-SQR(R^2-(A(I)-X)^2)
2600    Y2=Y-SQR(R^2-(A(I+1)-X)^2)
2610    A5=ATN(ABS(Y2-Y1)/F(I,4))
2620    IF Y2<Y1 THEN 2640
2630    GOTO 2650
2640    A5=-A5
2650    F(I,2)=A5
2660    IF A5=0 THEN 2680
2670    GOTO 2690
2680    F(I,2)=1.0E-5
2690    Y3=Y-SQR(R^2-(X3-X)^2)
2700    I4=0
2710    FOR J=1 TO L1
2720      L5=L(J,1)
2730      L6=L(J,2)
2740      IF (P(L5,2)<=Y3) AND (P(L6,2)<=Y3) THEN 2840
2750      IF (P(L5,1)<X3) AND (P(L6,1)<X3) THEN 2840
2760      IF (P(L5,1)>X3) AND (P(L6,1)>X3) THEN 2840
2770      Y6=P(L5,2)+(P(L5,2)-P(L6,2))/(P(L5,1)-P(L6,1))*(X3-P(L5,1))
2780      IF Y6<=Y3 THEN 2840
2790      I4=I4+1
2800      Z(I4,1)=Y6
2810      Z(I4,2)=L(J,3)
2820      W=0
2830      E=0
2840    NEXT J
2850    IF I4=1 THEN 2970
2860    FOR J=1 TO I4
2870      FOR J1=1 TO I4-1
2880        IF Z(J1,1)>=Z(J1+1,1) THEN 2950
2890        L5=Z(J1,1)
```

```
2900        L6=Z(J1,2)
2910        Z(J1,1)=Z(J1+1,1)
2920        Z(J1,2)=Z(J1+1,2)
2930        Z(J1+1,1)=L5
2940        Z(J1+1,2)=L6
2950      NEXT J1
2960    NEXT J
2970    I4=I4+1
2980    Z(I4,1)=Y3
2990    FOR J1=1 TO I4-1
3000      IF (I=1) AND (J1=1) AND (X3>=S6) THEN 3020
3010      GOTO 3030
3020      I6=S0-Y1
3030      IF (I=F1) AND (J1=1) AND (X3>=S6) AND (X3<=S7) THEN 3050
3040      GOTO 3060
3050      J6=S0-Y2
3060      W=W+(Z(J1,1)-Z(J1+1,1))*X6*S2(Z(J1,2),1)
3070      IF (Z(J1,1)<S0) AND (X3>=S6) AND (X3<=S7) THEN 3090
3080      GOTO 3100
3090      W=W+(S0-Z(J1,1))*X6*W0
3100      IF S2(Z(J1,2),4)>.95 THEN 3120
3110      GOTO 3130
3120      E4=S2(Z(J1,2),1)
3130      IF S2(Z(J1,2),4)<.95 THEN 3150
3140      GOTO 3160
3150      E4=S2(Z(J1,2),1)-W0
3160      E=E+(Z(J1,1)-Z(J1+1,1))*X6*E4
3170    NEXT J1
3180    F(I,1)=W
3190    F(I,5)=E
3200    F(I,3)=S2(Z(I4-1,2),2)
3210    F(I,6)=2*PI*(S2(Z(I4-1,2),3)/360)
3220  NEXT I
3221  NORMAL
3230  IF F9=0 THEN 3360
3240  PRINT USING 3250;CHR$(210)
3250  IMAGE "SLICE   WEIGHT   INCLINATION   COHESION   WIDTH    EFF WEIGHT    "A
"       X"
3280  O=360/(2*PI)
3290  FOR I=1 TO F1
3300    PRINT USING 3320;I,F(I,1),F(I,2)*O,F(I,3),F(I,4),F(I,5),F(I,6)*O,F(I,7)
3320    IMAGE 3D,10D.D,7D.D,12D,9D.D,11D.D,7D,7D.D
3340  NEXT I
3350  PRINT
3360  D=0
3361  PRINTER IS 0
3370  FOR I=1 TO F1
3380    D=D+F(I,1)*SIN(ABS(F(I,2)))*(F(I,2)/ABS(F(I,2)))
3390    D=D+E1*F(I,1)*COS(ABS(F(I,2)))
3400  NEXT I
3410  IF I6>0 THEN 3430
3420  GOTO 3440
3430  I7=W0*I6*I6*(R-I6/3)/(2*R)
3440  IF I6>0 THEN 3460
3450  GOTO 3470
3460  D=D-SGN(D)*I7
3470  IF (I6>0) AND (F9=1) THEN 3490
3480  GOTO 3510
3490  PRINT USING 3500;I7
3500  IMAGE "DRIVING FORCE COUNTER BALANCE OF",10D.2D
3510  IF J6>0 THEN 3530
3520  GOTO 3540
3530  I7=W0*J6*J6*(R-J6/3)/(2*R)
3540  IF J6>0 THEN 3560
3550  GOTO 3570
3560  D=D+SGN(D)*I7
3570  IF (J6>0) AND (F9=1) THEN 3590
```

```
3580  GOTO 3610
3590  PRINT USING 3600;I7
3600  IMAGE "DRIVING FORCE INCREASE OF",10D.2D


*** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***

3620  F0=1
3630  R4=0
3640  I6=0
3650  FOR I=1 TO F1
3660    R1=F(I,3)*F(I,4)+F(I,5)*TAN(F(I,6))
3670    R2=1/COS(ABS(F(I,2)))
3680    R3=1+TAN(F(I,6))*TAN(F(I,2))/F0
3690    R4=R4+R1*(R2/R3)
3700  NEXT I
3710  F2=R4/D
3720  I6=I6+1
3730  IF F9=1 THEN 3750
3740  GOTO 3820
3750  IF I6=1 THEN 3770
3760  GOTO 3800
3770  PRINT
3780  PRINT USING 3790
3790  IMAGE "ITERATION",11X,"INITIAL",10X,"CALCULATED"
3800  PRINT USING 3810;I6,F0,F2
3810  IMAGE 3X,3D,13X,3D.4D,12X,3D.4D
3820  IF I6>10 THEN 3840
3830  GOTO 3850
3840  PRINT "WILL NOT CLOSE"
3850  IF I6>10 THEN 3970
3860  IF ABS(ABS(F0)-ABS(F2))<.005 THEN 3900
3870  F0=ABS(F2)
3880  R4=0
3890  GOTO 3650
3900 !
