DLZ
ENGINEERS • ARCHITECTS • SCIENTISTS
PLANNERS • SURVEYORS

March 7, 2008

Michael D. Weeks, P.E.
Project Engineer
TranSystems Corporation
5747 Perimeter Drive, Suite 240
Dublin, Ohio 43017

Re: **SCI-823-6.81, Portsmouth Bypass Project, PID 19415**
Addendum to Report: Lucasville-Minford Road (CR 28) Interchange
Embankment Stability, Time-Rate of Consolidation, Soil Cut Slope Stability, and Subgrade Treatment
DLZ Job No.: 0121-3070.03, Document No. 108

Dear Mr. Weeks:

DLZ has reviewed ODOT-Office of Geotechnical Engineering's (OGE's) Stage I review comments (dated January 31, 2007) for Phase 1 of the SCI-823 project. In compliance with the review comments, DLZ has modified the slope stability analyses and time-rate of consolidation calculations for the Lucasville-Minford Road (CR 28) interchange embankments. This document also presents recommendations for soil cut slopes, and subgrade treatment for the interchange mainline roadway and ramp alignments contained within the interchange.

The following summarizes the OGE comments related to the interchange:

- OGE stated that DLZ should be consistent with the assumed shear strength values for the embankment fill material since some analyses used Φ=32 degrees while others used Φ=35 degrees, with no cohesion.
- OGE commented on the minimum required factor of safety against global stability used in the report (FS=1.25). The correct minimum required factor of safety should be 1.30 for the interchange embankments and soil cuts.
- OGE requested that DLZ use a standard degree of consolidation of ninety percent when citing consolidation times instead of eighty percent.
- OGE suggested that when estimated settlements are in excess of 24 inches, pavement preparation should not commence until at least ninety percent of primary consolidation has occurred.
- OGE stated that DLZ should evaluate soil cut slopes in the interchange to ensure that the recommended use of 2H:1V slopes in the soil cuts is adequate.
- OGE stated that mainline roadway and ramp subgrade contained within the interchange be evaluated as per GB1.

Summary of Report Modifications:

- The global stability of critical embankment sections have been reevaluated using Φ=35 degrees and a standard degree of consolidation of ninety percent to report estimated consolidation times. Additionally, the appropriate global stability conditions (undrained and drained) were held to the

minimum required factor of safety of 1.30. These modifications affected the embankment height during staged construction, the required consolidation times between stages, and the reporting of overall consolidation times.

- The stability of the soil cut slopes in the interchange area were evaluated for stability. The analyses indicate that 2H:1V slopes in soil cuts are stable. The results of the stability analyses are attached.
- The mainline and ramp subgrades in the interchange were evaluated to determine the proper course of subgrade mediation as per Geotechnical Bulletin No1 (GB1). Several areas require treatment to ensure a stable subgrade is provided. Refer to the Subgrade Recommendations section for more information.

A. Embankment Evaluations

As per ODOT's review comments, the stability analyses have been revised to reflect consistent shear strength parameters used for the embankment fill throughout the project. The analyses contained in the interchange report used Φ=32 degrees for the embankment fill material. For consistency, the revised analyses assumed Φ=35 degrees for all of the stability analyses. In addition, the required minimum factor of safety of 1.30 was used for the global stability analyses. When citing "benchmark" consolidation periods, the standard of ninety percent consolidation (U=90%) was used instead of eighty percent, as cited in the report.

Slope stability analyses contained in the Lucasville-Minford Road (CR 28) Interchange Report (hereafter referred to as the interchange report) indicated that the highest mainline embankment section (45 ft) is the most critical with respect to stability. Consequently, this embankment section was reevaluated. In the analyses, it was assumed that the embankments are characterized by 2H:1V side slopes. These analyses have been reevaluated using Φ=35; all other strength and consolidation parameters remained the same as those established in the interchange report. The details and results of these analyses are discussed in the following paragraphs.

A.1. Stability Analyses

Analyses performed for the full height embankment (45 ft) yielded a critical factor of safety of 0.96 for the undrained condition, which is well below the required minimum value of 1.30. Analyses performed for the drained and seismic conditions resulted in infinite slope type failures, with factors of safety of 1.40 and 1.30, respectively. Deeper, specified surfaces also resulted in factors of safety above the minimum required factor of safety of 1.30.

Due to the low in-situ undrained shear strength, construction of the interchange embankments using staged construction was investigated. Analyses indicate that the interchange embankments could be built in two stages. The first embankment stage may be constructed to a maximum height of 32 feet while maintaining the minimum required factor of safety of 1.30. After construction of the stage 1 embankment, a waiting period will be required prior to placing any additional fill. The waiting period is necessary to allow the foundation soil to consolidate under the influence of the stage 1 embankment load. Analyses indicate that at least fifty percent (U=50%) of the excess pore pressures should be allowed to dissipate prior to adding subsequent stages. In addition to the waiting period, the maximum pore water

pressure head during the stage 1 embankment construction should not be greater than 15 feet above the existing ground surface. If the pore pressure rises above this level, the placement of fill should halt immediately to allow the level of the pore pressure to dissipate. The placement of fill may resume after the excess pore pressure has dissipated to a level below 15 feet above the existing ground surface.

After the consolidation period (U=50%), fill operations for the stage 2 embankment may commence. The stage 2 embankment may be constructed up to the proposed grade level (45 ft). During construction of the stage 2 embankment, the maximum pore water pressure head should not be greater than 10 feet above the existing ground surface. If the pore pressure rises above this level, the placement of fill should halt immediately to allow the level of the pore pressure to dissipate. The placement of fill may resume after the excess pore pressure has dissipated to a level no greater than 10 feet above the existing ground surface. A summary of the analyses, as well as the graphic results of stability analyses are attached.

A.2. Time-Rate of Consolidation

There are no changes to the total settlement/consolidation calculations presented in the interchange report.

The time-rate of consolidation calculations were modified based upon the "benchmark" time-rate of consolidation of ninety percent instead of eighty percent. Various wick drain spacing options and the associated consolidation times are also presented. The results of the calculations are presented in the following paragraphs.

As mentioned above, after constructing the stage 1 embankment, fifty percent of consolidation (U=50%) should be achieved prior to placing the subsequent stage. The estimated consolidation times are presented in the following table. It should be noted that these consolidation times are estimates only. The ODOT construction representative should determine when the specified degree of consolidation has occurred based upon settlement and piezometer measurements in the field.

Time-Rate of Consolidation Estimates

Wick Drain Spacing	Time to Specified Degree of Consolidation, t			
	[1]Mainline Embankments (U=50%)	Mainline Embankments (U=90%)	Interchange – Ramp A/B (U=90%)	Interchange – Ramp C/D (U=90%)
No Wick Drains	27 years	115 years	13 years	45 years
3 ft	40 days	150 days	140 days	145 days
5 ft	110 days	405 days	360 days	395 days
7 ft	205 days	775 days	635 days	740 days

[1] Estimated waiting/consolidation period after placing stage 1, prior to placing subsequent stages.

Based upon OGE comments, in areas where the maximum anticipated settlement is in excess of 24 inches, steps for pavement preparations should not begin until at least ninety percent of the consolidation has been achieved. This recommendation is intended to prevent poor pavement performance due to excessive settlements.

A.3. Wick Drain and Instrumentation Plans

Due to changes in the time-rate of consolidation calculations and the addition of alternate wick drain spacing options, an update of the wick drain and instrumentation plans for the interchange are attached.

B. Soil Cut Slopes

As per ODOT's review comments, stability analyses have been performed for the soil cut slopes in the area of the Lucasville-Minford Road (CR 28) Interchange to verify the recommended use of 2H:1V slopes. Based upon the subsurface conditions encountered by the borings and the available cross sections, two sections appear to be the most critical with respect to stability. Consequently, these soil cuts, at Ramp B station 528+00 and Ramp D station 522+50 were analyzed for stability.

The soil cut at Ramp B station 528+00 is assumed to be approximately 22.8 feet high. The subsurface conditions encountered by boring B-1226 are assumed for these analyses. The undrained and drained conditions yielded critical factors of safety of 2.92 and 1.06, respectively. It should be noted that the critical failure surface for the drained condition was an infinite slope type failure, with a factor of safety of 1.06. However, specified surfaces, which are deeper, achieve factors of safety above the minimum required value of 1.30. The results of the stability analyses indicate that the use of 2H:1V slopes are acceptable.

The soil cut at Ramp D station 522+50 was evaluated for stability. This cut in soil is assumed to be approximately 30.5 feet high. The subsurface conditions encountered by boring R-457 are assumed for these analyses. The undrained and drained conditions yielded critical factors of safety of 1.35 and 1.31, respectively. The results of the stability analyses indicate that the use of 2H:1V slopes are acceptable. The results of the stability analyses are attached.

C. Subgrade Recommendations

The existing subgrade soils along the interchange alignments were evaluated for suitability according to the ODOT Geotechnical Bulletin GB1 "Plan Subgrade". The results of this evaluation are presented in the attached spreadsheet. Note only samples within six feet of the existing grade were evaluated. According to GB1 guidelines, any soils with moisture contents that exceed the optimum moisture content by three or more percentage points or any soils with N-values less than 10 will likely require some form of subgrade treatment. Results of the laboratory testing indicate that 48 percent of the samples tested had moisture contents exceeding the optimum moisture content by more than 3 percent, and 74 percent of the samples of the samples had N-values less than or equal to 10.

To determine the appropriate option, the average standard penetration value (N-value) and the plasticity index (PI) of the subgrade soils were considered. The average N-value, PI, and moisture content are presented in the following table.

Percent of Samples Over Optimum MC + 3 Percent	Average N_L*	Average PI	Average MC
48	8	19	20.0

* - N_L indicates lowest standard penetration value (N) in subgrade soil.

Cement stabilization is generally used for soils that have a PI less than 20. Lime stabilization is generally not effective in stabilizing subgrade soil with N-values less than 9. The PI of the soils encountered at the site ranged from 3 to 43, and the average N-value ranged from 2 to 21, with an average value of 8. Because neither cement, nor lime stabilization would effectively remediate the range of subgrade soils encountered at the subgrade level within the interchange, the use of cement and lime stabilization is not recommended. The recommended method for treating the subgrade soil is to undercut the unsuitable soils and replace the subgrade with compacted Type B or C granular material (ODOT Item 204). For ease of construction, it is recommended that one undercut depth of 36 inches be used on the site. The following table outlines the recommended undercut areas and depths in soil.

It should be noted that several borings encountered silt (A-4b) and elastic clay (A-7-5) at or near the top of the proposed subgrade. As per GB1, these materials must not be used in the upper three feet of the proposed subgrade. When elastic clay (A-7-5) is encountered at the subgrade level, it should be completely removed, or if that is not feasible, depending on stability, a minimum of 24 inches.

As per guidance from ODOT's Geotechnical Bulletin GB1 "Plan Subgrade", when rock, shale, and coal is encountered within 24 inches of the bottom of the asphalt or concrete pavement, they are removed according to 204.05 and replaced with Item 204 Embankment. Station limits, where rock is anticipated at the subgrade level are presented in the table on the following page.

It is anticipated that a portion of the subgrade of Ramp B may be founded partially in soil and partially in rock. Based upon the subsurface conditions evident in the nearby borings, the left portion of the Ramp B is most likely to be founded partially in rock from approximate station 523+50 to 527+00. Where rock is encountered, a subgrade undercut of 2 feet is required. While, where soil is present, subgrade treatment is not required.

Subgrade in Soil - Undercut Treatment Areas

Alignment	Begin Station	End Station	Depth of Undercut
Mainline SR 823	528+00	532+00	36 - inches
CR 28 – Ramp A	528+00	530+00	36 - inches
CR 28 – Ramp A	536+00	537+17	36 - inches
CR 28 – Ramp B	514+69	516+50	36 - inches
CR 28 – Ramp B	520+50	523+50	36 - inches
CR 28 – Ramp B	523+50	527+00	24 – inches in rock / no undercut in soil
CR 28 – Ramp B	527+00	531+46	36 - inches

DLZ
ENGINEERS • ARCHITECTS • SCIENTISTS
PLANNERS • SURVEYORS

Subgrade in Soil - Undercut Treatment Areas

Alignment	Begin Station	End Station	Depth of Undercut
CR 28 – Ramp C	506+41	512+50	36 - inches
CR 28 – Ramp C	516+00	522+00	36 - inches
CR 28 – Ramp C	528+00	532+00	36 - inches
CR 28 – Ramp D	526+50	544+74	36 - inches

Subgrade in Rock

Alignment	Begin Station	End Station	Depth of Undercut
Mainline SR 823	509+50	528+00	24 - inches
CR 28 – Ramp A	514+00	528+00	24 - inches
CR 28 – Ramp B	523+50	527+00	24 – inches in rock / no undercut in soil
CR 28 – Ramp C	522+00	528+00	24 - inches
CR 28 – Ramp D	517+00	526+50	24 - inches

We appreciate having the opportunity to be of service to you on this project. Please do not hesitate to call if you have any questions concerning our findings.

Sincerely,

DLZ OHIO, INC.

Steven J. Riedy
Geotechnical Engineer

Eric Tse, P.E.
Senior Geotechnical Engineer

STATE OF OHIO
ERIC WAI KEUNG TSE
PE. 70726
REGISTERED
PROFESSIONAL ENGINEER

Encl: As noted

cc: file

sjr

M:\proj\0121\3070.03\Correspondence\Addendum Letters_Phase 1 Stage I\Lucasville-Minford Road Interchange (CR 28) Addendum.doc

Embankment Evaluations

Embankment Stability Analyses
Time-Rate of Consolidation Calculations
Wick Drain and Instrumentation Plans

SCI-823 Portsmouth Bypass
Lucasville-Minford Road Interchange , Mainline Embankment Analyses
Analysis Results Summary

Project No: 0121-3070.03
Completed by: SJR
Date: 1/21/2008

Mainline Embankment Analysis - No Staged Construction

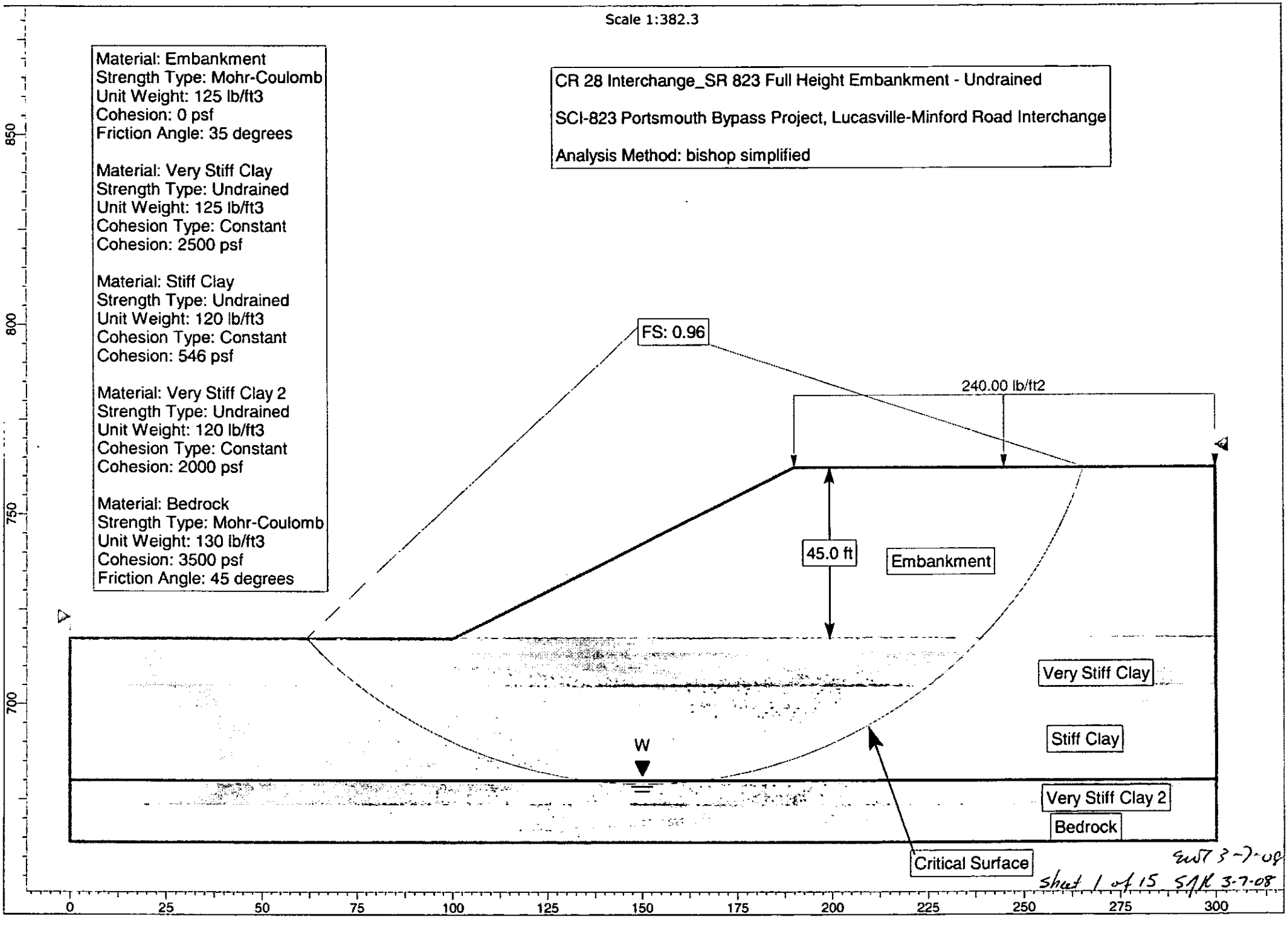
Embankment Height (ft)	Condition	Critical FS	Failure Surface	
45	Undrained	0.96	Critical Surface	
45	Drained	2.12	Specified Surface	u_e=0
45	D - Seismic	1.94	Specified Surface	u_e=0

