APPENDIX F

CALCULATIONS

APPENDIX F

TABLE OF CONTENTS
CALCULATION BRIEF

PAGES

PARAPET WALL OVERFLOW CALCULATION.....1 - 39

STABILITY ANALYSIS OF PARAPET WALL CALCULATION .....40 - 51

REINFORCED CONCRETE WALL CALCULATION .....52 - 55

SEEP2D ANALYSIS OF FAILED ZONE CALCULATION.....56 - 71

STABILITY ANALYSIS OF FAILED ZONE CALCULATION.....72 - 114

PARAPET WALL OVERFLOW CALCULATION

Purpose:

Estimate overtopping flow at each segment of the parapet wall for the December 14, 2005 overtopping event. Calculate the impact velocity and distance from the wall for water overtopping the parapet wall of the Taum Sauk upper reservoir at wall segments 48, 72, and 95. Determine the relationship between overtopping flow and time for wall segment 95

References:

1. KdG. (December 27, 2005) "Taum Sauk Upper Reservoir Crest Survey Data," Revision 2.
2. Merritt, Frederick S. (1983) "Standard Handbook for Civil Engineers," Third Edition, McGraw Hill. (excerpts included as ***Attachment A***)
3. United States Department of the Interior, Bureau of Reclamation (USBR). (1987) "Design of Small Dams," Third Edition, Water Resources Technical Publication. (excerpts included as ***Attachment B***)
4. Siemens. (February 10, 2006) "AmerenUE Taum Sauk Incident Investigation Report."
5. US Army Corps of Engineers, Hydrologic Engineering Center. (May 2003) "Hydrologic Modeling System HEC-HMS" Version 2.2.2.

Background:

The upper reservoir dike of the Taum Sauk Pumped Storage Project failed on December 14, 2005 due to uncontrolled overtopping. This resulted in a dike failure and release of water from the upper reservoir. The reservoir wall was breached at wall segments 88 to 99 and overtopped in three other locations.

Assumptions:

1. Flow into the reservoir was approximately 2600 cfs and one pump was running at the time of the event.

2. Weir coefficient is based on values published by Merritt (1983). See table in ***Attachment A***.

3. Estimation of top of wall elevations for breached section

   For wall segments surveyed in 2005, the top of wall height is the average of the surveyed elevations at each end (Reference 1). Wall segments 69 through 99 were not surveyed in 2005. Top of wall elevation for these wall segments is estimated using survey data from 2003 for the monuments at the base of the wall, average wall height, and maximum settlement for all monuments on the dam from 2003 to 2005. Average wall height is the average difference between the elevation of the monument at the base of the wall and the surveyed top of the wall. Settlement is the maximum difference in surveyed elevation for monuments around the dam in 2003 and 2005. Using the maximum settlement is justified because the highest

sections of rockfill have the largest settlements, and wall segments 69 through 99 are at the tallest section of rockfill dam.

Calculations:

1. Weir Equation

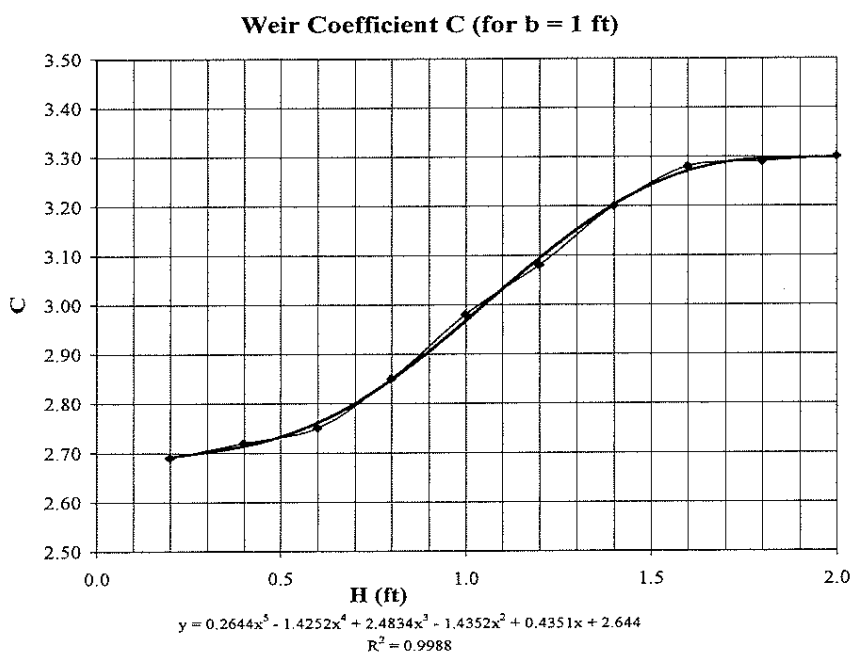
Each wall segment is modeled as a broad crested weir with the top at the elevation found previously. The flow over each segment is found for reservoir elevations ranging from 1597.00 to 1599.00 in 0.1 ft increments.

Flow over a broad crested weir is given by the equation

$Q = CLH^{3/2}$

where Q = flow in cfs
C = discharge coefficient
L = effective length of crest (ft)
H = depth of flow above elevation of crest (ft)

The discharge coefficient C depends on the head H and the breadth of the weir. For overtopping of the parapet wall, the breadth of the weir is 1 ft. A curve was fit in excel to estimate C for different heads with the top of the parapet wall acting as a broad crested weir. H vs C values are as taken from Merritt (1983) for a one foot wide broad crested weir.(see ***Attachment A***) The graph of C vs. H and the corresponding equation fit in Excel are shown below.



For each wall segment the head H is found for water heights from elevation 1597.00 to 1599.00. At each elevation, a weir coefficient is estimated using the equation shown on the graph above. The flow over each wall segment is estimated for the range of water elevations. These flows are summed for all wall segments to find the flow overtopping the reservoir at each elevation. The calculations for wall segments 88 to 95 are given in ***Attachment E***.

2. Flow Projection

Wall segments 48, 72, and 95 have the lowest elevation of all wall segments. At these segments the horizontal distance the flow travels and the impact velocity of the flow will be calculated. The shape of the flow over the crest of the wall can be approximated using the equation below for flow over a sharp crested weir.

$$\frac{y}{H_o} = -K\left(\frac{x}{H_o}\right)^n$$

where
y = vertical distance (ft)
H_o = depth of flow above crest (ft)
x = horizontal projection of flow (ft)
K and n are constants from Merritt (1983) Figure 21 (***Attachment B***). To find K and n, h_a and h_o are required. Values for h_o and h_a are found using the equations below and an iterative process in Excel.
$h_o = H_o - h_a$ and

$$h_a = \frac{q^2}{2g(P+h_o)^2}$$

Now solving for x,

$$x = H_o\left(\frac{y}{H_o K}\right)^{1/n}$$

3. Impact Velocity

The impact velocity of the flow over the parapet wall can be approximated using conservation of energy

$$V^2 = 2gH$$

where
V = impact velocity (fps)
g = gravity (ft/sec^2)
H = wall height (ft) + H_o (ft)

4. Overtopping flow vs. time

Based on the report by Siemens (Reference 4), the reservoir elevation at the time of failure was 1597.63 and one pump was on giving a flow into the reservoir of approximately 2600 cfs. For this inflow, the relationship between reservoir elevation and time was found using HEC-HMS (Reference 5). HEC-HMS results are given in ***Attachment D***. The flow overtopping the wall at specific times was then found by matching the flow over the wall calculated at each reservoir elevation with the time corresponding to that reservoir elevation from HEC-HMS. A reservoir elevation of 1597.00 is taken as time 0. Using this data, it will take the upper reservoir approximately 10 minutes 20 seconds to reach elevation 1597.63. Table 1 below shows the relationship between flow over wall segment 95 and time for 0 to 34 minutes.

Table 1

Flow Over Wall Segment 95						
Time (min)	Reservoir Elevation	Flow Over Wall Segment 95 (cfs)	Cumulative Outflow Wall Segment 95 (cf)	Flow per Foot Wall Segment 95 (cfs)	Cumulative flow per foot Wall Segment 95 (cf/ft)	Water in dam for 80% infiltration
0	1597	0.00	0.00	0.00	0.00	0.00
1	1597.1	0.00	0.00	0.00	0.00	0.00
2	1597.1	0.00	0.00	0.00	0.00	0.00
3	1597.2	0.00	0.00	0.00	0.00	0.00
4	1597.3	1.80	108.00	0.03	1.80	1.44
5	1597.3	1.80	216.00	0.03	3.60	2.88
6	1597.4	9.30	774.00	0.16	12.90	10.32
7	1597.4	9.30	1332.00	0.16	22.20	17.76
8	1597.5	20.20	2544.00	0.34	42.40	33.92
9	1597.6	33.70	4566.00	0.56	76.10	60.88
10	1597.6	33.70	6588.00	0.56	109.80	87.84
11	1597.7	49.30	9546.00	0.82	159.10	127.28
12	1597.7	49.30	12504.00	0.82	208.40	166.72
13	1597.7	49.30	15462.00	0.82	257.70	206.16
14	1597.8	67.30	19500.00	1.12	325.00	260.00
15	1597.8	67.30	23538.00	1.12	392.30	313.84
16	1597.8	67.30	27576.00	1.12	459.60	367.68
17	1597.9	87.40	32820.00	1.46	547.00	437.60
18	1597.9	87.40	38064.00	1.46	634.40	507.52
19	1597.9	87.40	43308.00	1.46	721.80	577.44
20	1597.9	87.40	48552.00	1.46	809.20	647.36
21	1597.9	87.40	53796.00	1.46	896.60	717.28
22	1597.9	87.40	59040.00	1.46	984.00	787.20
23	1597.9	87.40	64284.00	1.46	1071.40	857.12
24	1597.9	87.40	69528.00	1.46	1158.80	927.04
25	1598	109.90	76122.00	1.83	1268.70	1014.96
26	1598	109.90	82716.00	1.83	1378.60	1102.88
27	1598	109.90	89310.00	1.83	1488.50	1190.80
28	1598	109.90	95904.00	1.83	1598.40	1278.72
29	1598	109.90	102498.00	1.83	1708.30	1366.64
30	1598	109.90	109092.00	1.83	1818.20	1454.56
31	1598	109.90	115686.00	1.83	1928.10	1542.48
32	1598	109.90	122280.00	1.83	2038.00	1630.40
33	1598	109.90	128874.00	1.83	2147.90	1718.32
34	1598	109.90	135468.00	1.83	2257.80	1806.24

G:\jdeible\06-3551 Taum Sauk\overtopping\flow.xls

Summary of Results:

Based on the estimated top of wall elevations and the estimated reservoir elevation at the time of failure of 1597.63 overtopping will occur in four areas. Wall segments overtopped at reservoir elevation 1597.63 and the overtopping flow for each area at elevation 1597.00 to 1599.00 are listed in Table 2. The lowest wall segment in each overtopped section is also listed; wall segment 95 is the lowest in the breached area.

Figure 1

Estimated Overflow at Time = 10 min 20 sec

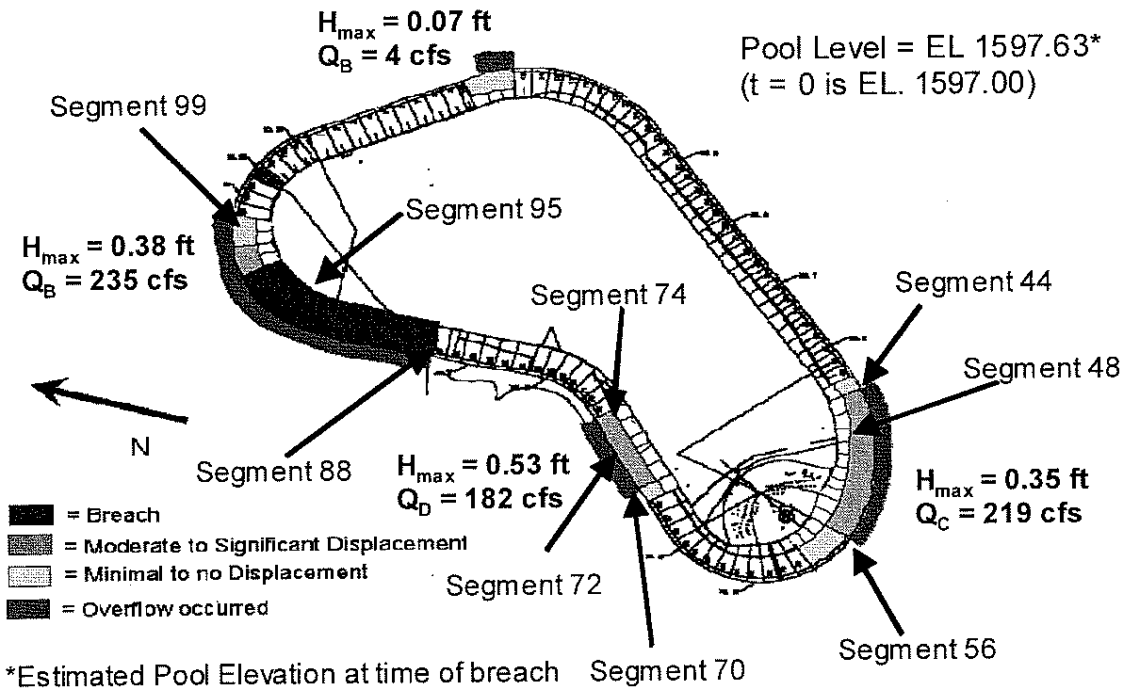


TABLE 2

TAUM SAUK UPPER RESERVOIR
ESTIMATED FLOW OVER WALL SEGMENTS

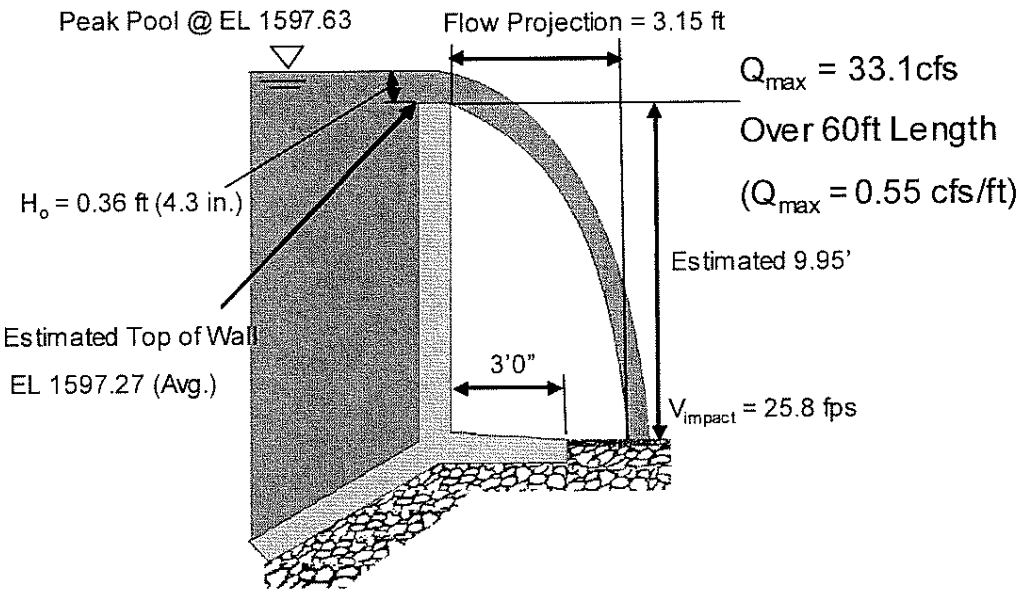
(segments grouped by pre-existing low sections)

GROUP	"A" (Breached)	"B"	"C"	"D"	ALL SEGMENTS	FLOW TO STORAGE
Lowest Wall Segment	Segment 95	Segment 12	Segment 49	Segment 72		
T.O.W.(EL)	1597.25	1597.56	1597.28	1597.1		
Overtopped @EL 1579.63	Segments 89 - 99	Segments 11 - 12	Segments 44 - 53	Segments 70 - 74		
Pool Level (EL)	Q_A (cfs)	Q_B (cfs)	Q_C (cfs)	Q_D (cfs)	$Q_{OVERFLOW}$ (cfs)	$Q_{STORAGE}$ (cfs)
1597.00	-	-	-	-	-	
1597.10	-	-	-	-	-	
1597.20	-	-	-	10.70	10.70	2,589.30
1597.30	2.7	-	1.2	31.80	35.70	2,564.30
1597.40	33.5	-	23.9	64.60	122.00	2,478.00
1597.50	99.7	-	84.7	107.00	291.40	2,308.60
1597.60	198.1	1.40	183.1	162.60	545.20	2,054.80
1597.63	234.5	4.10	218.6	181.70	638.90	1,961.10
1597.70	333.1	15.60	314.3	230.10	893.10	1,706.90
1597.80	509.8	59.10	482.5	308.10	1,359.50	1,240.50
1597.90	730.2	159.90	690.5	397.50	1,978.10	621.90
1597.98	939.3	293.40	883.4	483.90	2,600.00	-
1598.00	1,002.8	339.00	940.9	509.70	2,792.40	-
1598.10	1,333.1	614.00	1,241.9	649.70	3,838.70	-
1598.20	1,724.4	987.50	1,599.8	815.90	5,127.60	-
1598.30	2,178.7	1,459.70	2,007.0	1,005.90	6,651.30	-
1598.40	2,701.3	2,016.50	2,460.8	1,215.00	8,393.60	-
1598.50	3,297.3	2,654.90	2,962.2	1,443.30	10,357.70	-
1598.60	3,954.9	3,372.60	3,508.2	1,687.80	12,523.50	-
1598.70	4,671.8	4,175.20	4,093.5	1,950.40	14,890.90	-
1598.80	5,442.6	5,059.40	4,717.7	2,227.00	17,446.70	-
1598.90	6,259.9	6,029.80	5,375.1	2,517.40	20,182.20	-
1599.00	7,121.5	7,082.00	6,060.4	2,823.00	23,086.90	-

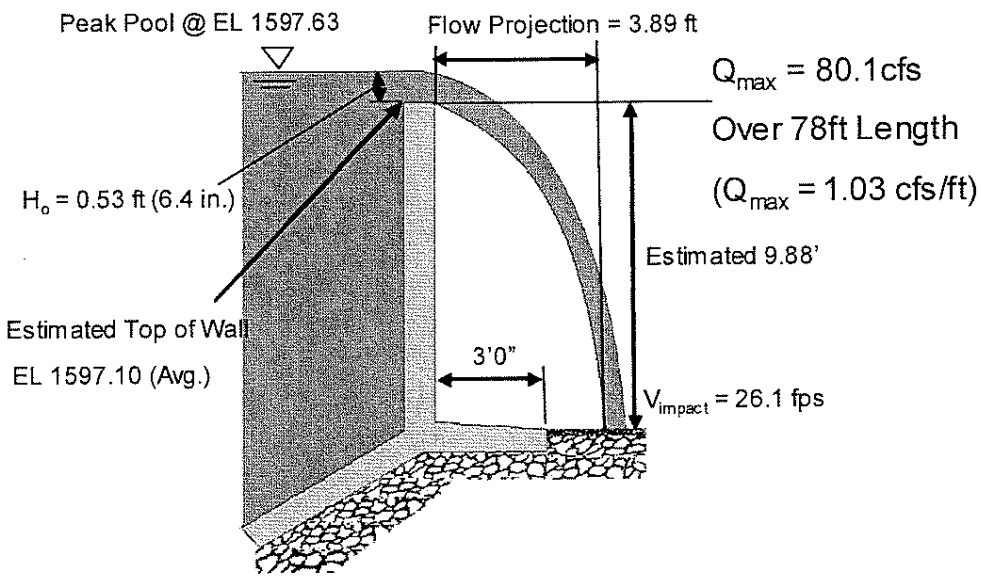
G:\paulm\06-3551 - Taum Sauk Dam\Taum Sauk - Reservoir Overflow 4 (REVISED jd 2-06).xls

The flow projection and impact velocity of overtopping flow for a reservoir elevation of 1597.63 at wall segments 48, 72 and 95 are shown in the figures below.

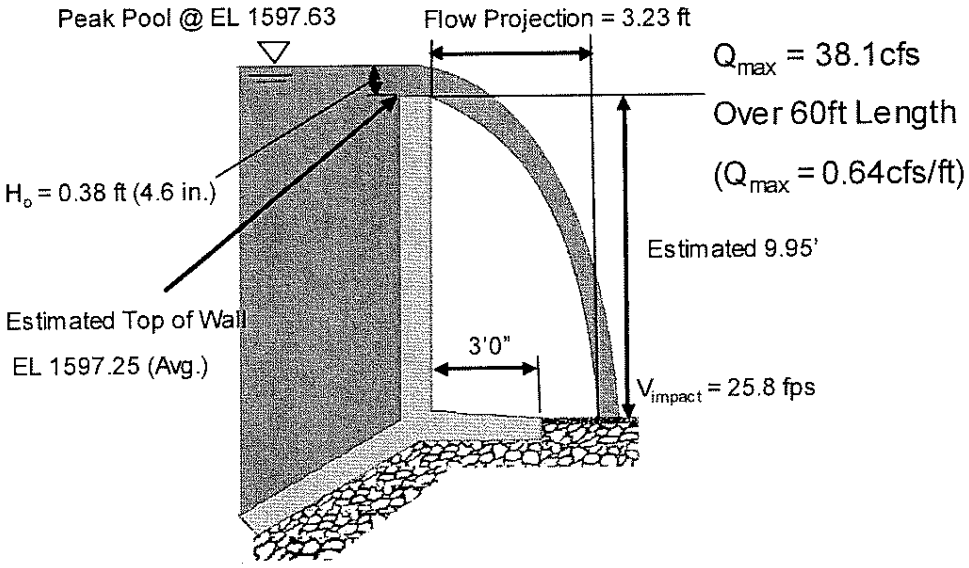
Wall Segment 48 at Time = 10 min 20 sec



Wall Segment 72 at Time = 10 min 20 sec



Wall Segment 95 at Time = 10 min 20 sec



Conclusions:

Overtopping would occur in four areas at a reservoir elevation of 1597.63. The greatest total flow would occur in the area of the breach. At the lower wall segments, flow overtopping the wall extends past the toe of the concrete parapet wall and strikes the crest of the rockfill berm which could cause undermining.

ATTACHMENTS

Attachment A

Weir Coefficients

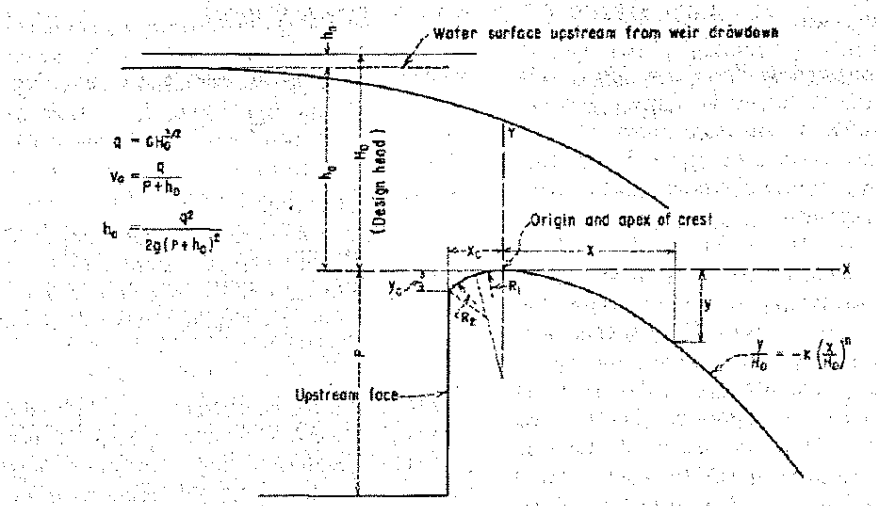
TABLE 21-15 Values of C in $Q = CLH^{3/2}$ for Broad-Crested Weirs

Measured head H, ft	Breadth of crest of weir, ft										
	0.50	0.75	1.00	1.50	2.00	2.50	3.00	4.00	5.00	10.00	15.00
0.2	2.80	2.75	2.69	2.62	2.54	2.48	2.44	2.38	2.34	2.49	2.68
0.4	2.92	2.80	2.72	2.64	2.61	2.60	2.58	2.54	2.50	2.56	2.70
0.6	3.08	2.89	2.75	2.64	2.61	2.60	2.68	2.69	2.70	2.70	2.70
0.8	3.30	3.04	2.85	2.68	2.60	2.60	2.67	2.68	2.68	2.69	2.64
1.0	3.32	3.14	2.98	2.75	2.66	2.64	2.65	2.67	2.68	2.68	2.63
1.2	3.32	3.20	3.08	2.86	2.70	2.65	2.64	2.67	2.66	2.69	2.64
1.4	3.32	3.26	3.20	2.92	2.77	2.68	2.64	2.65	2.65	2.67	2.64
1.6	3.32	3.29	3.28	3.07	2.89	2.75	2.68	2.66	2.65	2.64	2.63
1.8	3.32	3.32	3.31	3.07	2.88	2.74	2.68	2.66	2.65	2.34	2.63
2.0	3.32	3.31	3.30	3.03	2.85	2.76	2.72	2.68	2.65	2.64	2.63
2.5	3.32	3.32	3.31	3.28	3.07	2.89	2.81	2.72	2.67	2.64	2.63
3.0	3.32	3.32	3.32	3.32	3.20	3.05	2.92	2.73	2.66	2.64	2.63
3.5	3.32	3.32	3.32	3.32	3.32	3.19	2.97	2.76	2.68	2.64	2.63
4.0	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.70	2.64	2.63
4.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	1.88	2.74	2.64	2.63
5.0	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.64	2.63
5.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.64	2.63

Reference 2

Attachment B

Nappe Flow Projection from Parapet Wall



(A) ELEMENTS OF NAPPE-SHAPED CREST PROFILES

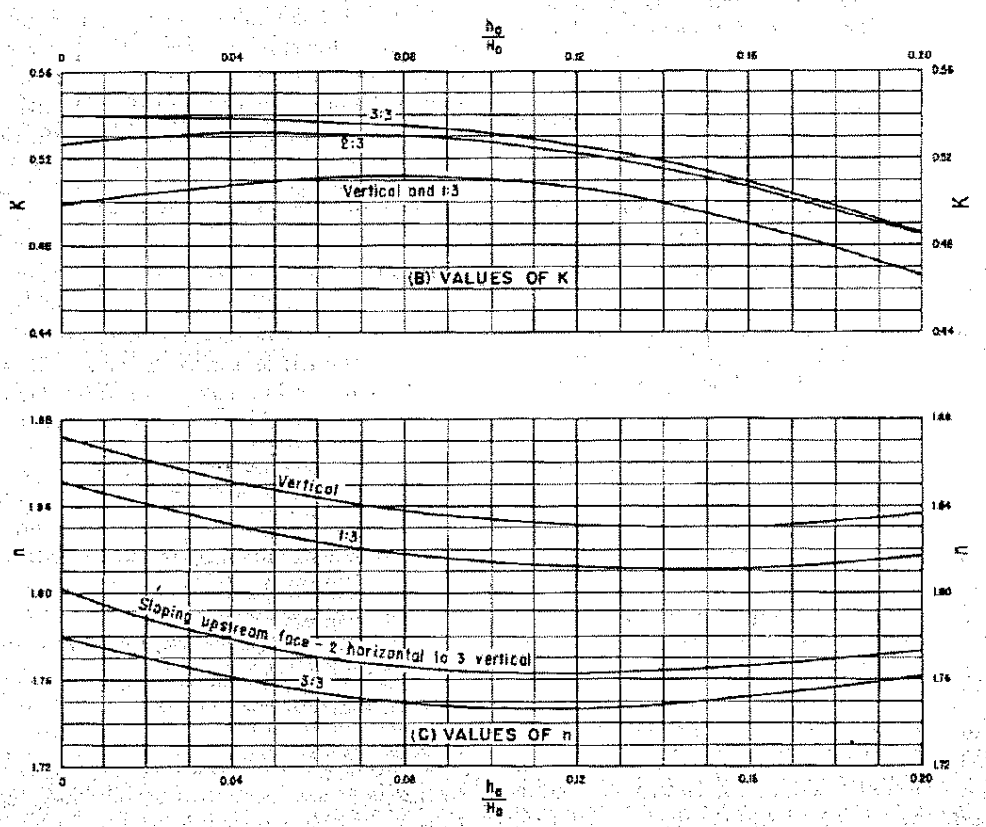


Figure 9-21.—Factors for definition of nappe-shaped crest profiles. 288-D-2406. (Sheet 1 of 2).

Reference 3

Attachment C

Estimation of Top of Wall Elevations in Breached Section

Estimation of Top of Wall Elevations

Monument Number	11/19/2003 Elevation	12/20/2005 Elevation	Change in Elevation	Wall Panel Number	12/20/2005 EL. T/Wall	Wall Height	Estimated Wall Height	Estimated Settlement	Estimated EL. T/Wall
1	1588.010	1587.950	-0.060	5	1597.770	9.820			
2	1587.920	1587.840	-0.080	10	1597.650	9.810			
3	1587.980	1587.910	-0.070	15	1597.740	9.830			
4	1588.090	1588.040	-0.050	20	1597.890	9.850			
5	1588.250	1588.200	-0.050	25	1598.080	9.880			
6	1588.410	1588.370	-0.040	30	1598.250	9.880			
7	1588.650	1588.570	-0.080	35	1598.430	9.860			
8	1588.220	1588.150	-0.070	40	1598.200	10.050			
9	1587.500	1587.430	-0.070	45	1597.380	9.950			
9A	1587.380			49	1597.280				
10	1587.360	1587.300	-0.060	50	1597.370	10.070			
11	1587.790	1587.730	-0.060	55	1597.750	10.020			
12	1588.330	1588.250	-0.080	60	1598.230	9.980			
13	1588.120	1588.090	-0.030	65	1598.130	10.040			
14	1587.680	1587.620	-0.060	70	1597.500	9.880			
15	1588.110			75	1597.920		9.951	-0.090	1597.971
16	1588.550			80			9.951	-0.090	1598.411
17	1588.330			85			9.951	-0.090	1598.191
18	1587.490			90			9.951	-0.090	1597.351
19	1587.390			95			9.951	-0.090	1597.251
20	1587.700	1587.630	-0.070	100	1597.690	10.060			
21	1588.090	1588.030	-0.060	105	1598.200	10.170			
22	1588.310	1588.220	-0.090	107	1598.220	10.000			
23	1588.150	1588.070	-0.080	110	1598.030	9.960			

Attachment D

HEC-HMS Results

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 17 of 39
Chkd. By: FM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

HMS * Summary of Results for Reservoir-1

Project : Taum Sauk Run Name : Run 2

Start of Run : 14Dec05 0000 Basin Model : Upper Res-2
End of Run : 14Dec05 0500 Met. Model : Met 1
Execution Time : 25Feb06 1648 Control Specs : Control 1

Date	Time	Reservoir Storage (ac-ft)	Reservoir Elevation (ft)	Inflow (cfs)	Outflow (cfs)
13 Dec 05	2400	0.000	1597.0 0	2600.0	0.0
14 Dec 05	0001	3.581	1597.1 0	2600.0	0.0
14 Dec 05	0002	7.160	1597.1	2600.0	3.1
14 Dec 05	0003	10.733	1597.2 0	2600.0	10.0
14 Dec 05	0004	14.290	1597.3 1.8	2600.0	25.1
14 Dec 05	0005	17.817	1597.3 4.23	2600.0	53.8
14 Dec 05	0006	21.287	1597.4	2600.0	107.8
14 Dec 05	0007	24.658	1597.4 9.3	2600.0	197.0
14 Dec 05	0008	27.898	1597.5 20.2	2600.0	298.2
14 Dec 05	0009	30.972	1597.6	2600.0	438.8
14 Dec 05	0010	33.854	1597.6 33.7	2600.0	576.4
14 Dec 05	0011	36.528	1597.7 46.3	2600.0	741.2
14 Dec 05	0012	38.976	1597.7	2600.0	903.9
14 Dec 05	0013	41.185	1597.7	2600.0	1089.3
14 Dec 05	0014	43.152	1597.8	2600.0	1254.5
14 Dec 05	0015	44.895	1597.8 67.3	2600.0	1414.4
14 Dec 05	0016	46.412	1597.8	2600.0	1583.5
14 Dec 05	0017	47.712	1597.9	2600.0	1728.4
14 Dec 05	0018	48.827	1597.9	2600.0	1852.7
14 Dec 05	0019	49.783	1597.9	2600.0	1959.3
14 Dec 05	0020	50.591	1597.9	2600.0	2067.7
14 Dec 05	0021	51.259	1597.9	2600.0	2161.4
14 Dec 05	0022	51.810	1597.9	2600.0	2238.6
14 Dec 05	0023	52.264	1597.9 87.9	2600.0	2302.2
14 Dec 05	0024	52.638	1597.9	2600.0	2354.7
14 Dec 05	0025	52.946	1598.0	2600.0	2397.8
14 Dec 05	0026	53.200	1598.0	2600.0	2433.4
14 Dec 05	0027	53.410	1598.0 109.9	2600.0	2462.8
14 Dec 05	0028	53.582	1598.0	2600.0	2486.9
14 Dec 05	0029	53.724	1598.0	2600.0	2506.8
14 Dec 05	0030	53.841	1598.0	2600.0	2523.2
14 Dec 05	0031	53.938	1598.0	2600.0	2536.7
14 Dec 05	0032	54.017	1598.0	2600.0	2547.9
14 Dec 05	0033	54.082	1598.0	2600.0	2557.1
14 Dec 05	0034	54.136	1598.0	2600.0	2564.6
14 Dec 05	0035	54.181	1598.0	2600.0	2570.8
14 Dec 05	0036	54.218	1598.0	2600.0	2576.0
14 Dec 05	0037	54.248	1598.0	2600.0	2580.2
14 Dec 05	0038	54.273	1598.0	2600.0	2583.7
14 Dec 05	0039	54.293	1598.0	2600.0	2586.6
14 Dec 05	0040	54.310	1598.0	2600.0	2588.9

Date	Time	Reservoir Storage (ac-ft)	Reservoir Elevation (ft)	Inflow (cfs)	Outflow (cfs)
14 Dec 05	0041	54.324	1598.0	2600.0	2590.9
14 Dec 05	0042	54.335	1598.0	2600.0	2592.5
14 Dec 05	0043	54.345	1598.0	2600.0	2593.8
14 Dec 05	0044	54.353	1598.0	2600.0	2594.9
14 Dec 05	0045	54.359	1598.0	2600.0	2595.8
14 Dec 05	0046	54.364	1598.0	2600.0	2596.5
14 Dec 05	0047	54.369	1598.0	2600.0	2597.1
14 Dec 05	0048	54.372	1598.0	2600.0	2597.6
14 Dec 05	0049	54.375	1598.0	2600.0	2598.1
14 Dec 05	0050	54.378	1598.0	2600.0	2598.4
14 Dec 05	0051	54.380	1598.0	2600.0	2598.7
14 Dec 05	0052	54.381	1598.0	2600.0	2598.9
14 Dec 05	0053	54.383	1598.0	2600.0	2599.1
14 Dec 05	0054	54.384	1598.0	2600.0	2599.3
14 Dec 05	0055	54.385	1598.0	2600.0	2599.4
14 Dec 05	0056	54.385	1598.0	2600.0	2599.5
14 Dec 05	0057	54.386	1598.0	2600.0	2599.6
14 Dec 05	0058	54.386	1598.0	2600.0	2599.7
14 Dec 05	0059	54.387	1598.0	2600.0	2599.7
14 Dec 05	0100	54.387	1598.0	2600.0	2599.8
14 Dec 05	0101	54.388	1598.0	2600.0	2599.8
14 Dec 05	0102	54.388	1598.0	2600.0	2599.8
14 Dec 05	0103	54.388	1598.0	2600.0	2599.9
14 Dec 05	0104	54.388	1598.0	2600.0	2599.9
14 Dec 05	0105	54.388	1598.0	2600.0	2599.9
14 Dec 05	0106	54.388	1598.0	2600.0	2599.9
14 Dec 05	0107	54.388	1598.0	2600.0	2599.9
14 Dec 05	0108	54.389	1598.0	2600.0	2600.0
14 Dec 05	0109	54.389	1598.0	2600.0	2600.0
14 Dec 05	0110	54.389	1598.0	2600.0	2600.0
14 Dec 05	0111	54.389	1598.0	2600.0	2600.0
14 Dec 05	0112	54.389	1598.0	2600.0	2600.0
14 Dec 05	0113	54.389	1598.0	2600.0	2600.0
14 Dec 05	0114	54.389	1598.0	2600.0	2600.0
14 Dec 05	0115	54.389	1598.0	2600.0	2600.0
14 Dec 05	0116	54.389	1598.0	2600.0	2600.0
14 Dec 05	0117	54.389	1598.0	2600.0	2600.0
14 Dec 05	0118	54.389	1598.0	2600.0	2600.0
14 Dec 05	0119	54.389	1598.0	2600.0	2600.0
14 Dec 05	0120	54.389	1598.0	2600.0	2600.0
14 Dec 05	0121	54.389	1598.0	2600.0	2600.0
14 Dec 05	0122	54.389	1598.0	2600.0	2600.0
14 Dec 05	0123	54.389	1598.0	2600.0	2600.0
14 Dec 05	0124	54.389	1598.0	2600.0	2600.0
14 Dec 05	0125	54.389	1598.0	2600.0	2600.0
14 Dec 05	0126	54.389	1598.0	2600.0	2600.0
14 Dec 05	0127	54.389	1598.0	2600.0	2600.0
14 Dec 05	0128	54.389	1598.0	2600.0	2600.0
14 Dec 05	0129	54.389	1598.0	2600.0	2600.0
14 Dec 05	0130	54.389	1598.0	2600.0	2600.0
14 Dec 05	0131	54.389	1598.0	2600.0	2600.0

Attachment E

Parapet Wall Overflow Calculations

(G:\paulm\06-3551 – Taum Sauk Dam\Taum Sauk Reservoir Overflow 4 (REVISED jd 2-06).xls)

Paul C. Rizzo Associates, Inc.
CONSULTANTS

(20)

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 20 of 39
Chkd. By: JPM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

Panel	1			2			3			4			5			6		
Data	T.O.W.(EL) = 1598.00 L (ft) = 75			T.O.W.(EL) = 1597.98 L (ft) = 60			T.O.W.(EL) = 1597.90 L (ft) = 60			T.O.W.(EL) = 1597.83 L (ft) = 60			T.O.W.(EL) = 1597.77 L (ft) = 60			T.O.W.(EL) = 1597.79 L (ft) = 60		
Pool Level (EL)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
1597.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1597.80	-	-	-	-	-	-	-	-	-	-	-	-	0.03	2.66	**0.8**	0.01	2.65	**0.2**
1597.90	-	-	-	-	-	-	-	-	-	0.07	2.67	**3.0**	0.13	2.68	**7.5**	0.11	2.68	**5.9**
1597.98	-	-	-	-	-	-	0.08	2.67	**3.5**	0.15	2.68	**9.2**	0.21	2.69	**15.4**	0.19	2.69	**13.2**
1598.00	-	-	-	0.02	2.65	**0.4**	0.10	2.68	**5.1**	0.17	2.69	**11.3**	0.23	2.69	**17.8**	0.21	2.69	**15.5**
1598.10	0.10	2.68	**6.4**	0.12	2.68	**6.7**	0.20	2.69	**14.4**	0.27	2.70	**22.7**	0.33	2.70	**30.7**	0.31	2.70	**28.0**
1598.20	0.20	2.69	**18.0**	0.22	2.69	**16.7**	0.30	2.70	**26.6**	0.37	2.71	**36.6**	0.43	2.72	**46.0**	0.41	2.72	**42.8**
1598.30	0.30	2.70	**33.3**	0.32	2.70	**29.3**	0.40	2.71	**41.1**	0.47	2.73	**52.8**	0.53	2.74	**63.4**	0.51	2.73	**59.7**
1598.40	0.40	2.71	**51.4**	0.42	2.72	**44.4**	0.50	2.73	**57.9**	0.57	2.75	**71.0**	0.63	2.77	**83.1**	0.61	2.76	**78.9**
1598.50	0.50	2.73	**72.4**	0.52	2.74	**61.6**	0.60	2.76	**77.0**	0.67	2.79	**91.8**	0.73	2.81	**105.2**	0.71	2.80	**100.5**
1598.60	0.60	2.76	**96.2**	0.62	2.77	**81.1**	0.70	2.80	**98.4**	0.77	2.83	**114.7**	0.83	2.86	**129.8**	0.81	2.85	**124.7**
1598.70	0.70	2.80	**123.0**	0.72	2.81	**103.0**	0.80	2.85	**122.4**	0.87	2.89	**140.7**	0.93	2.92	**157.1**	0.91	2.91	**151.6**
1598.80	0.80	2.85	**152.9**	0.82	2.86	**127.4**	0.90	2.90	**148.6**	0.97	2.95	**169.1**	1.03	2.99	**187.5**	1.01	2.97	**180.9**
1598.90	0.90	2.90	**185.7**	0.92	2.92	**154.6**	1.00	2.97	**178.2**	1.07	3.01	**199.9**	1.13	3.05	**219.8**	1.11	3.04	**213.3**
1599.00	1.00	2.97	**222.7**	1.02	2.98	**184.2**	1.10	3.03	**209.7**	1.17	3.07	**233.1**	1.23	3.11	**254.5**	1.21	3.10	**247.6**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