3901  IF NOT F9 THEN
3902    PRINTER IS 16
3903  ELSE
3904    PRINTER IS 0
3905  END IF
3910  PRINT
3920  PRINT USING 3930;F2,X,Y,R
3930  IMAGE "FACTOR OF SAFETY= ",5D.2D,"  AT X= ",4D," Y= ",4D, " R= ",4D
3940  PRINT USING 3950;E1
3950  IMAGE "EARTHQUAKE= ",2D.2D
3951  IF F9 THEN 4380
3960  PRINT
3961  A$=""
3970  INPUT "DO YOU WISH A FORMAL PRINTOUT (Y/N)",A$
3990  IF UPC$(A$[1,1])="N" THEN 4320
3991  PRINTER IS 0
4030  IMAGE @"WATER UNIT WEIGHT=",3D.2D
4040  PRINT USING 4030;W0
4041  IF S0 THEN
4050    PRINT
4060    IMAGE "SUBMERGENCE AT "3D.2D,"  FROM  ",3D.1D,"  TO  ",3D.1D
4070    PRINT USING 4060;S0,S6,S7
4071  END IF
4080  PRINT
4090  PRINT " POINT   X-ORD     Y-ORD"
4100  IMAGE 4D,7D.2D,7D.2D
4110  FOR I=1 TO P1
4120    PRINT USING 4100;I,P(I,1),P(I,2)
4130  NEXT I
4140  PRINT
```

```
4150  PRINT "      LINE     LEFT    RIGHT     SOIL"
4160  IMAGE 4(8D)
4170  FOR I=1 TO L1
4180    PRINT USING 4160;I,L(I,1),L(I,2),L(I,3)
4190  NEXT I
4200  PRINT
4210  PRINT "SOIL        UNIT WEIGHT        COHESION      "&CHR$(210)&"      SATURAT
ED"
4220  IMAGE 3D,15D,17D,9D,7X,3A
4230  FOR I=1 TO S1
4240    PRINT USING 4220;I,S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
4250  NEXT I
4260  PRINT
4270  PRINT "CIRCLE   X-ORD    Y-ORD   RADIUS  FACTOR OF SAFETY"
4280  IMAGE 12D.D,7D.D,7D.D,8D.2D
4290  PRINT USING 4280;X,Y,R,F2
4300  PRINT
4310  PRINT
4311  A$=""
4320  INPUT "DO YOU WISH A DIAGNOSTIC RUN (Y/N)",A$
4340  IF UPC$(A$[1,1])="N" THEN 4370
4360  F9=1
4370  IF UPC$(A$[1,1])<>"N" THEN 720
4371  A$=""
4380  INPUT "DO YOU WANT TO CONTINUE (Y/N)",A$
4400  IF UPC$(A$[1,1])<>"N" THEN 630
4401  DISP " FINISHED "
4410  STOP
4520 Logo:PLOTTER IS 13,"GRAPHICS"
4530  GRAPHICS
4540  SCALE 0,559,0,454
4550  LORG 2
4560  FOR I=0 TO 5
4570    Logo(1)=-2175
4580    Logo(2)=-4352
4590    R=454-I
4600    GLOAD Logo(*),0,R
4610  NEXT I
4620  FOR I=6 TO 14
4630    Logo(1)=-2115
4640    Logo(2)=-4352
4650    R=454-I
4660    GLOAD Logo(*),0,R
4670  NEXT I
4680  FOR I=15 TO 21
4690    Logo(1)=-2175
4700    Logo(2)=-4352
4710    R=454-I
4720    GLOAD Logo(*),0,R
4730  NEXT I
4740  CSIZE 15/4.54,9/15
4750  MOVE 27,450
4760  LABEL "HORROCKS"
4770  MOVE 27,437
4780  CSIZE 15/4.54,8/15
4790  LABEL "ENGINEERS"
4800  DUMP GRAPHICS 430,454
4810  GCLEAR
4820  EXIT GRAPHICS
4830  RETURN
```

Slope stability program

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For natural or man-made slopes, the index of stability with respect to a sudden failure is known as the safety factor of the slope. The safety factor may be defined as the ratio of the potential resisting forces to the drive forces tending to cause movement. A slope on the verge of failure would have a safety factor of 1.0. The analysis of slope stability is, therefore, the analytical procedure of determining the most critical, i.e., the lowest, factor of safety of given or proposed slope.

Manual methods of slope stability analysis were developed prior to the advent of the electronic computer. These approaches resulted in high analysis costs and conservative slope configurations. Repetitive calculations lended themselves to computerized methods and numerous programs exist that have been written for large computer systems to perform slope stability analysis according to a number of theoretical methods.