Mainline Embankment Analysis - Stage 1

[1]Embankment Height (ft)	Condition	Critical FS	Failure Surface	[2]Critical pore water pressure head (ft)
32	Undrained	1.31	Critical Surface	NA
32	Effective Stress Analysis with u_e	1.31	Specified Surface	+15.0

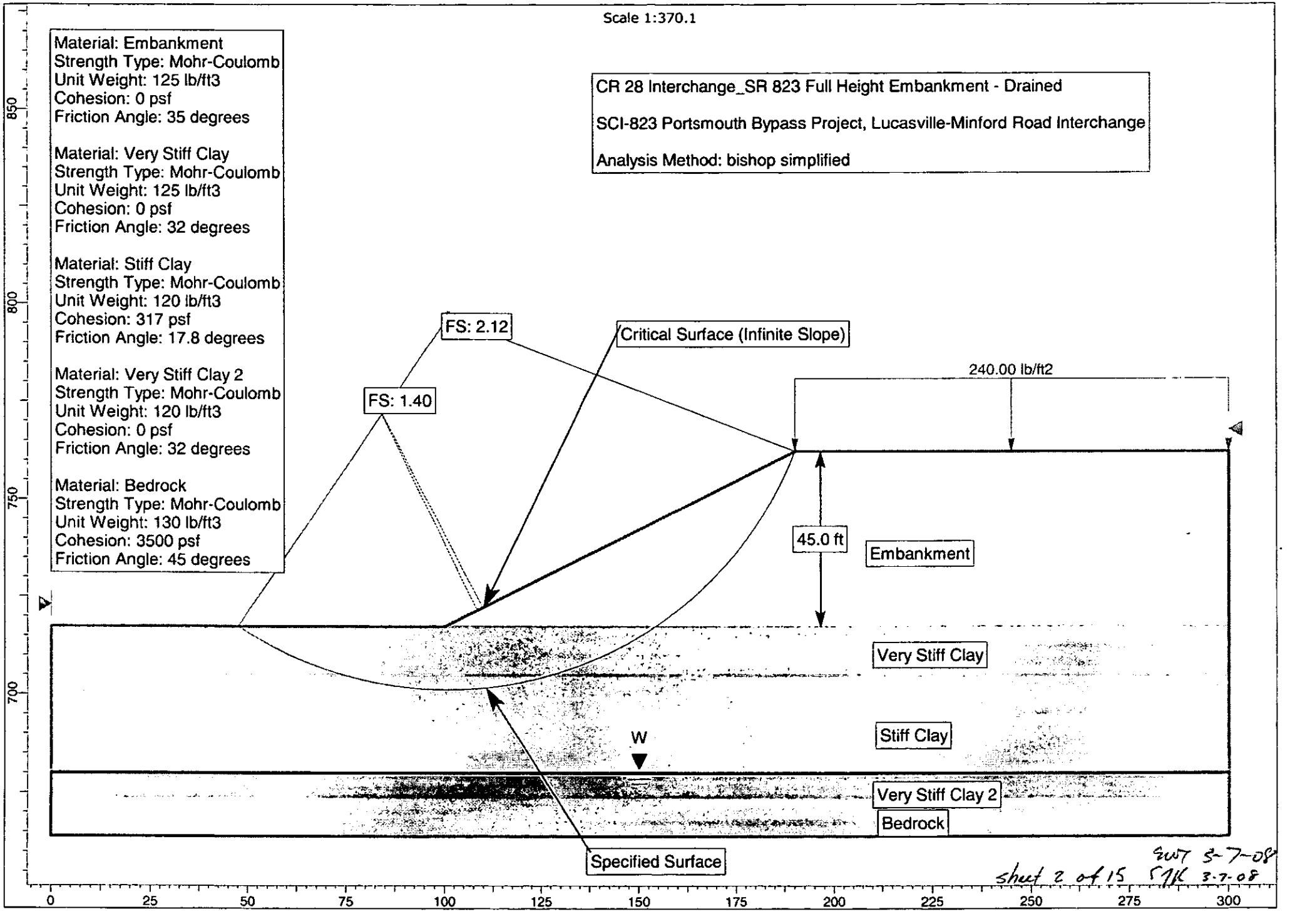
Mainline Embankment Analysis - Stage 2

[1]Embankment Height (ft)	Condition	Critical FS	Failure Surface	[2]Critical pore water pressure head (ft)
45	Undrained	1.39	Critical Surface	NA
45	Effective Stress Analysis with u_e	1.34	Critical Surface	+10.0

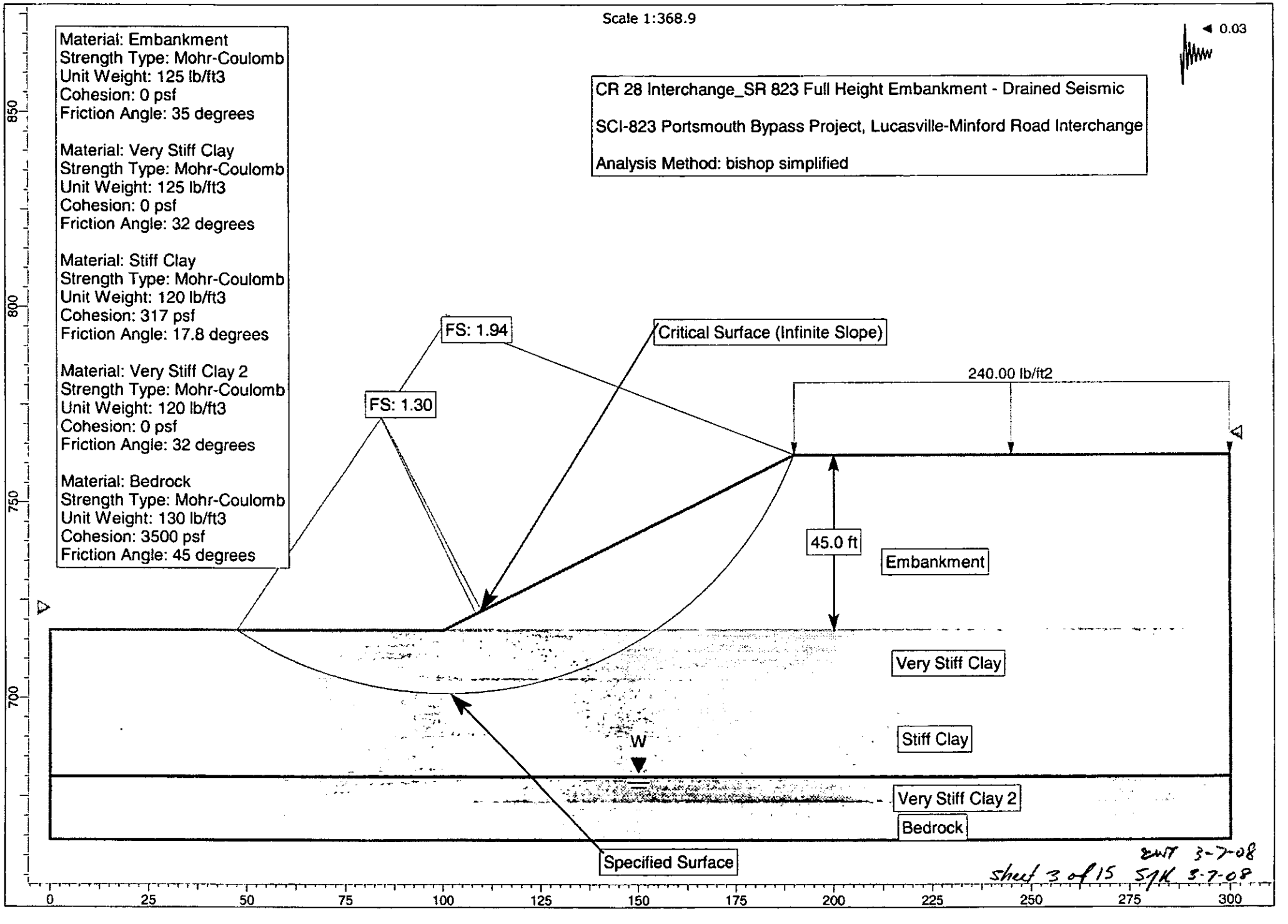


EWT 3-7-08

Sheet 1 of 15 SJK 3-7-08



EWT 3-7-08
sheet 2 of 15 TJK 3-7-08



EWT 3-7-08
sheet 3 of 15 SJK 3-7-08

Scale 1:358.6

Material: Embankment
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 35 degrees

Material: Very Stiff Clay
Strength Type: Undrained
Unit Weight: 125 lb/ft3
Cohesion Type: Constant
Cohesion: 2500 psf

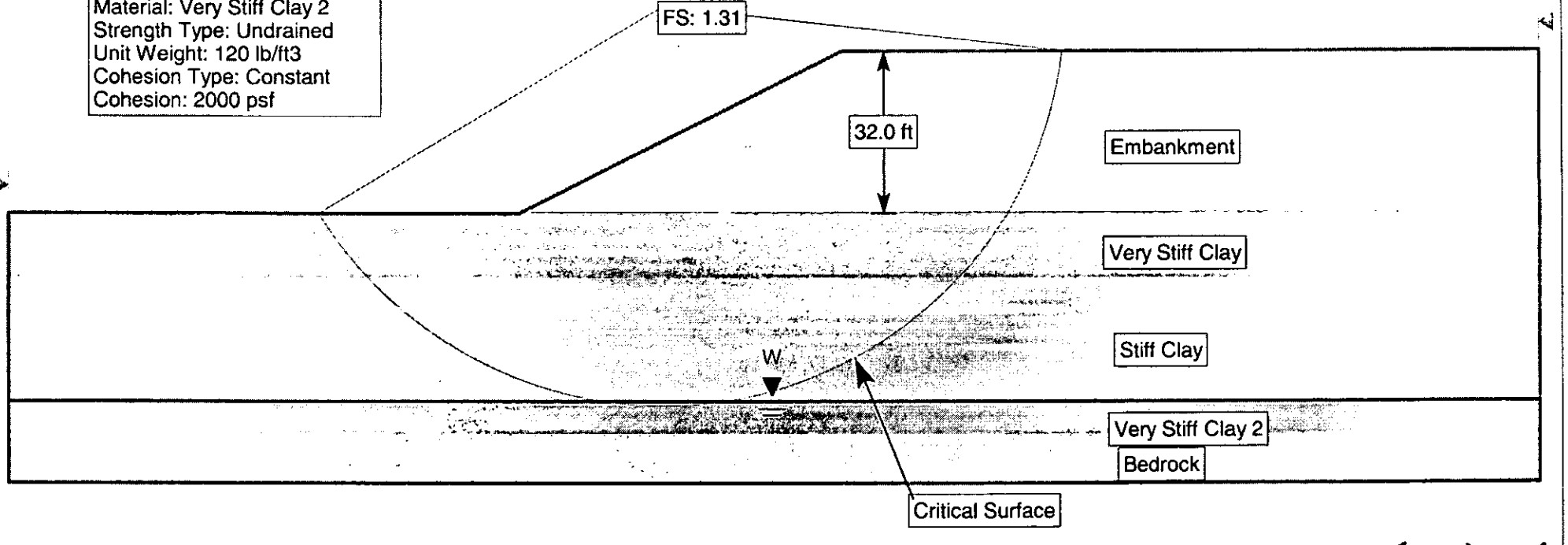
Material: Stiff Clay
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 546 psf

Material: Very Stiff Clay 2
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 2000 psf

CR 28 Interchange_SR 823 Embankment - Stage 1 - Undrained

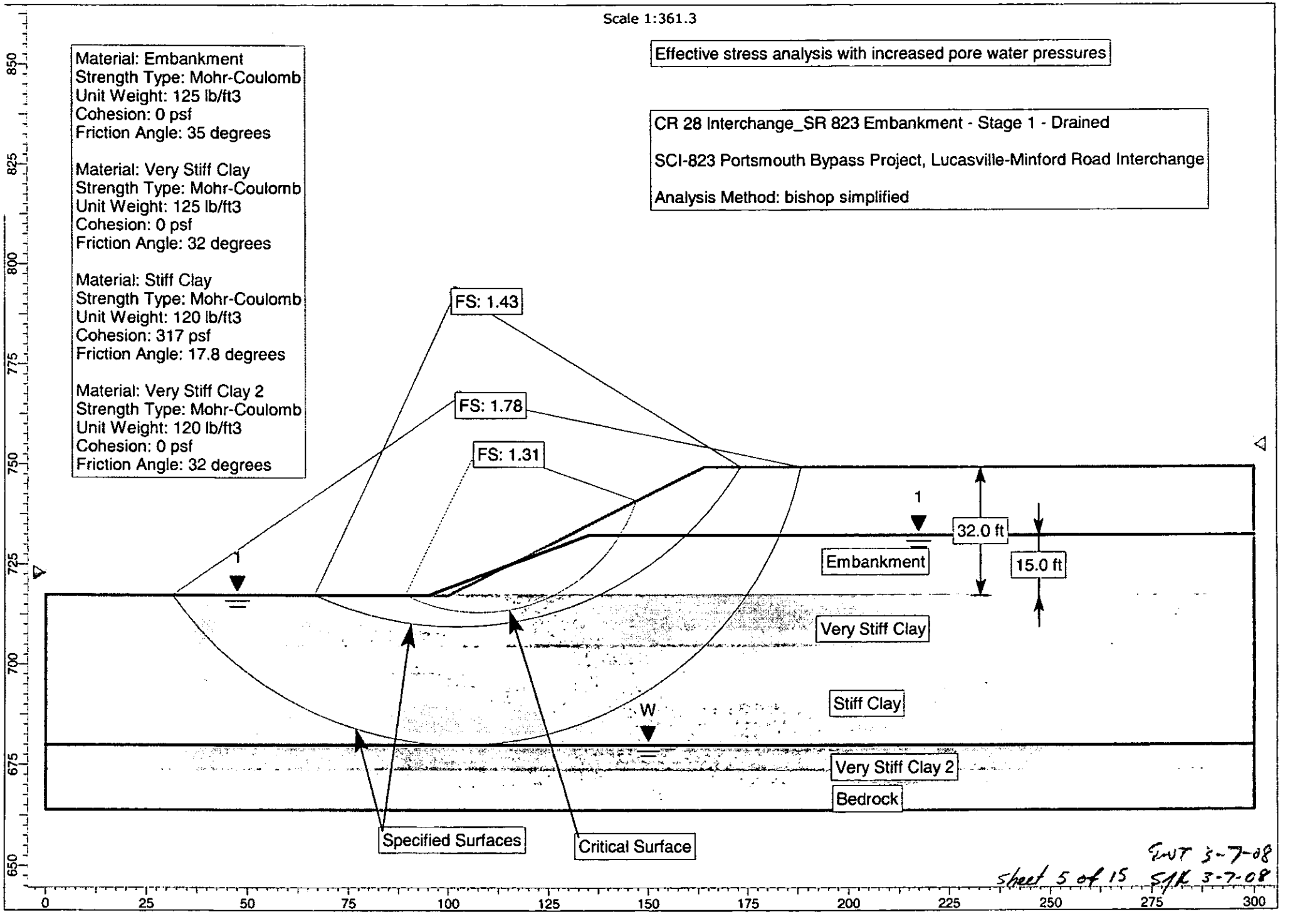
SCI-823 Portsmouth Bypass Project, Lucasville-Minford Road Interchange