(21)

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 21 of 39
Chkd. By: [illegible] Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

7			8			9			11A			10			11		
T.O.W.(EL) =		1597.91	T.O.W.(EL) =		1597.75	T.O.W.(EL) =		1597.73	T.O.W.(EL) =		1597.72	T.O.W.(EL) =		1597.65	T.O.W.(EL) =		1597.59
L (ft) =		60	L (ft) =		60	L (ft) =		58	L (ft) =		29	L (ft) =		61	L (ft) =		58
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	2.65	**0.2**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	2.66	**1.2**
-	-	-	-	-	-	-	-	-	-	-	-	0.05	2.66	**1.8**	0.11	2.68	**5.7**
-	-	-	0.05	2.66	**1.8**	0.07	2.67	**2.9**	0.08	2.67	**1.8**	0.15	2.68	**9.5**	0.21	2.69	**15.0**
-	-	-	0.15	2.68	**9.3**	0.17	2.69	**10.9**	0.18	2.69	**6.0**	0.25	2.70	**20.6**	0.31	2.70	**27.0**
0.07	2.67	**2.9**	0.23	2.69	**17.6**	0.25	2.70	**19.4**	0.26	2.70	**10.3**	0.33	2.70	**31.0**	0.39	2.71	**38.1**
0.09	2.67	**4.3**	0.25	2.70	**20.2**	0.27	2.70	**22.0**	0.28	2.70	**11.6**	0.35	2.71	**34.2**	0.41	2.72	**41.4**
0.19	2.69	**13.4**	0.35	2.71	**33.7**	0.37	2.71	**35.4**	0.38	2.71	**18.4**	0.45	2.72	**50.1**	0.51	2.73	**57.7**
0.29	2.70	**25.3**	0.45	2.72	**49.3**	0.47	2.73	**51.0**	0.48	2.73	**26.3**	0.55	2.75	**68.4**	0.61	2.76	**76.3**
0.39	2.71	**39.6**	0.55	2.75	**67.3**	0.57	2.75	**68.6**	0.58	2.75	**35.2**	0.65	2.78	**88.9**	0.71	2.80	**97.2**
0.49	2.73	**56.2**	0.65	2.78	**87.4**	0.67	2.79	**88.7**	0.68	2.79	**45.4**	0.75	2.82	**111.7**	0.81	2.85	**120.5**
0.59	2.76	**75.0**	0.75	2.82	**109.9**	0.77	2.83	**110.9**	0.78	2.84	**56.7**	0.85	2.88	**137.7**	0.91	2.91	**146.5**
0.69	2.80	**96.3**	0.85	2.88	**135.4**	0.87	2.89	**136.0**	0.88	2.89	**69.2**	0.95	2.94	**166.1**	1.01	2.97	**174.9**
0.79	2.84	**119.6**	0.95	2.94	**163.3**	0.97	2.95	**163.5**	0.98	2.95	**83.0**	1.05	3.00	**196.9**	1.11	3.04	**206.2**
0.89	2.90	**146.1**	1.05	3.00	**193.7**	1.07	3.01	**193.2**	1.08	3.02	**98.3**	1.15	3.06	**230.2**	1.21	3.10	**239.3**
0.99	2.96	**174.9**	1.15	3.06	**226.4**	1.17	3.07	**225.3**	1.18	3.08	**114.5**	1.25	3.12	**266.0**	1.31	3.16	**274.8**
1.09	3.02	**206.2**	1.25	3.12	**261.6**	1.27	3.13	**259.8**	1.28	3.14	**131.9**	1.35	3.18	**304.3**	1.41	3.21	**311.7**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 22 of 39
Chkd. By: JPM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

12			13			14			15			16			17		
T.O.W.(EL) =		1597.56	T.O.W.(EL) =		1597.73	T.O.W.(EL) =		1597.72	T.O.W.(EL) =		1597.74	T.O.W.(EL) =		1597.80	T.O.W.(EL) =		1597.90
L (ft) =		58	L (ft) =		65	L (ft) =		58	L (ft) =		50	L (ft) =		58	L (ft) =		54
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.04	2.66	**1.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.07	2.67	**2.9**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.14	2.68	**8.1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.24	2.70	**18.4**	0.07	2.67	**3.2**	0.08	2.67	**3.5**	0.06	2.67	**2.0**	-	-	-	-	-	-
0.34	2.71	**31.2**	0.17	2.69	**12.3**	0.18	2.69	**11.9**	0.16	2.69	**8.6**	0.10	2.68	**4.9**	-	-	-
0.42	2.72	**42.7**	0.25	2.70	**21.8**	0.26	2.70	**20.6**	0.24	2.70	**15.7**	0.18	2.69	**11.8**	0.08	2.67	**3.2**
0.44	2.72	**46.0**	0.27	2.70	**24.6**	0.28	2.70	**23.2**	0.26	2.70	**17.9**	0.20	2.69	**14.0**	0.10	2.68	**4.6**
0.54	2.74	**63.1**	0.37	2.71	**39.6**	0.38	2.71	**36.8**	0.36	2.71	**29.3**	0.30	2.70	**25.7**	0.20	2.69	**13.0**
0.64	2.77	**82.3**	0.47	2.73	**57.2**	0.48	2.73	**52.7**	0.46	2.72	**42.4**	0.40	2.71	**39.8**	0.30	2.70	**24.0**
0.74	2.82	**104.1**	0.57	2.75	**76.9**	0.58	2.75	**70.5**	0.56	2.75	**57.6**	0.50	2.73	**56.0**	0.40	2.71	**37.0**
0.84	2.87	**128.2**	0.67	2.79	**99.5**	0.68	2.79	**90.7**	0.66	2.78	**74.5**	0.60	2.76	**74.4**	0.50	2.73	**52.1**
0.94	2.93	**154.9**	0.77	2.83	**124.3**	0.78	2.84	**113.5**	0.76	2.83	**93.8**	0.70	2.80	**95.1**	0.60	2.76	**69.3**
1.04	2.99	**183.9**	0.87	2.89	**152.4**	0.88	2.89	**138.4**	0.86	2.88	**114.8**	0.80	2.85	**118.3**	0.70	2.80	**88.6**
1.14	3.06	**216.0**	0.97	2.95	**183.2**	0.98	2.95	**166.0**	0.96	2.94	**138.3**	0.90	2.90	**143.6**	0.80	2.85	**110.1**
1.24	3.12	**249.9**	1.07	3.01	**216.5**	1.08	3.02	**196.6**	1.06	3.00	**163.7**	1.00	2.97	**172.3**	0.90	2.90	**133.7**
1.34	3.17	**285.2**	1.17	3.07	**252.5**	1.18	3.08	**229.0**	1.16	3.07	**191.8**	1.10	3.03	**202.7**	1.00	2.97	**160.4**
1.44	3.22	**322.7**	1.27	3.13	**291.2**	1.28	3.14	**263.7**	1.26	3.13	**221.3**	1.20	3.09	**235.6**	1.10	3.03	**188.8**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 23 of 39
Chkd. By: [illegible] Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

18			19			20			21			22			23		
T.O.W.(EL) =		1597.88	T.O.W.(EL) =		1597.90	T.O.W.(EL) =		1597.89	T.O.W.(EL) =		1597.89	T.O.W.(EL) =		1597.96	T.O.W.(EL) =		1597.96
L (ft) =		56	L (ft) =		58	L (ft) =		58	L (ft) =		58	L (ft) =		58	L (ft) =		58
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.02	2.65	**0.4**	-	-	-	0.01	2.65	**0.2**	0.01	2.65	**0.2**	-	-	-	-	-	-
0.10	2.68	**4.6**	0.08	2.67	**3.4**	0.09	2.67	**4.1**	0.09	2.67	**4.1**	0.02	2.65	**0.4**	0.02	2.65	**0.4**
0.12	2.68	**6.2**	0.10	2.68	**4.9**	0.11	2.68	**5.7**	0.11	2.68	**5.7**	0.04	2.66	**1.2**	0.04	2.66	**1.2**
0.22	2.69	**15.5**	0.20	2.69	**14.0**	0.21	2.69	**15.0**	0.21	2.69	**15.0**	0.14	2.68	**8.1**	0.14	2.68	**8.1**
0.32	2.70	**27.4**	0.30	2.70	**25.7**	0.31	2.70	**27.0**	0.31	2.70	**27.0**	0.24	2.70	**18.4**	0.24	2.70	**18.4**
0.42	2.72	**41.5**	0.40	2.71	**39.8**	0.41	2.72	**41.4**	0.41	2.72	**41.4**	0.34	2.71	**31.2**	0.34	2.71	**31.2**
0.52	2.74	**57.5**	0.50	2.73	**56.0**	0.51	2.73	**57.7**	0.51	2.73	**57.7**	0.44	2.72	**46.0**	0.44	2.72	**46.0**
0.62	2.77	**75.7**	0.60	2.76	**74.4**	0.61	2.76	**76.3**	0.61	2.76	**76.3**	0.54	2.74	**63.1**	0.54	2.74	**63.1**
0.72	2.81	**96.1**	0.70	2.80	**95.1**	0.71	2.80	**97.2**	0.71	2.80	**97.2**	0.64	2.77	**82.3**	0.64	2.77	**82.3**
0.82	2.86	**118.9**	0.80	2.85	**118.3**	0.81	2.85	**120.5**	0.81	2.85	**120.5**	0.74	2.82	**104.1**	0.74	2.82	**104.1**
0.92	2.92	**144.3**	0.90	2.90	**143.6**	0.91	2.91	**146.5**	0.91	2.91	**146.5**	0.84	2.87	**128.2**	0.84	2.87	**128.2**
1.02	2.98	**171.9**	1.00	2.97	**172.3**	1.01	2.97	**174.9**	1.01	2.97	**174.9**	0.94	2.93	**154.9**	0.94	2.93	**154.9**
1.12	3.04	**201.8**	1.10	3.03	**202.7**	1.11	3.04	**206.2**	1.11	3.04	**206.2**	1.04	2.99	**183.9**	1.04	2.99	**183.9**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 24 of 39
Chkd. By: TM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

24			25			26			27			28			29		
T.O.W.(EL) =		1598.03	T.O.W.(EL) =		1598.08	T.O.W.(EL) =		1598.15	T.O.W.(EL) =		1598.14	T.O.W.(EL) =		1598.16	T.O.W.(EL) =		1598.18
L (ft) =		67	L (ft) =		66	L (ft) =		58	L (ft) =		59	L (ft) =		59	L (ft) =		58
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.07	2.67	**3.3**	0.02	2.65	**0.5**	-	-	-	-	-	-	-	-	-	-	-	-
0.17	2.69	**12.6**	0.12	2.68	**7.4**	0.05	2.66	**1.7**	0.06	2.67	**2.3**	0.04	2.66	**1.3**	0.02	2.65	**0.4**
0.27	2.70	**25.4**	0.22	2.69	**18.3**	0.15	2.68	**9.0**	0.16	2.69	**10.2**	0.14	2.68	**8.3**	0.12	2.68	**6.5**
0.37	2.71	**40.9**	0.32	2.70	**32.3**	0.25	2.70	**19.6**	0.26	2.70	**21.1**	0.24	2.70	**18.7**	0.22	2.69	**16.1**
0.47	2.73	**58.9**	0.42	2.72	**48.9**	0.35	2.71	**32.5**	0.36	2.71	**34.5**	0.34	2.71	**31.7**	0.32	2.70	**28.3**
0.57	2.75	**79.3**	0.52	2.74	**67.8**	0.45	2.72	**47.6**	0.46	2.72	**50.1**	0.44	2.72	**46.8**	0.42	2.72	**42.9**
0.67	2.79	**102.5**	0.62	2.77	**89.3**	0.55	2.75	**65.1**	0.56	2.75	**68.0**	0.54	2.74	**64.1**	0.52	2.74	**59.6**
0.77	2.83	**128.1**	0.72	2.81	**113.3**	0.65	2.78	**84.5**	0.66	2.78	**87.9**	0.64	2.77	**83.7**	0.62	2.77	**78.4**
0.87	2.89	**157.1**	0.82	2.86	**140.2**	0.75	2.82	**106.2**	0.76	2.83	**110.6**	0.74	2.82	**105.9**	0.72	2.81	**99.6**
0.97	2.95	**188.8**	0.92	2.92	**170.1**	0.85	2.88	**130.9**	0.86	2.88	**135.5**	0.84	2.87	**130.4**	0.82	2.86	**123.2**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 25 of 39
Chkd. By: PM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

30			31			32			33			34			35		
T.O.W.(EL) =		1598.25	T.O.W.(EL) =		1598.28	T.O.W.(EL) =		1598.35	T.O.W.(EL) =		1598.29	T.O.W.(EL) =		1598.28	T.O.W.(EL) =		1598.43
L (ft) =		60	L (ft) =		60	L (ft) =		68	L (ft) =		59	L (ft) =		58	L (ft) =		60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	2.66	**1.8**	0.02	2.65	**0.4**	-	-	-	0.01	2.65	**0.2**	0.02	2.65	**0.4**	-	-	-
0.15	2.68	**9.3**	0.12	2.68	**6.7**	0.05	2.66	**2.0**	0.11	2.68	**5.8**	0.12	2.68	**6.5**	-	-	-
0.25	2.70	**20.2**	0.22	2.69	**16.7**	0.15	2.68	**10.6**	0.21	2.69	**15.3**	0.22	2.69	**16.1**	0.07	2.67	**3.0**
0.35	2.71	**33.7**	0.32	2.70	**29.3**	0.25	2.70	**22.9**	0.31	2.70	**27.5**	0.32	2.70	**28.3**	0.17	2.69	**11.3**
0.45	2.72	**49.3**	0.42	2.72	**44.4**	0.35	2.71	**38.2**	0.41	2.72	**42.1**	0.42	2.72	**42.9**	0.27	2.70	**22.7**
0.55	2.75	**67.3**	0.52	2.74	**61.6**	0.45	2.72	**55.8**	0.51	2.73	**58.7**	0.52	2.74	**59.6**	0.37	2.71	**36.6**
0.65	2.78	**87.4**	0.62	2.77	**81.1**	0.55	2.75	**76.3**	0.61	2.76	**77.6**	0.62	2.77	**78.4**	0.47	2.73	**52.8**
0.75	2.82	**109.9**	0.72	2.81	**103.0**	0.65	2.78	**99.1**	0.71	2.80	**98.8**	0.72	2.81	**99.6**	0.57	2.75	**71.0**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 26 of 39
Chkd. By: SM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

36			37			38			39			40			41		
T.O.W.(EL) =		1598.61	T.O.W.(EL) =		1598.51	T.O.W.(EL) =		1598.44	T.O.W.(EL) =		1598.36	T.O.W.(EL) =		1598.20	T.O.W.(EL) =		1598.03
L (ft) =		59	L (ft) =		59	L (ft) =		58	L (ft) =		60	L (ft) =		60	L (ft) =		61
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	2.67	**3.0**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	2.69	**11.5**
-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.1**	0.27	2.70	**23.1**
-	-	-	-	-	-	-	-	-	0.04	2.66	**1.3**	0.20	2.69	**14.4**	0.37	2.71	**37.2**
-	-	-	-	-	-	0.06	2.67	**2.3**	0.14	2.68	**8.4**	0.30	2.70	**26.6**	0.47	2.73	**53.7**
-	-	-	0.09	2.67	**4.3**	0.16	2.69	**10.0**	0.24	2.70	**19.0**	0.40	2.71	**41.1**	0.57	2.75	**72.2**
0.09	2.67	**4.3**	0.19	2.69	**13.1**	0.26	2.70	**20.8**	0.34	2.71	**32.2**	0.50	2.73	**57.9**	0.67	2.79	**93.3**
0.19	2.69	**13.1**	0.29	2.70	**24.9**	0.36	2.71	**34.0**	0.44	2.72	**47.6**	0.60	2.76	**77.0**	0.77	2.83	**116.6**
0.29	2.70	**24.9**	0.39	2.71	**38.9**	0.46	2.72	**49.2**	0.54	2.74	**65.2**	0.70	2.80	**98.4**	0.87	2.89	**143.1**
0.39	2.71	**38.9**	0.49	2.73	**55.2**	0.56	2.75	**66.8**	0.64	2.77	**85.1**	0.80	2.85	**122.4**	0.97	2.95	**171.9**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 27 of 39
Chkd. By: JM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

42			43			44			45			46			47		
T.O.W.(EL) =		1597.82	T.O.W.(EL) =		1597.65	T.O.W.(EL) =		1597.50	T.O.W.(EL) =		1597.38	T.O.W.(EL) =		1597.31	T.O.W.(EL) =		1597.31
L (ft) =		60	L (ft) =		60	L (ft) =		60	L (ft) =		59	L (ft) =		60	L (ft) =		60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	0.02	2.65	**0.4**	0.09	2.67	**4.3**	0.09	2.67	**4.3**
-	-	-	-	-	-	-	-	-	0.12	2.68	**6.6**	0.19	2.69	**13.4**	0.19	2.69	**13.4**
-	-	-	-	-	-	0.10	2.68	**5.1**	0.22	2.69	**16.4**	0.29	2.70	**25.3**	0.29	2.70	**25.3**
-	-	-	-	-	-	0.13	2.68	**7.5**	0.25	2.70	**19.9**	0.32	2.70	**29.3**	0.32	2.70	**29.3**
-	-	-	0.05	2.66	**1.8**	0.20	2.69	**14.4**	0.32	2.70	**28.8**	0.39	2.71	**39.6**	0.39	2.71	**39.6**
-	-	-	0.15	2.68	**9.3**	0.30	2.70	**26.6**	0.42	2.72	**43.7**	0.49	2.73	**56.2**	0.49	2.73	**56.2**
0.08	2.67	**3.6**	0.25	2.70	**20.2**	0.40	2.71	**41.1**	0.52	2.74	**60.6**	0.59	2.76	**75.0**	0.59	2.76	**75.0**
0.16	2.69	**10.2**	0.33	2.70	**30.5**	0.48	2.73	**54.2**	0.60	2.76	**75.4**	0.67	2.79	**91.5**	0.67	2.79	**91.5**
0.18	2.69	**12.3**	0.35	2.71	**33.7**	0.50	2.73	**57.9**	0.62	2.77	**79.8**	0.69	2.80	**96.3**	0.69	2.80	**96.3**
0.28	2.70	**24.0**	0.45	2.72	**49.3**	0.60	2.76	**77.0**	0.72	2.81	**101.3**	0.79	2.84	**119.6**	0.79	2.84	**119.6**
0.38	2.71	**38.1**	0.55	2.75	**67.3**	0.70	2.80	**98.4**	0.82	2.86	**125.3**	0.89	2.90	**146.1**	0.89	2.90	**146.1**
0.48	2.73	**54.5**	0.65	2.78	**87.4**	0.80	2.85	**122.4**	0.92	2.92	**152.0**	0.99	2.96	**174.9**	0.99	2.96	**174.9**
0.58	2.75	**72.9**	0.75	2.82	**109.9**	0.90	2.90	**148.6**	1.02	2.98	**181.1**	1.09	3.02	**206.2**	1.09	3.02	**206.2**
0.68	2.79	**93.9**	0.85	2.88	**135.4**	1.00	2.97	**178.2**	1.12	3.04	**212.6**	1.19	3.09	**240.7**	1.19	3.09	**240.7**
0.78	2.84	**117.4**	0.95	2.94	**163.3**	1.10	3.03	**209.7**	1.22	3.11	**247.3**	1.29	3.15	**276.9**	1.29	3.15	**276.9**
0.88	2.89	**143.1**	1.05	3.00	**193.7**	1.20	3.09	**243.7**	1.32	3.16	**282.7**	1.39	3.20	**314.6**	1.39	3.20	**314.6**
0.98	2.95	**171.7**	1.15	3.06	**226.4**	1.30	3.15	**280.1**	1.42	3.21	**320.5**	1.49	3.24	**353.6**	1.49	3.24	**353.6**
1.08	3.02	**203.4**	1.25	3.12	**261.6**	1.40	3.20	**318.0**	1.52	3.25	**359.3**	1.59	3.27	**393.4**	1.59	3.27	**393.4**
1.18	3.08	**236.9**	1.35	3.18	**299.3**	1.50	3.24	**357.1**	1.62	3.27	**397.8**	1.69	3.29	**433.7**	1.69	3.29	**433.7**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 28 of 39
Chkd. By: [illegible] Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

48			49			50			51			52			53		
T.O.W.(EL) =		1597.27	T.O.W.(EL) =		1597.28	T.O.W.(EL) =		1597.37	T.O.W.(EL) =		1597.41	T.O.W.(EL) =		1597.49	T.O.W.(EL) =		1597.40
L (ft) =		60	L (ft) =		59	L (ft) =		60	L (ft) =		60	L (ft) =		60	L (ft) =		60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.03	2.66	**0.8**	0.02	2.65	**0.4**	-	-	-	-	-	-	-	-	-	-	-	-
0.13	2.68	**7.5**	0.12	2.68	**6.6**	0.03	2.66	**0.8**	-	-	-	-	-	-	-	-	-
0.23	2.69	**17.8**	0.22	2.69	**16.4**	0.13	2.68	**7.5**	0.09	2.67	**4.3**	0.01	2.65	**0.2**	0.10	2.68	**5.1**
0.33	2.70	**30.7**	0.32	2.70	**28.8**	0.23	2.69	**17.8**	0.19	2.69	**13.4**	0.11	2.68	**5.9**	0.20	2.69	**14.4**
0.36	2.71	**35.1**	0.35	2.71	**33.1**	0.26	2.70	**21.5**	0.22	2.69	**16.7**	0.14	2.68	**8.4**	0.23	2.69	**17.8**
0.43	2.72	**46.0**	0.42	2.72	**43.7**	0.33	2.70	**30.7**	0.29	2.70	**25.3**	0.21	2.69	**15.5**	0.30	2.70	**26.6**
0.53	2.74	**63.4**	0.52	2.74	**60.6**	0.43	2.72	**46.0**	0.39	2.71	**39.6**	0.31	2.70	**28.0**	0.40	2.71	**41.1**
0.63	2.77	**83.1**	0.62	2.77	**79.8**	0.53	2.74	**63.4**	0.49	2.73	**56.2**	0.41	2.72	**42.8**	0.50	2.73	**57.9**
0.71	2.80	**100.2**	0.70	2.80	**96.5**	0.61	2.76	**78.6**	0.57	2.75	**70.7**	0.49	2.73	**55.9**	0.58	2.75	**72.6**
0.73	2.81	**105.2**	0.72	2.81	**101.3**	0.63	2.77	**83.1**	0.59	2.76	**75.0**	0.51	2.73	**59.7**	0.60	2.76	**77.0**
0.83	2.86	**129.8**	0.82	2.86	**125.3**	0.73	2.81	**105.2**	0.69	2.80	**96.3**	0.61	2.76	**78.9**	0.70	2.80	**98.4**
0.93	2.92	**157.1**	0.92	2.92	**152.0**	0.83	2.86	**129.8**	0.79	2.84	**119.6**	0.71	2.80	**100.5**	0.80	2.85	**122.4**
1.03	2.99	**187.5**	1.02	2.98	**181.1**	0.93	2.92	**157.1**	0.89	2.90	**146.1**	0.81	2.85	**124.7**	0.90	2.90	**148.6**
1.13	3.05	**219.8**	1.12	3.04	**212.6**	1.03	2.99	**187.5**	0.99	2.96	**174.9**	0.91	2.91	**151.6**	1.00	2.97	**178.2**
1.23	3.11	**254.5**	1.22	3.11	**247.3**	1.13	3.05	**219.8**	1.09	3.02	**206.2**	1.01	2.97	**180.9**	1.10	3.03	**209.7**
1.33	3.17	**291.7**	1.32	3.16	**282.7**	1.23	3.11	**254.5**	1.19	3.09	**240.7**	1.11	3.04	**213.3**	1.20	3.09	**243.7**
1.43	3.21	**329.4**	1.42	3.21	**320.5**	1.33	3.17	**291.7**	1.29	3.15	**276.9**	1.21	3.10	**247.6**	1.30	3.15	**280.1**
1.53	3.25	**369.0**	1.52	3.25	**359.3**	1.43	3.21	**329.4**	1.39	3.20	**314.6**	1.31	3.16	**284.3**	1.40	3.20	**318.0**
1.63	3.28	**409.5**	1.62	3.27	**397.8**	1.53	3.25	**369.0**	1.49	3.24	**353.6**	1.41	3.21	**322.5**	1.50	3.24	**357.1**
1.73	3.29	**449.2**	1.72	3.29	**437.9**	1.63	3.28	**409.5**	1.59	3.27	**393.4**	1.51	3.25	**361.8**	1.60	3.27	**397.1**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 29 of 39
Chkd. By: [illegible] Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

54			55			56			57			58			59		
T.O.W.(EL) =		1597.64	T.O.W.(EL) =		1597.75	T.O.W.(EL) =		1597.85	T.O.W.(EL) =		1597.99	T.O.W.(EL) =		1598.00	T.O.W.(EL) =		1598.08
L (ft) =		58	L (ft) =		59	L (ft) =		59	L (ft) =		59	L (ft) =		68	L (ft) =		50
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.06	2.67	**2.3**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.16	2.69	**10.0**	0.05	2.66	**1.8**	-	-	-	-	-	-	-	-	-	-	-	-
0.26	2.70	**20.8**	0.15	2.68	**9.2**	0.05	2.66	**1.8**	-	-	-	-	-	-	-	-	-
0.34	2.71	**31.0**	0.23	2.69	**17.3**	0.13	2.68	**7.3**	-	-	-	-	-	-	-	-	-
0.36	2.71	**34.0**	0.25	2.70	**19.9**	0.15	2.68	**9.2**	0.01	2.65	**0.2**	-	-	-	-	-	-
0.46	2.72	**49.2**	0.35	2.71	**33.1**	0.25	2.70	**19.9**	0.11	2.68	**5.8**	0.10	2.68	**5.8**	0.02	2.65	**0.4**
0.56	2.75	**66.8**	0.45	2.72	**48.4**	0.35	2.71	**33.1**	0.21	2.69	**15.3**	0.20	2.69	**16.4**	0.12	2.68	**5.6**
0.66	2.78	**86.5**	0.55	2.75	**66.2**	0.45	2.72	**48.4**	0.31	2.70	**27.5**	0.30	2.70	**30.2**	0.22	2.69	**13.9**
0.76	2.83	**108.8**	0.65	2.78	**86.0**	0.55	2.75	**66.2**	0.41	2.72	**42.1**	0.40	2.71	**46.6**	0.32	2.70	**24.4**
0.86	2.88	**133.2**	0.75	2.82	**108.1**	0.65	2.78	**86.0**	0.51	2.73	**58.7**	0.50	2.73	**65.6**	0.42	2.72	**37.0**
0.96	2.94	**160.4**	0.85	2.88	**133.2**	0.75	2.82	**108.1**	0.61	2.76	**77.6**	0.60	2.76	**87.2**	0.52	2.74	**51.4**
1.06	3.00	**189.9**	0.95	2.94	**160.6**	0.85	2.88	**133.2**	0.71	2.80	**98.8**	0.70	2.80	**111.5**	0.62	2.77	**67.6**
1.16	3.07	**222.5**	1.05	3.00	**190.4**	0.95	2.94	**160.6**	0.81	2.85	**122.6**	0.80	2.85	**138.7**	0.72	2.81	**85.8**
1.26	3.13	**256.8**	1.15	3.06	**222.6**	1.05	3.00	**190.4**	0.91	2.91	**149.0**	0.90	2.90	**168.4**	0.82	2.86	**106.2**
1.36	3.18	**292.5**	1.25	3.12	**257.3**	1.15	3.06	**222.6**	1.01	2.97	**177.9**	1.00	2.97	**202.0**	0.92	2.92	**128.8**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 30 of 39
Chkd. By: JM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

60			61			62			63			64			65		
T.O.W.(EL) =		1598.23	T.O.W.(EL) =		1598.34	T.O.W.(EL) =		1598.35	T.O.W.(EL) =		1598.27	T.O.W.(EL) =		1598.16	T.O.W.(EL) =		1598.13
L (ft) =		58	L (ft) =		60	L (ft) =		59	L (ft) =		59	L (ft) =		61	L (ft) =		60
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	0.04	2.66	**1.3**	0.07	2.67	**3.0**
0.07	2.67	**2.9**	-	-	-	-	-	-	0.03	2.66	**0.8**	0.14	2.68	**8.6**	0.17	2.69	**11.3**
0.17	2.69	**10.9**	0.06	2.67	**2.4**	0.05	2.66	**1.8**	0.13	2.68	**7.4**	0.24	2.70	**19.4**	0.27	2.70	**22.7**
0.27	2.70	**22.0**	0.16	2.69	**10.3**	0.15	2.68	**9.2**	0.23	2.69	**17.5**	0.34	2.71	**32.8**	0.37	2.71	**36.6**
0.37	2.71	**35.4**	0.26	2.70	**21.5**	0.25	2.70	**19.9**	0.33	2.70	**30.2**	0.44	2.72	**48.4**	0.47	2.73	**52.8**
0.47	2.73	**51.0**	0.36	2.71	**35.1**	0.35	2.71	**33.1**	0.43	2.72	**45.3**	0.54	2.74	**66.3**	0.57	2.75	**71.0**
0.57	2.75	**68.6**	0.46	2.72	**50.9**	0.45	2.72	**48.4**	0.53	2.74	**62.4**	0.64	2.77	**86.5**	0.67	2.79	**91.8**
0.67	2.79	**88.7**	0.56	2.75	**69.1**	0.55	2.75	**66.2**	0.63	2.77	**81.7**	0.74	2.82	**109.5**	0.77	2.83	**114.7**
0.77	2.83	**110.9**	0.66	2.78	**89.4**	0.65	2.78	**86.0**	0.73	2.81	**103.4**	0.84	2.87	**134.8**	0.87	2.89	**140.7**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

(31)

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 31 of 39
Chkd. By: BM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

66			67			68			69			70			71		
T.O.W.(EL) =		1598.21	T.O.W.(EL) =		1598.25	T.O.W.(EL) =		1598.22	T.O.W.(EL) =		1598.03	T.O.W.(EL) =		1597.50	T.O.W.(EL) =		1597.10
L (ft) =		63	L (ft) =		58	L (ft) =		57	L (ft) =		60	L (ft) =		60	L (ft) =		60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.64	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.1**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	2.69	**14.4**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	2.70	**26.6**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.40	2.71	**41.1**
-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.1**	0.50	2.73	**57.9**
-	-	-	-	-	-	-	-	-	-	-	-	0.13	2.68	**7.5**	0.53	2.74	**63.4**
-	-	-	-	-	-	-	-	-	-	-	-	0.20	2.69	**14.4**	0.60	2.76	**77.0**
-	-	-	-	-	-	-	-	-	-	-	-	0.30	2.70	**26.6**	0.70	2.80	**98.4**
-	-	-	-	-	-	-	-	-	-	-	-	0.40	2.71	**41.1**	0.80	2.85	**122.4**
-	-	-	-	-	-	-	-	-	-	-	-	0.48	2.73	**54.2**	0.88	2.89	**142.8**
-	-	-	-	-	-	-	-	-	-	-	-	0.50	2.73	**57.9**	0.90	2.90	**148.6**
-	-	-	-	-	-	-	-	-	0.07	2.67	**3.0**	0.60	2.76	**77.0**	1.00	2.97	**178.2**
-	-	-	-	-	-	-	-	-	0.17	2.69	**11.3**	0.70	2.80	**98.4**	1.10	3.03	**209.7**
0.09	2.67	**4.5**	0.05	2.66	**1.7**	0.08	2.67	**3.4**	0.27	2.70	**22.7**	0.80	2.85	**122.4**	1.20	3.09	**243.7**
0.19	2.69	**14.0**	0.15	2.68	**9.0**	0.18	2.69	**11.7**	0.37	2.71	**36.6**	0.90	2.90	**148.6**	1.30	3.15	**280.1**
0.29	2.70	**26.6**	0.25	2.70	**19.6**	0.28	2.70	**22.8**	0.47	2.73	**52.8**	1.00	2.97	**178.2**	1.40	3.20	**318.0**
0.39	2.71	**41.6**	0.35	2.71	**32.5**	0.38	2.71	**36.2**	0.57	2.75	**71.0**	1.10	3.03	**209.7**	1.50	3.24	**357.1**
0.49	2.73	**59.0**	0.45	2.72	**47.6**	0.48	2.73	**51.7**	0.67	2.79	**91.8**	1.20	3.09	**243.7**	1.60	3.27	**397.1**
0.59	2.76	**78.8**	0.55	2.75	**65.1**	0.58	2.75	**69.2**	0.77	2.83	**114.7**	1.30	3.15	**280.1**	1.70	3.29	**437.5**
0.69	2.80	**101.1**	0.65	2.78	**84.5**	0.68	2.79	**89.2**	0.87	2.89	**140.7**	1.40	3.20	**318.0**	1.80	3.30	**478.2**
0.79	2.84	**125.6**	0.75	2.82	**106.2**	0.78	2.84	**111.5**	0.97	2.95	**169.1**	1.50	3.24	**357.1**	1.90	3.30	**518.6**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

(32)

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 32 of 39
Chkd. By: JM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

72			73			74			75			76			77		
T.O.W.(EL) =		1597.11	T.O.W.(EL) =		1597.30	T.O.W.(EL) =		1597.90	T.O.W.(EL) =		1597.85	T.O.W.(EL) =		1597.94	T.O.W.(EL) =		1598.03
L (ft) =		78	L (ft) =		60	L (ft) =		60	L (ft) =		52	L (ft) =		42	L (ft) =		45
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.09	2.67	**5.6**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.19	2.69	**17.4**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.29	2.70	**32.9**	0.10	2.68	**5.1**	-	-	-	-	-	-	-	-	-	-	-	-
0.39	2.71	**51.5**	0.20	2.69	**14.4**	-	-	-	-	-	-	-	-	-	-	-	-
0.49	2.73	**73.0**	0.30	2.70	**26.6**	-	-	-	-	-	-	-	-	-	-	-	-
0.52	2.74	**80.1**	0.33	2.70	**30.7**	-	-	-	-	-	-	-	-	-	-	-	-
0.59	2.76	**97.6**	0.40	2.71	**41.1**	-	-	-	-	-	-	-	-	-	-	-	-
0.69	2.80	**125.2**	0.50	2.73	**57.9**	-	-	-	-	-	-	-	-	-	-	-	-
0.79	2.84	**155.5**	0.60	2.76	**77.0**	-	-	-	0.05	2.66	**1.5**	-	-	-	-	-	-
0.87	2.89	**182.5**	0.68	2.79	**93.6**	0.08	2.67	**3.5**	0.13	2.68	**6.4**	0.04	2.66	**0.9**	-	-	-
0.89	2.90	**189.9**	0.70	2.80	**98.4**	0.10	2.68	**5.1**	0.15	2.68	**8.1**	0.06	2.67	**1.7**	-	-	-
0.99	2.96	**227.4**	0.80	2.85	**122.4**	0.20	2.69	**14.4**	0.25	2.70	**17.5**	0.16	2.69	**7.4**	0.07	2.67	**2.4**
1.09	3.02	**268.1**	0.90	2.90	**148.6**	0.30	2.70	**26.6**	0.35	2.71	**29.2**	0.26	2.70	**15.2**	0.17	2.69	**8.8**
1.19	3.09	**312.9**	1.00	2.97	**178.2**	0.40	2.71	**41.1**	0.45	2.72	**42.7**	0.36	2.71	**24.8**	0.27	2.70	**17.4**
1.29	3.15	**360.0**	1.10	3.03	**209.7**	0.50	2.73	**57.9**	0.55	2.75	**58.3**	0.46	2.72	**35.9**	0.37	2.71	**27.9**
1.39	3.20	**409.0**	1.20	3.09	**243.7**	0.60	2.76	**77.0**	0.65	2.78	**75.8**	0.56	2.75	**48.7**	0.47	2.73	**40.1**
1.49	3.24	**459.6**	1.30	3.15	**280.1**	0.70	2.80	**98.4**	0.75	2.82	**95.2**	0.66	2.78	**62.9**	0.57	2.75	**53.8**
1.59	3.27	**511.4**	1.40	3.20	**318.0**	0.80	2.85	**122.4**	0.85	2.88	**117.4**	0.76	2.83	**79.1**	0.67	2.79	**69.5**
1.69	3.29	**563.8**	1.50	3.24	**357.1**	0.90	2.90	**148.6**	0.95	2.94	**141.6**	0.86	2.88	**96.8**	0.77	2.83	**86.8**
1.79	3.29	**614.6**	1.60	3.27	**397.1**	1.00	2.97	**178.2**	1.05	3.00	**167.8**	0.96	2.94	**116.5**	0.87	2.89	**106.3**
1.89	3.30	**668.8**	1.70	3.29	**437.5**	1.10	3.03	**209.7**	1.15	3.06	**196.2**	1.06	3.01	**138.4**	0.97	2.95	**127.6**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 33 of 39
Chkd. By: PM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

78			79			80			81			82		
T.O.W.(EL) =		1598.11	T.O.W.(EL) =		1598.20	T.O.W.(EL) =		1598.29	T.O.W.(EL) =		1598.37	T.O.W.(EL) =		1598.33
L (ft) =		44	L (ft) =		44	L (ft) =		44	L (ft) =		50	L (ft) =		59
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.09	2.67	**3.0**	-	-	-	-	-	-	-	-	-	-	-	-
0.19	2.69	**9.5**	0.10	2.68	**3.6**	0.01	2.65	**0.1**	-	-	-	-	-	-
0.29	2.70	**18.2**	0.20	2.69	**10.5**	0.11	2.68	**4.3**	0.03	2.66	**0.7**	0.07	2.67	**3.1**
0.39	2.71	**28.6**	0.30	2.70	**19.4**	0.21	2.69	**11.4**	0.13	2.68	**6.3**	0.17	2.69	**11.4**
0.49	2.73	**40.7**	0.40	2.71	**30.0**	0.31	2.70	**20.6**	0.23	2.69	**14.8**	0.27	2.70	**22.6**
0.59	2.76	**54.5**	0.50	2.73	**42.3**	0.41	2.72	**31.5**	0.33	2.70	**25.6**	0.37	2.71	**36.3**
0.69	2.79	**69.8**	0.60	2.76	**56.2**	0.51	2.73	**43.8**	0.43	2.72	**38.3**	0.47	2.73	**52.3**
0.79	2.84	**87.1**	0.70	2.80	**71.9**	0.61	2.76	**57.9**	0.53	2.74	**52.9**	0.57	2.75	**70.3**
0.89	2.90	**106.5**	0.80	2.85	**89.5**	0.71	2.80	**73.8**	0.63	2.77	**69.3**	0.67	2.79	**90.8**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

(34)

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 34 of 39
Chkd. By: JM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

83			84			85			86			87			88		
T.O.W.(EL) =		1598.29	T.O.W.(EL) =		1598.24	T.O.W.(EL) =		1598.19	T.O.W.(EL) =		1598.03	T.O.W.(EL) =		1597.87	T.O.W.(EL) =		1597.70
L (ft) =		59	L (ft) =		60	L (ft) =		59	L (ft) =		59	L (ft) =		59	L (ft) =		60
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	2.64	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	2.68	**5.2**
-	-	-	-	-	-	-	-	-	-	-	-	0.03	2.66	**1.0**	0.20	2.69	**14.6**
-	-	-	-	-	-	-	-	-	-	-	-	0.11	2.68	**6.0**	0.28	2.70	**24.0**
-	-	-	-	-	-	-	-	-	-	-	-	0.13	2.68	**7.8**	0.30	2.70	**26.8**
-	-	-	-	-	-	-	-	-	0.07	2.67	**2.8**	0.23	2.70	**18.1**	0.40	2.71	**41.3**
-	-	-	-	-	-	0.01	2.65	**0.2**	0.17	2.69	**11.0**	0.33	2.71	**31.0**	0.50	2.73	**58.1**
0.01	2.65	**0.3**	0.06	2.66	**2.2**	0.11	2.68	**5.8**	0.27	2.70	**22.2**	0.43	2.72	**46.0**	0.60	2.76	**77.2**
0.11	2.68	**6.1**	0.16	2.69	**10.0**	0.21	2.69	**15.3**	0.37	2.71	**35.8**	0.53	2.74	**63.2**	0.70	2.80	**98.6**
0.21	2.69	**15.8**	0.26	2.70	**21.1**	0.31	2.70	**27.5**	0.47	2.73	**51.6**	0.63	2.77	**82.7**	0.80	2.85	**122.6**
0.31	2.70	**28.1**	0.36	2.71	**34.7**	0.41	2.72	**42.1**	0.57	2.75	**69.5**	0.73	2.82	**104.8**	0.90	2.91	**149.4**
0.41	2.72	**42.9**	0.46	2.72	**50.4**	0.51	2.73	**58.7**	0.67	2.79	**90.0**	0.83	2.87	**129.2**	1.00	2.97	**178.5**
0.51	2.74	**59.7**	0.56	2.75	**68.6**	0.61	2.76	**77.6**	0.77	2.83	**112.5**	0.93	2.93	**156.2**	1.10	3.03	**210.1**
0.61	2.77	**78.8**	0.66	2.78	**88.8**	0.71	2.80	**98.8**	0.87	2.89	**138.0**	1.03	2.99	**185.7**	1.20	3.09	**244.1**
0.71	2.81	**100.2**	0.76	2.83	**111.8**	0.81	2.85	**122.6**	0.97	2.95	**165.9**	1.13	3.05	**217.5**	1.30	3.15	**280.5**