The simplified or modified Bishop method is reasonably accurate for most purposes where the slope under analysis can be assumed to fail along a circular failure surface. The factor of safety is defined as the ratio of the resisting moments to driving moments around the center of the failure arc. Initially, a cross-section of the slope is drawn detailing soil strata and piezometric surfaces. A center point is then chosen from which an arc is taken through the cross-section. This arc represents the failure surface under evaluation. This failure zone is broken down into a series of slices which can be individually evaluated for their weight and strength characteristics. An illustration of a slope cross-section being defined by a series of slices is shown in Figure 1.

The forces acting on each slice are illustrated in Figure 1, where ΔX is the width of the slice, W is the weight of the slice, T is the force acting along the failure surface at the bottom of the slice, N is the effective force acting normally to the base of the slice and Θ is the inclination of the failure surface or slice base. The factor of safety is defined as:

$$F = \frac{\dfrac{\Sigma\,(C\,\Delta X + N \tan \Phi)\sec \Theta}{1 + \dfrac{\tan \Phi \tan \Theta}{F}}}{\Sigma\, W \sin \Theta}$$

Where C is the cohesion, Φ is the friction angle and the summation occurs over each slice of the failure zone. As the factor of safety, F, occurs on both sides of the equation. An interactive solution where F is initially estimated and then back substituted until the calculated F and estimated F close within a specified tolerance.

The equation can be modified to handle two additional conditions by adding additional factors to the term defining the driving force. These two conditions are standing pools, i.e., submergence of a portion of the slope, and earthquake loading. For submergence, the weight of water acting above the slice is added to the weight of the slice itself. The total driving force is increased or decreased by the weight of water above or below the exit of the failure surface from the slope. The second condition of earthquake loading can be handled by increasing the driving force calculated for each slice by $EW\cos\Theta$, where E is the earthquake loading factor. Similarly the resisting force is decreased by a decrease in the normal force due to the earthquake loading.

Following the calculation of the safety factor for this arc, the center or radius of the arc is modified to generate a new failure surface. The previously mentioned procedure is again followed with a new factor of safety being deter-

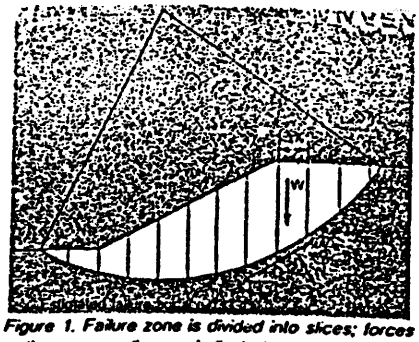

Figure 1. Failure zone is divided into slices; forces acting upon a slice are indicated.

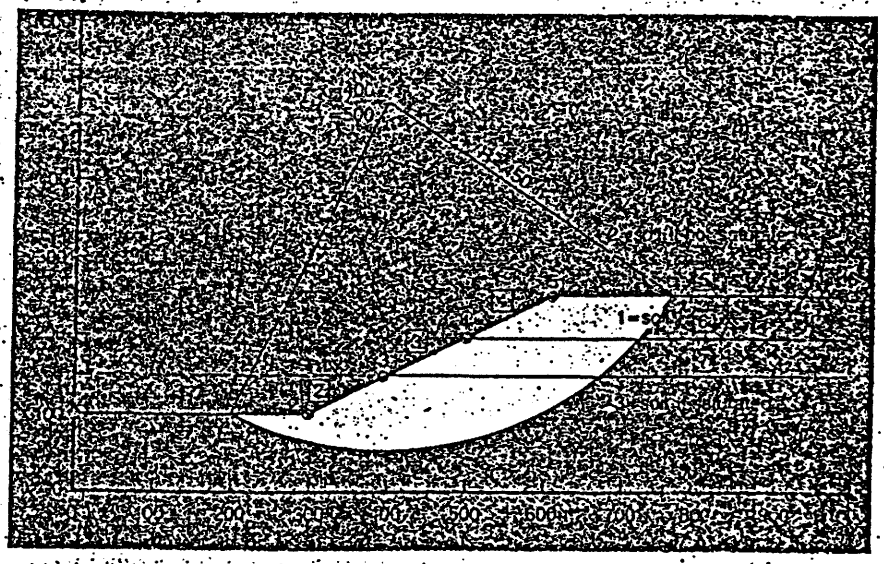

Figure 2. shows a typical cross-section and the input parameters required to define the cross-section for the program.