Analysis Method: bishop simplified



EWT 3-7-08

sheet 4 of 15 SJK 3-7-08



EWT 3-7-08

sheet 5 of 15 SJK 3-7-08

DLZ

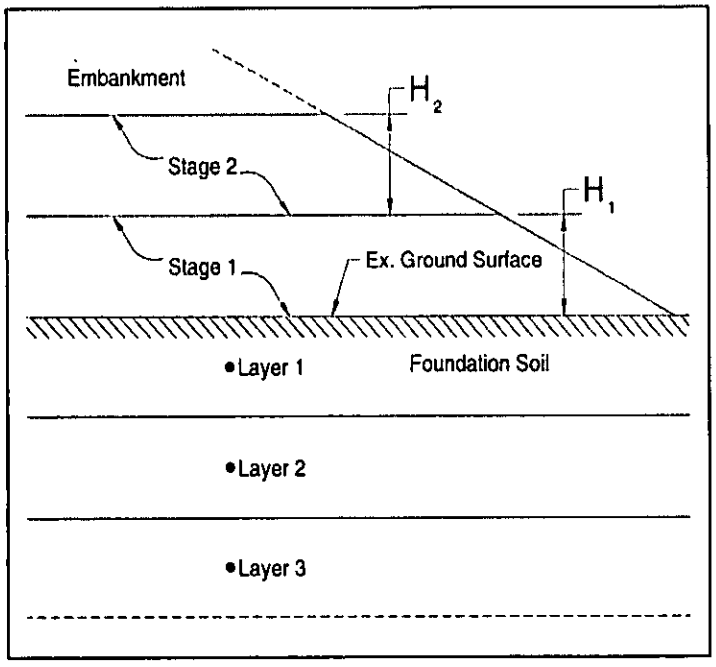
SUBJECT

Client	Transystems Corporation	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	6 OF 15
Item	Undrained Strength Analysis - Staged Const.	COMP. BY	SJK DATE 1-31-08
	C.R. 28 Interchange, Mainline Embankment	CHECKED BY	EWT DATE 3-7-08

Determine Increase in Undrained Shear Strength Due to Consolidation

Undrained Strength Analysis - Staged Construction

Ref: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi Lecture.*, Journal of Geotechnical Engineering, ASCE, 117(4), 540-615



Increase in Undrained Shear Strength from consolidation

$$c_u = c_{ui} + \Delta\sigma' \cdot \tan(\phi_{cu})$$

Where: c_{ui} Initial undrained shear strength, UU or q_u testing

ϕ_{cu} Determined from CIU testing

$\Delta\sigma'$ Effective stress increase due to embankment loading

$$\Delta\sigma' = (H_n \cdot \gamma_{emb}) \cdot U$$

Where: U Average degree of consolidation (%)

H_n Height of Embankment, Stage n (ft)

Embankment Fill

γ_{fill} 125 pcf

Stage 1 Embankment First Stage Embankment Height H_1= **32.0** Average Percent Consolidation U= **50%**

Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	ϕ_{cu} (deg)	Δc_u (psf)	c_u (psf), *After Consolidation*	Percent Increase
0-12.5	A-7-6	2500	2000	13.5	480	2980	19%
12.5-38.5	A-7-6	546	2000	13.5	480	1026	88%
38.5-43.5	A-7-6	2000	2000	13.5	480	2480	24%

Stage 2 Embankment Second Stage Embankment Height H_2= **13.0** Average Percent Consolidation U= **0%**

0-12.5	A-7-6	2980	0	13.5	0	2980	0%
12.5-38.5	A-7-6	1026	0	13.5	0	1026	0%
38.5-43.5	A-7-6	2480	0	13.5	0	2480	0%

Stage 3 Embankment Third Stage Embankment Height H_3= **2.0** Average Percent Consolidation U= **0%**

Scale 1:371.1

Undrained shear strengths assume that the foundation soils have consolidated to U=50% under the stress of Stage 1 embankment (32 ft)

CR 28 Interchange_SR 823 Embankment - Stage 2 - Undrained

SCI-823 Portsmouth Bypass Project, Lucasville-Minford Road Interchange

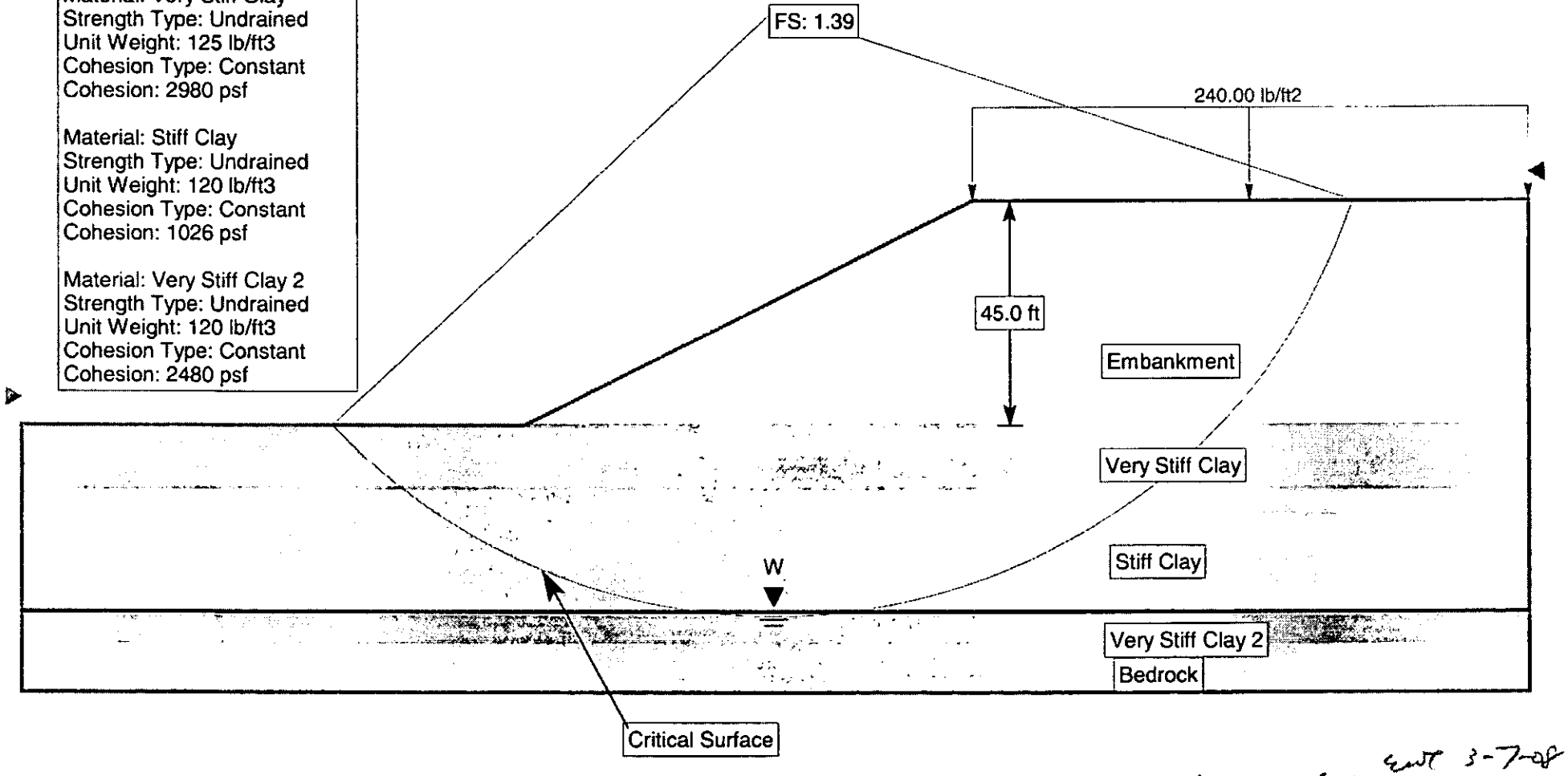
Analysis Method: bishop simplified

Material: Embankment
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 35 degrees

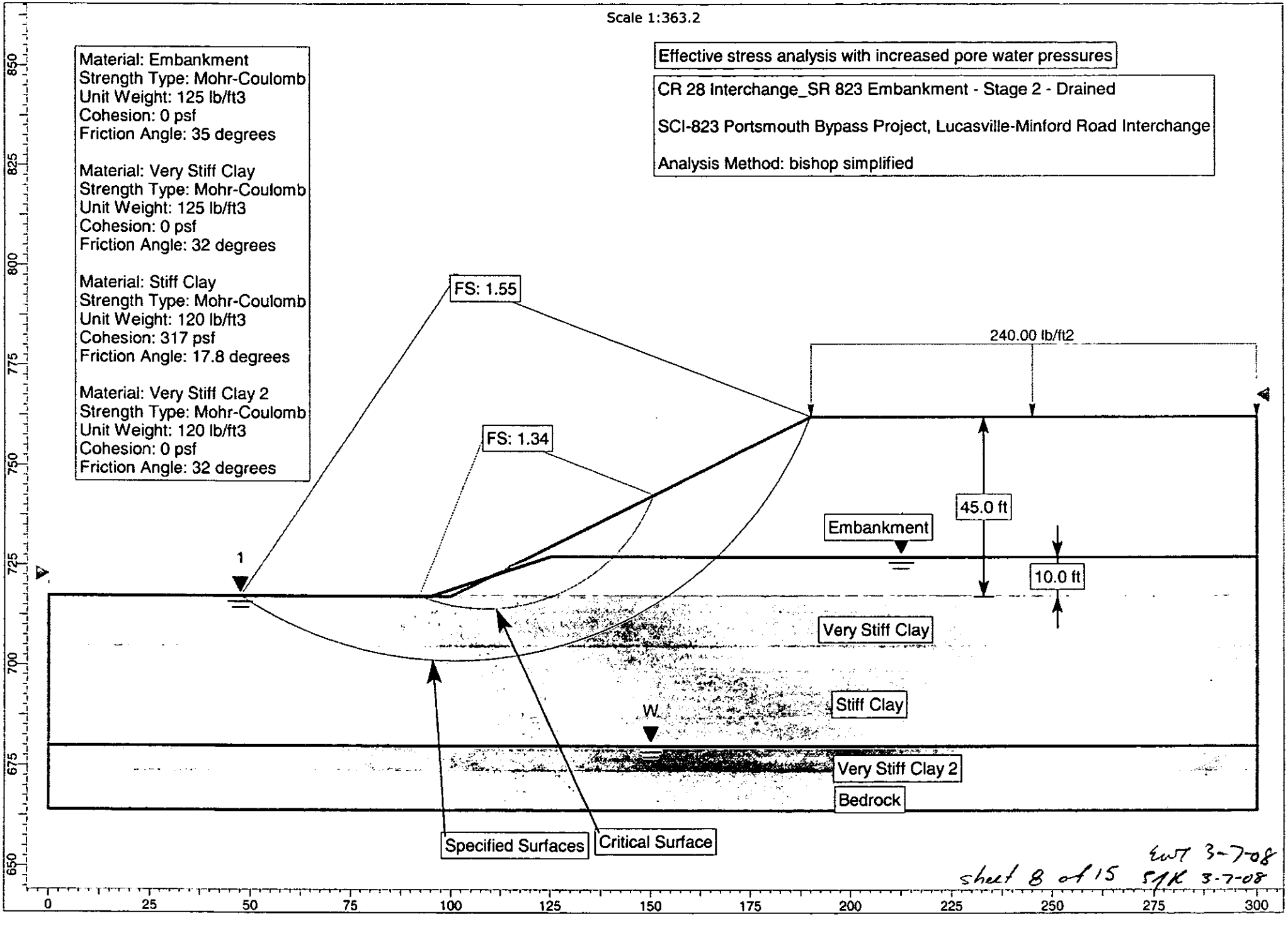
Material: Very Stiff Clay
Strength Type: Undrained
Unit Weight: 125 lb/ft3
Cohesion Type: Constant
Cohesion: 2980 psf

Material: Stiff Clay
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 1026 psf

Material: Very Stiff Clay 2
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 2480 psf



EWT 3-7-08
sheet 7 of 15 SJH 3-7-08



EWT 3-7-08
sheet 8 of 15 SJK 3-7-08

SCI-823 Portsmouth Bypass
Lucasville-Minford Road Interchange , Mainline Embankment Analyses
Analysis Results Summary - Settlement

Project No: 0121-3070.03
Completed by: SJR
Date: 1/21/2008

Mainline Embankment **Stage 1 Consolidation Time*

Maximum Settlement (in)	$*t_{50}$ (days) - Time to 50 % consolidation			
	No drains	S=3 ft	S=5 ft	S=7 ft
30	9696	40	110	205

Maximum Settlement (in)	t_{90} (days) - Time to 90 % consolidation			
	No drains	S=3 ft	S=5 ft	S=7 ft
30	41898	150	405	775

Lucasville-Minford Road Interchange - Ramp A/B

Maximum Settlement (in)	t_{90} (days) - Time to 90 % consolidation			
	No drains	S=3 ft	S=5 ft	S=7 ft
22	4777	140	360	635

Lucasville-Minford Road Interchange - Ramp C/D

Maximum Settlement (in)	t_{90} (days) - Time to 90 % consolidation			
	No drains	S=3 ft	S=5 ft	S=7 ft
11.0	16282	145	395	740

DLZ

SUBJECT	Client: Transystems Corp	JOB NUMBER	0121-3070.03
	Project: SCI-823 Portsmouth Bypass	SHEET NO.	9 OF 15
	Item: Time-rate of Settlement Calcs	COMP. BY	SJK DATE 1-31-08
	CR 28 Interchange, mainline embankment	CHECKED BY	GWT DATE 3-7-08

Consolidation period required after stage 1, prior to placing stage 2

TIME-RATE OF CONSOLIDATION CALCULATIONS

Ref: {FHWA/RD-86/168, Prefabricated Vertical Drains}

Time-Rate of Consolidation:

Without wick drains or other treatment

$$t = \frac{T_v H_{dr}^2}{c_v}$$

Input: U = 50 %

T_v = 0.1963

H_{dr} = 38.5 ft

c_v = 0.03 ft^2/day

Single (1) or double (2) drainage: 1

t = Time to specified degree of consolidation (days)

T_v = Time Factor

H_{dr} = Thickness of fine-grained layer (ft)

c_v = Coefficient of vertical consolidation (ft^2/day)

U = Average degree of consolidation (%)

50% of 20"=10" during stage 1

t_{50} = 9696 days = 26.6 years

$(\delta_c)_{ult}$ = 20 in

With wick drains (PVD) *Calculations on the following pages*

U = Average degree of consolidation (%)

S = Wick drain spacing (assume triangular pattern)

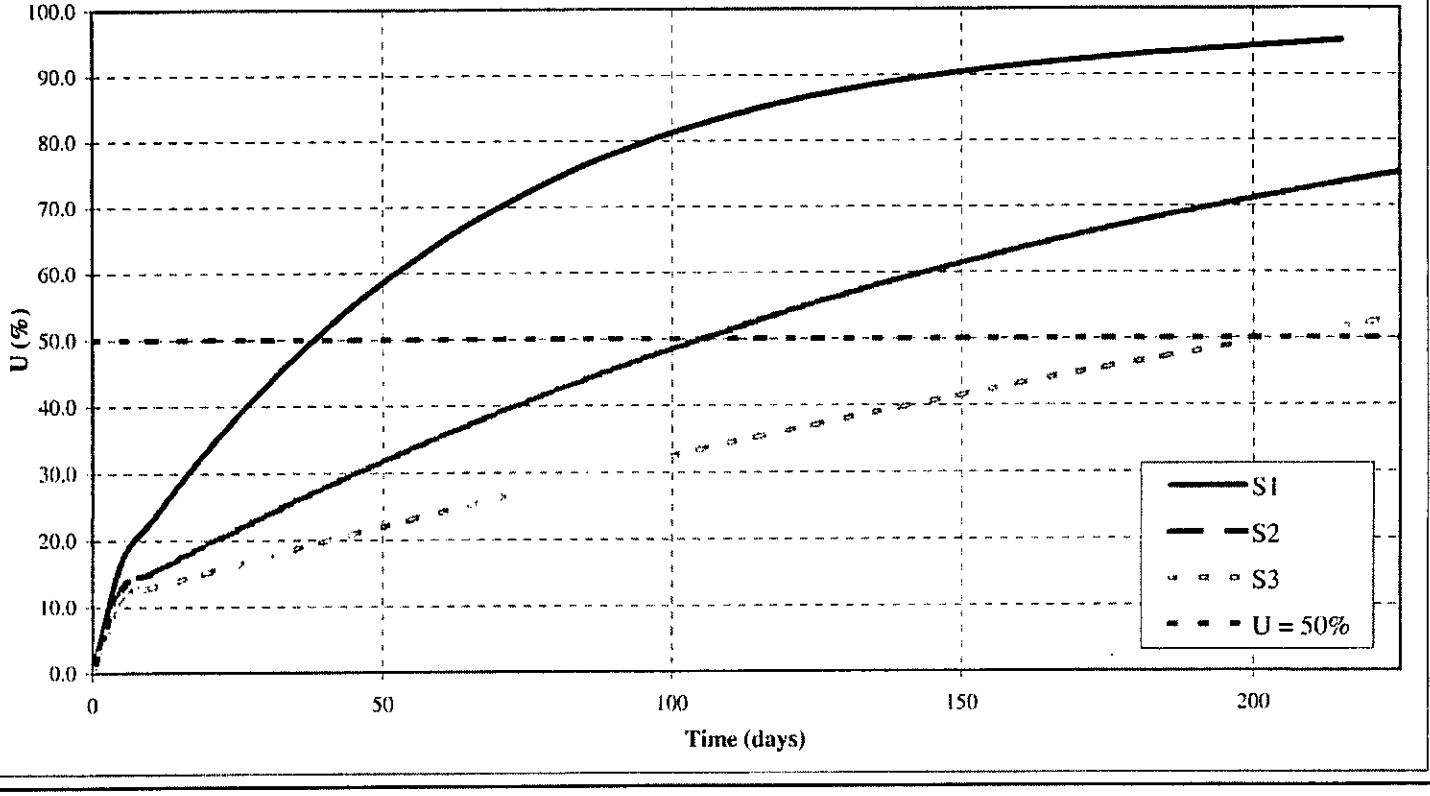
d_e = Effective drain influence zone

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v) \qquad d_e = 1.05 \cdot S$$

