APPENDIX C

Slope Stability Analysis Under Dynamic Conditions - Computer Output

```
PROFIL
GENWAL - Proposed storage pad expansion. Scoured debris slope. E.Q. = 0.07g
6
6
0.0 100.0 25.0 100.0 1
25.0 100.0 50.0 102.0 1
50.0 102.0 53.3 131.7 1
53.3 131.7 55.0 131.8 1
55.0 131.8 67.0 140.4 1
67.0 140.4 150.0 140.4 1
SOIL
1
120.0 130.0 700.0 46.0 0.0 0.0 1
EQUAKE
0.07
0.0
0.0
CIRCL2
11
10
50.0 52.0
55.0 90.0
0.0
3.0
80.0
5.0
```

GEOSLOPE
Version 3.11

Supplied by GEOCOMP Corp.
342 Sudbury Rd., Concord, MA. 01742
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GEOSLOPE is based on the program, STABL3, developed at Purdue University under sponsorship of the Federal Highway Administration.

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EARTH FAX
Midvale, UT (s/n 5080)

1
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--SLOPE STABILITY ANALYSIS--
SIMPLIFIED JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION GENWAL - Proposed storage pad expansion.
Scoured debris slope. E.Q. = 0.07g

BOUNDARY COORDINATES

6 TOP BOUNDARIES
6 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	100.00	25.00	100.00	1
2	25.00	100.00	50.00	102.00	1
3	50.00	102.00	53.30	131.70	1
4	53.30	131.70	55.00	131.80	1
5	55.00	131.80	67.00	140.40	1
6	67.00	140.40	150.00	140.40	1

ISOTROPIC SOIL PARAMETERS

1 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	120.0	130.0	700.0	46.0	.00	.0	1

A HORIZONTAL EARTHQUAKE LOADING COEFFICIENT
OF .070 HAS BEEN ASSIGNED

A VERTICAL EARTHQUAKE LOADING COEFFICIENT
OF .000 HAS BEEN ASSIGNED

CAVITATION PRESSURE = .0

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM
TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

110 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 11 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 50.00
AND X = 52.00

EACH SURFACE TERMINATES BETWEEN X = 55.00
AND X = 90.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00

3.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

RESTRICTIONS HAVE BEEN IMPOSED UPON THE ANGLE OF INITIATION.
THE ANGLE HAS BEEN RESTRICTED BETWEEN THE ANGLES OF 5.0 AND 80.0 DEG.

FACTOR OF SAFETY CALCULATION HAS GONE THROUGH TEN ITERATIONS

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL
FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL
FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE # 1 SPECIFIED BY 17 COORDINATE POINTS

SAFETY FACTOR = 1.450

X-CENTER = -226.27
Y-CENTER = 318.27
RADIUS = 350.85

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.00	102.00	52.19
2	51.84	104.37	52.68
3	53.66	106.76	53.17
4	55.46	109.16	53.66
5	57.23	111.58	54.15
6	58.99	114.01	54.64
7	60.73	116.46	55.13
8	62.44	118.92	55.62
9	64.14	121.39	56.11
10	65.81	123.88	56.60
11	67.46	126.39	57.09
12	69.09	128.91	57.58
13	70.70	131.44	58.07
14	72.29	133.99	58.56
15	73.85	136.55	59.05
16	75.39	139.12	59.54
17	76.15	140.40	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	50.92	1.84	1564.91	.00	.00	357.64	737.98
2	52.57	1.46	3469.14	.00	.00	2167.32	2030.05
3	53.48	.36	1083.11	.00	.00	729.28	1003.32
4	54.33	1.34	3880.66	.00	.00	2575.80	2321.69
5	55.23	.46	1266.32	.00	.00	830.12	1075.32
6	56.35	1.78	4777.27	.00	.00	3092.40	2690.53
7	58.11	1.76	4477.53	.00	.00	2837.50	2508.54
8	59.86	1.74	4176.98	.00	.00	2580.73	2325.21
9	61.59	1.72	3875.97	.00	.00	2322.28	2140.68
10	63.29	1.69	3574.77	.00	.00	2062.34	1955.10
11	64.97	1.67	3273.69	.00	.00	1801.11	1768.58
12	66.40	1.19	2169.54	.00	.00	1132.24	1291.02
13	67.23	.46	794.36	.00	.00	398.56	767.20
14	68.28	1.63	2494.25	.00	.00	1119.00	1281.57
15	69.90	1.61	1973.77	.00	.00	659.93	953.81
16	71.49	1.59	1463.65	.00	.00	206.93	630.37
17	73.07	1.56	964.15	.00	.00	-239.82	311.41
18	74.62	1.54	475.51	.00	.00	-680.12	-2.95
19	75.77	.75	57.98	.00	.00	-499.55	125.97