Table for Figure 2

Point	X	Y	Line	Left	Right	Soil	Soil	α	Cohesion	Phi	Saturated
1	0	100	1	1	2	3	1	127	2000	20	No
2	300	100	2	2	3	3	2	130	1000	33	No
3	400	150	3	3	4	2	3	130	1000	33	Yes
4	500	200	4	4	5	1					
5	600	250	5	5	6	1					
6	1000	250	6	4	7	2					
7	1000	200	7	3	8	3					
8	1000	150									

0360-0556/82/0010-0071/$01.00

```
100 REM ** SIMPLIFIED BISHOP SLOPE STABILITY ANALYS
110 REM ***********************************************
120 PRINT @40:"SLOPE STABILITY ANALYSIS"
130 DIM P(20,2),L(20,3),S2(5,4),A(20),F(20,7),Z(20,4)
150 S9=10
160 J6=0
170 REM *** INPUT@40: OF PROGRAM VARIABLES ***
180 PRINT @40:"HEADING *"
190 INPUT @40:H$
200 PRINT @40:"SUBMERGENCE ELEVATION (0 IF NO SUBMERGENCE) *"
210 INPUT @40:S0
220 PRINT @40:"FROM X-ORD *"
230 INPUT @40:S6
240 PRINT @40:"  TO X-ORD. *"
250 INPUT @40:S7
260 PRINT @40:"WATER UNIT WEIGHT *"
270 INPUT @40:W0
280 PRINT @40:"EARTHQUAKE *"
290 INPUT @40:E1
300 PRINT @40:"NUMBER OF POINTS *"
310 INPUT @40:P1
320 FOR I=1 TO P1
330 PRINT @40:"POINT--------> *"I
340 PRINT @40:"X-ORD *"
350 INPUT @40:P(I,1)
360 PRINT @40:"Y-ORD *"
370 INPUT @40:P(I,2)
380 NEXT I
390 PRINT @40:"NUMBER OF LINES *"
400 INPUT @40:L1
410 FOR I=1 TO L1
420 PRINT @40:"LINE--------> *"I
430 PRINT @40:"LEFT PT *"
440 INPUT @40:L(I,1)
450 PRINT @40:"RIGHT PT *"
460 INPUT @40:L(I,2)
470 PRINT @40:"SOIL BENEATH *"
480 INPUT @40:L(I,3)
490 NEXT I
500 PRINT @40:"NUMBER OF SOILS *"
510 INPUT @40:S1
520 FOR I=1 TO S1
530 PRINT @40:"SOIL--------> *"I
540 PRINT @40:"UNIT WEIGHT *"
550 INPUT @40:S2(I,1)
560 PRINT @40:"COHESION *"
570 INPUT @40:S2(I,2)
580 PRINT @40:"PHI ANGLE *"
590 INPUT @40:S2(I,3)
600 PRINT @40:"SATURATION (0=YES,1=NO)
610 INPUT @40:S2(I,4)
620 NEXT I
630 REM
640 F9=0
650 PRINT @40:"CIRCLE DEFINITION
660 PRINT @40:"X-ORD OF CENTER *"
670 INPUT @40:X
680 PRINT @40:"Y-ORD OF CENTER *"
690 INPUT @40:Y
700 PRINT @40:"CIRCLE RADIUS *"
710 INPUT @40:R
720 REM ***CHECK TO SEE IF CIRCLE EXCEEDS TOP LINE END POINTS ***
730 U1=P1
740 FOR I=2 TO P1
750 IF P(I,1)>P(I-1,1) AND U1=P1 THEN 770
760 GO TO 780
770 U1=I-1
780 NEXT I
790 J1=R*R-(P(U1,2)-Y)^2
800 J2=R*R-(P(U1,2)-Y)^2
810 IF J1<0 THEN 830
820 IF J1>0 AND P(U1,2)>Y+SQR(J1) THEN 840
830 IF J2<0 THEN 850
840 IF J2>0 AND P(U1+1)(X+SQR(J2)) THEN 840
850 GO TO 880
860 PRINT @40:"CIRCLE EXCEEDS TOP LINE END POINTS *"
870 GO TO 4380
880 REM ***DEFINE INTERSECTION OF CIRCLE WITH LINES ***
890 FOR I=1 TO L1
900 X1=P(L(I,1),1)
910 Y1=P(L(I,1),2)
920 X2=P(L(I,2),1)
930 Y2=P(L(I,2),2)
940 IF X2=X1 THEN 960
950 GO TO 970
960 S=9.99E+19
970 IF X2<>X1 THEN 990
980 GO TO 1000
990 S=(Y2-Y1)/(X2-X1)
1000 IF ABS(S)<1.0E-5 THEN 1150
1010 C1=X1-Y1/S
1020 C2=1/S^2+1
1030 C3=2*C1/S-2*X/S-2*Y
1040 C4=C1^2-2*X*C1/K^2+Y^2-R
1050 C5=C3^2-4*C2*C4
1060 IF C5<0 THEN 1080
1070 GO TO 1090
1080 Z(I,1)=0
1090 IF C5=0 THEN 1630
1100 01=-C3+SQR(C5))/(2*C2)
1110 02=(-C3-SQR(C5))/(2*C2)
1120 03=01/S+C1
1130 04=02/S+C1
1140 GO TO 1240
1150 C5=R^2-(Y-Y1)^2
1160 IF C5<0 THEN 1180
1170 GO TO 1190
1180 Z(I,1)=0
1190 IF C5<0 THEN 1630
1200 03=X+SQR(C5)
1210 04=X-SQR(C5)
1220 01=Y1
1230 02=Y1
1240 J1=0
1250 J2=0
1260 IF ABS(03)<9.99E+9 AND 03>X1 AND 03<X2 THEN 1280
1270 GO TO 1290
1280 J1=1
1290 IF ABS(04)<9.99E+9 AND 04>X1 AND 04<X2 THEN 1310
1300 GO TO 1320
1310 J2=1
1320 IF S<9.99E+9 AND 01>Y2 AND 01<Y1 THEN 1340
1330 GO TO 1350
1340 J1=1
1350 IF S<9.99E+9 AND 02>Y2 AND 02<Y1 THEN 1370
1360 GO TO 1380
1370 J2=1
1380 IF S>9.99E+9 AND 01>Y1 AND 01<Y2 THEN 1400
1390 GO TO 1410
1400 J1=1
1410 IF S>9.99E+9 AND 02>Y1 AND 02<Y2 THEN 1430
1420 GO TO 1440