Spacing Options

S_1 = 3	ft	t_{50} =	40	days
S_2 = 5	ft	t_{50} =	110	days
S_3 = 7	ft	t_{50} =	205	days

Percent Consolidation vs Time using Wick Drains



DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians

Example

Reference: FHWA-RD-86-168

Wick Drain Spacing **3.0** feet Use $n = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	3.15	**0.03**	**38.5**	**20**
5	0.0151	0.0001	0.09	0.08	16.7	3.3				
10	0.0302	0.0002	0.16	0.08	22.7	4.5				
15	0.0454	0.0003	0.22	0.08	28.4	5.7				
20	0.0605	0.0004	0.28	0.08	33.6	6.7				
25	0.0756	0.0005	0.33	0.08	38.6	7.7				
30	0.0907	0.0006	0.38	0.08	43.2	8.6				
35	0.1058	0.0007	0.43	0.08	47.4	9.5				
40	0.1209	0.0008	0.47	0.08	51.4	10.3				
45	0.1361	0.0009	0.51	0.08	55.1	11.0				
50	0.1512	0.0010	0.55	0.08	58.6	11.7				
55	0.1663	0.0011	0.58	0.08	61.8	12.4				
60	0.1814	0.0012	0.61	0.09	64.7	12.9				
65	0.1965	0.0013	0.64	0.09	67.4	13.5				
70	0.2116	0.0014	0.67	0.09	69.9	14.0				
75	0.2268	0.0015	0.70	0.09	72.2	14.4				
80	0.2419	0.0016	0.72	0.09	74.4	14.9				
85	0.2570	0.0017	0.74	0.09	76.3	15.3				
90	0.2721	0.0018	0.76	0.09	78.1	15.6				
95	0.2872	0.0019	0.78	0.09	79.7	15.9				
100	0.3023	0.0020	0.79	0.09	81.2	16.2				
105	0.3175	0.0021	0.81	0.09	82.6	16.5				
110	0.3326	0.0022	0.82	0.09	83.8	16.8				
115	0.3477	0.0023	0.83	0.09	85.0	17.0				
120	0.3628	0.0024	0.85	0.09	86.0	17.2				
125	0.3779	0.0025	0.86	0.09	86.9	17.4				
130	0.3930	0.0026	0.87	0.09	87.8	17.6				
135	0.4082	0.0027	0.87	0.09	88.5	17.7				
140	0.4233	0.0028	0.88	0.09	89.2	17.8				
145	0.4384	0.0029	0.89	0.09	89.9	18.0				
150	0.4535	0.0030	0.89	0.09	90.5	18.1				
155	0.4686	0.0031	0.90	0.09	91.0	18.2				
160	0.4837	0.0032	0.91	0.09	91.5	18.3				
165	0.4989	0.0033	0.91	0.09	91.9	18.4				
170	0.5140	0.0034	0.92	0.09	92.3	18.5				
175	0.5291	0.0035	0.92	0.09	92.7	18.5				
180	0.5442	0.0036	0.92	0.09	93.1	18.6				
185	0.5593	0.0037	0.93	0.09	93.4	18.7				
190	0.5745	0.0038	0.93	0.09	93.8	18.8				
195	0.5896	0.0039	0.93	0.09	94.1	18.8				
200	0.6047	0.0040	0.94	0.09	94.4	18.9				
205	0.6198	0.0041	0.94	0.10	94.7	18.9				
210	0.6349	0.0043	0.94	0.10	94.9	19.0				
215	0.6500	0.0044	0.95	0.10	95.2	19.0				

DLZ

SUBJECT	Client: Transystems Corp	JOB NUMBER	0121-3070.03
	Project: SCI-823 Portsmouth Bypass	SHEET NO.	11 OF 15
	Item: Time-rate of Settlement Calcs	COMP. BY	SJK DATE 1-31-08
	CR 28 Interchange, mainline embankment	CHECKED BY	GWT DATE 3-7-08

Consolidation period after placement of final stage required to achieve U=90%

TIME-RATE OF CONSOLIDATION CALCULATIONS

Ref: (FHWA/RD-86/168, Prefabricated Vertical Drains)

Time-Rate of Consolidation:

Without wick drains or other treatment

$$t = \frac{T_v H_{dr}^2}{c_v}$$

Input: U = 90 %

T_v = 0.848

H_{dr} = 38.5 ft

c_v = 0.03 ft^2/day

Single (1) or double (2) drainage 1

t = Time to specified degree of consolidation (days)

T_v = Time Factor

H_{dr} = Thickness of fine-grained layer (ft)

c_v = Coefficient of vertical consolidation (ft^2/day)

U = Average degree of consolidation (%)

10" left from stage 1+(20"-30")=20" during final stage

t_{90} = 41898 days = 114.8 years

$(\delta_c)_{ult}$ = 20 in

With wick drains (PVD) *Calculations on the following pages*

U = Average degree of consolidation (%)

S = Wick drain spacing (assume triangular pattern)

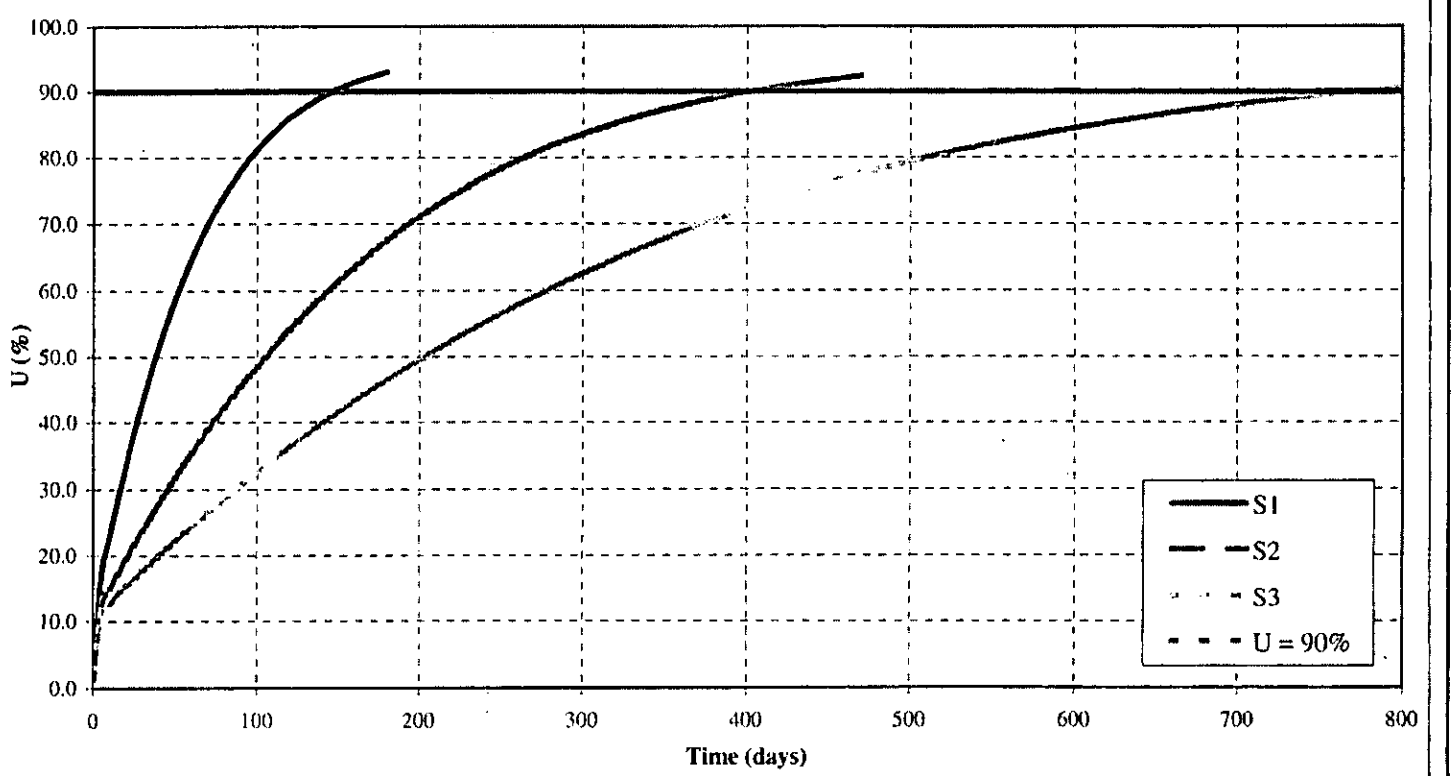
d_e = Effective drain influence zone

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v) \qquad d_e = 1.05 \cdot S$$

Spacing Options

S_1 =	3	ft	t_{90} =	150	days
S_2 =	5	ft	t_{90} =	405	days
S_3 =	7	ft	t_{90} =	775	days

Percent Consolidation vs Time using Wick Drains



DLZ

SUBJECT	Client: Transystems Corp	JOB NUMBER	0121-3070.03
	Project: SCI-823 Portsmouth Bypass	SHEET NO.	12 OF 15
	Item: Time-rate of Settlement Calcs	COMP. BY	SJR DATE 1-31-08
	CR 28 Interchange, Ramps A/B	CHECKED BY	DATE 3-7-08

TIME-RATE OF CONSOLIDATION CALCULATIONS

Ref: {FHWA/RD-86/168, Prefabricated Vertical Drains}

Time-Rate of Consolidation:

Without wick drains or other treatment

$$t = \frac{T_v H_{dr}^2}{c_v}$$

Input: U = 90 %

T_v = 0.848

H_{dr} = 13 ft

c_v = 0.03 ft^2/day

Single (1) or double (2) drainage: 1

t = Time to specified degree of consolidation (days)

T_v = Time Factor

H_{dr} = Thickness of fine-grained layer (ft)

c_v = Coefficient of vertical consolidation (ft^2/day)

U = Average degree of consolidation (%)

t_{90} = 4777 days = 13.1 years

$(\delta_c)_{ult}$ = 22 in

With wick drains (PVD) *Calculations on the following pages*

U = Average degree of consolidation (%)

S = Wick drain spacing (assume triangular pattern)

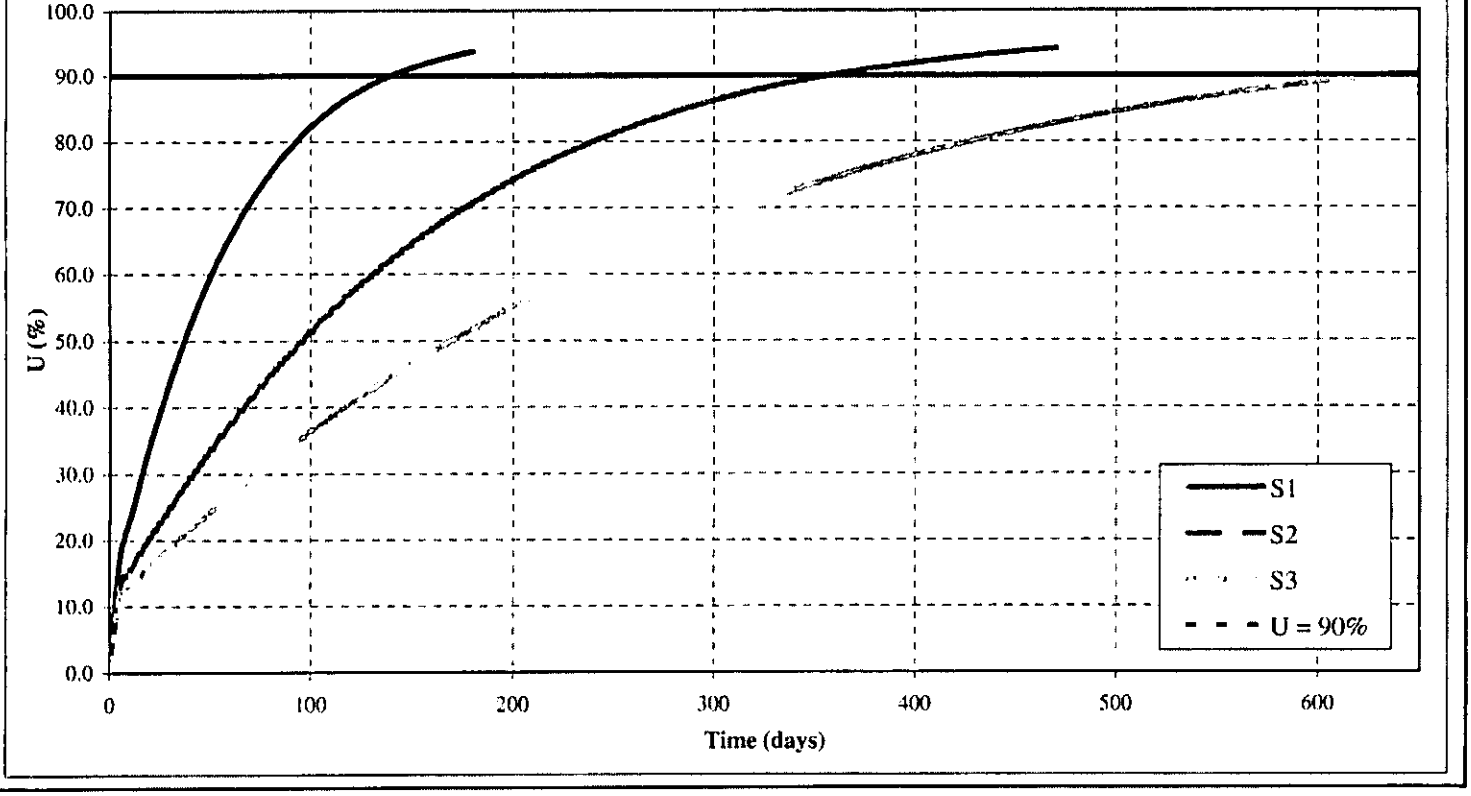
d_e = Effective drain influence zone

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v) \qquad d_e = 1.05 \cdot S$$

Spacing Options

S_1 = 3	ft	t_{90} = 140	days
S_2 = 5	ft	t_{90} = 360	days
S_3 = 7	ft	t_{90} = 635	days