89			90			91			92			93		
T.O.W.(EL) =		1597.53	T.O.W.(EL) =		1597.35	T.O.W.(EL) =		1597.33	T.O.W.(EL) =		1597.31	T.O.W.(EL) =		1597.29
L (ft) =		59	L (ft) =		59	L (ft) =		60	L (ft) =		60	L (ft) =		60
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	0.01	2.65	**0.1**
-	-	-	0.05	2.66	**1.8**	0.07	2.67	**2.9**	0.09	2.67	**4.1**	0.11	2.68	**5.5**
-	-	-	0.15	2.68	**9.2**	0.17	2.69	**11.2**	0.19	2.69	**13.0**	0.21	2.69	**15.0**
0.07	2.67	**2.8**	0.25	2.70	**19.9**	0.27	2.70	**22.5**	0.29	2.70	**24.9**	0.31	2.70	**27.3**
0.10	2.67	**4.8**	0.28	2.70	**23.6**	0.30	2.70	**26.4**	0.32	2.70	**28.9**	0.34	2.71	**31.6**
0.17	2.69	**10.9**	0.35	2.71	**33.1**	0.37	2.71	**36.4**	0.39	2.71	**39.1**	0.41	2.71	**42.0**
0.27	2.70	**22.1**	0.45	2.72	**48.4**	0.47	2.73	**52.5**	0.49	2.73	**55.7**	0.51	2.73	**58.8**
0.37	2.71	**35.6**	0.55	2.75	**66.2**	0.57	2.75	**70.7**	0.59	2.76	**74.5**	0.61	2.76	**78.0**
0.45	2.72	**47.8**	0.63	2.77	**81.5**	0.65	2.78	**86.8**	0.67	2.78	**90.6**	0.68	2.79	**94.7**
0.47	2.73	**51.5**	0.65	2.78	**86.0**	0.67	2.79	**91.5**	0.69	2.79	**95.3**	0.71	2.80	**99.5**
0.57	2.75	**69.4**	0.75	2.82	**108.1**	0.77	2.83	**114.4**	0.79	2.84	**118.9**	0.81	2.85	**123.6**
0.67	2.79	**89.8**	0.85	2.88	**133.2**	0.87	2.89	**140.3**	0.89	2.90	**145.3**	0.91	2.91	**150.4**
0.77	2.83	**112.3**	0.95	2.94	**160.6**	0.97	2.95	**168.7**	0.99	2.96	**174.1**	1.01	2.97	**179.6**
0.87	2.89	**137.8**	1.05	3.00	**190.4**	1.07	3.01	**199.5**	1.09	3.02	**205.3**	1.11	3.03	**211.3**
0.97	2.95	**165.7**	1.15	3.06	**222.6**	1.17	3.07	**232.7**	1.19	3.09	**239.7**	1.21	3.10	**246.1**
1.07	3.01	**195.9**	1.25	3.12	**257.3**	1.27	3.13	**268.3**	1.29	3.14	**275.0**	1.31	3.15	**281.9**
1.17	3.07	**228.5**	1.35	3.18	**294.3**	1.37	3.19	**306.4**	1.39	3.20	**313.6**	1.41	3.20	**319.9**
1.27	3.13	**263.6**	1.45	3.22	**331.7**	1.47	3.23	**344.9**	1.49	3.24	**352.5**	1.51	3.24	**359.0**
1.37	3.19	**301.0**	1.55	3.26	**371.2**	1.57	3.26	**384.2**	1.59	3.27	**392.2**	1.61	3.27	**399.1**
1.47	3.23	**338.8**	1.65	3.28	**410.2**	1.67	3.28	**424.1**	1.69	3.29	**432.5**	1.71	3.29	**439.6**

94			95			96			97			98		
T.O.W.(EL) =		1597.27	T.O.W.(EL) =		1597.25	T.O.W.(EL) =		1597.34	T.O.W.(EL) =		1597.43	T.O.W.(EL) =		1597.52
L (ft) =		60	L (ft) =		60	L (ft) =		60	L (ft) =		60	L (ft) =		58
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.03	2.66	**0.8**	0.05	2.66	**1.8**	-	-	-	-	-	-	-	-	-
0.13	2.68	**7.5**	0.15	2.68	**9.3**	0.06	2.67	**2.4**	-	-	-	-	-	-
0.23	2.69	**17.8**	0.25	2.70	**20.2**	0.16	2.69	**10.3**	0.07	2.67	**3.0**	-	-	-
0.33	2.70	**30.7**	0.35	2.71	**33.7**	0.26	2.70	**21.5**	0.17	2.69	**11.3**	0.08	2.67	**3.5**
0.36	2.71	**35.1**	0.38	2.71	**38.1**	0.29	2.70	**25.3**	0.20	2.69	**14.4**	0.11	2.68	**5.7**
0.43	2.72	**46.0**	0.45	2.72	**49.3**	0.36	2.71	**35.1**	0.27	2.70	**22.7**	0.18	2.69	**11.9**
0.53	2.74	**63.4**	0.55	2.75	**67.3**	0.46	2.72	**50.9**	0.37	2.71	**36.6**	0.28	2.70	**23.2**
0.63	2.77	**83.1**	0.65	2.78	**87.4**	0.56	2.75	**69.1**	0.47	2.73	**52.8**	0.38	2.71	**36.8**
0.71	2.80	**100.2**	0.73	2.81	**104.9**	0.64	2.77	**84.8**	0.55	2.74	**66.8**	0.46	2.72	**49.0**
0.73	2.81	**105.2**	0.75	2.82	**109.9**	0.66	2.78	**89.4**	0.57	2.75	**71.0**	0.48	2.73	**52.7**
0.83	2.86	**129.8**	0.85	2.88	**135.4**	0.76	2.83	**112.5**	0.67	2.79	**91.8**	0.58	2.75	**70.5**
0.93	2.92	**157.1**	0.95	2.94	**163.3**	0.86	2.88	**137.8**	0.77	2.83	**114.7**	0.68	2.79	**90.7**
1.03	2.99	**187.5**	1.05	3.00	**193.7**	0.96	2.94	**165.9**	0.87	2.89	**140.7**	0.78	2.84	**113.5**
1.13	3.05	**219.8**	1.15	3.06	**226.4**	1.06	3.00	**196.4**	0.97	2.95	**169.1**	0.88	2.89	**138.4**
1.23	3.11	**254.5**	1.25	3.12	**261.6**	1.16	3.07	**230.1**	1.07	3.01	**199.9**	0.98	2.95	**166.0**
1.33	3.17	**291.7**	1.35	3.18	**299.3**	1.26	3.13	**265.6**	1.17	3.07	**233.1**	1.08	3.02	**196.6**
1.43	3.21	**329.4**	1.45	3.22	**337.3**	1.36	3.18	**302.6**	1.27	3.13	**268.8**	1.18	3.08	**229.0**
1.53	3.25	**369.0**	1.55	3.26	**377.5**	1.46	3.23	**341.9**	1.37	3.19	**306.9**	1.28	3.14	**263.7**
1.63	3.28	**409.5**	1.65	3.28	**417.1**	1.56	3.26	**381.1**	1.47	3.23	**345.4**	1.38	3.19	**299.9**
1.73	3.29	**449.2**	1.75	3.29	**457.0**	1.66	3.28	**420.9**	1.57	3.26	**384.8**	1.48	3.23	**337.3**

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 37 of 39
Chkd. By: FM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

99			100			101			102			103		
T.O.W.(EL) =		1597.61	T.O.W.(EL) =		1597.67	T.O.W.(EL) =		1597.78	T.O.W.(EL) =		1597.83	T.O.W.(EL) =		1597.92
	L (ft) =	80		L (ft) =	60		L (ft) =	57		L (ft) =	51		L (ft) =	62
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.02	2.65	**0.6**	-	-	-	-	-	-	-	-	-	-	-	-
0.09	2.67	**5.8**	0.03	2.66	**0.8**	-	-	-	-	-	-	-	-	-
0.19	2.69	**17.8**	0.13	2.68	**7.5**	0.02	2.65	**0.4**	-	-	-	-	-	-
0.29	2.70	**33.7**	0.23	2.69	**17.8**	0.12	2.68	**6.4**	0.07	2.67	**2.5**	-	-	-
0.37	2.71	**48.5**	0.31	2.70	**27.8**	0.20	2.69	**13.6**	0.15	2.68	**7.8**	0.06	2.67	**2.3**
0.39	2.71	**52.8**	0.33	2.70	**30.7**	0.22	2.69	**15.8**	0.17	2.69	**9.6**	0.08	2.67	**3.7**
0.49	2.73	**74.9**	0.43	2.72	**46.0**	0.32	2.70	**27.9**	0.27	2.70	**19.3**	0.18	2.69	**12.7**
0.59	2.76	**100.1**	0.53	2.74	**63.4**	0.42	2.72	**42.2**	0.37	2.71	**31.1**	0.28	2.70	**24.8**
0.69	2.80	**128.4**	0.63	2.77	**83.1**	0.52	2.74	**58.6**	0.47	2.73	**44.9**	0.38	2.71	**39.4**
0.79	2.84	**159.5**	0.73	2.81	**105.2**	0.62	2.77	**77.1**	0.57	2.75	**60.4**	0.48	2.73	**56.3**
0.89	2.90	**194.8**	0.83	2.86	**129.8**	0.72	2.81	**97.9**	0.67	2.79	**78.0**	0.58	2.75	**75.3**
0.99	2.96	**233.3**	0.93	2.92	**157.1**	0.82	2.86	**121.0**	0.77	2.83	**97.5**	0.68	2.79	**97.0**
1.09	3.02	**274.9**	1.03	2.99	**187.5**	0.92	2.92	**146.9**	0.87	2.89	**119.6**	0.78	2.84	**121.3**
1.19	3.09	**320.9**	1.13	3.05	**219.8**	1.02	2.98	**175.0**	0.97	2.95	**143.7**	0.88	2.89	**147.9**
1.29	3.15	**369.2**	1.23	3.11	**254.5**	1.12	3.04	**205.4**	1.07	3.01	**169.9**	0.98	2.95	**177.4**
1.39	3.20	**419.5**	1.33	3.17	**291.7**	1.22	3.11	**238.9**	1.17	3.07	**198.1**	1.08	3.02	**210.2**

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By: JD Date: 3-7-06 Subject Estimate of Parapet Wall Sheet No. 38 of 39
Chkd. By: JM Date: 3/7/06 Overflow Conditions Proj. No. 06-3551

104			105			106			107			108		
T.O.W.(EL) =		1597.92	T.O.W.(EL) =		1598.02	T.O.W.(EL) =		1598.11	T.O.W.(EL) =		1598.22	T.O.W.(EL) =		1598.03
	L (ft) =	59		L (ft) =	59		L (ft) =	58		L (ft) =	58		L (ft) =	68
H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)	H (ft)	C	Q (cfs)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.06	2.67	**2.2**	-	-	-	-	-	-	-	-	-	-	-	-
0.08	2.67	**3.6**	-	-	-	-	-	-	-	-	-	-	-	-
0.18	2.69	**12.1**	0.08	2.67	**3.6**	-	-	-	-	-	-	0.07	2.67	**3.4**
0.28	2.70	**23.6**	0.18	2.69	**12.1**	0.09	2.67	**4.2**	-	-	-	0.17	2.69	**12.8**
0.38	2.71	**37.5**	0.28	2.70	**23.6**	0.19	2.69	**12.9**	0.08	2.67	**3.5**	0.27	2.70	**25.8**
0.48	2.73	**53.6**	0.38	2.71	**37.5**	0.29	2.70	**24.5**	0.18	2.69	**11.9**	0.37	2.71	**41.5**
0.58	2.75	**71.7**	0.48	2.73	**53.6**	0.39	2.71	**38.3**	0.28	2.70	**23.2**	0.47	2.73	**59.8**
0.68	2.79	**92.3**	0.58	2.75	**71.7**	0.49	2.73	**54.3**	0.38	2.71	**36.8**	0.57	2.75	**80.5**
0.78	2.84	**115.4**	0.68	2.79	**92.3**	0.59	2.76	**72.5**	0.48	2.73	**52.7**	0.67	2.79	**104.0**
0.88	2.89	**140.8**	0.78	2.84	**115.4**	0.69	2.80	**93.1**	0.58	2.75	**70.5**	0.77	2.83	**130.0**
0.98	2.95	**168.9**	0.88	2.89	**140.8**	0.79	2.84	**115.7**	0.68	2.79	**90.7**	0.87	2.89	**159.5**
1.08	3.02	**200.0**	0.98	2.95	**168.9**	0.89	2.90	**141.2**	0.78	2.84	**113.5**	0.97	2.95	**191.6**

109			110			111		
T.O.W.(EL) =		1598.06	T.O.W.(EL) =		1598.03	T.O.W.(EL) =		1598.00
L (ft) =		60	L (ft) =		36	L (ft) =		34
H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**	H (ft)	C	**Q (cfs)**
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
0.04	2.66	**1.3**	0.07	2.67	**1.8**	0.10	2.68	**2.9**
0.14	2.68	**8.4**	0.17	2.69	**6.8**	0.20	2.69	**8.2**
0.24	2.70	**19.0**	0.27	2.70	**13.6**	0.30	2.70	**15.1**
0.34	2.71	**32.2**	0.37	2.71	**22.0**	0.40	2.71	**23.3**
0.44	2.72	**47.6**	0.47	2.73	**31.7**	0.50	2.73	**32.8**
0.54	2.74	**65.2**	0.57	2.75	**42.6**	0.60	2.76	**43.6**
0.64	2.77	**85.1**	0.67	2.79	**55.1**	0.70	2.80	**55.8**
0.74	2.82	**107.7**	0.77	2.83	**68.8**	0.80	2.85	**69.3**
0.84	2.87	**132.6**	0.87	2.89	**84.4**	0.90	2.90	**84.2**
0.94	2.93	**160.2**	0.97	2.95	**101.5**	1.00	2.97	**101.0**

STABILITY ANALYSIS OF PARAPET WALL CALCULATION

Objective:

Determine the Factor of Safety for the reinforced concrete parapet wall of the Taum Sauk upper reservoir against overturning and sliding assuming seepage occurs under the wall.

Background:

The upper reservoir dike of the Taum Sauk Pumped Storage Project failed on December 14, 2005 due to flooding. This resulted in a dike failure and release of water from the upper reservoir. The parapet wall was shown to be stable in the original analysis if no seepage under the wall occurs.

References:

1) Lindeburg, Michael R. Civil Engineering Reference Manual, Fourth Edition. Belmont, CA: Professional Publications, Inc. 1986.
2) Reference Design Theory Manual for Armor Form, Erosion Protection Mats. Nicolon Corporation. 1989. p. 283
3) Das, Braja M. Principles of Geotechnical Engineering. Brooks/Cole. 2002. p. 411 – 413., p. 420 – 422.
4) PCRA Calculation. Taum Sauk Plant, Stability Analysis of Failed Zone. February 2006. p. 8-13.

Methodology:

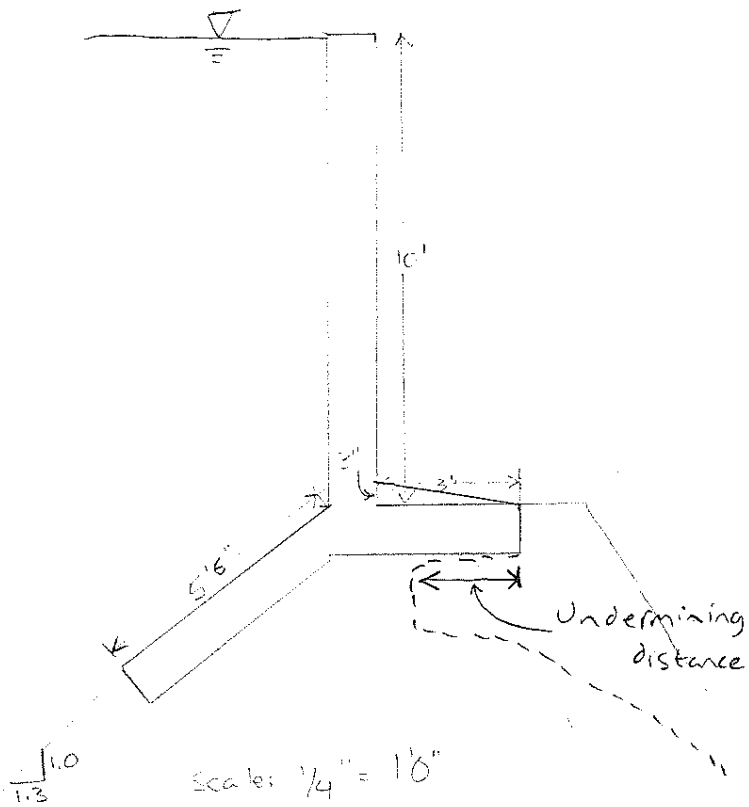
This calculation checks the stability of the parapet wall of the upper reservoir. The factor of safety against overturning and sliding are calculated. To check overturning, all forces acting on the wall are calculated. Lever arms are calculated for each force, and the moment about the toe of the wall is calculated. To check sliding, the horizontal forces are compared to the resistance due to friction at the base from the vertical forces and passive soil force.

Assumptions:

1) Water in the reservoir is at the top of the parapet wall, an elevation of 1599'.
2) Leakage occurs under the base of the wall causing an uplift pressure.
3) Unit weight of concrete is 150lb/ft^3.
4) The uplift pressure is assumed to be equal to the full depth of the water at the bottom of the footing at the upstream side and zero at the toe of the parapet wall.
5) In the sliding calculation; wall friction angle $\delta = 30$ degrees (Reference 3), Rockfill friction angle $\Phi = 41$ degrees (Reference 4) and $\gamma = 130.5$ lb/ft^3.

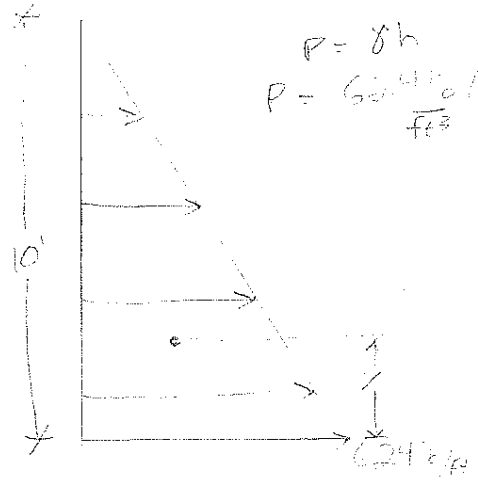
Taum Sauk Parapet Wall Cross section

(i) Overturning



Scale: 1/4" = 1'0"

Step 1: Water Pressure



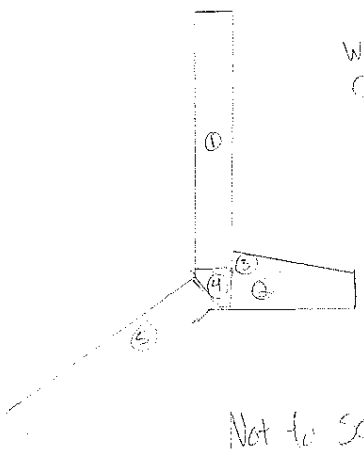
$P = \gamma h$

$P = 62.4\,lb/ft^3 \times 10\,ft = 624\,lb/ft^2$

$\frac{1}{2}(624\,lb/ft)(10\,ft) = 3120\,lb$

$X = \frac{1}{3}(10) = 3.33\,ft$

Step 2: Vertical Forces



Weights of conc. sections

1) $10\,ft(1\,ft)(1\,ft) = 10\,ft^3(150\,lb/ft^3) = 1500\,lb$

2) $3\,ft(1)(1)(150\,lb/ft^3) = 450\,lb$

3) $0.25\,ft(\frac{1}{2})(3)(1)(150\,lb/ft^3) = 56.3\,lb$

4) $\frac{1}{2}(1)(1)(1) = 0.5\,ft^3(150\,lb/ft^3) = 75\,lb$

5) $5.5\,ft(1)(1)(150\,lb/ft^3) = 825\,lb$

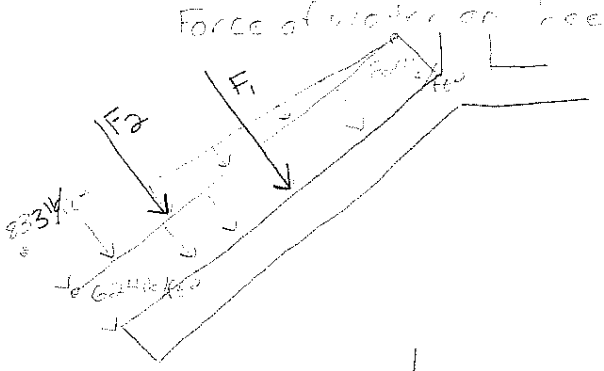
Total - 2906 lb concrete

Not to scale

By JDD Date 1/13/06 Subject Taum Sauk Parapet Wall Sheet No. 3 of 12

Chkd. By KZ Date 3-3-06 Proj. No. 06-3551

Force of water on heel



Pressures -

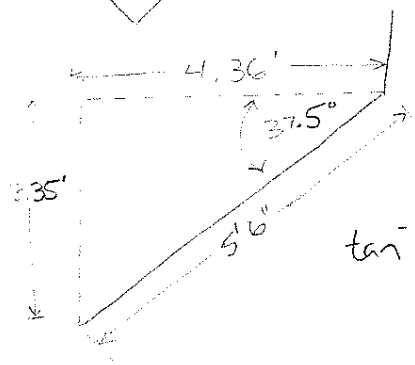
$P_1 = 62.4 \frac{lb}{ft^3}(10ft) = 624\ lb/ft^2$

$P_2 = 62.4\ lb/ft^3(10 + 3.35) = 833\ lb/ft^2$

Forces -

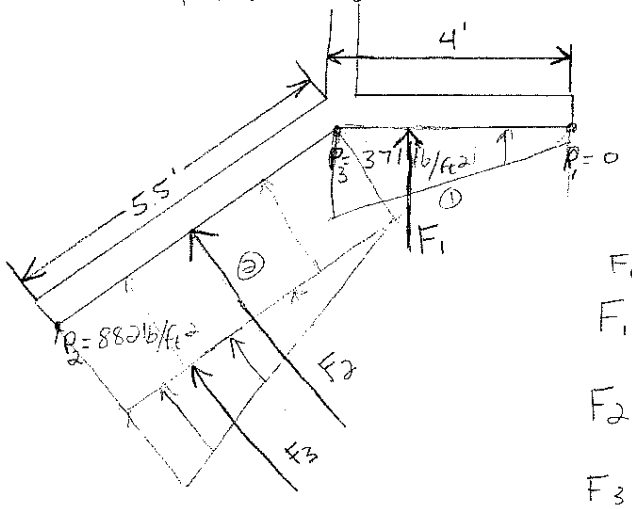
$F_1 = 624\ lb/ft^2\ (5.5ft) = 3432\ lb$

$F_2 = \frac{1}{2}(833 - 624)(5.5) = 575\ lb$



$\tan^{-1}\left(\frac{3.35}{4.36}\right) = 37.5°$

Uplift Pressure



Pressures

$P_1 = 0$

$P_2 = (10 + 3.35 + 1(\cos 37.5))62.4 = 883\ lb/ft^2$

$P_3 = \frac{4}{9.5}(882) = 372\ lb/ft^2$

Forces

$F_1 = 372(4)(\frac{1}{2}) = 744\ lb$

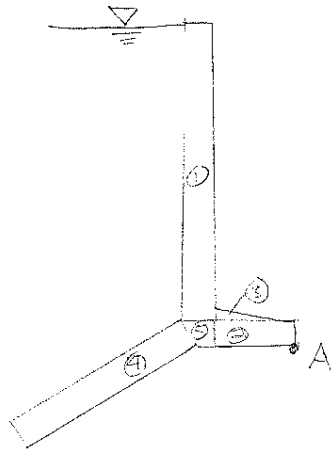
$F_2 = 372(5.5) = 2046\ lb$

$F_3 = (883 - 372)(5.5)(\frac{1}{2}) = 1403\ lb$

By JDD Date 1/13/06 Subject Tourn Sauk Parapet Wall Sheet No. 4 of 12

Chkd. By EZ Date 3-3-06 Proj. No. 06-3551

Step 3: Moments



ΣM_A (+)

(a) Stabilizing

concrete footers

1) 1500 lb (3 + 0.5) = 5250 ft·lb

2) 450 lb (1.5) = 675 ft·lb

3) 56.3 lb (2/3)(3) = 112.7 ft·lb

4) 825 lb (4.36/2 + 1 + 3) = 5098.5 ft·lb

5) 75 lb (3 + 1/3(1)) = 250 ft·lb

water on heel

3430 lb (cos 37.5° (6.18 ft) + 3430 (sin 37.5°)(3.35/2 - 1)

16827 + 1410 = 18237 lb·ft

575 lb (cos 37.5°)(4 + 2/3(4.36)) + 575 (sin 37.5°)(3.35(2/3) - 1)

3151 + 432 = 3583 ft·lb

(b) Overturning

Active pressure

3120 lb (3.33 + 1) = 13,510 ft·lb

Uplift on toe

744 lb (4)(2/3) = 1984 ft·lb

Uplift on heel

2046 (cos 37.5°)(4.36/2 + 4) + 2046 (sin 37.5°)(3.35/2)

= 10031 + 2086 = 12117 ft·lb

$1403(\cos 37.5°)(4 + 4.36(2/3)) + 1403(\sin 37.5°)(3.35(2/3))$

$7688 + 1907 = 9595 \text{ ft}\cdot\text{lb}$

Overtopping Force Assuming depth of water above wall of 0.8ft
Average tractive stress due to flowing water (Ref. Design Theory Manual for Armor Form, Erosion Protection Mats, Nicolon Corporation, 1989 P. 283)

$\tau = \gamma_w d S \quad \gamma_w = 62.4 \quad d = 0.8 \quad S = 1$

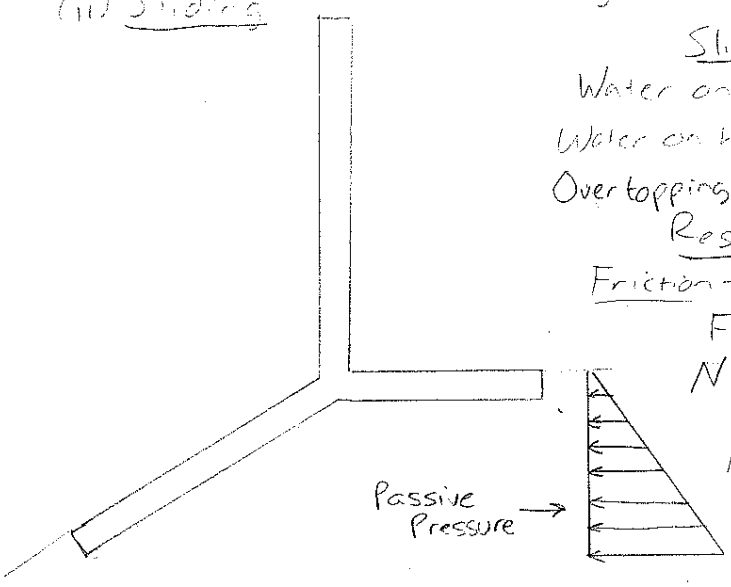
$\tau = 62.4(0.8) = 49.9 \text{ lb/ft}^2$

Total tractive force per unit length $= 49.9(1) = 50 \text{ lb}$

$50 \text{ lb}(11 \text{ ft}) = 550 \text{ ft}\cdot\text{lb}$

$F.S. = \frac{\text{Stabilizing}}{\text{Overturning}} = \frac{33206}{37756} = 0.879$

(ii) Sliding



Sliding Forces

Water on stem - 3120 lb

Water on heel - $4007(\sin 37.5°) = 2439 \text{ lb}$

Overtopping - $50 \text{ lb/ft}(1 \text{ ft}) = 50 \text{ lb}$

Resisting Forces

Friction -

$F = N \tan\phi$ (Reference 3)

$N = 2906 + (4007 \cos 37.5°) - 744 - 2046(\cos 37.5°) - 1403(\cos 37.5°)$

$F = 2605 \text{ lb}(\tan 30°) = 1505 \text{ lb}$

Passive Pressure

$\gamma' = (130.5 - 62.4) = 68.1 \text{ lb/ft}^3$

$K_p = \frac{1+\sin\phi}{1-\sin\phi} = 4.8$ (for cohesionless soils, Ref. 3)

$P_p = \frac{1}{2} K_p \gamma' H^2$

$= \frac{1}{2}(4.8)(68.1)(4.35)^2 = 3093 \text{ lb/ft}^2$

Uplift on heel -

$2046(\sin 37.5°) + 1403(\sin 37.5°) = 2100 \text{ lb}$

$F.S. = \frac{\text{Resisting}}{\text{Sliding}} = \frac{6698}{5609} = 1.19$

Results:

Factors of safety against sliding and overturning were calculated using the excel spreadsheet shown on sheet 7. The values on sheet 7 are for a specific case with no undermining and a water elevation of 1599 feet. Graphs and data tables for the following cases are included in ***Attachment A***.

- Factor of Safety against overturning vs. water elevation for varying amounts of uplift
- Factor of Safety against sliding vs. water elevation for varying amounts of uplift
- Factor of Safety against overturning vs. undermining distance for varying amounts of uplift
- Factor of Safety against sliding vs. undermining distance for varying amounts of passive pressure

Conclusions:

The stability analysis shows that the factor of safety against overturning is inadequate. Overturning could occur when there is leakage under the parapet wall. The factor of safety against sliding is also inadequate when there is leakage under the parapet wall. Undermining further reduces the factor of safety against overturning and sliding. As undermine distance increases, the Factors of Safety for overturning and sliding are reduced.

Attachment A
Stability Analysis Data Tables and Graphs

STABILITY CALCULATION OF PARAPET WALL ASSUMING LEAKAGE UNDER WALL

OVERTURNING

Density of Concrete (pcf)	150
Density of Water (pcf)	62.4

Top El. of Wall	1599
Bottom El. of Wall	1589
Bottom El. of Toe	1588
Stem height (ft)	10
Stem Thickness (ft)	1
Length of Toe (ft)	3
Toe Thickness(ft)	1
Length of Heel (ft)	5.5
Heel Thickness (ft)	1
U/S Slope	1.3
Horz. Proj. of Heel	4.36
Vertical Proj. Of Heel	3.35
Angle of Heel (rad)	0.66
Water Press on Stem	624
Water Press on Heel	833.25
Max Toe Thickness	1.25
Uplift Pressure at toe	0
Uplift Pressure under stem	371.7
Uplift Pressure at heel	882.7
Effective Drag	1.0

Item	Force (lb)	Lv. Arm (ft)	Moment (ft*lb)
Stem	1500	3.50	5250
Toe 1	450	1.50	675
Toe2	56	2.00	112.5
Triangle	75	3.33	250
Heel	825	6.18	5098.3
Water Pr. On Stem	3120	4.33	13520.0
Water Pr. 1 On Heel	3432	-	18226.61
Water Pr. 2 On Heel	575	-	3583.6
Uplift Pr. 1 On Heel	2044	-	12102.5
Uplift Pr. 2 On Heel	1405	-	9608.8
Uplift on Toe	743	2.67	1982.2
Overtopping Drag	50	11.00	550.0

OVERTURNING

Total Stabilizing	**33196**
Total Overturning	**37764**
F.S.	**0.879**

SLIDING

Horiz. force of water on stem	3120.0
Horiz. force of water on heel	2443.4
Horiz. force of uplift on heel	2103.2
wall friction Φ (degrees)	30.0
N	2605.1
friction	1504.1
Passive Pressure	
Rockfill friction angle (rad)	0.72
Kp	4.82
Gamma	130.5
Gamma effective	68.1
H (vert. dist. of heel)	4.35
Pp (at bottom of heel)	3107

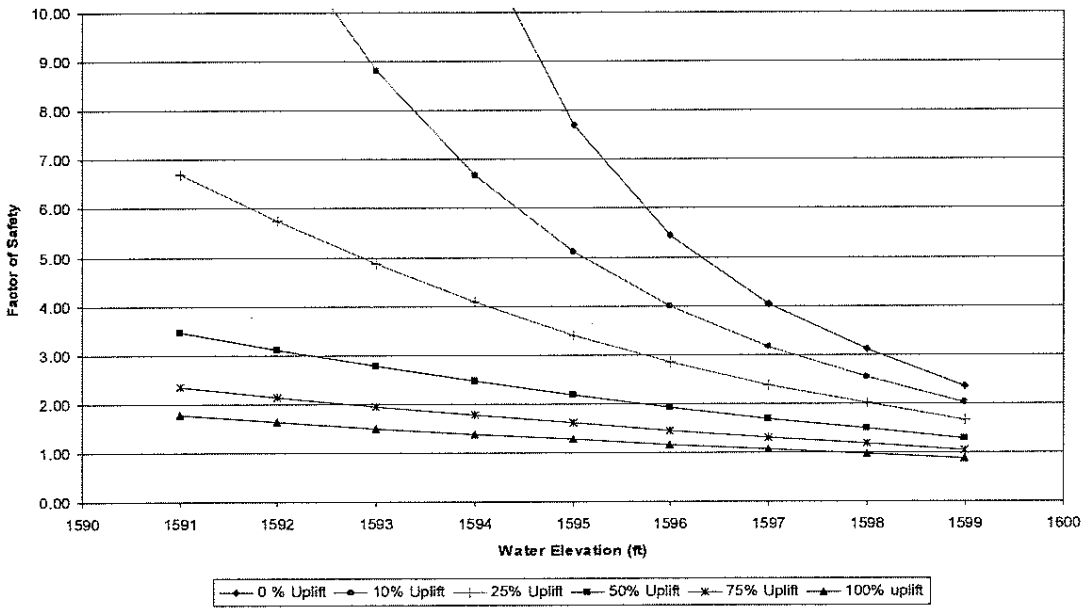
SLIDING

Total sliding	**5563.4**
Total resisting	**6714.6**
F.S.	**1.207**

G:\jdeible\06-3551 Taum Sauk\Parapet wall\Parapet Wall Stability2.xls

Overturning Analysis

Factor of Safety vs. Water Elevation



Factor of Safety Against Overturning

0 % Uplift	Water Depth	Overturning
	1599	2.36
	1598	3.10
	1597	4.04
	1596	5.44
	1595	7.69
	1594	11.58
	1593	19.11
	1592	36.39
	1591	89.49

10% Uplift	Water Depth	Factor of Safety
	1599	2.02
	1598	2.55
	1597	3.16
	1596	3.98
	1595	5.11
	1594	6.67
	1593	8.80
	1592	11.62
	1591	15.04

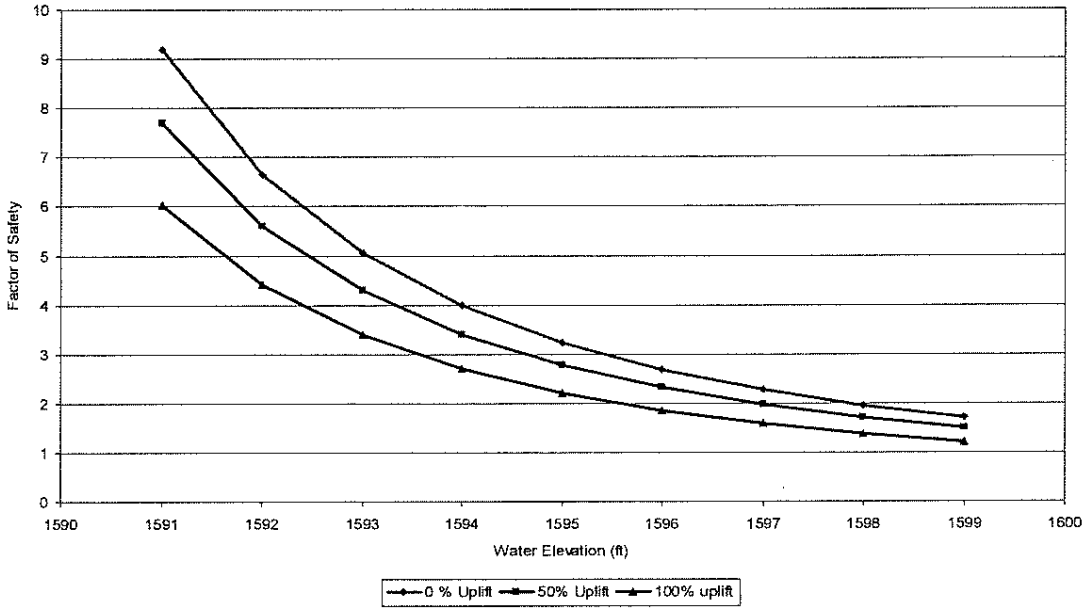
25% Uplift	Water Depth	Factor of Safety
	1599	1.66
	1598	2.01
	1597	2.38
	1596	2.84
	1595	3.40
	1594	4.08
	1593	4.86
	1592	5.75
	1591	6.69

50% Uplift	Water Depth	Factor of Safety
	1599	1.28
	1598	1.49
	1597	1.69
	1596	1.92
	1595	2.18
	1594	2.47
	1593	2.79
	1592	3.12
	1591	3.48

75% Uplift	Water Depth	Factor of Safety
	1599	1.04
	1598	1.18
	1597	1.31
	1596	1.45
	1595	1.61
	1594	1.77
	1593	1.95
	1592	2.14
	1591	2.35

100% uplift	Water Depth	Factor of Safety
	1599	0.88
	1598	0.98
	1597	1.07
	1596	1.17
	1595	1.27
	1594	1.38
	1593	1.50
	1592	1.63
	1591	1.77

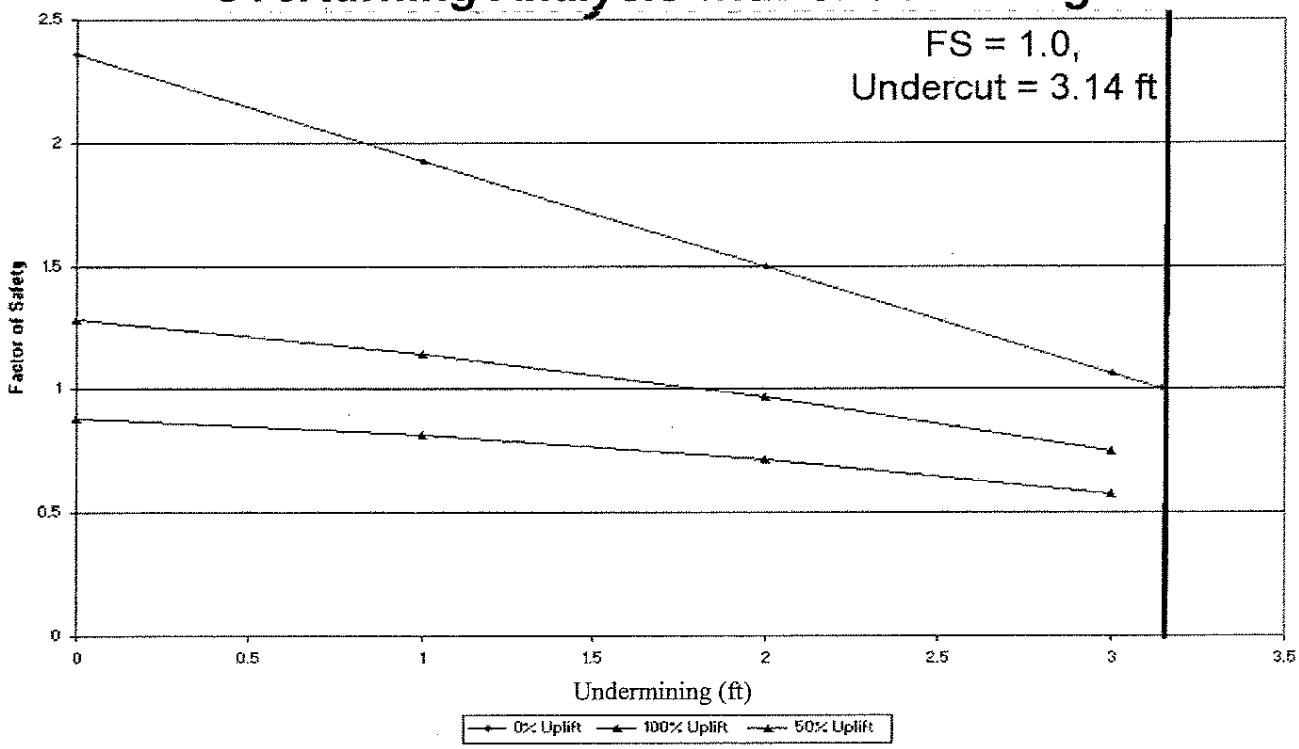
Sliding Analysis
Factor of Safety vs. Water Elevation



Factor of Safety against Sliding

0 % Uplift	Water Depth	Factor of Safety
	1599	1.70
	1598	1.96
	1597	2.28
	1596	2.69
	1595	3.24
	1594	3.99
	1593	5.05
	1592	6.64
	1591	9.18
50% Uplift	Water Depth	Factor of Safety
	1599	1.49
	1598	1.70
	1597	1.97
	1596	2.32
	1595	2.78
	1594	3.40
	1593	4.29
	1592	5.61
	1591	7.71
100% uplift	Water Depth	Factor of Safety
	1599	1.21
	1598	1.38
	1597	1.59
	1596	1.86
	1595	2.22
	1594	2.71
	1593	3.40
	1592	4.42
	1591	6.04

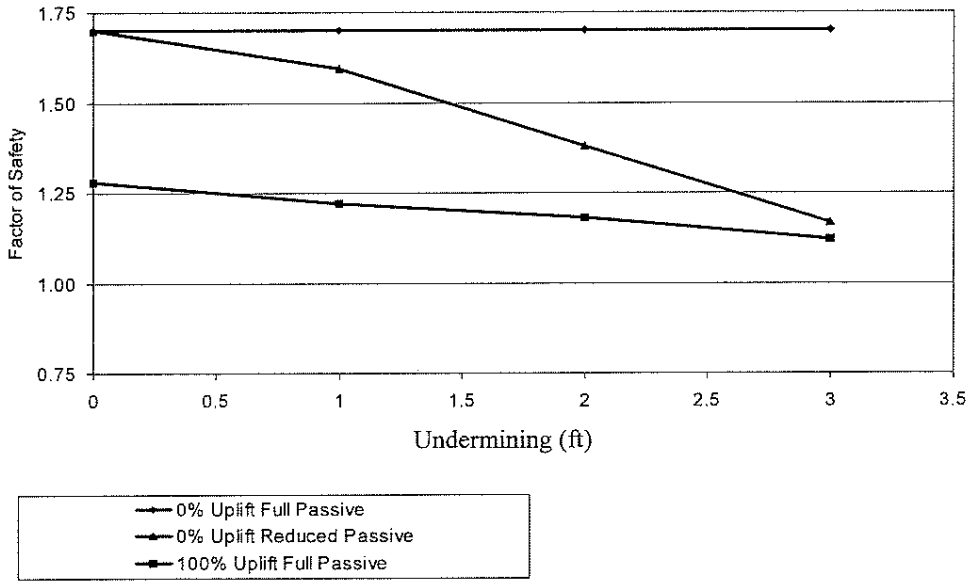
Overturning Analysis with Undermining



Factor of Safety Against Overturning with Undermining

	Undermining	Factor of Safety
0% Uplift	0	2.36
	1	1.93
	2	1.49
	3	1.06
100% Uplift	0	0.88
	1	0.81
	2	0.72
	3	0.58
100% Uplift Full Passive	0	1.28
	1	1.22
	2	1.18
	3	1.12

Sliding Analysis with Undermining



*Passive Pressure is reduced as undercut distance increases. reduction for each undercut distance is shown in the table to the right.