1430 J2=1
1440 Z(I,1)=J1+J2
1450 IF J1=1 THEN 1470
1460 GO TO 1480
1470 Z(I,2)=03
1480 IF J1=1 THEN 1500
1490 GO TO 1510
1500 Z(I,3)=01
1510 IF J1=0 AND J2=1 THEN 1530
1520 GO TO 1540
1530 Z(I,2)=04
1540 IF J1=0 AND J2=1 THEN 1560
1550 GO TO 1570
1560 Z(I,3)=02
1570 IF J1=1 AND J2=1 THEN 1590
1580 GO TO 1600
1590 Z(I,4)=04
1600 IF J1=1 AND J2=1 THEN 1620
1610 GO TO 1630
1620 Z(I,3)=02
1630 NEXT I
1640 X4=0
1650 X5=9.99E+20
1660 FOR I=1 TO L1
1670 FOR J=1 TO 2
1680 IF Z(I,J)>1 THEN 1700
1690 GO TO 1710
1700 A(I)=Z(I,J)
1710 IF Z(I,J)>U THEN 1730
1720 GO TO 1740
1730 I1=I
1740 IF Z(I,J)=2 THEN 1760
1750 GO TO 1770
1760 A(I)=Z(I,4)
1770 IF Z(I,J)=2 THEN 1790
1780 GO TO 1800
1790 I1=I
1800 NEXT I
1810 IF I1=1 THEN 1830
1820 GO TO 1840
1830 PRINT @40:"CIRCLE DOES NOT INTERSECT SLOPE *"
1840 IF I1=1 THEN 4380
1850 REM ***SET UP OF SLICE ARRAY ***
1860 FOR I=1 TO I1
1870 IF A(I)>X4 THEN 1890
1880 GO TO 1900
1890 X4=A(I)
1900 IF A(I)<X5 THEN 1920
1910 GO TO 1930
1920 X5=A(I)
1930 NEXT I
1940 FOR I=1 TO I1
1950 IF F(I,1)<X4 AND F(I,1)>X5 THEN 1970
1960 GO TO 1980
1970 A(I)=F(I,1)
1980 IF F(I,1)<X4 AND F(I,1)>X5 THEN 2000
1990 GO TO 2010
2000 I1=I1-1
2010 NEXT I
2020 I1=I1-1
2030 FOR I=1 TO I1
2040 FOR J=1 TO I1-1
```

mined. This entire sequence is repeated until the failure surface for the minimum factor of safety is determined.

The program included in this article follows the same general procedure as previously defined. The program can be broken down into nine segments. Lines 100-620 are input routines for the entry of data defining the cross-section, lines 630-710 define the circle that will generate the failure surface, lines 720-860 perform a verification that the failure arc falls fully within the cross-section and lines 880-1840 define the intersection points between the line segments and the failure arc. The slice array is set up between line 1850 and 2220, with slice boundaries defined in lines 2230-2510. Lines 2520-3600 include the definition of the soil parameters for each slice and the actual iterative solution for the factor of safety occurs between lines 3610 and 3950. The remainder of the program is the formal output of the results.

The program includes a diagnostic print-out where all the slice parameters can be displayed for any given failure surface. As currently configured the program can handle models including

```
2050 IF A(J+1)<A(J) THEN 2090
2060 J1=A(J+1)
2070 A(J+1)=A(J)
2080 A(J)=J1
2090 NEXT J
2100 NEXT I
2110 U1=0
2120 FOR I=1 TO I1-1
2130 IF A(I)<A(I+1) THEN 2150
2140 GO TO 2160
2150 U1=U1+1
2160 IF A(I)<A(I+1) THEN 2180
2170 GO TO 2190
2180 A(U1)=A(I)
2190 NEXT I
2200 U1=U1+1
2210 A(U1)=A(I1)
2220 I1=U1
2230 REM *** DEFINE SLICE BOUNDARIES ***
2240 Q1=A(I1)-A(1)
2250 Q2=Q1/S9
2260 U1=I1
2270 FOR I=1 TO U1-1
2280 Q3=A(I+1)-A(I)
2290 Q4=INT(Q3/Q2)+1
2300 C1=Q3/Q4
2310 C2=A(I)
2320 FOR J=1 TO Q4
2330 IF J<Q4 THEN 2350
2340 GO TO 2360
2350 I1=I1+1
2360 IF J<Q4 THEN 2380
2370 GO TO 2390
2380 A(I1)=C2+C1
2390 IF J<Q4 THEN 2410
2400 GO TO 2420
2410 C2=C2+C1
2420 NEXT J
2430 NEXT I
2440 FOR I=1 TO I1
2450 FOR J=1 TO I1-I
2460 IF A(J+1)>A(J) THEN 2500
2470 J1=A(J+1)
2480 A(J+1)=A(J)
2490 A(J)=J1
2500 NEXT J
2510 NEXT I
2520 REM *** DEFINE SOIL PARAMETERS FOR EACH SLICE ***
2530 F1=I1-1
2540 FOR I=1 TO F1
2550 F(I,4)=A(I+1)-A(I)
2560 X6=F(I,4)
2570 F(I,7)=(A(I+1)+A(I))/2
2580 X3=F(I,7)
2590 Y1=Y-SQR(R^2-(A(I)-X)^2)
2600 Y2=Y-SQR(R^2-(A(I+1)-X)^2)
2610 A5=ATN(ABS(Y2-Y1)/F(I,4))
2620 IF Y2<Y1 THEN 2640
2630 GO TO 2650
2640 A5=-A5
2650 F(I,2)=A5
2660 IF A5=0 THEN 2680