Percent Consolidation vs Time using Wick Drains



DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians

Reference: FHWA-RD-86-168

Wick Drain Spacing 3.0 feet Use $n = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	3.15	0.03	13	22
5	0.0151	0.0009	0.09	0.08	17.0	3.7				
10	0.0302	0.0018	0.16	0.09	23.2	5.1				
15	0.0454	0.0027	0.22	0.09	29.0	6.4				
20	0.0605	0.0036	0.28	0.09	34.4	7.6				
25	0.0756	0.0044	0.33	0.10	39.5	8.7				
30	0.0907	0.0053	0.38	0.10	44.1	9.7				
35	0.1058	0.0062	0.43	0.10	48.5	10.7				
40	0.1209	0.0071	0.47	0.11	52.5	11.6				
45	0.1361	0.0080	0.51	0.11	56.3	12.4				
50	0.1512	0.0089	0.55	0.11	59.8	13.1				
55	0.1663	0.0098	0.58	0.11	63.0	13.9				
60	0.1814	0.0107	0.61	0.12	65.9	14.5				
65	0.1965	0.0115	0.64	0.12	68.6	15.1				
70	0.2116	0.0124	0.67	0.12	71.1	15.6				
75	0.2268	0.0133	0.70	0.13	73.4	16.2				
80	0.2419	0.0142	0.72	0.13	75.5	16.6				
85	0.2570	0.0151	0.74	0.13	77.5	17.0				
90	0.2721	0.0160	0.76	0.13	79.2	17.4				
95	0.2872	0.0169	0.78	0.14	80.8	17.8				
100	0.3023	0.0178	0.79	0.14	82.3	18.1				
105	0.3175	0.0186	0.81	0.14	83.6	18.4				
110	0.3326	0.0195	0.82	0.15	84.8	18.7				
115	0.3477	0.0204	0.83	0.15	85.9	18.9				
120	0.3628	0.0213	0.85	0.15	86.9	19.1				
125	0.3779	0.0222	0.86	0.15	87.8	19.3				
130	0.3930	0.0231	0.87	0.16	88.7	19.5				
135	0.4082	0.0240	0.87	0.16	89.4	19.7				
140	0.4233	0.0249	0.88	0.16	90.1	19.8				
145	0.4384	0.0257	0.89	0.16	90.7	20.0				
150	0.4535	0.0266	0.89	0.17	91.3	20.1				
155	0.4686	0.0275	0.90	0.17	91.8	20.2				
160	0.4837	0.0284	0.91	0.17	92.2	20.3				
165	0.4989	0.0293	0.91	0.18	92.7	20.4				
170	0.5140	0.0302	0.92	0.18	93.1	20.5				
175	0.5291	0.0311	0.92	0.18	93.4	20.6				
180	0.5442	0.0320	0.92	0.18	93.8	20.6				
185	0.5593	0.0328	0.93	0.19	94.1	20.7				
190	0.5745	0.0337	0.93	0.19	94.4	20.8				
195	0.5896	0.0346	0.93	0.19	94.7	20.8				
200	0.6047	0.0355	0.94	0.19	95.0	20.9				

DLZ

SUBJECT	Client: Transystems Corp	JOB NUMBER	0121-3070.03
	Project: SCI-823 Portsmouth Bypass	SHEET NO.	14 OF 15
	Item: Time-rate of Settlement Calcs	COMP. BY	SJK DATE 1-31-08
	CR 28 Interchange, Ramps C/D	CHECKED BY	DATE 2-7-08

TIME-RATE OF CONSOLIDATION CALCULATIONS

Ref: (FHWA/RD-86/168, Prefabricated Vertical Drains)

Time-Rate of Consolidation:

Without wick drains or other treatment

$$t = \frac{T_v H_{dr}^2}{c_v}$$

Input:
- U = 90 %
- T_v = 0.848
- H_{dr} = 24 ft
- c_v = 0.03 ft^2/day
- Single (1) or double (2) drainage: 1

t = Time to specified degree of consolidation (days)
T_v = Time Factor
H_{dr} = Thickness of fine-grained layer (ft)
c_v = Coefficient of vertical consolidation (ft^2/day)
U = Average degree of consolidation (%)

t_{90} = 16282 days = 44.6 years

$(\delta_c)_{ult}$ = 11 in

With wick drains (PVD)

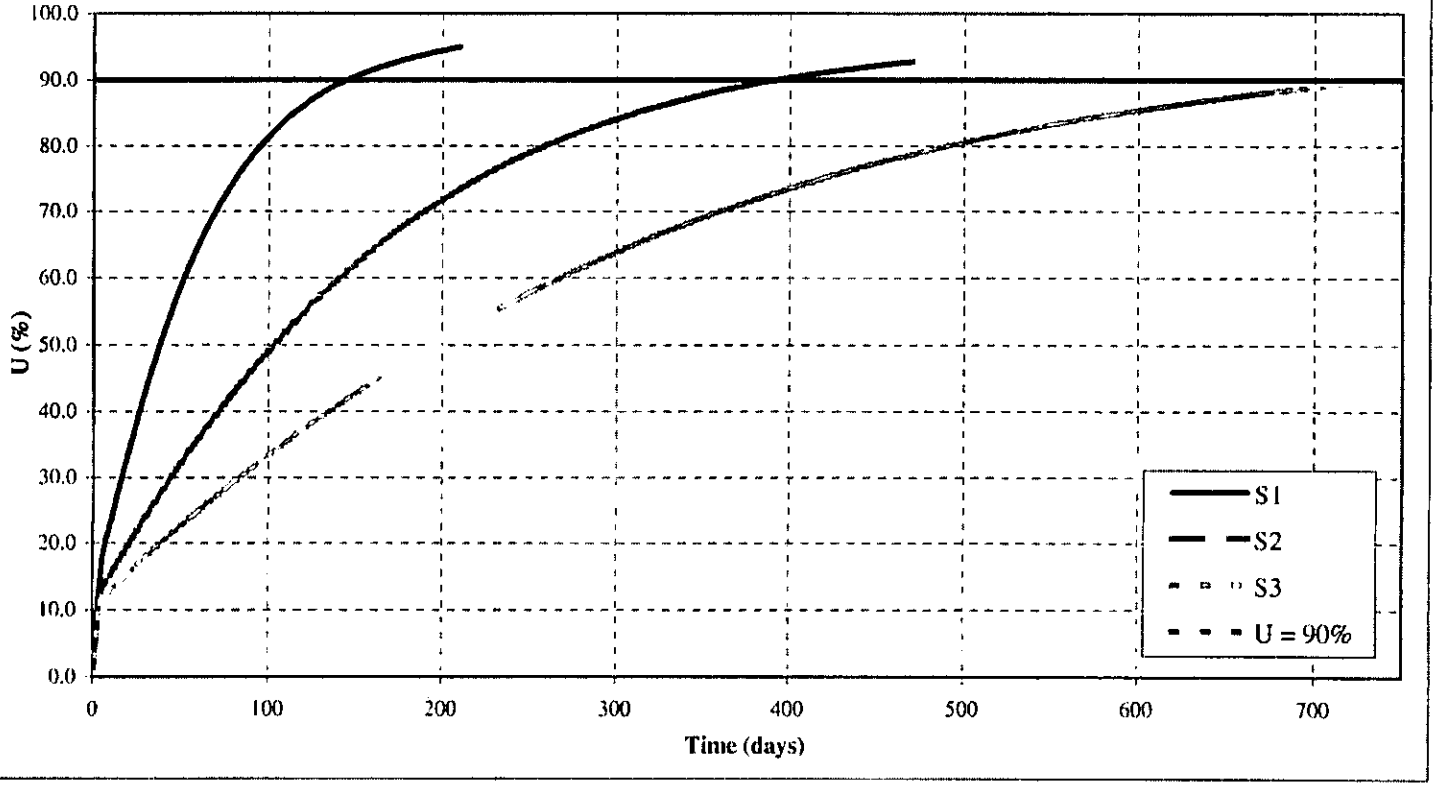
U = Average degree of consolidation (%)
S = Wick drain spacing (assume triangular pattern)
d_e = Effective drain influence zone

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v) \qquad d_e = 1.05 \cdot S$$

Spacing Options

S_1 =	3	ft	t_{90} =	145	days
S_2 =	5	ft	t_{90} =	395	days
S_3 =	7	ft	t_{90} =	740	days

Percent Consolidation vs Time using Wick Drains



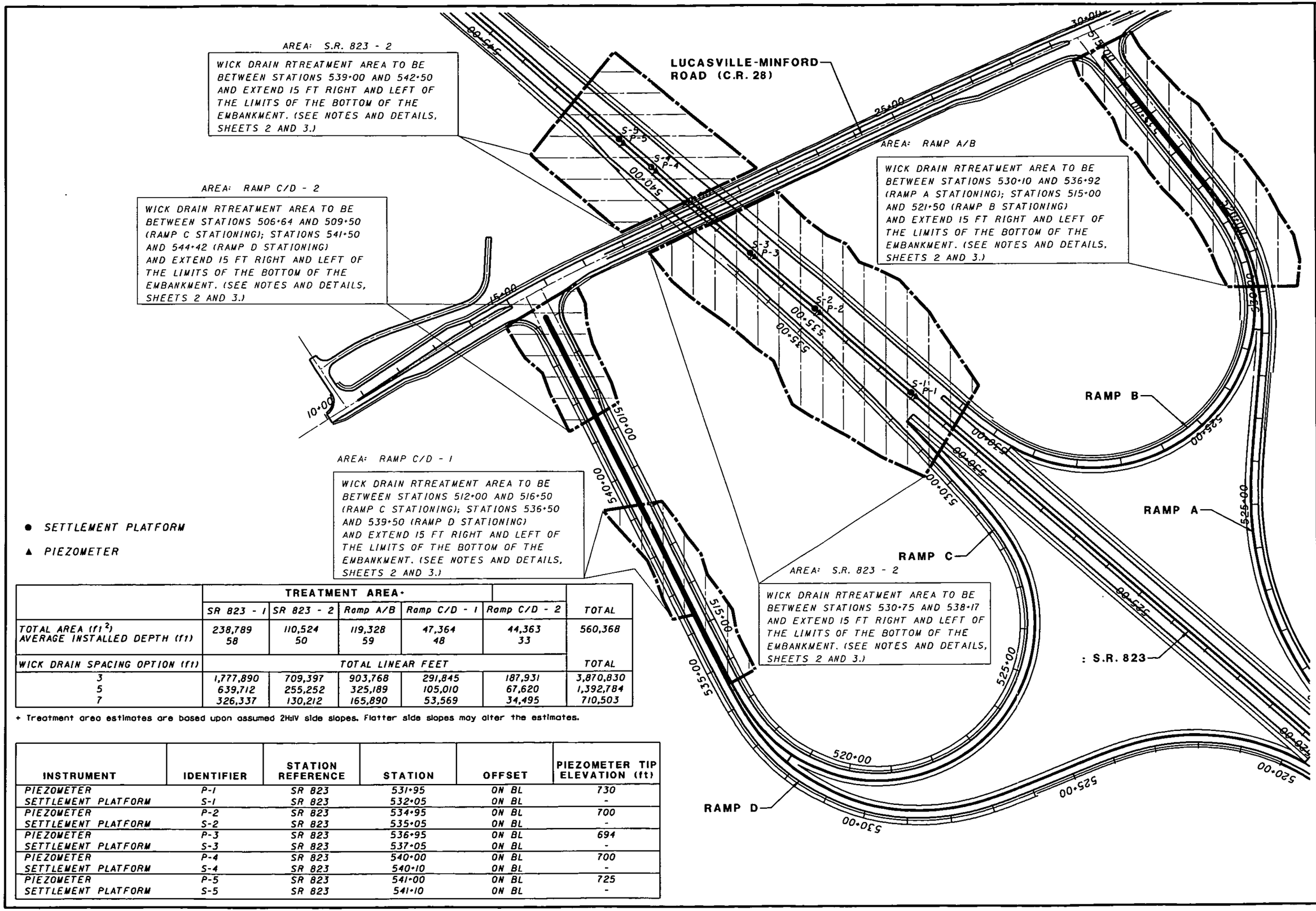
DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians

Reference: FHWA-RD-86-168

Wick Drain Spacing **3.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	3.15	0.03	24	11
5	0.0151	0.0003	0.09	0.08	16.8	1.8				
10	0.0302	0.0005	0.16	0.08	22.8	2.5				
15	0.0454	0.0008	0.22	0.08	28.5	3.1				
20	0.0605	0.0010	0.28	0.08	33.8	3.7				
25	0.0756	0.0013	0.33	0.09	38.7	4.3				
30	0.0907	0.0016	0.38	0.09	43.4	4.8				
35	0.1058	0.0018	0.43	0.09	47.7	5.2				
40	0.1209	0.0021	0.47	0.09	51.7	5.7				
45	0.1361	0.0023	0.51	0.09	55.4	6.1				
50	0.1512	0.0026	0.55	0.09	58.8	6.5				
55	0.1663	0.0029	0.58	0.09	62.0	6.8				
60	0.1814	0.0031	0.61	0.09	65.0	7.1				
65	0.1965	0.0034	0.64	0.09	67.7	7.4				
70	0.2116	0.0036	0.67	0.09	70.2	7.7				
75	0.2268	0.0039	0.70	0.09	72.5	8.0				
80	0.2419	0.0042	0.72	0.10	74.6	8.2				
85	0.2570	0.0044	0.74	0.10	76.6	8.4				
90	0.2721	0.0047	0.76	0.10	78.3	8.6				
95	0.2872	0.0049	0.78	0.10	80.0	8.8				
100	0.3023	0.0052	0.79	0.10	81.5	9.0				
105	0.3175	0.0055	0.81	0.10	82.8	9.1				
110	0.3326	0.0057	0.82	0.10	84.0	9.2				
115	0.3477	0.0060	0.83	0.10	85.2	9.4				
120	0.3628	0.0063	0.85	0.10	86.2	9.5				
125	0.3779	0.0065	0.86	0.10	87.1	9.6				
130	0.3930	0.0068	0.87	0.10	88.0	9.7				
135	0.4082	0.0070	0.87	0.10	88.7	9.8				
140	0.4233	0.0073	0.88	0.11	89.4	9.8				
145	0.4384	0.0076	0.89	0.11	90.1	9.9				
150	0.4535	0.0078	0.89	0.11	90.6	10.0				
155	0.4686	0.0081	0.90	0.11	91.2	10.0				
160	0.4837	0.0083	0.91	0.11	91.6	10.1				
165	0.4989	0.0086	0.91	0.11	92.1	10.1				
170	0.5140	0.0089	0.92	0.11	92.5	10.2				
175	0.5291	0.0091	0.92	0.11	92.9	10.2				
180	0.5442	0.0094	0.92	0.11	93.2	10.3				
185	0.5593	0.0096	0.93	0.11	93.6	10.3				
190	0.5745	0.0099	0.93	0.11	93.9	10.3				
195	0.5896	0.0102	0.93	0.12	94.2	10.4				
200	0.6047	0.0104	0.94	0.12	94.5	10.4				
205	0.6198	0.0107	0.94	0.12	94.8	10.4				
210	0.6349	0.0109	0.94	0.12	95.1	10.5				



	TREATMENT AREA+					
	SR 823 - 1	SR 823 - 2	Ramp A/B	Ramp C/D - 1	Ramp C/D - 2	TOTAL
TOTAL AREA (ft^2) AVERAGE INSTALLED DEPTH (ft)	238,789 58	110,524 50	119,328 59	47,364 48	44,363 33	560,368
WICK DRAIN SPACING OPTION (ft)	TOTAL LINEAR FEET					TOTAL
3	1,777,890	709,397	903,768	291,845	187,931	3,870,830
5	639,712	255,252	325,189	105,010	67,620	1,392,784
7	326,337	130,212	165,890	53,569	34,495	710,503

+ Treatment area estimates are based upon assumed 2H:1V side slopes. Flatter side slopes may alter the estimates.