Undermining (ft)	% of Passive Pressure
3	50
2	70
1	90
0	100

Factor of Safety Against Sliding with Undermining

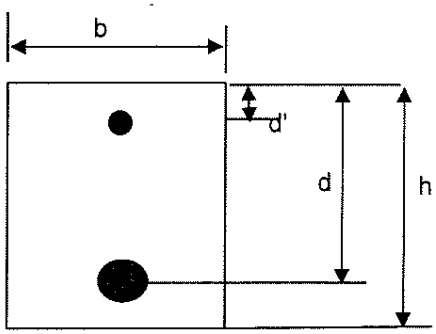
Undermining	Full Passive Pressure	Reduced Passive Pressure	100% Uplift Full Passive
0	1.70	1.70	1.28
1	1.70	1.59	1.22
2	1.70	1.38	1.18
3	1.70	1.17	1.12

REINFORCED CONCRETE WALL CALCULATION

Purpose: Check the section design of water pond retaining wall

Reference: Reinforced Concrete, Fifth edition, Edward G. Nawy. Chapter 5 and Chapter 6

Assumption: Selfweight has little effect on structure and can be neglected.
Assume single-reinforced concrete beam behavior



water pressure

level(ft)	density(lb/f	water pressure(lb/ft^2)
0	62.41983	0
10	62.41983	624.2
13.35	62.41983	833.3

Moment and shear force

	Length(ft)	M_max @ pt. A (lb-ft)	shear_max(lb)
Upright	10	10403	3121
Slant	5.5	11549	4008
Back	3	10403	3633

material property

fc'=	3	ksi	beta1=	0.85	for fc'<4ksi	refer to 5.9
fy=	40	ksi				

A: Check Critical Section of Upright Wall

section property

b=	12	in	h=	12	in
d,dt=	9.5625	in			

	area(in^2)	diameter(in)
#7	0.6	0.875

ρ=A/bd 0.005229 > pmin= 0.005 yes

Use single #7 reinforcement:

a=As*fy/(0.85*f'c*b= 0.784314 in

c=a/beta1= 0.922722 in refer to 5.3

c/dt= 0.096494 <0.375 Φ= 0.9 refer to Fig 5.5

Mn=As*fy*(d-a/2)= 220.0882 k-ft refer to 5.4b

ΦMn=0.9*Mn= 198.0794 k-ft >> M_A_max= 10.403 k-ft ok

Vn>Vc>1.9*b*d*sqrt(fc')= 11941.72 lb refer to 6.8, 6.11
ΦVn=0.75Vn> 8956.291 >> V_max= 3121 lb ok

B: Check Critical Section of Slant Wall

section property

b=	12	in	h=	12	in
d,dt=	9.5625	in			

	area(in^2)	diameter(in)					
#7	0.6	0.875		ρ=A/bd	0.005229 >	ρmin=	0.005 yes

Use single #7 reinforcement:

a=As*fy/(0.85*f'c*b= 0.784314 in
c=a/beta1= 0.922722 in refer to 5.3
c/dt= 0.096494 <0.375 Φ= 0.9 refer to Fig 5.5
Mn=As*fy*(d-a/2)= 220.0882 k-ft refer to 5.4b
ΦMn=0.9*Mn= 198.0794 k-ft >> M_A_max= 11.5 k-ft ok

Vn>Vc>1.9*b*d*sqrt(fc')= 11941.72 lb refer to 6.8, 6.11
ΦVn=0.75Vn> 8956.291 >> V_max= 4008.1 lb ok

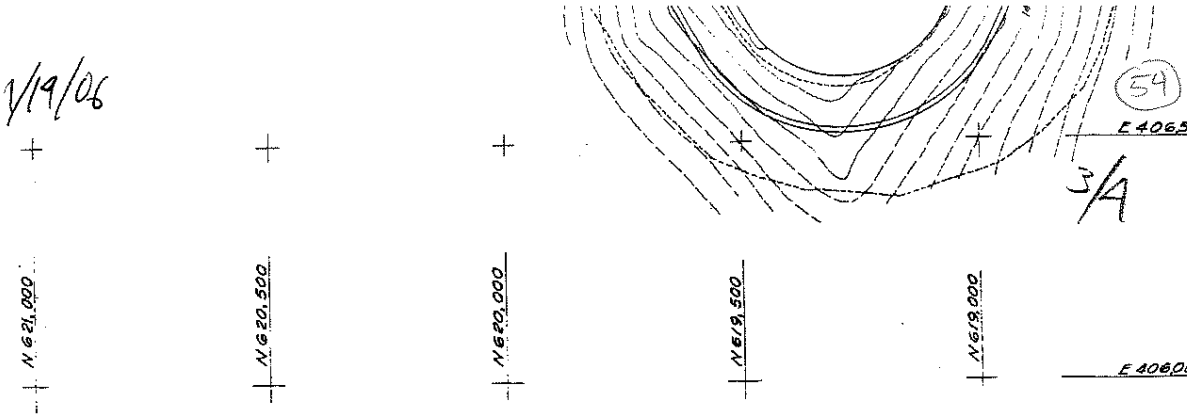
C: Check Critical Section of Back Wall

Same as A. ok

Chkd NG 1/19/06

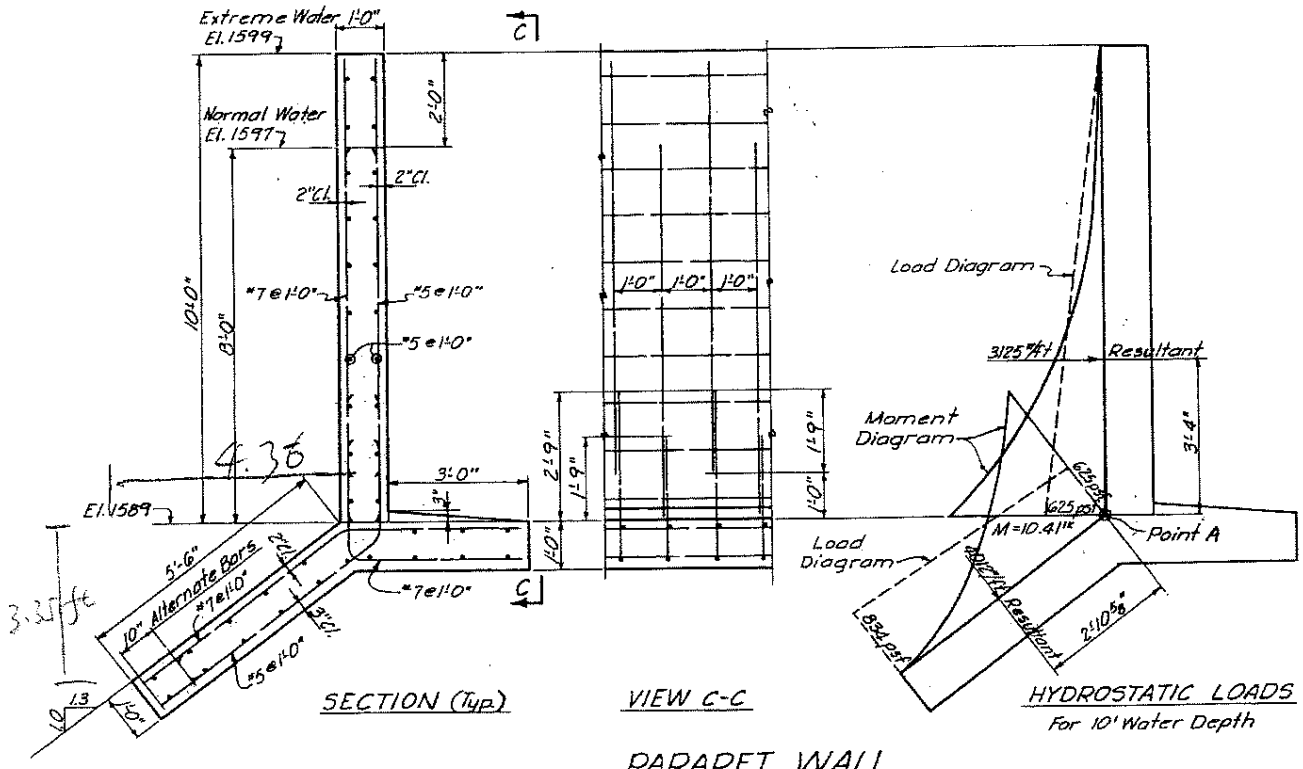
(54)

3/4



LOCATION PLAN

Upper Reservoir
Scale: 1"=200'-0"
Rock surface contours from dwg. 8304-X-26021



PARAPET WALL

Reinforcing steel bars are of billet steel, A.S.T.M. A15 Specification, intermediate grade, with deformations to A.S.T.M. A 305 specification.

Physical Properties:

Ultimate —— 70 - 90,000 p.s.i. ✓

~~Yield~~ —— 40,000 p.s.i. Minimum

Concrete is of 3000 pound strength at 28 days.

Loads on wall at base (Elev. 1589) per foot of wall:	Extreme High Water	Normal Water
Moment	10.41'k	5.33'k
Axial Load	1.50k	1.50k
Shear	3.125k	2.00k
Maximum Unit Stresses		
Reinforcing Steel	22,600 p.s.i.	10,900 p.s.i.
Concrete Fibre Stress	910 p.s.i.	465 p.s.i.
Concrete Shear Stress	30 p.s.i.	20 p.s.i.
Bond	131 p.s.i.	85 p.s.i.
Bond in Lap of 2'-3"	183 p.s.i.	88 p.s.i.

Stability under hydrostatic pressure for 10 ft. head of water.

Moments about Point A.

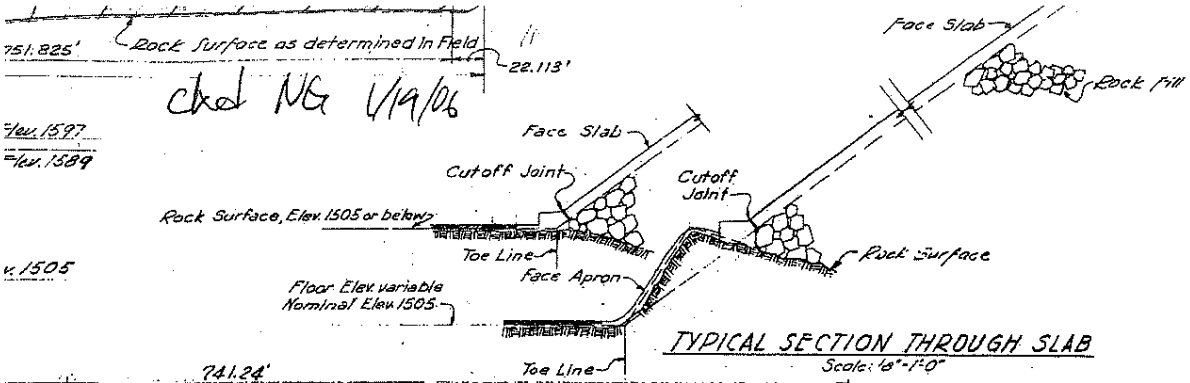
Overturning 3125# x 3.33' = 10,406#

Stabilizing 4012# x 2.88' = 11,555'#

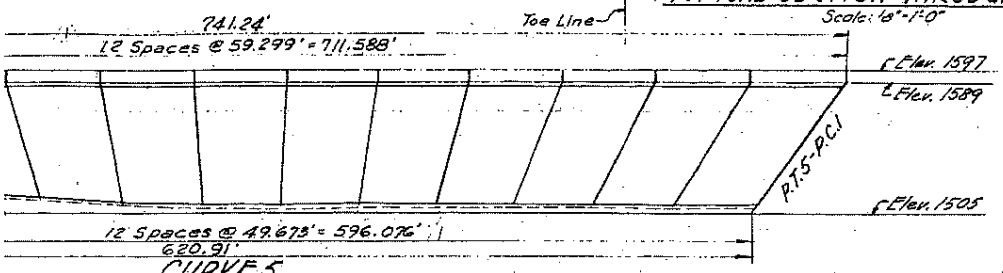
1,149'#

Therefore, stabilizing moment on toe is greater than overturning moment on wall. Additional factor in favor of stability is pressure under downstream footing of wall, not included in this analysis.

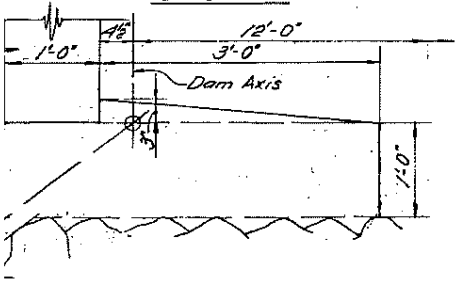
From DWG # 8304-X-26157

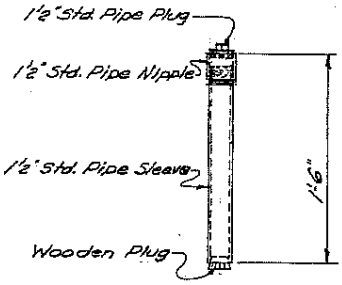


TYPICAL SECTION THROUGH SLAB
Scale: 1/8"=1'-0"

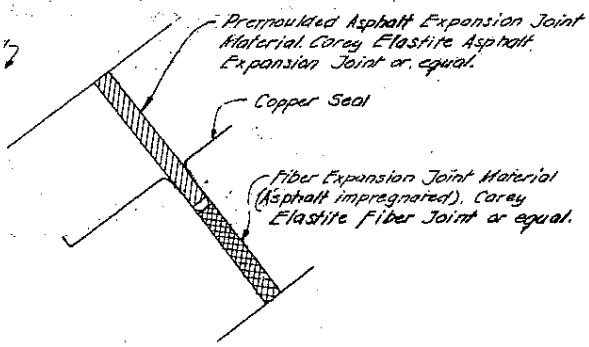


CURVE 5



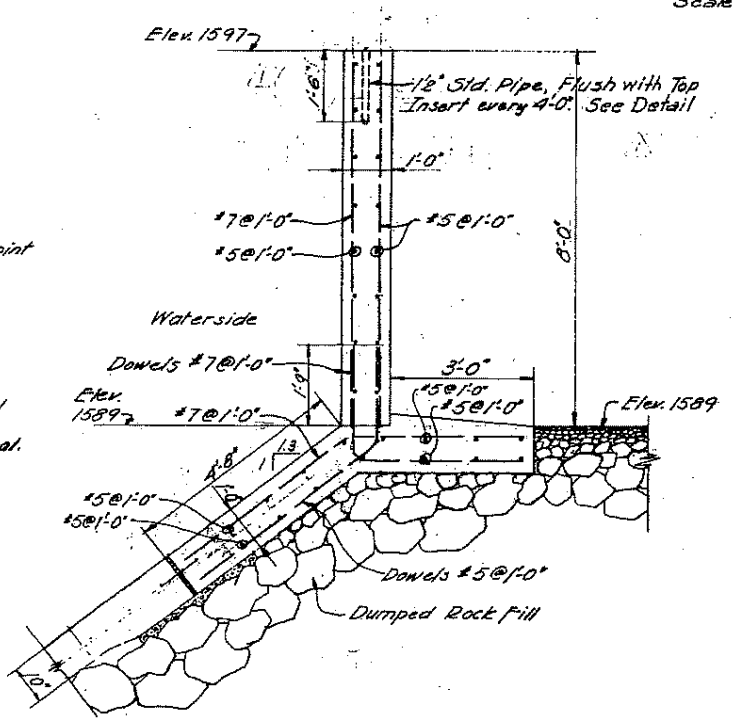


PIPE SLEEVE
Scale: 1½"=1'-0"

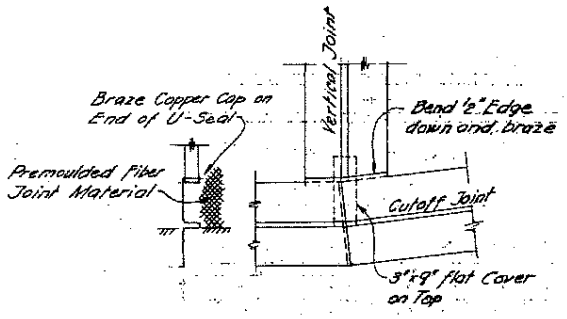


APET FOOTING JOINT
Scale: 1/4"=1'

al Joint on the two central Joints only
al Joint (except for the two central Joints)
rtical Joint



TYPICAL SECTION THROUGH PARAPET WALL
Scale: 1/2"=1'-0"



INTERSECTION VERTICAL JOINT AND CUTOFF JOINT
Scale: 1"=1'-0"

NOTE:
Work this Drawing with Drawings 8304-X-26055 & 26115

½" min. Lap

½" min. Lap

REFERENCE DRAWINGS:
Upper Reservoir

8304-X-026054

SEEP2D ANALYSIS OF FAILED ZONE CALCULATION

OBJECTIVE:

The forensic stability analysis of the failed embankment of the Upper Reservoir of Taum Sauk Plant requires the calibration of the Seepage Model and determination of phreatic surface and/or flownet through the failed section of the berm. For the stability analysis of the berm, a typical cross section has been selected as shown in ***Figure 1*** which is based on the details given in ***Reference 1***. The seepage analysis is carried out for different values of the permeability to investigate the sensitivity of various material properties and then to develop the best estimate phreatic surface which can be utilized in the slope stability analysis.

REFERENCES:

1. Sverdrup & Parcel Engineering Co., Upper Reservoir, Site Plan and General Design, Taum Sauk Project, Union Electric System, St. Louis, MD, 7-7-60.
2. Surdex Corporation, "Upper Reservoir, Rockfill Dike, Ameren Service Co., Job No. 1501211/62, Date of Photography 12/19/2005.
3. SEEP 2-D Analysis, "GMS, Ground Water Modeling System", Boss International, Inc and Brigham Young University, 1999.
4. FFC Safety Report Prepared by J. Barry Cooke, Consulting Engineer, Taum Sauk Project, Upper Dam, Union Electric Company, 7-26-1968.
5. 1998 Review of Safety Report (Seventh Five-Year Report), Inspection of Project Works, Taum Sauk Project, FERC, Licensed Project No. 2277, Union Electric Company, St. Louis, Missouri, Prepared by J. Barry Cooke and Arthur G. Strassburger, March 1998.
6. 8th FERC Part 12 Independent Report, Taum Sauk Project, FERC, Project No. 2277, Prepared for AmerenUE, Prepared by MWH, August 2003.

METHODOLOGY:

Calibration Modeling:
Parapet Wall Segment No. 95, located approximately in the middle of the failed section, was selected for developing the seepage model and calibration of permeability values of the various materials. The bedrock elevations and the general cross-sections are developed from ***References 1 and 2***. In ***Reference 6***, the average flow of seepage through the entire section of the dam is reported to be about 40 cfs prior to installation of HDPE and LDPE Liners on the Upstream Face of the Dike. Assuming total length of rockfill dike of 6562 feet (***Reference 5***), the seepage is calculated to be 527 cu ft/day/ft. ***Figure 1*** shows the Calibration Model which consists of following:

- 1' thick Upstream Face of Concrete/HDPE Liner
- Rockfill
- 1' thick Upstream Asphalt Layer
- Two rows of Grout Curtains (***Reference 4***)
- 6" Gravel Layer
- 10' Thick Downstream Soil Layer extending 20' in to the rockfill
- Bedrock

The Flownets for the analyzed cross sections were calculated using the GMS3.0/SEEP2D program. SEEP2D is a two-dimensional finite element groundwater model developed by U.S. Army Corps of Engineers Waterways Experiment Station (WES). GMS3.0, a graphical representation of the program, is developed by Brigham Young University (***Reference 3***).

To check the validity and compatibility of our estimate of the basic relative permeability values, we performed a set of calibration runs. We estimated the seepage from the Upper Reservoir without the HDPE Liner (installed in 2004) and compared our results with estimated seepage reported in the ***Reference 5***. We then slightly adjusted our model to find a reasonable match between our estimate of seepage and measured values. The phreatic surface and flow net for the calibration model is shown on ***Figure 2***.
The permeability values for the various materials as determined from the Calibration Model are given in ***Table 1***. As shown on ***Figure 2***, the average seepage flow for this model is about 525 cu ft/day.

Table 1: Values of permeability used for seepage analysis

Type of soil	**Permeability, k (cm/s)**	**Soil #**
Bedrock	10^{-4}	1
Rockfill	10^{-3}	2
Concrete Face	10^{-4}	3
Concrete/Liner	10^{-11}	4
Grout Barrier	10^{-11}	5
Asphalt	10^{-5}	6
Soil	1.6×10^{-1}	7
Gravel	1.6×10^{-1}	8

The overall calibration check is somewhat crude as the accuracy of the leakage rate available is limited. Specifically, the available leakage rates are such that one cannot distinguish from that lost through the Dike, the bottom of the Upper Reservoir, or evaporation. Also, the configuration of the Dike varies significantly around the perimeter of the Upper Reservoir, whereas we considered only the geometry at the Breach Area as being reasonably indicative of all cross sections. Therefore, we are able to conclude only that our chosen parameters are in the proper range, but parametric runs as described below are necessary to fully understand the range of possible behavior of the Dike.

PARAMETRIC EVALUATIONS

After calibrating the model shown in ***Figure 1*** and adding the HDPE Liner on the upstream face of the Dike, a series of seepage analysis runs were performed on the "Best Estimate" Model shown on ***Figure 3***. Analyses were carried out on each geometry assuming:

a) Water pool elevation = 1598 ft, (Assuming a one foot of settlement)
b) The embankment with a 1 ft concrete/rubber liner with permeability of 10^{-11} cm/s,
c) Two rows of Grout Curtains each 20 feet deep,
d) Asphalt Liner at the bottom of the dam.

The results are summarized in ***Table 2*** and resulting flow net are shown on ***Figures 4 through 12***. The results indicate that the Liner significantly changed the flow regime, dropping the phreatic surface to the level of the interface. The range of properties used in the parametric analysis of the seepage is summarized on ***Figure 3*** and parametric variations in ***Table 2***. It is to be noted that variations of the Best Estimate Model for those parameters determined to be significant with respect to overall seepage and overall flow net configurations are presented in this analysis. Not all parameters comprising the model are shown on the table as several were assessed interactively on the computer screen as not being significant. For example, we varied the permeability of the two Grout Curtains, but no significant changes in the results were observed and therefore, we have not included these analyses in the present calculations.

Table 2: Summary of SEEP2D Analysis Results

Case	Description	Figure No.	Discharge (ft^3/d/ft)	Phreatic Surface	Remark	Filename
Calibration Model	Permeability Calibration	1	40cfs (for entire reservoir length)		Assuming concrete is leaking	
A-1	Liner 10-4	2	525.7	Very High in Rockfill	Other K's unchanged	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-i.sps
Liner Model	Liner 10-11	3	2 cfs (for entire reservoir length)		Other K's unchanged	
B-1	Rockfill 10-2	4	25.9	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-m.sps
B-2	Rockfill 10-3	5	25.9	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-l.sps
B-3	Rockfill 10-4	6	25.9	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-n.sps
B-4	Interface 1.6x10-2	7	24.7	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-q.sps
B-5 (A)	Interface 1.6x10-4	8	20.5	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-r.sps
B-5 (B)	Interface 1.0x10-5	9	19.6	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-s.sps
B-6 (A)	Soil 1.6x10-2 Filter 1.6x10-1	10	25.8	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-o.sps
B-6 (B)	Soil 1.6x10-3 Filter 1.6x10-1	11	25.7	Within interface	Other K's unchanged, Liner 10-11	G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-p.sps

ASSUMPTIONS:

1. The general geometry of the section is taken from ***Reference 1***.
2. Boundary conditions for each trial are marked on ***Figure 3***.
3. Reservoir elevation has been set at 1598 feet for this analysis.
4. The geometry with no concrete/rubber liner has been simplified by setting the permeability of the liner equal to the permeability of the concrete.
5. To simplify the seepage analysis the permeability of concrete, the liner, and the grout barrier are assumed equal to $K=10^{-11}$ cm/sec. This conservative value has been selected to ensure that all the barriers are impermeable. Other permeability values have been assumed either based on the Calibration Model shown on ***Figure 3*** or from the parametric evaluation.
6. The exit face is assumed to be located along the downstream slope of the embankment and the rock-face.

INPUT:

The input parameters required for GMS3.0/SEEP2D program consist of the dam cross-sections, permeability of various soil/rock layers, Maximum upstream water head and exit face of the seepage. ***Figures 1 and 3*** present the cross sections, boundary conditions and other required input parameters.

COMPUTER OUTPUT & RESULTS:

The output flow nets are shown in ***Figures 2 and 4 through 11***. Each geometry is analyzed for upstream water elevation of 1598 ft.

CONCLUSIONS:

The results of these parametric evaluations indicate that the permeability of the soil at the Dike/foundation interface and the Filters has a significant effect on the flow net and the pore pressure on the interface. The seepage is within the soil/filter layer.

FIGURES

FIGURE 1

Model Calibrated for 40 cfs – No HDPE Liner

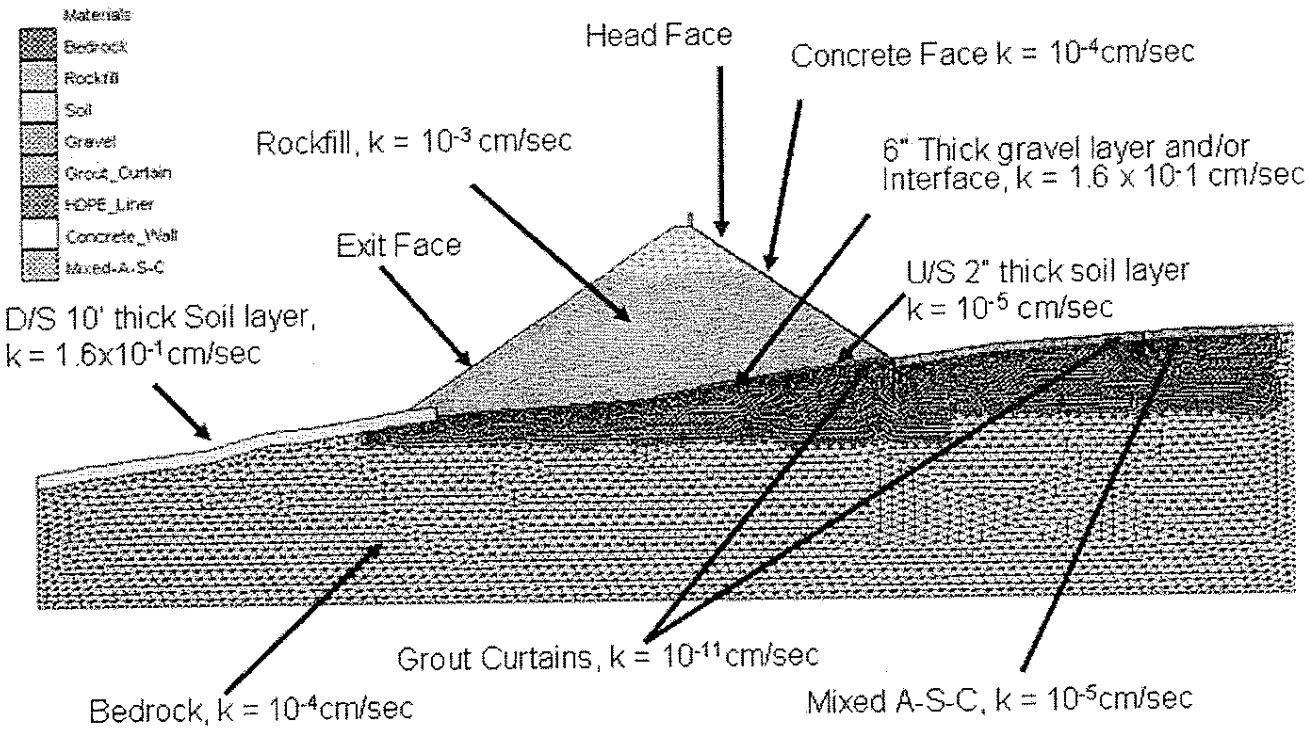
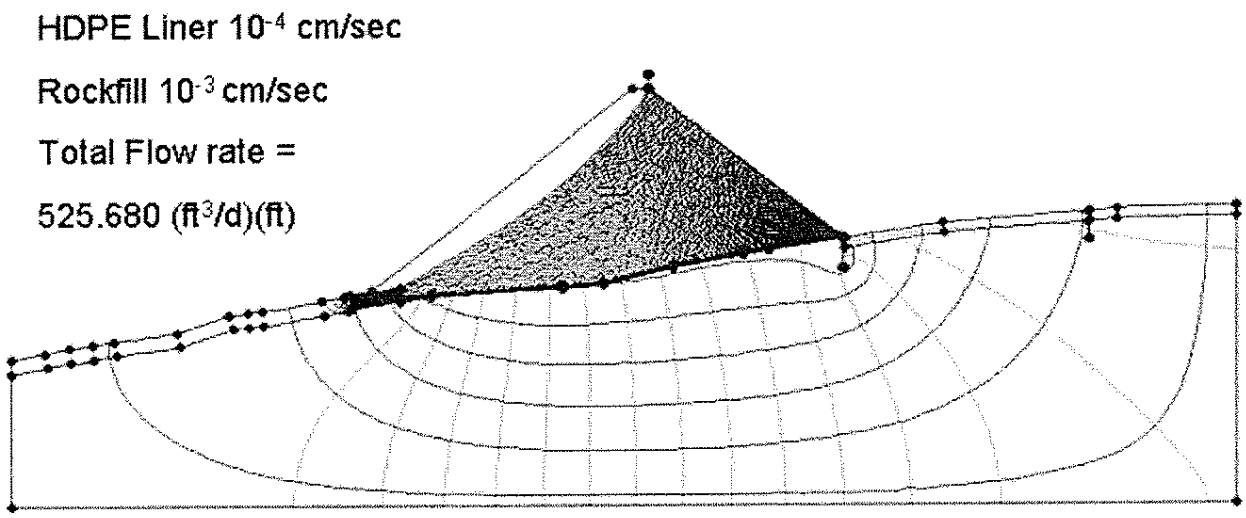


FIGURE 2



G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-i.sps

FIGURE 3

HDPE Liner Used

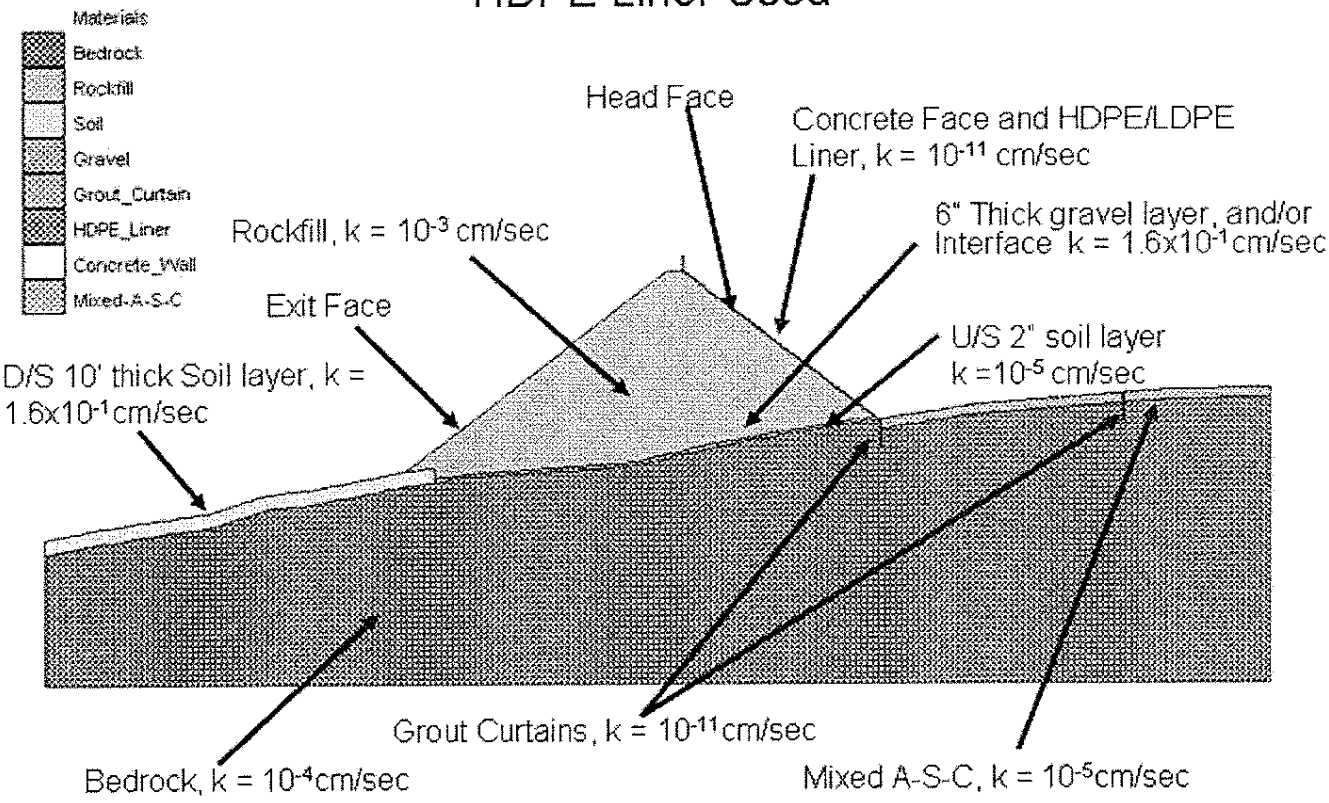
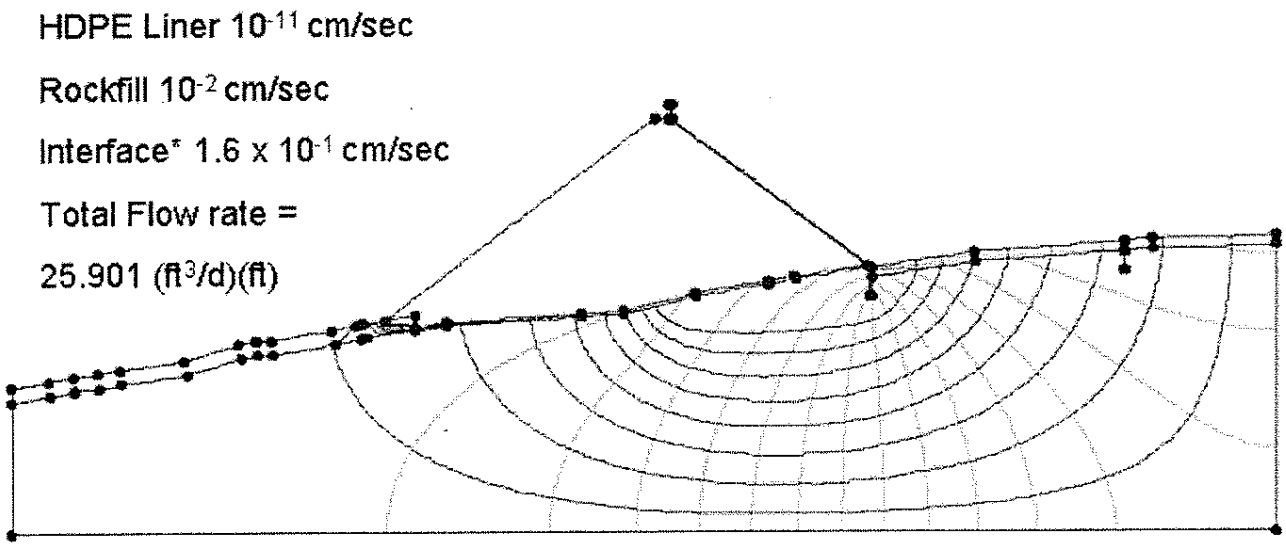