2670 GO TO 2690
2680 F(I,2)=1.0E-3
2690 Y3=Y-SQR(R^2-(X3-X)^2)
2700 I4=0
2710 FOR J=1 TO L1
2720 L5=C(J,1)
2730 L4=C(J,2)
2740 IF P(L5,2)<Y3 AND P(L4,2)<Y3 THEN 2840
2750 IF P(L5,1)<X3 AND P(L4,1)<X3 THEN 2840
2760 IF P(L5,1)>X3 AND P(L4,1)>X3 THEN 2840
2770 Y4=P(L5,2)+(P(L5,2)-P(L4,2))/(P(L5,1)-P(L4,1))*(X3-P(L5,1))
2780 IF Y4<Y3 THEN 2840
2790 I4=I4+1
2800 Z(I4,1)=Y4
2810 Z(I4,2)=L(J,1)
2820 W=0
2830 E=0
2840 NEXT J
2850 IF I4=0 THEN 2770
2860 FOR J=1 TO I4-1
2870 FOR J1=1 TO I4-1
2880 IF Z(J,1)>Z(J1,1) THEN 2930
2890 L5=Z(J,1)
2900 L4=Z(J,2)
2910 Z(J,1)=Z(J1,1)
2920 Z(J,2)=Z(J1,2)
2930 Z(J1,1)=L5
2940 Z(J1,2)=L4
2950 NEXT J1
2960 NEXT J
2970 I4=I4+1
2980 Z(I4,1)=Y3
2990 FOR J1=1 TO I4-1
3000 IF Z(J1,1)=Y3 AND J1=1 AND X3>S4 THEN 3020
3010 GO TO 3030
3020 I4=S0-Y1
3030 IF Z(J1,1)=Y3 AND J1=I4 AND X3>S4 AND X3<S7 THEN 3050
3040 GO TO 3060
3050 I4=S0-Y2
3060 W=W+(Z(J1,1)-Z(J1+1,1))*X6*S2(Z(J1,2)+1)
3070 IF Z(J1+1)<S0 AND X3>S4 AND X3<S7 THEN 3090
3080 GO TO 3100
3090 W=W+(S0-Z(J1+1))*X6*W0
3100 IF S2(Z(J1,2)+4)>0.95 THEN 3120
3110 GO TO 3130
3120 E4=S2(Z(J1,2)+1)
3130 IF S2(Z(J1,2)+4)<0.95 THEN 3150
3140 GO TO 3160
3150 E4=S2(Z(J1,2)+1)-W0
3160 E=E+(Z(J1+1)-Z(J1+1,1))*X6*E4
3170 NEXT J1
3180 F(I,1)=W
3190 F(I,5)=E
3200 F(I,3)=S2(Z(I4-1,2),2)
3210 F(I,6)=2*PI*(S2(Z(I4-1,2),3)/360)
3220 NEXT I
3230 IF F9=0 THEN 3260
3240 PRINT @40: USING 3250:
3250 IMAGE "SLICE  WEIGHT   INCLINATION ",S
3260 PRINT @40: USING 3270:
3270 IMAGE " COHESION  WIDTH  EFF WEIGTH     PHI     K"
3280 D=360/(2*PI)
3290 FOR I=1 TO F1
3300 PRINT @40: USING 3320:I,F(I,1),F(I,2)*D,F(I,3),F(I,4),F(I,5)
3310 PRINT @40: USING 3330:F(I,6)*D,F(I,7)
3320 IMAGE (3D,09D.1D,07D.1D,12D,07D.1D,,09D.1D),S
3330 IMAGE   7D.1D ,5D.2D
3340 NEXT I
3350 PRINT @40:
3360 D=0
3370 FOR I=1 TO F1
3380 D=D+F(I,1)*SIN(ABS(F(I,2)))*(F(I,2)/ABS(F(I,2)))
3390 D=D+E1*F(I,1)*COS(ABS(F(I,2)))
3400 NEXT I
3410 IF I6>0 THEN 3430
3420 GO TO 3440
3430 I7=W0*I6*I6*(R-I6/3)/(2*R)
3440 IF I6>0 THEN 3460
3450 GO TO 3470
3460 D=D-SGN(D)*I7
3470 IF I6>0 AND F9=1 THEN 3490
3480 GO TO 3510
3490 PRINT @40: USING 3500:I7
3500 IMAGE "DRIVING FORCE COUNTER BALANCE OF",10D.2D
3510 IF J6>0 THEN 3530
3520 GO TO 3540
3530 I7=W0*J6*J6*(R-J6/3)/(2*R)
3540 IF J6>0 THEN 3560
3550 GO TO 3570
3560 D=D+SGN(D)*I7
3570 IF J6>0 AND F9=1 THEN 3590
3580 GO TO 3610
3590 PRINT @40: USING 3600:I7
3600 IMAGE "DRIVING FORCE INCREASE OF",10D.2D
3610 REM *** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***
3620 F0=1
3630 R4=0
3640 I6=0
3650 FOR I=1 TO F1
3660 R1=F(I,3)*F(I,4)+F(I,5)*TAN(F(I,6))
3670 R2=1/COS(ABS(F(I,2)))
3680 R3=1+TAN(F(I,6))*TAN(F(I,2))/F0
3690 R4=R4+R1*(R2/R3)
3700 NEXT I
3710 F2=R4/D
3720 I6=I6+1
3730 IF F9=1 THEN 3750
3740 GO TO 3820
3750 IF I6=1 THEN 3770
3760 GO TO 3800
3770 PRINT @40:
3780 PRINT @40: USING 3790:
3790 IMAGE "I","ITERATION",10X,"INITIAL",10X,"CALCULATED"
3800 PRINT @40: USING 3810:I6,F0,F2
3810 IMAGE 3I,3D,13X,3D,4D,12X,3D,4D
3820 IF I6>10 THEN 3840
3830 GO TO 3850
3840 PRINT @40:"WILL NOT CLOSE"
3850 IF I6>10 THEN 3970
3860 IF ABS(ABS(F0)-ABS(F2))<0.005 THEN 3900
3870 F0=ABS(F2)
3880 R4=0
3890 GO TO 3650
3900 REM
3910 PRINT @40:
3920 PRINT @40: USING 3930:F2,X,Y,R
3930 IMAGE "FACTOR OF SAFETY=",2D.2D,"  AT X=",4D,"  Y=",4D,"  R=",4D
3940 PRINT @40: USING 3950:E1
3950 IMAGE "EARTHQUAKE=",-.2D.2D
3960 PRINT @40:
3970 PRINT @40:"DO YOU WISH A FORMAL PRINTOUT (Y OR N)"
3980 INPUT @40:A6
3990 IF A6="N" THEN 4320
4000 PRINT @40:
4010 PRINT @40:H0
4020 PRINT @40:
4030 IMAGE "WATER UNIT WEIGHT=",3D.2D,"  EARTHQUAKE=",1D.2D