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE # 2 SPECIFIED BY 16 COORDINATE POINTS

SAFETY FACTOR = 1.470

X-CENTER = -13.14
Y-CENTER = 167.20
RADIUS = 89.61

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.20	103.80	45.93
2	52.29	105.96	47.85
3	54.30	108.18	49.77
4	56.24	110.47	51.69
5	58.10	112.83	53.60
6	59.88	115.24	55.52
7	61.58	117.72	57.44
8	63.19	120.24	59.36
9	64.72	122.83	61.28
10	66.16	125.46	63.20
11	67.51	128.13	65.11
12	68.78	130.86	67.03
13	69.95	133.62	68.95
14	71.02	136.42	70.87
15	72.01	139.25	72.79
16	72.36	140.40	

1

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE # 3 SPECIFIED BY 16 COORDINATE POINTS

SAFETY FACTOR = 1.483

X-CENTER = -92.96
Y-CENTER = 199.06
RADIUS = 172.79

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.00	102.00	56.32
2	51.66	104.50	57.32
3	53.28	107.03	58.31
4	54.86	109.58	59.31
5	56.39	112.16	60.30
6	57.88	114.76	61.30
7	59.32	117.40	62.29
8	60.71	120.05	63.29
9	62.06	122.73	64.28

10	63.36	125.43	65.28
11	64.62	128.16	66.27
12	65.83	130.91	67.27
13	66.98	133.67	68.26
14	68.10	136.46	69.26
15	69.16	139.26	70.25
16	69.57	140.40	

1

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE # 4 SPECIFIED BY 15 COORDINATE POINTS

SAFETY FACTOR = 1.520

X-CENTER = 2.42
Y-CENTER = 157.34
RADIUS = 70.56

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.40	105.60	44.06
2	52.56	107.69	46.50
3	54.62	109.87	48.93
4	56.59	112.13	51.37
5	58.46	114.47	53.81
6	60.24	116.89	56.24
7	61.90	119.39	58.68
8	63.46	121.95	61.12
9	64.91	124.58	63.55
10	66.25	127.26	65.99
11	67.47	130.00	68.42
12	68.57	132.79	70.86
13	69.56	135.63	73.30
14	70.42	138.50	75.73
15	70.90	140.40	

1

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE # 5 SPECIFIED BY 19 COORDINATE POINTS

SAFETY FACTOR = 1.535

X-CENTER = -648.15
Y-CENTER = 764.60
RADIUS = 962.53

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.00	102.00	46.59
2	52.06	104.18	46.76

3	54.12	106.37	46.94
4	56.17	108.56	47.12
5	58.21	110.76	47.30
6	60.24	112.96	47.48
7	62.27	115.18	47.66
8	64.29	117.39	47.84
9	66.30	119.62	48.01
10	68.31	121.85	48.19
11	70.31	124.08	48.37
12	72.30	126.33	48.55
13	74.29	128.57	48.73
14	76.27	130.83	48.91
15	78.24	133.09	49.09
16	80.20	135.36	49.26
17	82.16	137.63	49.44
18	84.11	139.91	49.62
19	84.53	140.40	

1

FAILURE SURFACE # 6 SPECIFIED BY 17 COORDINATE POINTS

SAFETY FACTOR = 1.546

X-CENTER = -68.42
Y-CENTER = 234.85
RADIUS = 176.76

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.20	103.80	42.64
2	52.41	105.84	43.61
3	54.58	107.91	44.58
4	56.72	110.01	45.55
5	58.82	112.15	46.53
6	60.88	114.33	47.50
7	62.91	116.54	48.47
8	64.90	118.79	49.44
9	66.85	121.07	50.42
10	68.76	123.38	51.39
11	70.63	125.72	52.36
12	72.46	128.10	53.33
13	74.25	130.51	54.31
14	76.00	132.94	55.28
15	77.71	135.41	56.25
16	79.38	137.90	57.22
17	80.99	140.40	