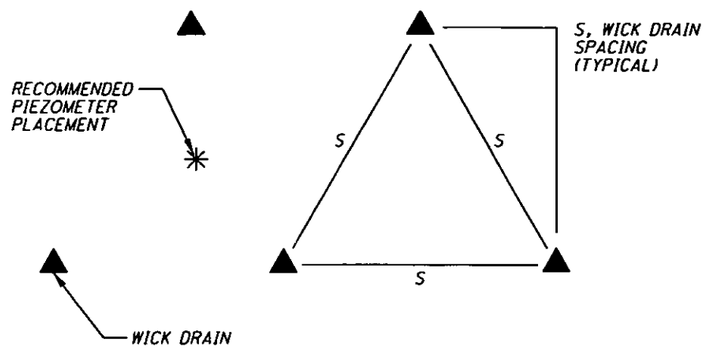
INSTRUMENT	IDENTIFIER	STATION REFERENCE	STATION	OFFSET	PIEZOMETER TIP ELEVATION (ft)
PIEZOMETER	P-1	SR 823	531+95	ON BL	730
SETTLEMENT PLATFORM	S-1	SR 823	532+05	ON BL	-
PIEZOMETER	P-2	SR 823	534+95	ON BL	700
SETTLEMENT PLATFORM	S-2	SR 823	535+05	ON BL	-
PIEZOMETER	P-3	SR 823	536+95	ON BL	694
SETTLEMENT PLATFORM	S-3	SR 823	537+05	ON BL	-
PIEZOMETER	P-4	SR 823	540+00	ON BL	700
SETTLEMENT PLATFORM	S-4	SR 823	540+10	ON BL	-
PIEZOMETER	P-5	SR 823	541+00	ON BL	725
SETTLEMENT PLATFORM	S-5	SR 823	541+10	ON BL	-

WICK DRAIN AND INSTRUMENTATION PLAN
C.R. 28/SR 823 INTERCHANGE
PID NO. 19415
SCI-823-6.81

3/6/2008
3:49:47 PM
M:\PROJ\81213\3870.03\INTERCHANGES\LUCASVILLE MINFORD\WICK DRAIN & INSTRUMENTATION PLAN\LUC-MINWICKAREAS.DGN

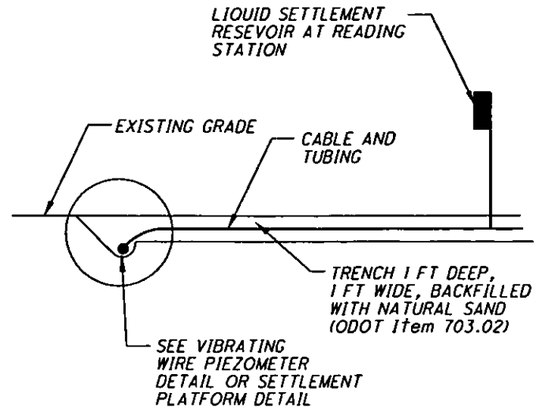
DETAIL "A"

WICK DRAIN TYPICAL LAYOUT-PLAN VIEW
(NOT TO SCALE)



DETAIL "B"

INSTRUMENTATION DETAILS
(NOT TO SCALE)



VIBRATING WIRE PIEZOMETER DETAIL

(NOT TO SCALE)

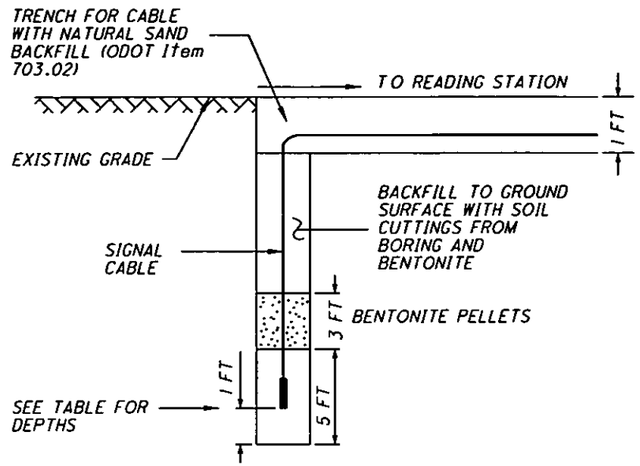


TABLE 1 -STAGED CONSTRUCTION DETAILS

EMBANKMENT SECTIONS, APPROXIMATE STATIONS	Total Embankment Height (ft)		Required Degree of Consolidation Prior to Placing Subsequent Stages	Maximum Excess Pore Pressure Head+	REQUIRED WAITING PERIOD*			
					WICK DRAIN SPACING			
					NO WICK DRAINS	3 ft	5 ft	7 ft
SR 823 530+75 to 542+50	Stage 1	32	50%	+15 ft (above)	27 years	40 days	110 days	205 days
	Stage 2++	45	NA	+10 ft (above)	NA	NA	NA	NA

* Provided waiting periods are estimates only. Piezometer and settlement readings should verify that consolidation requirements are met.
\+ Excess pore pressures should not be allowed to rise above specified level at any time. Level measured relative to existing ground surface.
++ Embankment may be constructed up to the proposed grade. Approximate maximum height is 45 feet.

SETTLEMENT PLATFORM DETAIL

(NOT TO SCALE)

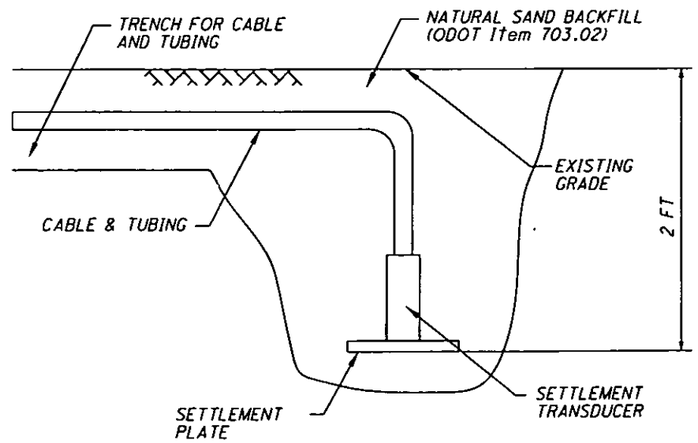


Table 2 - Time-Rate of Consolidation Details

Embankment Sections, Approximate Stations	Time to Ninety Percent Consolidation (U=90%)+			
		Wick Drain Spacing		
	No Wick Drains	3 ft	5 ft	7 ft
SR 823 530+75 to 542+50	115 years	150 days	405 days	775 days
Ramp A/B Station 529+00 to 537+00 (Ramp A)	13 years	140 days	360 days	635 days
Ramp C/D Station 506+30 to 517+00 (Ramp C)	45 years	145 days	395 days	740 days

\+ In areas where the maximum settlement is anticipated to exceed 24 inches, it is recommended that ninety percent consolidation be achieved prior to preparing the pavement.

CALCULATED SJR
CHECKED DAA

INSTRUMENTATION AND SPECIAL CONSTRUCTION NOTES AND DETAILS

SCI-823-6.81

2

3/6/2008
2:51:11 PM
M:\PROJ\08121\3078.03\INTERCHANGES\LUCASVILLE MINFORD\WICK DRAIN & INSTRUMENTATION PLAN\LUCMIN_SR823_INSTRPLAN03.DGN

NOTES:

1. PLACE 3 FEET OF ODOT ITEM 703.02 BEFORE THE INSTALLATION OF THE WICK DRAINS. WICK DRAINS TO BE INSTALLED PRIOR TO EMBANKMENT CONSTRUCTION.

2. THE SAND SHALL CONSIST OF CLEAN, FREE-DRAINING, COARSE NATURAL SAND, OR SAND AND PEA GRAVEL, SHALL BE GRADED UNIFORMLY FROM COARSE TO FINE, AND SHALL BE OF SUCH SIZE THAT, WHEN TESTING ON U.S. STANDARD SIEVES IN ACCORDANCE WITH AASHTO T27 AND WASHING THE SAMPLE IN ACCORDANCE WITH AASHTO T11, SHALL CONFORM TO THE GRADING REQUIREMENTS OF ODOT CMS 703.02.

3. THE SAND SHALL NOT CONTAIN ANY ORGANIC OR OTHER DELETERIOUS MATERIALS AND SHALL NOT BE FROZEN WHEN PLACED.

4. IF DENSE SAND, GRAVEL OR HARD SOIL LAYERS ARE ENCOUNTERED BELOW THE GROUND SURFACE AND CANNOT BE PENETRATED WITH REASONABLE EFFORT, THE CONTRACTOR SHALL BE REQUIRED TO PRE-DRILL THE WICK DRAIN LOCATIONS.

5. WICK DRAINS SHALL BE INSTALLED FROM THE WORKING SURFACE TO THE DEPTH SHOWN IN THE PLANS, OR TO COMPLETELY PENETRATE THE COMPRESSIBLE FOUNDATION SOILS AT SUCH A DEPTH EITHER SHALLOWER OR DEEPER THAN PLAN DEPTH WHERE THE SOIL RESISTS A REASONABLE EFFORT AT FURTHER PENETRATION.

6. SETTLEMENT PLATES SHALL BE GEOKON MODEL 4600 OR EQUIVALENT.

7. VIBRATING WIRE PIEZOMETERS SHALL BE SLOPE INDICATOR MODEL 52611099 OR EQUIVALENT.

8. MAINLINE SR 823 ROADWAY EMBANKMENTS MUST BE BUILT USING STAGED CONSTRUCTION. THE FOUNDAITON PORE WATER PRESSURES AND SETTLEMENTS SHALL BE MONITORED. THE STAGED CONSTRUCTION STATION LIMITS, STAGED HEIGHTS, PORE PRESSURE DETAILS ARE PRESENTED IN TABLE 1. A WAITING PERIOD WILL BE REQUIRED BETWEEN STAGES TO ALLOW PORE PRESSURES TO DISSIPATE PRIOR TO PLACING SUBSEQUENT STAGES. THE MAXIMUM ALLOWABLE PORE PRESSURE AS WELL AS THE REQUIRED WAITING PERIOD FOR SELECTED WICK DRAIN SPACING OPTIONS ARE ALSO PRESENTED IN TABLE 1. THE ESTIMATED CONSOLIDATION TIMES (U=90%) FOR OTHER INTERCHANGE FEATURES ARE PRESENTED IN TABLE 2. ESTIMATES FOR WICK DRAIN QUANTITIES ARE PRESENTED IN TABULAR FORM ON SHEET 1.

9. THE ACTUAL WICK DRAIN TREATMENT AREA AND DEPTH MIGHT DIFFER FROM THE PROPOSED LIMITS DUE TO SOIL VARIATIONS AT THE SITE AND THEREFORE SHOULD BE CONFIRMED IN THE FIELD BY THE ODOT CONSTRUCTION REPRESENTATIVE.

10. IT IS RECOMMENDED THAT WICK DRAINS BE INSTALLED PRIOR TO THE INSTALLATION OF SETTLEMENT PLATFORMS OR PIEZOMETERS. PIEZOMETERS SHOULD BE PLACED EQUAL DISTANCES FROM ADJACENT WICK DRAINS TO PREVENT PORE PRESSURE DISSIPATION NEAR THE DRAINS FROM SKEWING MEASUREMENTS, SEE DETAIL "A". THE ODOT CONSTRUCTION REPRESENTATIVE MAY MODIFY THE INSTRUMENTATION PLAN BASED UPON FIELD CONDITIONS.

CALCULATED SJR
CHECKED DAA

INSTRUMENTATION AND SPECIAL CONSTRUCTION NOTES AND DETAILS

SCI-823-6.81

3

3/6/2008
2:51:44 PM
M:\PROJ\0121\3078.83\INTERCHANGES\LUCASVILLE MINFORD\WICK DRAIN & INSTRUMENTATION PLAN\LUCMIN_INSTRPLAN84.DGN

Soil Cut Slope Stability Analyses

Scale 1:444.6

Ramp B 528+00 Soil Cut UD

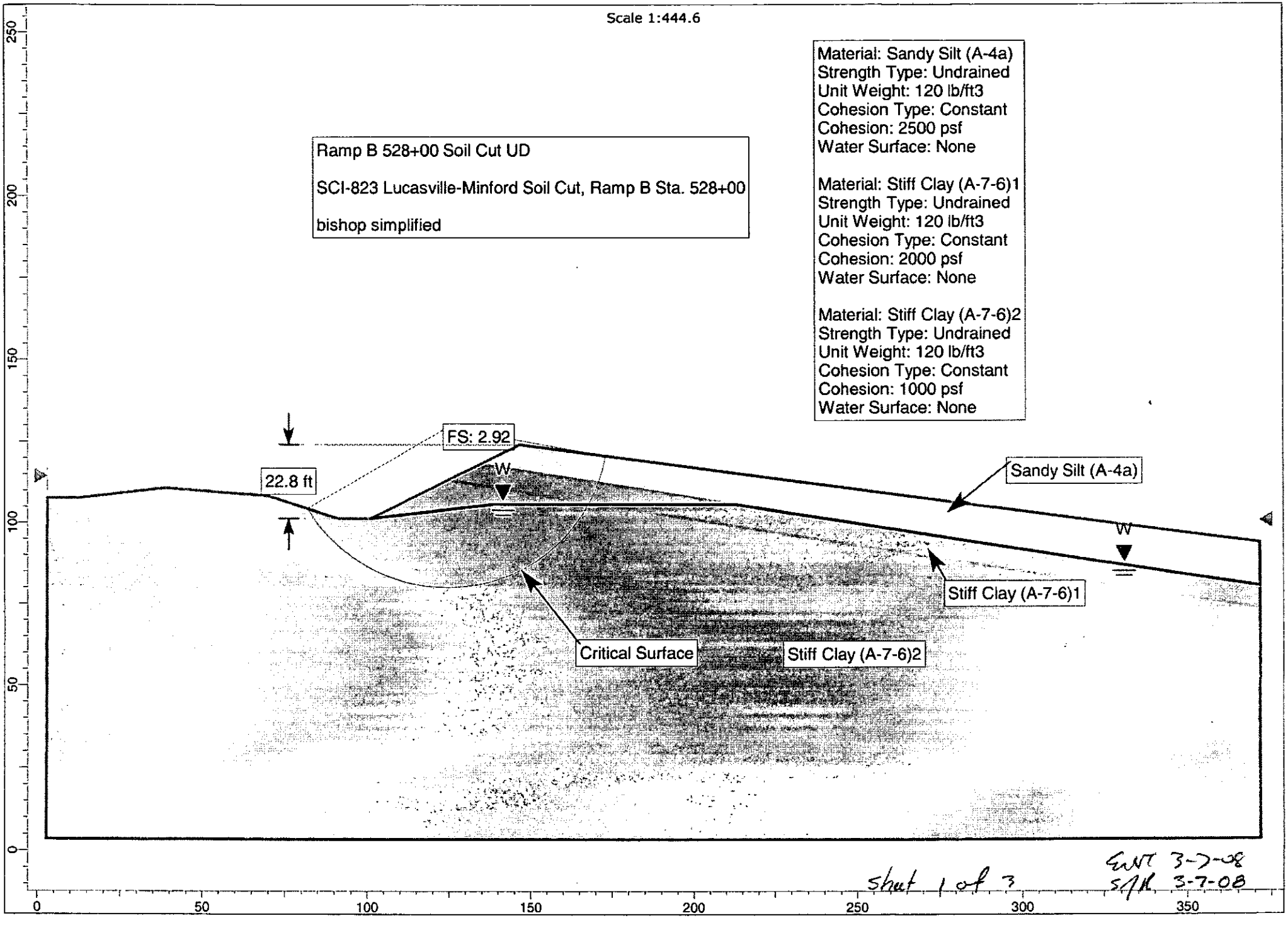
SCI-823 Lucasville-Minford Soil Cut, Ramp B Sta. 528+00

bishop simplified

Material: Sandy Silt (A-4a)
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 2500 psf
Water Surface: None

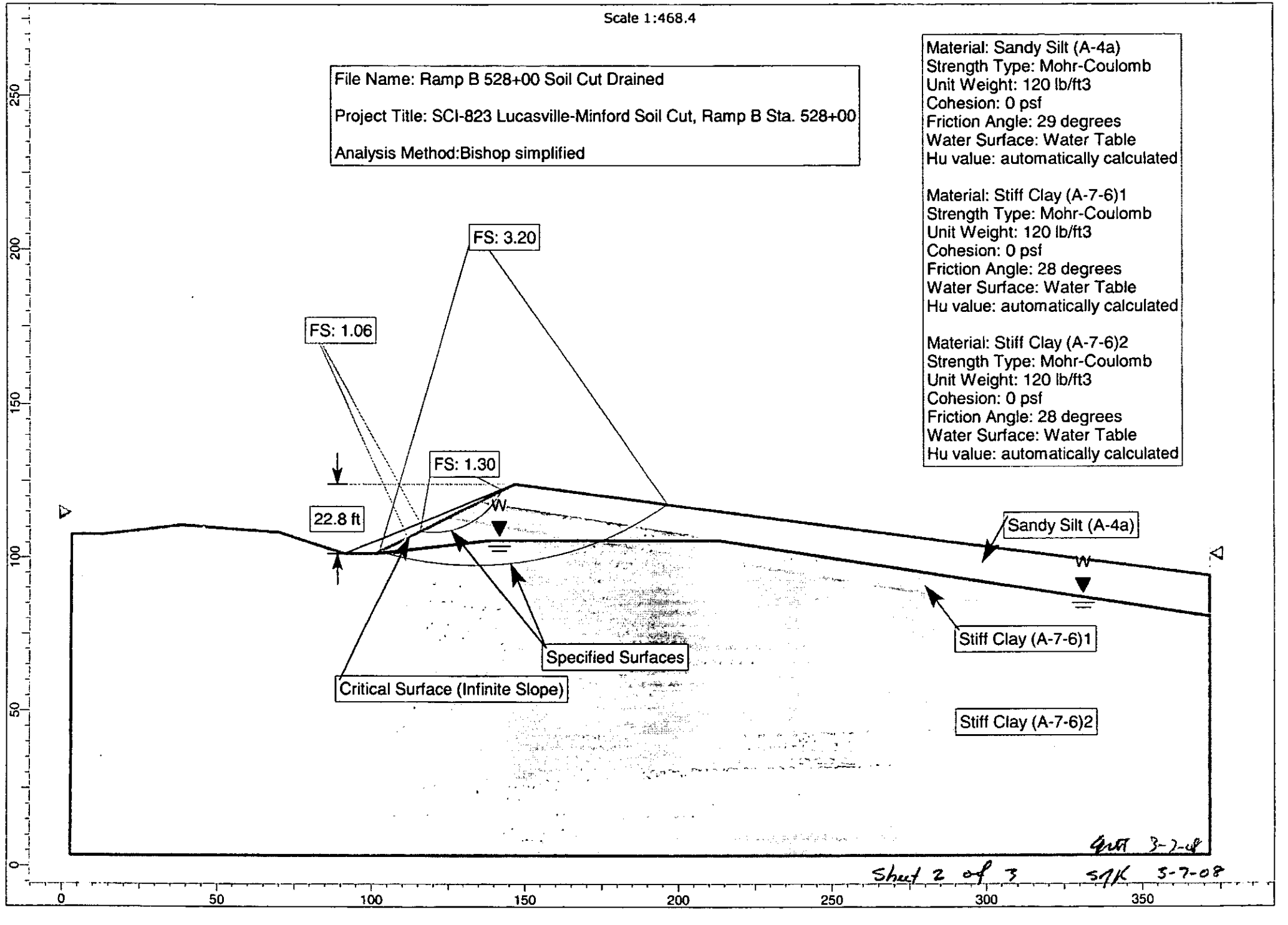
Material: Stiff Clay (A-7-6)1
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 2000 psf
Water Surface: None