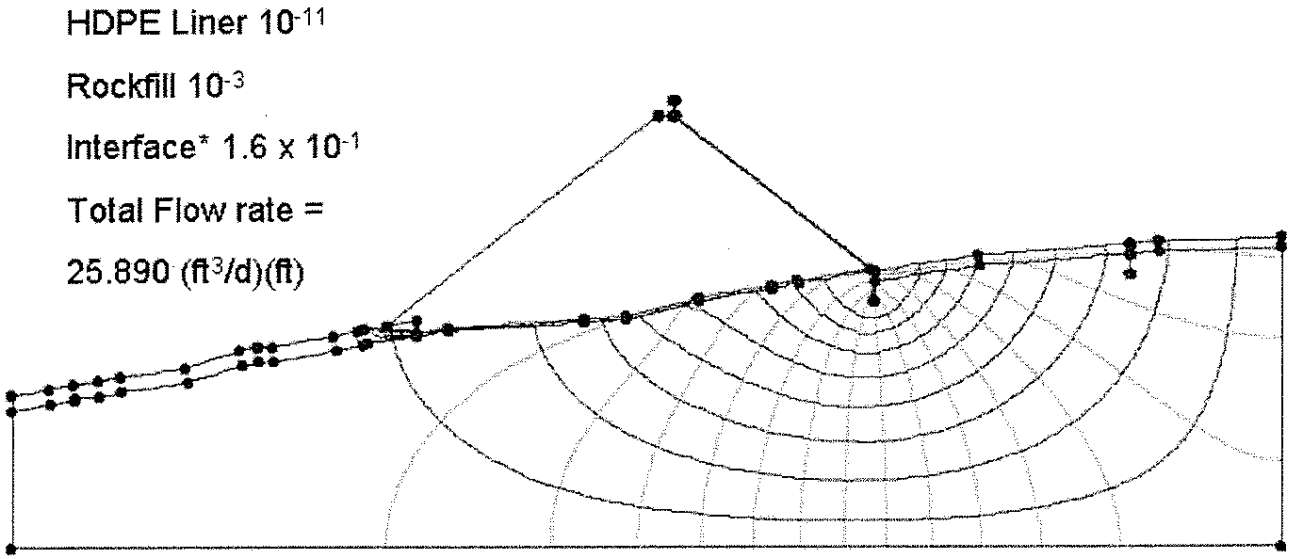
FIGURE 4



*Interface is composed of soil and gravel layer

G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-m.sps

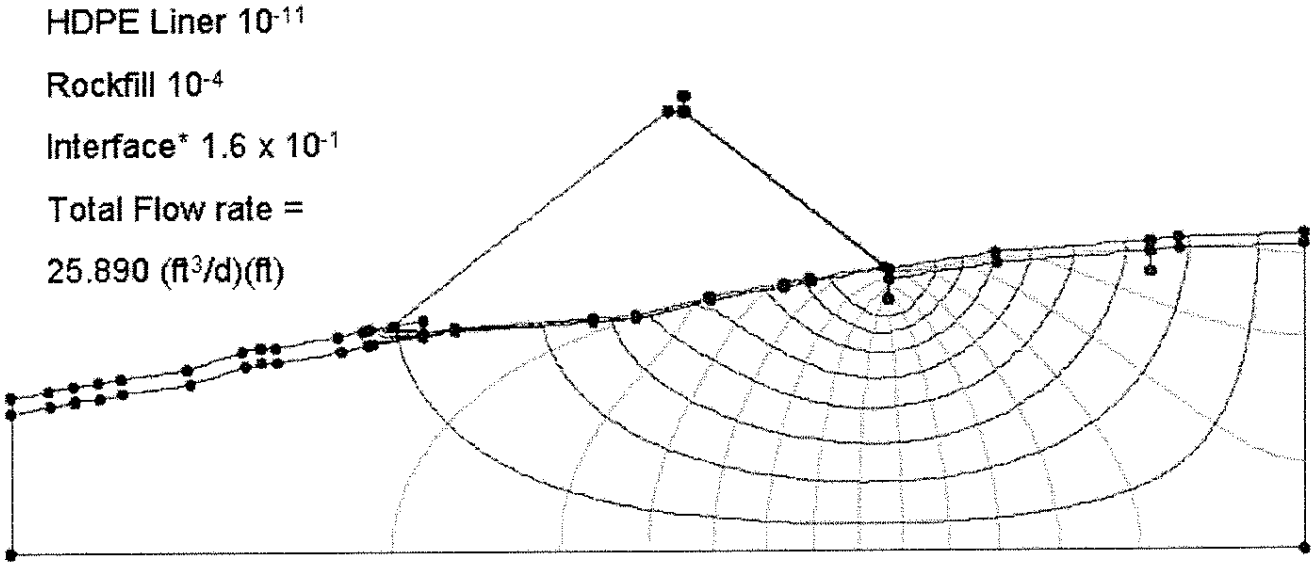
FIGURE 5



*Interface is composed of soil and gravel layer

G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-I.sps

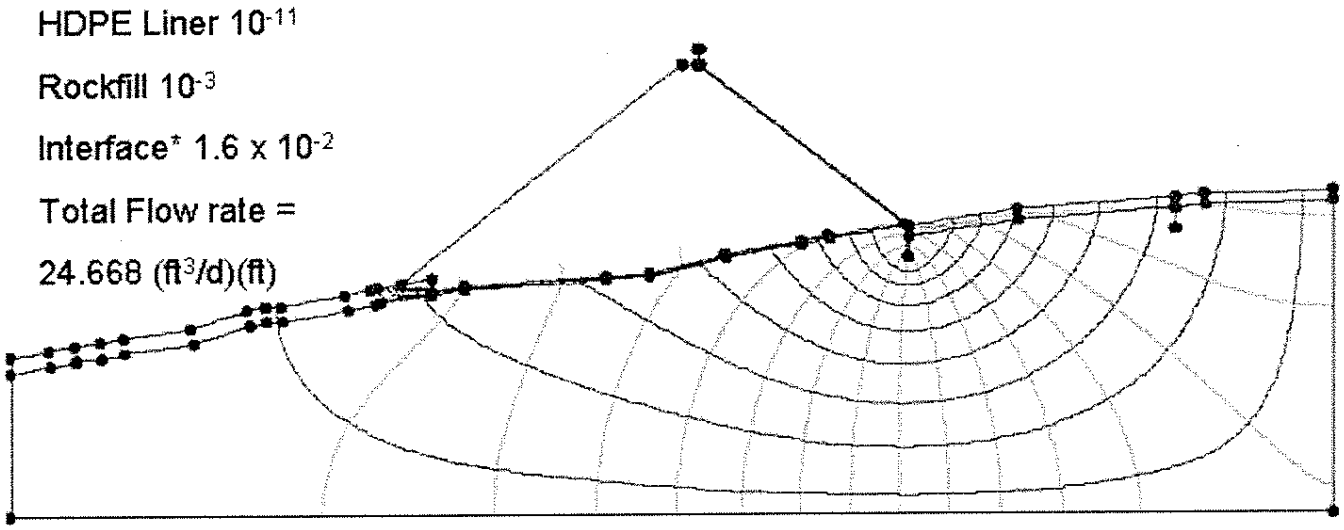
FIGURE 6



*Interface is composed of soil and gravel layer

G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-n.sps

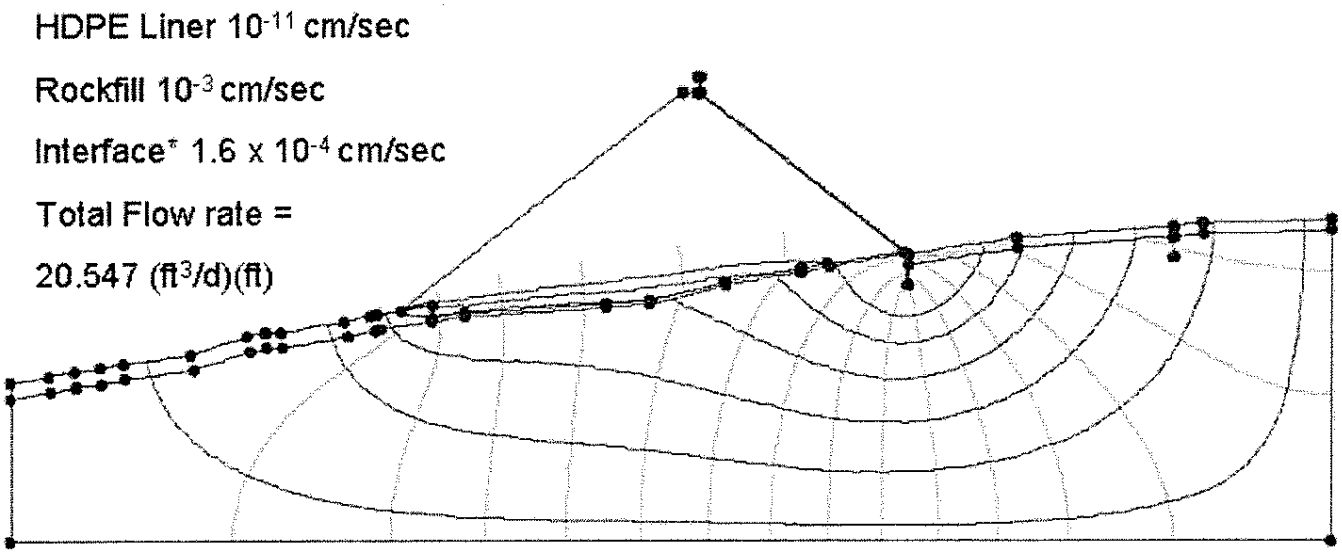
FIGURE 7



*Interface is composed of soil and gravel layer

G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-q.sps

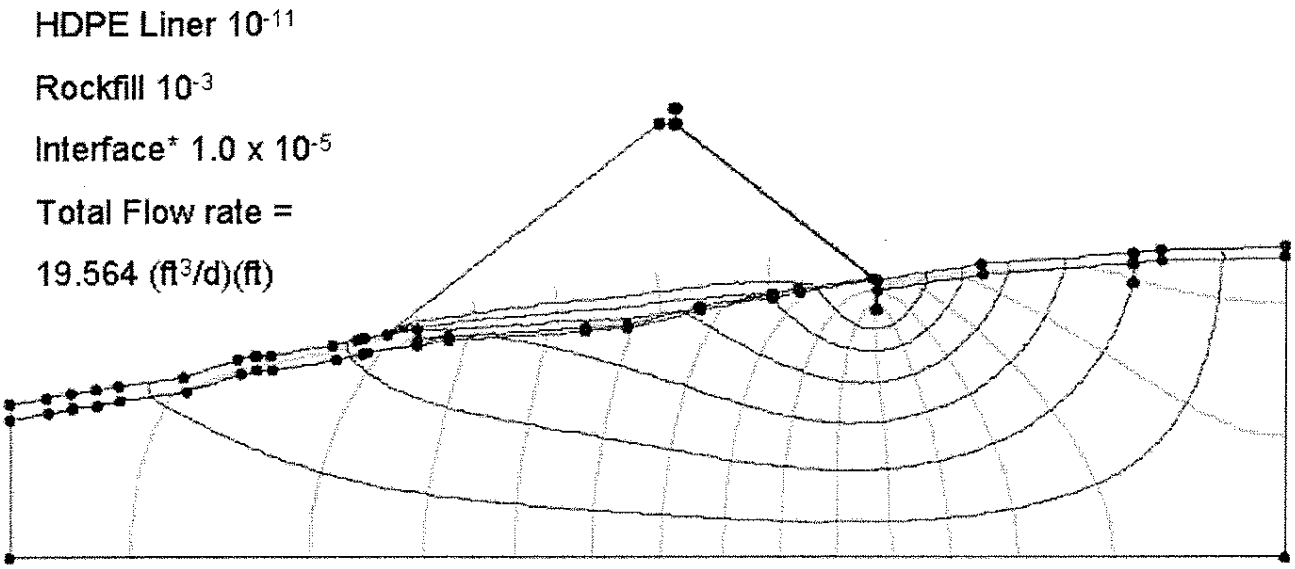
FIGURE 8



*Interface is composed of soil and gravel layer

G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-r.sps

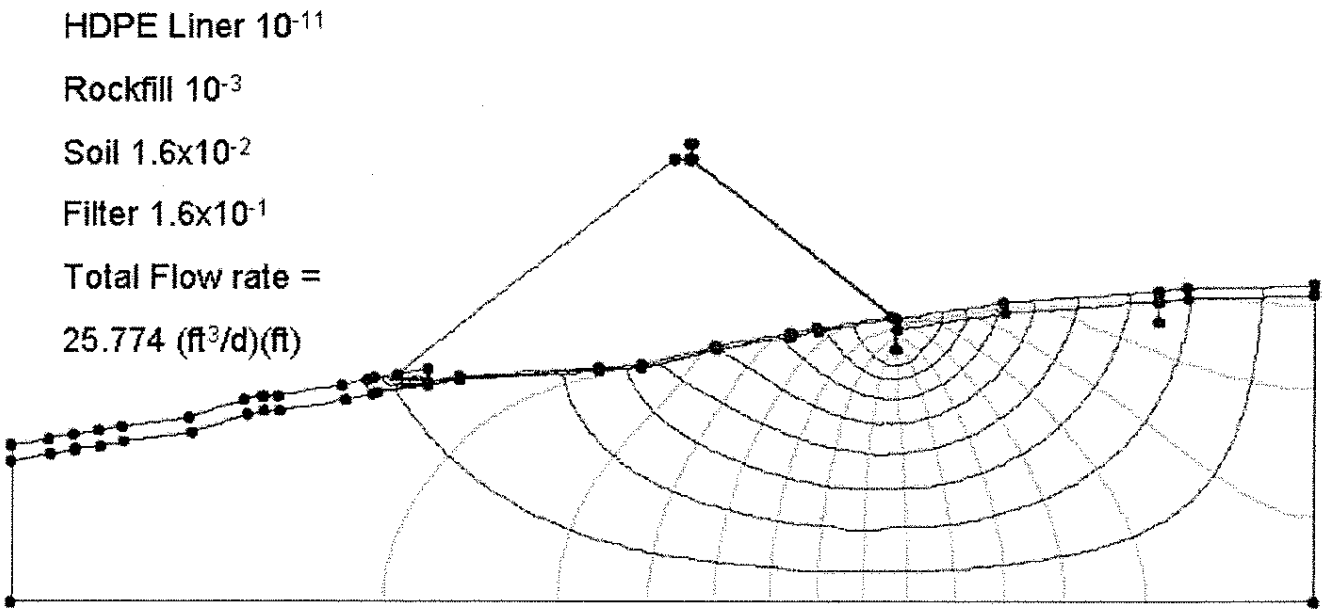
FIGURE 9



*Interface is composed of soil and gravel layer

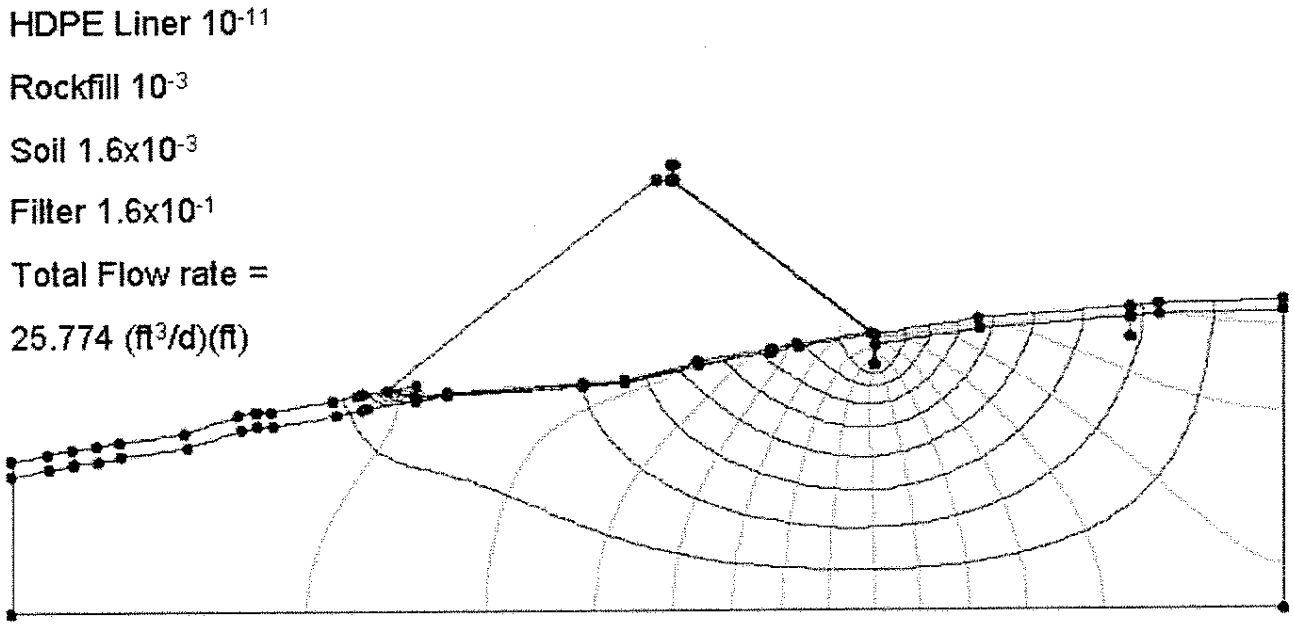
G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-s.sps

FIGURE 10



G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-o.sps

FIGURE 11



G:\KRC\063551 Taum Sauk\Panel 95\Seep2d\seepP95-p.sps

STABILITY ANALYSIS OF FAILED ZONE CALCULATION

OBJECTIVE:

To evaluation of the stability of slope of the failed dike of the Upper Reservoir of Taum Sauk Plant. A typical cross section of the failed dike has been selected from ***Ref. 1*** for analysis. The slope stability analyses are carried out for a range of soil strength properties and possible phreatic surfaces as obtained from the SEEP2D analysis.

REFERENCES:

1. Sverdrup & Parcel Engineering Co., Upper Reservoir, Site Plan and General Design, Taum Sauk Project, Union Electric System, St. Louis, MD, 7-7-60.
2. Surdex Corporation, "Upper Reservoir, Rockfill Dike, Ameran Service Co., Job No. 1501211/62, Date of Photography 12/19/2005.
3. PRCA Calc. "Taum Sauk Plant, Seep2d Analysis of Failed Zone Project", February 2006.
4. Gregory G. H., "GSTABL7 with STEDwin, Slope Stability Analysis", Program Manual Version 2.004, Geotechnical Engineering Software, 2003.
5. FFC Safety Report Prepared by J. Barry Cooke, Consulting Engineer, Taum Sauk Project, Upper Dam, Union Electric Company, 7-26-1968.
6. 1998 Review of Safety Report (Seventh Five-Year Report), Inspection of Project Works, Taum Sauk Project, FERC, Licensed Project No. 2277, Union Electric Company, St. Louis, Missouri, Prepared by J. Barry Cooke and Arthur G. Strassburger, March 1998.
7. 8th FERC Part 12 Independent Report, Taum Sauk Project, FERC, Project No. 2277, Prepared for AmerenUE, Prepared by MWH, August 2003.
8. PCRA Calc. "Estimate of Parapet Wall Overflow Conditions" , February 2006.

METHODOLOGY:

The slope stability analysis for the Dike was performed using the computer program GSTABL7 with STEDwin (Gregory 2003). This program was originally developed by Purdue University for the Indiana State Highway Commission in 1986 and later revised and marketed by Geotechnical Engineering Software Company. This program estimates the factor of safety against slope failure utilizing a two-dimensional limiting equilibrium method. The estimate of the factor of safety against slope instability is performed using the Simplified Bishop method of slices, which is applicable to circular shaped failure surfaces, the Simplified Janbu method of slices, which is applicable to failure surfaces of a general shape, or Spencer's method of slices which is applicable to surfaces having a circular and/or random failure surfaces. The analysis performed by RIZZO is based on the Modified Bishop Method. Information about the theory used in GSTALB7 can be found User's Manual (Ref. 4). This program has been verified in accordance with RIZZO's Quality Assurance Program.

ASSUMPTIONS:

(1) Typical Section:

The Parapet Wall Segment No. 95, located approximately in the middle of the failed section, is selected for this stability analysis. The bedrock elevations and the general cross-section are developed from ***References 1 and 2***. The crest of the dike is located at Elevation 1588 ft (assuming rockfill settlement of a foot). A ten feet high concrete wall has been constructed on the top of the crest to allow for additional storage. The dike was a rockfill berm on a bedrock foundation. A concrete lining covers the entire upstream slope. In 2004, HDPE/LDPE was installed on the top of the concrete lining to minimize the seepage. Two rows of 20 ft deep grout barriers are located at the heel of the upstream slope. A seepage analysis (***Ref. 3***) was performed to obtain the phreatic surface applicable for the pre-failure analyses. The typical cross-section used for stability analyses is given in ***Attachment B***.

(2) Phreatic Surface:

Following phreatic surfaces were assumed for the analysis:

Condition A – Flownet condition prior to installation of geosynthetic liner was established from SEEP2D, assuming a leaking concrete lining barrier. The Flownet of this model is shown in ***Figure No. 2 of Reference 3,*** and top phreatic surface is shown in the Slope Stability analysis results (***Attachment A***).As shown in these figures, more than 90% of the dike is found to be saturated for this condition of analysis.

Condition B – Flownet condition after installation of geosynthetic liner, assuming an impermeable barrier (***Figure No. 3 of Reference 3***). We have used a variety of phreatic surfaces in a parametric manner to capture the range of possible seepage conditions.

Condition C – Flownet condition during over topping event where the phreatic surface is interactively varied with a series of runs starting with the Condition B case until a phreatic surface is located where the factor of safety against failure is 1.0.

Condition D – Flownet condition after installation of geosynthetic liner, assuming permeability of the interface material (k = higher than the rockfill and impermeable barrier (***Figure No. 9 of Reference 3***)

(3) Material Properties:

Table 1 gives the strength properties selected for the lower bound estimate, best estimate and upper bound estimate. These properties are depicted in Attachment B.
Two slide zones were found on the D/S toe of the Upper Reservoir; one is located at the south side and the other one at south-east corner of the reservoir. Those slides were analysis, assuming fully saturated conditions (the slides are located below the U/S bottom elevation of the reservoir) and infinite slope. The calculation is given in Attachment A. Based on these calculations the best estimate soil properties were $\Phi = 33^0$ for soil fill / natural soil and $\Phi = 43^0$ for rockfill.

TABLE 1: SUMMARY OF SOIL AND ROCK PROPERTIES

Material	Lower Bound	Best Estimate	Upper Bound	Basis
D/S Foundation Soil at toe	c = 0 $\phi = 30^o$	c = 0 $\phi = 33^o$	c = 0 $\phi = 35^o$	Field Observations & Lab Tests
Filter Material/ Interface	c = 0 $\phi = 30^o$	c = 0 $\phi = 33^o$	c = 0 $\phi = 35^o$	Field Observations
Bedrock	c = 3000 psf $\phi = 50^o$	c = 3000 psf $\phi = 50^o$	c = 3000 psf $\phi = 50^o$	Judgment No parametrics
U/S Foundation Soil at toe	c = 0 $\phi = 30^o$	c = 0 $\phi = 33^o$	c = 0 $\phi = 35^o$	Field Observations & Lab Tests
Concrete Face	c = 3000 psf $\phi = 50^o$	c = 3000 psf $\phi = 50^o$	c = 3000 psf $\phi = 50^o$	Judgment No parametrics
Rockfill	c = 0 psf $\phi = 41^o$	c = 0 $\phi = 43^o$	c = 0 $\phi = 45^o$	LB – suggested by BOC BE – Back calculated from surface slides UB – Back calculated from Breach Area

(4) Estimated Time of Failure:
The time of failure is estimated by calculating the time it takes to saturate the rockfill up to the phreatic surface in the dike to a level where the factor of safety against sliding is 1.0 for Condition C. The height of the phreatic surface is estimated by trial and error from GSTABL for each of the 12 cases analyzed. The phreatic surface in the dike is assumed to be of the same level from U/S to D/S ends, and the bottom five feet of the rockfill above bedrock of the cross section at wall segment 95 is assumed to be saturated. A one foot wide cross section of the dam at wall segment 95 is considered. An effective porosity of 15% is used for the rockfill in the dam (assuming total porosity of 20% with 5% reduction due to natural moisture). The complete analysis of estimated time of failure is given in Attachment D.

STABILITY ANALYSIS:

Forty eight separate analyses have been run on the typical cross section. The analyses are carried out for four phreatic conditions listed above and variation of soil properties as listed in Table 1. Each condition is analyzed for deep circular failure, deep wedge failure, circular toe failure and circular toe wedge failure.

RESULTS:

The slope stability analysis results are summarized in Table 2, 3, 4 and 5 for various assumed phreatic conditions. Plots of the ten most critical failure surfaces plots are given in Attachment B and computer output results are in Attachment C.

TABLE 2: SUMMARY OF FACTORS OF SAFETY FOR CONDITION A

PHREATIC SURFACE	LB PROPERTIES	BE PROPERTIES	UB PROPERTIES	FAILURE TYPE
Condition A	0.92	1.01	1.09	Deep Wedge
Condition A	0.98	1.05	1.12	Deep Circle
Condition A	1.06	1.15	1.13	Toe Wedge
Condition A	1.11	1.13	1.21	Toe Circle

TABLE 3: SUMMARY OF FACTOR OF SAFETY FOR CONDITION B

PHREATIC SURFACE	LB PROPERTIES	BE PROPERTIES	UB PROPERTIES	FAILURE TYPE
Condition B	1.24	1.35	1.45	Deep Wedge
Condition B	1.23	1.33	1.42	Deep Circle
Condition B	1.10	1.21	1.30	Toe Wedge
Condition B	1.11	1.23	1.32	Toe Circle

TABLE 4: SUMMARY OF PHREATIC SURFACE HEIGHT FOR CONDITION C AND FACTOR OF SAFETY = 1.00

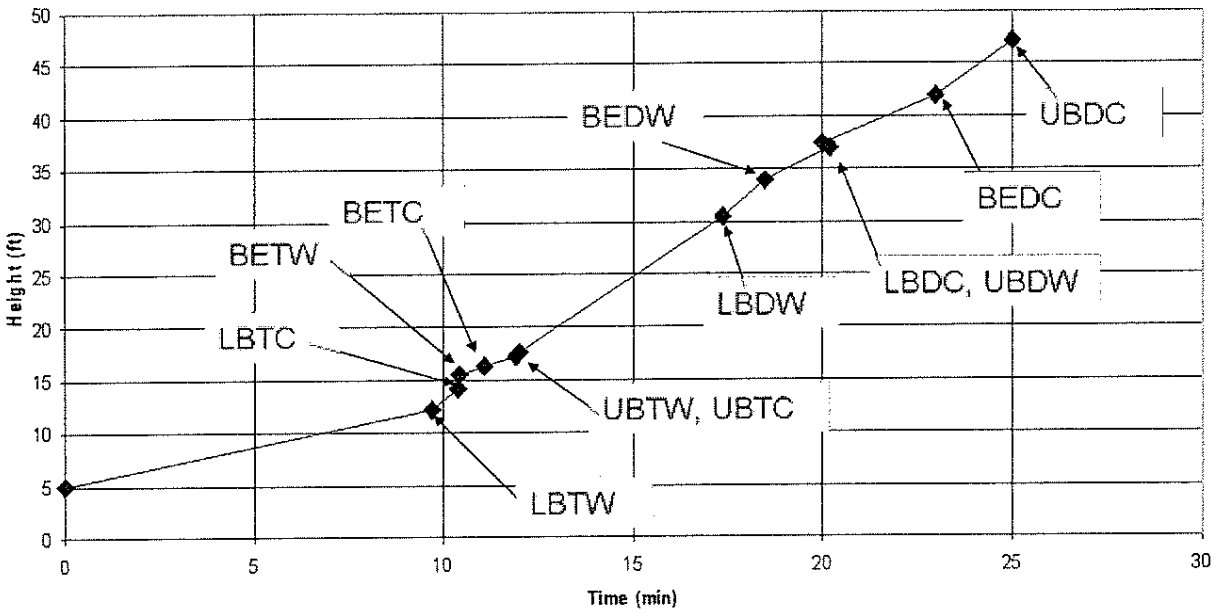
LB PROPERTIES (1) (FEET)	BE PROPERTIES(1) (FEET)	UB PROPERTIES(1) (FEET)	FAILURE TYPE	ESTIMATED TIME OF FAILURE (BE PROPERTIES) (2)
31	34	37	Intermediate to Deep Wedge	18 min
37	42	47	Deep Circle (Infinite Slope)	23 min
12	16	17	Toe Wedge	11 min
14	16	17	Toe Circle	12 min

Notes:
1.The height of the phreatic surface is measured above the bedrock directly at the downstream toe.
2. The estimated time of failure is our estimate of when the failure type occurred. See ***Appendix D.***

TABLE 5: SUMMARY OF FACTORS OF SAFETY FOR CONDITION D

PHREATIC SURFACE	LB PROPERTIES	BE PROPERTIES	UB PROPERTIES	FAILURE TYPE
Condition D	1.16	1.26	1.36	Deep Wedge
Condition D	1.14	1.22	1.31	Deep Circle
Condition D	0.91	1.01	1.08	Toe Wedge
Condition D	0.98	1.09	1.17	Toe Circle

FIGURE 1: HEIGHT OF SATURATION VS. TIME FOR CONDITION C



CONCLUSIONS:

1. The results presented in ***Table 2*** indicate that the Rockfill Dike prior to installation of the geosynthetic liner in the Breach Area was marginally stable and possibly near a failure condition in some locations where the material properties were in the range of selected Lower Bounds.
2. The results presented in ***Table 3*** indicate that the Rockfill Dike after installation of the geosynthetic liner in the Breach Area was marginally stable and would not meet FERC criteria for stability under static conditions for maximum storage pool (i.e., FS=1.5)(FERC, 1991). Although dynamic analyses have not been run, past experience suggests a high probability of failure under significant earthquake.
3. The results presented in ***Table 4*** and ***Figure 1*** indicate that the Rockfill Dike failed when the phreatic surface was in the range of 12 feet to 17 feet above the bedrock at the toe. This

occurred in the range of 10 to 13 minutes after the Upper Reservoir level reached El. 1597.00. The results also indicate that while failure began at the toe, probably exacerbated by run off down the slope, it rapidly progressed up slope within minutes.

4. The results presented in ***Table 5*** indicate that with the HDPE Liner in place, the rockfill slope is marginally stable and the factor of safety values are lower than for Condition B.

ATTACHMENT – A

Back Calculations of Soil and Rockfill Material Parameters

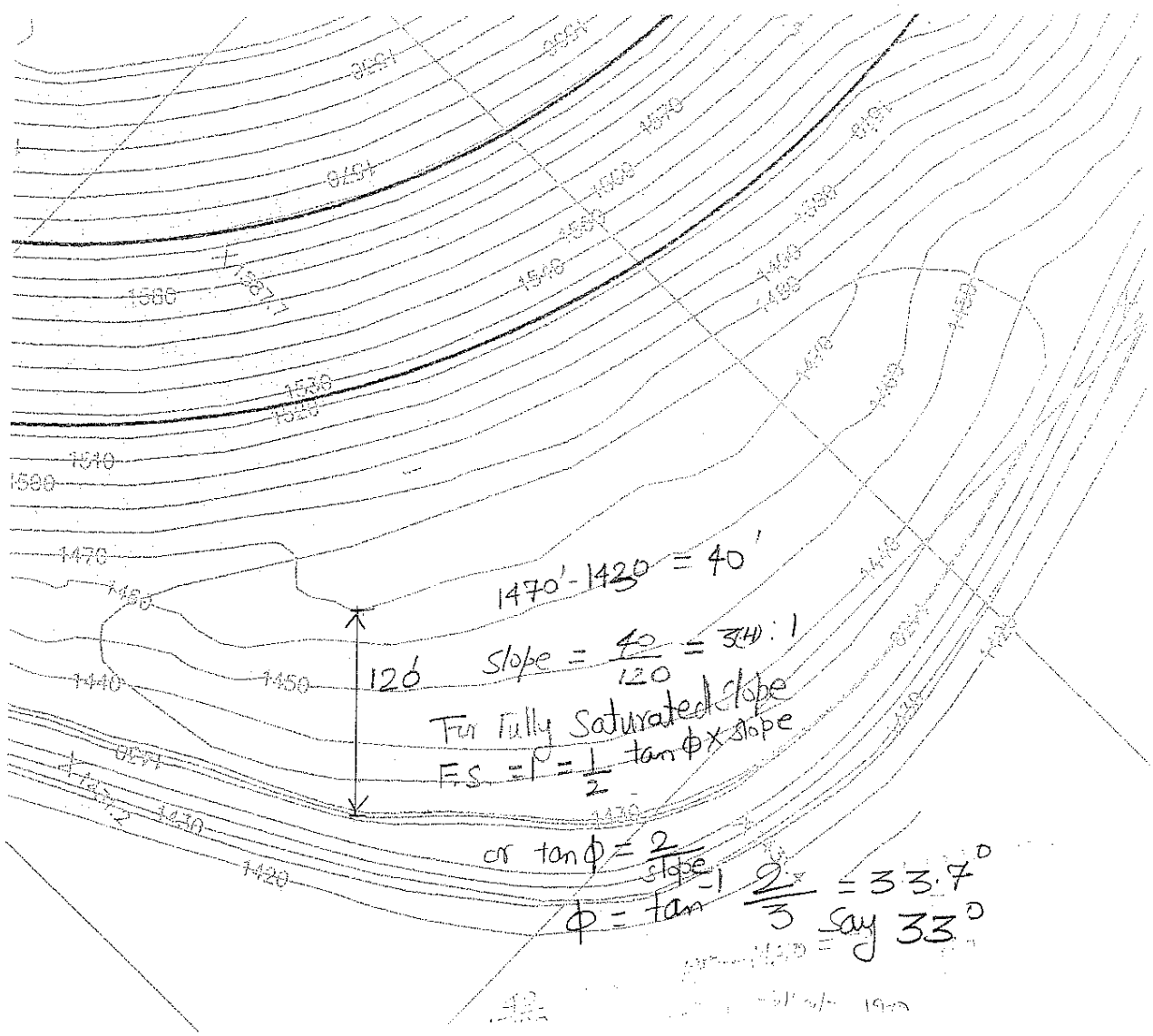
By UD Date 2/13/06 Subject Taum Sauk Upper Reservoir Sheet No. 8 of 43

Chkd. By JPG Date 3/20/06 Estimation of Fill Properties Proj. No. 06-3551

Objective: Estimate the Angle of Internal Friction (ϕ) of Rockfill & Soil Embankment/Natural Soil Fill from the past slides of soil/rockfill embankment at Taum Sauk

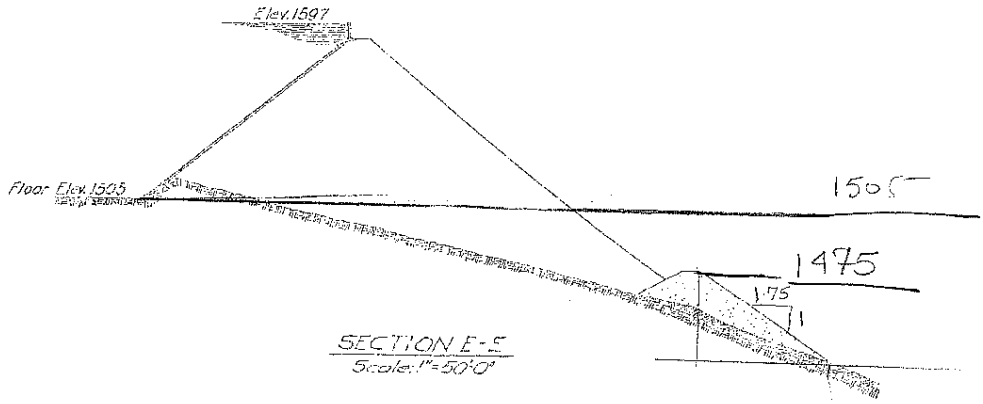
Soil Embankment

Location of Slide: The location of the slide and most critical failure plane is shown below for soil embankment



Soil Fill/Natural Soil Slide

The section E-E of the original Drawing is taken at close vicinity of the failure area.



According to the section E-E the soil berm is constructed below El. 1475. The failure has occured below the El. 1470 and therefore, it is presumed that this slide failure has occured in soil berm. The reservoir bottom near the slide failure surface is 1505 ±. The critical failure slope is likely to be saturated.

Assuming infinite slope the F.S. (H.Y. Huang 1983)

$$= (1 - r_u) \frac{\tan \phi}{\tan \alpha}$$

$$\tan \alpha = \frac{1470 - 1430}{120}$$

$$= 0.333$$

$r_u = 0.5$ for fully saturated condition

$$\tan \phi = \frac{\tan \alpha}{(1 - 1/2)} \quad \text{for } F.S. = 1$$

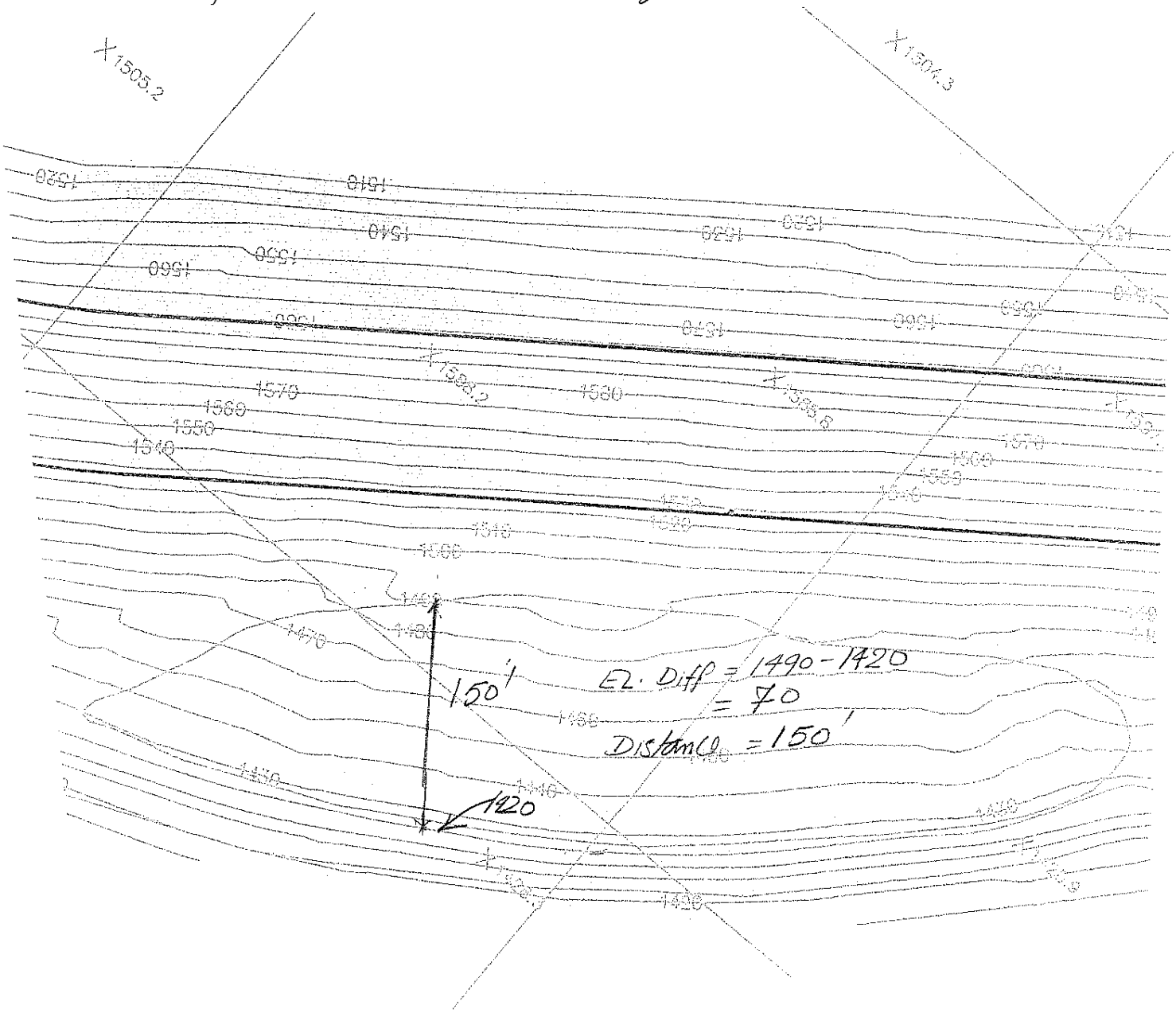
$$\phi = 33.7^\circ$$

say $\underline{33^\circ}$

By UD Date 2/13/06 Subject Turn Sauk Upper Reservoir Sheet No. 11 of 43

Chkd. By JPG Date 3/20/06 Estimation of Fill Properties Proj. No. 06-3551

Rockfill Embankment: The location of Critical failure plane of Rock Embankment is given below:



Rockfill Slide

$$\tan\alpha = \frac{70}{150}$$

Assuming fully saturated conditions as the reservoir bottom is at El. 1505. and the slide failure is below El. 149

$$\tan\phi = \frac{\tan\alpha}{\left(1-\frac{1}{2}\right)}$$

$$= \frac{70}{150 \times 0.5}$$

$$\phi = 43^\circ$$

Therefore Assume $\phi = 33^\circ$ for soil fill and natural soil and for rockfill 43°

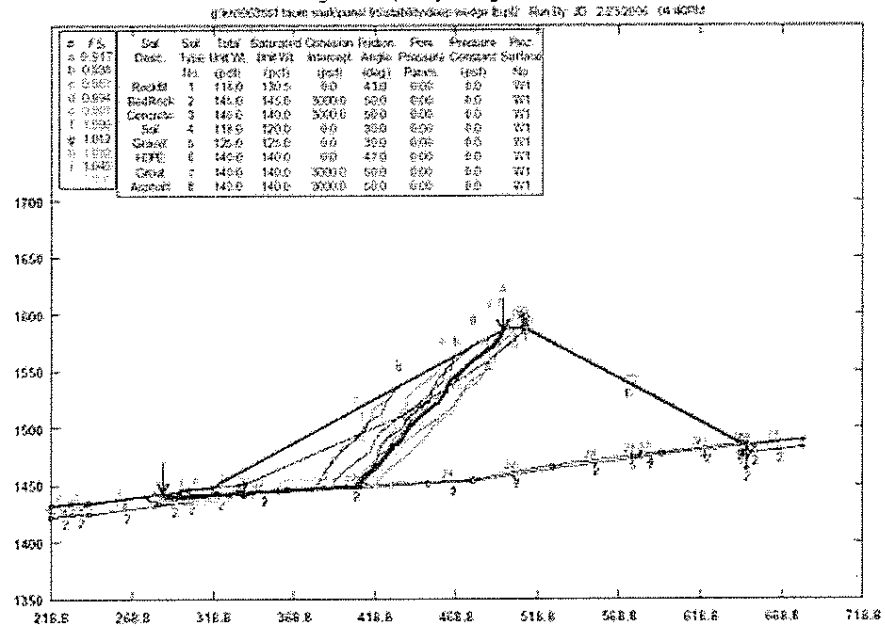
Reference: Stability Analysis of Earth Slopes by Yang H. Huang, Van Nostrand Reinhold Company, New York, 1983, Page 72.