4040 PRINT @40: USING 4030:W0,E1
4050 PRINT @40:
4060 IMAGE "SUBMERGENCE AT",3D,2D,"  FROM",4D,4D,"  TO",4D,4D
4070 PRINT @40: USING 4060:S0,S4,S7
4080 PRINT @40:
4090 PRINT @40:"POINT","X-ORD","Y-ORD"
4100 IMAGE 4D,7D,2D,7D,2D
4110 FOR I=1 TO P1
4120 PRINT @40: USING 4100:I,P(I,1),P(I,2)
4130 NEXT I
4140 PRINT @40:
4150 PRINT @40:"LINE","LEFT","RIGHT","SOIL"
4160 IMAGE 4(8D)
4170 FOR I=1 TO L1
4180 PRINT @40: USING 4190:I,L(I,1),L(I,2),C(I,3)
4190 NEXT I
4200 PRINT @40:
4210 PRI @40:"SOIL","UNIT WEIGHT","COHESION","PHI","SATURATED"
4220 IMAGE 3D,15D,17D,9D,9D
4230 FOR I=1 TO S1
4240 PRINT @40: USING 4220:I,S2(I,1),S2(I,2),S2(I,3),S2(I,4)
4250 NEXT I
4260 PRINT @40:
4270 PRINT @40:"CIRCLE","X-ORD","Y-ORD","RADIUS","FACTOR OF SAFETY"
4280 IMAGE 12D,1D,7D,1D,7D,1D,8D,2D
4290 PRINT @40: USING 4280:X,Y,R,F2
4300 PRINT @40:
4310 PRINT @40:
4320 PRINT @40:"DO YOU WISH A DIAGNOSTIC RUN (Y OR N)"
4330 INPUT @40:A6
4340 IF A6="Y" THEN 4360
4350 GO TO 4370
4360 F9=1
4370 IF A6="Y" THEN 720
4380 PRINT @40:"CONTINUE (Y OR N)"
4390 INPUT @40:A6
4400 IF A6="Y" THEN 630
```

```
WATER UNIT WEIGHT 62.4
EARTHQUAKE 0.05
NUMBER OF POINTS 8
POINT------> 1
X-ORD 0
Y-ORD 100
POINT------> 2
X-ORD 300
Y-ORD 100
POINT------> 3
X-ORD 400
Y-ORD 150
POINT------> 4
X-ORD 500
Y-ORD 200
POINT------> 5
X-ORD 600
Y-ORD 230
POINT------> 6
X-ORD 1000
Y-ORD 230
POINT------> 7
X-ORD 1000
Y-ORD 100
POINT------> 8
X-ORD 1000
Y-ORD 50
NUMBER OF LINES 7
LINE------> 1
LEFT PT 1
RIGHT PT 2
SOIL BENEATH 1
LINE------> 2
LEFT PT 2
RIGHT PT 3
SOIL BENEATH 1
LINE------> 3
LEFT PT 3
RIGHT PT 4
SOIL BENEATH 1
LINE------> 4
LEFT PT 4
RIGHT PT 5
SOIL BENEATH 1
LINE------> 5
LEFT PT 5
RIGHT PT 6
SOIL BENEATH 1
LINE------> 6
LEFT PT 6
RIGHT PT 7
SOIL BENEATH 2
LINE------> 7
LEFT PT 7
RIGHT PT 8
SOIL BENEATH 2
NUMBER OF SOILS 3
SOIL------> 1
UNIT WEIGHT 127
COHESION 2000
PHI ANGLE 20
SATURATION (0=YES,1=NO) 1
SOIL------> 2
UNIT WEIGHT 130
COHESION 1000
PHI ANGLE 33
SATURATION (0=YES,1=NO) 1
SOIL------> 3
UNIT WEIGHT 130
COHESION 1000
PHI ANGLE 33
SATURATION (0=YES,1=NO) 0
CIRCLE DEFINITION (1=YES,2=NO) 2
X-ORD OF CENTER 400
Y-ORD OF CENTER 300
CIRCLE RADIUS 430
FACTOR OF SAFETY 1.96 AT X 400 Y 300
EARTHQUAKE 0.05
DO YOU WISH A FORMAL PRINTOUT (Y OR N)? Y
SAMPLE SLOPE STABILITY PROBLEM
WATER UNIT WEIGHT 62.40 EARTHQUAKE 0.05
SUBMERGENCE AT 150.00 FROM 0.00 TO 400.00
POINT X-ORD Y-ORD
1 0.00 100.00
2 300.00 100.00
3 400.00 150.00
4 500.00 200.00
5 600.00 230.00
6 1000.00 230.00
7 1000.00 100.00
8 1000.00 50.00
LINE LEFT RIGHT SOIL
1 1 2 1
2 2 3 1
3 3 4 1
4 4 5 1
5 5 6 1
6 6 7 2
7 7 8 2
SOIL UNIT WEIGHT COHESION PHI SATURATED
1 127 2000 20 1
2 130 1000 33 1
3 130 1000 33 0
CIRCLE X-ORD Y-ORD RADIUS FACTOR OF SAFETY
1 400.0 300.0 430.0 1.96
DO YOU WISH A DIAGNOSTIC RUN (Y OR N)? N
SOIL WEIGHT INCLINATION COHESION WIDTH EFF WEIGHT PHI
1 2232316 23.7 1000 37.7 452207.8 1130 0.38
2 1853318 16.4 1000 53. 114252.6 33.0 273.45
3 1823308 9.6 1000 9.01 109976.2 33.0 22.00
4 1603232.6 3.7 1000 50.0 283401.0 33.0 175.00
5 1726232.4 1.7 1000 50. 416707.0 33.0 22.00
6 1852818.7 1.6 1000 50.0 360717.2 33.0 475.00
7 1739262.2 1.6 1000 50.0 483316.6 33.0 325.00
8 1728288.6 7.7 1000 0.0 781397.0 33.0 575.00
9 1757268.3 29.4 1000 41.4 430374.4 33.0 41.71
10 1617172.2 33.9 1000 0.0 576418.3 33.0 442.71
11 1518439.7 43.8 1000 22.4 518439.7 33.0 707.13
12 1319722.7 21.5 2000 30.8 1319722.9 2010 754.29
DRIVING FORCE COUNTER BALANCE OF Z (1,1)
ITERATION INITIAL CALCULATED
1 1.0000 1.8106
2 1.8106 1.9335
3 1.9335 1.9701
4 1.9701 1.9781
5 1.9770 1.9781