1

FAILURE SURFACE # 7 SPECIFIED BY 16 COORDINATE POINTS

SAFETY FACTOR = 1.555

X-CENTER = -1430.94
Y-CENTER = 1028.77
RADIUS = 1746.23

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.20	103.80	58.06
2	51.79	106.35	58.16
3	53.37	108.90	58.26
4	54.95	111.45	58.36
5	56.52	114.00	58.46
6	58.09	116.56	58.56
7	59.66	119.12	58.65
8	61.22	121.68	58.75
9	62.77	124.25	58.85
10	64.32	126.82	58.95
11	65.87	129.39	59.05
12	67.41	131.96	59.15
13	68.95	134.53	59.24
14	70.49	137.11	59.34
15	72.02	139.69	59.44
16	72.44	140.40	

1

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE # 8 SPECIFIED BY 17 COORDINATE POINTS

SAFETY FACTOR = 1.594

X-CENTER = -126.92
Y-CENTER = 285.45
RADIUS = 252.56

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.40	105.60	44.94
2	52.52	107.72	45.62
3	54.62	109.87	46.30
4	56.70	112.04	46.98
5	58.74	114.23	47.66
6	60.76	116.45	48.34
7	62.76	118.69	49.02
8	64.72	120.95	49.70
9	66.66	123.24	50.38
10	68.58	125.55	51.06
11	70.46	127.89	51.74
12	72.32	130.24	52.42

13	74.15	132.62	53.10
14	75.95	135.02	53.78
15	77.72	137.44	54.46
16	79.47	139.88	55.14
17	79.83	140.40	

1

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE # 9 SPECIFIED BY 19 COORDINATE POINTS

SAFETY FACTOR = 1.689

X-CENTER = 20.10
Y-CENTER = 163.40
RADIUS = 68.29

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.00	102.00	27.22
2	52.67	103.38	29.74
3	55.27	104.86	32.26
4	57.81	106.47	34.77
5	60.27	108.18	37.29
6	62.66	109.99	39.81
7	64.97	111.92	42.33
8	67.18	113.94	44.84
9	69.31	116.05	47.36
10	71.34	118.26	49.88
11	73.28	120.55	52.39
12	75.11	122.93	54.91
13	76.83	125.38	57.43
14	78.45	127.91	59.95
15	79.95	130.51	62.46
16	81.34	133.17	64.98
17	82.60	135.89	67.50
18	83.75	138.66	70.02
19	84.39	140.40	

1

EARTH FAX
Midvale, UT (s/n 5080)

FAILURE SURFACE #10 SPECIFIED BY 15 COORDINATE POINTS

SAFETY FACTOR = 1.692

X-CENTER = -67.32
Y-CENTER = 225.16
RADIUS = 165.52

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.80	109.20	46.05
2	52.88	111.36	47.09
3	54.93	113.56	48.13
4	56.93	115.80	49.16
5	58.89	118.07	50.20
6	60.81	120.37	51.24
7	62.69	122.71	52.28
8	64.52	125.08	53.32
9	66.32	127.49	54.36
10	68.06	129.93	55.39
11	69.77	132.40	56.43
12	71.43	134.90	57.47
13	73.04	137.42	58.51
14	74.61	139.98	59.55
15	74.85	140.40	

1

EARTH FAX
Midvale, UT (s/n 5080)