Material: Stiff Clay (A-7-6)2
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 1000 psf
Water Surface: None

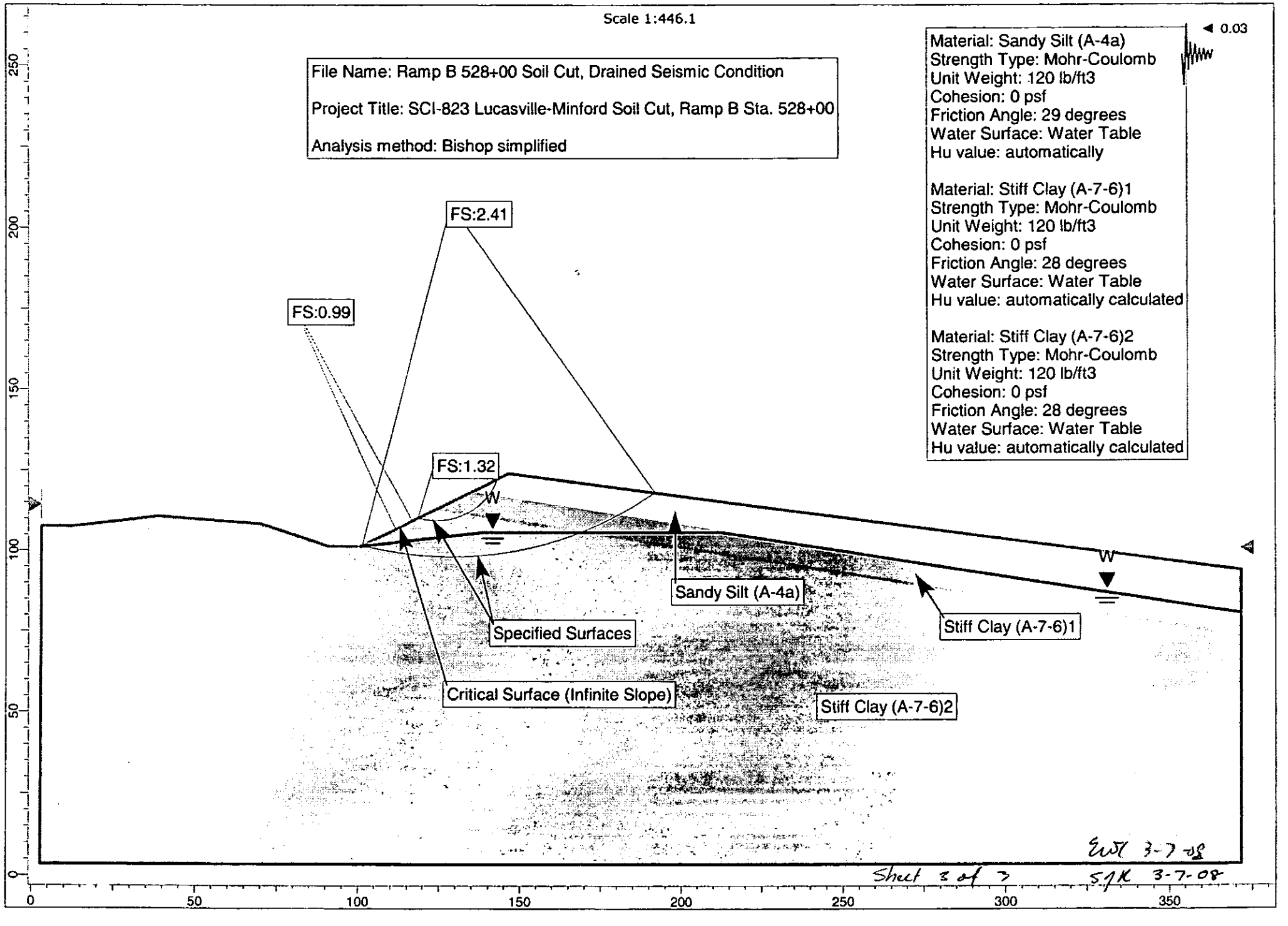


Sheet 1 of 3

GWT 3-7-08
S/R 3-7-08



Shut 2 of 3 SJK 3-7-08


Scale 1:446.1
File Name: Ramp B 528+00 Soil Cut, Drained Seismic Condition
Project Title: SCI-823 Lucasville-Minford Soil Cut, Ramp B Sta. 528+00
Analysis method: Bishop simplified
0.03
Material: Sandy Silt (A-4a)
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 29 degrees
Water Surface: Water Table
Hu value: automatically
Material: Stiff Clay (A-7-6)1
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 28 degrees
Water Surface: Water Table
Hu value: automatically calculated
Material: Stiff Clay (A-7-6)2
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 28 degrees
Water Surface: Water Table
Hu value: automatically calculated
FS:2.41
FS:0.99
FS:1.32
W
W
W
Sandy Silt (A-4a)
Specified Surfaces
Stiff Clay (A-7-6)1
Critical Surface (Infinite Slope)
Stiff Clay (A-7-6)2
0
50
100
150
200
250
300
350
Sheet 3 of 7
3-7-08

Slide Analysis Information

Document Name

File Name: Ramp B 528+00 Soil Cut UD

Project Settings

Project Title: SCI-823 Lucasville-Minford Soil Cut, Ramp B Sta. 528+00
Failure Direction: Right to Left
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu corrected
Spencer

Number of slices: 20
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Sandy Silt (A-4a)
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 2500 psf
Water Surface: None

Material: Stiff Clay (A-7-6)1
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 2000 psf
Water Surface: None

Material: Stiff Clay (A-7-6)2
Strength Type: Undrained
Unit Weight: 120 lb/ft3
Cohesion Type: Constant
Cohesion: 1000 psf
Water Surface: None

Global Minimums

Method: bishop simplified
FS: 2.915710
Center: 124.565, 129.388
Radius: 49.333
Left Slip Surface Endpoint: 81.946, 104.540
Right Slip Surface Endpoint: 173.131, 120.720
Resisting Moment=6.88938e+006 lb-ft
Driving Moment=2.36285e+006 lb-ft

Method: janbu corrected
FS: 3.533610
Center: 129.027, 142.356
Radius: 58.175
Left Slip Surface Endpoint: 86.019, 103.183
Right Slip Surface Endpoint: 182.511, 119.469
Resisting Horizontal Force=119629 lb
Driving Horizontal Force=33854.7 lb

Method: spencer
FS: 3.382230
Center: 129.027, 159.648
Radius: 70.487
Left Slip Surface Endpoint: 87.508, 102.686
Right Slip Surface Endpoint: 186.564, 118.929
Resisting Moment=9.5431e+006 lb-ft
Driving Moment=2.82154e+006 lb-ft
Resisting Horizontal Force=114810 lb
Driving Horizontal Force=33945 lb

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 3281
Number of Invalid Surfaces: 1559

Error Codes:
Error Code -103 reported for 15 surfaces
Error Code -107 reported for 1353 surfaces
Error Code -112 reported for 191 surfaces

Method: janbu corrected
Number of Valid Surfaces: 2581
Number of Invalid Surfaces: 2259
Error Codes:
Error Code -103 reported for 15 surfaces
Error Code -107 reported for 1353 surfaces
Error Code -108 reported for 521 surfaces
Error Code -111 reported for 179 surfaces
Error Code -112 reported for 191 surfaces

Method: spencer
Number of Valid Surfaces: 1499
Number of Invalid Surfaces: 3341
Error Codes:
Error Code -103 reported for 15 surfaces
Error Code -107 reported for 1353 surfaces
Error Code -108 reported for 658 surfaces
Error Code -111 reported for 1124 surfaces
Error Code -112 reported for 191 surfaces

Error Codes

The following errors were encountered during the computation:

-103 = Two surface / slope intersections,
but one or more surface / nonslope external polygon
intersections lie between them. This usually occurs
when the slip surface extends past the bottom of the
soil region, but may also occur on a benched
slope model with two sets of Slope Limits.

-107 = Total driving moment or
total driving force is negative. This will occur
if the wrong failure direction is specified,
or if high external or anchor loads are applied
against the failure direction.

-108 = Total driving moment
or total driving force < 0.1. This is to
limit the calculation of extremely high safety
factors if the driving force is very small
(0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F)

< 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

List of All Coordinates

Material Boundary

134.576	118.191
371.525	80.872

Material Boundary

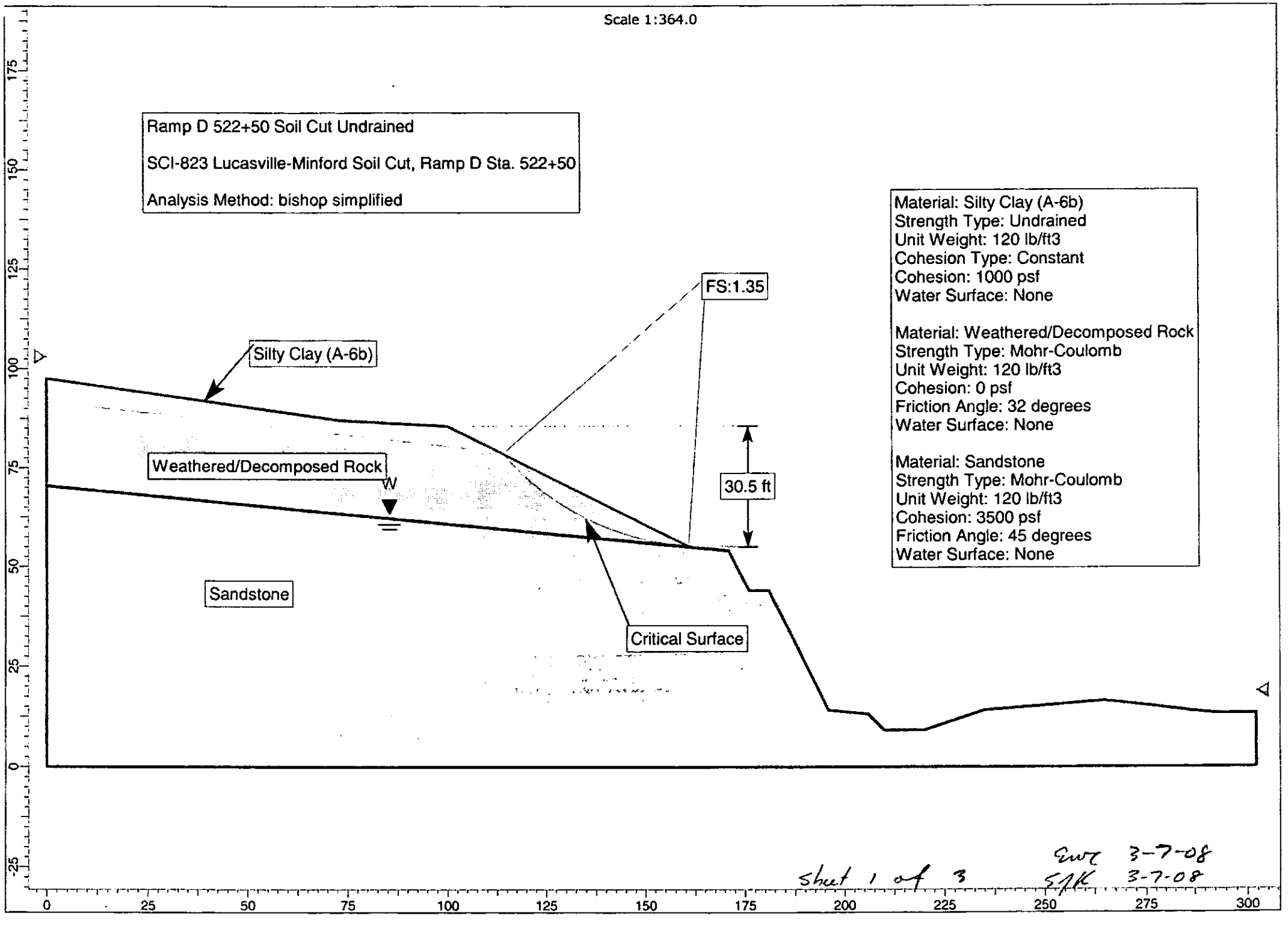
124.757	113.281
371.525	73.948

External Boundary

2.759	3.518
371.525	3.518
371.525	73.948
371.525	80.872
371.525	94.271
146.685	124.245
134.576	118.191
124.757	113.281
101.144	101.474
91.144	101.474
70.115	108.484
38.781	110.763
13.115	107.709
3.115	107.709

Water Table

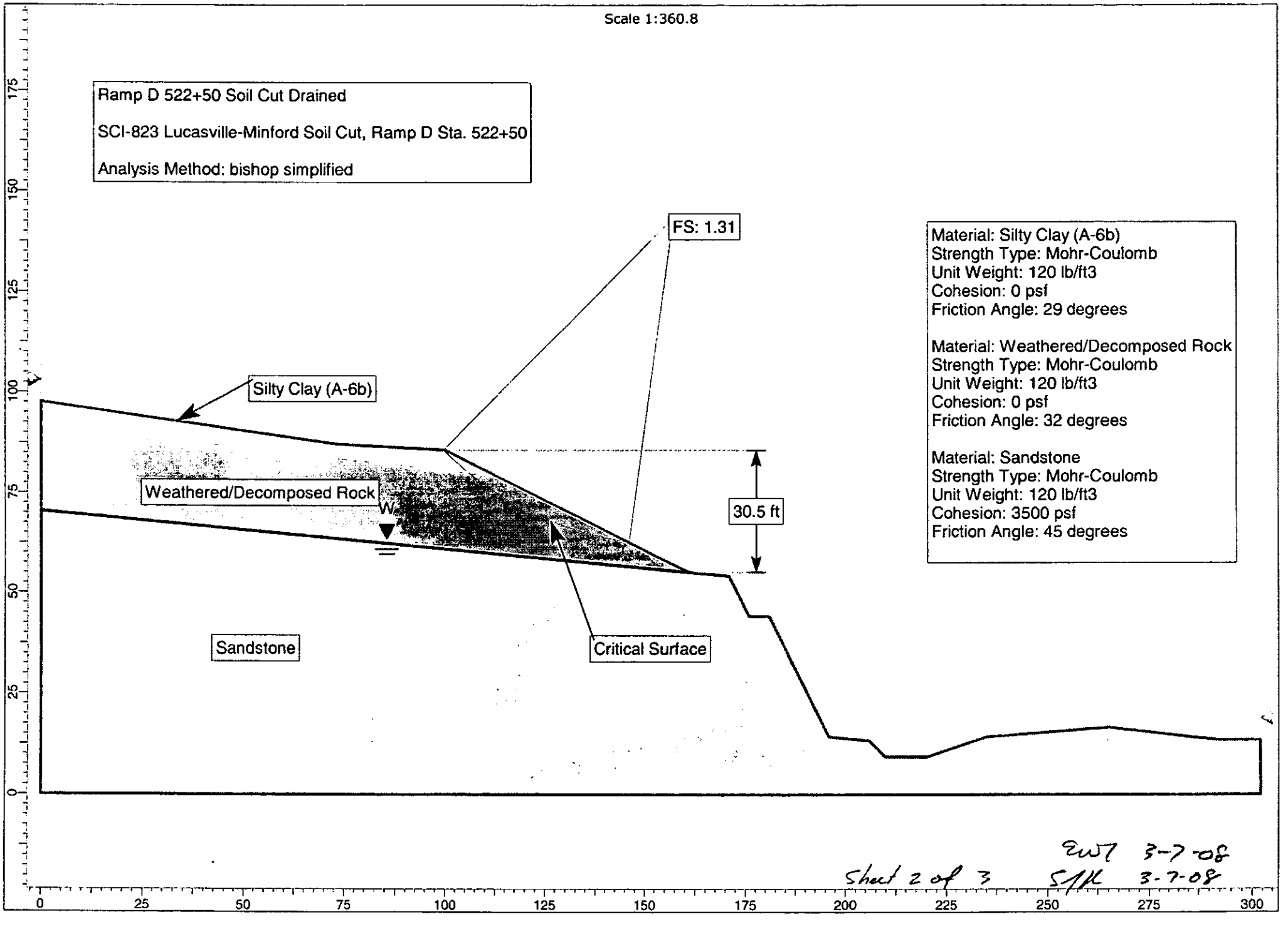
101.144	101.474
138.605	105.861
171.311	105.861
212.863	105.861
270.762	96.742
371.525	80.872