ATTACHMENT – B
Slope Stability Analysis Results

Condition A Leaking Liner

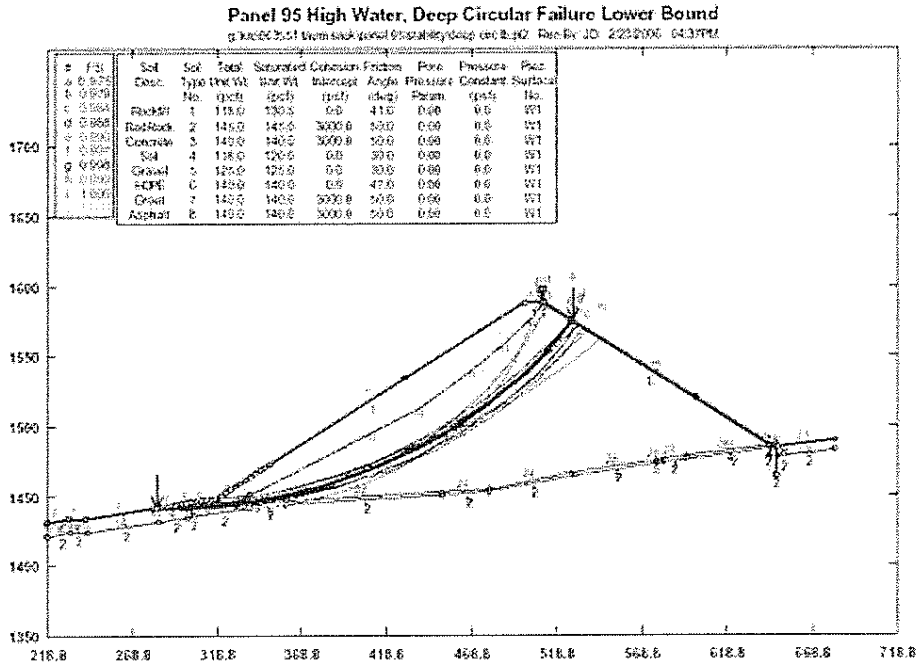
Lower Bound

Panel 95 High Water, Deep Wedge Failure Lower Bound



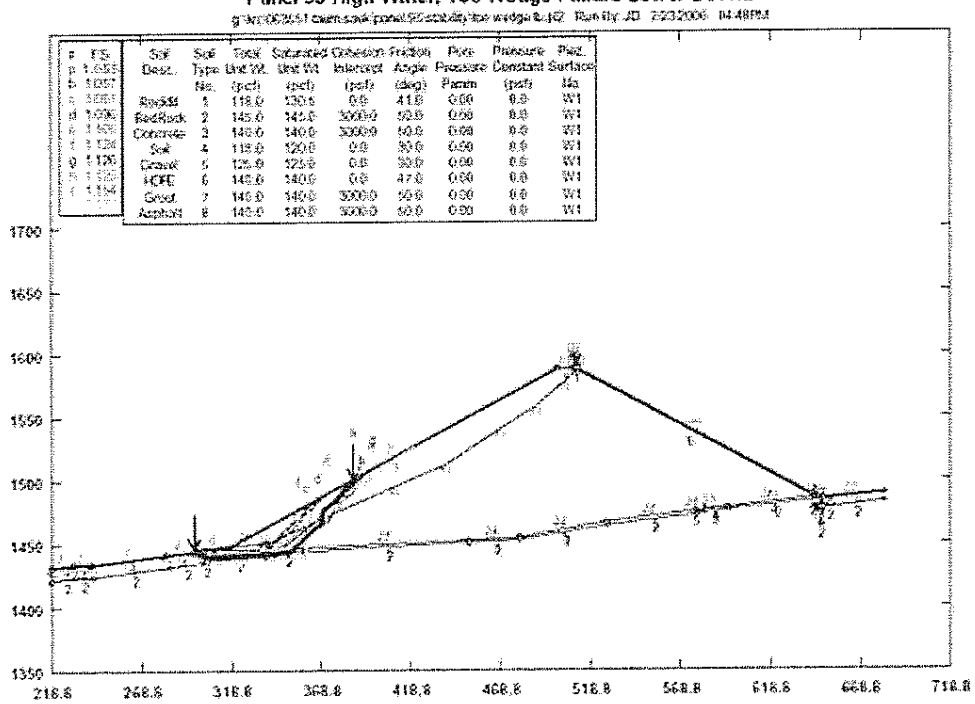
GSTABL7 v.2 FSmin=0.917
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 High Water, Deep Circular Failure Lower Bound



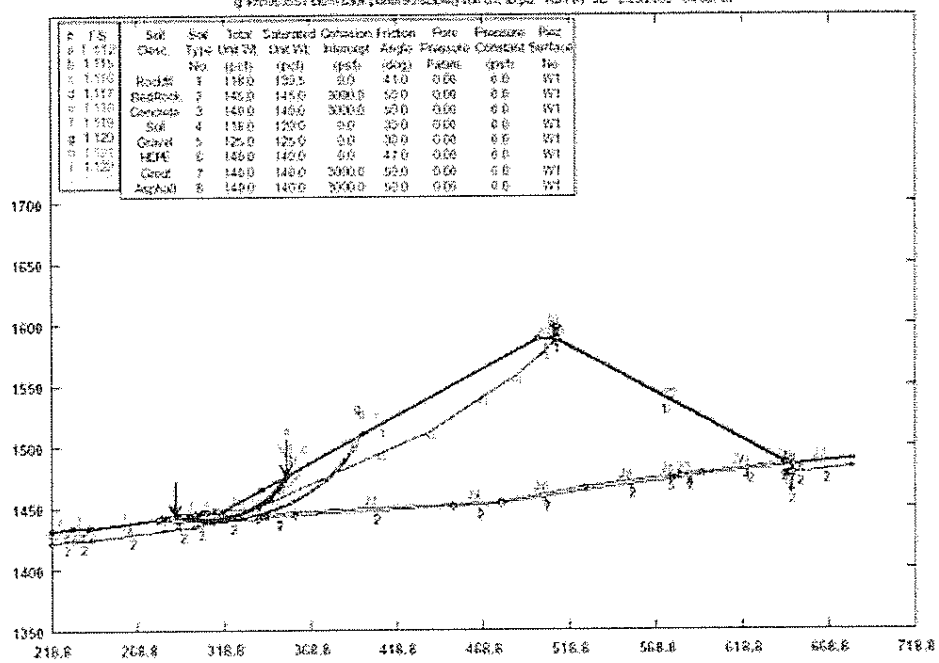
GSTABL7 v.2 FSmin=0.975
Safety Factors Are Calculated By The Modified Bishop Method

Panel 95 High Water, Toe Wedge Failure Lower Bound



GSTABL7 v.2 FSmin=1.055
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 High Water, Toe Circular Failure Lower Bound

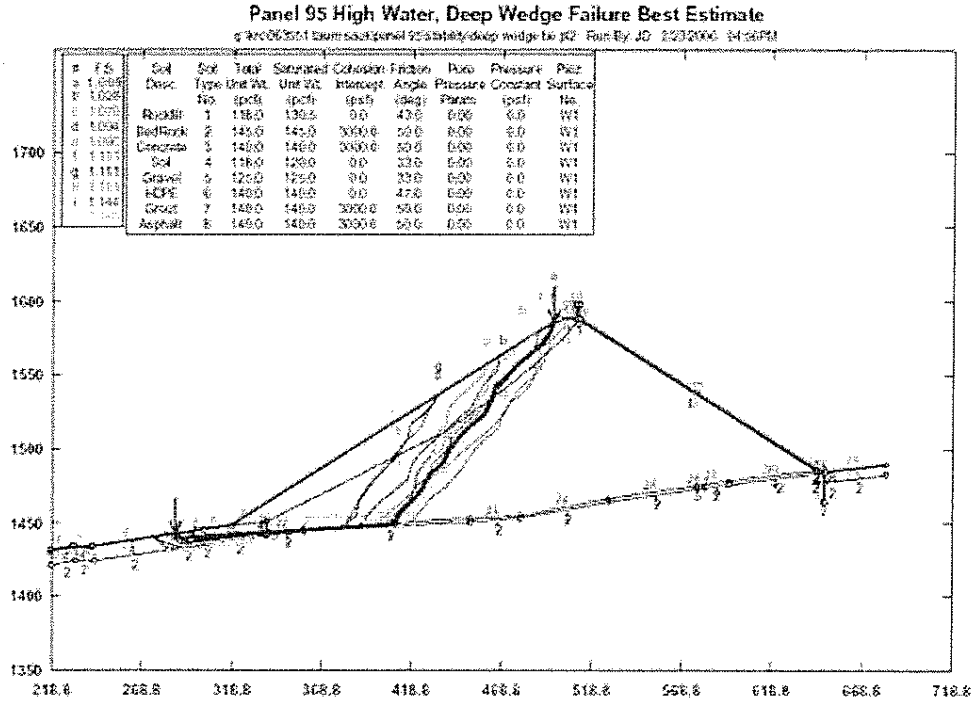


GSTABL7 v.2 FSmin=1.112
Safety Factors Are Calculated By The Modified Bishop Method

Condition A Leaking Liner

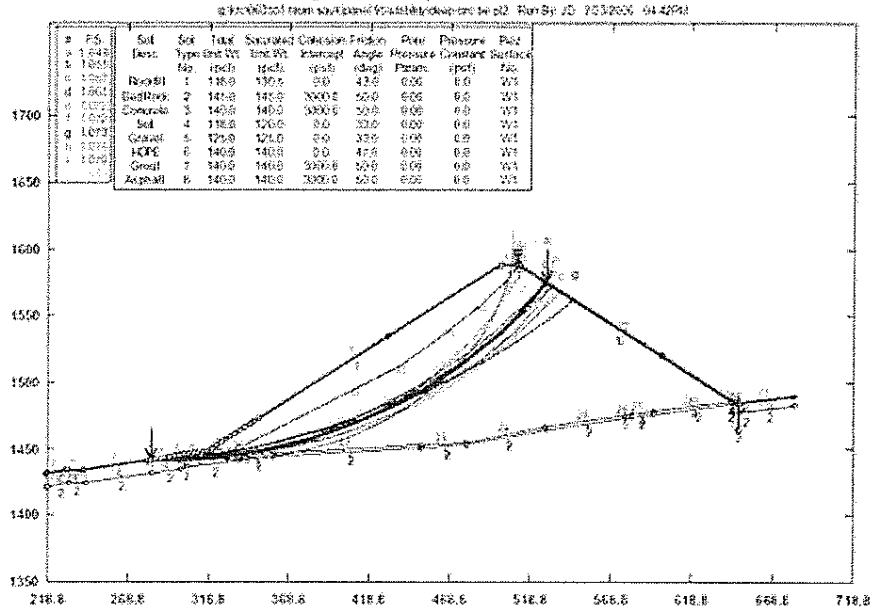
Best Estimate

Panel 95 High Water, Deep Wedge Failure Best Estimate



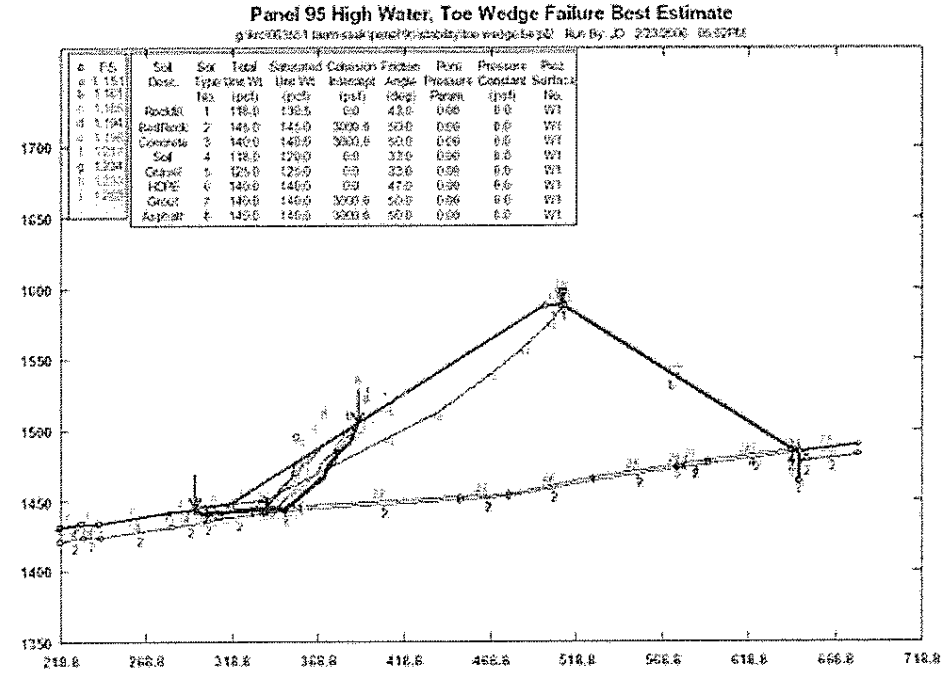
GSTABL7 v.2 FSmin=1.009
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 High Water, Deep Circular Failure Best Estimate



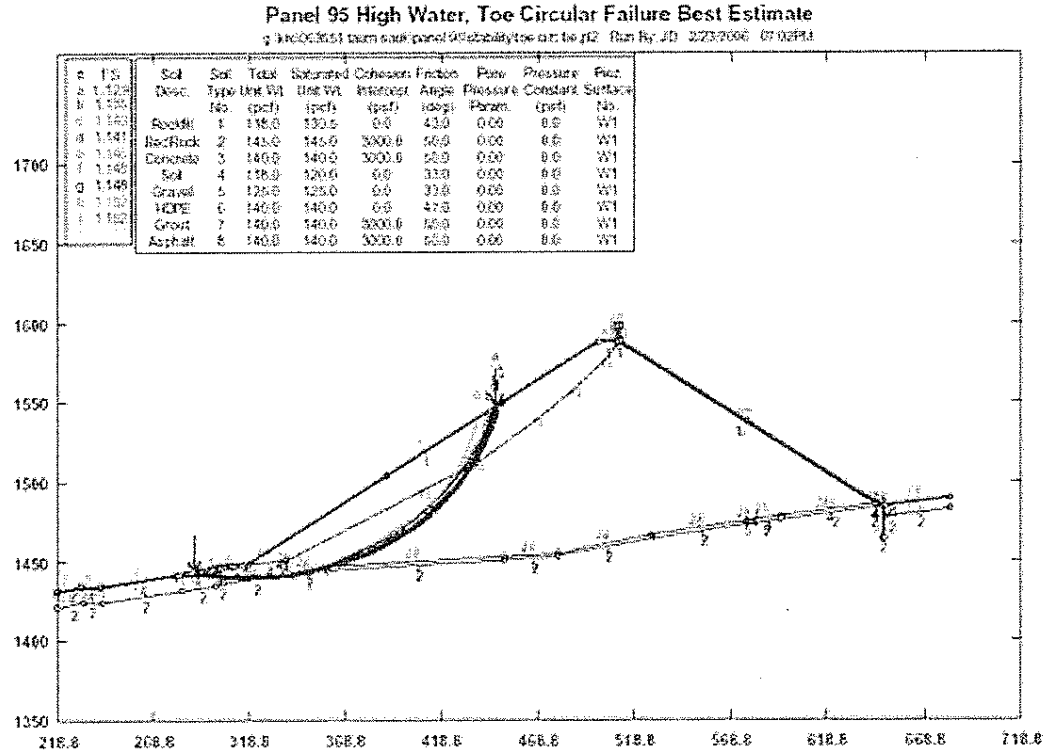
GSTABL7 v.2 FSmin=1.645
Safety Factors Are Calculated By The Modified Bishop Method

Panel 95 High Water, Toe Wedge Failure Best Estimate



GSTABL7 v.2 FSmin=1.151
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 High Water, Toe Circular Failure Best Estimate

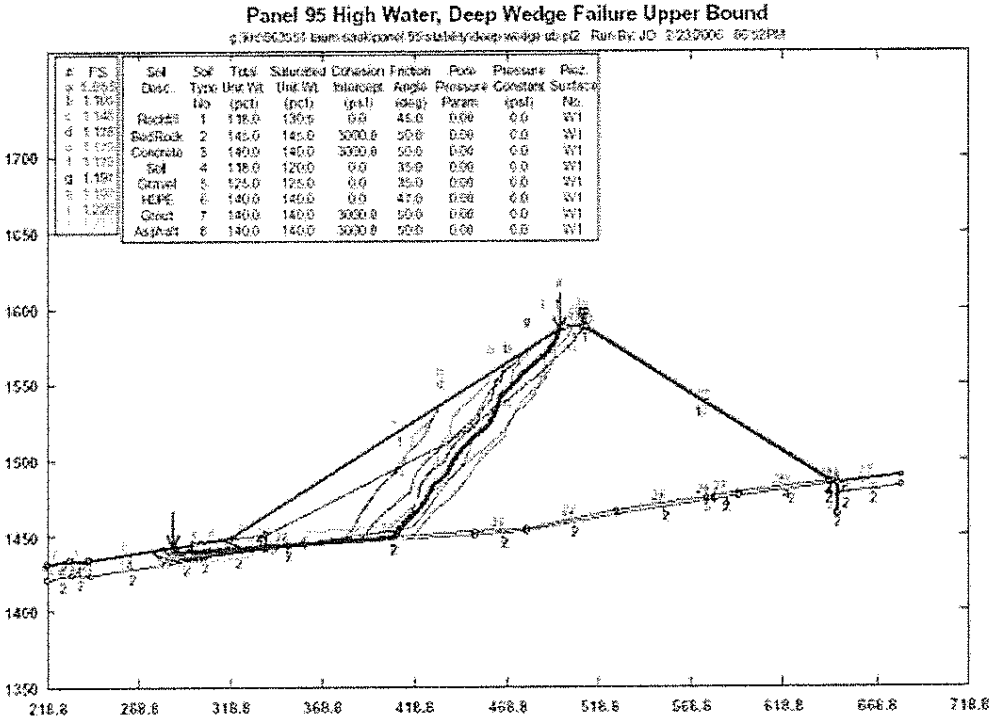


GSTABL7 v.2 FSmin=1.129
Safety Factors Are Calculated By The Modified Bishop Method

Condition A Leaking Liner

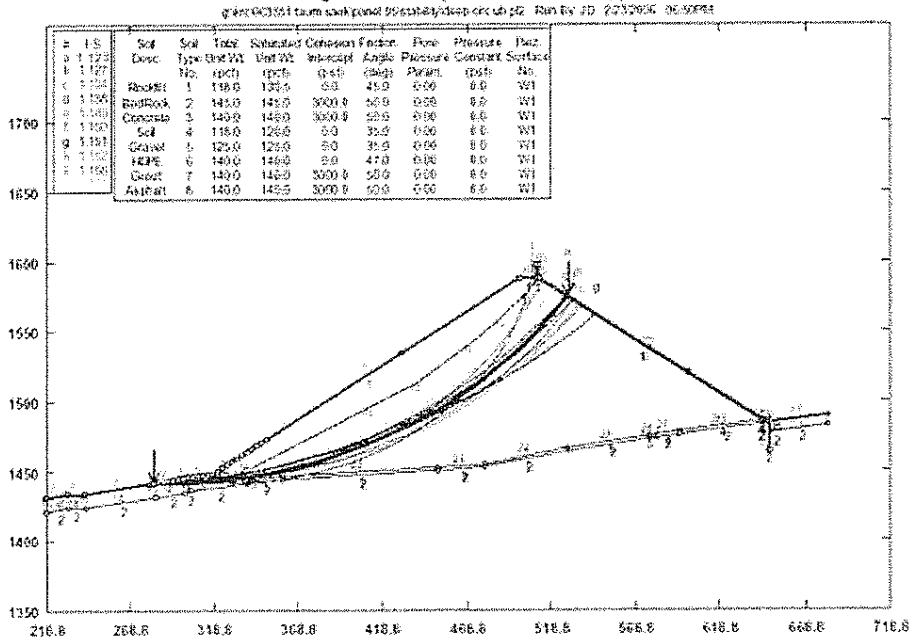
Upper Bound

Panel 95 High Water, Deep Wedge Failure Upper Bound



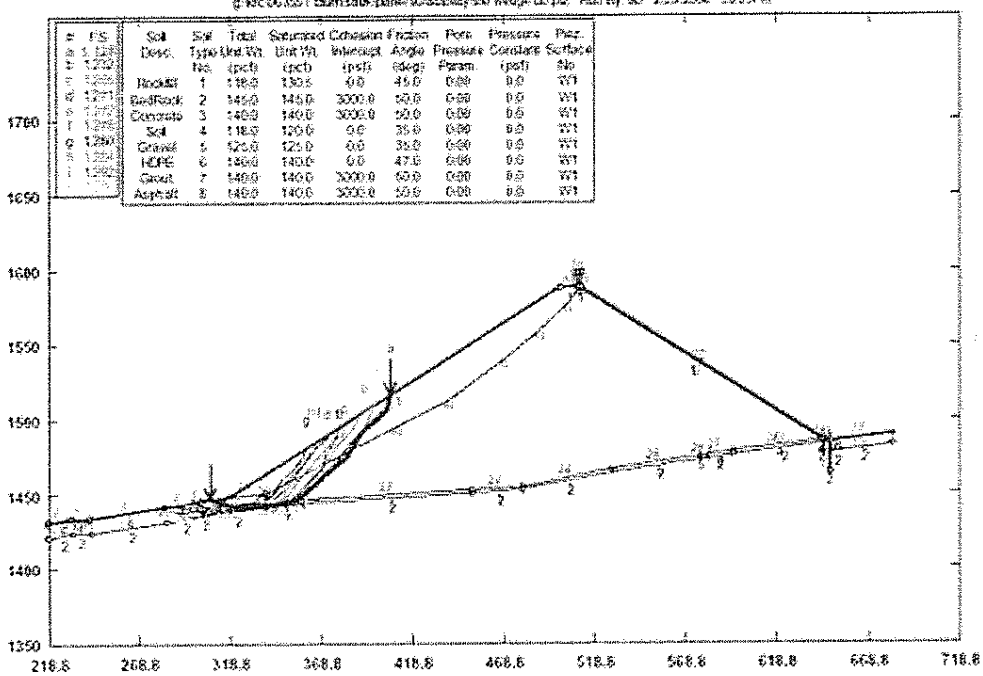
GSTABL7 v.2 FSmin=1.085
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 High Water, Deep Circular Failure Upper Bound



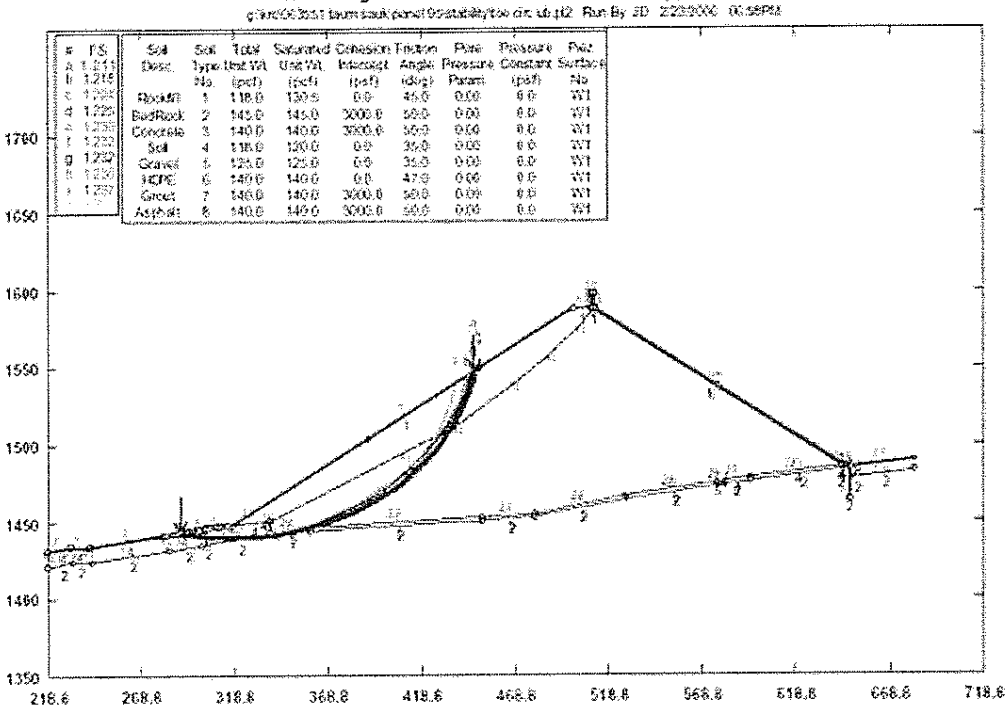
GSTABL7 v.2 FSmin=1.123
Safety Factors Are Calculated By The Modified Bishop Method

Panel 95 High Water, Toe Wedge Failure Upper Bound



GSTABL7 v.2 FSmin=1.128
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 High Water, Toe Circular Failure Upper Bound

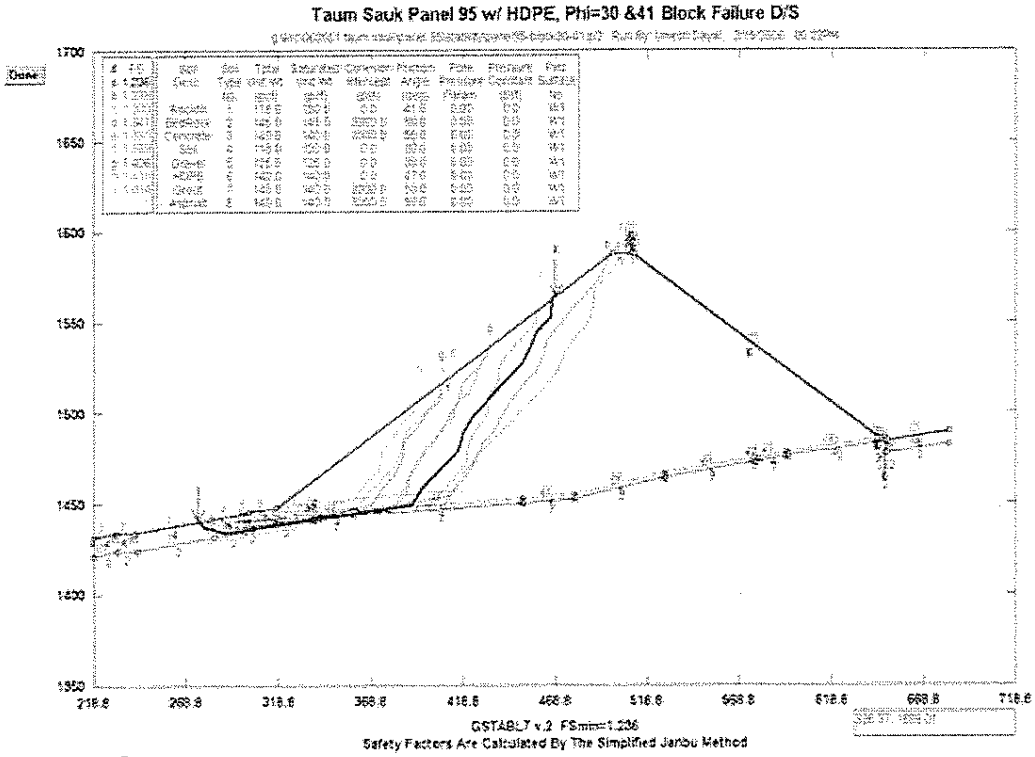


GSTABL7 v.2 FSmin=1.211
Safety Factors Are Calculated By The Modified Bishop Method

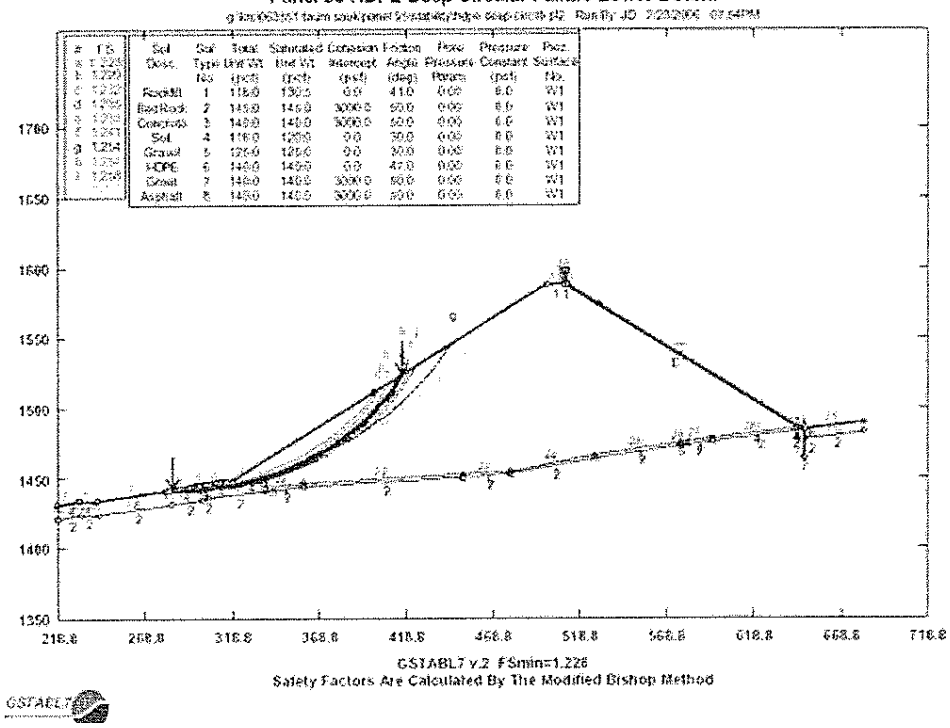
Condition B HDPE effective

Lower Bound

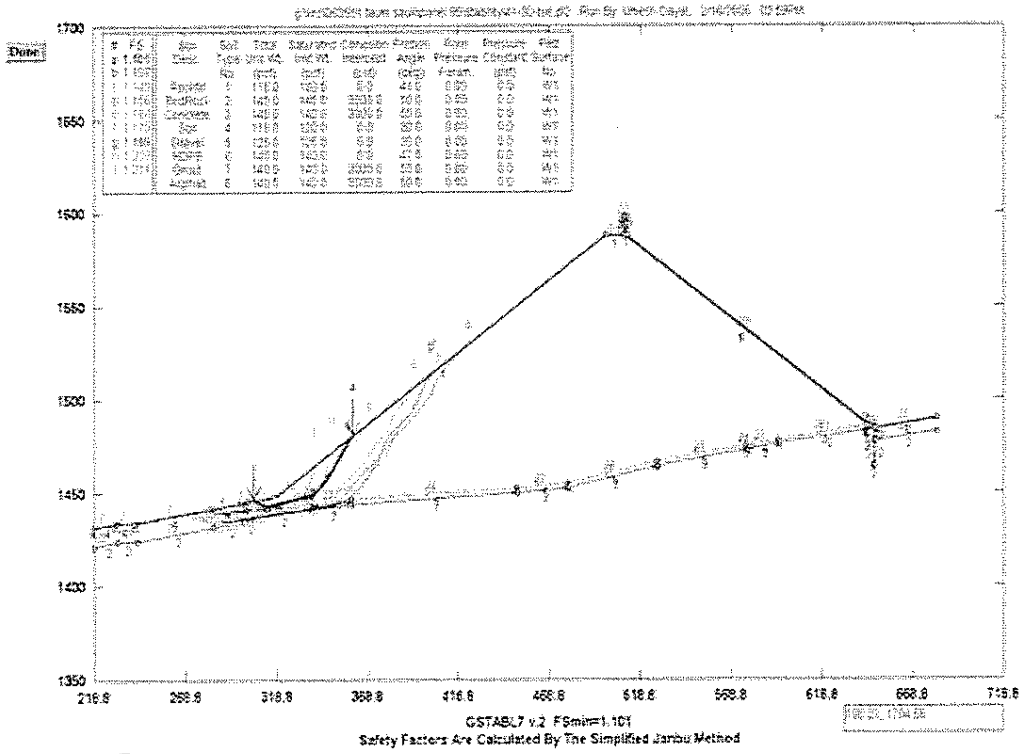
Taum Sauk Panel 95 w/ HDPE, Phi=30 &41 Block Failure D/S



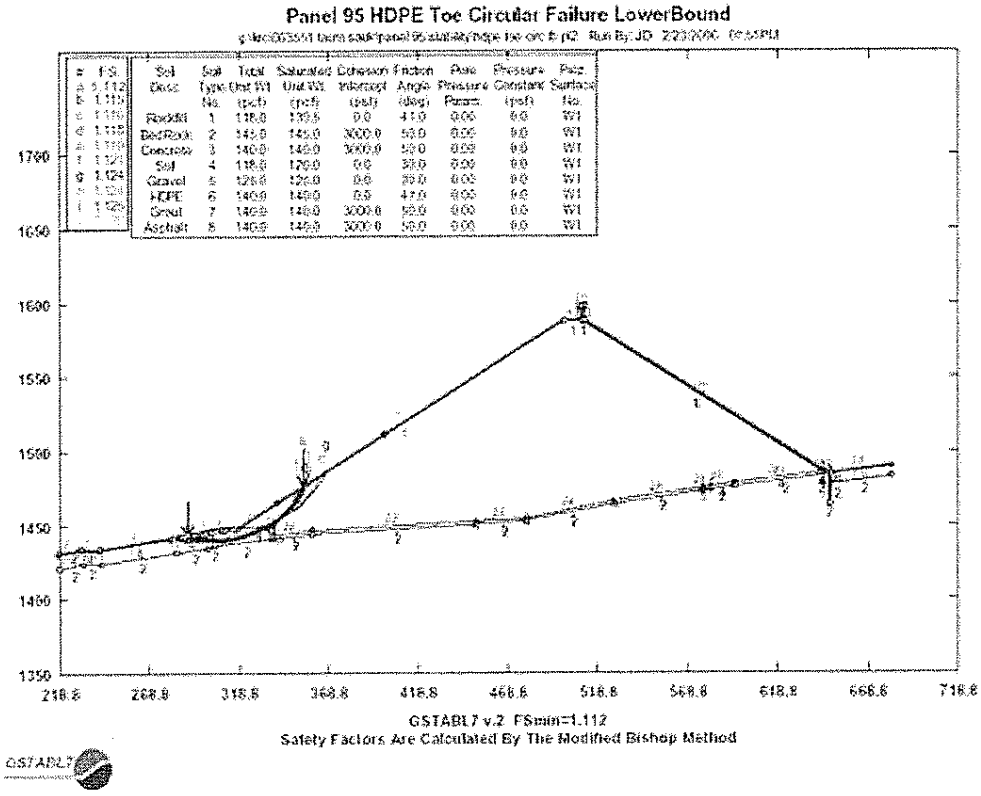
Panel 95 HDPE Deep Circular Failure Lower Bound



Taum Sauk Panel 95 Toe Failure 41-30 Block Failure at Toe



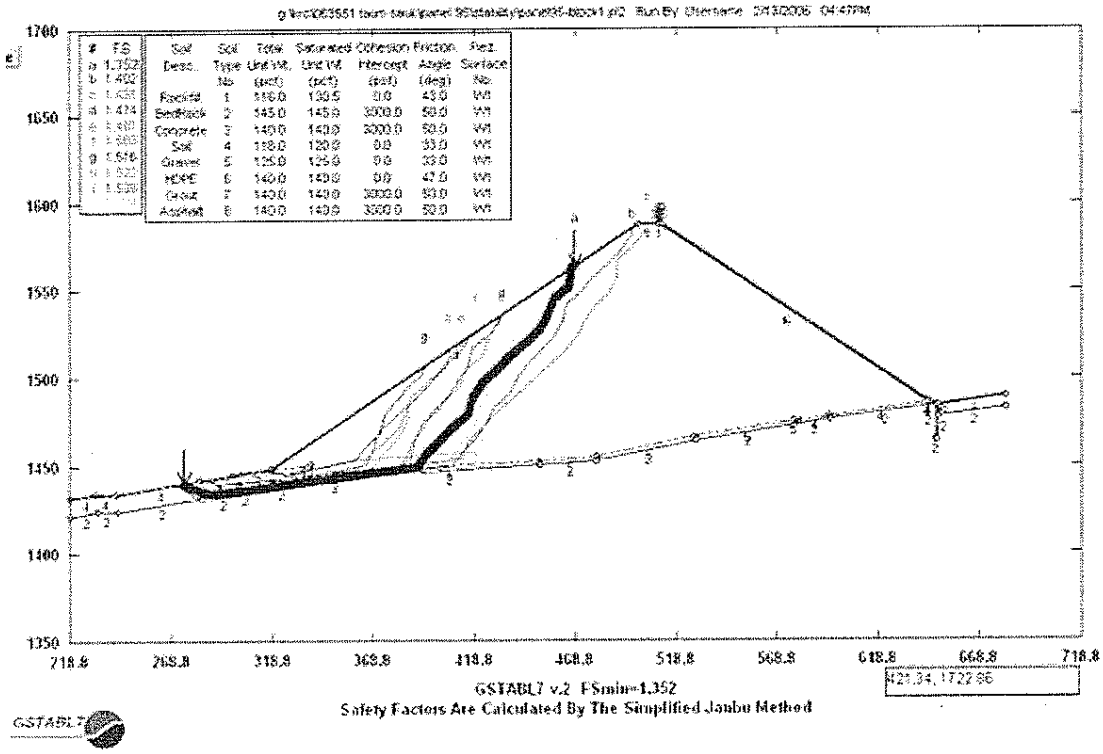
Panel 95 HDPE Toe Circular Failure LowerBound



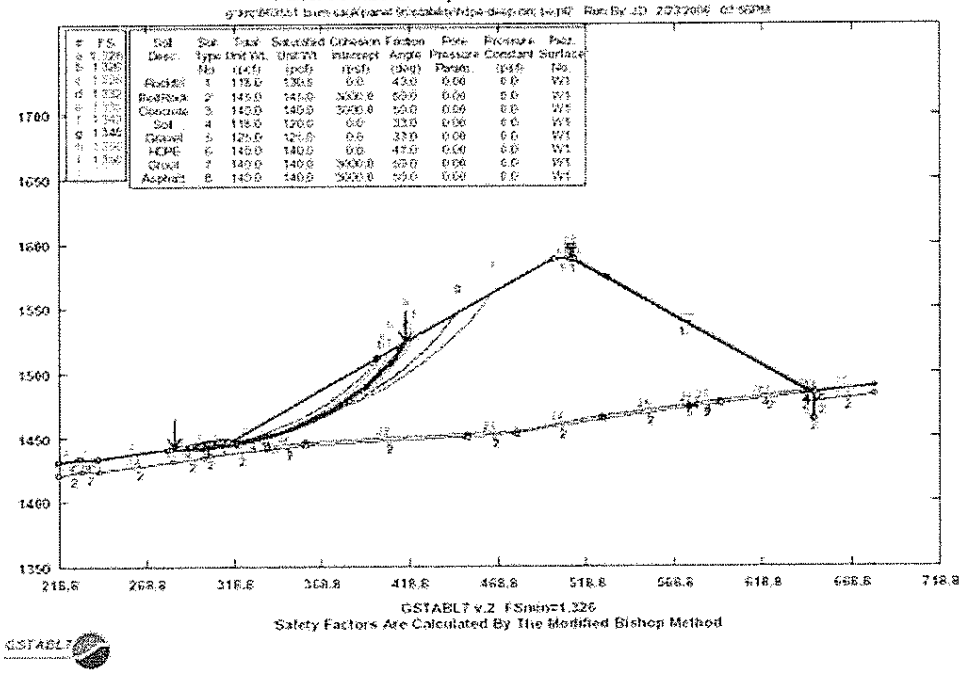
Condition B HDPE effective

Best Estimate

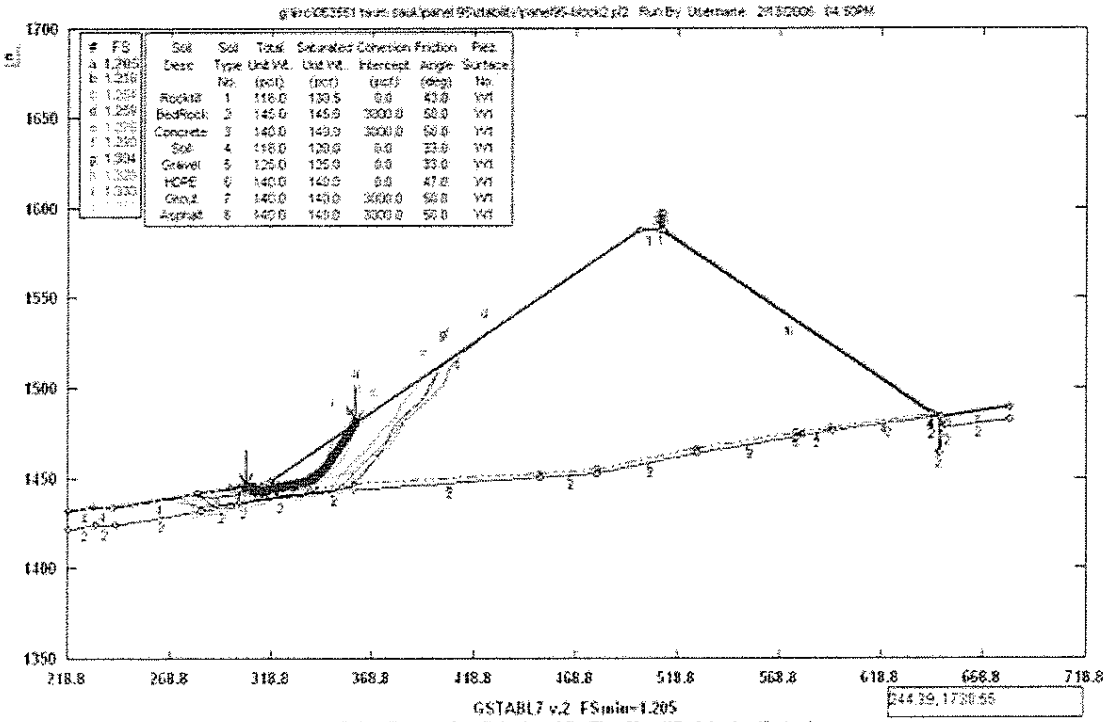
Taum Sauk Panel 95 w/ HDPE Liner Block Failure D/S