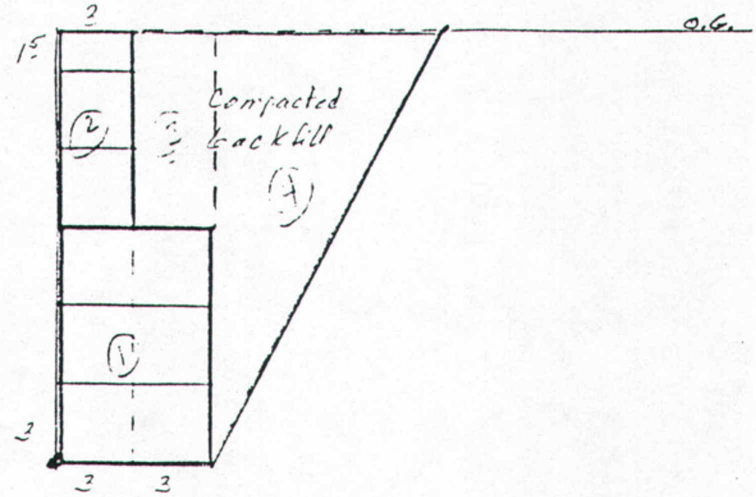
```
          Y            A     X     I     S

         100.00    118.75    137.50    156.25    175.00    193.75
X        .00 *---------+---------+---------+---------+---------+
             -
             -
             -
             -
             -
       18.75 +
             -
             *
             -
             -
             -
A      37.50 +
             -
             -
             -
             -*24.0..
             -.12140...... .  *
X      56.25 +..9.1170...... .*.
             - ..9.512173........
             - ...9..5212373. ....
             -  ...99.55121233 3 ..*
             -   .....9..55112423.33
             -    .....99..568112722
I      75.00 +     ......9..55861 11
             -      .......99..5668.
             -         ......9.955.6
             -           .........55
             -              ........
             -                   ...
S      93.75 +
             -
             -
             -
             -
             -
      112.50 +
             -
             -
             -
             -
             -
      131.25 +
             -
             -
             -
             -
             -
      150.00 +                     *
```

Appendix 3-20

Road Expansion (within permit area)

Safety Factor, Drawings



Given:

Wire baskets

γ = 112 lb/ft^3

Section (1) l = 6' h = 9' x = 0 y = 0 shape 1 (Square)

Section (2) l = 3' h = 7.5 x = 0 y = 9 shape 1

Compacted Backfill

γ = 137 lb/ft^3 Gm material ϕ = 34° Tan ϕ = .67

Section (3) l = 3 h = 7.5 x = 3 y = 9 shape 1

Section (4) l = 9 h = 16.5 x = 6 y = 0 shape 2 (Triangle)

Rotation: 1:6 = 9.5°
friction factor = 0.67 (Tan ϕ)
Top of wall = 16.5 ft
Pressure @ Top = 0
Pressure @ Bottom =

$p = \gamma z \tan^2(45 - 1/2\,\phi)$
$p = 137 z (.28)$
$p = 38.7 \cdot z$
when z = 16.5 P = <u>640</u>

F_S overturn = 5.2
F_S sliding = 9.3

RETAINING WALLS

Enter up to 10 areas.
Enter <Return> only for type to end.

TYPE: 1 - RECTANGLE (L & H)
2 - TRIANGLE (L & H)
3 - 1/4 CIRCLE (R & -)
4 - 1/2 CIRCLE (R & -)
5 - CIRCLE (R & -)

TYPE	WEIGHT	DIM-A	DIM-B	ROT.	X-DIST.	Y-DIST.
1	1[illegible]	6	9	0	0	0
1	112	3	7.3	0	0	9
[illegible]	1[illegible]7	3	7.5	0	3	9
2	1[illegible]	9	16.5	0	6	0

RESULTS

WT=	21,622.750
LH=	6.[illegible]25
LV=	5.50[illegible]
FH=	5,280.[illegible]
FV=	21,6[illegible].750
FT=	1,[illegible]
FN=	22,3[illegible]
FS-O=	[illegible]
FS-S=	[illegible]
S=	[illegible]
S-TOE=	-5,415.[illegible]
S-HEEL=	[illegible]

[illegible] 5.5 FRICTION FACTOR ? .[illegible]
[illegible] PRESSURE HEIGHT ? 16.5 PRESSURE ? [illegible]
[illegible] PRESSURE ? [illegible]

ENTER [illegible] ROTATION/FRICTION/PRESSURE (Y/N) ? N

REGISTERED PROFESSIONAL ENGINEER
3403
CRAIG E.
JOHANSEN
STATE OF UTAH

4.0 HAUL ROAD DESIGN

In accordance with recommendations by Genwal, the haul road was designed as a flexible pavement structure with a 5-year design life. The AASHTO Interim Guide for the Design of Pavement Structures (1972) was used as the design procedure.