Sheet 1 of 3

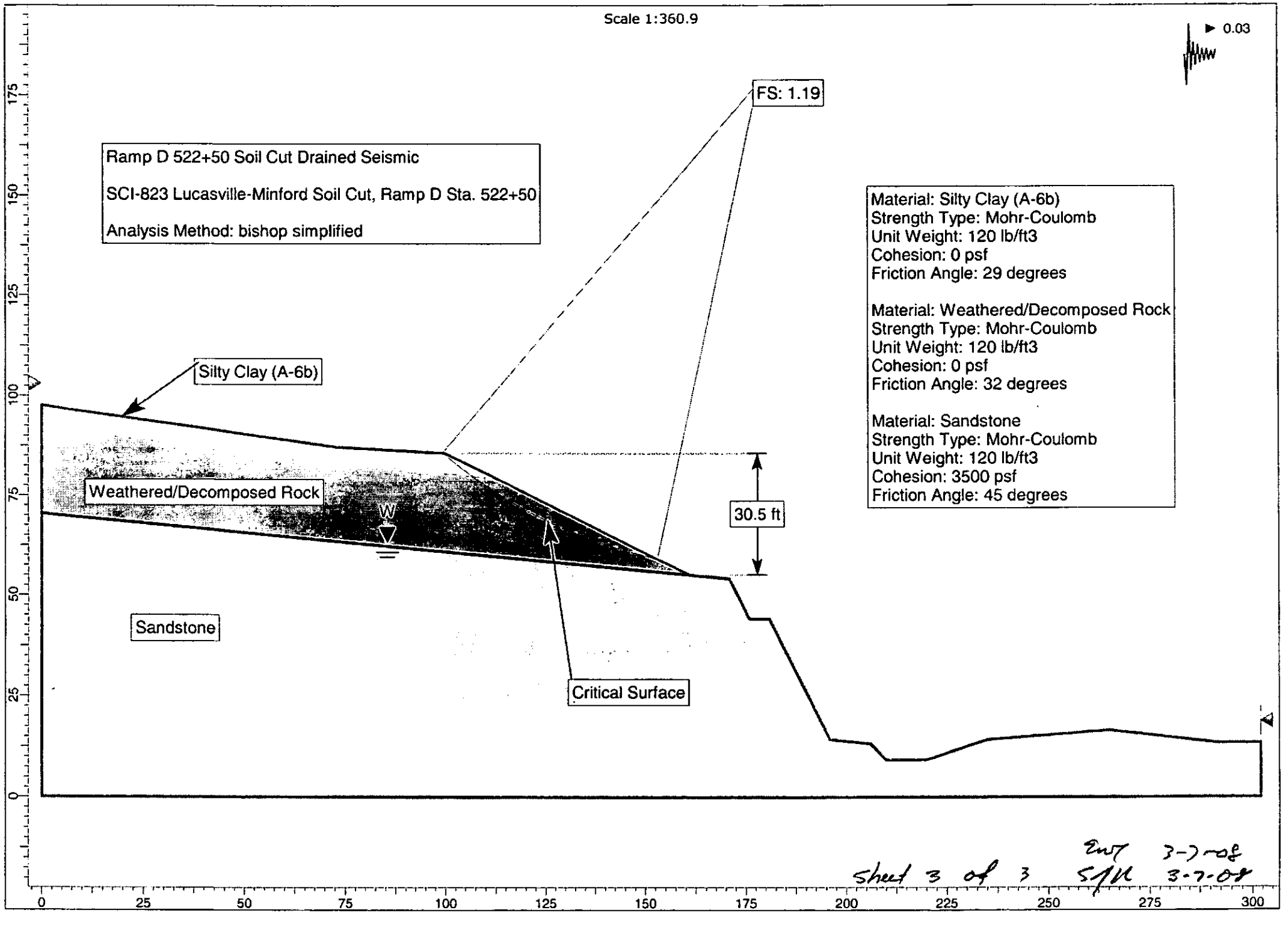
EWT 3-7-08

SJK 3-7-08



EWT 3-7-08

Sheet 2 of 3 SJK 3-7-08



EWT 3-7-08

Sheet 3 of 3 SJH 3-7-08

Slide Analysis Information

Document Name

File Name: Ramp D 522+50 Soil Cut Drained Seismic

Project Settings

Project Title: SCI-823 Lucasville-Minford Soil Cut, Ramp D Sta. 522+50
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu corrected
Spencer

Number of slices: 20
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.03

Material Properties

Material: Silty Clay (A-6b)
Strength Type: Mohr-Coulomb

Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 29 degrees
Water Surface: Water Table
Hu value: automatically calculated

Material: Weathered/Decomposed Rock
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Hu value: automatically calculated

Material: Sandstone
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 3500 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Hu value: automatically calculated

List of All Coordinates

Material Boundary

0.000	91.498
113.724	78.858

Material Boundary

0.000	70.451
160.931	55.255

External Boundary

301.949	0.000
301.949	13.462
291.949	13.462
264.949	16.627
234.949	14.237
219.949	9.237
209.949	9.237
205.931	13.255
195.931	14.255
180.931	44.255
175.931	44.255
170.931	54.255
160.931	55.255
113.724	78.858
100.000	85.720
73.050	87.180
0.000	97.594
0.000	91.498

0.000	70.451
0.000	0.000

Water Table

0.000	70.451
170.931	54.255

Search Grid

104.582	175.160
184.574	175.160
184.574	94.102
104.582	94.102

Subgrade – GB1 Spreadsheet

Subgrade Analysis

V. 9.09 08/10/07

Design	
CBR	5
Item 320	No
Global CS	Option
Global LS	No

23 Total Borings

Classification Counts by Sample

R	1a	1b	3	3a	2-4	2-5	2-6	2-7	4a	4b	5	6a	6b	7-5	7-6	8a	8b
0	0	0	0	0	0	0	0	0	6	9	0	10	2	2	29	0	0
									10%	16%		17%	3%	3%	50%		
0.0%	0.0%								100.0%								

Class @ Surface

2-5	0	
4b	6	26%
5	0	
7-5	0	
7-6	7	30%
8a	0	
8b	0	
R	0	

% Borings	
N_L<= 5	17%
N_L<=10	74%
N_L>=20	4%
M+	48%
R	0%

% Surface	
83%	
26%	74%
% Borings	
91%	
9%	35% 35% 83%

Rig	ER
A	60
B	
C	
D	
E	
F	
G	
H	

	N_{60}	N_L			PI		Clay		M	M_{OPT}		GI
Average	10.0	8.3			19.0		46.0		20.0	15.8		11.65
Maximum	24	21	65	34	43	70	96	100	37	24		20
Minimum	2	2	21	12	3	3	16	47	13	10		2

SCI-823, SR 728 Ramps A - D, PID 19415

#	B #	Boring Location	Depth	To	Cut Fill	Standard Penetration n_2	n_3	N_m	Rig	N_{60}	N_L	Physical Characteristics LL	PL	PI	% Silt	% Clay	P 200	Moisture M	M_{OPT}	Classification Class	GI	Comments	Problem w/ Class	w/ MN	Treatments LS	CS	UC Class	UC MN	Analysis
1	B-1222	Sta. 529+64.0	0.0	1.5	0.0	2	4	6	A	6		24	14	10	41	20	61	14	10	4a	5			MN		16		3	
Ramp A		4.6' Rt	1.5	3.0		8	12	20		20		28	19	9	52	21	73	13	14	4b	8		4b				3	
		Ramp A	3.0	4.5		5	8	13		13		33	16	17	44	28	72	15	16	6b	10							
			4.5	6.0		5	6	11		11	6								14	6a	8							
2	B-1219	Sta. 516+57.6	5.0	6.5	5.0	4	4	8	A	8		29	17	12	65	27	92	22	14	6a	9			MN		14		2	
Ramp A/B		28.5' Lt																											
		Ramp B									8																		
3	B-1207	Sta. 29+94.9	1.0	2.5	0.0	12	8	20	A	20		21	18	3	70	16	86	19	13	4b	8		4b	M			3	1
Ramp A/B		7.1' Rt	3.5	5.0		1	1	2		2		35	20	15	58	32	90	22	15	6a	10			MN		--		5	
		SR 728									2																		
4	B-1221	Sta. 520+43.5	6.0	7.5	6.0	12	9	21	A	21									14	6a									
Ramp B		35.1' Lt																											
		Ramp B									21																		
5	B-1222	Sta. 529+64	1.0	3.0	-1.0	8	12	20	A	20		28	19	9	52	21	73	13	14	4b	8		4b				3	
Ramp B		4.6' Rt	3.0	5.0		5	8	13		13		33	16	17	44	28	72	15	16	6b	10							
		Ramp A									13																		
6	B-1230	Sta. 525+09.2	5.0	6.5	4.0	8	9	17	A	17									10	4a	5	Rock slopes very steeply in this area Portion of Subgrade may be in rock							
Ramp B		24.2' Rt.																											
		Ramp B									17																		
7	B-1226	Sta. 528+21.7	-1.0	0.5	-27.0	2	4	6	A	6									18	7-6	14			N				3	
Ramp B		15.1' Lt.	1.5	3.0		3	3	6		6									18	7-6	14			N				3	
		Ramp B									6																		
8	R-463	Sta. 529+20.1	-0.5	1.0	-14.0	3	5	8	A	8									18	7-6	14			N				2	
Ramp B		93.2' Rt.	2.0	3.5		4	5	9		9									18	7-6	14			N				1	
		SR 823	4.5	6.0		3	3	6		6									18	7-6	14			N				3	
											6																		
9	B-1224	Sta. 531+05.5	4.0	6.0	4.0	3	4	7	A	7		25	15	10	23	24	47	15	10	4a	2			MN		16		3	
Ramp B		39.2' Lt.	6.0	8.0		5	5	10		10		49	22	27	27	63	90	22	19	7-6									
		Ramp B									7																		
10	B-1203	Sta. 15+63.3	1.0	3.0	0.0	7	5	12	A	12		26	18	8	58	34	92	18	13	4b	8		4b	MN		12	3	1	
Ramp C/D		6.2' Rt	3.0	5.0		3	3	6		6		52	24	28	22	71	93	25	21	7-6	18			MN	--			3	
		SR 723	5.0	7.0		4	3	7		7		65	31	34	3	96	99	35		7-5	20		Un	N			All	2	
											6																		
11	B-1209	Sta. 508+24.4	4.0	5.5	4.0	2	3	5	A	5		24	18	6	68	22	90	18	13	4b	8		4b	MN		--	3	5	
Ramp C/D		19.7' Rt.	5.5	7.0		3	3	6		6		25	21	4	67	22	89	17	16	4b			4b	N		16	3	3	
		Ramp C									5																		
12	B-1210	Sta. 540+98.2	0.0	1.5	-6.0	3	5	8	A	8									18	7-6	14			N				2	
Ramp C/D		22.7' Rt.	2.5	4.0		3	3	6		6									18	7-6	14			N				3	
		Ramp D	5.0	6.5		3	4	7		7		65	23	42	5	94	99	37	20	7-6	20			MN	--			3	
											6																		

SCI-823, SR 728 Ramps A - D, PID 19415						Standard Penetration						Physical Characteristics						Moisture		Classification		Comments	Problem		Treatments				Analysis
#	B #	Boring Location	Depth	To	Cut Fill	n_2	n_3	N_m	Rig	N_{60}	N_L	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Class	GI		w/ Class	w/ MN	LS	CS	UC Class	UC MN	
13	B-1211	Sta. 512+06.9	3.0	4.5	3.0	3	4	7	A	7		23	16	7	52	21	73	14	11	4b	8		4b	N		16	3	2	
Ramp C/D		0.5' Rt.	4.5	6.0		3	4	7		7		52	19	33	21	73	94	22	18	7-6	18			MN	--			3	
		Ramp C	6.0	7.5		3	4	7		7		50	27	23	7	93	100	29	24	7-6				MN	--			3	
											7																		
14	B-1212	Sta. 536+98.4	4.5	6.0	5.0	5	7	12	A	12		64	21	43	8	92	100	22	18	7-6	20			MN	12			1	
Ramp C/D		23.5' Rt.	6.0	7.5		8	12	20		20									18	7-6									
		Ramp D																											
											12																		
15	B-1213	Sta. 516+09.5	0.0	1.5	0.0	2	2	4	A	4		25	12	13	57	28	85	17	14	6a	9			N		--		5	
Ramp C/D		14.6' Rt.	1.5	3.0		3	4	7		7		30	17	13	51	32	83	16	14	6a	9			N		16		2	
		Ramp C	3.0	4.5		3	6	9		9		62	34	28	13	87	100	16		7-5	19		Un	N			All	1	
			4.5	6.0		3	6	9		9	4								18	7-6	14			N				1	
16	B-1214	Sta. 532+88.8	1.5	3.0	-7.0	4	4	8	A	8									18	7-6	14			N				2	
Ramp C/D		30.5' Rt.	4.5	6.0		4	5	9		9									18	7-6	14			N				1	
		Ramp D																											
											8																		
17	B-1215	Sta. 520+18.8	0.0	2.0	2.0	4	4	8	A	8									14	6a	8			N				2	
Ramp C		7.9 ' Rt.	2.0	4.0		4	4	8		8									18	7-6	14			N				2	
		Ramp C	4.0	5.5		4	5	9		9									18	7-6	14			N				1	
											8																		
18	B-1216	Sta. 522+07.5	0.0	2.0	0.0	4	6	10	A	10									14	6a	8								
Ramp C		16.1' Rt.	2.0	4.0		7	9	16		16									14	6a	8								
		Ramp C	4.0	6.0		3	6	9		9									14	6a	8			N				1	
											9																		
19	B-1225	Sta. 528+38.8	0.0	1.5	-23.5	2	2	4	A	4									18	7-6	14			N				5	
Ramp C		1.3' Rt.	3.0	4.5		2	2	4		4									18	7-6	14			N				5	
		Ramp C	6.0	7.5		1	2	3		3									18	7-6				N				5	
											3																		
20	R-461	Sta. 529+17.9	0.0	1.5	-11.0	5	8	13	A	13		59	23	36	48	52	100	28	20	7-6	20			MN	12			1	
Ramp C		97.4' Lt.	3.0	4.5		4	7	11		11									18	7-6	14								
		SR 823	6.0	7.5		4	7	11		11									18	7-6									
											11																		
21	B-1224	Sta. 531+05.5	4.0	6.0	4.0	3	4	7	A	7		25	15	10	23	24	47	15	10	4a	2			MN		16		3	
Ramp C		39.2' Lt.	6.0	8.0		5	5	10		10		49	22	27	27	63	90	22	19	7-6									
		Ramp B																											
											7																		
22	B-1217	Sta. 530+13.7	1.5	3.0	1.5	11	12	23	A	23									10	4b			4b				3		
Ramp D		4.8' Lt	3.0	4.5		6	7	13		13									10	4b			4b				3		
		Ramp D	4.5	6.0		6	8	14		14									10	4a	5								
											13																		
23	B-1218	Sta. 527+80.1	0.0	1.5	-3.5	15	9	24	A	24									10	4a	5								
Ramp D		13.7' Lt	1.5	3.0		5	3	8		8		47	18	29	26	58	84	19	18	7-6	17			N	--			2	
		Ramp D	3.0	4.5		4	6	10		10									18	7-6	14								
			5.0	6.5		3	4	7		7	7								18	7-6	14			N				2	