Panel 95 HDPE Deep Circular Failure BestEstimate

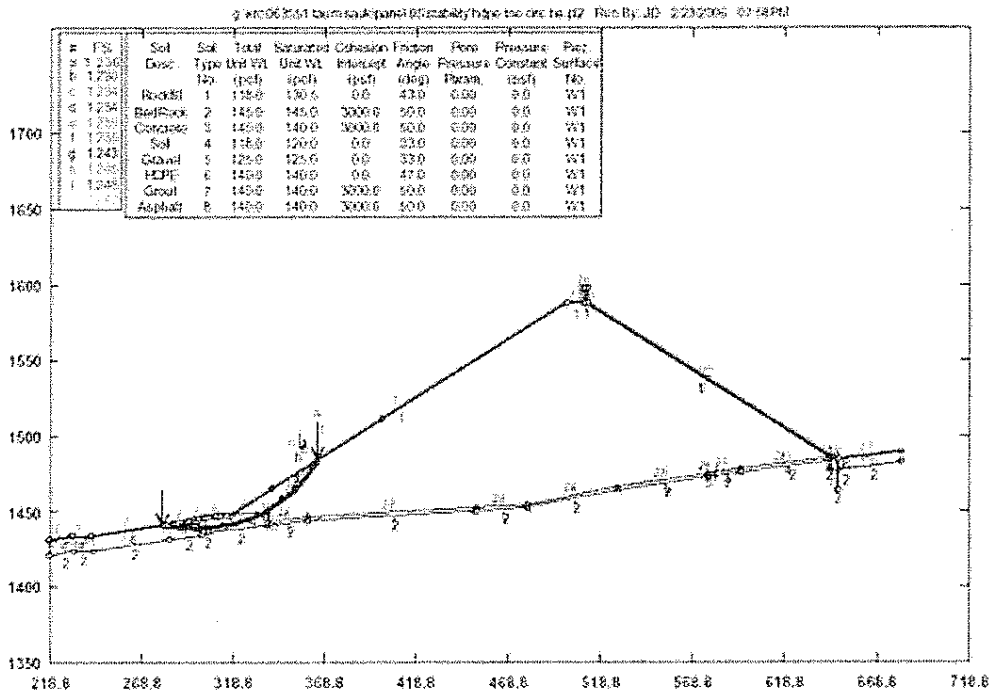


Taum Sauk Panel 95 w/ HDPE Liner Block Failure at Toe



GSTABL7 v.2 FSmin=1.205
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 HDPE Toe Circular Failure Best Estimate

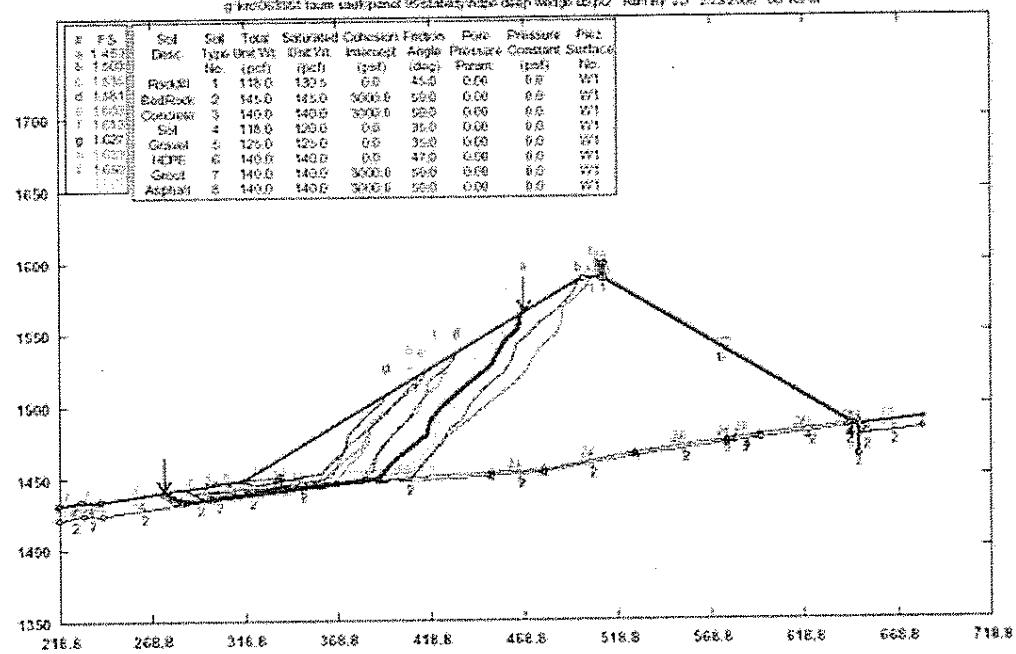


GSTABL7 v.2 FSmin=1.230
Safety Factors Are Calculated By The Modified Bishop Method

Condition B HDPE effective

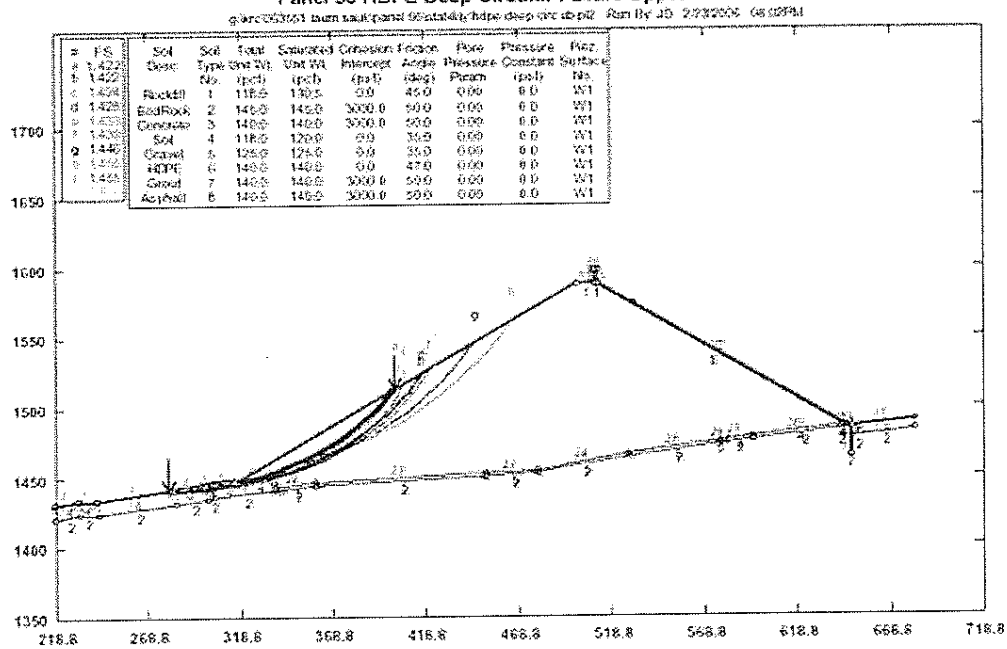
Upper Bound

HDPE Deep Wedge Failure Upper Bound



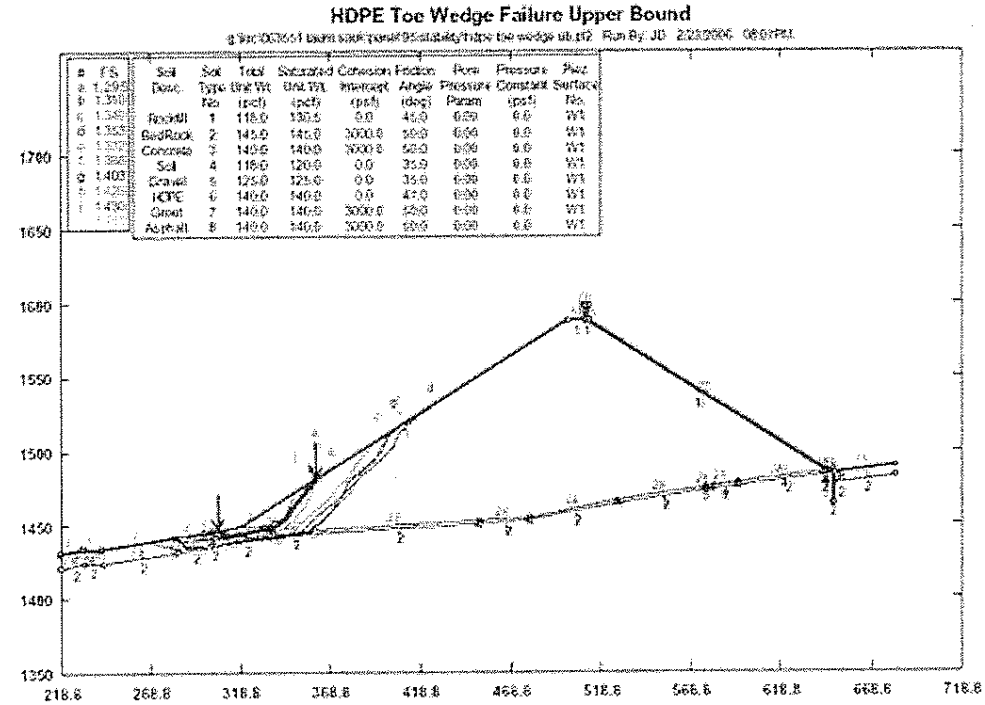
GSTABL7 v.2 FSmin=1.453
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 HDPE Deep Circular Failure Upper Bound



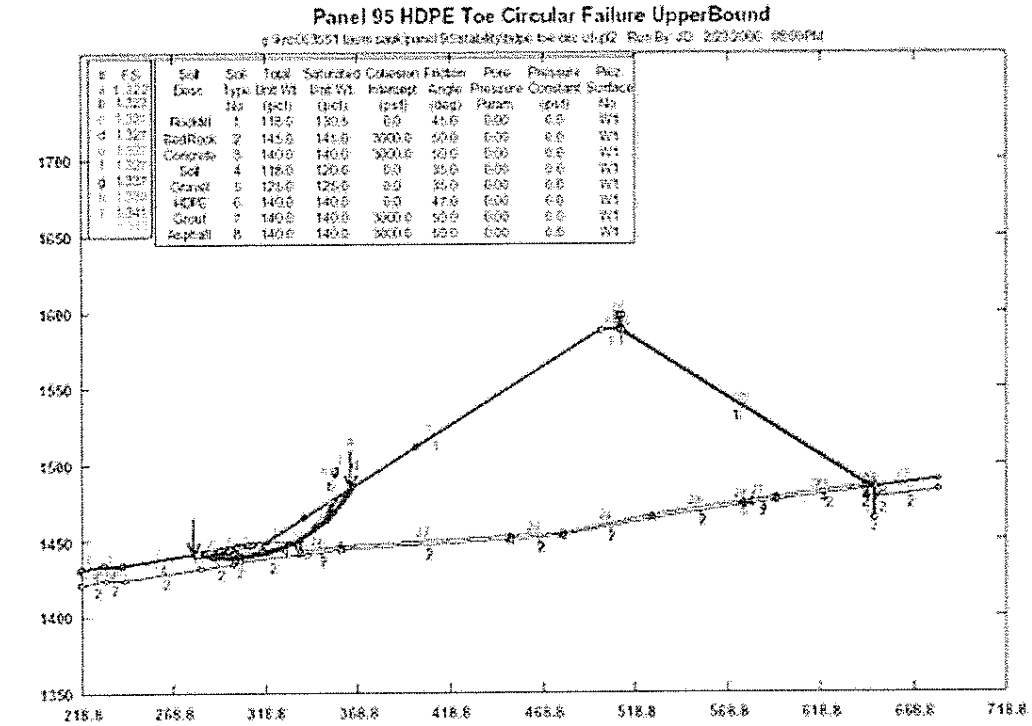
GSTABL7 v.2 FSmin=1.422
Safety Factors Are Calculated By The Modified Bishop Method

HDPE Toe Wedge Failure Upper Bound



GSTABL7 v.2 FSmin=1.295
Safety Factors Are Calculated By The Simplified Janbu Method

Panel 95 HDPE Toe Circular Failure UpperBound

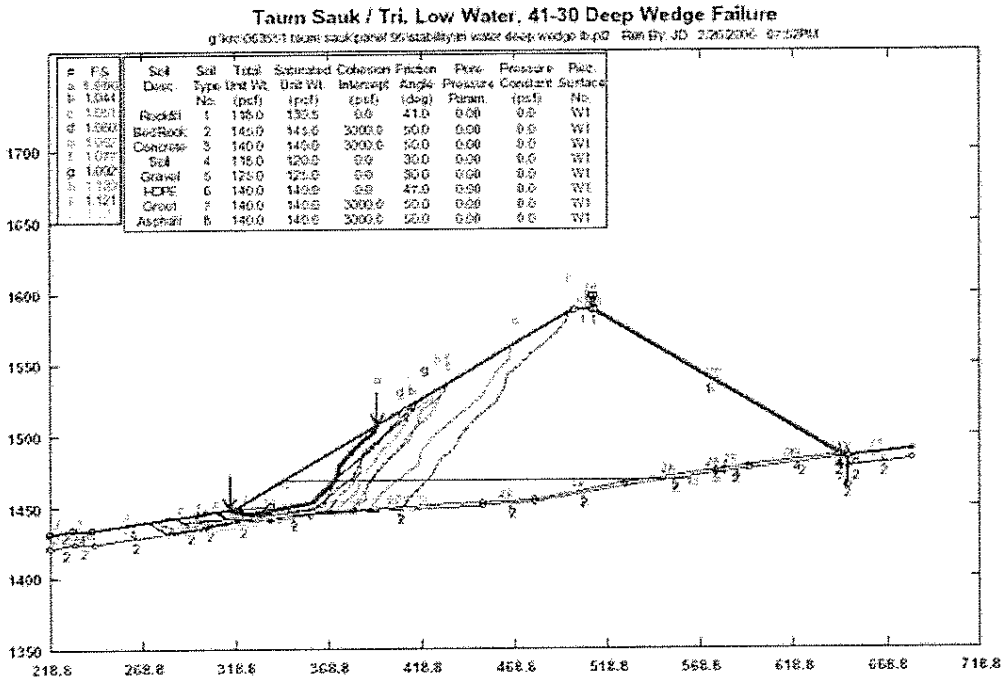


GSTABL7 v.2 FSmin=1.322
Safety Factors Are Calculated By The Modified Bishop Method

Condition C F.S. = 1 with level water surface

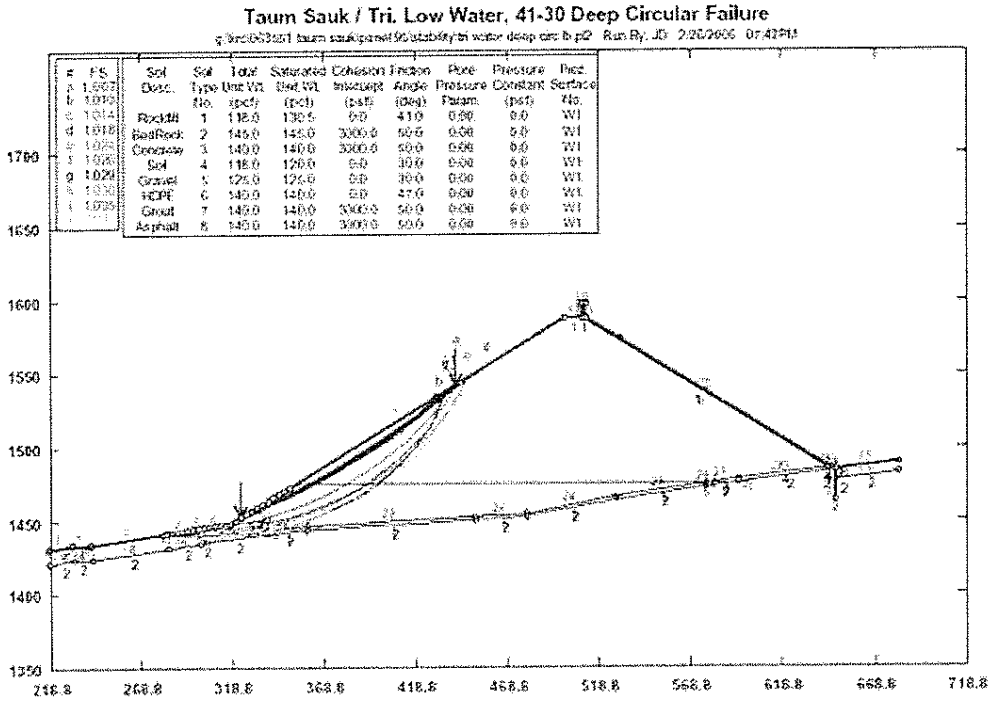
Lower Bound

Taum Sauk / Tri. Low Water, 41-30 Deep Wedge Failure



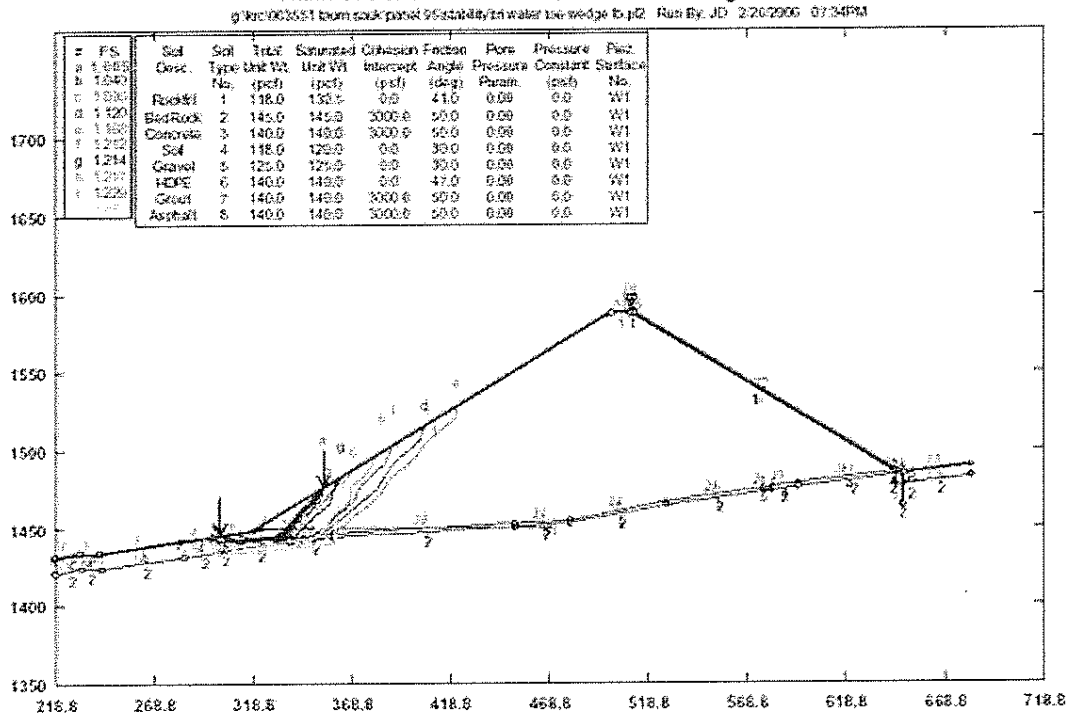
GSTABL7 v.2 FSmin=1.006
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Tri. Low Water, 41-30 Deep Circular Failure



GSTABL7 v.2 FSmin=1.007
Safety Factors Are Calculated By The Modified Bishop Method

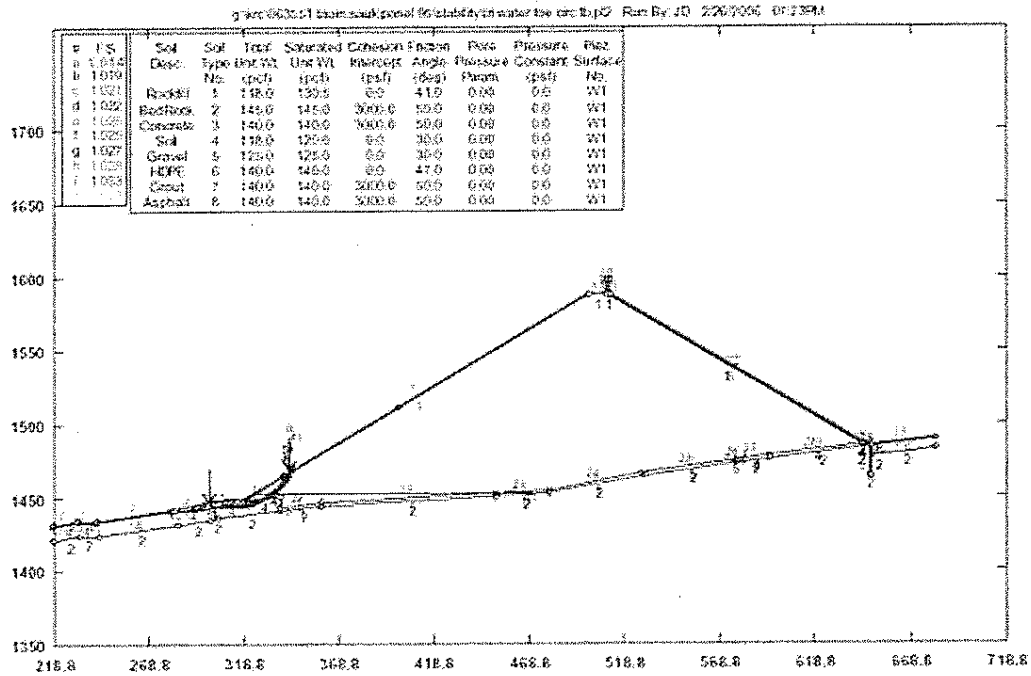
Taum Sauk / Tri. Low Water, 41-30 Toe W edge Failure



GSTABL7 v.2 FSmin=1.005
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Taum Sauk / Tri. Low Water, 41-30 Toe Circular Failure



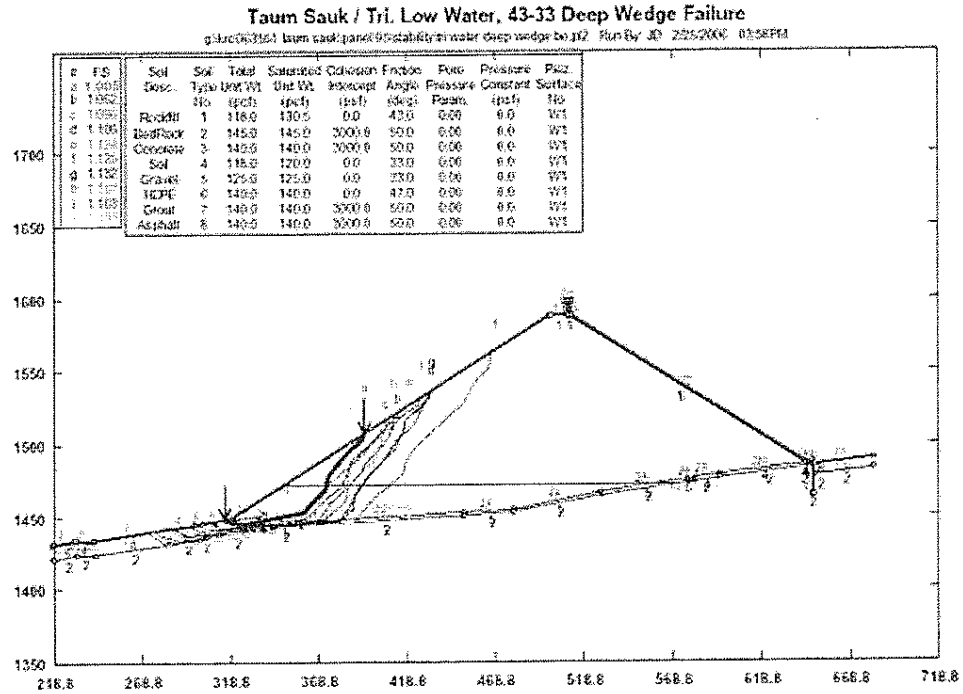
GSTABL7 v.2 FSmin=1.014
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

Condition C F.S. = 1 with level water surface

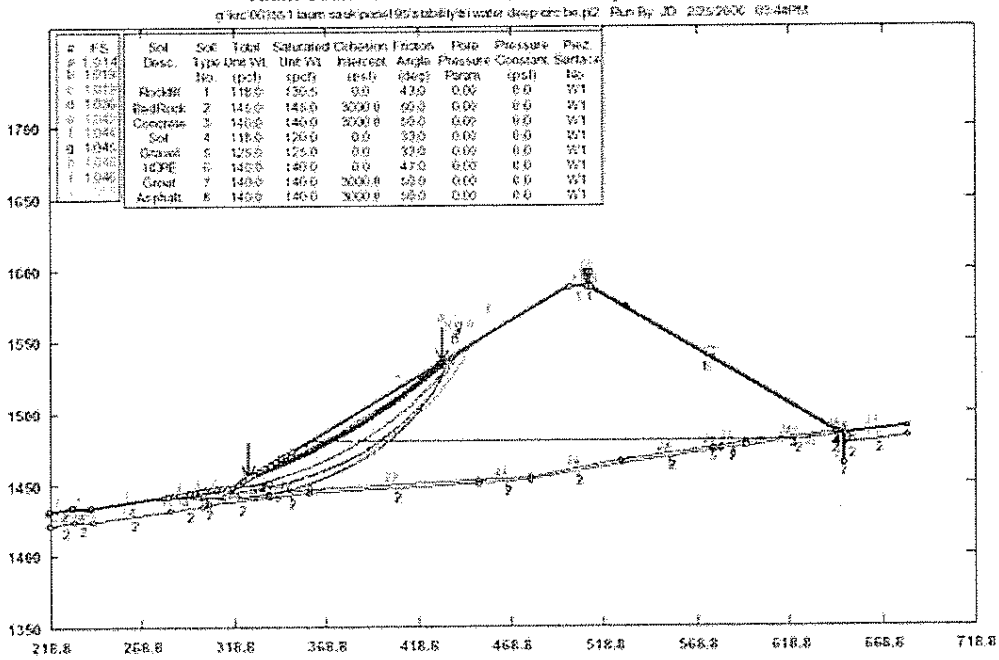
Best Estimate

Taum Sauk / Tri. Low Water, 43-33 Deep Wedge Failure



GSTABL7 v.2 FSmin=1.005
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Tri. Low Water, 43-33 Deep Circular Failure



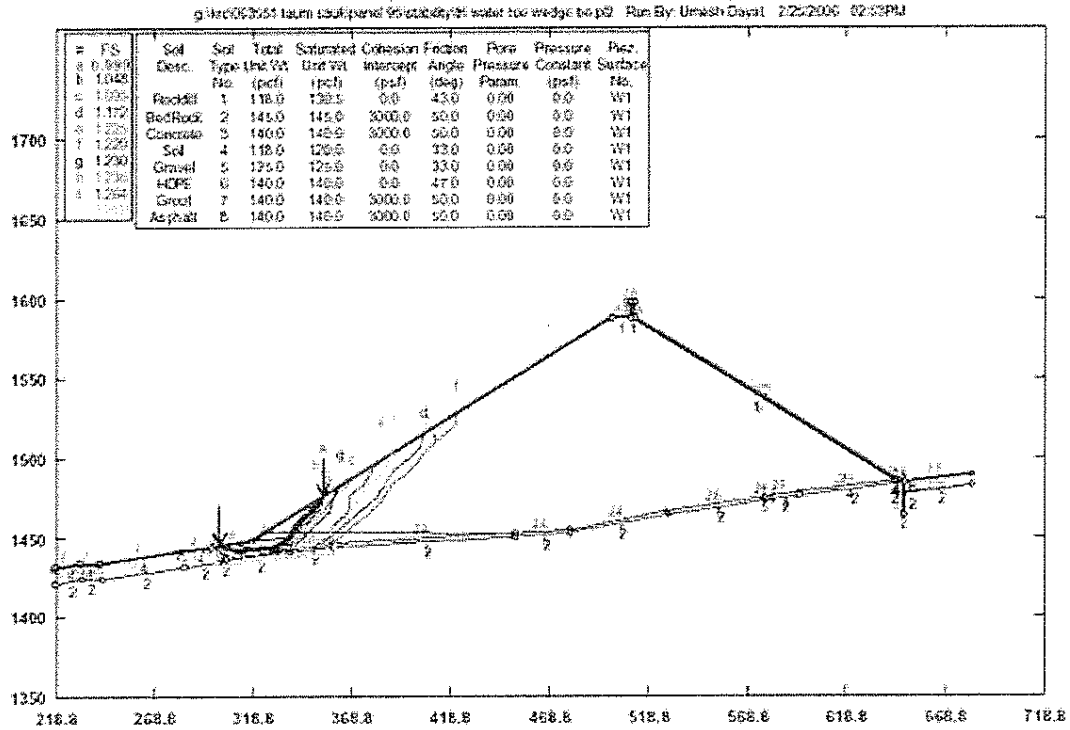
GSTABL7 v.2 FSmin=1.014
Safety Factors Are Calculated By The Modified Bishop Method

Taum Sauk / Tri. Low Water, 43-33 Toe W edge Failure

g:\lec\06\551 taum sauk\panel 95\stability\tri water toe wedge to p3 Run By: Umesh Dayal 2/25/2006 02:53PM

=	FS
a	0.999
b	1.043
c	1.095
d	1.157
e	1.205
f	1.225
g	1.230
h	1.236
i	1.264

Soil Desc.	Soil Type No.	Total Unit Wt (pcf)	Saturated Unit Wt (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
RockFill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1



GSTABL7 v.2 FSmin=0.999
Safety Factors Are Calculated By The Simplified Janbu Method

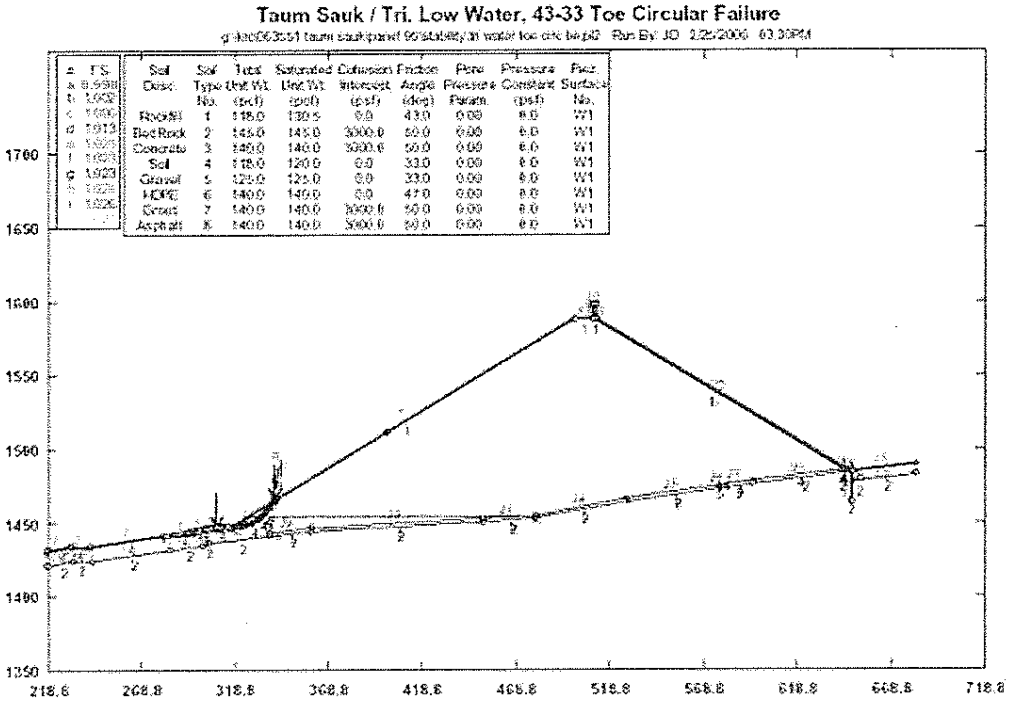
GSTABL7

Taum Sauk / Tri. Low Water, 43-33 Toe Circular Failure

g:\lec\06\551 taum sauk\panel 95\stability\tri water toe circ to p3 Run By: JD 2/25/2006 03:30PM

=	FS
a	0.998
b	1.002
c	1.009
d	1.013
e	1.021
f	1.023
g	1.023
h	1.025
i	1.026

Soil Desc.	Soil Type No.	Total Unit Wt (pcf)	Saturated Unit Wt (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
RockFill	1	118.0	130.5	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1



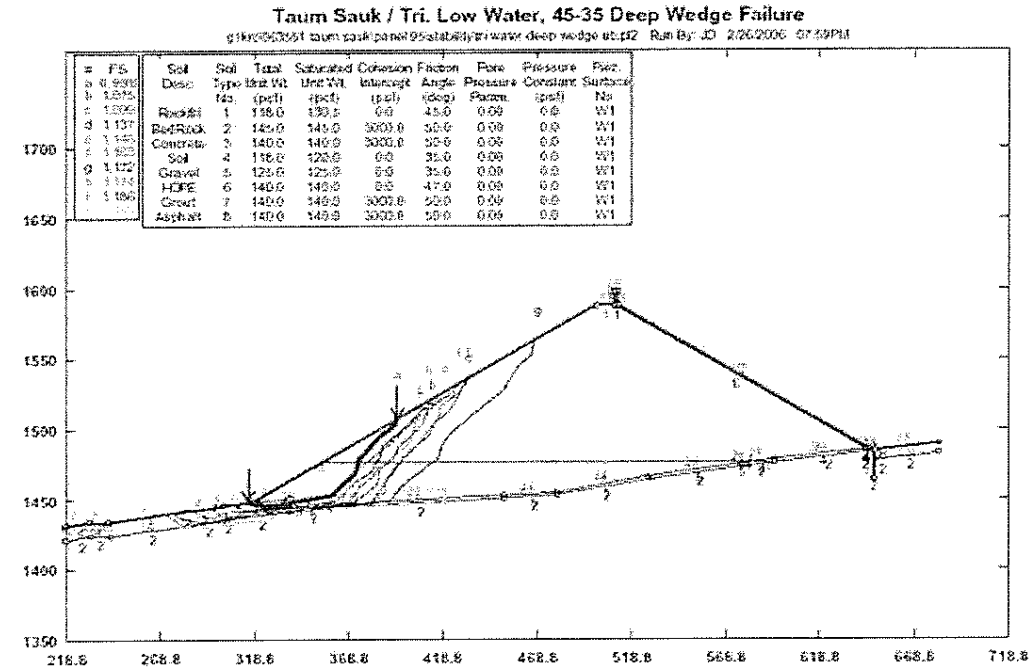
GSTABL7 v.2 FSmin=0.998
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

Condition C F.S. = 1 with level water surface

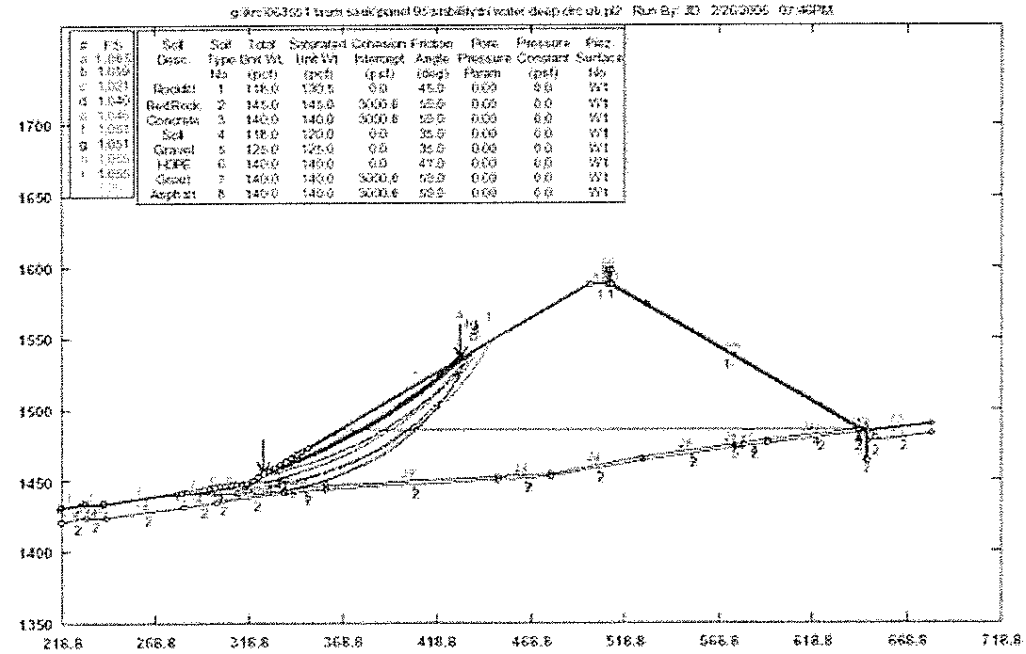
Upper Bound

Taum Sauk / Tri. Low Water, 45-35 Deep Wedge Failure



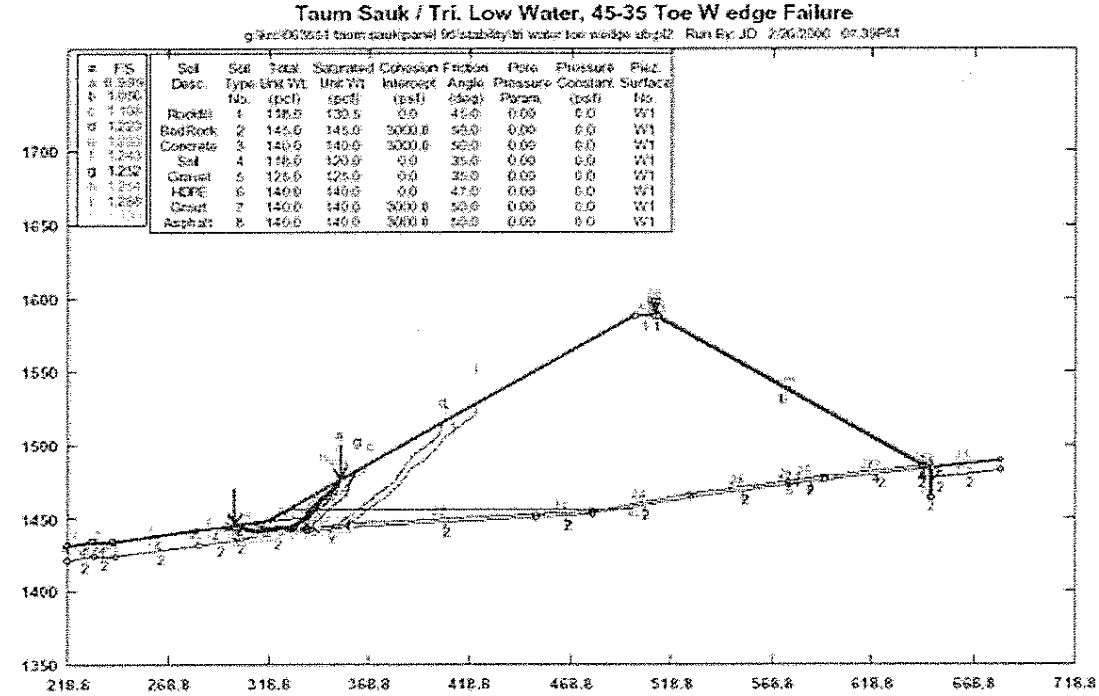
GSTABL7 v.2 FSmin=0.998
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Tri. Low Water, 45-35 Deep Circular Failure



GSTABL7 v.2 FSmin=1.005
Safety Factors Are Calculated By The Modified Bishop Method

Taum Sauk / Tri. Low Water, 45-35 Toe W edge Failure

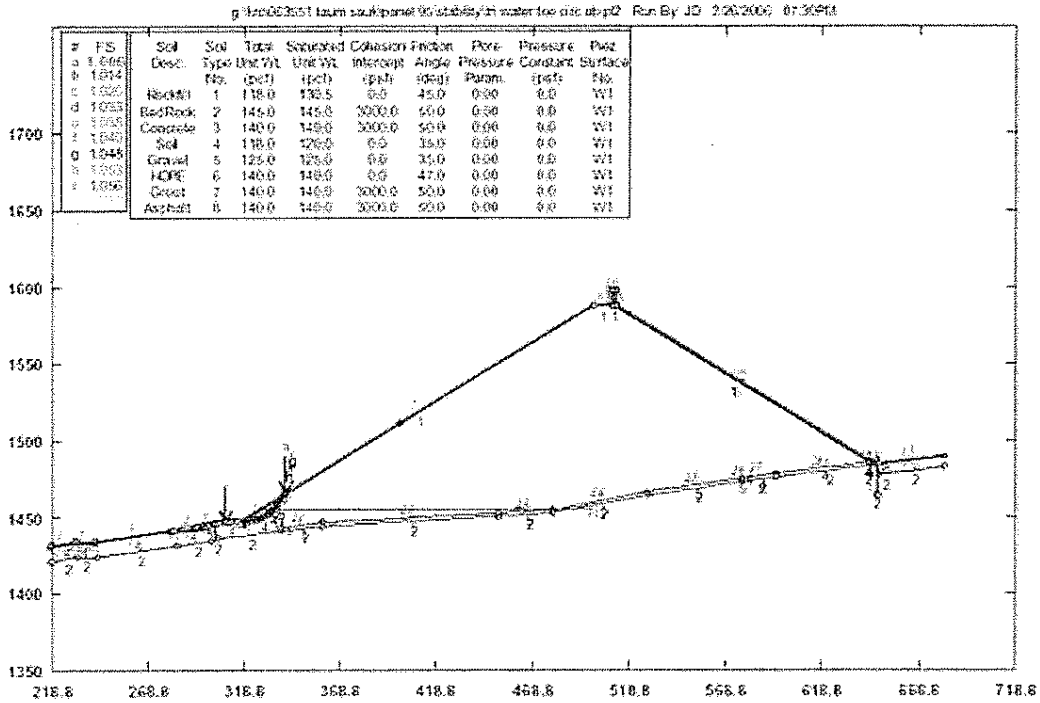


#	FS
a	0.999
b	1.000
c	1.105
d	1.229
e	1.233
f	1.243
g	1.252
h	1.254
i	1.268

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=0.999
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Tri. Low Water, 45-35 Toe Circular Failure