The following assumptions were made for the flexible pavement design:

1. The serviceability index of the road is 2.0 (recommended value for highways with low traffic volumes). The serviceability index of a pavement is defined as the lowest index that will be tolerated before resurfacing or reconstruction becomes necessary. The factors used to calculate the serviceability index include the slope variance along the wheel path, the depth of the wheel path rut, the area of asphalt which has cracked, and the area of asphalt which has been patched (Oglesby and Hicks, 1982). In comparison, a serviceability index of 2.5 is used for the interstate system where high velocity and high volume traffic is expected.

2. The native soil classifies as a good subgrade material and has a minimum California Bearing Ratio of 10% of standard at 0.1-inch penetration.

3. The empty weight of the tractor/trailer vehicles is 38,940 lbs and the loaded weight is 129,000 lbs. Therefore, the payload is 90,060 lbs. The axle loadings are as presented in Appendix D (from Genwal).

4. 1,000,000 tons of coal are hauled from the mine annually (Genwal). Therefore, with a payload of 90,060 lbs, 22,207 empty and loaded rigs will drive the road annually (85 trucks daily).

5. Load contributions through passenger cars and light trucks are negligible.

The haul road design procedures and calculations are presented in Appendix B. From these calculations, recommended combinations of pavement and road base thicknesses for various Marshall Stability values are presented in Table 4-1.

TABLE 4-1

Recommended Pavement Thicknesses for Various Marshall Stability Values

Marshall Stability Value of Pavement (lbs)[(a)]	Recommended Pavement Thickness (inches)	Recommended Road Base Thickness (Total) (inches)
1200	6.5	8.0
1500	6.0	7.0
1800	5.5	7.0
2100	5.0	7.0
2400	4.5	8.0

(a) Minimum Marshall Stability Value which can be consistently produced by the asphalt plant.

The Marshall Stability is a laboratory test conducted on the asphalt to determine the flexural strength. Marshall stability values generally range between 1000 pounds for parking lots to more than 2500 pounds for good interstate pavements. Selection of the design Marshall Stability should be based on the minimum value which can be consistently achieved by the asphalt producer. The road should be constructed of plant mix asphalt rather than road mix to achieve a higher Marshall Stability and, consequently, a lesser pavement thickness.

According to Table 4-1, 7 to 8 inches of road base (total) are required to preclude failure of the subgrade soil. According to Genwal, approximately 8 inches of road base have currently been placed along the haul road and compacted with repeated passes of haul trucks. Therefore, additional road base is not required for structural purposes. Additional road base should be placed and compacted, however, to even the roadbed prior to placing the asphaltic surface.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This report represents an expression of opinions and recommendations based on field observations, laboratory analyses, and professional judgement. It is recommended that a geotechnical or geological engineer be on site during construction of the haul road to allow adequate field decisions to be made regarding local conditions.

In accordance with recommendations by Genwal, the haul road was designed as a flexible pavement structure with a 5-year design life. The AASHTO Interim Guide for the Design of Pavement Structures (1972) was used as the design procedure. Actual conditions which significantly deviate from the assumptions listed in Section 4.0 may render the design inadequate and in need of revision.

Recommended combinations of pavement and road base thicknesses for various Marshall Stability values were provided in Table 4-1. The road should be constructed of plant mix asphalt rather than road mix. Selection of the Marshall Stability value should be based on the minimum value which the asphalt plant can consistently produce. The pavement should be placed and compacted in accordance with standard construction practices.

For structural purposes, it is not necessary to place additional road base along the haul road if the nominal thickness of the existing road base is approximately 8 inches. However, it may be necessary to place additional road base to even the roadbed prior to placing the asphaltic surface.

Road base material should have a minimum CBR value of 48% of standard at 0.1-inch penetration and should conform to the AASHTO A-1 soil requirements. Road base should be compacted to a minimum of 96% of the modified Proctor density (132.8 pcf at 6.9% moisture from Table 3-1). All materials larger than 2 inches in diameter should be removed from the base course material to promote more effective compaction and to avoid stress concentrations which can cause local shear failure of the asphaltic pavement.

6.0 REFERENCES

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