FACTOR OF SAFETY 1.96 AT X 400.0 Y 300.0 R 430.
EARTHQUAKE 0.05
DO YOU WISH A FORMAL PRINTOUT (Y OR N)?
DO YOU WISH A DIAGNOSTIC RUN (Y OR N)?
CONTINUE (Y OR N)?
```

up to 20 points, 20 lines, and 5 soil types. The minimum number of slices is set at 10, but can be changed by modifying the value of S9 at line 150 and changing the dimensioning of arrays A, F and Z.

A cross-section is drawn of the slope showing all soil strata and piezometric surfaces. Each intersect point between lines on the cross-section is numbered, with the constraint that all points along the top line must be numbered consecutively from left to right initiating with point 1. Points beneath the top line may be numbered in any order. These points are then defined with X and Y coordinates (the entire cross-section must fall in the first quadrant).

Lines are then specified by assigning line numbers for each line occurring between two end points. These lines are defined by a left point, a right point and the number of the soil type occurring beneath the line. Vertical lines are not allowed and should be modeled by offsetting the X-coordinate of one end point by a small amount, i.e., .01. Piezometric surfaces within the cross-section are treated as any other soil strata interface with saturated soil beneath and unsaturated soil above the line segment. Soil types are defined by specifying a unit weight, cohesion, phi angle and an indication of whether the soil is saturated.

Additional information that must be supplied includes the unit weight of water, the earthquake loading factor and information defining any standing pool of water. This pool is specified by inputting the Y-coordinate of the pool elevation and the left and right X-coordinates defining the extent of the pool. The only remaining input parameters are the center coordinates and radius of the failure arc. The input can be in any consistent set of units.

Figure 2 shows a typical cross-section and the input parameters required to define the cross-section for the program. The sample execution in the box shows the typical input sequence and output formats. This result is not necessarily the minimum factor of safety for this slope, but the factor of safety for the specified failure surface. Additional runs should be made using different centers and radii until the minimum factor of safety is located.

The program presented here is the nucleus from which system specific enhancements should be made. These enhancements are not included in this version for the purpose of minimizing the size of the program presented. Particularly valuable enhancements include the ability to edit interactively, save input on a disc or tape and perform a search for the minimum factor of safety without manually inputting each circle definition. Additional enhancements could include plotting capabilities and more detailed diagnostic features.

A computerized evaluation of slope stability should never take place apart from a complete evaluation of the geophysical conditions involved. Likewise, the results should always be subjected to evaluation and interpretation based on current engineering practice and experience. ∇

Cross received his M.S. degree in civil engineering from Rose-Hulman Institute of Technology, Terre Haute, Indiana in 1972. Currently data processing manager/project engineer, Cross has been with STS (formerly Soil Testing Services) for 10 years. He holds a Master of Divinity from Trinity Evangelical Divinity School and is working on an MBA at the Keller Graduate School of Management.