#	FS
a	1.006
b	1.014
c	1.026
d	1.053
e	1.055
f	1.043
g	1.045
h	1.053
i	1.056

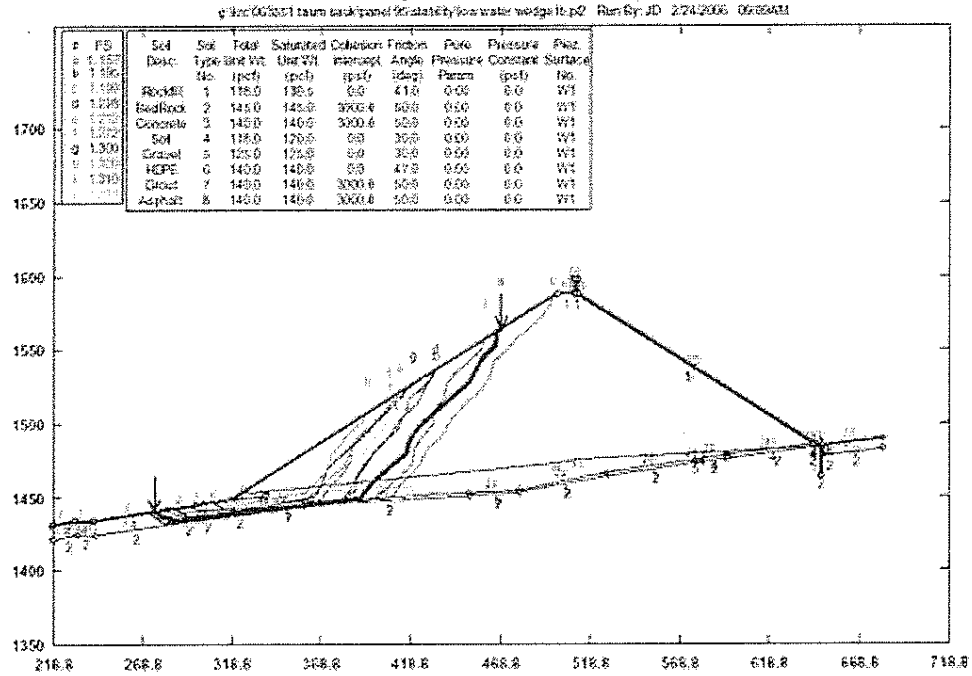
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.5	0.0	45.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.006
Safety Factors Are Calculated By The Modified Bishop Method

Condition D Low Water Level

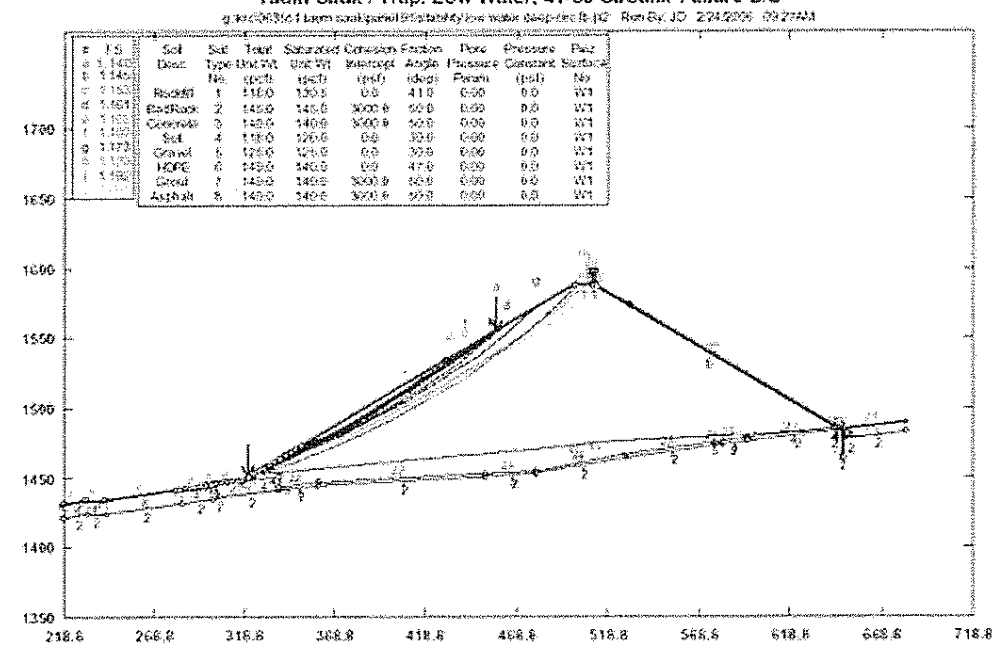
Lower Bound

Taum Sauk / Trap. Low Water, 41-30 WedgeFailure D/S



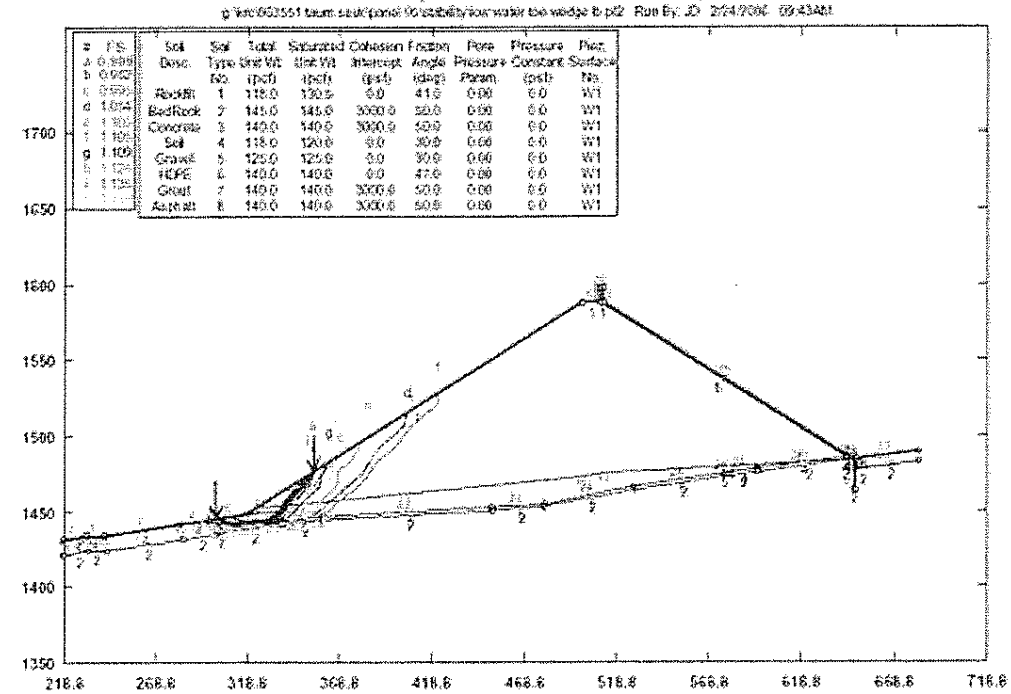
GSTABL7 v.2 FSmin=1.157
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Trap. Low Water, 41-30 Circular Failure D/S



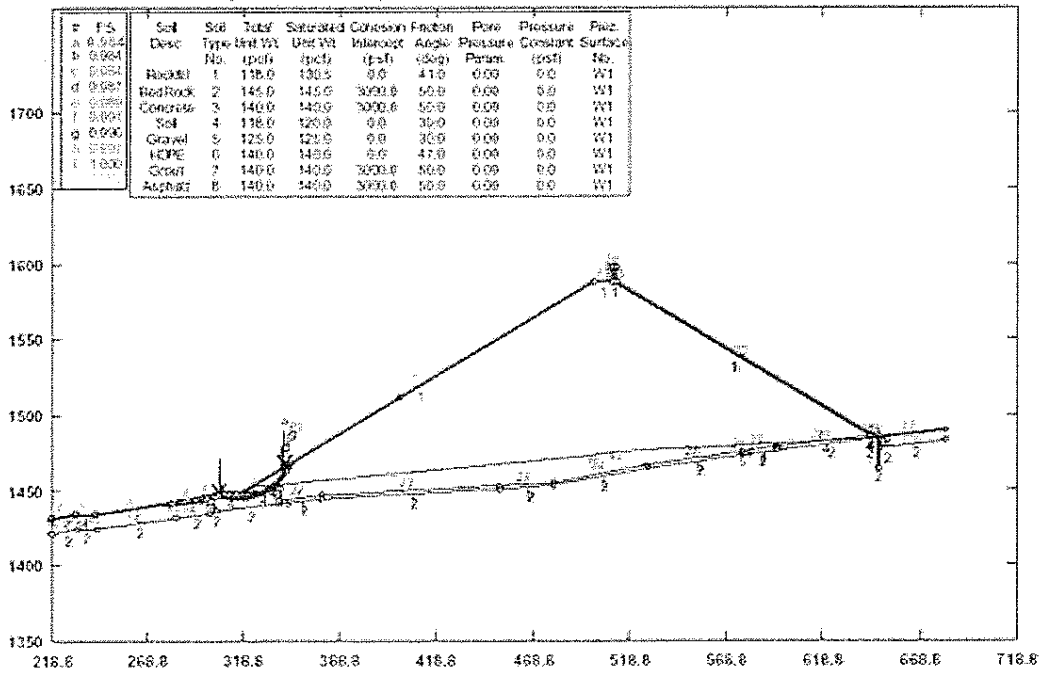
GSTABL7 v.2 FSmin=1.140
Safety Factors Are Calculated By The Modified Bishop Method

Taum Sauk / Trap. Low Water, 41-30 Toe Wedge Failure



GSTABL7 v.2 FSmin=0.909
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Trap. Low Water, 41-30 Toe Circular Failure

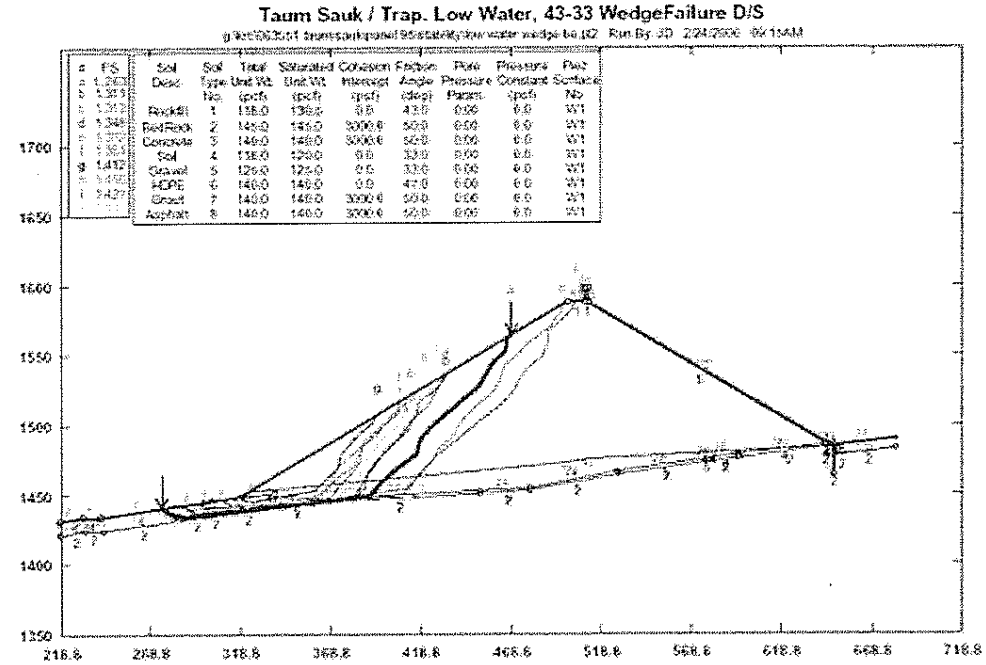


GSTABL7 v.2 FSmin=0.964
Safety Factors Are Calculated By The Modified Bishop Method

Condition D Low Water Level

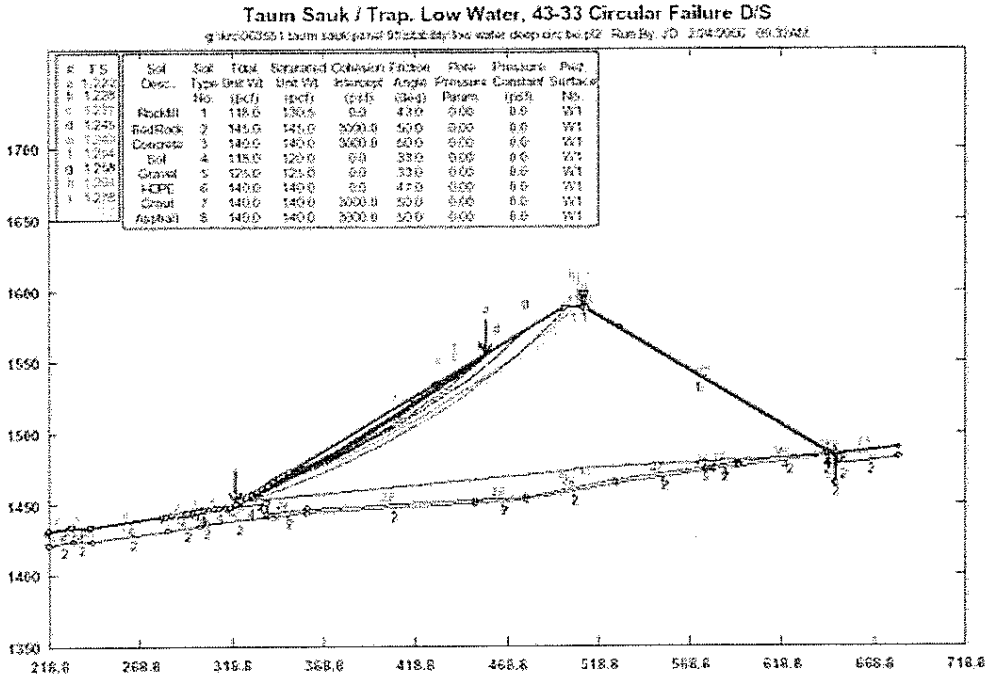
Best Estimate

Taum Sauk / Trap. Low Water, 43-33 WedgeFailure D/S



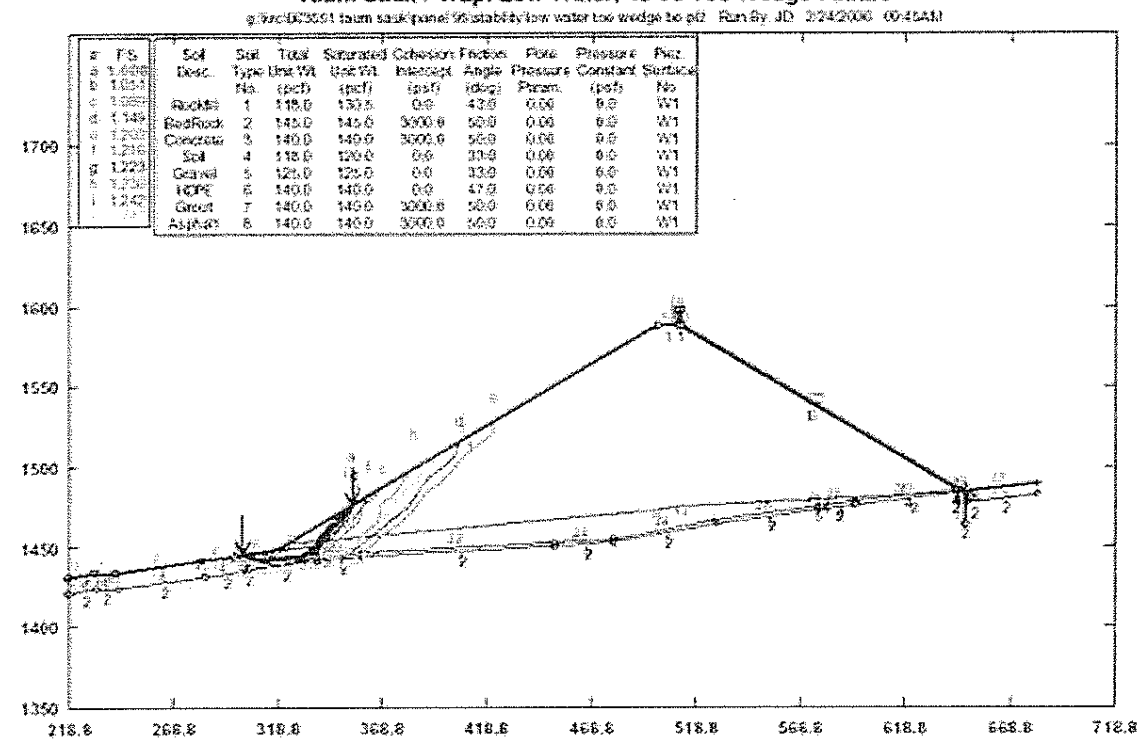
GSTABL7 v.2 FSmin=1.263
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Trap. Low Water, 43-33 Circular Failure D/S



GSTABL7 v.2 FSmin=1.222
Safety Factors Are Calculated By The Modified Bishop Method

Taum Sauk / Trap. Low Water, 43-33 Toe Wedge Failure



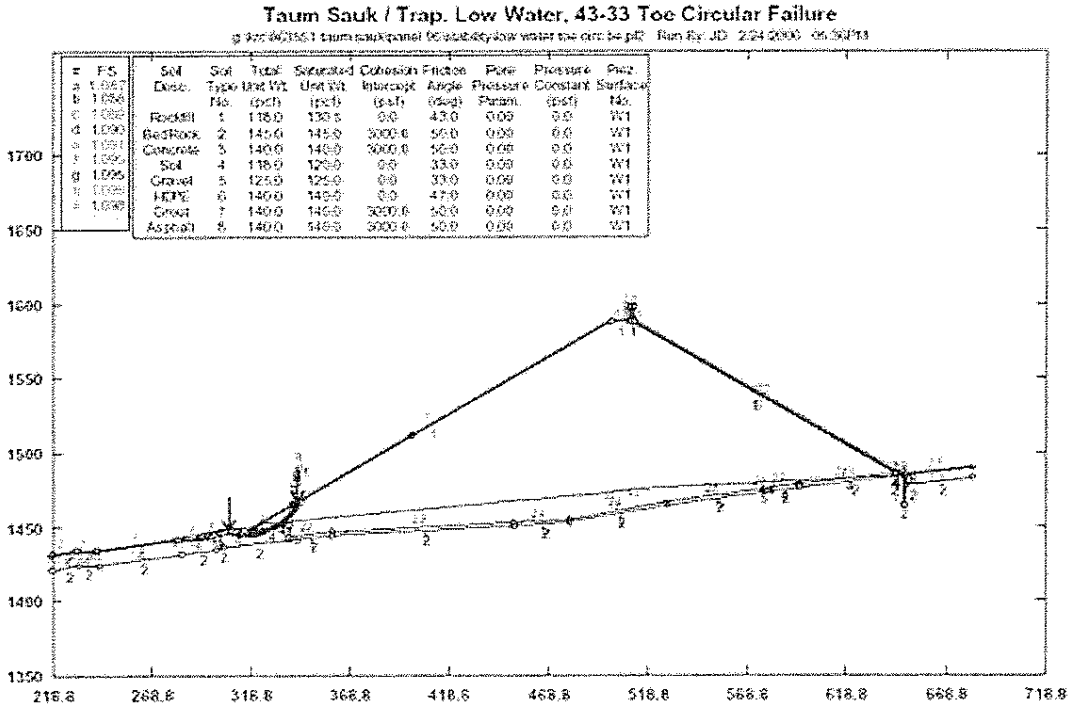
#	F.S.
a	1.[illegible]
b	1.[illegible]
c	1.[illegible]
d	1.149
e	1.[illegible]
f	1.216
g	1.223
h	1.[illegible]
i	1.242

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.0	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.008
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Taum Sauk / Trap. Low Water, 43-33 Toe Circular Failure



#	F.S.
a	1.067
b	1.056
c	1.082
d	1.090
e	1.091
f	1.095
g	1.095
h	1.099
i	1.099

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Rockfill	1	118.0	130.0	0.0	43.0	0.00	0.0	W1
BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Soil	4	118.0	120.0	0.0	33.0	0.00	0.0	W1
Gravel	5	125.0	125.0	0.0	33.0	0.00	0.0	W1
HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

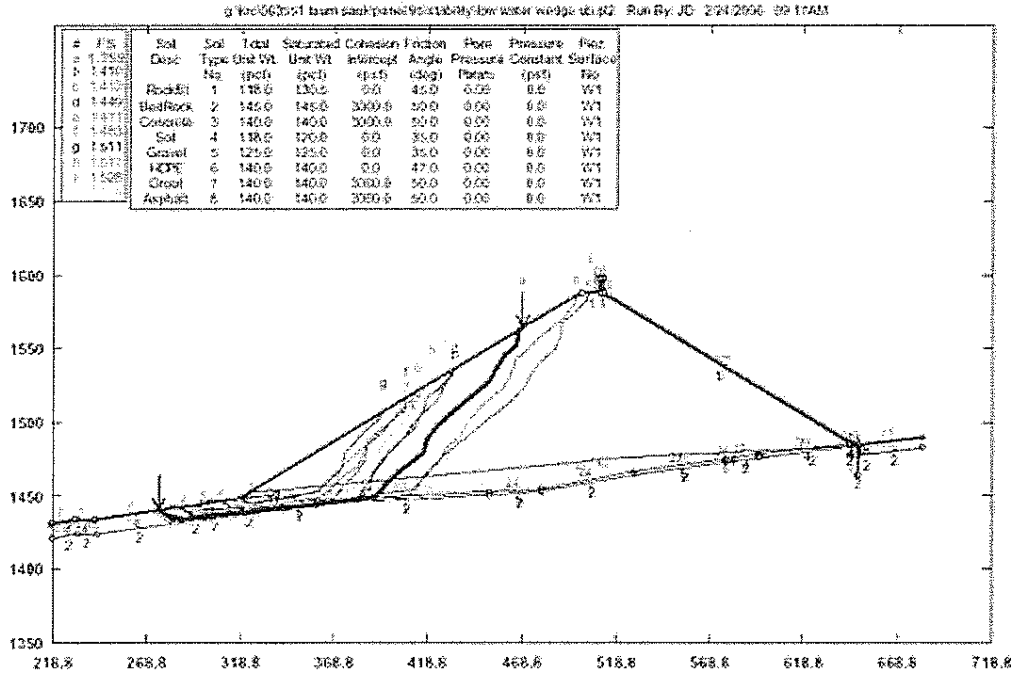
GSTABL7 v.2 FSmin=1.067
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

Condition D Low Water Level

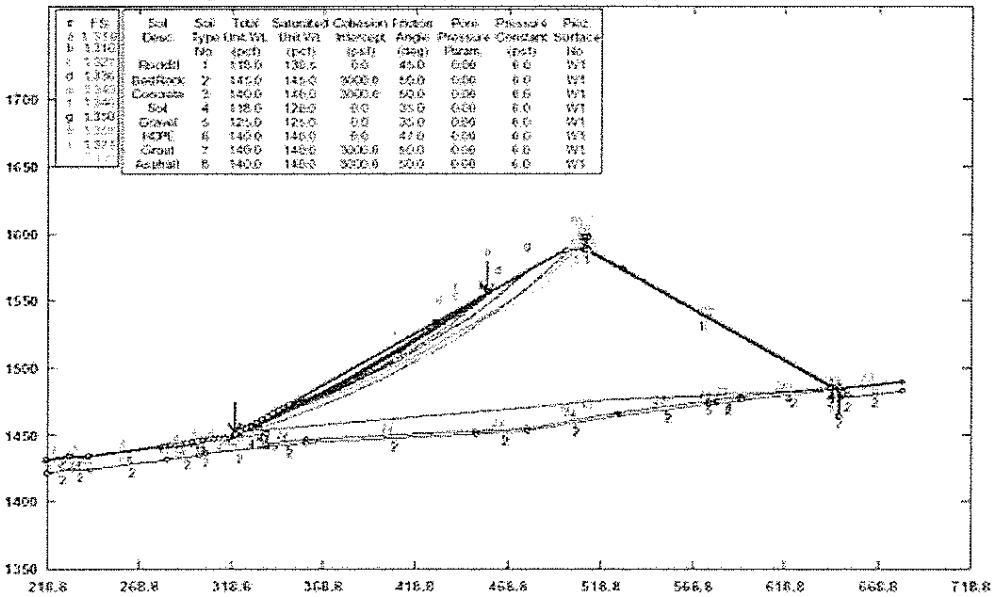
Upper Bound

Taum Sauk / Trap. Low Water, 45-35 WedgeFailure D/S



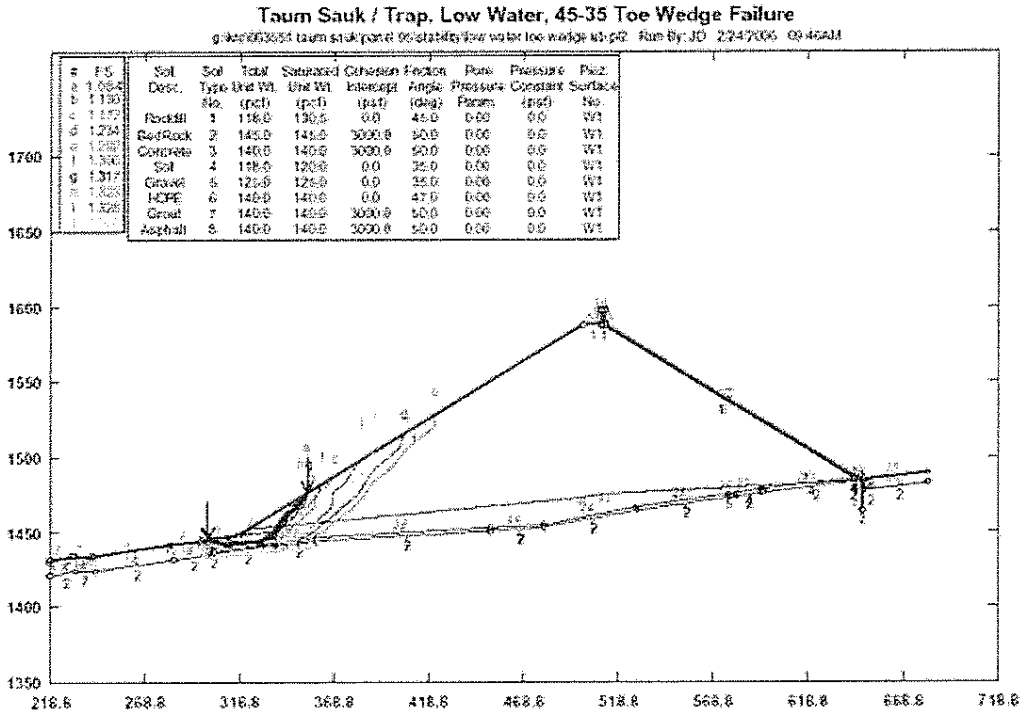
GSTABL7 v.2 FSmin=1.359
Safety Factors Are Calculated By The Simplified Janbu Method

Taum Sauk / Trap. Low Water, 45-35 Circular Failure D/S



GSTABL7 v.2 FSmin=1.310
Safety Factors Are Calculated By The Modified Bishop Method

Taum Sauk / Trap. Low Water, 45-35 Toe Wedge Failure

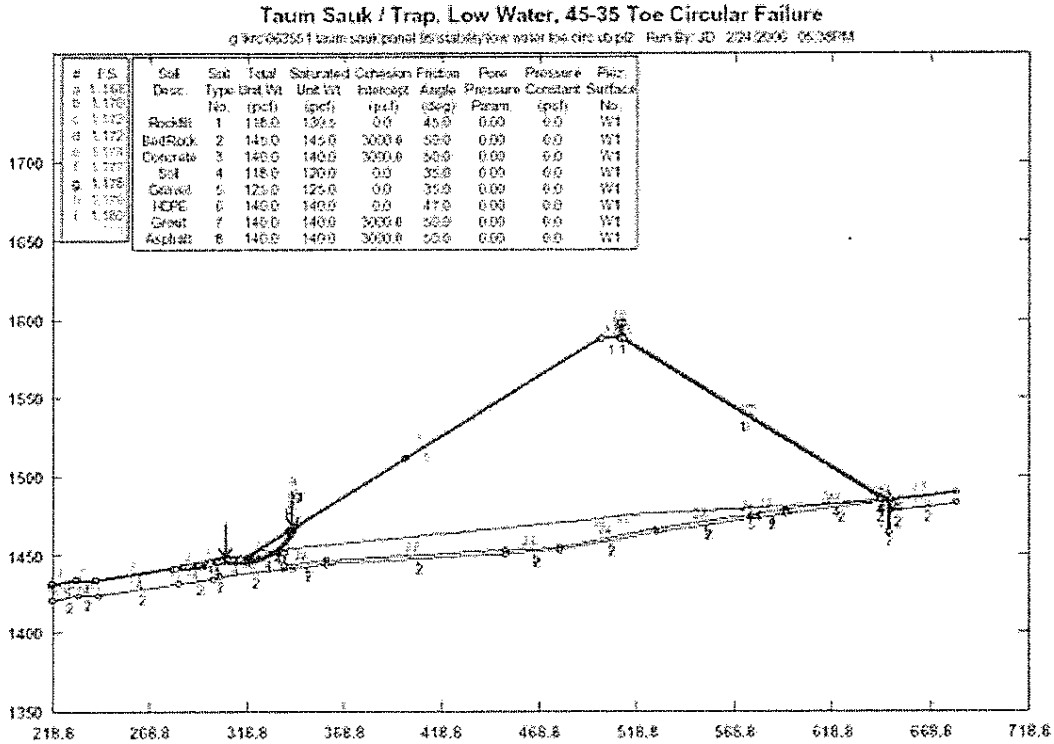


#	F.S.	Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
a	1.084									
b	1.130									
c	1.172									
d	1.234									
e	1.288									
f	1.300									
g	1.312									
h	1.325									
i	1.328									
		Rockfill	1	118.0	130.0	0.0	45.0	0.00	0.0	W1
		BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
		Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
		Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
		Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
		HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
		Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
		Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.084
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Taum Sauk / Trap. Low Water, 45-35 Toe Circular Failure



#	F.S.	Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
a	1.166									
b	1.170									
c	1.172									
d	1.172									
e	1.173									
f	1.177									
g	1.178									
h	1.179									
i	1.180									
		Rockfill	1	118.0	130.0	0.0	45.0	0.00	0.0	W1
		BedRock	2	145.0	145.0	3000.0	50.0	0.00	0.0	W1
		Concrete	3	140.0	140.0	3000.0	50.0	0.00	0.0	W1
		Soil	4	118.0	120.0	0.0	35.0	0.00	0.0	W1
		Gravel	5	125.0	125.0	0.0	35.0	0.00	0.0	W1
		HDPE	6	140.0	140.0	0.0	47.0	0.00	0.0	W1
		Grout	7	140.0	140.0	3000.0	50.0	0.00	0.0	W1
		Asphalt	8	140.0	140.0	3000.0	50.0	0.00	0.0	W1

GSTABL7 v.2 FSmin=1.168
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

ATTACHMENT – C
Computer Output of Slope Stability Analysis

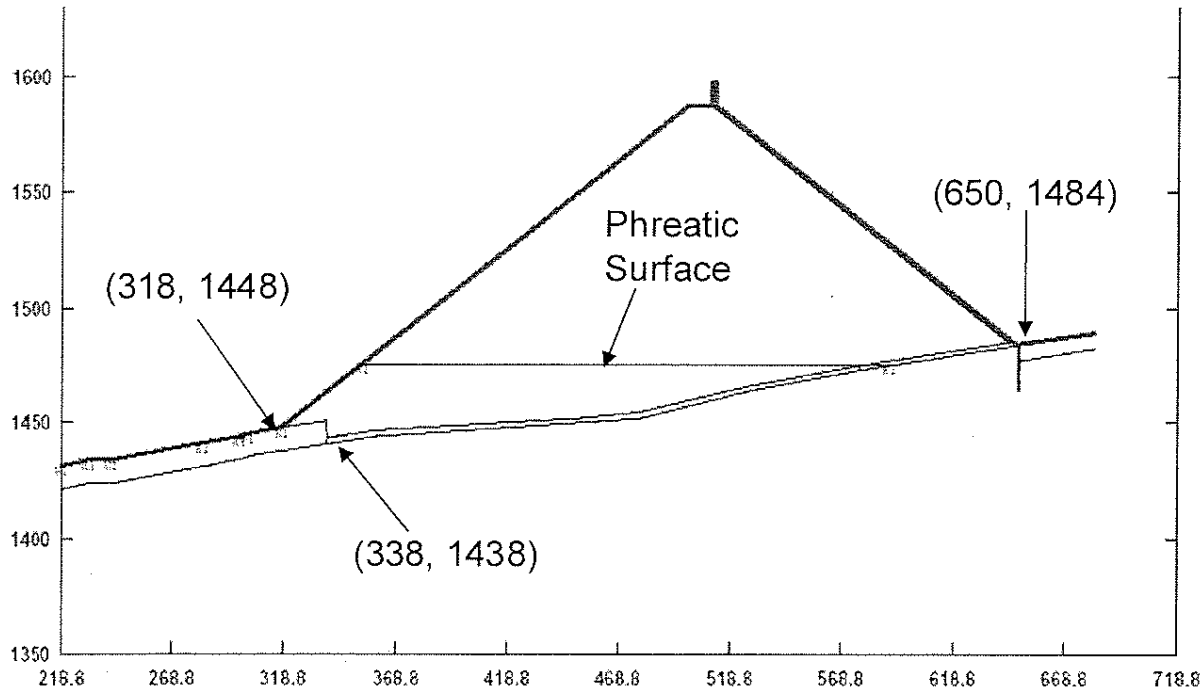
List of GSTABL Files

Condition	Material Properties	Failure Type	Filename*
A	Lower Bound	Deep Wedge	deep wedge lb.pl2
		Deep Circular	deep circ lb.pl2
		Toe Wedge	toe wedge lb.pl2
		Toe Circular	toe circ lb.pl2
	Best Estimate	Deep Wedge	deep wedge be.pl2
		Deep Circular	deep circ be.pl2
		Toe Wedge	toe wedge be.pl2
		Toe Circular	toe circ be.pl2
	Upper Bound	Deep Wedge	deep wedge ub.pl2
		Deep Circular	deep circ ub.pl2
		Toe Wedge	toe wedge ub.pl2
		Toe Circular	toe circ ub.pl2
B	Lower Bound	Deep Wedge	panel95-block30-41.pl2
		Deep Circular	hdpe deep circ lb.pl2
		Toe Wedge	41-30 toe.pl2
		Toe Circular	hdpe toe circ lb.pl2
	Best Estimate	Deep Wedge	panel95-block1.pl2
		Deep Circular	hdpe deep circ be.pl2
		Toe Wedge	panel95-block2.pl2
		Toe Circular	hdpe toe circ be.pl2
	Upper Bound	Deep Wedge	hdpe deep wedge ub.pl2
		Deep Circular	hdpe deep circ ub.pl2
		Toe Wedge	hdpe toe wedge ub.pl2
		Toe Circular	hdpe toe circ ub.pl2
C	Lower Bound	Deep Wedge	tri water deep wedge lb.pl2
		Deep Circular	tri water deep circ lb.pl2
		Toe Wedge	tri water toe wedge lb.pl2
		Toe Circular	tri water toe circ lb.pl2
	Best Estimate	Deep Wedge	tri water deep wedge be.pl2
		Deep Circular	tri water deep circ be.pl2
		Toe Wedge	tri water toe wedge be.pl2
		Toe Circular	tri water toe circ be.pl2
	Upper Bound	Deep Wedge	tri water deep wedge ub.pl2
		Deep Circular	tri water deep circ ub.pl2
		Toe Wedge	tri water toe wedge ub.pl2
		Toe Circular	tri water toe circ ub.pl2
D	Lower Bound	Deep Wedge	low water wedge lb.pl2
		Deep Circular	low water deep circ lb.pl2
		Toe Wedge	low water toe wedge lb.pl2
		Toe Circular	low water toe circ lb.pl2
	Best Estimate	Deep Wedge	low water wedge be.pl2
		Deep Circular	low water deep circ be.pl2
		Toe Wedge	low water toe wedge be.pl2
		Toe Circular	low water toe circ be.pl2
	Upper Bound	Deep Wedge	low water wedge ub.pl2
		Deep Circular	low water deep circ ub.pl2
		Toe Wedge	low water toe wedge ub.pl2
		Toe Circular	low water toe circ ub.pl2

*All files are located in G:\KRC\063551 Taum Sauk\Panel 95\Stability and on the CD included with this calculation

ATTACHMENT – D
Estimation of Time of Failure

The time of failure is estimated by finding the time it takes water that is overtopping the parapet wall at segment 95 to raise the phreatic surface in the dam to a level where the factor of safety against sliding is 1. The height of the phreatic surface that will cause a failure is estimated in GSTABL (Reference 4) for each of the 12 cases analyzed. The phreatic surface in the dam is assumed to be at the same elevation at the upstream and downstream ends, and the bottom five feet of rockfill above bedrock of the cross section at wall segment 95 are assumed to be saturated. A one foot wide cross section of the dam at wall segment 95 is considered. An effective porosity of 15% is used for the rockfill in the dam (assuming total porosity of 20% with 5% reduction due to natural moisture. A figure showing the cross section considered with key coordinates and an example phreatic surface is shown below.



The area under the phreatic surface is approximated with two triangles. The bottom five feet of rockfill are assumed to be saturated, so this area is subtracted from the total. A table listing the area under the phreatic surface, accounting for 15% porosity and 5 feet of saturation, is shown below.

Areas (sf)			
Net Porosity = 15%			
Failure Type	Lower Bound	Best Estimate	Upper Bound
Deep Wedge	462	536	650
Deep Circular	664	850	1017
Toe Wedge	80	102	170
Toe Circular	103	134	163

Areas listed in the table above are considered for a one foot wide cross section, so volume is found by multiplying the areas by the one foot width. The flow over the parapet wall at segment 95 is considered for a one foot wide section from 0 to 34 minutes (Reference 8) and is shown below.

Flow Over Wall Segment 95						
Time (min)	Reservoir Elevation	Flow Over Wall Segment 95	Cumulative Outflow Wall Segment 95 (cf)	Flow per Foot Wall Segment 95 (cfs)	Cumulative flow per foot Wall Segment 95 (cf/ft)	Water in dam for 80% infiltration
0	1597	0.00	0.00	0.00	0.00	0.00
1	1597.1	0.00	0.00	0.00	0.00	0.00
2	1597.1	0.00	0.00	0.00	0.00	0.00
3	1597.2	0.00	0.00	0.00	0.00	0.00
4	1597.3	1.80	108.00	0.03	1.80	1.44
5	1597.3	1.80	216.00	0.03	3.60	2.88
6	1597.4	9.30	774.00	0.16	12.90	10.32
7	1597.4	9.30	1332.00	0.16	22.20	17.76
8	1597.5	20.20	2544.00	0.34	42.40	33.92
9	1597.6	33.70	4566.00	0.56	76.10	60.88
10	1597.6	33.70	6588.00	0.56	109.80	87.84
11	1597.7	49.30	9546.00	0.82	159.10	127.28
12	1597.7	49.30	12504.00	0.82	208.40	166.72
13	1597.7	49.30	15462.00	0.82	257.70	206.16
14	1597.8	67.30	19500.00	1.12	325.00	260.00
15	1597.8	67.30	23538.00	1.12	392.30	313.84
16	1597.8	67.30	27576.00	1.12	459.60	367.68
17	1597.9	87.40	32820.00	1.46	547.00	437.60
18	1597.9	87.40	38064.00	1.46	634.40	507.52
19	1597.9	87.40	43308.00	1.46	721.80	577.44
20	1597.9	87.40	48552.00	1.46	809.20	647.36
21	1597.9	87.40	53796.00	1.46	896.60	717.28
22	1597.9	87.40	59040.00	1.46	984.00	787.20
23	1597.9	87.40	64284.00	1.46	1071.40	857.12
24	1597.9	87.40	69528.00	1.46	1158.80	927.04
25	1598	109.90	76122.00	1.83	1268.70	1014.96
26	1598	109.90	82716.00	1.83	1378.60	1102.88
27	1598	109.90	89310.00	1.83	1488.50	1190.80
28	1598	109.90	95904.00	1.83	1598.40	1278.72
29	1598	109.90	102498.00	1.83	1708.30	1366.64
30	1598	109.90	109092.00	1.83	1818.20	1454.56
31	1598	109.90	115686.00	1.83	1928.10	1542.48
32	1598	109.90	122280.00	1.83	2038.00	1630.40
33	1598	109.90	128874.00	1.83	2147.90	1718.32
34	1598	109.90	135468.00	1.83	2257.80	1806.24

An infiltration rate of 80% is assumed, meaning that 80% of the flow overtopping the parapet wall enters the dam and 20% runs off. Time to failure using the assumptions and values listed above is shown below for each of the 12 failure conditions.

Time to Failure (min)*			
	Lower Bound	Best Estimate	Upper Bound
Deep Wedge	17.4	18.5	20.0
Deep Circular	20.2	23.0	25.0
Toe Wedge	9.7	10.4	11.9
Toe Circular	10.4	11.1	12.0

*time 0 corresponds to reservoir elevation 1597.00